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Corporate Social Responsibility Politics in Small and Medium-sized Companies from Poland

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Abstract
It would be seemed that Corporate Social Responsibility is the domain of large companies, which due to their adopted policy and financial means, are able to perform actions according to the scope of CSR. However, as with the principles of the Sustainable Development concept, companies from the SME sector are able, to some extent, carry out activities in line with the CSR policy. The main purpose of this article was to conduct the research among Polish companies from the SME sector, related to the CSR concept implementation. The author have studied what kind of actions are being, the most often, performed, to what extent, the employees and immediate surroundings, are engaged in the implementation of these actions and whether they bring concrete results in the form of, for ex ample, an increasing number of customers, bigger market share or higher profits. At the end, the possibility of developing some guidelines for SME companies, declaring their willingness to take action in the field of CSR, has been also discussed.

Keywords: Corporate Social Responsibility, Small and medium-sized enterprises, environment, profits, micro enterprise

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Introduction

At present, CSR is understood as a central feature in the business strategy of companies, also it means large energy resources are used by the company for CSR concept realization. The concept of Corporate Social Responsibility (CSR) first appeared in the 50s, but till the 80s there was only a definition. The first action in the field of CSR activities were purely philanthropic and very often based on personal benefits, very rarely they were taken for the benefit of business for the company. Above all, these activities were not considered as strategic activities, with considerable benefits for the company. Only when it became clear that properly conducted policy of CSR can contribute to a significant competitive advantage in the market, CSR has become an integral part of the activities, which are strategic actions for the development of enterprises. In Europe, the introduction of the concept of CSR practice took place many years later than in America. The explanation for this may be the fact that the responsibility initially was seen as a duty to perform and not as a way to expand business.

The CSR concept has been significantly expanded in comparison to the historical origins and is still the subject of public debate. The essence of CSR with a modern twist faithfully reflects the ISO 26000 norm on CSR. ISO 26000 norm, in the "Guidance on social responsibility", provides guidance on Social Responsibility defined as the organization's responsibility for the impact of its decisions and activities on society and the environment, through transparent and ethical behavior in key areas such as:
-   Corporate governance,
-   Human rights,
-   Best practices at work,
-   Environment,
-   Fair operational practices,
-   Consumers' issues,
-   Social engagement and local community development.

The ISO 26000 norm is intended for all organizations: business, central and local government and the third sector.
The definition that summarizes the key aspects of CSR is the definition given by the European Commission in 2001, contained in the Green Paper: „Social and environmental concerns in their business operations and in their interaction with their stakeholders on a voluntary basis. Being socially responsible mean not only fulfilling legal expectations, but also going beyond compliance and investing 'more' into human capital, the environment and the relations with stakeholders".

It is also worth quoting the definition of CSR given by Kellie McElhaney'a, a professor at the University of California, who stated that: „CSR is not about how you spend the Money – it is about how you make the money you spend!"

The global perspective of the development of corporate social responsibility shows the study "State of Sustainable Business Survey. Comparing Perceptions of Current and Future Sustainability Leaders", conducted by 3 organizations: BSR, GlobeScan and Net Impact. To carried out periodically poll of professionals involved in sustainable development around the world, added response analysis of future leaders -

students affiliated to the network Net Impact. Both groups have agreed to assess progress in the field of sustainable development, what business has made in the last 5 years, and also what to do for the next 5 years. A small part of them (approx. 20%) agree with the statement that this progress can be assessed as very significant, but the vast majority confirms that sees a change in this respect. The most important challenges facing business leaders in the field of sustainable development, respondents received: to integrate the concept of sustainable development to the core business activities of companies; confidence of investors as to the appropriateness and cost-effectiveness of sustainable development; long-term planning and greater transparency in business. The biggest differences between the two study groups can be observed when asked about what the priorities should guide companies when it comes to issues of sustainable development. For the current business leaders are the most important human rights and workers' rights, while the future leaders of the most important recognized sustainable consumption, access to water and the fight against climate change.

Corporate Social Responsibility in Polish Companies

The results of the global survey can be compared with similar realized in Poland. The study "Corporate Social Responsibility: facts and opinions" was conducted by KPMG and the Responsible Business Forum among large and medium-sized companies operating in our country - 96% of them believe that the duty of business is to respond to societal and environmental challenges. Such an opinion prevails universally, regardless of the current commitment to CSR. Both the representatives of the top management, as well as people in other positions agree with the statement that business should conduct its business in order to respond to these types of challenges. Among the tasks of sustainable development as the most important, from the point of view of their business, respondents recognized the protection of the environment, support the development of local communities, as well as issues of science and education.

A positive surprise of this survey is the result of 77% - so many respondents agreed with the statement that the operation in accordance with the concept of CSR had a positive impact on financial results. This conviction expressed slightly less members of the top management (73% of responses) than other employees (81%). Less should enjoy that ranked the most benefit from conducting activities in accordance with the concept of CSR is to improve the company's image on the market (52%).

From the another survey conducted by the Responsible Business Forum and GoodBrand "CSR in Poland. Managers/500 as manager, leader of CSR", shows that the knowledge of the representatives of the largest companies in Poland about socially responsible business (CSR) is growing. More and more managers perceive the operation of the business in a broader perspective, the social environment, but also the impact on the environment. This mental opening does not always go hand in hand with the attitudes and practical action - clearly visible is a problem in recognizing the social responsibility characteristics of long-term social investment, having a real impact on business success. Many managers still have trouble to adopt the awareness of "do it now!", pressure on the immediate-profit and short budget perspective. In Poland we still have to deal with the preliminary stage of development of CSR, which is reflected in the fact that the main actions are still in form of charitable activities

and, therefore, mainly various types of financial and material support. However, steadily increasing the perception of business representatives on the importance of local communities and cooperation with non-governmental organizations. The least popular among managers enjoys volunteering, especially implemented during working hours. Therefore, identifying the main barriers facing the development of socially responsible business, it should be noted:

• low level of knowledge about CSR and this, which tools should be used and where the good practices should be received from;
• immediacy pressure – a pressure on short-term target and business strategies;
• related with the above, low level of engagement and lack of support from top management for CSR idea.

Based on the results of the study, a conclusion that, at present the biggest challenge is the need to disseminate knowledge on CSR and an indication of the potential market leaders CSR legible and reliable relationships existing between the principles of socially responsible business and market success, can be formulated.

The Research Methodology

The survey was conducted at the beginning of 2015 and covered polish enterprises from SME sector (including micro ones as well). The research questionnaires have been sent to 500 companies, but for the final research, 467 was included. 33 questionnaires have been rejected due to formal mistakes, also some of them have never been returned. The selected companies operate in the sector such as: oils and fats production, dairy products production, clothing production, printing and typography services, plastics production, households appliances production, kitchen furniture production, children accessories products production and toys and games production, transportation and storage, information and communication.

Table 1. Profiles of surveyed enterprises according to the polish classification of activities

Activity profile	No.	Amount	%
Oils and fats production	10.4	9	2
Dairy products production	10.5	9	2
Clothing production	14.3	106	23
Printing and typography services	18.1	23	5
Plastics production	22.2	80	17
Households appliances production	27.5	32	7
Kitchen furniture production	31.02	14	3
Toys and games production	32.4	70	15
Children accessories production	32.3	28	6
Transportation and storage	49.2	51	11
Information and communication	63.4	45	9

Source: Authors' own work.

The minimum sample size for estimating the probability of p success in a general population, was calculated on the basis of the formula for sample size with a very large population. As was evident from the calculations, the minimum sample size, should be 384 questionnaires. Due to the fact that the study involved 467 questionnaires, it can be assumed that this condition has been met.

The research results

As was mentioned in the beginning, we have studied what kind actions are being performed and to what extent, the employees and immediate surroundings, are engaged in the implementation of these actions and whether they bring concrete results in the form of, for example, an increasing number of customers, bigger market share or higher profits received by the company. But at the beginning the structure of surveyed companies has been presented.
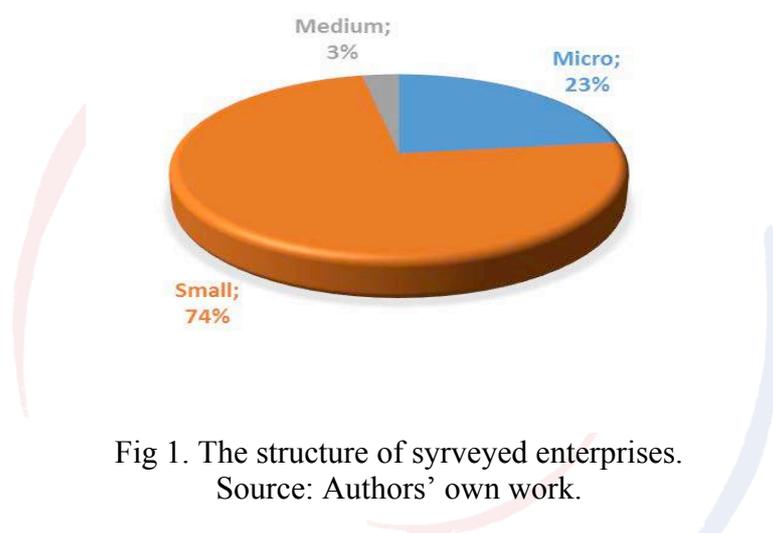
Fig 1. The structure of syrveyed enterprises.
Source: Authors' own work.

From the figure is visible that small companies (from 10 up to 49 employees) are the vast majority of surveyed companies. In total, 345 of this kind of enterprises have returned the filled questionnaires. On the second place were the micro ones (up to 10 employees) – 107 companies and medium sized companies are on the last place – only 15 of them have taken a part in a research.
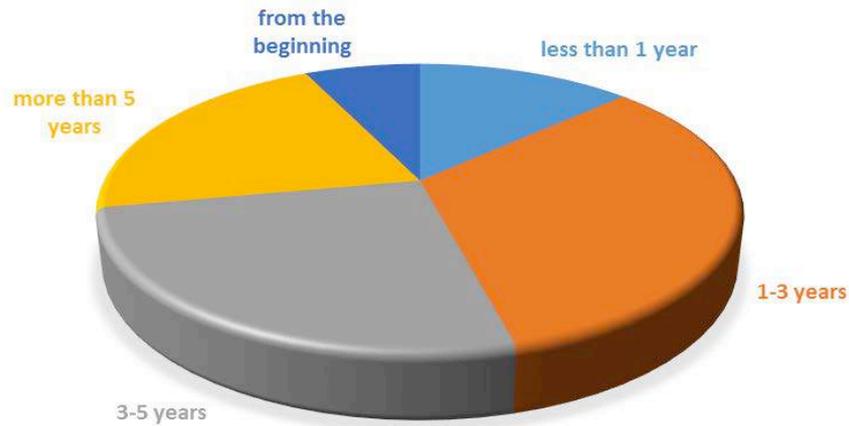
Fig 2. The period of conducting activites related to CSR.
Source: Authors' own work.

According to figure 2, is it visible that the biggest number of companies, 154 units, have been conducting CSR action for 3 to 5 years. On the second place are the companies, 121 of them, who have been performing these actions for 1 to 3 years. And only 33 of the surveyed companies have been performing these actions from the very beginning, meaning, from the time they have started operating on the market. And almost one hundred (98 units) companies have been conducting CSR actions for more than 5 years. From this we can assume that mostly, the companies have decided to take this kind of actions, when they can afford this or they have a stable position on the market. Is it clear that CSR is still not a priority for the companies operating on the polish market. From the other side, the vast majority of companies, who have been doing this for 1 up to 5 years, means that CSR issue is not a new concept any more. And we can only predict that in the following years, more and more companies will decide to implement CSR into their basic operation. Or will start treat CSR as a necessary actions during their life on the market.
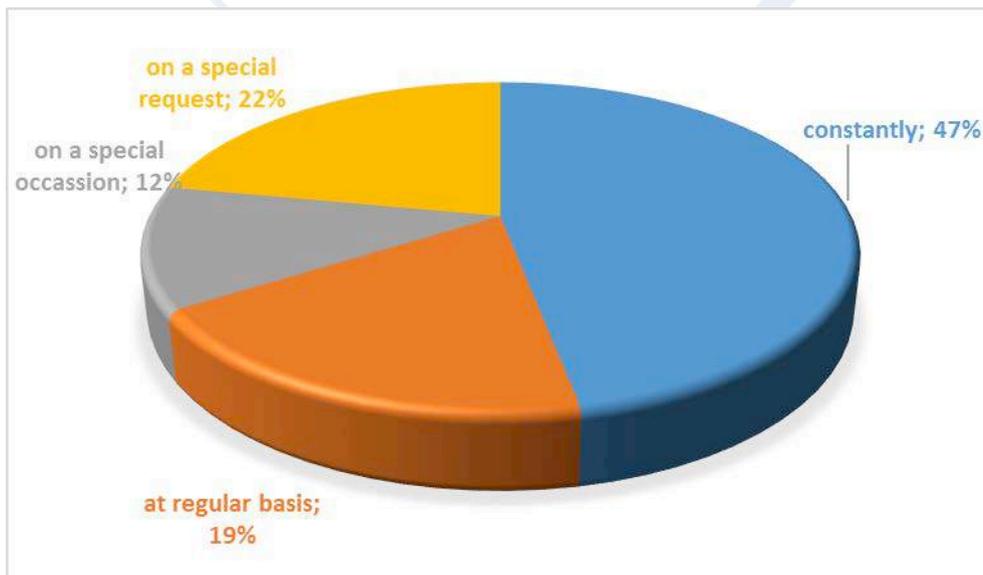
Fig 3. The frequency of taking CSR actions.
Source: Authors' own work.

Almost half of surveyed companies have stated that CSR actions are being constantly performed. It means that CSR become an integral part of the overall company's functioning. It has the same level of importance as actions such as: advertising and promotion, work and safety regulations, environment protection or communication with the clients. CSR in these companies is present in their mission, vision, targets and daily operations. As one of the managers said: "We have work and safety regulations on the walls, and also we have CSR policy on the wall". More than one hundred (103) companies perform CSR actions on a special request – the most often when they are being asked for it by the public authority, local authorities or foundations. By "special occasion" companies understand, the most often, CSR actions if the form of sponsorship. For example, one company always buys a school kit for the kids who are going to start a school – every year, at the end of holidays a city, which the company is located in, organizes a picnic called "Ready to school?" and then the company is one of the sponsors. And also, quite a large part of surveyed companies perform CSR actions on the regular basis – every year, a month before Christmas, company's employee receive a bonus in a form of money and gifts and also, company participates in a Christmas Eve dinner for homeless in the city. From the above results is visible that CSR, for most companies, is treated as an integral part of the overall company's activity. And for the rest companies will be the same soon.

Fig 4. The main reasons for conducting activites related to CSR.
Source: Authors' own work.

As it is visible from the figure above, Human Resources department usually give a signal to perform CSR actions. Of course, HR department at first must know from the top management, that these kind of actions have the full support or CSR concept is favorable by the top management. In this case, HR department is looking for the opportunities to take this actions, based on the information from the outside or from the company's employees. Here, it is worth to notice that most of the CSR actions performed by the companies, are directed to its employees, in a less extent to local community. But, when CSR actions are directed to the local community, most often they are initiated by marketing department. The next reason are the work and safety regulations. Every company must have a work and safety policy and regulations

which must be adopted to prevent accidents at work. But in this case, CSR actions are in the form of additional protection tools which are not necessary. For example, in one company, protection glass are necessary to fulfill work and safety regulation, but the company has decided to distribute among employees, special gloves and hats as well. In other companies, employees have received a special clothes, which are also not necessary but provide extra protection for them.
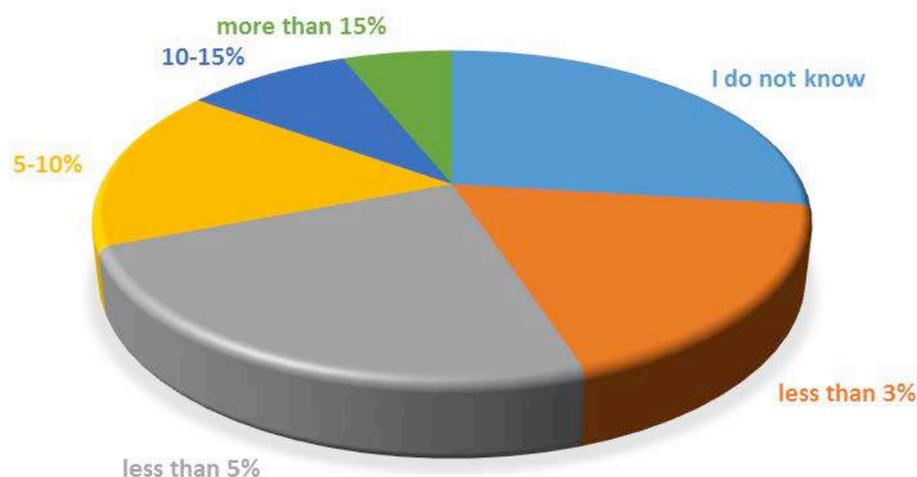
Fig 5. The percentage of the overall company's budget spent on CSR.
Source: Authors' own work.

The vast majority of surveyed companies do not know how much they spend on CSR actions and to what extent the CSR expenditures represent the budget. The most often companies spend some amount the of the money to perform CSR actions but they do not know the exact number. But few managers, in a direct talk, admitted that these expenditures cannot be very high. More than one hundred (112 units) companies admitted that CSR expenditures represent no more than 5% of the overall company's budget, almost one hundred (84 units) admitted that no more than 3%. And less than 30 companies spend on CSR actions more than 15% of the budget. From the above we can conclude that, from one side CSR concept and actions are more and more popular in polish SME companies, but still most of them are not willing to spend more than 5% of their budget. Also, some companies admitted that they prefer to offer their products or services instead of money. In means, that they prefer to offer some non-material benefits, such as planting trees by the employees during the weekend. Of course, employees later can take an extra day off.

Fig 6. The profits received by the company in return of CSR implementation.
Source: Authors' own work.

To the biggest profits, caused by CSR, companies include the increasing number of customers and bigger profits. It means that people in Poland are aware of CSR adoption by the companies and they prefer these companies, who are operating with the CSR policies in mind. This also indicates that polish society do not only choose the company, its products and services, by the price criteria, but also have in mind some additional characteristics. The second profit is a results of the first one – bigger number of customers brings bigger profits for the company. On the further places are: better recognition among the potential customers, better image, bigger market share and rewards. In Poland the most recognized reward is a RESPECT Index - this award the companies which, in respect of social responsibility and sustainable development endeavor going well beyond their obligations under law and include an element of social responsibility internship in the business. The possibility of finding in the index are all companies listed on WSE excluding NewConnect and beyond WSE (dual listing). But, for the small and medium sized companies in Poland, CSR reward are in the form of medal or diploma received from the local authorities, associations or foundations.

Conclusion

From the obtained results it is visible that polish companies from SME sector are familiar with CSR concept and perform actions related to this issue. To summarize we can conclude that:
- The vast majority of surveyed companies have performed CSR action for more than 3 years, also most of them treat them as a constant actions. Only 12% companies undertake CSR actions on a special occassions,
- Most of them implement CSR actions in HR Management – so they care about their employees, on the third place are actions connected with environmental protection,
- 27% companies do no know what is the percentage of the overall budget, spent on CSR activities, and 24% of them spend lass than 5%,

- As the biggest profit, companies have selected increase in customer numer together with bigger profits.

Despite its efforts, there are a number of challenges in the field of CSR, which need to be met. An increase the transparency, and build broad public support for the concept of CSR and civil society development are still they key issues. A Polish government support is also important, which now manifests eg. in Ministry of Economy activities, such as commissioned a handbook on CSR "Sustainable business handbook for small and medium-sized enterprises". The purpose of this manual is to provide knowledge about available tools and practices in the area of CSR, which can contribute to achieving a competitive advantage.

Poland participates, among others, in the project "Sustainable Production through Innovation in Small and Medium Sized Enterprises in the Baltic Sea Region, SPIN)." This project is aimed at promoting innovative solutions for sustainable development, including eco-innovation, environmental technologies and CSR. In addition, Polish Agency for Enterprise Development carries out a research project "Sustainable production patterns in the activities of SMEs - offer system solutions supporting the implementation of sustainable production in SMEs" within the Human Capital Operational Programme. The aim of the project is to provide conclusions, recommendations and proposals of system solutions to support the implementation of sustainable production in SMEs, including legislative instruments, institutional and direct support system. These activities as well as activities of smaller groups, for example Responsible Business Forum, to disseminate knowledge and facilitate access to it, allowing for a better understanding of CSR certainly to some extent contribute to increase the level of CSR importance for Polish companies. It can therefore be assumed that within a few years, the awareness and importance of CSR in the consciousness of Polish companies significantly increase and thus will they treat CSR as an integral part of business strategy, synonymous with the determination of its vision and mission, which are formulated at the very beginning of its activity.

References

Astupan D., Schönbohm A. (2012). *Sustainability reporting performance in Poland:*

Crane A., Matten D. (2004). *Cusiness Ethics: A European Perspective,* Oxford University Press.

CSR w Polsce. Menedżerowie/Menedżerki 500, Lider/Liderka CSR, Forum Odpowiedzialnego Biznesu, GoodBrand, Warszawa 2010, 1-44.

CSR. Społeczna odpowiedzialność biznesu w Polsce, Ministerstwo Gospodarki, Warszawa 2013, 1-16.

Empirical evidence from the WIG20 and MWIG40 Companies, Polish Journal of Management Studies, 6/2012, 68-80.

Herbuś A., Ślusarczyk B. (2012). *The use of Corporate Social Responsibility idea in business management,* Polish Journal of Management Studies, 6/2012, 234-240.

McElhaney K. (2007). *A Catechism on Corporate Social Responsibility,* Ernst&Young, Silberhorn and Warren, UK.

Odpowiedzialny Biznes w Polsce. Dobre praktyki, Forum Odpowiedzialnego Biznesu, Warszawa 2014, 1-85.

Okwiet B. (2012). *CSR-issues in the value chains of multi national companies (mncs) – challenges and best practices,* Annals of the University of Petrosani, Economics, 12/4/2012, 155-168.

Polonsky M., Jevons C. (2006). *Understanding issue complexity when building a socially responsible brand,* European Business Review, 9/2006.

Ptak A., Sroka M. (2014). *Entrepreneurial Activity in the EU Member States, International Conference on Horizontal Approaches in Education and Culture in the Context of European Macro-Strategies*, 30 October 2013, Bucharest, Editura Universitatii Titu Maiorescu, 63-69.

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Effect of Non-Uniform Inlet Flow Rate on the Preheating Process of a Solid Oxide Fuel Cell Unit

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Abstract

This study simulates the preheating process of a solid oxide fuel cell unit with the cross-flow configuration, and investigates the effect of the non-uniform inlet flow pattern and the non-uniform deviation on the maximum temperature gradient and preheating time. The numerical method is accuracy and reliable through the comparison with the analytical solution of previous literature. The results show that the effect of non-uniform inlet flow pattern on the maximum temperature gradient is obvious, and the effect in the fuel side is more obvious than that in the airside. The best choice of the inlet flow pattern is C, which the fuel side is uniform and the airside is the progressively increasing profile. Additionally, the effect of non-uniform inlet flow pattern on the preheating time is slight, but the effect of non-uniform deviation on the preheating time should be considered.

Keywords: Non-uniform, Preheating, Cross-flow, Solid oxide fuel cell, Maximum temperature gradient, Preheating time

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Introduction

The structure of a solid oxide fuel cell (SOFC) includes an anode, a cathode, an electrolyte, and an inter-connector, and its operating temperature is 600-1000°C. The SOFC has wider usage of the fuel, such as methane, ethanol, etc. Because the electrolyte is solid, the SOFC is easier to be produced different geometries such as cylindrical and plate form. The plate shape is easy to stack, so it becomes more popular in the application. Figure 1 shows the schematic of a plate solid oxide fuel cell unit.
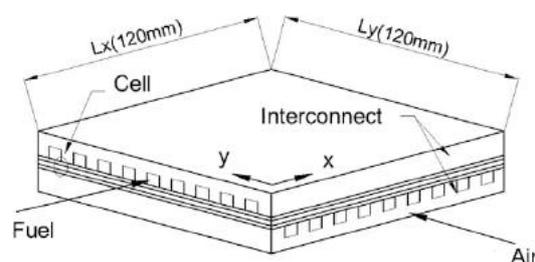
Fig. 1 Schematic of a plate solid oxide fuel cell unit

The SOFC must be heated up before the normal operation because of its high operating temperature. When the SOFC is to be an assistant power, it will not satisfy the necessary of the market if its time of heat up is too long. The quick rate of temperature increasing of a SOFC can short the heat up time, but this will occur large temperature gradient that can induce the damage of the seal due to the thermal stress. In the past two decades, there are many literature [1-12] focus on the transient analysis of a SOFC, and investigate the performance of its heat up, start up, and shut down process.

Author has published papers [13,14] for investigating the effect of non-uniform inlet flow rate on the thermal and electrical performance of a SOFC with the cross-flow configuration in the steady state. Most of the previous literature [1-12] analyzes the preheating time and temperature gradient of a SOFC at the heat up process with co-flow or counter flow configuration. Recently, the application of a cross-flow configuration on a SOFC becomes popular because of its easy of inlet arrangement. Because the properties and variables are function of x and y direction, few literature focus on the transient analysis of a SOFC at the heat up process in the cross-flow configuration. Moreover, the inlet positions of fuel and air as well as the design of flow distributor will induce a non-uniform inlet flow, this non-uniform factor must affect the efficiency of preheating process of a SOFC. Therefore, this study investigates the effect of the non-uniform inlet flow rate on the transient performance of a SOFC unit with a cross-flow configuration at the heat up process.

Analysis

In the preheating process, the velocity increasing of the preheating gas (i.e. flow rate increasing) will decrease the temperature gradient and preheating time of a fuel cell. Moreover, the temperature increasing of the preheating gas will decrease the preheating time, but increase the temperature gradient [4]. If someone selects more flow rate of the preheating gas and higher preheating temperature for shorting the preheating time and dropping the temperature gradient, it must need more energy for this promotion. Therefore, this study considers the preheating model as previous literature [9], which has a constant preheating energy from a preheating burner as shown in Fig. 2.
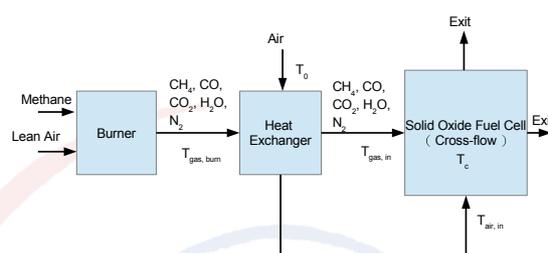
Fig. 2 The preheating model of a solid oxide fuel cell unit

Figure 2 depicts the process of preparing preheating gas with a methane burner. The methane combusts with lean air in the burner for maintaining the low oxygen in the exhaust, because the exhaust gas will be the fuel of the SOFC. In order to avoid producing high temperature gradient due to the exhaust gas with over 1000K, a heat exchanger exchanges the heat from the exhaust gas to the fresh air. When the flow rate of the air increases, the exit temperature of the gas will decrease. This study set the temperature difference between the preheating gas/air and the cell temperature at the inlet corner to be 100K [9].

$$T_{gas,in} = T_{air,in} = T_c(0,0) + 100 \tag{1}$$

This study keeps the flow rate of the methane and lean airflowing into the burner to be constant, so the energy of the exhaust gas is also constant when the combustion is stable. Because the preheating temperature of the gas and air in the exit of the heat exchanger must be kept based on Eq. (1), the flow rate of the air in the inlet of the heat exchanger should be controlled. This inlet flow rate of the air can be calculated according to the energy conservation as following.

$$n_{air} = n_{gas} \sum_i c_{p,i} X_i (T_{gas,burn} - T_{gas,in}) / \sum_j c_{p,j} X_j (T_{air,in} - T_0) \tag{2}$$

This study considers the configuration of the fuel and airflowing direction is cross-flow. The flow distributor arranges the fuel and airflowing into each channel, which is always a part of the inter-connector for stacking easily as shown in Fig. 3.
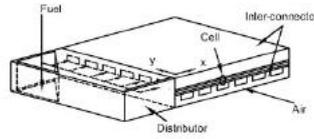
Fig. 3 Schematic of the flow distributor in the fuel side of a SOFC unit

Figure 3 only shows the fuel distributor for easy demonstration. Meanwhile, the inlet of the fuel usually locates one side of the distributor, and the fuel flows into each channel through the geometry inside the distributor. The location of the fuel inlet and the design of the distributor will induce a non-uniform inlet flow rate of each channel. This study assumes the distributor will produce a straight line of non-uniform profile, and considers the inlet position of the fuel and air may be one side of the distributor. Therefore, the non-uniform inlet flow rate of the SOFC unit has 8 patterns as shown in Fig. 4. Moreover, this study also considers the uniform pattern (both the fuel and air inlet is uniform profile) for the comparison. Actually, the design of the distributor will induce the different slopes of the straight line of non-uniform profile. This study ignores the existence of the rib in the channels, and expresses the relationship between the flow rate along the cross section and the slope in the following.

$$n_{gas}(y) = (n_{gas}/k_{gas})(2d_{gas}y/l_y + 1 - d_{gas}) \tag{3}$$

$$n_{air}(x) = (n_{air}/k_{air})(2d_{air}x/l_x + 1 - d_{air}) \tag{4}$$

Meanwhile, the l_x and l_y represent the length in the x and y, respectively. The d stands for the deviation away the average flow rate. The different value of d will represent different slopes.
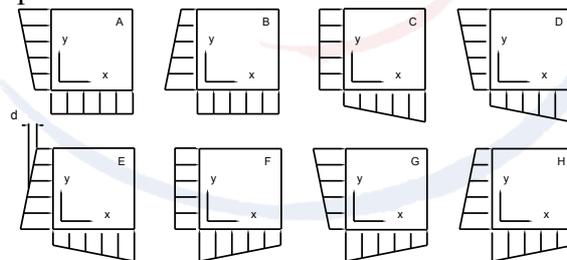
Fig. 4 Non-uniform patterns in this study

This study assumes the anode, cathode, and the electrolyte to be a combination, which is named the cell. Moreover, the scale in the x and y direction are far larger than the scale in the z direction, so this study neglects the change of variables in the z direction. Therefore, the analysis becomes a two dimensional problem. This study takes the energy conservation for the fuel, air, cell, and inter-connector in the following.

For the fuel

$$\frac{\partial}{\partial t}\left(\sum_j n_{gas}X_j c_{p,j}T_{gas}\right) + \frac{\partial}{\partial x}\left(\sum_j n_{gas}X_j c_{p,j}T_{gas}\right) = (ha)_{i-gas}(T_i - T_{gas}) + (ha)_{c-gas}(T_c - T_{gas}) \tag{5}$$

For the air

$$\frac{\partial}{\partial t}\left(\sum_j n_{air}X_j c_{p,j}T_{air}\right) + \frac{\partial}{\partial y}\left(\sum_j n_{air}X_j c_{p,j}T_{air}\right) = (ha)_{i-air}(T_i - T_{air}) + (ha)_{c-air}(T_c - T_{air})$$

(6)

For the cell

$$\frac{\partial}{\partial t}\left(\rho c_p T\right)_c - (k\rho)_c \frac{\partial^2 T_c}{\partial x^2} - (k\rho)_c \frac{\partial^2 T_c}{\partial y^2} = (ka)_{i-c}\frac{(T_i - T_c)}{\delta_{i-c}} + (ka)_{i-c}\frac{(T_i - T_c)}{\delta_{i-c}} + (ha)_{c-gas}\left(T_{gas} - T_c\right) +$$

$$(ha)_{c-air}(T_{air} - T_c) \qquad (7)$$

For the inter-connector

$$\frac{\partial}{\partial t}\left(\rho c_p T\right)_i - (k\rho)_i \frac{\partial^2 T_i}{\partial x^2} - (k\rho)_i \frac{\partial^2 T_i}{\partial y^2} = (ka)_{i-c}\frac{(T_c - T_i)}{\delta_{i-c}} + (ka)_{i-c}\frac{(T_c - T_i)}{\delta_{i-c}} + (ha)_{i-gas}\left(T_{gas} - T_i\right) +$$

$$(ha)_{i-air}(T_{air} - T_i) \qquad (8)$$

Because this study neglects the z direction, the convection area and conduction area due the ribs in channels are merged into the parameter of a.

Author has published some papers of a SOFC performance simulation applying the FlexPDE software and Fortran code developing by himself [13,14]. The software of FlexPDE has been proved to be reliable. Therefore this study utilizes this software to simulate the transient performance in the heat up of a SOFC unit.

Results and Discussion

Figure 5 shows the accuracy comparison according to the analysis case [4]. The literature [4] analyzes the preheating process of an one dimensional SOFC unit when the fuel gas is static and only the air preheats the fuel cell, so it has two energy equations for the air gas and the solid, respectively. Moreover, the literature [4] assumes the temperature of air equals to that of solid, so it becomes a one energy equation problem in this analysis case. This study applies the FlexPDE software to solve the Eq. (12) [4], which results are shown in Fig. 5 by the continue line with square symbol. In order to prove the numerical method is reliable, this study tries to follow the analytical solution in Appendix [4], but the calculating values are unreasonable (maybe there are typos in the reference). Therefore, this study directly describes the analytical line of Fig. 3 in the literature [4], and shows them in the Fig. 5 by the symbol of solid circle. In the Fig. 5, it shows that the continue line with square symbol match well with the solid circle. Therefore, the FlexPDE solution is accuracy and reliable. Moreover, author uses the software to solve the Eq. (5)-(8) of this study with the same conditions [4], which the cell temperatures are shown in Fig. 5 by the dashed line with solid square symbol. In this figure, the continue line has obvious difference to the continue with square symbol (one equation model), and the shape of the lines at x=0 are also different, because the boundary condition for the solid at x=0 of one equation [4] and four equations is different, which one is function of time and another is the adiabatic. Moreover, the one equation model assumes the thermal equilibrium, and the energy equation of solid also includes the convection effect, which will over predict the heat transfer along the x direction. Although the cell temperature in one equation model at x=0 is higher than that in four equation model of this study due to the different boundary condition, the cell temperature along the x direction in one equation model drops more quickly than that in four equation model due to the convection term in the one equation model.
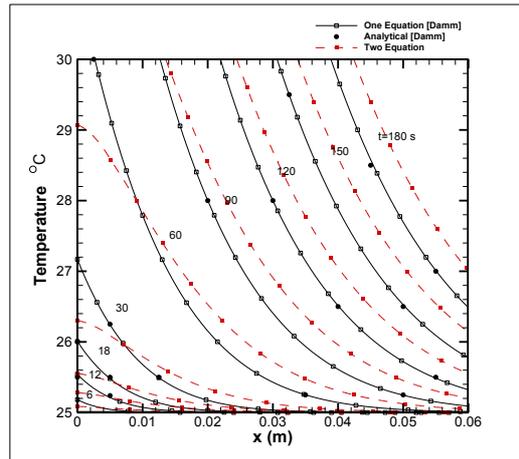
Fig. 5 Accuracy comparison

Figure 6 depicts the temperature distribution of one-equation model [4] and four-equation model of this study when the time is 90s. Meanwhile, the dashed line with square, triangle, gradient, and right triangle symbol respects the cell, fuel, air, and separator temperature, respectively. In this figure, the cell, separator, and fuel temperature are similar and all of them have same pattern at x=0, because the cell and separator are solid and the fuel is static, which have the adiabatic condition at x=0. The air temperature is higher than all of them because its inlet condition is a function of time. The temperature of one-equation model near x=0 is between the fuel temperature and other temperature of the four-equation model, because its inlet condition is the combination of heat flux and function of time.
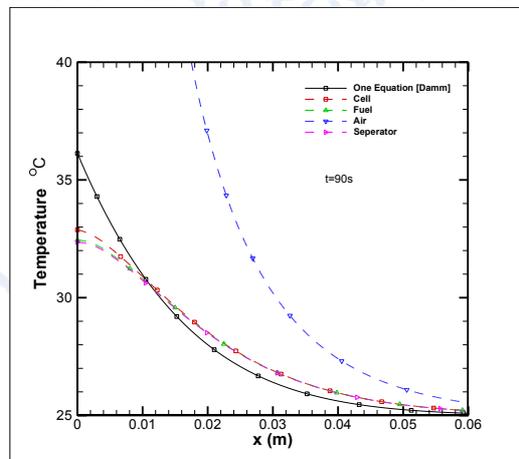
Fig. 6 Temperature distributions of one-equation and four-equation model at 90s of the accuracy comparison case

Figure 7 shows the center temperature response in different convergent conditions when both the fuel and air preheat the SOFC unit, and their configuration is cross-flow. In this figure, this study analyze a same condition with different convergent conditions from 0.05 to 0.005. The results show that the temperatrue response approachs to the case of 0.005 when the convergent condition decreases, and the temperature response in the convergent condition of 0.009 has already coincided with the case of 0.005. Therefore, this study selects the convergent condition of the numerical analysis to be 0.009 for the following analysis.
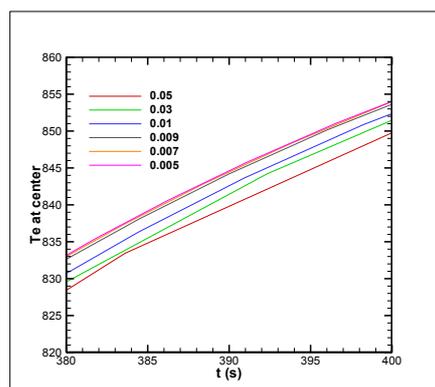
Fig. 7 Center temperature response of the cell in different convergent conditions

Figure 8 depicts the maximum temperature gradient response of the cell at different non-uniform pattern and deviation. In this figure, this study considers 9 non-uniform inlet flow patterns, which include 8 patterns in Fig. 3 and one uniform pattern (both the fuel and air are uniform inlet flow). Moreover, this study also considers these 9 patterns with three kinds of non-uniform deviation, which are 0.25, 0.5, and 0.75. The cell temperature is atmosphere temperature when the SOFC begins the starting, so the airflow rate will be adjusted to large for providing suitable preheating temperature of the fuel and air according to the Eq. (2). Along with the increasing of the preheating time, the cell temperature becomes higher and simultaneously the airflow rate decreases for getting higher preheating temperature of the fuel and air. Once the cell temperature at the reference position arrives 798K, the airflow rate is kept a constant and the preheating temperature stays the value of 898K for the operation of a SOFC. In the Fig. 8, the results show that the maximum temperature gradient occurs at about 350s no matter the different non-uniform patterns or different deviations. Moreover, all analyzing cases have finished the preheating process after 800s. However, the preheating time slightly becomes longer when the deviation is larger. In Fig. 8(a), the maximum temperature gradient is close to zero at 600s, and it is higher than zero at 600s when the deviation is 0.5, and 0.75. Therefore, the effect of non-uniform pattern and deviation on the occurring time of the maximum temperature gradient can be neglected. However, the non-uniform patterns and deviations obviously affect the value of maximum temperature gradient and slightly affect the preheating time.

In Fig. 8, this study marks the same color for same inlet flow distribution in the fuel side, and finds the maximum temperature gradient response rank from high to low is blue, green, and red. This means that the fuel inlet flow distribution rank for a good preheating is the uniform profile, progressively increasing profile, and progressively decreasing profile. Moreover, the maximum temperature gradient response rank in the same color group of Fig. 8 is the result with delta symbol, no symbol, and square symbol. This means that the inlet flow distribution rank of the air for a good uniform preheating is the progressively increasing profile, uniform profile, and progressively decreasing profile. Therefore, the non-uniform inlet flow of fuel dominates the maximum temperature gradient, and the best profile in the fuel side is uniform. The non-uniform profile in the airside also affects the maximum temperature gradient, and the progressively increasing profile is the best. Therefore, the pattern C is the optimal design for a good uniform preheating.
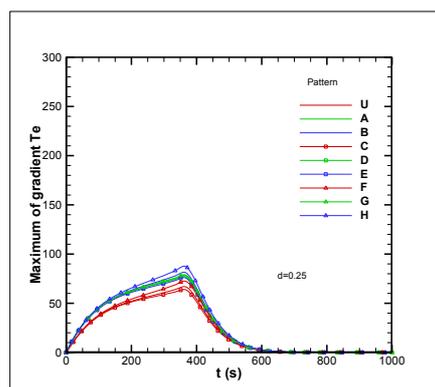
(a) d=0.25
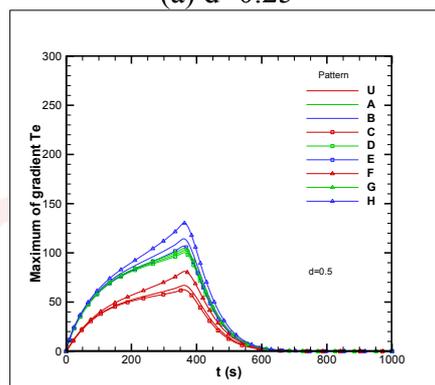
(b) d=0.5
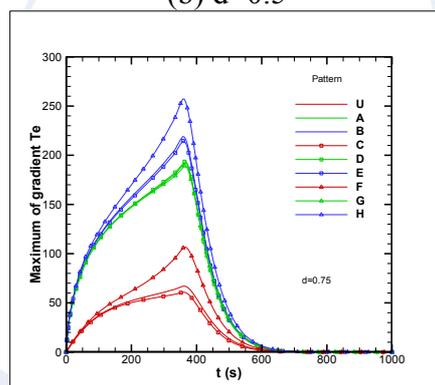
(c) d=0.75

Fig. 8 The maximum temperature gradient response of the cell at different non-uniform pattern and non-uniform deviation

Figure 9 depicts the difference bewteen the maximum and minimum cell temperature in different non-uniform patterns and deviations in order to analyze the effect of these two factors on the preheating time. This figure shows that the effect of different non-uniform pattern on the preheating time is slight, and the better uniform preheating in Fig. 8 has little quick preheating. Moreover, the effect of non-uniform deviation on the preheating time is more obvious, and the preheating time is close to 600s, 650s, and 700s for d=0.25, 0.5, and 0.75, respectively.
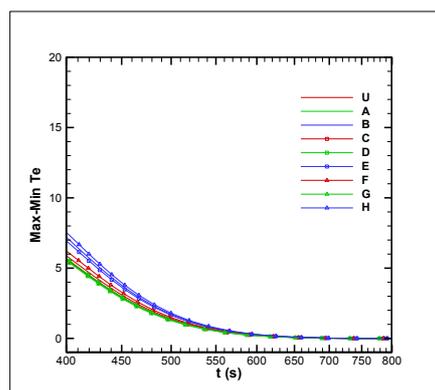
(a) d=0.25
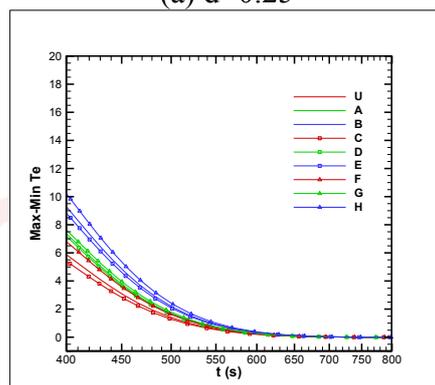
(b) d=0.5
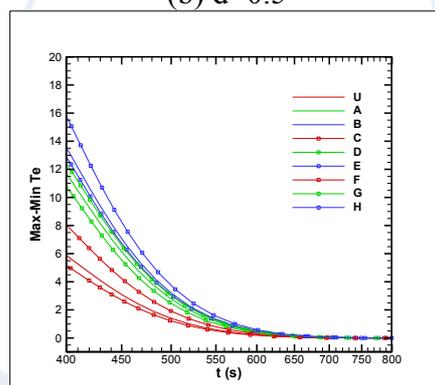
(c) d=0.75

Fig. 9 The difference bewteen the maximum and minimum cell temperature in different non-uniform patterns and deviations

Conclusion

This study applies a software to analyze the preheating process of a solid oxide fuel cell unit considering the different non-uniform inlet flow patterns and deviations. This study prove accuracy and reliable of the software through comparing the previous analytical solution. The results indicate that the effect of non-uniform inlet flow pattern on the maximum temperature gradient is obvious, and the effect in the fuel side is more obvious than that in the airside. The best choice of the inlet flow pattern is C, which the fuel side is uniform and the airside is the progressively increasing profile. Additionally, the effect of non-uniform inlet flow pattern on the preheating time is slight, but the effect of non-uniform deviation on the preheating time should be considered.

References

L. Petruzzi, S. Cocchi, F. Fineschi, A global thermo-electrochemical model for SOFC systems design and engineering, Journal of Power Sources 118 (2003) 96–107.

R. S. Gemmen, C. D. Johnson, Effect of load transients on SOFC operation—current reversal on loss of load, Journal of Power Sources 144 (2005) 152–164.

A. Selimovic, M. Kemm, T. Torisson, M. Assadi, Steady state and transient thermal stress analysis in planar solid oxide fuel cells, Journal of Power Sources 145 (2005) 463–469.

D. L. Damm, A. G. Fedorov, Reduced-order transient thermal modeling for SOFC heating and cooling, Journal of Power Sources 159 (2006) 956–967.

Michael J. Stutza, Robert N. Grassb, Stefan Loherb,Wendelin J. Starkb, Dimos Poulikakosa, Fast and exergy efficient start-up of micro-solid oxide fuel cell systems by using the reformer or the post-combustor for start-up heating, Journal of Power Sources 182 (2008) 558–564.

Mustafa Fazil Serincan, Ugur Pasaogullaria, Nigel M. Sammes, A transient analysis of a micro-tubular solid oxide fuel cell (SOFC), Journal of Power Sources 194 (2009) 864–872.

C. Ozgur Colpana, Feridun Hamdullahpur, Ibrahim Dincer, Heat-up and start-up modeling of direct internal reforming solid oxide fuel cells, Journal of Power Sources 195 (2010) 3579–3589.

Jeongpill Ki, Daejong Kim, Computational model to predict thermal dynamics of planar solid oxide fuel cell stack during start-up process, Journal of Power Sources 195 (2010) 3186–3200.

Ming-Hong Chen a, Tsung Leo Jiang, The analyses of the heat-up process of a planar, anode-supported solid oxide fuel cell using the dual-channel heating strategy, International Journal of Hydrogen Energy 36 (2011) 6882-6893.

M. Peksen, A. Al-Masri, L. Blum, D. Stolten, 3D transient thermomechanical behaviour of a full scale SOFC short stack, International Journal of Hydrogen Energy 38 (2013) 4099-4107.

A. Al-Masri, M. Peksen, L. Blum, D. Stolten, A 3D CFD model for predicting the temperature distribution in a full scale APU SOFC short stack under transient operating conditions, Applied Energy 135 (2014) 539–547.

M. Halinen, O. Thomann, J. Kiviaho, Experimental study of SOFC system heat-up without safety gases, International Journal of Hydrogen Energy 39 (2014) 552-561.

P. Yuan and S.F. Liu, Numerical Analysis of Temperature and Current Density Distribution of a Planar Solid Oxide Fuel Cell Unit with Non-uniform Inlet Flow, Numerical Heat Transfer, Part A 51 (10) (2007) 941-957.

P. Yuan, Effect of inlet flow maldistribution in the stacking direction on the performance of a solid oxide fuel cell stack, Journal of Power Sources 185 (2008) 381-391.

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Research on Spatial Sustainability of Land-Use Patterns in Urban Fringe: A Study on Erxianguan Region, Shenzhen, China

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Abstract
With the rapid development of China's urbanization, the urban land has been spreading to the rural areas, leading to an increasing evolution of the land use pattern in urban fringe. The sustainability of land use in urban fringe is supposed to be significant to urban spatial expansion, urban function realization, urban economic development and ecological environment construction, while the evolution process and mechanism of land use, and problems such as "urban village", ecological destruction, waste of land resource, remain unsolved. This paper takes Erxianguan region as its research object, which has been serving as the boundary of Shenzhen Special Economic Zone for 30 years since Chinese Reform and Opening up. Based on statistics via field research, interviews and literature research, the historical changing of land use in Erxianguan urban fringe is arranged. The spatial form of land use in Erxianguan is analyzed emphatically, and two types of land use patterns are proposed: Closed street block developed from above to below; Informal patches self-organized from bottom to up. Comprehensive evaluation of the two land use patterns is conducted in consideration of social function, utilization of resources, ecological environment and cultural heritage, which aims to classify the sustainability degree, and put forward the improved direction and optimization of sustainable development of urban fringe land use.

Keywords: Land use, sustainability, urban fringe, planning, self-organization

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Introduction

Since the founding of new China, the number of China's urban population and urban has been increasing gradually, as well as the urbanization rate, however, behind the rapid process of urbanization, there is a lot of problems. Especially after the reform and opening up, the process of urbanization in China has been significantly speeding up, into the urban rapid expansion, which is a new stage of social and economic structure of the rapid transformation. Development of space brought many problems: urban sprawl, waste land, landscape construction disorder, loss in the history and culture, the rural population flows, the regional cultural identity loss and deterioration of the ecological environment etc.

Urban fringe is a unique geographical entity, which turns out to be a result of the urban development to a certain stage, located between the city and its rural hinterland, being a main area for the expansion of urban space. Urban fringe has the biggest change scale and fastest change speed in the urban spatial expansion, as well as the most sensitiveness to environmental changes. Urban fringe has not only witnessed the expansion of the city, but also carrying the problems existing in the expansion. As the link between urban fringe area, as a core area of the city and the rural hinterland contact, urban fringe can complete display process of urban space.
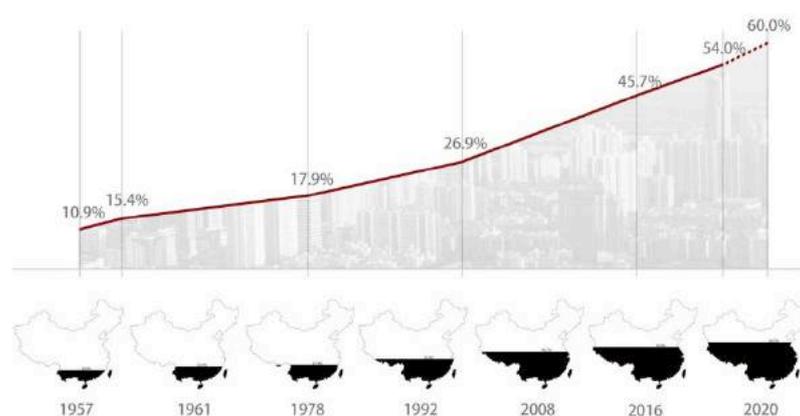
Figure 1: China's urbanization level from 1957 to 2020

Moreover, the urban fringe is the concentrated reflection of the regional man land relationship, which is under the pressure of urban development, are facing or experiencing a dramatic spatial evolution and the modern transformation and its spatial evolution is different from other regions of the rules.

Therefore, the sustainability of land-use in urban fringe is of significance to the urban space expansion, realization of the functions of cities, urban economic development and ecological environment construction. This paper takes Erxianguan region, Shenzhen, China for example, analyzing the characteristics of urban fringe land use, in terms of space, society and economic features, classifying the prototype according to the characteristics, and describing in detail the life history of the settlement of the urban fringe, and finally constructing the analysis framework of the evolution of urban fringe space settlement.

Figure 2: Erxianguan region as the urban fringe of Shenzhen

Urban fringe with urban and rural land-use

Urbanfringe was first discovered by a German geographer Louts, researching city form and region structure in Berlin, showing that part of the original rural area is occupied and gradually becomes part of the city built area, which is known as the "urban fringe". Golledge pointed out that the spatial characteristics of urban fringe is due to the interaction of formation of city and region rural land use form.1975 Los Umm put forward the regional city structure, including the core area of the city, urban fringe area, urban affected zone, part of the rural hinterland. Urban fringe area is usually located in the periphery of the core area of the city, having its land use turning from agricultural land to city land. With the city development direction factors penetrating to the area, Urban fringe is the main area that urbanism exists.
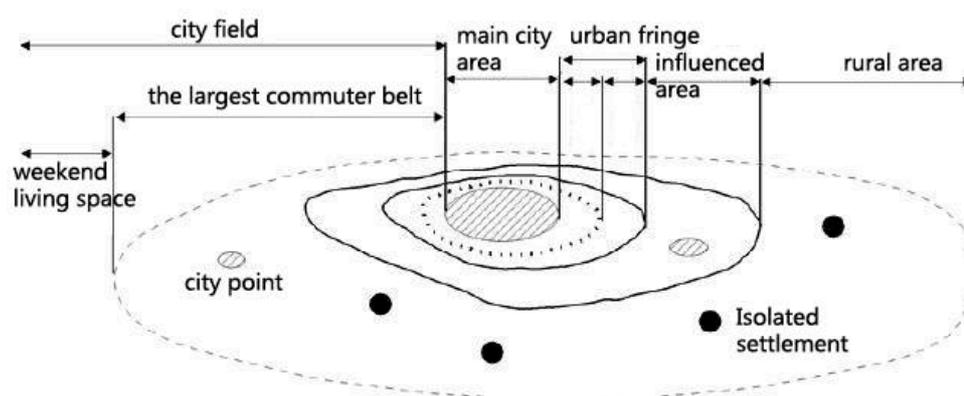
Figure 3: City structure pointed out by Los Umm

Urban fringe area, as a result of dynamic urban expansion, leads to a most obvious change in land use. Land use form in urban fringe area becomes the main content of urban sustainable development. The dual economic structure of developing countries, in the process of urbanization in cities and country boundaries become increasingly blurred, closely linked to agricultural activities and non-agricultural activities, urban and rural land use is mixed with each other. Therefore, there is a different urban regional space pattern from that in western developed countries.

With 30 years' rapid development of city and economy, Shenzhen turns out to be a frontier window of Chinese reform and opening up, which becomes a miracle city. In February, 1979, Baoan County to Shenzhen City, as an export production base combining industry and agriculture; in May 1980, Shenzhen was officially designated as a "special Economic Zone". At that time, the urban population is only 10 thousand, the rural population is 300 thousand, the urban area was only 3 square kilometers; Urbanism level of 1980-1984 rapidly increased from 23.91% to 66.1% years, then entered a stage of stable growth in 1993-2003, increasing from 66.1% to 91.25%. Erxianguan region, which is urban fringe of Shenzhen, has been serving as the important boundary of Shenzhen Special Economic Zone. Erxianguan region not only witnessed the development of the special zone, but also covers the city stratification.

a) 1983   b) 1996   c) 2001
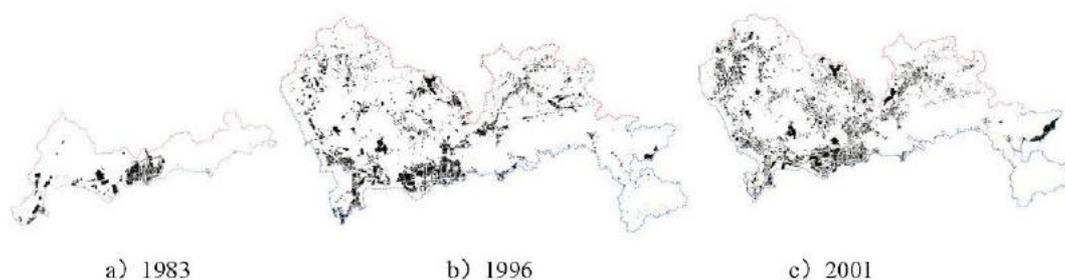
Figure 4: Urbanization of Shenzhen

From the point of spatial structure, there are smaller rural settlements in Erxianguan region, as well as concentrated contiguous urban residential area, which show significant differences in the size. From rural area to the urban core area, the urban fringe settlements are mainly from the agricultural landscape, to the scene of the workers, peasants and mixed view, to the gradient variation of the total urban landscape. Urban fringe area turns out to be of irregular landscape and extreme fragmentation, due to the discontinuous intervention of industry, residence, and commercial land.

From the point of economic structure, there is a gradient variation in urban fringe from agricultural land to the non-agriculture land, which is obvious in the gradient of time and space of urban fringe area. Moreover, non-agricultural employment in urban fringe has a considerable degree of dependence on land rental income and rental income is considered to be influenced by location greatly, so that the locational differences bring the vast difference between the incomes of residents in urban fringe district.

From the point of social structure, the household composition is more complex due to diversity of land use types and the large number of floating population, therefore, mixed urban and agricultural household are largely existed. With the development of the city, registration transformation from agricultural household to non-agricultural household is the main trend. Traditional rural settlements are closely linked mostly due to genetic and geographical links, while the city is showing loose and weak social relations, causing collision between urban and rural life and ideas.
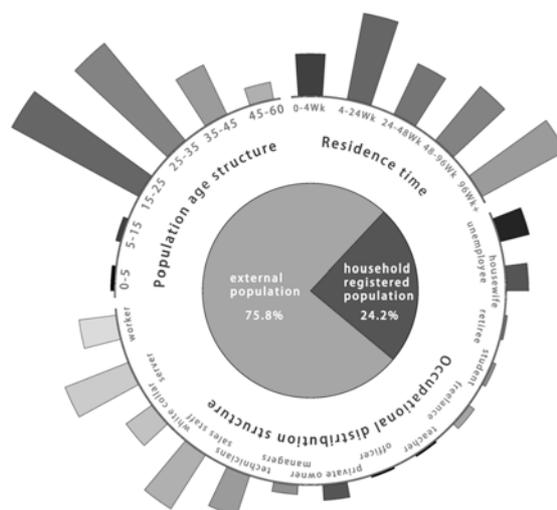
Figure 5: Social structure of Shenzhen

Types of land use in urban fringe

Urban fringe land use morphology can be summed up as two types: closed street block developed from top to bottom, such as the high-grade residential areas, villas, factories, schools, and hospitals; Informal patches developed from bottom to up, such as urban villages, urban outskirts, cultivated land and wild land.

Closed street blocks and informal patches have obvious difference in spatial characteristics and social attributes. In terms of spatial characteristics, closed blocks are state-owned and closer to the city land; Informal patches are self-organized and closer to collective land. While in the dimension of time, since 1970s, due to the transformation of urban and rural spatial structure, the rural collective land property changed into the country land after the national expropriation, transition and relocation, which finally turn into closed street blocks. Some rural collective land has not been completely transformed because of the property rights and history problems, scattered in the city, which turns out to be shaped City enclave like "patches".

Characteristics of land use in urban fringe

The characteristics of land use in urban fringe can be summarized as transitional, mixed and para variable.

(1) the transitional nature of land use

Urban fringe has significant characteristics of gradient change in land use, social attribute, demographic characteristics, economic characteristics, which is reflected in the gradual separation of landscape space, mixed land use type, and plaque distribution of the construction area. In urban fringe of Shenzhen, land use types varies from urban land such as the suburbs Industrial Zone, residential area, urban external communication ports and stations, material distribution center and warehouse district, urban green space, and so on to agricultural land such as vegetable land, cultivated land and garden. There is a clear hierarchy in architectural form in terms of urban landscape.

(2) the mixed nature of land use

The evolution of the urban fringe intensity is much higher than in any other region. In the rapid expansion of cities, urban fringe land ownership changes acceleratedly, often appears with "mutation" in attributes. For example, the original rural residential land, directly converted to real estate, public infrastructure and other types of urban land in a short term.

The driving force of dynamic changes of the urban fringe in Shenzhen is urbanization. In early stage of land conversion, the suburb agriculture transfers mainly from grain crops planting to mainly in fruits and vegetables. With the development of the city and the outward diffusion of industrial city, industrial land increases rapidly and a lot of agricultural land change for the industrial land, forming a certain scale of industrial zone. With industrial diffusion, living land passively migrates to the outskirts of the city, promoting the development of commercial for shift outside.

(3) the para variable nature of land use

With the development of the city, urban fringe in Shenzhen shows an order change. In terms of dynamic spatial evolution, there are two ways: epitaxial expansion and jump diffusion. The two regional diffusions form multi-level outlying areas of the city land space structure, the inner peripheral area near the city is more general, high residential land. Often the middle peripheral area become large industrial enterprises, the establishment of the new economic development zone and the choice of location large institutions, the low efficiency of the farmland to the original this kind of high income form of land conversion: between the inner peripheral area and middle peripheral area in a certain period of time still retains a high yield vegetable, recreational parks and outlying areas: the outer There are large tracts of woodland and nature reserves and suburban parks in the periphery.

Land conversion in urban fringe

The life course of the Land in urban fringe is a process that traditional rural land converts to urban land. Canadian scholar Pond proposed the process model of "rural urban transformation", the model visually show characteristics of structural changes in urban fringe land use. There are several processes in transformation from rural to urban.

First of all, City Industrial Zone takes advantages of low land prices and more convenient transportation benefit in urban fringe district. Residential land and cultivated land is used as part of the leasing industrial land; As a result, agricultural proportion of the city fringe area declines, agricultural planting structure and employment of farmers changes; In addition, the development of the industry brings most of the foreign population, a large number of associated infrastructure needs, and life services immediately rise, leading to the villagers' housing rental ratio increases gradually; Industry increases the proportion of farmers' employment expansion mode, increases the income of farmers. As a result, farmers have the ability of residential construction, coupled with increased demand of house renting, resulting in the whole village space changes; With a further increase of population, the building density increases gradually, the level of land use from the extension of the way gradually

transformed into vertical growth. Thus, high density city village barrier was born, causing the city life space debris; With capital, industry, and further transfer of population, village prices gradually rise, further increases the density situation. Urban villages, which is messy, crowded, dilapidated, and in the high cost of demolition and complex property relations, making the government difficult to reform urban villages; Finally with the development of city and improvement of economy efficiency , the income of village reformation will be higher than the cost of it, so there is possibility of demolition and renovation. In this stage the industrial land begins to pay the higher rents and gives way to business land, villagers' rental income continues to rise, the role of the market economy has gradually transformed collective land into state owned land, the transformation of urban villages comes into implement, and finally the urban village changes into the urban community.

At the beginning of the reform and opening up, the special zone has just started, only in the center there is part of urban land, most of the land is for the agricultural use, with a low proportion of industrial land. In the 1990s, with a rapid urban expansion, a lot of industrial land set up around the boundary and form an industrial enclave. However the living land is in low proportion, so factories and rural residential form detailing contrast, reflecting typically the dual structure in urban and rural.

In 1993s, Baoan and Longgang District were formed, promoting a further expansion of the city. Local areas developed faster with good traffic condition, such as Buji, Longhua, etc. These areas increased the proportion of industrial land use greatly, driving residents shift outside, when the farm land ratio decreased rapidly. For example, in 1996s agricultural land in Buji remained 9.3 square kilometers, accounting for 17%, and industrial land is more than 35% of the total.
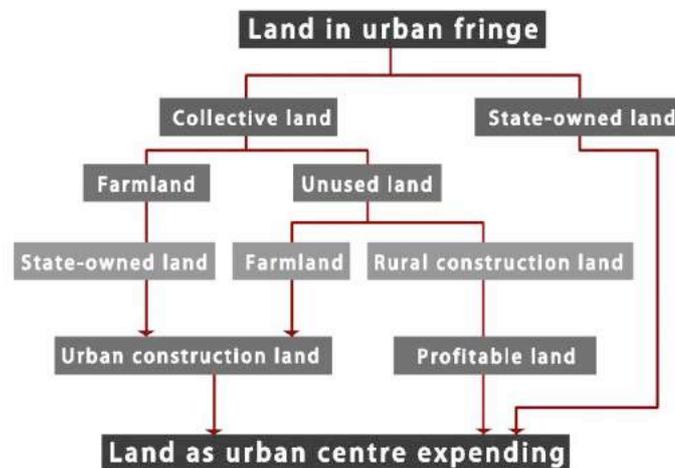
Figure 6: Land conversion in urban fringe

Spatial pattern evolution mechanism of urban fringe

Research on Mechanism of urban fringe area and its influencing factors are widely concerned about social and political factors. Community school claims that urban expansion essence is the reflection of the human social and economic activities in space. Urban spatial structure is the cumulative results in the process of long-term

human space activities and location selection. They think that the market is the driving force of land use change. Political economy school thinks that behavior right force is the driving force of urban land use change.

Urban fringe land use pattern evolution is influenced by the two space process. First is the spatial expansion process in the center of urban, second is the rural spontaneous space transformation process. The two spatial processes can be respectively considered as top-down administrative dominant and bottom-up market leading, respectively, the birth of a group to develop the closed block and self-organized growth of informal patches, covering different mechanisms of land use type.

Market forces acting on the urban fringe land use, the main way is to optimize the allocation of various resources, to play the maximum economic benefits. The process turns out to be rise in the city land price, causing industrial relocation, changing industrial structure. However, bottom-up mechanism brings fragmented, heterogeneous miscellaneous land use for the reason that reactions of each individual to the market forces are not the same.

The role of administrative power in urban fringe area urbanization development, mainly through system reform and macro-control means. The land policy, urban planning, urban development strategy and spatial development related policy making directly affects the urban space expansion. New rural policy, for urban and rural areas of development strategy and other administrative power through macro-control intervened free allocation of resources is to promote the urbanization process of a security and. However, government group often develop a whole block, which is not very friendly to urban public living, for the reason that administrative power is usually too strong.

Figure 7: Evolution mechanism of urban fringe

Problems of land use in urban fringe

(1) The contradiction between urban construction land and non-urban construction land

Urban fringe of Shenzhen is area that growing rapidly outward the city, as well as all kinds of urban land rapidly extending outward, it also contains ecological protection space such as water, cultivated land, garden land, woodland and garden plot.

Strain on the resources of land, arable land, woodland, water area in the city will continue to spread in the process of gradually being eroded. In Shenzhen land resources are scarce, there is no scientific planning and management if only rely on the market economy regulation, and land use is bound to the economic benefits of high land type transformation, bringing many serious consequences. In a short span of five years of 1994-1998, , construction land of Shenzhen Longgang District increased from 108 square kilometers to 132 square kilometers, with the Land Bureau and becoming more and more serious. Moreover, woodland and arable land are eroded by urban construction land and illegal construction, and as a result, agricultural land has been 40% reduced.

(2) ecological deterioration

Urban fringe is a zone where non-agricultural land has risen sharply, reducing the primary production function of ecosystem; the waste of land resources, weakened the ecological function of land system; the severe soil erosion, ecological environment is threatened; aggravated environmental pollution and ecological environment deterioration.

(3) Low quality of living environment

In terms of the nature of land utilization, strength, regional spatial structure and geographical landscape square, there are both urban construction land and non-urban construction land in urban fringe, with a mixed and staggered spatial distribution of land use. Residential and industrial area mixed together, causing the complex pattern "urban villages".

There are a large number of illegal buildings and an increasing number of low quality housing in urban fringe, which leading to infrastructure overload operation, poor living environment, and the floating population increasing. All of these factors caused urban fringe unsustainable, affecting the coordinated development of the whole city.

(4) Urban construction land structure imbalance

There is a serious lack in urban fringe in Shenzhen of infrastructure and public facilities construction. Present situation is that the construction land is used mainly for industrial warehousing, business administration and public facilities land are considered to be small   proportion, single function. Moreover, the infrastructure is backward, can't meet the economic development need. Lack of urban public facilities and public buildings cause inconvenience to urban life, seriously affect the city's further development.

Figure 8: Problems of land use in urban fringe

Strategies for sustainable development of land use in urban fringe

In view of the above problems, four strategies for sustainable development of land use in urban fringe are proposed.

(1) Sustainability of public life

Firstly, urban public space meets the continuous communication between human being, nature and society. In today's densely populated urban land resources, public space is not only a sign of urban development, but also one of the driving force for sustainable urban development. The comprehensive functions In the urban fringe should be focused, including time, space, communication, activities, to restore the pedestrian system, so that people become the master of the city rather than the vehicle.

(2) Sustainability of industry

Secondly, the sustainable development of urban fringe is facing difficulties, mainly in: the land property right is not clear, the land resources use efficiency is low, and the traditional industrial structure is challenged. In order to promote the sustainable development of the urban fringe, the property right of land and house should be clear, industrial structure and its development spaces should be rebuilt, and administrative power and market force should be balanced.

(3) Sustainability of ecology

Thirdly, the original ecological landscape of the urban fringe should be preserved and strengthened, and the urban ecological landscape system should be improved. The traditional agriculture should change into ecological tourism agriculture. Solid waste and domestic sewage should be comprehensively treated, including garbage collection and utilization, waste conversion.

(4) Sustainability of livelihood

And finally, Livelihood sustainability refers to the ability, assets and income activities of individuals or families to make a living for the improvement of their long-term living conditions. The most important core of sustainable livelihoods is justice. Landless farmers have made contributions and sacrifices for the city, only their livelihood can continue, their contribution and sacrifice is to be considered fair treatment.

References

RONG Yuefang, GUO Siwei, ZHANG Yunfeng, J. (2011). A review of researches on urban fringe. Urban planning forum,04,93-100.

LI Shifeng, D. (2005). *Study on evolution mechanism and development strategies of metropolitan fringe*. China Agricultural University.

CHENG Deli, J. (2008). Research on the scientific development of urban village in china—in perspective of land-losing farmer's sustainable livelihoods. Urban studies, 03, 68-79.

GU Fengxia, D. (2011). *An investigation of spatiotemporal evolution regularity of anduse patterns of ecological cities*. Shandong University of Science and Technology.

SHEN Ying, D. (2003). *Current situation and transition of living modality of "urban village"—study case of Xi'an*. Xi`an University of Architecture and Technology.

LI MengYiXin, D. (2011). *The study on the country park pattern and the conservation of urban fringe*. Beijing Forestry University.

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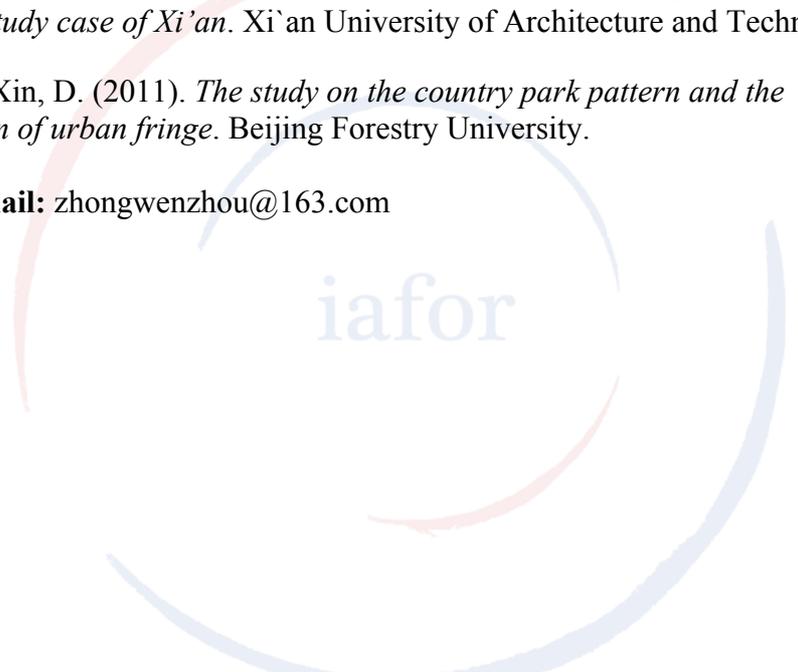
Sustainable Study on Rural River Landscape Based on the Eco-Priority Principle: A Case Study of Landscape Design for the River Yaxi

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Abstract

Accompanying the increasingly conspicuous homogeneity in urban and rural development in the process of China's contemporary urban development, the rural river landscape is largely copying the landscape construction techniques available to urban rivers, causing several inappropriateness. This paper argues that rural river landscape design has two core demands. First, to achieve sustainable development of rivers via regeneration of natural landscape based on the Eco-Priority Principle. Second, to arouse viewers' emotional return to the river landscape by following the design principle of localness. Taking the River Yaxi of Yaxi Town, Gaochun District, Nanjing City as a case study, this paper presents the application process of rural river landscape in its township planning and design, and summarizes its sustainable regeneration methods under the eco-priority principle as follows. Firstly, make interpretation for natural ecological conditions of rivers based on present situation survey, apply centralized and detailed analysis on such basic elements as height of normal water level, water quality and surrounding situation of the site in recent ten years, and understand the historical memory of local residents for River Yaxi through questionnaire survey. Secondly, address the flood discharge specific to the existing rivers under the eco-priority principle, realize landscape regeneration by treating river revetments and arranging pumps, etc., and based on the confirmed node type of landscape design as per space atmosphere and historical imprint, adopt three design strategies of retention, extraction and derivation. Finally, while fully considering the ecological sustainability and emotional return of river landscape, satisfy the modern lifestyle needs.

Keywords: Rural rivers, Landscape design, Eco-regeneration, Loss of local characters, Gaochun, China

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1   Background

1.1   Present Situations

China is now becoming a highly urbanized country with the urbanization rate over 50%. People pay more attentions to the residential environment, and the problems that have been challenging urban waterfront spaces are being solved gradually. Along with the advancement of China's new countryside construction, built-up environment of the rural areas, instead of urban areas in the past, is becoming a concern of the public. Rural river landscapes surrounding urban areas also come to be valued. Rural rivers are quite different from urban ones in their spatial, ecological and functional properties, making the research on rural rivers an urgent issue.

1.2   Difference between urban and rural rivers

Location. Most rivers in cities are closely connected with surrounding public spaces, construction structures and roadways. For this reason, they are renovated, often cemented (by pavement), to match the urban spaces. While in rural areas, most rivers remain their natural forms except that some are rebuilt to ditches for irrigation or other agricultural purposes.

Function. There are two obvious differences. Firstly, in cities rivers collect water not only by confluence on the earth surface. Rain water is separated from sewage and then drained through pipe network into rivers. Sewage is purified to the state or local standard and then also drained into rivers. In rural areas water are collected into rivers mainly through confluence on the earth surface. Therefore most rivers are low-lying linear spaces that facilitate natural confluence of surface water. Secondly, cities have more flood prevention requirements, and therefore embankments become higher and higher, and other facilities such as wave walls are set in key areas. Those soaring structures separate the river from the city spaces. In the contrast, embankments and other structures in the countryside, though also are necessary, are lower and smaller because of less flood prevention requirements. The surrounding spaces are less affected and keep close with the rivers.

Transportation. Rivers inside urban areas are often a significant part of the city's waterlogging prevention and flood draining system. They seldom play the function of shipping or irrigation. Rivers in the countryside, however, are important not only for drainage, but also for water supply and even shipping.
Ecology. In cities rivers are over-intervened by human being. Besides embankments **and other** structures, revetments are always hardened, destroying the bog plant systems near the waterfront line. While in the countryside, such bog plant systems are well reserved. There are waterfront vegetations like reeds and giant reeds, and other signs of life resting along the revetment, such as shrimps, loaches, etc. In one word, biosystems in the rural water environment are more complete than those in urban areas.

Landscape. Banks of urban rivers are mostly used for human activities, and thus are artificially designed to satisfy the demands and tastes of human being. For rural rivers, bank spaces are in their primitive conditions, with the natural forms and complete ecological plant systems (underwater plants, bog plants and terrestrial plants) better preserved.

To summarize, rural river systems largely differ from urban ones in many ways. Regulation methods for the latter are not suitable for the former, and will cause a lot of problems if applied irrespective of these differences. We need to find the way for regulating rivers in the rural areas of China.

2   Challenges for rural rivers and design principles

Simply building some parks cannot promote social development. The overall construction of landscape in a country is the key. Switzerland is an example, whose rural river system pattern was changed as the mode of agriculture varied. Once a lot of terraced fields had been constructed in Switzerland to meet the needs of production. Later however, those water systems were restored to a more ecological and naturalized pattern. This is also the trend for rural river construction in China. At present we have two major problems in rural river development, namely ecological pollution is increasing and river characteristics are lost day by day.

2.1 Increasing ecological pollution

Situations: most rural rivers in China are now facing eutrophication of different degrees. Signs of life are becoming less and less, and the water environment of rural rivers is trapped in vicious circle (*1).

Figure 1: Increasing pollution of rural rivers (Internet image)

Reason: in traditional agricultural societies, the traditional farming practices largely relied on the water source. Drainage of domestic sewage is the major pollution source of rural rivers. However, at that time this caused just a little negative effects because the rural population is small. Nowadays as the rural areas are developed, industry and excessive agricultural farming result in non-point source pollution. This becomes the root of rural water environment deterioration, and brings much more negative effects than domestic sewage. [1]

Principles of design: we need to find scientific methods to cope with the pollution of rural rivers, which becomes increasingly intensified during the urbanization process. Firstly, river eutrophication shall be solved through both waste water purification and scientific fertilization and irrigation. Thus the source of pollution can be controlled from both rural industry and agriculture. Secondly, function of rivers shall be improved. The function of any independent water system is minimal comparing with

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[1]Non-point source pollution: in agricultural production, large amounts of fertilizers are used and could not be totally absorbed by the crops. Most fertilizer residues penetrate into underground water and then are segregated into river water systems, causing non-point source pollution.

the network of rivers. We shall connect the existing river systems into a network, avoiding fragmentation of single water system or stagnant water. In addition, we shall increase the mobility of water systems by utilizing the natural height differences in landforms, so as to rely less on irrigation and drainage, and keep the water flowing. Finally, aquatic plants shall be grown along the riverbanks to further relieve pollution. Common aquatic plants like calamus, canna and iris can remove nitrogen and phosphorus in river water with slight eutrophication. Flush-irrigation and flushing shall be used as supplement to improve the self-purification of riverways.

2.2 Loss of local characteristics

Situations: rivers in urban and rural areas of China nowadays tend to become identical. River landscape in the countryside lost their individual characteristics, becoming similar to the river landscape in cities.

Figure 2: River landscape in different cities (Nanjing, Jiangsu VS Hanzhong, Shaanxi) are becoming alike (Internet image)

Reason: Water environment in rural areas tightly connects with local features. As a result, river landscape often becomes the carrier of local culture and nostalgia culture. The unique features of a local environment not only give special characteristics to its inhabitants, but also "nurture" the diversified ecological structure of a specific region, and thus creating varied modes of production and styles of life . For example, the river network of Xiazhu Lake region in Zhejiang is quite different from that of Lixiahe region in north Jiangsu, which is only 300km away. Those differences involving agricultural operation patterns, spatial forms, etc. Totally distinct regional characteristics are caused by differed physical forms, production modes and life styles even across such a short distance. Nowadays river construction in rural areas is often copied from urban areas, erasing the original characteristics of the rural rivers.

Principles of design: local characteristics of rural areas involve the ecological environment, life style and mode of production. Rural river landscape shall be constructed to match the three. The construction shall include growing region-specific plants, collecting regional elements and so on. Moreover, traditional life style and production mode shall be revitalized. For example, evident symbols of agricultural production like watermills can be used in river building. In this way the original landscape features may be all restored (*2).

3   Rural river space building strategies

Currently most rivers of China are facing the major problems of intensified ecological pollution and loss of rural characteristics, but the actual situations may differ because of varied river locations, natural conditions, degree of pollution, etc. Therefore, we shall seek for different strategies suitable for those specific situations. In general two strategies can be considered, ecology-first and function-first.

3.1   Ecology-first strategy

This is a principle of application considering ecology elements in all subjects. In the construction of rural rivers, it mainly refers to planning and building rivers by first considering protection and restoration, so as to protect regional ecological environment against impacts or even damage from the construction. This is often suitable for rural areas with developed river network, which have higher ecological adaptability because of widely-covering water network and favorable natural resources. During rural river space construction, ecological adaptability and biological diversity of the rivers and surrounding regions shall be preserved. Significant natural landscape resources shall also be protected and optimized, such as primitive/historic cultural heritages, natural reserves and ecological-sensitive natural patches, etc.
The ecology-first strategy can be widely applied in the rural districts in the south to Huaihe River and some north areas with dense river network and not restricted by river functions, such as Mudu (in Jiangsu) and Langchuan (in Zhejiang) villages.

3.2   Function-first strategy

This principle is mainly applicable to rural rivers used for shipping or production functions. These rivers, for better functioning, were often cut off to become as straight as possible. In a short period their expected functions are not possible to change. In construction of such rivers, we shall comprehensively consider what future impacts will these functions have on the rivers. The current environment status shall be sorted out and assessed in details, so that we can decide which lands are suitable for the construction. The development shall mainly include ecological planting and revetment restoration. In addition, ecological optimization measures shall be taken along the whole riverway, such as aeration basin, ecological floating bed or other artificial technologies. This can restore the riverway ecological environment in a short period, but does not address the cause of ecological problems of rural rivers as what the ecological-first strategy does.
The function-first strategy is suitable for most rural rivers used for shipping, production, etc. in China, such as surrounding villages along the lower-and-middle section of Yangtze River.
The ecology-first strategy is more practical than function-first for landscape construction of most rural rivers in China, and therefore shall become our focus. Proper landscape design could rebuild the traditional rural river spaces, restore their original ecological patterns, renovate rural characteristics and appearance, revive productivity as well as provide new style of recreation in the rural regions. It is an effective way for revitalizing our rural rivers.

4   Case study of Yaxi, Gaochun

The Yaxi river in Yaxi town, Gaochun has favorable ecological conditions, and rather complete local characteristics available for collection and restoration. Landscape design in an ecological-first way is possible here. In the overall planning of the town,

the Yaxi river is the focus of development in recent years, and the target is to recover its original natural landscape features. It will be a practical example for exploring the sustainable development of rural rivers.

4.1 Overview of Yaxi town, Gaochun

Yaxi town is a new small town located in the west of Gaochun District of Nanjing City, Jiangsu Province. It borders Liyang City in the west, 8km away from Dingbu village in Langxi county in Anhui Province, and is adjacent to the Lishui District. The town covers 115km2 in total with a population of 50,000, enjoying convenient land and water transportation. Yaxi river flows through the town. It is a branch of Xu river, the earliest artificial canal in ancient times. It is a "golden channel" connecting to the Taihu water system, and forms a river network together with surrounding water bodies in Suzhou, Wuxi, Changzhou and Shanghai. Yaxi river is 31km long, with the average width from 10m to 160m. Rice and tea grow in abundance on its both banks. Our study, accompanied with field practices, mainly researches a 1.5km section (town area section) of the river, which nears the main town area of Yaxi.

4.2 Current situations of Yaxi river

We have interpreted the natural ecological conditions of the river through field investigation. First the hydrological conditions of the river including precipitation, flow capacity, flow rate and peak flow, are sorted out, and those useful for the research object (the town area section) are picked over. The straight-line length of town area section is 1500m. On its south side there are residential houses, and its north side nears the new agricultural trade market of the town and some plant areas. The main statistics of Yaxi river in the last decade measured by the water authorities are as follows: the highest water level in flood season is 7.62m, the normal water level 3.4m, the average riverway width 7-10m, the average height between water surface and embankment 2.4m, degree of slope at north bank (steeper) 1:4.5, and that at south bank (gentler) 1:1.5. (*3)
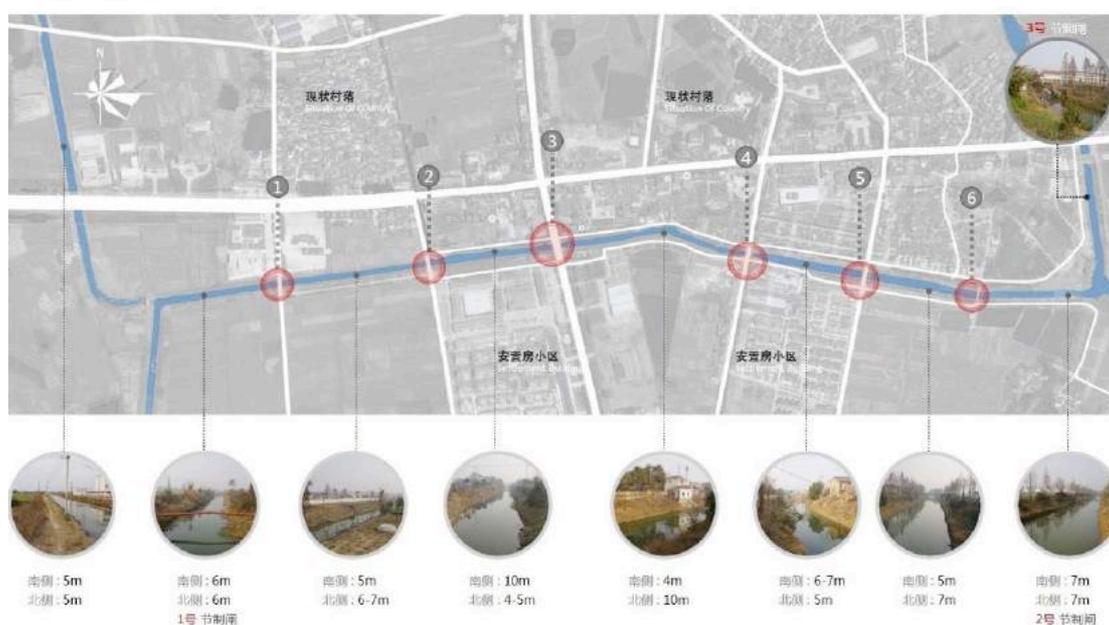
Figure 3: Current status of Yaxi river system (drawn by the author)

Along the Yaxi river there are altogether 9 pump stations for flood storage, two of which within the town area section. The river enjoys relatively favorable natural conditions and is equipped with complete flood prevention facilities. However, currently there are two major problems. Firstly, the riverway lacks vitality and connection with the surrounding environment. The existing green land is not reasonably developed, and nodes are not sufficient. Secondly, there are seldom human activities on the riverbank due to spatial restrictions. For example, the riverway is narrow, water level is low, revetment is also narrow with steep slope (often between 45% and 60%), and plantation is too simple.

4.3   The ecology-first strategy for rural river landscape design

For a long time we rely too much on the human intervention to the nature during the development of agricultural culture. For convenient and efficient agricultural production, we excavated numerous water systems on the basis of even water resource distribution. These water bodies were mostly cut off to a straight-line form. Besides that, riverbed tops were modified artificially to satisfy human irrigation needs. The change of revetment forms and riverbed height indirectly affects the natural distribution of water systems, and thus reducing the self-cleaning abilities of riverways. Not to mention the irreversible damage of natural river ecological systems by discharged domestic and industrial sewage. As times progresses, economy develops and new industries emerge, rural rivers shall have more functions than meeting agricultural production requirements. People pay more and more attention to their emotional needs. They hope that Yaxi river could recall things of the past, offering them a sense of belonging and resonance. For these reasons, the ecological-first strategy is ideal for revitalizing the landscape of Yaxi river. To be specific, the construction shall take the regeneration and sustainability of natural river characteristics as the first consideration, and try to arouse people's sense of nostalgia. On this basis, we shall reduce human disturbance to the river to the least. To summarize, the strategy is to, through smaller economic investment and less human interference, restore the original river characteristics and satisfy the emotional demands and modern life style of people.

(1) Regeneration of natural characteristics

Yaxi river faces the common problems of any other rural river in China nowadays, i.e. damage to natural ecology. The main pollutant of Yaxi river is discharged domestic sewage; so regulation is not difficult. Based on the current situations of the river and the requirement that design shall facilitate sustainable development, the regulation work will be divided into three stages, namely the near term, the middle term and long term. The former two will be the focus of our current work.

Figure 4:Rain water and sewage separation establishment in rural areas

In the near term, clear away silt and dredge waterways

In this stage, clear away matters that block the water flow, such as silt, sandstone and garbage, to dredge the riverway, recover and improve its flood passage and waterlogging drainage capabilities, increase water movement and improve the water quality. Waste water discharge shall be controlled from the sources. The water quality of Yaxi river is lever 3 according to the current waste water control standards in China. Rain water and sewage separation facilities shall be equipped at residences and factories along both riverbanks, protecting the riverway against pollution by the large amount of waste water. The waste water is discharged by the separation facilities through sewage pipes to the sewage treatment plant or sewage pump stations, purified by the activated sludge process, and then discharged into the riverway (*4) . Rain water and surface water is collected by rain water pipes and directly drained into the riverway. This could effectively control the pollution of Yaxi river.

In the midterm, build embankments and revetments

This involves waterfront sort-out, waterfront repair, adding plantation revetment, etc. The form of embankment and revetment shall be selected to suit the actual conditions. In the sections where the riverway is greatly affected by water flow scouring, use rigid embankments; while in other sections, adopt ecological embankment as much as possible to reserve the original ecological features. For regions where people may gather, allow the intimity between the embankment and persons. Maintain the natural forms of the river and revetments and avoid cut-off. Diversity of the river and aquatic lives in it shall be also protected.

By sorting out revetments of the Yaxi river and based on the current situations, three methods were put forward to renovate the revetments. 1. Make the slope of revetments gentler. As restricted by the riverbank width (7m) and slope rate (1:4.5), this shall be realized by a vertical change along the banks. 2. Parts of revetments can be curved to reduce the flow rate and thus protect the revetment against damage by

the water level in flood seasons. 3. According to surrounding waterfront conditions, add river islets in central sections of the riverway, which can be built with the small amount of earthwork generated by waterfront adjustment(*5) .
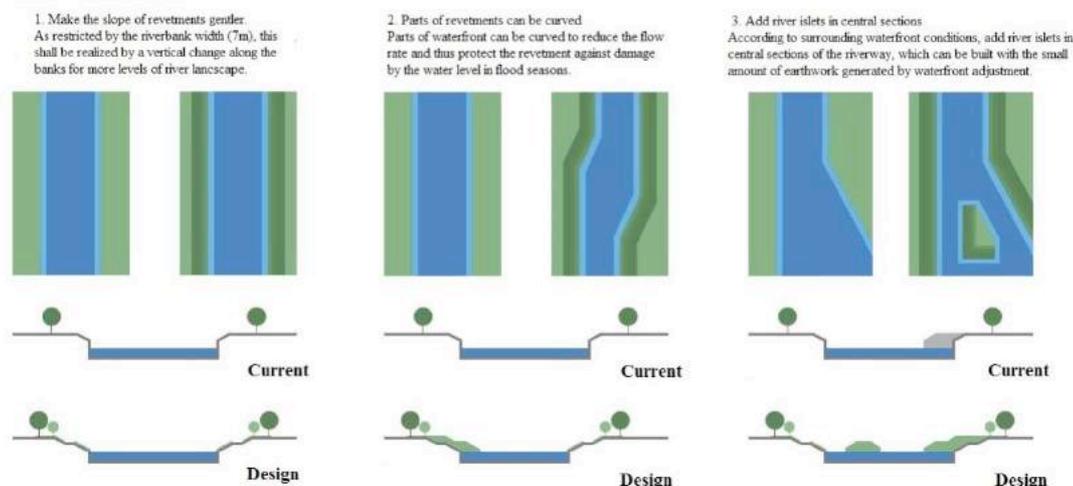
Figure 5: Revetment renovation method
(drawn by the author)

In the long term, initiate water system connection work

The object of our research is a water system in a plain region, where water flows at a low rate and the directions are variable. In addition, water levels at different stations such a region are tightly connected;their water level differences can be used to define the hydrological connectivity. That is, the connectivity between two neighboring stations on a riverway is reflected on the water level difference. We can collect the average water level data of a certain time period. Small water level difference between two neighboring stations shows smooth connectivity (water levels are synchronized) and large difference shows poor connectivity. Therefore, we shall utilize the existing water conservancy facilities of Yaxi river and build new water gates, stations and channels, so that the river connect with proper surrounding water systems. In this way its water mobility can be increased, water quality improved, flood prevention and waterlogging drainage capabilities strengthened, guaranteeing the persistent development of the area.

 (2) Recall of nostalgia emotions

Along with the development of Yaxi town, the Yaxi river, once a significant water system for the life of local residents, has gradually become no more than a "ditch". The memories it had been carrying are getting lost. The traditional ecological environment, production mode and life style are dying out. As stated above, such loss of local characteristics is common in rural rivers during the development process of "China's new countryside". To carry on the local cultures in river landscape design for rural areas, the nodes shall be selected according to the features of space and traces of the history. Design can be realized through reservation, extraction and continuation.

Figure 6:Rendering of rural river landscape renovation (drawn by the author)

1. Reservation

Taking respect to and protection of local cultures and spatial features as the first principle, investigate the spaces surrounding the river, and organize the data. Classify the spatial nodes which are rather completely maintained and which greatly embodies local cultures, and work out measures for reservation as well as schemes for successive development. Repair of update those nodes according to the classification, so as to make them suitable for the existing spaces and reserve people's memories about these spaces.

2. Extraction

Through field investigation and interactive interviews, find out and maintain the historic atmosphere and local features. Firstly, extract and utilize local culture symbols. As the form to represent and pass local cultures, these symbols played a key role in the inheritance and development of historic cultures. They can evoke people's emotion and memory about local cultures. Secondly, use local materials in the landscape, because these materials, as unique production of the local geographical environment and climate conditions,are a significant means to express the emotions about local cultures. Traditional landscape materials such as regional plantation, woods, stones, soil and bricks reflect the change of nature and mark the development of human being. Application of such materials in the landscape will further improve the local flavors of the site.

3. Continuance

Original textures and dimensions of the riverway is an external expression of the town's internal mechanism and order. They shall be continued as a response to the original mechanism and order. Thus the landscape is filled with the vitality of rural life. The continuance is also realized by connecting river landscape with surrounding spaces such as courtyards, streets and lanes. It extend the local style of life, creating unique experience of the rural river(*6).

5   Conclusion

Based on theoretical and practical researches, we conclude that,

1. Two major problems have emerged to rural rivers in China during the urbanization process, namely the increasingly intensified ecological pollution and the loss of rural characteristics along the river banks. Generally speaking, development of most rural rivers is a lagging-behind issue, and the renewal of rural river spaces are being widely focused. To build rural rivers, we shall, taking into first consideration the natural pattern, textures and modern life style, optimize the landscape pattern and ecological environment in our country.
2. Taking Yaxi in Gaochun as an example, we worked on the specific ecological-first design strategy for a rural river. It mainly involves regeneration of natural characteristics of the river and recall of local emotions. The regeneration work is divided into the three stages of the near term (silt clear-away and waterway dredging), midterm (embankment and revetment protection) and long-term (water system connection). The restoration of local landscape features are supposed to be realized through reservation, extraction and continuance.
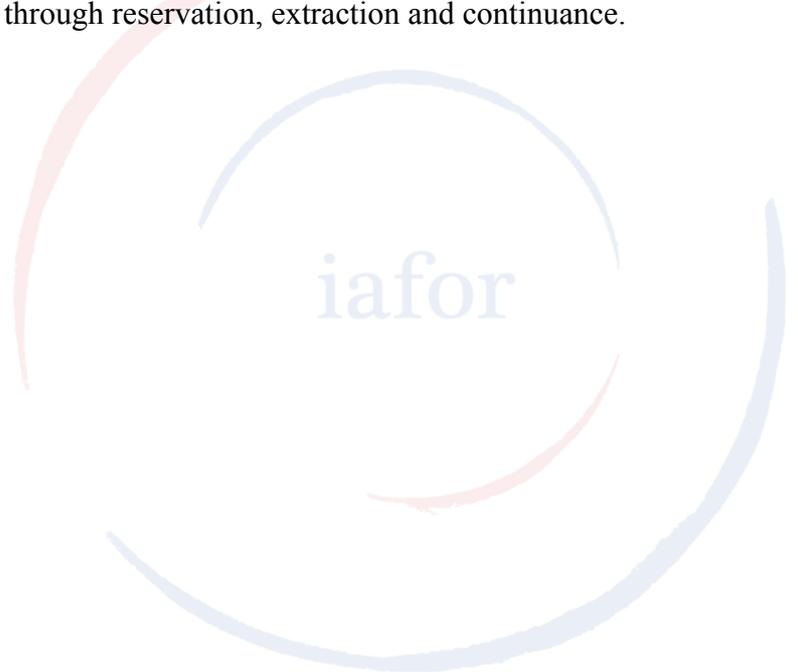
References

Wang Jianguo. (2001).*Modern Urban Design: Theory & Methodology*. Nanjing: Southeast University Press.

Mengistu Woube. (1999).*Flooding and sustainable land-water management in the lower Baro-Akobo river basin, Ethiopia*. Applied Geog-raphy, (19):235 -251.

Fei Xiaotong. (1985). *Four Records of the Small Town*.Beijing: Xinhua Publishing House.

Cheng Yuning. (2010).*Modern Landscape Design: Theory & Methodology* .Nanjing: Southeast University Press.

Fan Jianhong, Wei Cheng, Li Songzhi, (2009).*Research on the Conceptual Connotations and Development of Rural Landscape*. Guangzhou: Tropical Geography.

Wang Yuncai, (2003). *Planning and Design of Modern Rural Landscape Tourism*. Shandong: Qingdao Publishing Group.

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Upgrading Marginal Settlements: Studies on Li-nong Settlements in Shanghai Old Railway Station Area

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Abstract

Marginal Li-nong settlements have always been considered as the backward, dirty and negative parts of inner city of Shanghai and are in a pressing need of upgrading. The wholesale demolition, which is a generally applied strategy of urban renewal, has been proved to erode distinction of places, exacerbate urban gentrification and inequality, and strip the city of its cheap workforce. Characteristics of density, diversity, vitality and flexibility have made marginal settlements the most sustainable places for low-income urban residents and migrants, forming an indispensable part of social and economic networks on a larger scale. With a community-based research of marginal Li-nong settlements in Shanghai Old Railway Station Area, multiple upgrading strategies were put forward, which mainly contained minor interventions on upgrading pedestrian system, enabling productive utilization of public space, stimulating active engagements of dwellers with great emphasis on the maintainence and promotion of mixed-use, adaptation, sustainability and dynamism already embodied in the place. Also, the research enables new understanding of informal and ad hoc model of urbanism which greatly transgresses the standardized concept of architecture and city.

Keywords: upgrading strategy, Li-nong settlements, informal, marginal, sustainability, public space

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Introduction

In Shanghai, a large number of people live in ancient Li-nong settlements. Despite its dirty, crowded and dilapidated characters, Li-nong settlement is a traditional type of residential architecture derived from the force of western colonization and the demand of domestic housing with great density during the period of rapid urbanization in 1930s. Only one-third of Li-nong settlements survived from the wholesale demolition since Chinese reform and opening policy. Most of the remained Li-nong settlements occupy land close to physical boundaries such as waterfronts, city walls or transport infrastructure of freeways and railways. Because of the low financial rewards of property development, these Li-nong settlements are able to survive through eight decades and have turned into marginal spaces within the context of urbanization.

Figure 1: wholesale demolition of Li-nong, photographed by Xi Zi

The academic attention on urban marginal space, sometimes called urban fringe or urban periphery, could be traced back to the studies on urban morphology by geographers at the end of 19th century. The German geographer, Herbert Louts found in his research of Berlin that the previous rural area was replaced by urban construction area and became a part of city. He defined this type of area as urban-rural fringe (Figure 2). Later, the widely accepted definition of urban-rural fringe was came from R.G.Rryor in 1968, who deemed that rural-urban fringe was the "zone of transition in land use, social and demographic characteristics, lying between the continuously built-up urban and suburban areas of the central city and the rural hinterland".
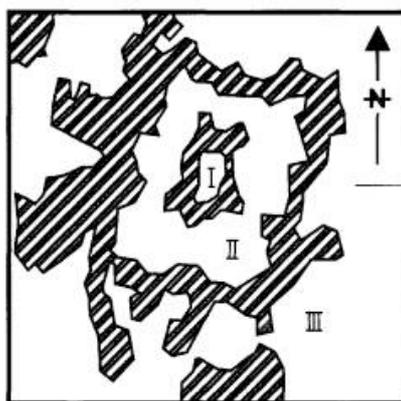
Figure 2: Model of Berlin urban fringes by Herbert Louis (1936)
Ⅰ. Old city Ⅱ. Former Suburb Ⅲ. Residential Area

According to core-periphery theory, marginal space could be defined in a broader sense. A finite space model is composed of two elements: the core and the periphery, which is similar to the structure of a traditional city. While as urban development pattern shifted from single-core to multi-core over the past years, the clear differentiation of core and periphery has disappeared. The concept of margin showed its hierarchical nature with higher levels of margins existing between urban and rural areas, lower levels of margins appearing in-between construction clusters. Therefore, locations of marginal space are no longer limited in geographical periphery of urban areas, and also might be modified through time.

Different from western "residential-oriented" marginal space, Chinese marginal space is mostly "service-oriented" or "industry-oriented". Multi-core development pattern motivated by the construction of infrastructure has driven to the engulfment of previous marginal space into the grand metropolitan area. A large number of the marginal areas now located on interstitial lands in city core areas have a long history and profound cultural heritage, remaining certain rural characteristics such as informality, autonomy and etc., which transgress the regulations and hierarchy of a well-planned city. They bring about a heterogeneous but common type of urban space, and they also arouse questions about how to identify their roles in the city and how to deal with the great challenge of urban regeneration.

During the last thirty years, Chinese strategy of urban renewal was to totally demolish shanty buildings and disperse residents to cheap land on the new urban fringes, which has gradually been proved to be both a political and economic failure, as it exacerbated urban gentrification and inequality, and at the same time stripped the city of its cheap workforce. Marginal Li-nong settlements accommodate local residents of Shanghai with low income, and are also anchor points to young immigrants as the only affordable housing with easy access to jobs and public transport. Mobile population and informal squatters constructed by Li-nong dwellers all drive to the complexity and ambiguity of buildings' property rights, making demolition and relocation extremely difficult.

Sustainability of Marginal Li-nong Settlements

Marginal Li-nong Settlement is a high-density, walkable and mix-used habitation with abundant communal vitality and culture. It is composed of 'Li', the entity of residential buildings, and 'Nong', the laneway systems within blocks. Usually, a block of Li-nong settlement is comparatively large in size, sometimes exceeding 200-meter in length on each side. The laneway system consisting of several main lanes and a series of sub-lanes cuts the block into smaller clusters. The main lanes are the most important public passages which mostly have direct connection with urban roads, often serving as gathering places for various social activities such as playing mah-jong, chatting, buying daily necessaries, doing exercise and so on. Perpendicular to main lanes, sub-lanes are semi-public, semi-private places. They bear the continuity of publicity from main lanes and become gathering places for a few households. Since per capita living space of marginal Li-nong settlements is only about 5.8 square meters (statistics in 2011), lots of private activities are forced to spill into public space – the laneways, creating frequent interactions and tight communal networks, which greatly contribute to social sustainability.
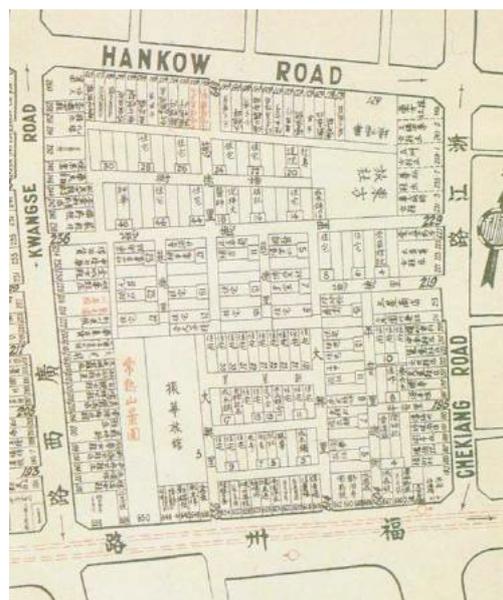
Figure 3: Plan of a typical Li-nong settlement

At the beginning of Li-nong settlements' design and construction, the neighborhood service facilities were not taken into consideration. While under the self-regulation of market mechanism, service facilities emerged along the urban streets on the periphery of Li-nong blocks and then gradually infiltrated into the interior. Many retail stores, entertainment venues, newspaper offices, assembly halls, family hotels and private clinics filled up both sides of laneways (Figure 4). That's why even nowadays some of the old service facilities still have "Li" as a part of their addresses. In the respect, Li-nong settlement could be regarded as an urban complex with the capability of independent operation. It is similar to what John.O.Brow-der addressed during his research on marginal neighborhoods in Bangkok, Jakarta and Santiago that the variety in functions and forms made marginal urban places a polyhedron in terms of economy and sociology, thus such kind of places could not simply be judged based on universal social, economic or spatial standards.

Figure 4: a drawing of laneways of Li-nong

The old movie 'Shanghai Fever'(1994) told a story about the life conditions of people living in Li-nong under the influence of the outbreak of Stock Market Craze in 1990s. By means of realistic narratives, a vivid representation of life scenarios was unveiled to the audiences. The heroine named Lili and her family were living in a typical Li-

nong settlement. A series of continuous lens was applied to portray their interactions with neighbors on their way from entrance of Li-nong to their own home (Figure 5). In the first screenshot, the spatial relationship between main lane and the external street was clearly shown with surrounding walls, a stone gate and the settlement's name "Bugao Li" on the top. Then, the scene turned to the interior, showing dwellers taking relax, chatting, washing and hanging clothes in the main lane, exposing their private life to the public space. Just in ten seconds, Lili had verbal communications with three people. When she was bargaining with the owner of a barber shop for a discounted haircut, her daughter seized the change to play hide-and-seek with her friends in a little square with hundreds of clothes racks acting as perfect game tools. Just in this very short film section, the spatial layout, business format and public relationship all revealed Li-nong's nature of autonomy and independence, indicating the close social and economic networks.

Figure 5: Movie 'Shanghai Fever'(1994)

Compared with well-planned, designed and controlled districts, marginal settlements may seem undesirable for a range of reasons, while high levels of diversity, flexibility and informality, and also the adjacency to transit nodes enable efficient flows of labor, information and goods, contributing to affordable products, cheap labor force and adaptive utilization of space, which the other parts of city also have strong dependence on. Based on this understanding, the purge of marginal settlements and removal of dwellers from transport and employment would be both a disaster to these dwellers and breakdowns of social and economic networks of the whole city.

There are also cultural and aesthetic reasons to retain the basic morphology of marginal Li-nong settlements. Their morphology is an exotic product from western townhouse with orderly traffic systems and arrays of residential clusters. While, their present appearance shows how elements of informality interact with primitive base grids by the engagement of everyday life that creates a picturesque of freedom, cultural enrichment and nostalgia. Traditional handicrafts such as tinkering, tailoring, sugar painting, paper cutting and etc., which hardly exist in other parts of city are still active in marginal Li-nong settlements, not to mention the dwellers' everyday activities including singing Chinese operas, playing games of go and dialect art, which often take place in multi-functional spaces with every piece of nature and man-made elements including sunlight, shadow, trees and wind becoming parts of the stage background. Walter Benjamin identified the marginal settlements of early 20th-century Naples with the urban quality of 'porosity', where the interpenetrations of

buildings and actions 'become a theatre of new, unforeseen constellations'. Also the emergence of Li-nong tourism in recent years shows the public's attention and interest on Li-nong settlements as parts of the city's heritage. Thus, not only the conservation of morphology, but also the inheritance of life style should be taken into serious consideration.

Upgrading Strategies for Marginal Settlements

Upgrading strategies for marginal settlements such as Li-nong have long been in the center of academic discussion. First of all, as their advantages of social and economic sustainability are primarily based on high density and certain levels of informality, the renovation policy which imposes strict regulations upon any type of activities, or simply moves a part of dwellers away to reduce density for the sake of improving quality of life is in need of further deliberation. Opposing to decreasing density, the 'Support' system, developed by John Habraken (1972), proposed a model of three-dimensional infrastructure frames with the infill of dwelling units (Figure 6). By offering only supporting structures and allowing the provision of dwellings, Habraken promoted an indeterminate design that enabled high levels of density, and at the same time allowed for serendipitous outcomes once the framework was activated by actions of its intended inhabitants, inserting their needs, desires, and preferences, creating internal adaptation to changing circumstances.
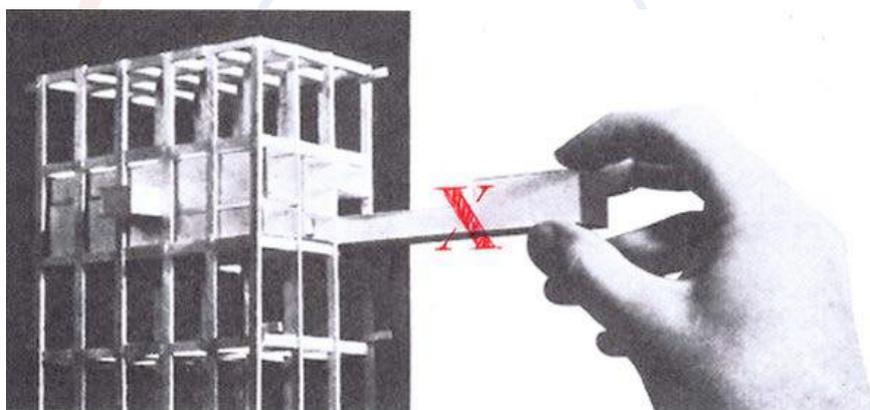
Figure 6: the 'Support' system by John Habraken (1972)

As it has been asserted above that any attempt to instantly regulate or formalize marginal settlements should be taken carefully, marginal settlements have their own latent codes and rules of operation which have stood the test of time. However, these codes and rules are necessary but insufficient in several aspects. For example, the sides of a typical Li-nong block could reach 200-meters, which are too long thus less walkable along the peripheral roads compared with the sides of blocks in the earlier concessions which are about 80 to 120 meters. The interior laneway networks are self-contained and are capable of offering all kinds of services to meet daily needs of living, while they could hardly be incorporated into the urban road system and have no relationship with adjacent blocks, driving to the condition of closed isolation. Moreover, rampant and continuous encroachment of open space to maximize personal benefit makes marginal settlements intolerable in environmental and experiential qualities, such as light, space , ventilation, sanitation , etc..

The challenge of marginal settlements' upgrading is to fully understand the existing codes and rules – how marginal settlements are formed, emerge and grow, and how they are inhabited, used and engaged with urban circumstances. Professor Kim Dovey addressed in 'Informalising Architecture: the Challenge of Informal Settlements' (2013), 'any newly formalized codes that emerge need to sustain the productivity, amenity and sociality that is already embodied in the place'. That means that it is unworkable to develop a set of new codes which are subversive to the existing inner structures of settlements. Beginning with incorporating marginal settlements as indispensable elements of the whole city, respecting their development tracks and life style of dwellers, upgrading strategies could then be developed to optimize morphology and network of marginal settlements by promoting their potentials of mix-use, diversity and dynamism, looking for appropriate media to sew the gaps between interior and exterior, and stimulating active engagements within a larger, urban-scale network of social, political and economic activities. Since marginal settlements may differ from place to place, community-based research becomes the key task in building the knowledge base for upgrading strategies.

Case of Shanghai Old Railway Station Area

Shanghai old railway station area is located in Zhabei District on the edge of city center, where Museum of Relics of old railway station and railway stabling yard which is still in operation occupy a large area of land. The two-kilometer-long stabling yard forms a huge north-south barrier and has in the long term hindered the district's development. Having access to several public transport junctions, the area's advantages in location and public transport make it a favorable place for the gathering of marginal Li-nong settlements. Nowadays, there is still a large number of Li-nong remained, taking over south and east of the district and forming the biggest agglomeration in Shanghai (Figure 7).
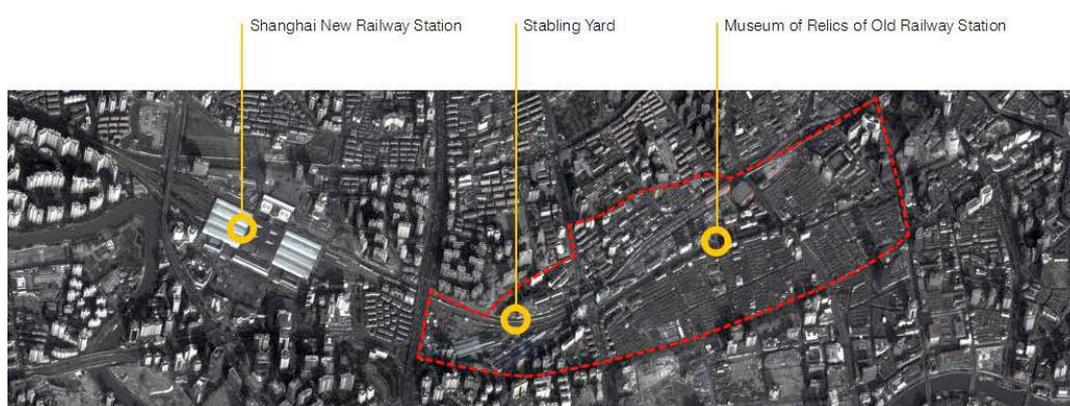
Figure 7: satellite map of Shanghai old railway station area

The emergence of Li-nong settlements in this district in 1930s had a close relationship with the establishment of old railway station and the sprawl of concessions. Concessions began to take shape in 1843 in ruined reed lard about ten miles north to Shanghai's ancient walled residences. In the following years, foreign colonists established a new city center, the Bund, in traditional colonial mode and constructed piers along Huangpu River. As concessions flourished and spread northward, two of the earliest railways in China, Songhu Railway and Huning Railway, opened to traffic

in 1876 and 1908, with their terminals located on cheaper lands to the north of concessions. Together with water transports on Suzhou River, railways brought freights and people to and out of concessions through the complete and convenient transportation network. Still belonging to Chinese settlements and only several blocks north to the concession, Shanghai old railway station area enjoyed exceptional advantages in location, transportation and cheap land price, attracting enterprises and migrant workers from all over the country. Surging waves of immigration resulted in explosive growth of population in the area and massive emergence of slums, some of which were later be transformed to Li-nong settlements.
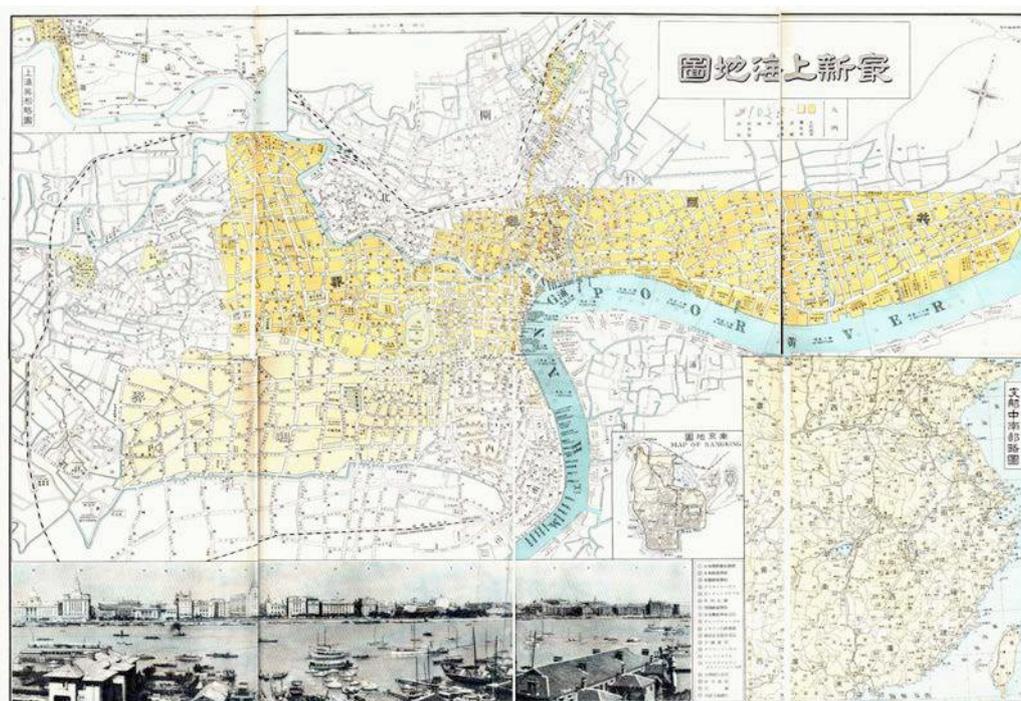
Figure 8: an ancient map of Shanghai with concessions in yellow (1939)

Marginal characteristics of Shanghai old railway station area could be examined and summarized from three aspects. In terms of political pattern, juxtaposition of Concessions and Chinese settlements exerted both positive and negative influence on the development of urban morphology and socio-economic structure of this area, as the urban fabric of Chinese settlements was the spontaneous and random extensions of the well-planned, designed and constructed fabric of Concessions, resulting in mega-blocks and fragmented infrastructure networks. In terms of physical space, railway stabling yard forms a huge, linear blank zone, cutting off urban fabric and networks especially the pedestrian system, resulting in the poor accessibility and inefficient utilization of public facilities which gives rise to the damage of public rights and the lack of interaction among different communities. From social and historical perspectives, accumulation of population with low income and inadequate education has led to class-based social segregation, which further hindered the invasion of new companies and creative clusters and brought troubles to industrial reconstruction. In conclusion, the circumstances of social and spatial segregations are often interrelated and reinforcing each other, leading to unpredictable complexity of understanding intrinsic mechanism and formulating strategies.
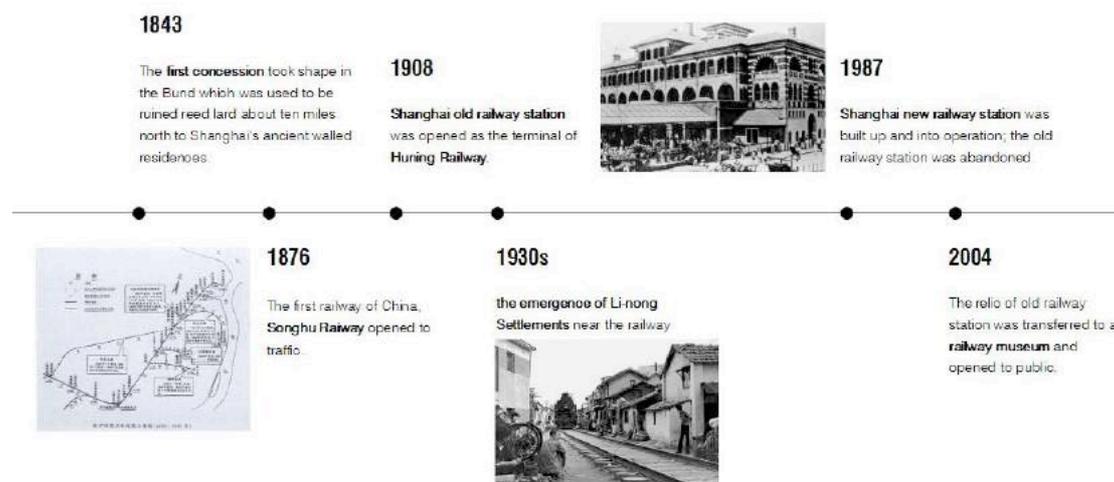
Figure 9: historical change of Shanghai old railway station area in timeline, drew by author

A community-based research is necessary to answer the following questions: what is the condition of public space in the marginal Li-nong settlements in the target area? How does it function and how is it occupied? As informal constructions often transgress boundaries of architectural ideology and enable demand-driven, adaptive and participatory practices, how do they actually interact with dwellers and how do they establish relationships with economic and social networks on a larger scale?

During the field survey, photographic recording, target tracing and questionnaire investigation were the three main methods. The focus was primarily on the public space including shops, mobile booths, laneways and the affiliated open space, markets, threshold in-between private and public space, flow of dwellers, and etc.. The field survey showed that main lanes were the most mixed-use, socially and formally dynamic places, with shops on both sides extruding onto pedestrians during certain periods of the day, creating ambiguous space for both traffic and commodity trading covered with canopies made by recycled materials and light structure. By documenting paths of several mobile booths, it was inspiring to find that their services and locations were shifting to cater for actual market demands, and they also little by little influenced the flow of people, freights and information. For example, trace records showed that an old granny selling breakfast with a trolley close to the urban road in the early morning might work as a darner in the afternoon with her working place shifting to a shady corner in the main lane, because the group of no-residents who worked nearby constituted a large portion of customers of her breakfast business, while the target group of darning was limited to local residents whom she was familiar with. People gathered around mobile booths often gave rise to the exchange and promotion of information, gossip and rumors, forming a latent information network which was highly efficient and autonomous.

Figure 10: photographs of the laneways

Upgrading strategies should be made with acknowledge that high levels of informality and encroachment of public space enable efficiency in space utilization and are supremely demand-orientated. Instead of cleaning up illegal occupations of pedestrian, the real factors of congestion and mess have been deliberately questioned and examined. One of the essential factors are about the width of pedestrians on both sides. Since Li-nong settlements were mostly built in 1930s when walk and jinriksha (a two-wheeled vehicle drawn by man) were the only two means of transportation, the average distance between exterior walls of houses on both sides of main lanes was no more than eight meters. While, the current situation is that the eight-meter wide main lane is divided into a five-meter wide two-way motor way and pedestrians of one meter and a half on both sides. The narrow space of pedestrians are almost fully occupied by shops, parking, piles of waste, clothes racks and etc., pushing pedestrians and cyclists to share motor ways with running vehicles and leading to a dreadful chaos. Questionnaires also show that only 15 percent of Li-nong dwellers own private vehicles, and more than half of them have complained about the traffic conditions in main lanes, especially the lack of parking facilities and management in the neighborhood and the unsafe and unpleasant walking experience.

As the phase achievements of this research, multiple upgrading strategies have been worked out. In terms of improving the spatial environment, priorities on street utilization should be given to slow transport; volume and speed of vehicles passing through laneways should be subjected to a certain degree of restriction. Accordingly, the two-way motor ways which are five meters wide would be narrowed to three meters and a half and only allow one-way traffic. Pedestrians get wider and are capable of holding more activities. Informal constructions on pedestrians are encouraged, while the area of land occupied should be limited within designated zones to ensure enough space for the fluent flow of pedestrians.
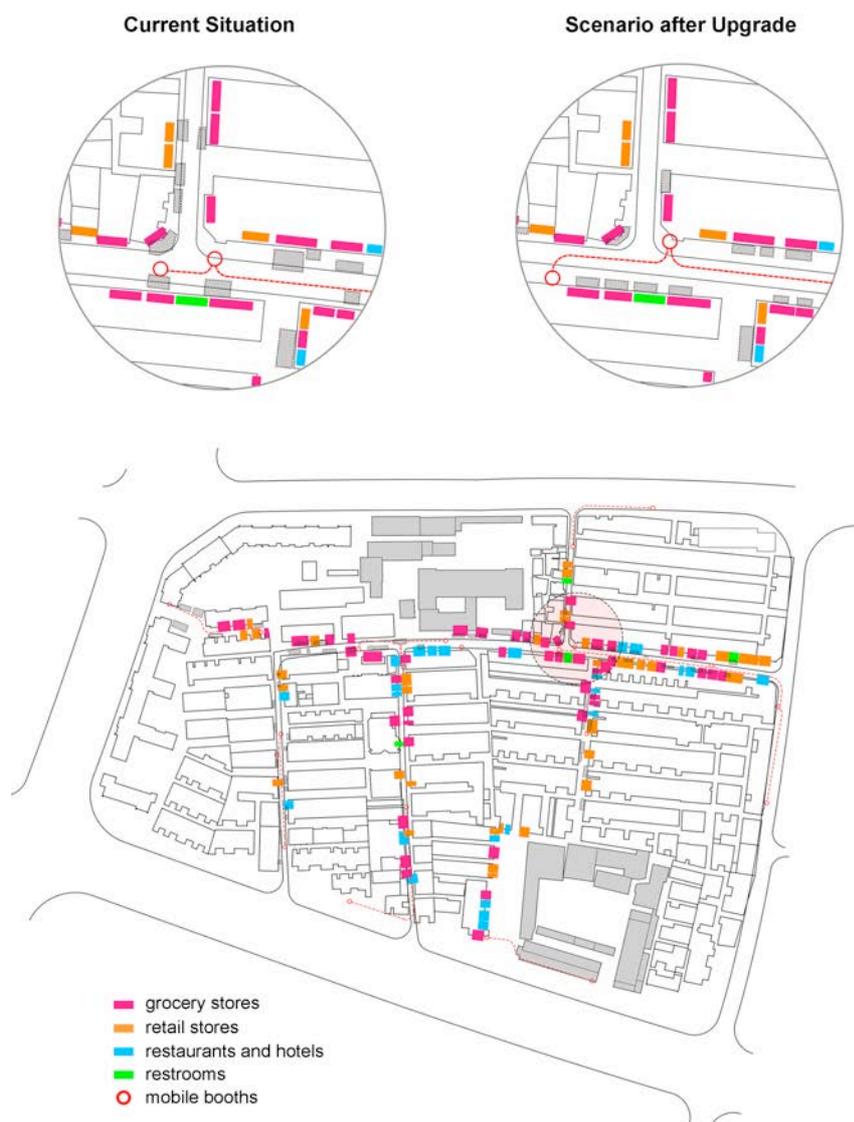
Figure 11: community-based mapping and scenario planning,drew by author

In marginal Li-nong blocks, it is common that several parcels of land along urban roads which obtain higher accessibility and land use value have been cut out and sold to private companies or government organizations during the process of urban development. Buildings located on these parcels of land are mostly gated and separated from their urban contexts, and also are comparatively low in density and lack of vitality. Renewal and reutilization of these parcels give a chance to achieve mixed-use programs in close relationship with the built environment of Li-nong settlements and abundant underground parking open to both the organizations themselves and Li-nong communities. In this way, strict control could be put on the duration and quantity of street parking such as the application of meters on street parking in many Western cities.

Other upgrading strategies may include building a bridge across the stabling yard to sew the fragmented pedestrian network on two sides, developing district-scale cultural tourism with old railway station museum and certain parts of Li-nong settlements included, attracting artists and small-scale cultural media companies with preferential

policy to rent studios in Li-nong settlements, teaching unemployed dwellers traditional techniques, and etc.. All these strategies are aiming at bringing about only minor interventions on the change of existing morphologies, stimulating both top-down operations and bottom-up participation, and constantly keeping self-adjustment based on periodic results and feedback in an incremental way.

Conclusion

The upgrading of marginal settlements has long been a global issue. In western cities, there are many successful precedents that former marginal settlements have been transformed to be the most dynamic, attractive and diverse creative clusters. While, accompanied side effects such as inner city gentrification, unaffordable land price and disagreeable life condition of former dwellers after regeneration should always be the key considerations. During the community-based research on marginal Li-nong settlements in Shanghai old railway station area, the crucial issue in practice is to explore and then celebrate the diversity and dynamism of existing morphology and social networks which have a lot to do with the flourishing of informality through an integrated way of thinking that may cover social, spatial, economic and aesthetic issues. The research also teaches a lesson to transgress the established and fixed disciplinary knowledge and explore a more complicated and critical realm of thinking and practice through which people with various professional backgrounds are able to get engaged with the built environment with idea exchanged and knowledge shared.
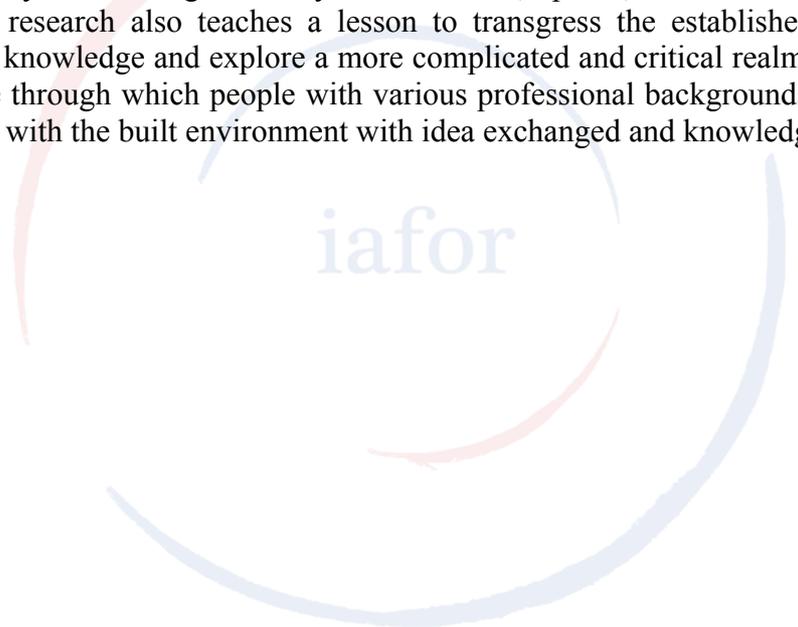
References

Pryor R J. (1968). Defining the rural-urban fringe. *Social Forces, 47,*202-215.

Rong Yuefang, Guo Siwei, Zhang Yunfeng. (2011). A review of researches on the urban fringe. *Urban Planning, 196*, 93-100.

Kim Dovey. (2013). Informalising architecture: the challenge of informal settlements. *Architectural Design, 83*, 82-89.

Liang Hong, Sun Hui. (2007). *Pattern and mechanism - the urban transformation of the city centers in China*. Beijing: China Architecture & Building Press.

Shen Hua. (1993). *Li-nong housing in Shanghai*. Beijing: China Architecture & Building Press.

Walter Benjamin. (1978). *Reflections* (pp. 168). New York: Harcourt, Brace & Jovanovich.

John Habraken. (1972). *Supports*. London: The Architectural Press.

Christian Henriot. (2004). *Shanghai, 1827-1937: municipal power, locality, and modernization*. Shanghai: Shanghai Ancient Books Publishing House.

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Biotyping of Jatropha Curcas L. from Thailand, Laos and Tanzania by MALDI-TOF MS Technique

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Abstract
It was shown that *Jatropha curcas* L. of the family *Euphorbiaceae* had significant economic importance for its seed oil, which could be used to substitute for diesel oil. It had been widely distributed in Thailand. This study was aimed at determining the biotype that could produce better oil content by using biotyping technique. It was found that among the biodiversity of 15 populations of *J. curcas*, Jc1 to Jc13 were obtained from different localities in Thailand, Jc 14 was obtained from Laos, and Jc15 was obtained from Tanzania. The biotyping technique, Matrix-Assisted Laser Desorption Ionization Time-of-Flight (MALDI-TOF) Mass Spectrometry method, was used for this purpose. The MALDI-TOF method was an inexpensive method that yielded rapidly with high accuracy results. Also, the results showed that the m/z spectrum pattern profiles of all populations were the same, and were confirmed with program ClinProTools 2.2. Therefore, it could be concluded that all populations (Jc1-15) were the same strain.

Keywords: Jatropha curcas L., Biotyping, MALDI-TOF, spectrum pattern

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Introduction

Jatropha curcas, a biotype that belong to family *Euphobiaceae*, has attained significant economic importance due to its industrial uses and as very promising source of non-edible oil that can be used as feed stock for production of bio-diesel oil (Openshaw, 2000). The quality of biodiesel depends on the chemical composition of the fatty acids present in the oil. The fatty acids profile has a direct impact on ignition quality, heat of combustion and oxidative stability. An ideal biodiesel composition should have monounsaturated fatty acid such as oleic acid in high content. Jatropha oil fraction consists of two saturated fatty acids, i.e., 14.1-15.3% of palmitic acid and 3.7-9.8% of stearic acid, and several unsaturated fatty acids, i.e., 34.3-45.8% of oleic acid, and 29.0-44.2 % of linoleic acid (Berchmans and Hirata, 2008). It is a non-food crop with high quality of oil and it can grow on degraded soils. This plant, can be cultivated on non-agricultural land, and does not require a land that good for the production of food. Moreover, it can be used to control erosion and grown as a fence, especially for animal farms. Many parts of plant can be used as medicine, its leaves are a feed stock for silk worms, its flowers attract bees and then the plant has a honey production potential. The most important part is fruit that contain viscous oil that can be used for soap making in the cosmetics industry and as a diesel substitute (Openshaw, 2000). It is a tropical plant that can be grown in low to high rainfall areas. In several continents, i.e., America, Africa and Asia, it is cultivated mainly as a hedge to protect fields (Gübitz et al., 1999). The Portuguese merchants have introduced *J. curcas* in to Thailand for more than two centuries ago and now the crop is widely grown in various regions of Thailand (Sadakorn, 1984).

The biotyping technique is needed to classify plants into group individuals, which having the same genotype. The use of PCR-based molecular marker in *J. curcas* plant is a common method nowadays.

It was reported that 94.6% of similarity between toxic and non-toxic varieties using RAPD fingerprinting, whereas in recent study showed that the percentage of similarity was 84.91 by RAPD and 83.59 by AFLP fingerprinting (Sujatha et al., 2005; Pamidimarri et al., 2008). Not Only RAPD and AFLP but also SSRs were being widely employed in many studies because of high polymorphism of microsatellites.

Ranade and coworkers collected *J. curcas* leaves from different region more recently in India (2008), and assessed for the bio-diversity among any collections using SPAR, single-primer amplification reaction method. They found that the North East accessions were most dissimilar relative to other collections.

Mass spectrometry has used and enabled great advantages to characterized proteins. Among the aforementioned techniques, the MALDI-TOF MS, matrix-assisted laser desorption ionization time of flight mass spectrometry, technique was chosen as a biotype tool in this research because of several advantages, such as, great tolerance for impurities, a possibility of reanalyze the same sample, the optimal compatibility with simple technique and inexpensive time-of-flight (TOF) analyzers. This is a rapid, straightforward and high accuracy method to generate peak patterns from whole proteins (Monagas et al., 2010).

The results represent in mass to charge (m/z) spectrum, which specific to each protein. The MALDI-TOF MS technique has been applied to analyze bacterial cells such as grouping Myxococci (*Corallococcus*) strains, discrimination between wild-type and ampicillin-resistant strains of *Escherichia coli*, and phylogenetic classification of *Pseudomonas putida* strains. Furthermore, the MALDI-TOF MS method can be used to analyze mammalian cell lines (Stackebrandt et al., 2005; Johanna and Faith, 2007; Teramoto et al., 2007; Zhang et al., 2006). Several applications of MALDI-TOF MS analysis have been used. In the determination of the structure features of different plant pro-anthocyanidin types from food and non-food plants, an analysis of the N-linked glycan structures, and an analysis of condensed tannin in plant leaves and needles (Mokrzycki-Issartel et al., 2003; Karg et al., 2009; Behrens et al. 2003). In recently years, many researches of plants were carried out by this technique. Oszvald and team (2013) used MALDI-TOF-MS to identified molecular size of HMW glutenin subunit (HMW-GS) protein in rice endosperm, and found that expressed wheat HMW-GS showed positive effect on the functional properties of rice dough by significantly increasing the size distribution. In the same year, researchers from Japan reported that high –resolution MALDI-TOF MS showed that the structure of polyphenolic compounds from almond is a series of polyflavan-3-ol polymers composed of catechin/epicatechin units and gallocatechin/epigallocatechin units up to 11-mer with with several interflavanoid ether linkages. The results suggest almond seed skin contains highly polymerized polyphenols with strong α-amylase inhibitory activity, which retard absorption of carbohydrate (Tsujita et al., 2013). Morover, MALDI-TOF-MS analysis in apple leaves found interested proteins that located in chloroplast, and they play important roles in photosynthesis and stress resistance for plants (Ning et al., 2013).

About MALDI-TOF-MS in *J. curcas*, researchers from department of Biochemistry, Faculty of Science, Kasetsart University, Bangkok, Thailand reported that after purified seed coat of *J. curcas* by ammonium sulfate precipition and chromatography on DEAE SephacelTM and CM-cellulose columns and protein determined by MALDI-TOF-MS. The results suggested that Jc-SCRIP may be a potential natural antimicrobial and anticancer agent in medical application (Nuchsuk et al., 2013). However, this is the first report of a comparative analysis of *J. curcas* strains in Thailand, Laos and Tanzania using MALDI-TOF-MS.

The sample preparation is a crucial step in MALDI-TOF MS analysis, a careful optimization of the experimental parameters and sample preparation, i.e., matrix, concentration, solvents, and crystallization conditions. The use of internal standards for calibration and an averaging of multiple spectra are required in order to reduce the great variability of observed results (Szajli et al., 2008). In this study, proteins were extracted by SDS, and subsequently precipitated by cold acetone, and TCA. Sinapic acid (SA) matrice was used as matrix solution in this approach. Samples were mixed with matrix solution and analyzed directly by the MALDI-TOF MS.

Methodology

Plant material preparation

The final stage of full-developed fruits of fifteen local varieties of *J. curcas* were collected as shown in Table 1, where the varieties, Jc1 to 13, were obtained from

different localities in Thailand. The variety Jc 14 was collected from Laos, and the variety Jc 15 was obtained from Tanzania. Their seeds were stored at -80 ℃ until used.

Table 1 Details of fifteen *J. curcas* plants (Jc1-15) from different localities in Thailand, Laos and Tanzania

No. of samples	Local source	A part of Thailand
Jc 1	Nakhon Ratchasima 1	Northeast
Jc 2	Nakhon Nayok	Central
Jc 3	Bangkok 1	Central
Jc 4	Nakhon Sawan 1	North
Jc 5	Chiang Mai	North
Jc 6	Chon Buri	East
Jc 7	Nakhon Sawan 2	North
Jc 8	Chanthaburi	East
Jc 9	Suphan Buri	Central
Jc 10	Satun	South
Jc 11	Prachin Buri	East
Jc 12	Nakhon Ratchasima 2	Northeast
Jc 13	Bangkok 2	Central
Jc 14	Laos	-
Jc 15	Tanzania	-

Protein extraction and precipitation

Seed coat tissue (Figure 1) from each sample was ground by mortar and pestle with liquid nitrogen. A 250 mg of a fine powder sample was transferred into a microtube, added 1 ml of 0.1% SDS and then shaking vigorously with vortex for 1 hour. A 1 ml of cold acetone was added into a supernatant in a ratio of 2:1 between acetone and sample, mixed the mixture vigorously and finally frozen overnight at -20 ℃. The frozen sample was thawed and centrifuged at 10,000 rpm for 15 min, and the supernatant was discarded. The pellet was resuspended directly in 1,100 μl 0.15% DOC (deoxycholic acid), mixed well and let it settled for 15 min. A 100 μl 72% TCA (trichloroacetic acid) was added, mixed, and frozen overnight at -20 ℃. The frozen sample was thawed and centrifuged at 10,000 rpm for 15 min, then kept the pellet and resuspended in 0.1% TFA (trifluoroacetic acid).

Figure 1 Components of *J. curcas* seed: a) seed b) seed coat and c) kernel. Seed kernels were used to protein prepared.

(a) Seed

(b) Seed coat

(c) Kernel
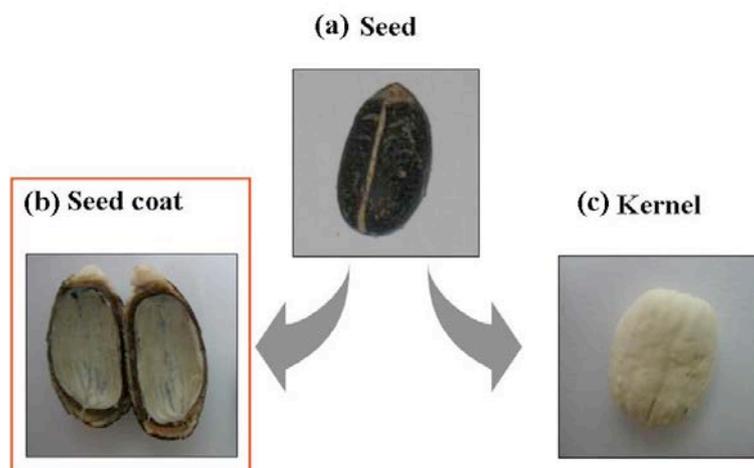
Matrix solution preparation

Sinapic acid, the matrices that most commonly used in MALDI-TOF-MS, was freshly prepared daily as saturated solution in a solvent mixture. The mixture ratio between 0.1% Trifluoroacetic acid and 100% Acetonitrile was 2:1.

Analysis of the preparation

Sixteen dilutions of analyzed mixtures, i.e., 1X, 5X, 10X, 25X, 50X, 100X, 250X, 500X, 1000X, 1500X, 2000X, 2500X, 3000X, 3500X, 4000X and 5000X, were tested with the Jc 5. The analyzed mixture was prepared on a stainless steel template. The dilution mixture at 1X concentration was spotted in 1 µl for a sample, 1 µl for the matrix solution, and the others used matrix solution as a diluent and were spotted in 2 µl. ProteoMass^{TM} Peptide & Protein MALDI-MS Calibration Kit (Sigma Aldrich Co., USA) was used to analyze the spectra.

The dilution of the mixture that showed the most obvious peak spectrum was used in all samples for 8 repeats each.

MALDI-TOF MS analysis

All dilutions of analyzed mixtures were air dried at room temperature, then the template was conducted in UltraFlex III TOF/TOF (Bruker Daltonik GmbH, Germany) equipped with N_2 laser. All spectra were recorded in linear, positive ion mode. Laser shot was controlled by FlexControl 3.0 (Bruker Daltonik GmbH, Germany), which the laser was randomly shot until it accumulated to 3,000 shots across a spot. Mass range of 1,000-20,000 m/z (Da) was used for analysis.

The peak of MALDI-TOF MS spectra were detected and listed as mass using FlexAnalysis 3.0 (Bruker Daltonik GmbH, Germany). Spectra analysis generated data that included both peak position and the intensity. All data samples were compared by ClinProTools 2.2 (Bruker Daltonik GmbH, Germany) and peak spectrum were analyzed using statistics.

Results, discussion and conclusion

Comparison of optimal dilution mixtures

The comparison of MALDI-TOF MS profiles in the mass range of interest (1,000-20,000 m/z) using 16 dilution mixtures revealed the appropriate dilution was 250X that showed the most obvious and more peak spectrums. Then, the 250X dilution was chosen for all samples.

MALDI-TOF MS analysis of 15 *J. curcas* samples

The experiments were repeated for 8 times for each sample to confirm the results with 120 (15x8) spots totally. It was interesting to note that after peaks detected by FlexAnalysis software, all samples produced highly similar characteristic spectra pattern as demonstrated in figure 2. The mass spectra of whole protein exhibited a large number of peaks in the m/z range between 1,000-20,000 Da. Many of the major peaks observed in all samples are common, such as, the peak at 1978.92, 3495.33 and 5744.11 Da. All 21 spectra peak masses that found in all samples and their standard deviation are shown in Table 2.

Figure 2 The representative spectra of the MALDI-TOF MS spectra peak patterns of the Jc 1-15 where whole proteins ranging from 1000 to 20000 Da

Table 2 Peak statistic table show the mass averages and their standard deviation

Index	Mass	StdDev
1	1350.19	0.71
2	1367.14	0.57
3	1428.48	2.05
4	1450.61	2.42
5	1467.64	2.64
6	1487.77	1.47
7	1497.81	1.73
8	1528.99	1.94
9	1544.93	1.48
10	1574.29	2.68
11	1591.93	2.5
12	1737.02	3.87
13	1753.76	3.46
14	1769.44	2.94
15	1938.53	3.88
16	1945.64	3.43
17	1961.38	4.24
18	1978.92	3.28
19	1994.53	2.4

ClinProTool 2.2 was used to compare peak patterns of all samples in order to determine the reliability of the data. According to Figure 3, each gray stripe represented of each peak, the dark one meant high intensity peak. From the results, it was observed that the stripe patterns of all samples were highly similar and the average peaks intensity was shown in figure 4.

Figure 3 Photography of gel view showing the spectra of 15 *J. curcas* samples with 120 spots. The x-axis records the m/z value from 1000 to 10000 Da. The left y-axis displays the running spectrum number originating from subsequent spectra loading. The peak intensity is expressed by color intensity.
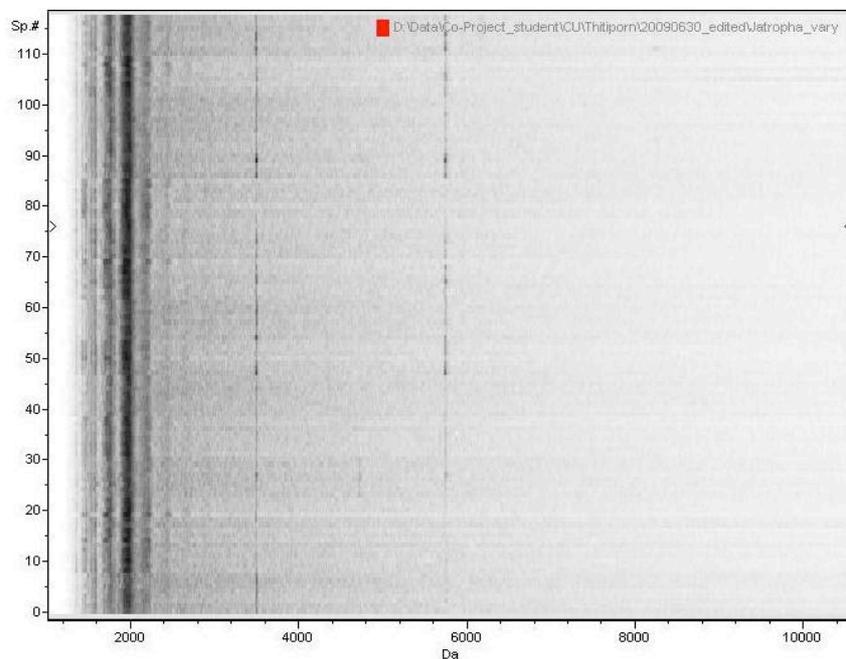
Figure 4 The average peak intensity of all samples.
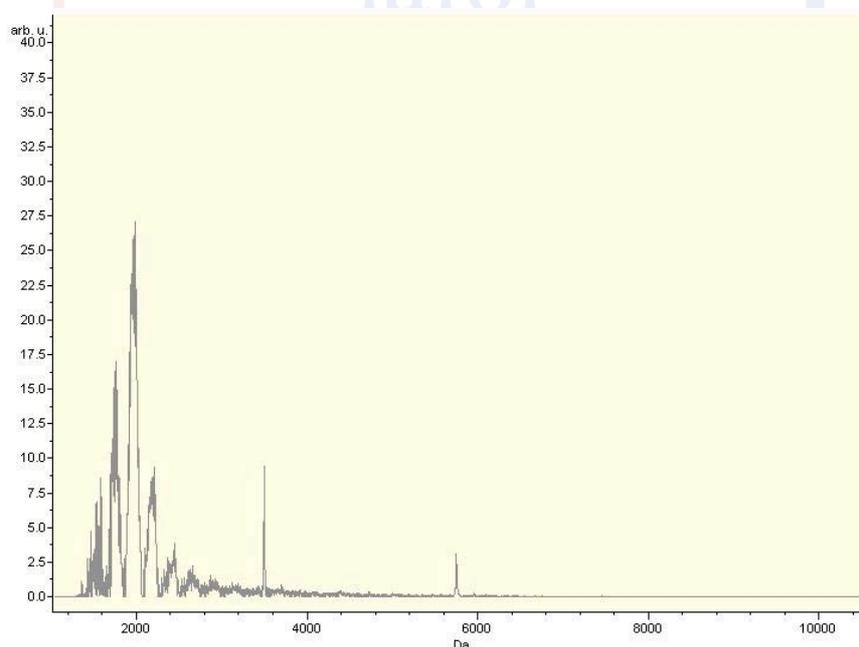
Moreover, to show an obvious result, ClinProTool was used to integrate a statistic data and shown in terms of principle component analysis (PCA). In the case of mass spectra, the variables are represented by the intensity at defined masses. According to the resolution, the number of these variables can be very high. The PCA reduces the number of dependent variables contained within the spectra set replacing groups of variables by a single new variable. By this, a set of new variables, so called principle

components will be generated. Each principle component (PC) is a linear combination of the original variables. All principle components are orthogonal to each other, so there is no redundant information.

As demonstrated in figure 5, the obtained data shown that majority plotted spot concentrated together in the centre and only about 20 spots or approximately 10% were disperse around. The PCA result implied that the set of data have little variances. The result indicates that all samples of *J. curcas* are the same strain. This conclusion was related to the report of Sadakorn in 1984 that *J. curcas* in Thailand was introduced by the Portuguese merchants more than two centuries ago and now the crop is widely grown in various regions of Thailand. It is possible, if *J. curcas* from different part in Thailand are the same strain.

Figure 5 A statistic data shown in terms of principle component analysis (PCA)
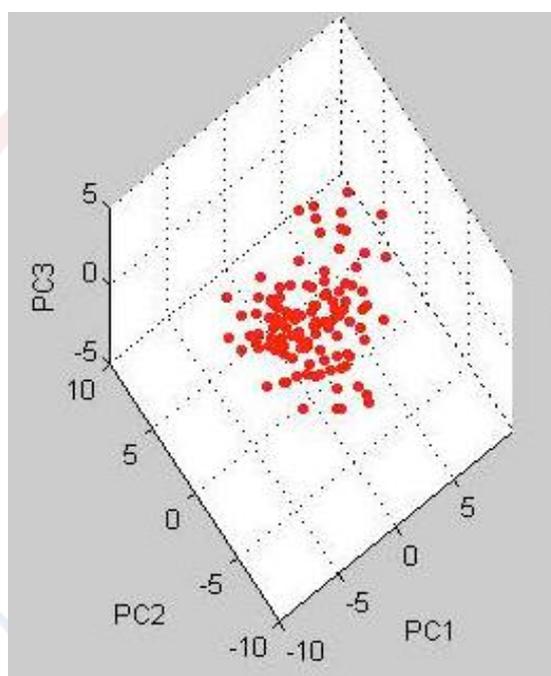
References

Behrens, A., Maie, N., Knicker, H., & Kögel-Knabner, I. (2003) MALDI-TOF mass spectrometry and PSD fragmentation as means for the analysis of condensed tannins in plant leaves and needles. *Phytochemistry.* 62, 1159-1170.

Berchmans, H.J., & Hirata, S. (2008) Biodiesel production from crude *Jatropha curcas* L. seed oil with a high content of free fatty acids. *Bioresource Technology.* 99, 1716-1721.

Gübitz, G.M., Mittelbach, M., & Trabi, M. (1999) Exploitation of the tropical oil seed plant *Jatropha curcas* L. *Bioresource Technology.* 67, 73-82.

Johanna, E.C., & Faith, A. H. (2007) Discrimination between wild-type and ampicillin-resistant *Escherichia coli* by matrix-assisted laser desorption/ ionization time-of-flight mass spectrometry. *Analytical and Bioanalytical Chemistry*. 389,1633–1638.

Karg, S.R., Frey, A.D., Ferrara, C., Streich, D.K., Umaña, P., & Kallio, P.T. (2009) A small-scale method for the preparation of plant N-linked glycans from soluble proteins for analysis by MALDI-TOF mass spectrometry. *Plant Physiology and Biochemistry.* 47, 160-166.

Mokrzycki-Issartel, N., Bouchon, B., Farrer, S., Berland, P., Laparra, H., Madelmont, J. C., & Theisen, M. (2003) Transient tobacco expression system coupled to MALDI-TOF MS allows validation of the impact of differential targeting on structure and activity of a recombinant therapeutic glycoprotein produced in plants. *FEBS Letters.* 552, 170-176.

Monagas, M., Quintanilla-López, J. E., Gómez-Cordovés, C., Bartolomé, B., & Lebrón-Aguilar, R. (2010) MALDI-TOF MS analysis of plant proanthocyanidins. *Journal of Pharmaceutical and Biomedical Analysis*. 51, 358-372.

Ning, C.J., Ding, N., Wu, G.L., Meng, H.J., Wang, Y.N., & Wang, O.H. (2013) Proteomics research on the effects of applying selenium to apple leaves on photosynthesis. *Plant Physiology and Biochemistry.* 70: 1-6.

Nuchsuk, C., Wetprasit, N., Roytrakul, S., Choowongkomon, K., Panjaworayan, N., Yokthongwattana, C., Arpornsuwan, T., & Ratanapo, S. (2013) Bioactivities of Jc-SCRIP, a type 1 ribosome-inactivating protein from *Jatropha curcas* seed coat. *Chemical Biology & Drug Design*. 2013 Jun 17. doi: 10.1111/cbdd.12175.

Openshaw, K. (2000) A review of *Jatropha curcas*: an oil plant of unfullled promise. *Biomass & Bioenerg*y. 9, 1-15.

Oszvald, M., Balazs, G., Polya, S., Tomoskozi, S., Appels, R., Bekes, F., & Tamas, L. (2013) Wheat storage proteins in transgenic rice endosperm. *Journal of Agricultural and Food Chemistry*. 61, 7606-7614.

Pamidimarri, D. V. N. S., Singh, S., Mastan, S. G., Patel, J., & Reddy, M. P. (2008) Molecular characterization and identification of markers for toxic and non-toxic varieties of *Jatropha curcas* L. using RAPD, AFLP and SSR markers. *Molecular Biology Reports. doi* 10.1007/s1103-008-9320-6.

Ranade, S. A., Srivastava A. P., Rana T. S., Srivastava, J., & Tuli, R. (2008) Easy assessment of diversity in *Jatropha curcas* L. plants using two single-primer amplification reaction (SPAR) methods. *Biomass & Bioenergy.* 32, 533-540.

Sadakorn, J. (1984) Physic nut (*Jatropaha curcas* Linn.), a potential source of fuel oil from seeds for an alternative choice of energy. *Thai Agricultural Research Journal.* 2, 67-72.

Stackebrandt, E., Päuker, O., & Urhard, M. (2005) Grouping Myxococci (*Corallococcus*) Strains by Matrix Assisted–Laser Desorption Ionization Time-of-Flight (MALDI-TOF) Mass Spectrometry: Comparison with Gene Sequence Phylogenies. *Current Microbiology.* 50, 71-77.

Sujatha, M., Makkar, H. P. S., & Becker, K. (2005) Shoot bud proliferation from axillary nodes and leaf sections of non-toxic *Jatropha curcas* L. *Plant Growth Regulation.* 47, 83-90.

Szajli, E., Feher, T., & Medzihradszky, K. F. (2008) Investigating the quantitative nature of MALDI-TOF MS. *Molecular and Cellular Proteomics.* 7, 2410-2418.

Teramoto, K., Sato, H., Sun, L., Torimura, M., Tao, H. Yoshikawa, H. Hotta, Y. Hosoda, A., & Tamura, H. (2007) Phylogenetic Classification of *Pseudomonas putida* Strains by MALDI MS Using Ribosomal Subunit Proteins as Biomarkers. *Analytical Chemistry.* 79, 8712-8719.

Tsujita, T., Shintani, T., & Sato, H. (2013) α-Amylase Inhibitory activity from nut seed skin polyphenols. *Journal of Agricultural and Food Chemistry.* 61: 4570-4576.

Zhang, X., Scalf, M., Berggren,T. W., Westphall, M. S., & Smith L. M. (2006) Identification of Mammalian Cell Lines Using MALDI-TOF and LC-ESI-MS/MS Mass Spectrometry. *Journal of American Society for Mass Spectrometry.* 17, 490–499.

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Development of a High Fiber Mango Jam

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Abstract

This research was aimed to produce a high fiber mango jam using gel derived from the corm of the konjac that had been recognized by the consumers for sometimes. The product of mango jam was studied and characterized in several ways, i.e., physical and chemical properties, and the determination of the plausible contamination with microorganism. The basic jam's formula was consisted of pectin. Various concentrations of the konjac gel used were 0.5, 1, and 1.5 %. The konjac gel was prepared using konjac flour mixed with warm water in a ratio of 1:30. It was found that the jam that containing konjac gel at the concentration of 1% was the most acceptable product by the consumers with the score was 3.57. In regarding to the physical quality, the appropriate viscosity level was at 4,650 centipoises, where adulterated thing was not observed with naked eyes. The chemical quality of konjac gel was consisted of 67 Brix of total soluble solid, water activity 0.3, and pH at 0.32, with no food coloring. A total concentration of detected microorganism was less than 10 cfu/ml, while yeast and mold were detected less than 100 cfu/ml. Cooperative Women Group in Mueang district carried out the production of high fiber jam mixed with mango in Bang-Pai sub-district, Chachoengsao province in order to use as an alternative way in processing of mango and value added for local agriculture products.

Keywords: High fiber jam, mango-jam.

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Introduction

The total area of land in Chachoengsao province is approximately 3,344,375 acres, while only 2,002,798 acres are used for agricultural purposes, which is equivalent to 59.88 percent of the total area. The 70 percent of citizens are agricultures and the agricultural products in Chachoengsao province consist of rice, tapioca, cane, coconut, mango, and betel nut, where many varieties of high quality of mango fruits are produced mainly in Bang Khla, Sanamchaikheat and Thatakeab district (Provincial Development Plans of Chachoengsao 2014 - 2017). However the biggest drawback of the agricultural production is that people are lack of knowledge concerning the process of the agricultural products, which is equivalent to 14.71 % of the total population (Provincial development plans of Chachoengsao 2014 - 2017). The mango fruits are happened to be a major seasonal and agricultural product of Chachoengsao. The preservation and processing practices are one of various methods that can extend the life of mango fruits. The popular practices in processing of mango fruits such as stirring, dehydrating, and pickling are the most popular ones, where the popular processing in foreign countries is the production of jam. The mango products can be stored for a long period of time because of the high sugar content is up to 55 percent according to the finding of the project of technology and community product. Since the pectin is a major content in the product that acts as a stabilizer in the jam product where its content is a gel, which has high sugar content (Chompoo, 2005).

It has been shown that konjac powder is a dietary fiber with very low calories nutrient derived from the corm of Konjac plant. The konjac powder has a Glucomannan that acts as a dietary fiber with no calories food content, which is not digested by enzymes naturally within the human digestive system resulting in a low energy diet (Wisaksomboon, 2006). In this study, the konjac powder is chosen as a mixing content to produce a high fiber mango jam. The supplementation of dietary fiber from the konjac powder will serve as value added mango jam formulation and can promote local fruit production in Chachoengsao to be accepted by the consumer both at national and the international levels. This study was aimed to develop the proper formulation of dietary fiber mango jam from konjac.

Materials and Methods

The production of dietary fiber mango jam was started by mango cv. Nam Dok Mai where all mango allowed to grow for 130 days and maintained the total soluble solid not less than 29°Brix was studied. Adding the konjac powder into the paste of mango pulp derived from the basic formulation to make three final formulations of mango jam, i.e., 0.5, 1, and 1.5 %, which these three jam mixture were called as the formulation I, II, and III, respectively. The level of sweetness and pH values were controlled at the selected level during the mixing process of the konjac powder with the flesh of mango. The final product of individual formulation was analyzed for its physical, chemical and microbiological components. These three formulations were used for the sense of taste evaluation in order to determine the acceptance of consumers. The participants that served as the tester were recruited from the semi-trained panelists who had the testing experience to a sensory test. They were student from food and business service branch, Faculty of Science and Technology, Rajabhat Rajanagarindra University, Chachoengsao. These 30 students were travel around the Somdej Phrasrinagarindra Baromrajachonnee Park, where they requested a total of

100 people to do the quality test, and the duration of the research was carried out in January 2012 to May 2014. This research is quantitative rules-based experimental research the implementation of research as follows

The basic formulation of mango jam

The production of mango jam, which was modified from the basic formulation of the basic fruit jam recipes that based on concept and theory of related research, where three formulations were set up and applied to the evaluation of various sensory qualities, i.e., color, smell, the stability of the gel to disperse, sour taste, sweetness, and overall likeliness, by using the method to taste preference score of five sequences. Thirty students who participated in the quality test were recruited from the Branch of Food and business service, Faculty of Science and Technology, Rajabhat Rajanagarindra University, Chachoengsao, Thailand. Results of the determination of the test samples were reported, where several items were used, i.e., color of the jam, smell of test sample, stability of gel, fragmentation, sour taste, sweetness, which the jam sample was presented to the tester with bread. Each item was scored in order to determine the average of qualities. All data were used to develop mango jam with an aid of konjac powder.

Table 1. The characteristics of 3 formulations of mango jam.

Ingredient	The basic mango jam Weight (gram)		
	First formulation	Second formulation	Third formulation
Mango	400	500	250
Sugar	500	737.5	300
Citric acid	13.87	6.25	-
Lemonade	-	-	50
Pectin	9.25	6.25	5
Total	100	100	100

The first formulation was done following the formulation described by Deepu (2008).
The Second formulation was done following the formulation described by Sinlapanapaporn (1988).
The Third formulation was done following the formulation described by Promprasir & Prasitworakarn (1999).

Evaluation of the jam's quality using sense of taste

Data of sense of taste were recorded using Hedonic Scale with five levels (1=dislike to 4 levels of like). Several items for the sense of taste were used, i.e., color of the test sample, mango's smell, stability of gel, sour taste, sweetness and desirability of the tester. The samples were served with bread for testers. An analysis of variance was done by using ANOVA at statistical confidence level 95 percent, while the different of average was carried out by Duncan's Multiple Range Test. The selection of the best basic formulation was based on results of the most preference from the average score. The selected basic formulation was used as the basic ingredient for the development of dietary fiber mango jam supplemented with konjac powder.

The result of studying and discussion

Table 2 The result of studying the basic mango jam

The sense of taste quality	Preference Scores		
	The first formulation	The second formulation	The third formulation
Color	2.97[a]	3.43[a]	3.33[a]
Smell	3.20[a]	3.30[a]	3.93[b]
The stability of gel	2.13[a]	2.37[a]	2.37[a]
spread ability	2.07[a]	2.47[a]	3.13[b]
Sour taste	1.97[a]	2.43[a]	2.30[a]
Sweetness	3.17[a]	3.90[b]	3.40[ab]
desirability	3.17[a]	3.90[b]	3.40[ab]

* In the horizontal, same alphabet is symbol of same group in duncan method

Results in Table 2 show the quality of mango jam using the sense of taste method, where the basic characteristics of three formulations of mango jam products, i.e., from an assessed in sensory, touching of color, smell, the stability of gel, spreading ability, sour taste, sweetness, and the desirability of testers. It was found that the mango jam in the second formulation was accepted from the testers, where the degrees of sense of taste are the same for color, which was equivalent to 3.43, the stability of jam was equivalent to 2.37, the spread ability was equivalent to 2.47, the sour flavor was equivalent to 2.43, the sweetness was equivalent to 3.90, and the desirability was equivalent to 3.90. Results of testing by Duncan method found that all of 3 formulations were not different in color and smell was different between first and second formulation, whereas there were differences with the third formulation, i.e., there were no different in the part of stability and the spreading ability between the second and third formulation, whereas there were different in the first formulation. The sour flavor was not different between the first and third formulation, but there was different in the second formulation. There were different in sweetness and the desirability among all of 3 formulations with a statistically significant difference at the level of p 95. Therefore, the researcher had chosen the second formulation as an appropriate formulation of the supplemented dietary fiber mango jam made from the konjac powder.

The result appropriate quantity of konjac

Table 3 Results of an appropriate quantity of konjac, by filling konjac in 3 levels, i.e., 0.5, 1.0, and 1.5 percent of all mango pulp for the production of mango jam in 3 formulations.

Ingredient	Konjac powder (gram)		
	First formulation (0.5%)	Second formulation (1%)	Third formulation (1.5%)
Mango	500	500	500
Sugar	737.50	737.50	737.50
Citric acid	6.25	6.25	6.25
Pectin	6.25	6.25	6.25
Konjac powder	2.50	5	7.5

Adding konjac powder in 3 levels 0.5 % 1% and 1.5 % in mango jam. Three different dose levels of the control variables 1. the sweetness 2. pH 3. Total soluble solids

Table 4. Results of the preference scores of the quality test of the three formulations of the test samples using the sense of taste.

The sense quality	Preference Scores		
	The first formulation	The second formulation	The third formulation
Color	3.40^a	3.23^a	3.60^a
Smell	3.27^b	3.30^b	2.13^a
The stability of gel	1.90^a	3.37^b	2.90^b
spreading ability	2.60^a	3.53^b	3.53^b
Sour taste	2.07^a	3.80^b	2.50^a
Sweetness	2.13^a	2.93^b	3.67^c
desirability	2.67^a	3.17^b	3.73^c

* In the horizontal, same alphabet is symbol of same group in duncan method

It was found that the second formulation of mango jam was accepted from the testers, where the Duncan test revealed that all of 3 formulations were not different in color and smell between the first formulation and the second formulation, but there were differences in the stability of the third formulation, whereas the spreading ability was not different between the first and second formulation. It was shown that there were differences in the sour taste, where the first and second formulation, but it was not different between the first formulation and the third formulation. The sweetness was different between the first and second formulation, while the sweetness and desirability were different among all 3 formulation at 95 % significant level. Details of second formaulation was chosen to serve as an appropriate basic formulation to produce the supplemented dietary fiber mango jam.

Studying the result of accepting in consumer.

Table 4. The average scores of acceptance for the quality of mango jam using the sense of taste results of the supplemented dietary fiber mango jam.

The quality of sense	$\bar{\text{x}}$	S.D.	Level of acceptance
1.color	3.26	0.93	Medium
2.Mango's smell	3.23	1.17	Medium
3.The stability of gel	3.50	0.73	Much
4. spreading ability	3.58	0.94	Much
5.Sour tase	4.02	0.87	Much
6 Sweetness	3.59	0.96	Much
7.The desirability	3.86	0.91	Much
Average	3.57	0.93	Much

Results in the Table 4 show that almost testers and consumers were accepted with the sour product in a high average at 4.02, while the acceptance in the desirability, sweetness, spreading ability, and stability of gel were accepted by the consumers. The average scores of color and smell were at the medium range at 3.26 and 3.23. However the researcher increased the ingredient up, where the consumers still accepted the test sample of supplemented dietary fiber mango jam at a high average score at 3.57.

The study result quality of products

Table 5. Results of the testing of the quality of products

Testing of Quality		The basic mango jam with formulation	Supplemented dietary fiber mango with konjac
Physical	The viscosity	3900 centipoise	4650 centipoise
	Adulterated thing cannot observed with the naked eyes	Not found	Not found
Chemical	Water activity	0.48	0.35
	pH	0.32	0.32
	Total fiber	3.62 g/100g	4.12g/100g
	Total soluble solid	65 °Brix	67 °Brix
Microorganism	Total microorganism	< 10 cfu/g	< 10 cfu/g
	Yeast and mold	<100 est cfu/g	<100 est cfu/g

Results in Table 5 show that the physical quality of the mango jam in the basic mango formulation in viciousness is 3,900 centipoise, where the supplemented dietary fiber mango jam with konjac has viciousness at 4,650 centipoise. All of the 2 mango jam formulations where adulterated things could not observed with the naked eyes. The chemical quality of the mango jam in the basic mango formulation in water activity is 0.48, pH 0.32, Total fiber 3.52g/100g and total soluble solid 65 °Brix where the supplemented dietary fiber mango jam with konjac has 0.35, pH 0.32, Total fiber 4.12g/100g and total soluble solid 67 °Brix .The microorganism quality . All of the 2

mango jam formulations where total microorganism less than 10 cfu/g and yeast and mole less than 100 est cfu/g

Conclusion and discussion

Results of the supplementary of konjac powder to make a dietary fiber mango jam are summarized with mango 5oo g, sugar 737.50 g, citric acid 6.25 g, pectin 6.25 g, and Konjac powder 7.5 g. The ingredient of mango jam in the basic formulation in all of 3 formulations regarding to the assessment of quality in color, smell, stability of gel, spreading ability, sour taste, sweetness, and the desirability using Hedonic Scaling to five levels, as shown in Table 1. It was found that testers did not find any different in color, stability, sour taste, and sweetness because the quality of ingredients in the selected test sample was controlled by the mango cv. Nam Dok Mai where all mango allowed to grow for 130 days and maintained the total soluble solid not less than 29ºBrix. The controlled quality of raw materials was agreed with the research of Sinlapanapaporn (1988). Noparatana et al. (1991) found that testers gave different scores in stability, sour, and desirability, which all of 3 formulations had used lemonade instead of citric acid that resulted in its good smelling in lemonade where the testers could differentiate it in the second formulation of mango jam. The researcher has found that the testers are accepted the sense of taste of several items, i.e., color, stability of gel, sour taste, sweetness and the desirability. The quality of the second formulation of mango jam has less proportion of citric acid than the first formulation. It was shown that konjac powder makes the mango jam become stickier and jelly, which agreed with results of other studies (Promtongdee et al., 2007; Deepu, 2008; Nitimongkonchai, 2001). It was shown that konjac contained inflatable water, so the jam would become sticky when too much amount of konjac was added (Wisaksomboon, 2006). The concentration of konjac in this study is maintained at one percent of a total weight of mango pulp, and the tester accepted the sense of taste of the test sample with a statistically significant at the 95 % confidence level. Konjac will become jelly when the substance is heated during the food processing. If the mango jams were added with sugar, the product would appear in a dark color (Caramelization) jam with bad smell too. This will lead to a less acceptance from the consumers. It was found that filling the mango jam with konjac could make fiber to increase from 3.62g/100 g to be 4.11g/100 g, which was equivalent to 11.38 %, where the ability to dissolve in water was still remaining. This characteristic of dietary jam will help the digesting of food getting better with low calories (Wisaksomboon, 2006).

References

Deepu. S. (2008). *The study of fruits jam manufacturing*. Rajabhat Phetburi University, Phetburi, Thailand (in Thai).

Nitimongkonchai. N. (2001). *Product development of Leb Mu Nang jam with Konjac flour*. Academic Conference: Vol. 40. Agro Industry (pp 399-404). Kasetsart University, Bangkok, Thailand (in Thai).

Noparatana.M., Vongsawasdi.P., Yuvidhaya.T., Kasemsukchotikul. S., & Pinprapai, W. (1991). *Effect of raw-material storage methods on strawberry jam Qualtties*. Academic Conference: Vol. 3. Agro Industry (pp 371-379). Kasetsart University, Bangkok, Thailand (in Thai).

Promprasir. S. & Prasitworakarn. J (1999) *Three flavor of Aloe vera jam*. Rajabhat Phetburi University, Phetburi, Thailand (in Thai).

Promtongdee.K., Fungkajorn.S., &Chaisang.A. (2007). *Development of sunlady jam from glucomanan* . Rajabhat Nakornpratom University, Nakornpratom, Thailand (in Thai).

Sinlapanapaporn.O. (1988).*Development of Pineapple Jam to Meet Quality Standard for Industry*. Kasetsart University, Bangkok, Thailand (in Thai).

The project of technology and community product, (n.d). *Fruit Jam*. Srinakharinwirot University, Bangkok, Thailand (in Thai).

Wisaksomboon. W., (2006). *Fiber*. Bangkok : Feels good, Bangkok, Thailand (in Thai).

Yimto.C. (2006) *Food Preserve*. Bangkok:Odien store, Bangkok, Thailand (in Thai).

Chachoengsao Province.(2013) .*Provincial development plans of Chachoengsao 2014 – 2017*. Chachoengsao:Goverment office.from http:// www.chachoengsao.most.go.th, Chachoengsao, Thailand (in Thai)

Study on Quality Parameters of Raw Natural Water for the Production of Tap Water at Bangka Sub-District, Ratchasan District, Chachoengsao

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Abstract

The study on water quality at Bangka Sub-District, Ratchasan District, Chachoengsao Province, Thailand was the survey research. The study was undertaken to determine the quality of raw natural water before used as raw material to produce tap water. The findings would submit to the Provincial Authority of Waterworks to consider for the production of tap water. We measured the water quality from Ta Lad canal, which had been using to produce the tap water two times each during the rainy season and dry season. The quality of water was analyzed and compared with the class 3 of The Surface Water Standard for Agriculture and Water Quality for Protection of Aquatic Resources. Results showed that the water quality of raw natural water collected on 31 May 2012 was in the range of standard values except the level of Lead was higher than that of the standard one. The water quality of raw natural water collected on 19 September 2012 was also in the range of standard values except the value of the Biochemical Oxygen Demand, which was higher than that of the standard one. These results were probably caused by contaminants leaked into the water. Therefore we should educate and encourage people in the community to become aware of this situation, while the water quality should be monitored regularly and stimulate the cooperation among government authorities, community and stakeholders in helping hands for the preservation of the water quality.

Keywords: Water quality, Tap water, Water resource management.

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Introduction

Water is an indispensable natural resource for the survival and well being of mankind. Water is fundamental for life and health. The human right to water is indispensable for leading a healthy life in human dignity. Therefore, the water quality of water supply should stay clean and clear with pleasant taste and odor. However, the water quality and water supply in the villages of Bangka Sub-District, Ratchasan District, Chachoengsao Province, are not suitable to be used to produce tap water because the quality of tap water that produced from this raw natural water is under the standard criteria for water quality consumption, and water is not enough to support all villagers in a village of Bangka Sub-District even the village has a water supply system, which retrieved from Ta Lad canal. Therefore it is interested to study and analyze the quality parameters of raw natural water in the canal. This research is carried out in the collaboration between the researchers and villagers of Bangka community. The results of this research would be useful for people in the Bangka Sub-District areas and could be used for the basic information for other communities or organizations.

Methodology

This research used a survey research design to collect data both of primary data and secondary data. The secondary data were basic data of Bangka district and data that related to tap water supply system of Bangka Sub-district Administrative Organization. The majority of primary data were obtained from interviewing that related to problems of water quality from the residents of Bangka Sub-District area. The water samples of raw natural water were sampling both from the rainwater during summer and rainy seasons and stored in laboratory for water analysis.

The water sample was analyzed against various parameters by comparing with the surface water quality standard class 3, which was equivalent to medium clean fresh surface water resources. The parameters that need to be considered were described as follows: (1) the water to be used for consumption should pass through an ordinary treatment process before being used. (2) Water that used for agricultural purpose should have the quality met the notification of the National Environmental Board, No. 8, B.E.2537 (1994), which was issued under the Enhancement and Conservation of National Environmental Quality Act B.E.2535 (1992) for the standards of surface water quality. The selected 17 parameters of raw natural water comprised of color and odor, temperature, acidity and alkalinity (pH), dissolved oxygen (DO), biochemical oxygen demand (BOD), total Coliform bacteria, fecal Coliform bacteria, Nitrate (NO_3) in Nitrogen, Copper (Cu), Manganese (Mn), Zinc (Zn), Lead (Pb), Arsenic (As), total Organochlorine pesticides, Dieldrin, Endrin, and Iron (Fe).

The sampling of raw natural water was collected 2 times, where the water sample was taken on May 31, 2012 for summer, and on September 19, 2012 for rainy season. The sites for taking the water sampling were selected along the Ta Lad canal near the water pump station. The water sample was taken before the water was pumped to the water production system

The researchers carried out the experiment for measuring the temperature, pH, and dissolved Oxygen immediately before the water samples were taken at the water sampling point.

The technique that used to preserve the water sample for analysis of individual parameter was done as follows: (1) water sample to be used for the determination of heavy metals as preserved by adding the concentrated nitric acid at pH below 2. (2) The water sample to be used for the determination of the content of nitrate – nitrogen was preserved by adding concentrated sulfuric acid of 2 ml per 1 liter of water sample. (3) The water sample to be used for the determination of the content of phosphate was preserved by adding the concentrated hydrochloric acid 1 ml per 1 liter of the water sample. (4) The water sample to be used for the determination of the content of sulfate by keeping the water samples in the brown bottle. (5) The water sample to be used for the determination of Coliform bacteria and fecal Coliform bacteria by storing the water samples under 4 to 8 ° C conditions in the refrigerator.

All water samples were labeled according to the name and type of sample, place and environments, date, time, and names of the sample collectors, and also recorded all of the details in the logbook. All samples were sent to the Central Laboratory (Thailand) Co., Ltd., Chachoengsao branch for the analysis.

The collection of the secondary data that included information regarding the area base, populations, and socio-economics were done through the survey of the tap water production system in Bangka Sub-District area and discussion with the committees and the Chief Executive of the Sub-District Administrative Organization on March 23, 2012. The consultation was carried out in collaboration between staff of the Faculty of Science and Technology, Rajabhat Rajanagarindra University, and authorities of local organizations.

Results

It was shown that the amount of raw natural water in Ta Lad canal was abundant all the year, where the water was clear with low in numbers of suspended solids. All residents in the village were able to use water for consumption all the year. The amount of water in rainy season was higher than the amount of water that was available in the summer. This observation was probably due to the fact that water in Ta Lad canal was originated from Klong Si Yad diversion dam, the water current was flowed continuously with brown color water and much more turbidity of the water body, where most of residents used water from the canal for the agricultural purposes. Information obtained from interviewing suggested that the pressure of the water pump house located at the bridge across Ta Lad canal in front of Bangka temple was too low, where the water was allowed to sit in a clarifier of Bangka Sub-District Administrative Organization, and was subsequently pumped into the village tap water production system. The water was filtered through the sand and fine sieve with adsorbents, where the filtrate was disinfected with chlorine. The filtered water was then pumped in to the storage room to silt settle. The final water product was then released into the tap water system in the village using high pressure water pump and distributed to all subscribed recipients in the village.

Results of interviewing that obtained from residents demonstrated a positive satisfaction concerning the quality of tap water in Bangka Sub-District Administrative Organization, where most of the residents were satisfied for the quality of tap water. But there were some complaints about the sour taste and rust odor occurred sometimes. It was found that there was more sediment in tap water during rainy

season; this might due to the efficiency of filter system was reduced during heavy rain in the rainy season.

Results of water analysis related to the quality of raw water samples that collected at Ta Lad canal are summarized in Table 1. The samples that collected during the summer month showed that most of the parameters of the water quality fell in the water quality standards class 3 criteria, i.e., color, odor, temperature, pH, dissolved oxygen, BOD, total Coliform bacteria, fecal Coliform bacteria, nitrate as nitrogen, copper, manganese, zinc, arsenic, Total organochlorine pesticides, dieldrin, endrin and iron; whereas the lead was higher than the standard criteria. The content of iron was rather high, even though the water quality standards class 3 did not require as an important parameter.

Table 1. Results of the analysis of the water quality parameters of raw natural water at Ta Lad canal.

No.	Parameters	Unit	Water quality standards class 3	Samples collected during Summer	Samples collected during Rainy season
1.	Colour and Odour	-	Natural	Normal both Colour and Odour	Normal both Colour and Odour
2.	Temperature	$^{\circ}C$	Natural	29.7	29.5
3.	Acidity and alkalinity (pH)	-	5.0 - 9.0	7.4	7.2
4.	Dissolved oxygen	mg/l	> 4.0	5.71	8.0
5.	Biochemical Oxygen Demand (BOD)	mg/l	2.0	1.25	3.33*
6.	Total Coliform Bacteria	MPN/100 ml	20,000	1,600	9,200
7.	Fecal Coliform Bacteria	MPN/100 ml	4,000	540	3,500
8.	Nitrate (NO_3) in Nitrogen	mg/l	5.0	0.25	0.29
9.	Copper (Cu)	mg/l	0.1	0.011	0.006
10.	Manganese (Mn)	mg/l	1.0	0.142	0.287
11.	Zinc (Zn)	mg/l	1.0	0.097	0.014
12.	Lead (Pb)	mg/l	0.05	0.310*	0.008
13.	Arsenic (As)	mg/l	0.01	0.003	0.004
14.	Total Organochlorine Pesticides	mg/l	0.05	Not Detected	Not Detected
15.	Dieldrin	µg/l	Not Detected	Not Detected	Not Detected
16.	Endrin	µg/l	Not Detected	Not Detected	Not Detected
17.	Iron (Fe)	µg/l	-	4.610	7.488

Remark: * = higher than standard criteria

The secondary data were collected from the study area using surveying method and group discussion with committees and the Chief Executive of the Sub-District Administrative Organization. The activities of group discussion between researchers and the executive officers of the organization are shown in Figure 1.

Figure 1. Showing activities during group discussion between researchers and executives of Bangka Sub-District Administrative Organization.

The examples of activities during attempts to collect the secondary data at the study area are summarized in Figures 2 and 3. All information that related to the tap water production system, tap water's demand of community, tap water production rate, amount of raw natural water that was used from Ta Lad canal, water quality during each season, quality of village tap water, and tap water issues from past to present were collected.

Figure 2. Pictures showing environment status at and around Ta Lad canal that used for the production of tap water for the communities.

Figure 3. Pictures showing activities related to the collection of water samples at the study area for an analysis in the laboratory.

Discussion

It is shown that almost all parameters of the water quality that collected during summer months are fallen in the ranges of the water quality standards class 3 criteria except the lead which is higher than that of the standard one. This observation may be due to the contamination from materials used in daily activities of man, i.e., paints, fuel oil, batteries, ink, colors, and other materials that contain lead components.
Results obtained from the analysis of the water quality of water samples collected during rainy season show that almost all parameters of the water quality that collected during summer months are also fallen in the ranges of the water quality standards class 3 criteria except BOD value, which is higher than that of the standard criteria. The high value of BOD means that the water is contaminated with more organic substances. The microorganisms in the water are usually required high amounts of oxygen to decompose the organic matter in the water. Therefore, BOD value is higher than that of the standard one. The contaminants maybe derived from the communities or other sources that flow into the canal. However, the level of lead content in water is lower than that of the standard one.

The level of Fe in the water is rather high, but is not higher than that of the quality standards. This observation is probably related to the contamination of iron from organic mater in wastewater that releases into the canal.

The study of the quality of raw natural water in Ta Lad canal during the summer months and during rainy season showed that there were some parameters had values higher than those of the standard ones, i.e., lead during the summer months and values of BOD in the rainy season. Therefore, it is recommended that guideline to prevent and solve the problems that make the quality of raw water to become lower than the standard ones should be established, and the guideline of how to maintain the quality of raw water in the range of the standard ones should be published.

Conclusion

The study on the quality of raw natural water was carried out at the Bangka canal where the water in the canal was used for the production of tap water for the consumption of residents in Bangka Sub-District, Ratchasan District, Chachoengsao Province, Thailand. All information concerning both the preliminary and secondary data was collected from the study area. All parameters required to determine the quality of raw water that needed for the consideration for the production of tap water were studied, while the secondary data concerning information that related to the tap water production system, tap water's demand of community, tap water production rate, amount of raw natural water that was used from Ta Lad canal, water quality during each season, quality of village tap water, and tap water issues from past to present were obtained through interviewing and group discussion with local residents and authorities and executives of Bangka Sub-District Administrative Organization. The quality of raw water in Ta Lad canal both during summer months and rainy season were appropriate to be used for the production of tap water

Recommendations for the activities to maintain the production of tap water

The study on all parameters of raw natural water in Ta Lad canal should be carried out all year round in order to monitor the quality of raw natural water using in the production of tap water. The sites for water sampling should be expanded further above the water current of Ta Lad canal in order to monitor all parameters of the quality of raw natural water for more distant above the site that water was used. All environmental conditions above and along the site of collection of water should be maintained as clean and green environment all year round.

References

Basic data of Bangka Sub-District Administration Organization. (20 May, 2012). [Online]. Retrieved from http://www.bangka.go.th/index.php

Pollution Control Department. (1 July, 2014). The Quality Standards of Surface Water. [Online]. Retrieved from http://www.pcd.go.th/info_serv/reg_std_water05.html

Simla, S. and Chaiha, S. (2007). The Tap Water Quality on Physicals and Chemicals in Konkhan University. Thailand.

Sombatsiri, P. (2008). The Development of Standard Tap Water Production. A Case Study of Ban Pong Chai Village, Lampang Province. Lampang Rajabhat University.

Sungsittisawas, W. (2005). The Quality of Raw Natural Water and Tap Water in Tap Water System. Konkhan. Konkhan University. Thailand.

Tokamoltham, J., Angkanasayan, S., Phettong, C., Nilnon, N., Kiratisewee, H., and Kerdsiri, P. (2006). A Study on Tap Water Quality in Nong Bua Sub-District, Kanchanaburi Province. Kanchanaburi Rajabhat University. Thailand.
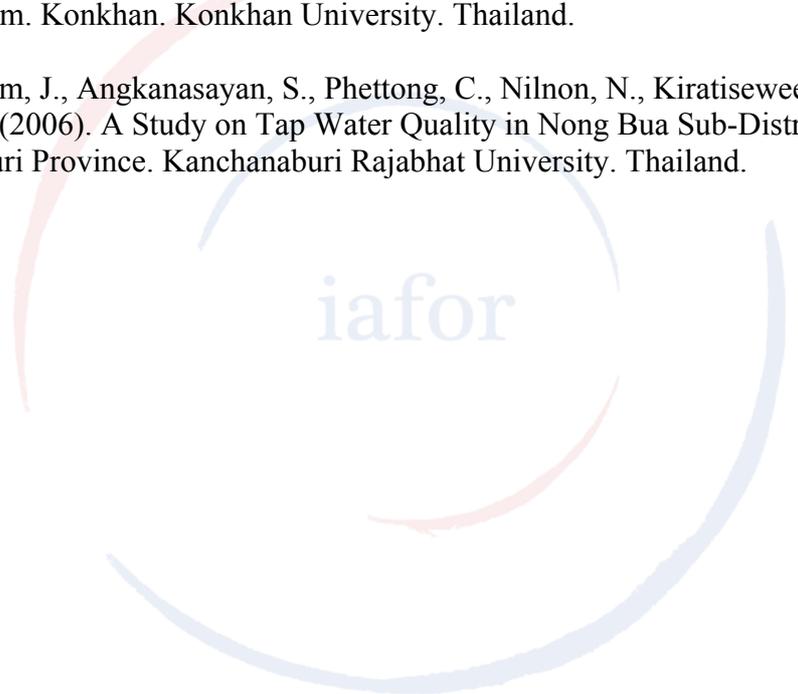
The Development of Learning Communities for Conservation and Sustainable Transfering of Knowledge to Children and Youth in Chachoengsao Province, Thailand

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Abstract
This research was aimed to study the needs of children to learn a body of conservation knowledge that existed in the local community, in order to develop the resources of the local community and provide the conservation knowledge transfer to children, which would promote the children's learning with the conservation knowledge that was available in the local community. The research was conducted through the consideration of the conservation potential resources to develop the learning community and participatory sustainability in order to transfer the knowledge to children. The process was carried out through lecturing, focus group, workshops and demonstrations to achieve the learning process and preparation of learning media in the forms of paper, posters and video media in Chachoengsao Province.
It was found that the local community in Samet Tai sub-district had selected the integrated agricultural learning resources by adopting the King's Sufficiency Economy Principle for organic waste management by using household waste. The knowledge and development were transferred to students at Ban Nong-Sano School through workshops concerning the use of biological compost and herbal insect repellents. The local community in Nong Naer sub-district had selected the learning resources at bamboo community forest (Pa Pai Park), which was the bamboo forest found only in Eastern Thailand. The knowledge concerning conservation awareness of bamboo forest was transferred to students at Wat Nong Naer School.

Keywords: Knowledge transfer, conservation utilization, organic waste management, and bamboo community forest

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Introduction

The strategic plan for the development of Thailand National Economic and Social Development Plan No. 11 (2012 - 2016) had been featured in the strategic development and social reintegration of Thai wisdom and learning-oriented management knowledge, wisdom and modern knowledge from the community level to the national level by focusing on the management of natural resources and the environment sufficient to maintain the ecological balance and a solid base of national development. Such strategies from reflecting the learning community develop management of natural resources and environmental sustainability from the district level was the key to strengthening the community, through development and transfer of knowledge in the management and conservation of natural resources and the environment in the context of each local community. It has been documented that the learning process of the community has many ways including the group of community members get together to exchange ideas and to learn each other (Nakorntub, 1997). Results of learning from practice of the community and learning to work together as a network with a similar concept will make public to learn the importance of community, understanding of the situation of the communities, and ready to participate in the management and conservation of natural resources and environment of the communities by themselves. This practice with an initiative event of a great unit parties to relate network jointly develop a learning community that involves by focusing on the cognitive development to children. The development of the learning process of children and young people is aimed to bring the knowledge from academic institutions to transfer to children and bringing knowledge of wisdom of the community to the education institute for the development of learning process. This will give an opportunity for the children to learn both the theory coupled with the lifestyle of the local community, so that the operation should focused on the development of learning communities to be ready by the greenway lessons learned knowledge, and then pass on into the process of transferring knowledge through group workshops for children to learn more concretely. The learning process model including several practices, i.e., media relation campaign, establishing data centers in the community, demonstrations, training, studying, seminars, sharing of knowledge, brainstorming and organizing stage for an exhibition to disseminate information, and broadcasting online media. The authorities in all sectors should be involved in the operation to jointly inherit the knowledge of the management, conservation of natural resources, maintaining the environment to remain as a community-based capital context and the potential contribution for the development of knowledge and the development of learning process for children (Walaisatiean, 2000).

Therefore, one of the interesting areas is the development of learning communities, and transferring of the knowledge that relate to the management and conservation of natural resources and environment for children in Chachoengsao Province by gathering existing data that are currently available to develop the learning process for children. The collection of knowledge that relates to the conservation and sustainable forest management will be developed for children to participate in the project. In-depth interviews and site visiting should lead to the implementation of the education institute that creates critical thinking for conservation and sustainable life skills development of children (Munkept, 2008).

This study was aimed for transferring the knowledge of the conservation and sustainable environments to children, where the development of the project required a

survey the need of children and young people regarding factors for the learning of cognitive conservation with local communities, and resources in the local community, while the local community should provide space for the knowledge conservation in Chachoengsao Province. Results of the study are expected to lead to the preparation of the information media and technical documents to be used in knowledge management and conservation of natural resources and environment for children and youth.

Research Methodology

Participants
The population in this research was a group of children in elementary schools located in Samet Tai sub-district and Nong Naer sub-district, Phanom Sarakham district, Chachoengsao Province, Thailand. Thirty participants were selected from students in the fourth to sixth grade of the primary school, who interested in the learning process of cognitive conservation.

A qualitative method was used to collect information from participants, where the processes that used to collect information were divided into four stages. The first stage was a collection of information concerning a potential of social capital of the community from all documents that were currently available. An in-depth interview was also carried out in order to obtain for information concerning community resources for use in the transfer of knowledge and encourage the learning activities of children in the area of research. An analysis of the requirement of children groups was done in order to learn knowledge, conservation of existing resources in the local community based on the availability of knowledge that needs to pass on the conservation. The development of learning media and learning process for children to be used in the parish, where the knowledge of local communities were carried on various techniques, i.e., group participatory workshops, lectures, demonstration of knowledge, and developed learning materials, i.e., videos, posters, books, paper, a presentation format that children used in the education institutes, for sharing and distribute to other children. Finally, the fourth phase was done by publishing and used as learning materials to promote learning processes. This was a transferring of knowledge from research to children, where a network of learning knowledge and conservation of the children would be created.

Instrumentation
The instrument used for data collection consisted of a survey/recorded data of a learning community, and a semi-structure interviewing information to explore the knowledge of specialists in order to bring the knowledge to children in the study area.

Data Analysis
All data were analyzed using content analysis with qualitative data that obtained from surveys, a summary of in-depth interviews, and the observed resources potential of the local community data. An interpretation and content analysis for the requirement of children to the learning knowledge related to social potential and conservation community for the determination of developing community resources.

Results

Knowledge concerning the conservation and natural management was obtained from the first phase of investigation, i.e., an integrated agricultural, production of mushroom using non-toxic fertilizer and bio-fertilizer production in Samet Tai sub-district and natural management of bamboo forest that was existed at Pa Pai Park, agriculture farmer and the weaved products made from materials of the tree truck and leaves of coconut palm tree in Nong Naer sub-district. All of the information would be used as learning resources for the knowledge transferring to children. The processes that involved the community forum in local community activities to obtain materials and information for learning process are shown in Figure 1.

Figure 1. Pictures showing some activities during the gathering of community forum in the local community.

Results of an analysis to determine the requirement of children as recipients of knowledge transferring process, where the selected 57 children, which were recruited from students who were studying in grades 4 and 5 of Ban Nong-Sano School, Samet Tai sub-district, showed that 68.42 percent of children would like to learn the conservation process. The well-known project that currently existed in the community was the King's Sufficiency Economy Principle of organic waste management using household waste and agricultural farms to compose and used for the cultivation that resulted in the increment of agricultural products and reduction in the use of chemical insecticides and pesticides in agricultural fields.

The participants in Nong Naer sub-district consisted of 72 children who were studying in grades 5 and 6 at Wat Nong Naer School. The need of children was obtained through focus group discussion with consensus, that resulting in 73.61 percent of children were needed to take part in learning process concerning the conservation of bamboo community forest (Pa Pai Park) as the learning resources.

The bamboo community forest was the special bamboo forest that only found in Eastern Thailand, which occupied 367 rai and more than 200 species of herbs to make a perfect ecosystem. This bamboo community forest has been registered timber by the Forestry Department, Ministry of Natural Resources and Environment. This bamboo community forest was registered as public forest areas, where public were allowed to visit and utilized it as a learning resource. The activities of focus group discussion are summarized in Figure 2.

Figure 2. Pictures showing activities of focus group discussion of children for their needs related to conservation.

Table 1. Results of an analysis for the needs of children concerning the use of conservation knowledge in the local community as learning resources in Samet Tai sub-district, Chachoengsao Province.

Transferred conservation knowledge	Sample group (people)	Percent
Integrated agricultural learning resources	39	68.42
Bio-fertilizer learning resources	12	21.05
Non-toxic mushroom learning resources	6	10.53
Total	57	100

Table 2. Results of an analysis for the needs of children concerning the use of conservation knowledge in the local community as learning resources in Nong Naer sub-district, Chachoengsao Province.

Transferred conservation knowledge	Sample group (people)	Percent
Bamboo community forest (Pa Pai Park) learning resources	53	73.61
Agricultural farmer learning resources	12	16.67
Coconut palms weave learning resources	7	9.72
Total	72	100

In terms of the development of the learning media for learning process of the children, where the learning media were constructed and subsequently used in the knowledge transferring to students using lecturing, focus group discussion, workshops and demonstration.

The integrated agricultural knowledge was created as media for learning and knowledge transferring to children at Ban Nong-Sano School, Samet Tai sub-district, where various kinds of media were produced, i.e., poster, papers, flap sheets, video, that were used in workshop's activities. All media were used as demonstration of experts. Various topics, i.e., biological compost from organic waste, effective microorganisms from pineapple, and herbal insect repellents, were used in the workshop. These workshops affected children's learning process, where they used the knowledge for the application in their household, resulting in increasing of agricultural productivity, improved the quality of soil, enhancing wastewater treatment, and replacing natural herb compensate chemical insecticides, which was known as bioremediation. The activities of integrated agricultural workshop for children are summarized in Figure 3.

Figure 3. Pictures showing activities of children who participating in the integrated agricultural workshop.

The learning media related to the conservation knowledge were distributed to local organizations, school, and farmer in local community. This learning media were known as "Walk along with King's Sufficiency Economy Principle, Samet Tai sub-district, Chachoengsao Province", which would apply to promote the conservation knowledge and integrated agricultural in order to create a network of King's Sufficiency Economy Principle to children both inside and outside of local community.

In Nong Naer Sub-district, all learning media the related to knowledge transferring of the bamboo community forest were created in the form of poster, paper flap and video, where the knowledge transferring was carried out with children at Wat Nong Naer school. The knowledge concerning conservation awareness of bamboo forest was transferred to children by training under specialists, where the workshop in real area such as bamboo forest survey, walk nature trails and herb bamboo forest learning were also performed. The examples of topics used in training were, i.e., the importance of bamboo forest to community, bamboo ecosystem, bamboo conservation, bamboo collection, charcoal product from bamboo. The properties of herbs in the bamboo forest, i.e., *Gooseberry, East Indian Screw Tree, Pueraria Mirifica and Cotton Tree* were also used as topics in the workshop. Children were enjoying in helping to create the boundary of the forest, and planted some tree *Yang, Pterocarpus, and Siamese Rosewood*. These learning skills were related to the
utilization of bamboo. Thus, these workshops affected children's learning process in the way that they could help the community to produce new created goods, i.e., conscience to appropriately utilize a piece of bamboo. They also become aware of policy and penalty of bamboo forest community, where they were realized and cherish the bamboo forest for a conservation of the bamboo forest in the local community. The activities during the survey of the bamboo forest and walk nature trails of children are summarized in Figure 4.

Figure 4. Pictures showing the activities of children during survey and walking through the bamboo forest and walking trails.

The constructed learning media derived from bamboo forest and the conservation were distributed to local organizations, school, and local community in order to promote the media. These learning media derived from the "Bamboo forest (Pa Pai Park) were inherited from generation to generation in the community, Nong Naer sub-district, Chachoengsao Province. The learning media were maintained in the community to promote the conservation knowledge of bamboo forest community,

resulting in the increment of children awareness, and the consciousness of children, contributed to the sustainable conservation of the bamboo forest.

The example of learning media for knowledge transferring that is currently available are shown in Figure 5 and Figure 6.

Figure 5. Pictures showing learning media for knowledge transferring to children that were currently available in the community in Samet Tai sub-district.

Figure 6. Pictures showing learning media for knowledge transferring to children that were currently available in the community in Nong Naer sub-district.

All of the learning media that were developed in those three phases were promoted and advertised for networking to participate in knowledge transferring to children both living in and outside of the community.

Conclusion and Discussion

It is expected that the conservation knowledge will be transferred to children through the learning process with active participation of children in the community.

In the research area, Samet Tai sub-district that integrated agricultural knowledge transferred to children in Ban Nong-Sano School. The learning resource has been adopting the King's Sufficiency Economy Principle for organic waste management using household waste. Children are experienced several knowledge's concerning biological compost of organic waste to improve soil and wastewater treatment, effective microorganisms derived from pineapple that affect to an increasing in agriculture productivity, while herbal insect repellents to replace chemical insecticides. The farmers will obtain more incomes after the application of this knowledge. The outcome of this study will create collaboration among local community conservation knowledge of learning resource and networking to another community. The learning media, "Walk along with King's Sufficiency Economy Principle" at Samet Tai sub-district, Chachoengsao Province will be an efficiency media and beneficial to public relations, which will be serving as learning center of sufficiency economy for local community in the future.

In the research area, Nong Naer sub-district, the knowledge concerning the conservation of the bamboo forest will be transferred to children in Wat Nong Naer School, where the bamboo forest is only found in Eastern Thailand. It has been shown that the diversities of herbs are contributed to lifestyle of people in community for quite some time. The community leaders and people in the community have established bamboo forest community, which is known as Pa Pai Park for the appropriate utilization of bamboo. The activities regarding to conservation and restoration of the bamboo forest, i.e., set up the boundary of forest, planting tree and herb in the forest, labeling the species of herb, and allow local people to use bamboo between May to September. Children can participate in surveying; walking nature trails, cultivation of bamboo, labeling the properties of herb. The outcome of this study will promote the conservation knowledge of learning resources. The children become awareness and are conscious for bamboo forest conservation to make it sustainable for the local community. The director of school is agreeing to develop the school to become the learning center of sufficiency economy for local community in the future.

References

Janbuala, S., Dhirapongs, S., Issaramanorose, N., Nakprada, S., Kongsila, T., Aermbua, M. (2012). *The Development of Media to Aid in Science Learning for an Early Childhood Center Managed by the Department of Local Administration in Thailand's Northeastern Region*. Suan Dusit Rajabhat University, Bangkok, Thailand (in Thai).

Munkept, B. (2008). *The Type of Community Forest for Sustainable Learning Resource with Participation Process of School and Community: Case study of Donyang Community Forest Larkmueng Sub-district, Kalasin Province.* Bangkok, Thailand : The Thailand Research Fund.

Nakorntub, S. (1997). *The Type of the Participation Promote of Teacher for Protect and Prevent for the Child Labor in Thailand*. Journal of Education study research. 20(2), 24 - 32.

Ramasute, P. (1997). *Participation Action Research*. Bangkok : ASEAN Institute for Health Development, Mahidol University, Bangkok, Thailand (in Thai).

The National Child and Youth Development Committee. (2011). *Thailand National Economic and Social Development Plan No. 11 (2012 - 2016)*. Bangkok, Thailand (in Thai).

Walaisatiean, P. (2000). *Process and Working Techniques of Developers*. Bangkok, Thailand **:** The Thailand Research Fund.

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Mango Sheet Drying by the Solar Dryer Combine with Electric Coil

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Abstract
This research was aimed to compare the duration of drying, energy consumption and yield of drying mango sheet between drying with solar energy and drying with the combination of solar energy and electric coil. The designed condition of the temperature divided into 3 ranges, i.e., 45-50°C, 55-60°C, and 65-70 °C, to find the optimal range of the temperature.
The result found that the optimum temperature for drying was 65 - 70°C which used the time less than the other conditions. The combined system was more efficiency than that of the solar energy because it could dry the product more than that of the solar system approximately 60%.

Keywords: Solar Dryer, Mango Sheet
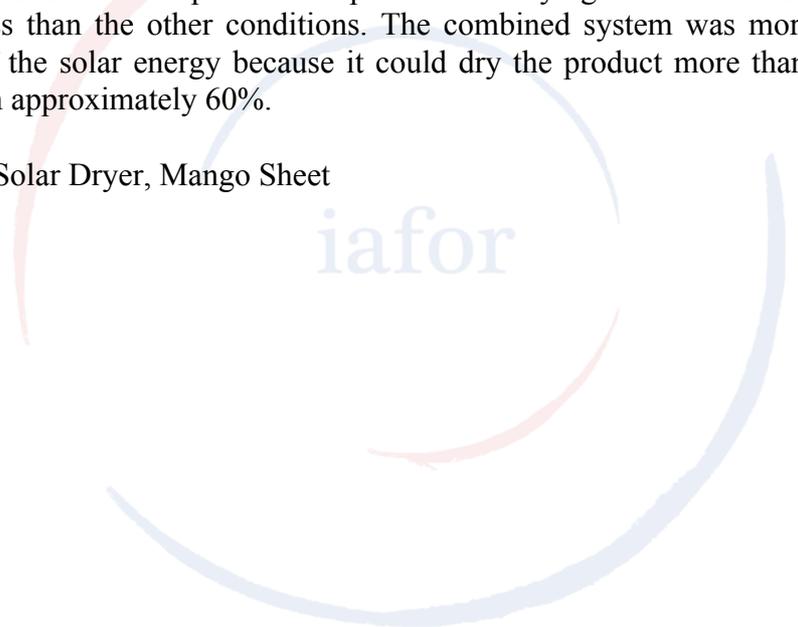
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Introduction

Chachoengsao province is the venue for the most favorite fruit in Thailand where mangoes are the major products, with the area of 34,400 Acre available for agriculture, which mangoes are grown mostly in Bang Khla and Plaeng Yao districts. The most popular cultivars of mango are Rad, Khaew Sawei, Chao Khun Thip, and Thongdam. The mango fruits season is in March, where the mango festival will be held annually for selling the mango fruits to tourists and local people. It has been shown that the mango fruits are oversupply during this period where the left over mangoes become ripe and lead to the lower price of mango due to the fruits become rotten during the shelf life. In order to reduce the economic lost of unsold mango fruits, there is a need to transform the mango fruits into the value added products such as the dried mango paste derived from the pulp of ripe mango fruits.

Drying process is the procedure that is defined as the removal process of water or moisture from the mango pulp. Food drying is also a process of food preservation that can help to keep fruits and vegetables last longer time by reducing the amount of water they contain from 80 - 90% to 10 - 20%. Therefore, drying can be defined as a process that reduces the amount of moisture in products to a level that they can be preserved against decay.

To date, the qualities of driers that commercially available are not quite satisfied in drying facilities they provided. Each method has some limitations and deficiencies in terms of power consumption, drying cost and quality variables in products. The current commercially available driers are designed to use one or a few methods such as contact drying, convective drying, drying with radiation, dielectric drying, and freeze drying, osmotic drying and vacuum drying. Among drying methods, the most commonly used one is the convective drying method carried out with the help of airflow. Various types of energy sources (electric, LPG, fuel oil) are still being used to heat the air in dryers in industry. Since the utilization of commercial power sources in heating air will increase the expenses of drying, this method is not suitable for use in drying fruits and vegetables in rural areas. For this reason, solar power dryers have been focused on the development of dryers based on solar energy in order to dry vegetables and fruits.

Drying method by means of solar power is divided into two major groups, i.e., passive and active method, according to air circulation technique in dryer. In passive dryers, air circulation is activated by means of thermal power (according to the "Principle of Convection"). In active dryers, air circulation is provided by means of an electric fan. Although active dryers facilitate a faster drying compared to passive dryers, they cannot be used in places where there is no electricity, which necessitates an additional cost. Active dryers should be preferred when product to be dried is in a large amount; and when the drying period is short. Solar power dryers are classified as direct, indirect, and combined types according to the forms of exposing to solar radiations (Ekechukwu and Norton, 1999). Many types of solar air heaters and dryers have been developed in the past for the efficient utilization of solar energy (Sami et al., 2011). Among stationary solar heaters, air flat-plate collectors (FPCs) have been widely used for energy management in an increasing number of installations. They are quite attractive for low-temperature solar energy technology, which requires air temperatures below 100 °C. In fact, solar air FPCs are extensively used over years

because they are relatively simple with a minimal use of materials, easy to operate and have low capital costs (Duffie and Beckman, 2013; Kalogirou, 2004). Furthermore, it is established that the introduction of different geometries of artificial roughness, in the dynamic air vein of the FPC, increases the transfer rate and favors the creation of turbulences near the absorber plate (Karim and Hawlader, 2006).

The objective of this research was aimed to compare the temperature and time that effecting change color, where the moisture content of mango and stirring process during drying would base on using solar drying and solar energy in combination with the heater. The cost of drying under solar drying would be compared with that using solar energy in combination with the heater.

Method

Experiment setup

In this study, a solar air power cabin dryer collector was designed in order to dry mango sheets and used the electric power combine to the drying process for increasing the temperature or used when the solar radiation was low. The designed conditions of the temperature divided into 3 ranges, i.e., 45-50°C, 55-60°C, and 65-70 °C. in order to find the optimal temperature where the power consumption was considered as the major factor.

Solar dryers combined with electrical coils shown in Figure 1 (a) a solar collector panel, which used to generate hot air for drying. The product tray was placed with clear glass the heat of solar could pass through the glass for drying the products that could be dried by direct sunlight (b). An electric coil heater was used to generate heat to raise the temperature when the solar heat was not sufficient (c).

Figure 1. Solar dryer combine with electric coil

Data reduction

This study was to analyze the results to know the time to change the color of mango and stir in water each hour. To find the optimal conditions for drying mango stir and comparison between drying using solar drying using solar heater with temperature 45-50 ° c, 55-60 ° c and 65-70 ° c with the following steps

Prepare the product the mango cooked taken through the process of stirring until dry and can be made up of 5 kg.

Figure 2. Mango stir

Record the weight of mangoes sheet and arrange on the product tray. Then, dried with a solar dryer with the electric coil. Record the inside and outside temperature of the solar dryer. Record the weight of the product and compare color of the mango sheet with the standard color every 1 hour and read the electric power consumption, too.

Once the data has been completed the data were analyzed. It is possible to calculate the moisture content of crop being dried at any t time as follows:

$$\text{Moisture content} = \frac{M_t - M_e}{M_e}$$

(1)

In the term of M_t is the mass of the drying product at a time t (kg) and M_e dry mass of product (kg)

In drying process, dimensionless moisture ratio (MR) is one of the most important parameters while examining drying and dryer parameters. While calculating dimensionless moisture ratio, measurement time, moisture content, initial moisture content and balance moisture content are taken into consideration.

$$MR = \frac{M_t - M_e}{M_i - M_e}$$

(2)

Term M_i is initial of product's mass.

Moisture content wet basis (%MC$_{wb}$) is compare the weight of the total weight of the product. Can be written as an equation.

$$\%MC_{wb} = \frac{M_w}{M_w - M_s} \times 100$$

(3)

When, M_w is the mass moisture in the product and M_s is the mass of the dry product.

Results and Discussion

Dried mango stir with a combined process which compared between drying by using the solar power alone and in combination with solar heaters. Setting the temperature inside the dryer at 45-50 ° C, 55-60 ° C and 65-70 ° C to find the right time and the drying mango stir colorful appetizing compared to the market. With the change of the temperature outside and inside the dryer every one hour the temperature changes, humidity and the weight.

Temperature and Drying time
Experiment setting for drying mango sheet in 4 cases that are drying with
solar power only, solar power combine with electric coil and setting the temperature
at 45-50 ° C, 55-60 ° C and 65-70 ° C. The result shown in figure 3-6.
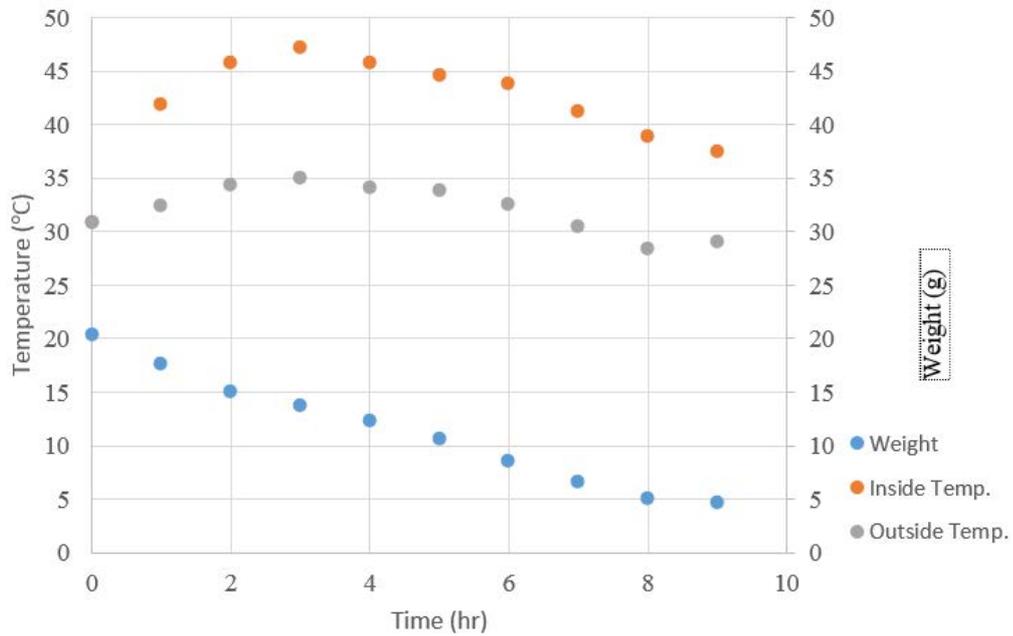
Figure 3. Drying with solar power
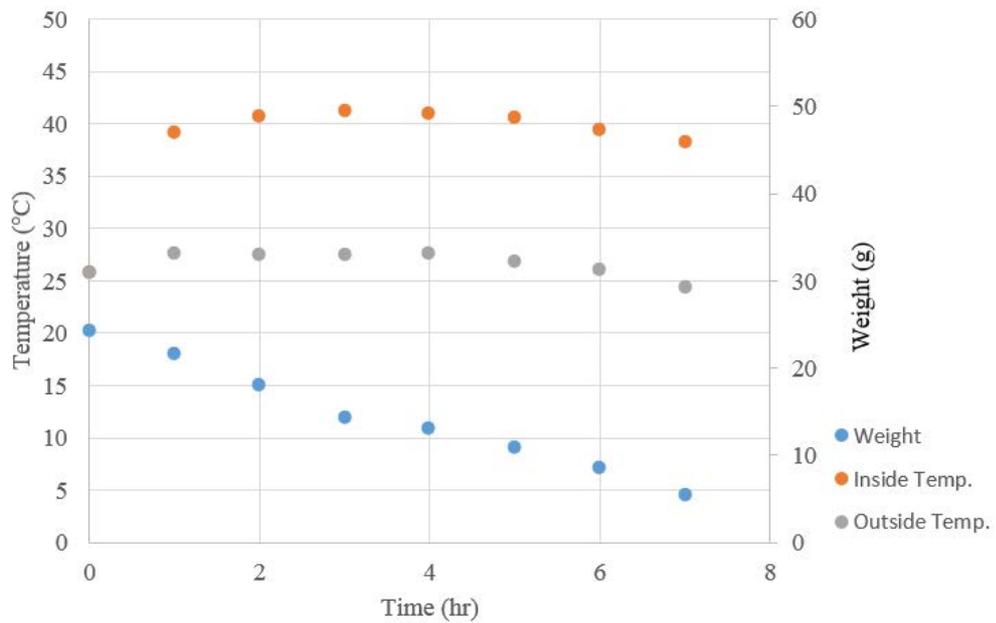
. **Figure 4.** Solar drying with electric coil (45-50 °C)
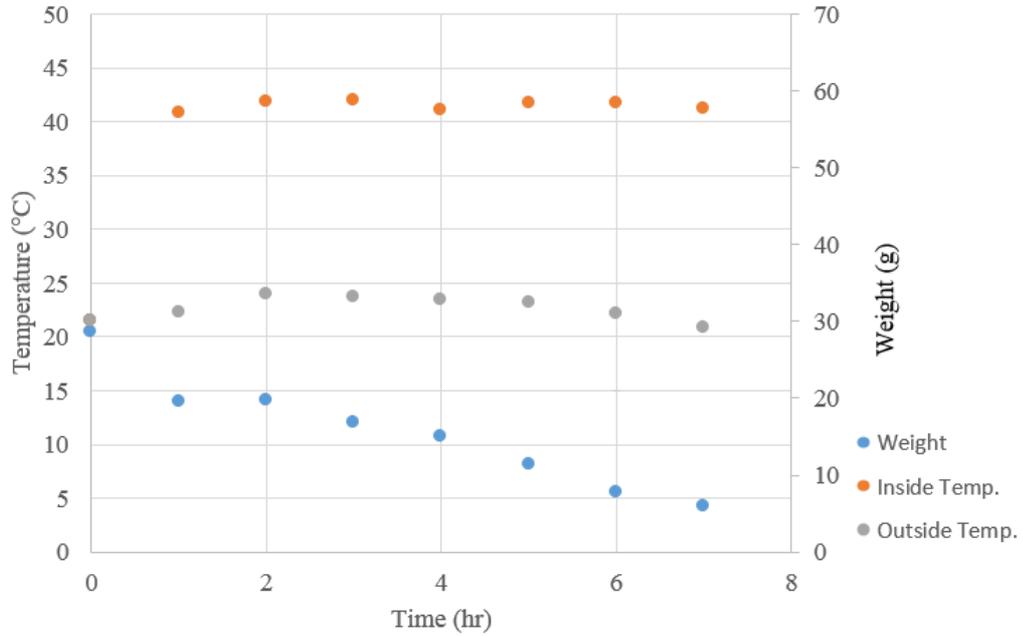
Figure 5. Solar drying with electric coil (55-60 °C)
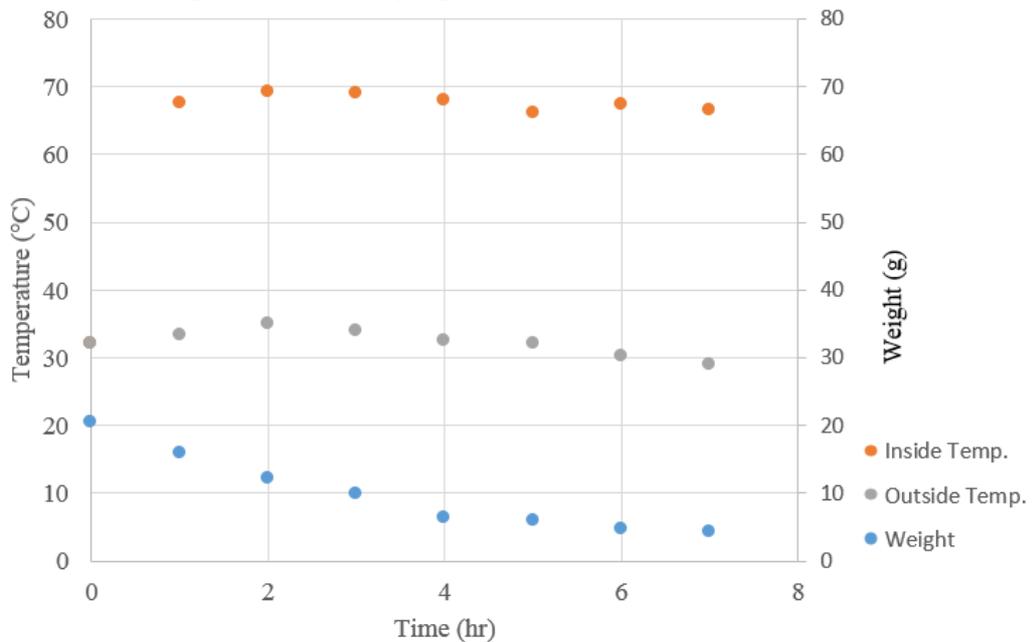
Figure 6. Solar drying with electric coil (65-70 °C)

In Figure 3. Shown mango sheet drying with solar power only, the maximum temperature is 51 °C and the time to use for drying is 8-9 hours (compare with the standard color). Figure 4-6 Shown a mango sheet drying with solar power combine of the electric coil. The temperature setting to 45-50 °C, 55-60 °C and 65-70 °C, respectively. The result shown the maximum temperature in each case are 50 °C, 60 °C and 70 °C and the time to use for drying are 7, 6 and 5 hours, respectively.

Moisture content of the mango sheet
Moisture content in drying process shown in figure 7. It can be seen that the temperature at 65-70 °C with the evaporation of the water dropped quickly, within a period of five hours to get the color of mango stir compliant reference. The

temperature of 45-50 °C and 55-60 °C for a period of up to 6 hours and 7 respectively. In the case of solar power only it takes 8 hours to calculate the moisture content of 3-5%, which is close to the base wet mango agitation used as the reference standard.
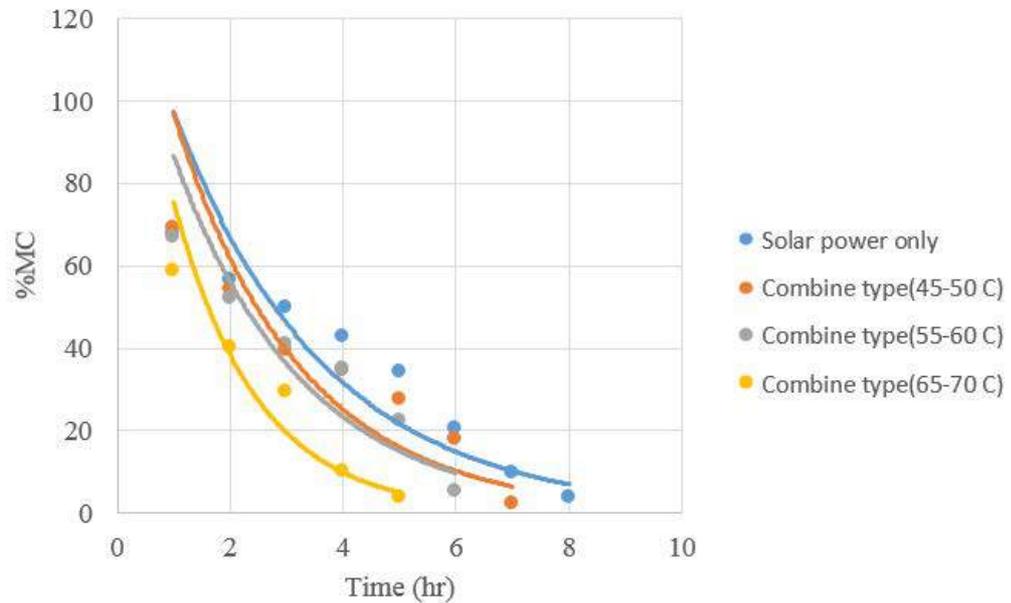
Figure 7. Moisture content of drying mango sheet

Power consumption

Information from the electric power meter drying. Solar electric fans are used alone. The power consumption is minimal the temperature at 45-50 °C with the operation of the heater periodically. Due to the change in solar the use of more electricity. The temperature range of 55-65 °C, 65-70 °C heat energy from the sun is not hot enough. The temperature inside a low heater work more. The use of energy more time. The power consumption shown in figure 8.
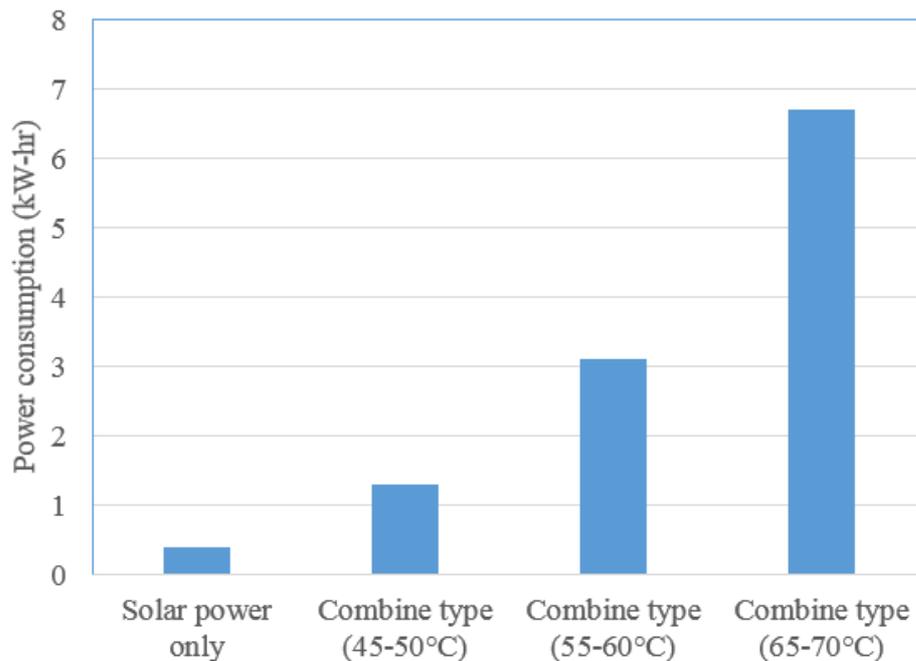
Figure 8. Power consumption in drying process

The ability to stir the mango drying up of solar dryers. Drying can be stirred mango 150 sheet/time period of drying, using solar power criteria for the extrapolation. Drying temperature is 45-50 °C, 55-60 °C and 65-70 °C oven can stir the mango pieces of 171.4, 200 and 240, respectively, revenues from the sale of mangoes found much less electricity. 65-70 °C temperature drying period, drying more quickly than it can be dried mango quantities. The net income for the most power.

Conclusion

The experiments compare the drying mango sheet process. By using a solar power and solar drying with the heater. It is seen that the dried mango stir using solar drying takes eight hours until the color that meets the needs of the market. Unlike drying using solar heater with temperature 45-50 °C, 55-60 °C and 65-70 °C takes the drying 7 hours, 6 hours and 5 hours reduced accordingly. Due to the higher temperatures result in a discoloration of mango stir quickly. But there will be electricity consumption increases. The heater requires more work as well. The drying temperature is 65-70 °C use the power is 6.7 kWh, temperature 55-60 °C use the power is 3.1 kWh electricity consumption and the drying temperature 45-50 °C use the power 1.3 kWh. The drying temperature is 65-70 °C drying rate was over. Despite the high electricity consumption. But it can be much more than dried mango, dried using solar energy and drying at temperatures of 45-50 °C and 55-60 °C compared to the same period of drying off.
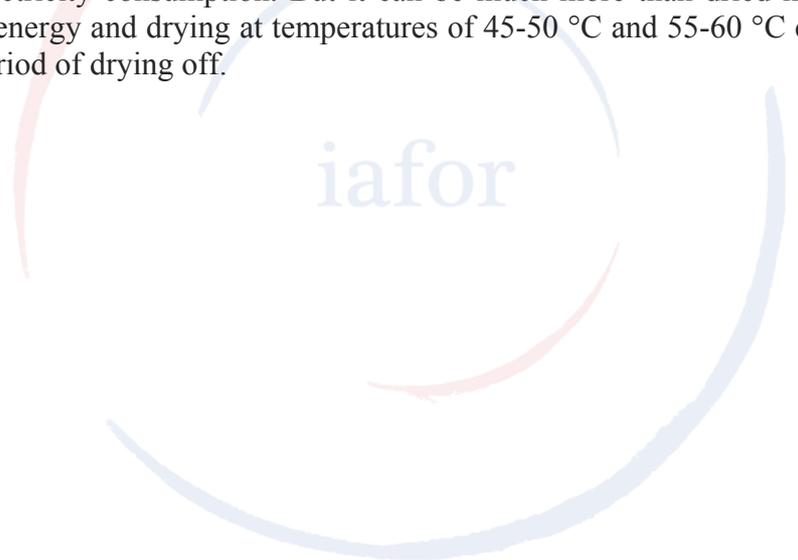
References

Duffie, J.A., and Beckman, W.A. (2013). *Solar Engineering of Thermal Process*. John Wiley & Sons. New York.

Ekechukwu, O.V., and Norton, B. (1999). Review of solar energy drying systems II: an overview of solar drying technology. Energy Convs. Manag. 40, 615-655.

Kalogirou, S.A. (2004). Solar thermal collectors and applications. Pong. Energy Combust. Sci, 30, 231-295.

Karim, M. A., and Hawlader, M.N.A. (2006). Performance investigation of flat plate, v-corrugated and finned air collectors. Energy 31, 452-470.

Sami, S., Rahimi, A., Etesami, N. (2001). Dynamic modelling and a parametric study of an indirect solar cabinet dryer. Dry. Technol. 29, 825-835.

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Synthesis of Poly (Acrylic Acid-Co-Sodium Styrene Sulfonate) as Scale Inhibitor for Industrial Cooling Water System

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Abstract

Water from most natural sources usually contains dissolved minerals and scale forming ions such as Ca^{2+} and Mg^{2+} ions. Poly (acrylic acid) (PAA) is one of the scale inhibitor polymers, commonly used in the industrial circulating cooling water system. However, the remaining polymer concentrations of scale inhibitors are facing some level of difficulty for determination. This is mainly due to the fact that there is a similar range of UV adsorption to another organic compound in the cooling water system. For that, the modification of PAA to copolymer of acrylic acid and sodium styrene sulfonate (NaSS) are being thoroughly investigated. Poly (acrylic acid-*co*-sodium styrene sulfonate) are synthesized by a free radical polymerization procedure under the water solution technique being performed, together with potassium persulfate as a free radical initiator. The synthesized copolymers are confirmed by ^{1}H-NMR, FTIR and UV-Vis Spectroscopy. As such, the molecular weights of PAA-*co*-NaSSs are characterized by ^{1}H-NMR and thermal analysis data are also being conducted by a TGA. Concentration of polymer dosages at 20, 30, 40, 50, 60, 80 and 100 ppm are consecutively tested in supersaturated calcium ion (400 ppm) and bicarbonate ion (500 ppm) solutions at a temperature of 70°C for a time period of 24 hours. Most importantly, the performance of PAA-*co*-NaSS on complexes with Ca^{2+} and ratio of scale inhibitor are also being studied.

Keywords: Poly(acrylic acid-co-sodium styrene sulfonate), Scale inhibitor, Cooling water system

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Introduction

Cooling water system is water to control the temperature of machine or processes to lower temperature by transferred heat from machine or processes to the coolant. (Hill, Pring, & Osborn, 1990; Frayne, 1999; Herro, & Port, 1993). In the industrial cooling systems today, use of water from the river as the source material is common such as calcium and magnesium ions. Under conditions of temperature, pH, pressure, dissolved mineral etc., relatively insoluble species such as carbonates and sulphates may deposit from solution as scale. When scale problems occur on the surface of the cooling system leads to reduction in heat transfer, clogging of filters, reduces the flow rate, loss of system performance and complete shutdown of the installation.

Generally this water needs to be purified before it can be used in the process. However, when the water circulating in the system indefinitely. Require water treatment such as blowdown or ion-exchange regeneration effluents or additional chemical into the processes as an alternative to solve the problems of fouling and corrosion in the system. There are water-soluble molecules or polymers with several functional groups, the most common groups being phosphates. Although, phosphates are highly efficient as a scale inhibitor, which cause of the Eutrophication phenomenon. Thus, the polymer additives category is the way to control water quality, quantity of ion in the appropriate level. Polymer could react with cation contained in the water, especially Ca^{2+} and Mg^{2+} occur as complex compounds and removed from the manufacturing process by precipitation processes. (Chuang et al., 2013; Volkringer et al., 2007).

Polymer used to control water quality in many species, such as poly (maleic acid) and poly (acrylic acid) due to chemical structures and functional groups that assist in create a bond with the metal ions. (Amjad, & Koutsoukos, 2014; Martinoda, Euvrard, Foissyb, & Neville, 2008). However, the polymer used to control water quality in recirculating cooling water systems must be able to measure the amount of polymer used. Polymer of each plant will require a set of measurements that are highly specific of the factory and cannot use a series of sensors with polymer type, so the remaining polymer concentrations of scale inhibitors are facing some level of difficulty for determination.

In this work, focuses on the quantitative analysis of polymer remaining in the cooling water systems. The scale inhibitor synthesis between acrylic acid and sodium styrene sulfonate, were tested with respect to their ability to inhibit calcium carbonate.

Material and Experimental

Materials
Acrylic acid, Sodium 4-vinylbenzene sulfonate, Calcium chloride and Sodium bicarbonate were supplied by Sigma-Aldrich Co. LLC., USA. Potassium persulfate was purchased from Ajax Finechem Pty. Ltd., Australia. Magnesium chloride and Disodium EDTA were product from Merck KGaA, Germany.

Synthesis of PAA-*co*-NaSS
Acrylic acid (AA) : sodium 4-vinylbenzene sulfonate (NaSS) (5:5, 6:4, 7:3, 8:2 and 9:1 by weight, respectively) and potassium persulfate ($K_2S_2O_8$) were dissolved in 100

ml of distilled water in a two-neck round-bottom flask (250 ml) equipped with a condenser and an inlet of dry nitrogen. (Weiss, Turner, & Lunberg, 1985). The ratio of synthetic polymer is summarized in Table 1. The reaction proceeded with continuous stirring at 70°C for 3 hr. The solution was stop reaction by 10 ml of methanol. Then, bottle was stirring for 5 min. Spread the product on a petri dish and dry in oven at 70°C for 12 hr. Chemical structure, molecular weight and residual of polymer were characterized by FTIR, ^{1}H NMR, and UV-Visible spectrophotometer, respectively.
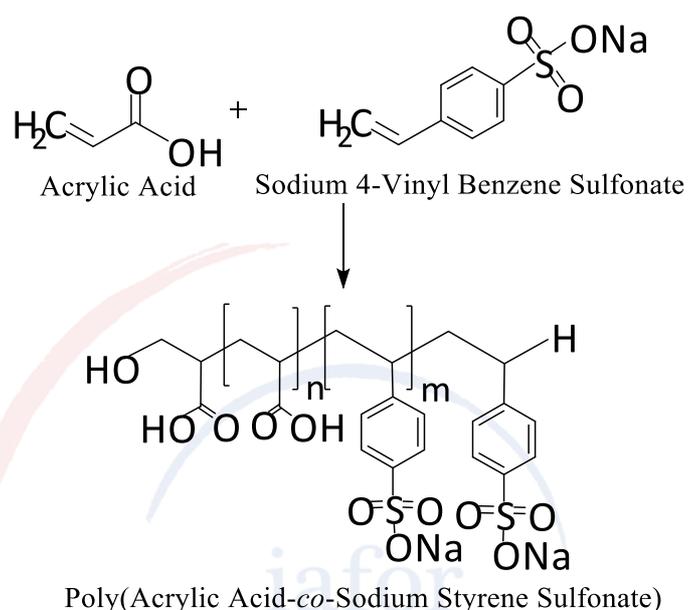
Figure 1: Preparation of PAA-*co*-NaSS.
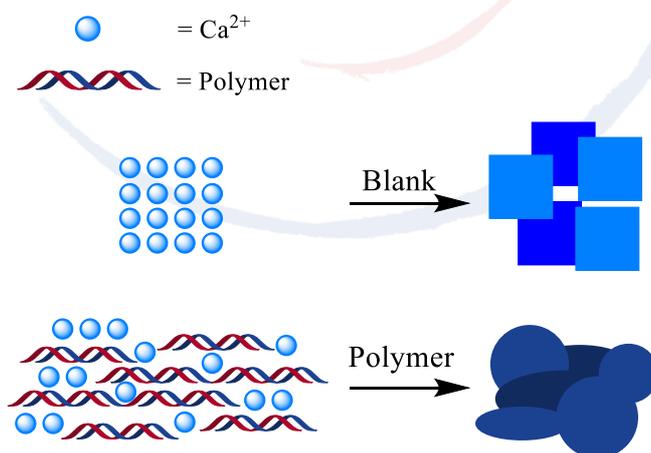
Figure 2: Schematic diagram of the effect of Polymer on the morphology of calcium carbonate crystals.

Table 1: Ratio of synthetic polymer between AA, NaSS and $K_2S_2O_8$

Polymer	AA (g)	NaSS (g)	$K_2S_2O_8$ (g)
PAA	10	0	0.1666
PNaSS	0	10	0.0203
PAA-*co*-NaSS-155	5	5	0.2105
PAA-*co*-NaSS-164	6	4	0.2534
PAA-*co*-NaSS-173	7	3	0.2998
PAA-*co*-NaSS-182	8	2	0.3501
PAA-*co*-NaSS-191	9	1	0.4042
PAA-*co*-NaSS-255	5	5	0.0758
PAA-*co*-NaSS-264	6	4	0.0912
PAA-*co*-NaSS-273	7	3	0.1079
PAA-*co*-NaSS-282	8	2	0.1260
PAA-*co*-NaSS-291	9	1	0.1455
PAA-*co*-NaSS-355	5	5	0.0189
PAA-*co*-NaSS-364	6	4	0.0228
PAA-*co*-NaSS-373	7	3	0.0270
PAA-*co*-NaSS-382	8	2	0.0315
PAA-*co*-NaSS-391	9	1	0.0364

Scale inhibition method

Calcium inhibition was studied in artificial cooling water which was prepared by dissolving a quantity of $CaCl_2$ and $NaHCO_3$ in distilled water as concentrations of Ca^{2+} and HCO^{3-} were 400 and 500 mg·L^{-1}, respectively. Then, add polymer at dosage 20, 30, 40, 50, 60, 80 and 100 ppm in the artificial cooling water adjusted at 70°C for 24 hr.

The performance of the tested compounds as calcium carbonate inhibitor was calculated using eq. (1).

$$\%CaCO_3 \text{ inhibition} = \frac{\text{EDTA Sample (ml)} - \text{EDTA Blank (ml)}}{\text{EDTA Standard (ml)} - \text{EDTA Blank (ml)}} \times 100 \quad (1)$$

Where: EDTA Sample was the concentrations of Ca^{2+} (mg·L^{-1}) in the filtrate in the presence of an inhibitor at 24 hr.

EDTA Blank was the concentrations of Ca^{2+} (mg·L^{-1}) in the filtrate in the absence of an inhibitor at 24 hr.

EDTA Standard was the total concentrations of Ca^{2+} (mg·L^{-1}).

Results and Discussion

Characterization of PAA-*co*-NaSS

Molecular structures of AA, PAA and PAA-*co*-NaSS characterized by FTIR were compared in fig. 3 and fig. 4, taken over the range of wavenumber from 400 to 4000 cm^{-1}. In case of PAA, the new peaks at 1714 cm^{-1} corresponding to C=O stretching, appear clearly. Moreover, the missing peak of C=C stretching at 1635 and 1616 cm^{-1} of AA and turn to be single bond in the main structure of PAA. (Moulay, & Mehdaoui, 2004). But for the analysis of PAA-*co*-NaSS, spectra are shown over the range from 3200 to 3550 cm^{-1} which is belonging to O-H stretching of aromatic and the absorption at approximately 1475 and 1600 cm^{-1} result from a C=C stretching vibration of aromatic.
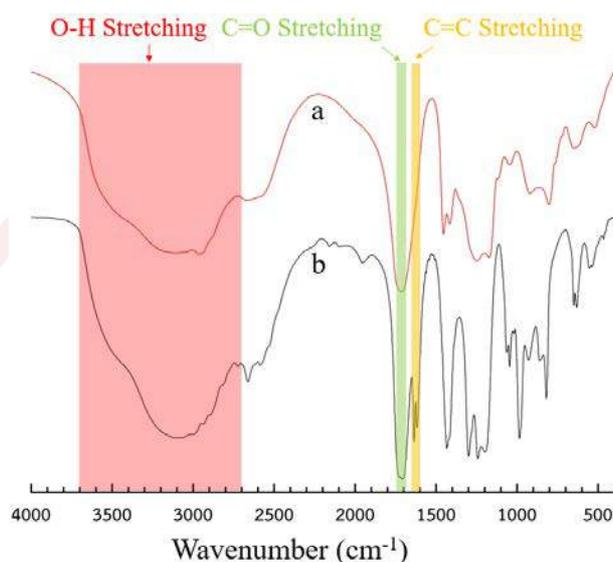
Figure 3: FTIR spectra (a) PAA, (b) AA
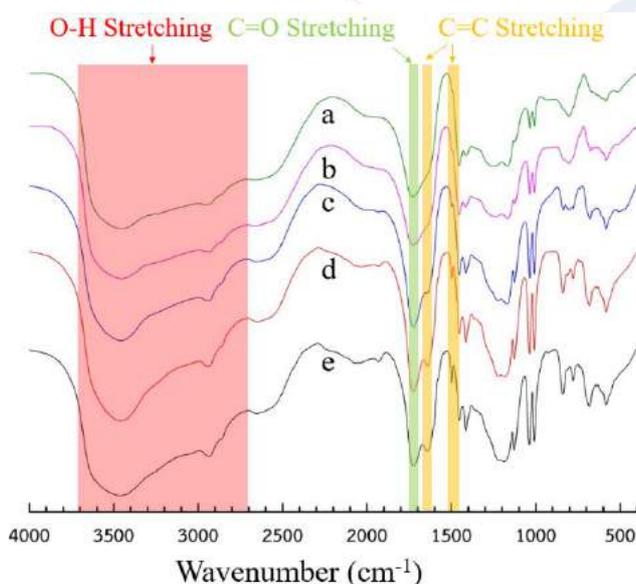
Figure 4: FTIR spectra (a) PAA-*co*-NaSS-391, (b) PAA-*co*-NaSS-382, (c) PAA-*co*-NaSS-373, (d) PAA-*co*-NaSS-364 and (e) PAA-*co*-NaSS-355

The chemical structure of PAA and PAA-*co*-NaSS were studied by UV-vis spectroscopy, carried out in water and results are shown in figure 5. UV-vis spectra of acetic acid and sodium styrene sulfonate were also used to identify the structure of PAA and PAA-*co*-NaSS. Absorptions at 200 and 256 nm correspond to the benzene ring absorption of sodium styrene sulfonate and acetic acid as shown the carboxylic at 210 nm. The absorption of PAA at 210 nm, the fact that organic compounds are generally the absorption wavelength in this range. The remaining polymer concentrations of scale inhibitors are facing some level of difficulty for determination. In case of PAA-*co*-NaSS, the 210 nm peak shifts to 225 nm corresponding to overlap of carboxylic and benzene ring. The 225 and 256 nm peak increase, when higher amount of NaSS.

The relationship between PAA-*co*-NaSS intensity and the concentration is shown in fig. 5, provides an almost linear response (correlation coefficient r = 0.9991-0.9999). This positive linear relationship could be used to quantitatively measure the concentration of PAA-*co*-NaSS in cooling water system.
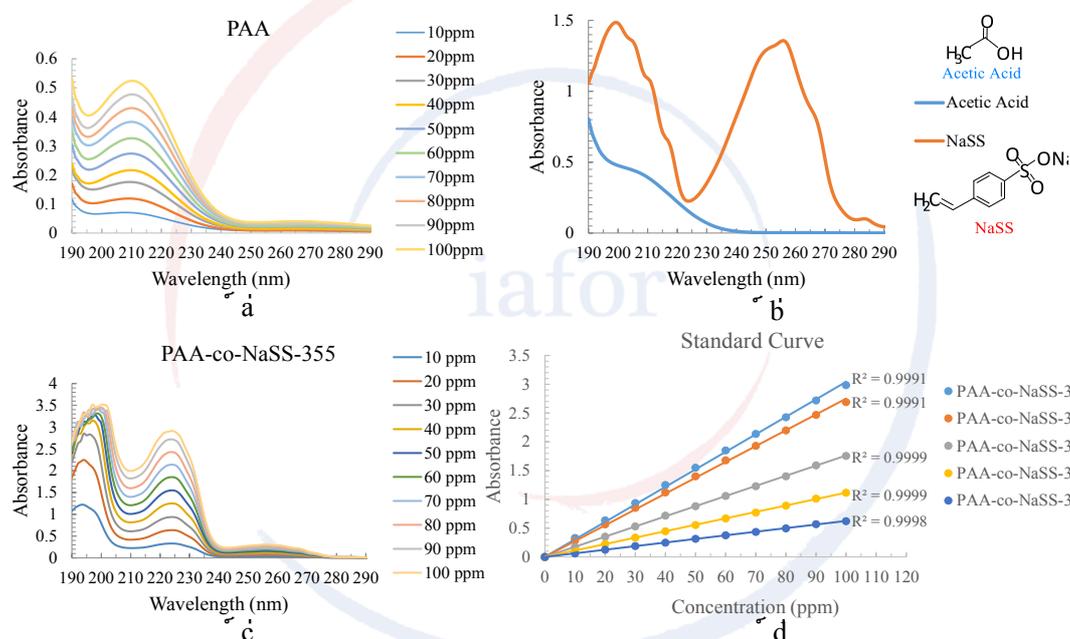
Figure 5: UV-Visible spectra (a) PAA, (b) Acetic acid and NaSS, (c) PAA-*co*-NaSS-355 and (d) Relationship between PAA-*co*-NaSS intensity and the concentration of PAA-*co*-NaSS-355

The ability to the complexation of PAA-*co*-NaSS with Ca^{2+} can be determined by percent of scale inhibition. Fig. 6 and 7 show calcium inhibition as the different concentration of PAA, PNaSS, PAA-*co*-NaSS and mixed between PAA and PNaSS (PAA+PNaSS) from 20 to 100 ppm at 70°C. Solution of PAA and PAA+PNaSS are turbidity and scale deposits around the bottle as well as PNaSS, but solution of PNaSS is clearer. While PAA-*co*-NaSS is the clearest. (Wang, Cölfen, & Antonietti, 2005). PAA, PNaSS and PAA+PNaSS exhibited an ability to control scale, with 35% Ca^{2+} inhibition at 20 ppm, 60% for 100 ppm. Scale inhibition effect were in a similar linear increasing trend with increasing the polymer concentration, when the PAA-*co*-NaSS dosing changed at the range of 20-100 ppm, scale inhibition increased from 60-100%.
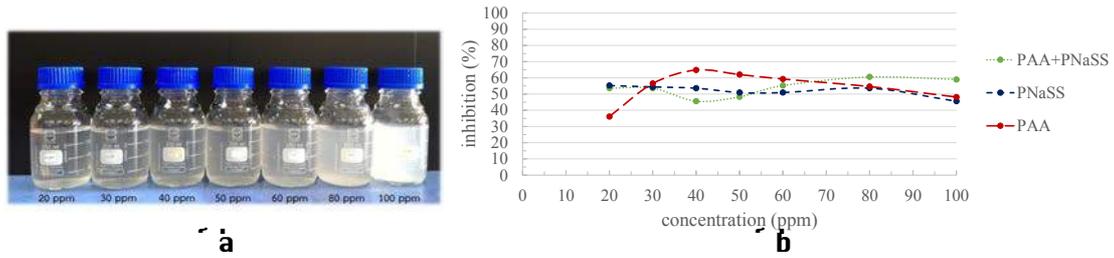
Figure 6: (a) Solution of PAA with the concentrations of Ca^2 and (b) percent inhibition PAA, PNaSS and PAA+PNaSS
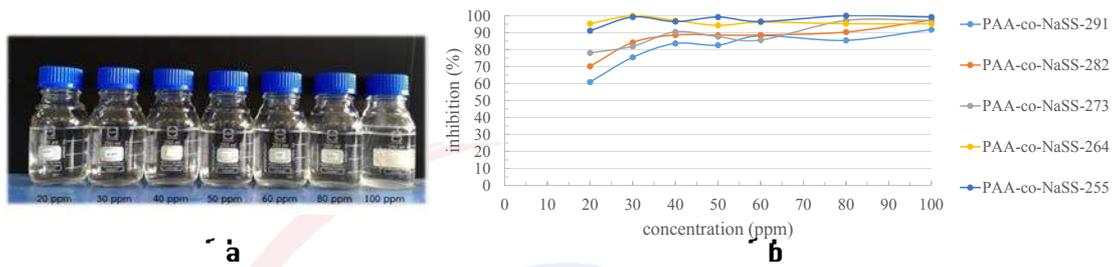
Figure 7: (a) Solution of PAA-*co*-NaSS with the concentrations of Ca^2 and (b) percent inhibition PAA-*co*-NaSS-291, PAA-*co*-282, PAA-*co*-NaSS-273, PAA-*co*-NaSS-264 and PAA-*co*-NaSS-255

Conclusion

In this research study to prepare poly (acrylic acid-co-sodium styrene sulfonate) through a free radical polymerization, and then implemented in the scale inhibition caused by calcium ion. The structure of synthesized copolymers are characterized by ^{1}H-NMR, FTIR and UV-Vis Spectroscopy. The correlation coefficient of PAA-*co*-NaSS was 0.9999 and the scale inhibition efficiency at the range 80-100% when the dosage was 40-100 ppm.

References

Amjad, Z., & Koutsoukos, P. G. (2014). Evaluation of maleic acid based polymers as scale inhibitors and dispersants for industrial water applications. *Desalination.* 335, 55-63.

Chuang, E., Lin, K., Su, F., Chen, H., Maiti, B., Ho, Y., et al. (2013). Calcium depletion-mediated protease inhibition and apical-junctional-complex disassembly via an EGTA-conjugated carrier for oral insulin delivery. *Journal of Controlled Release.* 169, 296-305.

Frayne, C. (1999). *Cooling water treatment: Principles and practice.* New York: Chemical.

Herro, H. M., & Port, R. D. (1993). *The Nalco guide to cooling water system failure analysis.* New York: McGraw-Hill.

Hill, G. B., Pring, E. J., & Osborn, P. D. (1990). *Cooling towers: Principles and practice.* (3rd ed.). London: Butterworths.

Martinoda, A., Euvrard, M., Foissyb, A. & Neville, A. (2008). Progressing the understanding of chemical inhibition of mineral scale by green inhibitors. *Desalination.* 220, 345-352.

Moulay, S., & Mehdaoui, R. (2004). Hydroquinone/catechol-bearing polyacrylic acid: Redox polymer. *Reactive and Functional Polymers.* 61, 265-275.

Volkringer, C., Loiseau, T., Ferey, G., Warren, J. E., Wragg, D. S., & Morris, R. E. (2007). A new calcium trimellitate coordination polymer with a chain-like structure. *Solid State Sciences.* 9, 455-458.

Wang, T., Cölfen, H., & Antonietti, M. (2005). Nonclassical crystallization: Mesocrystals and morphology change of $CaCO_3$ crystals in the presence of a polyelectrolyte additive. *Journal of the American Chemical Society.* 127, 3246-3247.

Weiss, R. A., Turner, S. R., & Lunberg, R. D. (1985). Sulfonated polystyrene ionomers prepared by emulsion copolymerization of styrene and sodium styrene sulfonate. *Journal of Polymer Science.* 23, 525-533.

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Efficient Method of Transaction Processing for Secure Mobile Bill Payments: Pay2S (Save&Safe)

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Abstract

This paper proposed a new method for transaction processing of secure mobile bill payment. Focusing on the performance of the bill payment system which comparison between the transaction processing of new method and the trandition method. The transaction processing of tranditional method is single bill single transaction (SB-ST) and this method is multiple bills single transaction (MB-ST). Two dimensions of transaction processing method comparison were Save&Safe, (Save: memory usage , time usage, energy consumption and Safe: security: confidentialily, integrity, availability and non-repudiation). The peformance is testing on this paper by developed the Pay2S $^{(save\&safe)}$ application with Java on Android. The measure of save dimension are turnaround time, message size and cpu energy consumption. The security measure is analyze the message by using cryptography technique : encryption, decryption, Has function, and HMAC (Message Authentication Code). The environment for experimental consist of four parties : mobile client, intermediary, merchant, and payment service provider. All parties have a share secret key for exchange the message for protect the people who attack the system or replay attack. The result   founded the performance of the new method get the better than the tranditional method and the seurity properties are same. So, the Pay2S (save&safe) application should development to the new business product for support the new lifestyle.

Keywords: Mobile bill Payment, Pay2S, Transaction Processing, Secure mobile Payment

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Introduction

Nowadays, The mobile phone is one of the most important technological developments of our age. It has become the primary tool of people around the world for communication and business applications. The trend of global mobile phone usage increased from the year 2012 from 1.2 billion people to 4.5 billion people in 2018[2]. One of the applications that people use is a mobile payment (m-payment), which can pay for goods and services on mobile phone by using the prepaid or postpaid method. Currently, worldwide mobile payments are showing vigorous growth. Gartner, Inc., a leading research company, predicts that in 2016 there will be 448 million m-payment users, in a market worth $617 billion. The Asia/Pacific region will have the most m-payment users[3]. There are many applications from the payment service providers that were developed for supporting mobile payments including: issuer, card network and, mobile company. Examples of the application are Apple pay, LoopPay, Google Wallet, Paypal, Paypass, Dwallo, and Square Financial. However, most of the applications mentioned above use the traditional form transaction processing: one bill, one transaction. In the future, this may affect the performance potential of the mobile payment process.

The Research Framework

a) Mobile payment concept

 In concept, the primitive mobile payment is composed of three basic steps. Payment: Client makes a payment to the merchant. Value Subtraction: lient requests to the payment gateway for his debit. Value Claim: Merchant requests to the payment gateway to credit transaction amount into his account.

b) Mobile Payment Framework of Pay2S (save&safe)

Mobile payment framework consists of Merchant, Customer and Counter Service. The processing of framework start at the merchant sent bills to the customer , then the customer using the mobile application (Pay2S (save&safe)) to pay for bill   or using   counter service.   Currently, almost customer   pay by counterservice. But now the authors design a new method for bill payment. It provided a high performance : low cost, low time, convenience, high security. The framework of mobile bill payment depict in Figure 1.
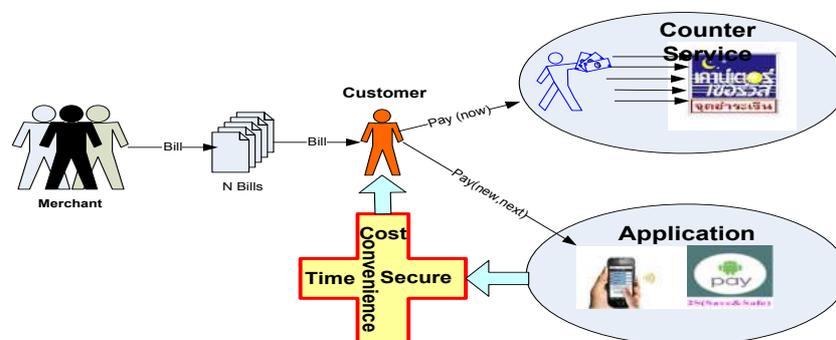
Figure 1: Pay2S (save&safe) Model

c) **Method of Secure   Mobile bill Payment**
- Symmetric Key cryptography
- Symmetric Key + Shared Key
- Hash Function
- MAC
- HMAC

Transaction Processing Model

Transaction Processing Model consist of 2 type as belows:
  a) Single Bill Single Transaction (SB-ST) : The system execute the transaction processing of one bill per one transaction.
   b) Multiple Bills Single Transaction (MB-ST): The system excute the transaction processing many bills per one transaction depict Figure .
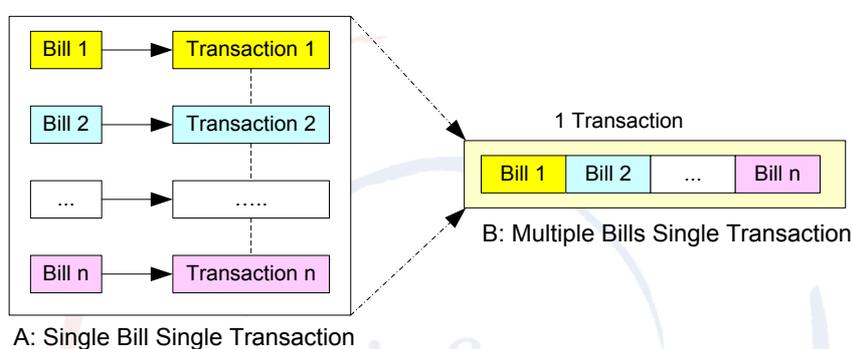
Figure 2 : Transaction Model

Security and Performance Issue

The   proposed model   ensure the security properties : CAIN. All messages that are transfers on network by using a cryptographic technique that consist of symmetric key cryptography, hashing. And provided a high performance

-The security properties of CAIN
-Confidientiality : Ensures that private or confidential information is not made available or disclosed to unauthorized individuals. Encryption technique using a symmetric key with   secret key, hash function and hash function with MAC (Message A*uthentication* Code). These provided the desired properties.

- Authentication : Authentication: Ensures that the origin of a message is correctly identified, with an assurance that the identity is not false. Encryption technique using a symmetric key with   hash function with MAC that   provided   authentication properties.

-Integrity :   Ensures that only authorized parties are able to modify computer system assets and transmitted information. Encryption technique using a symmetric key with secret key and MAC, and hash function are provided in the properties.

-Non-Repudiation : Ensures that the user cannot deny that he/she has performed a transaction and he/she must provide proof if such a situation occurs. Encryption technique using a symmetric key with MAC is provided in the properties.

-Performance Analysis

In this view point we focus on three approaches to measure the performance of the mobile payment system . These consist of:
- Memory usage : The memory that is used for data processing at that time. It is measured in bytes.
- Time usage: The time it takes to process an application at that time. It is measured in millisecond (ms).
- Power consumption : The energy use in processing the application. It is measured in Millijoules (Mj) : 1 Mj = 3.6 Kwh (Kilowatt hour)

Experiments

The experiments were conducted on wireless network and fixed network for comparison of performance and security. TheArchitecture of the experiments depict Figure 3**.**
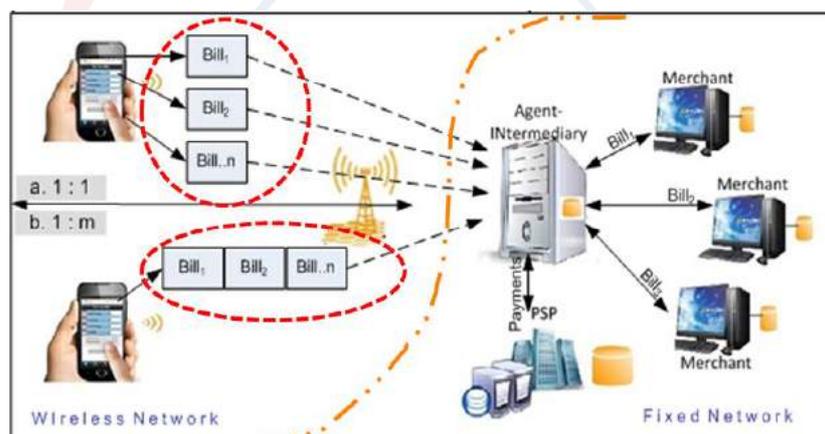
Figure 3: Architecture of the model

-Tools
This scenario uses many tools for testing the security and performance. These were designed for hardware, software requirement and function of the system.

-Hardware Requirment
Client: Samsung Galaxy S5 (CPU : 2.5 GHz Quad core, RAM 2 GB, Internal Storage 16 GB, OS : Android 4.4.2 (Kitkat)
Intermediary, Merchant, Payment Service Provider : HP Pavillion 23-g025x (CPU : Intel Core i5-4570T processor, 4M cach, up to 3.60 GHz), RAM 4 GB DDR3, Storage 1TB 7200 RPM, OS : Windows 7 Enterprise

-Software Requirement
Apache HTTP Server: HTTP Server for Web Services Deployment
PHP: Programming Lanugage for Web Services
Android SDK : Development Tools for Client Mobile Application
SQLite (Embedded with Android OS): Embedded Database for Client Mobile

-Application
MySQL : DBMS for Intermediary, M and PSP
C#: Programming Language for IN, M and PSP Application
Security Function in C# and Java and tool
GenerateAESkey(): Symmetric key algorithm (AES 128 bit)
AESEnc(): Hash Function (MD5)
AESDec(): Key-Hash Function (HMAC-MD5)
Power Tutor: Monitoring Power Consumption
DDMS: Monitoring Android Application
Wireshark: Testing the security properties

Results

From the experiments, we can conclude the results on the table I. The security properties of the two payment types   provides   confidentiality, authentication, Integrity and non-repudiation. The performance of the payment methods are base on transaction processing. We found that the one to one relationship payment has a time average of 31.50 (ms), memory usage is 1,414 bytes and CPU energy consumption is 262.13 Mj. The one to many relationship payment has a time average of 17.37 (ms), memory usage of 756 bytes and CPU energy consumption is 66.55 Mj.

   In summary, overall performance of the one to many relationship delivers better performance than one to one relationship. That makes the new protocol suitable for a new era which uses mobile phones to support convenience, because it is high in performance and security.

Table I Result of Testing the Security and Performance

Tx : Bill	Security				Performance		
	C	A	I	N	Time Average (ms)	Memory Usage (byte)	CPU energy Consumption (mj)
1 : 1	Y	Y	Y	Y	31.50	1,213	162.13
1 : M	Y	Y	Y	Y	17.37	756	56.55

Tx : Transaction , ms :millisecond , mj : milli joule

From the results in Table II. we compare the security properties and performance between two types of transactions. The security properties tested by using the Wireshark   program that decrypts message at the destination. This ensures confidentiality, authentication, integrity and non-repudiation of both types. The performance was tested by running the mobile application and monitoring by DSK program and Power Tutor. We tried to input a the different number of bills when testing the performance, such as time testing using fourteen bills per transaction, memory testing use three bills per transaction and CPU energy consumption using

fourteen bills per transaction. As a result, we discovered that the performance of the proposed protocol delivers better performance than traditional transaction processing.

Discussion

The result of experiments shows the improved performance of a secure mobile bill payment application. The characteristics of model are lightweight platform, high security , memory conservation, less time consumption, and reduced cpu energy consumption. In accordance with the requirements of the 21st century, it also supports a change in the concept of the "Bill Gates", which, in the latest Gate Notes annual letter, Microsoft founder and philanthropist Bill Gates writes about the effect smartphones and mobile banking will have in the next 15 years. He observed that "Digital banking will give the poor more control over their assets and help them transform their lives and, by 2030, 2-billion people who don't have a bank account today will be storing money and making payment with their phones"[12].

In the real world we have many mobile payment applications such as Apple pay, LoopPay, Google Wallet, Paypal, Paypass, Dwallo, Square Financial, etc. These currently do not supporting multiple bill payment. In The future, we should adjust the mobile payment system to accommodate the needs of a new era.

Conclusion

This paper proposes experiments to measure the performance of mobile payment Applications($Pay2S$ $^{(save\&safe\,)}$) , which are applied form a lightweight agent-base secure mobile payment protocol that supporting the multiple payment. We developed the application for testing security and performance. The security properties use an encryption technique that supports CAIN: confidentiality, authentication, integrity, and non-repudiation. The performance is tested by placing the application on the experimental design.   Overall, the experiments revealed that the one to one relationship between transaction and number of bills provides far less performance than the one to many relationships. It should be develop into a the business product.

Reference

Fun, T. S., Beng, L. Y., Roslan, R. and Habeeb, H. S. (2008). Privacy in newmobile payment protocol, World Academy of Science, Engineering and Technology. Vol:2, pp. 198-202.

Kungpisdan, S., Srinivasan, B., Le, P. D. (2004). A secure Account-based Mobile Payment protocol , Proceedings of the International Conference on Information Technology: Coding and Computing (ITCC 2004) , available online at https://en.wikipedia.org/wiki/Mobile_payment

W., Stalling, "Cryptography and Network Security," Principles and Practice 6th Edition. 2013, Prentice Hall International, Inc.

Daniel O. R. et al., "Adaptive Query Algorithm for Location Oriented Applications" Roedunet International Conference (RoEduNet), 2013 th, Romania

10 of the hottest trends in consumer behavior in 2015. http://www.manager.co.th/Weekly54/ViewNews.aspx?NewsID=9560000157612&TabID=3&

https://mobiforge.com/research-analysis/global-mobile-statistics-2012-section-f-mobile-payment-nfc-m-commerce-m-ticketing-and-m-coupons

Effect of Heat Treatment and Shelf Life on Chilling Injury of Mango Cv. Nam Dok Mai

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Abstract

This study investigated chilling injury (CI) effects from heat treatment and pre-cooling on the shelf life potential of mango cultivated variety cv. Nam Dok Mai. The first phase involved heat treatment in hot-air ovens of stored mango pulp at both 34° Celsius and 38° Celsius for three separate periods of 24, 48, and 72 hours. The second phase of testing involved the storage of the mango at 5° Celsius for a period of 10, 20, and 30 days to determine the appropriate shelf life. The findings showed that chilling injury (CI) appeared within 30 days of storage at 5° Celsius which included pitting, skin browning, water soaking, and rapid rotting of the fruit that resulted in shorter shelf life. Findings also indicated that chilling injury symptoms from mangos included a lower level of total soluble solid (TSS), higher disease rates, and lower fruit quality when compared with normally ripened mango fruit at 25° Celsius. These results however were improved over non-heat treated fruits when the mangoes were heat treated at 34° Celsius for either 24 or 48 hours or at 38° Celsius for 24 hours prior to cold storage for 10 or 20 days at 5° Celsius. Furthermore, heat treatment did not affect fruit weight loss, firmness, color changes, or water soaking during the storage period at 25° Celsius.

Keywords: chilling injury, heat treatment, shelf life, *Mangifera indica* L., Nam Dok Mai

Introduction

Globally, there are 160 varieties of mangoes that are cultivated in more than 90 countries and in 2013, if all categories of mangoes are considered, 43.3 million tons were harvested (World Mango Market, 2015). Mango ranks third among the tropical fruits grown in the world with the mango (*Mangifera indica* L.) fruit helping make Thailand the third largest exporter in the world. In 2011 Thailand had an export harvest of 63,827 metric tons representing a value of $US 57 million dollars (Thailand Foreign Agricultural Trade Statistics, 2011). As this was a significant increase from previous years, one of the main problems became an oversupply during the harvest season which subsequently led to the oversupply being refrigerated. From this came the need for greater awareness of chilling injury (CI) and how long and under what conditions this fruit could be stored.

Pre-cooling effects on CI

According to the Food and Agricultural Organization (FAO) of the United Nations, precooling is 'amongst the most efficient quality enhancements available' and is regarded 'as one of the most value-adding activities in the horticultural chain' (Borompichaichartkul, Kanlayanarat, Rolle and Acedo Jr., 2009). Previous studies have already shown the importance of temperature on shelf life storage. Wang et al. (2008) indicated that mango fruit shelf life CI can be significantly alleviated along with disease incidence after 7 days of storage at 4 °C, followed by an additional 14 days at 20 °C. This is consistent with Gonzakez-Aguilar et al. (2008) which showed that mango fruit kept at 5°C showed considerably less symptoms of water soaking compared to storage at a lesser temperature of 2°C.

Industry research has already determined that the use of low temperatures prior to storage reduces the effects of CI on mango fruit with most harvesters, warehouses, and retail merchants making efforts to preserve their commodities and prolong shelf life by use of lower temperatures (Gonzakez-Aguilaret et al., 2008; Ghasemnezhad et al., 2008; Dea et al., 2010)

Heat treatment effects on CI

Dea, Brecht, Nunes, and Baldwin (2010) stated that it is known that heat treatment has a positive effect on fruit quality such as extending storability and marketing by inhibiting ripening processes or inducing resistance to chilling injury (CI). Ghasemnezhad, Marsh, Shilton, Babbalar, and Woolf (2008) also confirmed this indicating that CI was reduced and durability was increased by using hot air ovens prior to storage with temperatures ranging from 30 – 40 °C before storage.

CI can also be reduced by storing mango fruit at 38 °C with a 90 percent relative humidity for 24 and 48 hours. This is followed by a storage period of 11 days at 5 °C which is followed by storage at 21 °C (Tasneem, 2004).

According to Field (1984), ethylene is involved in many aspects of fruit ripening and its production is inhibited by high temperatures. Tasneem (2004) confirmed this when mango fruits cv. Nam Dokmai were kept at 38 ºC for 3 days and then transferred to 20 ºC. According to Wang (2010) heat treatment induces heat shock proteins (HSP), suppresses oxidative activity, and maintains membrane stability. HSP are a family of proteins that are produced by cells in response to exposure to stressful conditions. This is consistent with Luengwilai and Beckle (2010) which discovered that tomatoes which underwent heat treatment at 38°C for 3 days before storage showed a reduction of CI symptoms. Also, tomatoes treated with heat treatment had increasing HSP and became endurable to CI.

The objective of this study therefore was to investigate the effects of heat treatment and pre-cooling on shelf life CI of mango cv. (cultivated variety) Nam Dok Mai under various conditions.

Material and methods

Mango fruit test sample preparation

For the study the researchers used mango fruit that weighed 300-350 grams and were 115 days old from their initial flowering. Samples were collected from the district of Bangkla located in Chachoengsao Province just east of Bangkok in Thailand. All of the selected samples were of the same maturity and were initially disease-free and exhibited no skin wounds selected by using a floating technique in 3% salt solution but downward sunk in 1% salt solutions. The mango fruits were subsequently cleaned with water and air dried in ambient temperature.

Experiments were designed so that there were 0, 10, 20, and 30 days storage times at 5°C. Effects of chilling injury (CI) from shelf storage were determined on days 0, 3, 6, and 9 after the start of the storage experiment.

Heat effects experimentation at both 34°C and 38°C at 5°C was also carried out to determine mango fruit quality by varying the time increments to 24, 48, and 72 hours.

The third experiment used pre-cooling at 5°C for 10, 20, and 30 days to determine the quality of mango fruit against various conditions of shelf life.

The lay out was planned by Completely Randomized Design (CRD) (Jayaraman, 1999). There were three components to the experiment which have been labeled 'Factors'. They consisted of the following:

> **Factor 1** contained two level of heat treatment at 34°C and 38°C (Table 3).
> **Factor 2** also used three levels of heat treatment but was measured in time units of 24, 48, and 72 hours (Table 3).
> **Factor 3** used three levels of storage time at 5°C which consisted of 10, 20 and 30 days (Table 3).

Each testing period had 12 mango fruits packed in 20x30 inch plastic bags with some small pores for aeration.

Data collection

All data were records according to the protocols that listed in the previously mentioned experiments, and used for the calculation, where % (percentage) of weight loss was equivalent to 100 times of the difference between the weight detected before and after storage and then divided by the weight detected before storage. Mango fruit firmness was determined by fruit firmness testing equipment with 0.65 centimeter in diameter and 0.7 centimeter on slant high.

The value of Total Solid Solution (TSS) was carried out using the liquid solution that was derived from squeezing the mango pulp into distillated water. A refractometer measures TSS as °Brix in 0.1% graduations (OECD, 2009). The degree of disease symptom of mango fruits was rated depending on the severity of the appearance, i.e., 1 indicated no disease symptoms, 2 represented 40 millimeters or less of discoloration, 3 indicated 40-60 millimeters of discoloration, and 4 was greater than 60 millimeters.

Results and discussion

Research results from the heating and refrigeration of mango fruit on shelf life and the related chilling injury (CI) of Nam Dok Mai mango cv. are summarized in Table 1. Results also indicated that the CI effect on shelf life was not significant when refrigerated at 5°C for 0, 10 and 20 days but when stored for a longer period of 30 days; there was a significant difference as shown in Figure 1. Results from chilling at 5°C on mango shelf life showed that the shelf life could last for 20 days. This agrees with the results of other researchers including Kasim and Kasim (2011), Dea et al. (2010) and Wang (2010).

Table 1 Results on shelf life after storing the test sample at 0, 3, 6, and 9 days at 5°C.

Storage time at 5°C (days)	Mango shelf life chilling injury (CI) score			
	0 day	3 days	6 days	9 days
0 day	1.00^b	1.00^b	1.19^c	1.28^c
10 days	1.00^b	1.28^b	1.95^b	2.20^b
20 days	1.00^b	1.45^b	3.53^a	3.95^a
30 days	1.70^a	3.36^a	-	-
LSD$_{0.05}$	0.41^*	0.50^*	0.40^*	1.01^*
%CV	15.21	15.35	12.12	14.65

Note. * represents a statistical significance level of 0.05. Numbers followed by a letter in the column represent the statistical significance of the mean comparison according to Least Square Difference (LSD) (p ≤ 0.05). Chilling injury scores: 1=no chilling injury, 2= chilling injury symptom 1-40 centimeter², 3= chilling injury symptom 40-60 centimeter², 4= chilling injury symptom 60 centimeter².

Figure 1 Effects of refrigeration on mango fruit after cooling at 5°C for 30 days.

Table 2 shows the effects on weight loss and fruit firmness from pre-heating and pre-cooling treatment of mango fruit. Results indicated that heat treatment at both 34°C and 38°C gave better results. This is consistent with Nair and Singh (2003), where it was concluded that the application of heat treatment to plant material was a means of controlling pests which provided a non-chemical method of control.

The effect of heat treatment can reduce the rate of ripening as well, while any damage by heat may be immediately or develop after a period of storage. From the research, mangoes stored at 38°C showed a significant difference to mangoes stored at 34°C in both weight lost and fruit firmness.

In weight loss, the lowest score was 14.68 % when the test sample was kept at 5°C for 20 hours. The highest score for fruit firmness was 1.15 kg/cm^2 after the test sample was kept at 5°C for 20 hours. This agrees with other research from Tasneem (2004) and Dea et al. (2010).

Table 2 Results of weight lost and fruit firmness at both 34°C and 38°C as well as refrigeration storage effects for 10, 20, and 30 days at 5°C after which, the samples were stored at 25 ° C for 6 days.

Temp. (°C)	Heat treatment time (hours.)	Pre-cooling time 5 °C time (days)	Weight loss (%)	Fruit firmness (kg/cm²)
34	24	10	18.02[c]	0.47[c]
		20	18.97[c]	0.49[c]
		30	26.75[a]	0.36[c]
	48	10	16.34[d]	0.66[b]
		20	18.44[c]	0.56[b]
		30	24.55[a]	0.41[c]
	72	10	15.77[d]	0.52[b]
		20	14.68[d]	1.15[a]
		30	25.58[a]	0.39[c]
38	24	10	20.19[c]	0.44[c]
		20	17.21[d]	0.45[c]
		30	27.34[a]	0.41[c]
	48	10	18.54[c]	0.65[b]
		20	16.21[d]	0.56[b]
		30	26.15[a]	0.36[c]
	72	10	14.95[d]	0.74[b]
		20	14.85[d]	0.36[c]
		30	22.87[b]	0.54[b]
	control (no pre-heating)	10	15.85[d]	0.41[c]
		20	17.77[c]	0.60[b]
		30	19.31[c]	0.32[c]
	control (25°C or normal T. = check)		9.66[e]	1.02[a]
	LSD$_{0.05}$		3.05*	0.23*
	%CV.		10.25	15.94

Note. * represents a statistical significance level of 0.05. Numbers followed by a letter in the column represent the statistical significance of the mean comparison according to Least Square Difference (LSD) (p ≤ 0.05).

Table 3 reveals the results of mango heating at 34°C and 38°C and mango cooling at 5°C for 10, 20 and 30 days. Table 3 also indicated temperature as Factor 1, heating time in hours as Factor 2, and cooling time at 5°C time in days as Factor 3. Factor 1's contribution to mango fruit weight loss and fruit firmness was insignificant. Factor 2's contribution to weight loss and fruit firmness however was significant. For Factor 3, storage also played a significant role on weight loss and fruit firmness.

Table 3 The results of mango heating at 34°C and 38°C and mango cooling at 5°C for 10, 20 and 30 days.

Temperature in °Celsius (factor 1)	Weight loss (%)	Fruit firmness (kg/cm^2)
34	19.90	0.56
38	19.81	0.50
LSD$_{0.05}$	ns	ns
Heat treatment time in hours (factor 2)	**Weight loss (%)**	**Fruit firmness (kg/cm^2)**
24	21.41^a	0.44^c
48	20.04^b	0.53^b
72	18.12^c	0.61^a
LSD$_{0.05}$	1.05*	0.98*
Pre-cooling at 5°C in days (factor 3)	**Weight loss (%)**	**Fruit firmness (kg/cm^2)**
10	17.30^b	0.58^a
20	16.73^b	0.59^a
30	25.54^a	0.41^b
LSD$_{0.05}$	1.12*	0.08*
factor 1	ns	ns
factor 2	*	*
factor 3	*	*
1x2	ns	ns
1x3	ns	*
2x3	ns	ns
1x2x3	ns	*
%CV	9.83	17.21

Note. * represents a statistical significance level of 0.05. ns = no statistically significant level 0.05. Numbers followed by a letter in the column represent the statistical significance of the mean comparison according to Least Square Difference (LSD) ($p \leq 0.05$).

Table 4 and Table 5 show the effects of heat treatment and pre-cooling on mango TSS and disease symptoms of the test sample of Nam Dok Mai mango fruit. It was shown that the time that was used for heat treatment at 34°C and 38°C was not significantly different in the values and scores for TSS samples and disease symptoms. However, as time increased, the values changed significantly (Luengwilai and Beckle, 2010). Finally, the pre-cooling treatment at 5°C for 10, 20 and 30 days showed a significant difference among them.

Table 4 Results of the determination of TSS and disease symptom testing after heating at both 34°C and 38°C, and pre-cooling at 5°C for 10, 20, and 30 days after which, the samples were stored at 25 ° C for 6 days.

Temperature in °Celsius	Heat treatment time (hours.)	Pre-cooling time 5°C time (days)	TSS (brix)	Disease symptom (scores)
34	24	10	18.39[a]	2.24[b]
		20	19.76[a]	2.36[b]
		30	17.61[b]	2.86[b]
	48	10	17.01[c]	2.24[b]
		20	17.76[b]	2.74[b]
		30	16.71[c]	3.24[a]
	72	10	15.36[d]	1.86[c]
		20	14.31[e]	2.61[b]
		30	15.01[e]	3.89[a]
38	24	10	18.56[a]	1.99[c]
		20	18.51[a]	2.24[b]
		30	17.96[b]	2.74[b]
	48	10	17.51[b]	1.99[c]
		20	18.91[a]	2.86[b]
		30	16.21[c]	2.99[b]
	72	10	15.81[d]	1.99[c]
		20	16.01[d]	2.86[b]
		30	14.56[e]	3.49[a]
control (25 °C or normal T.=check)			17.71[b]	1.00[c]
LSD 0.05			1.64*	1.22*
%CV			6.42	18.20

Note. * represents a statistical significance level of 0.05. Numbers followed by a letter in the column represent the statistical significance of the mean comparison according to Least Square Difference (LSD) (p ≤ 0.05). TSS (brix) is total soluble solid.

Table 5 Conclusion of TSS and disease symptom testing after pre-heating at both 34°C and 38°C, and cooling at 5°C for 10, 20, and 30 days after which, the samples were stored at 25 ° C for 6 days.

Temperature in °Celsius (factor 1)	TSS (brix)	Disease symptom (scores)
34	16.88	2.62
38	17.12	2.43
LSD 0.05	ns	ns
Heat treatment time in hours (factor 2)	**TSS (brix)**	**Disease symptom (scores)**
24	18.46[a]	2.40
48	17.35[b]	2.46
72	15.18[c]	2.71
LSD 0.05	0.57*	ns
Cooling at 5°C in days (factor 3)	**TSS (brix)**	**Disease symptom (scores)**
10	17.11[a]	2.05[b]
20	17.54[a]	2.40[b]
30	16.34[b]	3.13[a]
LSD 0.05	0.57*	0.46*
factor 1	ns	ns
factor 2	*	ns
factor 3	*	*
1x2	ns	ns
1x3	ns	ns
2x3	ns	ns
1x2x3	ns	ns
%CV	3.01	17.05

Note. * represents a statistical significance level of 0.05. ns = no statistically significant level .05. Numbers followed by a letter in the column represent the statistical significance of the mean comparison according to Least Square Difference (LSD) (p ≤ 0.05). TSS (brix) is total soluble solid.

Conclusion

Results demonstrated that the storage time at 5°C and shelf life of mango fruits affected the test sample, which could cause damages after chilling treatment that relevant to the storage time, where longer storage time could reduce the shelf life or increase the chilling injury symptoms.

The pre heating treatment on the test sample at 34°C for either 24 or 48 days or at 38°C for 24 hours could reduce the damage on the test sample after chilling treatment in mango after the test sample had been kept after pre cooling treatment at 5°C for 10 and 20 days.

The test sample that had been kept for 30 days after pre-cooling treatment ***could not*** maintain weight lost and fruit firmness, whereas the value and score of total solid solution and disease symptom were increased when the comparisons were made to those of 10 and 20 days, and the control group.

From the 10, 20, and 30 day test groups, it was determined that exceeding 20 days showed a rapid deterioration of the sample group including weight loss and disease symptoms even though it had been exposed to pre-cooling. Storage of fruits at 5 ° C for 30 days also caused CI which included darker fruit, tissue collapse and rotten fruit.

The mango fruits that treated by heat treatment for 72 hours gave an abnormal ripening. The cooling treatment at 5°C that kept for 30 days after treatment showed some changes in color of the skin of mango fruits, ***become a lofted fruit***, and reducing in fruit quality in a short time. The mango fruits that had been kept after the chilling treatment would have all qualities lower than the control group.

Mango fruit exposed to heat treatment for 72 hours had an abnormal ripening. Additionally, pre-cooling treatment at 5°C for 30 days contributed to skin color changes, darker fruit, tissue collapse, and rotten fruit and reduced the fruit quality quickly. All fruit kept after chilling treatments had qualities lower than the control group.

References

Borompichaichartkul, Kanlayanarat, Rolle & Acedo Jr., (2009). Module 4 – Cooling and cold storage. In S. Kanlayanarat, R. Rolle, & A. Acedo Jr., A. (Eds.), *Horticultural chain management for countries of Asia and the Pacific region: A training package.* Retrieved from http://tinyurl.com/jzmyjgk

Dea, S., Brecht, J. K., Nunes, M. C. N., & Baldwin, E. A. (2010). Occurrence of chilling injury in fresh-cut 'Kent' mangoes. *Postharvest Biology and Technology, 57,* 61 – 71.

Field, R. J. (1984). The effect of temperature on ethylene production by plant tissue. In*: Roberts, J. A., Tucker, G. A. (Eds.), Ethylene and Plant Development. Butterworth, London,* pp. 47-69.

Ghasemnezhad, M., Marsh, K., Shilton, R., Babbalar, M., & Woolf, A. (2008). Effect of hot water treatments on chilling injury and heat damage in 'satsuma'mandarins: Antioxidant enzymes and vacuolar ATPase and pyrophosphatase. *Postharvest Biology and Technology*, *48*(3), 364 – 371.

Gonzakez-Aguilar, G. A., Celis, J., Sotelo-Mondo, R. R., Rosa, L. A., Rodrigo Garcia, J., & Alvarez-Parrilla, E. (2008). Physiological and biochemical changes of different fresh-cut mango cultivars stored at 5°C. *International Journal of Food Science Technology, 43,* 91 – 101.

Jayaraman, J. (1999). *A statistical manual for forestry research*. FORSPA, Bangkok. Retrieved from http://tinyurl.com/zh5qho8

Kasim, M. U., & Kasim, R. (2011). Vapor heat treatment increase quality and prevent chilling injury of cucumbers (*Cucumis melo* L. cv. Silor). *American-Eurasian Journal of Agriculture & Environment, 11*(2), 269 – 274.

Luengwilai, K., & Beckle, D. M. (2010). Climacteric ethylene is not essential for initiating chilling injury of tomato (*Lycopersicone sculentum*) cv. Ailsa Craig. *Journal of Stored Products and Postharvest Research, 1*(1), 1 – 8.

Nair, S., & Singh, Z. (2003). Pre-storage ethrel dip reduces chilling injury, enhances respiration rate, ethylene production and improves fruit quality of 'Kensington' mango. *Food Agriculture Environment, 1,* 93 – 97.

OECD (2009). Guidance on Objective Tests to determine Quality of Fruits and Vegetables fresh and dry and dried produce. Retrieved from http://tinyurl.com/gvu22yy

Tasneem, A. (2004). *Postharvest treatments to reduce chilling injury symptoms in stored mangoes*. Master Thesis. Canada: Macdonald Campus of McGill University, Montreal. Retrieved from http://tinyurl.com/zykaxv3

Thailand Foreign Agricultural Trade Statistics, 2011. Retrieved from http://tinyurl.com/ho6qp5s

Wang, C. Y. (2010). Alleviation of chilling injury in tropical and subtropical fruits. *Acta Horticulturae*, 864, 267 – 273.
 http://dx.doi.org/10.17660/ActaHortic.2010.864.35

Wang, B., Wang, J., Liang, H., Jianyong, Y., Zhang, J., Lin, L., Wu, Y., Feng, X., Cao, J., & Jiang, W. (2008). Reduced chilling injury in mango fruit by 2,4-dichlorophenoxyacetic acid and the antioxidant response. *Postharvest Biology   and Technology, 48*(2), 172 – 181.

World Mango Market Supply, Demand and Forecast (2015, March). GBD Network. Retrieved from http://tinyurl.com/zm9e84o

The Study on the Development and Processing Transfer of Lip Balm Products from Virgin Coconut Oil: A Case Study

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Abstract

The purpose of this research was aimed to study the development and processing transfer of lip balm products from virgin coconut oil by herbal producing group of the Sibedsok sub-district, Banpho district, Chachoengsao province, Thailand. Their physical properties and stability test at various storage conditions were performed. The results showed that all of the formulations (6 formulas) were stable under tested conditions. The formula that contained only virgin coconut oil was selected by 6 volunteers of 20 volunteers, which were considered from the physical properties: texture, color and smelling. The selected formula was then evaluated from satisfaction of 30 volunteers, and compared with lip balm containing mineral oil. It was found that most of volunteers were more satisfied in the physical property of lip balm containing virgin coconut oil. Results of the sensation test showed that the lip balm containing virgin coconut oil was also found to be softer, more moisturizing and smoothing to the lip. Moreover, it was easier to apply and spread on lip with positively long-lasting effect. All volunteers felt that their lip were soft and moisturized without any irritation after they applied continuously.

Keywords: Virgin Coconut Oil, Lip Balm, Herbal Cosmetics

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Introduction

Nowadays, consumers in Thailand and foreign countries have turned their attention to the cosmetic products that are composed of natural extracts into their formulations. Since the extracts from natural resources are less harmful and safer than substances of chemical synthesis, so it supposes that cosmetic industries in Thailand will be able to expand the opportunities of development of natural extract ingredient cosmetics as well as it can contribute to promote and support agriculturists in the country. At the moment, there has project to be encouraging village communities to improve local product quality as it is called "One Tambon One Product" which this projects designed by Thailand government aiming to generate income and occupation to people and also continually keep local wisdom.

Skin on lip called as Stratum corneum is different from another skin area with its rapider evaporating moisture than face skin with twice times to gain the easy dried and chapped lip. Lip balm is the cosmetics product with the main components as waxes , butters and oils from natural extracts or synthesized ones with the objective to increase the moistures to the lip as well as avoiding the peeling skin on lip.

Coconut is accounted as the important economic plants of Thailand Similarly, it utilizes as a raw material to produce virgin coconut oil. Currently, virgin coconut oil has plentifully attracted to transform into cosmetic products due to the gentleness for hypoallergenic properties. Additionally, it contained a number of beneficial natural extracts, especially vitamin E that exists in form of "Tocotrienol" which is more powerful antioxidant 40-50 times compared with another form of vitamin E "Tocopherol" found in general sources. This would be the option for consumers to choose natural extract products instead of raw materials from other counties. Besides, this can increase the new products to communities and cosmetic industrial market.

Thus, the researcher has the concept idea to bring the coconut oil for applying as the main component in lip balm formulation , study the stability of coconut oil lip balm formulation in terms of making comparison to lip balm containing with mineral oil and test the satisfaction from the volunteers as the guideline for studying to develop the product in order to gain the most benefit further.

Materials and Methods

This study was conducted in the Faculty of Science and Technology, Rajabhat Rajanagarindra University, Chachoengsao, Thailand.

Materials :
Virgin Coconut oil : This was obtained by extraction from coconut fruits sourced locally.

Methods :
Development of Lip Balm Containing Virgin Coconut Oil
To determine quantity of virgin coconut oil for replacing mineral oil on lip balm basic formula as shown in the table no.1, while it implemented observing the appearance, spread ability, investigating pH, melting point and stability by heating and cooling thaw cycle (switching among 4°C 48hrs. and 45°C 48hrs.) for 5 times. Then, picking

the best formula and most satisfactory one from 20 volunteers which took texture, spread ability during application, moisture, colour and scent into consideration.

Table 1. Preparation of lip balm containing virgin coconut oil with its prescribed quantity

Ingredients	\multicolumn{6}{c}{Percentage (%)}	Funtion in formulation
	L1	L2	L3	L4	L5	L6	
Petroleum jelly	40	40	40	40	40	40	Increases viscometer
Shear butter	2	2	2	2	2	2	Hydrating,reduces melting point
Bees wax	3	3	3	3	3	3	Increases viscometer and melting point
Canubar wax	1.5	1.5	1.5	1.5	1.5	1.5	Increases viscometer and melting point
Paraffin wax	3	3	3	3	3	3	Increases viscometer and melting point
Benzoic acid	0.5	0.5	0.5	0.5	0.5	0.5	Preservative
Coconut oil	0	10	20	30	40	50	Emoilient,reduces viscometer
Mineral oil	50	40	30	20	10	0	Emoilient,reduces viscometer

Consumer Satisfactory Test on Virgin Coconut Oil Lip Balm
Mineral oil lip balm and virgin coconut oil lip balm were compared to do experimentally on satisfaction of 20 volunteers relating to consumers' satisfaction before and after using the product, moisture, spread ability, texture, colour and scent. Mineral oil lip balm formula no.6 which was the basic one would be represented as A and lip balm with 50% of virgin coconut oil as B.

Result and discussion

Results of Virgin Coconut Oil Lip Balm
Referring to virgin coconut oil replaced mineral oil into lip balm basic formula tested on physical stability by heating and cooling thaw cycle, it found out that total lip balm formulas no. 1-6 were submitted to normal stability, light yellow-white colour, melting point during 48-51C and pH 5.5-7. However, the formula no. 6 mostly gained satisfaction from 20 volunteers, hence virgin coconut oil lip balm formula no.6 would be chosen to examine bearing comparison with mineral oil lip balm basic formula.

Table 2. Evaluation of Prepared lip balm containing virgin coconut oil

Parameters	L1	L2	L3	L4	L5	L6
Colour	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow	Light yellow
Odour	Coconut oil	Coconut oil	Coconut oil	Coconut oil	Coconut oil	Coconut oil
Spreadability	G	G	G	G	G	G
MP	70.1	70.7	70.5	71.1	70.8	71.1
pH	5.3	5.7	5.8	6	5.5	5.4
Stability	pass	pass	pass	pass	pass	pass

Spreadability:**G**-Good; **I**-Intermediate; **B**-Bad

Results of Virgin Coconut Oil Lip Balm Based on Consumers' Satisfaction20 volunteers as a sample group aged 20 and over from Chachoengsao province, 20 volunteers were classified into age between 20-40 as 80% and age between 41-60 as 20% respectively; the youngest person in the group was 20, while the oldest one was

45. The condition of volunteers group possessed dry lips 65% and normal lips 35% which volunteers mainly agreed with physical product results towards coconut oil lip balm that was smooth texture, pleasure scent, great spread ability of application as well as moistening lips with it was slightly feeling sticky.

Conclusion

Lip Balm has contained of virgin coconut oil only without the mixing of mineral oil with good product properties and stable conditions. According to the result from 20 volunteers, it was found that most volunteers have satisfied with the overall of physical products with clear texture. Moreover, when the customer wears the Lip Balm it sticks with the skin excellently,spreads on the lip nicely and makes it moisture. Therefore, this product is one of alternative for the customers to select for applying the natural extracts product made from local materials. Furthermore, the manufacturing of virgin coconut oil cosmetics with various patterns can be applied further in business too.

References

Phupoksakul, N. 2004. *Cosmetic Products Market in Thailand.* Available Source: http://strategis.ic.gc.ca

Arai,S.,Oshida, K., T. Hikima and Y. Fukada. (1997). Study on lip surface-characteristic of stratum corneum and corneocytes on lip. *Journal of Japanese Cosmetic Science Society,14*, 66-70.

BAREL, A.O.; PAYE, M.; MAIBACH, H.I. (2001).*Handbook of cosmetic science and technology*. New York: Marcel Dekker,. 904p.

Kapoor VP, (2005). Herbal Cosmetic for skin and Hair care, Natural Product Radiance,4(4):306-314.

Carames, M. (1978). Development of a lipstick base. *Cosmet Toilet;* 93(1): 15-26.

Kongmuang, S., T. Phaechamud and G. Chansiri. (2005). Herbal Lipstick : Sunflower Oil as Ingredient. pp. 36-1 – 36-6. In *Sciencetific Conference Asian Societies of Cosmetic Scientists (ASCS).* 7th ed. Society of Cosmetic Chemists of Thailand (SCCT). Queen Sirikit National Convention Center, Bangkok Thailand.

Bawalan, DD., and Chapman, KR. (2006). *Virgin coconut oil production manual for micro and village-scale processing.* Bangkok FAO Regional Office for Asia and the Pacific, 112 p.

Enig, M. C. (1999). *Coconut.* Retrieved August 4, 2011, http://www.coconutthai.org/ pdf_journal/kulapraplue/cdcot-book10.pdf

APCC standards for virgin coconut oil. [Online] [cited 1 February 2010]Available from internet : http//www.apccsec.org/document/VCNO.PDF

Dayrit, FM., et al. (2008). Analysis of monoglycerides, Diglycerides, sterols, and fatty acidsin coconut (*Cocos nucifera* L.) oil by P NMR spectroscopy. *Journal of Agricultural and Food Chemistry*, vol. 56, no.14, p. 5766-5769.

Marina, AM., Che Man, YB. and Nazimah, SA. (2009). Chemical properties of virgin coconut oil. *J Am Oil Chem Soc*, vol. 86, no. 4, p. 301-307.

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Handmade Toy Development for Early Childhood Using Local Wisdom

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Abstract
This study was aimed to develop and produce toys from handmade materials for young children by the application of local wisdom. The participants consisted of young children in the kindergartens in Chachoengsao Province, Thailand. The selection was made by the purposive sampling from 10 schools, where each school selected 1 classroom, and each classroom selected 10 students. The constructed instrument used in this study was a quality assessment of the toys for young children, which was including observation and documentation. The results showed that the quality of toys for young children that made from local materials using a local wisdom was equivalent to 82.00/87.00, which was higher than the standard one (80/80). As a result of the implementation of toys by the participants, it was found that the young children gained more intelligence and creativity after learning with the toys, which had the statistical significant difference at the level of $p = <0.01$. These toys, which stimulated awareness of the conservation of local wisdom among the young children, might result in maintaining local wisdom and knowledge in the community to promote a new project business enterprise.

Keywords: Toys, young children, handmade toys

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Introduction

It is considered that the children at 3 to 6 years of age are in the "period of opportunity to lay the foundation of human life." This is because it is the earliest phase of learning during their childhood due to the optimum growth stage of the brain cells. The development of the brain and learning are at its fastest speed. Therefore, the development of early childhood becomes the development of the human resources of the nation for the future.

In developed countries such as the, United States of America (USA), President Barack Obama (Barack Obama) stated the policy of the USA (State of the Union: SOU) firstly when he was elected into the presidency for the second term (Pattarawad, 2013). President Obama has referred to consistent results of many researches over many decades that investing in early childhood is an extremely worthwhile investment both for the future of the children and for the society and the economy of the country. If the rate of return on this investment in early childhood is one dollar in the present day, the country will yield returns as high as seven times in the future. These returns are in terms of increasing the chances of completing basic education of children, reducing the chance of school age pregnancy, and reducing the rate of crime in the future. These are but a cost that the state has to pay for the treatment and tackle the higher cost of building a system for prevention in children in the primary level (Early intervention).

According to the policy-level meeting of the Asia-Pacific region in the field of early childhood education and care (Asia-Pacific Regional Policy Forum on Early Childhood Care and Education) on 10th -12th September 2013 in Seoul, South Korea, the summary of the conference featured the issue of the investment in early childhood care and education for effective economic development and human development. The development will have to be developed to its full potential as a whole. This includes the quality of teachers, parents, care takers, and the children health as well as an environment that is conducive to learning. These affect the learning of the children and are worth the investment to solve the social problems that can possibly occur in the future. (Office of the Education Council of Thailand. 2014: 7-8)

In Thailand, every government focuses on improving the quality and standards of education at all levels by reforming the system of education in the Thai society. They reform the curriculum at all levels to support the global transformation and to become on a par with international standards, local standards and Thai culture. These include both international and domestic knowledge. Although Thailand has allocated the budget for education with more than 20 percent of the national budge, when considering the budget, it is evident that most of the government budget allocated to education was distributed to wages of the teachers rather than improving the quality of students. The percentage of the education budget, that is allocated to the textbooks and other learning materials, from the total national budget are presented as an overall description without the separation of the education levels (preschool, primary, junior, high school). It was found that in the year 2010-2012, these levels 6.86 percent, 6.19 and 5.96, were declining each year, respectively. The government has repeatedly recycled the use of books, school supplies, materials, journals and textbooks. Meanwhile, in the past year, the government has allocated from the central budget to purchase tablets for students in basic education (Office of the Education

Council of Thailand. 2014: 62-69), without including the early childhood education. This would provide that the budget allocated for education in Thailand is relatively high compared to other countries. Therefore, the investment for early childhood development, which is the basic foundation and the heart of national development, is not yet equal to the investment in other levels as they should. The overall goal of quality education in Thailand, considering the indications given, is carried out in a satisfied level.

From the major reasons given above, the researchers are interested in developing a set of toys for children from local knowledge to promote and support the family, school and community to provide the children with toys that are made from the wisdom of the district. This conserved wisdom passed down from the grandparents will be preserved and prevent from being lost as well as reduces the costs of households in purchasing the expensive toys for children. It can also become a series of products to generate income for the community. The researchers expect the development of the toy sets made from local wisdom for children will guide the parents, teachers and the general public to the early childhood development. This can become a guideline to save spending and increase the income for the family, school and community.

Methods

This study is an experimental research.

Sample Size

The sample population consisted of two groups. The first group included the contributors consisting of five elders who live in the province. The group provided local information. The second group consisted of the preschool children. Kindergarten level young children were selected by using the method of purposive sampling from 10 schools under the Chachoengsao Primary Education Office. One classroom was selected from each school and 10 students were selected from each classroom with a total of 100 students.

Variables

1. Handmade toy sets for young children.
2. The results of the experiment including behavioral observation and learning of young children.
3. Satisfaction of family, school and community on the toy sets for children made from local wisdom.

Materials

1. Handmade toy sets made from the local wisdom for children that the researchers developed called "the coconut grater."
2. The quality assessment of handmade toys for young children by the application of local wisdom.
3. Playing behavior in young children observation survey.

Experimental Period

The children were observed while playing the toys 30 minutes per day, 4 days per week, in total of 16 weeks. The behavioral survey was used to evaluate the behaviors of the children.

Results

Behavioral observation and assessment of the children.

Table 1. The comparison of the playing behavior and learning of young children before and after the experiment.

Behaviors and learning of young children	K	Before			After		
		M	SD	Performance	M	SD	Performance
Sample Size (n=100)							
Playing in groups	5	16.84	4.75	Teachers' suggestions	28.74	3.06	Enjoying playing by themselves
Waiting period for the toys	5	17.13	4.29	Teachers' suggestions	28.26	3.61	Enjoying playing by themselves
Sharing of the toys	5	17.75	4.15	Teachers' suggestions	29.05	3.19	Enjoying playing by themselves
The use of intelligence and creativity	5	13.58	3.82	Playing by themselves	22.00	2.32	Enjoying playing by themselves
Total	20	65.30	14.63	Partially needed suggestions	108.05	10.39	Enjoying playing by themselves

K= Numbers of Questions, M=Mean, SD=Standard Deviation

The playing behavior and learning of young children after the children were given the toy sets "the coconut grater," showed that the children were enjoying playing with the toys by themselves (Table 1). The mean of 108.05 was shown after the children received the toys. Furthermore, the playing behaviors in children encouraged them to play in group, disciplined them to be patient, learned to share, and used their intelligence and creativity while they were playing.

Opinions of the teachers, parents, and the community to the toy sets

After the interviews with the teachers, their opinions were analyzed. Table 2 showed the analysis of the overall satisfaction of the teachers, parents, and the community members involved in the experiment towards the effects of the toy sets on the behaviors and learning of the children. The opinions noted that the toy sets were appropriate for the young children in the age period. The wooden blocks of the toys could be held easily and created the opportunity for the children to develop imaginations and creativities. The toys are light weighted and could be easily made.

Table 2. The satisfaction of the teachers, parents, and the community members involved in the experiment for the toy sets.

Questions	5	4	3	2	1	$\overline{x}$	S.D.	Interpretations
1	7	2	1	0	0	4.60	.69	Very satisfied
2	6	3	1	0	0	4.50	.70	Very satisfied
3	3	6	1	0	0	4.20	.63	Satisfied
4	6	3	1	0	0	4.50	.70	Very satisfied
5	8	2	0	0	0	4.80	.42	Very satisfied
6	7	3	0	0	0	4.70	.48	Very satisfied
7	5	4	1	0	0	4.40	.69	Satisfied
8	4	5	1	0	0	4.40	.69	Satisfied
9	5	4	1	0	0	4.40	.69	Satisfied
10	6	4	0	0	0	4.60	.51	Very satisfied
Total						4.51	2.42	Very satisfied

Discussions

The result showed that the toys for young children that are made from local materials using local wisdom are able to support the better development of different aspects in the children. Especially, the toys that are produced from a wood should be small, lightweight, have smooth surface and natural color or other appropriate colors can be applied. The adults should allow the children to independently select the toys by themselves and let them play freely and creatively while stimulate them to use their capacity to play to their fullest. As a result, all the aspects of the children are developed because while playing, they have freedom, think freely, can make a decision, and are confident. Each time they play, the children can develop to their fullest. These handmade toys made from the local wisdom are able to respond to the need of the young children.

There are four aspects of the benefits the young children received from applying these toys. Firstly, in terms of cognitive development, when the children are playing with the toy sets, the children will be able to learn about the numbers, size, shape, characteristic, and about to sort from the largest to the smallest blocks. They are also able to arrange the blocks into different kinds of sorting depending on their imagination. This enables them to use their creativity to their fullest. Secondly, the toy sets can assist in children growth as they can sit, stand, or walk around while playing the toys as they are able to move freely. This helps develop the postures to their bodies. Lastly, the emotional and social developments can be ignited by the playing. The children are able to play with friends and share their enjoyment. In addition, the children are free to play. They learn to listen, be patient, take turn to play, and accept others' opinions while participating in the group play.

The playing of the children is one of the most important phases of their lives. The children enjoy the opportunity to observe, participate in the activity, try the trials and errors, and stimulate the creative thinking, problem solving and self discovery. The playing is influential and have a positive impact on growth of the children on their physical, emotional, mental, social, and intellectual developments. The children are

able to use their senses and perception. While playing, they can feel relaxed and able to express themselves. They also learn to sympathize with the feelings of others. The playing is the one of the ways the children can experience the learning environment and examine the well-being of others. These encourage them to build relationships with their playmates. Therefore, the parents or the caretakers should stay close to procure or build toys for children to play. The children can even participate in the making of the toys to build their psychomotor skills. The toys can be made of wood or other materials that can be obtained locally. This would save the cost of the toys and lessen the burden of the parents to spend more on toys.

Conclusion

As a result, the implementation of handmade toys showed that the young children gained more intelligence and creativity after learning with the toys, which has the statistical significant difference at the level of $p= <0.01$. These toys stimulated the awareness in the conservation of local wisdom among the young children, which might result in maintaining local wisdom and knowledge in the community to promote a new project business enterprise.
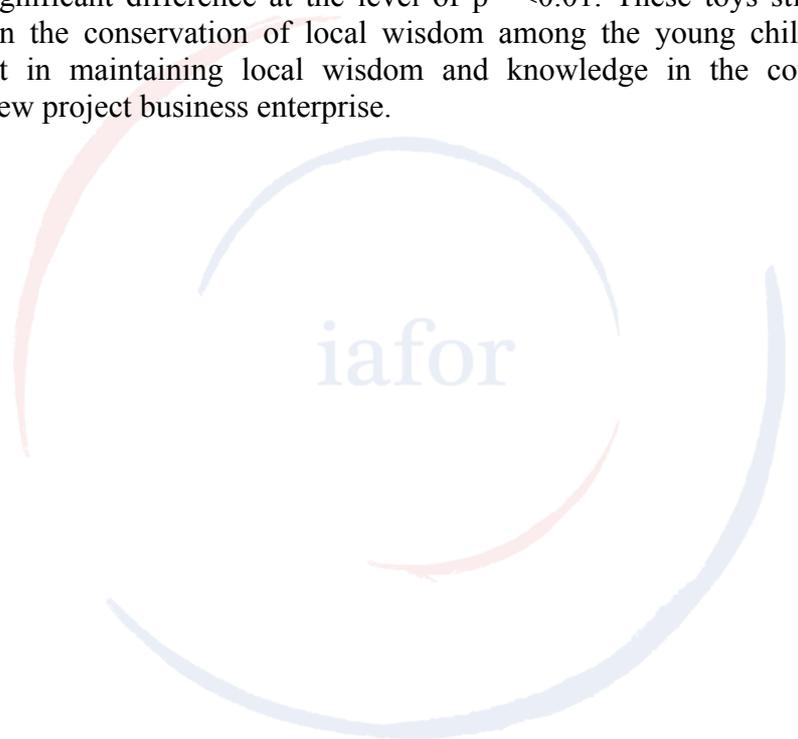
References

Udom J.) 2008 .(Development the play toy from nature material for early childhood, Thesis of master degree program in teaching and curriculum. Rajabhat Thepsatree University. Lopburi Province.

Janjat R.) 2005 .(The local toy for transfer the local wisdom and create a relationship between olderly and young children at Padad Tombol, Measarung district, Chiengrai Province. Faculty of Mass Communication, Chulalongkorn University.

Office of the Education Council of Thailand) .2014 .(Thailand Education for All Monitoring Report 2013. Bangkok: 21 Century.

Tachasot A. (2009). Using local toy for development the science process skill of level 4 children. Independent study of Education master degree program in secondary school, Chiengmai University**.**

 Pattarawad, K.(2013). Barack Obama : Sate of the Union : Nationwide Early Childhood Pre-school Program, available online at http://campus.sanook.com/1304593/

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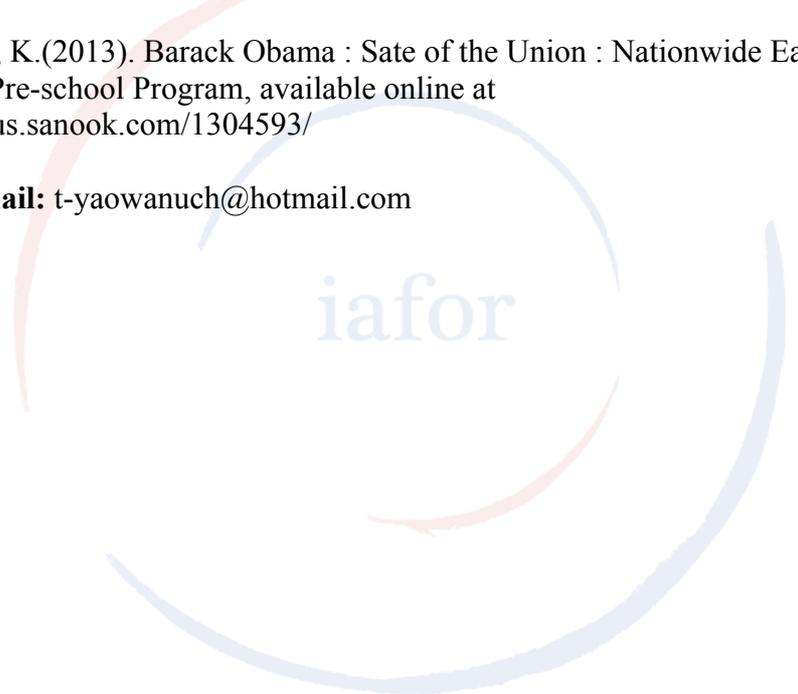
Synthesis and Characterization of Bioi/TiO2 Photocatalysts for Waste Water Treatment

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Abstract

The main cause of water pollution was generally due to human acts. Activities such as transporting the already used industrial or generated waste water and garbages from the community and put them into the water resources. As a result of the pollution occurring, organic matters were degraded and natural forms were eventually changed into other organic compounds that were not suitable in human lives and aquatic life. This research aimed to synthesize the series of BiOI doped titanium dioxide (TiO_2) photocatalysts by wetness impregnation method to test the decomposition of organic matter (Methyl orange, MO) under UV-Visible light irradiation. The study focused on the effects of BiOI doped at 2% and 4% by weight on the performance of photocatalytic process. These photocatalysts were characterized by BET technique. With that, we found out when BiOI were doped, the specific surface area and pore size was decreased in comparison with TiO_2 substance. From FT-IR the spectrum showed that the presence of adsorption peak of Ti-O-Ti stretching at 400-800 cm^{-1}. And the UV-DRS technique also reflected that the $BiOI/TiO_2$ was a stronger absorption, ranging from 190-300 nm. Moreover, the photocatalysts were thoroughly investigated via the photocatalytic degradation process of MO at a room temperature with a time period of 48 hrs. The degradations of MO were further analyzed by UV-Visible spectroscopy at 464 nm. This analysis clearly shown that $4\%BiOI/TiO_2$ was the best photocatalysts. The outcome reflected that 97.26% degradation of MO at time range of 16 hrs as compared to other series of synthesized photocatalysts for the same period of time.

Keywords: BiOX/TiO2 Photocatalysts, Photodegradation, Waste water treatment

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1. Introduction

Water is one of the essential requirements for all living things including human lives and has a very great effect on aquatic life. Due to the rapid increase in human population worldwide and the rapid growth of industrial development, the demand for water resources also increases respectively. This includes the vital role of new technology played in human life where the important reasons that causes the expansion of the water pollution. [1]

Domestic households, industrial and agricultural practices produce wastewater that can cause water pollution. The wastewater contained high concentration of organic compound such as polychlorinated biphenyl (PCBs), phenols, polycyclic aromatic hydrocarbons (PAHs), aliphatic and heterocyclic compounds. These waste organic compounds cause damages to the aquatic lives. For example the scenery degeneration of polluted water contained diseases that have an adverse impact on aquatic living.

Various methods are currently used for treatment of industrial contaminated wastewater such as precipitation, neutralization, adsorption and ion-exchange. In addition to these methods mentioned, the photocatalytic method is an alternative for the removal of organic compound in water resource using heterogeneous catalysts such as cadmium sulfide (CdS), zinc oxide (ZnO) and titanium dioxide (TiO_2). [2-4]

TiO_2 having a crystal form of anatase is known to be one of the most effective photocatalysts for the removal organic compound due to strong oxidation, high photocatalytic degradation ability, chemical and biological stability, low cost and abundance. Mechanism of the photocatalytic degradation of organic compounds is under uv-visible light irradiation, the electrons from valence band (VB) are first excited to conduction band (CB) of TiO_2. This method results in more effective separation of photogenerated electron-hole pair. The excited electrons can be trapped by surface absorbed molecular oxygen (O_2) to form super oxide anion radicals ($\bullet O_2^-$). Meanwhile, the photogenerated holes in the VB can be trapped by OH^- or H_2O species absorbed on the surface to generated hydroxyl radicals ($\bullet OH$). These two radicals are powerful oxidizing agents capable of degrading organic compound form to carbon dioxide (CO_2) and H_2O.

However, the large band gap of TiO_2 (3.2 eV) and high recombination rate of the electron-hole pairs causes photocatalytic activity of TiO_2 in visible light is very low. To solve these problems, we have attempted to improve activity of TiO_2 by modifying surface or bulk properties such as doping, surface chelating and impregnation of two semiconductor.

Bismuth oxyhalides (BiOI) semiconductors have demonstrated excellent photocatalytic activities. [5] During this process, we synthesized $BiOI/TiO_2$ photocatalysts varied the amount of BIOI by wetness impregnation. Methyl orange (MO) is chosen as model pollutants to evaluate the photocatalytic performance of the series of $BiOI/TiO_2$ under uv-visible light irradiation.

2. Experiment

2.1 Synthesis of photocatalysts.

The BiOI doped TiO_2 photocatalysts (ABiOIT where A is 2% and 4%) were synthesized by wetness impregnation method at room temperature. In a typical synthetic route, $Bi(NO_3)_3 \cdot 5H_2O$ was dissolved in 30 mL glycerol and 20 mL distilled water with stirring (Solution A). Meanwhile KI was dissolved in 30 mL distilled water with stirring then added TiO_2 20 g (Solution B). The Solution A was added dropwise to solution B under vigorous stirring. The mixture was stirred overnight. Then the mixture was clean by acetone and poured through a filter paper (125mm) in a Buchner funnel. The resulted was dried at 120 °C for 4 hrs. and calcined at 550 °C for 3hrs. Then the particle size was sieved between 250-75 μm.

2.2 Characterization of photocatalysts.

The surface area and pore size of the BiOI doped TiO_2 were characterized by the Brunauer-Emmett-Teller (BET) surface area and porosity analyzer (BEL Japan Model BELSORP-mini) at liquid nitrogen temperature (77K). The UV-Vis diffuse reflectance spectroscopy (UV-Vis DRS, UV-Visible Spectrometer; Analytic-Jena AG; SPECORD 210) equipped with an integrating sphere attachment. The function group of photocatalysts has been studied by Fourier Transform Infrared Spectroscopy (FT-IR, Perkin-Elmer, Spectrum one)

2.3 Photocatalytic activity test.

The photocatalytic activity test was carried out by decomposing of methyl orange (MO) under uv-visible light irradiation at room temperature. The uv-visible light source was a 30 W (uv-c range 100-280 nm). In a typical experiment, 0.036 g BiOI doped TiO_2 photocatalysts were add into 250 ml of a 15 ppm MO solution. Before irradiation, the mixture was stirred in the dark for 45 min to ensure the equilibrium adsorption-desorption. Then the mixture was stirring for 48 hrs and collected MO solution at 15, 30 min 1, 2, 4, 8, 12, 16, 32 and 48 hrs.

The MO solution was analyzed by UV-Visible spectroscopy (UV-Vis DRS, UV-Visible Spectrometer; Analytic-Jena AG; SPECORD 210) at 464 nm. The degradation of MO (%D) was calculated by the following equation.

$$\%D = \frac{(C_0 - C_t)}{C_0} \times 100\%$$

(1)

where, C_0 was initial concentration of MO solution (15 ppm) and C_t was final concentration of MO solution after irradiation.

3. Results and discussion

3.1 BET analysis.

The surface area and pore size of BiOI doped TiO_2 photocatalysts were investigated by using nitrogen adsorption and desorption isotherm. **Table 1** clearly shown that the series of BiOI doped TiO_2. As a result, all photocatalysts included mean pore diameters in range of 2-50 nm indicated the presence of mesoporous. The adsorption and desorption isotherm in **Figure 1** indicated that the adsorption and desorption isotherm of 4%BiOI doped TiO_2 summarized type IV due to in the first period, it showed the less amount of p/p_0. However, the amount of adsorption was increased rapidly when there was a lot of p/p_0 (S shape) because of the condensation in the capillary pore. It caused hysteresis effect which also caused from the instability of adsorption and desorption in the graph since the adsorption happened more difficultly because it needed to conquer the capillary force and the adsorption and desorption isotherm were happened at high p/p_0, Thus, that isotherm included characterized pore were funnel shape. Moreover, surface area was increased when increased the amount of BiOI.
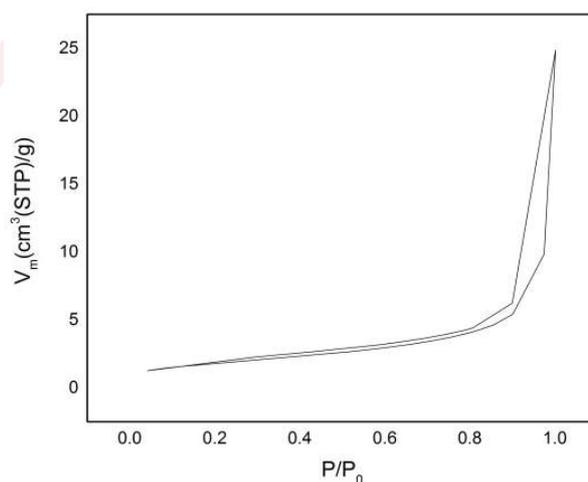
Figure 1 The adsorption and desorption isotherm of 4%BiOI doped TiO_2

Table 1 Properties of photocatalysts.

Photocatalysts	S_{BET} (m^3/g)	M_d (nm)	V_m (cm^3(STP)/g)	W (nm)	E_g (eV)
T	5.64	25.19	1.29	400	3.10
2BiOIT	5.99	13.28	1.37	405	3.06
4BiOIT	6.25	18.87	1.43	410	3.03

3.2 FT-IR Spectroscopy analysis.

The BiOI doped TiO_2 photocatalysts were observed by FT-IR spectroscopy that resulted shown in **Figure 2** the presence broad peak at 3200-3800 cm^{-1} and 400-800 cm^{-1} were indicated that –OH stretching and Ti-O-Ti stretching respectively.
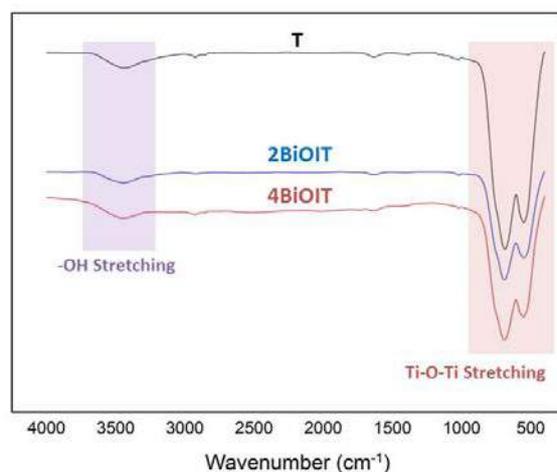
Figure 2 FT-IR spectra for 2%, 4% BiOI doped TiO_2 and pure TiO_2

3.3 UV-Vis DRS Spectroscopy analysis

The UV-Vis diffuse reflectance spectrum of the BiOI doped TiO_2 series photocatalysts shown in **Figure 3** the results shown that pure TiO_2, 2BiOIT and 4BiOIT were absorbed at 400, 405 and 410 nm respectively. As a result, from **Table 1** the band gap energy of the photocatalysts were decreased when increased the amount of BiOI. Thus the photocatalysts were added BiOI can absorbed light at increased wavelength (visible light).
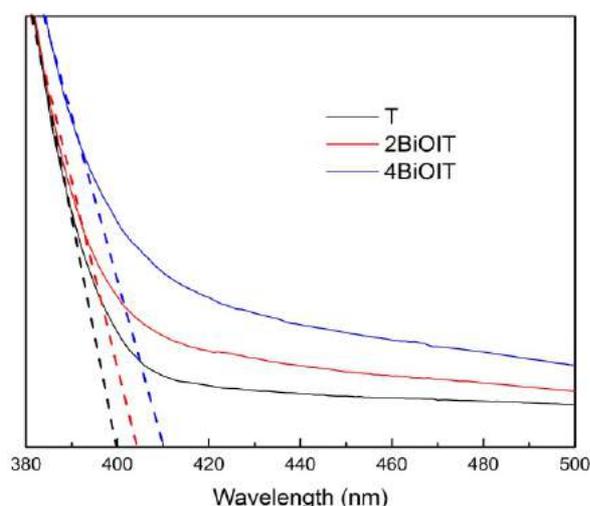
Figure 3 The UV-Vis DRS for 2%, 4% BiOI doped TiO_2 and pure TiO_2

3.4 Photocatalytic activity test.

The photocatalytic activity test carried out by decomposing of MO under uv-visible light irradiation at room temperature for 48 hrs, then used pure TiO_2, 2BiOIT and 4BiOIT**.** The result shown in **Figure 4** the 4BiOIT photocatalyst was the best performance for degraded MO at 16 hrs, about 97.26% caused when added BiOI on TiO_2. As a result, the band gap energy of BiOI and TiO_2 were overlapped caused decreased electron-hole combination. Thus the BiOI doped TiO_2 photocatalysts can be generated scavenger radicals form redox reaction for degraded MO better than pure TiO_2. This is the one reason corresponding with surface area of photocatalysts.

3.5 Mechanism of photocatalytic process.

The photocatalytic degradation mechanism of MO by 2BiOIT, 4BiOIT and pure TiO_2 following the process of equation when photocatalysts absorbed high energy from uv-visible source or sunlight, it produced excited electron transferred through band gap to the electron to the conduction band (CB) and hole at valence band (VB). The electron at CB were reacts with electron acceptor (O_2) to form superoxide anion ($O_2^{\bullet-}$) and the hole at VB were reacts with electron donor (H_2O) to form hydroxyl radical (OH•)

$$TiO_2 + hV \longrightarrow h^+ (VB) + e^- (CB)$$

Oxidation reaction; $\quad e^- (CB) + O_2 \longrightarrow \bullet O_2^-$

Reduction reaction; $\quad h^+ (VB) + OH^-, H_2O \longrightarrow OH\bullet$
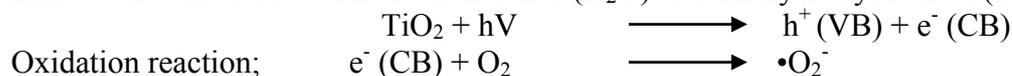
The hydroxyl radical and super oxide anion that the best oxidize reagent for degraded organic compounds to form H_2O and CO_2.
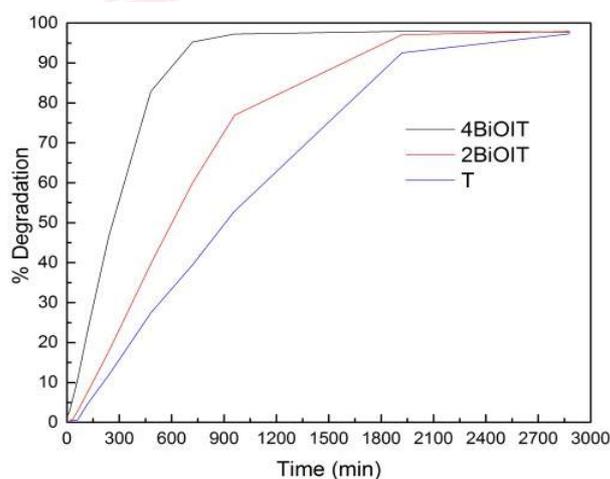
Figure 4 %Degradation for 2%, 4%BiOI doped TiO_2 and pure TiO_2

4. Conclusions

In summary, we synthesized $BiOI/TiO_2$ photocatalysts varied the amount of BIOI by wetness impregnation. Methyl orange (MO) is chosen as model pollutants to evaluate the photocatalytic performance of the series of $BiOI/TiO_2$ under uv-visible light irradiation. This analysis clearly shown that $4\%BiOI/TiO_2$ was the best photocatalysts. The outcome reflected that 97.26% degradation of MO at time range of 16 hrs as compared to other series of synthesized photocatalysts for the same period of time. The enhanced photocatalytic activity test was attributed to low band gap for decreased electron-hole recombination energy and high surface area.

5. References

O. Carp, C.L. Huisman, A. Reller, Photoinduced reactivity of titanium dioxide, Progress in Solid State Chemistry, 32 (2004) 33-177.

D. Zhao, Q. Wu, C. Yang, R.T. Koodali, Visible light driven photocatalytic hydrogen evolution over CdS incorporated mesoporous silica derived from MCM-48, Applied Surface Science, 356 (2015) 308-316.

J. Yang, X. Kong, W. Jiang, J. Cao, P. Zou, H. Luan, L. Yang, Size-controllable synthesis and photocatalytic performance of ZnO hollow spheres, Materials Science in Semiconductor Processing, 40 (2015) 713-719.

H. Zangeneh, A.A.L. Zinatizadeh, M. Habibi, M. Akia, M. Hasnain Isa, Photocatalytic oxidation of organic dyes and pollutants in wastewater using different modified titanium dioxides: A comparative review, Journal of Industrial and Engineering Chemistry, 26 (2015) 1-36.

L.G. Devi, R. Kavitha, A review on non metal ion doped titania for the photocatalytic degradation of organic pollutants under UV/solar light: Role of photogenerated charge carrier dynamics in enhancing the activity, Applied Catalysis B: Environmental, 140–141 (2013) 559-587.

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Research and Prospects of Urban Morphology Evolution in the Information Age

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Abstract

The evolution of urban morphology was usually seen as a response of human science and technology in different periods. Firstly, as a crucial area in future, information technology would be closely associated with the evolution of urban morphology. Then, based on six aspects: relationship between urban and rural, regional differences, city scale, the central area, spatial relationships and inhabitation form, the article was discussed about the possible changes of urban morphology in the information age – the decline of metropolis, the desalination of regional differences, the enlargement of city's bearing scale, the contraction of the center area, the disappearance of space barriers and the mixed autonomous community. At last, the author prospected the future trend of urban planning discipline after a review on the development of modern urban planning since the middle of the 19th century.

Keywords: the information age; urban morphology; urban planning; evolution.
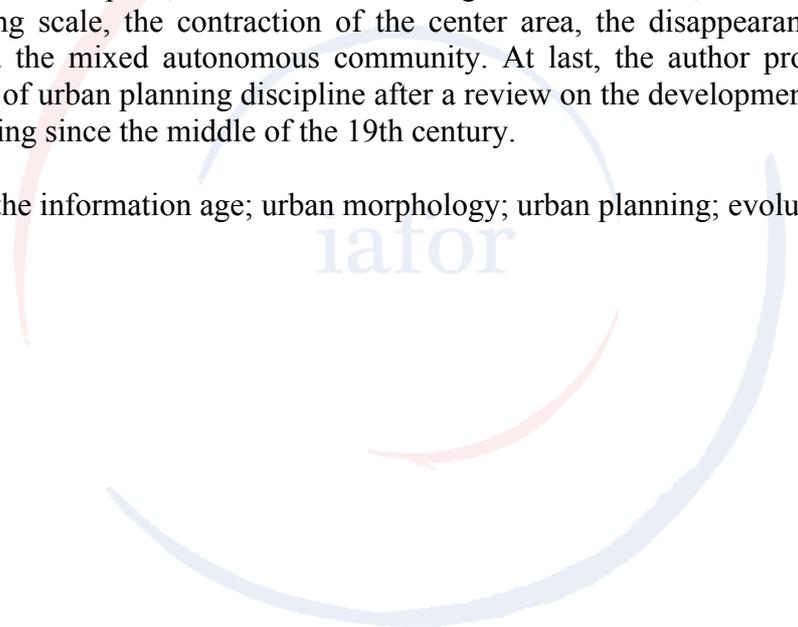
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Based on the advantage of capacity, speed and efficiency, computer has greatly enriched and changed human beings' lives during last 30 years. Considering the continuously popularity of computer throughout the world, a number of scientists, most of whom even called this century "the information age", predicted that information technology would bring a revolution in the way of human beings' production and living as what steam technology ever did in 18th century.

1. The coupling of urban morphology and information technology

The evolution of urban morphology was usually seen as a response of human science and technology in different periods. For example, Borchert(1991) divided the development of American cities into five periods: pre- railway era, "iron horse" era, trams era, auto/cheap oil era and jet/electronic communication era. As we see in China, Japan and other countries, although human beings' requirements for space retain a lot in physiology and psychology, the present morphology of city is completely different from the past.
(*1)

Figure 1: The historical map of Paris

The foundation for the formation of city is concentration, through which human beings can take all kinds of public activities, such as communication, security and trade. Carmona(2002) divided the revolution of city into 3 steps:1. as the place where market located; 2. as a center of industry; 3. as a center of modern service and consumption. Now, the significance of city is its provision of public space, to satisfy people's requirement – "appearing in the same place at the same time"(Oldenburg, 1999). Generally, the scale of old cities was small for walking before the mechanized traffic tools appeared. After the industrial revolution, the city's scale increased sharply and the space distance got shortened mentally as a result of widespread use for train and bus.

However, the most obvious difference is that physical concentration is not necessary for internet any more. Just as William Mitchell(1994) said "information technology would make people liberated from the limit of space and time". It seems no matter where you are, the distance with anybody was the same. If we realize the importance of information technology in future, its effects on the urban morphology would be inevitable. Unlike those visual inventions, it may bring a more radical change. As computer is getting prosperous all over the world, any hesitation could cause a huge loss just like our past ignorance for environmental issue in many regions. So, it is necessary to research with discretion in response to the information age.

2. The characteristics of urban morphology in the information age

The information technology's influence on urban morphology would vary a lot, such as the changes of city's size, height, density and so on. Manual Castells (1989) put forward that the computer network would become the basis of city life as the streets and screen space would be valuable as the real estate. In the next section, these changes were divided into six aspects:

2.1 The decline of metropolis

German economist Alfred weber established an urban planning theory in his famous book – *Theory of The Location of Industries* in 1909, with an emphasis on industrial agglomeration can bring effective industry competition and resource sharing, thus resulting in an economic benefits increase. The theory partly explained why metropolis could get a rapid prosperity and why people migrated from rural area to city in China(China's urbanization rate increased almost 30% in past 30 years). (*2)
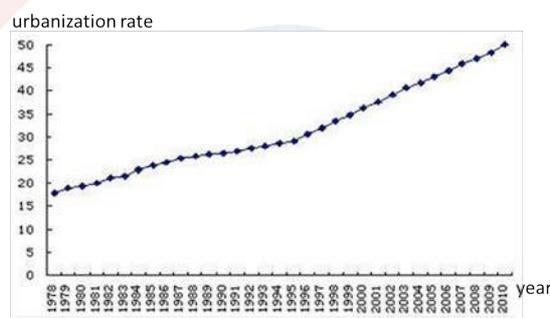
Figure 2: The change of China's urbanization rate from 1978 to 2010

However, this phenomenon is likely to reverse because of the development of information technology. The requirement for spatial concentration would be replaced by network platform without time and space restriction, while small cities obtain development opportunities due to the advantages of land, environment and labor price. There are two things happening worthy of attention in China: the industrial transfer from east to west and the development of electronic commerce and logistics industry (The transaction amount of e-commerce increased by four times from 2010 to 2015), which would be impacts to big cities. (*3)

Based on the experience of Beijing and Shanghai, after a rapid development in last several years, environment and housing problems began to burst, and the advantage of education, health, employment got weakened either. What we did only in metropolis previously can take place on internet now, such as purchasing luxury goods, joining clubs, listening to the concert and so on. When small cities rich in living space and healthy environment are contrasted with the blocked and polluted metropolis, the difference is apparent.

Transaction amount(trillion)
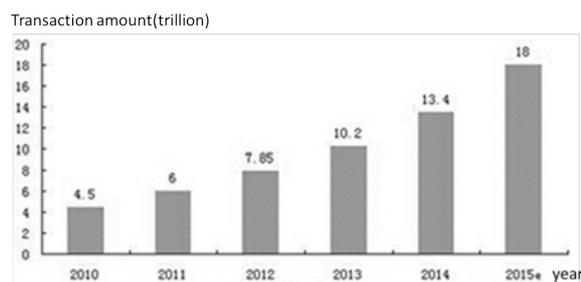
Figure 3: China's e-commerce market size from 2010 to 2015

2.2 The fade of regional differences

Regional culture suffers from the information globalization. At first, most of local features would be exhibited without concealing in internet database. If you want, any feature can be found in a few seconds, and it's hard to image what kind of culture wouldn't be known in future. Then, pioneer designers and academic authorities would have led the trend that others followe, and architects begin to search for "standard answer" via digital technique instead of referring to the regional culture. Finally, cities are likely to become a mixture of international culture created by designers from all over the world. In fact, it is what we called "world culture" that no longer belongs to a single country.
(*4)

Figure 4: The image of Shanghai, China

It is certain that some architecture samples would appear in the information age just like we met the box building with modernism technique in1920s. Those old forms in response to local climate and landform would be replaced by new technology and symbolization. For example, in Incheon, Korea, where the 2014 Asian games were just held, architects are designing "the information architecture" which meets the needs for the integration of lives. However, while virtual space becomes increasingly important, it also would be a question – "how much passion do people have for physical space?", which urges us to consider what we need from culture indeed.
(*5)

Figure 5: Modernism architecture designed by Le Corbusier

2.3 The enlargement of city's bearing scale

Generally, city's bearing scale was related to the means of transportation. But in the information age, something might be different. On the one hand, the demands for concentration are reduced by network. People no longer need to choose their residence considering the distance with CBD or factory. By contrast, living environment seems more practical. When "the tall building competition", occurred in Dubai, Shanghai and any other places, is ended as the result of the economic factors in one day, cities might expand outward in 2d space instead. Just as what happened in Mexico City recently, the value of city was reflected in providing equal living conditions.
(*6)

Figure 6: The expansion of Mexico City in 2d space

On the other hand, it is possible to take instant communication via Electronic equipment, thus helping people to work at home (what we called "SOHO") ignoring the commuter factors. Compared with face-to-face communication on transportation cost and pollution, network communication seems more cheap and low carbon. The more digital technology progresses, the less the advantages of face-to-face communication would be. It is indicated that the proportion of online communication in people's life is increasing. If the existing communication space is less attractive and urban population remains constant, the suburb would be a potential growth area.

2.4 The contraction of the center area

Accordingly, information technology reduces people's reliance to the city center. Unlike the suburbanization of American cities, European and Chinese cities kept relatively concentrated for plenty of relics and customs. A large number of commercial service facilities and business offices been provided, people preferred to live in the center area emotionally. Then, the population agglomeration and high land

prices prompted to vertical development of construction activities. For example of Xinjiekou district, Nanjing, as the most active district in the city, its construction is 3 to 4 times size of the around.

With the development of e-commerce industry, the traditional commercial space especially in the center area was severely squeezed. According to the statistics of PwC, China had hit the top of online shopping proportion in the world during 2008 to 2013, which made traditional bricks-and-mortar grocery stores suffer a serious defeat. At the same time, the administrative, health, and education departments also reduced their demands for space, and some of them even began to handle official business on the internet. The failure of Aggregation Theory would lead to the contraction of the center area, and three changes in terms of urban form are predictable: flattening of the downtown skyline, new construction instead of original open space, disappearance of the border between core and around.

2.5 The disappearance of space barriers

Once upon a time, city was divided into several isolated units by all kinds of entity borders, from which citizens could got a sense of security. In a way, the flow of urban space only occurred in the public space, such as streets, squares and parks, which hindered the communication of people. However, some space with fences, like university campus, was not used adequately. Compared to the fence, the electronic monitoring and face recognition systems can fight crime more effectively. Then, the information technology would make all pieces of urban space as a whole, and the broken and negative places would be replaced by flowing space.
(*7)

Figure 7: The split to city caused by fence

As a widely accepted method in modern urban design, functional partition is that designers give land a certain property, so as to organize and manage the construction activities. From a traditional view, a clear functional partition was conducive to strengthening citizens' communication and saving the cost of transportation. However, it is ignoring the complexity of city and imposing barriers in space that makes the method in question. On the contrary, the necessity of functional partition is denied in the information age. What information technology encourages are the mix of various functions and the diversity of urban space. With more random process for space choosing, people's daily life begins to face more possibilities.

2.6 The mixed autonomous community

In the information age, it is no doubt that more information would be received via

network media in people's daily life, but at the sacrifice of face-to-face contacts. Due to the greatly reduction of unnecessary transportation, the urban road network would have some changes: At first, people are unlikely to visit the territory of others unless necessary, so the branch roads get reduced as a result of the convenient underground transmit system. Secondly, in order to maintain the normal operation of community, the main roads would be the channels for goods supply.

The city consist of mixed autonomous communities might be adopted as the resident manner to reduce the energy cost in future. Similar to the prototype of early settlements, the new living unit composed of families or communities, is kept within walking distance. The disappearance of the locational factors makes space mixed indiscriminately, so the community can keep autonomous at a reasonable and balanced level. In addition to physiological health maintaining, people can almost do study, work and entertain in it. The amount of requiered facilities would be calculated by the computer software, which avoids energy waste necessarily. Further more people could reform their communies moderately according to individual willingness. (Fishman, 1987)
(*8)
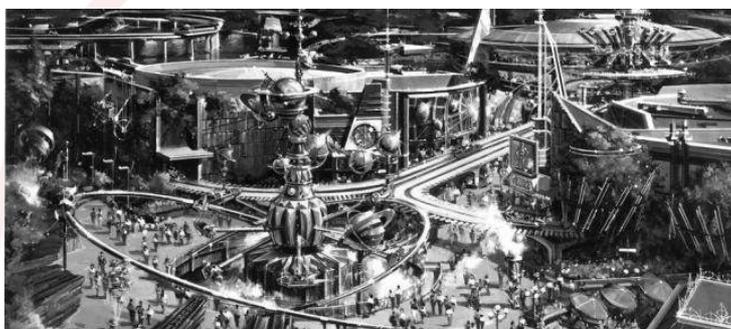
Figure 8: The imagine of future city in the information age

3. Prospects and thinking

With arranging land rapidly, the discipline of modern urban planning originating in the west, met people's needs for modern economic activities. Its vigorous development within hundred years confirmed that urban planning could not only create comfortable and beautiful space, but also realize economic value. As known, reasonable spatial layout and land consolidation were the precondition of enterprise operation, and scientific public facility mating and construction control, as important marketing manners, could even protect the citizens' rights and interests. In china, when land economy flourished was also the golden age for urban planning, so the three factors – "planning", "space" and "economy" were inseparable.

However, as the importance of land use is falling, information technology looks to break the original order someday. On the one hand, the information age will no doubt bring new opportunities to cities, such as the improvement of production efficiency and the evolution of the space pattern. On the other hand, it also inevitably brings new problems, such as the impacts on the traditional commerce and communication means. In a word, every country will confront the challenge in similar situations – "How to deal with the advantages or disadvantages of information technology correctly?" and "How to build our cities in response to the development of information technology?"

How much demand does economic activity have on space in the information age? How much promotion does reasonable land use have to information industry? Does locational condition still drive the development of enterprise? Is living in urban or village still bothering people? These questions make us worry about the future of the urban planning discipline: in a day that robots act as labor and people turn to virtual space, planners need more creativity to make their value judged. Now, Incheon and Shanghai have started the plan for "future information city", our answers are approaching step by step…

References

Duan Jin.(1999). *The development theory of urban space*. Nanjing: Jiangsu Science and Technology Press.

Duan Jin and Qiu Guochao.(2008). Appearance and development of foreign urban morphology research. *Journal of urban planning, 5*.

Carmona compiled; Feng Jiang translation.(2002). *Public places urban space: the dimension of the urban design*. Nanjing: Jiangsu Science and Technology Press.

Alfred weber.(1997). *Theory of The Location of Industries*. Beijing: The Commercial Press.

Wu Jiang.(1998). Some characteristics and trend of information city. *Modern urban research, 5*.

Spiro Kostof; Shan Hao translation.(2005). *The formation of city*. Beijing: China Building Industry Press.

Wang Jianguo compiled.(1999). *Urban design*. Nanjing: Southeast University Press.

Duan Jin.(2005). The theory and thinking of China's urban planning. *Journal of urban planning, 5*.

Song Gang and Wu Lun.(2012). The smart city under the vision of innovation 2.0. *Urban development research, 9*.

Jiang Yang.(2004). The philosophical exploration for future urban form and urban architecture. *Jiangsu social science, 1*.

K. lynch.(1981). *A Theory of Good City Form*. Cambridge MA: MIT Press.

Norberg Schulz.(1975). *Meaning in Western Architecture*.

L. Mumford.(1961). *City in History*, London: Penguin Books.

E. Saarinen.(1943). *The City*. New York: Reinhold.

T. Roger.(1987). *Finding Lost Space*, New York: Reinhold.

Su Ni, Li Xixuan and Jia Yanfei.(2007). Analysis on urban lifestyle and public building shape in the information age. *Journal of information science and technology*.

Hou Xin, Zeng Jian and Wang Xun.(2004). The urban culture in the information age – the urban space under the perspective of cultural ecology. *Journal of architects*.

Mao Yalong and Ouyang Mei'e.(2006). Urban space structure of the knowledge economy and information age. *Journal of planner, 12*.

Wu Qianbo, Huang Shan and Cui Wanzhen.(2013). The development trend of urban consumption space under the perspective of Retail format evolution. *Modern urban research, 12*.

Liu Yu.(2003). The study of urban-rural interaction and evolution of regional spatial structure in the information age. *Modern urban research, 1*.

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A study into residential energy use in Adelaide metropolitan: determinants and effects on household's consumption

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Abstract

Energy consumption in residential buildings is a significant contributor to world energy use and related greenhouse gas emissions. Residential sector contributes to about one-fifth of global energy demand that stems from space heating, cooling, lighting and use of appliances in dwellings.

This paper builds on the existing literature on domestic energy use and examines the effects of various determinants on household energy consumption in Adelaide metropolitan area in Australia. Household characteristics, dwelling type and energy related behaviour are discussed as important drivers of household energy consumption.

Data collected from a survey of 300 households in 19 sample suburbs in Adelaide is used in this research. Sample suburbs consist of different types of development, dwelling type and demographic characteristics of residents. The results confirm the importance of these factors on residential consumption and it is expected that this study will lead to develop new policy guidelines towards cities become more sustainable.

Keywords: energy consumption, household characteristics, dwelling type, consumption behaviour

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Introduction

Energy consumption is a significant element towards environmental policies addressing carbon reduction and global warming (Brounen, Kok, & Quigley, 2013). Roughly half of the world's populations live in cities and it is projected to reach 60% by 2030. As a consequence, the way cities manage energy consumption will be a key to a successful climate policy (Hallegatte & Corfee-Morlot, 2011). Since urban areas are currently the main energy consumers worldwide, energy consumption is an important element of strategies on urban environmental sustainability (Gu, Sun, & Wennersten, 2013).

Urban residential energy consumption is a significant contributor to world energy use and related greenhouse gas emissions, mainly because residential sector consume about one-fifth of global energy demand which stems from energy for space heating, cooling, lighting and running appliances in dwellings (Brounen, Kok, & Quigley, 2012).

Globally, household energy consumption grew by 20% between 1990 and 2006, accounting for almost 30% of total final consumption. Worldwide residential energy use is expected to increase by an average of 1.4% per year by 2030 (OECD, 2011).

Concerns about environmental impacts of residential energy consumption put household as the focus of policy agenda. So that study on household energy consumption and the way people use energy in their dwellings, offers an important opportunity for policy makers to develop the environmental and sustainable energy policies in order to conserve resources and to reduce carbon emissions.

Several studies have been undertaken in recent years documenting the determinants of energy consumption in various categories. Intergovernmental panel on climate change (IPCC, 2014) highlighted three arenas, namely behaviour, lifestyle and culture, technology and architecture, influencing household energy consumption. Ratti, Baker, and Steemers (2005) classified building energy consumption into four groups including urban geometry, building design, system efficiency, and occupant behaviour.

Kriström (2008) provided a review of the empirical literature on residential energy demand and categorised the variables influencing resident's energy use in two main groups: economic variables including income and energy price and non-economic variables including individual characteristics, household characteristics, information and weather. Kristrom (2008) found that income encompasses a large number of factors effecting energy consumption. For example, additional appliances which increase energy consumption are bought and used by higher income residents. A study by Australian Conservation Foundation (2007) argued however that, an increase in wealth could direct residents to buy higher quality and more environmental friendly products, in practice the opposite trend is observed.

In Australian cities, residential sector is an important component of total energy use as a result of fossil fuels based electricity generation, energy consumption in houses is one of the main contributor to national greenhouse gas emissions (ABS, 2010). Moreover, household energy use and related GHG emission has been increasing in recent years. A study undertaken by Kellet and Pullen (2012) has shown a significant growth in household annual energy use in past 30 years, particularly because of increasing floor area in new dwellings and increasing use of appliances by households. ABS (2015) findings demonstrated that household sector's net energy use increased 4.18% between 2008-09 and 2012-13. Energy use in this sector is projected to increase in the coming decade due to the increasing number of housing, increasing average floor space, declining number of people per household and use of more electrical appliances and equipment (ABS, 2010; Department of Infrastructure and Transport, 2010; Newton & Meyer, 2011).

Given that there is an extensive academic literature exists on household energy consumption, this field of academia is still new in Australia. Lenzena et al. (2006) investigated the household energy requirement on sustainable household consumption from global perspective in five countries (Australia, Brazil, Denmark, India and Japan). The results proved that characteristics of energy consumption are unique to each country and depends on various factors (i.e., socio-cultural norms, behaviour, market conditions and policy measures). Consequently it is difficult to develop effective environmental policies using research studied being undertaken outside of Australia without sufficient information and analysis related to Australian cities. Moreover residential energy use reflects entrenched and complex attitudes to the energy consumption within a unique broader society (Randolph & Troy, 2007).

Randolph and Troy (2007) is one of the first systematic attempt to explore behavioural aspects of household energy consumption in Australia. They examined in two stages how socio-behavioural characteristics and dwelling types impact household energy use. The findings show that type of housing (high-rise or low-rise), tenure, socio-demographic profile of household and lifestyle position all have impact on household energy consumption. Newton and Myer (2011) adopted a comprehensive approach to investigate consumption behaviour in Australia. They found that determinants of consumption vary for different domains of consumption. Contextual (household, dwelling and location) factors have more influence on per capita resource consumption and recognized as a key environment shaping consumption behaviour. Consumption of small-higher income household is found to be much higher than others (Newton & Meyer, 2011, 2012).

This paper attempts to determine the effect of dwelling factors and household characteristics on household energy consumption in order to provide a greater insight into residential energy use in Australians cities.

Data and methods

Nineteen suburbs in Adelaide, capital city of South Australia, were selected as the case study areas. Sample suburbs were selected according to distance to CBD, degree of differences on neighbourhood form and design and demographic characteristics of residents; and as total those suburbs represent Adelaide which reflects variations in housing size, style, type, and age. Figure 1 illustrates the location of sample areas within Adelaide. According to number of dwelling unit in each suburb, the number of household for household survey was calculated.

A postal and web based mixed-mode survey was undertaken to capture data on the determinants of household energy consumption in Adelaide. The survey targeted a household member aged 18 and older. The survey was carried out simultaneously in sample suburbs, with a total sample size of 300, in the winter of 2015. Households were selected randomly using random numbers considering the percentages of building type in each suburb.

Figure 1: Location of sample suburbs in Adelaide city

The questionnaire was divided into four sections. The first section included questions on socio-demographic profile and environmental attitude of respondents and also demographic information of household. Section 2 included questions that aimed at exploring the neighbourhood characteristics and housing type. Third section was energy consumption of transport and is not included in this paper. Finally the questionnaire was concluded by collecting data based on type of energy using in house, expenditure on energy and use of domestic appliances and energy related behaviour and concerns. A summary of demographic information and dwelling type of the sample population is provided in table 1.

Table1: Demographic characteristic and housing type of sample population

Individual characteristics								
Sex		Age group				Educational qualification level		
F 46%	M 54%	18-30 8.5 %	31-50 28%	51-70 42%	>70 21.5%	High 42%	Average 48.8%	Low 9.2%

Household					
Annual income (Australian dollar)			Ownership status		
<$50k 43.3%	$50k-$100k 32.5%	>$100k 24.2%	Owner 54%	Owner-Commit to mortgage 24%	Tenant 22%

Household type			Dwelling type	
Single HH 21.5%	Family HH 76.5%	Group HH 2%	Detached 68% Semi-detached, row 18% house 14% Unit and apartment	

In order to evaluate individual environmental attitude and individual energy consumption behaviour, respondents were asked to rank series of questions pertaining to energy use and environmental concerns. Figure 2 depicts majority of the sample population agreed that they can contribute to a better environment. However the willingness to make compromises to life style is 32% and willingness to spend extra money on energy efficient products is about 18%.

In relation to demographic factors, women respondents were defined to be more sensitive toward environmental issues and level of environmental concern. Moreover, the level of environmental concerns is higher in older age groups (51-70 years old) followed by middle age respondents (31-50 years old).
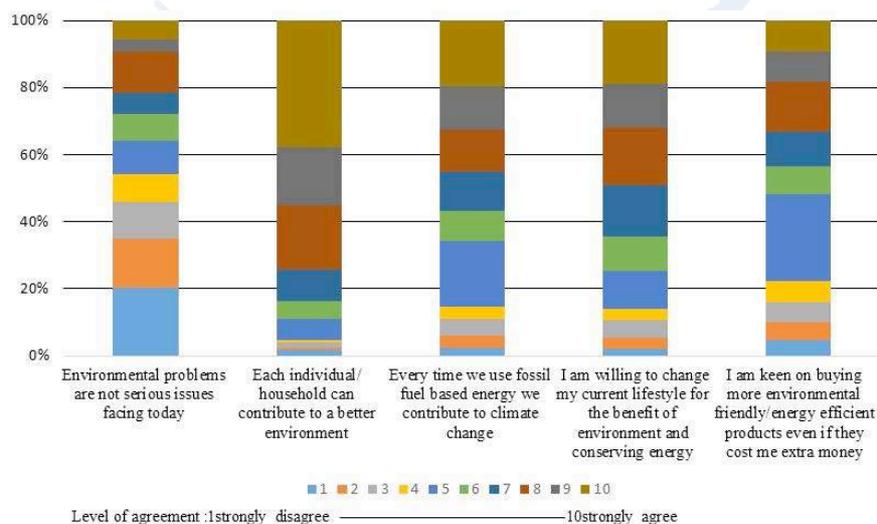
Figure 2: Environmental attitudes

It is be seen from Figure 3, the majority of respondents were involved in energy conserving behaviour in most categories. Compared to male, female participants

behaved more in energy saving matters. However there were no significant differences in engaging in conservation behaviour among all age groups of respondents.
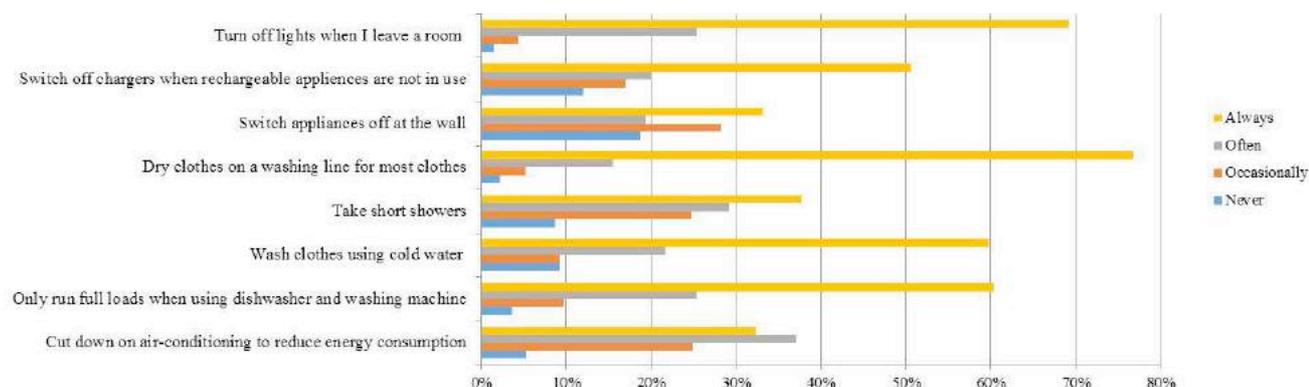
Figure 3: Energy conserving behaviour

Results and discussions

Data on types of energy used in house (including electricity and gas and presence of solar photovoltaic panels) were collected through survey. Respondents were asked to provide the expenditure on electricity and gas according to their latest billing cycle. In South Australia, households receive energy bills in three months cycle. Electricity was used by 100% of the sample population, whereas about 76% of sample households had natural gas connection. In this paper only in-home energy use, including energy for space heating, cooling, operating appliances are included in analysis.

Multiple regression analysis was performed to investigate the influence of various factors on per capita energy consumption of sample households. In this model the basic equation is as follows:

Per capita energy use $= \beta_0 + \beta_1 X_1 + \beta_2 X_1 + \ldots + \beta_n X_n + \varepsilon$

Where: β_0 =addictive constant; β_1 to β_n = regression coefficient for input variable; X_1 to X_n = all independent variables.

During the analysis insignificant variables were excluded from the model. The model enables to assess relative effects of variables on household energy use. The analysis confirms that household energy consumption is a function of household characteristics and dwelling factors. Table 2 presents the regression model for the sample population.

The model explains 35% of variance in per capita energy use. Obviously there are other significant factors like consumption behaviour suggested by other researchers (e. g., Fielding, Louis, Warren, & Thompson, 2011; OECD, 2008, 2011; Randolph & Troy, 2007; Wyatt, 2013) are not included in this model.

The most statistically significant factors associated with household energy at 1% significant level are number of occupants (household size), size of dwelling, age of dwelling, availability of solar panels and electricity for space heating and water heating. Coefficient for solar panel and household size are remarkable and negative. Smaller households account for larger amount of per capita energy use and it is significant at 5% significance level for single household type. Also household annual income and running pool and spa have positive effect at 5% level and use of top rated energy efficient appliances has negative coefficient and significant at 5% level.

Table2: Regression analysis for Energy consumption

	Coefficient	t	Sig.
Constant	49.673		
Household characteristics			
HH size	-37.745 ***	-4.142	0.000
Owner commit to mortgage	-5.644	-0.350	0.727
Household annual income	9.360 **	2.387	0.018
Presence of children	-17.855	-0.786	0.432
HH type: Single household	59.487**	1.960	0.050
Couple without children	25.755	1.226	0.221
Dwelling characteristics			
Dwelling type: Detached house	15.410	1.204	0.230
Building size	20.337 ***	2.615	0.009
Age of house	16.553***	3.414	0.001
Wall Double brick	-10.015	-0.557	0.580
material: Brick veneer	10.632	0.638	0.524
Thermal insulation of roof/walls	35.687 *	1.587	0.098
Availability of solar panels	-45.397 ***	-3.375	0.001
Electricity: Water heating	47.315***	3.440	0.001
Space heating	38.234 ***	2.458	0.009
Appliances: using top rated energy efficient appliances Running pool and spa	-30.267 ** 54.231 **	-1.923 2.098	0.055 0.037
F 5.68 ***			
***P<0.01, **P<0.05, *P<0.1			
Dependent variable: Per capita energy consumption			

Since the majority of respondents reported brick veneer and double brick as outside wall material, wall material is not defined as significant predictor for energy in this study.

Conclusion

This study reports the findings of the household energy survey of a representative sample of 300 households in Adelaide city. First the level of environmental concerns and energy consumption attributes of individual respondents was investigated. Then, the effect of various factors on per capita household energy consumption was examined. The findings of this study reveal that in-home energy use varies between households and dwelling factors and household characteristics play a significant role on the per capita energy use of households.

Household size is one of the remarkable variables and has a strong negative effect on energy consumption, so that single person households consume higher amount of energy. Household annual income is also a significant determinant which leads to greater use of energy.

The model outcome shows that there is an association between the level of energy use and dwelling characteristics. Five variables relating to housing characteristics namely building size, age of house, installed solar panels on roof, electricity use for space heating and water heating and type of appliances utilized in home, are recognized as dominant factors for energy use.

The model explained about 35% of total variance of the domestic energy use. Further investigation is required to include set of other related indicators like household behaviour in this model. Understanding the actual occupant behaviour toward energy use will give us a better insight on determinant factors of residential energy consumption.

References

ABS. (2010, April 2010). Energy in Focus: Energy Efficiency of Australian Homes. Retrieved 30 MAY, 2014, from http://www.abs.gov.au/AUSSTATS/abs@.nsf/Lookup/4614.0.55.002Main+Features2 Apr+2010

ABS. (2015). Australian Environmental-Economic Accounts, 2015. 9 April 2015. Retrieved 7 May, 2015, from http://www.abs.gov.au/ausstats/abs@.nsf/mf/4655.0

Australian Conservation Foundation. (2007). Consuming Australia: Main Findings Melbourne.

Brounen, D., Kok, N., & Quigley, J. M. (2012). Residential energy literacy and capitalization. Retrieved on, 23.

Brounen, D., Kok, N., & Quigley, J. M. (2013). Energy literacy, awareness, and conservation behavior of residential households. Energy Economics, 38, 42-50.

Department of Infrastructure and Transport. (2010). Our Cities: The Challenge of Change – Background and Research Paper: Department of Infrastructure and Transport.

Gu, Z. H., Sun, Q., & Wennersten, R. (2013). Impacts of urban residences on energy consumption and carbon emissions: An investigation in Nanjing, China. Sustainable Cities and society, 7, 52-61.

Hallegatte, S., & Corfee-Morlot, J. (2011). Understanding climate change impacts, vulnerability and adaptation at city scale: an introduction. Climatic Change, 104(1), 1-12.

IPCC. (2014). Climate change 2014: Mitigation of Climate Change Working group III contribution on the IPCC fifth Assessment Report. Berlin, Germany Intergovernmental Panel on Climate Change.

Kellet, J., & Pullen, S. (2012). Prospects for energy efficiency in Australian buildings: a review of current opportunities. Architectural Science Review, 55:2, 92-101.

Kriström, B. (2008). Residential Energy Demand. OECD Journal: General Papers, 2008, 95-115.

Lenzena, M., Wierb, W., Cohen, C., Hayamid, H., Pachaurie, P., & Schaefferf, R. (2006). A comparative multivariate analysis of household energy requirements in Australia, Brazil, Denmark, India and Japan. Energy, 31, 181-207.

Newton, P., & Meyer, D. (2011). Consuming the urban environment: a study of the factors that influence resource use in an Australian city In P. Newton (Ed.), Urban Consumption (pp. 173-197): CSIRO PUBLISHING.

Newton, P., & Meyer, D. (2012). The Determinants of Urban Resource Consumption Environment and Behavior, 44(1), 107-135.

OECD. (2011). Greening Household Behaviour: The Role of Public Policy, . Paris: OECD Publishing

Randolph, B., & Troy, P. N. (2007). Energy Consumption and the Built Environment: A social and behavioural analysis: City Futures Research Centre, University of New South Wales Sydney.

Ratti, C., Baker, N., & Steemers, K. (2005). Energy consumption and urban texture. Energy and Buildings, 37(7), 762-776. doi: http://dx.doi.org/10.1016/j.enbuild.2004.10.010

Wyatt, P. (2013). A dwelling-level investigation into the physical and socio-economic drivers of domestic energy consumption in England. Energy Policy, 60, 540-549.

Evaluation of Zeolite Efficiency for Removal of Cesium Ions from Seawater

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Abstract

Cesium is a dangerous radioactive material which is a problem to marine life when it leaks into seawater. Zeolites are substances for removing cesium because they absorb cationic elements and are widely used due to their simplicity, high efficiency and low cost. The objective of this study was to investigate the efficiency of NaCl treated zeolite for removal of cesium ion from synthetic seawater. This study was carried out by performing batch experiments. A synthetic seawater solution of 100 mL containing 80 mg L-1 of non-radioactive cesium was mixed with NaCl treated zeolite of two sizes, 300-424 µm. and 425-850 µm. The sorbent weight per solution volume ratios used in the experiment were 5, 10, 15, and 20 g. per 100 mL of seawater. The contact times were 10, 20, 30, 60 and 120 minutes. The effect of zeolite size was an important factor in cesium removal. Zeolite with a size of 300-424 µm. showed greater efficiency than that with a size of 425-850 µm. The optimum sorbent weight per solution volume ratio was 15 g. per 100 mL of seawater. The best contact time was 60 minutes with more than 80% uptake occurring through rapid adsorption. These results show that NaCl treated zeolite is a promising material for removing cesium from contaminated seawater.

Keywords: Adsorption, Zeolite, Cesium removal

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1. Introduction

Releasing radiation into the environment is a serious problem because radiation can produce harmful effects on living organisms. The release of large amounts of radioactive elements into aquatic environment can be accumulated by biota and are cycled through the food web to eventually threaten human health, ranging from minor early skin lesions to cancer (Shaw & Bell, 1994).

Cesium is the most plentiful radionuclide in nuclear fission products that is accidentally released. It has a long half-life of about 30 years and is considered a hazardous element to the environment. Currently, among many techniques used for the treatment of radioactive waste, the most common ones are chemical precipitation, ion-exchange, adsorption and reverse osmosis. The ion exchange process is considered one of the more effective methods for the removal of radioisotopes from liquid waste. Ion exchange is a chemical treatment process used to remove unwanted ionic species from wastewater. It is basically a simple process based on reversible interchange of ions between liquid and solid with no permanent changes in the structure of the solid.

Zeolite is the focus in this study because it has high cation-exchange capacities and selectivity for many radioactive materials (El-Kamash, 2008) & (Yasmen & Maysoon, 2011). This experiment aims to study the appropriate conditions for removal of cesium and strontium contamination in artificial seawater using a batch experiment.

2. Materials and methods

2.1 Adsorbents

Selected zeolite with particle size of 300-424 μm and 425-850 μm was obtained by crushing zeolite and using sediment sieves with different mesh sizes ranging between 300-424 μm and 425-850 μm.

2.2 Preparation of treated NaCl zeolite particles as adsorbents

First, refluxe 3 g. of zeolite with 100 mL of 1.0 M NaCl at room temperature for 24 hours. After 24 hours, rinse the mixture and wash zeolite with 300 mL of deionized water. Then, activate the zeolite by mechanical shaking with 25 mL of methanol for 60 minutes. Filter and dry the zeolite at 50 °C for 3 h. Then, the activated zeolite samples were ready to be used in the experiment.

2.3 Artificial seawater

The artificial seawater was prepared by dissolving commercial sea salt in deionized water. An appropriate amount of commercial sea salt was added into deionized water to obtain a salinity of 35 ppt. A digital salinity probe was used to measure salinities in the artificial seawater. In addition, a pH value was recorded in order to be used as additional information of the experiment.

2.4 Chemical preparation

A solution of 80 mg/l of cesium chloride was prepared by dissolving 0.1014 gram of cesium chloride (MW 168.35) in 1,000 ml of artificial seawater with salinity of 35 ppt.

2.5 Batch sorption experiment

The experiments were performed in a batch reactor at room temperature with continuous stirring at 160 rpm.

2.6 Sorption isotherm

NaCl treated zeolite of 5 g., 10 g., 15 g., and 20 g. of were left in contact with 100 ml of cesium chloride solution (80 mg/l) at pH values of 8.4. The samples were filtered with No.5 filter paper to avoid any precipitation before the ICP-MS measurement.

The analysis of the isotherm data is important to develop an equation which accurately represents the results and which could be used for design purposes. In order to investigate the sorption isotherm, two equilibrium models were analyzed: Langmuir and Freundlich isotherm equations. These two isotherm models were derived and used for gas adsorption by microporous adsorbents, and then extended to solute adsorption from aqueous solutions. The Langmuir model is obtained under the ideal assumption of a totally homogeneous adsorption surface, where the Freundlich isotherm is suitable for a highly heterogeneous surface (Hui, Chao & Kot, 2005).

2.6.1 Langmuir isotherm

The Langmuir sorption isotherm is the best known of all isotherms describing sorption and it has been successfully applied to many sorption processes. It is represented as:

$$q_e = q_m \frac{bC_e}{1+bC_e} \qquad (1)$$

In the formula, Ce is the equilibrium aqueous metal ions concentration (mg/l), q_e the amount of metal ions adsorbed per gram of adsorbent at equilibrium (mg/g), q_m and b is the Langmuir constants related to the maximum adsorption capacity and energy of adsorption, respectively. The values of q_m (mg/g) and b (mg^{-1}) can be determined from the linear plot of C_e/q_e versus C_e.

2.6.2. Freundlich isotherm

The Freundlich isotherm is most frequently used to describe the adsorption of inorganic and organic components in solution. This fairly satisfactory empirical isotherm can be used for a non-ideal sorption that involves heterogeneous sorption and is expressed as:

$$\log q_e = \log K + \frac{1}{n}\log C_e \qquad (2)$$

In the formula, K is briefly an indicator of the adsorption capacity and $1/n$ the adsorption intensity. The magnitude of the exponent $1/n$ gives an indication of the favorability of adsorption. Values of n, where $n > 1$ represent a favorable adsorption condition. By plotting log q_e versus logC_e, values of K and n can be determined from the slope and intercept of the plot.

2.7 Removal efficiency

In order to obtain the removal efficiency of metal ions by the adsorbent, one must considerthe percent removal as:

$$\text{Removal efficiency} = \frac{C_0 - C_e}{C_0} \times 100 \qquad (3)$$

C_0 is the initial metal ion concentration (mg/l), and C_e the equilibrium metal ion concentration (mg/l)

3. Results and discussion

3.1 Characterization

The zeolite sample must be analyzed for chemical composition and crystal structures of the zeolite sample, since the ion exchange characteristics of any zeolite are dependent on the chemical composition and crystal structures of zeolite. Chemical compositions were analyzed by X-Ray Fluorescence Spectrometer (XRF) and crystal structures were identified from X-ray diffraction (XRD). The result of chemical composition of zeolite is shown in Table1.

Table 1

Chemical composition of the zeolite sample

Element	Concentration (%wt)
SiO_2	78.00
Al_2O_3	12.60
CaO	3.50
K_2O	3.11
Fe_2O_3	1.32
MgO	0.73
Na_2O	0.38
TiO_2	0.19
BaO	-
SrO	-

3.2 Effect of particle size

Figure 1 shows relationship between size of zeolite and percentage removal of cesium. Two sizes of Zeolite were prepared, 300-424 μm and 425-850 μm, then shaken in 100 ml cesium contaminated seawater for 120 min. In general, the smaller size has a greater efficiency than the larger size because it has larger surface areas of its particles (Suzuki, Ozawa, Ochi, Chikuma & Watanabe, 2013). Findings showed that zeolite of the size 300-424 μm could adsorb cesium ions from seawater (74.38%) better than at a size of 425-850 μm (67.51%).
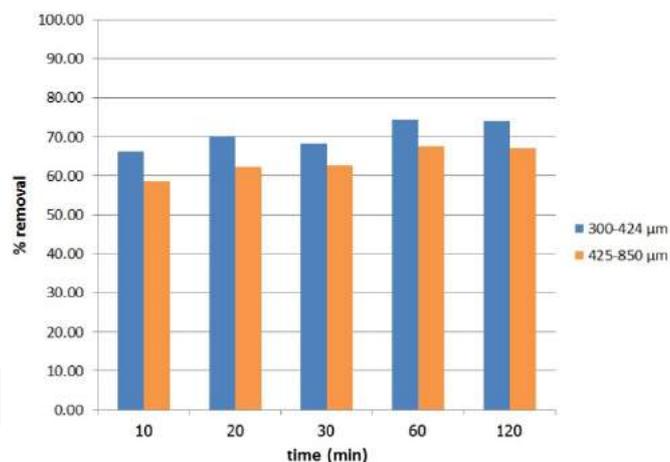
Figure 1: removal capacity comparison by size of zeolite

3.3 Effect of shaking time

The effect of shaking time was studied; 15 g. of zeolite was shaken in 100 ml seawater for different periods ranging from 10 minutes to 2 hours. The result in Figure2 shows that zeolite of 300-424 μm has a fast adsorption of cesium in seawater, more than 80%, within 20 minutes, followed by steady adsorption.
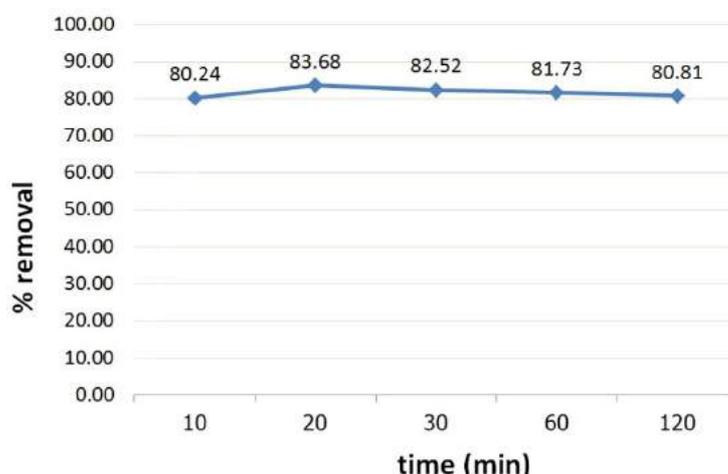
Figure 2: Time dependence of Cs uptake

3.4 Effect of adsorbent weight

The different amounts of zeolite used in this study were 5 g. 10 g. 15 g. and 20 g. shaken in 100 ml. seawater solution for 2 hours. These factors were expected to show the optimum adsorbent weights that could be used to achieve high removal efficiency. Figure 3 shows that the efficiency of using 300-424 μm zeolite for 15 g. was similar to that using 20 g. zeolite (p-value >0.05) for the removal of cesium from seawater. For this reason, the optimum adsorbent in this study was 15 g/100 ml.
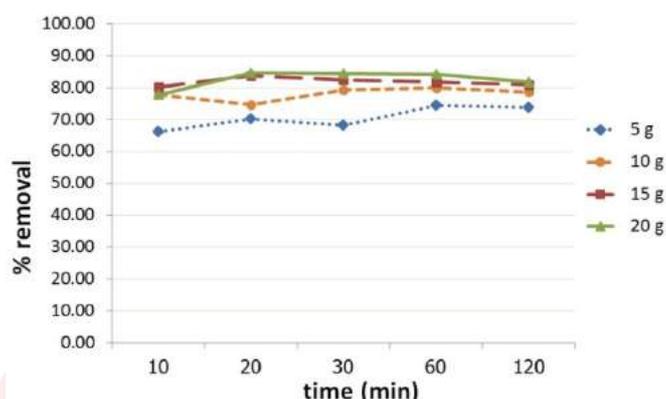
Figure 3: Relationship between adsorbent weight and percent cesium removal

3.5 Sorption isotherm study

Figure 4 and Figure 5 show the correlation coefficients (R^2) of cesium adsorption isotherms by zeolite in Langmuir's equation and Freundlich's equation were 0.9555 and 0.9606 respectively. The adsorption isotherm data was fitted to both the Freundlich and Langmuir isotherm equations ($R^2 > 0.9$). However, the linear Langmuir adsorption equation of cesium showed a negative value as indicated in Table 2. Thus, adsorbent better fit the Freundlich's equation as shown by the higher regression coefficient.
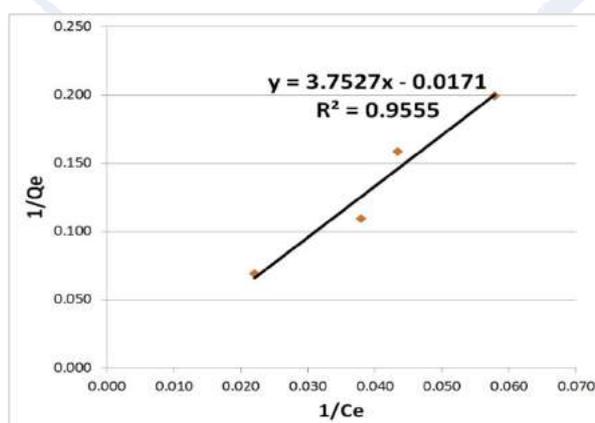
Figure 4: Linear Langmuir adsorption isotherm of Cesium
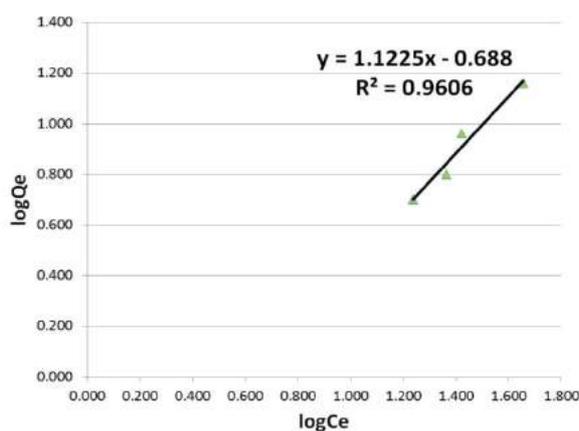
Figure 5: Linear Freundlish adsorption isotherm of Cesium

Table 2

Isotherm parameters for adsorption of cesium onto zeolite

Isotherm model	Isotherm parameters	Metal cesium
Langmuir isotherm	Qmax (mg/g)	0.2664
	b	-219.51
	R^2	0.9555
Freundlish isotherm	K (mg/g)	0.205
	1/n	1.1225
	R^2	0.9606

4. Conclusions

The zeolite had increased removal capacity when the size was small. The optimum zeolite used was 15 g/100 ml and the maximum removal efficiency of cesium was 83.68%. Zeolite had rapid adsorption of cesium in seawater, more than 80% within 20 minutes. The adsorption isotherm data best fits the Freundlich model with a maximum adsorption capacity of 0.205 mg/g.

References

El-Kamash, A.M. (2008). Evaluation of zeolite A for the sorptive removal of Cs^+ and Sr^{2+} ions from aqueous solutions using batch and fixed bed column operations. *Journal of Hazardous Materials, 151*, 432–445.

Hui, K.S., Chao, C.Y.H., Kot, S.C. (2005). Removal of mixed heavy metal ions in wastewater by zeolite 4A and residual products from recycled coal fly ash. *Journal of Hazardous Materials. B127.* 89–101.

Suzuki, N., Ozawa, S., Ochi, K., Chikuma, T., Watanabe, Y. (2013). Approaches for cesium uptake by vermiculite. *Journal of Chem Technol Biotechnol, 88,* 1603–1605.

Shaw, G. & Bell, J.N.B. (1994). Plants and radionuclides in Plants and Chemical Elements: Biochemistry, Uptake, Tolerance and Toxicity. pp. 179–220. Ed. by M.E. Farago, VCH, Germany.

Yasmen, A.M. & Maysoon, J. Z. (2011). Treatment of radioactive liquid waste (Co-60) by sorption on Zeolite Na-A prepared from Iraqi kaolin. *Journal of Hazardous Materials, 196,* 228– 233.

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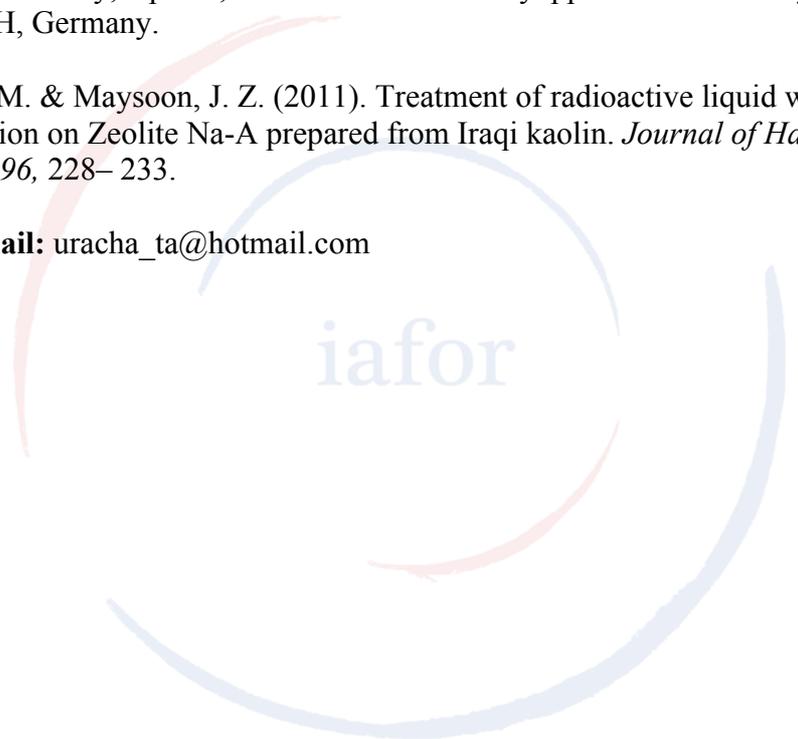
Removal Efficiency of Cesium and Strontium in Seawater by Zeolite Fixed-Bed Columns

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Abstract
It is documented that the Chernobyl nuclear meltdown released large amounts of Cs-137, Cs-134 and Sr-90 (100, 50 and 8 PBq, respectively). The accident had a devastating impact on the marine environment. The main aim of this research was to study the removal of cesium and strontium in seawater by natural zeolite. Experiments using fixed bed column with different bed depths, pH levels, and flow rates of seawater were conducted. The salinity of experimental seawater was adjusted to 35 ppt.; and concentrations of cesium and strontium were 80 and 20 mg/l. Natural zeolite treated with NaCl was found appropriate for use in this experiment. Zeolite could remove cesium but not strontium from the marine environment. The zeolite removal efficiency of cesium was compared at seawater pH values of 4, 7, and 9. Zeolite efficiency was significantly greater at a pH of 9 than at a pH of 4 ($P<0.05$). Efficiency removal by zeolite was significantly better at a bed depth of 6 cm. (18.84 cm^3) than at only 3 cm. depth (9.42 cm^3) ($P<0.05$). However, different flow rates of 3 and 6 ml/min. during zeolite removal did not significantly affect cesium levels ($P>0.05$).

Keywords: Cesium, Strontium, Removal, Zeolite

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1. Introduction

It is documented that the Chernobyl nuclear meltdown released large amounts of Cs-137, Cs-134 and Sr-90 (100, 50 and 8 PBq, respectively) (Holm, 1997). The accident had a devastating impact on the marine environment. These radionuclides arise from the burning of uranium fuel in a nuclear reactor (high-level waste), which pose a great risk to human health. Radioactive uptake pathways are quite variable according to species and their habitats. Fish in nature normally encounter different uptake routes for radionuclides present in the environment. Radioactivity will enter the organism via contaminated food or will be accumulated directly from the surrounding water through drinking, by absorption across the gills, and to a minor extent by absorption through the total surface of the fish. Humans also experience radionuclide uptake through fish consumption.

Different techniques such as chemical precipitation, evaporation, and ion exchange have been used for the treatment of aqueous waste solutions containing these radioactive wastes. Ion exchange technique has become one of the most commonly used treatment methods for such aqueous streams due to its simplicity, selectivity and efficiency. Ion exchange resins are insoluble granular substances which have in their molecular structure acidic or basic radicals that can be exchanged. The positive or negative ions fixed on these radicals are replaced by ions of the same sign in solution in the liquid in contact with them (Lenntech, 2013).

The ion exchange property is one of the main features that zeolites exhibit (Rodriguez-lznag, Petranovskii, & Rodriguez-Fuentes, 2014); Zeolite can be used for cation exchange. Zeolites are used in process water softening and water treatment for the removal of lead, mercury, cadmium and silver ions. Moreover, zeolites are absorbent materials that can separate a mixture of gases and vapors such as ammonia, hydrogen, oxygen, nitrogen, carbon dioxide and sulfur dioxide.

The main aim of this research was to study the removal of cesium and strontium in seawater by natural zeolite.

2. Experimental Design

An experiment was designed using zeolite fixed bed columns with different bed depths of zeolite, and several pH levels and flow rates of seawater. The salinity of experimental seawater was adjusted to 35 ppt.; CsCl and SrCl were used to represent Cs and Sr ions in the seawater and the concentrations of Cs and Sr ions were 80 and 20 mg/l, respectively.

2.1 Materials

2.1.1 Preparation of zeolite particles as adsorbents

Three types of natural zeolite were purchased: Classica Zeolite, Hi Filter Zeolite and MA Zeolite. The natural zeolite was sent for analysis at the Department of Geology, Faculty of Science, Chulalongkorn University. Prior to the experiment, the zeolite sample must be analyzed for crystal structures and chemical composition of the

zeolite sample. The ion exchange characteristics of any zeolite are dependent on its crystal structures and chemical composition. Crystal structures were identified from X-ray diffraction (XRD) and chemical composition analyzed by X-Ray Fluorescence Spectrometer (XRF) at Chulalongkorn University (CU, 2014).

Table 1

Chemical composition of the zeolite sample

Element	Classica Zeolite(%wt)	Hi Filter Zeolite(%wt)	MA Zeolite(%wt)
SiO_2	78.00	76.50	73.60
Al_2O_3	12.60	12.70	13.60
CaO	3.50	0.24	4.27
K_2O	3.11	5.39	2.87
Fe_2O_3	1.32	0.90	2.21
MgO	0.73	-	0.88
Na_2O	0.38	3.99	1.82
TiO_2	0.19	0.15	0.33
BaO	-	-	0.14
SrO	-	-	0.12

Table 2

Crystal structures of the zeolite sample

Zeolite name	Mineral compositions
Classica Zeolite	- Calcium Aluminum Silicate Hydrate - Potassium Aluminum Silicate Hydrate - Sodium Calcium Aluminum Iodide Silicate
Hi Filter Zeolite	- Calcium Aluminum Silicate - Potassium Sodium Aluminum Silicate Hydrate - Sodium Calcium Aluminum Iodide Silicate - Sanidine
MA Zeolite	- Calcium Aluminum Silicate Hydrate - Sodium Calcium Aluminum Iodide Silicate - Barium Aluminum Chloride Silicate Hydrate - Strontium Aluminum Silicate Hydrate

The result shown in Table 1 and Table 2 indicated that Classica Zeolite has the least chemical composition. Therefore, Classica Zeolite was used in all experiments.

Natural zeolite was washed with deionized water and dried at 103∘C for 3 hours. Then, the required particle size of 850-1000 μm was obtained from the natural zeolite using sediment sieving with different mesh sizes ranging from 850-1000 μm.

2.1.2 Natural zeolite treated by sodium chloride

The zeolite was crushed to a size of 850-1000 μm.; 3.0 g of zeolite was continuously refluxed with 100 mL of 1.0 M NaCl at room temperature (R.T) for 24 hours. The mixture was filtered and the zeolite was, then, washed with 300 mL of deionized water. The zeolite was activated by mechanical shaking with 25 mL of methanol twice for 60 minutes. The zeolite was filtered and dried at 50∘C for 3 hours.

2.1.3 Preparation of synthetic seawater

Synthetic seawater was prepared by adding commercial sea salt into demineralized water. An appropriate amount of the commercial sea salt was added to demineralized water to obtain the salinity of 35 ppt. The salinity was measured by a digital salinity probe. At the pilot study, four liters of synthetic seawater was used for each set of experiments; and appropriately 160 grams of commercial sea salt was added into this amount of demineralized water. The pH of synthetic seawater was adjusted to be 4, 7 and 9.

2.1.4 Chemical preparation

A solution of cesium and strontium in synthetic seawater at the concentration of 80 and 20 mg/l was prepared by dissolving 0.1014 g. and 0.0609 g. of cesium chloride and strontium chloride in 1000 ml of the synthetic seawater. The synthetic seawater, which was prepared in the previous step, with salinity of 35 ppt., was adjusted to pH levels of 4, 7 and 9.

2.2 Experimental Procedures

A set of pilot experiments was conducted to determine the feasibility of the study. The study of Cesium and Strontium removal efficiency consisted of the following steps:

1. A 2 cm-diameter column was filled with ten grams and five grams of the sieved natural zeolite to reach the height of 3 cm. and 6 cm, respectively. An amount of fiberglass was placed at the bottom of the column with thickness of 1 cm.
2. One liter of solution containing cesium and strontium and salinities of 35 ppt. was poured into the zeolite-packed columns with controlled flow rate continuously through the column. The flow rates were 3 ml/min and 6 ml/min.
3. After the continuous flow, every 100 ml of the outlet solution was collected for cesium and strontium concentration analysis using ICP-MS.
4. The process from Steps1, 2 and 3 was repeated for natural zeolite treated by sodium chloride.
5. Experiments using natural zeolite and treated natural zeolite were conducted three times to obtain mean values as results.

2.3 Data record

The distribution coefficient (K_d) in radionuclide removal: The efficiency of an ion exchange is often measured by distribution coefficient K_d of radionuclides with the percent removal ($E\%$) and percent cesium and strontium remaining in solutions R (%) as well as amount of metal ion adsorbed onto the zeolite materials were calculated from the following equations (Borai, Harjulab, Malinenb, & Paajanenb, 2009):

$$E\ (\%) = \frac{Ao - Ae}{Ao} \times 100 \tag{1}$$

$$R\ (\%) = (Ae \div Ao) \times 100 \tag{2}$$

$$Kd = \frac{Ao - Ae}{Ae} \times \frac{V}{m} \qquad \text{(ml/g)} \tag{3}$$

Where A_o and A_e are the initial and equilibrium activities per unit volume for the corresponding radionuclide, respectively; V is the volume of the aqueous phase (ml), and m is the weight of the zeolite material (*g*).

3. Results and discussion

Initial results revealed that zeolite treated with NaCl was appropriate for use in this experiment. Zeolite could remove cesium and strontium from the deionized water (Figure 1.), but not strontium from synthetic seawater at all pH levels (Figure 2.). Results of chemical composition analyzed by X-Ray Fluorescence Spectrometer (XRF) revealed that Strontium in the structure of the zeolite sample only increased by 0.01%wt (Table 3).

Analysis shows that the zeolite could not remove strontium from synthetic seawater at all pH levels. At higher salinity levels in seawater, various positive ions were present in the solution competing with strontium. The ion exchange process could have been disrupted by various ions in seawater (Borai et al., 2009).
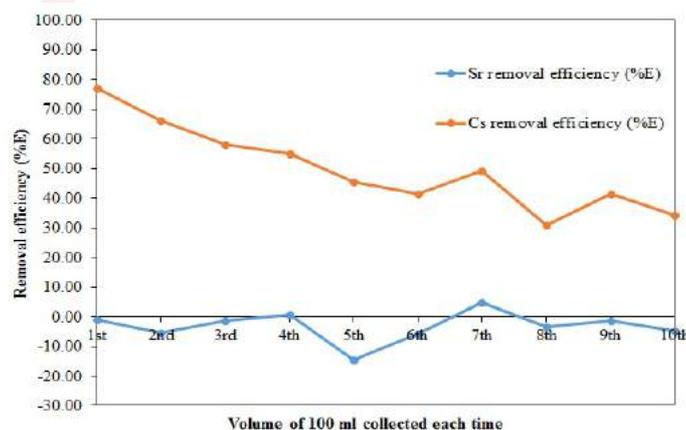
Figure 1. Removal efficiency of cesium and strontium in seawater
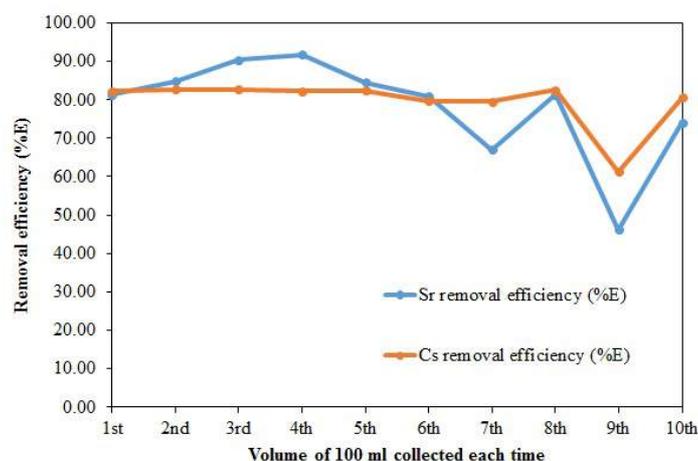
Figure 2. Removal efficiency of cesium and strontium in DI water

Table 3

Chemical composition of the zeolite sample

Element	Non-treat (%wt)	Treat (Before) (%wt)	Treat (After) (%wt)
SiO_2	78.00	77.40	76.00
Al_2O_3	12.60	13.00	12.80
CaO	3.50	1.33	1.14
K_2O	3.11	3.08	4.55
Fe_2O_3	1.32	1.40	1.45
MgO	0.73	0.75	0.81
Na_2O	0.38	2.68	1.92
TiO_2	0.19	0.25	0.25
BaO	-	-	-
SrO	-	0.05	0.06
Cs_2O	-	0<LLD (0)	0.84
ZrO_2	-	0.04	0.04
MnO	-	0.03	0.04

Note. Non-treat is natural zeolite
Treat (Before) is natural zeolite treated by sodium chloride that before used in the process
Treat (After) is natural zeolite treated by sodium chloride that after used in the process

3.1 Bed depth effects

Zeolite packed columns were used at heights of 6 cm. and 3 cm. (18.84 and 9.42 cm^3). The study involved an experiment with seawater salinity at 35 ppt., the concentration of cesium at 80 mg/l and, pH levels of seawater of 4, 7, 9, and flow rates of 3 and 6 ml/min. Results revealed that the cesium removal efficiency (%E) decreased with increasing time at all flow rates of seawater and bed depths. At a bed depth of 6 cm (18.84 cm^3), Zeolite efficiency is greater than at a bed depth of 3 cm. (9.42 cm^3) (Figures 3 and 4). The efficiency of removal by zeolite was significantly better at a bed depth of 6 cm. (18.84 cm^3) than with only a 3 cm. depth (9.42 cm^3) (P<0.05). The increase in the ion sorption with bed depth was due to the increase in the sorption doses in a larger bed, which provided greater sorption sites for cesium ions (EI-Kamash, 2008.) Therefore, a bed depth of 6 cm. is appropriate for use in this experiment.
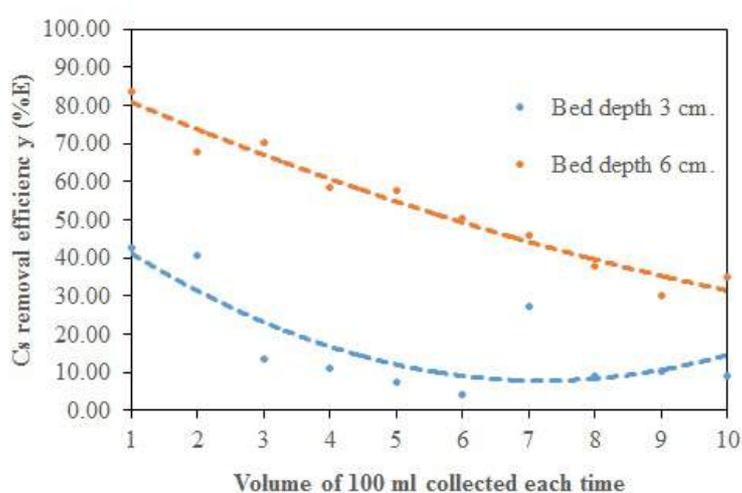
Figure 3. Removal efficiency of cesium in seawater at flow rate 3 ml/min
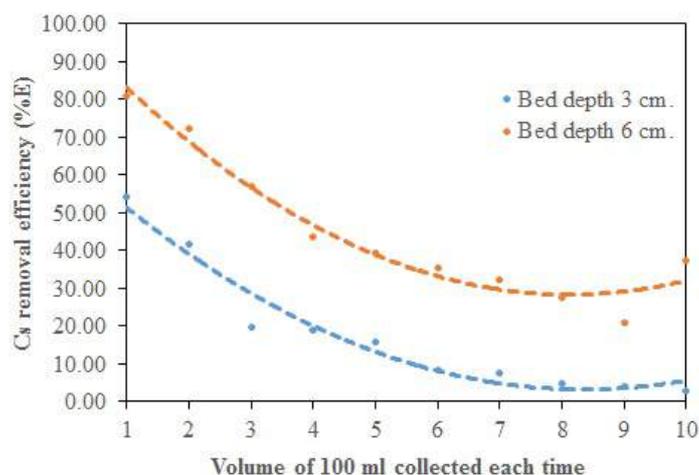
Figure 4. Removal efficiency of cesium in seawater at flow rate 6 ml/min

3.2 pH effects at different flow rates

In this part of the study, a bed depth was selected at 6 cm., while seawater salinity at 35 ppt., and concentration of cesium at 80 mg/l with various pH levels, 4, 7, and 9.

3.2.1 Flow rate of 3 ml/min

The effect of pH on the removal efficiency of cesium in seawater by zeolite fixed-bed columns at a flow rate of 3 ml/min was tested under different pH levels. Results revealed that the zeolite removal efficiency of cesium decreases from the 1st -100 ml collected to the 10th-100 ml collected of the outlet solution. The highest zeolite removal efficiency (%E) of cesium of 59.70, 70.70, and 83.50 of the mixed solution (pH of 4, 7, and 9) was at the 2nd-100 ml, 1st-100 ml, and 1st-100 ml, respectively (Figure 5). The maximum removal efficiency of cesium was observed at pH of 9. The zeolite removal efficiencies of cesium were compared at seawater pH values of 4, 7, and 9. Zeolite efficiency was significantly greater at pH of 9 than at pH of 4 ($P<0.05$) (Figure 5). At lower pH values, the metal ion uptake was inhibited in the acidic medium which can be attributed to the presence of H^+ ions competing with the Cesium ions (El-Kamash, 2008).

Remaining cesium increases from each consecutive batch from the 1st-100 ml collected to the 10th-100 ml collected (Figure 6).

The highest distribution coefficient (Kd) of 15.45, 34.32, and 51.51 of the mixed solution (pH of 4, 7, and 9) was observed at the 2nd-100 ml, 1st-100 ml, and 1st-100 ml, respectively (Figure 7).
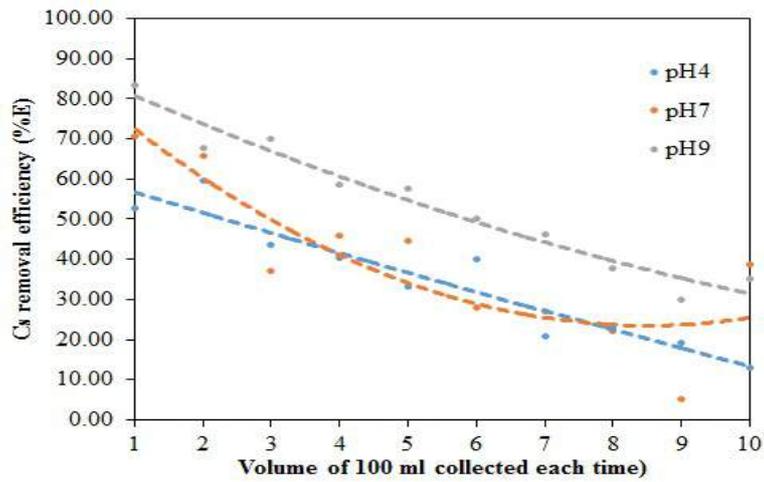
Figure 5. Cesium removal efficiency (%E)
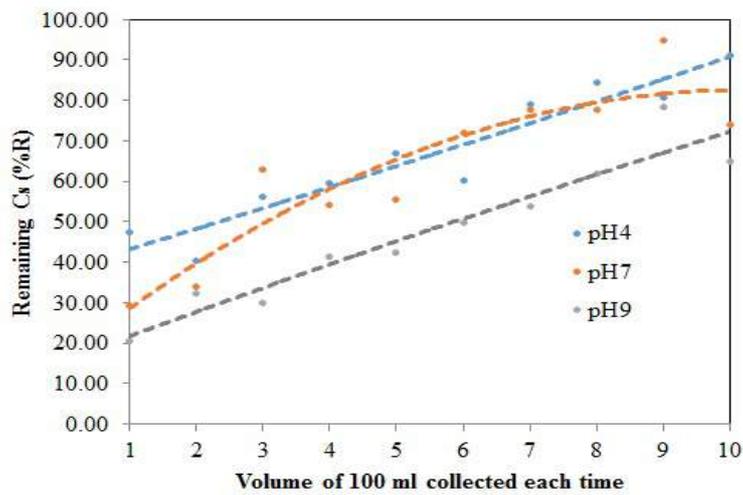
Figure 6. Remaining Cesium (%R)
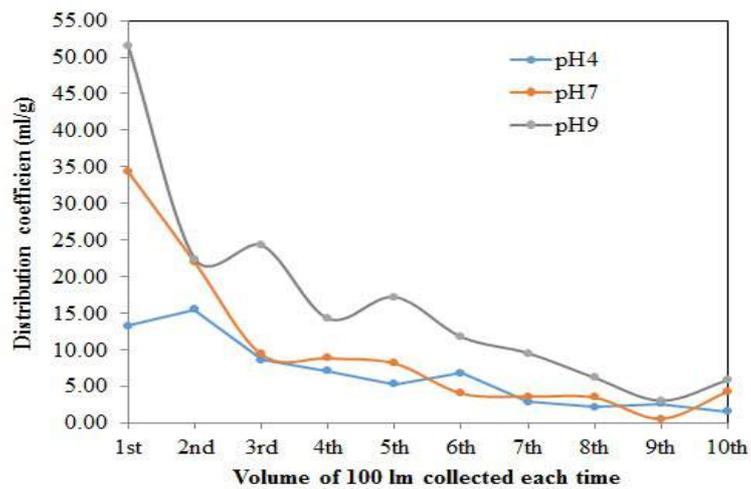
Figure 7. Distribution coefficient (ml/g)

3.2.2 Flow rate of 6 ml/min

At a flow rate of 6 ml/min, similar results to those at 3 ml/min were obtained. Zeolite removal efficiency of cesium decreases from the 1st-100 ml collected to the 10th-100 ml. The greatest zeolite removal efficiency (%E) of cesium of 66.67, 78.47, and 81.08 of the mixed solution (pH of 4,7, and9) was at the 1st-100 ml for all three pH values(Fig 8). The maximum removal efficiency of cesium was observed at pH of 9. The zeolite removal efficiencies of cesium were compared at seawater pH values of 4, 7, and 9. Zeolite efficiency was significantly greater at pH of 9 than at pH of 4 (P<0.05) (Figure 8). At lower pH values, the metal ion uptake was inhibited in the acidic medium which can be attributed to the presence of H+ ions competing with the Cesium ions (El-Kamash, 2008).

Similarly, the increase of remaining cesium occurred from the 1st-100 ml collected to the 10th-100 ml collected (Figure 9).

The highest distribution coefficient (Kd) of 23.62, 36.52, and 50.92 of the mixed solution (pH of 4, 7, and 9) was at the 1st-100 ml (Figure 10).
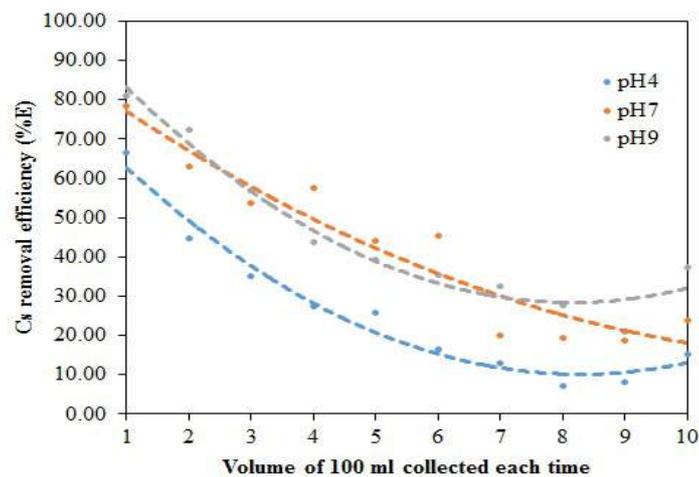
Figure 8. Cesium removal efficiency (%E)
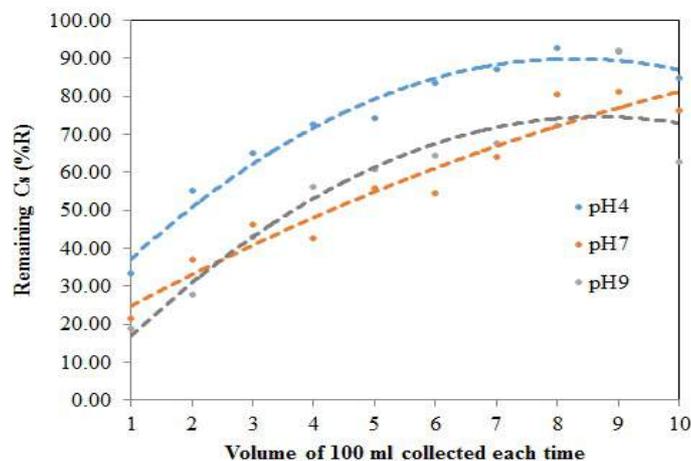
Figure 9. Remaining Cesium (%R)
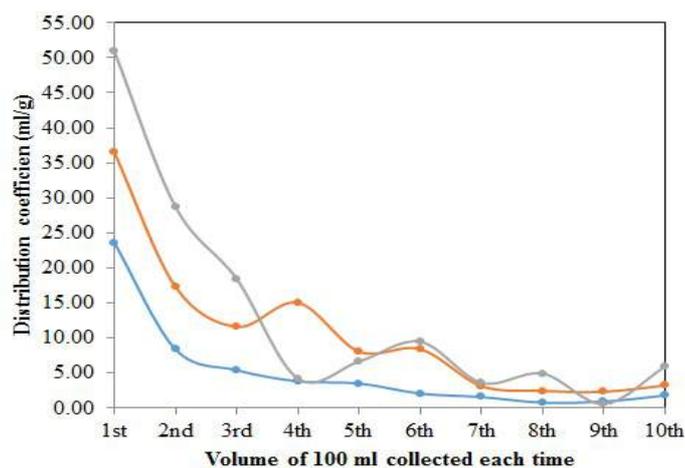
Figure 10. Distribution coefficient (ml/g)

3.3 Flow rate effects

We tested the effect of flow rate of seawater on the removal efficiency of cesium in seawater by zeolite fixed-bed columns. Results revealed that the flow rates of 3 and 6 ml/min. did not show any significant differences in zeolite efficiencies for removing cesium at any pH levels (P>0.05).
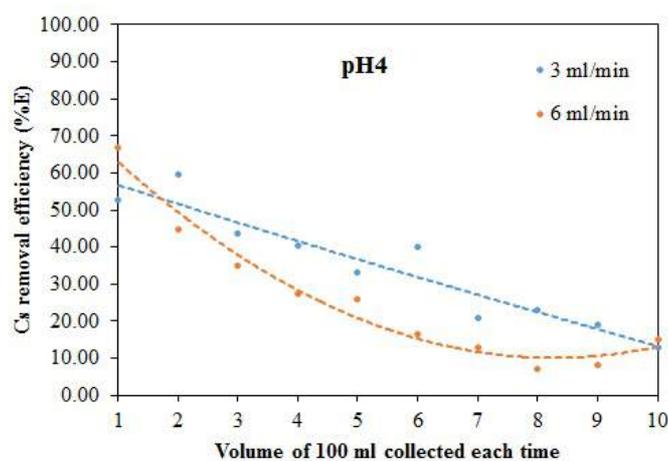
Figure 11. Cesium removal efficiency (%E) at pH4
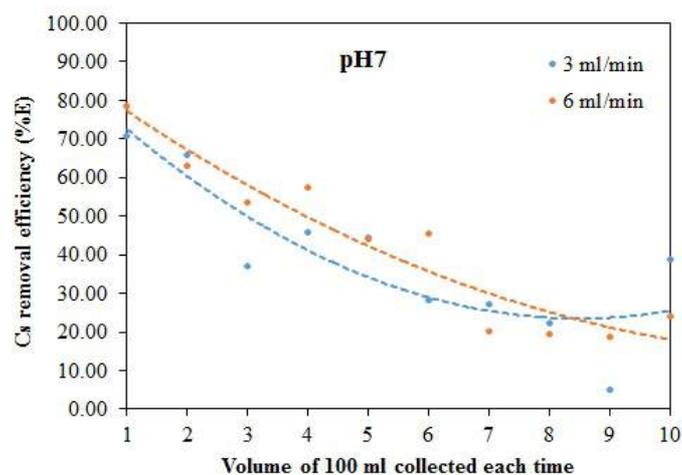
Figure 12. Cesium removal efficiency (%E) at pH7
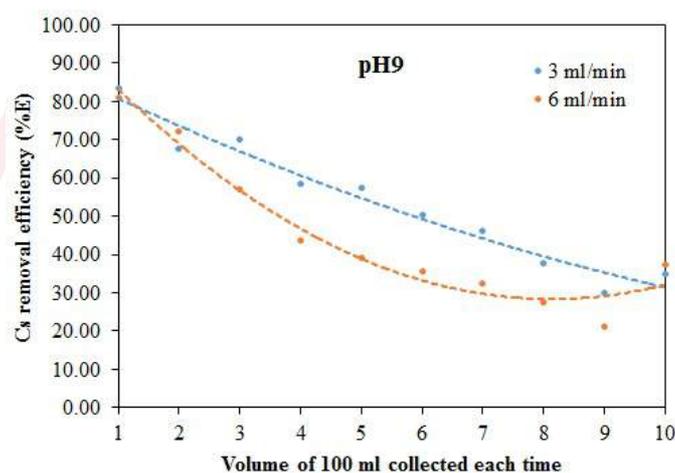
Figure 13. Cesium removal efficiency (%E) at pH9

4. Conclusion

The study was conducted to determine the efficiency of natural zeolite for the removal of cesium and strontium in synthetic seawater by zeolite-fixed bed column. The initial concentration of cesium and strontium was set at 80 and 20 mg/l respectively as cesium chloride and strontium chloride in seawater. Seawater adjusted salinity was 35 ppt. Several variables were considered in the study such as preparation of zeolite (Natural zeolite and natural zeolite treated by sodium chloride), bed depth, pH of seawater and flow rate. Results revealed that natural zeolite treated with NaCl was appropriate for use in this experiment. Zeolite could remove cesium but not strontium from the marine environment. The zeolite removal efficiencies of cesium were compared at seawater pH values of 4, 7, and 9. Zeolite efficiency was significantly greater at a pH of 9 than ata pH of 4 ($P<0.05$). Efficiency of removal by zeolite was significantly better at a bed depth of 6 cm. (18.84 cm^3) than at only a 3 cm. depth (9.42 cm^3) ($P<0.05$). However, different flow rates of 3 and 6 ml/min. during zeolite removal did not significantly affect cesium levels ($P>0.05$).

References

Borai, E.H., Harjulab, R., Malinenb, L., Paajanenb, A. (2009). Efficient removal of cesium from low-level radioactive liquid waste using natural and impregnated zeolite minerals. *Journal of Hazardous Materials*, *172*, 416–422.

Chemistry Explained (2009). Strontium. Retrieved from http://www.chemistryexplained.com/elements/PT/Strontium.html.

CU (2014). X-Ray Fluorescence Spectrometer(XRF) and X-ray diffraction(XRD). Department of Geology, Faculty of science, Chulalongkorn University.

Department of Marine and Coastal Resources. (2013). Sea water quality of Thailand. Retrieved from http://marinegiscenter.dmcr.go.th/km/oceanography_doc11/#. VXaqls-qqkp.

El-Kamash, A.M. (2008). Evaluation of zeolite A for the sorptive removal of Cs^+ and Sr^{2+} ions from aqueous solutions using batch and fixed bed column operations. *Journal of Hazardous Materials. 151*, 432–445.

Holm, E., (1997). Sources and distribution of anthropogenic radionuclides in different marine environments. In International Atomic Energy Agency, *Strategies and Methodologies for Applied Marine Radioactivity Studies.* Retrieved from http://www.iaea.org/inis/collection/NCLCollectionStore/_ Public/32 /034/32034847.pdf.

Lenntech. (2013). Ion Exchange-Principle. Retrieved from http://www.lenntech.com/ionenwisselaar-principe.htm.

Rodriguez-lznag, I., Petranovskii, V., Rodriguez-Fuentes, G. (2014). Ion-exchange of amino-and aqua-complexes of nickel and cobalt in natural clinoptilolite. *Journal of Environmental Chemical Engineering. 2,* 1221-1227.

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From Design to Management -Task Shift of Architects in Urban Regeneration Process

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Abstract

The urban regeneration in China is entering a new stage as the past pattern of large-scale demolition and reconstruction is called into question. Now a new consensus is made on making small-scale and gradual regeneration in urban areas. Although more and more architects are involved in various stages of such projects, these actions are fragmented and deeper insight into the whole process has rarely been done. This article aims to examine the new tasks of architects under the gradual urban regeneration background in developing countries and make an overview of this task shift. The main method of this article is by case study. First, the gain and lose of selected cases related to the hot issues on bottom-up and community empowerment are discussed with comments presented. In the following part, a pilot project done in China is introduced by three facets of the task shift, namely the role that architects play, the scheme form of their work and conservation focus. They respond strongly to the new urban regeneration trend. All the cases together help to make a comprehensive understanding of the task shift and propose a universal toolset for further studies.

Keywords: Task Shift, Architect, Urban Regeneration, Process

1 Introduction

The working form and contents of architects have changed a lot according to current city development situation. In the ancient times, architecture is defined as "harmony and concord of all the parts achieved in such a manner that nothing could be added or taken away or altered except for the worse(Alberti, L,1452)." It is interesting if Alberti could saw the Quinta Monroy Housing project designed by the 2016 Pritzker Prize winner Alejandro Aravena, who encouraged residents' self-building and modification with only the core structure built by the architect. What will he say about that? The definition of architecture is no longer a permanent one. Apart from the architecture itself, the planning rules and regulations are also evolving, affecting the work of architects. In America, urban designers and planners serve as consultants in many participatory planning; in Japan, architecture studios facilitate community empowerment in the renaissance of villages. All these phenomenon prove that nowadays architects are doing more integrated work beyond designing permanent buildings.

In the urban regeneration realm, a change of the architects' work is even more necessary. On the one hand, the schemes made by architects is about the final output after a long time enforcement, during which many new situations may occur. The lack of flexibility makes it difficult to realize the original intension. And it is often based only on the judgment of experts, ignoring the thoughts of residents. So the traditional work requirement is unrealizable to a great extent and causing social unfair. On the other hand, spontaneous adjustments made by residents are constantly ongoing, especially in the areas like shanty areas and urban villages. Improper regulations on these informal actions cause either chaos or barrier to residents' reasonable rights. There is a need for more guidance and regulations. Obviously, this is the time for architects to put down their schemes drawn on papers and take on the work in the ongoing practice. Then the question arises: Is there some new work for architects under this circumstance? What are the forms of them? If the former regeneration scheme output is unrealizable, then what kind of output may be realizable? What kind of role should architects play in the whole process of urban regeneration? If the output is changed, then how to make new evaluation in conservation areas?

This paper tries to make some reflections on these questions by case study method. First, some former cases are analyzed for their experiences and lessons. Causes of the deficiencies are shown, based on which possible modifications are discussed. Advantages of the cases are also discussed from the view of their extending possibilities. Scholars and related literatures are also discussed along with the cases. Then a pilot project responds to the issues is shown in the following part, with a relatively comprehensive process scheme. The task shifts of architects is explained in three facets in this pilot scheme. Finally, a possible toolset with its key points is raised based on the case studies, which may provoke further study.

2 Former cases and Reflections

2.1 The power and restrictions of bottom-up actions

Tianzifang is a famous arts and craft block in Shanghai, China, developed from a traditional residential area with Shikumen traditional architecture style. It is well

known because of its unique bottom-up process in China. At 1988, a famous artist set up his art studio there and then several artists followed to rent houses in the same block. They took inspiration of the traditional architecture style and decorated the houses with modern art taste. Although this action was really accidental, it made tremendous difference to this area. When the government intended to demolish this block to make way for real estate development in 2006, rejections were raised by local residents, artists and business owners, as well as scholars and social experts. It is extraordinary compared with similar blocks in other parts of the city. Generally speaking, this kind of block will be torn down for new development with the former residents arranged to move out. The Tianzifang case was an exception. Stakeholders made an effort and the government finally agreed to make a moderate renewal proposal instead of demolition. After gaining the legal approval, this block accelerated on its path to a commercial block with traditional art icon. There established several boutique shops, cafes, studios and even museums along with art studios. Many residents are happy to make modifications to their two-story houses: the ground floor for rent and the upper floor for live. After decades of regeneration, mainly by the bottom-up actions, this area has been turned into a mixed use block (Fig1)

Fig1 the mixed-use of Tianzifang-ground floor commercial and upper floors living
(Source: http://zcnfoto.lofter.com/post/eacdf_27db7a)

Is the Tianzifang project a success? To some extent, it is a model for bottom-up regeneration in China. The most obvious result is remain of locales and prevention of gentrification. However, it is so unique that difficult for other blocks to follow. If were not for the famous artist and urban design experts, the government wouldn't investigate the existing condition and make specific policies for the regeneration. So there is a need to regularize different stakeholders' involvement in the decision making system.

Aside of the lively condition of mixed use, troubles also occur. According to investigations, some locales' life is greatly disturbed by out-comers, even leading to conflicts. The starting point of the regeneration - to gain economic profit via rent, has become a barrier for its further development. The profound aspect of this conflict may lie in the misplacing of space-function relationship. In this area, the public facilities

were shared by several families and not properly treated in accordance with the function change. The work on facilities and the reorganize of spaces is indispensable for architects. Disappointingly, it is an important top-down work yet well done.

2.2 Reflections of community empowerment

Since the 1980s, Japanese urban development has endured a shift from the central government level to the local government level, and the citizens' participation has been strongly promoted (Masami K, 2015). The "Charrette Workshop" developed by Meiji University is a case in point. They held the workshop regularly every year since 1993 as a part of the university curriculum. Till now the process has lasted more than twenty years. If not for their workshop, the historical assets are very likely to be destroyed from the development pressure and the building owner's generation change. The "Charrette Workshop" shows great accountability of the design process to the public. Their working process consists of five parts: sharing basic information, site survey, collecting local opinions, analysis of the site and neighboring areas, specific design for an effective site. Among the five parts, the first threes have a close relationship with the locales' participation. After the whole process, in order to make the workshop output more than an instant event, they also make digital records of the whole process for the local press. (Fig2)

Fig2 Scene of presentation to the municipality and citizens
(Source: Masami, K. 2015)

Based on the workshop practice, scholars made reflections on Japanese municipal policy, building administration and architectural education. The similar problems occur in other Asians countries like China as well. For example, the Japanese scholar argues that "Japan had preferred the task which the effort appears in concrete figures, and ordinarily postponed the quality of the environment and value of the town scape (Masami K, 2015)." This is what also happens in China. Although this problems are revealed to known, still many works are to be done. The evaluation system is the basic cause leading to this fault and deserves a change. Furthermore, the urban policy is criticized for its sophistication and difficulty for understanding. The top-down approach is not done in a comprehensive way because of the useless vertical administration structure and conflicts among different ministries. The proposal of a fundamental decompose of the political administration structure is reasonable.

Similar to the important role that Meiji University plays in urban regeneration process, in Taiwan China there are some NPOs (Non-profit Organization) and NGOs (Non-governmental Organization) making their voices heard to public. Sometimes they work directly towards the objective goal, and sometimes they serve as catalysts. They do not play roles as community leaders, expert consultants, or direct change agents. Rather, they make it possible for others to carry out these roles (Milofsky, C. 2006). The involvement of participation in every successful project proves that the voluntary part is as important as the participation of local residents. As for architects, the involvement of architecture scholars and students is a feasible way to provide this kind of power to facilitate the process of a small-scale and gradual urban regeneration.

2.3 Beyond the architectural form

Urban regeneration is a comprehensive integration of vision and action aimed at resolving the multi-faceted problems of deprived urban areas to improve their economic, physical, social, and environmental conditions (Ercan, 2011). In this integrated target, the strategies for buildings and urban space is directly linked with physical and environmental conditions, and also have a profound impact on the economic and social aspects of the target area, which makes the work of architects a fundamental one.

Ordinarily in regeneration process, the architects figure out the elements for conservation at the first stage. Normally, these elements are all things about architecture-the construction-itself. In other words, the urban context and the logic of space are ignored partly due to the difficulty to be illustrated. The urban context refers to things such as block size, density and height of buildings, the direction and width of lanes inside the block and so on may be altered greatly. The result is that in many regeneration cases, the elements of architecture are kept with its space logic totally changed. Either new commercial shops along wide roads with traditional building style or high class townhouse residential areas with segregated community structure is this kind of misplacing. For example, the width of path in Fig3 is totally altered from traditional Chinese style path, with its width multiplied two or three times. In this sense, although the buildings are meant to be in traditional style, the block can only be understood as a new developed real estate program rather than a regeneration of a traditional one.

Fig3 buildings with tradition elements in an altered spacial context
(Source:
http://blog.sciencenet.cn/home.php?mod=space&uid=69051&do=blog&id=749016)

Just as Hillier.B pointed out that space largely influences people's behavior and the space logic is the code for the city and city life (Hillier, B. 1996), thus the logic of space is equally important as the form of it. Especially in urban regeneration projects that concerning conservation issue, the characteristics of public space and the social relationships carried by community layout deserve to be paid more attention to.

3 Pilot project of Xiaoxihu

The following part is based on an urban regeneration pilot project carried out in Nanjing, China, in the year 2015. It is a voluntary campaign organized by the local government for the architecture scholars and students to investigate in the possible way to make a proper regeneration scheme for a historical conservation residential area. The work lasted for four months and yielded results that had good public feedback. In this case, the key elements discussed above are generally taken into consideration. This is a project that organizes the responses to the task shift in a relatively comprehensive way.

3.1 Current situation and former scheme

The project site-Xiaoxihu community-is located in the south part of Nanjing inner city with Qinhuai River historical area to the south. Several famous celebrities lived in this block in the history. Now the block is among the list of traditional neighborhood conservation areas in Nanjing. However, the current situation in this area with high density and population and low level of building environment needs to be regenerated. The government had organized some investigation works by experts to map the sophisticated property condition with a scheme for the regeneration made. However, the former scheme is something only about the final vision of this area. There hasn't been an implementation plan for the whole process. Thus the former scheme only portrayed an ideal status like castles in the air.

On this basis, the pilot scheme with new working procedure and output is done. A five-party platform is proposed for the process and the works are carried out in a different way. As for the task shift of architects, the following are the three main facets.

3.2 The role-from controller to organizer

In old inner city neighborhoods, urban renewal and revitalization often fuels gentrification process, during which residents with lower income are gradually displaced by more affluent newcomers, who can afford refurbished apartments and the offerings of new elegant shops and restaurants emerging in the area (Lees, Slater, & Wyly, 2008). While in this project, the aim is to revive the community without gentrification, thus the participation of locales will be a key feature. In fact, the residents have done various kinds of modifications to their living environment. As in Fig4, these actions including adding to the existing building, partly reconstructions and the transfer of usage. (Fig4) However, they encounter bottleneck now – the too crowed and disordered situation make them unable to go on spontaneous update. To conclude, this area needs a municipal framework to facilitate further development.

Fig4 the current condition of spontaneous reconstruction on site
(Source: photographed by author)

In order to regulate the modifications, a municipal platform is formed. It is a five-party platform comprising of the government departments, neighborhood administrators, community empowerment organizations, the capital and professionals. The first two are different levels of government offices-one for policy and one for detailed implementation. Community empowerment organization will be developed based on current groups of people sharing the same social activities and introducing other NGOs. The role of architects in this platform is no longer only a designer, but also a part of organizer. They take on the responsibilities of informing and explaining to the public, collecting their opinions to consider the overall condition. (Fig6)

Fig6 an architect explaining the investigation to a local resident
(Source: photographed by author)

This shifting role of architects is necessary to integrate top-down and bottom-up in the whole process. Learned from the experiences of Japanese and Taiwanese regeneration cases, the gap between local residents and the government needs the interventions from a third party, and the architect is a suitable choice. Architects now face the challenge to add locales' need to their scheme. After all, the locales are supposed to be the key concern of the regeneration.

3.3 The scheme form-from end to process

Architects often seek for an ideal condition that once reached, no more modification is needed. Just as the former scheme, the finally blueprint is done without the steps to realize it. The underlying logic is: first formulate an end output and then try to realize it. This logic is not applicable in such regeneration project because it's adverse to embrace bottom-up process.

The new scheme made by the project team is a possible paradigm of process management. The ultimate objective is divided into three phases, and each phase contains a five-year plan. In the first five years, the construction mainly concerns about public facilities, public spaces along the inner lanes and public services. The community empowerment organizations are also fostered in this stage. In phase two, the most important historical buildings and courtyards are under renewal. They may develop into the economy engine of this area. At the same time, the public owned properties with the form of courtyards are also having the priority to be tackled with. Finally in the third phase, the environment is supposed to be suitable to encourage high quality spontaneous modifications wherever on site. Of course, the measurements began in the first phase to improve public space quality still continue all the way. So the final status is partly controlled and leaded process, not a goal set at first. These flexibility phases contribute to a small-scale and gradual regeneration of this area.

Fig7 shows the scheme made for the first phase. Unlike an ultimate work, this scheme highlights the key sections of the phase and leaves the possibility for spontaneous bottom-up actions. The definition of an ideal end is replaced by a strategic process framework. The architects' work will be a long period of management with time-limited interventions and long pauses to witness the impetus impacts.
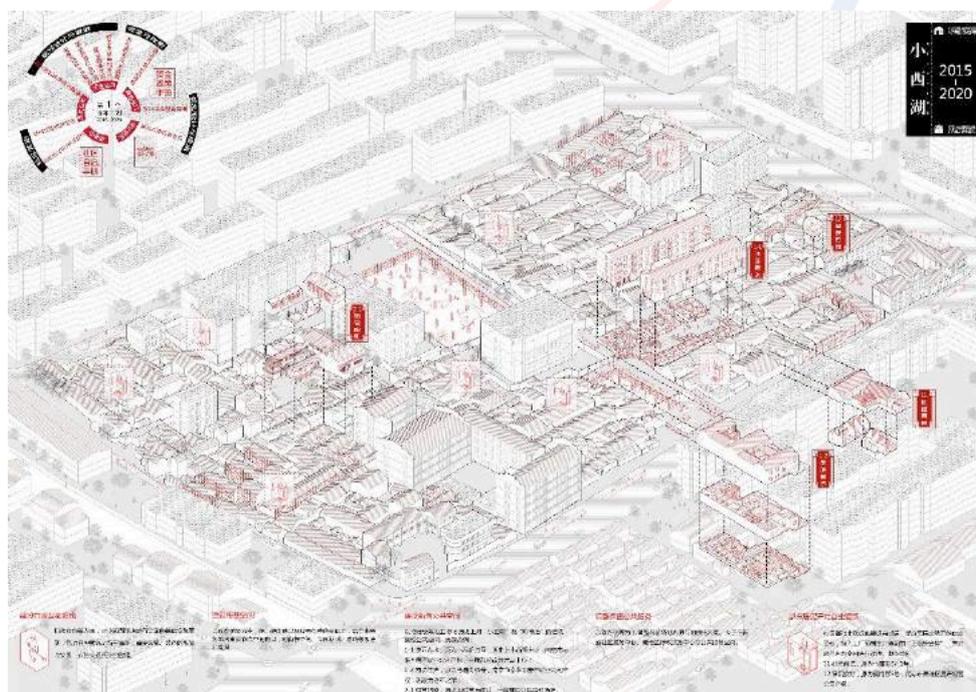
Fig7 the first phase scheme - mainly facilities and public spaces renewal
(Source: drawn by the author and the project team)

The transfer of the scheme form also influences the evaluation methods. The new evaluation system can't only concentrate on the ultimate result, but should also put emphasis on the rationality of the process. As this is a weak side in the ordinary evaluation system, some inspirations can be taken from the life-cycle calculation of green buildings and other quantitative evaluation methods. Maybe the degree of participation will be another important evaluation indicator in regeneration projects in the future. Another change of evaluation is related to the multi-phase feature. The indicators may not be so concrete in each phase end. Balance and strategic goals are to be considered, helping the judgment to be fair and the whole process adaptable to new condition.

3.4 The conservation focus-from building elements to space logic

Urban renewal involves changes in the physical and functional aspects of cities as a response to urban design; it is a process of making decisions about the location and physical fabric of investment in the built environment and the adaption of these decisions to functional and aesthetic ends (Couch, 1990). In this sense, the physical fabric has a strong relationship with the functions and activity pattern. Every block has its unique characteristics in the context of cultural and city development background that should be carefully examined.

Take Xiaoxihu pilot project for example. This community block is listed as a historical features conservation area. By investigating into the historical buildings in the block, we can find that their conservation grade is not very high and their conditions are not agreeable. Then why is this area worth to be conserved? It is due to its urban fabric patterns-the scale, the courtyard housing patterns-something about the logic of space. Specifically, the courtyards that one can go through after modification of splitting the whole family house into several independent residential units is one of the most eminent features. As the comparison in Fig8, the difference between the roof view and the accessibility of the ground floor manifests the interesting space logic. If look on the whole, the feature of high integration value of inner block spaces is formed by the aggregation of such courtyards. (Fig9) This layout contributes a lot to the neighborhood atmosphere and the traditional residential culture.

Fig8 the contradiction of roof view courtyard layout and ground floor accessibility
(Source: google map and drawn by author)

Fig9 the integration value of inner block routes (red for high and blue for low)
(Source: analyzed in Depthmap3.0 by author)

The space logic is the material carrier of history. So the space organization logic with a strong support of cultural background deserves the same value as the traditional elements used on buildings. In the past it was often ignored because of the large-scale redevelopment pattern and figurative evaluation system, and nowadays it is becoming a significant part of conservation work. To sum up, in a whole process scheme that includes public participation, the features of space logic are important for a proper correlation between the physical environment and people's real use of them.

The three facets all together form a toolset that may be applicable to other regeneration projects in China. They response strongly to the concepts discussed in former cases such as participation, bottom-up, indispensable municipal base and so on. The local residents and the press both made high evaluation of the pilot project. As the whole scheme is finished within one year with the first stage just started, the final gains and lose is to be examined by time.

4 Conclusion

According to the small-scale and gradual urban regeneration trend, architects find that both their working methods and working outputs are changing. However there has rarely been a comprehensive scheme to embrace the concerns. Based on case studies, the multi facets of task shift of architects are discussed. In the pilot project, the role that architects play, the scheme form of their work and the conservation focus all together formed a toolset that might be applicable in general. As new detailed problems may occur during the practice, further study on how to transfer smoothly from the old municipal system to the new one, what modifications should be made in different situations may be the next to explore. Luckily, this article provides a comprehensive basis for more detailed study of this theme.

References

Alberti, L. (1452) De Re Aedificatroria – *Ten Books of Architecture*.

Couch, C. (1990). *Urban renewal: theory and practice*. In Macmillan building and surveying series. London: Macmillan Education.

Ercan, M. A. (2011). Challenges and conflicts in achieving sustainable communities in historic neighborhoods of Istanbul. *Habitat International*, 35(2), 95e306.

Hillier, B. (1996). *Space is the machine*. Cambridge University Press Cambridge UK (3), 333-335.

Lees, L., Slater, T., & Wyly, E. (2008). *Gentrification*. Routledge.

Masami, K. (2015).*The regeneration of historical blocks*. (G.W.Zhang, Trans).Beijing: Qsinghua University Press. (Original work published 2013).

Milofsky, C. (2006). *The catalyst process: what academics provide to practitioners*. Nonprofit Management & Leadership, 16(4), 467-480.

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Non–Vegetated Constructed Wetland with Graded Sand Bed System for Hazardous Landfill Leachate Treatment and Heavy Metals Removal

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Abstract

Three pilot scale non-vegetated constructed wetland with graded sand bed systems (N-VCWGS) were investigated for the treatment of hazardous landfill leachate and heavy metals removal. The reactors were filled with graded sand media. The pilot systems were operated at the same Hydraulic Retention Time (HRT) of 5 days. The results showed that the N-VCWGS which consists of three reactors (CW3) was very efficient for the removal of heavy metals. The removal efficiency was 63% for iron (Fe^{+3}), 89% for copper (Cu^{+2}), and 68% for manganese (Mn^{+2}). The results showed that it was very efficient in ammonia removal with efficiency 84%, total suspended solids removal efficiency was 48%, and 62% removal efficiency for volatile suspended solids. The results approved that vegetation is not essential for heavy metals removal and hazardous landfill leachate treatment, but it has an important role in Chemical Oxygen Demand (COD) removal due to the higher microbial activities and aeration in root zone.

Keywords: Constructed wetland, hazardous landfill leachate, industrial wastewater treatment, heavy metals removal.

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Introduction

The industrial production of Alexandria city is 40% of the total industrial production of Egypt. There are more than 1900 industrial institution in Alexandria include food processing, chemicals, petrochemical, pharmaceuticals, hydrocarbons, construction, cement, metals, light and electronics manufactures [1]. The increase of industrial activities has increased the amount of the produced hazardous wastes. Hazardous waste landfills were established for the environmental disposal of hazardous wastes [2]. Landfill leachate is a highly contaminated liquid [3], [4], generated due to the percolation of rainfall through waste materials, or due to the inherent water content resulting from chemical and biological reaction in wastes. Leachate components depend on the waste type that is disposed within the landfill and reactions taking place in it. Hazardous landfill leachate has high chemical oxygen demand (COD), ammonia nitrogen (NH_4-N), heavy metals, and alkalinity [5]. So that, hazardous landfill leachate treatment and contaminants removal before the safe disposal is considered an important environmental issue in our societies [6], [7]. Al-Nasreya hazardous waste treatment center in Alexandria produces highly concentrated, toxic and corrosive landfill leachate contains toxic heavy metals such as copper, zinc, iron, nickel and manganese and inorganic pollutants at high concentrations. It became a potential pollution source threats human health, air, soil, and groundwater. Several technologies are used for hazardous landfill leachate treatment, such as: precipitation, adsorption, oxidation, evaporation, reverse osmosis [8], [10]. Among the existing currently used wastewater treatment technologies, constructed wetland is considered the most economic and effective technology for its low cost, energy, land, operation and maintenance requirements [11], [14]. Constructed wetlands are widely used for many wastewater types treatment [15], [16], and achieved high treatment efficiency and heavy metals removal [17], [19]. The three main factors that affect the performance of constructed wetland systems include the granular media used, hydraulic retention time (HRT), and vegetation type [11], [17].

Many researchers investigated the role of vegetation in constructed wetland system for heavy metals removal and treatment. In several cases, researchers found that vegetation is not essential for wastewater treatment and heavy metals removal, and sometimes it may has negative effects on the performance of the system such as: [20] he found that the performance of non-vegetated constructed wetland was better than the vegetated constructed wetland in heavy metals removal for urban runoff wastewater. This was due to the decreased pH value resulted from the vegetation, which in turn inhibited heavy metals removal process. He also found that heavy metals removal mechanism depended mainly on filtration. Giovanni De Feo also found that vegetation did not affect chemical oxygen demand (COD) and suspended solids removal. As well, filtration process significantly controlled the treatment process for municipal solid waste landfill leachate. Additionally, it was reported that, the difference in the treatment efficiency between vegetated and non-vegetated constructed wetland ranged from 1.9 to 8.9% [12]. Therefore, this research was made for investigating two objectives: the first one was to compare among three different constructed wetland systems for the treatment of hazardous landfill leachate as well as heavy metals removal using the same granular media and under constant hydraulic retention time (HRT). The second objective was to investigate if the vegetation is essential for achieving higher performance or not.

Materials and Methods

A.   Laboratory System Design and Operation Conditions

Three pilot scale rectangular reactors were prepared as non-vegetated constructed wetlands with graded sand bed systems (N-VCWGS). Each reactor has the same working volume of 58 liters. Three different constructed wetland systems (CW) were constructed using these three reactors. The first system consists of only one reactor (CW1). The second system was made of two consecutive reactors (CW2), and the third system comprised of three consecutive reactors (CW3). The schematic diagram for the three constructed wetland systems is shown in Fig. 1. The consecutive reactors were placed in declining levels to provide a natural flow for water under gravity. All reactors media was graded sand. Water hose was used for leachate flow through the consecutive reactors. Systems were opened and exposed to ambient temperature. Experimental work was pursued for two months with 5 days' hydraulic retention time (HRT).
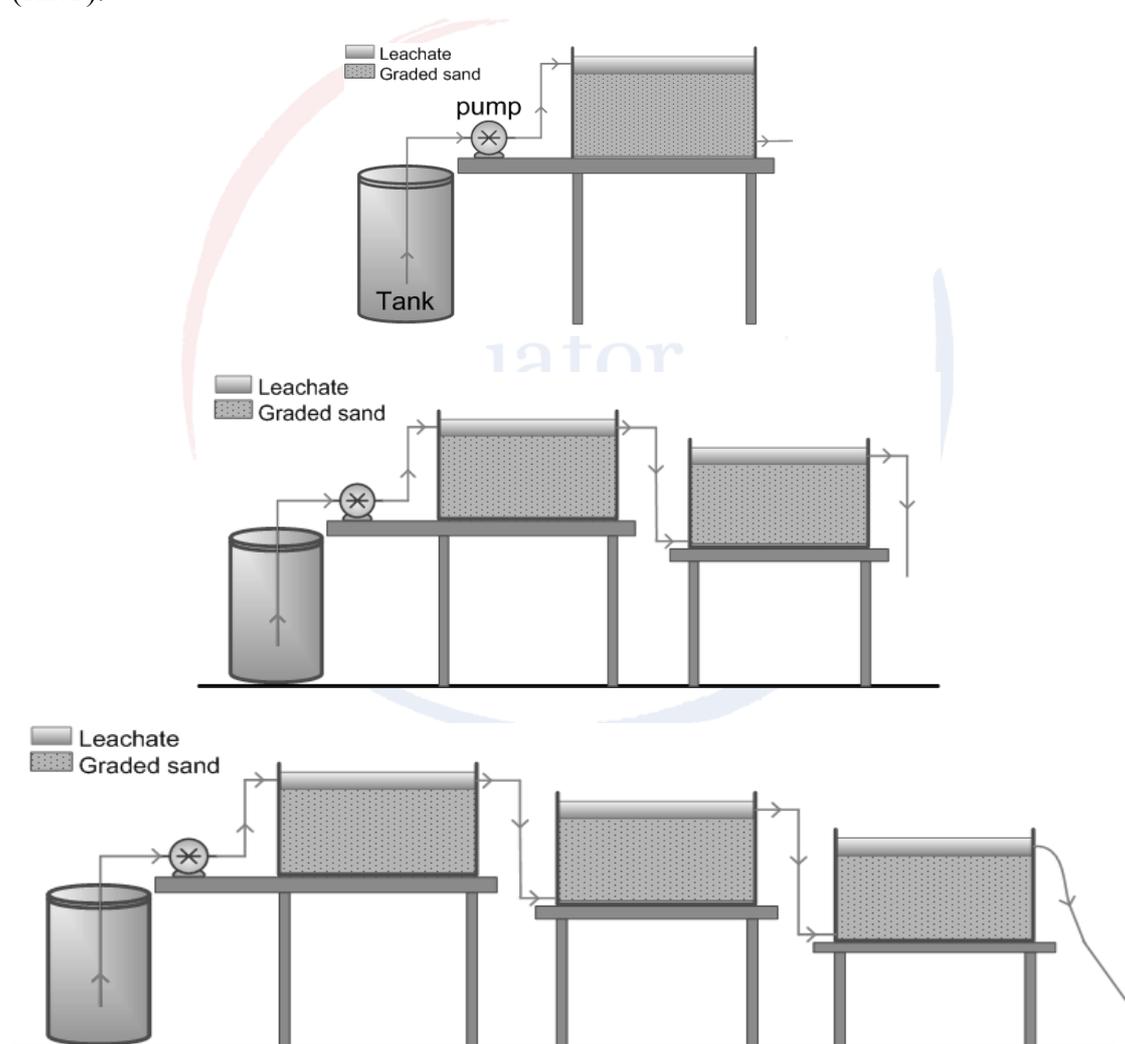
Figure 1: Schematic diagram for the three non-vegetated constructed wetland with graded sand bed systems.

B.   Hazardous Landfill Leachate

The influent for the three systems was the generated leachate from Al-Nasreya hazardous waste landfill. The leachate characteristics are presented in Table (1).

Parameter	Unit	Range	Average
PH-value	—	8.28 – 9.07	8.78
Total COD	mg/l	2665 – 4772	3529
Soluble COD	mg/l	2100 – 4752	3247
TSS	mg/l	505 – 1360	1360
VSS	mg/l	110 – 910	523
TDS	mg/l	44200 - 84600	62104
VDS	mg/l	5120 - 40600	27723
TKJ-N	mg/l	58 – 334	102
NH_4-N	mg/l	14 – 239	84
NO_3	mg/l	5 – 17	10
Cu^{+2}	mg/l	0.12 – 6.44	3.7
Ni^{+2}	mg/l	6.6 – 8.4	7.5
Fe^{+3}	mg/l	3.4 – 11.5	6.2
Zn^{+2}	mg/l	2.72 – 12	6.4
Mn^{+2}	mg/l	5.71 – 15.66	9.8

Table 1: Al-Nasreya Hazardous Landfill Leachate Characteristics and Heavy Metals Concentrations.

C.   Sampling and Experimental Work

Samples from the influent and effluent of each reactor were taken three times a week. Samples were analyzed for the following physicochemical parameters: pH, total and soluble chemical oxygen demand (COD), total kjeldahl nitrogen (TKN), ammonium nitrogen (NH_4-N), nitrate nitrogen (NO_3-N), total suspended solids (TDS), and volatile suspended solids (VDS) according to APHA (2005) [21]. Heavy metals: copper (Cu^{+2}), manganese (Mn^{+2}), iron (Fe^{+3}), zinc (Zn^{+2}), and nickel (Ni^{+2}) concentrations in the influent and effluent of each reactor were measured.

Results and Discussion

A.   Heavy Metals Removal

Fig. 2 shows the obtained experimental results for heavy metals concentrations in the influent and effluent of the N-VCWGS and the efficiency of heavy metals removal for each system. The results show that the N-VCWGS were very efficient for Cu^{+2}, Fe^{+3}, and Mn^{+2} removal and moderate efficient for Zn^{+2} and Ni^{+2} removal. From the results, the third system (CW3) which consists of three reactors was the most efficient system for heavy metals removal. In particular, the removal efficiency of Cu^{+2} was 89% for CW3, 45% for CW2, and 35% for CW1 as shown in Fig. 2 (a). Where, the removal efficiency for Fe^{+3} was 63%, 23%, and 11% for CW3, CW2, and CW1, respectively as shown in Fig. 2 (b). Furthermore, the Mn^{+2} removal efficiency of 86%, 72%, and 66% have been achieved for CW3, CW2, and CW1, respectively as shown in Fig. 2

(c). As well, moderate removal efficiency was obtained for Zn^{+2} of 37%, 13%, and 5% for CW3, CW2, and CW1, respectively as shown in Fig. 2 (d). The removal efficiencies of Ni^{+2} were 25%, 15%, and 14% for CW3, CW2, and CW1, respectively as shown in Fig. 2 (e). Significantly, the removal of heavy metals was mainly due to filtration, adsorption, and metal sulfides precipitation processes [11], [22]. In particular, the anaerobic conditions in the bottom layers of the graded sand in submerged non-vegetated constructed wetlands enhances sulfate-reducing bacteria (SRB) activity, which oxidizes the sulfate compounds presented in hazardous landfill leachate to produce sulfides and increase the alkalinity. In turn, the produced sulfides react with the heavy metals in dissolved or particulate forms resulting in metal sulfides which precipitate on sand [11], [22]. Taking into consideration that the toxicity of the produced metal sulfides is very low compared to the high toxicity of heavy metals [23].
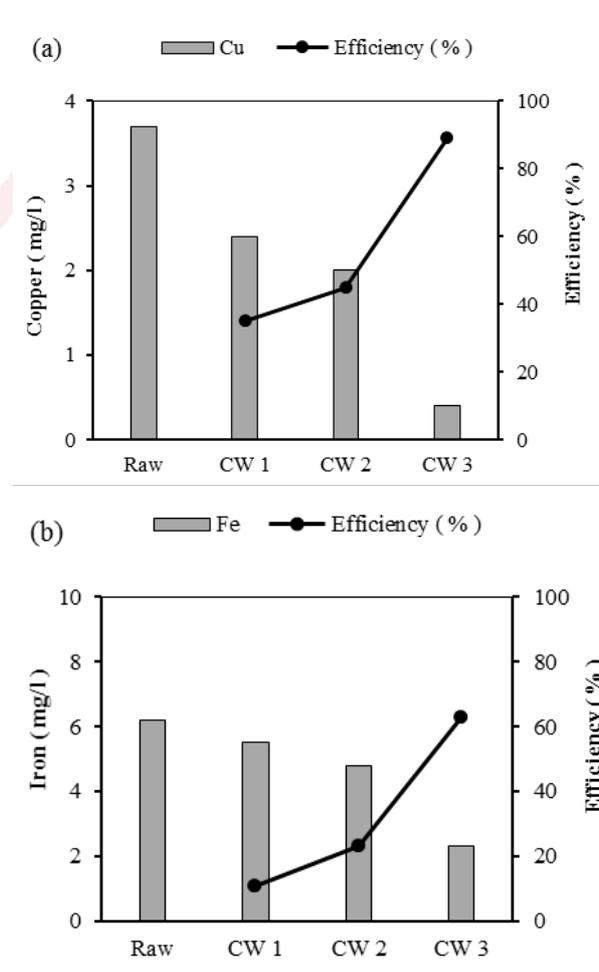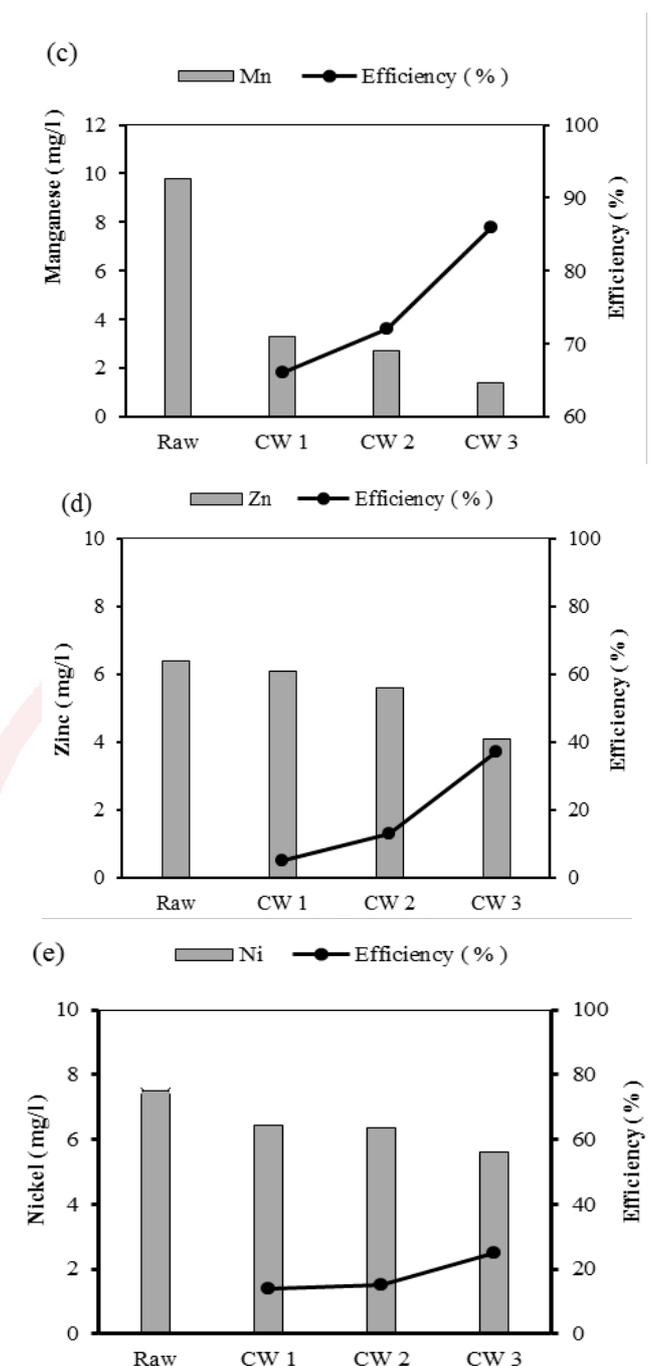
Figure 2: Heavy metals concentrations for the raw hazardous landfill leachate and the effluent of N-VCWGS and the removal efficiency of each system.

B. pH Value

As shown in Fig. 3, pH value was 8.78 for raw hazardous landfill leachate which increased respectively to 8.9, 9.1, and 9.2 in CW1, CW2, and CW3. This was due to the production of metal sulfides which are strong alkaline. The increasing of pH value causes reducing of heavy metals solubility which makes the wastewater less toxic and less harmful to the environment [24].
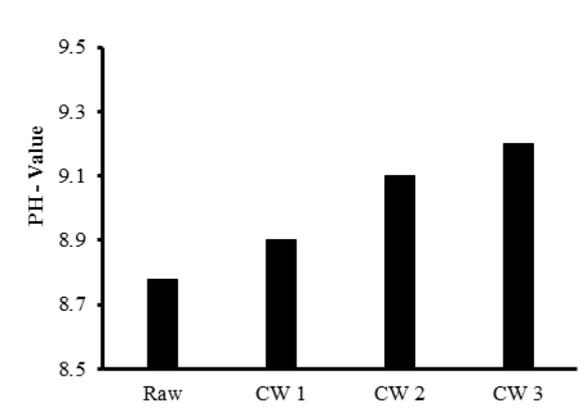
Figure 3: pH values for raw hazardous landfill leachate and each reactor effluent.

C.   COD Removal

The total and soluble chemical oxygen demand concentration in raw hazardous landfill leachate were 3529, 3247 mg/l, respectively. The N-VCWGS show low removal efficiency for both total and soluble COD. The total COD removal efficiency was 24%, 10%, and 7% in CW3, CW2, and CW1, respectively, and 22%, 10%, and 5.5% for soluble COD as shown in Fig. 4. The low removal efficiency of the three systems can be attributed to the absence of vegetation resulting in very low microbial activities in sand pores, and due to the low porosity of sand resulting in poor oxygen transfer through sand bed pores [25].
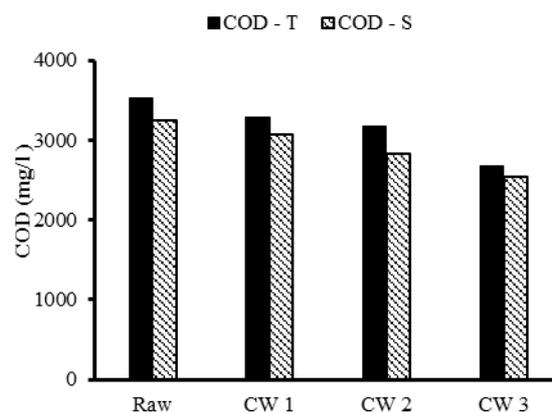
Figure 4: COD values for influent and each reactor effluent.

D.   Nitrogen Removal

As shown in Fig. 5, the results show that N-VCWGS achieved high efficiency of nitrogen removal. The highest removal efficiency was for CW3 of 40% and 84% for TKN and ammonia, respectively. The removal efficiency of TKN and ammonia decreased to 28% and 47% for CW2 and 13% and 31% for CW1, respectively. As for nitrates, it increased from 10 mg/l for raw hazardous leachate landfill to 13, 15.5, and 19 mg/l for CW1, CW2, and CW3, respectively resulting from nitrification.
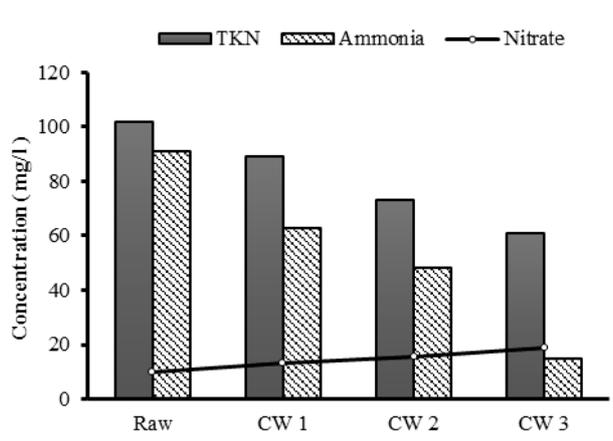
Figure 5: TKN, ammonia, and nitrates for influent and each reactor effluent.

E.   Suspended Solids Removal

Fig. 6 shows that CW3 was the most efficient system for both suspended and volatile solids removal with 48% and 62%, respectively whereas, the removal efficiency decreased for TSS and VSS to 45% and 55% for CW2, and 21% and 35% for CW1, respectively.
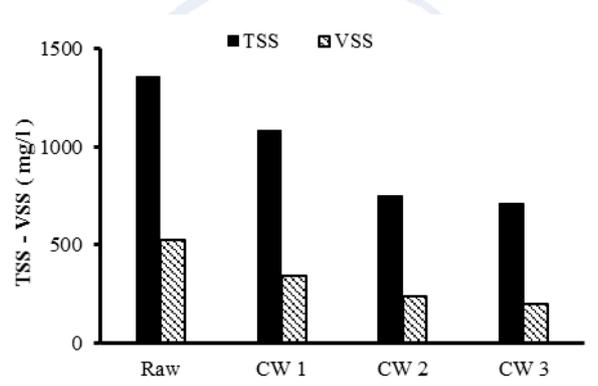
Figure 6: TSS and VSS values for influent and each reactor effluent.

Conclusion

In summary, the present study confirms the high performance of non-vegetated constructed wetlands with graded sand bed for Al-Nasreya hazardous landfill leachate treatment and heavy metals removal. The results proved that vegetation is not essential for heavy metals, nitrogen and solids removal. However, it is considered essential for COD removal due to the high microbial activities in the root zone. Also vegetation enhances aeration in sand pores due to the plants ability to transfer oxygen from surrounding atmosphere to root zone. Moreover, the results showed that the non-vegetated constructed wetland system which consists of three reactors was the most efficient system for hazardous landfill leachate treatment and heavy metals removal.

Acknowledgment

References

Ramadan, Adham R., Per Kock, and Amani Nadim. "Nasreya: a treatment and disposal facility for industrial hazardous waste in Alexandria, Egypt: phase I." Waste management & research 23.2 (2005): 167-170.

Setiadi, Tjandra, and Sirin Fairus. "Hazardous waste landfill leachate treatment using an activated sludge-membrane system." Water Science & Technology 48.8 (2003): 111-117.

Aziz, Hamidi Abdul, Osama Mohammed Othman, and Salem S. Abu Amr. "The performance of Electro-Fenton oxidation in the removal of coliform bacteria from landfill leachate." Waste management 33.2 (2013): 396-400.

Amr, Salem S. Abu, Hamidi Abdul Aziz, and Mohd Nordin Adlan. "Optimization of stabilized leachate treatment using ozone/persulfate in the advanced oxidation process." Waste management 33.6 (2013): 1434-1441.

Lugowski, A., et al. "Biological treatment of landfill leachate." Proceedings of the 44 th Purdue Industrial Waste Conference. May 9-11 1989, Purdue Univ., West Lafayette, Indiana. CRC Press, Inc., Boca Raton, Florida. 1990. p 565-571, 4 fig, 2 tab.. 1990.

Rafizul, Islam M., and Muhammed Alamgir. "Characterization and tropical seasonal variation of leachate: Results from landfill lysimeter studied." Waste management 32.11 (2012): 2080-2095.

Zhang, Qi-Qi, et al. "Investigation on characteristics of leachate and concentrated leachate in three landfill leachate treatment plants." Waste management 33.11 (2013): 2277-2286.

Bashir, Mohammed JK, et al. "Color and chemical oxygen demand removal from mature semi-aerobic landfill leachate using anion-exchange resin: An equilibrium and kinetic study." Environmental Engineering Science 29.5 (2012): 297-305.

Bashir, Mohammed JK, et al. "An overview of electro-oxidation processes performance in stabilized landfill leachate treatment." Desalination and Water Treatment 51.10-12 (2013): 2170-2184.

Amr, Salem S. Abu, Hamidi Abdul Aziz, and Mohammed JK Bashir. "Application of response surface methodology (RSM) for optimization of semi-aerobic landfill leachate treatment using ozone." Applied Water Science 4.3 (2014): 231-239.

Yeh, T. Y. "Removal of metals in constructed wetlands: review." Practice Periodical of Hazardous, Toxic, and Radioactive Waste Management 12.2 (2008): 96-101. W.

De Feo, Giovanni. "Performance of vegetated and non-vegetated vertical flow reed beds in the treatment of diluted leachate." Journal of Environmental Science and Health Part A 42.7 (2007): 1013-1020.

Schnoor, Jerald L., et al. "Phytoremediation of organic and nutrient contaminants." Environmental Science & Technology 29.7 (1995): 318A-323A.

Vymazal, Jan, and Lenka Kröpfelová. Wastewater treatment in constructed wetlands with horizontal sub-surface flow. Vol. 14. Springer Science & Business Media, 2008.

Kivaisi, Amelia K. "The potential for constructed wetlands for wastewater treatment and reuse in developing countries: a review." Ecological engineering 16.4 (2001): 545-560.

Rousseau, D. P. L., et al. "Constructed wetlands for water reclamation." Desalination 218.1 (2008): 181-189.

Sehar, Shama, et al. "A comparative study of macrophytes influence on wastewater treatment through subsurface flow hybrid constructed wetland." Ecological Engineering 81 (2015): 62-69

Kadlec, R. H., and R. L. Knight. "Treatment Wetlands. Lewis." Boca Raton (1996): 893.

Keffala, C., and A. Ghrabi. "Nitrogen and bacterial removal in constructed wetlands treating domestic waste water." Desalination 185.1 (2005): 383-389.

Lee Byoung-Hwa, and Miklas Scholz. "What is the role of Phragmites australis in experimental constructed wetland filters treating urban runoff?." Ecological Engineering 29.1 (2007): 87-95.

APHA, 2005. Standard Methods for the Examination of Water and Wastewater, twenty first ed. American Public Health Association, Washington, DC, USA.

Jong, Tony, and David L. Parry. "Removal of sulfate and heavy metals by sulfate reducing bacteria in short-term bench scale upflow anaerobic packed bed reactor runs." Water Research 37.14 (2003): 3379-3389.

Elliott, Phillip, Santo Ragusa, and David Catcheside. "Growth of sulfate-reducing bacteria under acidic conditions in an upflow anaerobic bioreactor as a treatment system for acid mine drainage." Water Research 32.12 (1998): 3724-3730.

Stoltz, Eva, and Maria Greger. "Influences of wetland plants on weathered acidic mine tailings." Environmental pollution, 144.2 (2006): 689-694.

Yang, Lei, Hui-Ting Chang, and Mong-Na Lo Huang. "Nutrient removal in gravel- and soil-based wetland microcosms with and without vegetation." Ecological engineering 18.1 (2001): 91-105.

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Foreign Investment and Environmental Protection: The Liability of Private Enterprises under International Environmental Law

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Abstract
Foreign investment and environmental protection entertain both synergistic and conflicting relations. On the one hand, multinational corporations (MNCs) can harness the resources (financial and technological) to promote environmental protection through various channels (e.g. Clean Development Mechanism, socially responsible investing and private environmental finance). On the other hand, foreign investment may adversely affect the environment of host State. The BP's Deepwater Horizon tragedy in the Gulf of Mexico in 2010, which caused the largest ever accidental marine oil spill, was a stark reminder of the environmental risks posed by the transnational economic operator.

However, traditionally, only States have legal subjectivity in international law. Due to the increasing global environmental challenges, calls for stronger obligations of MNCs under international law are not likely to subside. This paper therefore first aims to discuss the extent to which international environmental law can be directly applied to multinational corporations by analysing the status of MNCs under international law. Then the failure of public international law to achieve a global consensus on liability standards for environmental harm. It attributes this failure in part to the fact that public international law focuses on relations between states when most environmental harm is caused by the actions of private actors such as multinational corporations. After an overview of the recent progress of regulatory reforms at both domestic and international, this paper captures the emergence of two major 'informal' regulations – corporate self-regulation and 'civil regulation' – and argues that these 'bottom-up' approaches can help MNCs make contributions to international law making.

Keywords: foreign investment, environmental protection, Multinational Corporation, applicability, international environmental law

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1. Introduction - multinational enterprises and environmental protection

Multinational corporations (MNCs) wield increasing economic and social power. The most recent four decades have seen an emotional ascent of globalized business exchanges. Today, an estimated 100,000 MNCs represent around a fourth of the global gross domestic product (GDP)[1] and create a turnover which exceeds the public budget of many states[2].

The private sector wields considerable extensive financial and social power and even progressively expands into traditionally state-run sectors, satisfying (quasi-)governmental functions by providing infrastructure, housing, and health services or other social policies.

In fact, environmental protection can barely be accomplished without the participation or even the activity of the private sector, as has been recognised previously, in particular at the 2002 Johannesburg Summit. The contribution of the private sector is particularly important in connection with (i) project financing, (ii) technology transfer and also (iii) environmental governance[3].

From one perspective, MNCs may be seen as the main repositories of modern, environmentally friendly, technology, and as the most advanced experts on environmentally sound management practices[4].

Then again, MNCs can likewise hurt human rights, harm the earth, or commit crimes. For example, the BP's Deepwater Horizon tragedy in the Gulf of Mexico in 2010, which caused the largest ever accidental marine oil spill, was a stark reminder of the environmental risks posed by the transnational economic operator.

The challenge, therefore, is not just to steer private interest in pro-environment projects, additionally to present certain checks on the activities of the private sector (such as corporate social responsibility codes or accountability mechanisms). An ideal legal framework seeks to prevent environmental harm from arising out of the activities of MNCs, but also how MNCs might be encouraged to use the best technologies and managerial practices that will enhance the ability of host countries to develop their economies and societies in an environmentally friendly manner.

This paper therefore first aims to analyses the status of multinational corporations under international law, focusing in particular on international environmental law (2). Then the failure of public international law to achieve a global consensus on liability standards for environmental harm. It attributes this failure in part to the fact that

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[1] UNCTAD, 'World Investment Report: Non-Equity Modes of International Production and Development' (2011) UN Doc UNCTAD/WIR/2011, 24 and web table 34, <http://unctad.org/Sections/dite_dir/docs/WIR11_web%20tab%2034.pdf> accessed 5 December 2015.
[2] See John Mikler, 'Global Companies as Actors in Global Policy and Governance' in John Mikler (ed), The Handbook of Global Companies (Wiley-Blackwell 2013) 1, 4 ff.
[3] Dupuy, P.-M., & Vinuales, J. E. (2015). International Environmental Law. Cambridge: Cambridge University Press.
[4] Francioni, F. (2013). The private sector and the challenge of implementation. In P.-M. Dupuy & J. Vinuales (Eds.), Harnessing Foreign Investment to Promote Environmental ProtectionIncentives and Safeguards. Cambridge: Cambridge University Press.

public international law focuses on relations between states when most environmental harm is caused by the actions of private actors such as multinational corporations (3). After an overview of the progress of regulatory reforms at both domestic and international, this paper turns to capture the emergence of two major informal regulations and argues that these bottom-up approaches can help MNCs make contributions to international law making (4).

The focus will lie on discuss the extent to which international environmental law can be directly applied to multinational corporations, which helps to clarify the responsibility/liability of the economic operator for internationally wrongful acts in an environmental context.

2. International legal personality?

The central debate on MNCs in international law focuses on the question of whether or not they are subjects of international law, that is, whether they are 'capable of possessing international rights and duties, and [have] capacity to maintain [their] rights by bringing international claims'[5].

Personality is a requirement to bring legal claims in the various international enforcement tribunals. This means this international person would be a subject of international law defined by Brownlie (2008:57) as: 'an entity of the type recognized by customary law as capable of having these capacities (rights duties and powers to bring a legal claim) is a legal person.'[6] This is a crucial concept in public international law, as institutions and groups need it to operate within the international law arena. This can be contrasted with entities that are objects of the law; these are entities that might have legal rules to protect them (such as rules protecting animals and young children) but they do not in themselves have the legal rights and duties to enforce these rights in a court system.

Traditionally, international law was perceived as governing only the "mutual transactions between sovereigns". The classic position was that states were the principal (and sometimes argued to be only) subjects of public international law.

O'Conell (1970) argued that legal personality is only shorthand for the proposition that an entity is endowed by international law with legal capacity[7]. Jennings and Watts (1992) introduce the concept of international person as one who possesses legal personality in international law and enjoys rights, duties, or powers as established in international law and has the capacity to act on the international plane either directly or indirectly[8].

The classic view was that only states had international legal personality in international law, but that view radically changed in the twentieth century with the advent of international organizations and international criminal law which included international governmental organizations and individuals as international legal

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[5] Reparation for Injuries Suffered in the Service of the United Nations (Advisory Opinion) [1949] ICJ Rep 174, 179.

[6] Brownlie, I. (2008). Principles of Public International Law (7th ed.). Oxford: Oxford University Press.

[7] O'Connell, D. O. (1970). International Law (2nd ed.). London: Stevens & Sons.

[8] Jennings, R., & Watts, A. (1992). Oppenheim's International Law (9th ed.). London: Longman.

persons[9]. A few international legal scholars, on the other hand, have recognised MNCs as subjects of international law. Some have adopted a de facto approach based on their significant participation at the level of international law[10] and on the growing privatisation of international law as evidenced by investment law and arbitration[11].

Adhering to these formal prerequisites, the large majority of international legal scholars hold that MNCs do not possess international legal personality[12]. It is argued that they have not been granted rights or obligations under international law and that although companies benefit from a range of international law provisions, they do not necessarily enjoy corresponding rights[13].

It cannot be argued that corporations have international legal personality, as such, as they are subject to the particular national jurisdiction in which they are incorporated. There is a movement within human rights to bring corporations within international legal responsibility by the draft norms of corporate social responsibility, but they have been adopted by neither the Human Rights Council nor any sovereign states. Corporations have been brought into the international arena only voluntarily within such mechanisms as the global compact but it cannot be argued that they have full international legal personality.

Within the international law on foreign investment, there is clear indication that multinational corporations possess both rights and duties. There is a clear tendency to hold them responsible for certain types of conduct, though at the moment this is done largely through domestic law. Yet, the recognition of the multi-national corporation as a single entity and the recognition of its responsibility for violating international norms is slowly emerging. Though the draft Code on Transnational Corporations, which sought to achieve this, never progressed beyond its status as a draft, the principles it contains may well come to be recognised in the course of time.

Despite this enormous power both for good and for harm, the multi-national corporation has hardly been recognised as an entity capable of bearing rights and duties in positivist international law. Obviously, this position may have to change, given the reality that it is as dominant an actor on the international economic scene as the state.

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[9] Ibid

[10] See David Adedayo Ijalaye, The Extension of Corporate Personality in International Law (Oceana 1978) 244 f; Dominique Carreau and Fabrizio Marrella, Droit international (11th ed, Pedone 2012) 66.

[11] Tévar, Z. N. (2012). 'Shortcomings and Disadvantages of Existing Legal Mechanisms to Hold Multinational Corporations Accountable for Human Rights Violations' (2012) 4 Cuadernos de Derecho Transnacional 398, 400..

[12] Nowrot (n 23) 372 with further extensive references; Cassese (n 22) 103; Malanczuk (n 24) 100; Kay Hailbronner, 'Der Staat und der Einzelne als Völkerrechtssubjekte' in Wolfgang Graf Vitzthum (ed), Völkerrecht (4th edn, De Gruyter 2007) 178; Muchlinski, 'Corporations inInternational Law' (n 15); Eric De Brabandere, 'Human Rights and Transnational Corporations: The Limits of Direct Corporate Responsibility' (2010) 4 Human Rights and International Legal Discourse 66, 80; James Crawford, Brownlie's Principles of Public International Law (8th edn, OUP 2012) 122.

[13] See Malanczuk (n 24) 100: 'The fact that individuals or companies are the beneficiaries of many rules of international law does not mean that these rules create rights for the individual or companies, in much the same way as laws prohibiting cruelty to animals do not create rights for animals'.

As Gatto has observed, MNCs have 'no coherent existence as a legal entity [but are] a political and economic reality which articulates itself in a confusing variety of legal forms and devices.'[14] It is therefore more helpful to focus on the characteristics that distinguish MNCs from their national counterparts. Other than domestic businesses – even those that operate production facilities abroad, or export goods and know-how – MNCs have the capacity to flexibly move places of production and assets between countries. They structure management units independently of national borders and lose every tie to a nation state except for the formal nexus of incorporation. This operational fluidity and the ensuing detachedness from domestic bounds are one of the main reasons why national legislators fail to put adequate checks on the power of MNCs, and why MNCs have moved into the focus of international law.

Instead of taking a position in this discussion, the present contribution will follow Alvarez' advice and focus on 'addressing which international rules apply to corporations rather than whether corporations are or are not subjects of international law'[15].

3. Formal environmental regulation of MNCs: recent developments

This section deals with the detail of environmental regulation as applied to MNCs in particular. In this light it may be said that two main regulatory goals inform this area: first, to control any environmental harm caused by MNC operations, and to render such firms accountable for it and, secondly, to encourage MNCs to act as conduits for improved transnational environmental management practices and technology transfer.

'Formal' (or 'official') regulations undertaken by governmental (whether at the national or sub–national level) or inter–governmental authorities (whether at the regional or multilateral levels)[16]. Such regulation involves traditional 'command and control' techniques that are based on laws, regulations and administrative or judicial decisions and which ascribe responsibilities and liabilities upon firms directly. It can also be conducted through cooperative methods, in partnership with business groups, individual firms, and/or civil society groups and/or environmental NGOs, which may be based on mandatory obligations contained in contracts or on voluntary compliance mechanisms.

3.1 National law

Domestic law has proven to be insufficient to promote the positive effects of business by safeguarding a stable and reliable economic environment, and to curb the negative effects by ensuring accountability[17].

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[14] Alexandra Gatto, Multinational Enterprises and Human Rights: Obligations under EU Law and International Law (Elgar 2011) 4.

[15] Wouters, J., & Chane, A.-L. (2013). Multinational corporations in international law; José E. Alvarez, 'Are Corporations "Subjects" of International Law?' (2011) 9 Santa Clara Journal of International Law 1, 31.

[16] Muchlinski, P. (2007). Multinational enterprises and the law. Oxford: Oxford University Press.

[17] Percival, R. V. (2010). Liability for environmental harm and emerging global environmental law, Maryland journal of international law, 25(37).

National legislation is often unable to create a stable regulatory environment in which MNCs can operate, as well as to exercise control over the harmful acts of entities which fragment their activities globally, operate in decentralised network structures, and flexibly relocate operations and profits. In addition, economically weaker states depend on the investments of MNCs and may be unwilling to enact and enforce demanding human rights and environmental standards in order to enhance their attractiveness to foreign investors[18].

MNCs defy concepts of nationality and elude the grip of the – unwilling or unable – national legislator. The perceived inadequacy of domestic legislation to effectively regulate the activities of MNCs has moved the focus to the level of international law.

3.2 International law

For centuries legal systems around the world have sought to vindicate the principle that those who cause significant, foreseeable harm to others can be held liable for the damage their actions cause. Now widely known as the *"sic utere"* principle, this concept also has been incorporated into public international environmental law. It is recognized in Principle 21 of the 1972 Stockholm Declaration and Principle 2 of the 1992 Rio Declaration. These declarations acknowledge that nations have the duty "to ensure that activities within their jurisdiction or control do not cause damage to the environment of other States or of areas beyond the limits of national jurisdiction." [19]Thus, both private parties and sovereign nations have a duty to avoid causing harm to others.

Multilateral Environmental Agreements (MEAs) are addressed primarily at states and have at most indirect regulatory implications for MNCs. In accordance with the fundamental 'polluter pays' principle, a few specialised agreements establish civil liability rules for private actors which have the potential to cause particularly grave environmental damage, such as oil spills or nuclear leakages. All of these instruments rely on domestic implementation, and require the contracting parties to establish the necessary enforcement mechanisms[20].

Treaties regulating the liability of the economic operator (public or private) must be understood as what in private international law is often called 'uniform law' ('droit uniforme'), namely substantive law common to several States and established by treaty. 99 Indeed, the use of international law in this area is primarily intended to establish some parameters for the harmonised or at least equivalent operation of laws relating to compensation for certain damages resulting from regulated activities.

The first treaties or treaty systems were adopted in respect of damages resulting from the production of nuclear energy and oil pollution damage. As regards nuclear energy, two separate but related systems have been developed, one among OECD States and the other under the aegis of the International Atomic Energy Agency ('IAEA'). These systems are linked via a common protocol adopted in 1988, which seeks to harmonise

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[18] Sornarajah, M. (2010). The International Law on Foreign Investment (Second ed.): Cambridge University Press.

[19] Percival, R. V. (2010). Liability for environmental harm and emerging global environmental law, Maryland journal of international law, 25(37).

[20] Wouters, J., & Chane, A.-L. (2013). Multinational corporations in international law.

the situation of persons affected by the effects of a nuclear accident governed by one of the two systems[21].

Several treaties have provisions that incorporate the *sic utere* principle, but there is little or no consensus concerning precisely how it should be applied. More than a dozen multilateral agreements have been adopted to address transboundary pollution problems, but only five of these have entered into force. The inadequacy of public international law on liability for transboundary environmental harm is powerfully demonstrated by the fact that no nation asserted any liability claims for the Chernobyl nuclear accident, the worst nuclear accident in history.

Despite several incidents of severe transboundary pollution, including the April 1986 Chernobyl nuclear accident, little progress has been made in developing liability standards under public international law[22]. Nations have been less than enthusiastic about creating liability for themselves when companies subject to their jurisdiction cause transboundary harm. As Lakshman Guruswamy notes, "thus far it does not appear that states are willing to engage in the delicate process of defining the conditions and scope of international responsibility for environmental damage." The Third Restatement of Foreign Relations describes state responsibility for environmental harm as a concept "rooted in customary international law," but scant progress has been made in implementing it in practice[23].

Despite the promise of a "more determined" effort to develop global liability standards, little progress has been made since the Stockholm Conference 1992[24]. Since 1978 the International Law Commission (ILC) has been working to develop principles of "International Liability for Injurious Consequences Arising Out of Acts Not Prohibited by International Law." In 2001 it adopted a preamble and set of 19 articles on "Prevention of Transboundary Harm from Hazardous Activities" and in 2004 it released for comment eight draft principles on "The Allocation of Loss in the Case of Transboundary Harm Arising Out of Hazardous Activities." The ILC's approach has been to focus liability on the operator of the activity causing the harm rather than on the state it which it originates and to rely on states to develop their own procedures for compensating victims of environmental harm. While this initiative and other efforts may point the way for future progress, they fall considerably short of establishing effective global liability standards for environmental harm.

3.3 Environmental litigation

Private litigation seeking to hold polluters liable for harm has faced considerable obstacles[25]. Private plaintiffs occasionally have been able to recover damages when large, single sources of pollution caused visible harm (e.g, early 20th century smelter litigation, large oil spills) or where particular toxic substances (e.g., asbestos) have

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[21] Dupuy, P.-M., & Vinales, J. E. (2015). International Environmental Law. Cambridge: Cambridge University Press.
[22] Percival, R. V. (2010). Liability for environmental harm and emerging global environmental law, Maryland journal of international law, 25(37).
[23] Ibid.
[24] Ibid.
[25] Percival, R. V. (2010). Liability for environmental harm and emerging global environmental law, Maryland journal of international law, 25(37).

caused unique "signature" injuries. However, the difficulty of proving individual causation has rendered private law a poor vehicle for preventing the kind of harm now caused by multiple pollutants from multiple sources. While most countries now rely on public law to prevent environmental harm through comprehensive regulatory programs to regulate pollution, these programs usually do not provide compensation to the victims of such harm. When harm is caused by pollution originating in another country, it is even more difficult to hold polluters accountable because public international law has yet to create an effective global regime of liability for transboundary pollution despite commitments in both the Stockholm and Rio declarations to do so.

Despite the absence of an agreed-upon global liability regime, remarkable developments are occurring in several countries to make it easier to hold polluters accountable for the harm their emissions cause[26]. Some nations are modifying their laws to make it easier for private plaintiffs to overcome obstacles to recovering for harm caused by pollution. Public law also is being modified to enable governments to recoup damages for environmental harm. In the absence of an effective global liability regime, domestic legal systems are now entertaining more private transnational environmental litigation.

There is a duty on the part of all states to ensure compliance with standards that are prescribed either in international treaties or in customary international law relating to environmental protection. Home states of multinational corporations have the power of control over these corporations to ensure that they conduct themselves in accordance with the standards in the international law on the environment[27].

As in the case of human rights, there has also been an increase in the litigation before the domestic courts of home states alleging violation of environmental standards. The Bhopal litigation was unsuccessful because of the stringent application of the forum non conveniens doctrine. But, with new trends resulting in a more liberal application of the doctrine in various jurisdictions, it has become possible to contemplate the imposition of liability on parent corporations for environmental harm that had been caused in host states. These trends will accelerate, giving rise to the establishment of firm principles of liability of parent corporations for environmental harm caused by their subsidiaries[28].

4. The emergence of informal regulations: 'corporate self-regulation' and 'civil regulation'

Due to the limitations of formal regulation discussed above, this section covers in more detail the forms of environmental self–regulation undertaken by firms alone, or in partnership with environmental NGOs through methods of co–regulation.

4.1 Corporate self-regulation

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[26] Muchlinski, P. (2007). Multinational enterprises and the law. Oxford: Oxford University Press.
[27] Sornarajah, M. (2010). The International Law on Foreign Investment (Second ed.): Cambridge University Press.
[28] Ibid.

The rationale for self–regulation in this field was given in 1992 by Stephan Schmidheiny: global business had a responsibility to further sustainable development and that the best method for doing so was a combination of regulatory standards to direct performance and voluntary initiatives by the private sector. In particular, environmental harm was seen as a form of market failure that could be corrected through economic instruments that would offer incentives to firms to act in a more ecologically efficient way. The power of business to improve the environment was stressed as part of what has been termed 'eco–modernism': the faith that technology could be used to ameliorate the environmental harm caused by earlier generations of productive technologies. This approach amounted to a departure from earlier business perspectives on environmental issues, which saw environmental regulation as a barrier to the market and which sought to limit the effects of such regulation[29].

Of especial significance in relation to self–regulation has been the widespread adoption by MNCs of the International Standards Organization (ISO) 14000 series of environmental management standards[30]. These represent a hybrid private–public regulatory regime. It is private in that firms follow standards drawn up by a non–governmental international organization that represents the 134 national standard setting bodies of its member countries. These national bodies are in part governmental departments and in part hybrid or fully private bodies. Decision–making is, however, dominated by national industry groups in that the various national bodies that work towards the formulation of ISO standards have a strong local industry membership. On the other hand, the ISO is also a public regime to the extent that its standards are adopted as benchmarks for national laws and for the purposes of inter–governmental organization activities.

Negotiations on ISO Standards started in 1993 as part of the programme for meeting the aims of Agenda 21. The first five of the new standards were adopted in 1996. The ISO 14000 series covers six main areas including environmental management systems, environmental auditing, environmental labelling, environmental performance, evaluation, life cycle assessment, and terms and definitions. Of the already adopted ISO 14000 series it is ISO 14001 Environmental Management Systems – Specification with Guidance for Use which allows for corporate certification. The other four standards are for guidance only. To obtain certification each individual facility of the firm must apply.

Indeed, effective self–regulation may depend on effective standard setting and enforcement through traditional command and control regulation by host countries. Without this 'stick' firms may not act in the correct way. However, increased 'official' regulation may itself cause problems. It may be overbearing, by requiring too much of firms, and may not be effective, especially in resource–limited host countries. Against this background there may be an alternative approach, based on partnership between firms and environmental NGOs, or firms and governmental bodies, or a combination of both.

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[29] Segger, M.-C., & Weeramantry, C. G. (2004). Corporate social responsibility: international strategies and regimes. In M.-C. Segger & C. G. Weeramantry (Eds.), Sustainable Justice: Reconciling Economic, Social and Environmental Law (1st ed.): Brill - Nijhoff.

[30] Muchlinski, P. (2007). Multinational enterprises and the law. Oxford: Oxford University Press.

4.2 Civil regulation

The term 'civil regulation' has been coined to cover an emerging response to corporate environmental activity which is neither pure self–regulation by firms, nor formal 'command and control' regulation by states. It involves the active participation of environmental NGOs in the process of policy development, implementation, and compliance monitoring[31].

The participation of civil society is important to counterbalance the influence of economic interest groups, whose environmental externalities are often insufficiently addressed by State intervention or consumer behaviour[32]. Organisations such as Greenpeace, the World Wildlife Fund (WWF) or the International Union for the Conservation of Nature (IUCN), are but a few prominent examples of a vast and thriving body of environmental NGOs active at both the national and international levels, who have devoted substantial efforts to raise public awareness regarding environmental degradation and to channel public pressure. Indeed, the main functions performed by these NGOs can be classified into three main categories: (i) the formulation of the interests of civil society, (ii) assistance in implementation, and (iii) channeling public pressure. Of course, the performance of these functions can follow very different approaches.

This has come about as a result of a perceived 'regulatory gap' between traditional legal regulation by the territorial state and the increasingly transnational character of environmentally sensitive business activities. This 'gap' can also be attributed to the increased pursuit, by states, of market based economic policies that stress liberalization, privatization, and deregulation. Thus states may have consciously retreated from their role as environmental 'watchdogs' leaving much to self–regulation by firms. Such regulatory self–limitation will be compounded in developing countries that have little or no experience as environmental regulators, and which have few resources to devote to such tasks, but which have espoused market–based approaches to corporate regulation. The 'gap' is then filled by various civil society groups, including the major environmental NGOs, to create a sense of accountability that may have been lost in the process of deregulation. Thus the role of NGOs could also be characterized as one of filling the 'democratic deficit' that increasing marketization, of public economic functions in particular, might be said to create[33].

According to Peter Newell, civil society groups will pursue a binary policy of 'liberal' and 'critical' governance strategies. 'Liberal' strategies involve a cooperative approach to business and may lead to joint standard setting and to NGO/civil society–business partnerships devoted to the pursuit of particular environmental policy goals and/or the realization of particular projects. 'Critical' strategies involve NGOs and other civil society groups in a more familiar role as monitors of corporate activity, as expositors of corporate malpractices, and as advocates of more stringent controls over corporate excesses.

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[31] Muchlinski, P. (2007). Multinational enterprises and the law. Oxford: Oxford University Press.

[32] Dupuy, P.-M., & Vinuales, J. E. (2015). International Environmental Law. Cambridge: Cambridge University Press.

[33] Sornarajah, M. (2010). The International Law on Foreign Investment (Second ed.): Cambridge University Press.

The 'liberal' cooperative approach is evident in numerous cases of NGO–business partnership, which have had varying degrees of success. Perhaps the best–known example is the Forest Stewardship Council (FSC)[34]. Also, partnership arrangements have arisen in the context of industry privatizations that have environmental implications[35]. Thus in the water industry, NGOs, MNCs, UN agencies and government bodies have formed such arrangements. A final, noteworthy, example of NGO–business partnership in this field arose out of concerns as to how insurers could use their risk assessment procedures to create insurance incentives for firms to act in an environmentally responsible manner[36].

The last point leads to the consideration of 'critical' governance strategies by NGOs. Critical strategies have tended to lead to the development of partnerships with business[37]. For instance, the FSC is a direct result of protest against the rapid deforestation of Brazil undertaken by local groups and by Western NGOs during the 1980s and early 1990s. Also, the campaign against Shell concerning its operations in the Niger Delta, and their effect upon the Ogoni People, helped that firm to focus more critically on its environmental policy. The more powerful and respected NGOs have taken a dual liberal and critical approach to some firms. Thus, while it was mounting a hostile campaign against the Monsanto food company, for developing genetically modified food organisms, Greenpeace was also engaged in dialogue with that company about developing a PVC–free credit card for its supporters.

Ultimately, NGO monitoring and pressure will be of little avail without the commitment of government to set out benchmark standards that will result in legal sanctions if not followed. This will be the case not only in relation to the establishment of basic environmental standards in general regulatory statutes but also in relation to the provision of a legal framework for the conduct of business–NGO partnerships.

4.3 Contributions to international law making (bottom-up approach)

Although states are the primary creators of international law, MNCs have various avenues at their disposal to shape the law making process. They can contribute to the work of the ILO through the 'tripartism' mechanism and pursue their interests in international investment arbitration or (through WTO Members) WTO dispute settlement. Above all, they can use their political, social, and economic power to influence the legislative process by lobbying at the national level of the respective Member State, at the EU and international level, or by participating in dialogue and consultation. However, conflicting policy goals of states or international organisations as well as NGO activism can limit the clout of MNCs[38].

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[34] Muchlinski, P. (2007). Multinational enterprises and the law. Oxford: Oxford University Press.
[35] Ibid.
[36] Dupuy, P.-M., & Vinales, J. E. (2013). Harnessing foreign investment to promote environmental protection: incentives and safeguards. Cambridge: Cambridge University Press.
[37] Roberts, K. (2015). Corporate liability and complicity in International Crimes. In S. S. Jodoin, M-C. (Ed.), Sustainable Development, International Criminal Justice, and Treaty Implementation. Cambridge: Cambridge University Press.
[38] Wouters, J., & Chane, A.-L. (2013). Multinational corporations in international law.

The impact of NGOs is a new phenomenon. The role that they could play on the international scene was dramatically revealed in their ability to coordinate an international campaign against the acceptance of the Multilateral Agreement on Investment[39]. Their mobilising capabilities were repeatedly revealed in protests against the WTO at Seattle and Cancun, at successive World Bank meetings and whenever institutions regarded as being associated with neo-liberal notions met in Western capitals. Since their first rush onto the international scene was in connection with a foreign-investment-related issue – the scuttling of the MAI – they are likely to continue to play a leading role in determining such issues.

It is evident that NGOs will have a significant role to play in the future development of the international law on foreign investment. Their role has already helped to shift the law from the protection of multinational corporations to a consideration of their responsibility for misconduct. The view that is advanced by environmental and human rights groups is that a multilateral code on investments should be a balanced one conferring protection on foreign investment but also attributing responsibility when there are violations of environmental and human rights standards by these corporations.

For example, the adoption of the POP Convention was significantly facilitated by the momentum created by the publication of a report with support from WWF. Another example is the role of IUCN in the development of payment-for-ecosystem-services (PES) mechanisms, such as reservoirs of biodiversity and of greenhouse gas emissions. Finally, the intervention of NGOs can have significant influence on how a case is managed, as is evidenced by the famous Brent Spar case, where the intervention of Greenpeace prevented Shell from sinking an oil platform in the North Sea, by channeling public opinion against this form of decommissioning[40].

5. Conclusion

It has been seen in the proceeding discussions that, on the one hand, MNCs can contribute to economic and technological development, increasing the wealth and the living conditions of society. On the other hand, MNCs can severely impact human rights or the environment and even commit crimes for which they should be held accountable. Domestic law has proven to be insufficient to promote the positive effects of business by safeguarding a stable and reliable economic environment, and to curb the negative effects by ensuring accountability.

But the turn to international law has encountered difficulties as well. Lengthy debates about the international legal subjectivity of MNCs have precluded involvement with the substantive question of the rights and obligations of companies under international law. Subjectivity has been used as a threshold, awaiting the positive granting of rights and obligations by states. However, in light of the ever growing power of MNCs and considering ongoing reports about their involvement in human rights abuses and environmental harm, the calls for stronger obligations of MNCs under international law are not likely to subside.

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[39] Sornarajah, M. (2010). The International Law on Foreign Investment (Second ed.): Cambridge University Press.

[40] Dupuy, P.-M., & Vinuales, J. E. (2015). International Environmental Law. Cambridge: Cambridge University Press.

Caution should be exercised, though, since a single-minded focus on MNCs risks distracting from the primary responsibility of states. Here, many instruments are readily available which might benefit from increased attention and achieve similar results. It cannot be doubted that increased regulation of MNC environmental strategies through a combination of self–regulation, co–regulation, and command and control methods (through) will continue to develop. Equally, it is likely that environmental litigation will continue to make a significant contribution to the development of standards in the field.

It is not proposed to advocate one method or approach over any other. Indeed, the better view is that, in practice, given the political constraints placed upon governments and firms by the assumptions of the globalizing market economy, an eclectic mix of policy sites and techniques of regulation is most likely to be used. Thus 'command and control' methods will be useful, especially in setting benchmark standards and liability rules, and informal regulation will be of value in allowing for firm–specific expertise to be applied in solving environmental problems. Equally, a mix of local, national, regional, and multilateral regulatory sites may be involved in dealing with particular issues.

Thus it is not a simple matter of condemning or complementing MNCs on their environmental performance. Accordingly, the main theme of this paper has been to expose the variety of approaches to regulation and how these interact with each other, while at the same time placing these matters into the wider context of the debates on globalization and the environment. In some respects, this is a most tentative area for corporate regulation and one in which many new approaches to regulation have been experimented with. How effective these various approaches have been, or are likely to be, remain areas of keen controversy.

References

Brownlie, I. (2008). *Principles of Public International Law* (7th ed.). Oxford: Oxford University Press.

David A. I. (2012) The Extension of Corporate Personality in International Law (Oceana 1978) 244 f; Dominique Carreau and Fabrizio Marrella, Droit international (11th ed, Pedone) 66.

Dupuy, P.-M., & Vinales, J. E. (2015). *International Environmental Law*. Cambridge: Cambridge University Press.

Dupuy, P.-M., & Vinales, J. E. (2013). *Harnessing foreign investment to promote environmental protection: incentives and safeguards*. Cambridge: Cambridge University Press.

Francioni, F. (2013). The private sector and the challenge of implementation. In P.-M. Dupuy & J. Vinales (Eds.), *Harnessing Foreign Investment to Promote Environmental ProtectionIncentives and Safeguards*. Cambridge: Cambridge University Press.

Jennings, R., & Watts, A. (1992). *Oppenheim's International Law* (9th ed.). London: Longman.

Lowe, V. (2007). *International Law*. Oxford: Oxford University Press

Maljean-Dubois, S., & Richard, V. (2013). The applicability of international environmental law to private enterprises. In P.-M. Dupuy & J. Vinales (Eds.), *Harnessing Foreign Investment to Promote Environmental ProtectionIncentives and Safeguards*. Cambridge: Cambridge University Press.

McCorquodale, R. (2010). The individual and the international legal system. In M. Evans (Ed.), *International Law* (3rd ed.): Oxford University Press.

Mikler, J.(2013) 'Global Companies as Actors in Global Policy and Governance' in John Mikler (ed), The Handbook of Global Companies (Wiley-Blackwell) 1, 4 ff.

Muchlinski, P. (2007). *Multinational enterprises and the law*. Oxford: Oxford University Press.

O'Connell, D. O. (1970). *International Law* (2nd ed.). London: Stevens & Sons.

Percival, R. V. (2010). Liability for environmental harm and emerging global environmental law, *Maryland journal of international law, 25*(37).

Roberts, K. (2015). Corporate liability and complicity in International Crimes. In S. S. Jodoin, M-C. (Ed.), *Sustainable Development, International Criminal Justice, and Treaty Implementation*. Cambridge: Cambridge University Press.

Segger, M.-C., & Weeramantry, C. G. (2004). Corporate social responsibility: international strategies and regimes. In M.-C. Segger & C. G. Weeramantry (Eds.), *Sustainable Justice: Reconciling Economic, Social and Environmental Law* (1st ed.): Brill - Nijhoff.

Shaw, M. (2008). *International Law* (6th ed.). Cambridge: Cambridge University Press.

Sornarajah, M. (2010). *The International Law on Foreign Investment* (Second ed.): Cambridge University Press.

Tévar, Z. N. (2012). 'Shortcomings and Disadvantages of Existing Legal Mechanisms to Hold Multinational Corporations Accountable for Human Rights Violations' (2012) 4 *Cuadernos de Derecho Transnacional* 398, 400.

UNCTAD, 'World Investment Report: Non-Equity Modes of International Production and Development' (2011) *UN Doc UNCTAD/WIR/2011*, 24 and web table 34, <http://unctad.org/Sections/dite_dir/docs/WIR11_web%20tab%2034.pdf> accessed 5 December 2015.

Warbrick, C. (2006). States and recognition in international law. In M. Evan (Ed.), *International Law* (2nd ed.). Oxford: Oxford University Press.

Wouters, J., & Chane, A.-L. (2013). Multinational corporations in international law.

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Social fairness for a community in poverty in the natural area of environmental protection in Brazil: the Chapada dos Veadeiros National Park

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Abstract
This work is a case study that results from doctoral research, developed in the village of São Jorge, in the surroundings of Chapada dos Veadeiros National Park (PNVC) in Goiás. The population, consisting mainly of former miners, lives subjected to difficult survival situations for most. The intervention of the population could contribute to better living conditions, but this initiative is almost nonexistent. We investigated, through the perspective of critical environmental education, aspects of concepts and actions of subjects who favored greater community participation in the social context. Data collection was performed by suggested tools for qualitative research, and the analysis using the method of Content Analysis, through the technique of categorization. We concluded that the aspects in favor of greater participation are reduced, however, they can be extended to a larger number of people through the interaction with one another, which would favor the intervention in life situations surrounding the PNCV.

Keywords: environmental education, protected natural area, social inequalities.

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Introduction

We started from the idea that is already known in many areas of society, the severity of environmental problems to which we are subjected and for which we are primarily responsible. Exacerbated consumption of raw materials and products, the disappearance of species, degradation of the environment and negligence such as those that resulted in the recent case of Mariana, MG, exemplify some of these problems.

The socioeconomic and political insecurity is plaguing a great part of the world. Corruption, threat to life, oppression and various other forms of violence lead thousands of people to migrate in search of other places for survival.

This is a scenario whose crisis is not limited to deterioration of biogeochemical systems of the planet, but that permeates relations with each other in the environment. A crisis of values of the society, in which resources and people have been subjected to an unsustainable model of civilization.

Considering this background, a question arises: what to say about environmental education in times like this? At least, it is worth stating that only information about the natural components of the space and the formation of environmentally friendly attitudes are insufficient and that, with so many current adverse issues, a critical training of people is necessary to face such things.

In this sense, the critical environmental education can be constituted as a process capable of providing subsidies to the challenges of contemporary life. Building the capacity to identify, discuss and act upon the conditions of difficult survival could be a solution. Thus, we consider it as a process of training for life.

The constitution of questioning, analytical and active behavior is one of the main purposes of this process, which aims the setting up of people trained to intervene in situations that concern them, especially those that are essential to the struggle for better living conditions, in which the inequalities are accentuated.

In this context, among the various locations in Brazil that contain socioeconomic disparities among people, and the struggle for better living conditions is scarce, we find the Vila de São Jorge, located near the Chapada dos Veadeiros National Park (PNCV) in the state of Goiás. Initially, the aim of our research was to analyze the proposals of environmental education in state parks. Nevertheless, when we found ourselves confronted with the situation of this town, whose population, in most cases, is subjected to situations that make it difficult to survive on location, we were led to go other ways.

The modification of the original plan led for a sudden moment to the thought of designing a "proposal for environmental education" for the subjects of this village. However, it was soon discarded, given the perception that such purpose was very pretentious, since only a "course" would not be enough to solve the community's problems. Thus we assumed that the very people of the village would be the main responsible for the changes. And these changes would take place by the more effective participation of the villagers in situations which lead to difficult living

conditions in São George. With this position, we proposed to analyze aspects in the views and actions of the subjects that would be favorable to their own greater participation.

Having said that, we outlined the theoretical assumptions with which we dialogued for the analysis.

Theoretical assumptions of the study

In the field of environmental education, it is always worth reminding that there prevails a polysemy of different ways to think of it and practice it, ranging from the transmission of information about the components of space to the transformation of human relations. From this polysemy emerges the heterogeneity of intentions that lie in a non-neutrality sphere, with the materialization, whether conscious or not, of various ideological perspectives (SAUVÉ, 2005a, 2005b; CARVALHO, 2012; LOUREIRO, 2012).

In the discourse of environmental education there is a strong tendency to approaches regarding the natural characteristics of the area or the degradation by pollution. In many the emphasis on biological and physico-chemical characteristics of environmental degradation prevails, privileged at the expense of political, social and economic dimensions which characterize the environment space.

This conservative view expresses the belief that, transmitting information on the environment, we can alter people's "bad behavior". And the sum of individuals with behaviors changed would be the solution to the environmental issue, which is not true (GUIMARÃES 2011; LOUREIRO, 2012).

Leff (2010) considers that the concerns focused on the natural aspects contribute most to "greening" the thinking of society, reducing the interpretation of environmental issues to the description or conservation of natural systems. In this sense, Foladori (2001) points out that prospects facing this dimension promote a viewing shift on environmental issues to understanding inserted into a "natural" order.

The assumptions of critical environmental education guide the perspective of analysis. We adopted this framework because we believe that such a view takes the human being within the space of social and environmental dimensions; life in its complexity and understanding of environmental issues not restricted only to the natural dimensions of space. As its proposal is unveiling and committed to the transformation of social contexts, it would be possible to train people able to identify, challenge, propose solutions and act in the face of environmental issues through it.

We affirmed in this study that it is necessary to have perspectives among people that, when carrying out developments of relations, also favor the identification of the interests and behavior of the subjects in the places where they live (JACOBI, 2003; GUIMARÃES, 2007; LOUREIRO, 2012; PORTO-GONÇALVES, 2004; REIGOTA, 2009).

In this context, information is a key means to build knowledge, due to the fact that it allows people to take better advantage of opportunities, exert their rights, claim the provision of services, among other citizenship exercises (SAITO, 2000;

GUIMARÃES, 2007; LOUREIRO, 2012). Associated with this, the social contexts have elements that can be identified and leveraged to favor the empowerment of individuals (NARAYAN, 2002).

Empowerment here is understood as a dynamic process that aims to increase the autonomy of people in their social contexts. Generally, it refers to groups or individuals subjected to conditions of oppression and social vulnerability. In them, we try to develop a critical view and positions on social issues (FRIEDMANN, 1992; NARAYAN, 2002; GOHN, 2004).

Based on these guidelines, we believe that the participation of men and women in the socioeconomic context of their own lives, linked to critical perspectives, can lead to the empowerment of individuals, such a fundamental aspect in cases of difficulties in survival, as it is the one of the place of our study.

We conceived the empowerment and participation of individuals as integrated processes, and we believe that the very activity of subjects in the socioenvironmental dimensions of their contexts could structure and/or trigger these processes. In this sense, we considered the need for a non-reductionist view of space and interactions and policy stances for the sake of better conditions for the majority.

From these conjectures, we proposed the analysis of increased participation of community people in situations that cause difficult living conditions in São George.

The sociohistorical context of the research locus

In Brazil there are several conflicting situations or of social vulnerability in which people's participation is necessary. In this study, we focused on the social contexts of communities of protected natural areas, in particular the village of São Jorge nearby PNCV, whose sociohistorical context is outlined in this topic.

In this site there are noted survival difficulties for the majority of the population, which are arising mainly from the relationships that have been set in the location and accentuated with the arrival of tourism entrepreneurs; the remarkable political inattention of the municipality's management bodies; and a lower articulation of the subjects to cope with situations unfavorable to life in the village and to changes in this social context.

The research locus, the village of São Jorge, is a town whose population base consists of former quartz miners. Located less than two thousand meters from the entrance to PNCV, and at a distance of 480 km from Goiânia, in the northeast region of the state, the town began with the gathering of people in the place, attracted by the possibility of improvement in living conditions through the mining activities.

By being miners, these people were opening paths, trails and building huts, giving rise to different "villages" that have come and gone in the midst of the cerrado. The village of São Jorge originated from one of these villages (Fig. 1), which dates back, according to Almeida *et al.* (2007), to 1912, from a camp called Garimpão, which was later called Baixa dos Veadeiros and baptized in 1954 as Vila de São Jorge (São Jorge

Village). In 1996, the town became the district of Alto Paraíso de Goiás, located 35 km away from São Jorge.

Fig. 1: Aerial view of the village of São Jorge in the viccinity of the Chapada dos Veadeiros National Park. Source - Casa de Cultura Cavaleiros de Jorge/PNCV.

Historically, the difficulties for survival are the most striking features of the social fabric of the population life. From the invention of the synthetic crystal in the 1960s, mining was in crisis and the extraction of dry cerrado flowers became the main economic activity of these individuals' subsistence.

The harvest and trade of the cerrado flowers helped precariously in the town's livelihood. There are reports stating that entire families went to the fields and remained there for months, and that, at the beginning of the activity, traders in the region made their flower purchases directly; however, soon there appeared middlemen, which depreciated the price of the commodity, therefore increasing the difficulties for survival on site.

Although mining practices were already in decline, many families still survived the regional marketing of crystal chips. With this, the precarious livelihood was maintained for nearly two decades through this chips sale activity, as well as the depreciated flower trade and some subsistence farming practices.

The delimitation of the Park, which began in 1961, led to profound changes in the community's way of life (DOMICIANO & OLIVEIRA, 2012). Survival became even more difficult for the total ban on activities related to mining and the restriction on the subsistence farming with the expropriation of land ownership, completed in the late 1980s during the demarcation of PNCV area.

Many men and women interviewed for this study were children at the time while others were already adults. It was common, in the words of many, the story about facing hunger, conflicts between prospectors, physical violence, death and disappearance of people during this period.

Tourism was proposed in the 1980s as an alternative to the commercial decline of the crystal and the prohibition of mining activities. Immediately, the miners became tour guides and some of the women opened small inns and restaurants. Thus, since the 1980s, the inhabitants of the village have been involved directly or indirectly in tourism.

The surroundings of the park have great touristic potential due to their natural attractions, composed of archaeological sites, thermal water, rock formations, scenic beauty spaces, rapids and falls (Fig. 2). These could be used to structure activities that collaborate to improve the socioeconomic conditions of the majority of those who live around the PNCV.

Fig. 2: Aerial view of falls I and II of the Black River in PNCV. Source - Ion David, photographer in the region.

Nevertheless, there prevails a number of advantages of "newcomers" on the "natives". For example, the former can provide the tourist with services and accommodation options which differ significantly from the establishments of the natives. They also offer tourist better prices and food choices, given their logistics for the purchase of commodities and storage facilities. The "newcomers" can also offer more diverse and improved sightseeing activities.

Currently, in the village, the terms "native" and "newcomer" have been widely used. The "native" word is used to identify people who have their origin related to mining whereas "newcomer" designates those who chose the place to live or open a business related to ecotourism. The natives are usually tour guides, owners of small tourist attractions or of modest establishments; on the other hand, the newcomers are mostly wealthy businessmen, owners of agencies or hotels and upscale restaurants in São Jorge. The change in the base of the village population was due to the implementation of the Project Towards the Sun (Rumo ao Sol) and especially of the voluntary resignation program of president Collor's government in the 1980s. With funds from dismissal, several individuals migrated to São Jorge and have become tourism entrepreneurs.

Moreover, the fact that the "newcomer" entrepreneurs are mostly from Brasilia – the federal capital – collaborates with having political contacts that favor both the promotion of their businesses and the occupation of the hostels in the peak seasons. In the state's own touristic promotions, there is a highlight for establishments whose owners have this origin.

All this context accentuates socioeconomic inequalities among entrepreneurial newcomers and most of the village population. This, together with the poor organization of people to cope with this situation, corroborates the maintenance of

difficult economic conditions for the survival of people in the community in São Jorge.

This situation is compounded by the inattention of the political bodies towards the village. By the year 2016, the village had no paved streets (Fig. 3). Public lighting, which partially came in 1997, still does not exist in various parts of São Jorge. There are no banks, ATMs or gas stations on site.

Basic services are offered to the community with precarious or nonexistent conditions. There are no hospitals or health assistance centers in São Jorge and emergency calls occur at the pharmacy. Education is offered only for children in elementary school and there is a high level of illiteracy in the village. Safety check is performed only sporadically by cars sent from Alto Paraíso de Goiás.

Fig. 3: View of the Village of St. George with its unpaved streets. Source: the author.

It should be noted here that we call community members the group formed by natives and their descendants living in the village. Also inserted in this set are those who came from other places, which, unlike the newcomer entrepreneurs, assume an identity with the natives, establish emotional bonds with them and share the ideals of better living conditions for the majority. Thus we considered, as people from São Jorge, former miners, with their families, who correspond to the tour guides, female cooks, craftsmen, teachers, owners of Bed and Breakfasts and modest restaurants, cafeterias, people who develop projects for the benefit of the community and some owners of tourist attractions, all submitted in a greater or lesser degree to situations that cause unfavorable conditions for survival in the village.

All these facts we mentioned result in losses for the survival of the people of this place and influence on the formation of social, economic and adverse political life of these subjects.

It is true that many situations of life social difficulties in these communities derive from the low participation and little empowerment of individuals on issues that constitute social life. A greater participation would enable individuals to participate in the actions and decisions in their context. The increase of its influence in the resolution of problems, for the benefit of the majority, would contribute to the empowerment in social issues. And, therefore, it is essential to objectify collective and not only individual transformations.

Therefore, we decided to analyze, from the perspective of critical environmental education, aspects present in environmental concepts, in environmental education

concepts/practices and in the interests and participation of the subjects that would favor their greater participation in the village's socioenvironmental context nearby PNCV.

Methodological procedures of the research

The research conducted is a case study that was developed with field visitations in intermittent periods, for three years. The study included 44 respondents and, in the definition of the participants, we considered those who are part of the village's everyday life; we also delimited six groups from their main socioeconomic functions: Tourist Guides Group (GGT), Bed & Breakfast Owners Group (GPP) Group of Travel Agency Owners (GPAG), Tourist Attractions Owners Group (GPAT), Opinion Leaders Group (GFOP) and Political Agent Officers (GAPO).

Data collection was carried out by observation, with notes in field diary, registration by photographs, documents consultation and information from the PNCV collection on socio-historical aspects of the region and through semi-structured interviews (BOGDAN & BIKLEN, 1994).

Interviews are the main source of data. For the data analysis from this source, we chose the method of Bardin's Content Analysis (2011) and we used the technique of categorization. The analysis allowed to raise three categories: environmental concepts (category 1.0), environmental education conceptions/practices (category 2.0) and interest/participation of the subjects (category 3.0).

Results and discussion

The results and discussion of the study on the conceptions and actions reported by the subjects of the São Jorge Village are grounded in the critical perspectives of environmental education in dialogue with the concept of empowerment. Initially, we dialogued about environmental concepts and environmental education conceptions/practices. Later, we presented what was obtained about the interests and participation reported by the subjects in the Village.

On the environment concepts of subject

To start off with, it is important to emphasize that, in our study, we considered that the environmental conceptions determine the forms of interaction established by people with/in their space and influence their interests and actions (PORTO-GONÇALVES, 2004; REIGOTA, 2009; SAUVÉ 2005a), leading to a number of implications in the individuals' relationship with each other and in their role in the environment.

When analyzing the communications of 44 respondents, there were several environmental views which were classified into conceptions, based on Sauvé's typological definitions (2005a, 2005b).

In the study, 26 people (59%) presented the environment conception as a resource. We represented the occurrence of this and other views in Graph 1. About this result, we drew attention to the fact that seven participants expressed hybrid visions on the environment, as a resource and community project, as shown:
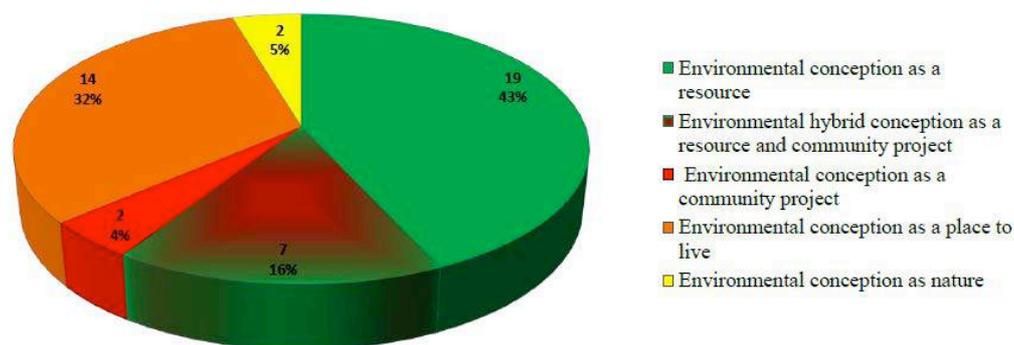
Graph 1: Environmental conceptions among the subjects of São Jorge. Source: research data, prepared by the author.

The frequency of reporting units and context in the communications confirms the inference that prevails, among those subjects, the environmental view as a resource. It is manifested by environmental ideas as a source of financial and food resources, guarantee space for the quality of life and resources for future generations, as can be seen in the following exchanges:

> [1] [...] it's our breadwinner! If I have no *interest in preserving* [...] in a few days I'll sell what? [...]. (PAG$_2$)
> [2] *We depend* on nature *to live*. [...] Otherwise *we'll lack* even *the food to survive*. (GT$_2$). [Emphasis added].
> [3] All that *the human being has* now *came from* the environment. The *production of everything we eat*. (PAT$_7$).
> [4] It's necessary that these woods are preserved *for me to have quality* water, *so I have quality weather*, which can *provide food*. (PP$_3$).
> [5] If we don't *take care of it*, if we don't *know how to use it, it will end*. (FOP$_7$).

These statements referring to the dependence of ideas and "care" about the environment, in fact, explicit subservience views of nature to humans, as exemplified by the speech of PAG$_2$ in exchange (1). As this speech, others that emerge in interviews, in which the environment is clearly stated as a commodity, reinforces our inference in the study that there is a predominantly utilitarian view of space.

This reductionist view, strongly perceived in the resource conception, is a negative aspect so there is a greater participation of people in situations involving the need to identify the difficulties experienced in their space, as well as the need for analysis and action against them (PORTO-GONÇALVES, 2004). Besides not favoring the identification of factors that cause the survival difficulties in São Jorge, this view also refers to the belief that only "care" with natural spaces are enough for the quality of life and its maintenance of today and in the future.

The views of the environment as a community space, obtained in the statements of nine respondents (20%), refer to understandings of the complex and conflictive nature of relationships on site. We considered these aspects in favor of greater participation

of people in the community, for they are interpretations that do not ignore the social context of São Jorge. As they are focused on the living conditions in the surrounding of the PNCV, they can collaborate to expand the sight field of the adverse conditions in the village.

On the conceptions/practices of environmental education on site

In the analysis of the conceptions and practices of environmental education existing among the subjects from São Jorge, we started from the assumption that they take place in political and ideological positions and acquire deployments according to the scenarios in which they articulate.

We believe that the conceptions and practices in place can influence for different forms of action and have implications in ways of thinking and acting on the environment (SAUVÉ, 2005a; 2005b). Thus, by appropriating the term used by Leff (2010), we believe that such conceptions and practices can contribute to what is called "greening of thought" of people of the place or the possibility of explanation of the contradictions that constitute the contexts of São Jorge.

The analysis on the concepts and practices among the subjects revealed that sustainability prospects are prevalent, among other conceptions / practices (holistic, critical and naturalist), as we represent:
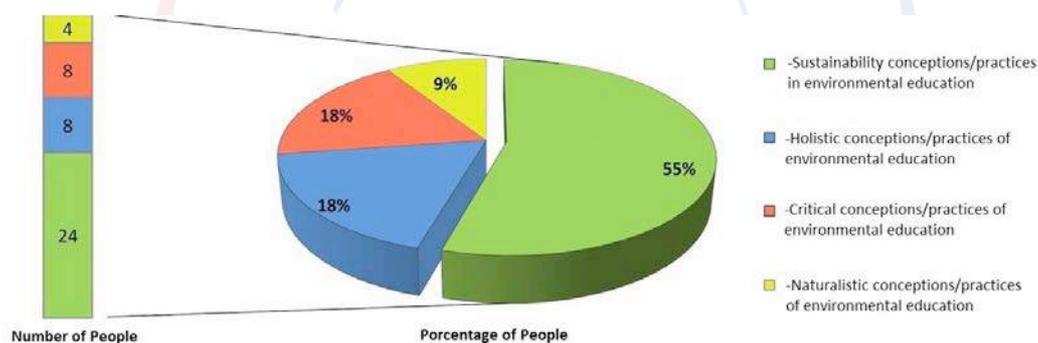
Graph 2: Conceptions / environmental education practices among the subjects of St. George. Source: research data, prepared by the author.

The view that prevails among the respondents can be exemplified by excerpts from communications of the participants, such as the following:

> [6] Environmental education is a job that will *get people to help conserve* what it has [...] (PAG$_1$).
> [7] *It's to recycle*! It is in this sense that we understand the environmental education here in São Jorge [...]. (PP$_5$).
> [8] [...] environmental education *would be to encourage* people *not to litter*, polluting. (PAT$_2$).
> [9] *It's to educate* the human being *for them to be aware of the concepts of sustainability*. (PAT$_5$).

We conceived that the prevailing claims in these ways of conceiving the process are in the development of attitudes of "care" towards this place, given the lines mainly

refer to the responsibility to the conservation of resources, decreased degradation of waste and reuse of materials.

All 44 respondents reported performing environmental education practices in São Jorge and nearby. As for these "practices", we focused on the analysis of only those that structure formation processes, such as those carried out by GT and performed in the existing projects in São Jorge.

The practices carried out by the GT aim primarily to train attitudes towards the conservation of spaces, particularly those surrounding the PNCV. We perceived that the GT seek to awaken the attention of people on the trails to the importance of conserving places for visitation. They talk about the importance of medicinal plants, consequences of deforestation and soil characteristics, directing at the conservation needs.

It is important to highlight that such information has value to knowledge related to natural spaces. However, we agree with the observations of Pedrini (2005), that practices such as those carried out by the GT, which emphasize physical and biological order factors, may favor more decontextualized understandings of their social environments.

Having said that, we affirm that practices with these characteristics contribute little to the reflection on the social dilemmas that pervade the lives of people. In São Jorge, they do not favor even the explanation of the interests which evolve the very conservation of tourism sites, and the main contribution of GGT practices for people who visit the place are the sensitization and the acknowledgement of natural space components.

Regarding the critical conceptions/practices of environmental education occurring in 9% of respondents, the analysis of this view showed the existence of aspects that would collaborate to critical understanding and intervention in the social issues of the place, as environmental education is designed, by those people, as a process geared towards the needs of the social context.

Aspects in favor of greater involvement of people emerge in these concepts, as they refer to the development of knowledge and intervention attitudes by the population. Nevertheless, the subjects who expressed them are not much involved in actions to the community currently. Only in one project, developed with children and adolescents around the PNCV, can we find the materialization of ideas close to that approach.

On the interests and subjects' participation in the village

In the analysis about the subjects' interests and participation, it is important to emphasize that the relevance of the investigation of such dimensions is in the fact that they provide clues about the respondents' attention and actions, which corroborates to respond to the study we proposed to. The occurrence of the record and context units in the communications allowed us to outline three categories of analysis, which refer to the interests and participation facing the following dimensions: natural of the space,

holistic and socioenvironmental. Regarding these, expressed by the respondents, we noted the following relationship specified in Graph 3:
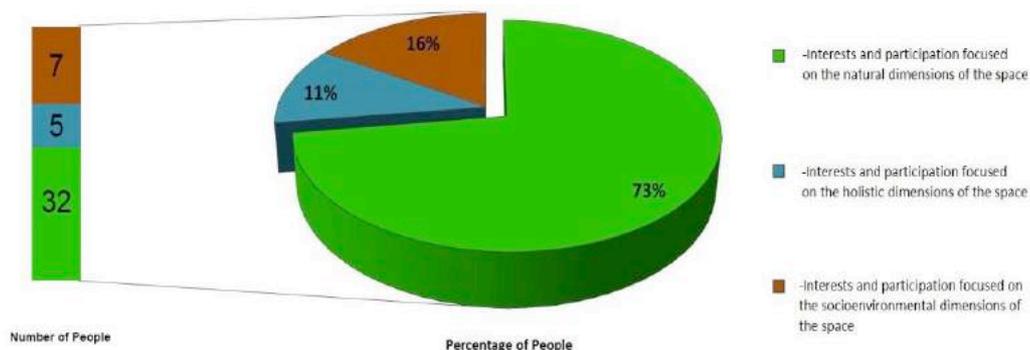
Graph 3: Interests and participation among the subjects of St. George. Source: research data, prepared by the author.

Most respondents (73%) reports that people have interests located in the natural dimensions of space, as exemplified some rounds of communications:

> [10] There is *an interest in permaculture* and the public who come to Chapada is interested in environment, *in forests.* (FOP_5).
> [11] They are *really interested* in knowing *how garbage from the bed and breakfasts is recycled, how the frying oil from restaurants is recycled* [...]. (PAT_7).
> [12] They *have an interest in environmental issues.* [...] They want to *know about the weather, the climate*, even about another area I've never been in. (GT_4).
> [13] [...] the people who settled down here *have this profile of nature lovers*, to *respect nature* [...] So this issue of environmental preservation, they *have that kind of worry: do not litter cigarettes, garbage* [...] these things [...]. (PP_6).

The interests focused on the socioenvironmental dimension of space emerged in a small portion (16% of people). In this regard, we believe that the interests facing the social and environmental dimensions of the village are a favorable aspect, which could lead to increased critical awareness and the ability to make decisions that would lead to empowerment.

Despite being low, the current participation of people in the village dilemmas, the analysis of documents showed that São Jorge was a place where most people got involved in actions organized in the village through associations. However, it is important to highlight that the people's action was predominantly directed at matters relating to the natural dimensions of the place. The analysis of the activities developed by the associations revealed that they were more centered in the development of actions of "care" towards the space, especially the attractions.

Currently, the associations that used to be spaces for people's dynamization are scrapped and were virtually inactive until the year 2014. However, at the end of that

year, a new direction took over ASJOR and resumed the Association's activities aiming to engage people by association in solving common problems. Hence, we believe that the purpose of the subjects' involvement in the identification and discussion on the village problems are favorable aspects to a greater participation and empowerment of people in the community.

Conclusion

In the study we conducted, we apprehended that the views, interests and actions prevalent among individuals determine a synergy of efforts to maintain natural spaces, with few enquiries about the real factors that determine the conditions of difficult survival in the village. We found few aspects in favor of greater participation and involvement of individuals but, even reduced, we believe that they have a potential for clarification of contradictions and can be extended through critical interaction with each other in organized collective processes.

In this sense, the reactivation of ASJOR in order to involve people from the community in finding ways for the social problems of the village is a quite favorable aspect to greater participation. Thus, based on these reflections, in a simplified way we can say that the aspects that would favor a greater community participation have to do with non-reductionist views of spaces and interactions, with processes that enable critical understanding for the identification and analysis of factors that condition the difficult situations of survival, and the organization of the population to intervene in the village's problems.

References

ALMEIDA, M. G. (2007). Vila de São Jorge e Parque Nacional da Chapada dos Veadeiros: os caminhos da geografia passam por lá. *Ateliê Geográfico: revista eletrônica do Instituto de Estudos Socioambientais da Universidade Federal de Goiás*, Goiânia, 1, 106-117.

BARDIN, L. (2011). *Análise de conteúdo*. São Paulo: EDIÇÕES.

BOGDAN, R., & BIKLEN, S. (1994). *Investigação qualitativa em educação.* Portugal: PORTO.

CARVALHO, I. C. M. (2012). *Educação ambiental: a formação do sujeito ecológico*. São Paulo: CORTEZ.

DOMICIANO, C. S., & OLIVEIRA, I. J. (2012). Cartografia dos impactos ambientais no Parque Nacional da Chapada dos Veadeiros (GO). *Revista Mercator*, 25, 179-199.

FOLADORI, G. (2001). *Limites do desenvolvimento sustentável*. Campinas: ED. UNICAMP.

FRIEDMANN, J. (1992). *Empowerment: the politics of the alternative development*. Cambridge: BLACKWELL PUBLISHERS.

GOHN, M. G. (2004). Empowerment and community participation in social policies. *Saúde e Sociedade*, 13, 20-31.

GUIMARÃES, M. (2011). Armadilha paradgmática na educação ambiental. In LOUREIRO, C. F. B. (Org.). *Pensamento complexo, dialética e educação ambiental.* São Paulo: CORTEZ.

GUIMARÃES, M. (2007). *Educação ambiental: no consenso um embate?* Campinas: PAPIRUS.

JACOBI, P. R. (2003). Educação ambiental, cidadania e sustentabilidade. *Cadernos de Pesquisa*, 18, 189-205.

LEFF, E. (2010). *Epistemologia ambiental.* São Paulo: CORTEZ.

LOUREIRO, C. F. B. (2012). *Trajetória e fundamentos da educação ambiental*. São Paulo: CORTEZ.

NARAYAN, D. (2002). Empoderamiento y reducción de la pobreza. Colômbia: BOGOTÁ.

PEDRINI, A. G. (2011). Educação ambiental: trajetórias da educação ambiental. In A. G. PEDRINI (Org.). *Educação ambiental: reflexões e práticas contemporâneas.* Petrópolis: VOZES.

PORTO-GONÇALVES, C. W. (2004). *Os (des)caminhos do meio ambiente.* São Paulo: CONTEXTO.

REIGOTA, M. (2009). *O que é educação ambiental*. São Paulo: BRASILIENSE.

SAITO, C. H. (2000). Educação ambiental, investigação-ação e empowerment: estudo de caso. *Revista Linhas Críticas*, 7, 31-44.

SAUVÉ, L. (2005). Educação ambiental: possibilidade e limitações. *Educação e Pesquisa,* 31, 317-322.
SAUVÉ, L. (2005). Uma cartografia das correntes em educação ambiental. In I. C. M. CARVALHO, & SATO, M. (Org.). *Educação ambiental: pesquisa e desafios.* Porto Alegre: ARTMED.

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Social Intervention: Center for Studies (IFG/GO/Brazil) in a Community of Small Farmers at Risk by the Use of Pesticides

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Abstract
The paper corresponds to an intervention of a Center for Research in Brazil (NUPEDEA) in a community of small farmers at risk situation by the use of pesticides. The study was conducted by undergraduate Chemistry students and professors from the Federal Institute of Education, Science and Technology of Goias, Anapolis Campus, in the city of Joanapolis/Goias/Brazil, in the rural area where the agricultures live and in the urban area where their children go to school. The problems which have led to the intervention in the community were: verification of high rate of cancer; children/juveniles working in the plantations without personal protective equipment (PPE); little knowledge about the products in use. The study takes place at the little town school and at the food production sites. Our aim is to provide knowledge about the risks to health, the importance of using PPE and about alternative products which can be less harmful. The food, soil, and people's clothing chemical analysis showed high rate of contamination. Thereby, we have developed materials with information and we have regularly visited the school and the farms. The field research demonstrates some changes in behavior that are considered favorable factors against the risk situation in which those people live.

Keywords: Critical Environmental Education; pesticides; social vulnerability.

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Introduction

The current study was held under the Critical Environmental Education perspective as a possibility of forming knowledge to fight the risks due to pesticides use in a small community of farmers in Joanapolis, Goias, Brazil. The focus of the proposal is to raise the main problems in this framework and start the process of empowerment of individuals through information on the use and problems arising from the indiscriminate application of pesticides in agriculture.

This research aims to contribute to the process of empowerment of individuals through education and knowledge by critical environmental education. This is a quantitative and qualitative research. Data were collected through observation notes in field diary, visual record of photographs, interviews with members of the community, access to official documents and sources of information on the Joanapolis community.

Center for Research in Brazil (NUPEDEA)

This paper presents the first stages of an action-research held by the Center for Studies and Research on Teacher Education and Environmental Education (NUPEDEA). NUPEDEA is a newly established center in the Federal Institute of Education, Science and Technology of Goias (IFG), Anapolis Campus. In 2014 it was registered and certified by the Brazilian National Council of Scientific and Technological Development. It is composed by professors from different fields and undergraduate students in the Bachelor in Chemistry and Education course.

Currently, NUPEDEA is located at the Anapolis Campus, one of 14 campi of IFG. Studies and researches have been held in two different but converging fields: teacher education, especially natural sciences teaching, and environmental education regarding sustainability and empowerment in situations of social-economical vulnerability. About 10 professors from various fields and 30 undergraduate students have been developing 12 different researches.

Figure 1: NUPEDEA location.   Figure 2: NUPEDEA researchers meeting.

NUPEDEA's main goal is to articulate research, teaching and outreach to develop education and social promotion. In this regard, all activities held by the group are greatly focused on social intervention.

Critical Environmental Education and Empowerment

The theoretical basis of critical environmental education guides the perspective of this study. We assume that only information about natural space components is insufficient and that, with so many adverse issues nowadays, critical formation is necessary for people to confront situations that jeopardize their very survival (FOLADORI, 2001; LEFF, 2010).

We believe that critical environmental education may be part of a process capable of providing subsidies to the challenges of contemporary life. This perspective considers the human being within the space of social and environmental dimensions, seeing life in its complexity and understanding environmental issues not restricted only to the natural dimensions of space (OLIVEIRA, 2016).

The main purpose of critical environmental education lies in the formation of a subject able to identify, challenge, propose solutions and act in the face of adverse social situations. And the development of these capabilities is through proper involvement of people in their social, political and economic contexts. In this sense, the critical perspective of environmental education would foster the formation of contextualized knowledge, a more complex and instrumentalized reading of the world for social intervention (GUIMARÃES, 2004; 2007).

However, it is important to note that knowledge alone does not guarantee changes in adverse social frameworks. Changes happen through the intervention of the subjects, in which collective action is critical because it potentiates greater involvement of individuals and stimulates the formation of leaders that streamline the organized social groups (OLIVEIRA, 2016). Thus, people may have increased capacity to identify, analyze, claim their rights and the provision of services, among other citizenship attitudes (SAITO, 2000; GUIMARÃES, 2004; LOUREIRO, 2012).

In this study, empowerment is understood as a dynamic process that aims to increase the autonomy of people in their social contexts. It generally refers to groups or individuals subjected to conditions of oppression and social vulnerability. In this sense, empowerment aims to develop critical views and sustainable positions to face adverse issues (BAQUERO, 2012; FRIEDMANN, 1992; GOHN, 2004; HOROCHOVSKI; MEIRELLES, 2007; NARAYAN, 2002; ROMANO, 2002; WENDAUSEN; KLEBA, 2009). It corresponds to the process in which people build conditions that allow them to have influence, capacity for action and decision to arbitrate on issues that concern themselves (FRIEDMANN, 1992; NARAYAN, 2002).

Research context

As already mentioned, this paper presents the early stages of an action-research held by NUPEDEA together with a small community of farmers at risk by the use of pesticides in the very small town of Joanapolis/Goias/Brazil/. The research has been

developed in site, i.e., in the plantations and farms where the people work and live and in the small town school where the farmers' children study.

NUPEDEA is located at the Anapolis Campus of IFG, a region where the city of Joanapolis and many other small towns and rural areas are located. The map below illustrates the area.
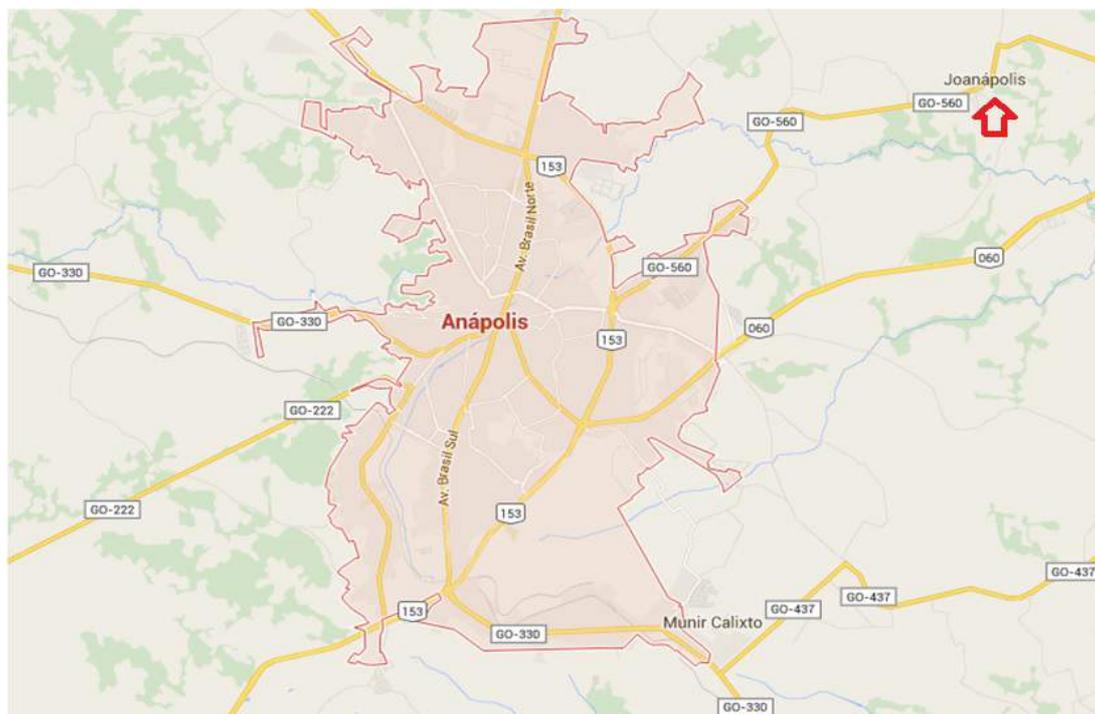
Figure 3: Place of research: Anapolis area and Joanapolis town.

When we turn to the environmental dilemmas surrounding the city and region of Joanapolis, we face situations of risk to the lives of people, which have led us to intervention in the community. We found high cancer rate, children and adolescents working in agriculture, inadequate and/or indiscriminate handling of pesticides, use of banned poisons, lack of protective equipment and little knowledge regarding the products used.

As NUPEDEA tries to articulate teacher education engaged in social environmental issues, we have tried to recognize and understand the social context of these farmers and intervene in situations of risk, with the development of actions that are planned and executed by the university professors, the undergraduate students of Bachelor in Chemistry and Education course and the community members.

The critical perspective of environmental education was assumed in the empowerment of individuals. However, it is important to note that this research effort is based on an empirical context, characterized by the interaction between small farmers and college students and professors, to provide a framework of lower risk to life resulting from the use of pesticides.

The constitution of this knowledge among farmers, contextualized in risk situations experienced by the use of pesticides, corresponds to the main objective of the study. Based on reports on the practices of farmers by one of the undergraduate students,

who has lived in the community since childhood, our hypothesis was that this knowledge would be low among these farmers.

Even though the study is still under progress, the research stage already allows some inferences, especially with regard to the socio-environmental context of farmers, as we are going to show next.

Results and analysis

To reach the objectives of this rsearch, two locations were chosen for the development of the activities: the small rural properties where the farmers work and live and where the plantations are located and; the small town school, where the farmers' children study.

The research was divided into 4 execution steps:
1. Identification of social-economic aspects of the community;
2. Identification of risk situations;
3. Knowledge formation regarding pesticides;
4. Implementation of changes in the community attitudes.

Regarding the first step, data were collect by means of observation notes in field diary, visual record of photographs, interviews and official documents. Although we already knew it is a very poor community in a situation of social vulnerability, data shows that 100% of families have over 5 people and, in this scenario, 75% of children over 8 years old work in agriculture with pesticides. Agriculture is the only income source for 96% of the families, but only 5% of them own the land where they live and work, and 93% of the people have studied under elementary school level. 85% of the people have lived in this rural area for over 10 years, and life has been very difficult, with little or no government interventions and/or access to public services. The chart below summarizes the social-economic aspects of the community.

Social-economic aspects of the community	
Families over 5 people	100%
Have lived in the rural area for over 10 years	85%
Agriculture as the only income	96%
Own the land	5%
Under elementary school level	93%
Children over 8 work in agriculture with pesticides	75%

Figure 4: Social-economic aspects of the community.

Regarding the second step, the following risk situations were found: use of prohibited poisons and pesticides harmful to human health; careless use of pesticides; contamination of local soil and water resources; low/non use of individual protection equipment; high levels of chemicals present in food items. The following images illustrate some the findings.

Figure 5: Use of prohibited pesticides.

Figure 6: Different kinds of pesticides.

As we can see in the images above, the farmers have been using DDT, pesticide derived from Aldrine, Endrine, BHC, amongst others illegal pesticides which they buy from dealers due to the low price compared to legal pesticides. On average, farmers use from 8 to 12 different kinds of pesticides in 80% of their plantations.

Figure 7: Handling pesticides with no personal protection equipment.

Figure 8: Using pesticides with no personal protection equipment.

As the images above clearly show us, 0% of the farmers uses suitable individual protection equipment. That includes the children who work in the plantations. To deepen the analysis and to provide a basis for knowledge formation, chemical analysis was held regarding the substances handled and their quantities. As a parameter, the

Brazilian laws and regulations on the use of pesticides and chemicals in food production were taken into consideration. The following chart presents the analysis results.

Analysed component	Predominant chemicals	Recommended level *– level of contamination (μg/L)
Superficial layer of soil in fruit and vegetables plantations (15 cm)	1-Organophosphorates: 2-Organochlorines: 3- Carbamates: 3-Metals (Pb, Cd e Ar):	1,57 μg/m^3 - 9,47 μg/m^3 2,09 μg/m^3 – 11,02 μg/m^3 12,01 μg/m^3 – 137 μg/m^3 0,2-20 mg/Kg -1,3-124 mg/Kg
Superficial running water nearby plantations (100 m)	4- Carbamates: 5- Organochlorines: 6-Glyphosate:	20 μg/L – 257μg/L 0,03 μg/L – 48,9 μg/L 500 μg/L – 3789 μg/L
Food (leaves and fruit)	7-Organochlorines: 8- Organophosphoratess: 9- Metals (Pb, Cd e Ar):	0,01μg/Kg – 1,2 μg/Kg 0,05μg/Kg – 2,1 μg/Kg 0,2-20 mg/Kg- 30-300 mg/Kg
Food (roots and tubers)	10- Organochlorines: 11- Organophosphorates: 12-Heavy metals:	0,01μg/Kg – 0,8 μg/Kg 0,05μg/Kg – 1,01 μg/Kg 0,2- 20 mg/Kg –8 -130 mg/Kg

*Recommended / permitted level according to Brazilian laws and regulations.

Figure 9: Chemical analysis.

As we may see, the levels of contamination greatly surpass what is permitted by law. Regarding the superficial layer of soil in the plantations, contamination reaches over 600% higher than permitted. Regarding water supplies, contamination reaches over 750% higher that permitted. Regarding direct food samples, leaves and fruit seem to be the most contaminated. Contamination in food samples reaches over 1500 times higher than permitted.

From these alarming findings, the next step of the research was put into implementation. Actions were promoted regarding knowledge formation about pesticides. In the school where the farmers' children study, the undergraduate students of Chemistry and Education conducted rounds of conversation, readings, educational activities, workshops, lectures etc. These activities were planned and organized together with the university professors and the local teachers at the school. The images that follow illustrate the execution of this step of the research.

Figure 10: Knowledge formation at the town school.

After the activities of knowledge formation at the school, the farms were also visited by the researchers together with the farmers' children. Rounds of conversation were also conducted by the undergraduate students.

Figure 11: Knowledge formation in the rural area.

As the fourth and last step of this action-research, we proceeded to the implementation of changes in the community attitudes. All the farmers were visited and rounds of conversation were held with all the farmers and their families. The farmers had the chance to share their experiences, doubts and insecurities and to build new knowledge and attitudes from that. The images that follow show this moment of the research.

Figure 12: Implementation of changes in the community attitudes.

The group of undergraduate students and professors also worked with the farmers in order to help them recognize and use alternative products and reduce the use of illegal pesticides. The images below show part of this work.

Figure 13: Implementation of changes in the community attitudes at the farms.

Conclusion

The research has allowed us to understand that the knowledge the farmers usually have regarding the use of pesticides come from their own experience and observation (by seeing others doing it) and from shared conversations and experiences with others who recommend the use of this or that product. This leads us to conclude that the farmers had little access to information regarding the toxicity or level of contamination which pesticides may cause.

From these initial evidences and based on the theoretical and methodological frameworks in which we based our work on, we can affirm that the construction of contextualized knowledge may contribute to people empowerment in risk situations they experience daily.

We emphasize that the perspective of environmental education we assume contributes to this process. In the current development stage of the study, we have built a gradual involvement with farmers and their families in their activities. We believe that the formation process of critical environmental education collaborates so that people can make their own choices, gain greater control over the circumstances, participate in decisions regarding their own lives, and develop a critical view and positions in the face of risk situations often ignored due to the little knowledge about its causes and consequences.

The empowerment process can occur in this community of small agricultural farmers through capacity building for these people to initially realize the facts that surround them, discuss and decide on situations that concern themselves. In this sense, their very participation/action in their social contexts, mediated by information and stimulating critical thinking, can lead them to empowerment.

We may conclude that ways might emerge to empower these individuals, since the results obtained in this part of the studies were satisfactory. We perceived good reception by the people who participated. They have shown interest in deepening their knowledge of the subject matter. We learned that they were surprised by some information that were addressed, but likewise excited by the possibility of information. We also highlight as positive the promotion of a sense of union among farmers, which until then did not exist, to approach the subject in a collective way.

We believe that the empowerment of these subjects for a better attitude against the risk of inappropriate use of pesticides corresponds to a process that will take place gradually over a systematized work. Regarding the development of this study, its main objectives were achieved. Thus, as the proposed empowerment of these subjects also results from NUPEDEA activities, the continuation of this process will take place by means of other forms of intervention in this community, which will be developed in 2016 and 2017.

References

BAQUERO, R. V. A. (2012). Empoderamento: instrumento de emancipação social? Uma discussão conceitual. *Revista Debates*, Porto Alegre, 6, 173-187.

FOLADORI, G. (2001). *Limites do desenvolvimento sustentável*. Campinas: ED. UNICAMP.

FRIEDMANN, J. (1992). *Empowerment: the politics of the alternative development*. Cambridge: BLACKWELL PUBLISHERS.

GOHN, M. G. (2004). Empowerment and community participation in social policies. *Saúde e Sociedade*, 13, 20-31.

GUIMARÃES, M. (2004). Educação ambiental crítica. In: MMA. Secretaria Executiva. Diretoria de Educação Ambiental (Org.). *Identidades da educação ambiental brasileira.* Brasília: MMA.

GUIMARÃES, M. (2007). *Educação ambiental: no consenso um embate?* Campinas: PAPIRUS.

HOROCHOVSKI, R. R.; MEIRELLES, G. (2007). Problematizando o conceito de empoderamento. In: SEMINÁRIO NACIONAL DE MOVIMENTOS SOCIAIS, PARTICIPAÇÃO E DEMOCRACIA, 2., Florianópolis, 25-27 abr. 2007. *Anais*. Florianópolis: UFSC, 2007. p. 485-506.

LEFF, E. (2010). *Epistemologia ambiental.* São Paulo: CORTEZ.

LOUREIRO, C. F. B. (2012). *Trajetória e fundamentos da educação ambiental*. São Paulo: CORTEZ.

NARAYAN, D. (2002). *Empoderamiento y reducción de la pobreza*. Colômbia: BOGOTÁ.

OLIVEIRA, A. S. O. (2016) *As possibilidades de uma educação ambiental crítica na Chapada dos Veadeiros*. 2 v. (Doutorado em Ciências Ambientais). Faculdade de Ciências Biológicas, Universidade Federal de São Goiás, Goiás.

ROMANO, J. O. (2002). Empoderamento: recuperando a questão do poder no combate à pobreza. In: ANTUNES, Marta; ROMANO, Jorge O. (Org.). *Empoderamento e direitos no combate à pobreza.* Rio de Janeiro: ActionAid Brasil.

SAITO, C. H. (2000). Educação ambiental, investigação-ação e empowerment: estudo de caso. *Revista Linhas Críticas*, 7, 31-44.

WENDAUSEN, A.; KLEBA, M. E. (2009). Empoderamento: processo de fortalecimento dos sujeitos nos espaços de participação social e democratização política. *Revista Saúde e Sociedade*, São Paulo, 18, 733-743.

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Utilization of Diatomite as Silica Source for the Synthesis of Ordered Mesoporous Silica Materials

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Abstract

Mesoporous silica is an important material which has wide range of industrial applications. Currently, it is produced from precursors that are costly. This paper presents the preparation of mesoporous silica MCM-41 materials using diatomite as inexpensive silica source and quaternary ammonium salt as structure directing agent by sol-gel method. The obtained samples were characterized by x-ray powder diffraction, N_2 physisorption, field emission scanning electron microscopy and transmission electron microscopy. The results indicated that as-synthesized MCM-41 possessed well-ordered hexagonal structure, monodispersed spheres particle, high surface area and pore volumes. MCM-41 was also produced from pure silica source for comparison. The results obtained in this work demonstrated the feasibility of diatomite as a potential source of silica and could significantly reduce the cost to preparation MCM-41 mesoporous materials.

Keywords: Diatomite; Mesoporous silica; MCM-41; Synthesis;

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1. Introduction

Mesoporous silica is a mesoporous form of silica and it is recently developed in nanotechnology. These materials present the diameter of the pore in the range of 2 – 50 nm. More importantly, it consists of Silicon oxide (SiO_2) arrangement in a well-defined symmetrical geometry. Currently, there are various forms of mesoporous silica and play an important roles in a modern science technology due to its unique properties. One of the most investigated material is M41S family especially MCM-41(Beck et al., 1992; Kresge, Leonowicz, Roth, VartUli, & Beck, 1992). MCM-41 possess a variety of attractive properties including highly ordered pore systems with pore diameter between 2 and 10 nm. , 2-D hexagonal structure with high surface area (>1000 m^2/g), large pore volume and good thermal stability. These characteristic make MCM-41 to be a promising option for use as catalyst, catalyst support, adsorbent and guest-host chemistry(Gaydhankar, Taralkar, Jha, Joshi, & Kumar, 2005; Mokhonoana, 2005).

Several synthesis routes have been developed to obtain these materials. Sol-gel technique has been widely used as a simple method that offers a low temperature for synthesizing. The process is based on the hydrolysis and condensation reaction of organometallic compounds in alcoholic solutions(Singh et al., 2014). In the sol-gel process, there are 3 main compositions including starting inorganic materials (e.g. Tetramethyl orthosilicate (TMOS), Tetraethyl orthosilicate (TEOS), etc.), structure directing agent (Cetyltrimethyl ammonium bromine (CTAB), Sodium dodecyl sulfonate (SDS), Pluronic P123, etc.), and solvent (e.g. ethanol or water). However, from the practical viewpoint of the preparation of these materials, the cost of desired material produced strongly depends on the cost of silica source used. In recent years, a lot of companies have been devoted to reducing the cost of preparation by using natural raw materials or industrial solid wastes which contain high silica content(Misrana, Singha, Beguma, & Yarmob, 2007).

Diatomite or diatomaceous earth is a sedimentary rock composing the fossilized skeleton remains of diatoms and typically found in the muck of wetlands or lakes. The diatomite particles show a porous structure approximately 80-90% void, light-weight, large specific surface area and thermal stability(A.Q.Selim, A.A.El-Midany, & S.S.Ibrahim, 2010; Elden, Morsy, & Bakr, 2010). Additionally, they can be used as alternative silica source for the production of mesoporous materials because of its price and high silica content. So, this study will focus on the use of diatomite as alternative silica source for mesoporous silica MCM-41 synthesis by sol-gel method. The obtained samples were characterized by x-ray powder diffraction, N_2 physisorption, field emission scanning electron microscopy and transmission electron microscopy.

2. Experiments

2.1 Materials

As the staring materials for synthesis of the mesoporous silica, Diatomite was obtained from Maetha District of the Lampang province, Thailand. The chemical composition are shown in Table 1. The as-received diatomite was dried at 373 K overnight and gently ground to pass through 270-mesh (<53 μm) metal sieve.

Tetraethyl ortho-silicate (TEOS, 98%), cetyltrimethylammonium bromide (CTAB, 98%), ethanol (99.8%), aqueous ammonia solution, sodium hydroxide, sulphuric acid (H_2SO_4, 37%) and hydrochloric acid (HCl, 70%) were purchased from Sigma-Aldrich (USA).

2.2 Synthesis of mesoporous MCM-41

The synthesis of MCM-41 was modified from the previous reports (P. Kumar, Mal, Oumi, Yamana, & Sano, 2001; Meléndez-Ortiz et al., 2012; Stöber & Fink, 1968). In the first step of sample preparation, the diatomite powders were treated with sodium hydroxide in a weight ratio of 1:1.2 and transferred into a hermetically closed Teflon vessel, and heated at 150 ºC for 24 h. The supernatant had to be filtered before the further reaction. Then, the organic template (CTAB) was dissolved in a solution of aqueous ammonia and ethanol. After 15 min, the supernatant was dropwise added and the mixture was kept under the vigorous stirring for 2 h at room temperature. The pH value of solution mixture was adjusted to approximately 10-11 with sulfuric acid. In each case, the solid product was obtained was filtered and dried at room temperature. Finally, the products were heated to 550 ºC and held for 6 h. For a comparison, the sample was also synthesized from pure silica source TEOS as the same procedure. The mesoporous silica synthesized from diatomite and pure silica source TEOS were denoted as MCM-41(DM) and MCM-41(TEOS), respectively.

2.3 Characterization

All mesoporous silica samples were analyzed by several techniques as follows;

X-ray powder diffraction (XRD): Phase analysis by XRD (Bruker AXS Model D8-Discover) was carried out at room temperature using CuK$_\alpha$ radiation as the radiation source (λ = 1.5406 Å) at a scan speed of 0.5° min^{-1} and a step scan of 0.02°. A scan angle over the range 0.6-10° (2θ) was used to identify mesoporous material. The difference phases observed in the XRD spectra were identified with reference to standard JCPDS cards available in the system software.

X-ray Fluorescence Spectrometer (XRF): Diatomite chemical compositions were obtained by XRF method using Philips PW2400.

N_2 physisorption: Surface area and porosity were determined from nitrogen adsorption-desorption isotherms obtained (at -196 ºC) on Micromeritics Chemisorb 2750 Pulse chemisorption system instrument.

Field emission scanning electron microscopy (FESEM): The particle morphologies were observed by FESEM image using JEOL mode JSM-5410LV, at an acceleration voltage of 10 kV.

Transmission Electron Microscopy (TEM): The TEM bright field image was taken using a JEM-200CX electron microscope operated at 200kV. The sample for TEM measurements were suspended in ethanol and dropped onto holey carbon films supported on Cu grids for imaging.

3. Results and discussion

3.1 Structural properties

The hexagonal mesoporous silica is normally detected by XRD at low 2θ angles from 0.6º to 10º as shown in Fig. 1. The diffraction peaks in both the material are presented in similar patterns and exhibited one sharp peak ascribed to the peak from *h k l* reflection plane 1 0 0 plane of the highly ordered two-dimensional hexagonal structure at $2\theta = 2.40$ and $2\theta = 2.28$ for MCM-41(TEOS) and MCM-41(DM), respectively(Beck et al., 1992). Decrease in peak intensities of the 1 1 0 and 2 0 0 plane were observed for both materials. These sharp signals indicated the long-range order of the uniformly hexagonal structure which is the distinctive characteristic of MCM-41 type. However, the characteristic peaks of MCM-41(TEOS) become sharper and more intense than that of MCM-41(DM), which indicates the higher degree of crystallinity.

In order to investigate in the degree of ordering, the unit cell parameter (a_0) of hexagonal structure was calculated according to the formula $a_0 = 2d_{100} / \sqrt{3}$, where d_{100} is the inter-planar spacing as a function of Miller indices 1 0 0 plane. The a_0 values can be calculated using XRD data of the profiles shown in Fig. 1 and summarized in Table 1. A slight decrease the d (1 0 0)-spacing and the unit cell parameter (a_0) of MCM-41(DM) were observed as compared to MCM-41(TEOS). This can be partly attributed to the lower degree of polymerization of silicate species under strong alkaline conditions.
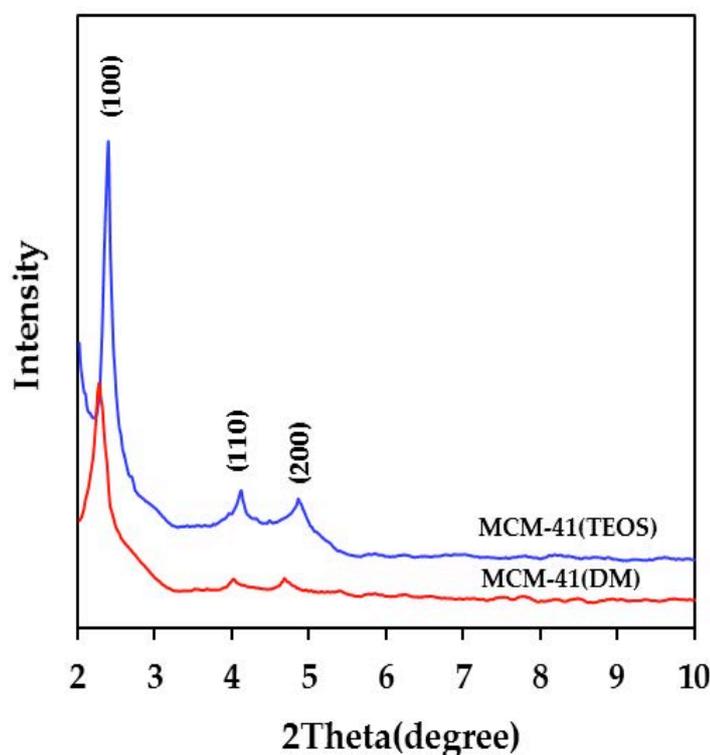
Figure 1: XRD patterns of MCM-41(TEOS) and MCM-41(DM) materials

Table 1. The unit cell parameter (a_0) of MCM-41(TEOS) and MCM-41(DM) materials

Sample designation	d_{100} (nm)[a]	Unit cell parameter a_0 (nm)[b]
MCM-41(TEOS)	3.68	4.25
MCM-41(DM)	3.87	4.47

[a] The observed length of 1 0 0 plane to another as obtained from XRD data.
[b] Unit cell parameter calculated as $a_0 = 2d_{100}/\sqrt{3}$.

3.2 Textural properties

The porosity structures were investigated by using the nitrogen sorption isotherms as given in Fig. 2. Data of their specific surface area, pore volume, pore diameter and wall thickness are summarized in Table 2. It can be observed from Fig. 2 that, the isotherms of both materials exhibit the typical isotherm type IV with the hysteresis loops of type H1, which are the characteristic feature of the ordered mesoporous materials with uniform cylindrical pores open at both ends, defined by IUPAC(Kruk & Jaroniec, 2001). Moreover, the steep curve and hysteresis loop take place in the range of relative pressure of $0.3 < P/P_0 < 0.5$ which is typical for the filling of mesoporous systems(Wang, Guo, Wang, Liu, & Wang, 2010) The inflection point of MCM-41(DM) slightly shifted toward a higher relative pressure (p/p0), which indicated the broadening of the pores to larger pores sizes compared to MCM-41(TEOS). This observation was corresponding with the XRD results.

The BET surface area of MCM-41(DM) was lower approximately by 26.72 % when compared to MCM-41(TEOS). This result may be associated with the reactivity of the chosen silica source, which pure silica sources produce the higher specific surface area.

Nevertheless, the pore diameter of both materials were rather close to each other and ranging between 2 – 10 nm. The wall thickness was calculated by the different between the unit cell parameter (a_0) and the pore diameter (D_p) as given in Table 2. It is obvious that the wall thickness of both materials were in the range of 1.91–2.24 nm, which is typical of traditional mesoporous MCM-41 materials.
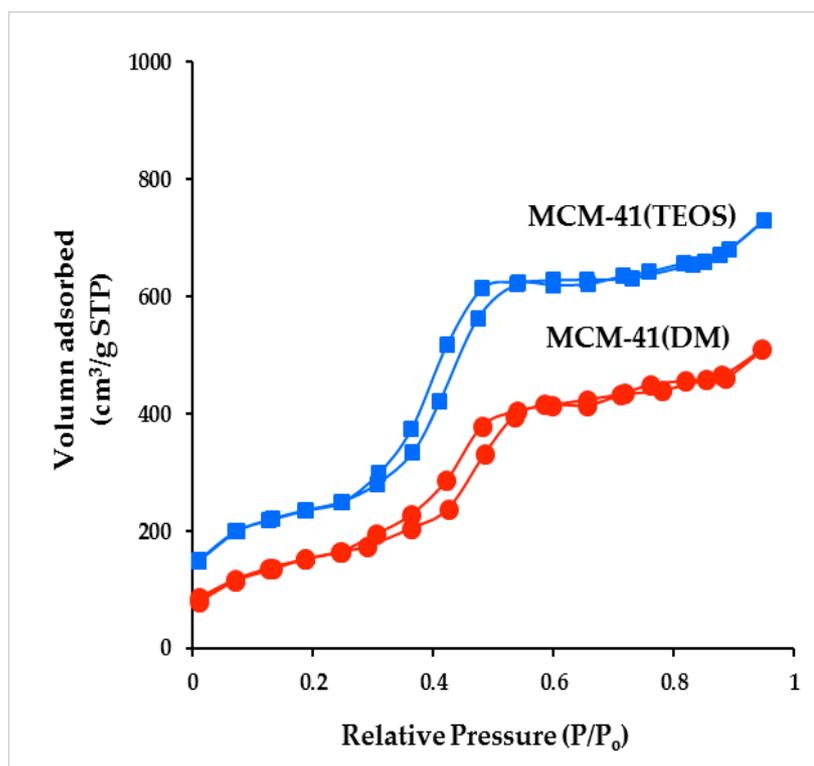
Figure 2: Nitrogen adsorption and desorption isotherms at 77 K on MCM-41(TEOS) and MCM-41(DM) materials. STP: standard temperature and pressure.

Table 2. Textural properties of MCM-41(TEOS) and MCM-41(DM) materials.

Sample designation	S_{BET} $(m^2g^{-1})^a$	V $(cm^3g^{-1})^b$	D_p $(nm)^c$	W_t $(nm)^d$
MCM-41(TEOS)	1077.00	0.94	3.3	1.61
MCM-41(DM)	789.24	0.58	2.3	2.17

[a] BET specific surface area

[b] V is the total pore volume were obtained by the BJH adsorption curves.

[c] D_p is the average pore diameter calculated using BJH method.

[d] Pore wall thickness, $W_t = a_0 - D_p$.

3.3 Particle morphology

SEM images of MCM-41(TEOS) and MCM-41(DM) materials are shown in Fig. 3. The morphologies of both materials are spherical shape. It can be observed that, The MCM-41(TEOS) particles can be clearly seen as spherical particles with uniform size distribution whereas the MCM-41(DM) particles are almost spherical with a slightly rough surface and partially non-uniform size distribution. TEM study was performed to further determine pore geometry structure. As shown in Fig. 4, both of materials possessed ordered hexagonal pore systems (honeycomb porous structure). These observations were in agreement with the results of XRD patterns and corresponding with that other reported MCM-41 materials (Beck et al., 1992; D. Kumar, Schumacher, Hohenesche, Gru, & Unger, 2001; Matsumoto, Chen, Tsutsumi, Gru, & Unger, 1999).

Eventually, all of these result suggest that the successful formation of mesoporous silica MCM-41 materials with two-dimensional hexagonal pore structure using

sodium silicate derived from natural diatomite. Thus, natural diatomite was proved to be an alternative of a cheap silica source for the production of mesoporous silica MCM-41 materials.
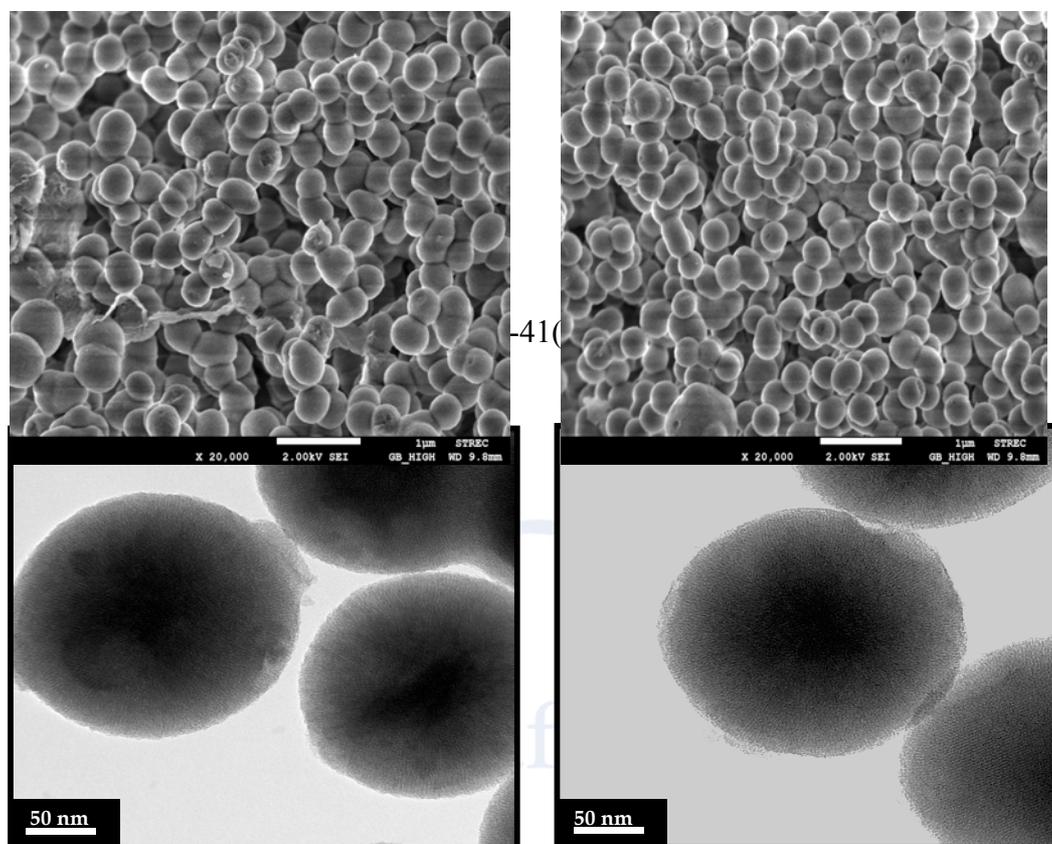
Figure 4: TEM images of MCM-41(TEOS) and MCM-41(DM) materials

4. Conclusion

In this study, well-ordered mesoporous MCM-41 materials has been successfully synthesized by condensation-polymerization with diatomite as a silica source. The morphological features of the mesoporous silica produced from diatomite was in good agreement with that derived from using pure commercial silica source. The XRD result indicated that the long-range order structure and the regular mesoporous hexagonal structure of typical MCM-41 was achieved. The specific surface area was slightly lower when compared to the former materials. The morphology of particles have shown spherical shape with fused particle were partly formed. This method can reduce the cost of preparation and also expand the commercial utilization of diatomite. Therefore, the diatomite has the potential to be used as an alternative and cheap source of silica in the production of mesoporous silica MCM-41 materials.

Acknowledgement

References

A.Q.Selim, A.A.El-Midany, & S.S.Ibrahim. (2010). Microscopic evaluation of diatomite for advanced applications: Case study. *Microscopy: Science, Technology, Applications and Education*.

Beck, J. S., VartUli, J. C., Roth, W. J., Leonowicz, M. E., Kresge, C. T., Schmitt, K. D., . . . Schlenkert, J. L. (1992). A New Family of Mesoporous Molecular Sieves Prepared with Liquid Crystal Templates. *Journal of the American Chemical Society, 114*(27), 10834 - 10843.

Elden, H., Morsy, G., & Bakr, M. (2010). Diatomite: Its Characterization, Modifications and Applications. *Asian Journal of Materials Science*.

Gaydhankar, T., Taralkar, U., Jha, R., Joshi, P., & Kumar, R. (2005). Textural/structural, stability and morphological properties of mesostructured silicas (MCM-41 and MCM-48) prepared using different silica sources. *Catalysis Communications, 6*(5), 361-366. doi:10.1016/j.catcom.2005.02.011

Kresge, C. T., Leonowicz, M. E., Roth, W. J., VartUli, J. C., & Beck, J. S. (1992). Ordered mesoporous molecular sieves synthesized by a liquid-crystal template mechanism. *Letter to nature, 359*, 710 - 712.

Kruk, M., & Jaroniec, M. (2001). Gas Adsorption Characterization of Ordered Organic-Inorganic Nanocomposite Materials. *Chem. Mater., 13*, 3169-3183

Kumar, D., Schumacher, K., Hohenesche, C. d. F. v., Gru, M., & Unger, K. K. (2001). MCM-41, MCM-48 and related mesoporous adsorbents: their synthesis and characterisation. *Colloids and Surfaces A: Physicochemical and Engineering Aspects, 187–188* (109–116).

Kumar, P., Mal, N., Oumi, Y., Yamana, K., & Sano, T. (2001). *Journal of Materials Chemistry, 11*(12), 3285-3290. doi:10.1039/b104810b

Matsumoto, A., Chen, H., Tsutsumi, K., Gru, M., & Unger, K. (1999). Novel route in the synthesis of MCM-41 containing framework aluminum and its characterization. *Microporous and Mesoporous Materials*(32), 55–62.

Meléndez-Ortiz, H. I., García-Cerda, L. A., Olivares-Maldonado, Y., Castruita, G., Mercado-Silva, J. A., & Perera-Mercado, Y. A. (2012). Preparation of spherical MCM-41 molecular sieve at room temperature: Influence of the synthesis conditions in the structural properties. *Ceramics International, 38*(8), 6353-6358. doi:10.1016/j.ceramint.2012.05.007

Misrana, H., Singha, R., Beguma, S., & Yarmob, M. A. (2007). Processing of mesoporous silica materials (MCM-41) from coal fly ash. *Journal of Materials Processing Technology, 186*, 8-13.

Mokhonoana, M. (2005). MESOPOROUS SILICA MCM-41 (Si-MCM-41). 95-154.

Singh, L. P., Bhattacharyya, S. K., Kumar, R., Mishra, G., Sharma, U., Singh, G., & Ahalawat, S. (2014). Sol-Gel processing of silica nanoparticles and their applications. *Advances in Colloid and Interface Science, 214*, 17-37.

Stöber, W., & Fink, A. (1968). Controlled Growth of Monodisperse Silica Spheres in the Micron Size Range. *Journal of colloid and interface science, 26*, 63-69.

Wang, Y., Guo, Y., Wang, G., Liu, Y., & Wang, F. (2010). Synthesis, characterization and catalytic activities of bimetallic modified MCM-41 for epoxidation of styrene. *Journal of Sol-Gel Science and Technology, 57*(2), 185-192. doi:10.1007/s10971-010-2340-4

Preparation and Properties of Konjac Bran-Graft-Poly (acrylic acid) Superabsorbent Polymer

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Abstract
Biopolymer-based superabsorbent was synthesized by graft copolymerization of partially neutralized acrylic acid (AA) onto glucomannan backbone in konjac bran via a thermal initiator system of potassium persulfate (KPS) and using N,N'-methylenebisacrylamide (NMBA) as a crosslinking agent. The synthesized superabsorbent polymer was characterized by FTIR and SEM. The influence of variables content on the water absorbency property including amounts of AA, KPS, NMBA and konjac bran were investigated. Results obtained from this studied showed that the maximum equilibrium water absorbency was 554 g g^{-1} in deionized water and 56 g g^{-1} in 0.9 wt% NaCl aqueous solution under the optimized conditions. Furthermore, the superabsorbent polymer was good water retention, being biodegradable and low cost that can be used in a various range of applications especially in the horticulture and agriculture industry.

Keywords: Konjac bran; Glucomannan; Acrylic acid; Superabsorbent polymer; Water absorbency

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1. Introduction

Superabsorbent polymers (SAPs) are crosslinked hydrophilic polymers chains forming a 3-dimensional network structure that have the ability to absorb and retain large volumes of water and aqueous solutions compared to their dry weight. Because of their excellent properties, superabsorbent polymers are widely used in many fields, such as baby nappies and adult incontinence pads, controlled release medium, agriculture and horticulture, etc. (Elliott, 2004). However, most of SAPs are based on chemical synthetic polymers, which are costly, poorly degradable, and environmentally-unfriendly.

Recent research focused attention on the superabsorbent polymers based on natural polysaccharides for their characteristic properties, including biodegradability, renewability and nontoxicity (Ma, Ran, Yang, Feng, & Lei, 2015). Some natural polysaccharides such as starches, celluloses, gum ghatti, chitosan and alginate can be prepared as superabsorbent polymers via graft copolymerization of vinyl monomers onto the chain of natural polymers.

Konjac bran is a kind of waste from tubers of amorphophallus konjac plant. It is contained the konjac glucomannan (KGM), a more abundant natural polysaccharide, that consist of β-1,4-linked D-mannose and D-glucose in an approximate ratio of 2 : 3 with a low degree of acetyl groups (approximately 1 acetyl group per 17 residues) at the side chain C-6 position (Chen, Zhang, & Li, 2015; Tian et al., 2012). Furthermore, KGM has a large number of hydrophilic groups in the molecular chains. The abundant hydroxyl groups on glucomannan backbone make KGM easily modified in chemical way and a better raw material for synthesis superabsorbent polymer.

The aim of this study is to investigate the synthesis of a novel konjac bran-graft-poly(acrylic acid) superabsorbent polymers (KB-g-PAA) by graft copolymerization reaction of partially neutralized acrylic acid (AA) and konjac bran (KB), using N,N'-methylenebisacrylamind (NMBA) as a crosslinking agent and potassium persulfate (KPS) as a initiator, in aqueous solution. The influent of the amount of reaction parameters (such as monomer, initiator, crosslinking agent and konjac bran) on water absorbency of the KB-g-PAA was studied in both deionized water and 0.9 wt% NaCl solution were investigated and discussed.

2. Experimental

2.1 Materials

Acrylic acid (AA, CP grade) and N, N'-methylenebisacrylamide (NMBA, CP grade) were purchased from Sigma-Aldrich Co. LLC. Potassium persulfate (KPS, AR grade) and Sodium hydroxide (NaOH, AR grade) purchased from Ajax Finechem, Australia. Konjac bran was purchased from Monkey King Food co.,LTD., Bangkok, Thailand. Mixed konjac bran and deionized water (ratio = 1 : 20) and stirred at 50 ˚C for 5 min until the konjac bran's gel was formed.

2.2 Preparation of KB-g-PAA superabsorbent polymer

Grafted copolymerization of superabsorbent polymer was prepared by slowly neutralizing AA (0.1 – 0.2 mol) with 5 M NaOH solution (degree of neutralization 65%) during which the temperature was keep < 20 °C by a cool water bath and put solution in a 500 mL four-necked flask equipped with a stirrer, a condenser, a thermometer, and a nitrogen line. Then, added the NMBA and konjac bran's gel to the acid solution sequentially. The mixture was heated to 70 °C and stirred for 30 min under nitrogen atmosphere and oil bath to completely dissolve konjac bran's gel into solution. Then, the initiator KPS (dissolved into 5 mL deionized water) was added to the mixture to initiate the polymerization. After 4 h, the resulting product was cut into small pieces and dried in an oven at 60 °C to a constant weight to evaporate the solvent. The dried product was milled and screened. All samples had a particle size in the range of 40 – 60 mesh.

2.3 Water absorbency measurement

The water absorbency of the prepared KB-g-PAA superabsorbent polymer was determined in deionized water and in saline solution of 0.9 wt% NaCl by tea bag method (Tian et al., 2012) as follow: accurately weighted 0.1 ± 0.001 g samples were put into a tea bag and immersed in excess medium at room temperature for 2 h. After that the water unabsorbed into swollen gels was removed by putting the tea bag in air for a short time. Then wiped with filter paper and weighed tea bag containing the swollen gels. The water absorbency was calculated by the following equation:

$$Q = \frac{m_2 - m_1 - m_0}{m_0} \tag{1}$$

where m_2, m_1, and m_0 were the weight of the wet tea bag containing the swollen gels, the tea bag, and the dried samples, respectively.

2.4 Characterization

2.4.1 FT-IR spectroscopy. The structure of the superabsorbent polymer was characterized by a Fourier Transform Infrared Spectrophotometer (Perkin Elmer spectrum one) in the range from 400 to 4000 cm^{-1}. KBr pellets of the samples were prepared.

2.4.2 SEM examination. The surface morphologies of the KB-g-PAA superabsorbent polymer were examined using a scanning electron microscope (JSM-6610LV). The samples were coated with Au before SEM examination.

3. Results and discussion

3.1 Effect of initial monomer content on water absorbency

The effect of initial monomer content on water absorbency of superabsorbent polymer was studied by varying the acrylic acid content from 0.1 to 0.2 mol, and keeping constant other parameters such as initiator (KPS, 0.35 mmol), crosslinking agent

(NMBA, 0.1 mmol), neutralization degree (65 %) and konjac bran (0.4 g). As shown in Fig.1, The water absorbency of KB-g-PAA SAP in both deionized water and 0.9 wt% NaCl solution was increasing with the raising of monomer content. The maximum absorbency (554 g g^{-1} and 56 g g^{-1} in deionized water and 0.9 wt% NaCl solution, respectively) was obtained at 0.2 mol of AA. The increase in water absorbency may be attributed to increase in the diffusion of AA molecules into the polysaccharide backbones and enhances the hydrophilicity of superabsorbent polymer
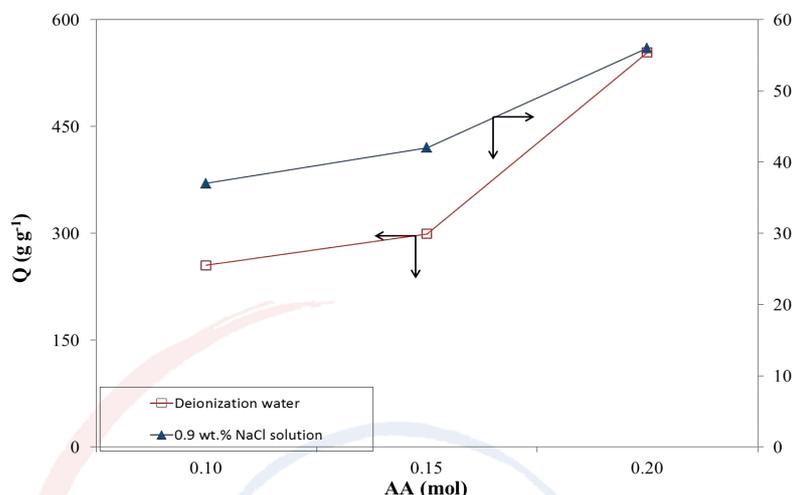
(Pourjavadi, Soleyman, & Barajee, 2008).
Fig.1. Effect of initial monomer content on water absorbency. Reaction conditions: KPS 0.35 mmol, NMBA 0.1 mmol, Konjac bran 0.4 g, neutralization degree 65%

3.2 Effect of initiator content on water absorbency

The effect of initiator content on water absorbency of superabsorbent polymer was investigated (Fig.2). The water absorbency was decreased versus increasing the initiator content from 0.35 to 1.05 mmol. This water absorbency loss can be attributed to an increase the terminating step of reaction via bimolecular collision which causes to enhance crosslinking density of SAP (Hosseinzadeh, Sadeghzadeh, & Babazadeh, 2011). In addition, the free radical degradation of glucomannan backbones by sulfate radical-anions is an additional reason for abatement of swelling at higher KPS content.
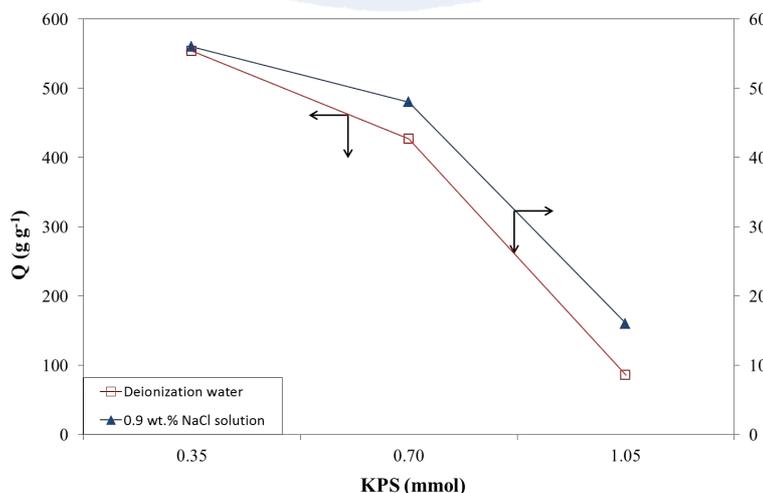
Fig.2. Effect of initiator content on water absorbency. Reaction conditions: AA 0.20 mol, NMBA 0.1 mmol, Konjac bran 0.4 g, neutralization degree 65%

3.3 Effect of crosslinking agent content on water absorbency

A crosslinking agent is used through SAP preparation to provide crosslinks between polymer chain to form a network structure and prevent the SAP swelling to infinity. The effect of NMBA content on water absorbency of KB-g-PAA SAP was studied by varying the NMBA content from 0.1 – 0.5 mmol and the results were shown in Fig.3. The water absorbency was decreased with increasing crosslinking agent. The high cross-linking density, contributed to a decreased space between polymer chains, that according to Flory's theory (Li & Wang, 2005).
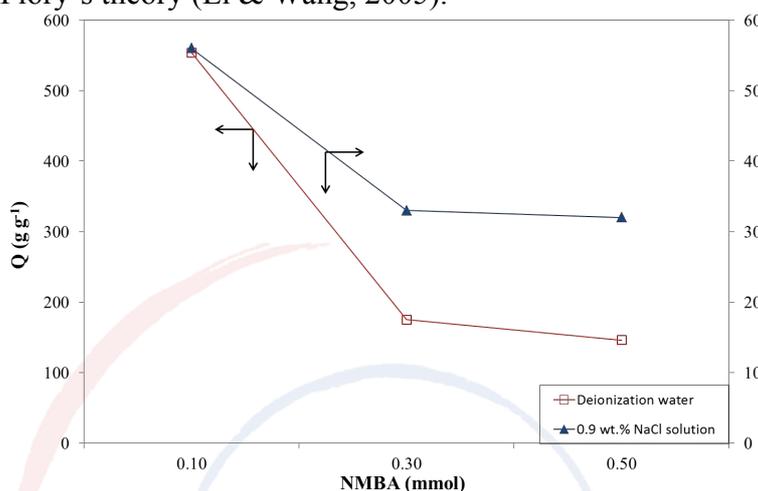
Fig.3. Effect of crosslinking agent content on water absorbency.
Reaction conditions: AA 0.20 mol, KPS 0.35 mmol, Konjac bran 0.4 g, neutralization degree 65%

3.4 Effect of konjac bran content on water absorbency

The swelling capacity of the KB-g-PAA SAP in deionized water and 0.9 wt% NaCl solution with difference contents of konjac bran was investigated. As shown in Fig.4, the water absorbency of samples in deionized water was increased with increasing the konjac bran content up to 0.4 g and then it was considerably decreased with a further increase in the content of konjac bran. On the other hand, the water absorbency of samples in 0.9 wt% NaCl solution was decreased with increasing the konjac bran content.
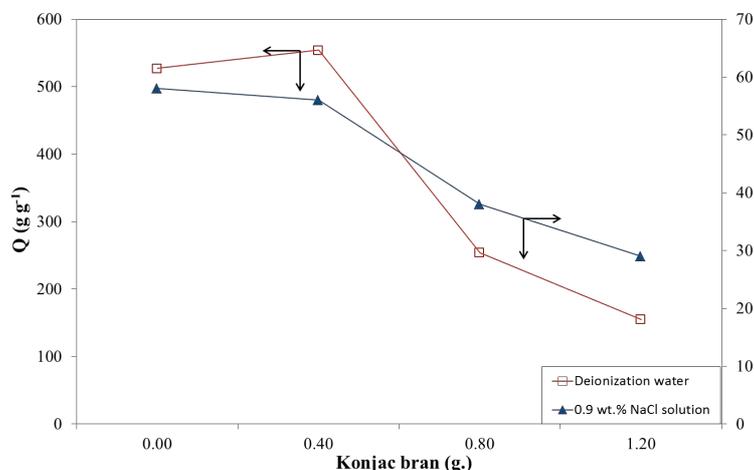
Fig.4. Effect of konjac bran content on water absorbency. Reaction conditions: AA 0.20 mol, KPS 0.35 mmol, NMBA 0.1 mmol, neutralization degree 65%

By increasing the amount of konjac bran up to 0.4 g, the number of active free radicals was enough to react with the glucomannan backbone. In addition, glucomannan structure contains a large number of hydrophilic groups in the molecular chains could attracted to water molecules and reacted with PAA-COO⁻ groups to enhance the polymeric network resulting in an increased water absorbency value (Mukerabigwi et al., 2015). However, the konjac bran content higher than the optimum value, water absorbency of samples was decreased, may be attributed to an increase in viscosity of the medium, which hinders the movement free radicals and monomer molecules in reaction system (Hosseinzadeh et al., 2011).

3.5 FTIR analysis

The structure changes of konjac bran and KB-g-PAA SAP were confirmed by FT-IR spectroscopy (presented in Fig.5). In the FTIR spectrum, a very broad between 3700 and 3200 cm^{-1} was observed. Fig.5a shows the FTIR spectrum of konjac bran, the peak at 3429 cm^{-1} was assigned to the stretching vibration of –OH groups of the methyl, the characteristic absorption peak in 1727 cm^{-1} was attributed to C=O stretching vibration of acyl groups in the glucomannan. Meanwhile, compared with the spectrum of KB-g-PAA SAP (Fig.5b), the peak at 3444 cm^{-1} was attributed to the –OH stretching vibration of the carboxylic groups and the intensity of the peak at 1719 cm^{-1} was stronger than the spectrum of konjac bran and assigned to the stretching of the C=O of the carbonyl of acetyl groups in KB-g-PAA SAP after the reaction.
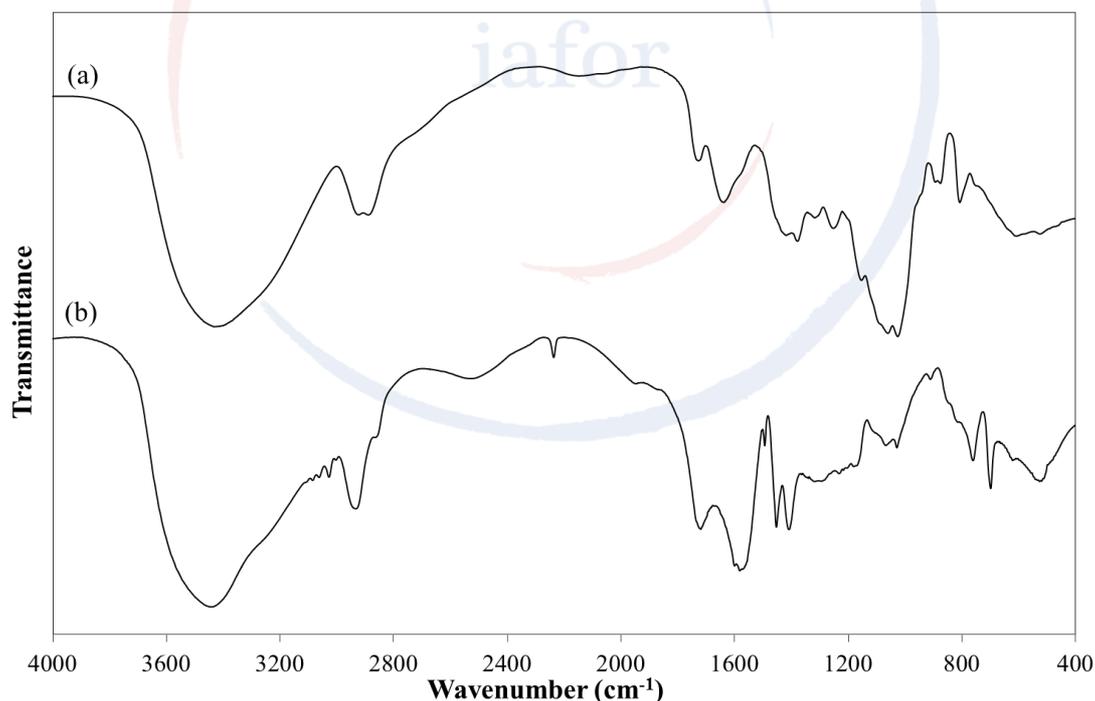
Fig.5 FTIR spectra of (a) konjac bran and (b) KB-g-PAA SAP

3.6 SEM observations

The morphology of microstructure was one of the most important factors which should be considered. Fig.6 shows the scanning electron microscope images of the superabsorbent polymer without konjac bran (PAA SAP) and superabsorbent polymers with different contents of konjac bran (KB-g-PAA SAP). Obviously from

Fig.6a, the surface morphology of the PAA presents a smooth and tight surface without any pores. However, the superabsorbent polymers containing konjac bran (Fig.6b – 6d) display an undulant, rough and tight surface without any pores.
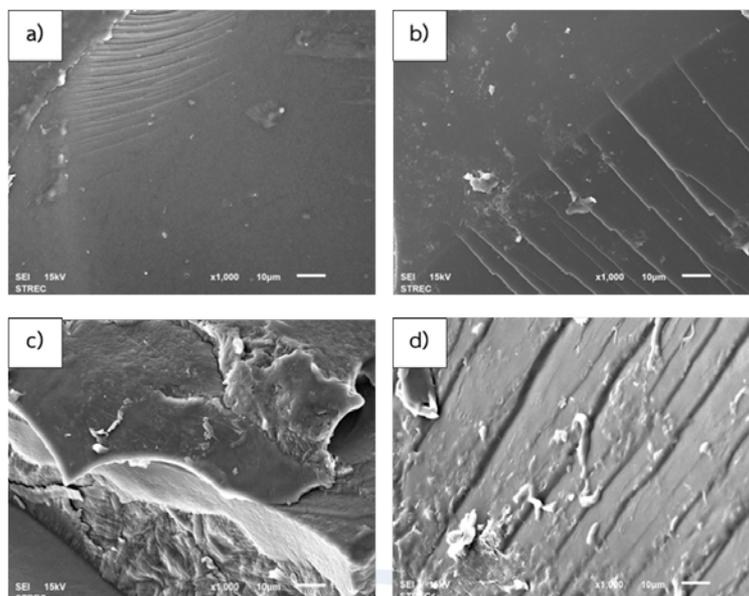
Fig.6 SEM images of PAA SAP (a) and KB-g-PAA SAP with difference contents of konjac bran: (b) 0.4 g, (c) 0.8 g, and (d) 1.2 g

4. Conclusions

In the present study, a novel superabsorbent polymers based on konjac bran was prepared by graft copolymerization of acrylic acid in the presence of a crosslinking agent. Under the optimized conditions, AA = 0.2 mol, neutralization degree = 65%, KPS = 0.35 mmol, NMBA = 0.1 mmol, and konjac bran 0.4 g, the water absorbency of KB-g-PAA superabsorbent in deionized water and 0.9 wt% NaCl saline solution was 554 g g^{-1} and 56 g g^{-1}, respectively. Furthermore, the superabsorbent polymer was good water retention, being biodegradable and low cost that can be used in a various range of applications especially in the horticulture and agriculture industry.

Acknowledgements

References

Chen, J., Zhang, W., & Li, X. (2015). Preparation and characterization of a novel superabsorbent of konjac glucomannan-poly (acrylic acid) with trimethylolpropane trimethacrylate cross-linker. *RSC Advances, 5*(48), 38417-38423.

Elliott, M. (2004). Superabsorbent polymers. *Product development scentist for SAP. BASF Aktiengesellschaft ss, 13*.

Hosseinzadeh, H., Sadeghzadeh, M., & Babazadeh, M. (2011). Preparation and properties of carrageenan-g-poly (acrylic acid)/bentonite superabsorbent composite. *Journal of biomaterials and Nanobiotechnology, 2*(03), 311.

Li, A., & Wang, A. (2005). Synthesis and properties of clay-based superabsorbent composite. *European Polymer Journal, 41*(7), 1630-1637.

Ma, G., Ran, F., Yang, Q., Feng, E., & Lei, Z. (2015). Eco-friendly superabsorbent composite based on sodium alginate and organo-loess with high swelling properties. *RSC Advances, 5*(66), 53819-53828.

Mukerabigwi, J. F., Lei, S., Wang, H., Luo, S., Ma, X., Qin, J., . . . Cao, Y. (2015). Synthesis and properties of a novel ecofriendly superabsorbent hydrogel nanocomposite based on xyloglucan-graft-poly (acrylic acid)/diatomite. *RSC Advances, 5*(102), 83732-83742.

Pourjavadi, A., Soleyman, R., & Barajee, G. R. (2008). Novel nanoporous superabsorbent hydrogel based on poly (acrylic acid) grafted onto salep: synthesis and swelling behavior. *Starch-Stärke, 60*(9), 467-475.

Tian, D. T., Li, S. R., Liu, X. P., Wang, J. S., Hu, S., Liu, C. M., & Xie, H. Q. (2012). Preparation of superabsorbent based on the graft copolymerization of acrylic acid and acrylamide onto konjac glucomannan and its application in the water retention in soils. *Journal of Applied Polymer Science, 125*(4), 2748-2754.

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Adsorption Of Pb(II) From Synthetic Solution By Pomelo Peel

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Abstract

Agricultural biomass waste can be used for producing adsorbents, because it is as low cost material and friendly for environment. This research aimed to study adsorbent preparation from pomelo peel by chemical activation with 0.1 M HNO_3 for investigating the removal efficiency and adsorption isotherm for adsorption of Pb(II) in synthetic solution. The batch experiment was carried out at various initial concentrations (10, 20, 40, 60, 80, 100, 120, 140 mg/L) by using adsorbent dose of 0.3 g and contact time of 30 min. The experimental conditions were implemented at solution pH 5-6, rotary-shaker speed of 120 rpm, particle size of activated pomelo peel at less than 0.2 mm and at room temperature.

The results show that the maximum removal efficiency of Pb(II) was 96.12 % at initial concentration of 10 mg/L. Experimental equilibrium data for Pb(II) adsorption were analyzed by the Langmuir and Freundlich isotherm models. The best fit was achieved with the Langmuir isotherm equation with maximum adsorptioncapacity of 909.09 mg/g. The study results can be a guideline for removal of Pb(II) in industrial wastewater.

Keywords: Pomelo Peel, Adsorption, Pb(II), Adsorption Isotherm

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1. Introduction

Wastewater containing heavy metals originates from many industries, such as metal finishing, electroplating, plastics, pigments and mining industries [1]. The specific gravity of heavy metals is generally 5 times more than that of water. So, heavy metals can be accumulated in the environment as sediment form. The living organisms in the water will receive the metals from water, sediment and aquatic plants from up taking through food chain. Thus metal accumulation in animal tissue and plant tissue are increased from accumulated pollution and following consumption. Lead is an important heavy metal in contaminated wastewater that discharged from industries. Many industries usually relate to lead substance, such as battery, tanneries, stabilizers, metal plating, textile production, smelting and others [2].

Lead produces negative human health effects because it can be absorbed into human bodies by three routes such as inhalation, ingestion and dermal contact. Lead toxicity includes irreversible brain disorders, effect on hemoglobin, renal breakdown, weakness and finally dead. The target organ of lead is bone and lead can be transmitted through mother's placenta and can be toxic to the nervous system of baby [3]. Therefore, it is urgent to remove the toxic heavy metal from wastewater.

Many methods have been used to remove heavy metals from wastewater or aqueous solutions, such as chemical precipitation, oxidation-reduction, electro-chemical treatment, evaporative recovery, filtration, ion exchange and membrane technologies. But, some of them may be less effective especially at low metal concentrations and require high cost in treating the metals. So the agricultural or biomass waste has been interested and considered for using as low-cost adsorbent material land it is also friendly for environment. Lead removal in many experiments was studied by adsorption technique with waste biosorbents which showed potential removal of heavy metals from aqueous solutions [4], such as using crab shell [5], wheat straw [6], rice straw [7], grape bagasse [8], mango peel[9], citrus peel and coffee husks [10]orange peels [11],and others.

The pomelo fruit is a famous Thai fruit, which a major producer of the fruit is in Nakhornpathom province of Thailand. The fruit is consumed within the country and also exported to neighboring countries. Generally, a pomelo fruit with weight of 940-1,060 g. has 320-400 g. of its peel [12]. So, it happened a lot of peel as utilizable waste. The aim of this research is to study the adsorbent prepared from pomelo peel. The pomelo peel adsorbent was prepared by chemically modified with nitric acid for investigating the adsorption of lead [Pb(II)] from synthetic solution. The parameters on initial concentration of the metal ion, adsorbent dose, contact time, solution pH, shaker speed, temperature, and particle size of pomelo peel were taken into account for studying the removal efficiency and adsorption isotherm of adsorbing Pb(II) in synthetic solution. The research results can be an application guideline for removal of lead in industrial wastewater.

2. Materials and methods

2.1 Preparation of adsorbents

Pomelo peel was dried for 24 hrs. in a convection oven at a temperature of 105 C°. The dry product was crushed and screened to the particle size of lower than 0.2 mm. The sorbent material was activated with 0.1 M HNO_3 10g of peel/L by soaking for 6 hrs. After activation, washed the pomelo peel with distilled water until the solution reached neutral pH value, and dried in oven at 105 C° for 24 hrs.

2.2 Adsorbate solution

Stock solution of Pb(II) were prepared 1000 mg/L by dissolving lead nitrate AR grade in distilled water, and adjusted pH in the range between 5 - 6 with 1M NaOH and 1M HCl.

2.3 Batch adsorption experiment

Adsorption studies were carried out by batch process for investigating the removal efficiency and adsorption isotherm for adsorption of Pb(II) in synthetic solution. The experiment was conducted by using 0.3 g sample of adsorbent which was placed in a Erlenmeyer flask contained with 100 mL solution of Pb(II)at various initial concentrations (10, 20, 40, 60, 80, 100, 120 and 140 mg/L) and contact time of 30 min for mixingon a rotary shaker with speed of 120 rpm at room temperature.The mixture was then filtered by filter paper (Whatman No.42)and the sample after digestion was analyzed by Flame Atomic Absorption Spectrometer (FAAS), Thermo scientific Solar, ICE 3000 series, United States.

3. Results and discussion

3.1 Removal efficiency

The results of percent removal efficiency of Pb(II) in synthetic solution on pomelo peel are shown in Fig.1.
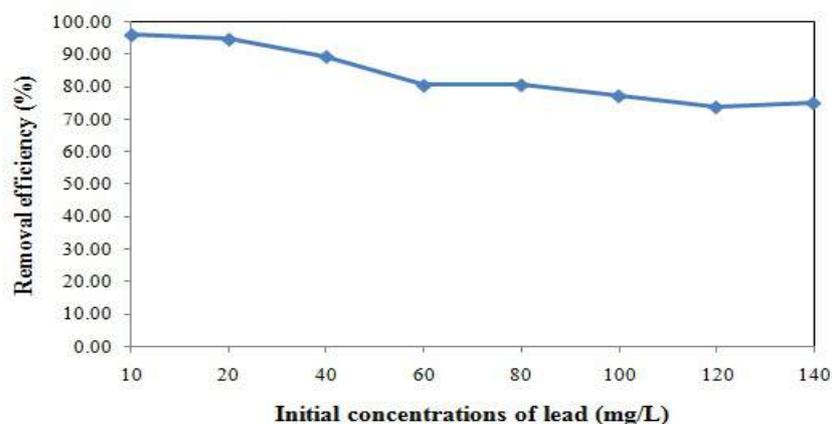
Fig 1: Removal efficiency (%) of Pb(II) in synthetic solution

From Fig 1, the adsorption of Pb(II) was maximum efficiency of 96.12 % at initial concentration of 10 mg/L and minimum efficiency was 73.75 % at initial concentration of 120 mg/L under the same experimental conditions were adsorbent dose of 0.3 g, contact time of 30 min and solution pH 5-6. At the fitted experimental conditions it were equilibrium for adsorption Pb(II) by pomelo peel because at pH lower than 2 it given low adsorption efficiency. Because the surface charge of the biomass is positive, which is not favorable to cations biosorption. Meanwhile, hydrogen ions compete strongly with metal ions at the active sites, resulting in less biosorption. Therefore, with increasing pH, electrostatic repulsions between cations and surface sites and the competing effect of hydrogen ions decrease. Consequently, the metal biosorption increases[16] and from study of Lasheen M.R et al [17], had been done to show the equilibrium time for sorption of Pb(II) ions onto the modified orange peel was reached within 30 min and at equilibrium adsorbent dosage 0.3 g.

It can be concluded from this figure that adsorption efficiency was affected by initial concentration. At higher initial concentration, the removal efficiency of Pb(II) was around 73-80 %. While with the lower initial concentration the removal efficiency of Pb(II) was around 89-96 %. Because in the adsorption process at higher initial concentrations result in lower heavy metals adsorption due to at lower initial concentrations cation in the adsorbate was low. So when used adsorbent it can uptake well in adsorption. While at higher initial concentrations it has many cation so it made cation uptake are not. Another study of Lasheen M.R et al [17] It was found that the removal efficiency 99.5 % at low initial concentrations 20 mg/L . So, it might can explained that at higher initial concentrations result in low removal efficiency adsorption.

3.2 Adsorption isotherm

The equilibrium adsorption data has been analyzed by the Langmuir and Freundlich isotherm models. The Langmuir isotherm can be expressed in equation (1).

$$Q_e = \frac{Q_{max}bC_e}{1+bC_e} \qquad (1)$$

Where Q_e is the amount of solute adsorbed per unit weight of adsorbent at equilibrium (mg/g), Q_{max} is maximum adsorption capacity (mg/g), b is Langmuir's constant and C_e is the equilibrium concentration of the solute in the bulk solution (mg/l). [13]

Moreover, the Langmuir equation can be rearranged in linear form as shown by :

$$\frac{1}{Qe} = \frac{1}{Qmax} + \left(\frac{1}{bQmax}\right)\left(\frac{1}{Ce}\right) \qquad (2)$$

However, the adsorption isotherm could be described by the Freundlich adsorption equation. The Freundlich isotherm can be expressed by equation (3).

$$Q_e = KC_e^{1/n} \qquad\qquad (3)$$

Where Q_e is the amount of solute adsorbed per unit weight of adsorbent at equilibrium (mg/g), C_e is the equilibrium concentration of the solute in the bulk solution(mg/l), K is Freundlich constant and 1/n is Freundlich slope.[14]

The Freundlich equation can be rearranged in linear form as shown by equation (4).

$$\text{Log } Q_e = \log K + (1/n) \log C_e \qquad\qquad (4)$$

Moreover, summary of isotherm models it was observed from Table 1

Table 1
Isotherm models and their linear forms [15]

Isotherm model	Isotherm Equation	Linear form	Plot
Freundlich	$Q_e = KC_e^{1/n}$	$\text{Log } Q_e = \log k + (1/n) \log C_e$	$\text{Log } Q_e$ vs $\text{Log } C_e$
Langmuir	$Q_e = \dfrac{Q_{max}bC_e}{1+bC_e}$	$\dfrac{1}{Qe} = \dfrac{1}{Qmax} + \left(\dfrac{1}{bQmax}\right)\left(\dfrac{1}{Ce}\right)$	$\dfrac{1}{Qe}$ vs $\dfrac{1}{Ce}$
		$\dfrac{Ce}{Qe} = \dfrac{1(Ce)}{Qmax} + \left(\dfrac{1}{bQmax}\right)$	$\dfrac{Ce}{Qe}$ vs C_e

The adsorption data were shown by linear transformation as in Fig. 2
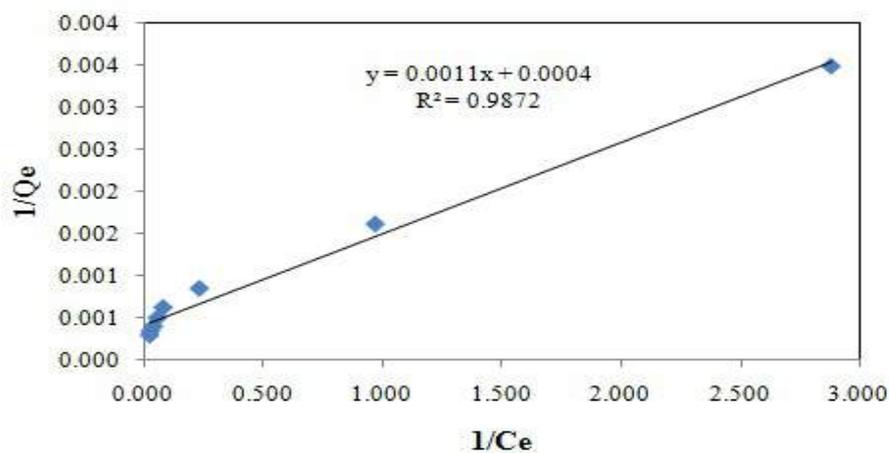
Fig 2: Linear Langmuir adsorption isotherm of Pb(II) on pomelo peel adsorbent

The adsorption data were shown by linear transformation as in Fig. 3
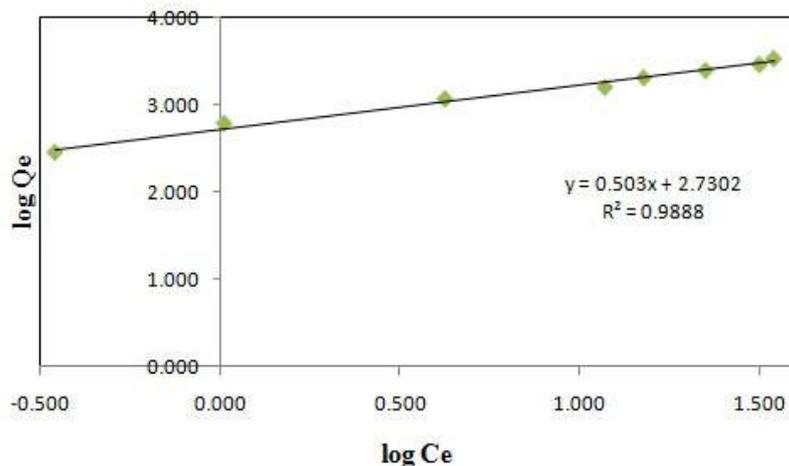
Fig 3: Linear Freundlish adsorption isotherm of Pb(II) on pomelo peel adsorbent

Due to their simplicity, the Langmuir and Freundlich equations are the most widely used models to describe the relationship between equilibrium metal uptake (Q_e) and final concentrations (C_e) at equilibrium. So, summary of isotherm model for adsorption Pb(II) by pomelo peel shown as Table 2

Table 2
Summary of isotherm model parameters adsorption Pb(II) by pomelo peel

Isotherm model	Isotherm parameters	Pb (II)
Langmuir Isotherm	Q_{max} (mg/g)	909.99
	b	2.75
	R^2	0.9872
Freundlich Isotherm	K (mg/g)	537.27
	1/n	0.503
	R^2	0.9888

The correlation coefficients (R^2) of Pb(II) adsorption isotherm by pomelo peel adsorbent in Langmuir's equation and Freundlich's equation were 0.9872 and 0.9888 respectively. The adsorption isotherm data was fitted to both the Freundlich and Langmuir isotherm equations because R^2 values closer 1 ($R^2 > 0.9$).

However, the Langmuir adsorption isotherm model for the adsorption of Pb(II) showed higher adsorption capacity (Q_{max}). The maximum monolayer adsorption capacity obtained from Langmuir isotherm model was 909.09 mg/g for the adsorption of Pb(II) by pomelo peel adsorbent. So, it meaning adsorption of Pb(II) by pomelo

peel adsorbent fitted well with Langmuir isotherm assumes this adsorption was a monolayer adsorption surface without any lateral interaction between adsorbed molecules[18].

While the Freundlich model does not describe the saturation behavior of the sorbents, the Langmuir model can explained about the monolayer saturation at equilibrium or the total capacity of the adsorbent for heavy metals in this adsorption experiments. Similar results were obtained by Lasheen et al. [17], on their studies of adsorption/desorption of Cd(II), Cu(II) and Pb(II) using chemically modified orange peel: equilibrium and kinetic studies and Anirudhan et al. [18], studies of adsorptive removal of heavy metal ions from industrial effluents using activated carbon derived from waste coconut buttons.

4. Conclusions

The present investigation showed that the adsorbent prepared from pomelo peel can be used as a potentially low-cost adsorbent for the removal of Pb(II) in synthetic solution. Batch adsorption test indicated that the extent of Pb(II) adsorption was dependent on initial metal concentrations. The maximum removal of Pb(II) was 96.12 % at the initialmetal concentration of 10 mg/L.

The Langmuir and Freundlich adsorption isotherm models could be used to evaluate the experimental data, but the previous model was better fitted for the adsorption of Pb(II) than the other one. The equilibrium experimental data fitted well with the Langmuir model showed the maximum Pb(II) adsorptioncapacity of 909.09 mg/g for the pomelo peel adsorbent.

References

1.Liang C, Guo X.Y, Feng N.C, Tian Q.H. Effective removal of heavy metals from aqueous solution by orange peel xanthate. Trans. Nonferrous Met. Soc. China 20(2010) s187-s191.

2.Ayyappan R, Camalin Sophai A, Swaminathan K, Sandhya S. Removal of Pb(II) From aqueous solution using carbon derived from agricultural wastes. Process Biochemistry. 2005; 40:1293-1299.

3.Chaiwang S. Effects of activation chemical types and temperatures on adsorption potential of adsorbents prepared from mangosteen shell.(Diddertation). Bangkok, Mahidol University; 2015.

4.Feng N.C, Guo X.Y, Liang Sha. Enhanced Cu(II) adsorption by orange peel modified with sodium hydroxide. Trans. Nonferrous Met. Soc. China 20(2010) s146-s152.

5.Vijayaraghavan K, Palanivelu K, Velan M. Biosorption of copper(II) and cobalt(II) from aqueous solutions by crab shell particles. Bioresour. Technol. 97 (2006) 1411-1419.

6.Dang V.B.H, Doan H.D., Dang-Vu T, Lohi A. Equilibrium and kinetics of biosorption of cadmium(II) and copper(II) ions by wheat straw. Biores. Technol. 100 (2009) 211-219.

7.Rocha C.G, Zaia D.A, Alfaya R.V.S, Alfaya A.A.S. Use of rice straw as biosorbents for removal of Cu(II), Zn(II) and Hg(II) ions in industrial effluents. J. Hazard Mater. 166 (2009) 383-388.

8.Farinella N.V, Matos G.D, Arruda M.A.Z. Grape bagasse as a potential sorbent of metals in effluent treatments. Bioresour. Technol. 98 (2007) 1940-1946.

9.Iqbal M, Saeed A, Zafar S.I. FTIR sepctrophotometry. Kinetics and adsorption isotherms modeling, ion exchange and EDX analysis for understanding the mechanism of Cd^{2+} and Pb^{2+} removal by mango peel waste. J. Hazard. Mater. 164 (2009) 161-171.

10.Jumle R, Narwade M.L, Wasnik U. Studies in adsorption of some toxic metal ions on *Citrus sinesis* skin and *Coffea Arabica* husk: Agricultural by product. Asian J. Chem. 14 (2002) 1257-1260.

11.Dhakal R.P, Ghimire K.N, Inoue K. Adsorptive separation of heavy metals from An aquatic environment using orange waste. Hydrometallurgy 79 (2005) 182-190.

12.สำนักงานพัฒนาที่ดินเขต 6 กรมพัฒนาที่ดิน กระทรวงเกษตรและสหกรณ์. 2556. ส้มโอ. ลักษณะทั่วไปของส้มโอแหล่งที่มา .: http://www.giswebr06.ldd.go.th/ lddweb/knowledge/plant/orange2/1.html18 มีนาคม 2556. 8 มิถุนายน 2558.

13.I. Langmuir, The constitution and fundamental properties of solids and liquids, J. Am. Chem. Soc. 38 (1916) 2221-2295.

14.H.M.F. Freundlich, Uber die adsorption in losungen, Z. Phys. Chem. 57 (1906) 385-470.

15.Oualid H, Emmanuel N. Modeling of adsorption isotherms of phenol and chlorophenols onto granular activated carbon Part I. Two-parameter models and equations allowing determination of thermodynamic parameters. Journal of Hazardous Material. 2007; 147: 381-394.

16.AKSU Z. Equilibrium and kinetic modeling of cadmium(II) biosorptions by C. *vulgaris* in a batch system: Effect of temperature[J]. Sep Purif Technol, 2001, 21: 285-294.

17.Lasheen M.R, Ammar N.S, Ibrahim H.S. Adsorption/desorption of Cd(II), Cu(II) and Pb(II) using chemically modified orange peel: Equilibrium and kinetic studies. Solid State Sciences 14 (2012) 202-210.

18. Anirudhan T.S, Sreekumari S.S. Adsorptive removal of heavy metal ions from industrial effluents using activated carbon derived from waste coconut buttons. Journal of Environmental Sciences 2011, 23(12) 1989-1998.

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Assessing Solar and Wind Energy Technical Potential using GIS Approach: A case study in Sumba Island, Indonesia

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Abstract
Rural areas with low density and scattered population usually suffer from low infrastructure, such as electricity which results in poverty. Sumba Island is a case in which it lacks public infrastructure, due to scattered population. Sumba Island has low economic activities as well as scattered population distribution which makes electrical company difficult to develop grid network. Nevertheless, studies show that this island has abundant renewable energy (RE) potentials. This study aims to assess the estimated technical potential from photovoltaic (PV) and wind energy to provide technical knowledge for investor to encourage their participation in achieving Sumba Iconic Island goals for 100% RE powered island. Geographic information system (GIS) approach was used to estimate available area by setting several criteria based on topographic and land-use conformances. Technical potentials were then estimated based on available areas, RE resource and also technological limitations. The results showed that the study area has notable potential of PV at 7,913 GWh/year and fair potential of wind at 794 GWh/year. Available area for PV can be found almost everywhere, but high wind speed sites only exist in Kamanggih, Lai Mbonga and Kambata Bundung villages. The results suggest that the big potentials of PV and wind turbine can be deployed to electrify scattered rural communities.

Keywords: Sumba Iconic Island, Solar, Wind, GIS, Technical Potentials of RE

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Introduction

Sumba Iconic Island (SII) is a multi-stakeholders initiative aimed to create a role model for 100% RE electrified island in Indonesia. It was started in 2010 by Ministry of Energy and Mineral Resources, State Ministry of Development Planning and HIVOS (an international NGO) which envisioned to increase RE penetration in Indonesia as well as to strengthen the commitment to reduce carbon dioxide emission (NREEC, 2012).

Sumba has been chosen as the ideal candidate because of its unique characteristics, such as low access to modern energy but storing big potential of RE. A study conducted by WinRock (2010) uncovered significant potential of RE in Sumba. The identification of several waterfalls in Sumba results in nearly 4.5 mega-watts (MW) hydroelectricity potentials. In addition, WinRock also visited three sites with notably good wind speed. The wind speed ranges from 5 to 9 m/s and it is estimated to have potential greater than 200 MW. Solar energy potentials also existed in Sumba with daily solar insolation of 5 kWh/m^2/day (kWh is kilo-watts/hour).

As part of the strategy to achieve the Sumba Iconic Island goals (HIVOS, 2014), research and development of RE related topics are encouraged. RE technical potential which represents the achievable energy generation after considering topographical, land-use, and technological constraints is expected to establish an upper-boundary estimate of development potential (Lopez, Roberts, Heimiller, Blair, & Porro, 2012). Several studies have been done to assess the RE potential in several countries, such as in USA (Dahle, 2008; Doris, Lopez, & Beckley, 2013; Lopez et al., 2012), Japan (Wakeyama & Ehara, 2011) and Taiwan (Yue & Wang, 2006).

The uses of GIS techniques in RE planning have benefits for collecting and elaborating all required information in order to make decision. The GIS tools enable users to perform spatial analyses through digital representations of geographic area, combined with other geographically referenced information (Pellegrino, Caiaffa, Grassi, & Pollino, 2008). Therefore, it can be used to efficiently estimate RE technical potential over wide areas.

Methods

The assessment of RE technical potential mainly considers land-use and topographical constrains and system performance of each RE technology. In this study, solar and wind energy technical potential were assessed using two different steps:
1. Evaluating topographical and land-use constraints
2. Estimating the electricity output based on technological constraints.

The first step is to evaluate the topographical and land-use constraints. The output of PV system and wind turbine highly depends on the shading effects on PV panels or variation of the wind speed which is immensely affected by geographic features of the site. The geographic analysis on site suitability for PV and wind was focused on terrain slope and conformance of the land-use (Table 1).

Space Radar Topography Mission (SRTM) Digital Elevation Model (DEM) data with 90 m spatial resolution was used to perform terrain analysis (USGS, 2004). Slope map was generated using spatial analysis tool in ArcGIS. In addition, the land-use map from Indonesia-Geospatial Portal (http://portal.ina-sdi.or.id/) was used for further analysis to exclude non-suitable land-use type to certain buffer.

Table 1. Summary of criteria for topographical and land-use constraints.

Criteria	PV System	Wind Turbine
Topographic constraints	▪ Slope less than 5%	▪ Slope less than 20%
Land-use exclusions	▪ Residential areas with 50 m buffer ▪ Water body with 50 m buffer ▪ Wetlands with 50 m buffer ▪ Forest with 100 m buffer ▪ National parks or protective forests with 300 m buffer	
Resources constraints	▪ N/A	▪ Wind speed at hub height $\geq$ 3 m/s

The next step is estimating electricity output based on system performance. Due to different characteristics of RE resources, detailed explanation for estimation of PV system and wind turbine electricity generation will be discussed in the separated parts.

Solar energy

Solar energy resource over suitable areas (after performing topographical and land-use assessment) is assumed to be uniform. Therefore, electricity output was calculated based on available areas from previous step, using several assumptions. PV capacity factor (Cf) are conservatively assumed at 14% as suggested by IRENA (2015) and Meier (2015). Whereas power density was assumed at 0.048 kW/m^2 (Lopez et al., 2012). The equation for annual electricity generation from PV is as follow,

$$E_{pv,ann} = A_{pv} \times Cf \times PD_{pv} \times 8760 \tag{1}$$

where $E_{pv,ann}$ is annual solar energy potential (kWh/year), PD_{pv} is power density (0.048 kW/m^2).

Wind energy

The wind speed data was gathered from the NREL Wind Resource Assessment Program (Elliott, 2002) which is also available at IRENA Global Atlas[1]. It gave the wind speed class map (with information of wind speed range) at 30 m height along with its Weibull parameters. Nevertheless, this map should be interpolated to get the average wind speed at designated height (12 m). The wind speed interpolation technique was used following wind profile power law formula (Bailey, McDonald, Bernadett, Markus, & Elsholz, 1997),

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[1] IRENA Global Atlas is an initiative to boost RE development by providing spatial data on RE resources, including solar energy, wind energy, bio energy, and geothermal energy along with marine energy (http://globalatlas.irena.org).

$$v = v_r \left(\frac{z}{z_r}\right)^\alpha \tag{2}$$

where v is the velocity at designated height z (m/s), v_r is the scaling velocity (reference velocity) (m/s), z_r is the reference height (m), α is wind shear exponent which may vary according to the type of terrain and surface roughness features (Olsen & Preus, 2015). In this study, the wind shear exponent will be based on land-use and terrain type (Table 2).

Table 2. Wind shear exponents based on land-use type (Olsen & Preus, 2015).

Land-use type wind shear	Exponent α
Agriculture	0.30
Dry forest	0.45
Lake	0.20
Plantation	0.35
Residential	0.31
River	0.20
Swamp	0.25
Shrub	0.30
Savanna	0.25

Electricity output from wind turbine depends on wind speed distribution throughout the year and power curve for specified wind turbine. Weibull distribution is used to get distribution of the data (Wakeyama & Ehara, 2011),

$$f(v) = \frac{k}{\lambda}\left(\frac{v}{\lambda}\right)^{k-1} e^{-(x/\lambda)^k} \tag{3}$$

where $f(v)$ is in percentage of occurrence of wind speed at v m/s, k is the Weibull k factor, λ is a function of k and average wind speed using gamma distribution.

In addition, TECO H3000 wind turbine was chosen to estimate the power output. It has the capacity of 3 kW with rotor diameter of 4.2 m and hub-height of 12 m. The power curve can be used to estimate the power output at specific wind speed (Figure 1). Estimated energy production was calculated using this formula,

$$E_{wind,ann} = \sum_{v=0}^{20}[f(v)p(v)8760] \tag{4}$$

where $E_{wind,ann}$ is annual electricity output from each wind turbine, $p(v)$ is the power output (W) at specified wind speed (Wakeyama & Ehara, 2011).

Required area for each wind turbine was calculated using 5 D x 10 D (D is rotor diameter) configuration (Irizarry-Rivera, O'Neill-Carillo, Colucci-Ríos, & de Asuntos Energéticos, 2009). Each wind turbine will be placed apart a distance of 10 D in the direction of prevailing wind and half of that separation in the direction perpendicular to the prevailing winds. Using TECO H3000 wind turbine with 4.2 m diameter, the required areas will be 882 m^2. Then, using available area from previous step, number of wind turbine or total capacity of wind farm can be calculated.
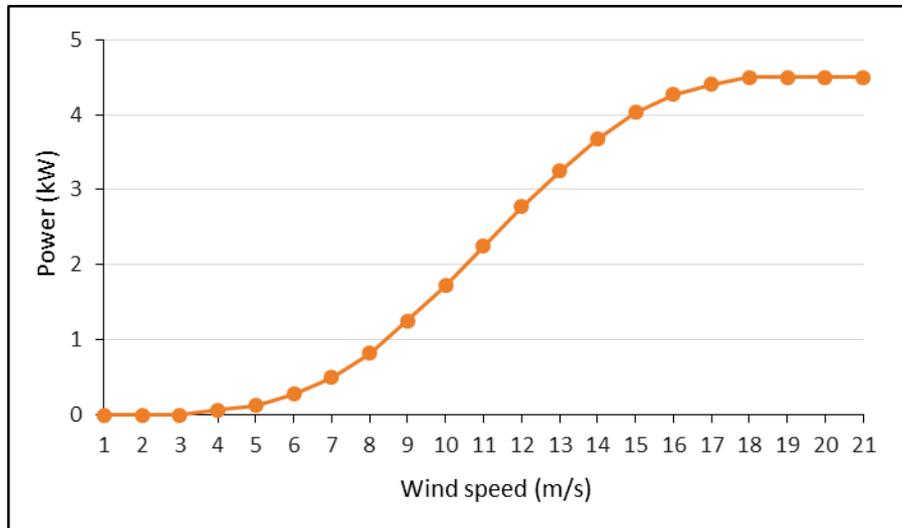
Figure 1. TECO H3000 power curve.

Results and Discussions

Study area

This study was conducted for the area of Kahaungu Eti sub-district, East Sumba, Indonesia (Figure 2). It has 9 villages spanning over 417.92 km^2 area with total population of 8,339 people (1,866 households). The settlement condition in Kahaungu Eti is scattered rather than clustered because Sumbanese tend to live within their tribes near their farms. Therefore, it is difficult for utility company to connect these villages to the central grid due to high inter-households distribution cost.

In general, almost all villages in Kahaungu Eti lack electricity infrastructures. Only in the capital of Kahaungu Eti, Kamanggih village, the Government has built public infrastructures, including isolated grid with 55 kW diesel generator as the main power plant. Following SII project, the Ministry of Energy and Mineral Resources has distributed small solar lighting system for each household. However, due to poor quality and lack of after-sales service, most products are failed before the first six month (JRI, 2013).
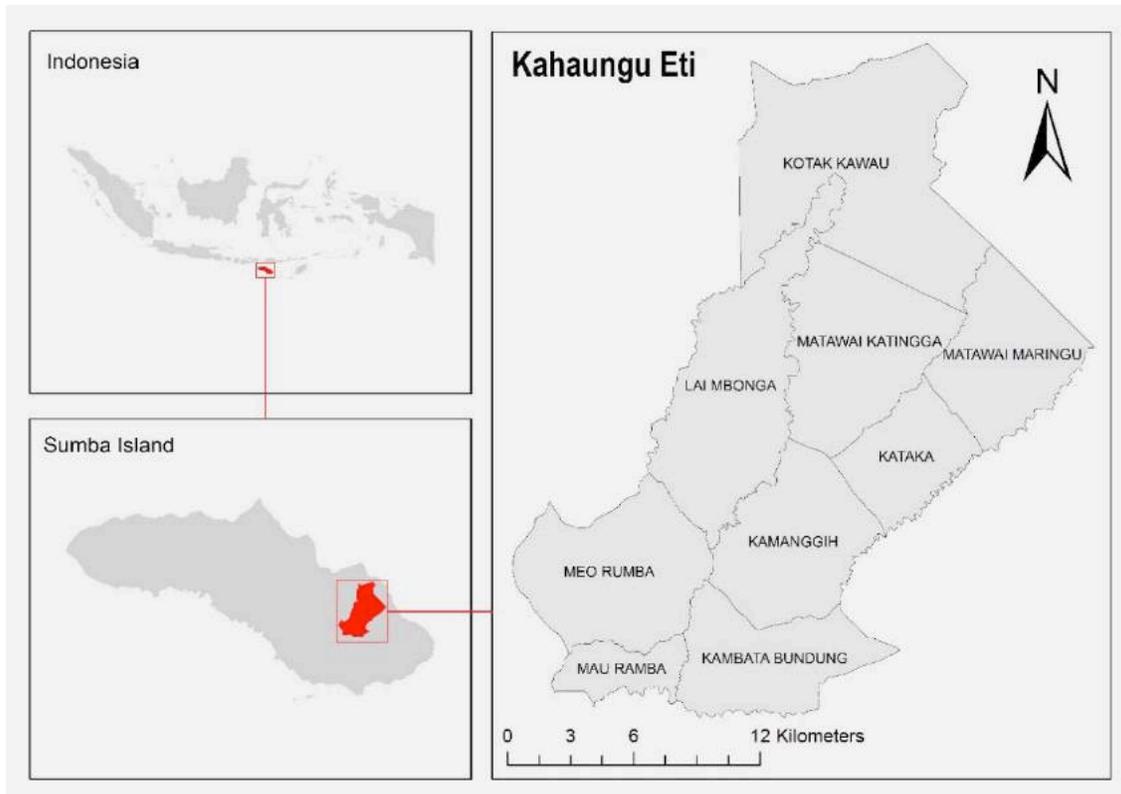
Figure 2. Study area of Kahaungu Eti sub-district

Southern part of Kahaungu Eti sub-district, especially in Meu Romba, Mau Ramba and Kambata Bundung villages are located on higher elevation and generally have mountainous topographic profiles. Steep terrains are found almost everywhere. Therefore, suitable areas from solar PV installation are very limited.

In addition, most areas in Kahaungu Eti sub-district are covered by dry grass savanna. There are two protective forests namely Luku Melolo in Kataka village and Lulundilu in Kambata Bundung. There are also small areas of settlements and waterbody. These protective forests, settlements and waterbody do not comply with solar and wind farm land-use requirements and therefore they were excluded from the RE potential map. Buffer zones were also applied with certain distances following different land-use types in order to further ascertain the land suitability for solar and wind potential map.

(a)   (b)
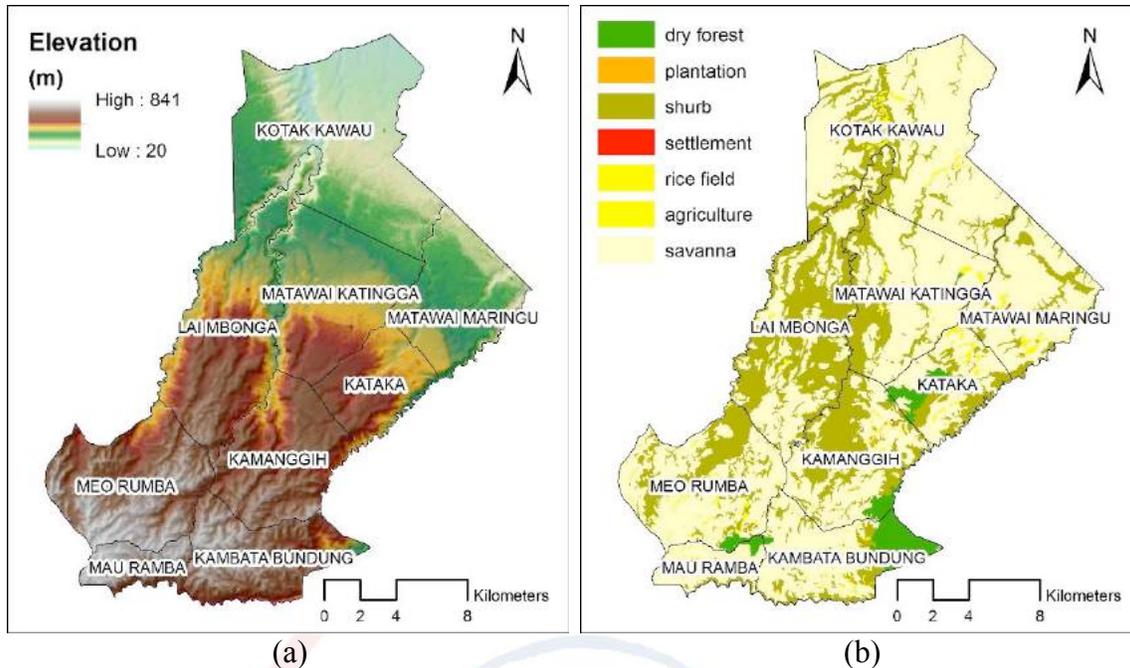
Figure 3. Local conditions of study area: (a) elevation map and (b) land-use map

Solar energy potential

Solar energy potential was calculated based on suitable area by firstly considering slope threshold and land-use compliance. The 5% threshold was applied and results in less available area in Southwestern part of Kahaungu Eti. In addition, buffer zone around protective forest also significantly removes some areas from solar potential map.

Villages located on the northern part generally have larger area available (Figure 4), such as Kotak Kawau (58.47 km^2), Matawai Katingga (26.8 km^2) and Matawai Maringu (24.23 km^2). The rests have available area of less than 10 km^2. Mau Ramba has the smallest area available with only 0.63 km^2. The limited availability of areas for PV are mostly attributed with mountainous terrain.

Solar energy potential per village is shown in Figure 5. It represents aggregated annual electricity production from PV on the areas within each village. The highest solar potential can be found in Kotak Kawau village with annual electricity production of approximately 3,870 GWh. It is followed by Lai Mbonga, Matawai Katingga and Matawai Maringu which are located in the central of Kahaungu Eti with annual production between 1,000 and 2,500 GWh/year. Less electricity production are found in Meo Rumba Kamanggih and Kataka while the least potential are found in Kambata Bundung and Mau Ramba.

(a)   (b)
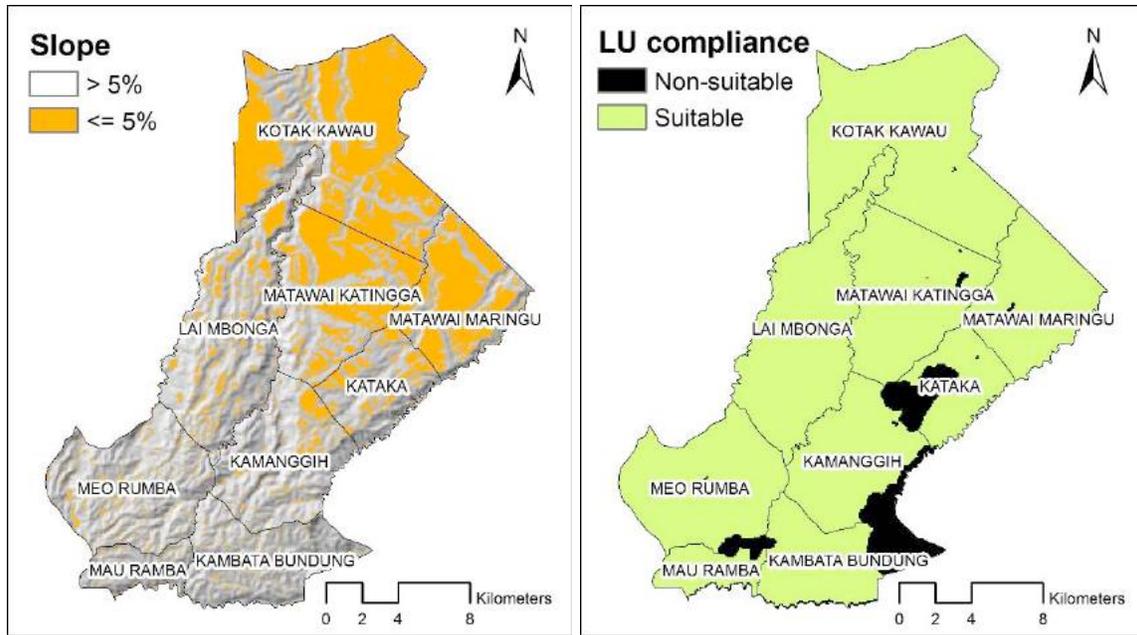
Figure 4. Analysis of topographic constraint (a) and land-use compliance (b)
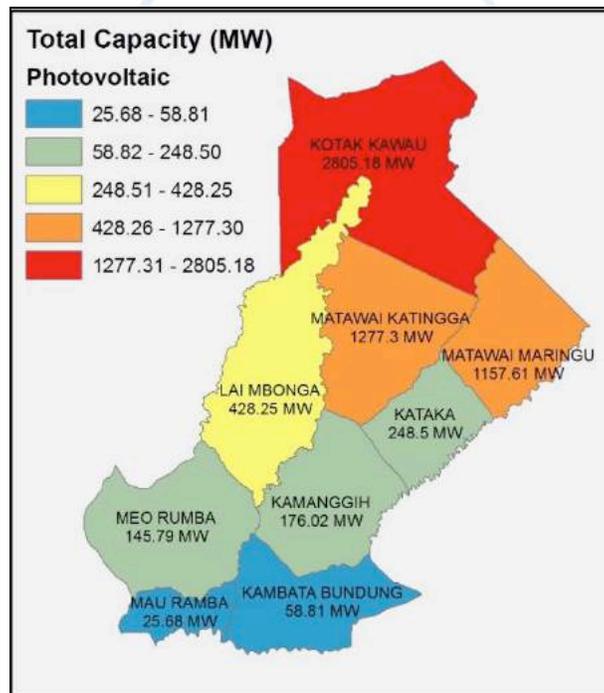
Figure 5. Estimation of total generating capacity for PV for each village.

At village level, annual electricity production from solar energy gradually decrease towards south where the elevation is higher and the topographic is mountainous. Therefore, this area is not suitable for PV installation. In addition, villages in the northern parts have larger areas, which can be seen on Table 3.

Table 3. Available areas, generating capacity and annual electricity production for solar energy for each village.

Village	Available area (km^2)	Capacity (GW)	Estimated output (GWh)
Kamanggih	3.7	176	215.9
Kambata Bundung	1.2	59	72.1
Kataka	5.2	249	304.8
Kotak Kawau	58.4	2,805	3,440.4
Lai Mbonga	8.9	428	525.2
Matawai Katingga	26.6	1,277	1,566.6
Matawai Maringu	24.1	1,158	1,419.8
Mau Ramba	0.5	26	31.5
Meo Rumba	3.0	146	178.8

Wind energy assessment

Sumba is considered as area with good wind resources. Based on wind speed map from NREL wind resource assessment program, the average wind speed in study area ranges from 4.3 to 8.2 m/s at 30 m height (Figure 6). Nevertheless, higher wind speed sites are only available in Lai Mbonga, Kamanggih and Kambata Bundung. The rest area has fair average wind speed.

TECO H3000 wind turbine with capacity of 3 kW was used to calculate the electricity output from the wind turbine. This wind turbine is able to generate up to 4.5 kW at 17 m/s wind speed. As the wind turbine hub is at 12 m height, the wind speed map should be adjusted as well. Following different wind shear exponent from various land-use type, wind speed was interpolated. The results show that the average wind speed at 12 m height varies from 3 m/s to 6.5 m/s.

(a)   (b)   (c)
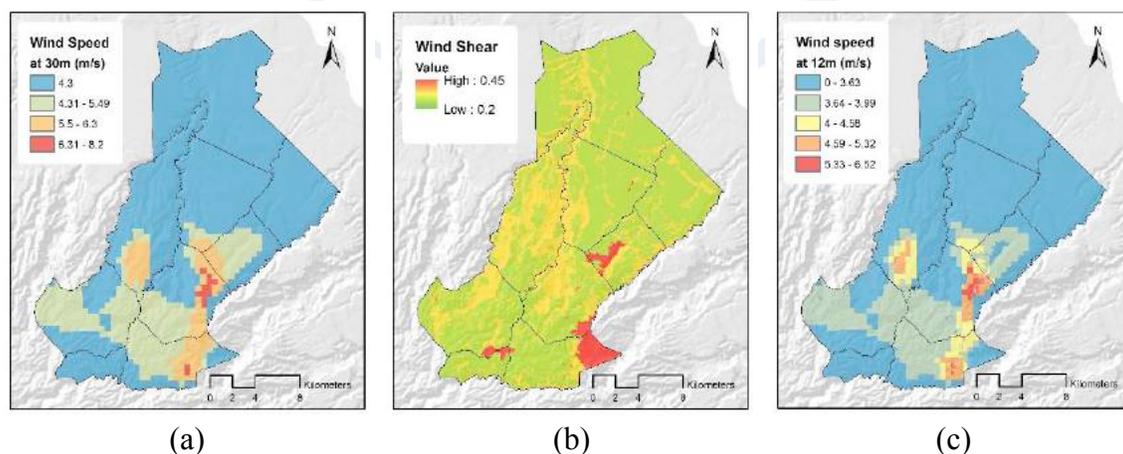
Figure 6. Wind speed map adjustment: (a) wind speed at 30 m height, (b) wind shear exponent and (c) wind speed at 12 m height.

For topographical and land-use constraint, the same process as the solar energy assessment was also implemented, except the slope threshold was set at 20% as suggested by previous study (Lopez et al., 2012). It results in significantly more areas available for wind turbine installation (Figure 7).

(a)   (b)
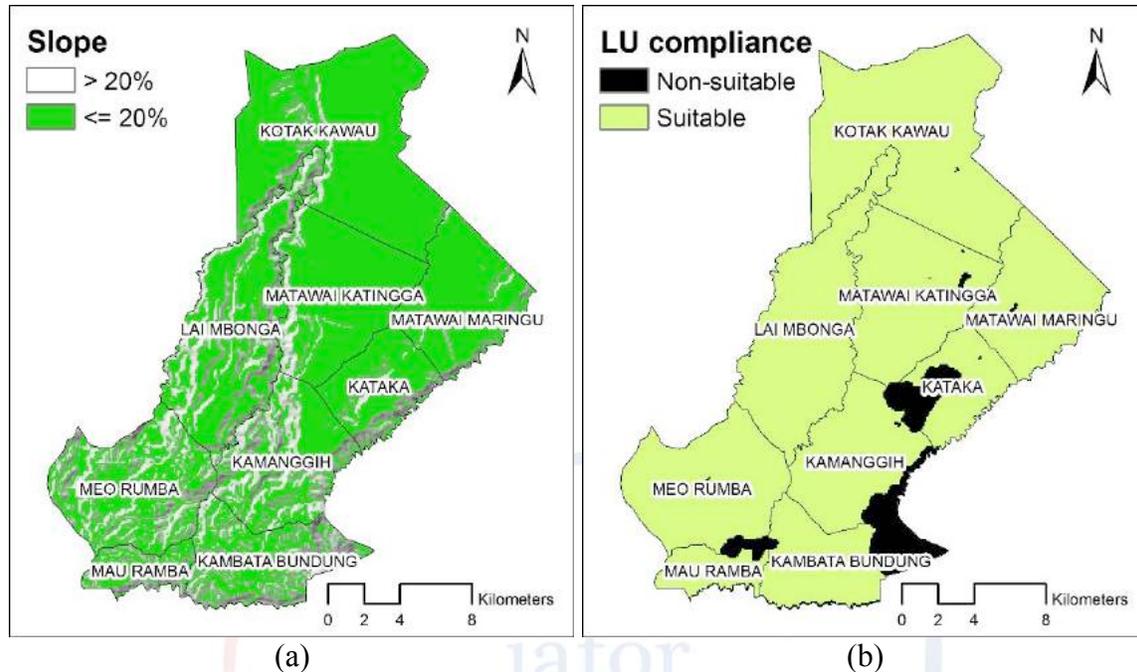
Figure 7. Suitable areas for wind farms: (a) slope classes and (b) land-use constraints.

The estimated output of wind turbine varies by its wind speed (Figure 8a). It ranges from 1,235 kWh/year for sites with the average wind speed of 3.12 m/s to 9,060 kWh/year for sites with the average wind speed of 6.52 m/s. As the wind speed variation affects the electricity production output, the capacity factor (Cf) for each sites with different wind speed are also different. TECO H3000 has rated capacity of 3 kW at 11 m/s. However, the maximum power can reach up to 4.5 kW at 17 m/s. Therefore, the Cf is up to 34%.

The aggregated electricity production from wind turbine per village can be seen at Figure 8. The highest annual electricity production can be found in Kotak Kawau village with 127.5 GWh electricity production per year from 236.4 MW generating capacity. The lowest potential can be found in Mau Ramba with only 10.8 GWh/year electricity production. However, electricity generation can be higher with less generating capacity in some villages, especially in the areas where the average wind speed is more than 5 m/s. For example, total wind farm capacity in Kamanggih is 60 MW but it can generate up to 59.3 GWh/year which is slightly higher than electricity generation in Matawai Maringu (54.8 GWh/year) with capacity of 101.6 MW.

(a)   (b)
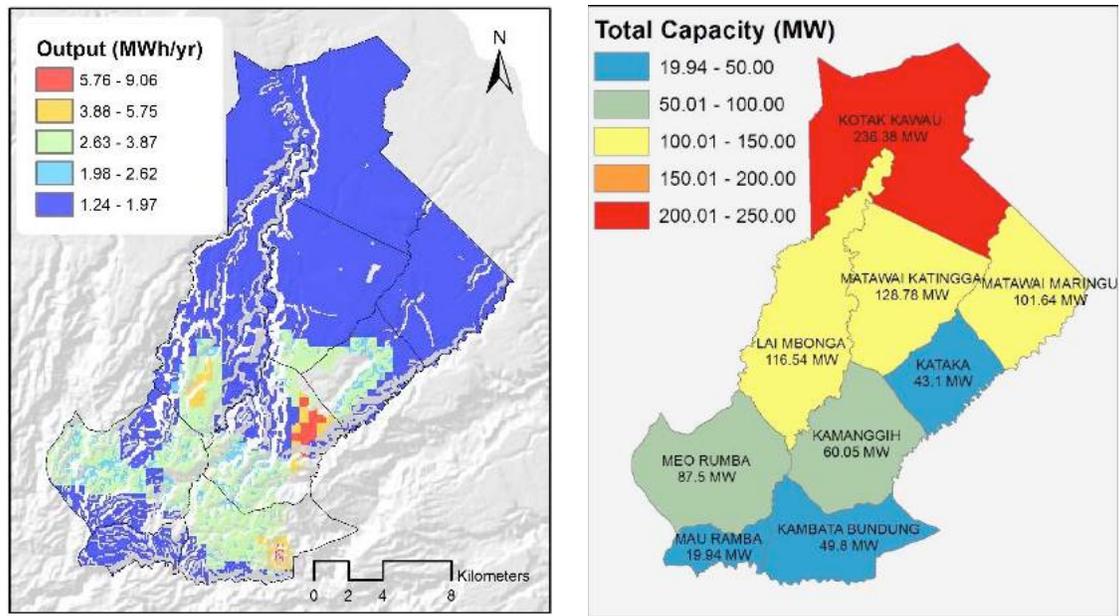
Figure 8. Wind energy potential: (a) Estimation of electricity output for each 3 kW wind turbine and (b) Total wind farm capacity for each village.

Table 4. Available areas, generating capacity and annual electricity production for wind energy for each village.

Villages	Available Area (km^2)	Capacity (MW)	Estimated output (GWh/year)
Kamanggih	21.6	60.0	59.3
Kambata Bundung	17.9	49.8	45.0
Kataka	15.5	43.1	29.7
Kotak Kawau	85.0	236.4	127.5
Lai Mbonga	41.9	116.5	74.5
Matawai Katingga	46.3	128.8	73.5
Matawai Maringu	36.5	101.6	54.8
Mau Ramba	7.2	19.9	10.8
Meo Rumba	31.5	87.5	62.1

Renewable energy technology comparison

In general, Kahaungu Eti has good potential of both solar and wind energy. Solar radiation in the study area ranges around 5 kWh/m^2/day which is considered as good. On the other hand, the average wind speed in the study area ranges from 4.5 m/s to 8.2 m/s at 30 m height, even though windy sites are only available in several villages. In addition, as this sub-district is considered as rural areas with less residential areas and mostly covered by savanna, there are still wide areas to install these two RE technologies.

Nevertheless, when considering annual electricity output, there is a significant difference between solar and wind energy. The total annual electricity production for solar energy in Kahaungu Eti was estimated to reach 7,913 GWh/year whereas the estimated electricity production for wind energy is only 793 GWh/year or about 10% of annual production of solar energy. The low electricity production from wind turbine might be associated with low capacity factor of small scale wind turbine. In addition, if electricity production per specific unit area was considered, solar energy is superior with around 59 GWh/km^2 compared to wind energy with only 1.9 GWh/km^2. It means that wind turbines require larger areas to produce the same amount of electricity output from PV.

The selection of small scale wind turbine in the analysis is related to economic activity in the study area which is relatively low (Castlerock, 2014). When there are only few industries and small shops, the demand becomes low as well. In addition, central grid does not exist in the study area. Previously, there was only 55 kW diesel generator operated under isolated grid configuration to power the whole Kamanggih village. Now, there are operating micro hydro power plant and also small scale wind farm (IBEKA, 2011; Pertamina, 2013).

Even though both technologies are found to be potential in the study area, they have intermittency characteristics which may become the bottleneck in electricity planning associated with balancing supply and demand (Mohammed, Mustafa, & Bashir, 2014). For example, solar radiation at Kelurahan Kambajawa, Kecamatan Kanatang is relatively constant throughout the year (WinRock, 2010). However, electricity from PV is only available during the night. Therefore, battery is essential for complementing PV system. On the other hand, electricity from wind turbine might be available during the day and the night but it has seasonal pattern. For example, observation station in Hambapraing shows that wind speed in that area is usually high during summer (between May to August) and low during winter (from November to March) (Hirsch et al., 2015). Therefore, in any off-grid or mini-grid system using these technologies, energy storage should be attached to ensure its reliability.

Conclusion

Sumba island, especially in Kahaungu Eti sub-district, has considerably good potential of solar and wind energy. Solar radiation is relatively constant throughout the year around 5 kWh/m^2/day while average wind speed on the study area are between 4.5 and 8.2 m/s. Solar and wind energy technical potential was assessed using GIS approach to further account achievable energy generation.

Suitable areas for solar or wind farms are limited with steep terrains and non-suitable land-use type and its buffer zone. Some areas are mountainous and too steep (especially in Southern part of Kahaungu Eti) so that they are not suitable for solar and/or wind energy installation. Northern part of study area has more flat areas which allow more PV and more wind turbines to install. Accordingly, Kotak Kawau has the largest capacity and the highest annual electricity production from both solar energy and wind energy system at village level.

Especially for wind energy potential, electricity output is highly influenced by average wind speed. In windy sites a wind turbine can generate more electricity. Therefore, wind turbine installation should consider high wind speed sites because smaller capacity of wind farm requires less investment.

In this study, electricity production from solar energy is estimated to be far away higher than electricity production from wind energy, due to the use of small-scale wind turbine. Considering the demand and suitability for the study area, small-scale wind turbine was chosen as reference to estimate annual electricity production from wind turbine. In addition, this small-scale wind turbine requires wide areas to install but does not deliver enough electricity.

However, both technologies have intermittency disadvantages. Therefore, energy storage should be included in the system. Furthermore, as the area is not constraint in the study area, the selection of RE technology should also be based on installation and maintenance costs.
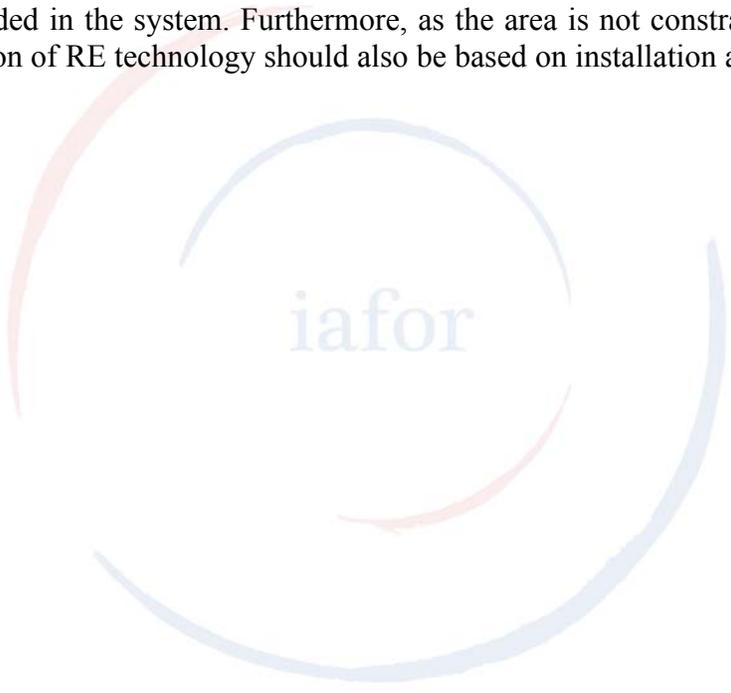
References

Bailey, B. H., McDonald, S. L., Bernadett, D., Markus, M., & Elsholz, K. (1997). Wind resource assessment handbook. *Albany-New York: AWS Scientific Inc*.

Castlerock. (2014). *Mid-Term Report (Final): Least-Cost Electrification Plan for the Iconic Island*. Retrieved from Jakarta: http://castlerockasia.com/sumba/Final%20Mid-Term%20Report%20141208.pdf

Dahle, D. (2008). *Assessing the potential for renewable energy development on DOE legacy management lands*: National Renewable Energy Laboratory.

Doris, E., Lopez, A., & Beckley, D. (2013). *Geospatial Analysis of Renewable Energy Technical Potential on Tribal Lands*: US Department of Energy, Office of Indian Energy.

Elliott, D. (2002). *Assessing the world's wind resources.* Paper presented at the Power Engineering Society Winter Meeting, 2002. IEEE.

Hirsch, B., Burman, K., Davidson, C., Elchinger, M., Hardison, R., Karsiwulan, D., & Castermans, B. (2015). *Sustainable Energy in Remote Indonesian Grids: Accelerating Project Development*. Retrieved from http://www.nrel.gov/docs/fy15osti/64018.pdf

HIVOS. (2014). *Stakeholder Report 2013-2014*. Retrieved from http://sumbaiconicisland.jxlbeta.com/wp-content/uploads/2015/09/Stakeholders-Report-2013-2014.pdf

IBEKA. (2011). *Bakuhau Microhydro Power* (IBEKA Ed.). Jakarta: IBEKA.

IRENA. (2015). *Renewable Power Generation Costs in 2014*. Retrieved from http://www.irena.org/documentdownloads/publications/irena_re_power_costs_2014_report.pdf

Irizarry-Rivera, A. A., O'Neill-Carillo, E., Colucci-Ríos, J. A., & de Asuntos Energéticos, P. R. A. (2009). *Achievable Renewable Energy Targets for Puerto Rico's Renewable Energy Portfolio Standard: Final Report*: Universidad de Puerto Rico, Recinto Universitario de Mayagüez.

JRI. (2013). *Socio-Economic-Gender Baseline Survey*. Retrieved from Jakarta: https://www.hivos.org/sites/default/files/jri_socio_economic_gender_survey_-_sumba_iconic_island_round12_-_hivos_2013.pdf

Lopez, A., Roberts, B., Heimiller, D., Blair, N., & Porro, G. (2012). US renewable energy technical potentials: a GIS-based analysis. *Contract, 303*, 275-3000.

Meier, P. (2015). *Tariff Support for Wind Power and Rooftop Solar PV in Indonesia*. Retrieved from Manila: http://static1.squarespace.com/static/

Mohammed, Y., Mustafa, M., & Bashir, N. (2014). Hybrid renewable energy systems for off-grid electric power: Review of substantial issues. *Renewable and Sustainable Energy Reviews, 35*, 527-539.

NREEC. (2012). *The Blueprint and Roadmap for Sumba Island Development Program as Renewable Energy Iconic Island*. Retrieved from http://sumbaiconicisland.org/wp-content/uploads/2015/09/Blueprint_Sumba_24Feb2014_editGM.pdf

Olsen, T., & Preus, R. (2015). *Small Wind Site Assessment Guidelines*. Retrieved from

Pellegrino, M., Caiaffa, E., Grassi, A., & Pollino, M. (2008). *GIS as a tool for solar urban planning*. Paper presented at the Proceedings of 3rd International Solar Energy Society Conference-Asia Pacific Region (ISES-AP 2008), Sydney, Australia.

Pertamina. (2013). *Towards Sustainable Energy for All*. Retrieved from Jakarta: http://www.pertamina.com/media/cfcb1866-8acc-4bdb-a658-f03f79194592/SR%20Pertamina%202013.pdf

USGS. (2004). *Shuttle Radar Topography Mission*. Retrieved from: http://srtm.csi.cgiar.org/SELECTION/inputCoord.asp

Wakeyama, T., & Ehara, S. (2011). *Estimation of renewable energy potential and use–a case study of Hokkaido, Northern-Tohoku area and Tokyo Metropolitan, Japan*. Paper presented at the World Renewable Energy Congress.

WinRock. (2010). *Preliminary Resource Assessment Sumba and Buru Islands, Indonesia Fuel Independent Renewable Energy "Iconic Island"*

Yue, C.-D., & Wang, S.-S. (2006). GIS-based evaluation of multifarious local renewable energy sources: a case study of the Chigu area of southwestern Taiwan. *Energy Policy, 34*(6), 730-742.

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Determinants of Household Pro-Environmental Behaviour: An Exploratory Analysis

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Abstract
What strongly influences or determines household pro-environmental behaviour (PEB) is a question of great curiosity across the globe. Solution to this research question has important implications for researchers, strategic planners and public policy makers. Multidisciplinary research seems necessary to answer this complex question identifying variables that influence PEB at individual level. In the light of recent work on environmental paradigms, the currents study attempts to explore and identify the relevant factors that contribute to PEB significantly. To achieve the stated objective, an in-depth literature review and qualitative analysis was carried out. A questionnaire was developed to measure the PEB construct and its determinants. Next, a pilot study was conducted to assess the reliability of the questionnaire. Following this, exploratory factor analysis was conducted to identify the major determinants. Construct validation using exploratory factor analysis showed an interpretable latent structure consisting of determinants of PEB. Results indicate that PEB comprises of nine dimensions viz., behavioural intention, attitude, personal moral norms, subjective norms, situational factors, perceived behavioural control, community concern, internal attribution and perceived consequences. Finally, the study integrates the internal and external determinants in an understanding framework to predict different types of PEBs. The results of the study provide insights for researchers, strategic planners and policymakers to help more people behave in environmentally responsible ways. On the theoretical side, the results of the study provide additional empirical evidence to researchers and a reliable scale to measure PEBs.

Keywords:Pro-environmental behaviour; Determinants of PEB; Reliability analysis; Exploratory factor analysis.

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Introduction

Environmental problems are becoming more acute with each passing year. The world is facing serious environmental issues related to, amongst others, global warming, air pollution, waste management, energy shortage, on-renewable resource conservation, water conservation and scarcity of safe drinking water. The most serious long-term threat facing the world is the danger that human actions are producing irreversible, harmful changes to the environmental conditions that support life on Earth (da Costa Ferreira and Barbi, 2016). The ultimate impacts of these problems are drastic changes to quality and quantity of all forms of life. These problems are, at least partly, rooted in human behaviour (Gardner and Stern, 2002; Vlek and Steg, 2007; Koger and Winter, 201; De Leeuw et al., 2015), and can thus be managed by changing the relevant behaviours so as to promote environmental quality (Reddy et al., 2016). As individual behaviour plays an important role in the preservation of environment, individuals can choose to adopt behaviours that are comparatively better for the environment (Scott et al., 2015). These behaviours are called responsible environmental behaviours, sustainable environmental behaviours or pro-environmental behaviours (PEBs) (Turaga et al., 2010; Allen, 2016).

In order to promote PEB effectively, an essential first step is to enhance the understanding of the factors influencing individual's engagement in PEB supportive of a sustainable future, this will help to develop effective social marketing initiatives that promote PEBs (Larson et al., 2015). Thus, it is noteworthy and interesting to study, which factors influence individual PEB? How individuals can be encouraged to get engaged in pro-environmental actions? Which motivations can best be targeted to promote behavioural changes? Major emphasis is required to be placed on encouraging pro-environmental action by individuals for sustainability.To address this, the current study aims to determine the factors that influence PEB. An attempt is made with the help of exploratory factor analysis, to conceptualize PEB and its antecedents. Determinants considered in the study were taken from the theory of planned behaviour (TPB) (Ajzen, 1991), as well as from literature comprising of personal moral norms, community concern, perceived consequences, internal attribution and situational factors (van der Werff, and Steg, 2015; Allen, 2016). Data from the research study was used to provide further evidence for the impact of various psychosocial, informational and situational variables influencing PEB. By means of statistical techniques such as reliability analysis and factor analysis, the current study developed a reliable and valid scale of PEB.

To demonstrate the approach taken, a case of household waste minimisation was undertaken in the metro city of Mumbai, India. The management of municipal solid waste (MSW) is an ongoing problem. The simplest and most effective way of dealing with waste is at source. Hence, waste minimisation at the source is an important focus of the MSW management strategy. Understanding behaviour is the key to taking waste minimisation forward, but there are significant barriers, such as lack of knowledge, facilities, motivation and influences (Allen, 2016). Given the potential implications of waste minimisation behaviour in environmental and economic terms, there is much to be learned about the operating mechanisms of its social and psychological antecedents. Policy makers and researchers are increasingly interested in what factors are associated with individuals engaging in waste minimisation activities. Thus, the current study attempts to understand the household participation

in waste minimisation behaviour i.e. PEB.The household waste minimisation behaviour is taken as targeted behaviour as it involves physical as well mental efforts to engage in the behaviour (PEB). For the purpose of the current study, waste minimisation is defined as the actions taken by householders to minimise their waste by reducing, recycling and re-using or repairing products rather than replacing them (Corvellec, 2016).

Literature review

There is rising interest in the extent to which people behave in pro-environmental ways and what makes them behave in more environmentally friendly ways than others (Fielding and Hornsey, 2016; Allen, 2016). The specific focus is based on the premise that individuals' behaviour towards the environment is influenced by what they feel and think about the environment and pro-environmental action (Oregand Katz-Gerro, 2006; Allen, 2016).A number of researchers have drawn on environmental psychology to analyse internal and external influences such as values, beliefs, attitudes, or norms as underlying motivations, which have turned out to be more successful in predicting PEBs (Davies et al., 2002, 2008; Hoyos et al., 2009; De Groot and Steg, 2010; Morren and Grinstein, 2016; Reddy et al., 2016).

Several models have been proposed to study PEB (van der Werff, and Steg, 2015; Allen, 2016). The two most popular ones, which serve as a starting point for several other theories, are the TPB, which relies on the assumption that attitudes have a causal impact on behaviours via behavioural intentions (Ajzen and Madden, 1986; Ajzen, 1988, 2005; Thøgersen, 1994; Boldero, 1995; Taylor and Todd, 1995; De Leeuw et al., 2015; Graham-Rowe et al., 2015); and Schwartz's altruistic model (Schwartz, 1970, 1973, 1977; Vining and Ebreo, 1990, 1992; Guagnano et al., 1995; Bissing-Olson et al., 2016), which explains pro-environmental actions by favourable personal norms; and other approaches include, for example, the value-attitude-behavior model (McCarty and Shrum, 1994), which shows that attitudes and beliefs mediate between abstract values and specific behaviours; operant conditioning theories, which explore how behaviour can be altered by providing informational feedback, rewards or penalties (e.g., Katzev and Mishima, 1992; Werner et al., 1995); or self-regulation theory (Sansone et al., 1992), which proposes that people regulate their behaviour by changing related cognitions, emotions, or perceptions (Werner and Makela, 1998).

The TPB, an extension model of the Theory of Reasoned Action (Ajzen, 1985, 1991; Ajzen and Madden, 1986), is one of the most widely researched models for predicting behavioural intentions by social psychologists (Armitage and Conner, 2001; Collins and Carey, 2007; Norman et al., 2007; Fielding et al., 2008). In the domain of PEB intentions, many researchers (e.g., Lam, 1999; Terry et al., 1999; Bamberg and Schmidt, 2001; Bamberg et al., 2003; Chen and Tung, 2010; De Leeuw et al., 2015) also considered the TPB as an important theoretical basis to understand whether individuals intend to perform environmentally friendly behaviour. The TPB provides a theoretical framework for systematically investigating the factors which influence behavioural choices (Fielding et al., 2008), and has been widely used to investigate behaviours, such as leisure choice (Ajzen and Driver, 1992), driving violations (Parker et al., 1992), shoplifting (Tonglet, 2002), dishonest actions (Beck and Ajzen, 1991),travel choice mode (Bamberg et al., 2003), green purchasing behaviour (McLeod et al., 2015)and waste recycling behaviours (Barr et al., 2001; Tonglet et al.,

2004, Yau, 2012; Botetzagias et al., 2015) etc. The theory assumes that people have a rational basis for their behaviour, in that they consider the implications of their actions. The TPB hypothesises that the immediate determinant of behaviour is the individual's intention to perform, or not to perform that behaviour. Intentions are, in turn, influenced by three factors:

1. Attitude, the individual's favourable or unfavourable evaluation of performing the behaviour.
2. The subjective norm, the individual's perception of social pressure to perform or not to perform the behaviour.
3. Perceived control, the individual's perception of their ability to perform the behaviour.

A number of recent studies have shed light on the behaviours in common dilemmas by accounting for other economic and social mechanisms such as economic incentives, communication, bio-spherism, altruism, reciprocity and social norms (Mulder et al., 2006; Thøgersen, 2008; Yau, 2010; Ostrom, 2014). Despite a considerable support of TPB, several authors have suggested that additional variables such as situational factors should be included within the model (e.g. Boldero, 1995; Cheung et al., 1999; Terry et al., 1999; Davies et al., 2008; Sniehotta et al., 2014; Conner et al., 2015). Consequently, some of the earlier studies combined and/or extended the TPB with other determinant factors into their research models. For example, Chen and Tung (2010) built an extended TPB research model that incorporated moral norms and consequences of recycling to explain individuals' recycling intentions and found that this extended TPB research model could explain individuals' recycling intentions well. Some studies rely on the development of the TPB to suggest that attitude is the main predictor regarding waste management intentions, and based on this positive intention, it is possible to predict the actual waste management behaviour of the individual (Tonglet et al., 2004; Barr and Gilg, 2005; Ghani, et al., 2013; Nguyen et al., 2015). Similar empirical evidence has been found in several studies regarding waste management behaviour (Chu and Chiu, 2003; Kanbar, 2005; Babaei et al., 2015; Botetzagias et al., 2015). In the pro-environmental context, Kaiser (2006) highlighted that a model predicting individuals' conservation behavioural intention may also contain a moral dimension, which is positively related to individuals' conservation behavioural intention.

The questions concerning how individual decisions are made and how defection problems are resolved have been addressed in various studies. The literature suggests that, the influences on PEB include experience; knowledge and education; personality; perceived behavioural control; values, attitudes, worldviews of various kinds; felt responsibility and moral commitment; norms and habits; goals; affect; and demographic factors (Tonglet et al., 2004; Barr and Gilg, 2005; De Groot and Steg, 2010; Ghani, et al., 2013). A number of previous studies have stressed the importance of environmental concern in predicting environmentally oriented behaviour (e.g., Laroche et al., 2001; do Paco and Rapose, 2009; Kim and Han, 2010; Dietz, 2015; Huddart Kennedy et al., 2015). Moreover, many previous studies indicate that PEB can be facilitated by convenience (Ando and Gosselin, 2005; Timlett and Williams, 2008; Sidique et al., 2010). This argument was supported recently by Bernstad (2014), who emphasised the importance of facilitating conditions and convenience and the existence of necessary infrastructure to participate in PEB specifically related to waste

management. For example, a convenient location of waste drop-off facilities was found to be a significant motivator (Lange et al., 2014). However, Yau (2012) suggested that the convenience of a floor-based system of waste separation facilities is by itself no guarantee of effective waste recycling in residential high-rises. On contrary, a study by Ghani et al. (2013) in Malaysia found that convenience was not a significant reason for not participating in waste recycling activities.

It is evident from literature that, there has been increasing interest in the use of socio-psychology models to provide a theoretical framework for understanding householders' PEB. However, in the existing literature, the measures of PEB do not always reflect the actual environmental impact of an individual or household. Most of the studies focus on relatively monotonous variables from an environmental point of view, that is, behaviours that have only a negligible effect on resource use and behaviours that do not significantly contribute to environmental problems. Consequently, the results of these studies provide little insight into variables that could be helpful in significantly reducing the environmental impacts of households. Thus, there is an utmost need to better understand what motivates people to adopt PEB. What are factors that encourage individuals to engage in pro-environmental actions? What are the drivers and determinants of PEB and the interactions between them?

The literature indicates that pro-environmental attitudes, psychological variables, and situational factors are likely to be important predictors of PEB, however, further investigation of the influence of these factors requires a theoretical framework, such as that provided by the TPB (Ajzen, 2015; Conner, 2015).Although TPB provides a logical outline of environmental behaviour, there are many concerns associated with the application of TPB such as, it does not adequately explain PEB (Sniehotta et al., 2014; Armitage, 2015, Conner, 2015).Further, it is recognised that factors external to the model, for example, altruistic and bio-spheric concern, situational factors, internal attributions (Bissing-Olson et al., 2016) and demographic characteristics (García, 2016)may also play a role in shaping behavioural intentioninfluencing behaviour, thus,suggesting incorporation of additional variables in the model (Barr and Gilg, 2005, Conner, 2015), provided that these variables make a significant contribution to the explanation of behaviour (Ajzen, 1991).In certain contexts, personal feelings of moral judgment, obligation to perform or refusal to perform a certain behaviour must be taken into account (Ajzen, 1991). Moral judgment and felt obligations are also identified as key variables in the Value-Belief-Norm theory developed by Stern et al. (1999). However, it is argued that the influence of additional variables is indirect, mediated through the components of the model (Ajzen, 1991, 2015).

Waste minimisation is a behaviour which requires considerable efforts on the part of individual, as household waste must be sorted, prepared and stored. Consequently the decision is likely to be complex and several factors to be taken into consideration. Thus, this study has incorporated a number of additional variables, including: the personal moral norms; community concern; situational factors; perceived consequences and internal attribution in the TPB framework.

Operationalisation of the constructs

The brief definition of the constructs (in the context of waste minimisation) included in the study is explained below:

Waste minimisation behaviour -frequency of minimisation, past behaviour.

Subjective norm - the individual's perception of social pressure to minimise household waste.

Perceived behavioural control - the individual's perception of their ability to perform the behaviour.

Situational factors- physical factors (infrastructure) which may facilitate or inhibit waste minimisation behaviour.

Perceived consequences of waste minimisation- the outcomes of performing the targeted behaviour.

Attitudes to waste minimisation - the respondents were asked the extent to which they engaged in a number of waste minimisation behaviours.

Community concern - Concern for the community and society in the daily behaviour.

Internal attribution-the feeling of guilt, shame of not behaving in environmental friendly way.

Personal moral norms – the moral norms of the person e.g. felt responsibility etc.

Behavioural intention – the intention of individual to engage or not to engage in PEB, future minimisation intentions.

Demographic information—age, gender, marital status, education, occupation, household role, and number of children in household.

Methodology

The purpose of the current study is to explore the factors that determine PEB and to develop, refine and validate a scale for measuring PEB.
In order to achieve the stated objectives, the following methodological steps were followed:

1. Item generation for the questionnaire with the help of extensive literature review and focus group interviews;
2. Data collection for pilot study;
3. Testing the scale for reliability and validity;
4. Analysing he item-to-total correlation and coefficient to assess the reliability of the scale and improve upon items to improve the reliability of the scale;
5. Large sample data collection;
6. Testing the scale was again for reliability; and

7.   To conduct factor analysis assessing the construct validity of the scale.

Item generation

The first step in the scale development process was the generation of a pool of items for each variable in the conceptual framework. Development of the scales to measure each dimension of PEB proceeded through a series of steps. Multiple measures for each of the dimensions of PEB were developed on the basis of the items from related existing scales and focussed group interviews. Items to measure behaviour, behavioural intention, attitude, subjective norm and perceived behavioural control were developed on the basis of the procedures suggested by Ajzen and Fishbein (1980) and Ajzen (1985, 1991). While items to measure personal moral norms, perceived consequences (outcomes of performing or not performing the specific behaviour) were generated on the basis of norm activation model (Schwartz, 1970, 1973, 1977). The salient beliefs about waste minimisation were elicited from a convenience sample of 30 people using focus group interviews. The beliefs were mapped into measures of community or societal concern, complexity, internal attribution, situational/facilitating conditions and self-efficacy. In the next step, a separate sample of ratters were asked to rate the measures representing each of the underlying constructs. This procedure was used to refine the items prior to conducting the pilot test.

Content validity

In total, 52 items under ten factors were reviewed by ten experts comprising of academicians, psychologists, consultants and public authorities to assess the content and face validity. The experts evaluated the items for clarity, representativeness and possibility of misinterpretation. The experts suggested rewording/reframing of five items.

Scale and measurement

The current study used a measure of ten latent variables. The instrument used to measure latent variables is a self-reporting questionnaire. The questionnaire comprised two parts. In Part A of the questionnaire, the respondents were requested to furnish the demographic information related to age, sex, household income and educational level. In Part B of the questionnaire, the respondents were asked to rate on a five-point scale (1 representing "strongly disagree" to 5 representing "strongly agree") their level of agreement for each statement of the ten dimensions of PEB. The final scales used for each construct are reproduced in the Appendix.

Questionnaire administration

Questionnaires were administered personally to the household respondents. Doubts and queries raised by the respondents with regard to any question were clarified instantly on the spot. Stratified random sampling technique was used for the data collection. The method comprised three types of strata i.e. high, middle and low income groups. Almost, equal numbers of respondents were chosen as per the convenience from each of the strata.

Data collection

A sample of one hundred respondents completed the pilot test. The questionnaire was tested for reliability. On the basis of the results of the pilot test, the questionnaire was further modified and shortened. In the next stage, the modified shortened questionnaire was used to collect data. A new sample of 250 households completed the survey. Again the questionnaire was subjected to reliability testing, validity and exploratory factor analysis.

Data analysis and results

The data that were collected was analysed through the use of a statistical package – Statistical Package for Social Sciences (SPSS Version 20). The data were analysed using reliability, validity and exploratory factor analysis (EFA) to assess the psychometric properties of the scale.

Reliability and item analysis

As recommended by Churchill (1979), the first and the foremost step to refine the scale is the computation of coefficient a, i.e. Cronbach alpha (Cronbach, 1951). Reliability was assessed through the following means –
(a) item-to-item correlation is more than 0.3,
(b) item-to-total (summated scale) correlation is more than 0.5, and
(c) Cronbach's alpha is at least 0.7.

For all factors of PEB, Cronbach alpha was computed, that ranged from 0.70 to 0.94 (pilot study, n=100). According to Nunnally's criterion, the minimum satisfactory value of Cronbach alpha is 0.7 (Nunnally, 1974). Although the criterion of alpha was satisfied, further to improve the value of alpha, corrected item-to-total correlations for each cluster of items were computed. Items possessing very low correlations and/or items whose correlations produce sharp drop among the corrected item-to-total correlations and/or items whose removal improves the value of alpha, were deleted. This iterative sequence was repeated numerous times which resulted in the form of 49 items and three items being deleted. The improved values of Cronbach's alpha for all 10 factors ranged from 0.81 to 0.97 specifying good internal consistencies among all the items. Further, the combined reliability was computed for all the 49-items (Nunnally, 1978) and it was found to be quite high, i.e. 0.91. Finally, total 49 items for all the 10 factors were retained for the next stage.

After item analysis, the questionnaire was used to collect data from new sample (n= 250). Again the reliability was computed and the improved values of Cronbach's alpha for all 10 factors ranged from 0.89 to 0.96. These values are shown in the Table 1.

Table 1: Reliability of Constructs

Construct	Reliability	Item to total Correlation (above 0.5)
Behaviour	0.890	All
Behavioural Intention	0.891	All
Perceived Behavior Control	0.957	All
Situational Factor	0.937	All
Subjective Norms	0.960	All
Personal Norms	0.961	All
Internal Attribution	0.933	All
Attitude	0.914	All
Perceived Relative Advantage	0.930	All
Complexity	0.934	All
Community Concern	0.944	All

Construct validity

After this, the EFA was performed on the remaining 49 items using principal component analysis and the Varimax rotation without specifying the number of factors to be extracted (Costello and Osborne, 2011). A minimum cut off criteria for the deletion of the items was: factor loadings (<0.50) (Karatepe et al., 2005), cross loadings (>0.40) or communalities (<0.50) (Hair et al., 2010). The appropriateness of the analysis was determined by the examination of Kaiser-Meyer-Olkin (KMO) statistic of sampling adequacy. For good factor analysis, the value of KMO must be at least 0.60 and above (Tabachnick and Fidell, 2001).

The following points relate to factor analysis (Williams et al., 2012).
Normality, linearity, homoscedasticity and homogeneity of the sample were assumed. The following criteria were satisfied:
(a) The minimum sample size is 50.
(b) The minimum respondents-to-variables ratio is 5.
(c) There exist significant correlations among many of the variables.
(d) Partial correlations among most of the variables are 0.5 or less.
(e) The measures of sampling adequacy (MSA), overall and for individual variables, are at least 0.5.

The number of factors was decided based on the following criteria –
   (i) Empirical evidence,
   (ii) Eigen value is more than 1, and
   (iii) Cumulative percentage of total variance extracted is at least 60%.
   (iv) To consider an item to load on a factor, a minimum absolute factor loading of 0.65 is required.
   (v) Unidimensionality is assessed in terms of items loading on a single factor and nonexistence of significant cross-loadings.

The results of the analysis revealed that Eigen value of all 10 factors was greater than 1 (Kaiser, 1960), therefore, none of the factors can be eliminated from the study. The Kaiser-Meyer-Olkin measure of sampling adequacy (MSA), a measure of the data set's appropriateness for factor analysis, was 0.89. The results depicted a 10 factors solution explaining 82.44 percent variance among the analysed items. The Bartlett's test of sphericity proved to be significant. All communalities ranged from 0.50 to 0.83. No items were dropped after inspection as all items fulfilled the minimum cut-off criteria mentioned above. The results of EFA are summarised in Table 2.

Table 2: Result of EFA

Constructs	B	BI	ATT	PN	SN	PBC	SF	CC	IA	PC
B1	0.883									
B2	0.877									
B3	0.886									
BI1		0.792								
BI2		0.769								
BI3		0.792								
ATT1			0.945							
ATT2			0.868							
ATT3			0.875							
ATT4			0.882							
PN1				0.884						
PN2				0.877						
PN3				0.883						
PN4				0.870						
PN5				0.880						
PN6				0.879						
SN1					0.954					
SN2					0.861					
SN3					0.848					
SN4					0.862					
SN5					0.864					
SN6					0.866					
SN7					0.863					
SN8					0.847					
PBC1						0.955				
PBC2						0.867				
PBC3						0.889				
PBC4						0.878				
PBC5						0.881				
PBC6						0.880				
PBC7						0.873				
SF1							0.876			
SF2							0.881			
SF3							0.856			
SF4							0.873			
SF5							0.878			
CC1								0.907		
CC2								0.900		
CC3								0.910		
IA1									0.906	
IA2									0.840	
IA3									0.953	
IA4									0.882	
IA5									0.898	
PC1										0.901
PC2										0.951
PC3										0.912
PC4										0.921
PC5										0.911
N = 250										
Eigenvalues	2.502	1.825	3.417	6.498	6.531	5.094	4.105	1.724	4.211	2.648

KMO = 0.893

Bartlett's Test = Chi-Square(df=1225)=28790.273, P=0.000

Criterion-related validity

The criteria-related validity is established when a criterion external to the measurement instrument is correlated with the factor structure (Nunnally, 1994). Criteria-related validity of the dimensions of PEB was measured by finding the correlation of each one of them with aPEB measure. All the correlations were significant at 0.05 significance level. The results of the correlation analysis are shown in the Table 3.

Table 3: Pearson's correlation analysis of the constructs

	B	BI	PBC	SF	SN	PN	IA	AT	CC	PC
B	**1.000**	0.374	0.497	0.148	0.215	0.222	0.113	0.217	0.076	0.151
BI	0.374	**1.000**	0.332	0.271	0.339	0.366	0.162	0.364	0.182	0.195
PBC	0.497	0.332	**1.000**	0.185	0.229	0.201	0.142	0.148	0.157	0.134
SF	0.148	0.271	0.185	**1.000**	0.143	0.197	0.163	0.197	0.131	0.114
SN	0.215	0.339	0.229	0.143	**1.000**	0.224	0.051	0.208	0.059	0.130
PN	0.222	0.366	0.201	0.197	0.224	**1.000**	0.126	0.213	0.096	0.085
IA	0.113	0.162	0.142	0.163	0.051	0.126	**1.000**	0.096	0.055	0.095
AT	0.217	0.364	0.148	0.197	0.208	0.213	0.096	**1.000**	0.105	0.186
CC	0.076	0.182	0.157	0.131	0.059	0.096	0.055	0.105	**1.000**	0.082
PC	0.151	0.195	0.134	0.114	0.130	0.085	0.095	0.186	0.082	**1.000**

Common method bias

The potential problem with self-reported, single respondent data is the possibility of common method variance (CMV). The current study conducted Harmon's one-factor test suggested by Podsakoff et al. (2003) to investigate the bias of CMV in the data set. This test assumes that if a substantial amount of CMV is present, either a single factor will emerge from the un-rotated factor analysis or one general factor will account for the majority of the covariance in the independent and dependent variables (Hair et al., 2010). Harmon's single-factor test showed that the ten factors were extracted from the entire set of variables. The results highlight that there is more than one factor in the un-rotated PCA solution of all variables and that the first factor explained22.68 percent of the variance out of total 82.44 percent.

Discussion and conclusions

The present study was primarily a psychological investigation of the intrapsychic relationship between affective, cognitive and behavioural components of pro-environmental actions. Cognitive psychological modelling can provide the means to identify the driving forces behind waste minimisation behaviour (PEB), and in a given area determine the main likely success factors. Once these factors have been established, cost-effective campaignscan be designed to maximise the outcome. The TPB provided a cognitive framework to understand and explain behaviour, and its use in this study has provided valuable insights into the factors which underpin waste minimisation behaviour. The results indicate that the affective, cognitive experiences and situational factors are involved in developing the highest level of environmentally responsible action.

The purpose of this study was to examine the antecedents of PEB. Inclusion of the additional factors of the moral norm, situational factors, perceived consequences,

community concern and internal attribution, resulted increase in the percentage of variance explained. This information can then be used to develop and implement waste minimisation schemes which are user friendly. Additionally, this information can be used as the basis for the marketing communication campaigns which advocate the use of such schemes. The individuals who were more likely to engage in waste minimisation behaviour were more likely to be concerned about environmental issues and the impact of waste on the environment and their community. The survey demonstrates that the individual has positive intention in participating provided the opportunities, facilities and knowledge on waste minimisation at source are adequately prepared by the respective local authorities. Good moral values and situational factors such as storage convenience and collection times are also found to encourage public's involvement and consequently, the participations rate. Furthermore, local authorities should take into consideration of individuals personal beliefs about the moral correctness and incorrectness of performing waste minimisation and factors that may motivate and inhibit waste minimisation behaviour. The findings from this study may provide useful indicator to the waste management authorities in identifying mechanisms for future development and implementation of waste source minimisation activities in household programmes and communication campaign which advocate the use of these programmes.

The scale developed in this study provides practitioners and researchers with a reliable and valid analytical tool for the measurement of household perceptions about PEB. This can be used as a diagnostic tool that allows identifying and solving problems that occur in the process of service provision. Based upon the feedback, the practitioners can reframe their management strategies and tactics to redesign the waste management system. In summary, the study outlines the development and validation of the scale of household waste minimisation and PEB. The results of the reliability, validity and EFA indicate that the scale is psychometrically sound. Overall, the utility of the framework, based on social-psychological constructs, has considerable potential to advance the academic and practical understanding of PEB. Although this study has provided useful information about the factors, which influence PEB of those who minimise their household waste on a regular basis, there are limitations to the approach taken. Firstly, a small sample size of participants restricts the extent to which the findings can be generalised throughout. The current study was confined to households in India, and thus, the results cannot be generalized. A potential limitation in the approach of current study is the lack of consideration of past experience.

References

Ajzen, I. (1985). *From intentions to actions: A theory of planned behavior.* In: Kuhl, J.,Beckmann, J. (Eds.), Action Control, From Cognition to Behavior. (pp. 11-39). Springer Berlin Heidelberg.

Ajzen, I., & Madden, T. J. (1986). Prediction of goal-directed behavior: Attitudes, intentions, and perceived behavioral control. *Journal of Experimental Social Psychology*, *22*(5), 453-474.

Ajzen, I. & M. Fishbein (1980). *Understanding Attitudes and Predicting Social Behavior*. Englewood Cliffs, NJ: Prentice-Hall, Inc.

Ajzen I. (1988). *Attitudes, personality and behaviour*. Milton Keynes: Open University Press.

Ajzen, I. (1991). The theory of planned behaviour. Organizational behaviour and human decision processes, 50(2), 179-211.

Ajzen, I., & Driver, B. L. (1992). Application of the theory of planned behavior to leisure choice. *Journal of Leisure Research*, *24*(3), 207.

Ajzen, I. (2005). *Attitudes, personality, and behavior*. McGraw-Hill Education (UK).

Ajzen, I. (2015). The theory of planned behaviour is alive and well, and not ready to retire: a commentary on Sniehotta, Presseau, and Araújo-Soares. *Health Psychology Review*, *9*(2), 131-137.

Allen, M. (2016). Understanding Pro-Environmental Behavior: Models and Messages. In *Strategic Communication for Sustainable Organizations* (pp. 105-137). Springer International Publishing.

Ando, A. W., & Gosselin, A. Y. (2005). Recycling in multifamily dwellings: does convenience matter?.*Economic inquiry*, *43*(2), 426-438.

Armitage, C. J., & Conner, M. (2001). Efficacy of the theory of planned behaviour: A meta-analytic review. *British journal of social psychology*, *40*(4), 471-499.

Armitage, C. J. (2015). Time to retire the theory of planned behaviour? A commentary on Sniehotta, Presseau and Araújo-Soares. *Health Psychology Review*, *9*(2), 151-155.

Babaei, A. A., Alavi, N., Goudarzi, G., Teymouri, P., Ahmadi, K., &Rafiee, M. (2015). Household recycling knowledge, attitudes and practices towards solid waste management. *Resources, Conservation and Recycling*, *102*, 94-100.

Bamberg, S., & Schmidt, P. (2001). Theory-Driven Subgroup-Specific Evaluation of an Intervention to Reduce Private Car Use1. *Journal of Applied Social Psychology*, *31*(6), 1300-1329.

Bamberg, S., Ajzen, I., & Schmidt, P. (2003). Choice of travel mode in the theory of planned behavior: The roles of past behavior, habit, and reasoned action. *Basic and Applied Social Psychology*, *25*(3), 175-187.

Barr, S., Gilg, A. W., & Ford, N. J. (2001). A conceptual framework for understanding and analysing attitudes towards household-waste management. *Environment and Planning A*, *33*(11), 2025-2048.

Barr, S., &Gilg, A. W. (2005). Conceptualising and analysing household attitudes and actions to a growing environmental problem: Development and application of a framework to guide local waste policy. *Applied Geography*, *25*(3), 226-247.

Beck, L., & Ajzen, I. (1991). Predicting dishonest actions using the theory of planned behavior. *Journal of Research in Personality*, *25*(3), 285-301.

Bernstad, A. (2014). Household food waste separation behavior and the importance of convenience. *Waste Management*, *34*(7), 1317-1323.

Bissing-Olson, M. J., Fielding, K. S., &Iyer, A. (2016). Experiences of pride, not guilt, predict pro-environmental behavior when pro-environmental descriptive norms are more positive. *Journal of Environmental Psychology*.

Boldero, J. (1995). The prediction of household recycling of newspapers: The role of attitudes, intentions, and situational factors1. *Journal of Applied Social Psychology*, *25*(5), 440-462.

Botetzagias, I., Dima, A. F., &Malesios, C. (2015). Extending the theory of planned behavior in the context of recycling: The role of moral norms and of demographic predictors. *Resources, Conservation and Recycling*, *95*, 58-67.

Chen, M.F., Tung, P.J. (2010). The moderating effect of perceived lack of facilities on consumers' recycling intentions. *Environment and Behavior,* 42(6), 824-844.

Cheung, S. F., Chan, D. K. S., & Wong, Z. S. Y. (1999). Re-examining the theory of planned behavior in understanding wastepaper recycling. *Environment and Behavior*, *31*(5), 587-612.

Chu, P. Y., & Chiu, J. F. (2003). Factors Influencing Household Waste Recycling Behavior: Test of an integrated Model1. *Journal of Applied Social Psychology*, *33*(3), 604-626.

Churchill Jr, G. A. (1979). A paradigm for developing better measures of marketing constructs. *Journal of Marketing Research*, 64-73.

Collins, S. E., & Carey, K. B. (2007). The theory of planned behavior as a model of heavy episodic drinking among college students. *Psychology of Addictive Behaviors*, *21*(4), 498.

Conner, M. (2015). Extending not retiring the theory of planned behaviour: a commentary on Sniehotta, Presseau and Araújo-Soares. *Health Psychology Review*, *9*(2), 141-145.

Corvellec, H. (2016). A performative definition of waste prevention. *Waste Management*, *52*, 3-13.

Costello, A. B., & Osborne, J. W. (2011). Best practices in exploratory factor analysis: four recommendations for getting the most from your analysis. Pract Assess Res Eval 2005; 10. *URL http://pareonline. net/getvn. asp*, *10*, 7.

Cronbach, L. J. (1951). Coefficient alpha and the internal structure of tests. *Psychometrika*, *16*(3), 297-334.

da Costa Ferreira, L., &Barbi, F. (2016). The Challenge of Global Environmental Change in the Anthropocene: An Analysis of Brazil and China. *Chinese Political Science Review*, 1-13.

Davies, J., Foxall, G. R., & Pallister, J. (2002). Beyond the intention–behaviour mythology an integrated model of recycling. *Marketing Theory*, *2*(1), 29-113.

Davis, G., & Morgan, A. (2008). Using the Theory of Planned Behaviour to determine recycling and waste minimisation behaviours: A case study of Bristol City, UK. *Special Edition Papers*, *20*(1).

De Groot, J. I., & Steg, L. (2010). Relationships between value orientations, self-determined motivational types and pro-environmental behavioural intentions. *Journal of Environmental Psychology*, *30*(4), 368-378.

De Leeuw, A., Valois, P., Ajzen, I., & Schmidt, P. (2015). Using the theory of planned behavior to identify key beliefs underlying pro-environmental behavior in high-school students: Implications for educational interventions. *Journal of Environmental Psychology*, *42*, 128-138.

Dietz, T. (2015). Environmental value. *Handbook of Value: Perspectives from Economics, Neuroscience, Philosophy, Psychology and Sociology*, 329.

doPaço, A., &Raposo, M. (2009). "Green" segmentation: an application to the Portuguese consumer market. *Marketing Intelligence & Planning*, *27*(3), 364-379.

Fielding, K. S., McDonald, R., & Louis, W. R. (2008). Theory of planned behaviour, identity and intentions to engage in environmental activism. *Journal of Environmental Psychology*, *28*(4), 318-326.

Fielding, K. S., & Hornsey, M. J. (2016). A social identity analysis of climate change and environmental attitudes and behaviors: Insights and opportunities. *Frontiers in Psychology*, *7*.

García, N. L. M. (2016). Gender differences, theory of planned behavior and willingness to pay. *Journal of Environmental Psychology*, *45(1),* 165-175.

Gardner, G. T., & Stern, P. C. (2002). *Environmental problems and human behavior* (2nd ed.). Boston, MA: Pearson Custom Publishing.

Ghani, W. A. W. A. K., Rusli, I. F., Biak, D. R. A., & Idris, A. (2013). An application of the theory of planned behaviour to study the influencing factors of participation in source separation of food waste. *Waste Management*, *33*(5), 1276-1281.

Graham-Rowe, E., Jessop, D. C., & Sparks, P. (2015). Predicting household food waste reduction using an extended theory of planned behaviour. *Resources, Conservation and Recycling*, *101*, 194-202.

Guagnano, G. A., Stern, P. C., & Dietz, T. (1995). Influences on attitude-behavior relationships a natural experiment with curbside recycling. *Environment and Behavior*, *27*(5), 699-718.

Hair, J. F., Black, W. C., & Babin, B. J. (2010). RE Anderson *Multivariate data analysis: A global perspective*, Pearson Prentice Hall.

Hoyos, D., Mariel, P., &Fernández-Macho, J. (2009). The influence of cultural identity on the WTP to protect natural resources: some empirical evidence. *Ecological Economics*, *68*(8), 2372-2381.

Huddart Kennedy, E., Krahn, H., &Krogman, N. T. (2015). Are we counting what counts? A closer look at environmental concern, pro-environmental behaviour, and carbon footprint. *Local Environment*, *20*(2), 220-236.

Kaiser, H. F. (1960). The application of electronic computers to factor analysis. *Educational and Psychological Measurement*, 20(1), 141-151.

Kaiser, F. G. (2006). A moral extension of the theory of planned behavior: Norms and anticipated feelings of regret in conservationism. *Personality and Individual Differences*, *41*(1), 71-81.

Kanbar, N. N. (2005). Analyzing individual behavior in commons dilemmas: A study of collective action in source separation of wastes (Dissertation). George Mason University.

Karatepe, O. M., Yavas, U., &Babakus, E. (2005). Measuring service quality of banks: Scale development and validation. Journal of Retailing and Consumer Services, *12(5),* 373-383

Katzev, R., &Mishima, H. R. (1992). The use of posted feedback to promote recycling. *Psychological Reports*, *71*(1), 259-264.

Kim, Y., & Han, H. (2010). Intention to pay conventional-hotel prices at a green hotel–a modification of the theory of planned behavior. *Journal of Sustainable Tourism*, *18*(8), 997-1014.

Koger, S. M., &Winter, D. D. (2011). *The psychology of environmental problems: Psychology for sustainability*. Psychology press.

Lam, S. P. (1999). Predicting intentions to conserve water from the theory of planned behavior, perceived moral obligation, and perceived water right1. *Journal of Applied Social Psychology*, *29*(5), 1058-1071.

Lange, F., Brückner, C., Kröger, B., Beller, J., & Eggert, F. (2014). Wasting ways: Perceived distance to the recycling facilities predicts pro-environmental behavior. *Resources, Conservation and Recycling*, *92*, 246-254.

Laroche, M., Bergeron, J., &Barbaro-Forleo, G. (2001). Targeting consumers who are willing to pay more for environmentally friendly products. *Journal of Consumer Marketing*, *18*(6), 503-520.

Larson, L. R., Stedman, R. C., Cooper, C. B., & Decker, D. J. (2015). Understanding the multi-dimensional structure of pro-environmental behavior. *Journal of Environmental Psychology*, *43(1)*, 112-124.

McCarty, J. A., & Shrum, L. J. (1994). The recycling of solid wastes: Personal values, value orientations, and attitudes about recycling as antecedents of recycling behavior. *Journal of Business Research*, *30*(1), 53-62.

McLeod, L. J., Hine, D. W., Please, P. M., & Driver, A. B. (2015). Applying behavioral theories to invasive animal management: Towards an integrated framework. *Journal of Environmental Management*, *161*, 63-71.

Morren, M., & Grinstein, A. (2016). Explaining environmental behavior across borders: A meta-analysis. *Journal of Environmental Psychology, 47(1),* 91-106.

Mulder, L. B., Van Dijk, E., De Cremer, D., & Wilke, H. A. (2006). Undermining trust and cooperation: The paradox of sanctioning systems in social dilemmas. *Journal of Experimental social psychology*, *42*(2), 147-162.

Nguyen, T. T. P., Zhu, D., & Le, N. P. (2015). Factors influencing waste separation intention of residential households in a developing country: Evidence from Hanoi, Vietnam. *Habitat International*, *48(1),* 169-176.

Norman, P., Armitage, C. J., & Quigley, C. (2007). The theory of planned behavior and binge drinking: Assessing the impact of binge drinker prototypes. *Addictive Behaviors*, *32*(9), 1753-1768.

Nunnally, J. C. (1978). *Psychometric Theory*, McGraw-Hill, New York, NY.

Nunnally, J. C., & Bernstein, I. (1994). *Psychometric theory*. New York, NY: McGraw-Hill.

Oreg, S., & Katz-Gerro, T. (2006). Predicting proenvironmental behavior cross-nationally values, the theory of planned behavior, and value-belief-norm theory. *Environment and Behavior*, *38*(4), 462-483.

Ostrom, E. (2014). Collective action and the evolution of social norms. *Journal of Natural Resources Policy Research*, *6*(4), 235-252.

Parker, D., Manstead, A. S., Stradling, S. G., Reason, J. T., & Baxter, J. S. (1992). Intention to commit driving violations: an application of the theory of planned behavior. *Journal of Applied Psychology*, *77*(1), 94.

Podsakoff, P. M., MacKenzie, S. B., Lee, J. Y., &Podsakoff, N. P. (2003). Common method biases in behavioral research: a critical review of the literature and recommended remedies. *Journal of Applied Psychology*, *88*(5), 879.

Reddy, S. M., Montambault, J., Masuda, Y. J., Gneezy, A., Keenan, E., Butler, W., &Asah, S. T. (2016). Advancing Conservation by Understanding and Influencing Human Behavior. *Conservation Letters (In press)*.

Sansone, C., Weir, C., Harpster, L., & Morgan, C. (1992). Once a boring task always a boring task? Interest as a self-regulatory mechanism. *Journal of Personality and Social Psychology*, *63*(3), 379.

Schwartz S. H. (1970). Moral decision making and behavior. In: Macauley J, Berkowitz L, editors. *Altruism and helping behavior*. Academic Press; p. 127-41, NY.

Schwartz, S. H. (1973). Normative explanations of helping behavior: A critique, proposal, and empirical test. *Journal of Experimental Social Psychology*, *9*(4), 349-364.

Schwartz S. H. (1977). Normative influences on altruism. *Advances in Experimental Social Psychology*, 10, 221-79.

Scott, A., Oates, C., & Young, W. (2015). A conceptual framework of the adoption and practice of environmental actions in households. *Sustainability*, *7*(5), 5793-5818.

Sidique, S. F., Lupi, F., & Joshi, S. V. (2010). The effects of behavior and attitudes on drop-off recycling activities. *Resources, Conservation and Recycling*, *54*(3), 163-170.

Sniehotta, F. F., Presseau, J., &Araújo-Soares, V. (2014). Time to retire the theory of planned behaviour. Health Psychology Review, 8, 1–7.

Stern, P. C., Dietz, T., Abel, T. D., Guagnano, G. A., &Kalof, L. (1999). A value-belief-norm theory of support for social movements: The case of environmentalism. *Human ecology review*, *6*(2), 81.

Tabachnick, B. G., Fidell, L. S., & Osterlind, S. J. (2001). Using multivariate statistics, Pearson Education Limited, New York.

Taylor, S., & Todd, P. (1995). An integrated model of waste management behavior a test of household recycling and composting intentions. *Environment and Behavior*, *27*(5), 603-630.

Terry, D. J., Hogg, M. A., & White, K. M. (1999). The theory of planned behaviour: self-identity, social identity and group norms. *British Journal of Social Psychology*, *38*(3), 225-244.

Thøgersen, J. (1994). A model of recycling behaviour, with evidence from Danish source separation programmes. *International Journal of Research in Marketing*, *11*(2), 145-163.

Thøgersen, J. (2008). Social norms and cooperation in real-life social dilemmas. *Journal of Economic Psychology*, *29*(4), 458-472.

Timlett, R. E., & Williams, I. D. (2008). Public participation and recycling performance in England: A comparison of tools for behaviour change. *Resources, Conservation and Recycling*, *52*(4), 622-634.

Tonglet, M. (2002). Consumer misbehaviour: an exploratory study of shoplifting. *Journal of Consumer Behaviour*, *1*(4), 336-354.

Tonglet, M., Phillips, P. S., & Read, A. D. (2004). Using the Theory of Planned Behaviour to investigate the determinants of recycling behaviour: a case study from Brixworth, UK. *Resources, Conservation and Recycling*, *41*(3), 191-214.

Turaga, R. M. R., Howarth, R. B., &Borsuk, M. E. (2010). Pro-environmental behavior. *Annals of the New York Academy of Sciences*, *1185*(1), 211-224.

van der Werff, E., & Steg, L. (2015). One model to predict them all: predicting energy behaviours with the norm activation model. *Energy Research & Social Science*, *6*, 8-14.

Vining, J., &Ebreo, A. (1990). What makes a recycler? A comparison of recyclers and nonrecyclers. *Environment and Behavior*, *22*(1), 55-73.

Vining, J., &Ebreo, A. (1992). Predicting recycling behavior from global and specific environmental attitudes and changes in recycling opportunities1. *Journal of Applied Social Psychology*, *22*(20), 1580-1607.

Vlek, C., & Steg, L. (2007). Human Behavior and Environmental Sustainability: Problems, Driving Forces, and Research Topics. *Journal of Social Issues*, *63*(1), 1-19.

Werner, C. M., Turner, J., Shipman, K., Twitchell, F. S., Dickson, B. R., Bruschke, G. V., & Wolfgang, B. (1995). Commitment, behavior, and attitude change: An analysis of voluntary recycling. *Journal of Environmental Psychology*, *15*(3), 197-208.

Werner, C. M., &Makela, E. (1998). Motivations and behaviors that support recycling. *Journal of Environmental Psychology*, *18*(4), 373-386.

Williams, B., Brown, T., &Onsman, A. (2012). Exploratory factor analysis: A five-step guide for novices. *Australasian Journal of Paramedicine*, *8*(3), 1.

Yau, Y. (2010). Domestic waste recycling, collective action and economic incentive: The case in Hong Kong. *Waste Management*, *30*(12), 2440-2447.

Yau, Y. (2012). Stakeholder engagement in waste recycling in a high-rise setting. *Sustainable Development*, *20*(2), 115-127.

Solar Powered Vapour Absorption Refrigeration (SPVAR) System as a rural microenterprise

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Abstract
The continuous increase in the cost and demand for energy has led to more research and development to utilize available and renewable energy resources efficiently. The absorption refrigeration system (ARS) is becoming more important because it can produce higher cooling capacity than vapor compression systems, and it can be powered by other sources of energy (like waste heat from gas and steam turbines, sun, geothermal, biomass) other than electricity. But as far as COP of these refrigeration systems is concerned, it is always a challenge to the researchers to significantly increase the COP for these systems. The most popular refrigeration and air conditioning systems at present are those based on the vapour absorption systems. These systems are popular because they are reliable, relatively inexpensive and their technology is well established. However, these systems require high grade energy for their operation. There are still problems to be solved in research field, especially small cooling capacity machine (about 1 to 10 kW) which are suitable for small farmers and residential uses. Apart from this, the recent discovery that the conventional working fluids of vapour absorption systems are causing the ozone layer depletion and greenhouse effects has forced the scientific researchers to look for alternative systems for cooling applications. The natural alternative is of course the absorption system, which mainly uses heat energy for its operation. Moreover, the working fluids of these systems are environment friendly. The present study elaborates feasibility of such systems using H_2O–LiBr solution and exergy analysis.

Keywords: Absorption refrigeration system, renewable energy, greenhouse effect

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Introduction

It is a well known fact that in Asian sub continent especially India, agriculture is main occupation. More than 70% of the population still lives in villages and their wealth totally or partially depend on what they cultivate [1]. Another important fact that needs to be focused, is, that a seasonal crop cultivates abundantly like tomato, grapes, mangoes and most of the vegetables. For farmers it becomes a challenge to transport it to the market in a short time and to sell it at proper price. Rural areas of India also lack in transport network. It is very expensive and difficult to transfer material to market. Farmers then have no choice other than either to get it spoiled in the field itself or to sell it at low price. Expensive cold storages are out of reach for small farmers. Middle Traders buy it at nominal price and store it in cold storages and sell it on high price afterwards. This leads to steep fluctuation in price of vegetables and even though producer and consumer both suffer. This situation is deteriorating farmer's financial and economic strength day by day and this is when they are doing real and most important ground work. They are finally not receiving for what they deserve. And this is simply because they don't have tools to preserve their hard earned crop.

Objectives

Broad objectives of the proposal are

• To design and fabricate a modified small boiler unit with Water Pre Heater (WPH) based on bio mass that will be used to maintain steam flow when sun light is not adequate. Dr Mudgal has designed and used similar kind of boiler in his Multiple effect distillation unit [2].
• To design and fabricate a unique solar collector capable of producing steam at about 150° C with the flow rate of about 15 kg/ hr
• To design and fabricate an effective Solar Power Vapour Absorption Refrigeration (SPVAR) System having "Low maintenance cost"
• Exploring possibilities of automated hybridization of boiler steam and solar collector steam supply with SPVAR unit as per the requirement
• Parametric study of different size and capacity SPVAR system in actual environment
•   Field testing of the finally designed and developed SPVAR Unit

Novelty / uniqueness of the Proposal

In present work, a solar powered, steam and hot water driven, single stage, absorption cooling system, using a lithium bromide water solution, will be analyzed for determining the effect of various parameters on coefficient of performance (COP). Four basic stages in the absorption cycle are generation, condensation, evaporation and absorption with ideally no moving part. This small scale system is the ever first approach to be deployed in rural areas for decentralized applications. Vapour Absorption Systems offer many advantages like

•   It offers flexibility to utilize any sort of low grade, low cost heat energy available   to produce cooling and thus giving a high savings in operating costs.
•   It can operate on steam or any other waste heat source as the energy source instead of costly and unreliable electric power [3].

•   No moving parts ensure noiseless, vibration-less and trouble free operation.
•   Moreover maintenance costs are negligible as compared to power driven mechanical systems.
•   Refrigerating effect is produced using a clean refrigerant in place of ozone-depleting chlorine based compounds.

Methodology

A suitable working fluid is probably the single most important factor in any refrigeration system. The cycle efficiency and operation characteristics of an absorption refrigeration system depend on the properties of refrigerant, absorbent and their mixtures. The most important thermo-physical properties are: heat of vaporization of refrigerant, heat of solution, vapour pressure of refrigerant and absorbent, solubility of refrigerant in solvent, heat capacity of solution, viscosity of solution and surface tension and thermal conductivity of the solution. Apart from this, the other selection criteria for the working fluids are their toxicity, chemical stability and corrosivity [1].

The proposed system in Fig. 1 bears a cooling capacity of around 1TR. Thermodynamic analysis of the system involves finding important parameters like enthalpy, mass flow rates, flow ratio, Heat and Mass Transfers for the whole system to finally calculate the system Coefficient of Performance (COP). These values are to be then used for design of the system. First some set of thermodynamic equations have been derived in terms of mass flow rates and enthalpy by applying mass and energy balance for each component. Then the actual system conditions like temperature, pressures, and enthalpies are substituted in the equations to finally obtain the COP value for the system.

A steady flow analysis of the system is carried out with the following assumptions:

1.   Steady state and steady flow
2.   Changes in potential and kinetic energies across each component are negligible
3.   No pressure drops due to friction
4.   Only pure refrigerant boils in the generator.

Outline of the proposal

Vapour Absorption Refrigeration Systems belong to the class of vapour cycles similar to vapour absorption refrigeration systems. However, unlike vapour absorption refrigeration systems, the required input to absorption systems is in the form of heat. Hence these systems are also called as heat operated or thermal energy driven systems. Both vapour absorption and absorption refrigeration cycles accomplish the removal of heat through the evaporation of a refrigerant at a low pressure and the rejection of heat through the condensation of the refrigerant at a higher pressure.
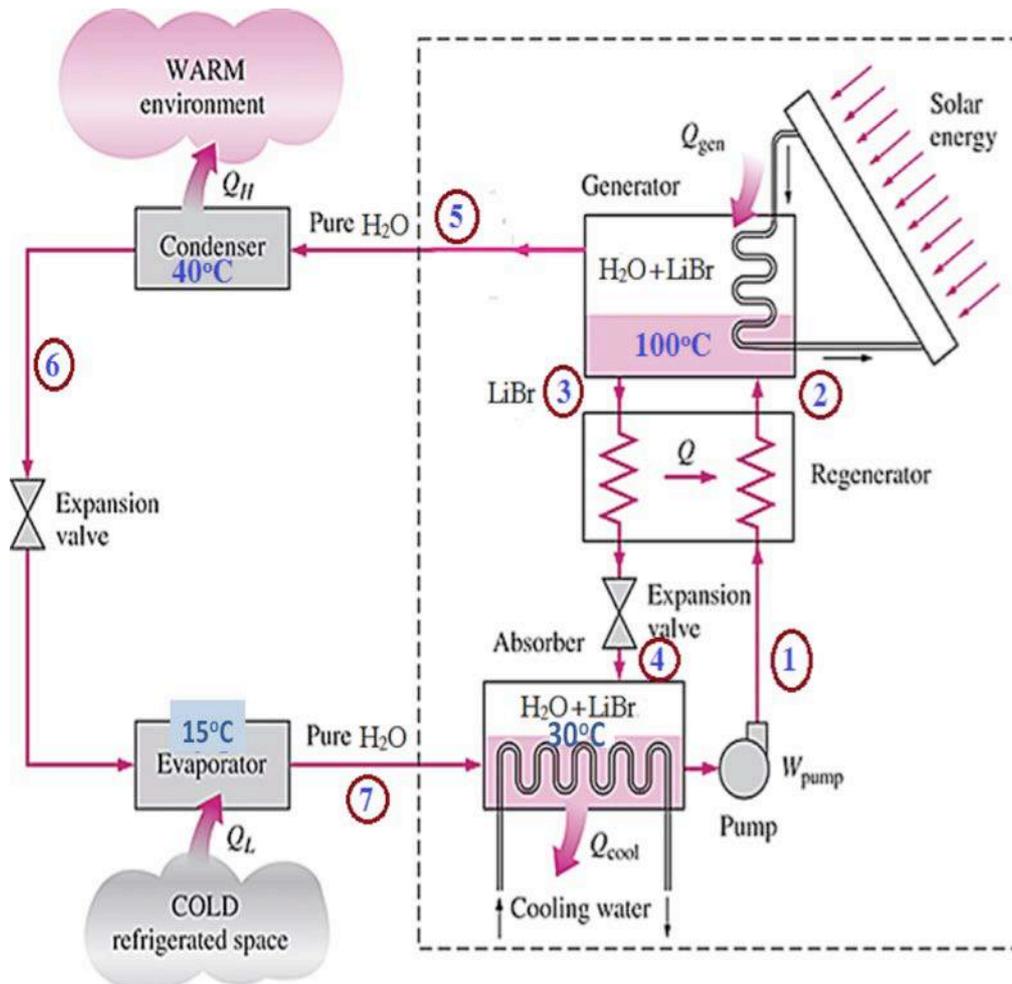
Figure 1: Schematic view of I TR Vapour Absorption Refrigeration Systems

The basic difference is that a vapour absorption system employs a mechanical compressor to create the pressure differences necessary to circulate the refrigerant whereas an absorption system uses heat source and the differences cause an absorption system to use little to no work input, but energy must be supplied in the form of heat. This makes the system very attractive when there is a cheap source of heat, such as solar heat or waste heat from electricity or heat generation.

Mathematical Calculations of Parameters:

Evaporator Capacity = 3.5KW = 1TR

Operating Temperatures and Pressures:

Most favorable conditions for optimum working of system with the utilization of waste heat source in environmental conditions are estimated as:

Operating Parameter	Calculated Value
Tg = Generator Temp	100^0C
Pg = Generator Pressure	7.38 kPa
Tc = Condenser Temp	40^0C
Pg = Condenser pressure	7.38 kPa

Ta = Absorber Temp.   30^{0}C
Pa = Pe= Absorber Pressure   1.70 kPa
Te = Evaporator Temp.   15^{0}C
Pe = Evaporator pressure   1.70 kPa

Conclusion

The proposed method of cooling will provide decentralized and affordable solutions for preservation of fruits and vegetables which otherwise, either get spoiled or farmer doesn't get reasonable price for it especially in summers when temperature is above 40-45°C. Solar Power Vapour Absorption Refrigeration (SPVAR) System will provide an affordable mechanism for preserving fruits and vegetables on site in the farmer's field itself for months even in typical summers.

References

Ramachandra K. Patil, B.W. Shende, Prasantha K. Ghosh, "Designing a helical-coil heat exchanger" The chemical engineer", December 13, 1982, pp. 85-89.

P.K. Sen, Padma Vasudevan Sen, **Anurag Mudgal**, S.N. Singh, S.K. Vyas, Philip Davies, *A small scale multi-effect distillation (MED) unit for rural micro enterprises Part I — design and fabrication*, International journal of desalination, Elsevier, 279 (2011), 15-26.

Anil Sharma, Bimal Kumar Mishra, Abhinav Dinesh, Ashok Misra, *"Configuration Of A 2 Kw Capacity Absorption Refrigeration System Driven By Low Grade Energy Source"* International Journal Of Metallurgical & Materials Science And Engineering (Ijmmse) Vol. 2 Issue 4 Dec - 2012 1 -10, Pp 1-9.

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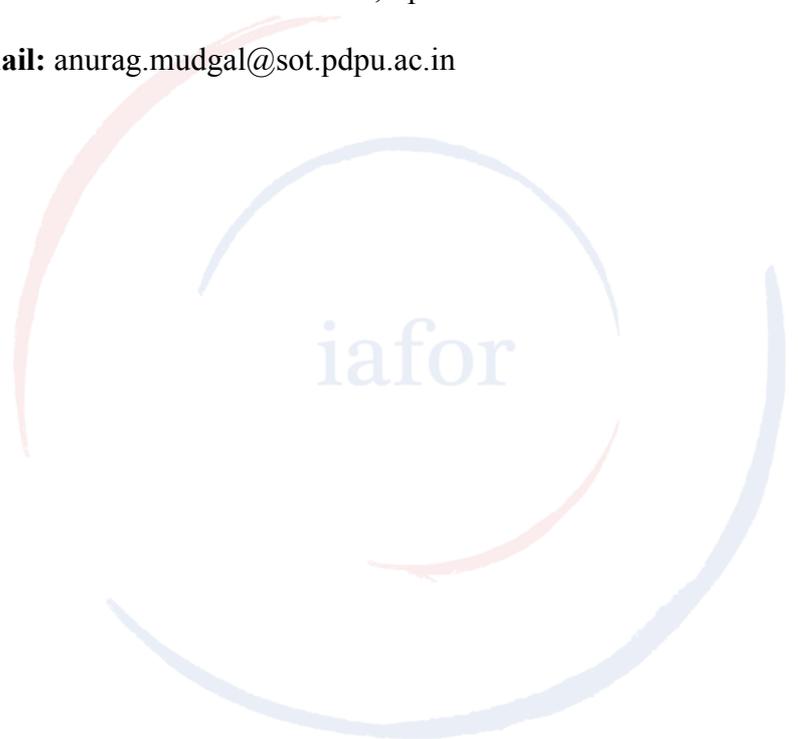
Drying of Fruits, Vegetables, Spices and Medicinal Plants with a Mixed-Mode Solar Drying System with Internal Reflectors

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Abstract

A high moisture content of fresh food products leads to rapid deterioration in the quality of the product because of the growth of micro flora insect infestation etc. It leads to a great loss of farmers. It is a basic fact that the sustainable development of any nation or society depends on a safe, nutritious, dependable, and affordable food supply. There is a way to minimize the food wastage is dehydrating food products up to a safe moisture level that can be achieved by one of the effective processing techniques as solar drying. Drying is one of the oldest methods of preserving food. A solar dryer shortens the drying time by increasing temperatures and air currents. Fortunately, India is blessed with abundant source of solar radiation. This paper addresses the experimental performances of a Mixed-Mode Solar Drying System with Internal Reflectors for drying of Fruits, Vegetables, Spices and Medicinal plants. The mixed-mode solar cabinet dryer with forced circulation and internal reflectors has been developed and evaluated for its performance for drying of agricultural foods. Two 6 W DC fans powered by PV modules were used to ventilate the dryer. The cabinet solar dryer is 0.7 m in length and 0.7 m wide. Food products were cut into slices and loaded in wire mesh tray into the cabinet. Finally, this paper deals with a suitable design of a solar agricultural dryer that can be built in rural area with locally available construction materials and skills and retains the desired food quality.

Keywords: Cabinet solar dryer, Agriculture products, Solar radiation, Drying time, Drying rate

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Introduction

It has been proved that moisture content from the agricultural food should be reduced to 10-20 % to prevent bacteria, yeast, mold and enzymes to prevent food spoilage. At the same time, the nutritional values, taste and flavour should be maintained. Drying is the traditional method to reduce the moisture content. It is the oldest preservation technique of agricultural food products and it is an energy intensive process. High prices and shortages of fossil fuels have increased the focus on using alternative renewable energy resources. Drying of agricultural food products using renewable energy such as solar energy is environmental friendly and has less environmental impact (Mühlbauer et al, 1986 and Zaman et al, 1989). The tropical and subtropical regions have abundant solar radiation. Hence the accessible option for drying would be the natural convection solar dryers. Many studies on natural convection solar drying of agricultural food products have been reported (Exell et al, 1980; Ekechukwu et al, 1999; Sharma et al, 1995; Bala et al, 1995 & Oosthuizen et al, 1995). The success achieved by indirect natural convection solar dryers has been limited, the drying rates achieved to date not having been very satisfactory (Oosthuizen et al, 1996). Furthermore, natural convection dryers are not suitable for small-scale industrial production of dried fruits, vegetables, spices and medicinal plants. These prompted researchers to develop forced convection solar dryers. These dryers are (1) solar tunnel drier (Bala et al, 2003), (2) indirect forced convection solar dryer (Mohanraj et al, 2009), (3) greenhouse-type solar dryer (Kaewkiew et al, 2012), (4) roof integrated solar dryer (Janjai et al, 2005), and (5) solar assisted dryer (Misha et al, 2016).

It is observed from the critical literature survey that temperature and air circulation over food during drying play a vital role in engineering design of solar dryer. The present study was undertaken to investigate the drying characteristics of various fruits, vegetables, spices and medicinal plants with a mixed-mode solar dying system with internal reflectors with air temperature and air velocity control.

Materials and methods

Drying equipment

The purpose of this work is to carry out a quality product output with the design of an energy efficient solar drying system. For this objective, the cabinet solar drying system provided with solar PV fans and internal reflectors was designed and manufactured.
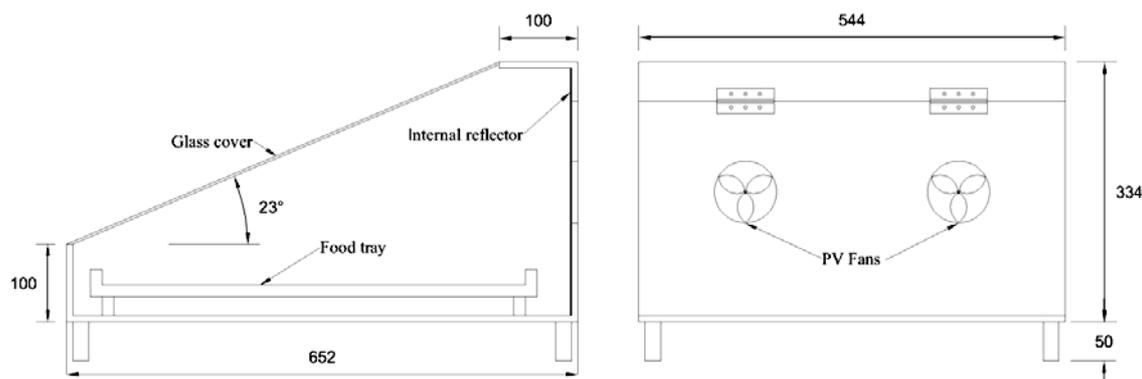
Figure 1: Schematic of proposed drying system

Solar radiation was allowed to pass through a transparent glass window located at the top of the cabinet, at south facing with a tilt equal to latitude to collect maximum solar radiation. The solar dryer has a cabinet made up of PVC foam board sheet with glass window on the top. Toughened glass of 4 mm thickness was used in glass window. The products to be dried are placed on wire mesh tray, placed within the cabinet. The inner surface of back vertical wall of cabinet is provided with reflective mirror sheet. The cabinet dryer is simple in construction. The ambient air enters from one of the hole kept at the backside of the cabinet and gets heated up with solar energy incident from the top window. Solar thermal energy is trapped in the cabinet and heats up the air and hence a green house effect is set into the cabinet. The hot air passes through the trays, carrying the moisture from the product. The forced circulation of air in the cabinet is achieved through the solar PV fan. There are two such fans provided in the cabinet dryer, one sucks the air while another discharges the air out of the cabinet. This arrangement sets the forced circulation of the air for attaining maximum moisture removal from the product. Table 1 shows the description of measuring instruments and equipments which were used in dryer.

Experimental setup

The air temperature (ambient and cabinet temperatures), relative humidity and solar radiation intensity were measured. PT-100 RTD sensors and SE20-D1 pyranometer with accuracy of 0.01 °C and 1% respectively, were used for temperature and solar radiation intensity. There are two temperature sensors and two humidity sensors were incorporated in the system, one measures the ambient air properties and other measures the cabinet air properties respectively. Weights of samples were measured every 60 minutes interval with a digital electronic balance with accuracy of 0.01 g and weight loss been recorded.

Drying experiment

The drying of the agricultural products depends on the temperature and humidity of the surroundings. Drying by traditional hot air under open sun, may prolong the drying time due to its intake of high humid air. But increasing the drying temperature seems necessary to shorten the drying time. On the other hand, the controlling temperature and rates of water removal is critical to gain optimal product quality during drying in solar dryer.

Fresh agriculture products of good quality from the same group of plants were procured from the local Market. Selection was based on visual evaluation of uniform color and geometry. The detail of solar drying system is shown in Figure 1. During each test, one kg agriculture products are washed, steamed and sliced. The sample was prepared in a hygienic procedure. Before inserting the samples into the dryer cabinet, the samples were weighted instantaneously. Weights of samples were measured every 60 minutes interval with a digital electronic balance and weight loss been recorded. The drying process was carried out from 9:00 am to 5:00 pm. The solar dryer was shut down at night. The drying action was continued until the required equilibrium moisture content was reached (no change was observed in mass). Furthermore, Solar PV fans were incorporated to the system to set the forced convection of hot air in the cabinet.

The experiments were conducted considering two cases:

Case 1: Cabinet dryer with natural convection
The air movement in the cabinet is simply generated by density gradients occurred due to absorption of solar radiation.

Case 2: Cabinet dryer with forced convection and internal reflectors
Along with Solar PV fans, internal reflector is placed at the inner side of cabinet dryer to reflect the solar rays falling on the sides of the cabinet.

The drying process was carried out from 9:00 am to 7:00 pm in the months of January to March 2016. The air temperature and relative humidity in and out of the solar dryer were measured. A temperature range of 14-33℃ outside the dryer and 50-63℃ inside the drying chamber with a corresponding relative humidity range of 32-39% outside and 24-42% in the drying chamber, were recorded during the drying process.

System analysis

Drying is basically a phenomenon of water removal by evaporation from a solid. Most part of the energy consumption during drying is for the evaporation of water in liquid phase into its vapor (2258 kJ/kg at 101.3 kPa). Moisture content in the product is expressed either on dry or wet basis. Moisture content in wet basis is given by:

$$M_{wb} = \frac{m_w}{m_w + m_d} \tag{1}$$

Similarly, moisture content in dry basis is given by:

$$M_{db} = \frac{m_w}{m_d} \tag{2}$$

The weight of the water that can be extracted by air flow from the products to be dried was defined as:

$$m_w = m_p \left(\frac{M_{wb,i} - M_{wb,f}}{100 - M_{wb,f}} \right) \tag{3}$$

Solar dryer efficiency is defined as the ratio of the energy required to evaporate moisture to the heat supplied to the dryer. It is a measure of the overall productiveness of a drying system. The heat supplied to the dryer is the solar radiation incident on the solar collector. The system drying efficiency can be obtained using the following equation:

$$\eta_d = \frac{m_w h_{fg}}{A_c I_{GT}} \tag{4}$$

The drying rate is a principal parameter to represent the rate of water removal from the sample food. The mathematical equation form of the drying rate is,

$$DR = \frac{M_{db,t+dt} - M_{db,t}}{dt} \tag{5}$$

where $M_{db,t+dt}$ is the moisture content (kg water per kg dry matter) while $t + dt$, and t is the drying time in minutes.

Experimental results and discussion

The food samples considered for drying were: Tomato, Potato, Cabbage, Ginger, Green chili and Mango. All the experiments were designed complete randomly in factorial. The data obtained were subjected to statistical analysis for analysis of variance using standard methods. Values were considered at 95% confidence level. All the experiments were performed in triplicate.

Comparison of the moisture contents of various foods in the solar cabinet dryer as per case 2 with those obtained by the system as per case 1 is shown in Fig. 3 to 8. The solar drying in case 1 required 1080 minutes to dry tomato samples from 92% to 9% as compared to 92% to 5% in 660 minutes in case 2 as shown in Fig. 3, while potatoes took 850 minutes in case 1 from 82% to 4.5 % and 680 minutes in case 2 from 82% to 4 % as shown in Fig. 4. Similarly, in cabbage, it is found as 480 minutes from 92% to 10% in case 1 and 300 minutes from 92% to 9.6% in case 2 which is clearly seen in Fig. 5. Fig. 6 shows that the Ginger took 840 minutes to dry from 89.1% to 10.1% in case 1 and 600 minutes from 89.3% to 10%. Green chili took more time for drying comparatively as shown in Fig. 7. It was found as 1560 minutes for drying from 78% to 20% in case 1 whereas in case 2, 1200 minutes were required for drying from 78% to 10%. In the last sample of mango, it was found 1260 minutes in case 1 and 1020 minutes in case 2 as shown in Fig. 8. The summary of various operational parameters and observed parameters during drying of above mentioned samples is tabulated in Table 1.
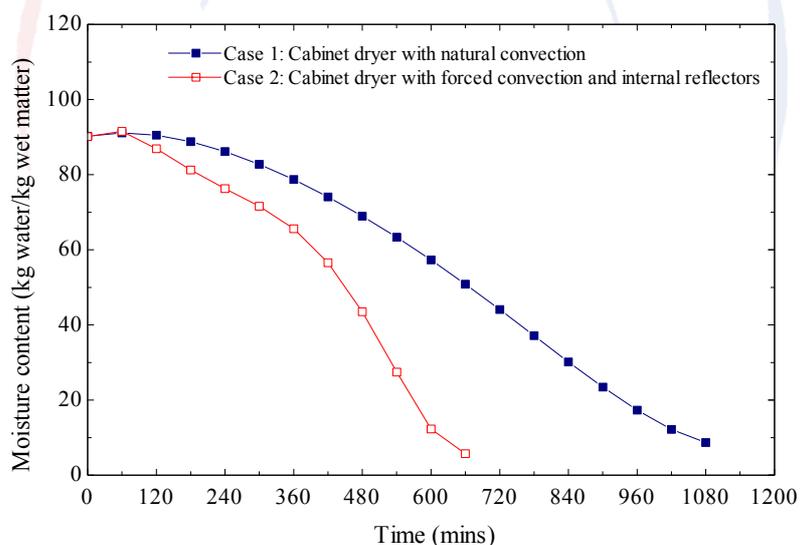
Figure 3: Variations of moisture content with time for a typical experimental run during solar drying of tomato
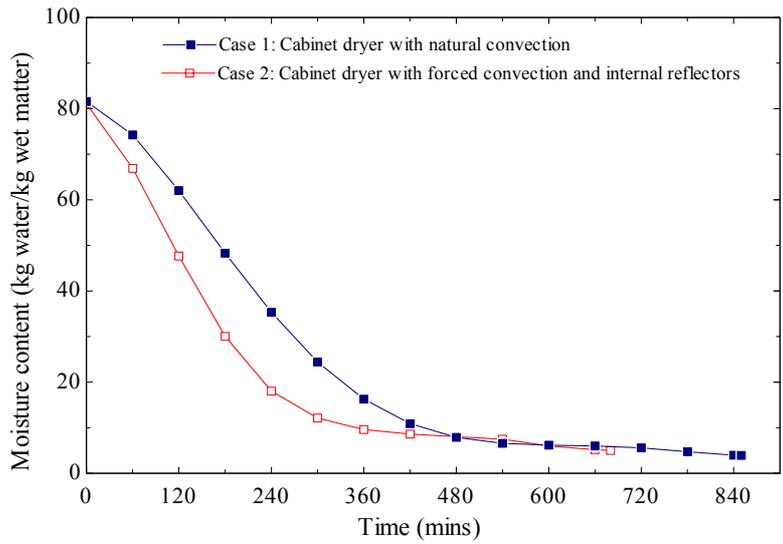
Figure 4: Variations of moisture content with time for a typical experimental run during solar drying of potato
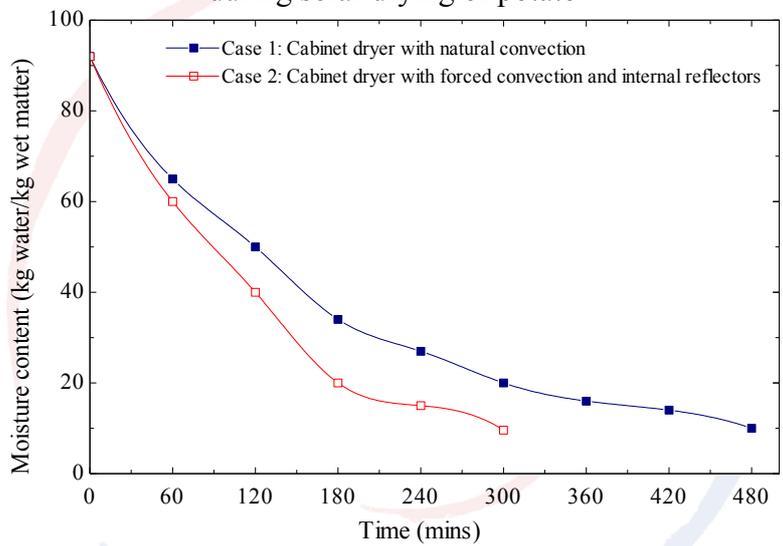
Figure 5: Variations of moisture content with time for a typical experimental run during solar drying of cabbage
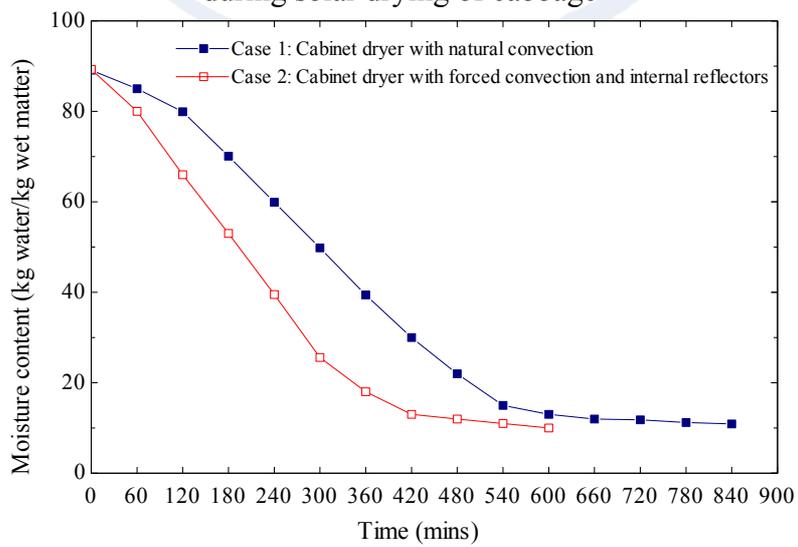
Figure 6: Variations of moisture content with time for a typical experimental run during solar drying of ginger
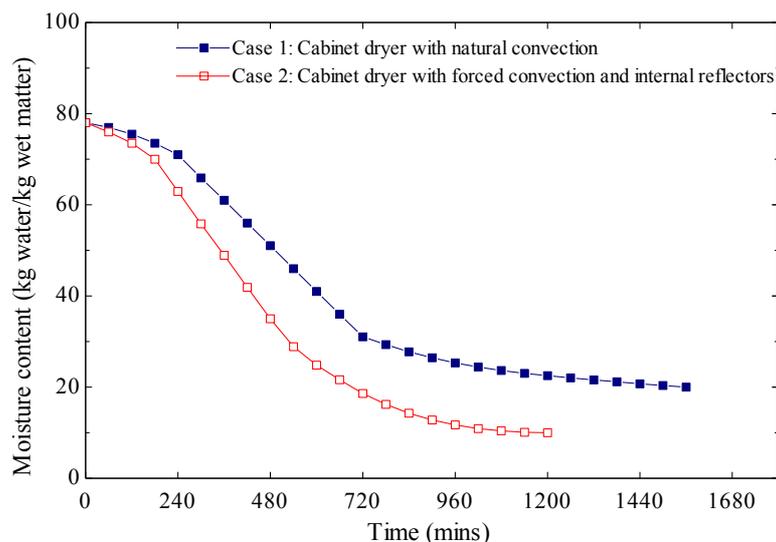
Figure 7: Variations of moisture content with time for a typical experimental run during solar drying of green chili
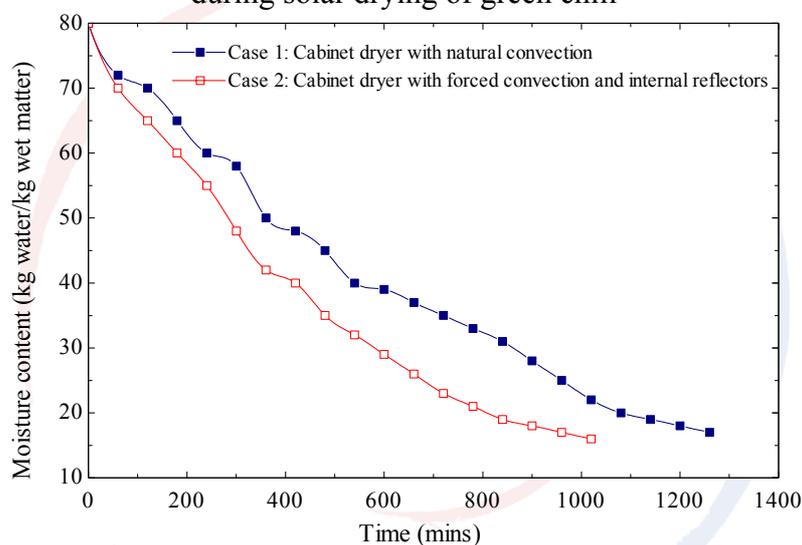
Figure 8: Variations of moisture content with time for a typical experimental run during solar drying of mango

Table 1: Summery of operational and observed parameters during drying of various food samples

Drying food	Ambient temperature Range (C)	Average Drying chamber temperature (C)	Average drying time		Time saving by Solar drier (%)
			Solar drying	Sun drying	
Tomato	14.1 - 25.6	50.1	1080	660	39
Potato	15.6 - 26.9	52.8	850	680	20
Cabbage	17.6 - 27.3	55.1	480	300	37.5
Ginger	17.7 – 28.2	57.8	840	600	28.6
Green chili	18.1 – 29.1	58.6	1560	1200	23
Mango	22.6 – 33.3	62.8	1260	1020	19

Conclusion

The dryer in the present study is easy to build and required only semi-skilled labor and limited manufacturing facilities to fabricate. Thus the dryer is most suitable for use in urban as well as rural areas of the country. It is found significant reduction in drying time with forced convection and internal reflectors. The farmers can dry vegetables and fruits when these are available in plenty and at low cost. Dried vegetables can be sold in the off season when prices of vegetables are high and farmers can generate more revenue. The use of the proposed solar dryer will be a great boon for farmers in the developing countries.

References

Mühlbauer, W. (1986). Present status of solar crop drying. *Energy in Agriculture*, *5*(2), 121-137.

Zaman, M. A., & Bala, B. K. (1989). Thin layer solar drying of rough rice. *Solar Energy*, *42*(2), 167-171.

Exell, R. H. B., & Kornsakoo, S. (1980). Basic design theory for a simple solar rice dryer. *Renewable Energy Review Journal*, *1*(2), 1-14.

Ekechukwu, O. V., & Norton, B. (1999). Review of solar-energy drying systems II: an overview of solar drying technology. *Energy conversion and management*, *40*(6), 615-655.

Sharma, V. K., Colangelo, A., & Spagna, G. (1995). Experimental investigation of different solar dryers suitable for fruit and vegetable drying. *Renewable Energy*, *6*(4), 413-424.

Bala, B. K., & Woods, J. L. (1995). Optimization of natural-convection, solar drying systems. *Energy*, *20*(4), 285-294.

Oosthuizen, P. H. (1995). The design of indirect solar rice dryers. *Journal of Engineering for International Development*, *2*(1), 20-27.

Oosthuizen, P. H. (1996). An experimental study of simulated indirect solar rice dryer fitted with a small fan. *Journal of Engineering for International Development*, *3*(1), 22-29.

Bala, B. K., Mondol, M. R. A., Biswas, B. K., Chowdury, B. D., & Janjai, S. (2003). Solar drying of pineapple using solar tunnel drier. *Renewable Energy*, *28*(2), 183-190.

Mohanraj, M., & Chandrasekar, P. (2009) Performance of a forced convection solar drier integrated with gravel as heat storage material. In *Proceedings of the IASTED International Conference* (Vol. 647, p. 029).

Kaewkiew, J., Nabnean, S., & Janjai, S. (2012). Experimental investigation of the performance of a large-scale greenhouse type solar dryer for drying chilli in Thailand. *Procedia Engineering*, *32*, 433-439.

Janjai, S., & Tung, P. (2005). Performance of a solar dryer using hot air from roof-integrated solar collectors for drying herbs and spices. *Renewable Energy*, *30*(14), 2085-2095.

Misha, S., Mat, S., Ruslan, M. H., Salleh, E., & Sopian, K. (2016). Performance of a solar-assisted solid desiccant dryer for oil palm fronds drying. *Solar Energy*, *132*, 415-429.

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Information Management in the Company's Information Space

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Abstract
In the modern companies activities, information plays a quite important role. Without adequate information and without an effective management system, it is not possible to achieve success on the current market. This is particularly related to dynamic character of present markets. It should be considered whether this dynamism and globalization as well, are not the result of blurring borders at the level of the information sphere of human functioning. In a such reality, it seems reasonable that the company management relys on information management in the real world (within the company), but especially in the information space (without time and space limitation).
The main purpose of the article is the analysis of the benefits, caused by active management in the information space. Another purpose is the analysis of the conditions, which a company must fulfill, in order to make this kind of management possible, together with achievement of expected results. In the research part of the article, the results of research, directly and indirectly related to the functioning of current man and enterprises in the information world, will be used. And the main emphasis will be placed on the functioning in the virtual space, in particular in the "world of the Internet" as a place of diffusion of information.

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Introduction

Information and, above all, the ability of its practical use is a very important success factor at the moment. Every human action is a result of information. They decide to take, change or abandon these activities. The determinant is to achieve the desired results, at present and in the future as well. In this regard, human activity should be considered as a conscious management based on the information. However a human functioning is not only about obtaining information and making decisions based on them. A phenomenon of generating information constantly accompany to that. Every human activity is also a source of information. And it has the conscious and unconscious nature. To consider the fact of management based on the information, it is clear that generated at any time information have an impact on individuals in connection with the source. Therefore information influence their decisions and actions. This creates a „cause-effect" loop, which is based on the information. With the passage of time, expands the spatial extent of the phenomenon in natural way takes place.

A number of individuals whose activity is derived from the information source increases. At the same time, each of them, generates another: information and action. The only condition for the phenomenon's occurrence is the ability to migrate the information generated from the information space to the units being outside for the source. Information space of the unit is holding immaterial dimension of the area in which it operates, and which contains all the information which influence on its life. Both generated and incoming. In this perspective, human activity is no longer limited only to the management based on information, but also through information. Implementation targets and achieving results are dependent on the information obtained and simultaneously generated. Strictly speaking skills of optimal use of incoming information and possibly up to a conscious process of generating.

Management and information

Information are commonly associated with the management process. Without having the right information, we cannot identify, pursue and implement the objectives that have led to a market success. This relationship is particularly actual at the moment, at a time: when dynamism became one of the most important markets description, when talking about the information age, and society is being called as information society. With the growing importance of information, resulting, among others, from the development of information technology, a necessity of information management has raised.

Among the other reasons are: increasing the complexity of the conditions in which businesses operate, the rise and demand for knowledge, the impact of information on the creation of value, the information as a factor in the competitive struggle. We can assume that all these factors are derived from the development of information technology. It influenced: to increase the technical feasibility of collecting the storage, transfer and analyze information. If accept the statement: man is what, how and where it does, and at the same time that all this is information, we note that the development of information technology has allowed it to fulfill the eternal thirst. Currently, in the information dimension is possible: being in every corner of the Earth, being in many places at the same time. And time and place limiting factors do not valid.

Information management is defined as "a set of principles, techniques, systems and devices that define the information and communication structure of the company, which is the basis for decision-making processes". In the area of interest, management refers to activities performed in the company, including those arising from the principles of the functioning of the market - cooperation with external units. The aim is to streamline operations, aimed at getting the intended competitive position. In this regard, information management can be described as a set of actions associated with the acquisition, collection, processing, analysis and practical use of the information.

Information management plays so called a complementary role in relation to business management. It has allowed to achieve its short-, medium- and long-periodic targets. This results in features, which should have information. They must be: timely, valuable, unique, verifiable, accurate, complete, etc. Among the stated features, the attention to the verifiability and unique information pays attention. Confirming information extends the decision-making process. It seems that in a dynamic market is a limiting factor for gaining competitive advantage. This is because the rapid spread of information. In such a reality a feature unique gains the importance, and thus the search for relevant information, but not confirmed (weak signals). Management with the use of weak signals can take action before others, but also increases the risk. The factor that allows them to reduce is the skillful and active functioning in the world of information. It must be carried out by staff who understand the realities of the market. Employees who are in relation to the subject position, which co-create and for which they are responsible, are aware of the importance of information that constantly generate. They have to provide information, the role of which is the optimal functioning of enterprises and the development of positive information about it and its range beyond the borders of that separate company. By shaping positive information we mean actions aimed at obtaining all the possible positive effects stemming from the impact of information on participants in the information space. This includes: adoption, acceptance and scale of absorption (sales) offer, the introduction of innovative solutions, optimizing the operation, as soon as possible adjust to changing market realities, including the expectations and requirements of customers, establishing cooperation with the best partners, to build networks. The aim is to manage and based on the information.

J. Kisielnicki writing about the role of information, refers to the French proverb, "there is nothing without matter, without energy everything is motionless, there is chaos without information". Attention is on three factors: matter, energy and information. Analyzing the contemporary realities can come to the conclusion that information is not only one of the three, but in fact two or even three of them. Matter is part of the structure. It can be considered as material or material in the context of the physical but also the information. According to the dictionary PWN is this:

• physical objects knowable through the senses or existing objectively, ie. Independent of its cognition,

• concept in the field of ontology (metaphysics) indicating the type of entity existing only or one of the existing ones,

• material, topic, content, which can be granted various forms,

-     thing, matter, about which one thinks, says or writes.

Information as matter and energy are inextricably linked to the dynamism of markets. M. Rafało based on the work of a number of scientists, presented the summary of the characteristics of a dynamic environment. Their analysis in the context of information, especially the information space of human life is included in the table below.

Table 1. The properties of dynamic environment and human's information space

The properties	Human's life information space
The boundaries of the organization are variable. There are new distribution channels and contact with customers and suppliers	With the development of technology, including information technology and particularly the Internet have blurred limitations of time and space. In the dimension of the information anyone can be anywhere in the world. It may also participate in the work of teams of any, variable structure. Criteria for the selection of their members are related to the needs of the initiator (eg. Company) and the characteristics of the participant information space (information available, the ability to produce information, access to information, the ability to spread information, the impact of information). No limitations of time and space made it became a necessity to constantly seek opportunities to shape new distribution channels and customer contact. The customer on the one hand remained recipient company's offer, but on the other has become the recipient and the provider of the information. These channels arise from the needs.
Uncertainty decision. It is difficult to determine the consequences of actions, and possible options for decision-making.	Integration of the information units (globally) as mentioned resulted in the dimension of the information galling limitations of time and space. In fact, such information each time causing certain actions of their customers spread almost instantly. At the same time the competitive struggle time to act (decision) is a key success factor. Therefore, the one who first take the right decisions is more likely to gain an advantage. At the same time accompanied by an increase in risk associated with a limited degree of verifiability of information and the number of possible courses of action to take. The amount of information appearing almost at the same moment of time makes it difficult to identify variants of possible decisions and their consequences.
High turnover of companies in the market.	The amount of information is constantly emerging, virtually unlimited flexibility of organizational structures, offer the possibility of migration in terms of market activity. The requirement is the ability to: operate effectively in the information space, the practical use of information, optimum adaptation to the realities. Companies change their business profiles, to the extent that they want, or that requires them to reality. From the

	partially complete. Determinant are: an opportunity or a threat, the possibility of effects.
There are new customer segments and new customer needs	Unrestricted and self-perpetuating mechanism: the generation, influence, calling the information dimension is the direct cause of the dynamism of the market. Participants in the information space is constantly changing. This happens both in real space and information. This is due to information, and generates information will always affect the other. This applies to all participants in the information space: customers and suppliers.
Changing role of information systems - greater interaction with the environment.	Integration of the information units affected the dynamism of markets. Information vital in the fight against the competitive functioning in the new reality. It took on a special meaning the ability of their collection, analysis and use in the shortest possible time from generating. Do not be hindered only to adapt to the changing environment - obtaining information. It is necessary to raise the process of providing information accompanied to the environment. The aim is to influence the various market participants so as to induce in them certain actions. Because a key element in the management information (including information space) is information technology that is required of the greater efficiency and effectiveness in the functioning of the information space.
Organizations are looking for innovation	Dynamism of markets makes enterprises must on the one hand constantly adapt to change - by making changes to the other in order to obtain a sustainable competitive advantage to introduce new solutions. Innovation must relate to every aspect of the operation. This can be achieved through: the constant search for information, providing information cause, engaging disposers of information, engaging sources of information affecting the other participants in the information space. Indicated by M. Rafalo creativity consists of two factors: the production and innovation, as well as providing (innovation as the information) in order to shape information in space. It is not enough to innovate, it must be in the form of information as soon as possible and as far as possible to spread in space. The aim is also increased by this process to identify and introduce new innovations and changes. Innovation and change are driving innovation and change
There are new organizational structures, which are informative solutions	The value of the participants information space in dynamic markets makes it one of the most important factors in the competitive struggle is the flexibility of the structures. Understood not as the ability to fit within the physical boundaries of the enterprise, but as the ability to engage the participants in the information space, which are optimal with respect to the objectives pursued. The target structure according to the authors is the only solution for the operation in a dynamic environment. The traditional

	organizational structure is part of a kind of initiation. Its task is to ensure the ability to function in the information space. Because the structure is deliberate in its information space is based on the linkage information.

As B. Stefanowicz points out "in the specialist literature you can meet with the opinion that the information is used mainly for human decision-making to economic activities". Can be said that the information was an essential element of management, allowed for the realization of its basic functions: planning, decision-making, organizing, leadership, control. Information management also plays a supporting role. There is no doubt that today in a time characterized by high dynamism, information remains a key factor in management. So still it plays a supporting role.

The information are collected, stored, processed and used. It is pointed out in this regard, of particular importance to observe the surroundings. Analyzing involvement in the process of seeking and obtaining important information, should be noted that about 12% of small and medium-sized companies and 21.4% of large doing it systematically. Approximately 87% of SMEs and 77.7% of large doing it as needed. Among the information sought and used by small and medium-sized companies shows that: 33.2% sought and used the information about new products and technologies, 17.4% limited only to seek up 49.4% not looking for and did not use; 25.4% sought and used the economic information, 23.3% limited only to seek up 51.3% not looking for and did not use; 24.4% sought and used the information about new customers, 23.6% limited only to seek, 52% are not looking for and did not use; changes in law, respectively, 30.5% sought and benefited, 16.1% sought, 53.3% are not looking for and did not use; on the actions of competitors, respectively, 23.6% sought and benefited, 20.6% sought, 55.7% are not looking for and did not use; changes in the market of suppliers and subcontractors, respectively, 26.9% sought and used the, 15.6% sought, 57.5% are not looking for and did not use; about the international environment of, respectively, 7.5% sought and used the, 6.8% sought, 85.7% are not looking for and did not use. The results indicate that companies still do not understand the role, which information exploration, acquisition and use play. It follows from this lack of understanding of the realities of today's markets. This happens at a time when information is to be or not to be, when as a result of the development of information technology has created a new information space operations. On the basis of those research results, we should ask how the information support the management, since the majority of them do not seek and do not use them?

Analyzing quoted in Table 1, features of dynamic environment with respect to the information space of human life, should be stated that the exploration and use of information is not enough to achieve real market success. Because: the boundaries of the organization are variable, there are organizational structures based on relationships of information, there is a need for development of new distribution channels and customer contact, increased the risk of the operation, there is difficulty in selecting specific courses of action and forecasting the impact of these choices, the company dynamically change their activity market, changing expectations of market participants, and thus it is necessary permanently to their matching, and even overtaking is needed integration and greater interaction systems with other participants in the information space, it is necessary permanent changes and innovations, it is necessary to conduct active management of the information space-

based information management. Management realizes all the classically accepted functions, involving the management of the use of information and using the information.

Information space in human's life and enterprise's functioning

Awareness of the need for active management in the information space, as well as the existence of the same information, require to present the results of several studies on the significance of information in human life and the functioning of the information-driven world.

Between 2005 and 2012 there has been a 18-fold increase in terms of visit and use the content of websites, including those localized in countries other than the user (web traffic with cross-border). From 2008 until 2012 there was a 500% increase in the number of hours spent by Internet users on Skype. 90% of retailers operating on EBay sells goods to other countries, while the sales recorded less than 25% of retailers operating in the traditional manner (not electronic). In 2005, sales of goods electronically was at 3% of the total trade in goods. In 2013 this share was already 12.1%. In 2005, 3% of all international calls were carried by Skype. In 2013 this share was already 39%. In 2005, sales of services electronically was at 51% of the total services trade. In 2013 this share was 63%.

More than 3 billion of the more than 7 billion people living at present, being active users of the Internet (2015). In comparison to the previous year was an increase of 21%.

It is estimated that in the year 2020 compared to 2010 will be: decreasing importance of traditional forms of sales from 63% to 14%, increasing importance of electronic sales of 7% to 21%, increasing the impact of the Internet / mobile devices from 30% to 65%. According to the authors of the referred report, it will result from the fact that the transition to electronic sources of information as a factor in the purchasing decisions. The authors mention here: social media, compare pricing and quotes, aggregators offers, applications, locating products. As noted, today the consumption of taking purchase decisions: searching the offer, compare prices, exchange views with colleagues, identify promotional offers, "visit" shops, make payments using the tools of information technology. These operations take place at the level of information.

The study Global Trust In Advertising from 2015 analyzed source of information influencing the purchasing decisions of customers. It was found that 83% of respondents trust the information obtained from persons known to them (compared to 2013, a decrease of 1%), 66% to the opinion of consumers placed on the Internet (compared to 2013, a decrease of 2%). 66% to the information obtained, eg. From press articles (in comparison to 2013, a decrease of 1%), 70% to the information contained on the company's web site (compared to 2013 increased by 1%), 61% to the information obtained from sources sponsored by a specific brand (unchanged compared to 2013), 56% to the information obtained from emails delivered directly by suppliers (unchanged compared to 2013.

It should be noted that the position of: confidence in the information obtained from persons known to them (83%), likely refers to the knowledge entered and maintained in the information space, using the tools of information technology. Today, contacts are moving more and more from the physical dimension to information. Direct talks are replaced by contact with social networks, and giving the opportunity to applications and websites. The confirmation of the results of the research, according to which 42% of active users use the Internet to communicate with friends and family.

Interesting results of the research can be found on the Consumer Barometer (2015). By studying the way in which potential customers seeking information about products and/or sales offers, it was found that 42% (Poland) to 36% (Japan) of them took particular note of their own previous experience, 12% (Poland), 8% (Japan) - conversations and discussions with other people, 17% (Poland), 21% (Japan) - generally searching for information before buying, 12% (Poland and Japan) through advertising, other 11% (Poland) and 19% (Japan). By studying the way in which potential customers before buying acquire knowledge about the product were found: 55% (Poland), 59% (Japan) - knowledge is acquired online, 37% (Poland), 39% (Japan) - knowledge acquired in stores and general places selling, 4% (Poland), 1% (Japan) - by phone: calls and text messages, 3% (Poland), 1% (Japan) - in other ways. When exploring ways of communication between potential customers acquiring knowledge about the product were found: 80% (Poland), 72% (Japan) - interviews, 8% (Poland), 9% (Japan) - through social media, 5% (Poland), 10 % (Japan) via e-mail, 6% (Poland), 5% (Japan) - in other ways. Explores different ways of advertising as a source of information about the product were found: 25% (Poland), 46% (Japan) - online advertising, 30% (Poland), 22% (Japan) - TV commercial, 2% (Poland), 1% (Japan) - radio advertising, 9% (Poland), 2% (Japan) - poster advertising, 11% (Poland), 6% (Japan) - advertising in newspapers and magazines, 5% (Poland), 4% (Japan) - advertising sent via e-mail, 2% (Poland and Japan) - a traditional post office, 9% (Poland), 11% (Japan) - at the point of sale, 3% (Poland, 4% (Japan) - in other ways. In examining the sources of information offline in making purchase decisions was found: 20% (Poland), 10% (Japan) - conversations with family, friends, friends, 6% (Poland), 5% (Japan) - TV, 3% (Poland) 1% (Japan) - radio, 8% (Poland), 7% (Japan) - printed materials, 8% (Poland), 4% (Japan) - meeting with the dealer and/or consultant, 3% (Poland), 1% (Japan) - posters, 16% (Poland), 14% (Japan) - retail stores, 41% (Poland), 35% (Japan) - shops offering for sale goods of different brands, 25% (Poland 13% (Japan) - conversations and discussions with other people. In examining the sources of information online in the process of making purchase decisions it was found: 26% (Poland), 30% (Japan) - corporate websites, 20% (Poland), 22% (Japan) - sellers, 56% (Poland), 49% (Japan) - search engines, 5% (Poland), 2% (Japan) - social media, 11% (Poland), 5% (Japan) - pages with video materials, 3% (Poland), 1% (Japan) - profiles corporate social media, 8% (Poland), 4% (Japan) - discussion groups, forums, blogs, 5% (Poland), 1% (Japan) - auction sites, 17% (Poland), 14% (Japan) - compare prices, 3% (Poland), 2% (Japan) - the magazine online, 5% (Poland), 3% (Japan) - offers and information sent by email, 4% (Poland and Japan) - other.

Conclusion

We live in an era in which as never before information decide about the human's behavior and all forms of his activity. The speed of life as a feature of contemporary reality, is nothing but a reference to the dynamics in terms of the spread and impact of information. The information are the result and a source of human's behavior. Thus, any activity which is derived from information produces information through the further steps. This process takes the form of a loop of cause and effect. Rarely it occurs at the same time that a single information induced reactions, mostly they are subject to a number of information. This is true even if the company reacts to a weak signal. It is the key information in terms of strategic, yet difficult, or even impossible to confirm. It gives the opportunity to respond to upcoming events market before the competition. In this regard, it may be single piece of information. At the same time it must be noted that its practical use is indeed associated with a number of other information. They are using the internal nature: experience, knowledge, skills, available resources and external information: indirect complementary information. Similarly, the information generated by actions. Source can be convinced that it provides a single and deliberate information. In reality, however, it provides a number of accompanying information, also affecting the operations environment. They can at the same time: strengthen, neutralize or negate the intended information.

Dynamism functioning is a direct result of technological development having a direct and indirect impact on the spread of the information. In this regard, the most important is the development of information and communication technology, particularly the Internet. This has led to a blurring of boundaries currently contractually limiting a person's life. There has been a blurring of the limitations of time and space. Each person in terms of the information may be anywhere in the world at any time. The condition is access to networks which provide communication.

In such a reality, the treatment of information only as an object of management should be regarded as an error. It is necessary to conduct active management in the information space, which is an area in which information is "live". Management, which is based on access to, and to the fullest extent conscious delivery, controlling, planning information. Globalization, dynamism, resulting from the separation of the living space in physical terms, the information space require active in the operation. Only in this way we can: keep up with the changes, seize opportunities and prepare for the threat and what's important to do it in front of others. It is necessary at the awareness and understanding of the process based on the following principles: every action is a cause of generating a series of information inducing effects, each action is carried out on the basis of information, each generated information, which is beyond consciousness and left a news, causes unpredictable and being without the influence of the effects of, any information (with a range of information relating to the company and its activities) comes to and located in the space already has an impact on the competitive position of the company. It is therefore necessary: conscious generation, exploration, acquisition, strengthening the positive, eliminating negative correction of false, use of - information. Functioning in space is as dynamic as rapidly spread information. Each even a slight delay in response, each of which is beyond the control of the impact of information act, may be the cause disproportionate as to the duration, nature and scope of activities and events effects.

References

Digital, social & mobile In 2015, http://smmeasure.eu/liczby-polskiego-internetu-2015/

Dragt B. (2012) *Universal Commerce: nowa jakość spersonalizowanych zakupów online dla współczesnych konsumentów*, First Data Corporation.

Eisenhardt K.M., Martin J.A. (2000). Dynamic capabilities: what are they? *Strategic Management Journal* 21 (10-11).

Frąś J. (2011). Zarządzanie informacją elementem budowy przewagi konkurencyjnej e-przedsiębiorstwa, [in:] *Przedsiębiorstwo zorientowane na wiedzę*, Studia i Prace Wydziału Nauk Ekonomicznych i Zarządzania vol. 21, Wydawnictwo Naukowe Uniwersytetu Szczecińskiego, Szczecin 2011

Global flows In a digital age: How trade, finance, people, and data connect the world economy, McKinsey Global Institute, April 2014.

Global trust in advertising, Winning strategies for an evolving media landscape, Nielsen, September 2015

Hammer M. (2001). The Superefficient company, *Harvard Business Review*. http://www.wirtualnemedia.pl/artykul/dla-polakow-internet-to-glownie-narzedzie-pracy-i-wyszukiwania-informacji

Kisielnicki J. (2012). *O synergii, czyli o nowym spojrzeniu na niektóre paradygmaty w naukach o zarządzaniu*, Zeszyty Naukowe WSIZiA 21 (4).

Kisielnicki J. (2013). Zarządzanie informacją we współczesnej organizacji [w:] *Zarządzanie, tradycja i nowoczesność*, J. Bogdanienko, W. Piotrowski (eds.), PWE, Warszawa.

Maik R., Gołoś A., Szczerbacz K., Walkiewicz P. (2010). *Strategiczne źródła informacji w działalności przedsiębiorstw*, raport z badania, Projekt współfinansowany przez Unię Europejską w ramach Europejskiego Funduszu Społecznego, Warszawa.

Milmo D. (2012), *Nokia slumps to €1.3bn loss under competition from Apple and Samsung*, https://www.theguardian.com/technology/2012/apr/19/nokia-slumps-loss-competition-apple-samsung,

Obora H. (2010). Wybrane problemy pomiaru jakości informacji, [in:] *Zarządzanie zasobami informacyjnymi w warunkach nowej gospodarki*, R. Borowiecki, J. Czekaj (eds.), Difin, Warszawa 2010

Platonoff A. L. (2009). *Zarządzanie dynamiczne*, Difin SA, Warszawa.

Porter M. (1996). *What is Strategy?,* Harvard Business Review.

Rafało M. (2013) Zarządzanie dynamiczne – podejście wielowymiarowe, *Ekonomia i Zarządzanie*, Vol. 5, no. 1, Oficyna Wydawnicza Politechniki Białostockiej, Białystok.

Romanowska M. (2012). Odporność przedsiębiorstwa na kryzys, *Studia i Prace Kolegium Zarządzania i Finansów, Zeszyt Naukowy* 116, Szkoła Główna Handlowa w Warszawie, Warszawa.

Słownik Języka Polskiego, http://sjp.pwn.pl/sjp/materia;2481783.html

Stefanowicz B. (2007), Rola informacji, E-mentor, *Dwumiesięcznik Szkoły Głównej Handlowej w Warszawie*, vol 5(22), 2007, http://www.e-mentor.edu.pl/artykul/index/numer/22/id/480

Walczak W. (2012), Cele i funkcje zarządzania w teoriach naukowych a praktyka – próba diagnozy źródeł występujących rozbieżności, *E-mentor*, Dwumiesięcznik Szkoły Głównej Handlowej w Warszawie, vol 2(44), http://www.e-mentor.edu.pl/artykul/index/numer/44/id/917

www.consumerbarometer.com

Zygała R. (2007). *Podstawy zarządzania informacją w przedsiębiorstwie*, Akademia Ekonomiczna we Wrocławiu, Wrocław.

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Road to Achieve Indonesia's Intended National Determined Contribution (INDC): Spearheading Stricter Preventive Reinforcement to Indonesia's Peat and Forest Fires

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Abstract

One of the most anticipated climate change negotiation, The Conference of Parties (COP) 21, has recently been concluded, leaving many sustainable development enthusiasts a hopeful trajectory about the future. The Intended Nationally Determined Contribution (INDC) was said to be the game-changer, turning the agreement with a largely bottom-up governance. It enables both developing and developed countries to embrace the climate reality, take nationally-driven initiatives to contribute in reducing anthropogenic interference to the climate system, while still acknowledging the varying degree of financial capital, culpability and capacity available to them. Indonesia was among the early conference parties to come up with its ambitious emission reduction target in its INDC. It pledged to reduce at least 26% of its GHG emission against business-as-usual scenario by 2020 with its own endeavor, and 41% by 2030 with international support. However, with the recent flaming of peat and forest fires, many critics question the efficacy of this ambition.

This paper will argue that in order to achieve its INDC target Indonesia needs to spearhead serious attention to put an end to its reoccurring haze. Against the direction of Indonesia's INDC that does not seem to prioritize ending the forest fires, the paper will elaborate on the following three premises: (i) that the major source of Indonesia's carbon emission is indeed coming from peat and forest fires: 63% of Indonesian carbon emission are from Peat and Land-Use, Land-Use-Change and Forestry (LULUCF); (ii) that forest fires prompts the largest amount of contingency costs among other sources of carbon emission; and (iii) that existing regime will make it feasible to tackle the reoccurrence of forest fires, if stronger reinforcement is exercised at full-throttle.

Keywords: Indonesia's Forest Fires, Intended Nationally Determined Contribution

Introduction

The 21st edition of the Conference of Parties (COP) for the United Nations Framework Convention of Climate Change (UNFCCC) has recently been concluded in December 2015. It was marked as a milestone in the global climate change agreement. It was the first time in history where all 169 nations, regardless of their development stages, agreed to pursue a common interest of keeping the rise of global temperature below 2 degree Celsius, and to attempt to halt it at 1.5 degree Celsius (UNFCCC, 2015).

The inclusive agreement was not the sole accomplishment made in COP21. Monetary provision of USD 100 billion to finance efforts to tackle the ramifications of climate change, commitment to an enhanced transparency and regular reporting mechanism are among the publicly heralded breakthrough achieved through the intense weeks of negotiation. The even more daunting task, however, is to ensure smooth implementation process, in which scholars are optimistic about. It is the Intended Nationally Determined Contribution (INDC) who was said to be the game-changing factor essential to the success of COP21.

INDC is a bottom-up initiative, where each country submits its own unique, nationally agreed set of target to curb carbon emissions. Unlike in other past COPs where targets where agreed on a higher ground through multilateral discussions and was later enforced to signatories. COP21 allows more flexibility for different context of countries situation and give room to them to endeavor combatting climate change at their own pace. This bottom-up approach also put an end to the dividing quarrel between developed and developing countries—whereas previously, climate change was considered to be the responsibility of mere developed countries that are more industrialized and have the financial capacity to finance the transition to environmentally-friendly technology—that now both fronts agree to embrace the urgency and responsibility to protect the planet, although still acknowledging differences and capacity and resources of each member states.

2015 was marked as the year of success, in terms of bringing the issue of climate change—which regardless of IPCCC conclusive statement about its eminent danger, is still highly contested among scholars—to a more prominent space. Nevertheless, it was also a year of contempt. The amount of carbon emission has ballooned to a staggering rate, reaching up to 35,669,000 kt. The year has also been dubbed as the hottest year in millennia.

Among the most talked-about culprit is the vast and long-ending forest fires from land clearance for palm oil plantation in Indonesia. The issue has long been renowned as a reemerging crises hampering Indonesia's economic development, having spillover to a variety of other problems, such as health concerns, lost of biodiversity, transboundary haze to the neighboring ASEAN countries, among others.

In 2015 alone, the amount of carbon emission released by Indonesia during the months when the fires occurred, surpassed the amount of carbon produced by industrialized countries, such as the US and Western Europe in the entire year. In fact, the 2015 haze has made Indonesia to jump the rank of the most-polluting carbon emitter from sixth to fourth worldwide. It is such an irony, considering the crisis

comes from the availability of in-land forests that are supposed to contribute to absorbing carbon and abate the climate avalanche. Yet, despite the enormous impacts it has caused year after year, the crisis receives very little attention from the government. And as soon as the fires were put off by the rain, it will soon be forgotten, until it reoccurs again the following year.

This year, however, Indonesia has boldly reiterated its stronger commitment to address the haze crisis by bringing it to attention in its submitted INDC to the COP21. This paper would highlight Indonesia's commitment in INDC and analyze the feasibility of its implementation, from the angle of forest preservation as the major culprit of Indonesia's carbon emission.

In answering the question of "what causes the seemingly unstoppable reoccurrence of Indonesia's forest fires and how to put it to an end in order to achieve Indonesia's targets as proposed in its INDC", this essay will be divided into three parts. It will first provide descriptive analysis of present global governance on climate change. Secondly, it will highlight Indonesia's commitment as set forth in its submitted INDC, dated in 24 September, 2015, in comparison to other countries' commitment and link the premise to Indonesia's forest fires and analyze the causes of it. It will then provide elaboration on the first three arguments in favor of the following hypothesis, that in order for Indonesia to achieve its INDC, it would have to address its peat and forest fires quandary to be among top national priorities:
1. Because the major source of Indonesia's carbon emission is indeed coming from peat and forest fires: 63% of Indonesian carbon emission are from Peat and Land-Use, Land-Use-Change and Forestry (LULUCF);
2. That forest fires prompts the largest amount of contingency costs among other sources of carbon emission;
3. That existing regime will make it feasible to tackle the reoccurrence of forest fires, if stronger reinforcement is exercised at full-throttle;

Global Governance on Climate Change

The United Nations Framework Convention of Climate Change (UNFCCC)

The UNFCCC is a United Nations Convention whose aims are to prevent human-driven activities or anthropogenic interference from causing climate system upheaval. The Convention entered into force on March 21, 1994, two years after its first establishment from the Rio Convention in the Rio Earth Summit 1992. With 196 member states, UNFCCC is able to govern universal legitimacy, including enforcing what is deemed to be binding agreements, resulted from the Conference of Parties (COP). Of all the 21 sessions of meeting convened by the COP, among the most significant ones are:
1. Kyoto Protocol (1997) was among the first convention to set a binding agreement to reduce Greenhouse Gas (GHS) emissions, with heavier burden placed onto developed countries—under the principle of "common but differentiated responsibilities. It offered three market-based mechanisms to achieve the emission reduction targets, namely i) international emissions trading, ii) clean development mechanism, and iii) joint implementation (UNFCCC, 2008).

2. Bali Road Map (2007) spelled out five pillars of long-term commitment to reduce carbon emissions, namely: i) shared vision, ii) mitigation, iii) adaptation, iv) technology, and v) financing.
3. Cancun Agreement (2010) was marked as a relatively successful climate negotiation due to its regarded comprehensive package, adding up capacity building and forest protection in developing countries as repository of carbon.
4. Durban Outcomes (2011) built from the previous climate agreements and established the roadmap for implementation, including i) continuing as a second commitment period of the Kyoto Protocol, ii) launching of a new platform of negotiations, iii) concluding in 2012 of a broad-based stream of negotiations, and iv) concluding a global review of reduction target.
5. Doha Climate Gateway (2012) addressed multifaceted roadblocks on the road to achieve emission target by strengthening the ongoing regime, including economic diversification initiative, action on forests and deforestation, new market mechanism, support to developing counties' action, completion of new infrastructure, and long-term climate finance to name a few.
6. Warsaw Outcomes (2013) reinforced the Green Climate Fund (GFC) to finance developing country action. It also builds on crucial foundation leading up to the 2015 COP21, including closing the pre-2020 ambition gap, supporting people affected by climate change impact, strengthening efforts to mobilize 100 billion USD by 2020, cutting emissions from deforestation with the so-called the Warsaw Framework for REDD+, emphasizing on driving adaptation, use of technology as well as heightened accountability.

Conference of Parties 21 (COP21)

COP21 is the continuation of UNFCCC's member states meeting, held in Lima in the year before. Although the ratification for the agreement to enter into force is pending upon each county's domestic approval, the conference was considered largely successful, gaining strong support by all the conference parties. Both developed and developing countries reached a common understanding of embracing climate reality and seek to enact proactive actions to tackle them (see Picture 2.1.).

Countries agreed "to keep global temperature increase well below 2 degree Celsius (3.6 degree Fahrenheit) and to pursue efforts to halt it up to 1.5 degree Celsius". They also called upon the speed up of financing resources for developing countries for US$ 100 billion a year by 2020 (UNFCCC, 2015). The underlying feature driving the success of the conference was the Intended Nationally Determined Contribution (INDC), which is a bottom-up governance approach where each country may propose its nationally set target, taking into consideration its national context and capacity. In the next chapter, this essay would turn into a case study of a country who can potentially strike the balance of reaching this global target through its vast availability of printing forests, yet become one of the seemingly insurmountable doers in heightening the heat: Indonesia.

Picture 2.1. COP21 Major Outcomes

(Source: World Resources Institute, 2015)

Clearing the Road to Achieve Indonesia's INDC

Indonesia is a disaster prone country due to its geographical location, and thus, recognizing the effort to combat climate change that may exacerbate natural disaster and, in turn, jeopardize food, water, and energy security is pivotal to Indonesia's development. For Indonesia, the impact of climate change is believed to increase disaster likelihood for up to 80%. This includes flood, landslides, sea-level rise, and water shortages during prolonged drought (Indonesia's INDC, 2015). Around 42 million Indonesians live in the low-lying coastal areas making it vulnerable to the long-term impact of increasing sea-level rise. 50% of the said areas is largely urbanized, making the cost significantly increase. Considering the magnitude of the long terms impacts climate change pose to Indonesia make the efforts to contribute in halting anthropogenic interference speeding up climate change a reasonable pursuit for Indonesia to follow.

If we put Indonesia's emission into global context, we'll find that the margin to the current top polluters remain considerably large. Nonetheless, the increasing trend of Indonesian emission, when other countries have successfully been able to either contain or even decrease theirs, making commitment and practical efforts from Indonesia to manage its emission become a vital element to the success of the ambitious global climate target (see Picture 3.1).

Picture 3.1. Selected Countries' CO2 Emissions (kg per 2005 PPP $ of GDP)
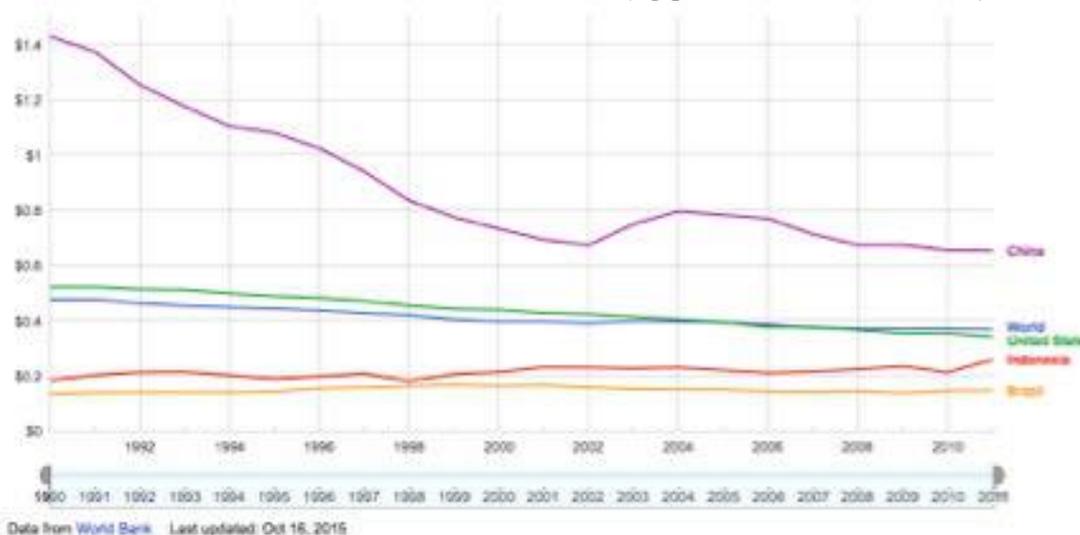
(Source: World Bank, 2015, accessed from Google Public Data Explorer)

The question that looms large right now how and by which fashion should Indonesia plan on achieving its INDC, considering its current developmental stage of still sniffling attempts to maximize economic gains for its people's welfare. 11% of Indonesia's population live below poverty line. This is around 27,500,000 headcounts, a large number indeed. By 2025, Indonesia aims to reduce poverty line to below 4% of its population. This means at least 17,500,000 people have to be lifted out of poverty within 10 years time span, assuming the fertility rate equals to 2, which, projection wise, might barely be the case. Meanwhile Indonesia's GDP growth has slowed down during 2010-2015, from up to 6.5% to 4% in the first quarter of 2015, with unemployment rate at 5.9% and rising at over 6% in the last quarter of 2015. To provide room for environmentally sustainable means of production and consumption pattern might as well be seen as an additional burden to its tight fiscal situation.

The commitment Indonesia proposed in the 2015 COP21 is the exact same notion previously proposed in 2009. Indonesia is willing to reduce its emission by 26% against business as usual (BAU) scenario in 2020 with its own effort, 29% against business as usual in 2030 and 41% against business as usual by 2030 with international support. This means that within 5 years time frame, Indonesia's emission should be 738 MtCO2e—with international support—and 468 MtCO2e with its own effort. The least Indonesia promised to do is to get its emission level to just slightly below 2005 level. The projected emission from BAU would be at 2,881 GtCO2e in 2030.

To enable the 41% ambitious target, Indonesia pledging for external assistance. The form of international support Indonesia seeks to attract, include: (i) technology development and transfer, (ii) capacity building, (iii) payment for performance mechanisms, (iv) technical cooperation, (v) access to financial resources. It is not clear how much each of this assistance deemed sufficient to provide the basis in achieving the increment of carbon emission target to arrive at 41% reduction point. However, regardless of the amount Indonesia expects, it can be hopeful about the flowing in of such assistance, given that records are kept at promising trend. This,

nonetheless, would not be achieved whatsoever with the forest crisis continue to backfire on the very currency that attract environment-related foreign assistance: the forest currency.

Other commitment from Indonesia side is to endeavor to increase the use of renewable energy to 23% of energy mix uses by 2025. It would also improve its waste management sector, hoping to convert it to renewable energy mix. It will seek to empower district level government's policy and institutional capacity through consultation and capacity building. The implementation process would also take into consideration the involvement of multistakeholder initiatives, such as by private sectors, non-governmental organizations, academia, vulnerable groups and women, and local groups (adat communities) with their respective local wisdom and practices.

According to Indonesia's submission, and conforming to the three pillars of sustainable development, there are three layers of resilience it will seek to comfort: economic, social and livelihood, as well as ecosystem and landscape resilience. Efforts for economic resilience will be directed into the following: (i) sustainable agriculture and plantations, (ii) integrated watershed management, (iii) reduction of deforestation and forest degradation, (iv) land conservation, (v) utilization of degraded land for renewable energy, (vi) improved water efficiency and consumption patterns. Efforts for social and livelihood resilience will be as follows: (i) enhancement of adaptive capacity by developing early warning systems, broad-based public awareness campaigns, and public health programs; (ii) development of community capacity and participation in local planning processes, to secure access to key natural resources, (iii) ramping up disaster preparedness programs for natural disaster reduction, (iv) identification of highly vulnerable areas in local spatial and land use planning efforts, (v) improvement of human settlements, provision of basic services, and climate resilient infrastructure development, (vi) conflict prevention and resolution. Efforts for ecosystem and landscape resilience: (i) ecosystem conservation and restoration, (ii) social forestry, (iii) coastal zone protection, (iv) integrated watershed management, (v) climate resilient cities.

In contrast to many doubts that Indonesia government is incapable to reach its targets, this paper would point out on several alternatives on how Indonesia may still be able to achieve its Intended Nationally Determined Contribution. The focus would be directed to the ongoing crisis of Indonesian peat and forest fires. The author argues, if this reoccurring crisis gets the attention it deserves, Indonesia's INDC is going to be largely achievable. This paper will provide three arguments why haze quandary needs to the uproot onto the top national priority.

Argument 1: statistics concludes that the major source of Indonesia's carbon emission comes from peat and forest fires.

Indonesia GHG Abatement Cost Curve shows that, in 2005, over 80% of Indonesia's carbon emission is resulted from Peat Fires (41%) and Land Use, Land-Use Change, and Forestry (37%) as a result of deforestation through logging and forest fires (see Picture 3.2.). DNPI estimates that the country's emission may reach up to 3.3 billion ton of carbon by 2030 should this trend continues.

Picture 3.2. Indonesian Carbon Emission (Past Record and Future Estimation)
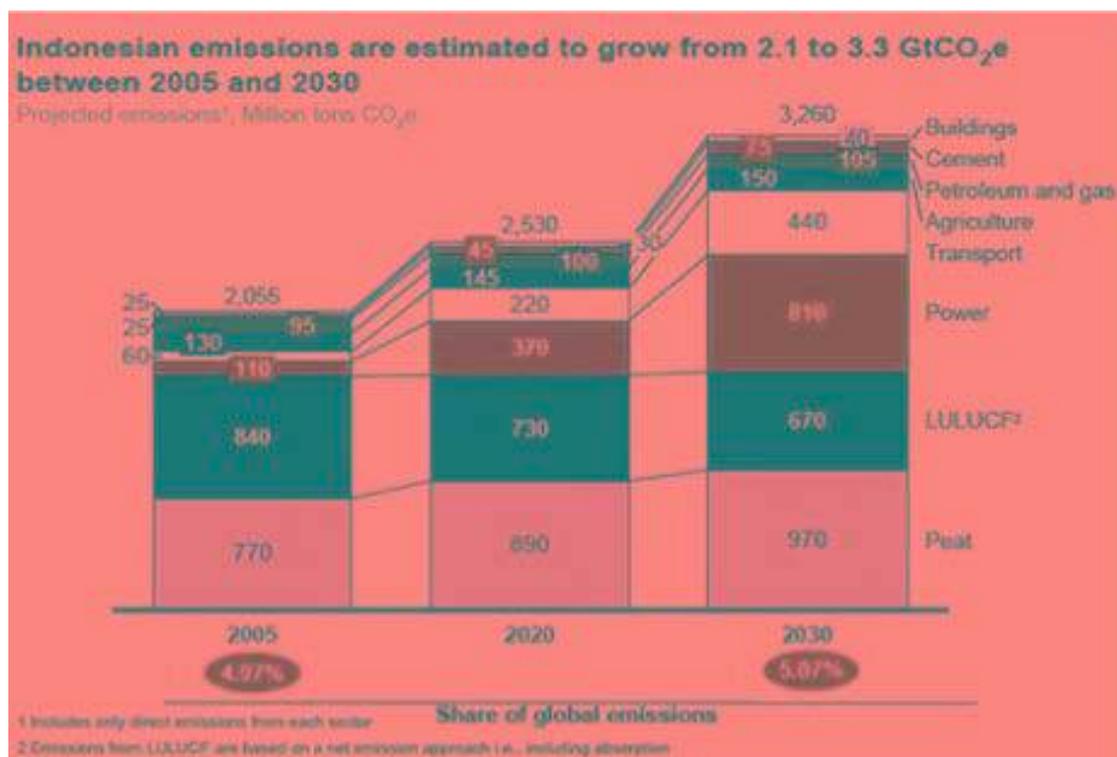
(Source: Indonesia GHG Abatement Cost Curve, 2006)

From 2005-2010, Indonesia's carbon emission increased for around 400 MtCO2e reaching 1,800 MtCO2e. According to Indonesia's Ministry of Environment and Forestry, 63% of these emissions were due to land conversion from peat and forest fires (Indonesia's INDC, 2015). 16% of it was resulted from fossil fuel combustion, i.e. transport and energy usage. Indonesia's INDC will use 2010 emission level as the baseline.

Indonesia is a leading producer of over 50% of global palm oil supply, essential in the production of a wide array of food, soaps, cosmetics, biofuel, as well as other products (Carlson et al., 2012). A vast amount of land in Sumatera and Kalimantan, two out of five biggest islands in Indonesia, are peatlands converted to cultivate palms for the oil supply, both for domestic and export use. Peatlands store a sizable amount of carbon dioxide, and are especially vulnerable to fire especially during dry season. Even the lightest exposure to fire may quickly spread over hectares of land, causing it particularly challenging to put off.

Due to rising global demand and attempt to suppress expensive initial production costs, many plantation owners often opt to short-cut by bribing local farmers to clear up land, sometimes pristine forest areas, through slash-and-burn method. Existing practices also permit small farmers to do this clearance, for maximum of two hectares, to level competition to big corporates. This is then considered as a loophole and has since been abused, causing open fire throughout the islands. What caused the 2015 forest-fire disaster especially fatal were the prolonged dry season and El Niño, making the spread quickly went out of hand. Picture 3.3. shows the continuing primary forest lost year after year precedent to the 2015 record-breaking fires.
Picture 3.3. Tree Cover Loss in Indonesia's Primary Forests
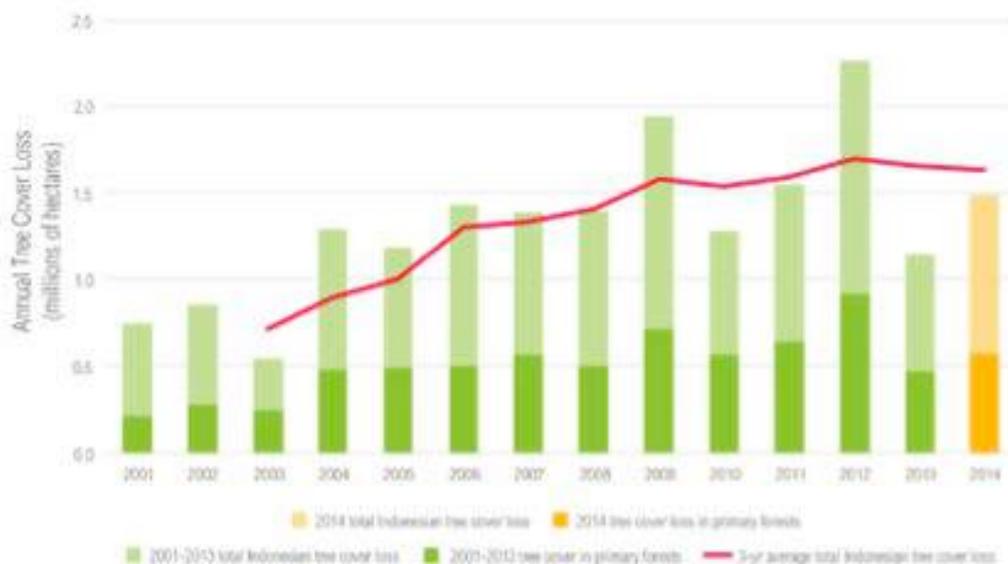
(Source: World Resource Institute, 2015)

Argument 2: that forest fires prompt the largest amount of contingency costs among other sources of carbon emission.

According to Indonesia Economic Quarterly Report, released by the World Bank, the 2015 forest fires has caused USD 16.1 billion, including the lost from declining tourism and halted productivity due to office and school closure, costs on environment and health ramifications, mitigation costs, among others (see Picture 3.4)

Picture 3.4. Estimated Loses and Damages from 2015 Forest Fires and Haze (in IDR m)

	Jambi	Riau	South Suma-tra	West Kaliman-tan	South Kaliman-tan	Central Kaliman-tan	East Kaliman-tan	Papua	Total
Agriculture	2,890	2,482	14,190	4,793	7,187	17,051	15,488	2,370	66,452
Estate crops	1,839	1,841	3,575	3,274	2,315	14,765	13,813	1,311	42,734
Food crops	1,052	641	10,615	1,519	4,872	2,286	1,675	1,059	23,718
Environment	3,109	3,139	16,552	5,158	5,317	10,660	7,282	7,188	58,406
Biodiversity loss	233	335	988	312	369	455	449	803	3,943
Carbon emission	2,876	2,805	15,565	4,846	4,947	10,205	6,833	6,385	54,462
Forestry	1,863	4,175	13,348	2,309	9,583	1,260	11,194	10,246	53,977
Manufacturing and mining	306	2,511	1,823	836	1,678	196	943	0	8,382
Trade	2,528	4,008	3,982	1,852	1,913	1,804	1,481	929	18,298
Transportation	280	430	1,106	237	912	1,522	435	185	5,107
Tourism	140	1599	1626	740	623	571	225	50	5,474
Health	485	298	388	165	327	230	167	8	2,079
Education	53	55	123	61	77	72	61	39	540
Firefighting costs	137	155	677	198	325	477	431	299	2,700
Total in IDR million	11,892	18,853	53,814	15,149	27,843	33,842	37,708	21,314	221,415

Note: Loses do not account for the economic benefit to those who set fires.
Source: Bogor Agricultural University; BPPT; BPS; CIFOR; media reports; Ministry of Health; regional governments; World Bank staff calculations

(Source: World Bank's Indonesia Economic Quarterly, 2015)

As a comparison, the financial lost is double the amount needed to reconstruct Aceh post the 2004 Tsunami tragedy. Although the 2015 haze is among the worst in history, it is not the only precedence that come with such an outstanding financial

blow. According to a different report by Asian Development Bank (2001), the contingency costs of 1997's forest fires are enough to provide basic sanitary and water provision to one-third of Indonesian poor (see Picture 3.5). Considering the eventual reoccurrence of the forest fires, the accumulative costs are beyond measure. Ending the forest fires, will not only help Indonesia's achieve its INDC, but also answer the problem of providing more fiscal room for actual economic stimulus for sustainable development.

Picture 3.5. Estimated Loses and Damages from 1997 Forest Fires and Haze (in USD m)

Sector	Minimum	Maximum	Mean
Agriculture			
Farm Crops	2,431	2,431	2,431
Plantation Crops	319	319	319
Forestry			
Timber from Natural Forests	1,461	2,165	1,813
Lost Growth in Natural Forest	256	377	316
Timber from Plantations	94	94	94
Non-wood Forest Products	586	586	586
Flood Protection	404	404	404
Erosion and Siltation	1,586	1,586	1,586
Carbon Sink	1,446	1,446	1,446
Health	145	145	145
Transmigration, Buildings and Property	1	1	1
Transportation	18	49	33
Tourism	111	111	111
Firefighting Costs	12	11	12
Total	8,870	9,726	9,298

Source: S. Tahir Qadri, ed., *Fire, Smoke, and the Haze: The ASEAN Response Strategy* (Manila: Asian Development Bank, 2001), p. 55.

(Source: Asian Development Bank, 2001)

Argument 3: that existing regime will make it feasible to tackle the reoccurance of forest fires, if stronger reinforcement is exercised at full-throttle.

Since 2009, Indonesia has started to spearhead its primary focus in addressing the haze issue. Among past actions taken under Susilo Bambang Yudhoyono's administration up to the recent initiatives as underpinned in the Indonesia's INDC document. The established foundation, given the grave situation at hand, making Jokowi's future inaction no longer tolerable. The following are among the key-enabler for stricter reinforcement:

1. Sets of regulatory framework to support domestic implementation: Presidential Regulation No. 61/2011, No. 71/2011. The latter would also deal with MRV program (Monitoring, Reporting, and Verifying). Also with the Environmental Protection and Management Law of 2009.
2. Moratorium on peat lands conversion and clearance of primary forests from 2010 to 2016.
3. Establishment of RAN-API (National Action Plan on Climate Change Adaptation) to assist in streamlining INDC into National Development Plan.
4. Having Director General of Climate Change, under the Ministry of Environment and Forestry (PERPRES 16/2015), with interministerial coordination with

Ministry of National Development Planning (BAPPENAS) and Ministry of Foreign Affairs.

5. Recently established Badan Restorasi Gambut (BRG or *Peatlands Restoration Agency*) as the focal point of prevention and restoration mechanism. It is tasked to rewetting and replanting 600 hectares peatlands in 4 different regencies in 2016, which are Pulang Pisau of Central Kalimantan, Ogan Komering Ilir and Musi Banyuasin of South Sumatra, and Meranti of Riau; along with longer timeline of assignment to achieve 2million hectares of restored peatlands in five years in 7 provinces, namely Riau, Jambi, South Sumatra, West Kalimantan, Central Kalimantan, South Kalimantan and Papua.

On top of these: (i) the active and ever-present NGOs, such as WALHI, in Sumatera and Kalimantan that can act as watchdogs; (ii) the prominence of certification scheme conducted by RSPO (Roundtable of Sustainable of Palm Oil); (iii) the increasing awareness from both global importers to domestic consumers, it should be relatively easier for Jokowi's prospectus bill, if any, to gain popular support and pass the hurdle in the House of Representative. The underlying problem, nonetheless, would foreseeably remain on the implementation process. National government claims to have no direct authority to reinforce this legal provision, pointing fingers at district and local government to be in touch with the issue. What is even more surprising, 24 agencies have mandates linked to forest preservation that makes the forest fires become a snowball of blame game, leaving no one to own the problem. Interministerial coordination continue to be a challenge and Jokowi's administration needs to step up its authority to really iron out the whole situation.

Conclusion

The Conference of Parties 21 was considered a historical success for the right reason. It was for the first time developing countries formally join the board in fighting against climate change calamity. It is only understandable, nonetheless, given the lack of resources and technical know-how, that developing countries might have different priorities on its agenda that starve them from having to consider the often-costly sustainable development practices. However, many of these nations are among the most vulnerable ones, given the irreversible and massively destructive impact climate change can cause. Looking at the highest global carbon-emitter chart, many developing countries--a lot of them with demographic boom--are also hanging on the top tiers, making their contribution an indispensable element to the success of this cause. This includes Indonesia.

This paper brought forward three arguments to draw Indonesia's attention to its peat and forest fires. In order for it to achieve the "26% of its GHG emission reduction against business-as-usual scenario by 2020 with its own endeavor, and 41% reduction by 2030 with international support", peat and forest fires are the first to face upfront. This paper has elaborated the following: (i) the major source of Indonesia's carbon emission is indeed coming from peat and forest fires: 63% of Indonesian carbon emission are from Peat and Land-Use, Land-Use-Change and Forestry (LULUCF); (ii) that forest fires prompts the largest amount of contingency costs among other sources of carbon emission; (iii) that existing regime will make it feasible to tackle the reoccurrence of forest fires, if stronger reinforcement is exercised at full-throttle. Driven by reliable data, this paper concludes that the ending forest fires drama is not

only key to debottleneck Indonesia's climate contribution, but also, considering the amount of contingency costs the fires have wasted into thin air, a catalyst to arrive at a more prosperous Indonesia.

References

Nguitragool, Paruedee. Negotiating the Haze Treaty Rationality and Institutions in the Negotiations for the ASEAN Agreement on Transboundary Haze Pollution (2002). Asian Survey Vol. 51, No. 2 (March/April 2011), pp. 356-378.

Aiken, S. Robert. 2004. "Runaway Fires, Smoke-haze Pollution, and Unnatural Disasters in Indonesia". Geographical Review 94 (1). [American Geographical Society, Wiley]: 55–79.

"ASEAN Co-operation Plan on Transboundary Pollution". 1995. "ASEAN Co-operation Plan on Transboundary Pollution". ASEAN Economic Bulletin 12 (1). Institute of Southeast Asian Studies (ISEAS): 89–95.

Othman, Jamal. 2003. "Linking Agricultural Trade, Land Demand, and Environmental Externalities: Case of Oil Palm in Southeast Asia". ASEAN Economic Bulletin 20 (3). Institute of Southeast Asian Studies (ISEAS): 244–55.

Cotton, James. 1999. "The "haze" over Southeast Asia: Challenging the ASEAN Mode of Regional Engagement". Pacific Affairs 72 (3). Pacific Affairs, University of British Columbia: 331–51. doi:10.2307/2672225.

Katsumata, Hiro. 2004. "WHY IS ASEAN DIPLOMACY CHANGING? from "non-interference" to "open and Frank Discussions"". Asian Survey 44 (2). University of California Press: 237– 54. doi:10.1525/as.2004.44.2.237.

Sastry, Narayan. 2002. "Forest Fires, Air Pollution, and Mortality in Southeast Asia". Demography 39 (1). Springer: 1–23.

Shiv Vishvanathan. 1997. "Politics of Indonesia's Forest Fires". Economic and Political Weekly 32 (41). Economic and Political Weekly: 2587–88.

Tan, Alan Khee-Jin. 1999. "Forest Fires of Indonesia: State Responsibility and International Liability". The International and Comparative Law Quarterly 48 (4). Cambridge University Press: 826–55.

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Low-Cost Technology for Water Utility Management

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Abstract

The amount of fresh water in the Middle East region is scarce due to long summer season with rising temperature, low precipitation, and lack of fresh water resources. Thus, fresh water supply depends mainly on non-conventional resources, such as desalination process, which converts the seawater into fresh water. The annual domestic-water consumption continues on an uptrend; and the rise is affected by diverse factors, such as the population growth, aging and poor maintenance of pipeline networks, and improper consumption. Further, the lack of up-to-date topology of existing water distribution network (WDN) and the present scenario of leakage detection by manual inspection necessitate the discovery of pipeline network through smart devices to minimize wastage and to monitor efficiently. In this paper, we have provided a soft-computing approach based custom-made WDN discovery tool, which aids in modeling the given WDN as a graph, and it explores the network graph utilizing classical breath-first and depth-first search algorithms.

Keywords: water distribution network; algorithm; discovery scheme; soft computing.

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1. Introduction

The scarcity of natural water resources and the higher processing cost associated with seawater desalination impose the inevitability to manage the water distribution network (WDN) in Middle Eastern countries. WDN experiences many challenges from the frequent changes in its topology due to new installations and breakages. Furthermore, the unnoticed leakages and improper consumption of water urge the necessity for the development of soft-computing tools to monitor WDN. The soft-computing approach aims to develop a pipeline network discovery tool, where the network is represented as a graph, so that the topology of the network gets updated periodically.

The State of Kuwait depends on 6 major seawater distillation plants, which meet 95% of the fresh water demands. The statistical report from Ministry of Electricity and Water (MEW) documents the activities of WDN in Kuwait, which shows that the annual fresh water consumptions are increasing every year according to (MEW Report, 2007-2011). The statistics on number of fresh water consumers for a span of 8 recent consecutive years shows that the number of users is increased by 36.47%, which claims a periodical updation in WDN topology (Ghunaimi, 2005).

In this paper, we have proposed a custom-made interactive network discovery tool, which models the given WDN as a graph and it facilitates the discovery of location of an unknown node from a selected root node. We have utilized Java Universal Network Graph (JUNG) (Madadhain et al., 2005), a software library to model WDN as a graph and we have applied classical search algorithms, such as the breath-first search (BFS) and depth-first search (DFS) to traverse the graph.

2. Background

2.1   *Network Discovery Tools*

Water distribution pipeline monitoring research focuses on network discovery tools and hardware units to mitigate the water losses. Few researchers have designed network discovery tools (Prisco et. al, 2011), (Rashid et. al, 2013), (Baáut and Urbaniak, 2011) and simulation software (Yang, et al., 2015), (Paluszczyszyn, 2015) to monitor the water losses. Our intensive literature survey revealed that there were few commercially available design software packages for designing water pipeline network, such as HydrauliCAD (2013), STANET (1984), EPANET (Rossman, 2000), Pipe2000 (Frazey, 2004) and AquaNET (1992). The summary of the existing discovery tools are illustrated in Table 1:

Table 1. Summary of water network discovery tools.

Software Package	Limitations	Cost ($)
HydrauliCAD	Run as a part of AutoCAD and it does not include transient analysis	Free
STANET	Data can be imported from Geographical Information system (GIS) and it needs dedicated interfaces to handle the data	≈ $1900
EPANET	Suitable for pressurized pipe networks and the map may not be to scale	Free
AquaNET	Suitable for pressurized pipe networks and it works with GIS	≈ $2000
Pipe2000	Hydraulic modeling software for simple and complex pipe systems	≈ $1495

We have utilized Java Universal Network Graph (JUNG), a software library that provides a common and extendible language for modeling, analyzing, and visualizing of data that can be represented as a graph or network. It is written in Java, which allows JUNG-based applications to make use of the extensive built-in capabilities of the Java API, as well as those of other existing third-party Java libraries. Moreover, the JUNG architecture is designed to support a variety of representations of entities and their relations, such as directed and undirected graphs. It provides a mechanism for annotating graphs, entities, and relations with metadata. This facilitates the creation of analytic tools for complex data sets that can examine the relations between entities as well as the metadata attached to each entity and relation. Our tool utilizes two classical graph traversal algorithms, such as the breath-first search and depth-first search to traverse the generated WDN graph.

2.2 Graph Traversal Algorithms

A graph G (V, E) is a data structure, consists of a finite non-empty set of vertices (V) and a set of edges (E), which is used to model pairwise relations between objects in a network or in a system. Understanding complex systems often requires a bottom-up analysis, which can be done by examining the elementary constituents individually and then how these are connected. The myriad components of a system and their interactions are mainly represented as graphs, which may be explored using traversal algorithms. A traversal algorithm is a systematic walk, which visits the nodes in a specified order, which can be used for solving real-world problems such as discovering, searching, scoring, and ranking. We have considered the breath-first search and depth-first search to traverse the generated WDN graph.

2.2.1   *Breath-First Search Algorithm*

The breath-first search (BFS) discovers the graph layer by layer (level by level) to identify all of the connected vertices within a graph (Cormen, 1992). The BFS algorithm illustrated in Figure 1, assumes that the input graph G (V, E) is represented using adjacency lists; and BFS maintains several additional data structures with each vertex in the graph. The color of each vertex $u \in V$ is stored in a vector *color[u]*, and the predecessor of u is stored in a vector $\pi[u]$. If u has no predecessor (no parent such as the root), then $\pi[u] = NIL$. The distance from starting vertex s to vertex u is stored in $d[u]$. The algorithm uses first-in, first-out queue Q to manage the set of vertices.

In Figure 1, Lines 1-4 perform initialization such as coloring every vertex white, setting $d[u]$ to be infinity for every vertex u, and setting the parent of every vertex to be *NIL*. In line 5, the starting vertex s is colored gray, since it is considered to be discovered initially. Line 6 initializes $d[s]$ *to 0*, and line 7 sets the predecessor of the starting vertex to be *NIL*. Line 8 initializes the queue (Q) containing the vertex s; thereafter Q always contains the set of gray vertices.

```
Algorithm BFS(G,S):
1      Begin
2          for each vertex u ∈ V[G]- {s}
3              do color[u] ← WHITE
4                  d[u] ←∞
5                  π[u] ← NIL
6          color[s] ← GRAY
7          d[s] ←0
8          π[s] ← NIL
9          Q ← {s}
10         while Q ≠ 0
11             do u ← head[Q]
12                 for each v ∈ Adj[u]
13                     do if color[v] = WHITE
14                         then color[v] ← GRAY
15                             d[v] ← d[u]+1
16                             π[v] ← u
17         ENQUEUE(Q,v)
18         DEQUEUE(Q)
19         color[u] ← BLACK
20     end
```

Figure 1. An overview of BFS algorithm according to (Cormen, 1992).

The main loop of the algorithm is contained in lines 9-18. The loop iterates as long as there remain gray vertices, which are discovered vertices that have not yet had their adjacency lists fully examined. Line 10 determines the gray vertex u at the head of the queue Q. The for-loop in lines 11-16 considers each vertex v in the adjacent list of u. If v is white, then it has not yet been discovered, and the algorithm discovers it by executing lines 13–16. It is first grayed, its distance $d[v]$ is set to $d[u]+1$. Then, the vertex u is recorded as its parent. Finally, it is placed at the tail of queue Q. When all the vertices on u's adjacency list have been explored, u is removed from Q and blacked in lines 17-18, where the color black, referred to a vertex, which had been discovered including all its adjacency list.

2.2.2   Depth-First Search Algorithm

Depth-first search processes the vertices first deep and then wide. DFS algorithm is illustrated in Figure 2, whereby the traversal algorithm visits all vertices $u \in V[G]$ reachable from an adjacent vertex before visiting another adjacent vertex. Lines 2-4 color all vertices white and initialize their π fields to NIL. Lines 5-7 check each vertex in V in turn and, when a white vertex is found, visit it using *DFS-VISIT*. Every time *DFS-VISIT* (u) is called in line 7, vertex *u* becomes the root of a new tree in the depth-first forest.

In each call *DFS-VISIT* (u), vertex u is initially white. Line 2 colors vertex *u* into gray, and lines 3 – 6 examine each vertex *v* adjacent to *u* and recursively visit *v* if it is white. As each vertex $v \in Adj[u]$ is considered in line 3, then, an edge *(u, v)* is explored by DFS. Finally, after every edge leaving u has been explored, line 7 paints u as a black.

DFS Algorithm (G)
```
1       {
2           for each vertex u ∈ V[G]
3               do color[u] ← WHITE
4                   π[u] ← NIL
5           for each u ∈ V[G]
6               do  If (color[u] == white)
7                   then DFS-VISIT (u);
8       }
```

DFS-VISIT (u)
```
1       {
2           color[u] ← GRAY
3           for each v ∈ Adj[u]
4               do if color[v] = white
5                   then π[v] ← u
6                       DFS-VISIT (v);
7           color[u] = Black
8       }
```

Figure 2. An overview of DFS algorithm according to (Storer, 2002).

3. Water Distribution Network Discovery Tool

We have applied the foundation of computer science in utilizing a graph theory to model WDN and then, we have utilized both breath-first search (BFS) and depth-first search (DFS) algorithms to traverse the generated graph. The proposed WPN discovery tool facilitates the discovery of location of an unknown node from a selected root node. The tool explores the WDN graph utilizing the classical breath-first search algorithm separately and it displays the estimated distance between any two node-pairs during the traversals. We have coded the WPN discovery tool within Java Universal Network/Graph Framework (JUNG), which facilitates visual modeling of networks.

The snapshot of the WDN discovery tool is illustrated in Figure 3, which is an interactive tool providing choice to the user to design a typical WDN. The user can create a water distribution network by placing the nodes and the links in *EDITING*

mode and user can move one or more nodes and links in *PICKING* mode. Hereby, WPN nodes are labeled in the order of generation. The button *TRANSFORMING* corresponds to move the entire graph to a specific area within the design space. The button, *ANNOTATING* marks the root node before traversal. The buttons, *Traverse BFS* and *Traverse DFS* correspond to the BFS and DFS traversal operations. The entire design area is cleared by *Clear* button. The buttons + and – perform the zoom operations.
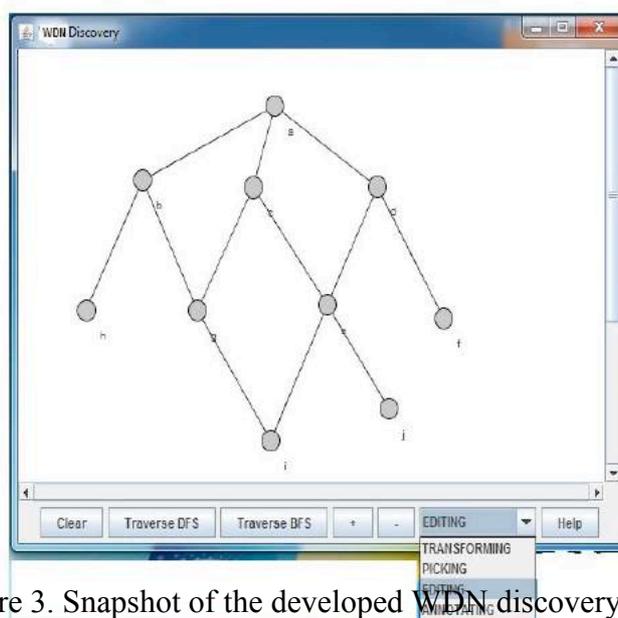
Figure 3. Snapshot of the developed WDN discovery tool.

4. Results and Discussions

We have considered a WDN comprising of pipes, tank, reservoir, pump and junctions, where we included loops and branches within WDN to reflect the structure of a practical distribution network within a street level. We have modeled the given WDN network as a graph with undirected edges and discovered the node locations using classical traversal algorithms.

4.1 Network Discovery Tool

The schematic diagram of a simple WDN is presented in Figure 4. The initial WDN graph generated using the WDN discovery tool is represented as in Figure 5. The snapshots of results after traversing the graph using DFS and BFS are given in Figures 6 and 7 respectively. In similarity with the data packet flooding in computer network discovery, our discovery tool stimulates a flooding of water from the selected root to discover its neighbors. The water flow is represented by the movement of red color line through the links. The initial nodes are presented as grey color circles and the selected root node is represented in yellow color. During the traversal, the visited nodes are represented as red color circles and the visited links are represented with thick lines.

Figure 4. A Section of Water Distribution Network.
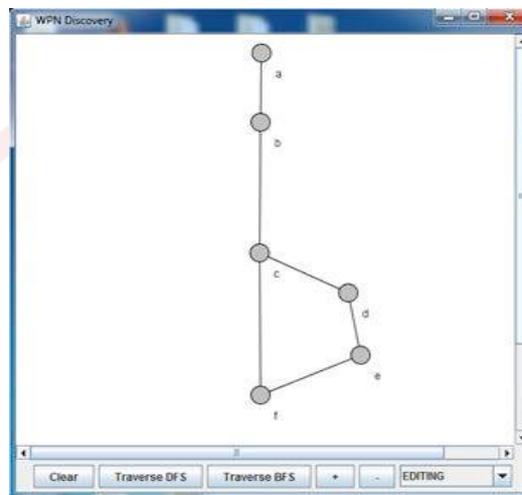
Figure 5. WPN discovery-initial network.
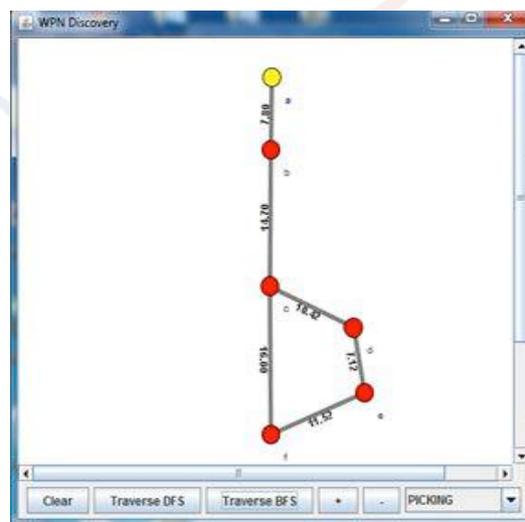
Figure 6. WPN discovery - DFS traversal.
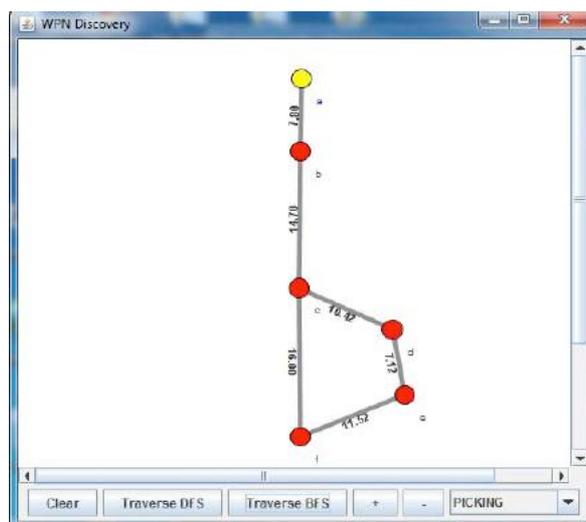
Figure 7. WPN discovery - BFS traversal.

In both DFS and BFS traversal, the Euclidian distance between two neighbor nodes are represented as the link weights. Our discovery tool has the flexibility in selecting any of the nodes as the root node within the generated graph.

5. Conclusion

We have developed a custom-made interactive network discovery tool utilizing Java Universal Network Graph (JUNG), which models the given WDN as a graph and it facilitates the discovery of location of unknown nodes from a selected root node by utilizing classical search algorithms, such as the breath-first and depth-first search algorithms. The outcome of the experiments utilizing WDN discovery tool will help us to design a low-cost technology hardware for water utility management in future.

References

AquaNET : http://www.inar.net/index.html

Balut, A., and Urbaniak, A. (2011). Management of Water Pipeline Networks Supported by Hydraulic Models and Information Systems, In the Proceedings of 12th International Conference on Carpathian Control, 25-28 May, Velke Karlovice, Czech Republic, 16-21.

Cormen, T.H., Leiserson, E., and Rivest, R.L. (1994). *Introduction to Algorithms*. McGraw-Hill, USA.

EPANET Hydraulic Analysis Package: *http://epanet.de/*

Frazey, J.S. (2004). The Development and Use of Distribution System Models for Improving the Security of Drinking Water System, Master Thesis. Airforce Institute of Technology, Ohio, USA.

Ghunaimi, Z. (2005). *Water Security in Kuwait and Arabian Gulf Countries.* published by Center for Research and Studies on Kuwait, Kuwait.

HydrauliCAD software*: http:// hydraulicad.com*

James A. S. (2002). *An Introduction to Data Structures and Algorithms*, Springer-verlag, NY, USA.

Madadhain, J., Fisher, D., Smyth, P., White, S., and Boey, Y.B. (2005). Analysis and Visualization of Network Data using JUNG. *Journal of Statistical Software,* pp. 1–25.

Paluszczyszyn, D., Skworcow, P., and Ulanicki, B. (2015). Modeling and Simulation of Water Distributed Systems with Quantized State System Methods. *Procedia Engineering,* 119, 554-563.

Prisco, G., D'Urso, M., Bernardi, G., Leopardi, A. and Schettino, F. (2011). An Effective Toolbox for Water Distribution Network Monitoring. In the Proceedings of the *5th European Conference on Antennas and Propagation*, 11-15 April, Rome, Italy, 886-887.

Rashid, S., Qaisar, S., Saeed, H., and Felemban, E. (2013). Performance Analysis of Wavelet Transforms for Leakage Detection in Long Range Pipeline Networks, In the Proceedings of *IEEE Conference on Systems, Process & Control*, 13-15 December, Kuala Lumpur, Malaysia.

Rossman, L.A. (2000). *EPANET 2 Users Manuel*. Water Supply and Water Resources Division, National Risk Managemnet Laboratory.

STANET software: *http://stafu.de/en*

Statistical Report on Water Network from Statistics Department and Information Center, Kuwait-2007-2011.

Yang, J., Li, Y., L., Zhang, N.F., Yang, J.F., Tang, J., and Su, Y.X. (2015). Water Quality Modeling for Pipeline Network Peripherals Based on Simulation of Water Age. In the Proceedings of *IEEE International Conference on Computer and Information Technology; Ubiquitous Computing and Communications;* Dependable, Autonomic and Secure Computing; Pervasive Intelligence and Computing, 26-28 October, Liverpool, UK, 2284-2290.

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Improving Energy Efficiency through Industrial Symbiosis in Energy Intensive Industries: A Comparative Study of Japan and China

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Abstract
The rising cost of energy has drawn focus to global energy issues. The industrial sector alone, consumes about 50% of the world's delivered energy. This significantly impacts global consumption and production. As China's economy burgeons, the resulted severe pollution from energy intensive industrial sector has yet to be addressed. Japan is a global leader of industrial energy efficiency (IEA, 2008), however, the removal of nuclear power after the Fukushima incident in 2011 forced Japan to seek alternative clean energy to meet their increasing energy demand. Industrial symbiosis (IS) is a promising approach for improving energy utilization efficiently. The majority of literature on IS focused on the exchange of materials among industrial processes. These literatures do not study efficient energy flow within and between firms.
This research is a study based on review of literature and industry on the energy flow in China and Japan. A conceptual framework is needed to enable companies to optimize their utilization of limited energy resources through IS with non-technical improvements. This research compares energy intensive industries and eco-industry parks in both Japan and China as case studies to investigate energy flow in energy intensive industries. Specifically, establishing a systematic process of waste energy management both within and between firms, which can contribute to the reduction of natural resources/energy consumption, cost benefit, and most importantly, a solution to the present-day severe environmental pollution.

Keywords: Industrial Symbiosis, Energy Efficiency, Energy Management

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Introduction

By 2040, it is estimated that the world energy industrial sector will consume approximately 51% of global delivered energy (U.S. Energy Information Agency, 2013). According to the AEO2013 report by IEA, a breakdown of this energy intensive industry shows iron & steel industry consuming 17% of the world's total energy. The increased demand and shortage of energy have led to a continuous increase in cost. This has brought pressure on many manufacturing companies. As a result, these enterprises face a huge challenge to reduce the consumption of energy and improve their corresponding energy efficiency. To survive this energy crisis and severe pollution, it is vital and urgent to improve energy efficiency (EE) within this energy intensive industry. Since industrial activities consume renewable or non-renewable materials and massive amounts of energy, they should be on the frontlines to address the resulted environmental problems (Duflou et al., 2012). To solve these problems, much attention has been on Green Manufacturing (GM) and industrial sustainability. There is a strong need for a systematic approach to manage industrial energy use (Schulze et al., 2015). The implementation of energy management in an organization is regarded as one of the most promising means of reducing energy consumption and related energy costs.

Industrial Symbiosis (IS) focuses on the material/energy exchange between different organizations or factories. Energy Efficiency (EE) is usually developed at an organization level. By combining EE with IS, the best practice of efficient energy utilisation within/between firms can be discovered. Thus, a conceptual framework is needed to enable companies (especially energy-intensive industries) to make the best use of limited energy through IS. This paper aim to explore the processes of IS with a focus on the energy flow and the energy management at both the intra-firm level and inter-firm level to understand the proper processes of achieving EE through IS.

Literature Review

1.   Literature Review on Industrial Symbiosis

The concept of 'IS' dates back to 1947 when George Renner pointed out that 'here are those industries which utilize waste products of other industries', and used 'industrial symbiosis' as a phenomenon in 'Industrial Interrelationships' to described the relationship between industries. Renner further indicated that IS 'is seen to be of two kinds, disjunctive and conjunctive' (Ranner, 1947). Ayres et al. (1994) used the term 'industrial metabolism' and described it as 'the whole integrated collection of physical processes that converts raw materials, energy, and labour into finished products and wastes in a (more or less) steady-state condition'. In 2000, Chertow pointed out that IS 'engages traditionally separate industries in a collective approach to competitive advantage involving physical exchange of materials, energy, water, and/or by-products', and is an essential part of IS. 'Geographic proximity' provides possibilities of collaboration and the synergy (Chertow, 2000). Based on the review of three IS networks in the United Kingdom (UK), Mirata et al. (2003) analyzed determinant factors of IS developments from technical, political, economic, informational, organisational perspectives, and the role of coordination. Mirata & Emtairah (2005) outlined three factors that are important for the innovation process to help analyze the effects IS networks can have on environmental innovation. They also

clarified the way activities in IS networks benefit environmental innovation (Mirata & Emtairah, 2005).

To tell IS from other types of exchanges in industries, Chertow (2007) indicated a '3-2 heuristic' criterion. This means, at a basic type of industrial symbiosis, there must be at least three different entities and at least two different resources must been involved in exchanging (Chertow, 2007). However, the boundary of the term 'entities' should be considered. In terms of reusing by-products as one of three main opportunities for resource exchange, by-product was described as 'the exchange of firm-specific materials between two or more parties for the use as substitutes for commercial products or raw materials (Chertow, 2007; Chertow et al., 2008). Most of the literatures utilized Chertow's definition to lay emphasis on the exchange between companies. However, there are emerging literatures looking at material and energy exchange between corporations and within a single corporation. For example, exchanges of by-products and energy within the firm can be seen in British sugar (Short et al., 2014) and Guitang Group (GG) in China (Zhu et al., 2007). In the case of GG, the phenomenon of by-products exchanging inside the firm are described as 'inter industrial symbiosis'. GG fits the core principle of IS because it's a mix of internal practices and new business units. This improves the utilization of materials and energy (Leigh et al., 2014; Lombardi et al., 2012; Zhu et al., 2007). From the case of British Sugar, it was observed that 'internal symbiosis' eventually evolved into IS as additional firms outside the sugar companies provided new growth opportunities and potential risk reduction' (Short et al., 2014). Walls et al. (2015) studied organizational theories in IS at four levels: institution level, network level, organizational level and individual level (Walls & Paquin, 2015). In recent years, some academia began to argue that IS engages 'both ends of the spectrum, with process and companies' (Lombardi & Laybourn, 2012). Yuan & Shi (2009) claimed that the IS concept used among different firms can also be used among different units within a company, as it improves the competitive advantages by reducing production cost and improving environmental performance. One of these approaches can be used to transform wastes/pollutants from one unit into another as inputs (Yuan & Shi, 2009). Three levels of resource optimization at the intra-firm, inter-firm, and regional levels, as Lowe (2001) puts it; are employed to improve the material and energy efficiencies of that industry. Dong et al. (2014) indicated that in present-day China, material symbiosis is much more prevalent than energy symbiosis. However, innovative energy symbiosis provides an extra opportunity to reduce greenhouse gases emissions (Dong et al., 2014).

In a traditional IS system, by-products or wastes from one manufacturer can serve as raw material for other manufacturer. Thus, helping to reduce costs, resource, energy and reducing environmental pollutants. However, it is unclear in literatures where the boundary is referred to as the 'entity'. Most researchers believe the main character of IS should be the exchange of material and energy between different firms, while more and more attention are paid on inner relationships of a firm. To date, there is little attention placed on the inner relationships of a firm. Majority of researchers in the field believe that the inner relationships are not in the scope of IS (Yuan & Shi, 2009). In this paper, each manufacturing process is seen as a unit and the boundary is drawn at unit process level. Thus, traditional IS can be regarded as an inter-firm level and the exchanges of materials and energy between different process within the firm can be seen as at intra-firm. The boundary of the term of 'entity' must be clarified.

2.   Literature Review on Energy Efficiency

This section illustrates the process of manufacturing from an energy related perspective. It is vital to consider energy consumption and efficiency at different level to understand how best to minimize energy consumed during each manufacturing processes. Rahimfard et al. (2010) outlined a framework for modeling Embodied Product Energy during manufacturing. They claimed that, only by considering energy consumption at both 'plant' and 'process' levels it is not able to provide an overview of the total energy required to manufacture a unit of product. The consideration from a 'product' perspective should be combined (Rahimifard et al., 2010). From an energy management perspective in manufacturing, Bunse et al. (2011) analyzed gaps between industrial companies' needs and scientific literature. Bunse then indicated that, in order to close the gap between existing solutions in academia and the implementation in industrial firms, 'the research should focus on developing efficiency and effective energy management in production'. They advocated that it is necessary to integrate management concepts and EE as a strategic factor with technical measures (Bunse et al., 2011). Duflou et al, (2012) identified opportunities to improve EE systematically by considering the minimization of energy consumption at five levels in the manufacturing system. Their research showed opportunities for efficiency improvement at corresponding distinguished levels, some could be combined, whereas, the possible measures are not independent. For instance, energy savings at process level will result in the decrease of energy consumption at multi-machine level. "Energy efficiency is a measure of energy used for delivering a given service. Improving EE means getting more from the energy we use" (Decc, 2012). Tanaka (2011) claimed proper boundary definitions are needed for a 'meaningful assessment' of EE. Several articles of EE in manufacturing have researchers drawing boundaries at different levels in manufacturing system. Apostolos et al. (2013) divided the study of EE of manufacturing process into 4 levels: factory level, line level, machine level and process level. Even though the energy spent within the process level is minor, it still plays a vital role in the manufacturing processes. Studying this process provides a better understanding of the energy transformation that is taking place within the manufacturing process. Also, the selection of suitable process parameters has a great influence on both machine peripherals consumption and production planning at line or factory level (Apostolos et.al, 2013). In cases that have several peripherals, which may be shared with different machines in the factory, it may be difficult to estimate how much energy has been spent on a single machine. Hence, some of these considerations need to be transferred into a higher level (the line or factory level) (Duflou et al., 2012). Based on the perspective of manufacturing system organization system, manufacturing activities can be divided into five levels. They are considered as; (1) Device/Unit process level, (2) Line/cell/multi-machine system level, (3) Facility level, (4) Multi-factory system level, (5) Enterprise/global supply chain level (Duflou et al., 2012).

(1)   Unit process level

The boundaries of a unit process correspond with individual machine tools that are regarded as the smallest unit to comprise production system.

(2)   Multi-machine system

Duflou et al. (2012) indicated that a network of machines in a factory can be seen as a 'multi-machine ecosystem' and 'due to the structure of the network, the output of one process may be the input for another' (Duflou et al., 2012). In this system boundary, the energetic flow and material flow can be reused within the process chain and in another process chain. At the end of these exchange stages, non-used energy (waste heat) and materials leave the system. At the machine level, the demand of related peripheral equipment that preforms auxiliary processes exceeds the actual energy required for machine process.

(3)   Factory level

To increase the effectiveness of manufacturing, the operation of a factory should be taken into consideration at a factory or plant level. Production planning can contribute to minimizing the total energy consumption (Duflou et al., 2012).

(4)   Multi-factory level

Consequently, it is necessary to consider the reaction between several companies, such as suppliers and companies who exchange energy or materials. Duflou et al. (2012) indicated that 'the mutualism in the interaction has led to the introduction of the term 'industrial symbiosis' from the examples of mutualistic symbiotic relationships between organisms of different species in natural ecosystems'. Many researchers have pointed out, in a symbiosis system, materials and energy are exchanged for the sake of mutual benefits to companies that are in participation.

(5)   Supply chain level

A supply chain is defined as 'a set of three or more entities (organizations or individuals) directly involved in the upstream and downstream flow of products, services, finances, and/or information from a source to a customer (Mentzer et al., 2001). Duflou et al. (2012) dissected the supply-chain level, the locations of specific production plays a significant role and can have a big influence on the energy embedded in a product. Sustainable supply chain management is defined as 'management of raw materials and services from suppliers to manufacturer/service provider to customer and back with improvement of the social and environmental impacts explicitly considered'.

Tanaka (2008) indicated that measures of energy efficiency performance (MEEPs) is based on three criteria (Reliability, Verifiability, Feasibility) and should be taken into consideration by policy makers. Tanaka (2011) analyzed EE policies within industries of several countries (IEA countries, Brazil, China, India, Mexico, Russia and South Africa) and assessed the key features of the main measures outlined from Tanaka's research. The research concluded that no single policy or measure could fit every country, types of industry, and situations. Thus, further in-depth research focus on selected countries is needed. Policy makers have paid much attention on measuring EE at the national level and international comparison. There are limited studies on a single firm or process even though indicators found at the general level are not suitable at a single firm (Bunse et al., 2011). Since there are different system scale levels claimed by researchers, it is important to clarify where to draw a boundary in manufacturing process. Also, it is necessary to integrate management concepts and EE as a strategic factor with technical measures to improve EE (Schulze et al., 2015).

3.   Energy Efficiency in Industrial symbiosis

'Industrial symbiosis, by itself, can be seen simply as a more efficient use of energy and materials' (Chertow & Ehrenfeld, 2012). In recent years, literatures have shown that, material flow account for a large part in IS studies. Only a few articles that focused on energy saving contributed to IS. Togawa et al. (2014) developed a simulation process model to maximize the utilization of waste heat from a power plant to plants nearby in Fukushima and proposed 'an energy symbiosis' concept. Dong et al. (2014) reported that a comprehensive energy network has been designed for Liuzhou Industrial Park and calculated the energy exchanged in both Jinan and Liuzhou IP in China. Sokka et al. (2011) studied the material and energy flow in forest industry in Kymenlaakso and calculated the total fuel and energy use. Comprehensively, they identified possibilities to reduce energy consumption and greenhouse gas emissions of the corresponding industrial park(s). Li et al. (2014) analyzed the energy flow among industrial chain in the XF IP in China and proposed 'an index system for the quantitative evaluation of the energy-saving efficiency of IS' (Dong et al., 2014).

Comparison of Japanese and Chinese Energy Intensive Industries

According to the statistics of IEA, Before the Fukushima accident, Japan relied on nuclear power generation and their domestic energy resources counts for approximately 20%. Since the removal of nuclear power in 2012, that count is now less than 9%. Today, Japan's energy import bills are surging and have pushed the country to a record trade deficit in 2013. To be more specific, the manufacturing sector accounts for over 40% of energy consumption in 2012, with manufacturing industries accounting for more than 90% of industrial energy consumption. It is crucial for Japan to improve its energy utilization minimize energy consumption to lower its bills. To be more specific, the manufacturing sector accounted for over 40% of energy consumption in 2012, with manufacturing industries accounting for more than 90% of industrial energy consumption. Accordingly, it is crucial to improve energy efficiency especially in manufacturing industry to save energy and minimize energy consumption. In April 1995, the government revised the Electricity Business Act, enabling manufacturing corporations to produce and sell electricity to power companies. Since this Electricity Liberalization, major steel companies their independence from national power companies. These companies started to invest in their own power plant and devoting their corporation to the power generation business. Steel companies' power generation is derived from the gases/waste heat (the by-product during the production process); this serves as the energy source for efficient power generation. In addition to the economic benefit, this approach significantly reduced industrial CO_2 emissions and saved natural energy sources. Shinko Kobe Power Station (owned by Kobe Steel Ltd.) is Japan's largest independent power producer (IPP) and self-sufficient with electricity. It is estimated that the generation capacity of the two power plants can cover 70% of the electricity used by Kobe City during peak times. This provided a new lifeline to the city devastated when the Great Hanshin Earthquake occurred in 1995. Sumitomo Metal Industries, Ltd. (Sumitomo Metals) resumed operation of its Blast Furnace in Kashima Steelworks immediately after the Great East Japan Earthquake for supplying electricity to Tokyo Electric Power Company (TEPCO) to meet the power demand in Ibaraki Prefecture. The Kashima Power Station is able to generate enough electricity to meet the power demand of all households for about 3 million people in Ibaraki Prefecture. Since the

Fukushima Disaster, there has been a trend to build local power generation system among manufacturing industries, especially among automotive corporations. In the case of Toyota Motor Corporation, the history of electricity self-generation dates back to the 1970's. As a part of the self-sufficiency at Toyota's plant, heat from the burning gases are collected and are used to dry the paint on finished vehicles. The hot water from the gas turbine runs through pipes into a nearby greenhouse that grows green peppers. Furthermore, Toyota took the lead in 'F-Grid (Factory-Grid) ' project, as a part of 'Smart Community Business', to develop an industrial area where the energy can be generated, stored, and used efficiently after the Great East Japan Earthquake. The 'F-Grid' combines the electricity from an electric power company, co-generation, and solar power generation to achieve economical and sustainable power supply over the industrial area. The factory can supply energy not only for its own manufacturing process but also for local businesses and the town. Other automakers such as Honda, Mitsubishi and Nissan have joined the power-producing field. Many have built power stations in some of their plants and introduced the self- sufficiency approach.

With 50% of the world steel production in 2014 (World Steel, 2015), China is the world's largest iron and steel producer. Although the manufacturing processes of steel making are improving, there is still a large potential for reducing CO_2 emission by achieving energy efficiency. Fig. 2-6 shows that if China can achieve the same level of energy efficiency as Japan, CO_2 emission from the Chinese Steel industry could be reduced significantly. In recent years, steel makers started to pay attention to waste heat recovery. In 2012, Taishan Steel completed the construction of a new power plant using the waste heat that was generated from the manufacturing process.

A large amount of waste heat produced by industrial processes in energy–intensive industry, such as automotive industry and steel Industry were usually emitted into atmosphere. However, this waste heat and gas can be used as a source of energy instead of being emitted as waste. Thus, the utilization of this waste energy and the energy flow within and between companies should be reconsidered. Since 1995, major steel companies have introduced electricity by developing self-generation system as IPPs (Independent Power Producer). These steel makers have become indispensable power producer that support the demand of electricity through out Japan, while Chinese steel companies are beginning to introduce this energy generation system. As for Automotive corporations, the generation of energy is for self-sufficient and supplement for the local power company, supporting the local area while gaining benefits from cost reduction. It is crucial to recover waste energy, which generated from manufacturing processes to achieve efficient energy utilization, especially in energy-intensive industries. Japanese companies can be seen as developed models while Chinese still need to gain experience from other countries, i.e. Japan. However, there is lack of established framework on the process of establishing and improving the electricity self-generation system at facility level, region level and city level.

Research Gap

A few gaps were identified while conducting the literature review:
1.   From a theoretical point-of-view, the boundary of 'entity' is not clearly stated. The definition has been developed over time to conform to the practical needs. In this paper, each manufacturing processes are regarded as an entity and the exchange of

material within the firm is seen as intra-firm level, while the material and energy flow between different firms are defined as inter-firm level IS.

2.   A majority of the existing literature on IS and EIPs have laid emphasis on both environmental perspective and social perspective with an aim to better understand how environmental and economic value can be created (Walls & Paquin, 2015). Only a few articles can be found from an energy efficiency perspective that can provide a potential solution to the worldwide energy scarcity problem.

3.   Much attention been paid on by policy makers on the national level and international comparison when energy efficiency be measured. However, there are limited studies based on a single firm or process although indicators found on general level are not suitable at a single firm (Bunse et al., 2011). Energy management is usually improved in individual organizations. The potential for improved EE could be higher if energy management is considered (Schulze et al., 2015). Thus, there is a need to develop managerial practice within and between organizations.

4.   From a practical point of view, there is lack of framework that shows the process of conducting IS from both intra-firm level and inter-firm level. This can directly help companies to achieve energy efficiency.

Preliminary Conceptual framework

Based on the research gaps have been identified, a conceptual framework is needed to enable companies to make the best use of limited energy through IS with non-technical improvements. More specifically, based on literature reviews, this paper aim to explore the processes of IS with a focus on the energy flow and the energy management at the intra-firm level and inter-firm level to understand the proper process(es) of achieving EE through IS. Research was conducted in three steps: (1) conducted a literature review of on Industrial Symbiosis (IS) and Energy Efficiency (EE)/Energy Management (EM) in manufacturing; (2) identified gaps in knowledge and practice; (3) developed a conceptual framework of efficient energy management through IS based on identified gaps.

Figure 1 shows the relationship between IS, EE, and EM literature. This research focus on the energy flow aspect of IS and the improvement of thermal efficiency of EE from a management perspective. Thus, a preliminary conceptual framework to understand the proper processes of achieving EE through IS.
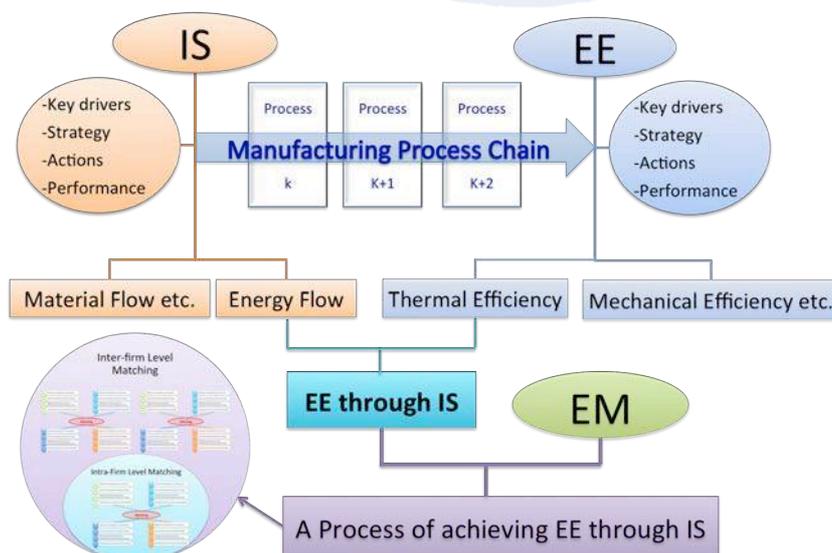
Figure 1 – Research Framework

More specifically, the process of achieving EE through IS can be divided into two main steps:
1.   Identify "hot spots" of waste energy and "cold spots" of energy demanding process (Monitoring – Assessment – Identification - Report)
2.   Based on theses reports, waste energy from one process to be matched to reuse in another process as resource within and between firms
In this research, each manufacturing process is seen as a unit and the boundary is drawn at unit process level. The energy exchanges between several process units within a firm are seen as intra-firm level IS and energy exchanges between different firms are seen as inter-firm level IS.

Contribution

The academic contribution of this research provides a conceptual framework of achieving EE utilization through IS. This fills the existing research gap in IS from an energy point of view. As a practical outcome, this conceptual framework provides a process of enabling local governments and companies to make the best use of limited energy through IS. The management of waste energy within/between firms can contribute to the reduction of natural resources/energy consumption, cost benefit, and most importantly, a solution to the present-day severe environmental pollution.

Further Research

Case studies will be carried out based on the proposed framework. Key drivers for IS promotion could be identified by comparing the advanced IS practices in Japan and developing IS practices in China at the intra-firm level and the inter-firm level.

References

Apostolos, F., Alexios, P., Georgios, P., Panagiotis, S., & George, C. (2013). Energy Efficiency of Manufacturing Processes: A Critical Review. *Procedia CIRP*, *7*, 628–633. http://doi.org/10.1016/j.procir.2013.06.044

Ayres, R. U., & Simonis, U. E. (Eds.). (1994). *Industrial metabolism: restructuring for sustainable development* (Vol. 376). New York: United Nations University Press.

Bunse, K., Vodicka, M., Schönsleben, P., Brülhart, M., & Ernst, F. O. (2011). Integrating energy efficiency performance in production management – gap analysis between industrial needs and scientific literature. *Journal of Cleaner Production*, *19*(6-7), 667–679. http://doi.org/10.1016/j.jclepro.2010.11.011

Chertow, M., & Ehrenfeld, J. (2012). Organizing Self-Organizing Systems: Toward a Theory of Industrial Symbiosis. *Journal of Industrial Ecology*, *16*(1), 13–27. http://doi.org/10.1111/j.1530-9290.2011.00450.x

Chertow, M. R. (2000). Industrial symbiosis : Literature and Taxonomy. *Annual Review of Energy Environment*, *25*(1), 313–337.

Chertow, M. R. (2007). " Uncovering " Industrial Symbiosis, *11*(1), 11–30.

Chertow, M. R., Ashton, W. S., & Espinosa, J. C. (2008). Industrial Symbiosis in Puerto Rico: Environmentally Related Agglomeration Economies. *Regional Studies*, *42*(10), 1299–1312. http://doi.org/10.1080/00343400701874123

Decc. (2012). The Energy Efficiency Strategy: The Energy Efficiency Opportunity in the UK. *Department of Energy and Climate Change*, (November), 30 pp.

Dong, L., Gu, F., Fujita, T., Hayashi, Y., & Gao, J. (2014). Uncovering opportunity of low-carbon city promotion with industrial system innovation: Case study on industrial symbiosis projects in China. *Energy Policy*, *65*, 388–397. http://doi.org/10.1016/j.enpol.2013.10.019

Duflou, J. R., Sutherland, J. W., Dornfeld, D., Herrmann, C., Jeswiet, J., Kara, S., … Kellens, K. (2012). Towards energy and resource efficient manufacturing: A processes and systems approach. *CIRP Annals - Manufacturing Technology*, *61*(2), 587–609. http://doi.org/10.1016/j.cirp.2012.05.002

Kellens, K., Dewulf, W., Overcash, M., Hauschild, M. Z., & Duflou, J. R. (2012). Methodology for systematic analysis and improvement of manufacturing unit process life cycle inventory (UPLCI) CO2PE! initiative (cooperative effort on process emissions in manufacturing). Part 2: Case studies. *International Journal of Life Cycle Assessment*, *17*(2), 242–251. http://doi.org/10.1007/s11367-011-0352-0

Leigh, M., & Li, X. (2014). Industrial ecology, industrial symbiosis and supply chain environmental sustainability: A case study of a large UK distributor. *Journal of Cleaner Production*. http://doi.org/10.1016/j.jclepro.2014.09.022

Li, W., Cui, Z., & Han, F. (2014). Methods for assessing the energy-saving efficiency of industrial symbiosis in industrial parks. *Environmental Science and Pollution Research*, *22*(1), 275–285. http://doi.org/10.1007/s11356-014-3327-4

Lombardi, D. R., & Laybourn, P. (2012). Redefining Industrial Symbiosis: Crossing Academic-Practitioner Boundaries. *Journal of Industrial Ecology*, *16*(1), 28–37. http://doi.org/10.1111/j.1530-9290.2011.00444.x

Lowe, E. (2001). Eco-industrial park handbook for Asian developing countries. *Report to Asian Development Bank*. Retrieved from http://scholar.google.com/scholar?hl=en&btnG=Search&q=intitle:Eco-industrial+Park+Handbook+for+Asian+Developing+Countries#0

Mentzer, J. T., Keebler, J. S., Nix, N. W., Smith, C. D., & Zacharia, Z. G. (2001). Defining supply chain management, *22*(2), 1–26.

Mirata, M., & Emtairah, T. (2005). Industrial symbiosis networks and the contribution to environmental innovation: The case of the Landskrona industrial symbiosis programme. *Journal of Cleaner Production*, *13*(10-11), 993–1002. http://doi.org/10.1016/j.jclepro.2004.12.010

Mirata, M., & Pearce, R. (2003). Industrial Symbiosis in the UK. *Industrial Ecology and Spaces of Innovation Workshop, University of Manchester, UK*, (17-18 June), 1–23. Retrieved from http://www.cric.ac.uk/cric/events/ecology/pdfs/mirata.pdf

Rahimifard, S., Seow, Y., & Childs, T. (2010). Minimising embodied product energy to support energy efficient manufacturing. *CIRP Annals - Manufacturing Technology*, *59*(1), 25–28. http://doi.org/10.1016/j.cirp.2010.03.048

Ranner, G. (1947). Geography of industrial localization. *Economic Geography*, *23*(3), 167–189. http://doi.org/10.1126/science.11.277.620

Schulze, M., Nehler, H., Ottosson, M., & Thollander, P. (2015). Energy management in industry – a systematic review of previous findings and an integrative conceptual framework. *Journal of Cleaner Production*, *112*, 3692–3708. http://doi.org/10.1016/j.jclepro.2015.06.060

Short, S. W., Bocken, N. M. P., Barlow, C. Y., & Chertow, M. R. (2014). From Refining Sugar to Growing Tomatoes: Industrial Ecology and Business Model Evolution. *Journal of Industrial Ecology*, *18*(In press), 603–618. http://doi.org/10.1111/jiec.12171

Sokka, L., Pakarinen, S., & Melanen, M. (2011). Industrial symbiosis contributing to more sustainable energy use - An example from the forest industry in Kymenlaakso, Finland. *Journal of Cleaner Production*, *19*(4), 285–293. http://doi.org/10.1016/j.jclepro.2009.08.014

Tanaka, K. (2008). Assessment of energy efficiency performance measures in industry and their application for policy. *Energy Policy*, *36*(8), 2887–2902. http://doi.org/10.1016/j.enpol.2008.03.032

Tanaka, K. (2011). Review of policies and measures for energy efficiency in industry sector. *Energy Policy*, *39*(10), 6532–6550. http://doi.org/10.1016/j.enpol.2011.07.058

Togawa, T., Fujita, T., Dong, L., Fujii, M., & Ooba, M. (2014). Feasibility assessment of the use of power plant-sourced waste heat for plant factory heating considering spatial configuration. *Journal of Cleaner Production*, *81*, 60–69. http://doi.org/10.1016/j.jclepro.2014.06.010

U.S. Energy Information Agency. (2013). International Energy Outlook 2013. *Outlook 2013*, 312. http://doi.org/EIA-0484(2013)

Walls, J. L., & Paquin, R. L. (2015). Organizational Perspectives of Industrial Symbiosis: A Review and Synthesis. *Organization & Environment*, *28*(1), 32–53. http://doi.org/10.1177/1086026615575333

Yuan, Z., & Shi, L. (2009). Improving enterprise competitive advantage with industrial symbiosis: case study of a smeltery in China. *Journal of Cleaner Production*, *17*(14), 1295–1302. http://doi.org/10.1016/j.jclepro.2009.03.016

Zhu, Q., Lowe, E. a, & Wei, Y. (2007). Industrial Symbiosis in China A Case Study of the Guitang Group. *Journal of Industrial Ecology*, *11*(1), 31–42. http://doi.org/10.1162/jiec.2007.929
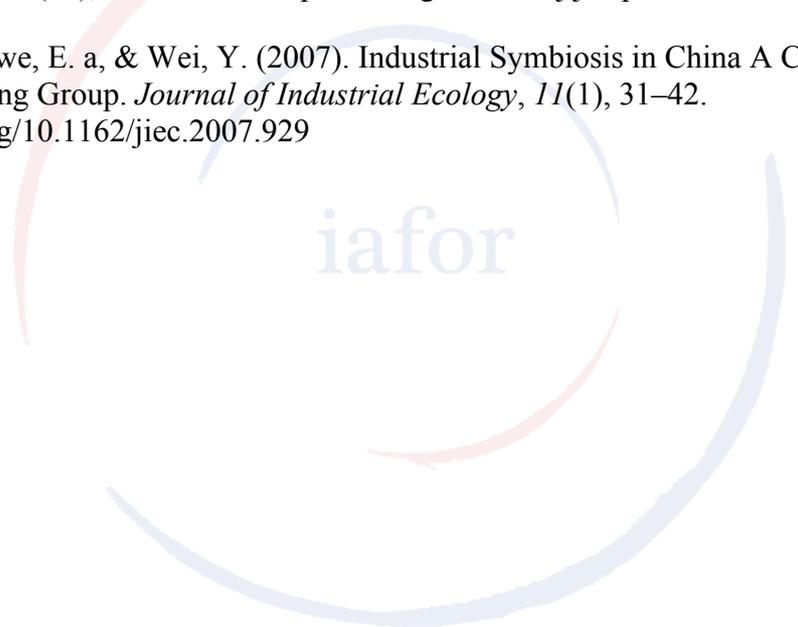
Comparative Embodied Carbon Analysis of the Volumetric Prefabrication Elements and In-situ Elements in Residential Building Development of Hong Kong

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Abstract
This paper reviews the greenhouse gas emissions of volumetric prefabrication elements for residential development in Hong Kong. Volumetric prefabrication becomes a common practice in residential development in Hong Kong and is considered as a green approach. In Hong Kong, volumetric prefabrication took place at factories in Pearl River Delta. Although volumetric prefabrication reduces construction wastage, it might generate more greenhouse gas emission from transportation and manufacturing processes. This study attempts to measure the "cradle to site" greenhouse gas emission from volumetric prefabrication elements for a public housing development in Kai Tak area. The findings could help further reduction of greenhouse gas emissions through process improvement.

Keywords: Volumetric prefabrication, greenhouse gas emission, cradle-to-site, residential development.

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Introduction

Volumetric prefabrication becomes a common practice in residential development in Hong Kong. Hong Kong will run out of landfill area for municipal solid waste within ten years (Environmental Protection Department, Hong Kong, 2011). To reduce the construction wastage of the municipal solid waste in Hong Kong, volumetric prefabrication is one of the ways to reduce waste on site. In recent years, public housing development adopts products, such as precast façade, precast wall, precast stair, precast tie beam and precast landing, to reduce construction waste. The application of prefabrication attempts to reduce construction wastage, enhance quality, workmanship and safety during construction.

Most of the local studies concern the reduction of construction wastage from prefabrication during construction stage. However, it seems there is no study concerning the greenhouse gas emission from volumetric prefabrication from "cradle to site" stage that includes raw-material extraction, prefabrication manufacturing, and transportation from extraction location to factory and from factory to site.

Although volumetric prefabrication reduces construction wastage, it might generate more greenhouse gas emission. In Hong Kong, volumetric prefabrication took place at factories in Pearl River Delta. Some of the raw-materials might source from Hong Kong. The travel distance will be double-up as raw-materials will travel from Hong Kong to Pearl River Delta and to Pearl River Delta and back to the construction site in Hong Kong. The real benefit from volumetric prefabrication on the reduction of "cradle to site" greenhouse gas emission in Hong Kong's context is unclear.

This study attempts to measure the "cradle to site" greenhouse gas emission from volumetric prefabrication elements (volumetric precast kitchen, volumetric precast bathroom) for a public housing development in Kai Tak area. The volumetric prefabrication factory was located at Shenzhen, China. The greenhouse gas emission from the raw-material extraction, prefabrication manufacturing, and transportation from extraction to factory and from factory to site was accounted. Improvement scheme would be proposed in this paper to reduce the greenhouse gas emission of volumetric prefabrication elements.

Methodology

The accounting of the greenhouse gas emission commences on March 2011. We follow the Life Cycle Assessment methodology for the accounting and reporting of the greenhouse gas emission for the "cradle to site" stages, including:

•   Raw-material extraction,
•   Transportation of raw-materials to prefabrication factory,
•   Prefabrication manufacturing, and
•   Transportation of prefabrication factory to construction site

Volumetric prefabrication elements used in the Kai Tak construction site comprises of volumetric precast kitchen and volumetric precast bathroom. The volumetric precast elements were basically reinforced concrete components prefabricated in factory with

rebar exposed at the end. Volumetric precast bathrooms and kitchens would install with aluminium window frame. Glasses will be installed on site later after delivery.

Fig. 1 Volumetric Precast Kitchens   Fig. 2 Volumetric Precast Bathrooms

The Life Cycle Assessment (LCA) was carried out for the manufacturing and transportation phase of 741 numbers of volumetric precast kitchens and 4910 volumetric precast bathrooms during the production period of April 2011. The LCA took account of all the background information, like raw material extraction, manufacturing and transports (cradle to site). For data source, checklists were sent to the following the prefabrication factory responsible for the production of prefabrication elements for the public-housing development of Kai Tak area. Data request comprised of quantities and types of raw-materials, fuel, waste and equipments used in the production of 741 numbers of volumetric precast kitchens and 4910 volumetric precast bathrooms for production period. As per the information of factory, 12 sets of steel formwork were used for the production of 4,910 volumetric precast bathrooms while 3 sets of steel formworks were used for the production 741 volumetric precast kitchens.   Fig. 3 shows the quantities of the raw-materials and the quantity of the steel formwork used in the production of the volumetric prefabrication elements in the public housing development in Kai Tak Area. Fig. 4, Fig. 5 and Fig. 6 shows the quantity of fuel, solid wastage and recycled waste of the volumetric prefabrication elements in the public housing development in Kai Tak area.   Fig. 7 shows the truck transport distance from raw-material extraction to prefabrication factory and from prefabrication factory to the construction site in Kai Tak area.
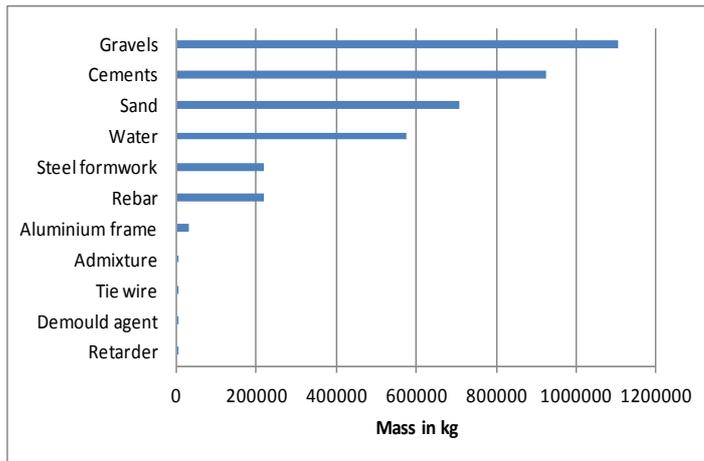
Fig. 3 The quantities of raw-materials or primary products of volumetric prefabrication elements for a public housing development in Kai Tak area
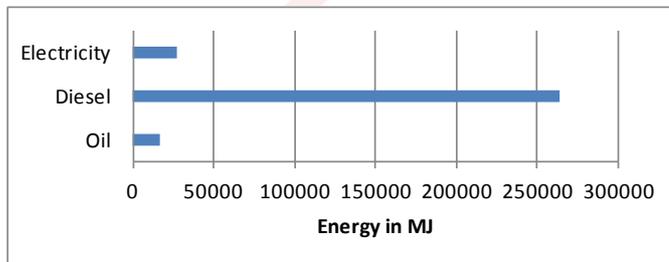
Fig. 4 The quantities of fuel used in the construction of volumetric prefabrication elements for a public housing development in Kai Tak area
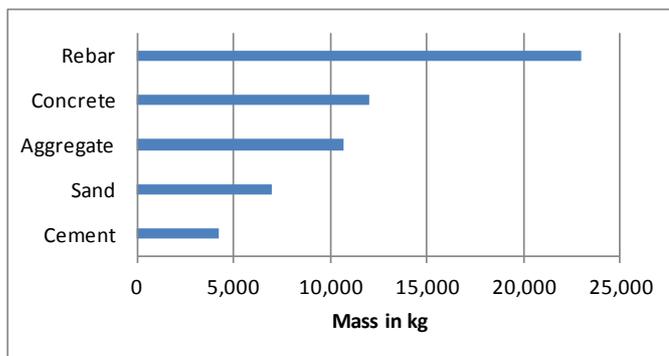

Fig. 5 The quantities of solid wastage from the production of volumetric prefabrication elements for a public housing development in Kai Tak area
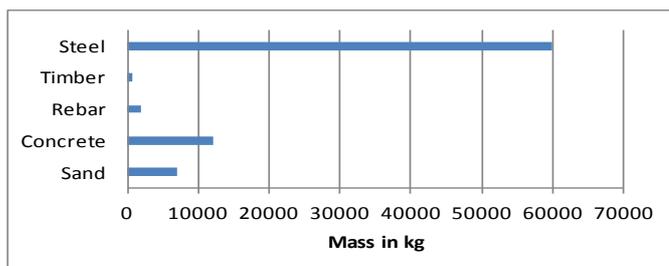
Fig. 6 The quantities of recycled wastage of volumetric prefabrication elements for a public housing development in Kai Tak area
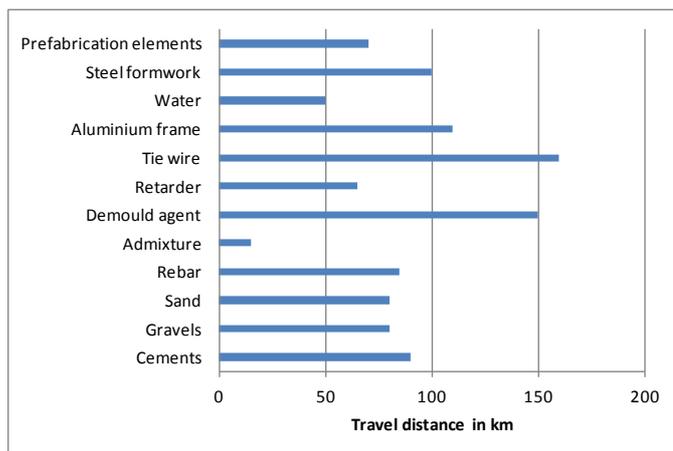
Fig. 7 The travel distance from raw-material extraction site to prefabrication factory for production of the volumetric prefabrication elements for a public housing development in Kai Tak area

Hypothesis Basecase

To find out the benefit or drawback on carbon emission, a hypothesis base case was set up. The following table shows the cases, production period and "cradle to site" stages for comparison. Raw-materials including rebar and retarder, were sourced from Hong Kong. Fig. 9 shows the truck travel distance for the raw materials for in-situ construction of volumetric prefabrication elements.

Transport carbon coefficient ("gate to site") "cradle to gate" embodied carbon coefficient was referred to the figure from Department for Environment, Food and Rural Affairs (DEFRA) published by UK Government in 2008 and UK figures. The references of electricity carbon coefficient of China Light Power (CLP) electricity and electricity in Shenzhen is extracted from (Environmental Protection Department and the Electrical and Mechanical Services Department, 2010) and (Tinjian University, 2010), respectively.

Table I

The Design Case and Hypothesis Basecase

Volumetric Prefabrication elements	Hypothesis Base
"cradle to site" stages	"cradle to site" stages
1. Raw-material extraction	1. Raw-material extraction
2. Transportation from extraction site to prefabrication factory at Shenzhen	2. Transportation from extraction to construction site at Kai Tak area, Hong Kong
3. Manufacturing of prefabrication elements at prefabrication factory at Shenzhen	3. In-situ construction at Kai Tak area, Hong Kong
4. Transportation from prefabrication factory to construction site at Kai Tak area	
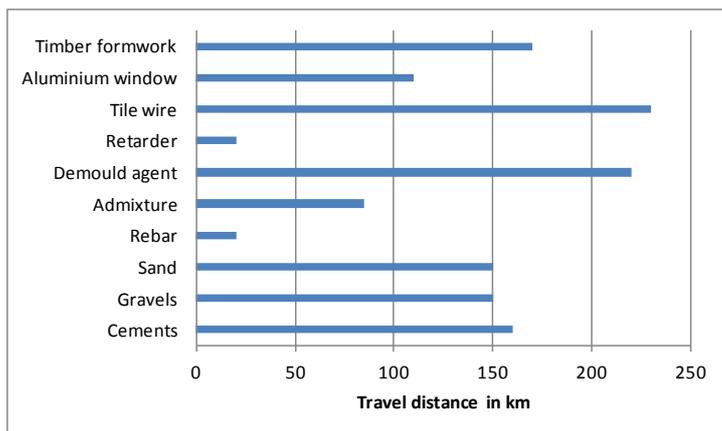
Fig. 8 The travel distance from raw-material extraction site to construction site for production of the in-situ elements for a public housing development in Kai Tak area
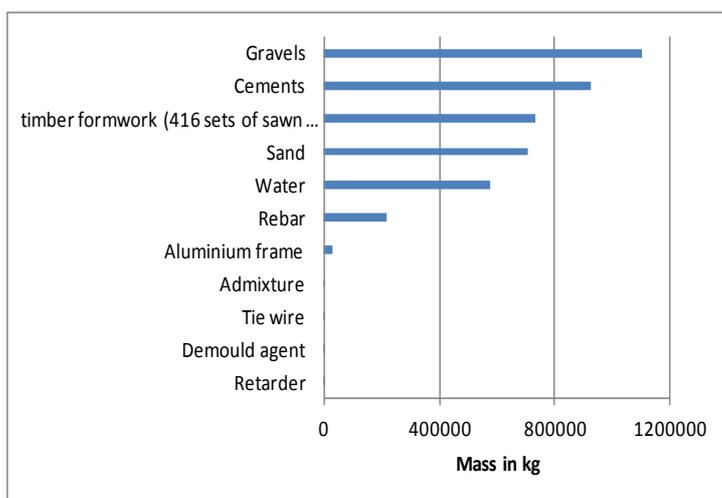
Fig. 9 The quantities of raw-materials or primary products of in-situ elements for hypothesis basecase

Results

Fig. 10, Fig 11 shows the total carbon emissions for 4,910 numbers of volumetric precast bathrooms, 741 numbers of volumetric precast kitchens and hypothesis in-situ elements (basecase) for raw-material extraction, prefabrication manufacturing and transportation stages. The 4,910 numbers of volumetric precast bathrooms emit a total of 24,422 tonne carbon emission. Compared with the hypothesis basecase (in-situ elements), the carbon emission is 2490 tonnes less than in-situ elements. It is equivalent to the carbon absorption of 108,261 numbers of trees per year. On the other hand, the 741 numbers of volumetric precast kitchens emit a total of 4,012 tonne carbon emission. Compared with the hypothesis basecase (in-situ elements), the carbon emission is 362 tonnes less than in-situ elements. It is equivalent to the carbon absorption of 15,738 numbers of trees per year.
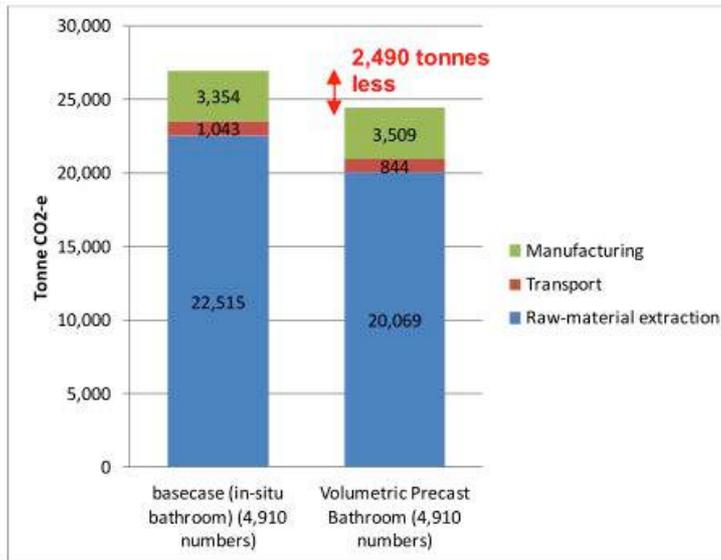
Fig. 10 The initial embodied carbon emission from the raw-material extraction to construction site for production of the 4910 volumetric bathroom elements for a public housing development in Kai Tak area
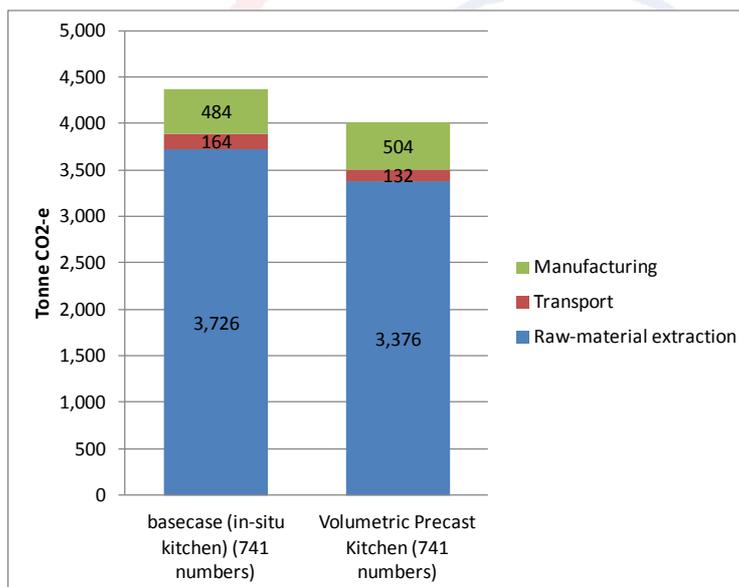
Fig. 11 The initial embodied carbon emission from the raw-material extraction to construction site for production of the 741 volumetric kitchen elements for a public housing development in Kai Tak area

Fig. 12 shows the breakdown of carbon emissions for volumetric prefabricated elements across the raw-material extraction, transport from extraction to factory, factory prefabrication, and transport from factory to site. 82% of the carbon emission comes from raw-material extraction. 15% of carbon emission comes from prefabrication-factory manufacturing. 2% of carbon emission comes from transportation (transports from raw-material extraction to factory and transports from factory to site). Raw-material extraction and prefabrication manufacturing contributed 97% of the carbon emissions. Transportation only contributed 2% of the indirect emissions. For process improvement, raw-material extraction drives the carbon emission for volumetric prefabricated elements.
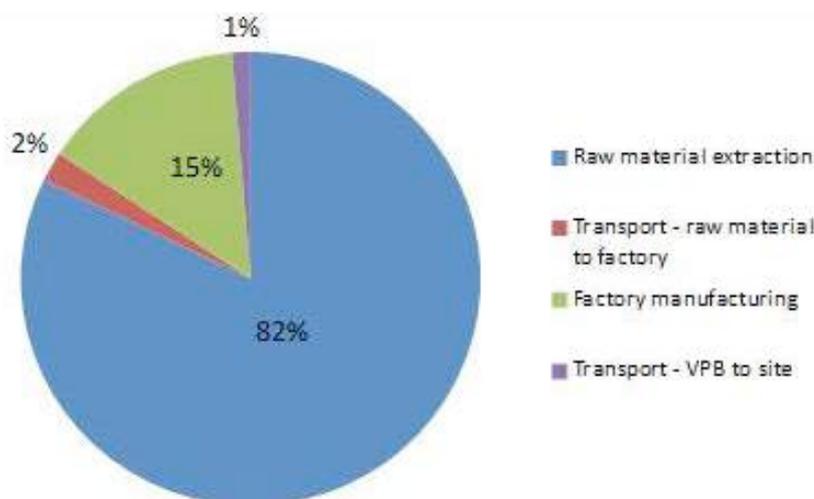
Fig. 12 The breakdown of carbon emissions for volumetric prefabricated elements across the raw-material extraction, transport from extraction to factory, factory prefabrication, and transport from factory to site

Carbon footprint of raw-material extraction

Compared with the carbon emission of the prefabricated elements with the in-situ elements, the carbon saving comes from raw-material extraction. It is because prefabricated elements adopt reusable steel formwork. As per the information of factory, 12 sets and 3 sets of steel formworks were used in the production of volumetric precast bathrooms and volumetric precast kitchens, respectively.
On the other hand, the hypothesis in-situ elements would use large amounts of sawn formworks. One set of sawn formwork can only reuse 6 times. For the same numbers of bathrooms and kitchens produced in the production period, approximately 942 sets of sawn formwork will be required. 2446 tonne more initial embodied carbon emission would emit during raw-material extraction and manufacturing of the formwork. It is equivalent to the carbon absorption of 106,348 numbers of trees per year.

Carbon footprint of factory manufacturing

Electricity in Shenzhen or most of China electricity is based on coal-fired (almost 74%), would have higher global warming potential. Volumetric prefabrication manufacturing of prefabrication elements had 175 tonne more carbon emissions than hypothesis in-situ construction. It is equivalent to the carbon absorption of 2087 numbers of trees per year.

Carbon footprint of transportation

Trucks were used to transport raw-materials and prefabrication elements to factory (and to site). Parts of raw-materials for volumetric prefabrication elements are sourced from Hong Kong. The raw-materials will travel from Hong Kong to Shenzhen and Shenzhen to Hong Kong again. The travel distance is slightly longer than in-situ construction. The transport distance is more direct if hypothesis in-situ construction uses the same local raw-materials. However, the excessive reduction of formwork usage in volumetric prefabrication. Therefore, construction of the

volumetric prefabrication elements on-site would have 231 tonne less transportation carbon emissions than in-situ construction. It is equivalent to the carbon absorption of 8,043 numbers of trees per year.

Carbon Reduction from Volumetric Prefabrication Elements

Although volumetric prefabrication elements emit 58 tonne more carbon emission during factory-manufacturing stage, volumetric prefabrication elements reduces overall 2,852 tonne carbon emission from "cradle to site" – raw-material extraction, transportation and factor manufacturing as prefabricated elements reduce formwork at the raw-material extraction. It is equivalent of the carbon absorption of 124,000 numbers of trees per year.

Conclusions

This study takes account of the carbon emissions from volumetric prefabrication elements of Kai Tak construction site.

Most of the carbon savings of prefabrication elements come from raw-material extraction. Increase of carbon emission occurs from prefabrication factory manufacturing. It is because electricity in Shenzhen or most of China electricity is based on coal-fired (almost 74%). The prefabrication plan produced in Shenzhen utilizing China's electricity would have higher global warming potential. It increases the carbon footprint of volumetric-prefabrication factory manufacturing.

Housing projects can further reduce the carbon emissions for volumetric prefabrication elements. On factory manufacturing, China electricity using the high global warming potential can be reduced through applying renewable energy and low emission fuel, such as biodiesel. On transportation, fuel with low carbon emission can reduce the transport carbon reduction vehicle with higher energy efficiency can also reduce carbon emission. Low emission carbon materials could reduce the carbon emission during the raw-material extraction. For volumetric prefabrication elements, cement and rebar contributes 32.4% and 25.6% of the carbon emission. Pulverized Fly Ash (PFA) might use to substitute part of the cement to reduce the carbon emission. However, PFA would increase the radon emanation rate of concrete (Yu, 1994). Steel rebar and steel formwork contributed 38% of the raw-material extraction carbon footprint. Recycle or reuse steel from previous projects could reduce the carbon emission of raw-material extraction.

Volumetric prefabrication elements can reduce construction waste as well as greenhouse gas emissions. For a typical residential estate of public housing comprised of six 40-storey high blocks, 5,651 numbers of volumetric prefabrication elements can reduce 9% of the greenhouse gas emission compared with in-situ elements. Volumetric prefabrication element is a low carbon and low-waste solution although improvement can be introduced to further reduce the transportation and manufacturing carbon emission of volumetric prefabrication elements.

References

Department for Environment Food and Rural Affairs, 2008 *Guidelines to DEFRA's GHG Conversion Factors: Methodology Paper for Transport Emission Factors,* London, UK, Department for Environment Food and Rural Affairs, 2008.

Environmental Protection Department and the Electrical and Mechanical Services Department. *Guidelines to Account for and Report on Greenhouse Gas Emissions and Removals for Buildings (Commercial, Residential or Institutional Purposes) in Hong Kong.* Hong Kong SAR, China, 2010.

Environmental Protection Department, *An Overview of Challenges for Waste Reduction and Management in Hong Kong.* Hong Kong SAR, China, 2011.

Yu, K. *Radon emanation from concrete with pulverized fuel ash (PFA).* Building and Environment Volume 29, Issue 4, October 1994, 545-547.

Beer, T., Grant, T., & Campbell, P. K. *The greenhouse and air quality emissions of biodiesel blends in Australia.* Victoria: CSIRO, 2007.

Environment Bureau, HKSAR Government. *Hong Kong's Climate Change Strategy and Action Agenda - Consultation Document.* Hong Kong.: Environment Bureau, HKSAR Government, 2011.

Promethium Carbon (Pty) Ltd. (2010). *Carbon Footprint Report - Financial and Calendar Year 2009*. Gold Fields.

The Hong Kong Green Building Council; BEAM Society. (April 2010). *BEAM Plus New Buildings Version 1.1. Hong Kong.*

Tinjian University. (2010). *Global Warming Potential of China electricity emission. Germany:* Global Emission Model for Integrated Systems.

Wong, F., & Amato, A. (Dec 2006). *Operational Model For A Combined Life Cycle Assessment (LCA) / Life Cycle Costing (LCC) Study For Office Of Swire Guangzhou Taikoo Hui Project.* 2nd Mega-Cities International Conference 2006. Guangzhou, China.

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Synthesis of Poly (Acrylic Acid) Based Polymers as Quantitative Determined Scale Inhibitor

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Abstract
In present days, the use of water transported from the river as the source material for generating electricity is very common. Generally, this water needs to be purified before it can be used in the process. However, during the water purification process, some calcium ion that existed is not uncommon. The calcium ion will somehow create some dregs when absorbing enormous heat, thus adding polymer to capture the calcium ion is necessary. In this research, we focused mainly on the synthesis of poly (acrylic acid) (PAA) as the material to eliminate the dregs by reducing the Calcium carbonate and Calcium sulfate in the water cooling system. This can be done by the free radical synthesis with emulsion technique. Comparison can be made by the length of Polymer Structure PAA-1, PAA-2, PAA-3 and PAA-4 in the solvent as well as adjustment for the mole ratio of potassium persulfate which is used as the initiator. Then, we can further analyze the structure by using FT-IR technique, resulting in the missing of double bond (C=C) of AA monomer in the 1640-1680 cm-1 wave length interval, and turn to be single bond in the main structure of PAA. This result reflected that the synthesis can truly produce polymer. With that, we can further analyze the ability to eliminate dregs by using titration technique with PAA-1, PAA-2, PAA3 and PAA-4 at the concentration of 20 ppm, with high preventive percentage of 72%, 81%, 100% and 90% accordingly. The test result clearly shows that low concentration can perform better in eliminating dregs. Lastly, the final product of this research can be proved by identifying using the UV-Vis spectroscopy technique.

Keywords: Poly(acrylic acid), Solution Polymerization, Scale Inhibitor

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1. Introduction

Circulating cooling water systems for industrial use in the production line has a quality control system. As water from the river is used in the cooling process has a relatively high hardness level. Therefore, there is need for water treatment before use. During the water treatment process a small amount of Ca^{2+} is contained. During water evaporation process, the saturated concentration will cause scale. To solve these problems, the use the polymer with properties to inhibit calcium ions is necessary in order to prevent scale. The addition use of chemicals as an alternative to solve the problem of scale and corrosion in the system is also required. Polymer as chemicals used to create a bond with cations contained in the water, especially Ca^{2+} and Mg^{2+} to produce complexing compounds [1,2] and then removed from the production process by precipitation. Normally the selected polymer to use for water quality control is a group of chemicals Poly(acrylic acid) (PAA) [3,4] which has a chemical structure and a functional group that helps to create a bond with metal ions as well. Acidity and properties to trap scale in order to made crystals of the scale distorted from normal and suspended in the water, so it could not reform to scale again.

In this research is focused on the synthesis and the ability to inhibit scale of Poly(acrylic acid) end capped with phenyl group with different weighing ratio of the monomer to initiator through solution polymerization (Scheme1) and quantitative analysis of remaining polymer in cooling water system.

acrylic acid   Benzoyl peroxide   Poly(acrylic acid)
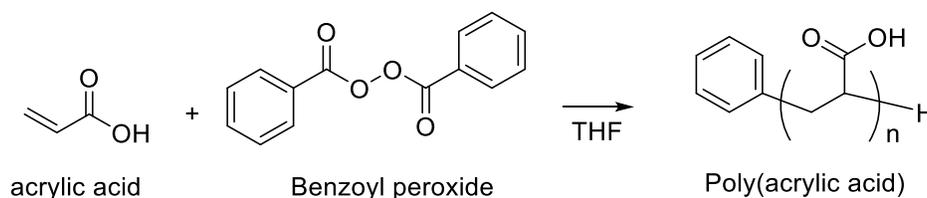
Scheme.1 The equation of synthesis polymer

2. Experimental

2.1 Polymer preparation

The series of PAAs were synthesized by solution polymerization of Acrylic acid and Benzoyl peroxide with dried THF as solvent. The solution of monomer was stirred under N_2 atmosphere for 10 minutes then refluxed at 70 °C for 3 hrs. The solvent was then removed under reduced pressure and was dried in oven at 70 °C for overnight to obtain the colorless solid polymer.

2.2 Polymer characterization

2.2.1 FTIR analytical

The prepared polymer was mixed with KBr in the ratio of 1:100 and grind to a find powder. The the finely ground mixture was placed into two stainless steel disks and transfer the sandwish disk onto the pistill in the hydraulic press with 4 ton compression for 10 minute and analysed with FTIR spectrometer range of wavelength between 400-4000 cm^{-1}.

2.2.2 UV-visible analytical

The stock solution of PAA 400 ppm was prepared and diluted the concentrations to 10-100 ppm. Measuring the absorbance of polymer solution at wavelength 190-300 nm by UV-Visible Spectrophotometer

2.3 Performance tests of [P(AA-co-AMPS)] as a scale inhibitor

Firstly, the stock solutions of 4000 ppm $CaCl_2$ and 5000 ppm $NaHCO_3$ were prepared as the source of Ca^{2+} ions and HCO^{3-} ions. Then, the blank solution was prepared by using $CaCl_2$ stock solution 12.50 ml and $NaHCO_3$ stock solution 12.50 ml then make volume to 250 ml by distilled water in volumetric flask. Next, the standard solution was prepared by using $CaCl_2$ stock solution 12.50 ml and make volume to 250 ml by distilled water in volumetric flask. Lastly, the sample solution was prepared by using stock solution of **[**P(AA-co-AMPS)] 2500 ppm and diluted to 10-100 ppm and add 12.50 ml of $CaCl_2$ stock solution and $NaHCO_3$ stock solution then make volume to 250 ml by distilled water in volumetric flask. All of portions was placed into shaking water bath at 70 °C shaking speed at 120 rpm for 24 hr, the solution portions were filtered under reduced pressure. The filtrates were titrated with standard EDTA solution and the performance of polymer as $CaCO_3$ inhibitor was calculated using the following equation.

$$\text{Inhibition (\%)} = \frac{\text{EDTA}_{\text{sample}} \text{ (ml)} - \text{EDTA}_{\text{blank}} \text{ (ml)}}{\text{EDTA}_{\text{std.}} \text{ (ml)} - \text{EDTA}_{\text{blank}} \text{ (ml)}} \, X100 \qquad (1)$$

3. Results and discussion.

3.1 Polymer preparation

All series of PAAs were synthesized via solution polymerization technique using weighing ratios of Acrylic acid to Benzoyl peroxide (Figure 1) which are summarized respectively on Table 1. The Obtained Polymer were tested for the scale inhibition and found that the ratio of synthetic PAA-4 effectively the highest scale inhibition. It has in turn created some aromatic structural in order to extend range of an absorption wavelength of UV-visible and can be quantified the polymer remaining in the cooling water system

Acrylic acid   Benzoyl peroxide
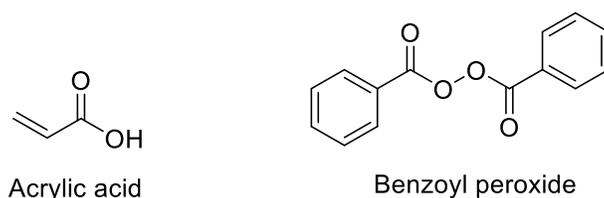
Figure 1 Structure of Monomer

Table.1 The weighing ratio of AA : BPO in each polymer.

No.	Sample	BPO:AA (g)	BPO (g)	AA (g)	M_w (Calculation)	M_w (GPC)
1	PAA-1	1:10	6.871	20.00	438	2,377
2	PAA-2	1:20	3.436	20.00	798	2,503
3	PAA-3	1:30	2.291	20.00	1,158	2,523
4	PAA-4	1:50	1.374	20.00	1,879	2,689
5	PAA-5	1:100	0.687	20.00	3,681	2,831
6	PAA-6	1:150	0.458	20.00	5,482	3,019
7	PAA-7	1:200	0.344	20.00	7,284	3,020

3.2 Polymer characterization

3.2.1 FTIR analytical

The IR spectra of PAAs are showed in Figure 2. The present of absorption at wave number 3400 cm^{-1} (a) are O-H stretching of carboxylic and alcohol group overlaping to the absorption of N-H stretching of the AMPS, C=O stretching of carboxylic and amide groups are presented at wave number 1714.79 cm^{-1} (b). The absent of absorption peak at 1600 cm^{-1}, which is -C=C- bond of the vinyl monomer converted -C-C- into a chain of polymer via the polymerization reaction
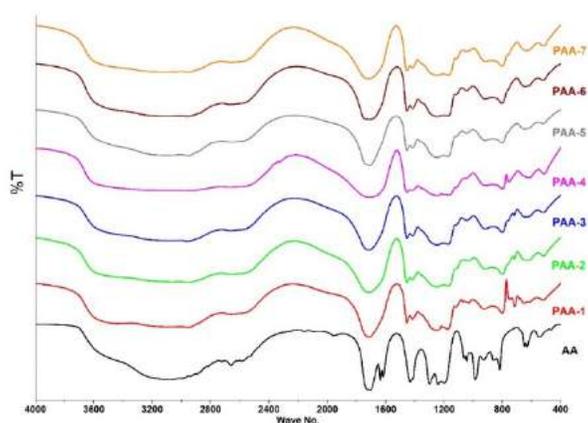
Figure 2 IR spectrum of PAAs

3.2.2 Measuring the UV-Vis absorbance

UV absorption spectra shown in Figure 3, the PAAs have the overlap absorption at wavelength range 195 nm and the line of PAAs, shown two peak of absorptions. By the first wavelength at 195 nm absorption is a carboxyl groups (COOH) of the monomer AA and wavelength at 230 nm is the absorption of aromatic structures of phenyl group.
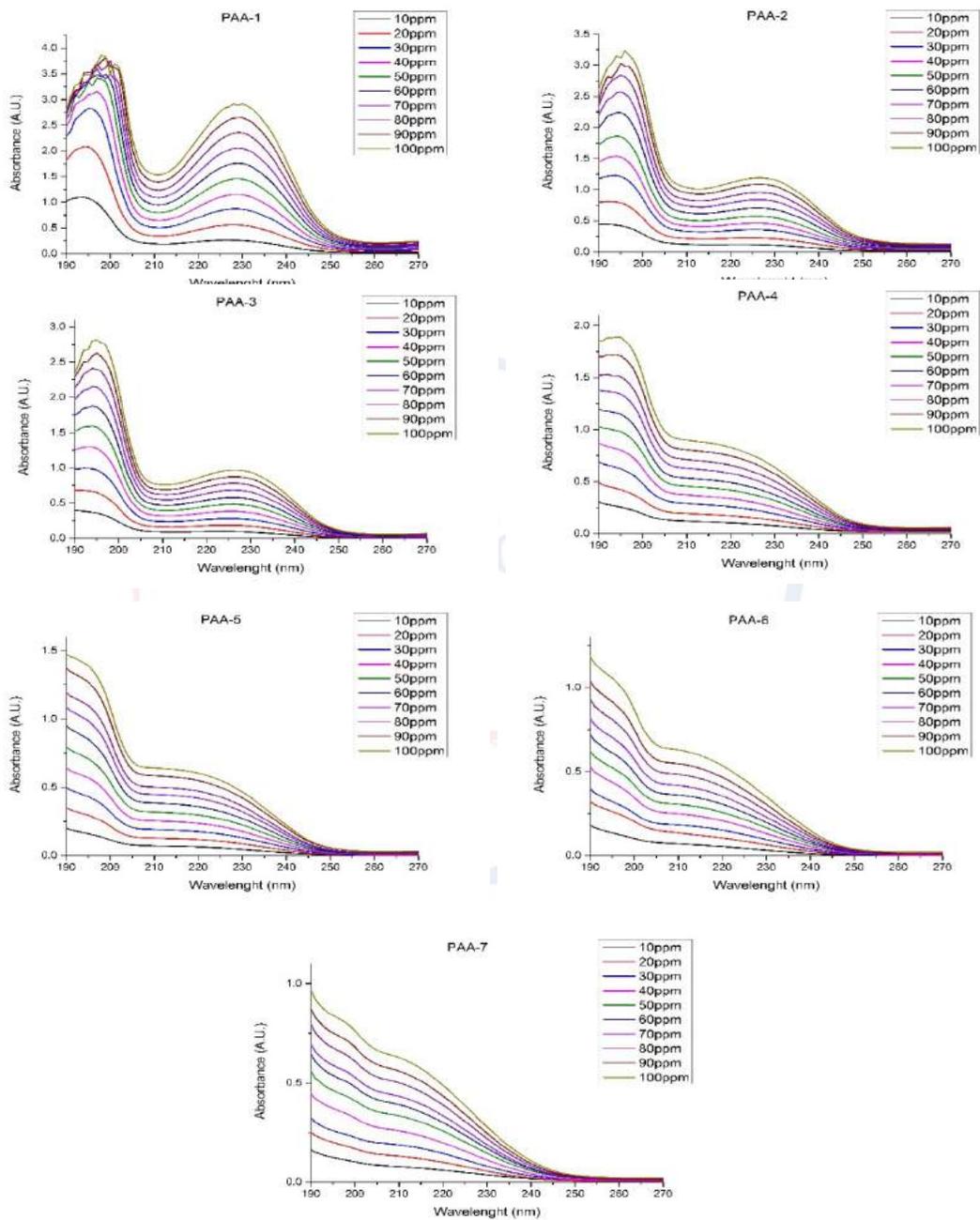
Figure 3 UV-absorbtion of PAAs

Figure 4 the λ_{max} at 230 nm of all series of polymers are used to plot a standard curve in order to quantify the concentration of the remaining of poly(acrylic acid) in the cooling water system. The water samples will be left in the system for measuring the absorbance at 230 nm
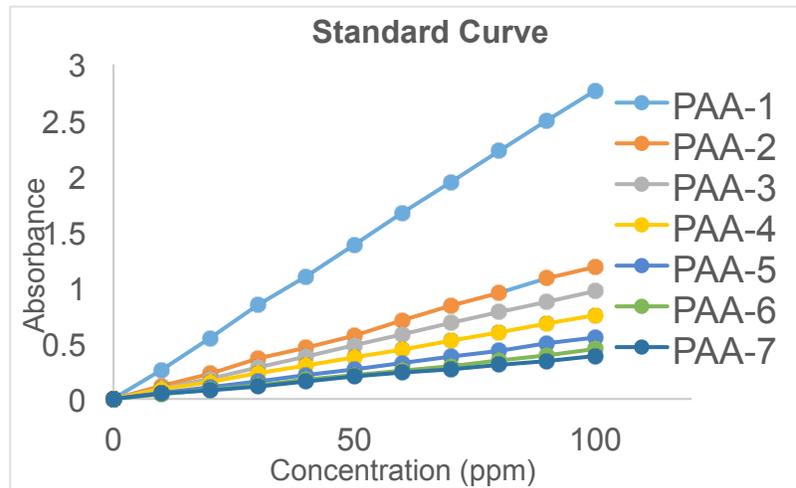
Figure 4 Standard Curve of PAAs

3.2.3 Scale Inhibitor Performance

From the relatively graph between the concentrations of polymers and the percent of scale inhibition which concluded in Figure 2, the data shown that the highest percentage of scale inhibition of polymer under the condition of 200 ppm $CaCl_2$ and 200 ppm $NaHCO_3$ is the polymer with weighing ratio of PAA-4. While effective in inhibiting scale of PAA-1, PAA-2, PAA-3, PAA-5, PAA-7 and PAA-7 was 82.98%, 87.19%, 99.47%, 84.74%, 83.68% and 80.70%, respectively. So ratio of monomer between AA and BPO of PAA-4 was the best ratio for use as scale inhibitor.
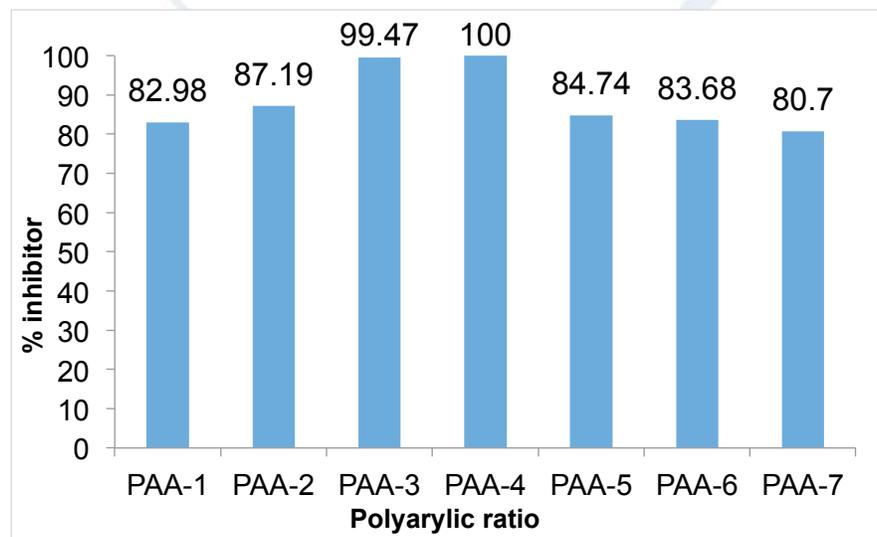
Figure 5 Influence of polymer on $CaCO_3$ inhibition

4. Conclusions.

The PAA-4 shown that it is the highest activity on scale inhibition. Assumptions made that the ratio of copolymer is a suitable match as scale Inhibitor. The short chain polymers (PAA-1, PAA-2 and PAA-3) may be not bonded well to Ca^{2+} ion result to reduce in inhibition performance. In furthermore, the long chain polymer (PAA-5, PAA-6 and PAA-7) are not dissolved well in water then the inhibition efficiency is lower than PAA-4.

5. Acknowledgements.

6. References

Chuang, E.-Y.; Lin, K.-J.; Su, F.-Y.; Chen, H.-L.; Maiti, B.; Ho, Y.-C.; Yen, T.-C.; Panda, N.; Sung, H.-W., Calcium depletion-mediated protease inhibition and apical-junctional-complex disassembly via an EGTA-conjugated carrier for oral insulin delivery. *Journal of Controlled Release* 2013, *169* (3), 296-305

Volkringer, C.; Loiseau, T.; Férey, G.; Warren, J. E.; Wragg, D. S.; Morris, R. E., A new calcium trimellitate coordination polymer with a chain-like structure. *Solid State Sciences* 2007, *9* (6), 455-458

Amjad, Z.; Koutsoukos, P. G., Evaluation of maleic acid based polymers as scale inhibitors and dispersants for industrial water applications. *Desalination* 2014, *335* (1), 55-63

Martinod, A.; Euvrard, M.; Foissy, A.; Neville, A., Progressing the understanding of chemicalinhibition of mineral scale by green inhibitors. *Desalination* 2008, *220* (1–3), 345-352

Shakkthivel, P.; Vasudevan, T., Acrylic acid-diphenylamine sulphonic acid copolymer threshold inhibitor for sulphate and carbonate scales incooling water systems. *Desalination 197* 2006,179-189

Senthilmurugan, B.; Ghosh, B.; Kundu, S. S.; Haroun, M.; Kameshwari, B., Maleic acid based scale inhibitors for calcium sulfate scale inhibition in high temperature application. *Journal of Petroleum Science and Engineering* 2010, *75* (1–2), 189-195

Ling, L.; Zhou,Y.; Huang, J.; Yao, Q.; Liu, G.; Zhang, P.; Sun, W.; Wu, W., Carboxylate-terminate double-hydrophilic block copolymer as an effective and environmental inhibitor in cooling water system. *Desalination* 2012, 33-40

Wang, H.; Zhou, Y.; Yao, Q.; Ma, S.; Wu, W.; Sun, W., Synthesis of fluorescent-tagged scale inhibitor and evaluation of its calcium carbonate precipitation performance. *Desalination* 2014, *340* (0), 1-10

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An overview of research projects investigating energy consumption in Multi-Unit Residential Buildings in Toronto

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Abstract
High-rise multi-unit residential buildings (MURBs) constructed in the 1960s and 70s are a prominent form of housing in Toronto; comprising over 50% of the City's residential stock. The majority of MURBs have become problem 'hot-spots' due to aging structures, poor maintenance and inefficient energy use. Studies indicate that MURBs are responsible for emitting over 2.6M tonnes of eCO_2 annually. In 2004, Toronto's Tower Renewal Program was launched to address concerns surrounding MURBs, becoming a municipal initiative in 2008 bridging between various interested parties. This includes a team at Ryerson University, investigating MURBs from an energy-efficiency standpoint. This contribution illustrates the diverse nature of studies undertaken at Ryerson between 2010 and 2015 under the Tower Renewal Program, to understand various facets of energy use in Toronto MURBs.

Studies undertaken are divided into two typologies. The first is aimed at understanding reasons underlying poor performance in MURBs. This includes conducting energy, water and solid waste benchmarking of up to 120 MURBs, and survey-based studies documenting tenants' self-reported behaviors. Finally an ANN model was developed to predict future energy use.

The second typology of studies tests proposed solutions to achieve energy reductions. One proposition simulated building envelope retrofits to meet OBC 2012. A comparison between pre-and post-retrofit standards showed up to 40% reductions in energy use. Finally, as part of a tenant engagement program, an Internet-Of-Things platform was developed and tested to provide visual feedback to tenants about their energy use. Results showed that the program instigated an annual reduction by up to 14.5%.

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Introduction

Toronto, the capital of Ontario, is the most heavily populated city in Canada. Approximately a third of the population lives in Multi-Unit Residential Buildings (MURBs), one of the most prominent forms of housing in the City of Toronto. The City of Toronto houses nearly 1,892 MURBs; which is the second highest number of MURBs in North America (City of Toronto, 2016), and comprises over 50% of the city's total residential building stock (Touchie et al., 2013). Most MURBs were constructed between 1945-1980 as part of the rapid urbanization that occurred during the post-war period. At the time, concrete MURBs were considered state-of-the art in modernist design and construction; and considered a trademark of the modernist lifestyle sought by mid-income families; rendering life in MURBs a popular housing choice for mid-income families (United Way Toronto, 2011).

Several decades later, aging MURBs have become problem hot-spots in the city. Most MURBs have severely degraded due to a lack of maintenance (United Way Toronto, 2011). Most rental MURBs are located in neighbourhoods that are isolated from key city infrastructure services (United Way Toronto, 2011); meaning that there are serious securities concerns within these neighbourhoods. As MURBs were constructed in an era during which energy-efficiency was less of a grave concern as it has increasingly become, many of the building features (e.g. concrete frames, non-operational building envelopes and aging appliances) perform poorly. This coupled with little maintenance and/or retrofitting procedures, means that most of the buildings perform poorly from an energy-efficiency perspective (City of Toronto, 2016). Correspondingly, it has been found that MURBs are responsible for emitting over 2.6M tonnes of eCO_2 annually (Touchie et al., 2014).

All of these features compounded have meant that the quality of life in MURBs has significantly deteriorated over time, and MURBs have transformed from a popular housing type for mid-income owners to become an affordable housing option for lower income tenants. Today, about 800 of Toronto's MURBs have privately owned rental properties. With little or no understanding of individual energy use, most tenants are reluctant to invest in energy-efficient appliances or improvements. From a building owner's perspective, there is similarly little motivation to invest in improving or retrofitting building features. Raising the rent is seen as a faster and easier response to rising energy costs than retrofitting; as payback of the latter is much slower (City of Toronto, 2016b; Counihan & Nemtzow, 1980). For some, demolishing these concrete towers and replacing them with newer developments with more energy-efficient features is a favourable solution to eradicate these problem hotspots. However, instigating retrofitting measures in MURBs, which provide affordable housing and offer large-size units for tenants, would improve quality of available housing. Similarly, revitalizing the neighbourhoods in which these MURBs are located promises greater benefit for the communities that reside within them, by ensuring occupants' health and comfort (ERA Group, 2011).

Toronto's Tower Renewal Program and Ryerson University's involvement

Inspired by similar community revitalization initiatives undertaken in Amsterdam and Berlin (Mehar, 2011), Toronto's Tower Renewal Program was launched in 2004 to address concerns surrounding MURBs. The program was adopted by the City of Toronto, making it a municipal initiative in late 2008. The overarching aims of this multi-component program include renewal of the aging physical features and structures of the buildings, and renewal of the urban communities and neighourhoods within which these MURBs are located; by making social improvements through job creation also toward increasing levels of safety in these neighbourhoods (City of Toronto, 2016b). A number of interested parties converge under the Tower Renewal umbrella, including Canada Mortgage Housing Corporation (CMHC), Ontario Ministry of Municipal Affairs and Housing (MAH), City of Toronto government agencies (e.g. TCHC), universities (e.g. University of Toronto and Ryerson University) and NGOs (e.g. Toronto Atmospheric Fund (TAF)). Seeing as Toronto has the second highest high-rise building density in North America, the Tower Renewal Program serves as an enormous opportunity to contribute toward sustainable development across all three of its spheres; by creating stronger communities, increasing local economic activity and improving environmental quality.

It is stated in the Toronto Renewal Implementation Book that if *"water and energy use and their associated greenhouse gas emissions can be drastically reduced; the production of renewable energy can be achieved; social networks, a sense of safety and the ease of traveling in the community can be considerably strengthened; and significant economic growth through job and local business creation realized"* (Pennachetti, 2010). From an energy and resource-efficiency vantage there is enormous room for improvement; the City envisages that savings in MURBs of up to 50% in electricity use can potentially be made and 70% savings in natural gas use (City of Toronto, 2016c). These would equate to 5% reduction of municipal energy consumption (City of Toronto, 2016c), and contribute to the Ontario government's plan to reduce carbon emissions from buildings by 15% in the Province by 2030; reaching zero emissions by 2050 (The Globe and Mail, 2016).

Between 2010 and 2015, a team of researchers at Ryerson University's Faculty of Engineering and Architectural Science (FEAS) has undertaken investigations and piloted studies of diverse natures as part of the energy and resource-use component in Toronto's MURBs. The purpose of this contribution is to therefore illustrate the diverse nature of studies undertaken at Ryerson University under the Tower Renewal Program, to better understand various facets of resource consumption in Toronto's MURBs.

Overview of Studies Undertaken

Studies conducted on Toronto MURBs as part of Ryerson University's contribution to the Tower Renewal Program are divided into two broad typologies. The first is aimed at understanding reasons underlying poor performance in MURBs. The second typology of studies tests proposed solutions to achieve energy reductions. In the forthcoming sub-sections, we outline studies falling under these two research categories.

1.   Understanding poor performance in Toronto MURBs.

a)   *Energy, water and solid waste benchmarking*

'Energy benchmarking' refers to the comparison of energy use with energy use in buildings exhibiting similar characteristics (Nikolaou et al., 2011). The purpose of benchmarking energy consumption is to promote efficient use of energy. Knowing that the energy used by a building is excessive is the first step to making positive changes (MacDonald and Livengood, 2000). By developing a benchmarking tool, one can estimate energy consumption of similar buildings and determine if a sample building is more efficient than other similar buildings (Chung, 2011).

With respect to MURBs, one major obstacle is that little is known about the energy intensity of that sector of residential buildings. For policy makers, energy benchmarking in existing high-rise MURBs would provide a realistic goal for setting building energy efficiency standards. There is an urgent need to benchmark a significant number of high-rise MURBs, to serve as a representative sample. Robust and accurate models are essential during the baseline process, and also to develop effective policies. These same benchmarking methods can then be used in future to determine whether buildings meet regulatory and baseline certification requirements.

To address this gap in the knowledge, an energy benchmark was developed by Huang (2012) to understand current energy use in 46 high-rise MURBs in Toronto. Of the 46 participating MURBs, 45 were gas heated and only one was heated by electricity. The number of floors of the buildings surveyed ranged from 7-24. The gross floor area of MURBs in this study ranged from 9,240m^2 to 34,850m^2. The number of residential units ranged from 128 and 439, with a mean of 252 units. The mean floor area per unit (including common areas) was between 55m^2 and 127m^2. Previous research shows that occupancy type has great influence on energy use (Enermodal Engineering Limited 2001), but unfortunately, occupancy type was not specified in the data collected from this study. Nevertheless, it is possible to infer to some degree occupancy type based on average unit size. Units less than 60m^2 were likely occupied by single persons or small families, whereas buildings with a mean greater than 120m^2 most likely accommodated for larger families.

Benchmarking was compiled by weather normalized annual energy consumption (NAC) of each MURB, which was calculated using PRISM to the 30-year typical weather of Toronto from January 1, 1981 to December 31, 2010 (Fels, 1996). The GHG emissions benchmarking was developed accordingly. To understand what factors influence overall energy consumption of the MURBs, the relationship between NACs and building characteristics such as vintage, gross floor area and occupancy were examined.

Results of this study are compiled and summarized in Figure 1, showing the energy benchmark with estimated end-uses for 46 high-rise MURBs in Toronto. For total energy consumption, building 3902, the electric-heated building showed much higher energy efficiency than gas-heated buildings. The normalized annual energy consumption for the electric-heated building was found to be 174kWh/m^2. For the 45 gas-heated high-rise MURBs, the range of NAC was 242-453kWh/m^2, with a mean of

336Wh/m^2 and standard deviation of 51kWh/m^2. The coefficient of variation, CV, of the sample was 15.1%.
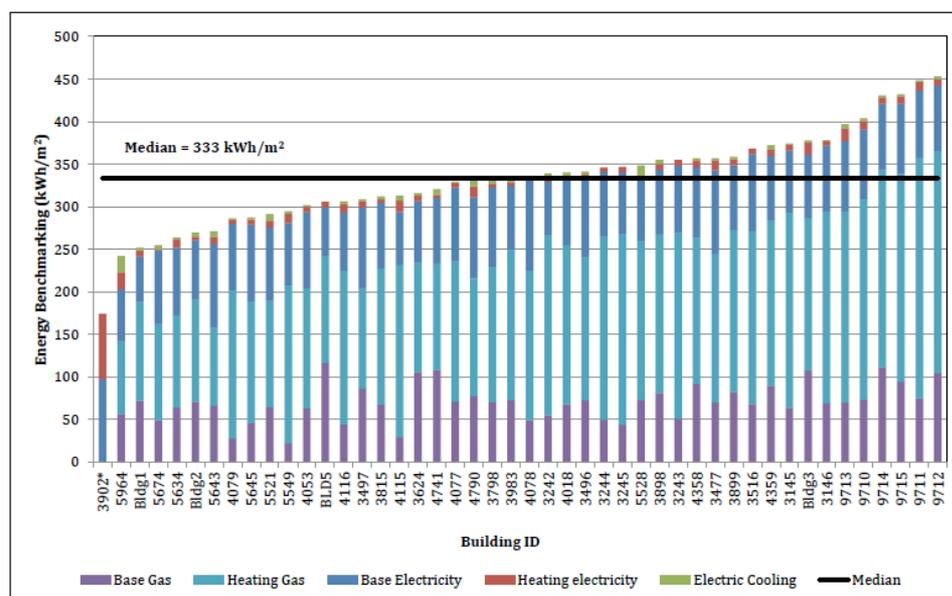
Figure 1: Energy benchmarks of 46 high-rise MURBs in Toronto.

Statistics for benchmarking results are summarized in Table 1. The result shows that the variations of overall energy consumption come mainly from gas consumption. The variation for electricity is relatively small. The CV for total electricity consumption and base electricity consumption are 14.2% and 12.7% respectively. This shows that the electricity consumption is comparable among these MURBs. On the other hand, heating-related electricity and cooling-related electricity showed large variations with CV 49.9% and 82.5%. This part of energy use is most likely to be caused by different and unpredictable behavior of tenants in each MURB. The highest electric demand, 20.1Wh/m^2, is identified in building 5964 (see Figure 1 above). This building was also found to be the most energy efficient building on total gas consumption and overall energy consumption. The gas heating for building 5964 was only 85kWh/m^2, only half of the average. The gas heating is used for central space heating. The high electric heating demand can be explained by the insufficient heating provided by the central space heating, and so tenants used other devices to improve comfort. Even so, the energy consumption for space heating purposes is combined gas and electricity consumption, at 105kWh/m^2; still much lower than the mean gas heating consumption.

Table 1: Summary of energy benchmarks of 45 gas-heated high-rise MURBs in Toronto.

		Total energy consumption (kWh/m^2)			
Normalized annual consumption - overall	**Lowest consumption**	242			
	Highest consumption	453			
	Mean	336			
	Standard deviation	51			
	CV (%)	15.1			
Normalized annual electricity consumption		**Base electricity (kWh/m^2)**	**Heating-related electric (kWh/m^2)**	**Cooling-related electric (kWh/m^2)***	**Total electricity (kWh/m^2)**
	Lowest consumption	53.2	0.8	0.9	63.3
	Highest consumption	106.0	20.1	19.2	114.7
	Mean	79.3	7.5	4.1	90.3
	Standard deviation	11.2	3.7	3.3	11.5
	CV (%)	14.2	49.9	82.5	12.7
Normalized annual gas consumption		**Base gas (kWh/m^2)**	**Heating-related gas (kWh/m^2)**		**Total gas (kWh/m^2)**
	Lowest consumption	21.9	85.0		141
	Highest consumption	116.5	283.2		365
	Mean	70.2	175.7		246
	Standard deviation	22.0	46.5		52
	CV (%)	31.4	26.5		21.0

In a later expansion of the afore-described study, energy benchmarking of 120 rental MURBs in Toronto was conducted. Water and solid waste benchmarking of these MURBs were also performed. Following a similar principle to energy benchmarking, water benchmarking serves as an effective instrument for water conservation policy-

making; to set proper water consumption reduction targets for MURBs. Solid waste benchmarking is also a necessary step to improve existing waste management systems, and to reduce the amount of waste being sent to landfills. This is important based on results published by Statistics Canada (2012), which indicated that the amount of waste generated by the residential sector in Canada is the third largest compared to other sectors (Statistics Canada, 2012).

To collect the data required for energy benchmarking, a survey was developed; requesting 2-5 years of monthly utility bills (gas, electricity, water consumption and waste generation), buildings' characteristics (size, age, number, type of units and number of floors), occupancy type and occupancy rate.

Energy consumption analysis was weather normalized using PRISM software, similar to the method used by Huang (2012), to provide a weather-adjusted Normalized Annual Consumption (NAC) index along with best reference temperature for the studied buildings. In this regression model NAC is the dependent variable while HDD/CDD is the independent variable. The degree to which one variable appears to explain the behavior of another variable has been studied by using the coefficient of correlation, R^2. The range of R^2 varies from 0 to 1, in which 0 shows that two variables have no relationships and 1 indicates the perfect relationship between two variables. It had been identified that the most reliable NAC can be achieved when the R^2 is higher than 0.7 and CV (measuring the scatterings of probability distributions) is less than 7% (Fels et al., 1995).

Water consumption analysis and solid waste generation analysis were performed by calculating annual consumption, calculating greenhouse gas emissions (GHG) associated with water use and solid waste disposal for MURBs and applying statistical correlation R^2 procedures similar to that described for energy (to develop water performance indicators and waste generation indicators).

Table 2 summarizes the relationships between each of the consumption variables (energy, gas, electricity, water consumption and solid waste generation) and key building characteristics. The strongest statistical relationships are highlighted in grey. Building size was found to have the strongest relationship with all consumption variables, with the exception of solid waste generation. On the other hand, the number of units in the building was found to have the strongest relationship with annual solid waste generation, albeit a weak correlation.

Table 2: Results of regression analysis of consumption variables and key building characteristics.

	R^2									
	Annual Energy Consumption		Total Annual Gas Consumption		Total Electricity Consumption		Annual Water Consumption		Annual Solid Waste Generation	
	kWh	kWh /m^2	kWh	kWh /m^2	kWh	kWh /m^2	m^3	m^3/ m^2	yd^3	yd^3 /m^2
Age	0.02	0.07	0.07	**0.26**	0.00	0.09	0.02	0.00	0.02	0.05
Building size (m^2)	**0.81**	0.00	**0.69**	0.00	**0.74**	0.00	**0.66**	0.00	0.15	0.14
No. of floors	**0.54**	0.00	**0.51**	0.01	**0.50**	0.00	**0.33**	0.00	0.12	0.05
No. of units	**0.51**	0.01	**0.43**	0.02	**0.57**	0.00	**0.37**	0.01	**0.22**	0.04
Capita	**0.73**	0.00	**0.65**	0.00	**0.61**	0.00	**0.66**	0.02	0.13	0.06
Capita/ m^2	0.08	0.00	0.05	0.00	0.14	0.00	0.01	0.13	0.01	0.09
Capita/ unit	0.01	0.00	0.02	0.00	0.00	0.00	0.06	0.10	0.04	0.00
CDD	0.18	0.00	0.02	0.00	-	-	0.02	0.00	-	-
HDD	0.01	0.01	0.02	0.00	-	-	0.02	0.00	-	-

b)   *Survey-based studies of tenants' self-reported behaviors.*

This section describes studies that were conducted under the rationale that, as a prerequisite to achieving significant reductions in energy consumption, it is important to first understand and evaluate occupants' household energy use and behaviors. This typology of study departs from the premise *that "buildings don't use energy, people do,"* (Janda, 2012), therefore relying on surveys of household energy use. Occupants are requested to provide detailed information on household characteristics (demographics, age, gender, income, etc.) as well as types of appliances owned, numbers of appliances owned and duration of use (e.g. SHEU 2007 in (Natural Resources Canada, 2010)).

There is a limited amount of research done on occupants' household energy use in Canadian MURBs. Most research on MURBs focus on the energy intensity of the entire building quantitatively. There is also a lack of information specifically related to high-rise MURBs at an occupant level. To address this gap, one study conducted at Ryerson (Roque, 2012) investigating occupants' household energy use in a Toronto MURB, evaluated the impact of various factors on household energy consumption in

one Toronto rental high-rise MURB situated in downtown Toronto. Monthly profiles of various factors, and their impact on household energy consumption were developed using an artificial neural network (ANN) model.

Artificial neural network modeling is able to discover internal relationships between data. It is able to classify nonlinear relationships with incomplete and small datasets. Because of this, ANN has become a huge interest in many fields and has matured over the past 40 years (Dayhoff and DeLeo, 2001). ANN is used for many applications, including national green energy use analysis (Ermis et al., 2007), public awareness campaign assessments (Mohamed and Alajmi, 2010), depression symptom analysis (Nair et al., 1999), perceptions of building quality (Rebano-Edwards, 2007), energy dependency projections (Sozen, 2009) amongst others. Recently, ANN has been used to predict energy consumption and distinguish relationships based on household energy use behaviour data. For example, Aydinalp et al. (2002) and (2008) use national household energy use survey data to discover relationships between the data. The study described here uses the same methodology as Aydinalp et al. (2003) to develop a similar ANN model.

The MURB that is the focus of (Roque, 2012) is owned and operated by a not-for-profit organization that provides affordable housing for primary single persons of modest incomes. The MURB recently underwent sustainable retrofits such as geothermal and solar thermal domestic hot water heating, sub-metering, etc. the MURB displays similar characteristics to a majority of Toronto MURBs; namely housing low-income households, and classification as a high density residential structure built between 1945 and 1984. Tenants do not pay for their energy consumption, which is included in the monthly rent. The MURB consists of 136 sub-metered units that track electrical energy consumption data per apartment unit.

A survey tool, consisting of 51 questions, was developed to collect information regarding household characteristics, electrical devices and appliances owned and used, heating and cooling, lighting, cooking activities and tenants' energy behaviors. The survey was distributed in the Toronto MURB between April 16th and May 4th 2012, and retained 49 usable responses.

The ANN model was created by using the Alyuda NeuroIntelligence Version 2.2 software and using a similar methodology as Aydinalp et al. (2003). In order to create the model, three sets of data were needed – survey data, weather data and energy consumption. Figure 2 below shows a flowchart of the methodology for the development of the neural network model. The result of the model is its ability to predict an occupant's energy consumption based on weather conditions and various factors from the survey. The output of the model has the ability to give an occupant's energy consumption (kWh) on a monthly basis.
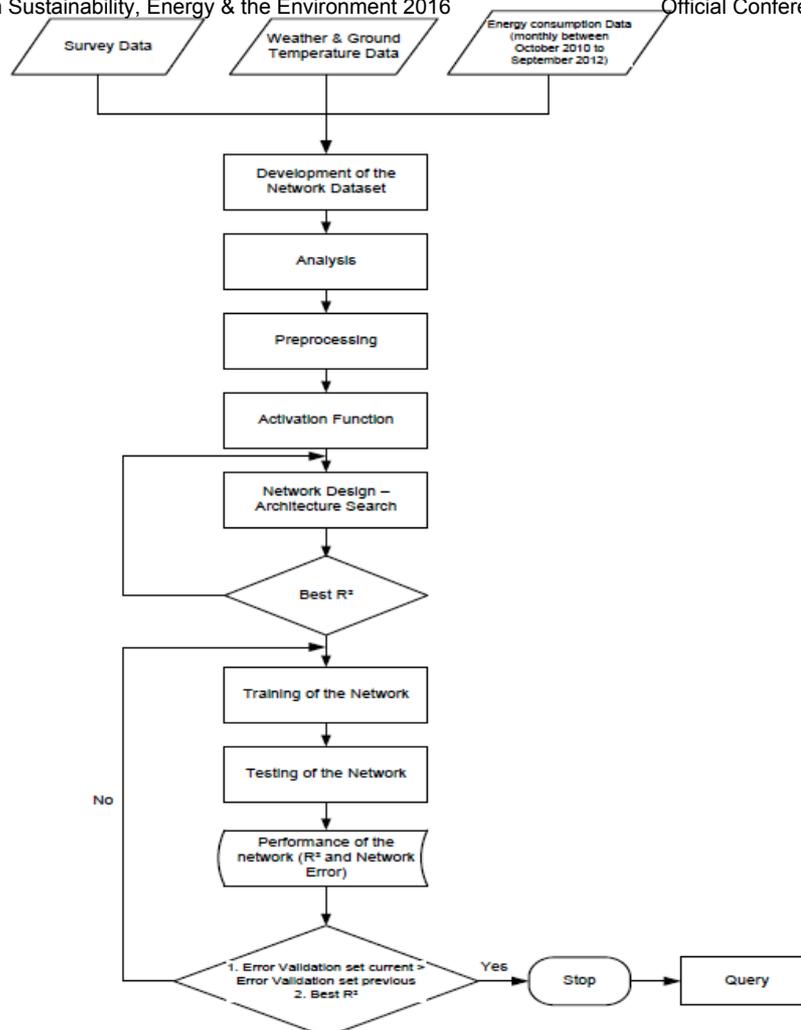
Figure 2: Flowchart of the methodology for the development of the ANN model.

Using a similar methodology as Aydinalp et al. (2003), an ANN model was created using a Quick Propogation training algorithm with 151 iterations. The dataset was divided into three sets – training, validation and testing. The training set creates the ANN model. The validation sets checks the model and the testing dataset fine-tunes and strengthens the model. The R^2 value was used to determine the best network/model. In each dataset, the R^2 was found to be 0.942 for validation dataset and 0.937 for the testing dataset.

General findings of the survey, regarding ownership of household appliances, are shown in Figure 3. The majority of survey respondents own a television, phone charger/lamp/light fixture, radio/stereo, DVD player and computer. Key results from the ANN model developed indicate that overall, males consumed slightly more energy per month than females. Highest income households consumed less than other income groups did, and units oriented in the Eastern direction consumed more energy than Western-oriented units. During the winter months (December to February), occupants who had grown up in Canada consumed 12.5% more energy than those from other geographical categories. On the other hand, occupants who had grown up in South and Central American consumed 21.6% less during winter months. Occupants who spent between 9 to 13 hours in their unit consumed 2.7% less energy compared to other durations of occupancy.
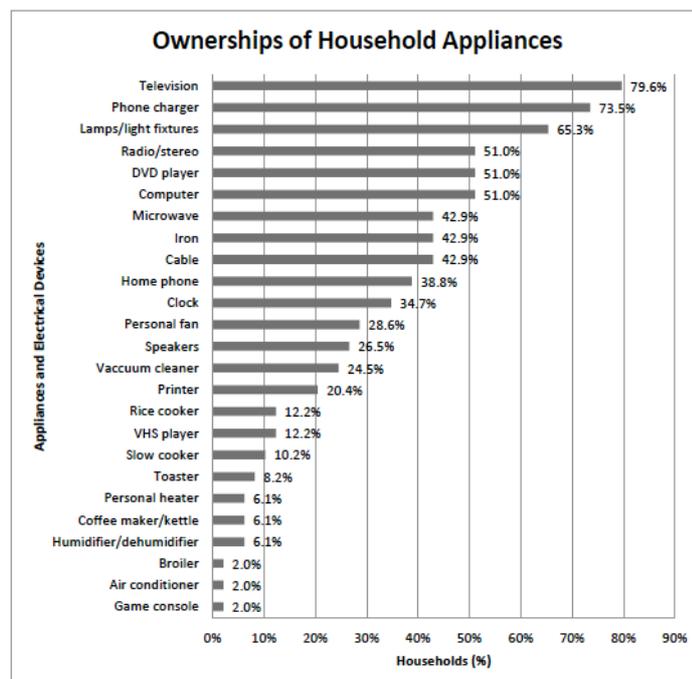
Figure 3: Ownership of appliances and electrical devices in the surveyed households.

In a subsequent survey-based study on the same Toronto MURB, the work of Mohazabieh (2014) aimed at understanding whether a significant relationship could be ascertained between occupants' environmental attitudes and their energy consumption. Previous research in this area (e.g. Thompson and Barton, 1994; Stern et al., 1995 and Poortinga et al., 2004) indicated that positive environmental attitudes do have a substantial effect on pro-environmental behaviors.

To measure tenants' environmental attitudes, the New Environmental Paradigm (NEP) scale (Dunlap et al., 2000) was used. The NEP scale consisted of fifteen Likert-scale statements that could be compounded on a single scale to demonstrate respondents' attitudes. The scale was distributed to 50 participating tenants in the Toronto MURB. Returned responses were categorized as follows:

-Pro-ecological attitudes (scores in the range of 59-75).
- Mid-ecological attitudes (scores in the range of 40-58).
- Anti-ecological attitudes (scores in the range of 15-39).

Historical energy consumption data, collected between October 1st 2010 to December 31st 2013 was weather normalized using PRISM software (Fels, 1996). Subsequently, Pearson's correlations were performed using IBM SPSS software to find whether a linear relationship between attitude data collected and energy consumption could be found at the following intervals:

-      Before survey implementation (2011-2012).
-      After survey implementation (2012-2013).
-      Whole survey implementation (2011-2013).

Results from this test are summarized in Table 3, and significant correlations are highlighted. Significant moderate negative correlations were found between the two variables for the 'after survey' (2012-2013) period and the whole survey duration

(2011-2013). This means that, as occupants' attitude scores increase, their energy consumption decreases.

Table 3: Results of correlation analysis between normalized annual consumption and attitude scores from the NEP survey.

	Normalized annual consumption (kWh) vs. Environmentally-conscious attitudes		
	Before survey (2011-2012)	After survey (2012-2013)	Whole survey duration (2011-2013)
Pearson Correlation (r)	-0.256	**-0.36***	**-0.33***
Sig. (2-tailed) (ρ)	0.073	**0.011***	**0.019***

*Correlation is significant at 0.05 level (2-tailed).

Finally, the implementation of the survey informed about Ryerson's energy efficiency study and may have influenced the tenant's energy consumption. The potential impact of survey implementation was calculated using two methods. The first method used was a comparison of actual energy consumption before and after implementation of the survey. Results of this method indicated that actual energy consumption dropped 8.3% after the survey. The second method created an ANN model using energy consumption data prior to the survey and forecasted the energy consumption after the survey (Before Survey model). Results of this method are shown in Table 4. The results indicate that the prediction from the Before Survey model overestimated compared to the actual energy consumption. This suggests that the respondents consumed less after the implementation of the survey. It can be inferred that by using the Before Survey model, the survey may have had some influence in decreasing occupant's energy consumption by 6%. (The Before Survey ANN model was used to project the same group of occupants' energy demand based on the actual weather conditions after the survey as if there was no survey implemented. In other words, the difference between Before Survey ANN prediction and actual consumption for the after survey (AS) period could be considered as the impact attributed to the introduction of the survey and related tenant engagement activities).

Table 4: Showing difference between prediction from BS Model to Actual Energy Consumption – May to September 2012.

	Prediction from BS Model	Actual Energy Consumption	Difference (Predicted-Actual)	Percent Difference
Total Energy Consumption (kWh)	32329	30299	+2030	+6.3%

2.   Proposed solutions to achieve energy reductions

In this section, studies proposing solutions to achieve reductions in energy consumption and improve overall performance are presented. In section 2a, one study exploring the impact of conducting building envelope retrofits on a MURB in Toronto to reach Ontario Building Code 2012 (OBC, 2012) standards is discussed. In Section 2b, an energy feedback research platform designed and implemented in a rental MURB to provide tenants with feedback on their energy use, as part of a tenant engagement program is demonstrated.

a)   Building envelope retrofits

It has been identified in previous research that one reason for poor energy performance in MURBs is that some of their physical components reach the end of their lifecycle, while others are in need of major restoration (Kesik and Saleff, 2009). A range of studies conducted (e.g. CMHC, 1990; Genge and Rousseau, 1996; Kesik and Saleff, 2009) agree that numerous deficiencies can be found in MURB building envelopes, and that upgrades are needed to make improvements in insulation, cladding, windows, balconies, exposed structural elements and at the interfaces where two components of the building envelope meet. Building envelope retrofitting is a top priority for postwar MURBs, to address existing problems, preserve a valuable building stock for tenants and improve energy efficiency.

However, prior to beginning costly retrofitting projects, it is essential to evaluate the savings that can be instigated from retrofitting measures. Particularly, thermal resistance value of retrofit projects must be carefully evaluated before application. While increasing RSI values enhance energy conservation, beyond a certain thickness insulation does not have a significant impact on energy savings. The same also applies to airtightness values. Analyzing the impact of increasing the thermal resistance and airtightness on the building envelope can help to identify the optimal upgrade values. Since standards and codes imply the minimum values for building envelope components for new constructions, the research described in Damyar (2014) aims to investigate optimal RSI and airtightness values for a 20-storey postwar MURB in Toronto, up to Ontario Building Code 2012 (SB-10) standards. The research also aims to evaluate how the impact of building envelope retrofits on energy use can be increased and optimized.

Four Building Envelope Retrofit Measures (BERMs 1-4) were proposed; (1) building envelope upgrades based on OBC 2012 (SB-10) standards (BERM 1), (2) incremental upgrades of building envelope components (RSI value) (BERM 2), (3) airtightness upgrades (BERM 3) and (4) combined comprehensive building envelope retrofit and airtightness upgrades (BERM 4).

To understand the annual consumption of the MURB, it was necessary to model the MURB in an energy simulation tool, and use this simulation to represent the baseline energy consumption of the building. Each upgrade could then also be simulated in the program, allowing us to quantify the impact of each BERM and comparison of the results instigated from each retrofitting scenario. The simulation tool selected for this purpose was The Quick Energy Simulation Tool (eQUEST), developed by the U.S. Department of Energy (DOE).

A base case energy model of the building was created in eQUEST using the information presented in the Tower Renewal Guideline Report and the model was calibrated so that gas and electricity use intensity of the model was close to previously reported values in Kesik and Saleff's (2009) study. Four other models were created, each changing one of the criteria based on BERMs 1-4 identified earlier to evaluate its contribution on energy intensity of the building. After evaluation of BERMs based on energy-efficiency measures, 4 major building envelope retrofit strategies (roof, exterior wall and balconies, windows and ground floor slab) (BERMs 5-8) were compared based on their energy-efficiency measure (BERM 8 is a comprehensive building envelope retrofit).

Results are illustrated Figure 4; showing the baseline energy intensity and the difference in energy intensity between the baseline and each of the retrofit cases. Percentage values indicate the improvement levels from the baseline. Results indicate that most of the energy savings can be attributed to a reduction in natural gas space heating. Electricity savings are negligible in comparison to natural gas since their impact on energy intensity was found to be less than 0.4%.

BERM 8, the comprehensive building envelope retrofit was found to have the most energy reduction benefit of 44.3%, followed by BERM 3 with 27% reduction. The impact of window and door upgrades (BERM 2) follows (BERM 3) with a 9.4% reduction. The roof upgrade (BERM 1) had the least impact on energy intensity (0.8%) because roof heat losses make up a smaller proportion of the total building heat losses in the base case.
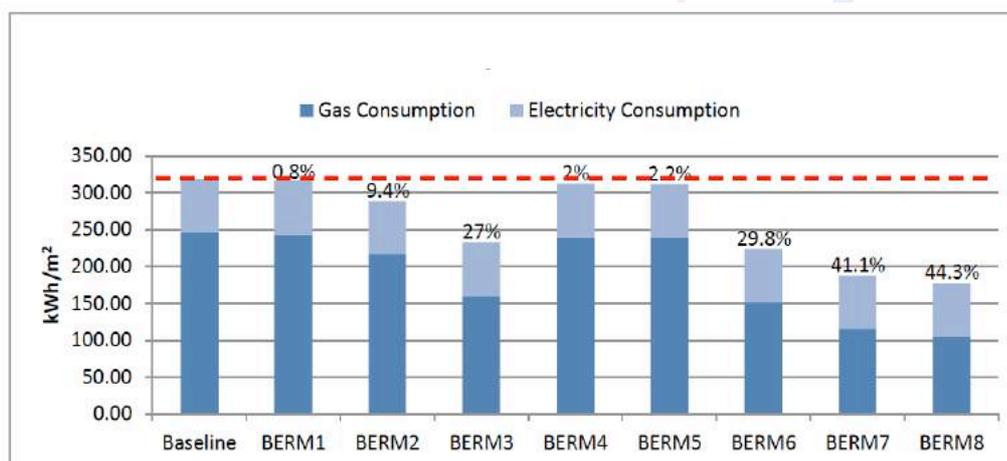
**Figure 4:** Annual energy consumption intensity analysis of upgrades of building envelope components based on OBC 2012.

b) *Energy feedback research platform*

The research described in this final study from (Trinh, 2016) is founded from the vantage that providing residential tenants with feedback on their energy use can serve as an effective intervention to instigate energy savings by up to 12% (Erhardt-

Martinez et al. 2010). However, despite the development of many commercial implementations of feedback and a plethora of studies on the efficacy of feedback approaches, researchers (e.g. Erhardt-Martinez et al., 2010; Fischer, 2008; Flemming et al. 2008) have pointed out two key challenges that limit our understanding of how to best design feedback. The first challenge is in the methodological variation of feedback projects with respect to study design, sampling, data-collection and reporting. The second challenge is that there is no consensus on how to best visually design feedback.

A key aim of this study was to demonstrate an Internet of Things (IoT) near real-time feedback platform that could be reconfigured to test a variety of feedback designs. A comprehensive review of the literature on feedback design and feedback intervention programs (Trinh 2016) revealed seven functional requirements are needed to design a sound feedback research platform:

1.   It should allow for the implementation of feedback on a multitude of design dimensions such as visual design, frequency and delivery format.
2.   It should allow for aggregated and disaggregated feedback data.
3.   It should allow for historical and social comparisons to be integrated with feedback.
4.   It should support researchers not only by delivering feedback but also standardizing how data is collected and managed.
5.   The data collected should not be limited to simple energy measurements, but should be widened to include survey data, thermal comfort data and energy use data.
6.   It should allow for data to be collected with a common structure and data format, to afford cross-experiment data analysis.
7.   Because the platform is built on open-source technology it should be freely available for others to use and customize.

For the study, the platform was configured as part of a year-long tenant engagement and energy conservation program, asking tenants to save 10% of their annual energy use while testing the effectiveness of real-time feedback and social comparisons. This field study was conducted on the same rental MURB that was the focus of studies described in Section 1(b) located in downtown Toronto. The primary research question for the field study was: Can combining real-time feedback with real-time social comparisons help communities of users reach individual and collective conservation goals?

Due to spatial limitations, it is not possible to discuss details of the system architecture used to design the feedback, but these are detailed in Trinh et al. (2015) and Trinh (2016). To provide visual feedback to tenants, Android Tablets (ASUS MemoPad 7 HD) were given to 24 tenants who agreed to participate in the study, allowing them to view their own energy feedback dashboards using an app that was developed specifically for the study (Figure 6). Two variations of feedback displays were designed in the app. The first was a basic feedback display showing the daily tenants' energy use as well as their energy use over the previous week (Figure 6a). The second variation added social comparisons to the average of the tenant's neighbours (Figure 6b). The app also allowed participants to complete in-situ thermal comfort surveys on a weekly basis. In addition, each suite was filled with the set of components shown in Figure 5.

Figure 5: Rich-picture diagram of feedback hardware installed for each tenant.
From bottom-left counterclockwise: emonTXv3 installed inside fan coil unit to measure power consumption and air temperature output, emonTH to sense ambient room temperature and humidity, a Raspberry pi gateway/hub, emonCMS cloud service, Android tablet with dashboard app. Additionally, but not pictured, were emonTXv3 units to measure suite-level power consumption.
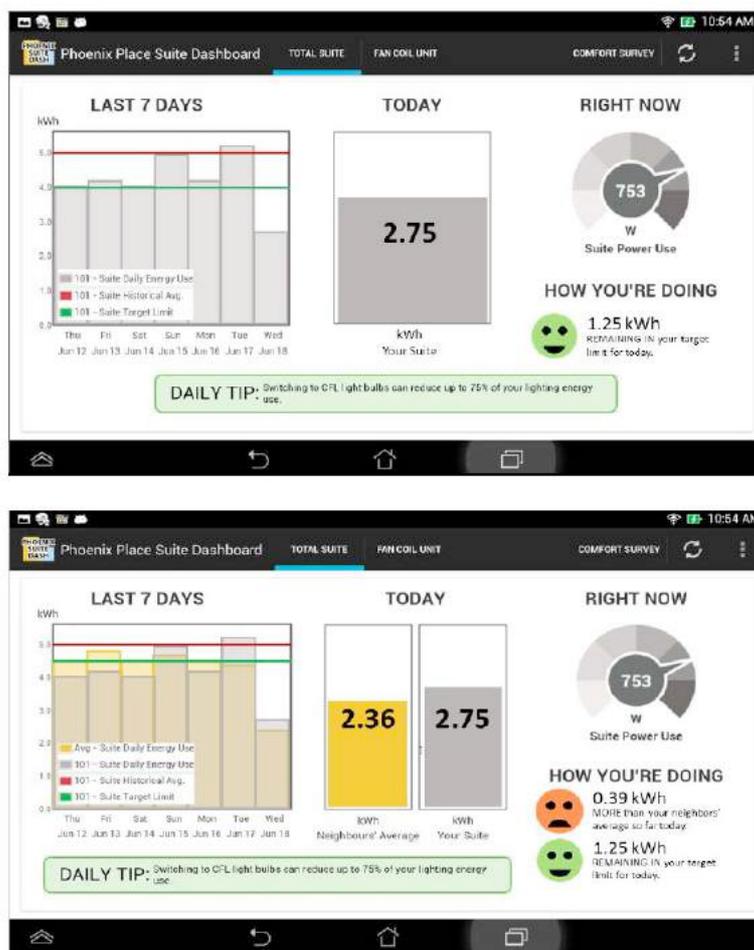
Figure 6: (Above) a) basic feedback display and (below) b) basic feedback display with social comparisons.

The field study used a uni-variate design with feedback type as a between-subjects variable. There were three levels of feedback: no feedback (control), basic feedback (real-time and historical comparisons) and basic feedback + social comparisons. Recruited participants were randomly assigned to receive one of the two feedback conditions. The final counts had 12 participants in each feedback condition and 106 in the control condition.

Results, pointing toward energy savings and the effectiveness of providing tenants with feedback on their energy use, are shown in Figure 7. This shows percentage savings of actual group-aggregated kWh use and weather-normalized group-aggregated kWh use across the three groups of participants. The average annual savings percentage between the two feedback groups was 10.6% compared to an increased use of 2.3% for those outside the study. Similarly for normalized savings percentage, the average for participants receiving feedback was 8.4%, while those outside the study increased their energy use by 2.8%. We can therefore conclude that the tenant energy conservation program and feedback platform was successful in surpassing the 10% energy savings target.
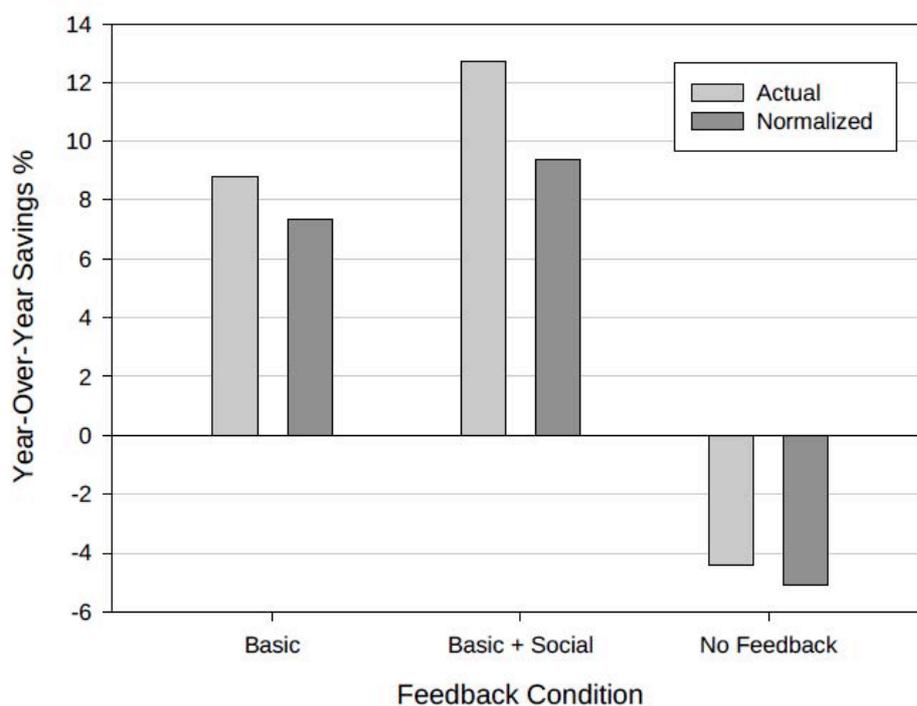
Figure 7: Aggregated year-over-year savings (%).

Conclusion

The purpose of this paper was to provide an overview of the types of research studies conducted at Ryerson University and undertaken within the City of Toronto's Tower Renewal Program. Empirical research described in this paper was performed on rental MURBs, which have been deemed as problem hot-spots in pre-existing literature.

This paper serves as an illustration of the diverse range of research directions that can be pursued, all essentially targeting a unified end-goal; instigating reductions in residential energy-use. It further demonstrates how varying research designs and methodologies can be applied in research focusing on energy-reductions (examples from this paper alone include energy, water and solid waste benchmarking using PRISM, survey-based studies using ANN modeling, simulating building retrofits using building simulation software and finally designing a tenant engagement program and feedback platform).

It is also noticeable that research described here was performed at a broad range of building scales, and targeting alternate dimensions of energy use within buildings. For example, when energy, water and solid waste benchmarking were performed, up to 120 MURBs were observed simultaneously; with each MURB serving as a single unit of analysis in the quantitative study. On the other hand, a more in-depth study was predicated in Damyar's (2010) study; in which only energy flows were studied in only one MURB, and only at the building envelope level, facilitating cross-comparison of multiple retrofit propositions. An even deeper level of granularity was necessary in research aiming to understand the impacts of tenants' individual energy behaviours

(e.g. Roque, 2012). When the aim of the research was to instigate change in energy behaviours; the sample consisted of 24 tenants residing in one building; which greatly contrasts with the 120 buildings sampled for Huang's (2012) benchmarking study, where behaviour was largely abstracted and assumed uniform across all tenants. This contrast highlights the multi-faceted nature of energy consumption, and serves as an indication of how energy consumption infiltrates building operation and use across all dimensions.

Moreover, the contrast in research designs pursued opens up a diverse range of avenues in future research that may be pursued towards reducing energy use. For example, it would be interesting, and predictably more fruitful from an energy reduction perspective, to combine multiple methodologies described in this paper (e.g. retrofitting building envelopes coupled with tenant engagement programs and feedback platforms), and to determine whether energy reductions instigated are equally multiplied. Finally, the ability to foster significant and non-negligible reductions in energy consumption using the methodologies described in this paper points toward their applicability in more typical housing types (e.g. high-rise condominiums and single-family housing) offering housing solutions to more representative households (i.e. households consisting of two ore more people) in Canadian cities.

Acknowledgements

References

Aydinalp, M., Ugursal, V. I., & Fung, A. S. (2002). Modeling of the appliance, lighting and space-cooling energy consumptions in the residential sector using neural networks. *Applied Energy, 71,* 87-110.

Aydinalp, M., Ugursal, V. I., & Fung, A. S. (2003). Modeling of residential energy consumption at the national level. *International Journal of Energy Research, 27,* 441-453.

Aydinalp, M., Ugursal, V. & Fung, A. (2003). Effects of socioeconomic factors on household appliance, lighting and space cooling electricity consumption. *International Journal of Energy Issues,* 20 (3), 302-315.

Aydinal-Koksal, M., Ugursal, V. I. (2008). Comparison of neural network, conditional demand analysis, and engineering approaches for modeling end-use energy consumption in the residential sector. *Applied Energy, 85,* 271-296.

Chung, W. (2011). Review of building energy-use performance benchmarking methodologies. *Applied Energy*, *88,* 140-179.

CMHC (1990). Extend of carbonization in Buildings in Toronto. Ottawa: Canada Mortgage and Housing Corporation.

Counihan, R. H. & Nemtzow, D. (1980). Energy conservation and the market rental housing market. *Solar Law Reporter, 1980-1981,* 1103-1132.

Dayhoff, J. E., DeLeo, J. M. (2001). Artificial Neural Networks: Opening the Black Box. *Conference on Prognostic Factors and Staging in Cancer Management: Contributions of Artificial Neural Networks and Other Statistical Methods.* 1615-1635.

Damyar, S. (2014). *The impact of building envelope retrofit measures on Post-War MURBs in Toronto*. Master's Research Paper (MRP), Ryerson University.

Dunlap, R., van Lierre, K., Kent, D., Mertif, A. & Jones, R. (2000). New trends in measuring environmental attitudes. Measuring endorsement of the new ecological paradigm: A revised NEP scale. *Journal of Social Issues, 56,* 425-442.

Enermodal Engineering Limited (2001). *Analysis of the annual energy and water consumption of apartment buildings in the CMHC HiSTAR database.* Kitchener.

ERA Group (2011). *Tower Renewal Implementation Booklet, An Apartment Community Initiative.* Toronto: City of Toronto.

Ermis, K., Midilli, A., Dincer, I., Rosen, M. A. (2007). Artificial neural network analysis of world green energy use. *Energy Policy, 35,* 1731-1743.

Erhardt-Martinez, Donnelly, K. A. & Laitner, J. A. (2010). Advanced metering initiatives and residential feedback programs: A meta-review for household

electricity-saving opportunities (Research Report no. E105). Washington DC, American Council for an energy-efficiency economy.

Fels, M. (1986). PRISM: An introduction. *Energy and Buildings,* 9 (1), 5-18.

Fels, M., Kissock, K. & Marean, M. A. (1995*). PRISM (Advanced Version 1.0) User's Guide.* Princeton University. New Jersey: Center for Energy and Environmental Studies.

Fischer, C. (2008). Feedback on household electricity consumption: A tool for saving energy? *Energy-efficiency* 1 (1), 79-104.

Flemming, S. A., Hilliard, A. and Jamieson, G. A. (2008). The need for human factors in the sustainability domain. Human Factors and Ergonomics Society Annual Meeting Proceedings, 52, 748-752.

Genge, G. and Rosseau, J. (1996). High-rise apartment repair needs assessment. Ottawa: Canada Mortgage and Housing Corporation. Technical Policy and Research Division.

Huang, Y. (2012). *Energy benchmarking and energy savings assessment in high-rise multi-unit residential buildings.* Thesis (MASc), Ryerson University.

Kesik, T. and Saleff, I. (2009). Tower Renewal Guidelines for the comprehensive retrofit of Multi-Unit Residential Buildings in Cold Climates. Toronto: Daniels Faculty of Architecture, Landscape and Design; University of Toronto.

Janda, K. (2011). Buildings don't use energy: people do. *Journal of Architectural Science*. 54 (1), pp. 15-22.

MacDonald, M. & Livengood, S. (2000). Benchmarking residential energy use. *ACEEE Buildings Summer Study* (Journal Article).

Mahmoud, M. A., & Alajmi, A. F. (2010). Quantitative assessment of energy conservation due to public awareness campaigns using neural networks. *Applied Energy, 87,* 220-228.

Mehar, S. (2011). *Development of sustainability assessment method for existing apartment tower buildings in Toronto, Canada.* Major Research Project, Department of Architectural Science, Ryerson University.

Mohazabieh, S. Z. (2014). *Environmental attitudes and energy consumption among tenants in a high-rise multi-unit residential building in Toronto, Canada.* Master's Research Paper (MRP), Ryerson University.

Natural Resources Canada (2010). *Office of Energy Efficiency*. Available online at: http://oee.nrcan.gc.ca/Publications/statistics/sheu-summary07/pdf/sheu-summary07.pdf, Accessed: September 23rd 2012.

Nikolaou, T., Kolokotsa, D. & Stavrakakis, G. (2011). Review on methodologies for energy benchmarking, rating and classification of buildings. *Advances in Building Energy Research*, 5 (1), 53-70.

Pennachetti, P. J. (2010). *Executive Committee Report on Tower Renewal City Wide Implementation.* City of Toronto, Toronto, ON. Retrieved from: http://www.toronto.ca/legdocs/mmis/2010/ex/bgrd/backgroundfile-30935.pdf [Accessed: April 28th 2016].

Poortinga, W., Steg, W. L. and Vlek, C. (2004). Values, environmental concern and environmental behaviour. A study into household energy use. *Environment and Behaviour* 36 (1), 70-93.

Rebano-Edwards, S. (2007). Modelling perceptions of building quality – A neural network approach. *Building and Environment, 42,* 2762-2777.

Roque, M. (2012). *Survey and artificial neural network analysis on occupants' household energy use in a high-rise multi-unit residential building in Toronto, Canada.* Thesis (MASc): Ryerson University.

Sozen, A. (2009). Future projection of the energy dependency of Turkey using artificial neural network. *Energy Policy, 37,* 235-246.

Statistics Canada (2012). *Human activity and the environment waste management in Canada report, 2012.* Ottawa: Statistics Canada.

Stern, P. C., Dietz, T. C. and Guagnano, G. A. (1995). The new ecological paradigm in social-psychological context. Environment and Behaviour 27 (6), 723-743.

The City of Toronto (2016). *Tower & Neighbourhood Revitalization Unit.* Available online at: http://www1.toronto.ca/wps/portal/contentonly?vgnextoid=7fe8f40f9aae0410VgnVCM10000071d60f89RCRD [Accessed: April 28th 2016].

The City of Toronto (2016b). *Tower Renewal Implementation Book.* Available online at: https://www1.toronto.ca/city_of_toronto/social_development_finance__administration/files/pdf/tr_implementation_book.pdf [Accessed: April 28th 2016].

The City of Toronto (2016c). *Tower Renewal City Manager.* Available online at: http://www.toronto.ca/city_manager/tower_renewal.htm [Accessed: April 28th 2016].

The Globe and Mail 2016. *New Ontario agency will be given sweeping mandate to overhaul energy use.* Available online at: http://www.theglobeandmail.com/news/national/ontario-to-create-agency-to-oversee-climate-change-goals-draft-plan-shows/article29781337/ [Accessed: April 28th 2016].

Thompson, S. C. & Barton, M. A. (1994). *Ecocentric and anthropocentric attitudes toward the environment.* Journal of Environmental Psychology 14, 149-157.

Touchie, M. K., Binkley, C. & Pressnail, K. D. (2013). Correlating energy consumption with multi-unit residential building characteristics in the city of Toronto. *Energy and Buildings* 66 (2013) pp. 648-656.

Touchie, M. K., Pressnail K. D. & Tzekova, E. S. (2014). Assessing potential energy retrofits of multi-unit residential buildings in the Greater Toronto Area. *14th Canadian Conference on Building Science and Technology,* October 28-30, 2014.

Trinh, K., Fung, A. & Straka, V. (2015). A demonstration of an energy feedback research platform in a field study of real-time social comparisons. Behaviour, Energy and Climate Change (BECC) Conference.

Trinh, K. (2016). *Development and demonstration of an energy feedback research platform in a field study with real-time social comparisons.* Thesis (MASc): Ryerson University.

United Way Toronto (2011). *Vertical Poverty.* Available online at: http://www.unitedwaytoronto.com/verticalpoverty/downloads/Report-PovertybyPostalCode2-VerticalPoverty-Final.pdf [Accessed: November 12th, 2011].

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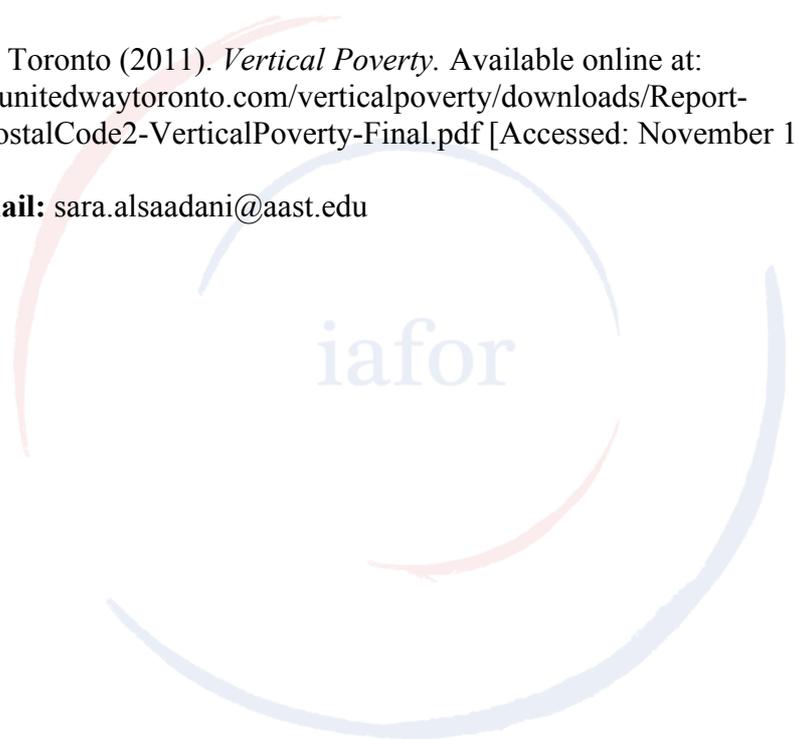
Waste Disposal Issues in a Philippine Upland Urban Center

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Abstract

Unsustainable human behavior and practices in relation to waste disposal invariably result to environmental degradation. Issues on these add to the ever-growing myriad of concerns and problems that beset highly urbanized centers all over the world. Previous and more recent studies on waste disposal in Baguio, an upland highly urbanized city in northern Philippines, indicate that the same problems still haunt this metropolis.

The city's fast-growing population and the unabated in-migration of people from the lowlands and from adjacent mountain provinces contribute to an infinitely increasing volume of waste generation, more rampant use of plastic materials and on the over-all, the worsening garbage problem of the city. Poor solid waste management, inefficient technological solutions and measures put in place by the local government unit have failed to address the city's waste disposal issues. A more pressing problem, however, is the resultant pollution of creeks, streams and river systems that flow into low-lying areas and how this has affected the water supply and the health of the residents of the localities. Various non-government organizations and people's organizations have joined forces to promote activities that will educate and foster the involvement of the residents on the waste disposal issues currently plaguing Baguio City.

Discussion of the above will be based from a study of the city's garbage in the early '80's, a research in the mid '90's on the socio-economic and environmental impacts of the then Baguio City's open dumpsite in Irisan, a survey among students in a premier Baguio City university on waste segregation in 2012 and current fact sheets from the local government unit and non-government organizations concerned with the city's waste disposal issues.

Keywords: environment, waste disposal, pollution, Baguio City

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Introduction

Baguio City is a highly urbanized center in upland northern Philippines. Known for its temperate climate and pine forests and designated in the 1900s as the summer capital of the country, the city has developed into a hub of commercial trading, education, industry, regional administration, and tourism. But unlike other sprawling metropolis, its land area is only 57 sq km with a population of more than 367,000 as of 2016 according to the latest National Statistics Office survey (Barangay-Population-CAR-2011-2016.). Unofficial figures put its population at over 400,000 with some 5,000 people added to the city's population every year surpassing the national average population growth rate but which is mainly attributed to migration rather than birth rate according to the Population Commission (Pop-Com). Baguio has been cited as having one of the highest population densities in the country. Its regular daytime population of approximately 400,000 is known to double or triple during Holy Week and Christmas vacations, two of the country's most-observed holidays.

Located 250 km north of Manila, the city is nestled on a plateau at an elevation of 1300 to 1600 meters asl (**Fig. I**).

Fig. I. Location map of Baguio City

According to the 2002-2008 Baguio Comprehensive Land Use Plan (CLUP), the city's terrain has a slope grade of 19-36% with most of the area being of undulating to moderately steep slope, Residential land use takes up 61.00 % of the city's land area followed by vacant forested area (12/38%), commercial area (2.57%) and forest/watershed reserves (2.54%).

In view of its very limited land area and the unabated influx of settlers, Baguio is beset with problems that include but are not limited to waste management. As of 2012, data show that the city generated 355 tons of solid waste materials per day or 130,000 tons for the year. Many of its residents are worried about the health of the city's urban ecosystem and the seemingly uncontrolled development in the city.

These have been expressed in numerous studies and researches involving this metropolis.

Solid Waste Disposal in the Early '80s

A study of Baguio City's waste situation and refuse management measures that were in place was undertaken in the early '80's concurrent with that of nearby La Trinidad (Macaranas, E., 1985). The main concerns then were public health impact, environmental protection, aesthetics and resource recycling. Health issues centered on the spread of parasites, increasing incidence of diarrhea, hepatitis and gastro-enteritis whereas damage to drainage, dumping of refuse in sidewalks and open canals and degradation of water quality were frequently mentioned as reasons behind the deteriorating environmental condition of the city,

The report indicated that the city's population as of 1984 was merely 133,726 with students making up approximately 30,000 of the said figure. The solid wastes collected per day from the city's municipal garbage averaged 145 m^3 with 128 m^3 being contributed by residential areas and the remaining 17 m^3 by institutional/commercial establishments. The solid wastes that were sampled over a period of ten days consisted mainly of putrescible garbage or what more modern terms would designate as biodegradable refuse (**Fig. 2**).
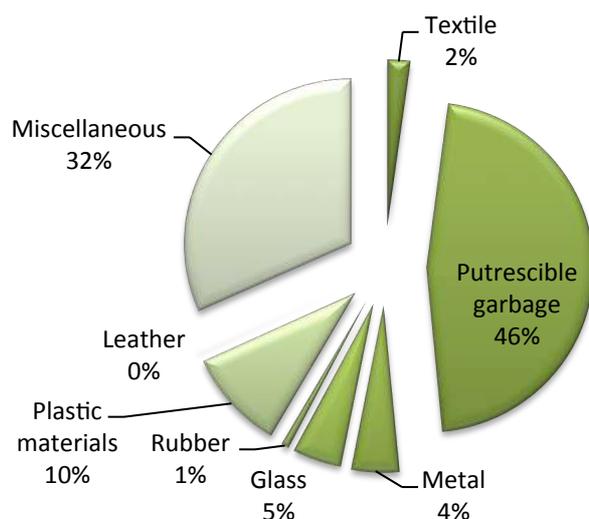
Fig. 2 Physical Composition of Solid Wastes of Baguio City*
based on data obtained over a 10-day period of collecting garbage in 150 households

Analyses of refuse obtained from the samples included measurements of solid waste generation rate, bulk densities, size analysis using 25 mm mesh, physical composition with the results utilized to arrive at improvements on existing waste management systems and possible measures to address the worsening problem on waste generation and disposal.

Results of the chemical composition analysis of putrescibles segregated based on source, namely residential and commercial sectors, yielded a C/N ratio ranging from 16.93 to 23.71for samples obtained from three densely populated localities and an

average of 9.55 for the commercial sector. The C//N ratios obtained were, however, lower than the optimal requirement for composting suggesting that composting will not be a practical solution at the city level but it can be practiced by households in their respective backyards instead of burning or using open dumps for the disposal of putrescibles.

Garbage collected along a sidewalk in the city market that consisted mainly of agricultural trash showed the following composition (averaged over a period of ten days of sampling): Chinese pechay – 40.22%, peas – 20.15%, strawberries – 13.70%, weeds – 10.82%, 14.11%. and plant residue. Rotting garbage thrown indiscriminately along the sidewalks was established as a major water pollutant as they leach into ground waters or join surface run-offs during the rainy months.

From a socio-political perspective, the study's assessment of the local government unit (LGU)'s fulfillment of its mandate to decide on ordinances involving garbage fees & the authorization to collect such fees, implement and impose existing laws and decrees regarding pollution is that of a passing mark, Two of the reasons put forward were the government's provision of garbage pick-up trucks and the financial support given to localities that needed help in the improvement of their SWM. The study clearly pointed out, however, that a review of the organizational structure of the city's Division of Sanitation and of the functions of each personnel should be a top priority in view of the unabated in-migration leading to a rapidly increasing population and the fast developments that the city have been experiencing. It likewise suggested increasing the number of garbage pick-up trucks, educating the residents on waste segregation and composting and prescribed the use of a sanitary landfill. The study also strongly suggested that the private sector and the LGU will have to work cooperatively to tackle problems on waste disposal and management.

Environmental and Socio-Economic Impact of the Irisan Dumpsite

Health concerns particularly from methane-emitting, degrading waste encouraged a similar study a decade later. But this time the research was focused on an area in barangay Irisan where approximately 150,000 kilos of waste 60% of which is spoiled vegetables are thrown daily and served as the sole open dumpsite of the city (**Fig. 3**).

Fig. 3. Irisan dumpsite *circa* 1990's

The study was an attempt to gather concrete data on the effects of the dumpsite to the water supply of low-lying communities particularly the locality of barangay Asin whose residents draw their water from a cave or tunnel located directly below the dumpsite (Giron, O., 1995). The parameters that were measured over a six-month period to establish the physico-chemical characteristics of water samples from the cave were pH, temperature, dissolved oxygen (DO), biochemical oxygen demand (BOD), total coliform organisms, and residual chlorine. Except for temperature and residual chlorine, all the parameters that were monitored constitute the minimum water quality parameters for the classification and reclassification of a water body according to a particular designated use or uses as mandated by Administrative Order No. 34, Series of 1990 of the Department of Natural Resources and Environment (DENR). The measurements obtained were definitive to the classification of the water as Class A or Public Water Supply Class II. According to the National Standards for Drinking Water (NSDW) of the Philippines, this classification is for sources of water supply that will require complete treatment (coagulation, sedimentation, filtration and disinfection). High levels of bacterial contamination particularly organisms of fecal origin like *E. coli* coupled with very low DO concentrations all point to high organic pollution that one may deduce as due to the decaying wastes from the dumpsite.

To determine the economic benefits that the residents were gaining from the dumpsite, a survey of randomly selected 48 households (21% of households in puroks that comprise the dumpsite) was carried out. The results confirmed economic benefits as 40 households were engaged in scavenging out of which 80% indicated scavenging as the main source of family income. The reported monthly earnings from the activity ranged from as high as P5000.00 to not lower than P400.00. Random interviews revealed that women and children pitched in for additional income, and as a result, the children are deprived of basic education, health care and play.

Table 1 enumerates the health and other concerns of 48 respondents andomly selected from the four *puroks* that comprise the dumpsite. The respondents were most concerned with health issues which were mainly respiratory diseases and the proliferation of flies, rodents and cockroaches. Ironically, the survey results on main concerns ruled out the relocation of the dumpsite to another area. Most of the respondents put more consideration on the LGU's adoption of proper waste management and the delivery of basic necessities particularly potable water than on problems attendant to the dumpsite itself.

Table 1. Health and Other Concerns of Irisan Residents

Health Concerns	# of Respondents
Respiratory diseases	44
Gastro-intestinal diseases	12
Proliferation of flies, rodents & cockroaches	28
Others (fever, headache, body malaise)	5
Other Concerns	**# of Respondents**
Sufficient protection gear for dumpsite "workers"	33
Dumpsite may stay but city should adopt proper waste management	35
Provision of incinerator	20
Inadequate water supply	30
Relocation of dumpsite to another area	8
Setting up of cooperative among those whose livelihood depends on the dumpsite	2
Mandatory recycling among city residents	10
Smoke from burning garbage	3
Lack of electricity	3
Lack of money to resettle in other areas	3
Lack of community clinic	3
Undisciplined garbage truck drivers	1
Water purifier	1

A move to convert the dumpsite from open to a controlled one came about in 2006 (City Ordinance No. 17, Series of 2006) but this never materialized due to lack of implementation by the city government. The closure of the dumpsite came about fortuitously as a result of trash slide that happened below the dumpsite where the retaining wall of its lower part collapsed due to the rains caused by Typhoon Mina in August 2011. The tragedy claimed 6 lives, including a 10-year-old boy. Only a small area in one of the *puroks* of Irisan has been left open as staging area where recyclables can be retrieved from the collected trash before the dump trucks transport them to landfills in the lowlands.

Survey on Waste Segregation

Another ordinance in 2006 (Comprehensive Solid Waste Management Ordinance of the City of Baguio, City Ordinance No. 16) mandated 3 type segregation of solid wastes in view of the proliferation of and increasing use of plastic materials. The city government likewise promulgated City Ordinance No. 26 in 2007 that sought to ban the use of plastic bags in the city. The LGU put more teeth into CO No. 16 and mandated waste segregation in households as one measure to curb excessive waste disposal after the tragic landslide that resulted to the closure of the Irisan dumpsite. In 2013, an informal survey on the question of awareness of waste segregation schemes was conducted involving 231 students from a population of approximately 2000 who were enrolled in a premier university of Baguio City. The results revealed that 30.7% of the respondents had no knowledge of the mandated waste segregation (Giron, O., 2013). A closer scrutiny of the types of dwellings where the students reside showed that 7 out of 10 are staying in boarding houses and are totally dependent on their landlords/ladies for information whereas only 1 out of 10 resides in student

dormitories where information dissemination is more systematic and a stricter implementation of the scheme is expected. On the question of how are plastic wastes disposed of, only 10% of the respondents practice recycling and selling to junk shops as a disposal method.

Current Programs and Alternative Solutions

Cause-oriented groups and citizens composed of Baguio old-timers, the religious sector, the young and old, students and professionals, the urban poor, the activists and environmentalists have incessantly expressed their waste disposal and management concerns through the media, through statements, through rallies and mass actions. One group that is into proper waste disposal is the Baguio Vermi Growers or BVG that was organized in 2009. The members of the BVG practice vermiculture or the process of raising African night crawler earthworms that are known to facilitate the fast decomposition of solid wastes such as vegetable and fruit peelings and even paper. The BVG members harvest the organic material that is produced to be marketed as organic fertilizers. Vermiculture has been cited as one of the workable solutions to at least 40 percent of the city's daily 200 tons of wastes.

Tebtebba, a non-government organization that promotes indigenous knowledge and rights, particularly through its Traditional Knowledge Network, helped organize and is currently providing support to the BVG by conducting forums and workshops on vermiculture.

Another cause-oriented group, the *Baguio Citizens No Waste Initiative*, was formally organized in 2012 with the primary aim of building citizen participation in waste management policy and

development and programs and unequivocally expressed in a statement its belief that citizens' participation is a necessary ingredient for successful and sustainable waste management in the city. The BCNWI has evolved into subgroups such as the *No to Plastic Wastes* cluster whose volunteer members are involved in various activities, information dissemination and educational campaign on the deleterious effects of plastic use. The *No to Plastic Wastes* members have also been rallying for the implementation of 2007 CO No. 26 as commercial establishments and market merchants have not been required to use non-plastic bags and packaging materials up to the present.

The Baguio City LGU has maintained that it has adopted a stricter implementation of the waste segregation plan. It also announced that the city has acquired two Environmental Recycling System (ERS) machines, each at a price of P64 million, to address the garbage issue with the ERS machines expected to manage biodegradable waste by converting it to organic fertilizer. The purchase of the ERS machines was based on an agreement between the city and an ERS provider wherein the latter would take charge of collecting the solid waste from the City's barangays and hauling the residuals to Engineered Sanitary Landfills (ESL) in the lowlands. Reports indicate that in 2014 the city generated 366 tons of solid waste per day, 122 tons were hauled out, 30 tons processed by the ERS, and 214 tons classified as recyclables and taken by waste pickers. Currently, the ERS machines are known to only able to reduce the volume of garbage by a measly 15% leaving the city faced with issues and problems on the remaining trash.

The Department of Interior and Local Government (DILG), as part of its assessment of the environmental governance of LGUs, has advised the city to shape up in urban ecosystems management and put to task the city particularly in the areas of pollution control and proper solid waste management. The DILG thus suggested the following actions for the city to undertake: (1) strengthen the Solid Waste Management Board; (2) prepare, if none has been formulated, or improve the quality of, the Solid Waste Management Plan; (3) ensure that every barangay has a material recovery facility; and (4) improve solid waste collection practices.

Based on the DILG's recommendations, the city government is pursuing an Integrated Solid Waste Management Plan (ISWMP) and started discussions on these as early as 2015. One of the strategies named in the ISWMP is the construction of an ESL to address the city's waste problem. The ISWMP also cites other strategies intended for long-term management of the city's wastes among which is a waste-to-energy technology, a central material recovery facility, anaerobic digester and health care waste treatment facility and the ERS machines.

Conclusion

Much has still to be undertaken to abate if not totally eradicate Baguio City's waste disposal and management problems. Based on the above discussion, the following recommendations might help the LGU:
1.   Strictly implement all city ordinances related to waste disposal.
2.   Increase LGU-citizens engagement in policy-making, plan of actions and activities involving waste disposal and management.
3.   Give due recognition, consideration and support to local initiatives to make them more sustainable.
4.   Encourage educational campaigns, information dissemination, advocacies and research
in all sectors – government, non-government and people's organizations.

References

Baguio City Environment Code

Comprehensive Land Use Plan of Baguio City, 2010 – 2020

DENR Administrative Order No. 34 Series of 1990, *Revised Water Usage and Classification/Water Quality Criteria Amending Sec. Nos. 68 and 69, Chap. III of the 1978 NECC Rules and Regulations.*

Giron, O. 1995. *An Initial Study of the Environmental and Socio-Economic Impact of the Irisan Dumpsite* (unpublished report).

Giron, O. 2013. *Students' Awareness of Waste Segregation Scheme* (unpublished report; non-commissioned survey for the *Baguio Citizens No Waste Initiative*)

Macaranas, E. M. 1985. *Joint Municipal and Agricultural Refuse Management for Baguio City and La Trinidad*, Quezon Cit: University of the Philippines, College of Engineering.

National Statistics Office. (2013, July 12). *Population of 319 thousand was recorded in Baguio City* – http://www.census.gov.ph/content/population-319-thousand - accessed 04/5/16

Tebtebba Foundation, 2012. Indigenous *Perspectives on the Baguio Urban Ecosystem*, Vol. 12.

*B*aguio *council wants solid waste plan presented @* www.sunstar.com.ph › Baguio › Local News, Friday, Sept 29, 2015 - accessed 04/6/16

Baguio's garbage woes refuse to disappear @inquirerdotnet_- accessed 04/5/16

http://ptvnews.ph/2/13-13-regional/44268-baguio-city-to-pursue-iswms-project - accessed 04/6/16

www.uncrd.or.jp/content/.../21038EST-City-Report_Philippines-Baguio - accessed 04/5/16.

Application of Low-Grade Industrial Waste Heat for Power Generation Using Organic Rankine Cycle Power Generator Combined with Gas Engine-Driven Heat Pump

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Abstract
This paper presents a power generation using Organic Rankine Cycle (ORC) power generation combined with Gas Engine-Driven Heat Pump (GEHP) by utilizing the low-grade industrial waste heat. In addition, the GEHP is used to upgrade the heat with temperature below 70 °C before supplying to a 20 kW_e ORC power generator. In this study, the GEHP-ORC system is mathematically modeled and simulated in order to evaluate the economics and the environmental impact of the system. The simulated results showed that as the system consumed the 60 °C waste heat for power generation, in term of the economic analysis, the levelized electricity cost (LEC), and the payback period were 0.095 USD/kWh, and 18.7 Year, respectively. In term of the environmental impact, the system could reduce CO_2 emission around at 22.8 Ton CO_2 eq./Year. From this study, it can be concluded that the GEHP-ORC system is applicable for an industry with low-temperature waste heat. This heat can generate more income back to the industry. However, the payback period is normally long for a renewable energy technology. Thus, a subsidy from the government is in need.

Keywords: Low-grade industrial waste heat, ORC power generator, Gas engine-driven heat pump

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Introduction

Energy is primarily significant for the living and economic development. From international Energy Outlook published by EIA, the world's total energy consumption increased from 403×10^{15} Btu in 2001 to 524.00×10^{15} Btu in 2010 [U.S. Energy Information Agency,2004; U.S. Energy Information Agency, 2013]. In addition, the industrial sector consumed more energy than any other end-use sectors (e.g., building sector, and transportation sector). It is also considered as one half of the world's total energy consumption. In industry processes, there is approximately 20 to 50 percent of energy inputs wasted and released into the environment [U.S. Departement of Energy, 2006; BSC, Incorporated, 2008]. Unfortunately, the wasted has the lower temperature than 230 °C and cannot directly be converted into electricity by steam Rankine cycle because this type of the cycle become less profitable at low-temperature below 340 °C [BSC, Incorporated, 2008]. However, it is still productive for power generation by employing the Organic Rankine Cycle (ORC) [Quoilin, S. et al., 2013; Bonilla, J.J. et al., 1997; Bao, J. J. et al., 2011].

Recently, there are many researchers working on the design, analysis, and development of the ORC system for low-temperature waste heat conversion. Le, V. L. et al., (2014) carried out the Exergy efficiency and Levelized Cost of Electricity (LCOE) optimizations of a waste heat to power plant driven by subcritical ORC using a pure or zeotropic mixture working fluid. Tchanche, B.F., (2011) showed that business of an Organic Rankine Cycles (ORCs) for waste heat recovery (ORC-WHR) application grow faster among ORC solution, with an enormous potential in industry and combined cycle power plant. Liu, H. et al., (2015) designed and modified a hybrid energy supply system, including the gas engine-driven heat pump system and ORC using the gas engine waste heat as low-grade heat source in order to transfer the low-grade gas engine waste heat into high-grade electricity by ORC. Chaiyat, N. (2014) proposed a concept to generate electricity from low-temperature heat by using an absorption heat transformer (AHT) coupled with an ORC.

From the literature review, it was found that the ORC power generation systems were generally supplied by heat sources having the temperature above 70 °C [Tchanche, B.F. et al., 2014; Quoilin, s. et al., 2013]. However, the system is less applicable with the below 70 °C heat source, having a large amount from the industrial process. If the ORC system is applied for power generation at below 70 °C heat source, the industrial sectors could benefit from this waste heat and save money from energy consumption, as well as reduce operation cost, and pollution (greenhouse gas emission, and thermal pollution). Upgrading the low-temperature heat to the high-temperature is an interesting approach for ORC power generation. In this research, the objective is to propose the concept of upgrading the low-grade industrial waste heat with the temperature below 70 °C by Gas Engine-driven Heat Pump (GEHP) and producing the electricity by Organic Rankine Cycle (ORC). The Gas Engine-driven Heat Pump integrated with Organic Rankine Cycle (GEHP-ORC) system is mathematically modeled and simulated in order to evaluate the economics and the environmental impact of the system.

Industrial Waste Heat

Industrial waste heat is the unusable heat generated from a combustion in industrial processes, and then directly exhausted to the environment. From the research publication of BSC, Incorporated, it was reported that the quantity of industrial waste heat was as much as 20 to 50% of industrial energy consumption [BSC, Incorporated, 2008]. Moreover, the exhausted gases are mostly at relatively high-temperature while water streams are mostly liquids at low-temperature [Bonilla, J.J. et al., 1997].

Waste heat sources from industries can be classified in 3 different temperature levels as low temperature (< 230 °C), medium temperature (230 – 650 °C), and high temperature (> 650 °C). This temperature classification of industrial waste heat sources with typical recovery method is listed in Table 1 [BSC, Incorporate, 2008]. From the list, none of available technologies can recovery the heat with temperature below 70 °C heat source. Thus, this source of heat will become more beneficial and interesting for industrial sectors.

Table 1: Temperature classification of industrial waste heat sources with typical recovery methods [BSC, Incorporate, 2008].

Categories	Example sources	Temperature (°C)	Typical Recovery Methods / Technologies
High [>650 °C]	Nickel refining furnace	1,370 – 1,650	Combustion air preheater
	Steel electric arc furnace	1,370 – 1,650	
	Basic oxygen furnace	1,200	Steam generation for process
	Aluminum reverberatory furnace	1,100 – 1,200	heating or for mechanical /
	Copper refining furnace	760 – 820	electrical work
	Steel heating furnace	930 – 1,040	
	Copper reverberatory furnace	900 – 1,090	Transfer to med-low
	Hydrogen plants	650 – 1,430	temperature processes
	Fume incinerators	1,300 – 1,540	
	Coke oven	650 – 1,000	
	Iron cupola	820 – 980	
Medium [230 - 650 °C]	Steam boiler exhaust	250 – 480	Combustion air preheat
	Gas turbine exhaust	370 – 540	Steam / power generation
	Reciprocating engine exhaust	320 – 590	Organic Rankine cycle for
	Heat treating furnace	430 – 650	power generation
	Drying & baking ovens	230 – 590	Furnace load preheating,
	Cement kilin	450 – 620	feedwater preheating
			Transfer to low-temperature processes
Low [<230 °C]	Exhaust gases exiting recovery Devices in gas-fired boilers, Ethylene furnaces, etc.	70 – 230	Space heating
			Domestic water heating
	Process steam condensate	50 – 90	
	Cooling water from:		Upgrading via a heat pump to
	Furnace doors	30 – 50	Increase temp for end use
	Annealing furnaces	70 – 230	Organic Rankine Cycle
	Air compressors	30 – 50	
	Internal combustion engines	70 – 120	
	Air conditioning and Refrigeration condensers	30 – 40	
	Drying, baking, and curing ovens		
	Hot processed liquids/solids		

Mathematical Modeling of Organic Rankine Cycle combined with Gas Engine-driven Heat Pump (GEHP-ORC)

In this research work, an Organic Rankine Cycle power generation system combined with Gas Engine-driven Heat Pump (GEHP) is proposed and named as GEHP-ORC system as shown in Figure 1. As the concept of this system, a waste heat from industries is stored in the heat source/thermal storage tank 1. This heat is then upgraded by GEHP to high-temperature heat. Then the heat is stored in the heat

reservoir/thermal storage tank 2. After that, a high-temperature thermal energy in the heat reservoir/thermal storage tank 2 is supplied to the ORC system to generate electricity.
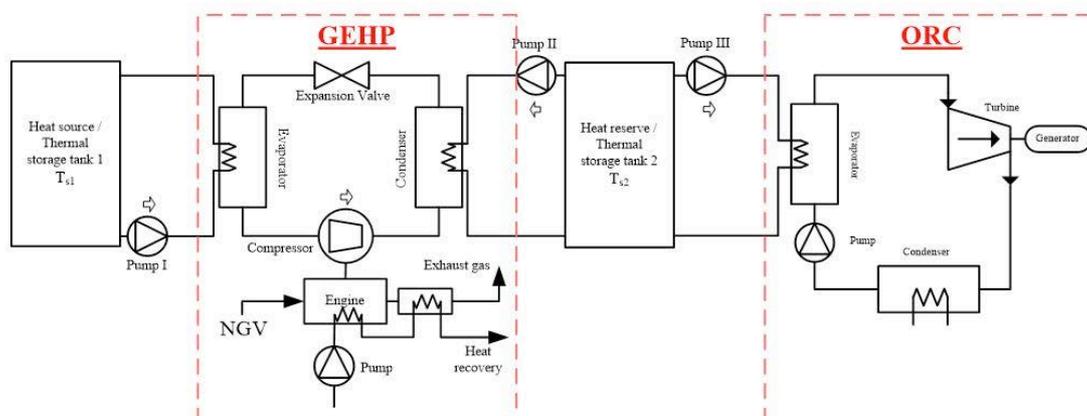

Figure 1: Schematic diagram of the proposed systems (GEHP-ORC system).

Conventional Organic Rankine Cycle system (ORCs)

Organic Rankine Cycle system (ORCs) is an alternative technology applicable for small-scale power generation. It is used for low-temperature heat recovery, by converting low-temperature thermal energy to electricity. Moreover, its operation is similar to that of the steam Rankine cycle but an organic working fluid is used instead of water.

The ORC technology has several advantages such as simple and autonomous operation, low-maintenance, favorable operating pressure, long lifetime (>20 years) and no need for demineralizing water. Thus, the technology has become increasingly interesting for small to medium sized power plants with low-temperature heat sources.

A schematic diagram of the conventional ORC system and the corresponding T-s diagram are shown in Figure 2 and Figure 3, respectively. A low-temperature heat transfer fluid (HTF) of the ORC system is heated by the stored heat in the heat source/thermal storage tank 1 via a heat exchanger (state 2). Then, the HTF is at saturated organic fluid vapor state with high pressure through an evaporator (from state 2 to state 3). Then the vapor is expanded through a turbine to generate power (from state 3 to state 4). Finally, it is condensed to a saturated liquid (state 1) in the condenser to complete the cycle.

The energy equations of the ORC system are summarized as follows.
The rate of heat transfer to the ORC evaporator:

$$\dot{Q}_{Evap,ORC} = \dot{m}_{r,ORC}(h_3 - h_{2a}) = (mc_p)_w(T_{w,i} - T_{w,o}) \tag{1}$$

The power output from the turbine:

$$\dot{W}_{Tur,th} = \dot{m}_{r,ORC}(h_3 - h_4)\eta_{Tur,s} \tag{2}$$

$$\dot{W}_{Tur,el} = \dot{m}_{r,ORC}(h_3 - h_4)\eta_{Tur,s}\eta_{Tur,ME} \tag{3}$$

$$\eta_{Tur,s} = (h_3 - h_{4a})/(h_3 - h_4) \tag{4}$$
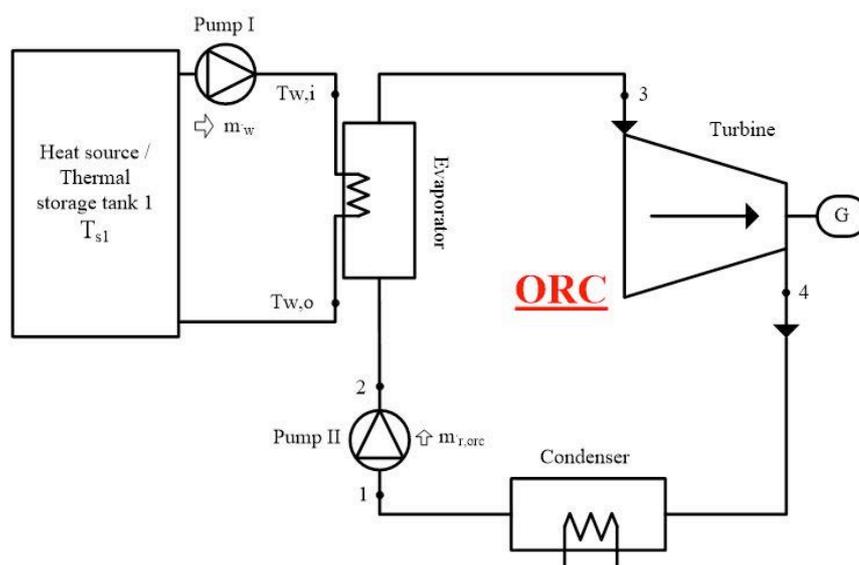
Figure 2: Schematic diagram of the conventional ORC system.
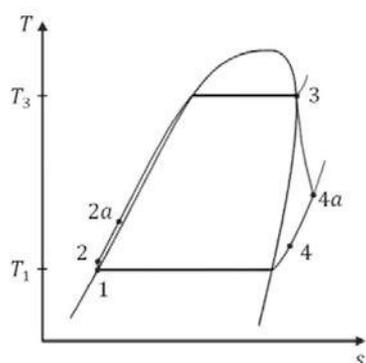
Figure 3: T-s diagram of the conventional ORC system.

The rate of heat transfer removal from the ORC condenser:

$$\dot{Q}_{Cond,ORC} = \dot{m}_{r,ORC}(h_{4a} - h_1) \tag{5}$$

The power input to the ORC pump:

$$\dot{W}_{P,ORC,th} = \dot{m}_{r,ORC}v_1(P_2 - P_1)/\eta_{P,s} = \dot{m}_{r,ORC}(h_{2a} - h_1) \tag{6}$$
$$\dot{W}_{P,ORC,el} = \dot{W}_{P,ORC,th}/(\eta_{P,ME}\eta_{P,MO}) \tag{7}$$
$$\eta_{P,s} = (h_2 - h_1)/(h_{2a} - h_1) \tag{8}$$

The thermal efficiency of the ORC system:

$$\eta_{ORC} = (\dot{W}_{Tur,th} - \dot{W}_{P,ORC,th})/\dot{Q}_{Evap,ORC} \tag{9}$$

Gas Engine-driven Heat Pump system (GEHP)

The Gas Engine-driven Heat Pump system (GEHP) is a vapor compression refrigeration type with an open compressor. It is driven by gas-fuel (i.e. Natural Gas (NG), Liquid Petroleum Gas (LPG)) internal combustion engine instead of an electrical motor. The GEHP mainly consists of two parts: (i) heat pump consisting of compressor, condenser, expansion valve, and evaporator, and (ii) gas engine system to drive the compressor. A schematic diagram of the GEHP system and corresponding T-s diagram are shown in Figure 4 and Figure 5, respectively.

A low-temperature HTF of the GEHP system is heated by the stored heat in the heat source/thermal storage tank 1 via a heat exchanger (state 1). Then, the HTF is compressed in the compressor to increase its temperature and pressure (state 2). The high-temperature HTF is condensed by releasing the heat at the condenser. The released heat is stored in the heat reservoir/thermal storage tank 2 via a heat exchanger. After that, the HTF (state 3) enters a capillary tube where its pressure and temperature drop drastically due to throttling effect. Finally, the low-temperature HTF enters the evaporator (state 4) to restart next cycle.
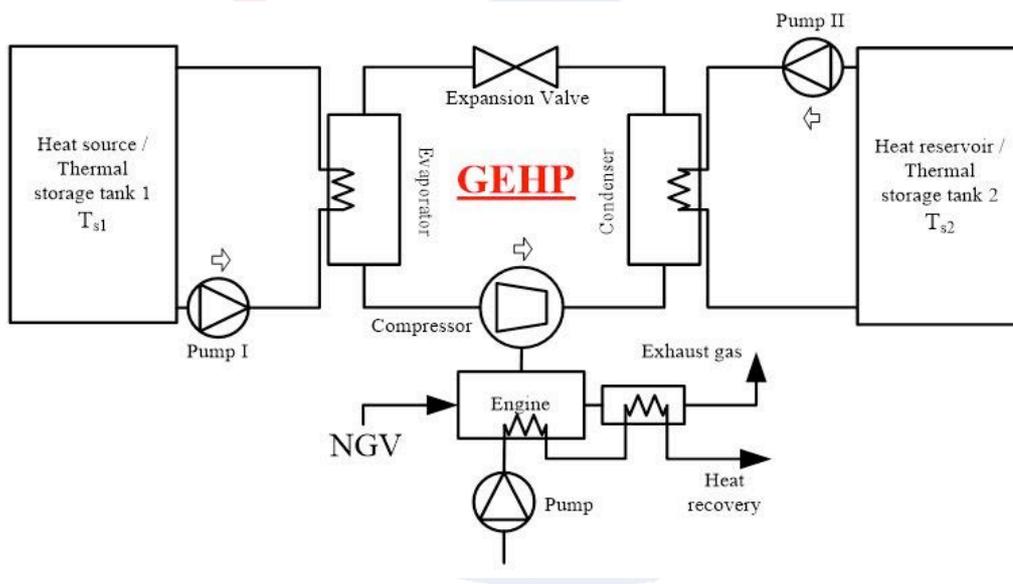

Figure 4: Schematic diagram of the GEHP system.
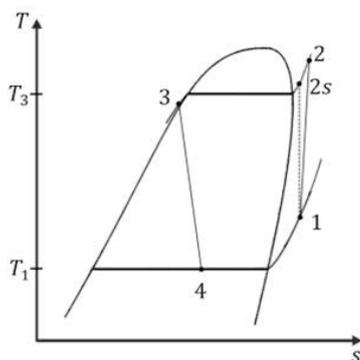
Figure 5: T-s diagram of the GEHP system.

The energy equations of the GEHP system are summarized as follows.
The rate of heat transfer to the GEHP evaporator:

$$\dot{Q}_{Evap,GEHP} = \dot{m}_{r,GEHP}(h_1 - h_4) = (mc_p)_{w1}(T_{w1,i} - T_{w1,o}) \tag{10}$$

The rate of heat transfer to the GEHP condenser:

$$\dot{Q}_{Cond,GEHP} = \dot{m}_{r,GEHP}(h_2 - h_3) = (mc_p)_{w1}(T_{w2,o} - T_{w2,i}) \tag{11}$$

The work input to the GEHP system:

$$\dot{W}_{Comp,GEHP,th} = \dot{Q}_{Cond,GEHP} - \dot{Q}_{Evap,GEHP} = \dot{m}_{r,GEHP}(h_2 - h_1) \tag{12}$$
$$H_{Comp,GEHP,s} = (h_{2s} - h_1)/(h_2 - h_1) \tag{13}$$

Gas engine power consumption:

$$\dot{W}_{Comp,GEHP,th} = \dot{W}_{ge,i}\eta_{ME,GEHP}\eta_{belt} \tag{14}$$

Gas engine thermal efficiency:

$$\eta_{ge,th} = \dot{W}_{ge,i}/\dot{Q}_{in,GEHP} = \dot{W}_{ge,i}/(\dot{m}_{fuel}q_{LHV}\eta_{comb}) \tag{15}$$

Fuel mass flow rate:

$$\dot{m}_{fuel} = \dot{W}_{ge,i}/(\eta_{comb}\eta_{th}q_{LHV}) = \dot{W}_{Comp,GEHP,th}/(\eta_{comb}\eta_{MO}\eta_{belt}\eta_{th}q_{LHV}) \tag{16}$$

Coefficient of performance of the GEHP system:

$$COP_{GEHP} = \dot{Q}_{Cond,GEHP}/\dot{Q}_{in,GEHP} \tag{17}$$

Thermal Storage tank
The water temperature in the thermal storage tank, can be estimated from a lumped model by considering that the thermal storage tank is non-stratified [Kiatsiriroat, T. et al., 1998]:

$$(T_w)^{t+\Delta t} = (T_w)^t + (\Delta t/(Mc_p))(\text{Heat Input} - \text{Heat Output} - \text{Heat Loss}) \tag{18}$$

System conditions

The GEHP-ORC system was mathematically modeled based on steady state condition. The pressure drop was neglected except in the turbine and the pump of an ORC system. Heat loss of system components such as the evaporator, the condenser, the generator, and the piping system was neglected. The temperature inside the thermal storage tank of the system was assumed to be uniform and non-stratified. Initial conditions of the system are shown in Table 2 and Table 3.

In the simulation, the low-grade industrial waste heat as a heat source/thermal storage tank 1 was varied from 60 to 68 °C, and heat reservoir/thermal storage tank 2 was set at 70 °C. The degree of superheating, subcooling and the pinch-point temperature difference was set at 5.0 °C. In addition, heat exchanger effectiveness (ε) was

assumed to be 90%. The thermodynamic properties of the GEHP system and the ORC system were calculated by REFPROP NIST7.0 [National Institute of Standard and Technology (NIST)., 2000]. From the above mentioned, the calculation steps of the GEHP-ORC system is shown in Figure 6.

Table 2: Initial condition of the GEHP system.

Descriptions	Data
Gas engine mechanical efficiency ($\eta_{ge,ME}$) [%]	82.0
Gas engine combustion efficiency ($\eta_{ge,comb}$) [%]	95.0
Efficiency of power transmission (η_{belt}) [%]	95.0
Gas engine thermal efficiency ($\eta_{ge,th}$) [%]	35.0
Fuel lower heating value (q_{LHV}) of the Natural Gas (NG) [kJ/kg]	47141
HP capacity [kWth]	250
Working fluid of HP system	R365mfc

Table 3: Initial condition of the conventional ORC system.

Descriptions	Data
Cycle power (W_{ORC}) [kW$_e$]	20.0
Isentropic turbine efficiency ($\eta_{Tur,s}$) [%]	85.0
Mechanical turbine efficiency ($\eta_{Tur,ME}$) [%]	90.0
Isentropic pump efficiency ($\eta_{P,s}$) [%]	85.0
Mechanical pump efficiency ($\eta_{P,ME}$) [%]	95.0
Motor pump efficiency ($\eta_{P,MO}$) [%]	95.0
ORC condenser temperature [°C]	30.0
Working fluid of the ORC system	R245fa

Economic analysis

The economic analysis was carried out in term of the payback period and the levelized electricity cost (LEC). The initial conditions and cost data used for the economic evaluation of the GEHP-ORC system is shown in Table 4, which could be calculated by

Payback Period:

Payback Period = (Initial investment cost)/(Cash inflow per period)   (19)

Levelized Electricity Cost (LEC):

LEC = (Investment cost + O&M cost×N + Fuel cost×N)/(Net power output×N)   (20)

Capital costs of the ORC power plant, the present cost of the ORC power plant varies between 2,500 – 3,000 USD/kW$_e$. A micro scale of the ORC power plant at capacity lower than 50 kW$_e$ is around 2,500 USD/kW$_e$ [Chaiyat, N., & Kiatsiriroat, T., 2015]. According to the information, 2,500 USD/kW$_e$ for a 20 kW$_e$ power plant was used in this study.
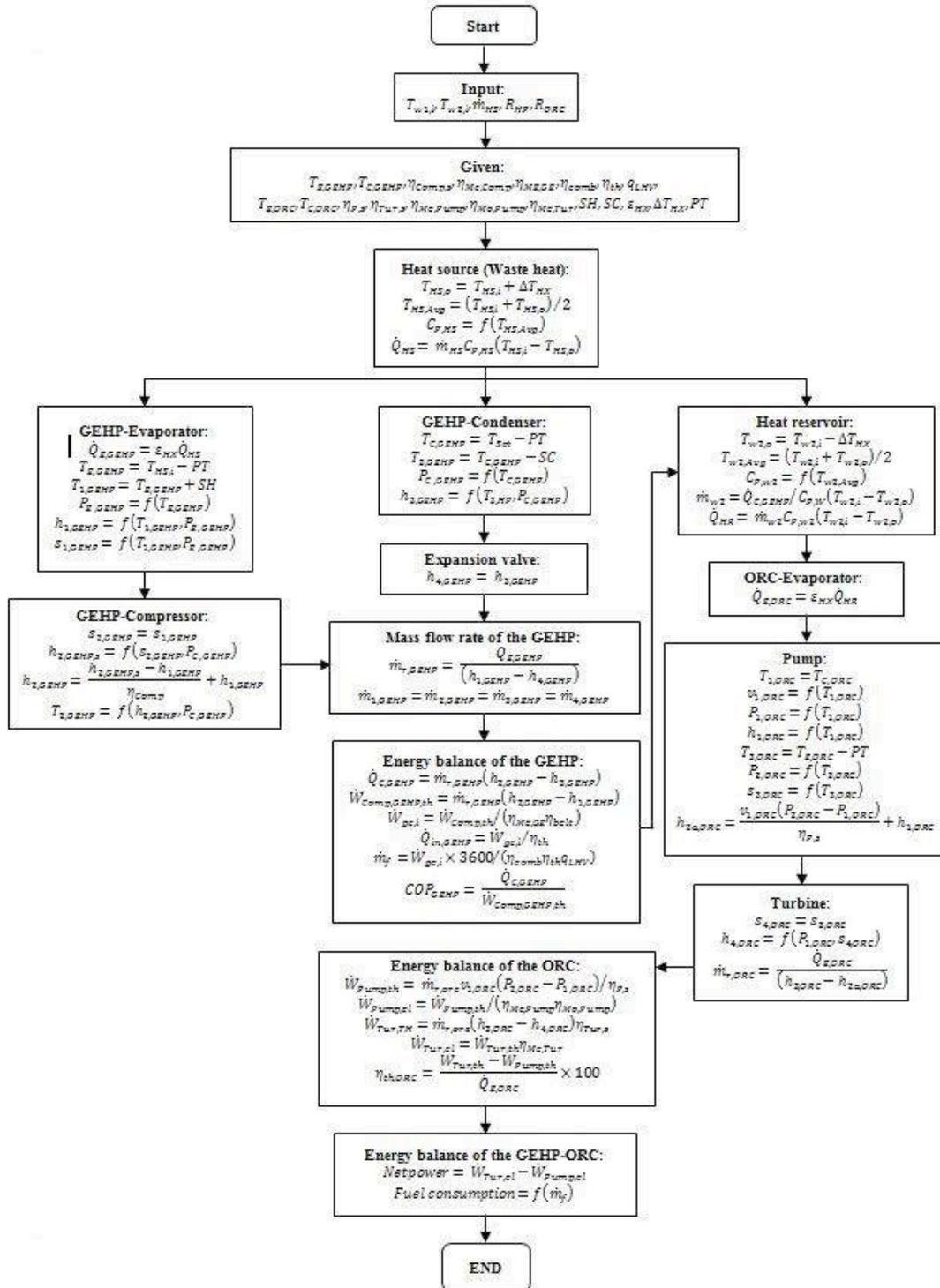
Figure 6: Calculation steps of the GEHP-ORC system.

Table 4: Initial condition, and cost data used for the economic evaluation of the GEHP-ORC system.

Descriptions	Data
Condition	
Operation time [h/d]	24
Operation day [d/y]	350
Investment cost	
Electricity cost [USD/kW$_e$]	0.108
Gas Engine Heat Pump (GEHP) [USD/kW$_{th}$]	326
Cost of the NGV [USD/kg]	0.37
Surcharge for construction and engineering [%]	10.0
Operating & maintenance (O&M) cost	
Operating & maintenance cost (% of investment cost per year)	0.5
Life time of plant [year, N]	25

Result and discussion

The net power output, levelized electricity cost (LEC), the payback period, and CO_2 reduction of the GEHP-ORC system when using the low-grade industrial waste heat were estimated based on the developed mathematical modeling. The results are shown as follows:

Net power output

The net power output and electrical consumption of the GEHP-ORC system, when the temperature of heat source increases from 60 to 68 °C, are constant approximately at 147, and 0.012 MWh/Year, respectively. However, the fuel consumption (Ton of NGV/Year) of the system has the downward trend when the temperature of heat source increases. Figure 7 shows the effect of a change in the heat source temperature (°C) on the fuel consumption (Ton of NGV/Year) of the system. The result found that when the temperature of heat source increases from 60 to 68 °C; the fuel consumption of the system was 20.3, 16.1, 12.0, 7.91, and 3.9 Ton of NGV/Year, respectively.
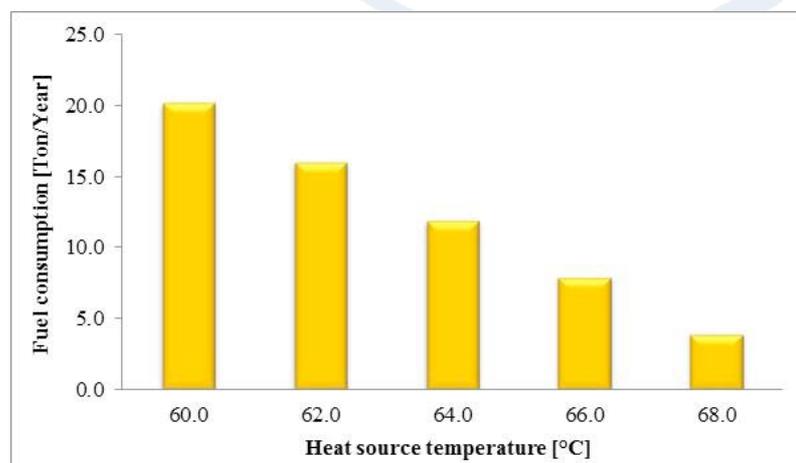

Figure 7: Effect of a change in the heat source temperature (°C) on the fuel consumption (Ton of NGV/Year).

Economic result

The levelized electricity cost (LEC) and the payback period of the GEHP-ORC system was found that when the temperature of heat source is 60 °C, the LEC and the payback period of the system were 0.095 USD/kWh, and 18.7 Year, respectively.

Moreover, the investment of the ORC power plant has an effect on the LEC and the payback period of the GEHP-ORC system. For instance, if the cost of the ORC power plant was set at 1,500 USD/kW$_e$ for a 20 kW$_e$ ORC power plant when the temperature of heat source is 60 °C, the LEC and the payback period of the system were 0.088 USD/kWh, and 15.7 Year, respectively. It can be concluded that the lower investment of the system is, the shorter of the payback period become.

Environment assessment

For environmental impact, carbon dioxide intensity of electricity of Thailand [Energy Policy and Planning, Thailand, 2015] at 0.548 kg CO_2 eq./kWh was used to estimate the CO_2 reduction of the GEHP-ORC system. Figure 8 shows the effect of a change in the heat source temperature (°C) on the CO_2 reduction (Ton CO_2 eq./Year) of the system. The result was found that the CO_2 reduction (Ton CO_2 eq./Year) of the system has the upward trend when the temperature of heat source increases. When the temperature of heat source increases from 60 to 68 °C, the system can reduce the CO_2 emission by approximately 22.8, 34.8, 46.6, 58.2, and 69.6 Ton CO_2 eq./Year, respectively.
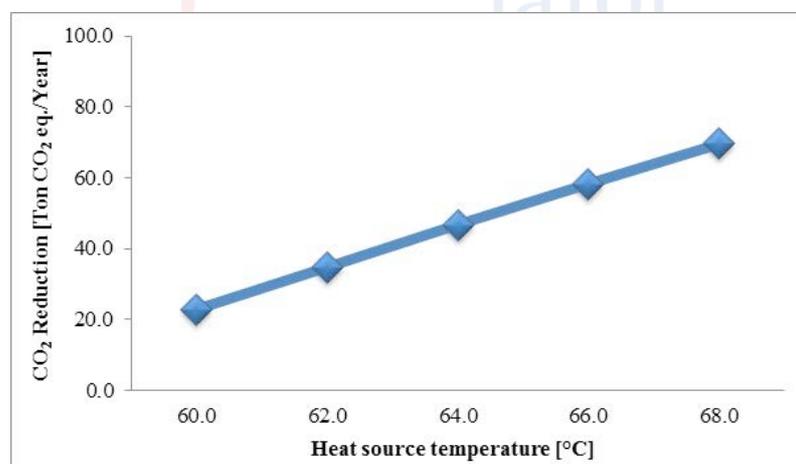
Figure 8: Effect of a change in the heat source temperature (°C)
on the CO_2 reduction (Ton CO_2 eq./Year).

Effect of the heat source temperature

The heat source temperature has an effect on the economic and the environment impact. The study was found that the LEC and the payback period of the system decrease when the temperature of heat source increases. Figure 9 and Figure 10 shows the effect of the heat source temperature (°C) on the levelized electricity cost (USD/kWh), and the payback period (Year) of the system, respectively. The results were found that when the temperature of heat source increases from 60 to 68 °C, the LEC and the payback period of the system were 0.095 USD/kWh and 18.7 Year,

0.085 USD/kWh and 15.6 Year, 0.074 USD/kWh and 13.4 Year, 0.064 USD/kWh and 11.8 Year, 0.054 USD/kWh and 10.5 Year, respectively.
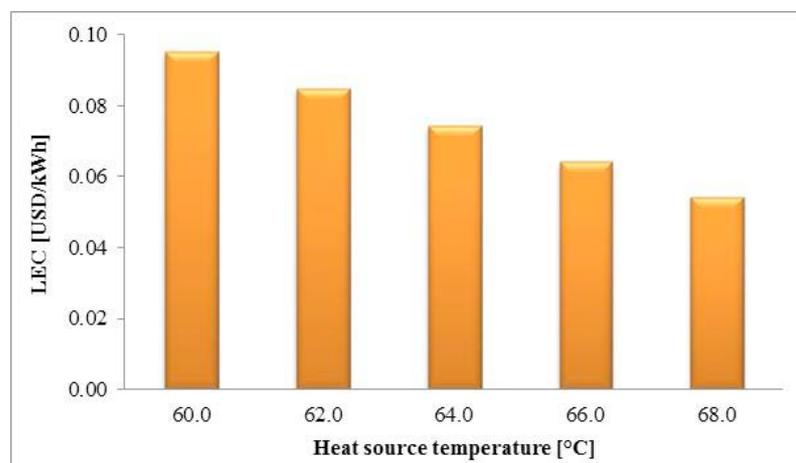
Figure 9: Effect of a change in the heat source temperature (°C) on the levelized electricity cost (LEC).
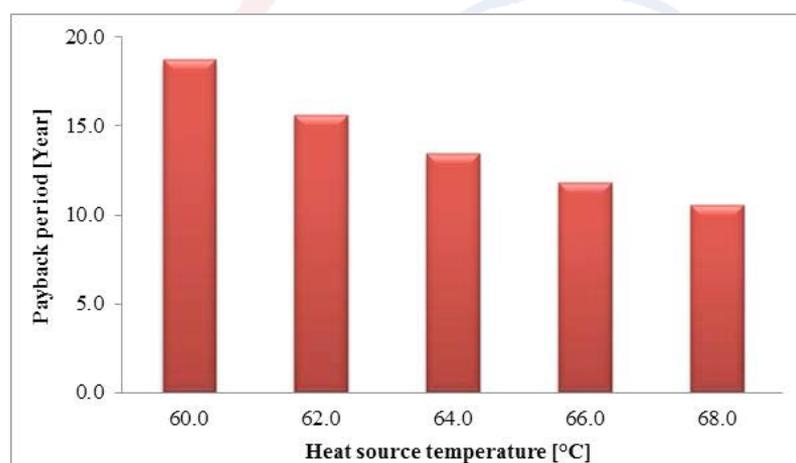
Figure 10: Effect of a change in the heat source temperature (°C) on the payback period (PB).

Conclusions

In this research, a concept of upgrading the low-grade industrial waste heat with the temperature below 70 °C by Gas Engine-driven Heat Pump (GEHP) and integrated by Organic Rankine Cycle (GEHP-ORC) for power production, was proposed and investigated. The system is mathematically modeled and simulated in order to evaluate the economics and the environmental impact of the system. The main conclusions were summarized as follows:

- The GEHP-ORC system can be applied to the low-temperature heat source for heat upgrading before supplying to the ORC power generation.

- The temperature of heat source effects on the GEHP-ORC system in term of the economic and the environmental impact. In term of the economic, the LEC and the

payback period of the system have the decreasing tend when the temperature of heat source increases. In term of the environment impact, the CO_2 reduction increases when the temperature of heat source increases.

- When the temperature of heat source is at 60 °C, the levelized electricity cost (LEC) and the payback period were 0.095 USD/kWh, and 18.7 Year, respectively. The system can reduce the CO_2 emission by approximately 22.8 Ton CO_2 eq./Year. However, the payback period is normally long for a renewable energy technology. Thus, a subsidy from the government is needed.

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References

Bao, J. J., Zhao, L., & Zhang, W. Z. (2011). A novel auto-cascade low-temperature solar Rankine cycle system for power generation. *Solar Energy*, *85*(11), 2710–2719.

Bonilla, J. J., Blanco, J. M., López, L., & Sala, J. M. (1997). Technological recovery potential of waste heat in the industry of the Basque Country. *Applied Thermal Engineering*, *17*(3), 283–288.

BSC, Incorporated. (2008). Waste Heat Recovery: Technology Opportunities in the US Industry. *Waste Heat Recovery: Technology Opportunities in the US Industry*, 1–112.

Chaiyat, N. (2014). Upgrading of Low Temperature Heat with Absorption Heat Transformer for Generating Electricity by Organic Rankine Cycle, *3*(9), 235–247.

Chaiyat, N., & Kiatsiriroat, T. (2015). Analysis of combined cooling heating and power generation from organic Rankine cycle and absorption system. *Energy*, *91*, 363–370.

Electricity cost of Thailand. (2016). Available from: <http://www.pea.co.th> [accessed 15.02.2016].

Energy Policy and Planning, Ministry of Energy, Thailand. (2015). *Energy Statistics of Thailand*, p. 316.

Kiatsiriroat, T., Siriplubpla, P., & Nuntaphan, A. (1998). Performance Analysis of a Refrigeration Cycle Using a Direct Contact Evaporator, *1190*(May), 1179–1190.

Le, V. L., Kheiri, A., Feidt, M., & Pelloux-Prayer, S. (2014). Thermodynamic and economic optimizations of a waste heat to power plant driven by a subcritical ORC (Organic Rankine Cycle) using pure or zeotropic working fluid. *Energy*, *78*, 622–638.

Liu, H., Zhou, Q., Zhao, H., & Wang, P. (2015). Experiments and thermal modeling on hybrid energy supply system of gas engine heat pumps and organic Rankine cycle. *Energy and Buildings*, *87*, 226–232.

National Institute of Standard and Technology (NIST). (2000). REFPROP Version 7. *Thermodynamic Properties of Refrigerants and Refrigerant Mixtures Software*.

Oil price in Bangkok and Vincinity. (2016). PTT Public Company Limited, Thailand. http://www.pttplc.com/TH/Media-Center/Oil-Price/pages/Bangkok-Oil-Price.aspx [accessed 25.02.16].

Quoilin, S., Broek, M. Van Den, Declaye, S., Dewallef, P., & Lemort, V. (2013). Techno-economic survey of organic rankine cycle (ORC) systems. *Renewable and Sustainable Energy Reviews*, *22*, 168–186.

Tchanche, B. F., Lambrinos, G., Frangoudakis, A., & Papadakis, G. (2011). Low-grade heat conversion into power using organic Rankine cycles - A review of various applications. *Renewable and Sustainable Energy Reviews*, *15*(8), 3963–3979.

Tchanche, B. F., Petrissans, M., & Papadakis, G. (2014). Heat resources and organic Rankine cycle machines. *Renewable and Sustainable Energy Reviews*, *39*, 1185–1199.

U.S. Departement of Energy. (2006). Opportunity Analysis for Recovering Energy from Industrial Waste Heat and Emissions. *Technology*, (April), p. 135.

U.S. Energy Information Agency. (2004). International Energy Outlook 2004. *Outlook 2004*, p. 256.

U.S. Energy Information Agency. (2013). International Energy Outlook 2013. *Outlook 2004*, p. 312.

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Surface Level Wind Forecast Simulation over the Land-Sea area and Mountain-Valley area in Thailand

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Abstract
It is known that the dispersion of pollutants from the source mainly depends on velocity and direction of the wind. For the purpose of air quality surveillance of Electricity Generating Authority of Thailand (EGAT), the Regional Atmospheric Modeling System (RAMS) is applied for simulating 168-h low-level wind forecasts over the area of two largest power plants, the Mae Moh Power Plant which is located in a mountain-valley area, and the Bang Pakong Power Plant which is located in a land-sea area. The simulation results were compared with observational wind speed, wind direction, and temperature from various local-based meteorological stations. The comparison shows that the modeled values are generally in good agreement with observations in both land-sea area and mountain-valley area. Furthermore, the model can capture many features of the observed data well and the precision level was internationally acceptable. As a consequence, EGAT's wind forecast simulation project was very effective for further implementation.

Keywords: Regional Atmospheric Modeling System (RAMS), Mae Moh Power Plant, mountain-valley area, Bang Pakong Power Plant, land-sea area

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1.   Introduction

The atmospheric flow is a key of the dispersion of pollutants from the sources. The movement of pollutants, the spread of pollutants, and the dilution of pollutants are all depends on it. Nevertheless, the wind flow data over area in varies attitudes is limited due to sparse meteorological data, particularly in regions of complex terrain. The realistic wind and turbulence fields can improve the mechanisms of pollutants dispersion in further air quality investigation of EGAT. The improvements are not possible while the wind homogeneity hypothesis is employed in most of the regulatory Gaussian dispersion models. It is known that the complex of terrain can cause large changes in wind speed and direction and in the turbulent fluxes that strongly affect to pollutant dispersion. Hanna, S.R. and Strimaitis D.G. (1990) listed some situations of pollutants distribution that are believed to lead increased concentration in complex terrain such as plume impingement on high terrain, pooling of pollutants in valleys, drainage towards population centers and persistence due to channeling inside valleys. The circulations that can give rise to recirculation of pollutants, like sea and mountain breezes. Moreover, breeze circulations can be disturbed by external processes such as synoptic forcing and orography.

The two prior power plants of EGAT, Mae Moh power plant is located in complex terrain, surrounded by mountain ranges where is considered as mountain-valley area and Bang Pakong Power Plant, the location is not far from Bangkok and close to gulf of Thailand where is considered as land-sea area influent. Thus both of these two important power plants are located in the complex terrain of Thailand. This numerical wind flow model is focused to use for meteorological driving in air quality around the power plant area of EGAT in next stage. However, even wind field simulation with meteorological models is a very powerful tool to use in air quality studies but there are a few models that can provide information about the wind behavior in the atmosphere near the surface well. In this study Regional Atmospheric Modeling System (RAMS) version 6.0 is considered to be applied for Mae Moh Power Plant area and Bang Pakong Power Plant area as it is widely using in air quality study. Moreover, the meteorological forecast in the area surrounding Mae Moh Power plant and Bang Pakong Power Plant are expected to be able to predict the distribution of pollutants from the combustion process that can be well-distributed, well-diluted in the atmosphere or the condition of the wind causes a low distribution and accumulation of pollutants in the area. Moreover, the forecast can be able to predict whether the wind blow pollutants from other sources into the power plant. The study would bring benefits in the prevention and mitigation of environmental impact and social issues surrounding the Mae Moh Power Plant and Bang Pakong Power Plant.

This study focuses on the wind field forecasting in those two power plants area by using RAMS, which permitted the study of the interaction of the different scales of motion in defining the regional- and local-scale flow through its nesting capabilities. Model results are also evaluated through analysis of the available meteorological data.

2.   Description of the Model and Model Setup

a.   The RAMS Model

RAMS was developed at Colorado State University and the ASTER Division of the Mission Research Corporation (Pielke et al. 1992). RAMS is constructed around full set of primitive dynamical equations which govern atmospheric motions, and supplements these equations with optional parameterizations for turbulent diffusion, solar and terrestrial radiation, moist processes including the formation and interaction of clouds and precipitating liquid and ice hydrometeors, sensible and latent heat exchange between the atmosphere, multiple soil layers, a vegetation canopy, surface water, the kinematic effects of terrain, and cumulus convection. It is the successor of coupling a cloud model developed by W.R. Cotton and a mesoscale model developed by R.A. Pielke. Continued development of RAMS has followed the philosophy of including a broad range of capabilities within one model system.

An important feature of RAMS is its capacity to perform two-way interactive grid nesting, which allows local fine-mesh grids to resolve small atmospheric systems, while simultaneously modeling the large-scale environment of the systems on a coarser grid. The important features of RAMS are summarized in Pielke et al. (1992). RAMS is using worldwide in difference purposes. Recent air quality studies in Asia region based on the application of RAMS can be found in many references such as Seiji Sugata et al. (2001), Meigen Zhang (2005), Meigen Zhang et al. (2006), Surachai Sathitkunarat et al. (2006), Sittichai Pimonsree et al.(2009), Xiao Han et al. (2009), Cui Ge et al. (2011), Yi Gao et al. (2014) and Zhen Peng et al. (2015).

b.   Model Setup

After several preliminary testing, the suitable model lateral boundary domain configuration for area over Mae Moh Power Plant and area over Bang Pakong Power Plant can be set. For the present study, a two-nesting model domain has been defined for both areas as follows.

1)   The outer model domain has a horizontal grid increment of 3 km with 120×120 grid points.

2)   The inner model domain has a horizontal grid increment of 1 km with 152×152 grid points centered at 18.3N, 99.7E for Mae Moh Power Plant area, and 13.5N, 101.0E for Bang Pakong Power Plant area.

Thirty vertical levels following the topography were used in all grids beginning with 30-m vertical spacing near the ground, the vertical thickness increasing up to 1,500 m at an altitude and remaining constant up to about 15 km. The horizontal perspective of outer and inner domain configuration for Mae Moh Power Plant area and Bang Pakong Power Plant area can be displayed as in Fig. 1 and 2 respectively. As seen in Fig. 1 and Fig.2, Mae Moh Power Plant is surrounded by mountains and Bang Pakong Power Plant is closed to the sea of gulf of Thailand.

Daily initial meteorological input dataset for RAMS calculating is downloaded periodically in each day, 4 times a day at 00 UTC, 06 UTC, 12 UTC, and 18 UTC, from the National Centers for Environmental Prediction (NCEP), National Oceanic Atmospheric Administration (NOAA). The dataset consists of set of parameters such as Pressure, Geopotential Height, Temperature, Humidity, Vertical Velocity, V-component Wind Speed, U-component Wind Speed, Accumulated Precipitation, Soil

Moisture, Total Cloud Cover, Radiation Fluxes, Categorical Precipitation, Convective Available Potential Energy, Convective Inhibition, Absolute Vorticity, and Albedo.
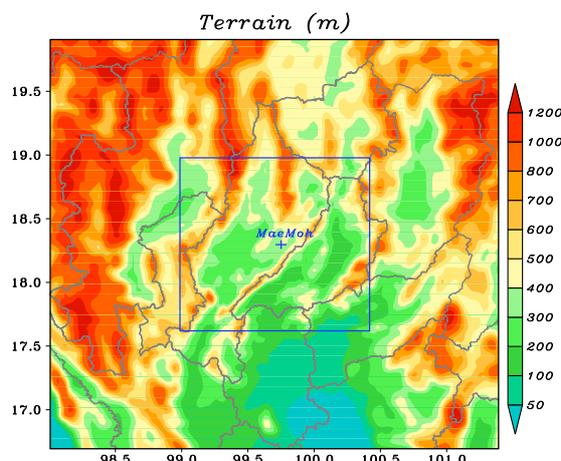
Figure 1 Outer and Inner Domain of Mae Moh Power Plant area.
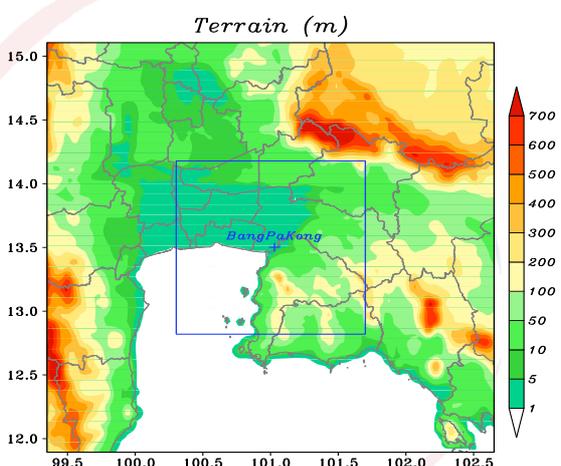
Figure 2 Outer and Inner Domain of Bang Pakong Power Plant area.

3. Simulation Results and Discussion

a. Model Performance

The performance of the modeling system was evaluated by comparison of simulation output and observation in whole year 2013. The statistical parameters which using for model performance evaluation are Mean bias (MB), Root mean square error (RMSE), and Fraction bias (FB).

Model Performance over Mae Moh Power Plant Area: The output results from RAMS, i.e., wind direction, wind speed, and temperature are compared with the observational data from 10 monitoring stations of EGAT.

− Wind direction: the evaluation of wind direction is done under the consideration of percentage of difference in modeled and observed wind directions less than 45°. The percentage which ≥50 shows the good performance of the simulation, from the comparison found comparison at 6 from 10 stations has ≥50 percentage that difference in modeled and observed wind directions less than 45°. From the observed hourly wind speed data over Mae Moh Power Plant area shows the greatest portion of wind speed is lesser than 1.5 m/s (more than 50 percent) and when consider in the Beaufort wind force scale which provides an empirical description of

wind speed based on observed sea and land conditions, the Beaufort wind force scale 1 is classified by wind speed 0.3–1.5 m/s with the land condition found leaves and wind vanes are stationary. Thus, even the wind over Mae Moh power plant area is light; we can say the model simulation output can reflect the wind direction quiet well. well.

Table 1 Model comparison results of wind direction

	Station	Symbol	N	45°	MB	RMSE	FB
1	Phatupha Army Camp	PC	5889	64.66	15.56	67.19	0.19
2	Ban Thasi	TS	3407	48.64	29.08	78.07	0.41
3	Ban Sadet	SD	5280	43.30	29.46	90.94	0.27
4	Ban Hua Fai	HF	6969	38.56	25.39	89.14	0.25
5	EGAT Housing Ban Huai King	HK	1528	61.78	10.38	64.19	0.20
6	Government Center	GC	5705	58.05	-1.47	65.59	0.05
7	Ban Sop Moh	SM	4253	52.10	-1.26	75.72	-0.03
8	Ban Sop Pad	SP	2405	50.31	23.39	77.22	0.11
9	Ban Mae Chang	MC	4987	47.48	40.30	87.34	0.30
10	Ban Mai Ratanakosin	RS	4423	53.29	25.57	67.76	0.13

Note: N = number of modeled and observed data paired in time and space
45^0 = percentage of difference in modeled and observed wind directions less than 45°

–   Wind speed: The comparison of wind speed is shown in Table 2. It is found MB is greater than zero in almost all stations, this comes from the most of simulation wind speed is greater than observed. By the way, the value of FB mostly is in range -0.5 to 0.5 (acceptance range is −2.0≤FB≤+2.0), it can be said the RAMS is the best performing model in simulation of wind speed over Mae Moh Power Plant area.

Table 2 Model comparison results of wind speed

	Station	Symbol	N	mean observed	mean modeled	standard deviation of observed	standard deviation of modeled	MB	RMSE	FB
1	Phatupha Army Camp	PC	5889	1.13	1.06	90.00	99.69	-0.07	0.62	-0.17
2	Ban Thasi	TS	3407	0.93	1.07	79.75	98.53	0.14	0.80	-0.11
3	Ban Sadet	SD	5283	1.16	1.29	70.79	94.59	0.13	1.04	-0.24
4	Ban Hua Fai	HF	6969	1.30	1.00	70.47	96.57	-0.30	0.96	-0.58
5	EGAT Housing Ban Huai King	HK	1528	0.76	1.52	63.87	88.74	0.76	1.25	0.37
6	Government Center	GC	5705	1.18	1.32	74.53	96.77	0.13	0.92	-0.12
7	Ban Sop Moh	SM	4253	1.20	1.21	70.30	94.12	0.01	1.05	-0.30
8	Ban Sop Pad	SP	2405	0.90	1.20	74.97	96.13	0.30	0.94	0.00
9	Ban Mae Chang	MC	4998	1.08	0.97	80.87	98.32	-0.11	2.62	-0.36
10	Ban Mai Ratanakosin	RS	4423	0.93	1.29	78.02	97.11	0.36	0.87	0.08

–   Temperature: Table 3 shows the comparison of temperature at each monitoring stations. It is found the value of FB is in range -0.5 to 0.5 in every

monitoring station. . It is also found most of model temperature is greater than observed as the MB is greater than zero in all stations.

Table 3 Model Comparison results of temperature

	Station	Symbol	N	mean observed	mean modeled	correlation coefficient	standard deviation of observed	standard deviation of observed	MB	RMSE	FB
1	Phatupha Army Camp	PC	8655	24.21	25.81	0.82	4.71	5.11	1.59	3.36	0.06
2	Ban Thasi	TS	8679	24.85	26.94	0.81	5.99	5.12	2.09	4.13	0.09
3	Ban Sadet	SD	8708	26.23	28.40	0.80	5.76	5.76	2.17	4.22	0.08
4	Ban Hua Fai	HF	8695	26.01	26.57	0.83	5.49	4.43	0.56	3.13	0.03
5	Meteo. Main Station	MS	8705	25.56	26.94	0.82	5.32	4.61	1.39	3.32	0.06
6	EGAT Housing Ban Huai King	HK	8676	25.84	26.80	0.82	5.22	4.55	0.96	3.15	0.04
7	Government Center	GC	8578	25.66	26.34	0.83	5.15	4.38	0.68	2.98	0.03
8	Ban Sop Moh	SM	8646	26.06	27.31	0.82	5.45	2.39	1.25	3.98	0.07
9	Ban Sop Pad	SP	8660	24.70	26.86	0.78	5.22	4.68	2.16	3.94	0.09
10	Ban Mae Chang	MC	8591	25.79	26.75	0.83	5.29	4.58	0.96	3.09	0.04
11	Ban Mai Ratanakosin	RS	8634	25.26	27.32	0.80	5.82	5.55	2.06	4.12	0.09

Besides the statistics evaluation, to see the hourly variation change in each day of temperature from modeled and observed, the time series plot is used such as Figure 3 and Figure 4. It is shown that the variation of modeled is in good agreement with observed. Besides it is found the magnitude of modeled in dry season is in better agreement with observed than in wet season.
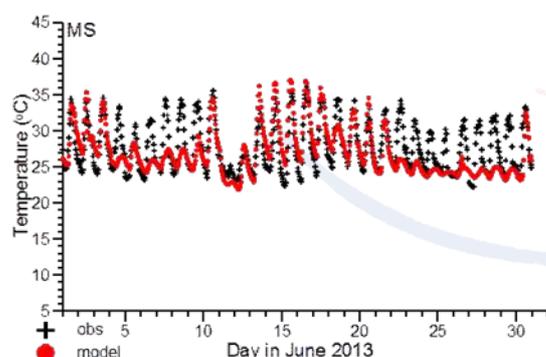

Figure 3 Time series plot of temperature between modeled and observed at Meteorological Main Station in June 2013 (wet season)
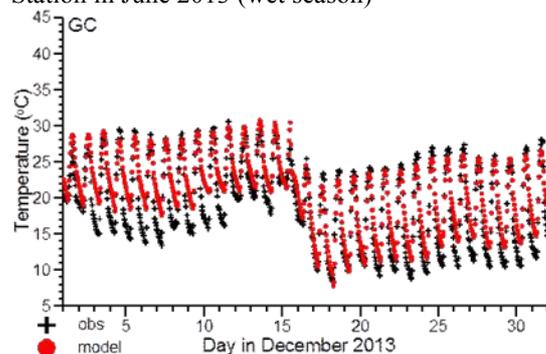

Figure 4 Time series plot of temperature between modeled and observed at Government Center Station in December 2013 (dry season)

Model Performance over Bang Pakong Power Plant Area: The model simulation results from RAMS are compared with the observational data from 2 monitoring stations of EGAT.

−　　　　Wind direction: The comparison is done for number of modeled and observed data paired in time and space comes from the paired data which observed wind speed is equal or greater than 0.5 m/s. This comparison found percentage of difference wind direction less than 45° greater than 70% in both monitoring stations, even the results from RAMS is the averaging over both space and time while the observed is the averaging over time only. That means the model output can reflect the wind direction over Bang Pakong Power Plant area much better than Mae Moh Power Plant area.

Table 4 Model comparison results of wind direction

STATION		SYMBOL	N	45°
1	Bang Pakong Training Center Station	TC	7735	73.55
2	Wat Lang Station	WL	7512	73.62

Note: N = number of modeled and observed data paired in time and space
45^0 = percentage of difference in modeled and observed wind directions less than 45°

−　　　　Wind speed: The evaluation of RAMS' simulation for wind speed over Bang Pakong area. It is found MB is greater than zero in both stations that means the model wind speed is greater than observed. It is found the value of FB is in range -0.5 to 0.5.

Table 5 Model Comparison results of wind speed

	Station	Symbol	N	mean observed	mean modeled	standard deviation of observed	standard deviation of modeled	MB	RMSE	FB
1	Bang Pakong Training Center Station	TC	7735	1.92	3.00	38.97	71.21	1.09	1.79	0.31
2	Wat Lang Station	WL	7512	1.52	2.39	50.21	85.05	0.87	1.36	0.36

−　　　　Temperature: The model can predict the value of temperature below the observed data at Bang Pakong Training Center Station (MB < 0) and over the observed at Wat Lang Station (MB>0). The value of FB is in range -0.5 to 0.5.

Table 6 Model Comparison results of temperature

	Station	Symbol	N	mean observed	mean modeled	correlation coefficient	standard deviation of observed	standard deviation of observed	MB	RMSE	FB
1	Bang Pakong Training Center Station	TC	8606	28.81	28.53	0.64	2.57	1.60	-0.28	1.98	-0.01
2	Wat Lang Station	WL	7676	28.23	29.17	0.86	3.19	3.70	0.95	2.13	0.03

Time series plot of temperature in wet and dry season shows the good agreement in variation. The modeled shows temperature variation in dry season better than wet season.
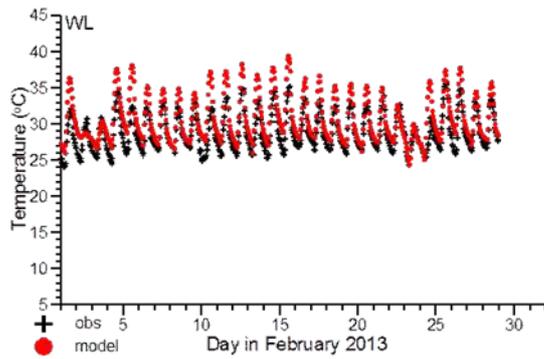
Figure 5 Time series plot of temperature between modeled and observed at Wat Lang Station in February 2013 (dry season)
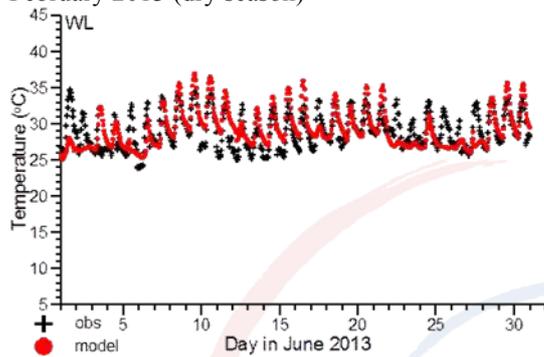

Figure 6 Time series plot of temperature between modeled and observed at Wat Lang Station in June 2013 (wet season)

b.   Wind Circulation over Land-Sea area and Mountain-Valley area
It is known that the terrain morphology can give the effect to surface wind circulation when the effects of synoptic weather is not strong. During the period that synoptic force is weak in area over Mae Moh Power Plant; in night-time the cooling of the air on the mountainsides generates downward streams (Figure 7) and in day-time after sunrise, opposite streams is progressively established at these mountains (Figure 8). This is the mountain-valley breeze found over Mae Moh Power Plant area.
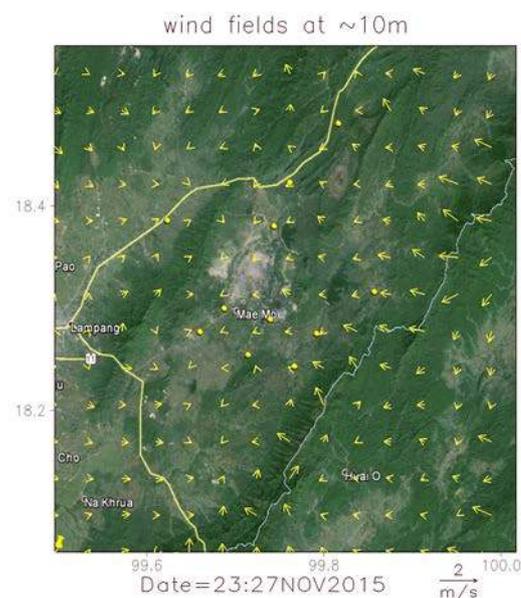
Figure 7   Mountain-breeze in night-time over Mae Moh Power Plant Area at 23:00 o'clock, 27 November 2015
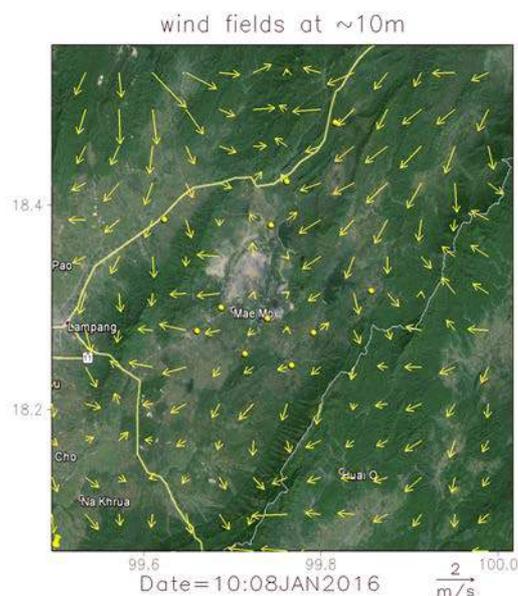
Figure 8 Valley-breeze in day-time over Mae Moh Power Plant Area at 10:00 o'clock, 8 January 2015

It is found that the boundary layer wind field over Bang Pakong Power Plant area is strongly dominated by effect from synoptic condition in almost whole year. However, when the synoptic condition is weak, surface wind is controlled by the morphology of the landscape. In day-time after sunrise temperature rising over the sea surface is relatively slower rate than temperature rising over the land surface, result in cool air from sea flow towards the lower pressure (warm temperature causes the air to expand, becoming less dense) over land as seen on Figure 9.
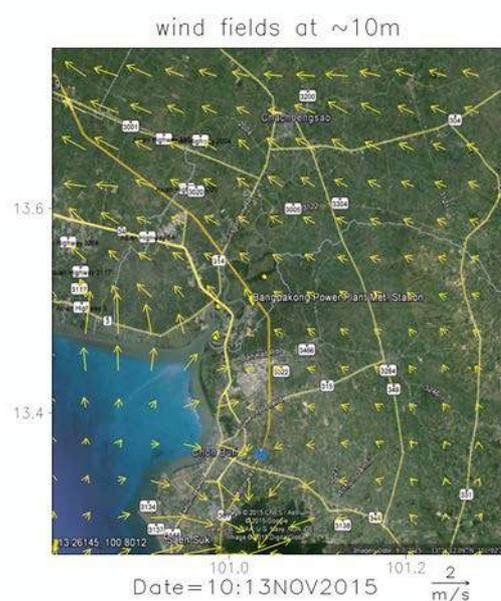
Figure 9 Sea-breeze in daytime over Bang Pakong Power Plant Area at 10:00 o'clock, 13 November 2015

4.   Conclusion

The Regional Atmospheric Modeling System (RAMS) is selected to simulate the planetary boundary wind over two complex terrains, the mountain-valley area and land-sea area in Thailand. The model evaluation was done for different weather condition in whole year 2013. Analysis of the model results indicates that the model can simulate major features of synoptic condition, terrain induced circulation and diurnal variations in temperature well.

The model still shows the simulation performance of temperature in dry season better than wet season. It is the impacts of clouds on radiative heating. In present, clouds forecasting is still one of the weakness aspects of the meso-scale meteorological modeling system in tropical region. The improving of the cloud process is still going on and need the more data in tropics.

Nowadays the simulation system of RAMS over area of Mae Moh Power Plant and Bang Pakong Power Plant can be run automatically every day. The modeling system output gives meteorological condition in hourly prediction for 168-hours (7 days) ahead in each daily period of simulation. The modeling output is extracted to show the results in graphic display on EGAT's website for all users at http://aether.egat.co.th.
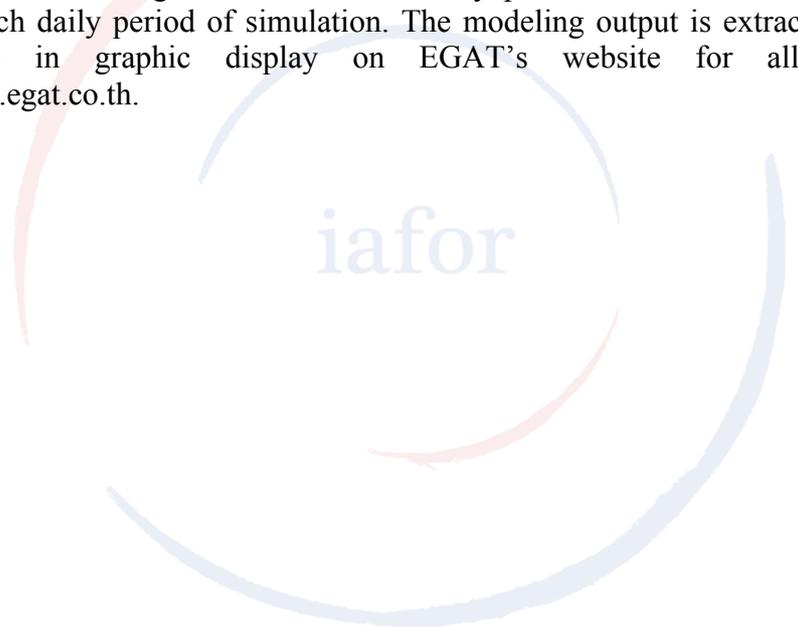
References

Hanna, S.R. and Strimaitis D.G., 1990: Rugged terrain effects on diffusion, in Blumen (Editor) Atmospheric processes over complex terrain, American Meteorological Society, Boston, 323 pp.

Pielke, R.A., Cotton, R.W., Walko, R.L., Tremback, C. J., Lyons, W.A., Grasso, D.L., Nicholls, M.E., Moran, M.D., Wesley, D.A., Lee, T.J., and Copeland, J.H., 1992: A Comprehensive Meteorological modelling System - RAMS, Meteorol. Atmos. Phys., 49, 69-91.

Seiji Sugata, Daewon W. Byun, and Itsushi Uno, 2001, Simulation of sulfate aerosol in east asia using models-3/CMAQ with RAMS meteorological data, Air Pollution Modeling and Its Application XIV, Edited by Gryning and Schiermeier, Kluwer Academic/Plenum Publishers, New York

Meigen Zhang, A multi-scale air quality modeling system and its evaluation I. Introduction to the model system and simulation of meteorological parameters. Chinese J. Atmos. Sci., 29(5), 805-813, 2005.
Meigen Zhang, A multi-scale air quality modeling system and its evaluation II. Simulation of tropospheric ozone and its precursors in East Asia. Chinese J. Atmos. Sci., 29(6), 926-936, 2005.

Meigen Zhang, Hajime Akimoto, Itsushi Uno, A three-dimensional simulation of HOx concentrations over East Asia during TRACE-P, J. Atmospheric Chemistry, doi:10.1007/s10874-006-9015-0, 2006. (SCI)
Meigen Zhang, Itsushi Uno, Renjian Zhang, Zhiwei Han, Zifa Wang, Yifen Pu, Evaluation of the Models-3 Community Multi-scale Air Quality (CMAQ) modeling system with observations obtained during the TRACE-P experiment: Comparison of ozone and its related species. Atmos. Environ., 10.1016/J.Atmos. Env.2005.06.063, 40(26), 4874-4882, 2006. (SCI)

Surachai Sathitkunarat, Prungchan Wongwises, Rudklao Pan-Aram, and Meigen Zhang, Carbon monoxide emission and concentration models for Chiang Mai urban area, Advance in Atmospheric Sciences, 23(6), 901-908, 2006.

Sittichai Pimonsree, Prungchan Wongwises, Rudklao Pan-Aram, Meigen Zhang, Model analysis of PM10 concentration variations over a mineral products industrial area in Saraburi, Thailand, Water, Air, & Soil Pollution, 201, 239–251, 2009.

Xiao Han, Meigen Zhang, Xiaohong Liu, Steven Ghan, Xin Jinyuan,Wang Lili, Development of RAMS-CMAQ to simulate aerosol optical depth and aerosol direct radiative forcing and its application to East Asia, AOSL, 2(6), 368-375, 2009.

Cui Ge, Meigen Zhang, Zhiwei Han, and Yanju Liu, Episode simulation of Asian dust storms with an air quality modeling system, Advances in Atmospheric Sciences, 28(3), 511-520, 2011.

Yi Gao, Chun Zhao, Xiaohong Liu, Meigen Zhang, L. Ruby Leung, WRF-Chem simulations of aerosols and anthropogenic aerosol radiative forcing in East Asia, Atmospheric Environment, 92, 250-266, DOI: 10.1016/j.atmosenv.2014.04.038, 2014. 2014.

Zhen Peng, Meigen Zhang, Xingxia Kou, Xiangjun Tian, and Xiaoguang Ma: A regional carbon flux data assimilation system and its preliminary evaluation in East Asia, Atmos. Chem. Phys. 15, 1087-1104, doi:10.5194/acp-15-1087-2015, 2015.

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Does Knowledge of Environmental Organizations Translate into Pro-Environmental Attitudes and Behaviors? Evidence from an Urbanized Tropical Watershed

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Abstract

Suitable watershed management and stewardship practices are essential in the provision of fresh water services. Several factors contribute to the degradation of surface water resources, including deforestation along coastal lowlands and weak regulatory environments. These conditions are observed in the Manatí river basin, a tropical urban watershed in Puerto Rico.

We will explore the association between knowledge of environmental organizations and pro-environmental attitudes and behaviors among those who benefit directly from ecosystem services in the Manatí watershed. Currently established measures of environmental consciousness and attitudes were tested to ensure they were not only appropriate for the local culture, but also comparable to a broader cultural context.

A 202 person stratified sample with a convenience component was obtained at three watershed sites in Puerto Rico during the summer of 2015. An exploratory analysis revealed that knowledge of environmental organizations is associated with pro-environmental behaviors such as recycling. Less knowledge of environmental organizations and espousing negative views of their role were associated with pessimism toward the possibility of changing the environment through personal behavioral change. Understanding how users' attitudes and behaviors are influenced by knowledge of pro-environmental organizations can help identify effective organizational roles as well as volunteering and stewardship efforts to implement watershed management and conservation strategies.

Keywords: pro-environmental organizations, environmental consciousness, environmental awareness, watershed management, pro-environmental behaviors.

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Introduction

During the second half of the 20th century, Puerto Rico's coastal population grew rapidly, slowing down or reversing forest restoration cover along the island's coastal lowlands, and resulting in the degradation of groundwater and surface water resources (Barreto, 1997). Population growth was accompanied by a less stringent enforcement of environmental laws compared to those of the U.S. mainland (Berman-Santana, 1996). Due to its urban character, the Manatí watershed is a location where ecosystem service degradation is evident. Its associated ecosystems have been impacted by coastal development, eutrophication, and debris disposal for decades but there have been minimal attempts to conduct formal studies of human attitudes and the behavior that may help reverse ecosystem degradation trends.

Until recently, the public sector has assumed jurisdiction and responsibility for appropriate watershed management and conservation. The Puerto Rico Department of Natural and Environmental Resources (DNER) and the Environmental Quality Board (EQB) are responsible for the enforcement of environmental protection laws and regulations. Budget cutbacks (Williams Walsh 2016), however, have made it increasingly difficult for the State to ensure compliance. As a result, pro-environmental non-profit organizations may have to assume a more prominent role in watershed conservation and management efforts.

Several stakeholders contribute to the deterioration of conditions in the watershed. For instance, there has been significant agricultural activity in the area during the last 35 years (M. Barreto, personal communication, April 13, 2016). While it is improper to diminish the contribution of any group to current watershed conditions, our aim is to further understanding of one particular sector that stands to lose much from the continued pattern of environmental degradation: resident and visitor recreationists.

The focus of this paper will be to examine potential determinants of knowledge and attitudes towards pro-environmental NGO's in the context of an urban tropical watershed. As pro-environmental organizations assume more environmental conservation and management responsibilities, resident involvement becomes increasingly important. Our research will focus on two components that may determine resident involvement in pro-environmental organizations: awareness or knowledge of their existence, and current attitudes towards their effectiveness in solving environmental problems. Previous studies have reported low levels of pro-environmental NGO awareness and involvement. For instance, Deale, Barber, Murray & Cashion (2012) examined awareness and involvement in non-profit pro-environmental NGO's in the Pamlico-Tar River basin in North Carolina. They reported that more than one-half of participants (54.5%) who stated not belonging to any pro-environmental organizations were not aware of any in their community. Dunlap & McCright (2008) also explored self-reported membership in environmental organizations using United States national Gallup Poll data, and found that only 9.3% of their respondents indicated belonging to local pro-environmental organizations, while 10.2% reported being unsympathetic.

We will initially examine determinants of knowledge or awareness of pro-environmental organizations. Are there any socio-demographic characteristics and

pro-environmental behaviors associated with awareness of pro-environmental organizations?

The second research area of interest is an exploration of possible determinants of attitudes toward the effectiveness of pro-environmental organizations. Are there any respondent socio-demographic characteristics associated with a more favorable opinion of pro-environmental organizations? Are there any particular pro-environmental attitudes and behaviors related to positive views of such organizations?

The current fiscal crisis has crippled the public sector's capacity to adequately manage environmental resources, and environmental NGO's may have to continue assuming increasing responsibilities to fill the resulting gap. This study aims to explore determinants of awareness and attitudes towards environmental organizations to identify possible initiatives undertaken by the public or nonprofit sector that may result in increased watershed resident and visitor involvement in NGO pro-environmental work.

Literature Review

There is ample literature on psychological processes that underlie a person's decision to engage in various pro-environmental behaviors (Kals, Schumacher & Montada 1999; Mayer & Frantz 2004; McPherson & Mayer 2014). Pro-environmental behavior is defined by Kollmuss & Agyeman (2002) as an individual's actions that consciously seek to reduce the negative impact of human activities on the environment. Jensen (2002) provided a similar definition, but focused on personal actions that are directly related to environmental improvements.

Participation in environmental organizations can be seen as a type of pro-environmental behavior that is of relevance to enhance the effectiveness of behavioral policies that require behavioral change (Saunders, Büchs, Papafragkou, Wallbridge, & Smith, 2014). McDougle, Greenspan & Handy (2011) describe environmental volunteerism as a non-activist form of pro-environmental behavior because engaging in environmental volunteer activities allows individuals to participate in civic actions with ecological implications (Liarakou, Kostelou & Gavrilakis 2011). Environmental movements influence behaviors of people, allowing them to engage in new lifestyles (Saunders, Büchs, Papafragkou, Wallbridge, & Smith, 2014), spreading beliefs across publics (Inglehart 1997), and encouraging new institutional practices (Epstein 1998).

Given the pivotal role of volunteerism in the work of pro-environmental organizations, various research efforts have focused on identifying determinants of environmental volunteerism. Environmental motivation, morale and pro-environmental attitudes have been shown to be highly relevant in understanding why people have a higher willingness to be involved in environmental protection, some through environmental organizations (Torgler & Garcia-Valiñas, 2006). Measham & Burnett (2007) describe a general attachment to the environment as well as opportunities to interact with nature as the most influential motives driving environmental volunteerism in urban areas. Liarakou et al. (2011) conducted a study with young adult environmental volunteers in Greece, finding they were more likely than non-volunteers to feel a strong emotional connection to the environment. Studies have also consistently found a positive relationship between pro-environmental

behavior and educational level (Van Liere & Dunlap, 1980; Nord, Luloff & Bridger 1998; Guerin, Crete, & Mercier 2001). Considering environmental participation as one of those behaviors, a correlation has also been observed between education and both environmental participation and unpaid work in environmental organizations (Torgler & Garcia-Valiñas, 2006).

Study Area and Methods

The Manatí watershed is located within 11 municipalities (equivalent to counties according to US Census geographic hierarchy) of the north-central region of Puerto Rico, and has a catchment area of approximately 609 km^2 (DNER, 2008) (see Figure 1). The region is characterized by a humid subtropical climate with an average annual precipitation of 190.5 cm (DNER, 2008). The watershed is mainly rural with a population of approximately 145,581 habitants (U.S. Census Bureau, 2010). Its land cover is mainly composed of forests and grasslands (74%), agriculture (19%), and urban zones (5%).
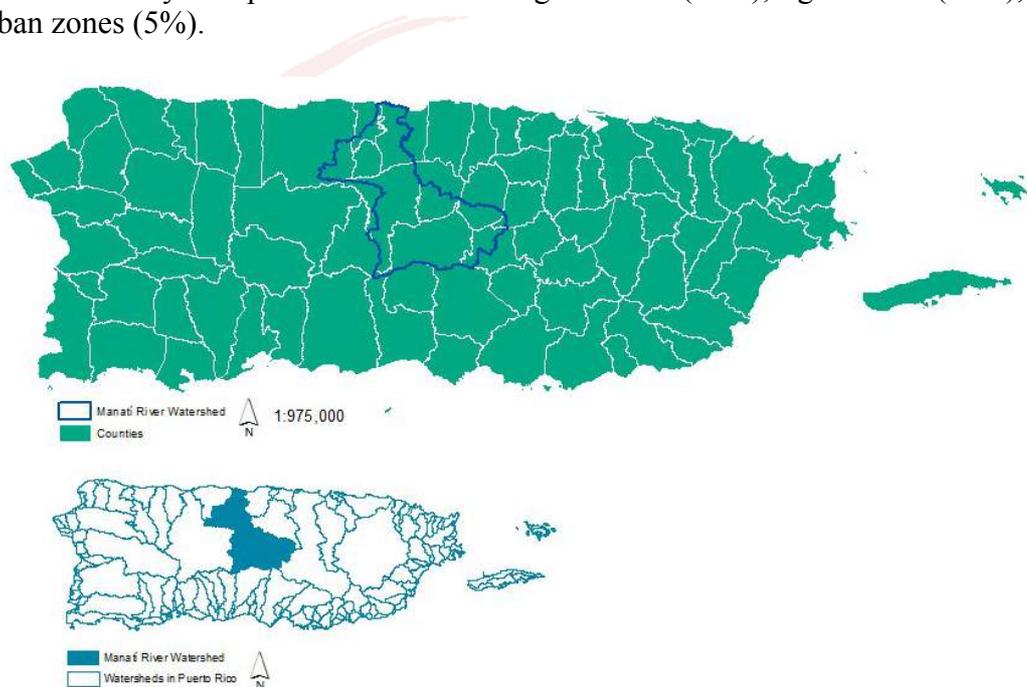
Figure 1: Study Area.

The intercept method was used to conduct in-person interviews in three Manatí watershed sites. The sampling technique has been used in previous studies on recreationists' attitudes towards the conservation and management of bodies of water (Loomis & Santiago 2013). Conducting interviews *in situ* allows us to ensure respondents are experiencing nature while being surveyed on pro-environmental attitudes and behaviors.

Three one-kilometer circles defined survey sites along upstream, midstream and downstream locations (see Figure 2). Upstream survey efforts were concentrated in Toro Negro, a recreation area in the central mountainous region. It is mainly covered by forest and secondary vegetation, and includes several recreation and conservation areas where visitors can bathe in the river and enjoy picnics. Midstream, the second sampling site was the Juan A. Corretjer Linear Walkway, popular as a rest stop for people to enjoy the views, eat and exercise. The downstream survey site, the river

basin outlet, is the location where the river meets the Atlantic Ocean. Alluvial and marine deposits rest over the northern limestone region where people enjoy fishing and surfing, among other recreational activities.

Figure 2: Survey Sites.

A total of 202 in person interviews were conducted during the months of June to August of 2015. Sampling was balanced by day of the week, i.e., weekdays, weekends and holidays. During interview hours (10:00AM to 4:00PM), the research team approached one adult per family, alternating between men and women to achieve a gender-balanced sample. The on-site refusal rate for the in person interviews was 5%, only 10 people out of the combined sample of 212 refused to participate.

The research team met to discuss some of the standard questions used to assess pro-environmental attitudes and behavior in the literature (i.e., Beery & Wolf-Watz 2014, Wilhelm-Rechmann, Cowling & Difford, 2014; Davis, Le & Coy 2011; Jimenez & La Fuente 2010; Perrin & Benassi 2009; and Van Liere & Dunlop 1980), and adapt them to the local cultural context. The survey instrument was designed to gather information on participants' attitudes and behavior by means of Likert scale and dichotomous choice questions. Respondent opinions on the following statements were of particular relevance to our research:

- Non-profit organizations are more interested in causing problems than in mitigating pollution.
- Pollution doesn't affect my life directly.
- Government should implement stronger policies to avoid pollution because people do not follow the rules.

- I think that it is better to solve water problems building more reservoirs and dams than reducing household consumption.
- The Puerto Rico Department of Natural Resources does a good job.
- Changing my behavior will not help environmental conditions.
- The value of nature is just because of its utility for human beings.

Respondents were asked to respond to the previous statements using a Likert scale ranging from 1 (Strong Disagreement) to 5 (Strong Agreement). The following dichotomous choice (Yes/No) questions were also asked as part of the interview process:

- Do you know any non-governmental organizations that deal with environmental issues?
- Do you buy organic products?
- Do you recycle in your house?

The survey instrument also gathered participant socio-demographic data. Questions were pre-tested before submitting them to IRB approval and conducting formal fieldwork.

Analysis

The sample was intentionally divided roughly evenly according to gender, so 53% of respondents were female and 47% were male. The remaining socio-demographic variables in our survey could not be controlled. Table 1 provides a summary of respondent socio-demographic characteristics. The mean age range of participants was 18 to 85, with an average of 42 years. The level of formal education varied from none to a doctoral degree, with the average participant reporting receiving some college education. Annual income, which was significantly correlated to education ($r=0.4438***$), also revealed a wide range, from \$2,500 to \$75,000, with an average of \$29,557.

Table 1. Socio-Demographic Characteristics

	Average	Minimum Value	Maximum Value	Standard Deviation
Age (years)	42	18	85	15
Education (years)	14	1	22	3
Income (US dollars)	\$29,557	\$2,500	\$75,000	\$21,981

	Women		Men	
Gender	Count	Percentage	Count	Percentage
	107	53%	95	47%

Another background variable of interest was the percentage of the population living in rural areas within the respondent's home municipality. There were some home municipalities with no rural population while others had as much as 38% of their population residing in rural areas. On average, nearly one tenth of the population within the respondent home municipalities lived in rural areas.

Overall, respondents have demonstrated varying degrees of agreement with the statements indicating pro-environmental attitudes and behaviors. Table 2 provides a summary of answers to key survey questions. Likert responses were grouped according to three categories: agree, neutral, and disagree. Counts and percentages were presented for dichotomous choice questions.

Table 2. Attitude and Behavior Response Summary

Variable Description	Disagree	Neutral	Agree
The value of nature is just because of its utility for human beings.	71	19	112
Pollution does not affect my life directly.	180	7	15
Government should implement stronger policies to avoid pollution because people don't follow the rules.	6	8	188
I think that it is better to solve water problems building more reservoirs and dams than reducing household consumption.	49	34	118
The Puerto Rico Department of Natural Resources does a good job.	82	71	49
Non-profit organizations are more interested in causing problems than mitigating pollution.	48	74	80
Changing my behavior will not help environmental conditions.	146	20	36

The main focus of this research was to identify possible determinants of awareness and attitudes towards pro-environmental organizations considering variations in socio-demographic profile. Analysis groups were defined as follows: level of education (less or greater than 14 years), income (less or greater than $29,557), number of family members (less or greater than 3) and the degree to which the individual's municipality of residence is rural (less or greater than 9%). Given the exploratory nature of our research, variable associations were examined using Pearson correlation and Chi-square analysis. Statistically significant results were informed according to their significance level: 1% (***), 5% (**), and 10% (*).

There is a strong positive association between knowledge of pro-environmental organizations and two self-reported pro-environmental behaviors: recycling (0.2360***) and purchasing of organic products (0.2647***). The relationship between knowledge of environmental organizations and recycling was particularly strong among older adults (r=0.3395***), those with a lower level of formal education (r=0.2671***), lower income (r=0.2202**), and those living in a more urban surrounding (r=0.3049***).

It seems that respondents familiar with environmental organizations approve of the role of government in environmental management and protection. There is a positive association between reported knowledge of pro-environmental organizations and approval of the tasks undertaken by the Puerto Rico Department of Natural and Environmental Resources (0.1146*).

Those who are aware of pro-environmental organizations also have a more positive attitude towards them. There was significant disagreement with the statement indicating that pro-environmental organizations are more interested in causing problems than solving environmental problems (-0.1691**).

Age is a significant mediating factor when examining the links between knowledge of pro-environmental organizations and associated attitudes and behaviors. There is a strong positive link between knowledge of organizations and recycling behavior only among older adults. Similarly, only older respondents rejected a utilitarian vision of nature, and were more optimistic when considering the impact of behavioral changes on solving environmental problems such as water shortage issues.

Education was also a significant mediator between organizational knowledge and pro-environmental attitudes and behaviors. Those with a higher level of formal education who knew about pro-environmental organizations disagreed with a utilitarian vision of nature and finding technical, instead of behavioral, solutions to water shortage problems.

The extent of rural surroundings in a participant's home municipality was also a mediating factor between knowledge of pro-environmental organizations and attitudes towards environmental issues. Participants living in more urban municipalities tended to reject utilitarian visions of nature, as well as technical solutions to the water shortage problem. They also were less pessimistic about the effectiveness of behavioral changes when addressing environmental problems.

Income did not seem to be as strong a mediating factor when discerning possible patterns between knowledge of pro-environmental organizations and pro-environmental attitudes. There was a positive association among both high and low income groups when it came to recycling, as well as rejecting a utilitarian vision of nature. Pessimistic attitudes towards behavioral change, however, were shown to have a negative relationship with knowledge of pro-environmental organizations only among the lower income group.

Preference for technical solutions to solve water shortage problems was also associated with knowledge of pro-environmental organizations. A significant negative relationship was found, but only among respondents with a higher level of formal education ($r=-0.1865*$), and those living in a more urban municipality ($r=-0.2140*$).

There was a negative relationship between stating being pessimistic that behavioral changes can have an impact on environmental problems and reported knowledge of pro-environmental organizations; that is, the more pessimistic about the effectiveness of behavioral change to address environmental problems, the less their reported knowledge of pro-environmental organizations ($r=-0.2198***$). This relationship was even stronger among older, lower income, and a less formally educated respondents.

A positive relationship was observed between having a negative view of pro-environmental organizations and reporting that behavioral changes will have no impact addressing environmental problems ($r=0.1367*$). A utilitarian view of nature was also positively correlated with having a pessimistic attitude toward the effectiveness of pro-environmental organizations ($r=0.1285*$). This pattern was

significant among older, more formally educated and urban respondents. It seems those who express defeatist attitudes also gravitate towards technical solutions, downplaying the need for behavioral change.

Discussion and Policy Implications

There is a strong link between recycling and having a positive perception of environmental organizations. This relationship was especially strong among older urban adults with a lower level of income and formal education. Mukherji, Mukherji & Evans (2011) reported related results among US Latinos, identifying environmental concern as a partial driver of recycling. Several municipalities in Puerto Rico currently have recycling programs, but most still operate on a voluntary basis. Broader participation in pro-environmental NGO's may have an impact on the acceptance of stricter enforcement of recycling regulations.

It is worth exploring whether there is a causal relationship between participation in environmental organizations and a broader range of pro-environmental behaviors. Resulting information may provide evidence of the broader impacts of involvement in pro-environmental organizations. This knowledge may be used to inform pro-environmental NGO's on their role and broader impacts.

Knowledge of pro-environmental organizations is also associated with pro-environmental consumption patterns. There is a strong association between those who reported knowledge of pro-environmental organizations and buying organic and second-hand products. Findings on consumption supplement those of Sánchez, López-Mosquera & Lera-López (2015), who found that Spanish consumers who are more educated and well-informed about environmental issues choose pro-environmental consumption. One possible vehicle worth exploring for shifting consumption towards more sustainable patterns could be resident involvement in pro-environmental organizations.

Lack of knowledge about pro-environmental organizations is also associated with a pessimistic attitude towards the effectiveness of behavioral change in addressing environmental problems. Convincing the broader public of the effectiveness of behavioral change to solve environmental problems is an area of opportunity that could be highlighted more in future pro-environmental NGO agendas.

External attributions may also play a significant role in fostering involvement in pro-environmental organizations. Kalamas, Cleveland & Laroche (2014) found consumers ascribing environmental responsibility to powerful others (corporations or governments), were more likely to engage in pro-environmental behavior that those attributing changes to chance or fate (a higher power, natural earth cycle facets). The authors state:

"It is vitally important to persuade these consumers and powerful others currently viewing the state of the environment as fate to instead see it as karma".

Future research into external attributions can delve into the motivation for defeatist attitudes found in this research. A sense of impotence when dealing with environmental change needs to be addressed as effective strategies for organizational

involvement are devised. Findings point to the importance of affective involvement, which may be provided by NGO's through watershed stewardship and recreation experiences, when trying to incentivize pro-environmental behaviors among broad sectors of the population, but further exploration into the reason for defeatist attitudes, such as external attribution, is an important component of the puzzle.

Another item that could be included in future NGO agendas is the opportunity to discuss the benefits and costs associated with solutions to environmental problems. Technical solutions seem to be a preferred alternative to address degradation of key ecosystem services. Respondents consistently agreed with building reservoirs and dams in the watershed, which require significant monetary investment, more than adopting behavioral solutions. The public sector and pro-environmental organizations can take the lead in communicating a broad variety of more cost-effective behavior-based solutions to pressing environmental problems such as water shortages. Our results indicate that on the one hand, non-governmental organizations may be more effective in communicating messages, due to respondent disagreement with public sector effectiveness. On the other hand, many distrust non-governmental organizations, so there is also a need for these organizations to strengthen their legitimacy among the general public to effectively convey cost-effective alternatives to watershed pollution problems.

A key component in solidifying the legitimacy of pro-environmental organizations is the recognition of pollution as a problem that affects citizens in their daily life. A number of younger urban respondents with a negative perception of pro-environmental organizations indicate that pollution does not affect their daily life, so pro-environmental organizations can strengthen their legitimacy by raising awareness among citizens on the immediacy of the problems they address on a daily basis, including diminished watershed recreation opportunities. It seems communicating the capacity to achieve change may not be sufficient, there is a need to first convince a segment of the population that pollution affects them directly.

The previous exploratory analysis has shown that pro-environmental organizations may play a role in fostering pro-environmental behaviors among its members and the broader population. These behaviors included recycling as well as purchasing organic and second-hand products. They may also play a key role in increasing awareness among the broader population of not only the immediacy of behavioral problems, but also the effectiveness of behavioral change to address them. Once NGO legitimacy is broadly recognized, it may be easier to involve residents in stewardship efforts and fostering adoption of pro-environmental behaviors to address watershed and other immediate pollution problems.

Acknowledgements

References

Barreto, M. (1997). *Shoreline changes at Puerto Rico*, 1-49 (Unpublished doctoral dissertation). University of Puerto Rico, Mayagüez.

Beery, T. H., & Wolf-Watz, D. (2014). Nature to place: Rethinking the environmental connectedness perspective. *Journal of Environmental Psychology*, *40*: 198-205.

Berman-Santana, D. (1996). Kicking off the bootstraps: environment, development, and community power in Puerto Rico. University of Arizona Press.

Bright, A. & Porter, R. (2001). Wildlife-Related Recreation, Meaning, and Environmental Concern. *Human Dimensions of Wildlife*, 6(4): 259-276.

Brugger, A., Kaiser, F., & Roczen, N. (2011). Connectedness to Nature, Inclusion of Nature, Environmental Identity, and Implicit Association with Nature. *European Psychologist*, 16(4): 324-333.

Capaldi, C., Dopko, R., & Zelenski, J. (2014). The relationship between nature connectedness and happiness: a meta-analysis. *Frontiers in Psychology*, 5(976): 1-15.

Cervinka, R., Roderer, K., & Hefler, E. (2011). Are nature lovers happy? On various indicators of well-being and connectedness to nature. *Journal of Health Psychology*, 17(3): 379-388.

Chochola, L. (2009). Exploring Altruism as a Possible Moderator between Connectedness to Nature and Pro-Environmental Behavior. Ph.D. Dissertation, Alliant International University, Los Angeles, California, 1-99.

Davis, J., Green, J., & Reed, A. (2009). Interdependence with the environment: Commitment, interconnectedness and environmental behavior. *Journal of Environmental Psychology*, 29(2009): 173-180.

Davis, J., Le, B. & Coy, A. (2011). Building a model of commitment to the natural environment to predict ecological behavior and willingness to sacrifice. *Journal of Environmental Psychology*, 31(2011): 257-265.

Deale, C. S., Barber, N., Murray, A., & Cashion, M. (2012). Tourism, Non-Profit Organizations, and Environmental Attitudes and Behaviors: A Pilot Study of Perceptions of Residents of a River Basin. *Consortium Journal of Hospitality & Tourism*, *17*(1): 47-65.

Department of Natural and Environmental Resources, Water Plan Monitoring Division (2008). *Comprehensive Plan for Water Resources* [PDF Document].

Dunlap, R. E., & McCright, A. M. (2008). Social Movement Identity: Validating a Measure of Identification with the Environmental Movement*. *Social Science Quarterly*, 89(5): 1045-1065.

Eliam, E. & Trop, T. (2012). Environmental Attitudes and Environmental Behavior-Which Is the Horse and Which Is the Cart? *Sustainability*, 4(2012): 2210-2246.

Epstein, S. (1998). Impure science: AIDS, activism and the politics of knowledge. Berkeley: University of California Press.

Fishbein, M.; Ajzen, I. *Belief, Attitude, Intention, and Behavior*; Addison-Wesley: Reading, MA, USA, 1975.

Fraj, E., & Martinez, E. (2006). Environmental values and lifestyles as determining factors of ecological consumer behaviour: An empirical analysis. *The Journal of Consumer Marketing*, 23(3): 133-144.

Gifford, R. & Nilsson, A. (2014). Personal and social factors that influence pro-environmental concern and behavior: A review. *International Journal of Psychology*, 49(3): 141-157.

Gosling, E., & Williams, K. (2010). Connectedness to nature, place attachment and conservation behavior: Testing connectedness theory among farmers. *Journal of Environmental Psychology*, 30(2010): 298-304.

Guerin, D., Crete, J., & Mercier, J. (2001). A multilevel analysis of the determinants of recycling behavior in the European countries. *Social Science Research* (30).

Hinds, J. & Sparks, P. (2008). Engaging with the natural environment: The role of affective connection and identity. *Journal of Environmental Psychology*, 28(2008): 109-120.

Inglehart, R. (1997). Modernization and postmodernization: Cultural, economic and political change in 43 societies. Princeton: Princeton University Press.

Jensen, B. B. (2002). Knowledge, action and pro-environmental behaviour. *Environmental education research*, 8(3): 325-334.

Jimenez, M. & La Fuente, R. (2010). Defining and measuring environmental consciousness. *Revista Internacional de Sociología*, 68(3): 731-755.

Kalamas, M., Cleveland, M. & Laroche, M. (2014). Pro-environmental behaviors for thee but not for me: Green giants, green Gods, and external environmental locus of control. *Journal of Business Research*, 67(2014):12-22.

Kals, E., Schumacher, D., & Montada, L. (1999). Emotional affinity toward nature as a motivational basis to protect nature. *Environment and Behavior, 31*(2): 178-202.

Kollmuss, A., & Agyeman, J. (2002). Mind the gap: why do people act environmentally and what are the barriers to pro-environmental behavior? *Environmental education research*, 8(3): 239-260.

Larson, S., De Freitas, D., & Hicks, C. (2013). Sense of place as a determinant of people's attitudes towards the environment: Implications for natural resources

management and planning in the Great Barrier Reef, Australia. *Journal of Environmental Management* 117(2013): 226-234.

Liarakou G, Kostelou E, & Gavrilakis C. (2011). Environmental volunteers: factors influencing their involvement in environmental action. *Environmental Education Research*: 1–23.

Loomis, J., & Santiago, L. (2013). Economic Valuation of Beach Quality Improvements: Comparing Incremental Attribute Values Estimated from Two Stated Preference Valuation Methods. *Coastal Management*, *41*(1): 75-86.

Mayer, F. & Frantz, C. M. (2004). The connectedness to nature scale: A measure of individuals' feeling in community with nature. *Journal of environmental psychology*, 24(4): 503-515.

Mayer, S., McPherson, C., Bruehlman-Senecal, E., & Dolliver, K. (2009). Why is Nature Beneficial? The Role of Connectedness to Nature. *Environment and Behavior*, 41(5): 607-643.

McDougle, L., Greenspan, I. & Handy, F. (2011). Generation green: understanding the motivations and mechanisms influencing young adults'' environmental volunteering. *International Journal of Nonprofit and Voluntary Sector Marketing*, 16(2011): 325-341.

McPherson, C., & Mayer, F. (2014). The importance of connection to nature in assessing environmental education programs. *Studies in Educational Evaluation*, 41(2014): 85-89.

Measham, T. & Burnett, G. (2007). Environmental Volunteering: Motivations, modes and outcomes. Socio-Economics and the Environment in Discussion. CISRO Working Paper Series 2007-03.

Mukherji, J., Mukherji, A., & Evans, R. (2011). Understanding Hispanic Environmental Attitudes and Recycling Behaviors. *Competition Forum*, 9(1): 106-112.

Nord, M., Luloff, A., & Bridger, J. (1998). The association of forest recreation with environmentalism. *Environment and Behaviour, 30*(2): 235-246.

Ong, T., & Musa, G. (2011). An examination of recreational divers' underwater behaviour by attitude-behaviour theories. *Current Issues in Tourism*, 14(8): 779-795.

Perrin, V., & Benassi, V. (2009). The connectedness to nature scale: A measure of emotional connection to nature? *Journal of Environmental Psychology*, 29(2009): 434-440.

Restall, B., & Conrad, E. (2015). A literature review of connectedness to nature and its potential for environmental management. *Journal of Environmental Management*, 159(2015): 264-278.

Sánchez, M., López-Mosquera, N. & Lera López, F. (2015). Improving Pro-environmental Behaviours in Spain. The Role of Attitudes and Socio-demographic and Political Factors. *Journal of Environmental Policy & Planning*, *18*(1): 47-66.

Saunders, C., Büchs, M., Papafragkou, A., Wallbridge, R., & Smith, G. (2014). Beyond the activist ghetto: a deductive blockmodelling approach to understanding the relationship between contact with environmental organizations and public attitudes and behavior. *Social Movement Studies*,*13*(1): 158-177.

Theimer, S., & Ernst, J. (2012). Fostering: Connectedness to Nature" through US Fish and Wildlife Service Education and Outreach Programming: A Qualitative Evaluation. *Applied Environmental Education and Communication*, 11:79-87.

Torgler, B., & Garcia-Valiñas, M. A. (2006). Participation in environmental organizations: an empirical análisis. *Berkeley Program in Law & Economics, Working Paper Series*.

Van Liere, K. D., & Dunlap, R. E. (1980). The social bases of environmental concern: A review of hypotheses, explanations and empirical evidence. *Public opinion quarterly*, *44*(2): 181-197.

Vining, J., Merrick, M., & Price, E. (2008). The Distinction between Humans and Nature: Human Perceptions of Connectedness to Nature and Elements of the Natural and Unnatural, *Research in Human Ecology*, 15(1): 1-11.

Welsch, H., & Kühling, J. (2009). Determinants of pro-environmental consumption: The role of reference groups and routine behavior. *Ecological Economics*, 69(2009): 166-176.

Whitmarsh, L. & O'Neill, S. (2010). Green Identity, green living? The role of pro-environmental self-identity in determining consistency across diverse pro-environmental behaviours. *Journal of Environmental Psychology*, 30(2010): 305-314.

Wilhelm-Rechmann, A., Cowling, R. M., & Difford, M. (2014). Responses of South African land-use planning stakeholders to the New Ecological Paradigm and the Inclusion of Nature in Self scales: Assessment of their potential as components of social assessments for conservation projects. *Biological Conservation*, *180*: 206-213.

Williams Walsh, M. (2016, May 20). Puerto Rico's Debt Crisis Explained. The New York Times. Retrieved from http://www.newyorktimes.com.

Zhang, J., Howell, R., & Iyer, R. (2014). Engagement with natural beauty moderates the positive relation between connectedness to nature and psychological well-being. *Journal of Environmental Psychology*, 38(2014): 55-63.

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Residential Farming: A Strategy on the Regeneration of Existing Chinese Residential Area Concerning Aged Caring Issue

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Abstract

Residential farming, as an exploration of neighborhood aged care strategy in China, advocated a mode of participatory residential regeneration concerning the aging issue. Taking the regeneration project of Xiangpuying Residential Area in Nanjing as a case, the investigation on existing community showed that both high quality public space and humanistic concerning activities for the elderly in their living neighborhood were in desperate need. Under such circumstances, the proposal of "Residential farming" put forward by architects were conducted in three stages, namely establishing farming system, reconstructing farming space and recreating farming tools, aimed to reshape the neighborhood life of the elderly without radically changing their existing living space but giving them proper, gentle and practical transformation. By injecting the vibrant activity of farming as a minimal state variable in the existing residential area, not only the monotonous mental life of the elderly was enriched, favorable environment for the neighborhood aged care was provided, communication between the elderly was promoted, the interaction between space, activities and users was achieved, but also a promising proposal for sustainable community renovation concerning aging issue was practised.

Keywords: Residential farming, community renovating, aging issue, community aged care

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1. Urban Community Aged Care Situation

1.1   An Aging World

A growing elderly population is posing a global challenge. The world's over-65 population now numbers more than 342 million, and that figure is expected to more than double by the year 2020, to 722 million according to *US census Bureau*, which means one in five people will be elderly all over the world. In recognition of this fact, the UN General Assembly has adopted a set of Principles for Older Persons that recognizes the elderly's need for independence, participation in community life, care, self-fulfillment, and dignity.
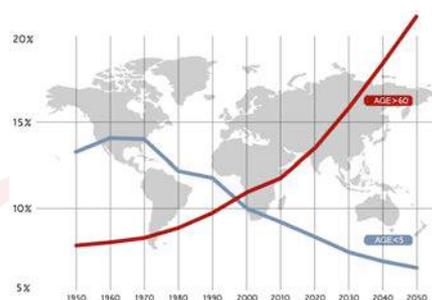

Figure 1: More elderly than children in the world

Figure 2: percentage of aged population all over the world

1.2   An Aging China

The developed countries such as Japan, Italy, Germany, Sweden etc. seem to suffer more from the aging issue, however, China, as the world's most populous country with the largest aging population, its provision of affordable and accessible social care services to older people has already become an urgent issue for the government to address. The aging issue in China has its own unique feathers. Firstly, China has huger quantity of aging population than any country in the world. Secondly, China is experiencing very high growth in elder population owing to the one child policy 30 years ago. Thirdly, both the nation and its individual people get old before getting rich. Looking into the future, the local government of a few developed area has adopted the aged care mode of "9073" which means community -based housing aged care for 90%, senior-housing care for 7% and nursing institutions for 3% according to the traditional Chinese family conception and the particular feature of the nation. In hence, community -based aged care, as the most important aged care mode in China, has already been laid more stress on. However, most existing urban community did not consider the special needs of elderly with many problems to be solved. Under such circumstances, what can we architects do in this progress is an important issue.
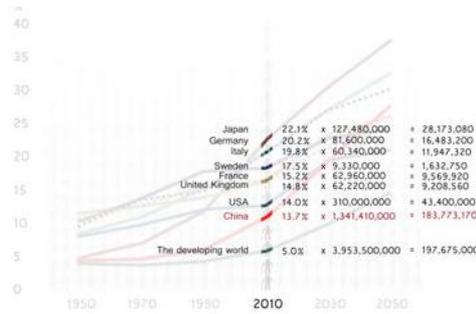
Figure 3: The most aged population in the world
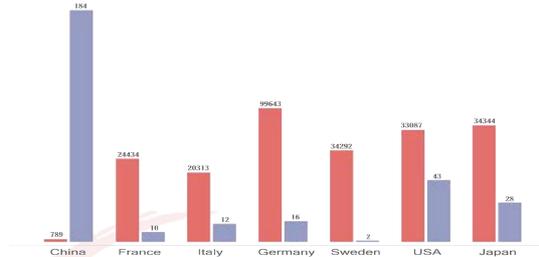
Figure 4: Comparation of GDP and aged proportion

1.3   An Aging Nanjing

Nanjing, the capital city of Jiangsu Province, has a typical aging population structure with more than 20 % people over 60 years old according to the previous population census, which stands out throughout the nation and even all over the world. With the most universities in China and its rich cultural deposits, besides huge quantity and high growth which shared by the whole nation, Nanjing has the most educated aging population. Therefore, psychological demand of the elderly in Nanjing is relatively more important, which means we should find something special to fulfil their monotonous life.

2. The existing community life of the elderly

2.1   Investigation on Site Zhenxiang

Located in the central area of Nanjing, Site Zhenxiang covers an area of 600,000 ㎡ with 36 communities which are mostly constructed in 1980s. Our investigation of Zhenxiang is conducted in 3 methods, namely mapping, video observation and questionnaire.
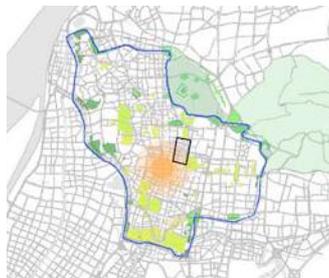
Figure 5: Location of Zhenxiang

2.1.1   Mapping

We draw all the kinds of information of Zhenxiang Area on a map which is overlaid by many layers, including the basic construction information of all the 34 communities, the road structure, service structure, the public transportation information, the distribution of service facilities, the distribution of outdoor activity space for the elderly, the distribution of activities of the elderly. With all this information overlaid together, we got the research map of Zhenxiang Area on which we can check all the information we need for further study on problems and the proper proposals concerning community aged care.

Figure 6: Map of Xiangpuying Residential.

Figure 7: overlapping of outdoor public space, service facilities and activities of the elderly

2.1.2   Video Observation

We took two kinds of video with different aims to study the activity features of the aged. One kind is the "tracking video" which is taken by tracing a certain elderly from the moment he or she went out of home to see where he is going, what he will do and who he will talk to, through which we can get to know the routine of the elderly's activities better. For the other kind, "fixed video", we set video camera in several public spaces which is frequently used by the elderly and took 10-minites-video in 8 a.m., 12 a.m. and 5 p.m.to study how the elderly use outdoor public spaces. By

accumulation of a certain quantity of video, we can get the activity routines of the elderly as follows.

•The aged strongly rely on outdoor activities. They are actually the main user of public facilities in community and thus suffered most from poor quality public spaces.
•The aged love to take part in collective activities.
•The main outdoor activities of the aged includes chatting, playing chess, exercise, basking, walking dogs, walking children, planting, reading, shopping, taking kids to school.
•Their major outdoor time is in the morning and evening.
•The aged love to stay with plants.

2.2   Spontaneous farming activities in community

"What's on hell is the value of that delicate grass! Why can't we plant!" shouted grandma Zhang, 68 years old, a resident of Xiangfuying Community during our investigation. Her little illegal "farm" which is built on original green bed attracted our attention. What she planted are not flowers but vegetables with turning a waste basin into a green container. There are spontaneous farms everywhere in community, the residents are quite love to plant vegetables themselves from small leeks to big loofahs. The "farmer" are actually the landscape created and maintained by the users rather than designers and administrators. It is actually a great way for the elderly to find something they love to kill time, to enrich their life and to keep them engaged in the public life of community. However, such activity is actually illegal because its disorder which is harm to the residential landscape in the eyes of the community administrators in China at present.

Figure 8: spontaneous farming

Figure 9: wiping out illegal farms

3. Analysis of Urban Community Aged Care problems

Through all the investigation we made, several problems existing in the life of the elderly in community come forward as follows,

• Outdoor safety of the elderly is not guaranteed because of the coexistence of people and vehicles, lack of barrier free design and lighting design.
• Communities are lack of high quality nursing homes.
• The elderly lack systematic urban public space. Even though the distribution of service facilities in this area is quite convenient, what they lack most is outdoor urban activity space.
• High quality outdoor public space within community is in desperate need. Firstly, parking, clutter and even backstage of commerce occupied too much activity space for the elderly. Secondly, there are too few plants in community. Thirdly, the existing public space lacks equipment and furniture both in quantity and variety. Fourthly, the elderly has too few varieties of activities apart from daily chatting and shopping. Fifthly, the immutable form of public space and landscape lacks interaction with residents and different activities. They stay still overlooking the need various uses of the space.
• The elderly lack psychological care. Loneliness is the most difficult part for the elderly to get through. They will suddenly find that they have too much time to kill and actually nothing to do. Moreover, the death cloud is always hanging over there.

Behind the war between the community old "farmers" and the administrators, the existing planting activity indeed have a lot of problems to be solved as followed,

• The radically spontaneous planting activities destroy the order of community landscape
• The private farms invade the original public grassland.
• There is no system guidance, design, and administration of residential farming.
• There is no enough specific space for residents to plant in existing residential.
•The relationship of public landscape and private farming is hard to tell and organize.

4. Residential farming, a Proposal for Change and Improvement

4.1 What if a farming community for the aged

As architects, we can't help asking what if the aged can participate in the construction of their community and create landscape or public space by themselves? What if the popular computer game in China, Happy Farm, can come into reality? What if we create a legalized and systematic residential farming with proper guidance?

Before trying to answer these "what if", we firstly find several benefits from planting community which focus on participatory planting of vegetables.

• Planting community creates the mode of participatorily constructed Community, realizing interaction between the ever-changing space, activities and users. Once we inject the "planting" into a community, the space and the landscape of the community would be ever-changing in response to the new activity. Consequently, such variable public space could have an influence on its users which would enhance the unity of community and promote communication between individuals. Thus we achieve the chain reaction of activity, space and users, which means we realize the participatorily constructed community.

• Planting community brings a new kind of activity to the aged without radically changing their familiar living space. The elderly does not like to radically change their familiar living space, but at the same time they need new kind of activities. Planting is something that save them from forever talking and basking and that would occupy large amount of time.

• Planting promotes neighborhood communication and cohesion of community. Planting provide a new topic in the community. The elderly would exchange their experience on planting. They would also help each other watering, cutting, fertilizing and so on. Meanwhile, collective planting also enhances the cohesion of community.

• Planting makes the environment in community greener and more favorable. Lacking of green is the typical problem in community built before 1990s in China with limited space between buildings. "Green" has become a luxury. Planting community just make full use of every corner of community with three-dimensional planting. Planting add more green to the old community.

• Planting reduces the cost of landscape maintenance in some sense. Rather than relying on community administrator to maintain the landscape in well situation, planting community encourage every resident to participate in the daily maintenance of public landscape.

• Planting can recall the deep memory of the old days. Chinese have a unique emotion of the earth with a history of agriculture for thousands of years. Especially for this generation of the elderly nowadays, most of them are from rural area in their early days when earth and planting are everything in life.

• Embrace aging through creating life, which is psychologically healing. The elderly is usually stressed with death. Instead of having nothing to do but count down the deadline of life, planting teach them the truth of life, death is a normal part of life. They will embrace aging and not be afraid of death any more.

• Planting in community is a positive respond to food security issue in China. Pesticide abuse and additive abuse made the food we bought is no longer safe. If we eat what we plant, I will be at ease.

• Planting community provides chance of waste recycle. Everything that piled in community public space and in residents' home can be used as green container for planting.

• Planting community creates the ever-changing landscape. Different kind of vegetables will create different kind of landscape. By the circulation of sowing, growing, blossom and gains the landscape of community would change during the year.

Figure 10: participatorily community landscape   Figure 11: recycle of the waste

4.2 Renovating of Xiangfuying Residential via farming practice

Xiangfuying Community, designed and built during 1986-1988, as the experimental site of planting community, is one of the earliest renewal projects of the old town center to meet the urgent need of improvement of residential condition and urban development in the middle of 1980's in China. The whole residential quarter is occupied by 1226 families.

Figure 12: exiting environment of Xiangpuying

4.2.1 Farming renovating strategies on residential scale

The original public space of Xiangfuying Community is somehow fragmented and isolated with very poor quality and quantity. As the main user of community facilities and outdoor public space, the elderly suffered a lot from low quality environment in Xiangfuying and other similar old residential block built in 1980s in China. Lack of systematic high quality public space, the majority of the elderly are even drifting out from the thinned out public realm which would be harmful to their physical and mental health.
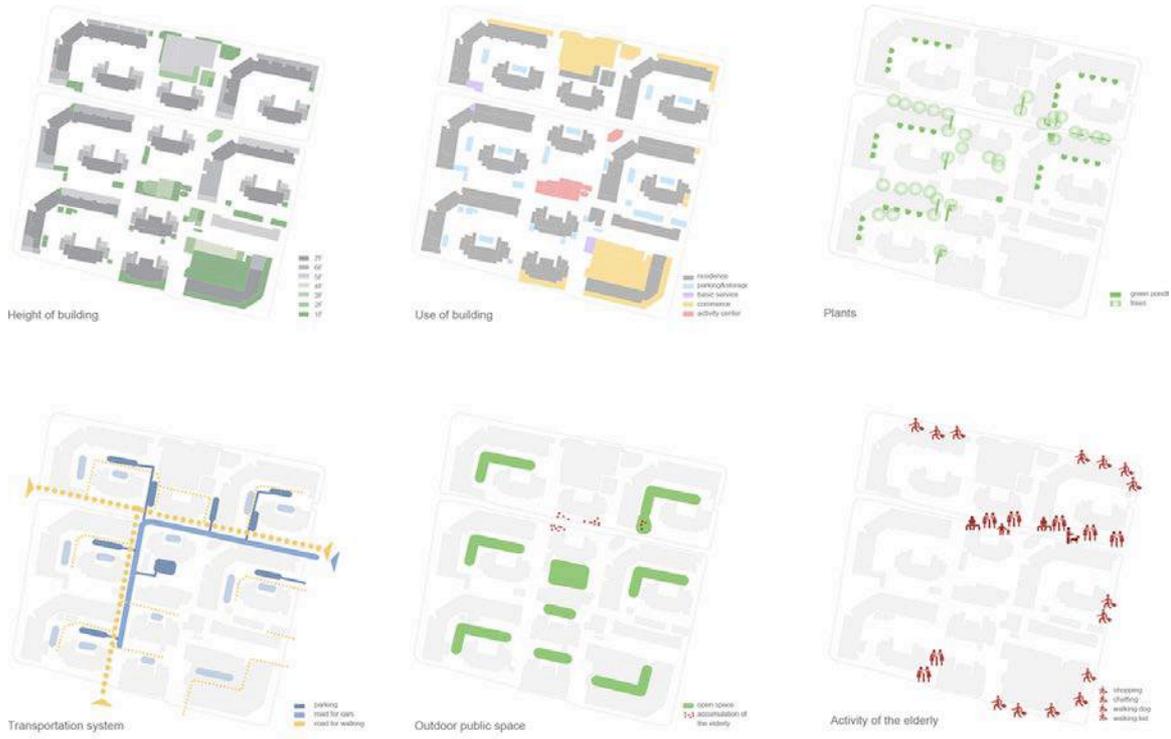

Figure 13: existing form of Xiangfuying
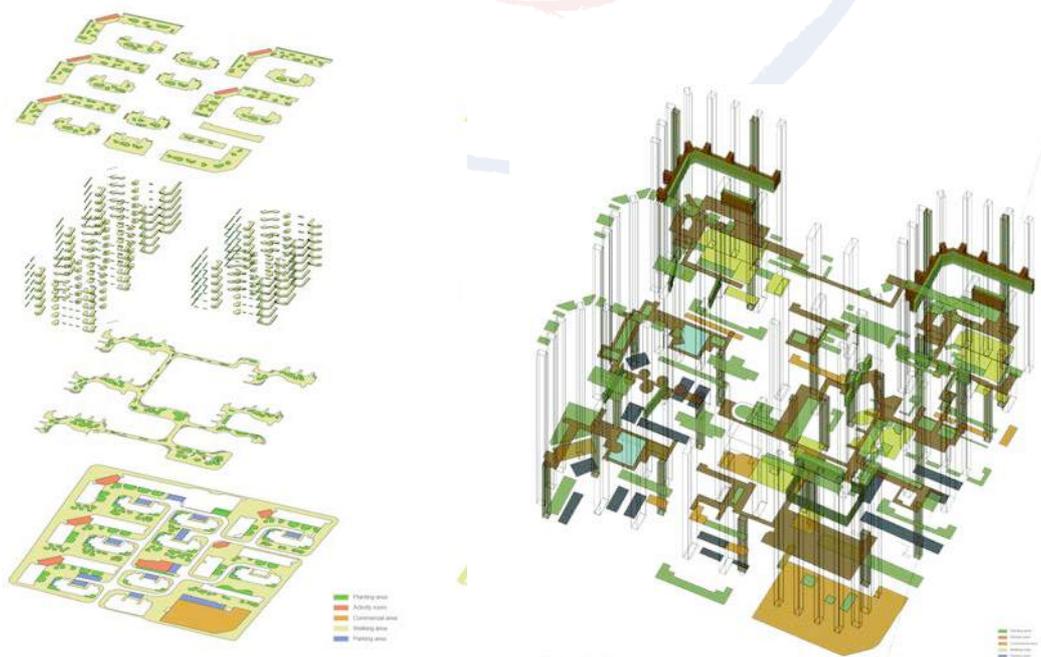
Figure 14: farming integrated public system of renovation of Xiangfuying

According to the existing use of building and the feature of the public space in community, we clear and reshape the structure of the public space in Xiangfuying Community by integrating public space and circulation in different level at different height.

Seeing from the section of this planting community, as for lower spaces, we build a second-floor level ground to increase the planting spaces, to protect the old people from the unsafe factors of motor traffic, to create more outdoor activity spaces both on the ground and second-floor spaces and spare more parking space on the ground level. Then, set functional space of public services in the indoor spaces on the first floor where the light condition is not suitable for living. As for higher spaces, we build various kinds forms of planting area, such as public planting balconies, planting corridors, Roof gardens, and so on. We hope people can share the planting space on different levels in community.

This three dimensional planting system makes full use of the existing ground, balcony, elevation and roof of the building to create farms in different level for the elderly with different demands. The farms on the ground floor and second floor are the most public ones. The elderly who are in good health can rent a farm from administrator and plant on this level. Meanwhile, they can also take part in the collective planting on the central public farm for the community. However, the floating farms on elevation and balcony are quite private for these who do not have the ability to get to the ground conveniently. What's more, the farms on floating platforms are semi-public which is shared for several families and thus those disabled elderly can also enjoy public space without much vertical movement. Additionally, the farms on the roof with the best sunlight are motivated by convenient vertical transportation with the ground.
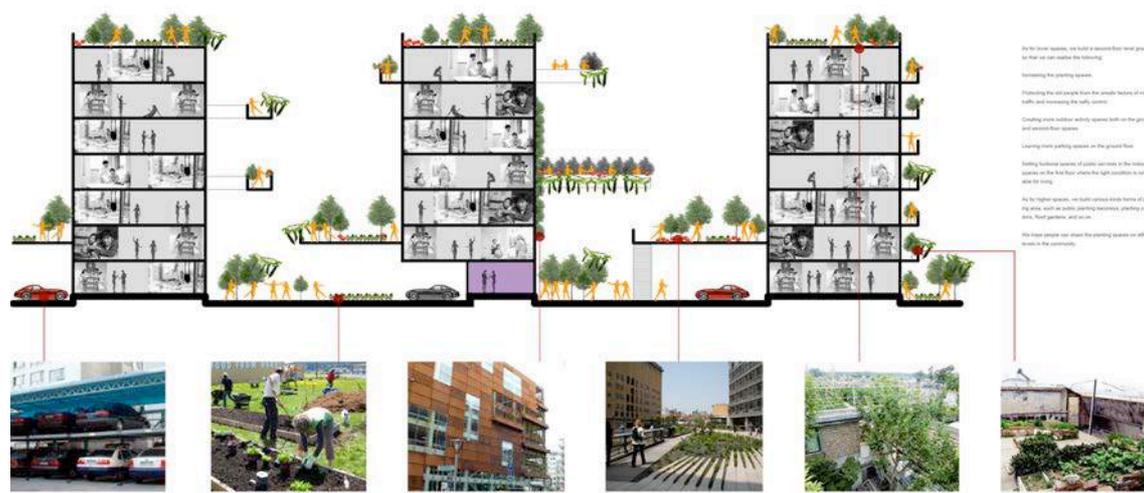

Figure 15: three dimensional planting system

4.2.2 Farming renovating strategies on building scale

According to the investigation, 20% residents in Xiangfuying are over 60 years old. As they get older, many of them may become disabled which means the existing staircase would be a barrier preventing them from going out of their home let alone joining the community activities. Considering this problem as the top obstacle for the

elderly to take part in the life in farming residential, lifts are actually necessary for the elderly. However, the elderly is scattered all around the whole building, it would cost too much to add a lift to each unit. We accumulate all the elderly in an apartment in one unit via encouraging exchange of room between the elderly who need a lift to go home and the healthy young family, thus, only one lift for an apartment would solve the problem. Such is residential replacement for the accessibility of farming activity.
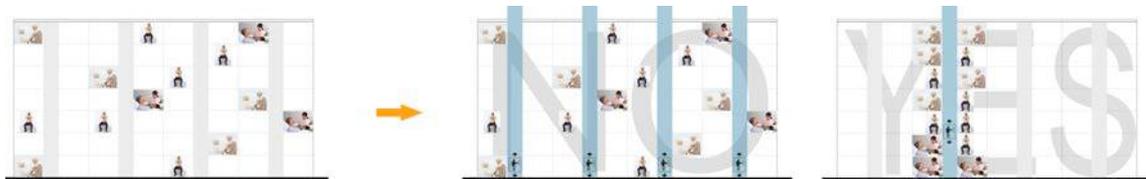
Figure 16: Residential replacement for the accessibility of farming

The platform added on the level of 1.5-story high would inevitably bring some problems such as lighting and ventilation to the rooms on the ground floor. In this case, we change the function of some rooms on ground floor from residence into parking, canteens, activity room and other service facilities for the elderly and all groups of residents in community, which would be like a big living room for each residential unit and spare more spaces for planting. Such is the function replacement strategy for farming activity.
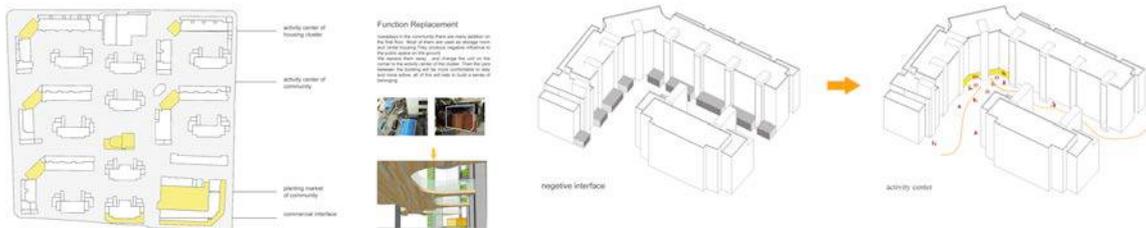

Figure 17: Function replacement strategy for farming

As it is a regulation to change the existing plat roof into sloping roof for the old residential buildings in Nanjing to avoid leakage of rain, we try to solve the same problem by transforming the original roof into roof farms, service facilities, and activity rooms and thus activate the roof into special public space with direct vertical transportation to access. Such is the roof farming activation.
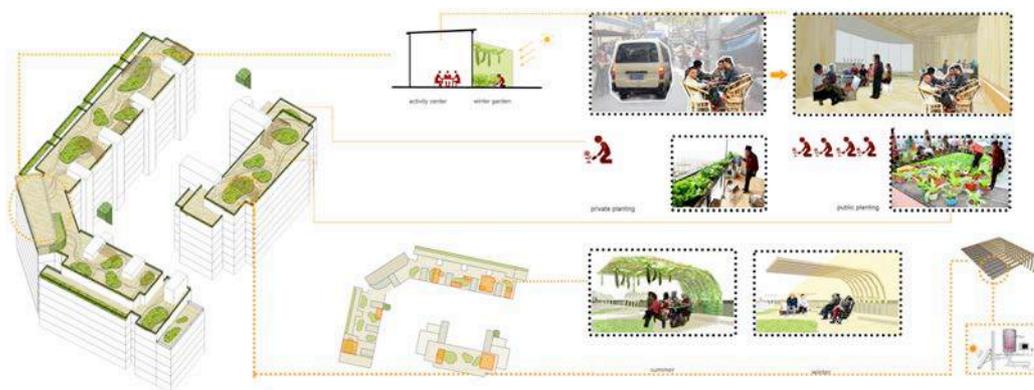

Figure 18: Roof farms

As for the people on level 1-level 3, they are close to the ground and platform. As for the people living on the 7th floor, they are close to the roof. So it is easy for them to get to public area. However, for the people living on the middle part of the apartment, it is difficult for them to get neither on the platform nor the roof. We hope to create some semi-public space which is shared by a certain number of families via elevation transformation. Every 12 families would share a floating farm which can be made of different forms are more private compared with the farms on the ground and platform levels.

Figure 19: Vertical farms

4.2.3 Farming renovating strategies in detail

The shading board on balcony could be curved with plants. In summer, plants grow lush which can keep resist the sunshine. In winter, when the leaves fall, more sunshine would come into rooms. We also divide the space of the balcony from the level 0.65m high by a board. The space above the board is used for farming and the space below is used for sun-cure whose position is easy to obtain for the elderly.
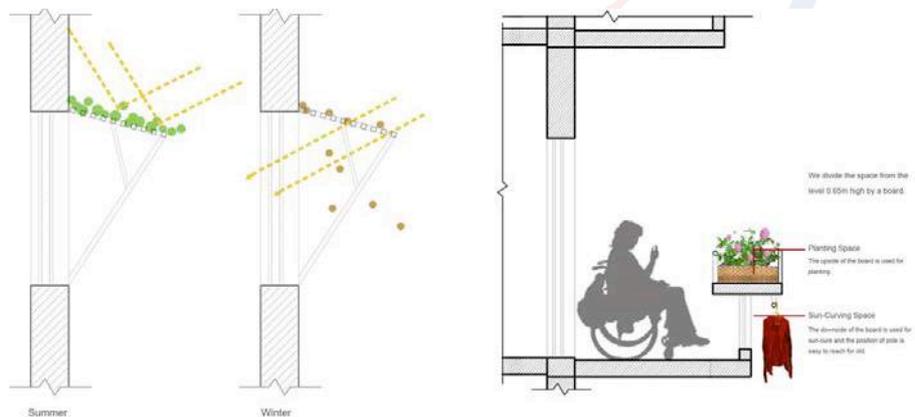

Figure 20: Balcony farms

Figure 21: Guidelines of distribution of vegetables

According to different lighting condition in different place of the planting community, we gave a recommended list on what and where to plant to the community "farmers".

On the Public Balcony we create the recycle green container supporting system, it consists of serious sizes of container holders where people can put their farming pot in them. Meanwhile people can take the farming pots to everywhere with the holders. We encourage them to use containers made of waste cats and dogs instead of buying new flower pots.
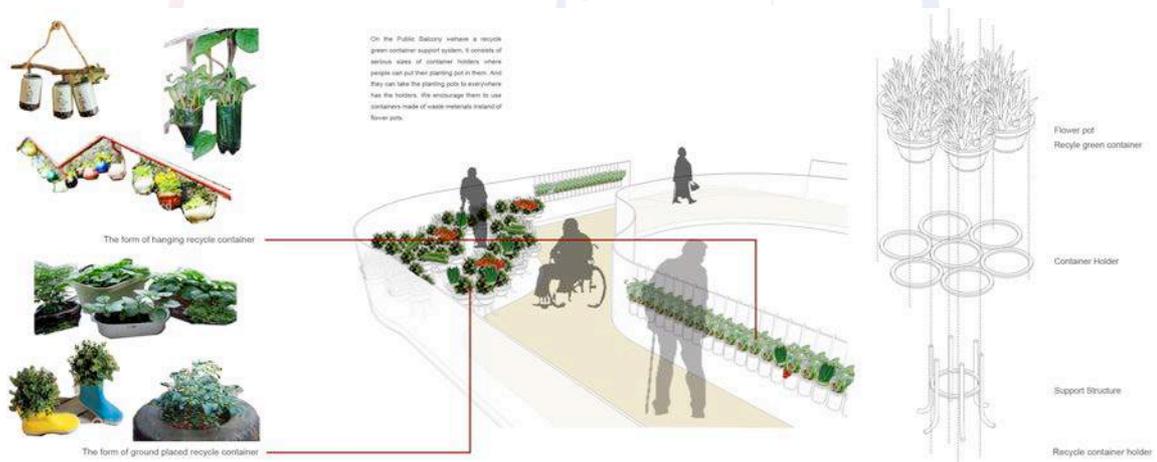
Figure 22: Recycled farming containers

As walking dogs are too tiring and walking kids are too stressing for the elderly, in planting community elderly can walk vegetables they planted with the tools we designed for such activity such as carts, hand pallet trucks, multi-story carts and so on. In case of the bad weather and the midnight theft, the elderly can just drive their beloved vegetables home, however in sunny days they can drive it out for a walk. The mobile farm also provides a new kind of daily topic in community for the elderly farmers to communicate with each other by exchanging their farming experiences and thus promote the cohesion of community.

Figure 23: Mobile farm

The variety of existing activities is very few owing to the poor condition. The elderly can either chat or sit for nothing in the isolated and fragmented and poor quality outdoor public space which would be harmful physically and mentally. Likewise, the invariable form and use of outdoor public space also add to the seriousness of this issue. Lack of transmutability, the existing public space cannot attract the elderly to go out of home let alone inspire them to create the new use and activity in community to enrich their life. Even though planting is a theme of the community, not every old resident in community would have the physical and mental capability for this manual labor honestly. Concerning that reality, many other activities for various conditions of health and interests are integrated with planting in different place. For example, there are small playgrounds for walking kids near the collective and public farm and continuous pavement for walking dogs and vegetables. Pergola for climbing vegetables, as well as a great place and furniture for the get-together of birds taken out for a walk while planting is set on the roof. Moreover, a large open space near the public farm is set on platform for the "farmers" to sell and exchange their gains. Activity greenhouses on the roof are for indoor activities like playing table games, movie, reading, party etc. which provide alternative for those who would not or could not go outside and for the conditions of bad weather. Along with the center farm of community on the ground, a small playground for exercise with several facilities provide residents with space for collective physical exercise with vegetables around that changes all over a year. On the floating semi-public farm, there would be relatively quiet space for individual activity such as basking and reading which would also provide outdoor space for those that can't or are not convenient to go downstairs but also need the sun and fresh air. By injecting the new public system into the old residential quarter, we reshape and enrich the public life in community especially for its main user, the elderly. We provide different kind of activity with different kind of space.   Thanks to the vegetables planted in community, the landscape and form of the public space in community would change in the repeating progress of seeding,

growing, blossoming and fruiting. Different kind of vegetables in different place of the community would create different landscape. Once the landscape changes with seasons, the activities around would change interactively. In this way, the space and landscape changes with the activity of planting which in turn would inspires new uses and activities of the space. Farming realize the interactive landscape in community.

Figure 23: scenarios of residential farming for the elderly

Conclusion

The participatory farming revolution of old residential quarter realize an interactively constructed community for home based aged care in China without radically changing the existing living space but giving positive, proper, smooth and practical transformation to the elderly. By injecting the activity of farming into old residential, we not only enrich the monotonous life of the elderly, provide favorable environment for the home-based community aged care, but also achieve the interaction between space, activities and users.

Under the crisis of global aging, residential farming, as a proposal given by architects, at least, is an experimental effort made to meet specific aging issue in China.

References

穆光宗，张团，北京大学人口研究所，《我国人口老龄化的发展趋势及其战略应对》,华中师范大学学报(人文社会科学版)

郑菲，南京市统计局,《南京城市人口老龄化现状及发展趋势》,中图分类号]C924. 24(53) [文章编号]1004 - 1516(2001) 03 - 0037‒02.

Thomas J. Schlerenth, "Burnham's Plan and Moody's Manual: City Planning as Progressive Reform," Journal of the American Planning Association 47, 1 (1983), 70-82.

Scott Greer, Urban Renewal and American Cities: The Dilemma of Democratic Intervention, (New York: Bobbs-Merrill Company, Inc., 1965), 89-91.

Sherry R. Arnstein, "A Ladder of Citizen Participation," Journal of the American Institute of Planners, July 1969.

John David Hulchanski, Citizen Participation in Urban and Regional Planning: A Comprehensive Bibliography, Council of Planning Libraries, Exchange Bibliography #1297, June 1977, 2, 55-61.

James L. Creighton, The Public Participation Handbook: Making Better Decisions Through Citizen Involvement,(San Francisco: Jossey-Bass, 2005), 9.

Samuel D. Brody, David R. Godschalk, Raymond J. Burby, "Mandating Citizen Participation in Plan Making: Six Strategic Planning Choices," Journal of the American Planning Association, Vol. 69 (2003), 248.

 Kathy Kem, BRR Architecture, "Citizen Participation Model Ordinances," 2005 American Planning Association National Conference Poster.

Judith E. Innes and David E. Booher, "Reframing Public Participation: Strategies for the 21st Century," Planning Theory and Practice, Vol. 5, No. 4, (December 2004) 419.

Diane Day, "Citizen Participation in the Planning Process: An Essentially Contested Concept ?" Journal of Planning Literature, Vol. 11, No. 3 (February 1997), 421-434. Peggy Robin, Saving the Neighborhood: You Can Fight Developers and Win! (Rockville, Md.: Woodbine House, copyright Adler and Robin Books, Inc., 1990).

Bao li, Experiment of housing refurbishment with the concept of levels initiative case study on Ruyi residential quarter in Nanjing, 2003

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The Sustainability and Justice of the Conservation of Modern Architecture in Thailand

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Abstract
The study of modern architecture in Thailand highlights the period of 1932-1985 A.D. which depicted the period of cultural transition and the founding of civilization that has been shaped by significant social, economic and political changes to the nation. All this has been much reflected in Thai architectural works. In that period, numerous buildings and structures have been constructed with the objective to serve the public interest, and have been continually maintained in service since the early 20th century onward until present-day. In the last decades, the architectural heritage of the modern movement appeared more at risk than during any other period, such as the Supreme Court was demolished in the year 2014. However, the conservation of architectural works that was built more than 50 years is registered as cultural heritage, for example the historical sites in Thailand, has been carried out for an extended time now under the care of the Fine Arts Department, which is governmental department of the Ministry of Culture. Buildings in the period of Modern Movement in Thailand have been studied in conjunction with the preservation of modern architecture on a global basis. Therefore to achieve justice and sustainability, for modern architectural works of the 20th century in Thailand, these are also should be well under conservation altogether under the same department. To enhance sustainability development, regulations and laws should line with the social and economics changed as a foundation for Thailand development.
Keywords: Modern architecture in Thailand, Modern Movement of Architecture, Modern Movement, Modern architecture

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Introduction

Background: The characteristics of Thai architecture has been greatly influenced by Western culture in the period from 1868-1910 A.D., in the reign of King Rama V. During this period, Thailand has been communicating with European countries on a broad scale, and European craftsmen have played an important role in creating many architectural works in Thailand, which can be seen in the monasteries or "Wats", and housing. From then on (1910-1925 A.D.), during the reign of King Rama 6 there has been extensive construction of public buildings, and various technicians and craftsmen from abroad with expertise in different fields have been hired to provide service for government sector. For this reason, architecture has been shaped in the way that integrates Thai architecture with the utilization of public buildings and construction technology; take for example, Bangkok railway station, King Chulalongkorn Memorial Hospital, and Vajiravudh College.

Figure 1: Bangkok railway station, 1910

Figure 2. Vajiravudh College, 1915

Modern architecture that originated in the Western world during the 1960s and evolved into an International Style can be considered as the starting point for the growth and expansion of modern architecture to Thailand. The period from 1958-1972 A.D. was when the architectural works in Thailand truly exhibited the characteristic of modern architecture, and completely abandoning the influence of

classical architecture from the Western world that has played an important role in the period from 1932-1957 A.D. Modern architecture in Thailand focuses on features that correspond to the environment, for example, the utilization of sun shades, long protruding eaves to guard against the sun and rain, and features that emphasize the use of modern advanced structures and technology, for instance, the use of steel-reinforced concrete with wide span to service the utility purpose of public building which can be considered as the original works of Thai architecture for the next period to come.

Figure 3. The New Suan Amporn Building, using folded-plate structure, 1972

Figure 4. Sri Feung Fung Building, a 10-storey office building, constructed in the year 1971.

Figure 5. Library building: A.U.A. (American University Alumni Association), 1972. (Demolished)

High-rise buildings from the early period of 1958-1972 A.D.
This can be considered as the period with highest level of advancement in early architectural works in Thailand. As the economy experienced the heights of growth during 1965-1969 A.D., with a large population of foreigners flocking into Thailand as a result of the Vietnam War, as well as American soldiers and businessmen, there has been significant projects which brought about development in both industry and travel; expansion and growth in transportation, agriculture and manufacturing, and particularly in commerce and banking. At the same time, there was also rapid growth in the Thai population from about 24 million in the year 1958, and increasing to 37 million by 1972, an increase by 54.17%. And for Bangkok alone, the population of 2 million people has grown to 3.8 million, a notable increase of 90%. The construction of buildings to sustain the growth in economy and society has fostered a continual development for architecture in Thailand.

Figure 6. Indra Hotel, 1971.

Figure 7. Dusit Thani Hotel, 1970.

Figure 8. Krung Thai Bank, 1960.

Buildings with International Style

The buildings constructed from modern types of materials in that period featured the utilization of steel reinforced-concrete structure of more than 5 storeys in height, and situated in the business center of Bangkok. "Curtain wall" was also used in the construction as part of the products from manufacturing. Those buildings that still function till present-day are as follows:

Figure 9. Holiday Inn hotel, Bangkok, 1966.

The design that utilizes shading panels was a highly distinctive characteristic in this period. Shading panels were created from steel-reinforced concrete, of both grid-type and egg crate type. At that time, the design of buildings that utilize shading panels are quite popular and common in South America, especially in Brazil, from the works of architects by the name of Lucio Costa ,Oscar Niemeyer and Alvar Aalto.

Figure 10. 72nd Anniversary Building, Siriraj Hospital, 1971.

Towards the end of period from 1958-1972, the architectural works began to exhibit the characteristics indicating the advancement in technology in terms of structure, engineering and steel-reinforced concrete, which can be seen in Indoor stadium Huamark, designed by Louis Baker Co., Ltd. (architect) and completed in 1966, and also the New Suan Amporn Building, designed by Casa Co., Ltd. (architect) and completed in 1972.

Figure 11. Indoor Stadium Huamark, 1966.

Towards the sustainability of the Conservation of the Modern Architecture in Thailand: Numbers of buildings and structures were constructed with the objective to serve the public interest, and have been maintained in service since the early 20th century onward until the last decades. They appeared more at risk than during any other period. Therefore, the Association of Siamese Architects under the Royal Patronage (ASA) had applied for the membership and new working party of Docomomo International organization which it was approved in the year 2014. Docomomo International is a non-profit organization devoted to International Working Party for Documentation and Conservation of buildings, sites and neighborhoods of the Modern Movement. Docomomo Thailand stands for; Do_co is Documentation and Conservation of buildings, sites and neighborhoods; Mo.mo_ is the Modern Movement of architecture in Thailand.

Justice : Cultural Heritage, The conservation of architectural works that was built more than 50 years is registered as cultural heritage under care of the Fine Arts Department, which is governmental department of the Ministry of Culture. However, modern architecture in Thailand, the buildings in the period of Modern Movement, most of them are less than 50 years old, the Association of Siamese Architects under the Royal Patronage (ASA) will give awards of well preserved and protect to those buildings that are less than 50 years.

ASA Conservation Award aimed at finding those winners who deserved to be granted the royal award from Her Royal Highness Princess Maha Chakri Sirindhorn. The awards were classified into many types including institutions and public buildings that have elements of architectural heritage, archaeological history and uphold proper conservation methods following legal regulations and traditions.

Figure 12 . Khurusammanakharn, Rajamangala University of Technology Isan, 1960.

Figure 13. Lecture Center, Faculty of Science (Pumpkin building), Prince of Songkla University, Hatyai Campus, 1966.

Conclusion

Towards the sustainability and justice of the conservation of the modern architecture in Thailand

1.   Docomomo Thailand established in 2014 in order to get awareness of demolishing in modern architecture.
2.   Docomomo Thailand joined a network of experts working together for conservation, for example: Docomomo International and Docomomo Japan
3.   Docomomo Thailand under The Association of Siamese Architects organized the national and the international seminar on the subject related to the conservation of the modern architecture in Thailand moderately each year.
4.   Make lists of buildings in the modern movement period.
5.   Giving awards to buildings that are well maintained and preserved.
6.   Website and links are established as www.docomomothailand.org

References

Pusadee Tipatus, *Siamese Architect: base, role, work and concept in the year 1933-1994, book 1,2,* Siamese Architect Association,Bangkok, 1996.

Wimonsit Harayangkul, Kobkul Indharavichit, Santhi Chanthaviratwong, Veera Inphanthung, **Development of Concept and Design for Architectural Works: Past, Present and Future**, Siamese Architect Association, Bangkok, 1993.

Laura Cerwinske, **Tropical Deco : The Architecture and Design of Old Miami Beach**, Rizzoli International Publications, New York, 1981.

Vittorio M. Lampugnani, **Architecture and City Planing in the Twentieth Century**, Van Nostrand Reinhold, New York, 1980.

Henrique E. Mindlin. **Modern Architecture in Brazil**, New York: Reinhold, 1959.

Photo credits:

1.**Mr.Thanakorn Chengaueng**, figure 4,5,6,11,13

2. Pusadee Tipatus, *Siamese Architect: base, role, work and concept in the year 1933-1994, book 1,2,* Siamese Architect Association,Bangkok, 1996.: figure 15, 16, 17

3. Wimonsit Harayangkul, Kobkul Indharavichit, Santhi Chanthaviratwong, Veera Inphanthung, **Development of Concept and Design for Architectural Works: Past, Present and Future**, Siamese Architect Association, Bangkok, 1993. : figure 9,10

4. www.vajiravudh.ac.th figure 2

5. www.railway.co.th figure 1

6.Suphawadee Ratanamart

7.Narathip Thubthun

8.Preecha Phuluang

9.Noppawan Ratanamart

Effect of Using Paperboard Bacterial Culture on Fermentative Hydrogen Production from Paperboard Mill Wastewater

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ABSTRACT

The effect of paperboard bacterial culture (PBC) supplementation during fermentative hydrogen production under the variation of initial substrate concentration to inoculum (S/X) ratio was studied. The paperboard mill wastewater (PMW) has been used as substrate. The results showed that supplementation of heat-pretreated PBC to PMW progressively improved the hydrogen productivity. Where, the hydrogen yield (HY) increased from 1.72 to 2.63 mmol/gCOD$_{initial}$ by supplementation of PBC to PMW compared to PMW as a sole substrate, with a peak hydrogen production (HP) of 2.4 mmol. Subsequently, different S/X ratios were studied: 0.05, 0.15, 0.3, and 1 gCOD/gVS. In which, HP at S/X ratio of 0.3 gCOD/gVS resulted in the highest value of 3.8 mmol, where lower and higher S/X ratios led to deterioration in HP in the range of (65 to 77%). Meanwhile, the highest % soluble/total carbohydrates and VSS removal of 72.73 and 63.16% % were corresponded to the highest HY (2.1 mmol H$_2$/gCODinitial) respectively at 0.3 gCOD/gVS. This indicates that most of produced H$_2$ was generated from the conversion of organic carbon in form of particulates. The main soluble metabolites analysis showed the butyrate fermentation type was occurred with small concentrations of propionate and lactate.

Keywords: Paperboard mill wastewater; Paperboard bacterial culture; Initial substrate concentration to inoculum ratio; Dark fermentation; Hydrogen

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1. Introduction

The increased concerns of greenhouse gas emissions and other environmental problems driving research in the area of alternative fuels for sustainable development (Gadhe et al., 2014). Hydrogen (H_2) is emerging as a strong candidate because it has the highest energy content per unit weight (122 kJ/g), and it produces water when combusted (Farghaly and Tawfik, 2015). Moreover, hydrogen appears to be one of the best transportation fuels, the most versatile and efficient fuel (Valdez-Vazquez et al., 2005). Also, H_2 is widely used for the synthesis of ammonia and alcohols, as well as for the hydrogenation of edible oils, petroleum, and shale oil (Zhang et al., 2003).

On the other hand, paperboard industry is one of the most important industries in Egypt. However, the effluents are considered from the major pollutants threats our country given the large wastes volume generation that are certainly harmful to the environment (Farghaly et al., 2015). In particular, the problems associated with paperboard mill wastewater (PMW) are high levels of organic pollutants and suspended solids (Kumar et al., 2014). Fortunately, production of hydrogen by PMW anaerobic processes is accompanied by the breakdown of organic substrates, and appears to be advantageous in converting organic wastes into more valuable energy resources (Chen and Chang, 2001). Therefore, converting low valuable feedstocks such as PMW into hydrogen is undoubtedly a challenging and emerging research area.

The performance of H_2-producing bacteria depends substantially on substrate, inoculum or both. Selection of the ecosystem for efficient hydrogen production is usually started by selecting a particular type of sludge as inoculum followed by its treatment (Mohammadi et al., 2012). In paperboard mills, the sludge produced from clarifiers is typically thickened and dewatered, and then disposed by landfilling or incineration which results in gaseous emissions and water pollution (Bayr et al., 2013). Using these sludge as mixed bacterial culture offers distinct advantages such as increasing H_2 yield and ability to utilize cellulose and hemicellulose present in PMW (Chaganti et al., 2012). As well as, tolerance to indigenous microbes in substrate and capability of producing a wide range of hydrolytic enzymes (Laothanachareon et al., 2014). Nevertheless, a major drawback of using mixed bacterial culture is the rapid consumption of the produced H_2 by methane-producers. Therefore, pretreatment of inoculum used in fermentative H_2 production process permits selective enrichment of specific group of bacteria (Mohan, 2008). According to the literature, cell wall and membrane of the microorganisms are disrupted effectively by heat applied during thermal pretreatment, resulting in a solubilization of the cell components (Assawamongkholsiri et al., 2013). In the same manner, according to (Kan, 2013), the highest H_2 yield was produced by using heat-treated culture followed by heat and acid-treated culture and the heat and base-treated culture.

Besides, the efficiency of hydrogen production is directly related to the initial substrate to inoculum ratio (S/X). Where, the initial substrate concentration represents the carbon and energy source for biosynthesis requirements and other energy purposes (Farghaly and Tawfik, 2015). As reported earlier (Chen et al., 2006), the hydrogen production potential and rate increased with increasing of S/X ratio. However, increased S/X would result in lower H_2 yields that likely have been attributed to the inhibitory effect of higher H_2 partial pressures in the growth medium (Hafez et al.,

2010). On the other hand, other researchers reported that lower S/X would inhibit the hydrogen production due to the inadequate food for the higher concentrations of inoculum (Sun et al., 2011). Besides, at lower S/X, the reactions were operated under substrate limiting conditions resulted in lower H_2 productivity (Elsamadony et al., 2015).

Therefore, the objectives of this study were to define the suitability of paperboard bacterial culture as a consortium for hydrogen production from paperboard mill wastewater. In addition, the influence of the initial substrate concentration to inoculum (S/X) ratio effect on the bacteria performance for efficient H_2 productivity, organic pollutants conversion, and the soluble metabolites production were also investigated.

2. Material and Methods

2.1. Mill description and inoculum

The studied mill has a capacity of 60 ton/day of paperboard production where the printing paper wastes are the raw material. The mill generates about 700 m^3/d of PMW that disposed to the sewage networks without any treatment. The end of pipe effluent was transported to the environmental lab for further experiments. The characteristics of PMW are presented in Table 1.

The paperboard bacterial culture (PBC) was collected from the thickener of the same mill. The PBC was further concentrated by settling for 24 h. where the supernatant has been withdrawn. Volatile suspended solids, total suspended solids contents, and sludge volume index (SVI) were 34.5±2.9, 16.2±1.3 g/l, and 28.9±2.6 ml/g-TS, respectively. The sludge was pre-treated at 90 °C for 30 min to harvest spore-forming bacteria and stored for 2 weeks under anaerobic conditions before being used as inoculum.

Table 1. Characteristics of PMW and seed sludge

Parameter	Value	Unit
Total COD	1870	Mg/l
Soluble COD	923	Mg/l
Particulate COD	947	Mg/l
BOD	1120	Mg/l
TSS	1370	Mg/l
VSS	790	Mg/l
pH	7.2	--
Carbohydrates	51	Mg/l
Total VFAs	187	Mg/l
HAc	86	Mg/l
HBu	52	Mg/l
HPr	20	Mg/l
HLa	19	Mg/l
NH4-N	3.2	Mg/l
TKj-N	52.1	Mg/l
C/N	35.9	--

2.2. Experimental set-up

Batch dark fermentation experiments were conducted in a series of 500/400 ml (total/working volume) serum bottles. Prior starting the experiments, pure N_2 gas was flushed into the bottles for 5 min. to eliminate the oxygen from the culture medium and headspace. The experiments were designed to study the effect of PBC supplementation and initial S/X ratio on H_2 production from PMW. Regarding to the 1st experiment, three duplicate batches were performed to study the effect of PBC supplementation to PMW namely: (1) PMW, (2) PBC, and (3) PMW+PBC (inoculums to substrate ratio of 0.32 gCOD/gVS (Yilmaz et al., 2008)). The experiments were conducted for 130 h. While at the 2nd experiment, different S/X ratios of 0.05, 0.15, 0.3, and 1 gCOD/gVS were applied as depicted in Table 2. This was achieved by keeping the inoculum concentration of PBC constant at 16.2±1.3 gVS/l with varying the substrate volume. Distilled water was added to make the working volume of each bottle to be 400 ml. The experiments were conducted at 37 ºC and pH of 7. The bottles were capped tightly with rubber stoppers and aluminum crimp seals. The produced biogas volume has been measured using the water displacement method and corrected to the standard conditions (25 ºC and 1 atm.) as described earlier (Lee et al., 2008).

Table 2. The experimental set-up of the initial S/X ratio effect on H_2 production

S/X (gCOD/gVS)	Bioreactor contents (ml)		
	PMW	PBC	Dist. H_2O
0.05	150	250	0
0.15	175	150	75
0.3	250	100	50
1	300	50	50

2.3. Data analysis

Cumulative H_2 production data that generated over the time course was analyzed using the modified Gompertz model (Eq. 1) (Farghaly et al., 2015). Where: HP is the hydrogen production (mmol). H is the cumulative hydrogen production at time (t), P is the H_2 potential (mmol), R_m is the maximum hydrogen production rate (mmol/h), λ is the lag phase required to commence H_2 evolution, and e is the Euler's number. Initial S/X ratio was calculated according to Eq. 2 as described by earlier (González-Fernández and García-Encina, 2009).

[1] $H(t) = P . \exp\left[-\exp\left(\frac{R_m}{P}(\lambda-1)+1\right)\right]$

[2] $S/X \text{ (gCOD/gVS)} = \dfrac{\text{Volume}_{PMW} \times \text{COD}_{PMW}}{\text{Volume}_{PBC} \times \text{VS}_{PBC}}$

2.4. Analytical methods

The biogas composition was analyzed using a gas chromatograph (GC-2014, Shimadzu, Japan). It is equipped with a thermal conductivity detector (TCD) and a 0.2 m, 3 mm diameter stainless column packed and Shin carbon (50/80 mesh). The operational temperatures of the injection port, the column oven, and the detector were 100, 120, and 150ºC, respectively. Helium was used as the carrier gas at a flow rate of 25 ml/min. Volatile fatty acids (VFAs) concentrations in terms of acetate (HAc),

butyrate (HBu), propionate (HPr) and lactate (HLa) were analyzed by high performance liquid chromatography (HPLC) (LC-10AD, Shimadzu, Japan) with ultraviolet detector using a shim-pack HPLC column (4.6x250 mm, VP-ODS, Vertical). The temperature of column oven was 40 °C. 4 mM H_2SO_4 was used as a mobile phase at a flow rate of 0.5 ml/min for 22 min followed by 0.4 ml/min for 8 min. Total suspended solids (TSS), volatile suspended solids (VSS), chemical oxygen demand (COD), biochemical oxygen demand (BOD_5), total Kjeldahl nitrogen (TKN), and ammonium nitrogen NH_4-N were determined according to APHA (2005). Soluble COD was determined using filter paper (0.45 µm-Whatman, 7141-104, Japan). The carbohydrate was measured according to the phenol-sulfuric acid method, using glucose as the standard.

3. Results and discussion

3.1. Effect of mixed culture bacteria

The results obtained from this study indicate that it is feasible to enhance the H_2 productivity from paperboard mill wastewater using paperboard bacterial culture as consortium. Fig. 1 shows the cumulative H_2 production from PMW, PBC, and PMW supplemented with PBC (0.32 gCOD/gVS). It was found that, when only PMW or PBC studied as a sole substrate, the hydrogen production (HP) was relatively low (1.6 and 2.0 mmol, respectively). However, the cumulative HP from PMW+PBC peaked at 2.4 mmol, i.e. 1.5 and 1.2 times than those obtained from PMW and PBC, respectively. This coincided to HP rate of 0.2 mmol/h for PMW+PBC. In addition, the produced H_2 content increased from 33.7% (PMW) to 54.3% by inoculating PBC to PMW. Meanwhile, the methanogens present in the PBC could be completely inhibited as a result of thermal pretreatment. Therefore, the PBC supplementation not only improved the HP but also accelerated the HP rate. This may be attributed to that the plentiful cellulosic substrate contained in PBC could be feasibly utilized for H_2 production by anaerobic digestion process (Chairattanamanokorn et al., 2012).

The results revealed that, the hydrogen yield (HY) increased to 2.63 mmol/gCOD$_{initial}$ by the PBC addition. Where, the HY was found lower using PMW (1.73 mmol/gCOD$_{initial}$) as sole substrate. Furthermore, the conversion efficiency would be observed to be enhanced using PBC supplementation. In specific, the COD R% amounted to 59.9% at the end of fermentation process, while 26.89% was registered to PMW. Accordingly, the PBC supplementation to PMW increased the microbial growth and substrate utilization, thereby enhancing the H_2 productivity.
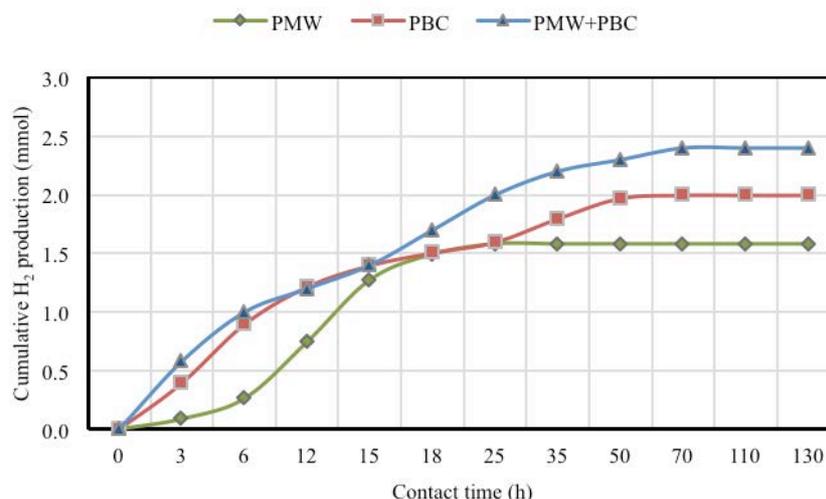
Figure 1. Effect of paperboard bacterial culture supplementation to PMW on cumulative H$_2$ production

3.2. Effect of initial S/X ratio

Fig. 2 shows the cumulative HP at different initial S/X ratios using PBC as inoculum and PMW as substrate. The results obtained indicated that increasing initial S/X ratio from 0.05 to 0.3 gCOD/gVS enhanced the cumulative HP from 0.9 to 3.8 mmol, respectively. Nevertheless, at a higher S/X ratio of 1 gCOD/gVS, the cumulative HP dropped to 1.3 mmol. In addition, cumulative H$_2$ production was fitted using Gompertz equation of which kinetics parameters were determined by regression analysis. The correlation coefficient between the experimental and simulated data was relatively high ($R^2 > 0.978$) as shown in Table 2. The kinetic results showed that the hydrogen potential (P) and the maximum hydrogen production rate (R_m) were S/X-dependent. In particular, the highest R_m and P were 0.19 mmol/h and 3.8 mmol at initial S/X ratio for 0.3 gCOD/gVS. The lower HP at S/X ratio of 0.05 gCOD/gVS was mainly due to the substrate limiting conditions of batch cultivation given that the most of substrate were consumed for bacterial growth. This behaviour was likely due to the biomass accumulation which further led to nutrients consumption and substrate inhibition (Sun et al., 2011). However, at the higher S/X ratio, a microbial shift occur resulting in increasing the biomass yield that is not related to hydrogen producers (Hafez et al., 2010).
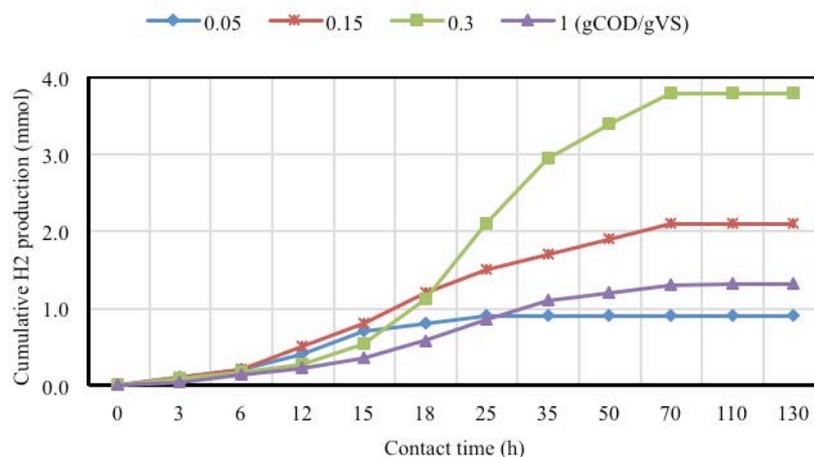
Figure 2. Effect of initial S/X ratio on cumulative H_2 production

The conversion efficiency of organic pollutants in PMW was highly affected by initial S/X ratio as shown in Table 3. Given that, it was observed that COD removal efficiency (% R) and HY increased from 43.63 to 51.66% and 0.5 to 2.1 mmol/gCOD$_{initial}$ with increasing S/X ratio from 0.05 to 0.3 gCOD/gVS, respectively. Furthermore, the solubility of organic matter at the end of fermentation was found S/X ratio-dependent, where the peak COD solubility of 22.94% was at S/X ratio of 0.3 gCOD/gVS, which was accorded to the highest HP. This ratio decreased at lower and higher S/X ratio of 7.45 and 14.18% at 0.05 and 1 gCOD/gVS, respectively. The increasing solubility at the end of fermentation indicated that a portion of organic matter was acidified and dissolved during the reaction due to the volatile fatty acids generation which is accompanied with H_2 production (Zhou et al., 2013).

Table 3. Performance of initial S/X ratio of fermentative H_2 production and conversion efficiency

S/X (gCOD/gVS)	Model simulation				HY (mmol/gCOD$_{initial}$)	COD R%	Solubility %
	P (mmol)	R$_m$ (mmol/h)	λ (h)	R²			
0.05	0.9	0.10	8	0.98	0.50	43.63	7.45
0.15	2.1	0.13	9	0.98	1.16	45.78	20
0.3	3.8	0.19	9	0.96	2.10	51.66	22.94
1	1.3	0.07	10	0.99	0.73	31.37	14.18

On the other hand, the carbohydrates conversion was also studied given the substrate affinity of the enriched hydrogen producing bacterial culture depends on carbohydrate content (Chen et al., 2006). In particular, it was observed that the peak carbohydrates removal efficiency was 48.25% at S/X ratio of 0.3 gCOD/gVS. Where, lower and higher S/X significantly decreased the removal efficiency to 32.05 and 15.5% at S/X of 0.05 and 1 gCOD/gVS, respectively. Besides, it was found that the highest HY (2.1 mmol H_2/gCOD$_{initial}$) was accorded to the highest % soluble/total carbohydrates removal (72.73%) as shown in Fig. 3. Moreover, this is coincided to the highest % removal of volatile suspended solids (63.16%). This indicates that most of produced H_2 was generated from the conversion of organic particulates in PMW. From the

aforementioned calculations, it is concluded that the ability of PBC to convert COD into hydrogen is greatly influenced by the initial S/X ratio.
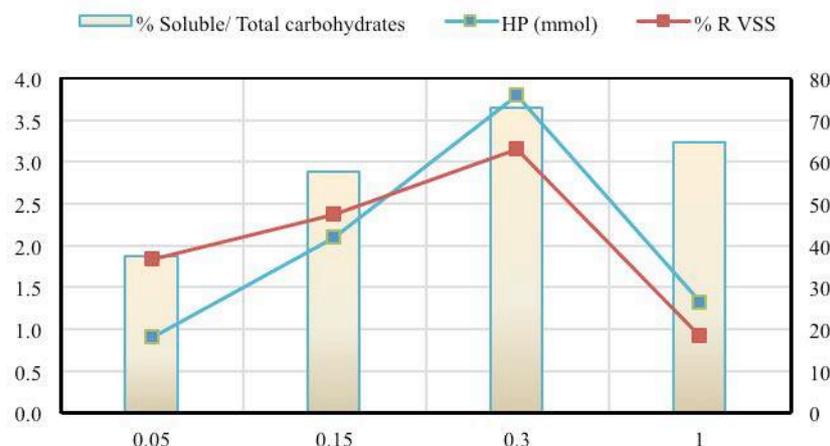

Figure 3. The relationship between HP and the percent of total suspended solids and carbohydrates removal

As reported in the literature, the initial (S/X) ratio significantly affects the metabolic production through the process (Chen et al., 2006). It was observed that the main VFAs produced were acetate (HAc) and butyrate (HBu) as shown in Fig. 4. Where, the HAc and HBu increased from 112.2 and 54 mg/l to 172.12 and 71.6 mg/l, respectively. Nevertheless, HAc and HBu decreased with increasing S/X ratio (1 gCOD/gVS) to 115.4 and 61.8 mg/l, respectively. As can be seen from Fig. 4, the highest HAc/HBu of 2.4 was coincided to the highest HP and HY. Comparable trends were observed elsewhere (Elsamadony et al., 2015), where HAc and HBu increased from 1.28 ± 0.11 and 2.2 ± 0.27 g/l to 3.82 ± 0.33 and 2.91 ± 0.12 g/l with increasing S/X ratio from 1.7 to 9.2 using organic fraction of municipal solid waste as a substrate. Accordingly, HAc and HBu are the desirable volatile fatty acids as they are indicative of hydrogenogenic metabolic pathway (Reungsang et al., 2013). On the other hand, the production of propionate (HPr) and lactate (HLa) was likely due to that there is such consumption of H_2 that may be caused by the lactic acid bacteria (Eqs. 3 and 4). Besides, the discrepancies in HPr and HLa trends with varying S/X ratios are possibly due to the polysaccharides behaviour in the cellulosic content of the PMW, which affected the VFAs fermentation process (Farghaly et al., 2015). The polysaccharides have resulted from the bleaching chemicals used in the manufacturing process of PMW, such as slimicides that control bacteria and fungi that produce polysaccharides in the finished product (Ozaki et al., 2004).

[3] $Glucose + 4H_2O \implies HLa^- + 2HCO_3^- + 4H^+$

[4] $HLa^- + H_2 \implies 2CH_3CHOHCOOH + H_2O$
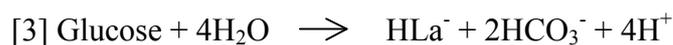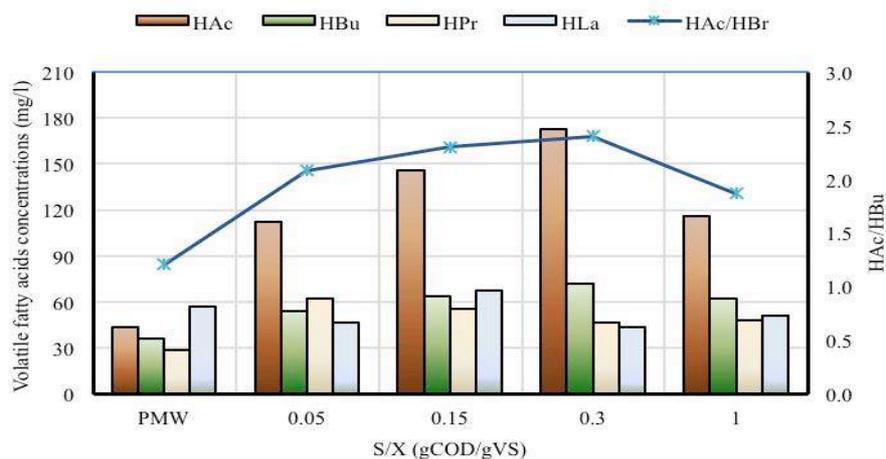
Figure 4. Effect of S/X ratio on the produced volatile fatty acids concentrations

4. Conclusions

The results obtained from this study showed the positive effect of PBC supplementation as consortium for fermentative H_2 production using paperboard mill wastewater. In addition, it was found that the HP and biodegradation process were strongly initial S/X-dependent. In particular, inoculating PBC to PMW resulted in HP and HY of 1.5-fold higher than those produced from PMW as a sole substrate. Moreover, HP and HY at S/X ratio of 0.3 gCOD/gVS resulted in the highest values of 3.8 mmol and 2.1 mmol/gCOD$_{initial}$, respectively. This was coincided to considerable organic pollutants removal in terms of COD, carbohydrates, TSS, and VSS of 51.6, 48.25, 82.1, and 63.16 %, respectively. Meanwhile, the volatile fatty acids analysis indicated that HAc-HBu fermentation pathway has been occurred accompanied with HPr and HLa production.

Acknowledgements

References

Assawamongkholsiri, T., Reungsang, A., Pattra, S., 2013. Effect of acid, heat and combined acid-heat pretreatments of anaerobic sludge on hydrogen production by anaerobic mixed cultures. Int. J. Hydrogen Energy 38, 6146–6153. doi:10.1016/j.ijhydene.2012.12.138

Bayr, S., Kaparaju, P., Rintala, J., 2013. Screening pretreatment methods to enhance thermophilic anaerobic digestion of pulp and paper mill wastewater treatment secondary sludge. Chem. Eng. J. 223, 479–486. doi:10.1016/j.cej.2013.02.119

Chaganti, S.R., Kim, D.H., Lalman, J. A., 2012. Dark fermentative hydrogen production by mixed anaerobic cultures: Effect of inoculum treatment methods on hydrogen yield. Renew. Energy 48, 117–121. doi:10.1016/j.renene.2012.04.015

Chairattanamanokorn, P., Tapananont, S., Detjaroen, S., Sangkhatim, J., Anurakpongsatorn, P., Sirirote, P., 2012. Additional paper waste in pulping sludge for biohydrogen production by heat-shocked sludge. Appl. Biochem. Biotechnol. 166, 389–401. doi:10.1007/s12010-011-9434-5

Chen, C., Chang, S., 2001. Kinetics of hydrogen production with continuous anaerobic cultures utilizing sucrose as the limiting substrate 56–64. doi:10.1007/s002530100747

Chen, W., Chen, S., Kumarkhanal, S., Sung, S., 2006. Kinetic study of biological hydrogen production by anaerobic fermentation. Int. J. Hydrogen Energy 31, 2170–2178. doi:10.1016/j.ijhydene.2006.02.020

Elsamadony, M., Tawfik, A., Danial, A., Suzuki, M., 2015. Optimization of hydrogen production from organic fraction of municipal solid waste (OFMSW) dry anaerobic digestion with analysis of microbial community. Int. J. energy Res. doi:10.1002/er.3297

Farghaly, A., Tawfik, A., 2015. Inoculation of paperboard sludge versus mixed culture bacteria for hydrogen production from paperboard mill wastewater. Environ. Sci. Pollut. Res.

Farghaly, A., Tawfik, A., Mona, G., 2015. Surfactant-supplemented mixed bacterial cultures to produce hydrogen from paperboard mill wastewater. Eng. Life Sci. 15, 525–532. doi:10.1002/elsc.201400099

Gadhe, A., Sonawane, S.S., Varma, M.N., 2014. Kinetic analysis of biohydrogen production from complex dairy wastewater under optimized condition. Int. J. Hydrogen Energy 39, 1306–1314. doi:10.1016/j.ijhydene.2013.11.022

González-Fernández, C., García-Encina, P.A., 2009. Impact of substrate to inoculum ratio in anaerobic digestion of swine slurry. Biomass and Bioenergy 33, 1065–1069. doi:10.1016/j.biombioe.2009.03.008

Hafez, H., Nakhla, G., El. Naggar, M.H., Elbeshbishy, E., Baghchehsaraee, B., 2010.

Effect of organic loading on a novel hydrogen bioreactor. Int. J. Hydrogen Energy 35, 81–92. doi:10.1016/j.ijhydene.2009.10.051

Kan, E., 2013. Effects of pretreatments of anaerobic sludge and culture conditions on hydrogen productivity in dark anaerobic fermentation. Renew. Energy 49, 227–231. doi:10.1016/j.renene.2012.01.026

Kumar, V., Dhall, P., Naithani, S., Kumar, A., Kumar, R., 2014. Biological approach for the treatment of pulp and paper industry effluent in sequence batch reactor. J. Bioremediation Biodegrad. 05, 1–10. doi:10.4172/2155-6199.1000218

Laothanachareon, T., Kanchanasuta, S., Mhuanthong, W., Phalakornkule, C., Pisutpaisal, N., Champreda, V., 2014. Analysis of microbial community adaptation in mesophilic hydrogen fermentation from food waste by tagged 16S rRNA gene pyrosequencing. J. Environ. Manage. 144, 143–51. doi:10.1016/j.jenvman.2014.05.019

Lee, K., Hsu, Y., Lo, Y., Lin, P., Lin, C., Chang, J., 2008. Exploring optimal environmental factors for fermentative hydrogen production from starch using mixed anaerobic microflora. Int. J. Hydrogen Energy 33, 1565–1572. doi:10.1016/j.ijhydene.2007.10.019

Mohammadi, P., Ibrahim, S., Annuar, M.S.M., 2012. Comparative study on the effect of various pretreatment methods on the enrichment of hydrogen producing bacteria in anaerobic granulated sludge from brewery wastewater. Korean J. Chem. Eng. 29, 1347–1351. doi:10.1007/s11814-012-0018-z

Mohan, S.V., 2008. Fermentative hydrogen production with simultaneous wastewater treatment : influence of pretreatment and system operating conditions. J. Sci. Ind. Res. 67, 950–961.

Ozaki, A., Yamaguchi, Y., Fujita, T., Kuroda, K., Endo, G., 2004. Chemical analysis and genotoxicological safety assessment of paper and paperboard used for food packaging. Food Chem. Toxicol. 42, 1323–37. doi:10.1016/j.fct.2004.03.010

Reungsang, A., Sreela-or, C., Plangklang, P., 2013. Non-sterile bio-hydrogen fermentation from food waste in a continuous stirred tank reactor (CSTR): Performance and population analysis. Int. J. Hydrogen Energy 38, 15630–15637. doi:10.1016/j.ijhydene.2013.03.138

Sun, J., Yuan, X., Shi, X., Chu, C., Guo, R., Kong, H., 2011. Fermentation of Chlorella sp. for anaerobic bio-hydrogen production: influences of inoculum-substrate ratio, volatile fatty acids and NADH. Bioresour. Technol. 102, 10480–5. doi:10.1016/j.biortech.2011.09.016

Valdez-Vazquez, I., Sparling, R., Risbey, D., Rinderknecht-Seijas, N., Poggi-Varaldo, H.M., 2005. Hydrogen generation via anaerobic fermentation of paper mill wastes. Bioresour. Technol. 96, 1907–13. doi:10.1016/j.biortech.2005.01.036

Yilmaz, T., Yuceer, A., Basibuyuk, M., 2008. A comparison of the performance of

mesophilic and thermophilic anaerobic filters treating papermill wastewater. Bioresour. Technol. 99, 156–63. doi:10.1016/j.biortech.2006.11.038

Zhang, T., Liu, H., Fang, H.H.P., 2003. Biohydrogen production from starch in wastewater under thermophilic condition. J. Environ. Manage. 69, 149–156. doi:10.1016/S0301-4797(03)00141-5

Zhou, P., Elbeshbishy, E., Nakhla, G., 2013. Optimization of biological hydrogen production for anaerobic co-digestion of food waste and wastewater biosolids. Bioresour. Technol. 130, 710–8. doi:10.1016/j.biortech.2012.12.069

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