Adapting the Design Principles of Business Dashboards for Visualizing Status and Trends of River Water Quality - A Case Study of Yogyakarta Province, Indonesia

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Abstract

Monitoring of river water quality is an essential part of environmental management activities. It is generating new data periodically, which are hard to keep track of with multiple pages of traditional reports or spreadsheets. A dashboard that can show a graphical presentation of the current status and historical trends of river water quality is needed to enable environmental managers to make right decisions at a glance. In this paper, we present the adaptation results of design principles of business dashboard to develop a web-based dashboard for river water quality. This adaptation includes use of officially published data by the environmental management agency of Yogyakarta Province Government of Indonesia. Google Map API is used to provide web mapping on the dashboard. Dynamic bar charts are used to visualize time series data. A slider is provided to show historical trends and progress. The approach of Web 2.0 is implemented to enable users to collaborate with each other to update data on the dashboard. Besides the capability to help users glean insights and make right decisions quickly on the sustainability and management of river water quality from a single interactive web-page screen, this dashboard is also a collaborative medium for multiple users to put and visualize river data together at one place.

keywords: River Water Quality, Environmental Management, Dashboard, Web-Mapping

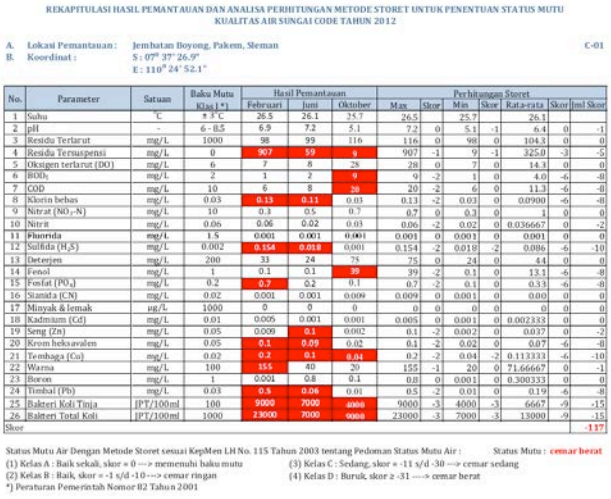
1. INTRODUCTION

Rivers are important natural resources particularly for agriculture, fisheries, recreational use, amenity value and as sources of drinking water (Department of the Environment – Northern Ireland, 2001). Maintaining the quality of the rivers will contribute significantly for the quality of the environment. Monitoring is an important part of it. It generates data periodically which are very useful for assessing the quality of an environment. It is also useful for evaluating the environmental performances such as the effectiveness of projects, programs or activities for river management. Proper evaluation will be achieved with a good insight of the data and will lead to good of river management. On the other hand, improper evaluation without good understanding of data will lead to the destruction of the river.

The data are necessary to be processed, presented, and publicly reported at least for two fundamental functions (The Ministry of The Environment - Japan, 2007). The first is an external function as a communication tool between the river management authority and society. It includes disclosing information based on the social accountability of organizations, providing useful information for stakeholders making decision, and promoting environmental initiatives between the organization and society. The second is an internal function which promotes ideas within the organization. It includes establishing or revising the environmental policy, objectives and action plans of the organization. It also is able to motivate and encourage the environmental activities of managements and employees. All of these functions play a very important role in promoting voluntary initiatives there.

Reporting publicly the environmental data also give benefits (Natural Heritage Trust - Australia, 2000) such as creation of market opportunities; indirect improvement in internal environmental performance; increased confidence of investors, insures and financial institutions; improvement of relationships with local communities, regulators, and non government organization, greater control of environmental disclosure, and increased staff commitment.

The Environmental Agency of Yogyakarta Province has reported and published publicly the Summaries of Water Quality Monitoring and Analysis from 2007 – 2012 (Badan Lingkungan Hidup Daerah Istimewa Yogyakarta, 2013). The summaries generally contains multiple pages of tables (Fig. 1). It is hard to keep track of the data with this kind of reports. Additional visualization is necessary to make sense of the data because research shows that data visualization can improve significantly the insights and accelerate time-needed to the insight (Eckerson, 2011).



REKAPITULASI HASIL PEMANTAUAN DAN ANALISA PERHITUNGAN METODE STORET UNTUK PENENTUAN STATUS MUTU KUALITAS AIR SUNGAI CODE TAHUN 2012

A. Lokasi Pemantauan : Jembatan Boyong, Pakem, Sleman C-01
B. Koordinat : S : 07° 37' 26.9" E : 110° 24' 52.1"

No.	Parameter	Satuan	Baku Mutu Kls I *)	Hasil Pemantauan			Perhitungan Storet						
				Februari	Juni	Oktober	Max	Skor	Min	Skor	Rata-rata	Skor	Jml Skor
1	Suhu	°C	± 3 °C	26.5	26.1	25.7	26.5		25.7		26.1		
2	pH	-	6 - 8.5	6.9	7.2	5.1	7.2	0	5.1	-1	6.4	0	-1
3	Residu Terlarut	mg/L	1000	98	99	116	116	0	98	0	104.3	0	0
4	Residu Tersuspensi	mg/L	0	907	59	9	907	-1	9	-1	325.0	-3	-5
5	Oksigen terlarut (DO)	mg/L	6	7	8	28	28	0	7	0	14.3	0	0
6	BOD_5	mg/L	2	1	2	9	9	-2	1	0	4.0	-6	-8
7	COD	mg/L	10	6	8	20	20	-2	6	0	11.3	-6	-8
8	Klorin bebas	mg/L	0.03	0.13	0.11	0.03	0.13	-2	0.03	0	0.0900	-6	-8
9	Nitrat (NO_3-N)	mg/L	10	0.1	0.5	0.7	0.7	0	0.1	0	1	0	0
10	Nitrit	mg/L	0.06	0.06	0.02	0.03	0.06	-2	0.02	0	0.036667	0	-2
11	Fluorida	mg/L	1.5	0.001	0.001	0.001	0.001	0	0.001	0	0.001	0	0
12	Sulfida (H_2S)	mg/L	0.002	0.154	0.018	0.001	0.154	-2	0.018	-2	0.086	-6	-10
13	Deterjen	mg/L	200	33	24	75	75	0	24	0	44	0	0
14	Fenol	mg/L	1	0.1	0.1	39	39	-2	0.1	0	13.1	-6	-8
15	Fosfat (PO_4)	mg/L	0.2	0.7	0.2	0.1	0.7	-2	0.1	0	0.33	-6	-8
16	Sianida (CN)	mg/L	0.02	0.001	0.001	0.009	0.009	0	0.001	0	0.00	0	0
17	Minyak & lemak	µg/L	1000	0	0	0	0	0	0	0	0	0	0
18	Kadmium (Cd)	mg/L	0.01	0.005	0.001	0.001	0.005	0	0.001	0	0.002333	0	0
19	Seng (Zn)	mg/L	0.05	0.009	0.1	0.002	0.1	-2	0.002	0	0.037	0	-2
20	Krom heksavalen	mg/L	0.05	0.1	0.09	0.02	0.1	-2	0.02	0	0.07	-6	-8
21	Tembaga (Cu)	mg/L	0.02	0.2	0.1	0.04	0.2	-2	0.04	-2	0.113333	-6	-10
22	Warna	mg/L	100	155	40	20	155	-1	20	0	71.66667	0	-1
23	Boron	mg/L	1	0.001	0.8	0.1	0.8	0	0.001	0	0.300333	0	0
24	Timbal (Pb)	mg/L	0.03	0.5	0.06	0.01	0.5	-2	0.01	0	0.19	-6	-8
25	Bakteri Koli Tinja	JPT/100ml	100	9000	7000	4000	9000	-3	4000	-3	6667	-9	-15
26	Bakteri Total Koli	JPT/100ml	1000	23000	7000	9000	23000	-3	7000	-3	13000	-9	-15
Skor													-117

Status Mutu Air Dengan Metode Storet sesuai KepMen LH No. 115 Tahun 2003 tentang Pedoman Status Mutu Air : Status Mutu : cemar berat
(1) Kelas A : Baik sekali, skor = 0 ---> memenuhi baku mutu (3) Kelas C : Sedang, skor = -11 s/d -30 ---> cemar sedang
(2) Kelas B : Baik, skor = -1 s/d -10 ---> cemar ringan (4) Kelas D : Buruk, skor ≥ -31 ---> cemar berat
*) Peraturan Pemerintah Nomor 82 Tahun 2001

Fig. 1 The format of River Water Quality Monitoring and Analysis Summaries of Yogyakarta Province , Indonesia

The initiative to visualize the river water quality status is not new. For example, Environmental Protection Agency (EPA) of Ireland has an accessible web-based data visualization screen (EPA of Ireland, 2013) for its rivers (Fig. 2). This data visualization shows five types of river status dots, among others are High (blue), Good (green), Moderate (yellow), Poor (orange), and Bad (red) from all spots of The republic of Ireland. Those dots can be clicked and will give the information about the name of the monitoring station.

Another example is Statewide River Water Quality Assessment (Fig. 3) by The Government of Western Australia (Department of Water - Western Australia, 2013). This data visualization shows spots of river monitoring as blue dots. Those blue dots can be clicked and will give you text based summary about the location such as the location name, the parameters, and the trends on the right panel of the browser.

Those visualizations are mainly based on maps and give the actual status of those spots. Confusion is there since it visualizes too broad areas for local authority and society. It is hard to give the real impact for the river stakeholders with this kind of visualizations. The visualization are not actionable since they are not clear about the metrics if it is on-target or off-target.

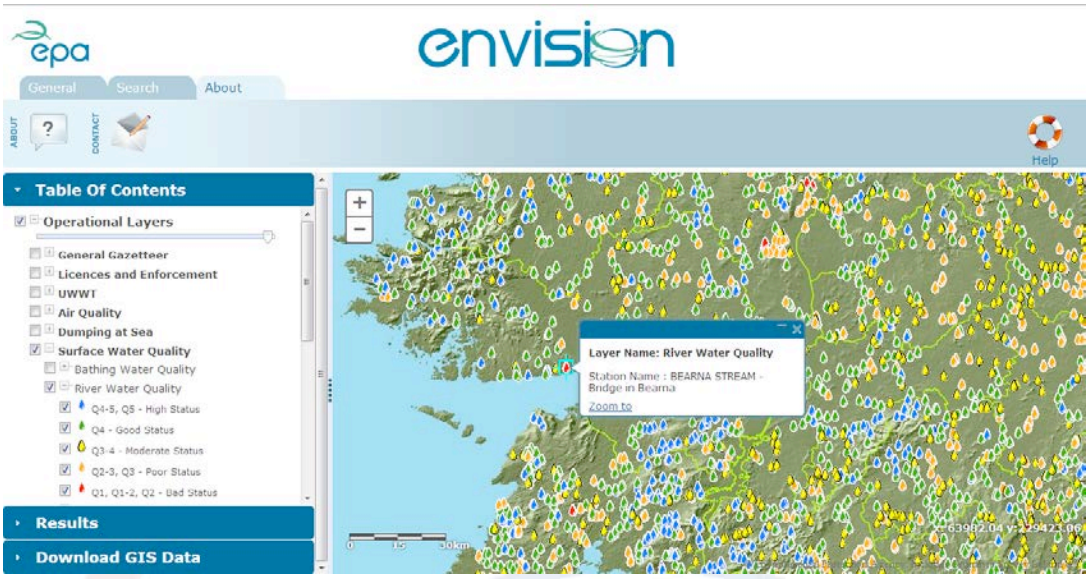


Fig. 2 The layout of Envision by EPA of the Republic of Ireland

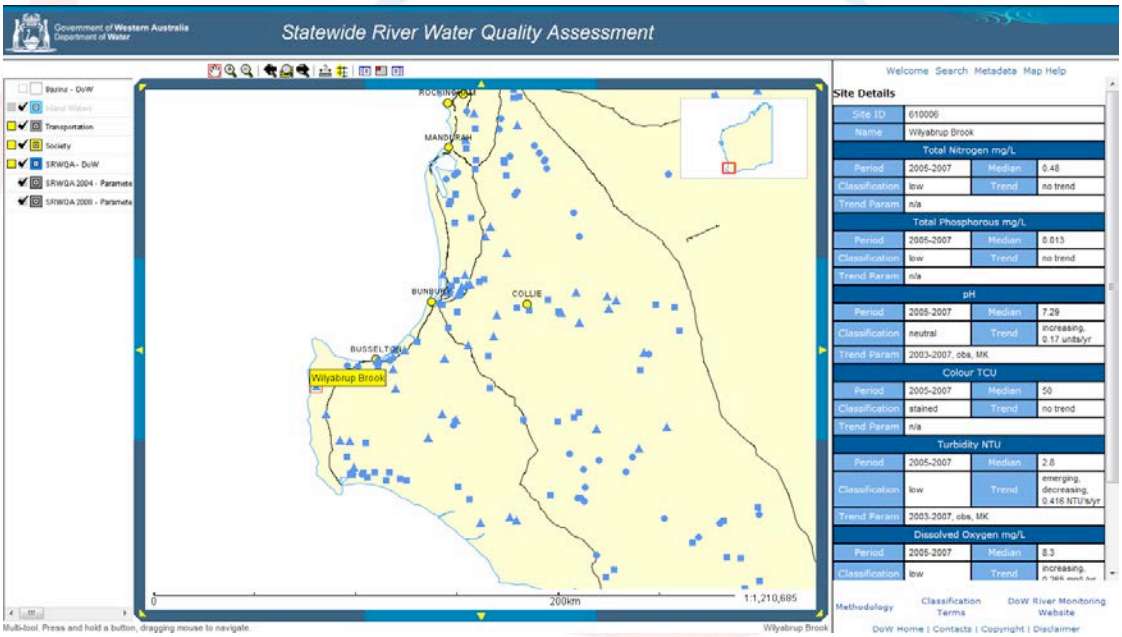


Fig. 3 The layout of Statewide River Water Quality Assessment by Department of Water, Government of Western Australia

For this reason, we are trying to come up with a new design for visualizing status and trends of river water quality that is user-friendly, non-confusing, high impact, and actionable particularly for the River Stakeholders of Yogyakarta Province. This new design tries to complement the public river water quality report so the dashboard can help it to give its purpose and benefits better.

2. METHODS

2.1 Design Principles

This web-application is designed as a dashboard which is a visual display of the most important information needed to achieve one or more objective which fits entirely on a single screen so it

can be monitored at a glance (Few, 2011). Business dashboard design principles (Juice, 2009) are used to make the river dashboard (Table 1).

Table 1. Business Dashboard Design Principles Implementation

Principles	Description	Implementation
Actionable	It is clear what is the source of the problem when the metric goes off-target	The dashboard focuses on showing the river status only whether it is on-target or off-target
Common interpretation	People in the organization recognize the metrics	The dashboard should use the metrics that are already understood and used by the local Environmental Authority
Transparent, simple calculation	How the metric is generated is shared and easy to understand	The dashboard assess the water quality in a very simple way. It is to present visually if the quality is on-target or not
Accessible, credible data	The data can be acquired with modest effort from a source that people trust	The dashboard should use the sample data which are officially published for public by local Environmental Authority.

2.2 Water Quality Parameter and Data Sample

The parameter of the water quality in this application uses the standards defined by the President of Indonesia (Presiden Indonesia, 2001) which are classified to some classes (Table 2). Each class has its own usages (Table 3) which are defined by the Governor of Yogyakarta Province (Gubernur Yogyakarta, 2008). The data sample for this application comes from the Water Quality Reports of three rivers in Yogyakarta Province which are Code, Winongo and Gadjahwong River from 2007 to 2012 including the standard of water quality in each monitoring location (Badan Lingkungan Hidup Yogyakarta, 2013).

Table 2. The Parameter of Water Quality

Parameter	Units	Class 1		Class 2		Class 3	
		Minimum	Maximum	Minimum	Maximum	Minimum	Maximum
pH	-	6	8.5	6	8.5	6	8.5
Total Dissolved Solid	mg/L	0	1000	0	1000	0	1000
Total Suspended Solid	mg/L	0	0	0	50	0	400
DO	mg/L	6	9	5	9	4	9
BOD5	mg/L	0	2	0	3	0	6
COD	mg/L	0	10	0	25	0	50
Free Chlorine	mg/L	0	0.03	0	0.03	0	0.03
Nitrate (NO_3^-)	mg/L	0	10	0	10	0	10
Nitrite (NO_2^-)	mg/L	0	0.06	0	0.06	0	0.06
Fluoride	mg/L	0	1.5	0	1.5	0	1.5
Sulfide (H_2S)	mg/L	0	0.002	0	0.002	0	0.002
Detergent	µg/L	0	200	0	200	0	200
Phenol	µg/L	0	1	0	1	0	1
Phosphate (PO_4^{3-})	mg/L	0	0.2	0	0.2	0	0.2
Cyanide (CN)	mg/L	0	0.02	0	0.02	0	0.02
Oils and Fats	µg/L	0	1000	0	1000	0	1000
Cadmium (Cd)	mg/L	0	0.01	0	0.01	0	0.01
Zinc (Zn)	mg/L	0	0.05	0	0.05	0	0.05
Chromium (VI)	mg/L	0	0.05	0	0.05	0	0.05
Copper (Cu)	mg/L	0	0.02	0	0.02	0	0.02
Color	mg/L	0	100	0	100	0	100
Boron (B)	mg/L	0	1	0	1	0	1
Lead (Pb)	mg/L	0	0.03	0	0.03	0	0.03
Fecal Coliform	MPN/100ml	0	100	0	1000	0	2000
Total Coliform	MPN/100ml	0	1000	0	5000	0	10000

Table 3. Water Quality Classification

Usage	Class 1	Class 2	Class 3
Drinking	ü	X	X
Water-based Recreational facilities	ü	ü	X
Freshwater Fish breeding, Livestock, and Irrigation	ü	ü	ü

2.3 Database Schema

The database of this web-application is designed to visualize river data. There are four tables which relates to each other for the visualization feature. The tables are “baku_mutu”, “parameter”, “data_sungai”, and “lokasi” (Fig. 4). For preventing repeated data, we implement One to Many relations on the “parameter” table to “baku_mutu” table, “data_sungai” table to “parameter” table and “lokasi” table to “data_sungai” table.

The “baku_mutu” table stores the data of the water quality threshold standards for each parameter. This table has the value of “parameterid” which is referencing to the primary key of the “parameter” table . The “parameter” table stores the name and the units of the parameters.

Table of “data_sungai” stores the actual value of water in a specific date, a specific location, the “parameterid” value for referencing to the table of “parameter”, and the target of what water quality class should be achieved in that location. The location value of “data_sungai ” table is referencing to the table of “lokasi” which stores the name of the river, the name of the monitoring location, the latitude, and the longitude.

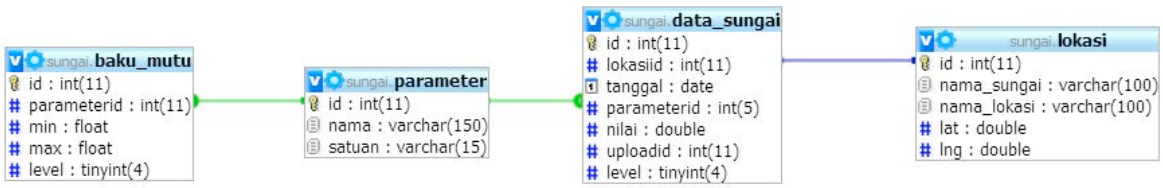


Fig. 4. Database schema of the river dashboard application

3. APPLICATION AND DISCUSSION

3.1 Dashboard Designs

The river dashboard we developed combines a map and bar-charts. The map is used to show the distribution of monitoring locations. Google Map API is chosen since it can show the contour of an area. Google Map API is also able to show the satellite image of an area that will give useful information for the users. On the map, points are dynamically generated from the selected year. Users can select the year by dragging the slider on top of the map. The points also show the results of water quality assessment in each year, when it is on-target, the points will be green otherwise the points will be red. The total numbers of the green and red dots are displayed on a summary box on on top-right of the map.

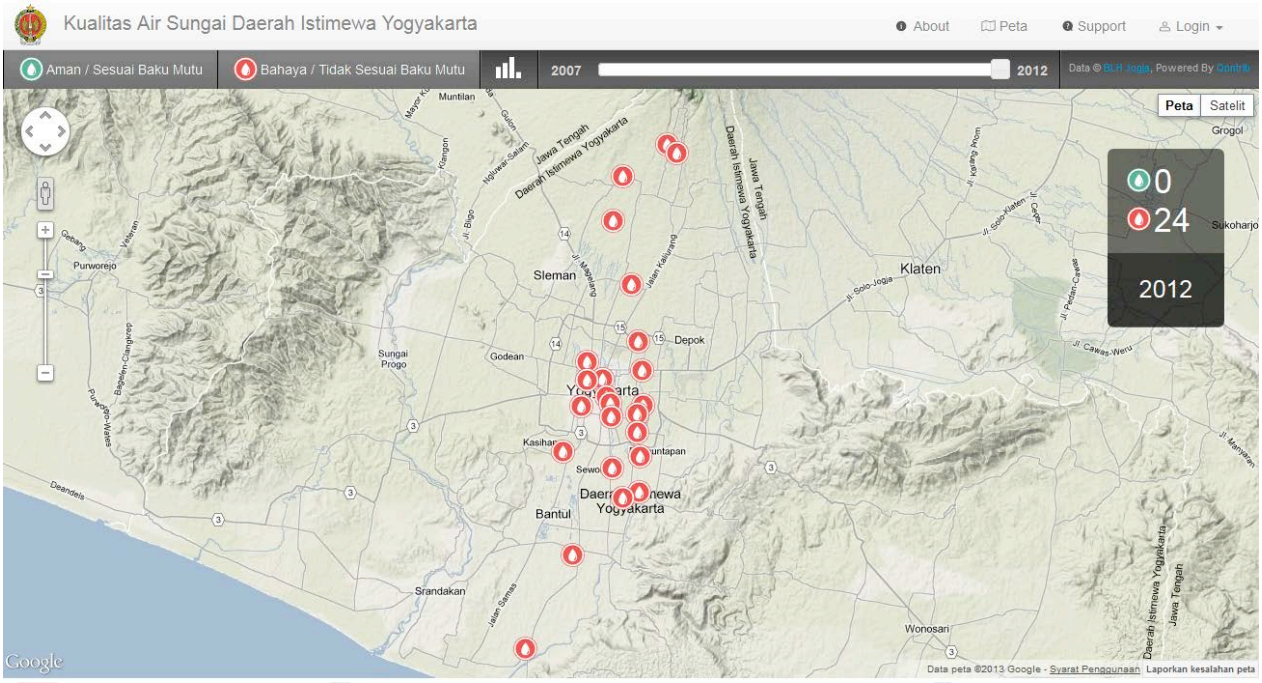


Fig. 5. The main interface of the dashboard that include main navigation, a map, points, a summary box, and a slider

Bar charts are used to visualize the numbers of monitoring locations and the value of each water quality parameter monthly. On top of the map, a button on the left side of the slider can be clicked to show the monthly river water quality data and assessment. The points on the map can be clicked to to show the value of the parameters in that location. The value of the parameter are shown per month as bar charts. The slider under the bar-charts can be dragged to select the year.

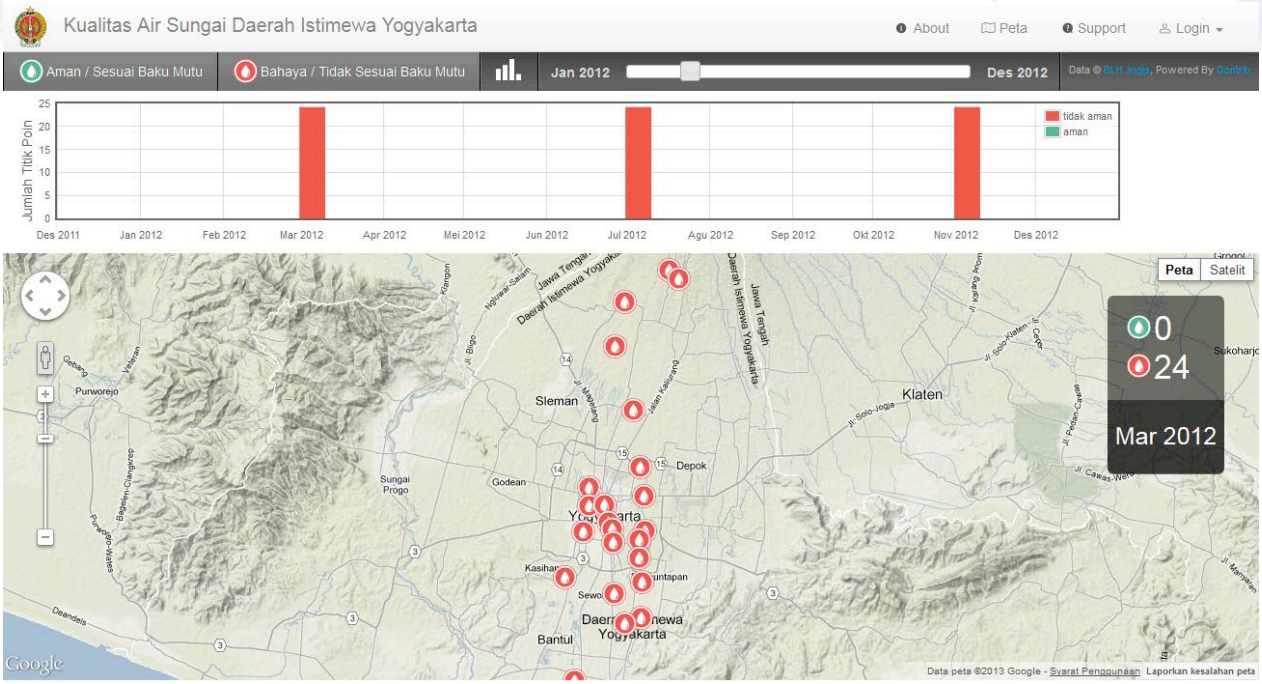


Fig. 6. The monthly review interface of the dashboard showing the numbers of the green and red points per month in a selected year

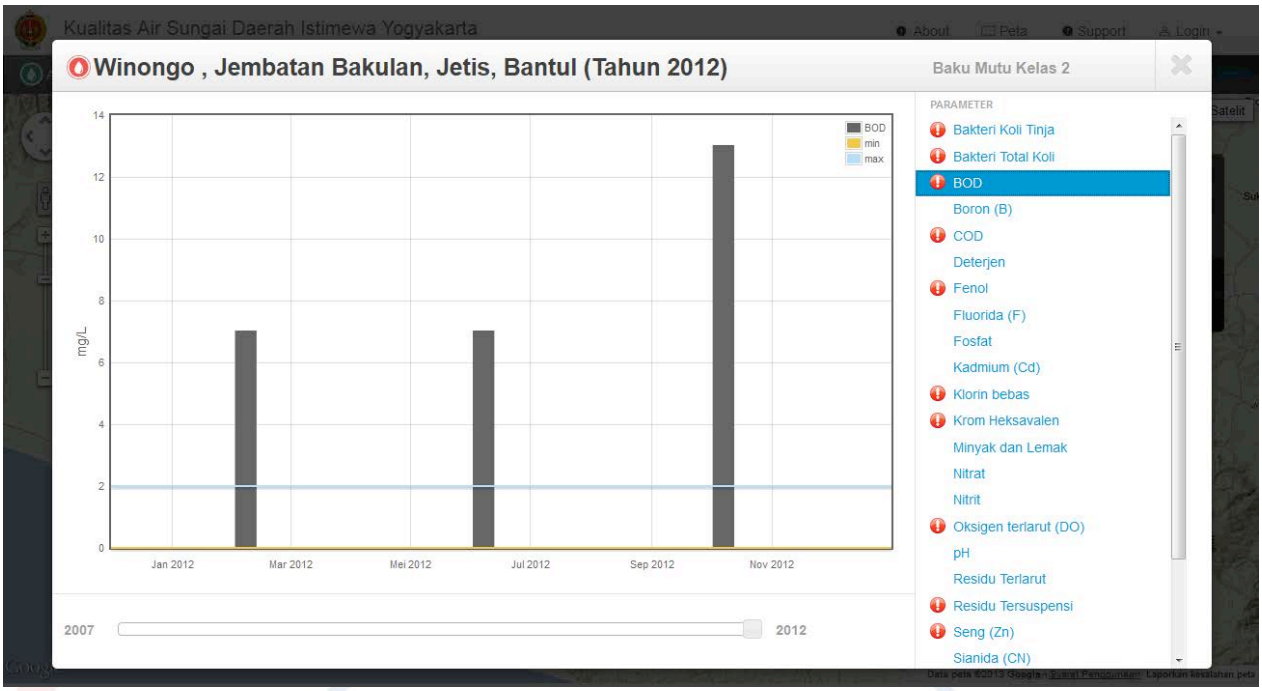


Fig. 6. The monthly review interface of the dashboard showing the value of each parameter per month in a selected location and year

Through this design, this river water quality dashboard is able to visualize water quality assessment automatically. The performance of a local river management authority can also be monthly or yearly reviewed. This dashboard also has a narrower targeted users which are local river authority and local society in a region so the information on the dashboard is more actionable.

These features differentiate this application in comparison to other web-based river data visualization application such as Envision of the Environmental Protection Agency of Ireland and Statewide Water Quality Assessment system of the Department of Water, Western Australia Government.

3.2 Data Collaboration and Management

The approach of Web 2.0 is implemented to this application by making this dashboard as a gateway rather than an endpoint of the river data visualization. A definition of Web 2.0 is the philosophy of mutually maximizing collective intelligence and added values for each participant by formalized and dynamic information sharing and creation (Wijaya, 2009). This application allows users to create and share river data in a collaborative environment to update and manage the dashboard. There are three levels of users in the dashboard which are “Sp-Admin”, “Admin”, and “Tim”. Each level has its own role for the dashboard. The interface of the web-page for this feature shows the list of the uploaded files and the list of the registered users (Fig. 7). This dashboard can handle the Open Office (.ods) and Microsoft Excel (.xls) files.

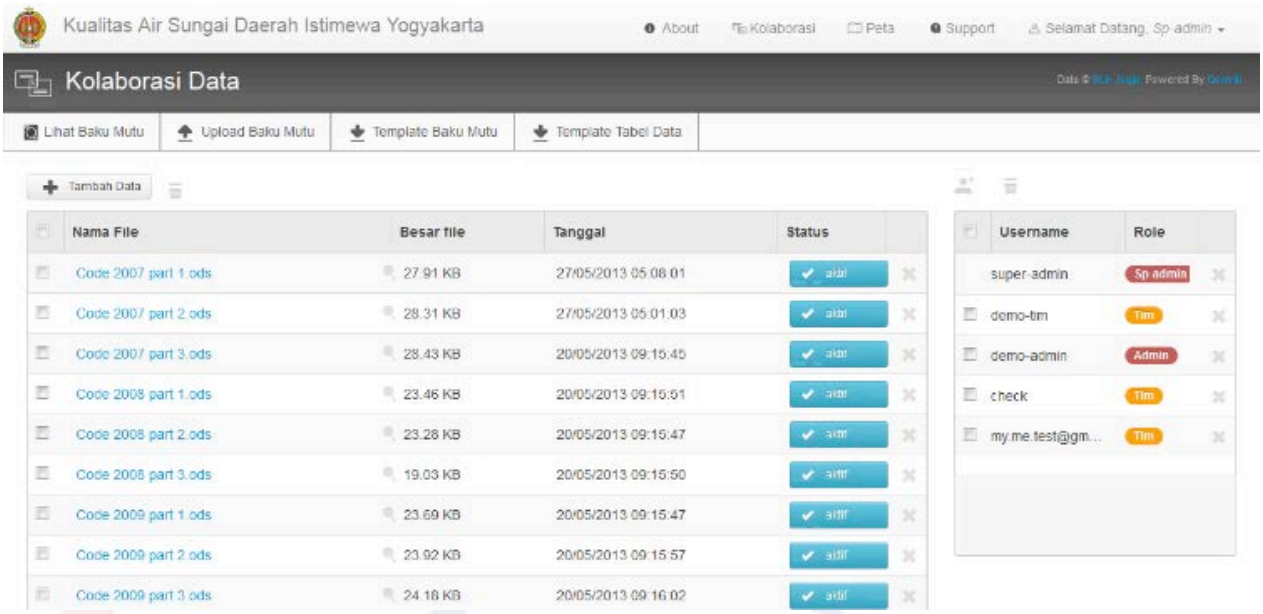


Fig.7 The interface for the collaborative environment of the dashboard

Table 4. Users Role

Role	Sp-Admin	Admin	Tim
Deleting “Admin” users	ü	X	X
Deleting “Tim” users	ü	ü	X
Activating the Data to be visualized and visible by public	ü	ü	X
Uploading the Water Quality Parameter Standards	ü	ü	ü
Uploading River Data	ü	ü	ü

3.3 Findings

After putting all the sample data to the dashboard, we can easily review the performance of the river management in Yogyakarta Province. We can find through the map and the bar charts on the dashboard (accessible at http://riverdemo.qontrib.com) that there is no significant improvement of the three rivers in six years from 2007 to 2012. BOD and COD remain off-target from 2007 to 2012. Even the monitoring locations for these three rivers in 2011 and 2012 are fewer than in the previous years. There are 24 locations in 2012 and 2011. There are 28 locations in 2010, 2009, 2008, and 2007. The frequency in 2012 is also fewer then in the other years. In the year 2012, there were three times of monitoring activities. But previously from 2007 to 2011, there were four times in each year. We also found the inconsistency when the monthly monitoring took place.

The current form of the reports published by the Environmental Authority of Yogyakarta Province uses 119 pages for putting all the data of the three rivers. This dashboard simplify the reports to be a single interactive web-screen and full of data visualization which is easier to understand. Through these findings we can see that there is a lot to improve in the efforts to manage the rivers. We also can conclude that the effectiveness of the current efforts is not enough.

5. CONCLUSION

This dashboard of river water quality simplify significantly the reports of three rivers monitored in six years and automatically assess if the water quality is on-target or off-target in each year. This dashboard stores, combines, and visualizes river water quality data. At this point, the dashboard is able to relate data instantly. It is also able to visualize its value and distribution on dynamic bar charts and Google Map. This implication is useful to look at data in a more meaningful way so we can easily review the performance of the river management. The functions that facilitate an easier way to update the dashboard will make this application as a gateway rather than an endpoint so it will help the continuous improvement of the river management from years to years.

ACKNOWLEDGEMENT

We thank the Environmental Authority (*Badan Lingkungan Hidup*) of The Yogyakarta Province Government for providing publicly the river water quality data on its accessible website at http://blh.jogjaprov.go.id/kualitas-air/ .

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