Health Risk Assessment of Heavy-Metal Containing Soil Near Some Auto Service Centers of Ulaanbaatar, Mongolia

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Abstract
In this study, assess contamination levels in soil and perform a health risk assessment in the vicinity of some auto service centers in the Ger area of Ulaanbaatar in Mongolia. Thirteen soil samples were collected from an auto services area and analyzed for the concentrations toxic elements such as Cr, Cu, Pb, and Zn, by Atomic Absorption Spectrometry (AAS). The contamination levels were evaluated using the geoaccumulation index. Results of statistical analysis indicated that the average concentration of heavy metals Cu and Pb in the samples exceeded the limits prescribed by the soil standard of Mongolia, with exceeding multiples of Cu (1.82) and Pb (2.48), while those of Cr and Zn were less than prescribed. A total of 12 samples was appearing to be in the range of the uncontaminated to heavily contaminated, with Igeo values less than 3.6 for all the heavy metals except Sample 2. The maximum index of bioaccumulation of soil in the study area was as high as 5.9, indicating the extremely contaminated by anthropogenic. Health risk assessment was performed using the US Environmental Protection Agency (USEPA). Health risk assessment determined that total HI for adults was no exceed than 1, however, for children was estimated exceed than 1. Moreover, the research area overall showed an acceptable range for carcinogenic risks, with the main contributor to the risk being Pb. It was found that 90% of the soil samples did not pose significant health risks in terms of carcinogenic risk, and 10% posed acceptable carcinogenic risks.

Keywords: Auto Service, Heavy Metal of Soil, Health Risk Assessment

Introduction

Heavy metals can affect the environment which dangerous for human health, the life of animals, and the quality of the atmosphere for a long time (Kasassi, A., et al 2008). An example is the heavy metal lead (Pb) which is a non-essential element to the human body, the excessive intake of which can damage the nervous, skeletal, circulatory, enzymatic, endocrine, and immune systems of those exposed to it (Zhang, X.,et al 2012). Moreover, chronic exposure to Cd can cause adverse effects such as lung cancer, pulmonary adenocarcinomas, prostatic proliferative lesions, bone fracture, kidney dysfunction, and hypertension, while the chronic effects of As can consist of dermal lesions, peripheral neuropathy, skin cancer, and peripheral vascular decease (Żukowska, J.et al 2008). Due to their potential toxic, persistent and irreversible characteristics, heavy metals such as Cadmium (Cd), Chromium (Cr), Arsenic (As), Mercury (Hg), Lead (Pb), Copper (Cu), Zinc (Zn) and Nickel (Ni) have been listed for priority control pollution by the United States Environmental Protection Agency (USEPA) and have been the subject of increasing attention in many part of the world (Abrahams, P.W. et al 2002, Rodrigues, S.M.,et al 1969)

As a result of reforms in the economic and social sectors of Mongolia, the number of vehicles in Ulaanbaatar has increased rapidly in the last two decades. In order to meet with customers' demands, second hand automobiles from Japan and Korea are dominant in Mongolia's auto market. This situation has resulted in an increasing number of auto repair and maintenance service centers. Ulaanbaatar city has 910 auto services centers consisting of 438 auto repair centers, 174 welding and wheel repair service centers, 151 car wash centers, and 54 lubricant-selling points and spare part businesses. There are two types of auto services in Ulaanbaatar city and these consist of public (20 percent) and private (80 percent) centers (National Statistics Office of Mongolia; 2018). The private auto repair services have not been granted licenses for their businesses. They do not have a workplace provided by the appropriate authorities and do not have proper equipment or the facilities for running this type of business.

Sources and literature show that the previous researches mainly emphasized on the air pollution caused by vehicle emission and fuel releasing impacts (Byambaa, B., 2019, Guttikunda, S.K., et al 2013, Bayasgalan, B. et al 2017. Environmental influences of auto repair service have not been studied yet, therefore a measurement of toxic substances and pollution intensity is considered as a priority of this study. The main purpose of this study was first, to assess the concentration of heavy metals in surface soil samples near some auto repair centers of Ulaanbaatar city, Mongolia. The second purpose was to conduct a health risk assessment, based on the concentration of heavy metals, to evaluate possible health risks to adults and children. Third, make proposals and recommendations to decrease the pollution rate.

Material and Methods

Study area. Soil, air, and water contamination occurred due to the population density, harsh climate, and geographical location of capital city of Mongolia. The capital city of Mongolia is located in the arid steppe zone of Central Asia, surrounded by mountains and located in a river valley, which contributes to the accumulation of pollutants in the city's air, water and soil. Ulaanbaatar is located in the southwestern part of the Khentii Range, in the mountain forest-steppe and dry steppe zone, in the northern part of the Tuul River valley, Chingeltei (1949.7 meters above sea level), in the south Bogd, and in the west Songino Khairkhan (1652.3 meters above sea level), to the east, surrounded by the Bayanzurkh (1845.5 m above sea level.) mountains, extending from east to west. Geomorphologically, it is divided into low and high floodplains. The low floodplain covers an area of 100-500 m north of the riverbed, and the high floodplain is about 0.51.0 m high.

Sample collection. Thirteen soil samples were collected from the soil in the vicinity of auto service centers in ditricts of Bayanzurkh, Chingeltei, Songinokhairkhan and Khan-Uul Ulaanbaatar city in August 2010. (Fig. 1). Those samples were the top 10 cm of soil and the surface soil samples were used to randomly sampling method and to collect using stainless steel scoops, then placed in polyethylene bags and labelled. Non-soil particles such as stones, wooden pieces, and rocks were removed from the soil. These 13 samples were prepared for measurement by acid digestion of sediments, sludge, and soils 3050 B method at the Soil Laboratory of Geographical Institute of Mongolian Scientific Academy. Their toxic substances (Cr, Cu, Pb, Zn) were identified by the Atomic Absorption Spectrometry or the device of VGP210. Results were compared with Mongolia National Standards (MNS5025:2010) [10].

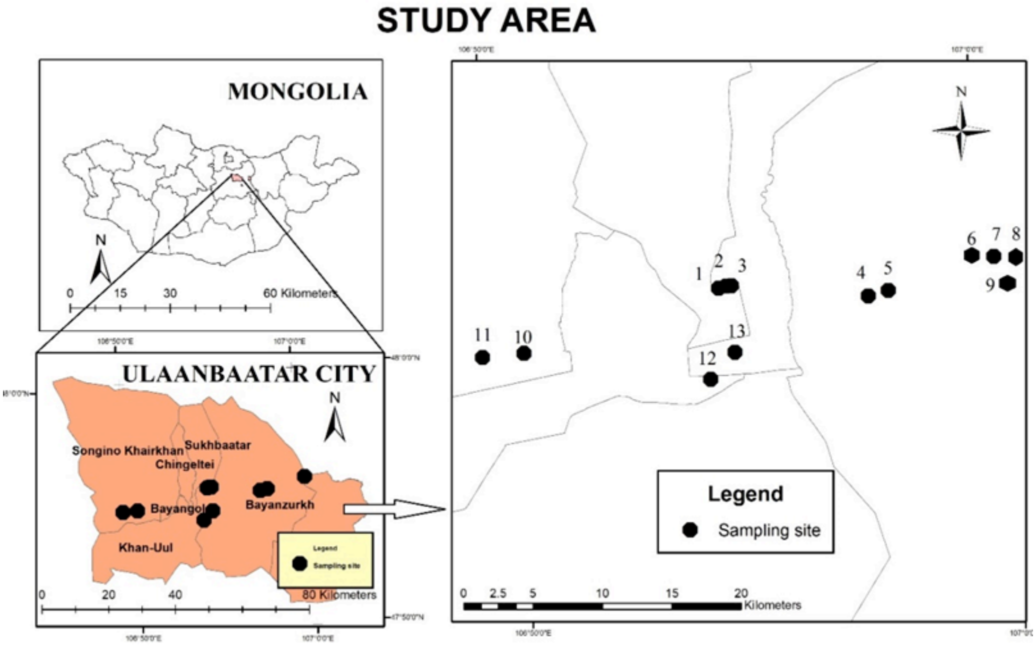


Figure 1. Locations of soil sampling site in Ulaanbaatar, Mongolia

Sample preparation for analysis. The 0.25 g of sample were weighed in a 250 ml Pyrex Erlenmeyer flask and 10 ml of 1:1 HNO3 were added. The solution was heated on a hot plate to ~95 °C without boiling and this temperature was maintained for 10-15 min. After cooling to less than 70 °C, 5 ml of concentrated HNO3 were added and the sample was refluxed at ~95 °C without boiling until the volume was 5 ml. Thereafter, the sample was evaporated to ~5 ml without boiling. After cooling to less than 70 °C, 2 ml of water were added followed by the slow addition of 3 ml of 30% H2O2. The solution was then heated until effervescence subsided. After cooling to less than 70 °C, 10 ml of conc. HCl were added and the sample was refluxed for 15 min. without boiling. After cooling to room temperature, the sample was filtered and diluted to 25 ml with double distilled water. The prepared sample was analyzed in AAS and results were calculated by Eq1.

$$Element(mg/kg) = \frac{\left(\frac{mg}{mL} in\ sample\ solution\right)\ x\ (dilution\ factor)}{weight\ of\ sample\ in\ grams} \quad (1)$$

Their potential health risks were evaluated by the US Environmental Protection Agency (USEPA). Due to determine to the source of anthropogenic, the geoaccumulation index was evaluated.

Geoaccumulation index

The geo-accumulation index (I_geo) was introduced by Muller, G (2018) and it enables the assessment of environmental contamination by comparing differences between current and preindustrial concentrations. The geoaccumulation index is calculated by Eq. 2 and consists 7 classes or grades which presented in Table 1 (Li, Z., 2014).

$$I_{geo} = log_2\left(\frac{C_n}{1.5 \cdot B_n}\right) \quad (2)$$

where, C_n – the measured concentration of every heavy metal (mg/kg). B_n – the geochemical background value of the heavy metals found in the soil (mg/kg). In this study, these reference values were obtained from (Kasimov, N. S.,2011) as Cr 66 mg/kg, Cu 42 mg/kg, Pb 27 mg/kg and Zn 52 mg/kg. The constant 1.5 (Loska, K.,et al 2004) was used due to potential variation in the baseline data.

Table 1. Seven Classes Comprising the Geoaccumulation Index.

Class	Value	Soil quality
0	$I_{geo} \leq 0$	Practically uncontaminated
1	$0 < I_{geo} < 1$	Uncontaminated to moderately contaminated
2	$1 < I_{geo} < 3$	Moderately contaminated
3	$2 < I_{geo} < 3$	Moderately to heavily contaminated
4	$3 < I_{geo} < 4$	Heavily contaminated
5	$4 < I_{geo} < 5$	Heavily to extremely contaminated
6	$5 < I_{geo} < 6$	Extremely contaminated

Health risk assessment. The health risk assessment was performed to assess the possible risk from contaminated soil by heavy metals for local residents in the vicinity of auto repairing centers near the Ger area of Ulaanbaatar. The health risk assessments, for both adults and children, were analyzed with the USEPA model which is a commonly used to evaluate carcinogenic and non-carcinogenic risk (USEPA,1996, 2001). The corresponding formulae that express the dose received through ingestion, and dermal and inhalation pathways are listed in Table 2.

Table 2. The Equations for Measuring Daily Intake via Various Exposure Pathways.

Pathways	Formula	
Ingestion	$ADI_{Ingestion} = \frac{C\ x\ IngR\ x\ EF\ x\ ED\ x\ CF}{BW\ x\ AT}$	(3)
Dermal contact	$ADI_{dermal\ contact} = \frac{C\ x\ SA\ x\ FE\ x\ ABS\ x\ EF\ x\ EDxCF}{BW\ x\ AT}$	(4)
Inhalation	$ADI_{inhalation} = \frac{C\ x\ InhR\ x\ EF\ x\ ED}{PEF\ x\ BW\ x\ AT}$	(5)

The parameters used in the health risk assessment are listed in Table 3. The two principal toxicity indices are known as slope factor (SF), and reference dose (RfD). The SF is a conservative estimate of the incremental probability of an individual developing cancer as a result of exposure over a lifetime and RfD is the estimated amount of the daily exposure level for the population that is likely to be without an appreciable risk of deleterious effects during a lifetime. The RfD and Slope factor values are utilized in calculations that are based on information issued by the (USEPA Integrated Risk Information System; Kamunda, C.,et al 1998; Huang, S.H.,et al 2017). The toxicity indices of the elements are presented in Table 4.

Table 3. The Parameters Used in the Health Risk Assessment are Listed.

Parameters	Adult	Children	Unit	References
ADI, average daily intake	-	-	[mg/kg day]	-
IngR, soil ingestion rate	100	200	[mg/day]	USEPA 1991
EF, exposure frequency	350	350	[day/year]	USEPA 1991
ED, exposure duration	30	6	[year]	USEPA 2004
BW, body weight	70	15	[kg]	USEPA 2004
SF, skin area exposed to soil contact	5700	2800	[cm^2]	USEPA 2004
AF, soil to skin adherence factor	0.07	0.2	[kg/cm day]	USEPA 2004
ABS, contact factor	0.1	0.1	none	USEPA 2004
InhR, inhalation rate	15	10	[m^3/day]	USEPA 1997
PEF, particle emission factor	$1.36x10^9$	$1.36x10^9$	[m^3/kg]	USEPA 2001
AT, average time non-carcinogenic	10950	2190	[days]	USEPA 2002
AT, average time carcinogenic	25550	25550	[days]	USEPA 2002
CR, Conversion factor	$1x10^{-6}$	$1x10^{-6}$	[mg/kg]	USEPA 2002
FE, Dermal exposure ratio	0.61	0.61	-	USEPA 2004

Table 4. Value of RfD and SF of Heavy Metals

Reference Dose [mg/kg day]	**Cr**	**Cu**	**Pb**	**Zn**
Ingestion	$3.0x10^{-3}$	$4.0x10^{-2}$	$3.5x10^{-3}$	$3.0x10^{-1}$
Dermal absorption	NA	$1.2x10^{-2}$	$5.3x10^{-4}$	$6.0x10^{-2}$
Inhalation	$1.0x10^{-4}$	NA	NA	NA
Slope Factor [mg/kg day]				
Ingestion	NA	NA	$8.5x10^{-3}$	NA
Dermal absorption	NA	NA	NA	NA

Inhalation	$1.2x10^{-2}$	NA	$4.2x10^{-2}$	NA

NA represents data not available

Non-carcinogenic risk assessment. Non-carcinogenic hazards are typically characterized by the hazard quotient (HQ). The hazard quotient is defined as the quotient of the chronic daily intake, or the dose divided by the toxicity threshold value, which is referred to as the reference dose (RfD) of a specific chemical. The hazard quotient of a single element is determined by Eq. 6.

$$HQ=ADI/RfD \quad (6)$$

To assess the overall potential for non-carcinogenic effects posed by more than one chemical, a hazard index (HI) approach has been applied. For a mixture of contaminants, the hazard index of the mixture is calculated from Eq. 7.

$$HI = \sum HQ = \sum \frac{ADI_i}{RfD_i} \quad (7)$$

If the HI value is less than 1, the exposed population is unlikely to experience obvious adverse health effects. If the HI value exceeds 1, then adverse health effects may occur.

Carcinogenic risk assessment. Carcinogenic risk is estimated by calculating the incremental probability of an individual developing cancer over a lifetime as a result of exposure to the potential carcinogen. The slope factor (SF) converts the estimated daily intake of a toxin averaged over a lifetime of exposure directly to the incremental risk of an individual developing cancer, and is calculated from Eq. 8.

$$Risk=ADI \times SF \quad (8)$$

The total excess lifetime cancer risk for an individual is finally calculated from the average contribution of the individual heavy metals for all the pathways using Eq.9

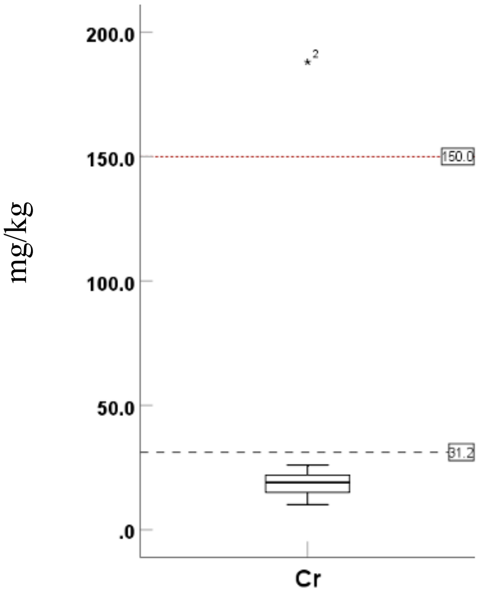
$$Risk(total)=Risk(inh)+Risk(ing)+Risk(dermal) \quad (9)$$

where Risk(ing), Risk (inh), and Risk (dermal) are risk contributions through ingestion, inhalation and dermal pathways. The risk surpassing 1x10-4 is viewed as unacceptable, risk below 1x10-6 is not considered to pose significant health effects, and risks lying between 1x10-4 and 1x10-6 are generally considered an acceptable range, depending on the situation and circumstances of exposure.

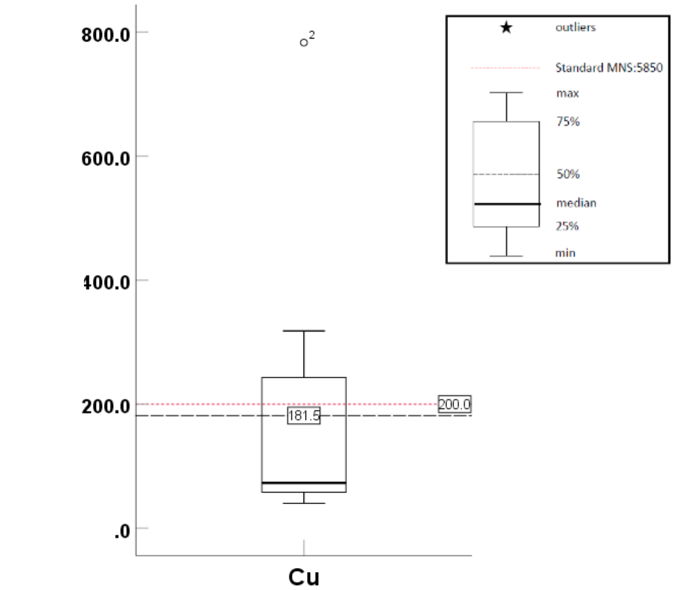
Results and Discussion

Results of Concentration of heavy metals in soil from the auto service areas. Concentrations of some heavy metals were higher than the soil standard of Mongolian standard, for example, the concentration of Cr (1 sample), Pb (3 samples), and Cu (5 samples) in total soil samples were 7.7 %, 23.1%, and 46.2% higher than the MNS, respectively, while the concentration of Zn was lower than the soil standard. The results showed that the average concentrations of heavy metals varied and decreased in the order of Cu>Pb>Cr>Zn.

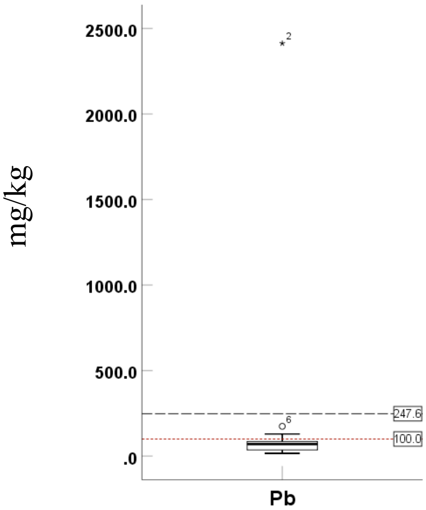
In Figure 2, the mean and median concentration of each heavy metal concentrations in soils are presented. The highest concentration of Cr, Cu and Pb were obtained near at Bayanburd’s circle or 2nd sample. There is one of the main areas of auto service centers in Ulaanbaatar city.



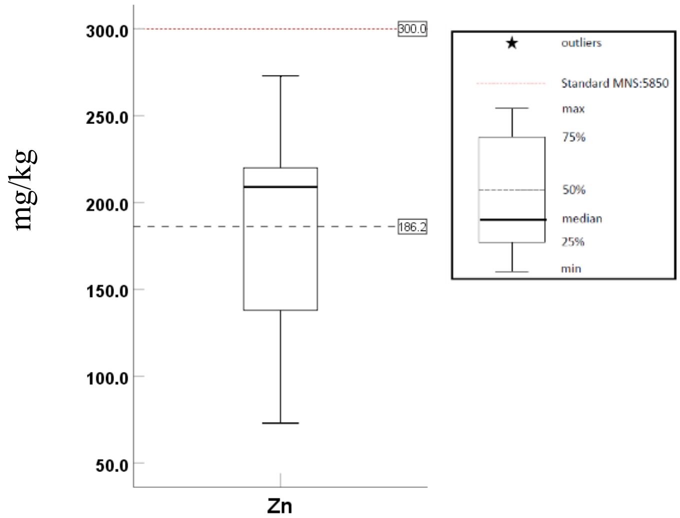
(a) Concentration of Cr mg/kg



(b) Concentration of Cu mg/kg



c) Concentration of Pb mg/kg



(d) Concentration of Zn mg/kg

Figure 2. Boxplots of the Heavy Metal Concentrations (mg/kg).

The concentration of Pb, Zn, Cu and Cr were determined by 16$\pm$2413mg/kg, (73$\pm$273mg/kg, 40$\pm$783mg/kg, and 10$\pm$188mg/kg, respectively. For example, for content of Zn was lower than standard for all samples. Moreover, the content of Cr in the samples was not exceeding the MNS, only in the sample 2 or Bayanburd’s “Lubricating material” 1.8 times higher than the MNS. On the other hand, the content of Cu was between 40 and 783 mg/kg which is around 2.6 times higher than the MNS. Distribution of Cu has determined at two main areas of the auto market and auto repairs centers such as at the Da Khuree market of Bayanzurkh district and auto repairs centers in Chingeltei district, respectively. The content of Pb was determined higher than MNS by 24 times at sample 2 that area had spilled by the oil of automobiles when soil samples were collected. It would be a reason why there was determined a higher concentration of Pb than other sampling sites. Moreover, a sample 2nd is located near bayanburd's circle in Chingelte district which is one of the main areas of auto repairs services in Ulaanbaatar city. Individual auto repairs services have been working on their business in this area for a long time. This study is discovered the distribution of Cu, Cr, and Pb was distributed at the district of Bayanzurkh, and Chingeltei.

Result of Index of geoaccumulation (Igeo). According to the geoaccumulation index, 12 samples appear to be in the range of uncontaminated to heavily contaminated. The calculated Igeo for Cu and Pb indicated that only one sampling station for those two elements had an Igeo value greater than 3.6. The maximum index of geoaccumulation of soil in the study area was as high as 5.9, indicating an extremely high contamination risk, which should give rise to widespread concern. Figure 3 and Table 6 shows the index of geoaccumulation in all samples for Cr, Cu, Pb and Zn.

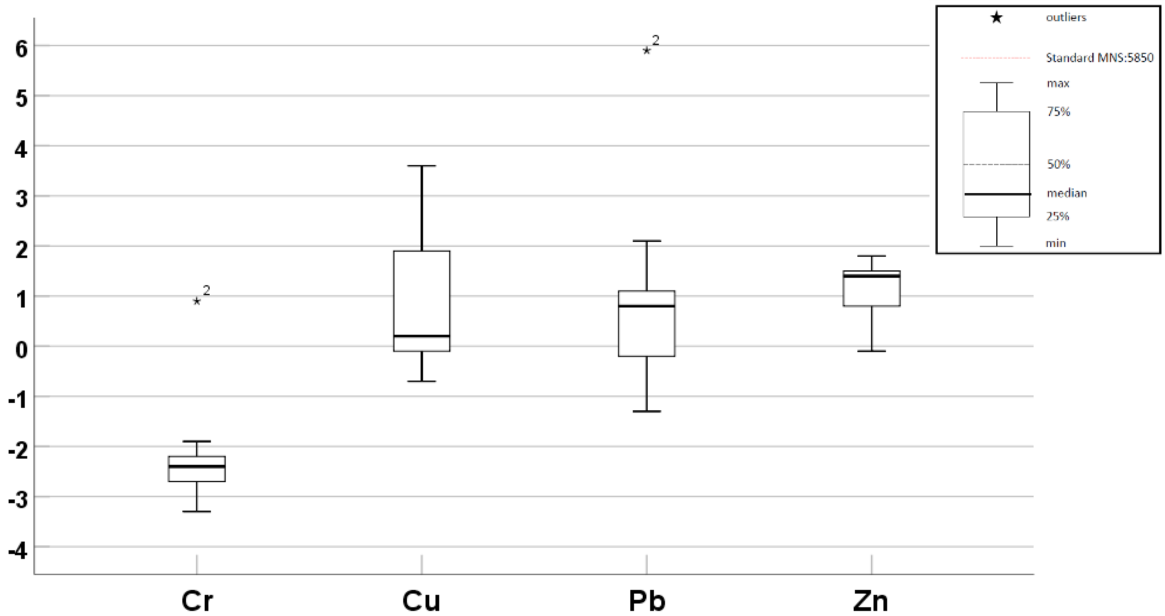


Figure 3. Boxplots of the Geoaccumulation Value for Four Heavy Metals

Human health risk assessment results. The non-carcinogenic and carcinogenic risks posed by Cr, Cu, Pb and Zn in soils of four districts (Bayanzurkh, Chingeltei, Songinokhairkhan and Khan-uul) in Ulaanbaatar area for adult and children, through different exposure pathways (ingestion, dermal contact and air inhalation), were evaluated. Non carcinogenic risk for adults and children were evaluated, as presented by the Hazard Index and Cancer Risk values (Tables 7 and 8).

Non-carcinogenic risk assessment result. Non-carcinogenic hazards or the hazard quotient (HQ) of some pathways were not evaluated by the dermal contact of Cr and the air inhalation of Cu, Pb and Zn because the non-carcinogenic reference dose (RfD) is not available for some pathways. Table 7 and Figure 5 shows that the dermal route posed the highest risk, followed by ingestion interaction and then inhalation of the soil particles. In children, the three different exposure routes caused HI in the sequence for all the metals studied as Zn>Cr>Cu>Pb. The ingestion and inhalation pathways had HQ and HI values greater than 1, for example Cu and Pb had total HI of equal to 1.23 for all pathways. This value indicates that heavy metal pollution may pose unacceptable non-cancer health risks to children living around the auto services areas. For adults, the same pattern was found except for Pb, which preceded Cu. The remainder of the HI sequence for all of the metals was found to be the same as the calculated values of HQ which were not exceed than 1 in all pathways for adult. This meant that the adult population was no risk of non-carcinogenic effects. The results also indicate that, for children, the dermal pathway contributes the greatest to non-carcinogenic risk, followed by the ingestion pathway. Inhalation is the smallest contributor to the risk. Children interact more with dust and soil particles than adults due to their behavioral activities, playing hours and carelessness with eating and drinking. Special provisions should be made to minimize the exposure of children to such hazardous health situations. According to Table 7, the HI for Pb (1.1 x100) showed the highest non-carcinogenic risk in children followed by Cu (3.6 x10-2), Cr (9.6x10-3) and Zn (7.2 x10-3). Therefore, Pb could be of the most concern regarding the potential occurrence of health hazards. The main sources of these elements are gasoline, hose paint, storage batteries, toys and faucets, the burning of oil and coal, petroleum, fertilizers, oil well drilling and metal plating tanners (Ghani 2011; Thurmer K, 2002). This concern is not only relevant to auto repair centers.

Table 7. Average Daily Intake (ADI) Values in mg/kg/day for Adults and Children in Soil from the Auto Services Area for Non-Carcinogenic Risk Calculations.

Receptor	Pathway	Average Daily Intake (ADI) values for heavy metals [mg/kg]				Total Hazard Index
		Cr	Cu	Pb	Zn	
Adult	Ingestion	$2.1x10^{-3}$	$9.3x10^{-4}$	$1.5\ x10^{-2}$	$1.3\ x10^{-4}$	$1.8\ x10^{-2}$
	Inhalation	$3.2x10^{-4}$	-	-	-	$3.2\ x10^{-3}$
	Dermal	-	$5.0\ x10^{-3}$	$1.6\ x10^{-1}$	$1.0\ x10^{-3}$	$1.6\ x10^{-1}$
	Total	$2.5x10^{-3}$	$6.0\ x10^{-3}$	$1.7\ x10^{-1}$	$1.2\ x10^{-3}$	$1.8\ x10^{-1}$
Children	Ingestion	$6.7x10^{-3}$	$2.9\ x10^{-3}$	$4.5\ x10^{-2}$	$4.0\ x10^{-4}$	$5.5\ x10^{-2}$
	Inhalation	$2.9x10^{-3}$	-	-	-	$2.9\ x10^{-3}$
	Dermal	-	$3.3\ x10^{-2}$	$1.03\ x10^{0}$	$6.8\ x10^{-3}$	$1.1\ x10^{0}$
	Total	$9.6x10^{-3}$	$3.6\ x10^{-2}$	$1.1\ x10^{0}$	$7.2\ x10^{-3}$	$1.1\ x10^{0}$

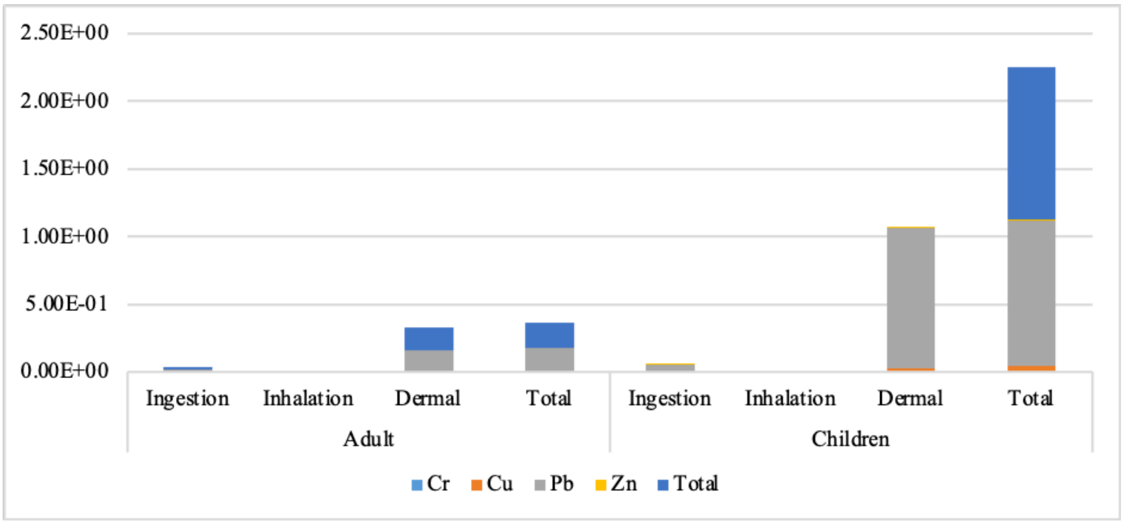


Figure 5. Hazard Quotient (HQ) Values for Heavy Metals in Adults and Children for Soil Form Auto Services Area

Carcinogenic risk assessment. The carcinogenic risk assessment results are listed in Table 8 and Figure 6. Because carcinogenic slope factors (SF) are unavailable in any references for Cu and Zn, the carcinogenic risk was estimated for Pb and Cr. In the case of Pb, the total risk was evaluated by ingestion and inhalation. The total risk by inhalation pathway, for Cr and Pb, was found to be the highest contributor to the cancer risk by the ingestion pathway but it did not pose a risk to human health. The cancer risk for adults was less than 1x10-6 for all pathways. However, for children, only the ingestion pathway had a cancer risk value that was equal to 2.3x10-6, which is considered an acceptable range, while the other two inhalation and dermal pathways were not considered to pose significant health effects. In this study area, children are more at risk than adults due to the dermal pathway. However, only in sample 2 the total cancer risk was estimated to be in an unacceptable range for children, especially with respect to Pb, which can lower energy levels and damage the brain, lungs, kidney, liver, blood composition, and other important organs. Long-term exposure can lead to physical, muscular and neurological degenerative processes that imitate diseases (Jarup L.2003).

Table 8. Average Daily Intake (ADI) values in mg/kg/day for Adults and Children in Soil from the Auto Services Area for Carcinogenic Risk Calculations.

Receptor Pathway		Average Daily Intake (ADI) Values for Heavy metals in mg/kg				Total Cancer Risk
		Cr	Cu	Pb	Zn	
Adult	Ingestion	-	-	$1.2x10^{-6}$	-	$1.2x10^{-6}$
	Inhalation	$1.6x10^{-10}$	-	$4.5x10^{-9}$	-	$4.7x10^{-9}$
	Dermal	-	-	-	-	-
	Total	$1.6x10^{-10}$	-	$1.2x10^{-6}$	-	$1.2x10^{-6}$
	Inhalation	$3.0x10^{-10}$	-	$8.4x10^{-9}$	-	$8.7x10^{-9}$
	Dermal	-	-	-	-	-
	Total	$3.0x10^{-10}$	-	$2.3x10^{-6}$	-	$2.3x10^{-6}$

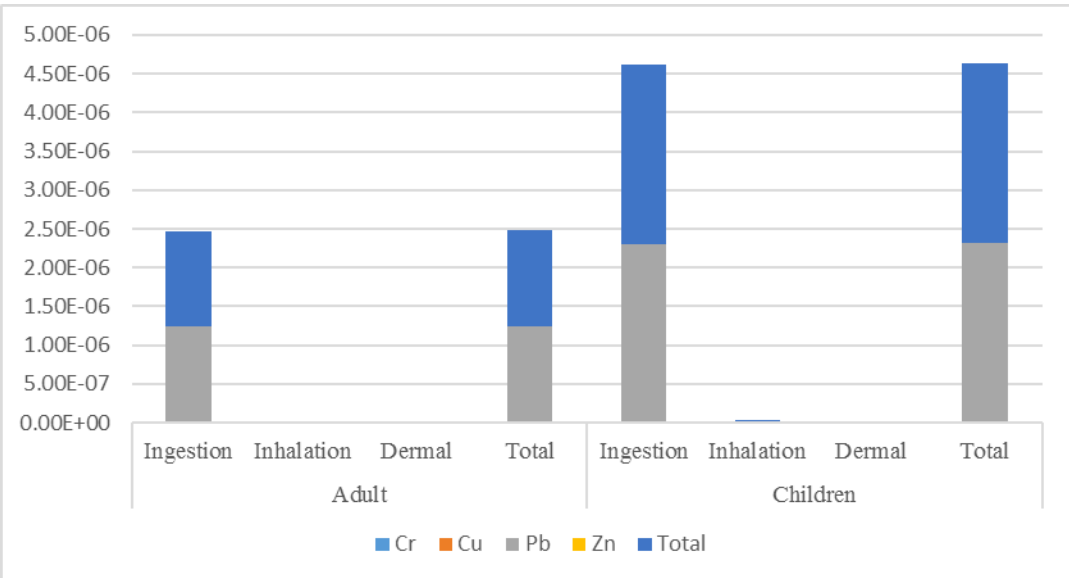


Figure 6. Cancer Risk (CR) Values for Heavy Metals in Adults and Children for Soil Form Auto Services Area

On the other hand, the children did not only affect the dermal pathway in the ger district but also exposed by the inhalation pathway, especially in wintertime. Most particulates form in the atmosphere as a result of complex reactions of chemicals such as sulfur dioxide and nitrogen oxides, which are pollutants emitted from power plants, industries, and automobiles. For example, the Ger area and traffic are the main pollution sources of SO2 and NO2 (Huang, Y.K.,). Moreover, the contribution of PM2.5 was sourced from soil 47%, coal combustion 35%, motor vehicles/road dust 13%, and biomass burning 4% in resident's area (Gunchin, G.,2012). Therefore, ger residents, who live near auto services centers may occur living not only the skin but also inhalation factors in the risk area due to soil pollution.

Conclusions

One of the biggest sources caused environmental pollution is open and inconvenient auto repair and maintenance service centers in Ulaanbaatar city. In order to identify soil pollution, we found out toxic substances /Cr, Cu, Pb, Zn/from the soil samples of Bayanburd in Chingeltei district, Ikhzasag University, and Million students dormitory in Bayanzurkh district, Da Khuree in Bayanzurkh district, Tavanshar area auto repair centers in Songinokhairkhan district. In the taken sample's soil, toxic elements amount was performed 24-70 times more than Mongolian Standard. Lately, lead and fuel products are included as one of the polluted anthropogenic sources. The survey was shown that the content of lead is 14-2413 mg/kg, an average of 67,1 mg/kg in the soil of the Ulaanbaatar auto repair center area. It has been 24 times exceed the accepted level. The average oil product content in soil is 14,4 %. It's considered 70 times exceed the Mongolian national standard. The concentration of Cr was 10.5-188 mg/kg, an average of 31.2mg/kg, but in the Bayanburd area's some points soil Cr is 1.8 times exceed the acceptable level of Mongolian standard. Copper concentration was 40-782.5 mg/kg. The health risk for both adults and children were evaluated to define the possible risk from soil contaminated by heavy metals near auto repairing centers in the Ger area of Ulaanbaatar city.

The human health risk assessment found that all soil samples were ranged by unacceptable at non-carcinogenic risks for adults and children. Carcinogenic risks were ranged to not significant risks all of the samples except sample no 2. But the only sample no 2 posed acceptable carcinogenic risks, especially for children.

The results of this study will help to contribute to a database for future monitoring and development of environmental standards for auto services in Ulaanbaatar city, Mongolia. This study could assist with strategic planning and management aimed at reducing heavy metal contamination in soil from near auto services and the risk to public health in the Ger area of Ulaanbaatar city.

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