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Health Risk Assessment of heavy metals in soil vicinity some auto services of Ulaanbaatar, Mongolia

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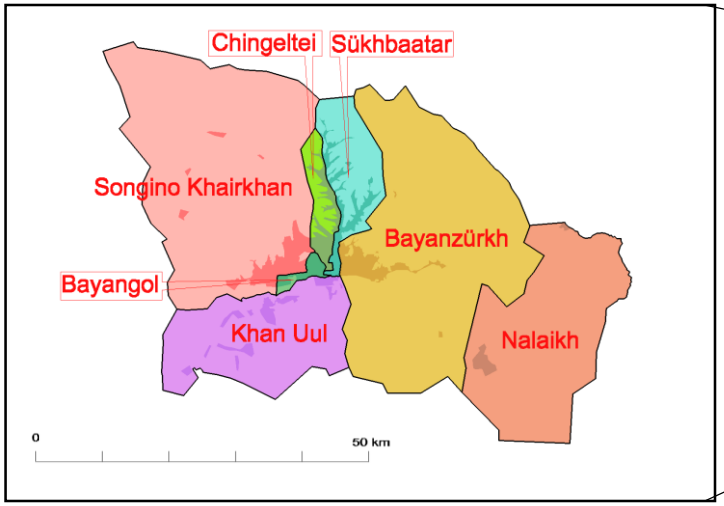
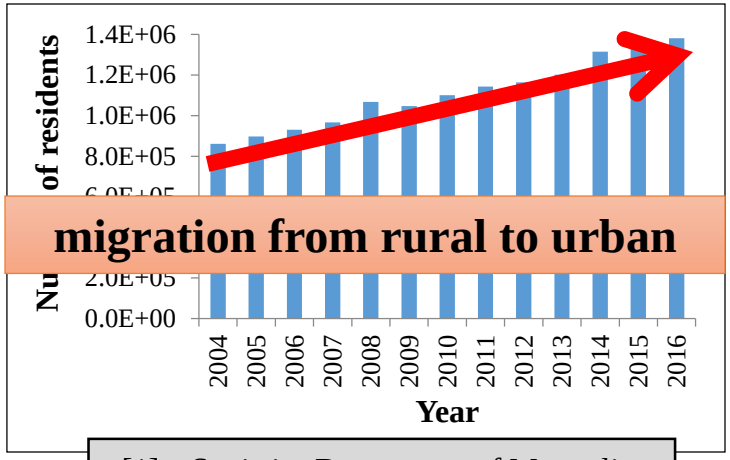
Introduction

Ulaanbaatar city, Mongolia



Total population of Mongolia: 3.1 million.
(45% of population resides in Ulaanbaatar [1])



[1] – Statistics Department of Mongolia.

Due to unpredicted population growth in capital city over last a decade, the city has expanded.

There are two types of dwelling: **apartment** and **"Ger"** area. The migrants from rural are settled in the Ger area.

Introduction

Introduction

Wide **inequalities** **exist between the "Ger" area and** **apartment** in terms of access to **heat**, **electricity**, **water**, **sanitation** and **communication**.

Due to the lack of a centralized heating system, a majority of the households use **stoves** for cooking and heating that are fuelled by the burning of coal, wood and other combustible materials.

Problem

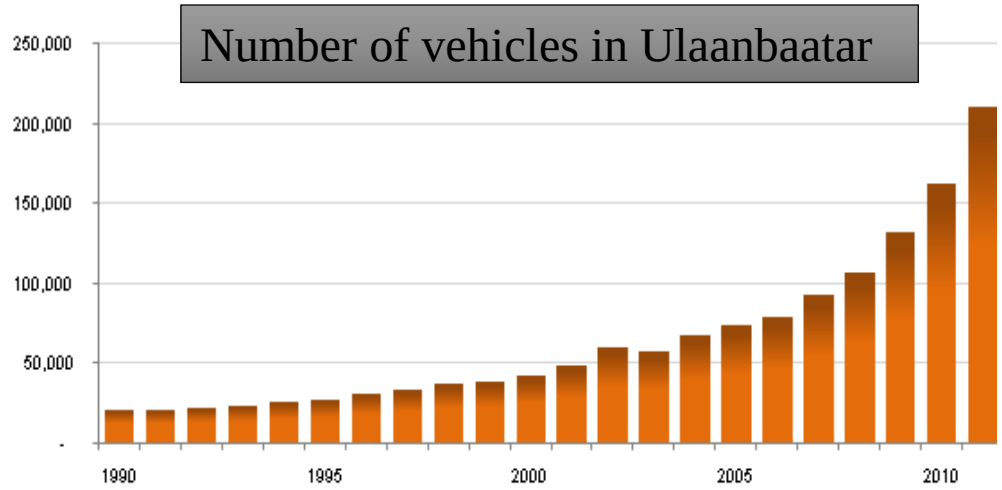
The Ger residents dump **ash** from combustion and **solid waste** outside (e.g. yards, streets), which is a source heavy metals contamination in the soil near Ger area.

Problem

Auto car services in the Ger area are one of the main source of soil contamination by heavy metals.

Introduction

Number of vehicles in Ulaanbaatar increasing rapidly → Number of auto service increases

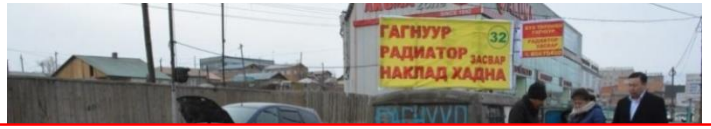


As statistics [1]

Auto repair centers – 438
Car wash service centers – 151
Lubricant-selling points – 54
Welding, wheel repairing service centers – 174

[1] – http://mrtd.gov.mn

However, they don't meet the national standards, aren't granted licenses for business, don't have workplace evaluation provided by the appropriate authorities, or they don't have proper equipment or facilities for running this kind of business.



As a consequence, **soil** around these services have been **polluted** by fuel wastes and other toxic elements and suffered from negative impacts on the environment.

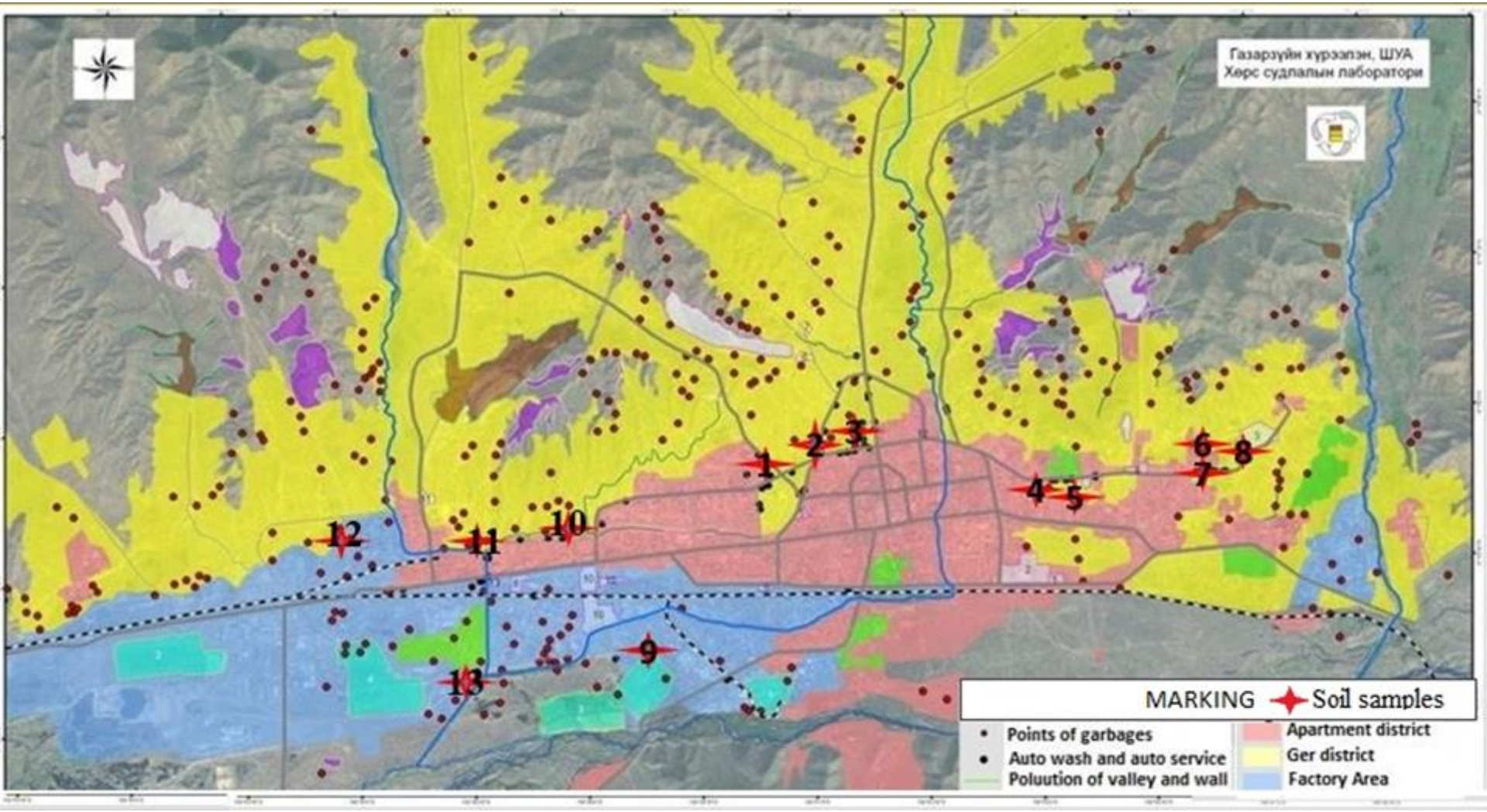
Research purpose

To identify the public health and environmental risks posed by contaminated soil near some auto services in Ulaanbaatar

Two steps to achieve this purpose:

1. To identify the right amount of toxic substances polluting the soil (Cr, Cu, Pb, Zn)
2. The health risk assessment based on (1)

Soil samples

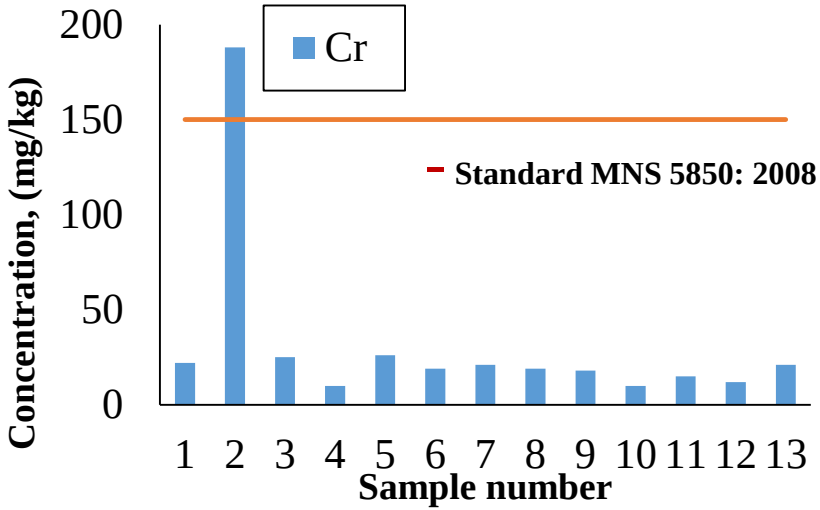


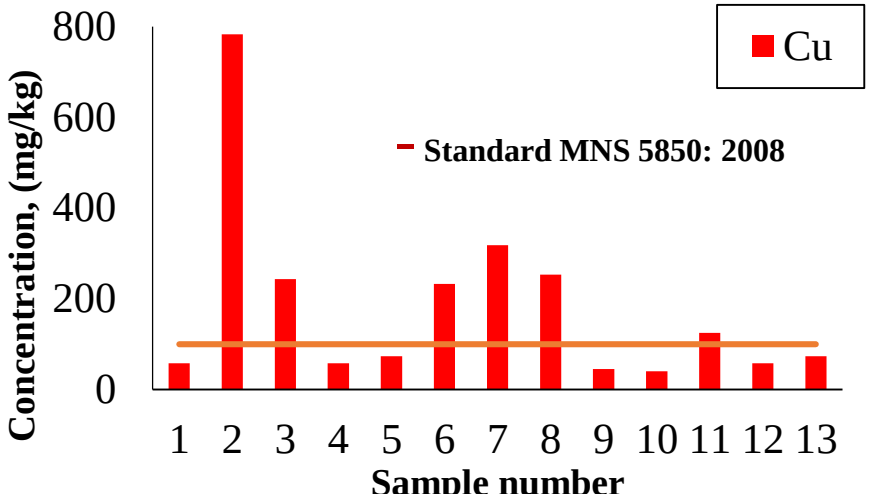
Soil samples process

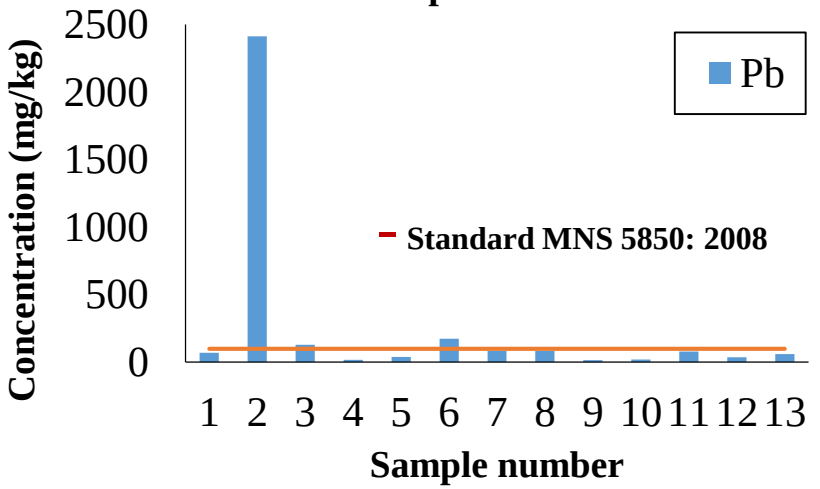
The surface soil samples (the top 10 cm of soil) were randomly collected using a stainless steel scoops, placed in a polyethylene bag and labeled. Non soil particles e.g. stones, wooden pieces and rocks were removed from soil.

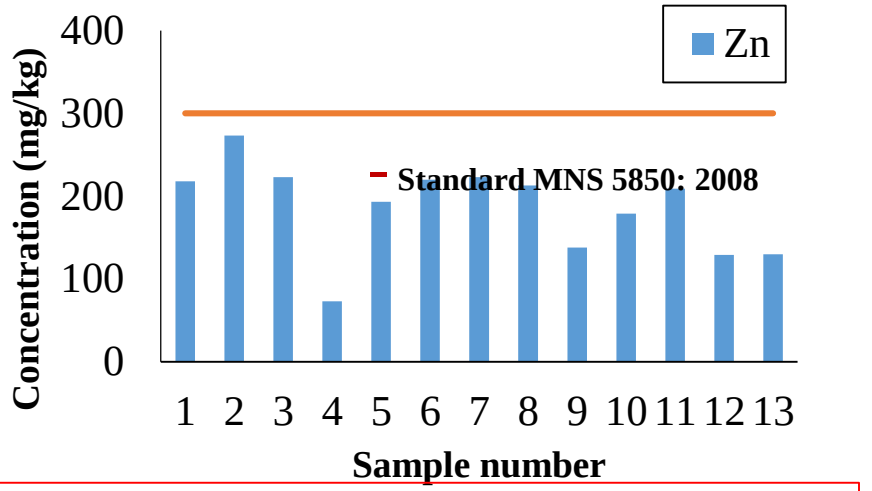
These 13 samples were investigated in the Soil Laboratory of Geographical Institute of Mongolian Scientific Academy and toxic substances (Cr, Cu, Pb, Zn) kept in the soil were identified by Atomic Absorption Spectroscopy (AAS).

Result (Concentration of heavy metals)









Results of concentration of elements indicated that the average concentration of heavy metals Cu and Pb in the samples exceeded the limits prescribed by the MNS 5850:2008 standard, with exceeding multiples Cu(1.82) and Pb(2.48). Although Sample 2 does not exceed the standard for Zn, the concentration of Cr(1.25), Cu (7.83) and Pb(24.13) are exceeded the standard.

Result (Index of Geoaccumlation)

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Index of geo-accumulation enables the assessment of environmental contamination by comparing differences between current and preindustrial concentrations.

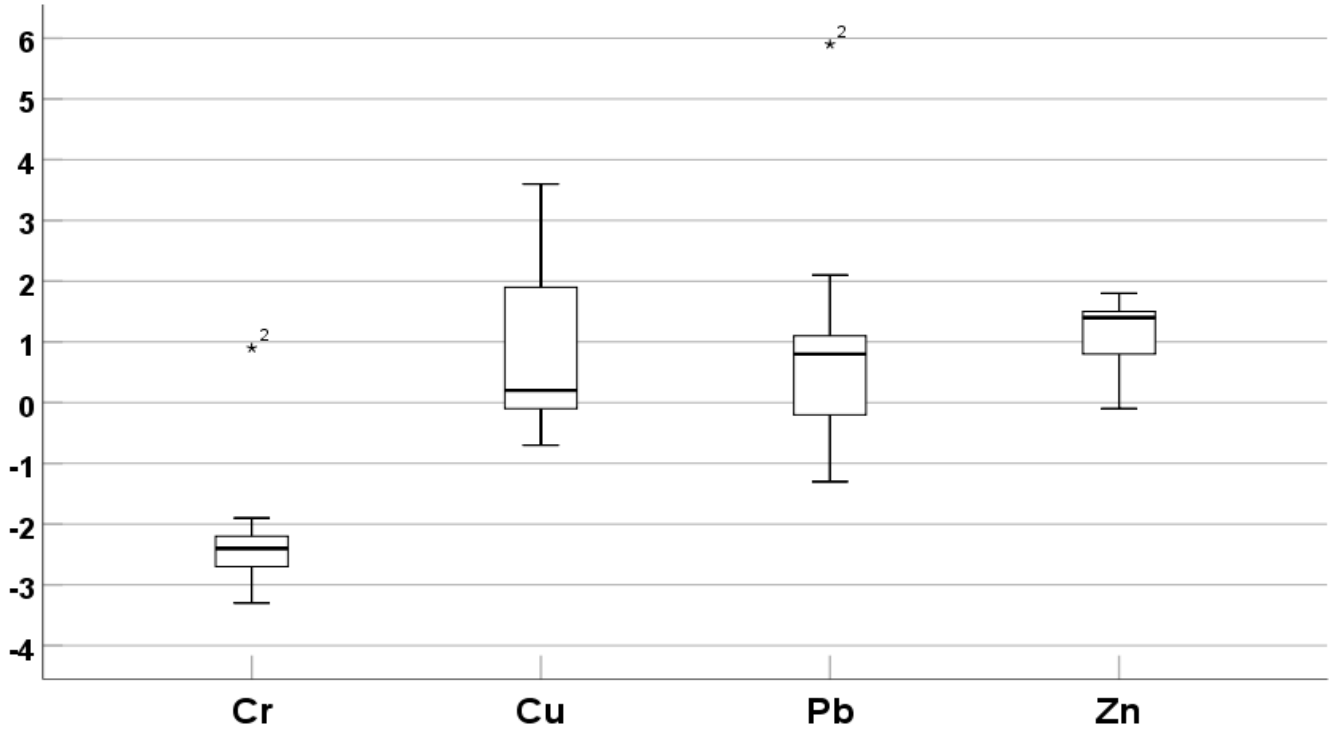
$$I_{geo} = log_2\left(\frac{C_n}{1.5 \cdot B_n}\right)$$

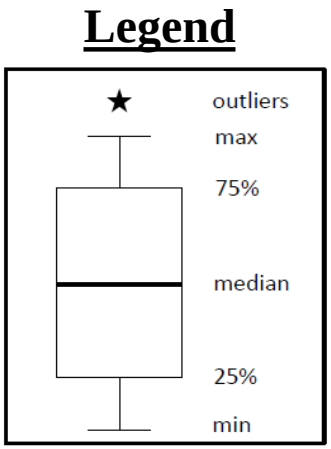
C_n – is the measured concentration of every heavy metal (mg/kg).

B_n – is the geochemical background value of the heavy metals found in the soil (mg/kg).

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

Result (Index of Geoaccumlation)





12 of 13 samples were appearing to be in range of the uncontaminated to heavily contaminated, with I_{geo} values less than 3.6 for all the heavy metals except Sample 2.
The maximum index of geoacumulation of soil in the study area was as high as 5.9, indicating the extremely contaminated risk.

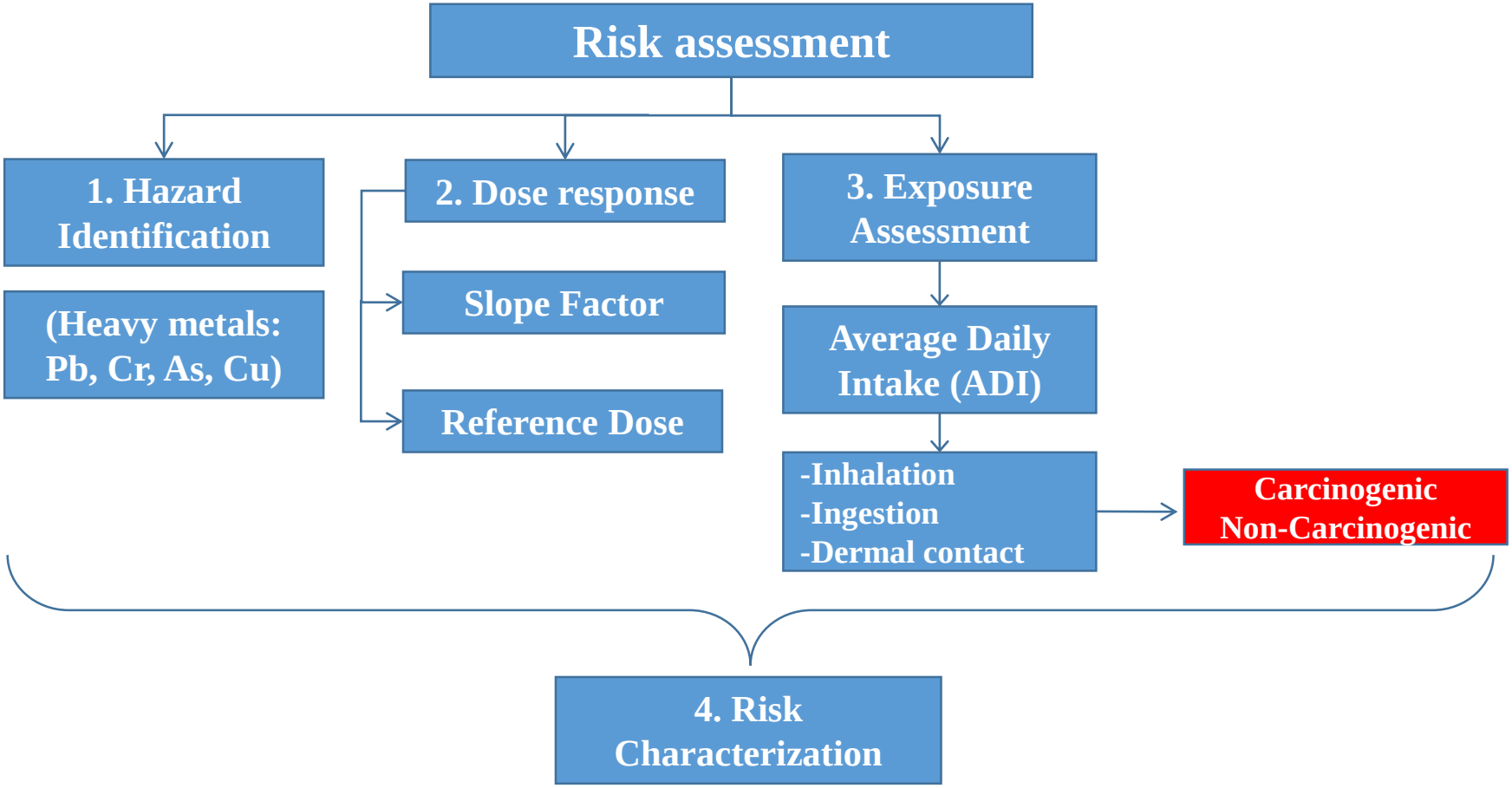
USEPA guideline

The human health risk models including carcinogenic and non-carcinogenic ones raised by US EPA, have proved successful and adopted worldwide.

There is no agreed limit for acceptable maximum carcinogenic and non-carcinogenic risk levels in Mongolia. Therefore, I employed the US EPA model and their threshold values to assess the potential human health risks posed by heavy metal pollution in this study.

Considering the residents living habits and daily activities, they are exposed to soil heavy metals through soil **ingestion**, **dermal contact**, and **air inhalation**.

Risk assessment framework



Carcinogenic and Non-carcinogenic health risks

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Average daily intake (ADI) of contaminants calculated using following equations.

Medium	Pathway	Calculation formula
Soil	Ingestion	$ADI_{Ingestion} = \frac{C\ x\ IngR\ x\ EF\ x\ ED}{BW\ x\ AT}$
	Dermal contact	$ADI_{dermal\ contact} = \frac{C\ x\ SF\ x\ AF\ x\ ABS\ x\ EF\ x\ ED}{BW\ x\ AT}$
	Inhalation	$ADI_{inhalation} = \frac{C\ x\ InhR\ x\ EF\ x\ ED}{PEF\ x\ BW\ x\ AT}$

Carcinogenic and non-carcinogenic health risks are estimated as following equations:

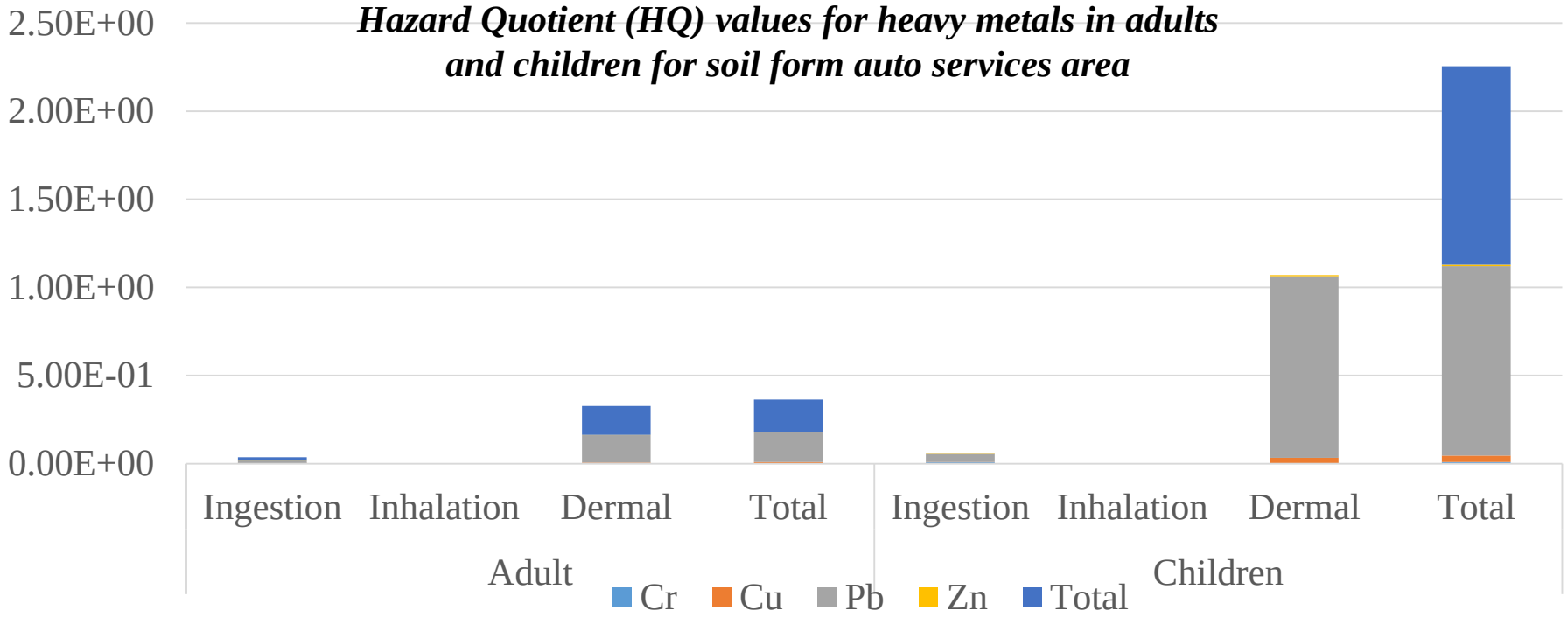
$$Risk = ADI\ x\ SF$$

$$HQ = \frac{ADI}{RfD}$$

$$HI = \sum HQ = \sum \frac{ADI_i}{RfD_i}$$

- $1x10^{-4}$ unacceptable
- risk below $1x10^{-6}$ not considered to pose significant health effect,
- between $1x10^{-4}$ and $1x10^{-6}$ an acceptable range

Result of health risk assessment



Receptor Pathway		Average Daily Intake (ADI) Values for Heavy metals in mg/kg				Total
		Cr	Cu	Pb	Zn	
Adult	Ingestion	2.14E-03	9.33E-04	1.45E-02	1.28E-04	1.77E-02
	Inhalation	3.15E-04	-	-	-	3.15E-04
	Dermal	-	5.04E-03	1.57E-01	1.03E-03	1.63E-01
	Total	**2.45E-03**	**5.98E-03**	**1.72E-01**	**1.16E-03**	**1.81E-01**
Children	Ingestion	6.65E-03	2.90E-03	4.52E-02	3.97E-04	5.51E-02
	Inhalation	2.94E-03	-	-	-	2.94E-03
	Dermal	-	3.30E-02	1.03E+00	6.78E-03	1.07E+00
	Total	**9.59E-03**	**3.59E-02**	**1.08E+00**	**7.17E-03**	**1.13E+00**

Result of health risk assessment

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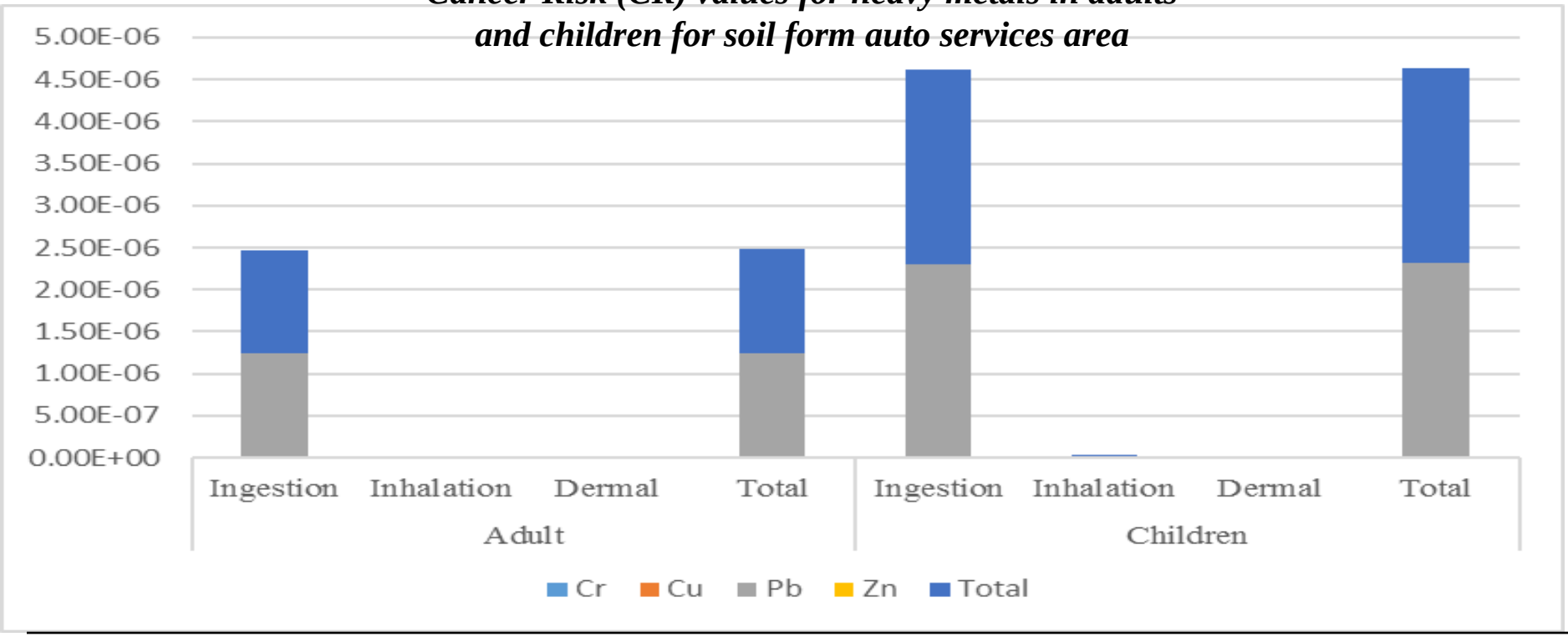
Cancer Risk (CR) values for heavy metals in adults and children for soil form auto services area



Receptor Pathway		Average Daily Intake (ADI) Values for Heavy metals in mg/kg				Total
		Cr	Cu	Pb	Zn	
Adult	Ingestion	-	-	1.24E-06	-	1.24E-06
	Inhalation	1.62E-10	-	4.49E-09	-	4.65E-09
	Dermal	-	-	-	-	-
	Total	**1.62E-10**	**-**	**1.24E-06**	**-**	**1.24E-06**
Children	Ingestion	-	-	2.31E-06	-	2.31E-06
	Inhalation	3.02E-10	-	8.38E-09	-	8.68E-09
	Dermal	-	-	-	-	-
	Total	**3.02E-10**	**-**	**2.32E-06**	**-**	**2.32E-06**

7. Conclusion

- Concentration of Cr and Zn in the samples exceeded the limits, with exceeding multiples Cu(1.82) and Pb(2.48)

- Sample 2 the concentration of Cr(1.25), Cu (7.83) and Pb(24.13) are exceeded the MNS 5850:2008 standard

- 12 samples were uncontaminated to heavily contaminate, but the maximum **index of geoacumulation** of soil in the study area was as high as 5.9, indicating the extremely contaminated risk which was only sample 2.

- Most of the risks were attributable to Pb and Cu as it can be concluded that was effect of human health especially children had the greatest risk of **non-carcinogenic** risk than adult.

- The cancer risk had for children, ingestion pathway had **carcinogenic value** was considered an acceptable range, However, only sample 2, total cancer risk value was considered as unacceptable range.

- This research result will provide basic information for heavy metal pollution prevention and control in Ulaanbaatar, Mongolia.

Thank you very much for your attention!