

# X-Ray Fluorescence Analysis as a Tool of Monitoring Soil Pollution Around The Central Geological Laboratory

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Heavy metal contamination of soil is a major concern from an ecological point of view. This study aims to characterize soil samples from different sites in the Central Geological Laboratory (CGL)'s area and to study heavy metal contamination in the environment. In this work Wavelength dispersive X-ray fluorescence spectrometry has been used to evaluate the heavy metals and some toxic elements pollution in the CGL area.

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## I. INTRODUCTION

Increasing human activities provide negative effects on the prevailing environment. Heavy metal contamination is considered as one of these negative effects.

Heavy metals have been associated with the contamination and potential toxicity, receive increasing attention due to the better understanding of their toxicological importance in ecosystems and human health.

An understanding of heavy metal sources, their accumulation in the soil and the effect of their presence in soil seem to be particularly important issues of present day research on risk assessments [1]. Elevated concentrations of heavy metals are universal in urban environments as result of a range of anthropogenic activities including industrial, agricultural, residential, and traffic-related emissions [2].

Monitoring of the soil elemental concentrations in the CGL area is important for reporting pollution inventory and importantly assessing health risk to population.

The objective of this study is to determine the concentrations of a wide range of elements including heavy metals and trace elements at the selected sites with the possible sources of the pollutants and to compare with the elemental distributions in the earth upper crust [4] and other literature values.

We have determined concentration of 44 elements including heavy metals and some toxic elements as uranium and thorium. The soil samples were collected at different depths from 20 to 40 cm deep in order to define the possibility of heavy metal migration from the waste cell into the deeper layers.

We used WDXRF spectrometry model of Axios and AxiosMAX. The Axios and AxiosMAX incorporates the SST-MAX X-ray tube, a unique

industry innovation that virtually eliminates instrument drift due to the X-ray source. That spectrometer has five diffraction crystals and three types of detector configuration. WDXRF allowed for elemental analysis from Sodium(Na) to Uranium(U) in wide range of concentration. Capable of analyzing elements from beryllium to uranium, at ppm to wt % levels, with excellent precision, the Axios and AxiosMAX can handle the toughest job.

The WDXRF analyzer uses a X-ray source to excite a sample. X-rays that have wavelengths that are characteristic to the elements within the sample are emitted and they along with scattered source X-rays go in all directions. A crystal or other diffraction device is placed in the way of the X-rays coming off the sample. A X-ray detector is position where it can detector the x-rays that are diffracted and scattered off the crystal. Depending on the spacing between the atoms of the crystal lattice (diffractive device) and its angle in relation to the sample and detector, specific wavelengths directed at the detector can be controlled. The angle can be changed in order to measure elements sequentially, or multiple crystals and detectors may be arrayed around a sample for simultaneous analysis.

## II. EXPERIMENTAL

### A. Sampling

Sampling points of this study lie within the CGL area (chosen from CGL's Southwest, Southeast, Near Radioactive material laboratory (RML), Underground waste container (UWC) sectors) and other two points were chosen far from the site (Bayanhoshuu-, Zuun ail-). Sampling was carried out in April 2013 and 2015, when a daily ambient mean temperature was around 15°C. Ten surface soils were taken from a depth 0-20 cm and four subsurface samples were collected at a depth of 20-40 cm.

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Year	The number of samples	
	Surface	Subsurface
2013	4	0
2015	6	4

Sample preparation in accordance with Mongolian standards MNS 3298:1991. Each sample was mixture of subsamples collected from 5 holes, which are located in 1 square meter area as shown in the figure 1.



Figure 1

### B. Analysis

WDXRF analysis main part is sample preparation and samples measuring. WDXRF analysis sample preparation is 4 steps.

1. Sample grinding: Using jaw crusher and standard ring mill. As a result of the sample can be <math><0.075\text{mm}</math>.
2. Sample drying: Using SANYO drying oven, The time is 90 minutes at 1050C.
3. Ignition: Calculation of the loss on ignition (L.O.I) and preliminary oxidation of the samples.
4. Preparation glass beads: Using automatic phoenix fusion machine to incinerated samples( 1g sample with 5g flux) convert to glass beads. Melting temperature is 11000C and total converting time is 16 minutes.

Samples were measured by Axios and AxiosMAX spectrometry by 45min and 25minutes.

### III. RESULTS

Concentration of 44 macro and micro elements and compounds, including heavy metals and some toxic elements were determined in soil samples. That following 14 elements were determined by concentration of which were above the detection limits: As, Ba, Co, Cr, Cu, Ga, Ni, Pb, Rb, Sr, V, Y, Zr, Zn. The following elements were not determined that were below the detection limits: Cs, Hf, Mo, Nb, Sc, Sn, Ta, W, U, Th.

The concentrations of heavy metals in soils from different sites in area the Central geological

laboratory(CGL) in 2013 are presented in Table 1, The concentrations of heavy metals in soils from different sites in area the Central geological laboratory and far from CGL in 2015 are presented in Table 2 in comparison to the Upper Continental Crust values [3] and Maximum Permissible Concentrations (MPC) for Mongolia of the heavy metals in soil.

TABLE 1. Concentration of some heavy metal in soils in 2013  $\text{mg}\cdot\text{kg}^{-1}$

Elements	Earth upper crust	MPC for Mongolia	Concentration $\text{mg}\cdot\text{kg}^{-1}$			
			South	South	RML	UWC
As	5	6	15	14	30	11
Cr	69	150	114	54	71	80
Co	17	50	16	11	9	<5
Cu	-	100	30	8	66	10
Ni	55	150	19	13	16	6
Zn	67	300	161	72	143	47
Sr	350	800	320	288	322	298
Zr	170	-	189	222	190	210
Ba	570	-	659	603	709	717
Pb	-	100	62	26	36	20
V	140	150	69	55	57	45
Ga	175		17	18	16	16
Rb	110		91	98	91	98
Y	21		24	25	22	16

TABLE 2. Concentration of some toxic and heavy metal in soils in 2015  $\text{mg}\cdot\text{kg}^{-1}$

Elements	Earth upper crust	MPC for Mongolia	Concentration $\text{mg}\cdot\text{kg}^{-1}$					
			South west	South east	RML	UWC	Zuun ail	Bayan hoshuu
As	5.0	6	11	8	16	12	9	17
Cr	69	150	95	68	69	75	45	63
Co	17	50	<5	9	8	8	<5	13
Cu	-	100	22	21	43	58	37	26
Ni	55	150	43	25	33	36	14	21
Zn	67	300	104	97	194	101	85	74
Sr	350	800	300	257	292	291	310	495
Zr	170	-	329	185	208	202	170	187
Ba	570	-	657	639	650	663	646	524
Pb	-	100	25	29	35	42	144	8
V	140	150	63	51	57	63	60	76
Ga	175		15	12	18	15	13	13
Rb	110		95	105	96	101	93	67
Y	21		22	18	18	18	17	24

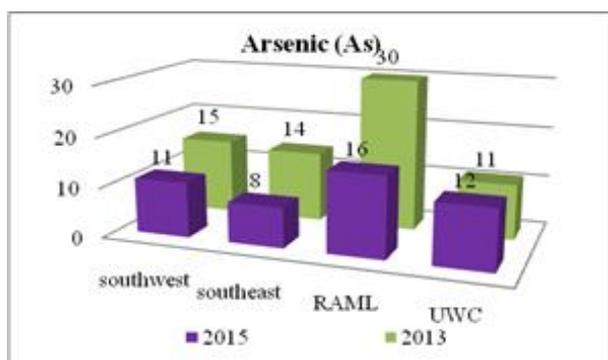
The observed concentrations of all heavy metals lie within the limiting values of world natural soil value which is in agreement with the report by [4]. Only the highest values of arsenic are observed in all samples. The lowest and highest concentrations

of As are 8.0 and 30 mg kg<sup>-1</sup> respectively. The collected the samples outside of system of the ventilator has a remarkably high concentration of As due to the availability of the tail of chemical in soil, the artificial pollution sources originated from anthropogenic activities. Comparison of the As results in 2013 and 2015 are presented in graphic 1.

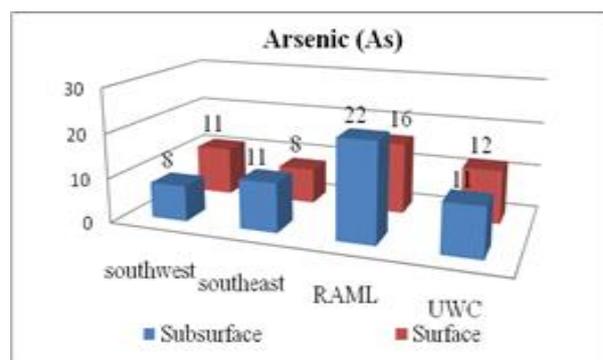
From the data processing, As concentration is higher than the accepted value. To determine if it's really caused by laboratory environment, I compare the other scientist result [5] with heavy metals and some toxic elements concentration of Ulaanbaatar city used by XRF analysis. Concentration of As in soils are presented Table 3

TABLE 3. Concentration of As in soils

Depth of sample	Concentration of As, mg·kg <sup>-1</sup>							
	CGL sites				Other sites in UB[5]			
Surface	11	8	16	12	11.1	9.99	9.36	11
Subsurface	8	11	17	11	11.4	13.5	15	11.7



Graphic 1: Comparison of the As results in 2013 and 2015



Graphic 2: Comparison of As results in Surface and Subsurface soil

The concentrations of heavy metals in surface and subsurface soils from different sites in area the Central geological laboratory (CGL) in 2015 are presented in Table 4.

Comparison of As results in Surface and Subsurface soils are presented Graphic 2.

TABLE 4. Comparison of results in Surface and Subsurface soil

Elements	Earth upper crust	MPC for Mongolia	Concentration mg·kg <sup>-1</sup>							
			Southwest		Southeast		RML		UWC	
As	5.0	6	11	8	8	11	16	17	12	11
Cr	69	150	95	45	68	49	69	63	75	70
Co	17	50	<5	<5	9	7	8	13	8	<5
Cu	-	100	22	24	21	22	43	26	58	34
Ni	55	150	43	16	25	17	33	21	36	19
Zn	67	300	104	80	97	109	194	74	101	84
Sr	350	800	300	318	257	289	292	495	291	304
Zr	170	-	329	198	185	175	208	215	202	221
Ba	570	-	657	645	639	594	650	621	663	633
Pb	-	100	25	24	29	20	35	8	42	27
V	140	150	63	46	51	48	57	76	63	64
Ga	17.5	-	15	15	12	13	18	16	15	17
Rb	110	-	95	94	105	103	96	95	101	97
Y	21	-	22	20	18	17	18	24	18	22

#### IV. CONCLUSION

1. Results of multi-elemental analysis of soil samples show that it is a valuable tool for monitoring the environmental quality and ecosystem of the CGL in accordance with environmental regulations.

2. The observed concentrations of all heavy metals lie within the limiting values of world natural soil. Only the highest values of arsenic are observed in all samples. The lowest and highest concentrations of As are  $8.0 \text{ mg kg}^{-1}$  and  $30 \text{ mg kg}^{-1}$  respectively.

3. The highest concentration of As was  $30 \text{ mg kg}^{-1}$  from RAML site in 2013. There are two reasons which related to the high concentration of As.

First reason is sample location. The collected the samples outside of system of the ventilator has a remarkably high concentration of As due to the availability of the tail of chemical in soil, the artificial pollution sources originated from anthropogenic activities.

Second, Number of the testing mineral in 2013 was more than in 2015.

4. It is required to increase frequency of sampling and number of samples in order to improve the evaluation of soil pollution.

5. In future, it is necessary to compare soils contamination between another industrial area and countryside (soil unaffected by human activities) to make comprehensive research.

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| <p>[1] R. K. Sharma, M. Agrawal and F. M. Marshall, "Effects of Waste Water Irrigation on Heavy Metal Accumulation in Soil and Plants," Paper presented at a National Seminar, Bangalore University, Bangalore, (2004), No. 7, p. 8.</p> <p>[2] Thornton, I. Soil contamination in urban areas. <i>Global and Planetary Change</i>, (1990), Vol. 82:121–40.</p> <p>[3] Condie K.C. Chemical composition and evolution of the upper continental crust: contrasting results from surface samples and shale's, <i>Chem, Geol.</i> (1993), Vol .0-4, P1.</p> | <p>[4] Alloway, B. J., 1994. <i>Heavy Metals in Soils</i>. 2nd Edn., Springer, New York (1994).</p> <p>[5] Tserenpil, Sh., Maslov, O.D., Norov, N., Liu, C-Q., Fillipov, M.F., Theng, B.K.G., Belov, A.G. (2013). Chemical and mineralogical composition of the Mongolian rural soils and their uranium sorption behavior. <i>Journal of Environmental Radioactivity</i>, 118 (2013) 105-1</p> |
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