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Physicochemical properties and heavy metal contents of mining tailings around small-scale gold mining areas in Mongolia

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Abstract

This study aimed to study about physicochemical properties and heavy metal contents of mining tailing samples around the small-scale gold mining area in Mongolia. The mining tailing samples were collected from 10 points of three different area of central and northern part of Mongolia. The pH of the mining tailing samples were determined as 6.10 – 7.37 and texture of the mining tailing samples were classified as silt and silt loam. The electrical conductivity is higher in the sample MT1 and MT10. The ignition losses and organic matter of the mining tailing samples were ranged 1.77–7.01 % and 0.55–1.31 %, respectively. The content of SO_4^{2-} was lower than $HCO_3^- + CO_3^{2-}$ and Cl^- in the mining tailing samples. Total N and total C contents varied from 0.016 – 0.075 g kg^{-1} and 1.465 – 4.130 g kg^{-1}, respectively. The contents of As, Pb, Cu and Mn were determined by XRF analysis, 1346 – 2970 mg kg^{-1}, 115 – 685 mg kg^{-1}, 20 – 70 mg kg^{-1} and 354 – 488 mg kg^{-1}, respectively. These results indicates that the mining tailing samples containing high amount of heavy metals which would affect to human health where living near around small-scale gold mining area.

Keywords: Small-scale mining, Heavy metals, Mining tailings, Arsenic

1. INTRODUCTION

Mining activity processing throughout environment have contaminated by mining waste that will occur major concerns around the world. In recent years, an increasing number of Mongolians has turned to informal gold mining for their livelihood. This is because a number of environmental and economic factors have reduced rural income opportunities, decimated livestock herds and led to rising unemployment in both rural and urban areas. These people see few alternatives to gold mining, which offers the hope of earning higher income (Navch et al., 2006).

In Mongolia, gold mining industries divided into two sections that large-scale gold mining and the artisanal or small-scale gold mining. Gold mining area existed placer and hard rock types in the Mongolia. The most sources of toxic elements formed cause by small-scale gold mining.

In this study, physicochemical properties and heavy metal contents of mining tailing samples around the small-scale gold mining area in Mongolia was investigated.

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2. MATERIALS AND METHODS

2.1 Study area

Mongolia has an extreme continental climate with long, cold winters and short summers, during which most of its annual precipitation falls (Ulziisaihan, 2013). Operation of gold mining area is only active in summer time.

The study area, Bornuur village of Boroo area (north latitude 48.27°, east longitude 106.18°) is MT1, Zuunkharaa, Mandal sum, Selenge province (north latitude 48.50°, east longitude 106.24°) is MT2-MT9 and Zuunkharaa, Surleg Mandal Company (north latitude 48.46°, east longitude 106.03°) is MT10 were located in the central and northern part of the Mongolia where the informal small-scale mining is conducted.

2.2 Field sampling and sample preparation

The sampling locations of mining tailing samples were sketched in the map of Figure 1. The Samples of mining tailings were collected the method of square template from three small – scale gold mining area of the central and northern part of Mongolia.

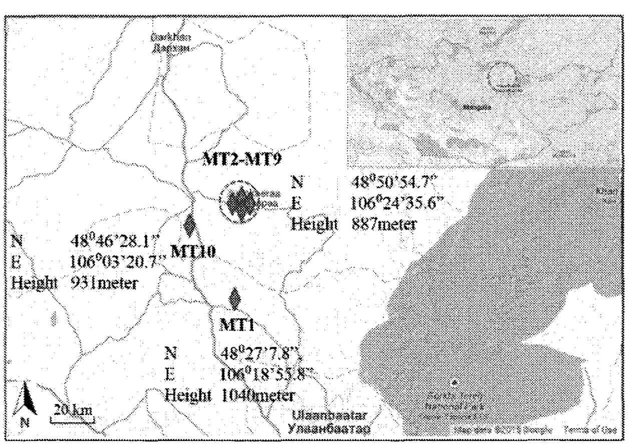

Figure 1. Location of the sampling sites

A mining tailing (MT1) was collected from Bornuur village, Tov province and mining tailings 2 – 9 (MT2 – MT9) along which 8 samples were collected, is located Mandal Sum, Zuunkharaa, Selenge province. A mining tailing 10 (MT10) was collected from Surleg Mandal Company, Selenge province.

2.3 Chemical analysis

The physicochemical properties of the mining tailing samples were prepared by sieved 60 mesh sieve. The values of pH and electrical conductivity (EC) of the mining tailing samples were measured in a 1:2.5 soil/water suspension by Mettler Toledo "S47" pH meter and HORIBA "B-173" electrical conductivity meter (Blakemore et al., 1977).

Total carbon and total nitrogen contents were analyzed using a CN analyzer (Sumika, Sumigraph NC – 80). Particle size distribution (wt%) was investigated by using the pipette method (ISO 13317-2:2001 Determination of particle size distribution by gravitational liquid sedimentation methods – Part 2: Fixed pipette method). Analysis of total element content in the bulk sample is determined using XRF FD-02 (Techno X Co.Ltd).

Energy dispersive X-ray spectroscopy is used where Scanning Electron Microscopes (SU-3500 scanning electron microscope technique/Hitachi) are in operation.

3. RESULTS AND DISCUSSIONS

3.1 Results of physico-chemical analysis

The physicochemical characterization of pH, electrical conductivity (EC), moisture (M), ignition losses (IL), total dissolved solids (TDS) and organic matters (OM) were assessed in three different localities sited in the small-scale gold mining areas in the Mongolia.

The physicochemical properties of the mining tailing samples are summarized in Table 1. The results showed around gold mining area were neutral. Therefore, pH of the MT2 – MT9 sample was slightly acidic which could be affined to forming processes of acids. The ignition losses and organic matter of mining tailing samples were ranged 1.77 – 7.01 % and 0.55 – 1.31 %, respectively.

Table 1. Physicochemical properties of the mining tailing samples

	pH	EC, mS/cm	M, %	IL, %	TDS, %	OM, %
MT1	6.88	24.0	0.38	1.77	0.30	0.55
MT2 – MT9	6.10	19.4	2.43	7.01	0.55	1.31
MT10	7.37	39.0	0.75	3.64	0.10	1.06

(Three replicates for each mining tailing samples)

The content of SO_4^{2-} was lower than $HCO_3^- + CO_3^{2-}$ and Cl^- in the mining tailing samples. Low amount of cation and anion were interconnected to the strong weathering process (Figure 2 and 3).

The total N and total C contents varied from 0.016 – 0.075 g kg^{-1} and 1.465 – 4.130 g kg^{-1}, respectively.

Particle size distribution analysis was done for understanding of the strength and load-bearing properties of the mining tailing samples. Therefore it affects the reactivity of solids participating in the chemical reactions.

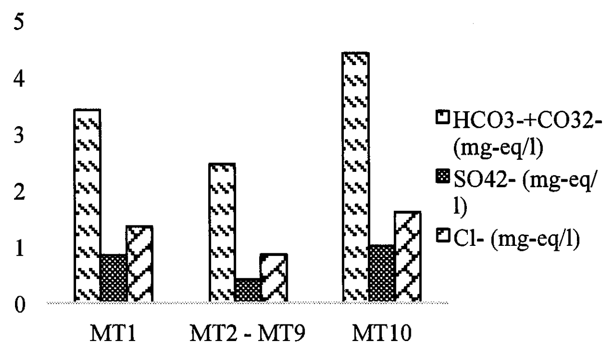

Figure 2. Anion contents of the mining tailing samples

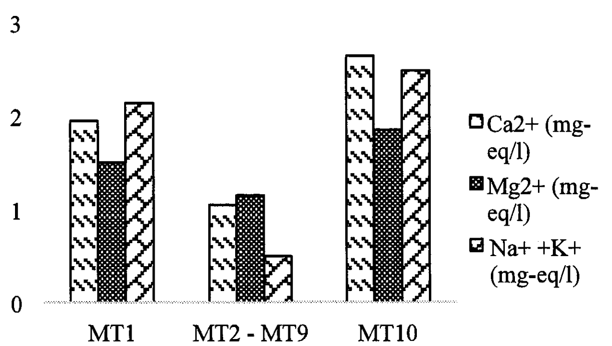

Figure 3. Cation contents of the mining tailing samples

According to the particle size distribution analysis, mining tailing samples percentage of clay was 16.21 – 25.25% and silt was 74.25 – 83.79% in MT1 sample. In MT2 – MT9 sample, the percentage of clay was 6.61 – 6.80%, sand was 1.62 – 2.63% and silt was 90.57 – 91.77%. Therefore, percentage of clay was 6.48 – 8.08%, sand was 22.51 – 25.18% and silt was 66.74 – 71.01% in MT10 sample (Table 2). The texture of mining tailing samples were classified as silt (Si) and silty loam (SiL).

Table 2. Particle size distribution of the mining tailing samples

	Total N, g kg^{-1}	Total C, g kg^{-1}	C/N	Soil texture, %		
				Silt	Clay	Sand
MT1	0.075 ± 0.006	4.130 ±0.495	55.26	74.25-83.79	16.21-25.25	ND
MT2 –MT9	0.043 ± 0.010	1.465 ±0.037	34.17	90.57-91.77	6.61-6.80	1.62-2.63
MT10	0.040 ± 0.013	2.310 ±0.164	57.92	66.74-71.01	6.48-8.08	22.51-25.18

(Four replicates for each mining tailing samples, ND: Not detectable)

3.2 Results of XRF analysis

Distribution of total element concentration data (XRF) was used to study concentration of metals. Some of the studied elements such as Fe, Ca, Mg, K and to a lesser degree Se, Cd and P are present at lower concentrations compared with other studied elements shown in Figure 4.

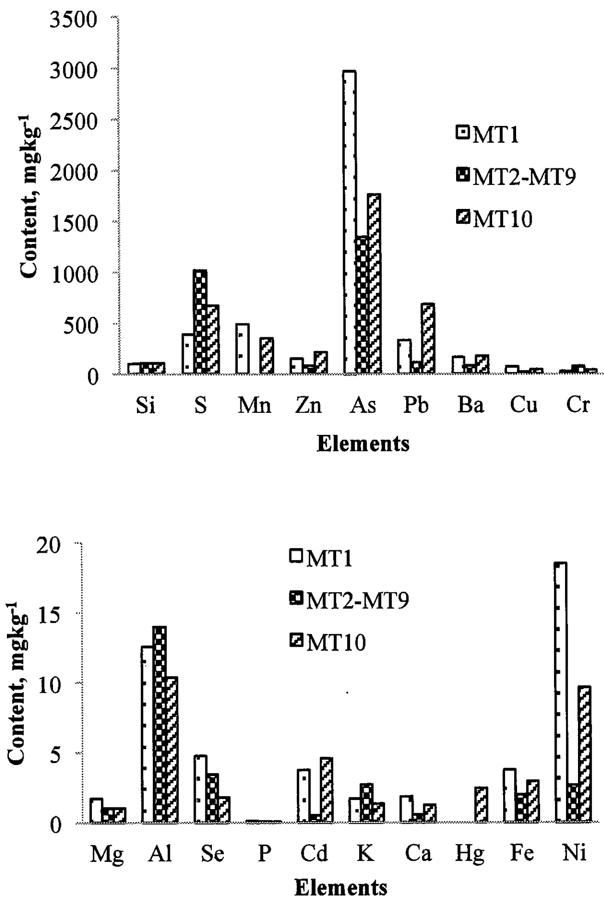

Figure 4. XRF analysis of the mining tailing samples

Heavy metals such as As, Pb and Cu were studied higher concentrations and mercury was not detected in the samples of MT1 and MT2 – MT9 although 2.47 mg/kg Hg detected in the MT10 samples. As, Cu and Mn concentrations were determined 1346 – 2970 mg/kg, 20 – 70 mg/kg and 354 – 488 mg/kg, respectively. Pb concentration range from 115 to 685 mg/kg which indicates these types of the mining tailing samples not argillaceous series.

3.3 Results of SEM and EDX analysis

Morphology of the mining tailing samples was observed using scanning electron microscopy (SEM) and energy dispersive X-ray spectroscopy. The SEM analysis of the mining tailing samples composite SEM images and EDX analysis shown in Figure 5 – 7.

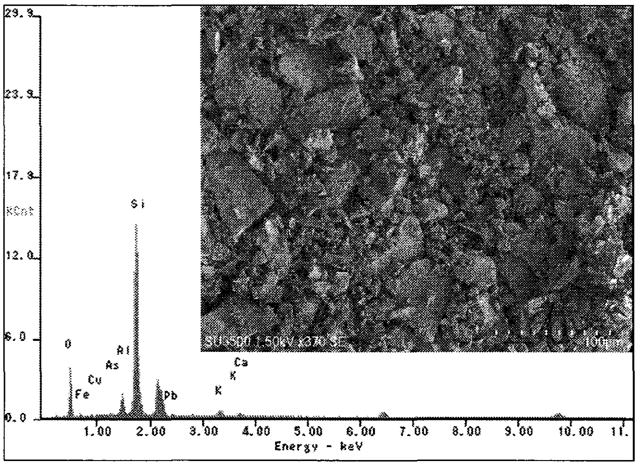

Figure 5. SEM and EDX analysis of the mining tailing sample (MT1)

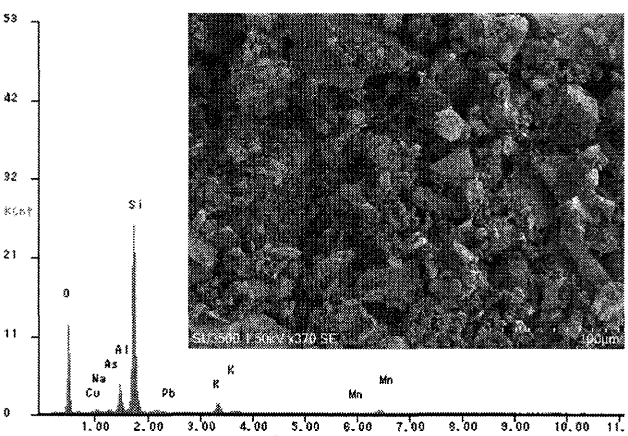

Figure 6. SEM and EDX analysis of the mining tailing samples (MT2 – MT9)

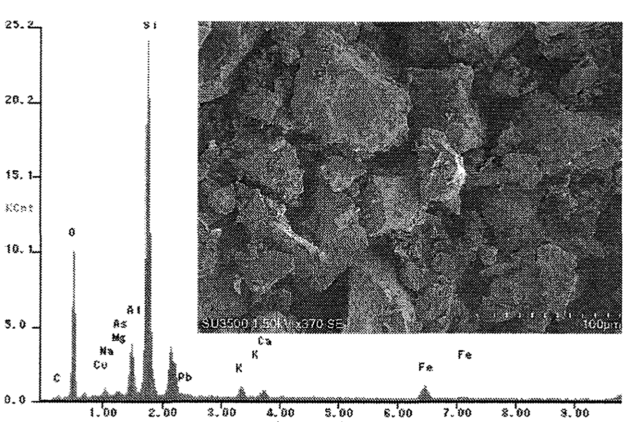

Figure 7. SEM and EDX analysis of mining the tailing sample (MT10)

SEM and EDX analysis reveal homogenous distribution of granules throughout the mining tailing samples and corresponding composition. Typical images shows that the particle size and surface structure of the MT1 and MT2 – MT9 samples were analyzed same but particle size of the MT10 sample was analyzed bigger than the MT1 and MT2 – MT9 samples.

EDX analysis was done for checking result of the XRF analysis and EDX analysis results shown the mining tailing samples are mainly consisting from oxygen and silicate. The few content of heavy metals detected in the mining tailing samples.

4. CONCLUSIONS

This study was determined heavy metals contents in mining tailing samples around small – scale gold mining area, northern part of Mongolia. Mining tailing samples pH was determined 6.10 – 7.37 and texture of the mining tailing samples were classified as silt (Si) and silt loam (SiL). Mining tailing samples were containing high amount of heavy metals such as As, Pb and Cu.

Analysis of the XRF results As, Pb, Cu and Mn concentrations were determined 1346 – 2970 mg/kg, 115 – 685 mg/kg, 20 – 70 mg/kg and 354 – 488 mg/kg, respectively. That indicates that the mining tailing samples containing high amount of heavy metals, especially arsenic which could be affect to human health where living near around small-scale gold mining area.

5. REFERENCES

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