Research article

Determination of Physicochemical Properties and Characterization of Soil from Gold Mining Areas of Kachin State, Myanmar

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Abstract This study revealed the determination of physicochemical parameters and characterization of mineral constituents of soils affected by the low-tech gold mining communities in the vicinity of Myitkyina town. The multi-increment soil samples with four replications were collected from two active mines (Location-1 and 2) and an abandoned mine (Location-3) during the first week of January 2018. Soil samples were analyzed for particle size distribution, pH, electrical conductivity, organic carbon, NH_3-N, and available phosphorus. Soluble salts of soil water extract were also examined by titration method. Then characterizations of soil mineral constituents were investigated by advanced spectroscopic techniques such as Fourier Transform Infrared Spectroscopy (FT-IR), Energy Dispersive X-ray (EDX) and Scanning Electron Microscope (SEM). The result showed that soil sample from location-1 was loam sand and the other two soil samples were sand textural class. Soil pH, electrical conductivity, organic carbon, and available phosphorus were significantly different among the three gold mining areas whereas NH_3-N content was not different by the gold mining. There was a high soluble salt accumulation in all locations. The highest soluble salt was Ca^{2+} followed by Mg^{2+}. It was found that iron (Fe) contained as the highest relative amount in the soil which could exist with gold altogether and the second largest amount was given by titanium (Ti).

Keywords physicochemical parameters, mineral, FT-IR, EDX and SEM

INTRODUCTION

Sand and gravel are produced economically from the bank and floodplains of river. Gold mining on the sand body of these areas can cause the damage of water table and distribution of sand structure. After taking some time, water way alters as a result of erosion and deposition of sand structure. Too much extraction of sand and gravel from rivers, streams, floodplains and channels for the construction of civil development and gold mining effects the ecosystems and functions of natural water resources. Most of water pollutants are closely related with the methods and machineries of gold mining. Among the gold mining, sand and gravel mining becomes the most treat to sustain the nature of the river and its surrounding area. It is also regarded as the current global issue and gradually increased with the reduction of fisheries, recreation and the stability of river channels (Images Asia and Pan Kachin Development Society, 2004). Much work has been carried out to access the environmental impacts of sand and gravel (Ako et al., 2014; Enkhzaya et al., 2016; Eludoyin et al., 2017). Artisanal mining is mainly based on the tools and manual activities by production small amounts of gold and minerals (Canaveslo, 2014). Informal procedure of gold mining associated hazardous water place, land structure degradation and contamination with heavy toxic minerals (Emel et al., 2011).

The research reported an investigation on the physical and chemical characteristics of soil from three riverbank gold mine sites near to Myitkyina Township (Fig. 1). Hydraulic mining and traditional panning techniques were observed in the study site for Location-1. Placer mining and traditional panning methods were applied in the Location-2. The selected study site for Location-3 was on abandoned mine area. There was a comparison between the characteristics of soil from two active mines, and those of abandoned mine. Lode gold districts in Myanmar are presented in Table 1.

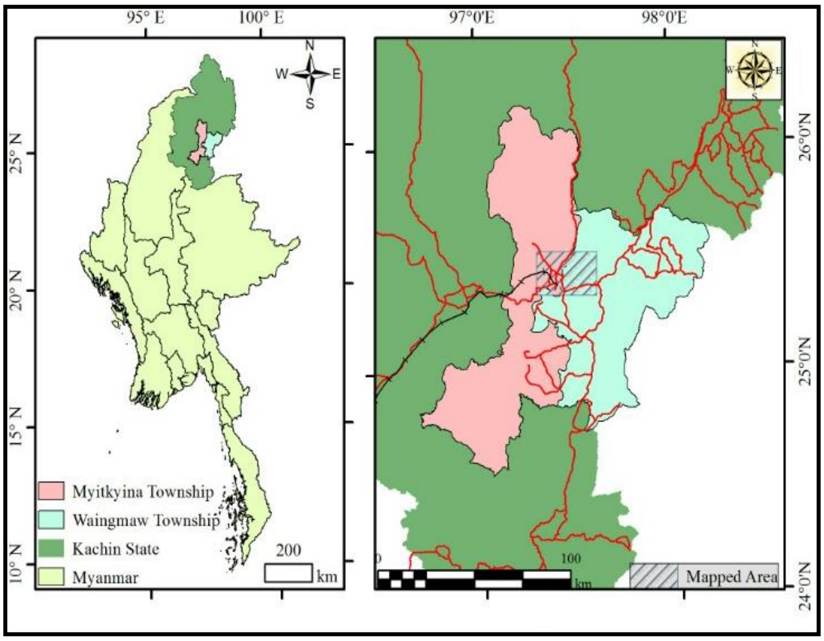


Fig. 1 Location map of study sites

Table 1 Lode gold districts in Myanmar

District	Setting	Type	Age
Wuntho and Mabein	Magmatic arc	Mesothermal veins	Latest Cretaceous
Daungyu-Monywa and Pegu Yoma	Magmatic arc and old-back	Sediment-hosted epithermal Au (As, Sb, Zn)	Miocene
Kyaukpahto-Gegalaw	Sagaing Fault	Sediment-hosted Au (Sb, As)	Late Eocene to Miocene
Phayaung Taung-Kyaikto	Proterozoic-state belt	Sandstone-hosted Au(Cu)	Jurassic to Paleocene
Thabyu	Fold-thrust belt	Sediment-hosted Sb (Au, As)	Post-Jurassic
Shante and Pyinmana	Medial metamorphic belt	Mesothermal (Au, Zn, Pb and Au)	Post-Cretaceous
Putao-Taungkamauk	Wuntho arc segment	High sulphidation Au(Cu)	Miocene
Mt Victoria-Kawlum	E Chin Hills antiform	Listwaenite Au	Upper Cretaceous-Paleocene

OBJECTIVES

The objective of this research was to determine physicochemical properties of soils affected by artisanal gold mining areas on the Irrawaddy riverbank in the vicinity of Myitkyina, Myanmar.

METHODOLOGY

Study Area

All selected artisanal gold mines in the vicinity of Myitkyina town to study for this research were situated on the Irrawaddy riverbank and therefore only sub-soil samples within two to six feet were collected. Soil samples were collected from Makawnyan (Latitude 25° 27.31' N and Longitude 97° 26.639' E) (designated as Location-1), Labanrosana (Latitude 25° 28.492' N and Longitude 97° 27.231' E) (designated as Location-2) and Thida-Aye (Latitude 25° 25.009' N and Longitude 97° 25.144' E) (designated as Location-3) as shown in Fig 2, 3, and 4, respectively.

Fig. 2 Location-1

Fig. 3 Location-2

Fig. 4 Location-3

Preparation of Multi-increment Soil Samples and Analysis

The individual soil increment collected was spaced out across each gold mining location as shown in Fig. 5. Ten individual soil samples or "increments" collected from each location were combined in one container to make up a multi-increment soil sample. Two other soil increments were also combined into two separate sample containers. Ten multi-increment soil samples were collected from each location during the first week of January, 2018. Then, the soil samples were allowed to air dry. Large lumps were broken up by hand and then the soil was ground by milling with a wooden roller. After grinding, the soil was screened through a 2 mm (10 meshes) sieve. The pH was measured by a pH meter. The electrical conductivity (EC) of the soil sample was determined electrometrically with a calibrated electrical conductivity meter. Determination of texture of collected soil sample was done by a Hydrometer method.

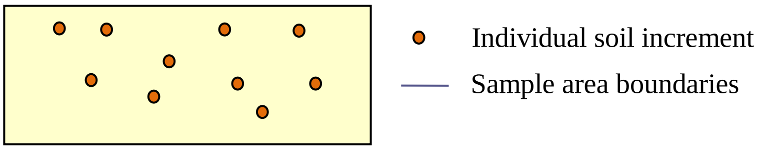


Fig. 5 Example with approximate locations of ten soil sample increments spread across the specific sample area

The determination of ammonia nitrogen (NH_3-N) and available phosphorus were done by alkaline permanganate method and Truog's method, respectively. Total organic matter contents in the soil samples were determined by titrimetric method at Soil Science Section, Department Agricultural Research, Yezin, NayPyiTaw. The determination of soluble salts such as calcium (Ca^{2+}), magnesium (Mg^{2+}), sodium (Na^+), potassium (K^+), carbonate (CO_3^{2-}), bicarbonate (HCO_3^-), sulphate (SO_4^{2-}) and chloride (Cl^-) were measured by titration method at the Soil Survey Section, Irrigation Department, Yangon.

The characterization of soil mineral constituents such as iron (Fe), titanium (Ti), calcium (Ca), zirconium (Zr), manganese (Mn), potassium (K), chromium (Cr), vanadium (V), yttrium (Y), strontium (Sr), niobium (Nb), silicon (Si) and gold (Au) and morphological structures were investigated by advanced spectroscopic techniques such as Fourier Transform Infrared Spectroscopy (FT-IR), Energy Dispersive X-ray (EDX) and Scanning Electron Microscope (SEM) at the Applied Geology Department, Yangon.

Statistical Analysis

Differences among the three gold mining locations were analyzed by one-way analysis of variance for each parameter and mean comparison among them were compared by least significant different (LSD) method at 5% level. All data analysis was done using STAR software and Microsoft Excel program (2010).

RESULTS AND DISCUSSION

Soil Physicochemical Properties in Gold Mining Areas

In textural analysis, it was found that soil from Location-1 was loam sand textural class while other two soil samples from Location-2 and 3 were sand class (Table 2). All soil samples showed similar pH values and nearly neutral in all locations (Table 3). Among all soil samples, Location-1 had low electrical conductivity (25.00 µmhos/cm) than Location-2 (32.80 µmhos/cm) and Location-3 (31.10 µmhos/cm).

NH_3-N, available phosphorus and organic matter contents were found in Table 4. All soil samples showed similar NH_3-N contents in all locations as indicating that there was no significant different among three gold mines. Location-1 gave the high available P and soil organic matter contents than others Location-2 and 3.

Table 2 Textural analysis in three gold mining areas

Location	Composition			
	Sand (%)	Silt (%)	Clay (%)	Texture class
Location-1	75	12	13	Loam sand
Location-2	89	9	2	Sand
Location-3	89	9	2	Sand

Table 3 Physicochemical properties in three gold mining areas (mean±S.E., n=4 per location)

Location	pH	EC (µmhos/cm)	Color
Location-1	7.43 ±0.03 a	25.00 ±0.13 c	Yellow
Location-2	7.25 ±0.03 b	32.80 ±0.36 a	Grey
Location-3	7.30 ±0.04 b	31.10 ±0.39 b	Grey

Mean values followed by different letters in the same column are not significantly different at 5% level by the LSD test

Table 4 Chemical properties in three gold mining areas (mean±S.E., n=4 per location)

Location	NH_3-N (ppm)	Available P (ppm)	Organic matter (%)
Location-1	6.39 ±0.01 a	5.07 ±0.14 a	0.71 ±0.02 a
Location-2	6.39 ±0.01 a	4.50 ±0.09 b	0.55 ±0.01 b
Location-3	6.37 ±0.01 a	4.30 ±0.10 b	0.52 ±0.02 b

Mean values followed by different letters in the same column are not significantly different at 5% level by the LSD test

Table 5 Soluble salt contents (cations) in the gold mining areas (mean±S.E., n=4 per location)

Location	Na^+	Ca^{2+}	Mg^{2+}	K^+
	meq/100 g of soil			
Location-1	0.22 ±0.01 a	4.01 ±0.06 a	0.98 ±0.03 b	0.10 ±0.01 b
Location-2	0.22 ±0.02 a	2.40 ±0.02 b	1.46 ±0.02 a	0.05 ±0.01 c
Location-3	0.20 ±0.02 a	2.31 ±0.02 c	1.01 ±0.06 b	0.12 ±0.01 a

Mean values followed by different letters in the same column are not significantly different at 5% level by the LSD test

There could be observed that a high soluble salts accumulation in all locations (Table 5 and 6). Soil sample from Location-1 showed the highest soluble salt, Ca^{2+} with the amount of 4.01

meq/100g of soil whereas the lowest SO_4^{2-} with the amount of 0.011 meq/100g of soil among the tested soil samples. Similarly, Location-2 and Location-3 also showed that the highest Ca^{2+} with the amount of 2.40 and 2.31 meq/100g of soil, respectively, while the lowest value of SO_4^{2-} was found with the amount of 0.011 meq/100g of soil.

Table 6 Soluble salt contents (anions) in the gold mining areas (mean±S.E., n=4 per location)

Location	CO_3^{2-}	HCO_3^-	SO_4^{2-}	Cl^-
	meq/100 g of soil			
Location-1	Non-detectable	0.60 ±0.009 a	0.011 ±0.003 b	0.18 ±0.020 a
Location-2	Non-detectable	0.40 ±0.013 b	0.011 ±0.003 a	0.09 ±0.010 b
Location-3	Non-detectable	0.41 ±0.011 b	0.011 ±0.003 b	0.09 ±0.011 b

Mean values followed by different letters in the same column are not significantly different at 5% level by the LSD test

Characterization of Soil Samples from Three Gold Mining Areas

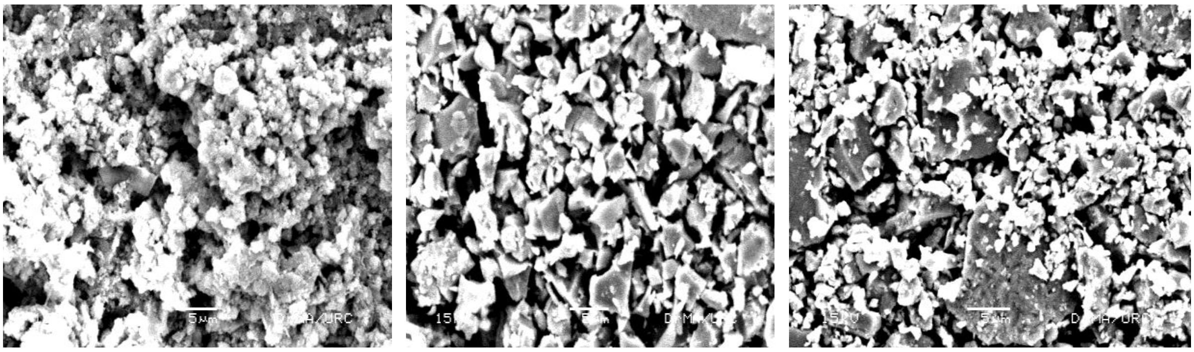
Shwe-chi in Myanmar which was finally obtained by traditional panning method was applied for the characterization of soil samples. All features appearing in the FT-IR spectral data pointed out a variety of Fe–O, Ti–O, Ca–O and Zn–O stretching and bending vibrations. According to Energy-Dispersive X-ray spectral data, all soil samples gave the highest relative proportion of Fe mineral in (Table 7). It was followed by Ti and then Au had the lowest proportion among the mineral constituents.

Table 7 Proportion of mineral constituents of soil sample in three gold mining areas

No.	Analyte metal	Location-1	Location-2	Location-3
		Per cent		
1	Fe	77.040	84.325	86.700
2	Ti	7.590	6.977	7.163
3	Ca	3.707	3.860	2.811
4	Zr	1.498	2.371	1.028
5	Mn	0.965	0.957	1.192
6	K	0.528	0.504	0.347
7	Cr	0.412	0.358	0.232
8	V	0.373	0.330	0.354
9	Y	0.172	0.130	0.058
10	Sr	0.077	0.131	0.113
11	Nb	0.058	0.058	-
12	Si	7.579	-	-
13	Au	0.001	-	0.001

The SEM microimage (Fig. 6) showed that the minerals were composed mostly of aggregates with sizes generally within 5 µm and indicated homogeneous distribution of granules throughout soil sample in Location-1. The SEM microimages also showed that the surface soils from different locations indicated that the minerals in these soil samples were composed of aggregates of different particles as given in the figures of Location-2 and 3 (Fig. 6) with no specific regular morphological structure. SEM micro-images indicated clearly the different soil morphologies between the loam sand and sand textural classes.

According to EDX analysis on three soil samples, Fe showed its highest relative amounts of (77.040%, 84.325% and 86.700%) and it was followed by the amount of Ti, (7.590%, 6.977% and 7.163%) respectively. Ca and Zr composed together with intermediate amount and K, Cr, V, Y, Sr, Nb and Au minerals were observed as the lowest constituents of these soil samples.



Location-1 **Location-2** **Location-3**

Fig. 6 SEM micro-images of Locaton-1, 2 and 3

CONCLUSION

According to the analyses of this study, riverbank sand mining can cause not only physical properties such as pH, EC, color and texture and destruction of the original landscape of the area and collapse of riverbank but also chemical effects like water pollution with many mineral contaminants from mine running off into river water and wetlands.

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REFERENCES

Ako, T.A., Onoduku, U.S., Oke, S.A., Essien, B.I., Idris, F.N. and Ahmed, A.A. 2014. Environmental effects of sand and gravel mining on land and soil in Luku, Minna, Niger State, North Central Nigeria. Journal of Geosciences and Geomatics, 2 (2), 42-49.

Canaveslo, R. 2014. Formal mining investments and artisanal mining in southern Madagascar: Effects of spontaneous reactions and adjustment polices on poverty alleviation. Land Use Policy, 36, 145-154.

Eludoyin, A.O., Ojo, A.T., Ojo, T.O. and Awotoye, O.O. 2017. Effect of artisanal gold mining activities on soil properties in a part of southwestern Nigeria. Cogent Environmental Science, 3 (1).

Emel, J., Huber, M.T. and Makene, M.H. 2011. Extracting sovereignty: Capital, territory, and gold mining in Tianzania. Polotical Geography, 30, 70-79.

Enkhzaya, S., Ohe , K., Shiomori, K., Oyuntsetseq, B., Bayanjorgal, O. and Watanable, M. 2016. Assessment of heavy metal in mining tailing around Boroo and Zuunkharaa gold mining areas of Mongolia. Journal of Environmental Science and Technology, 9 (5), 379-389.

Images Asia and Pan Kachin Development Society. 2004. At what price, gold mining in Kachin State, Burma.