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GEOCHEMICAL CHARACTERISTIC OF HEAVY METAL CONTAMINATION IN SURFACE SEDIMENTS ALONG THE UPPER AYEYARWADDY RIVER BANK OFMYITKYINA, KACHIN STATE

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Abstract

Ayeyarwaddy River is the country's largest river and Myanmar's most important commercial waterway. Gold mining is taking place in the headwaters of the Ayeyarwaddy, and sewage from the mining sites contaminates the rivers. The main objective of the present study is to assess heavy metal contamination in sediments from Ayeyarwaddy River. Surface sediments (0-60 cm) from 4 stations along river bank near Myitkyina region were sampled for metal concentration. The concentration of metals (mg/kg) was as follows: 0-670 Cr; 1000-7020 Mn; 4.28-15.99 (%) Fe; 0.446-1.445 (%) Ti and 0-920 Ni. The degree of sediment contaminations were computed using an enrichment factor (EF), geo-accumulation index (Igeo) and pollution load index (PLI). In this work, average EF of the heavy metals were between 0 and 5, therefore the river sediments were between no enrichment and moderate enrichment. The average Igeo values of these metals except Cr, Mn and Ni were less than zero (Igeo< 0), that the river sediments were not polluted by these metals. Therefore, the surface sediments are uncontaminated to moderately contaminated with Cr, Mn and Ni.PLI value of sampling point C was 2.79 indicating that Ayeyarwaddy River was polluted with the heavy metals. The PLI values of other sampling points were greater than 1 (PLI > 1) which would indicate deterioration of site quality. The study revealed that on the basis of computed indexes, the river is classified uncontaminated to moderately contaminated.

Keywords: Ayeyarwaddy River; heavy metals; indixes; surface sediment; contamination

Introduction

The Ayeyarwaddy River is the country's largest river and Myanmar's most important commercial waterway. Hydrological, ecological, anthropogenic pressures and socio-economic factors vary along the length of the Ayeyarwaddy River. Gold mining is taking place in the headwaters of the Ayeyarwaddy, the lifeline of the country and one of the greatest Asian rivers. It threatens the ecosystem of the entire river basin and along with it the livelihoods of about 20 million people. Gold mining is becoming an issue of debate in Kachin State as it has been expanding rapidly in the middle of 1990.It has resulted in serious social and environmental problems not only for those living in gold mining area but also the larger Kachin population.

Gold mining companies operate along all the major rivers and also on-land where gold yielding sediments are found. The main mining centers appear to be along the Ayeyarwaddy River north of the state capital Myitkyina. On land, more and more areas are deforested in order to make way for mining and to build the necessary infrastructure. Together with the mining activities, the use of the mining agent mercury has increased. The logging and gold mining has already caused incalculable loss of biodiversity in the riverine and forest ecosystems. Discarded engines are simply left behind whenever a mining operation moves on. Engine oil used to run machines and waste from mining camps all add to the pollution. Bioaccumulation of mining chemicals will continue to take its toll on species diversity and human health. Aside from the obvious pollution, mining causes structural changes to rivers which can cause severe ecological damage. Rivers are diverted for riverbed mining operations, while water blasting of sediments destroys riverbanks. These structural changes result in the loss of many riverine habitats for endemic fish species. They also affect the direction and speed of the water flow which reportedly has already led to unusually low water levels in some areas and increased flooding in others.

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The Mali Hka River is one of the main centres of mining activities in Kachin State. In contrast to the N'MaiHka River, most of the mining on the Mali Hka is done with floating dredges scooping up sediments from the bottom of the river. At some places the river is wide enough to allow river bank mining. Deforestation is a major concern since the trees of the surrounding forests are being cut to clear land, for the construction of mining camps, fuel wood or simply to make space for mining. Waste from the mining sites contaminates the rivers.

Literature Review

Calculation of Pollution Indices

In an attempt to understand the pattern of metal contamination in the study area, useful tools including pollution indices such as; enrichment factor (EF), geo-accumulation index (Igeo) and pollution load index (PLI) were used to calculate heavy metal concentration in sediments.

2.1 Enrichment Factor (EF)

The enrichment factor is established on the bases of standardization of a tested element against a reference one. A reference element is the one characterized by low occurrence variability such as Al, Fe, or Zn. In this study Al was used as a reference element since its concentration in earth's crust is low. Also, Al is a major constituent of clay mineral and has been used as a reference element to assess the status of heavy metals pollution.

EF was calculated using the relation as

$$EF = \left[\frac{C_n / C_{ref}}{B_n / B_{ref}} \right]$$

Where $C_n$is content of the examined element in the examined environment, $C_{ref}$is content of the examined element in the reference environment, $B_n$is content of the reference element in the examined environment and B_{ref} is content of the reference element in the reference environment. Classification of enrichment factor is shown in Table (2.1).

Table 2.1 Classification of enrichment factor

EF	Classification
EF < 1	No enrichment
EF < 3	Minor enrichment
EF = 3-5	Moderate enrichment
EF = 5-10	Moderately severe enrichment
EF = 10-25	Severe enrichment
EF = 25-50	Very severe enrichment
EF > 50	Extremely severe enrichment

2.2 Geo- accumulation Index (Igeo)

Geo-accumulation index serves to assess contamination by comparing current and preindustrial concentration of heavy metals (**Muller, 1981**). Background concentration of heavy metals in the earth's crust was used as a reference value implicating pre-industrial environment. Igeo is calculated through the following equation:

$$I_{geo} = \log_2 [C_n/1.5B_n]$$

Where $C_n$is concentration of the element (n) in the sediment sample and $B_n$is geochemical background value. The constant 1.5 helps to analyze natural fluctuation between a content of a given substance in environment and very small anthropogenic influences. Six classes of geochemical index are shown in Table (2.2).

Table 2.2 Classification of geo-accumulation index

Class	Value	Description of sediment quality
0	Igeo< 0	Practically uncontaminated
1	0 <Igeo< 1	Uncontaminated to moderately contaminated
2	1 <Igeo< 2	Moderately contaminated
3	2 <Igeo< 3	Moderately to heavily contaminated
4	3 <Igeo< 4	Heavily contaminated
5	4 <Igeo< 5	Heavily to extremely contaminated
6	5 <Igeo< 6	Extremely contaminated

2.3 Pollution Index (PI)

The assessment of the sediment contamination was also carried out using the pollution index PI and Pollution Load Index PLI. The contamination factor or pollution index was calculated using the relation described by Hakanson (1980);

$$PI = C_n / C_b$$

Where C_n is the mean content of metals from at least five sampling sites and $C_b$is the pre-industrial concentration of individual metal. Four categories of pollution index were defined by (Hakanson, 1980) as given in Table (2.3).

Table (2.3) Categories of pollution index

PI	Category
PI < 1	Low contamination factor
1 < PI < 3	Moderate contamination factor
3 < PI < 6	Considerable contamination factor
6 < PI	Very high contamination factor

2.4 Pollution Load Index(PLI)

Each sampling site was evaluated for the extent of the metal pollution by employing the method based on the pollution load index (PLI) developed by Tomlinson et al. as follows:

$$PLI = \left(PI_1 * PI_2 * PI_3 * .....PI_n\right)^{1/n}$$

Where n is the number of metals studied and PI is the pollution index as mentioned above. The PLI provides simple but comparative means for assessing a site quality, where a value of PLI < 1 denotes perfection; PLI = 1 denotes that only baseline levels of pollutants are present and PLI > 1 would indicate deterioration of site quality.

Material and Methods

3.1 Study Area and Sampling Points

The Ayeyarwaddy River is named from the confluence of the N'maiH’ka and MaliH’ka Rivers in Kachin State. The upper part from the headwaters of the Ayeyarwaddy river, NmaiH’ka and Mali H’ka rivers that join about 50 km north of Myitkyina. The four sampling points were selected for the present study. In NmaiH'ka , sampling point (A) is 1.6 km upstream north of the confluence. In Mali H'ka, sampling point (B) is situated about 1.6 km upstream north of confluence. Confluence lies 28 miles (45 km) north of Myitkyina, capital of the Kachin State. In Ayeyarwaddy River, sampling point (C) is located on 1.6 km and sampling point (D) is 3.6 km downstream south of confluence. Map of study area showing sampling sites A, B, C and D is as shown in Fig. (3.1). Coordinate of each sampling site is shown in Table (3.1).

3.2 Sample Collection and Preparation

Freshly deposited sediments from shallow water near the banks of Ayeyarwaddy River at different sites were collected with the help of PVC pipe during the month of July 2016 from the river bed where flow rates were low and sedimentation was assumed to occur. Collected samples were air dried at room temperature. From the bulk sediment, a representative sub sample was powdered and sieved through 100 mesh. After getting the fine powder of sediment samples, they were analysed by EDXRF technique.

Figure 3.1 Map of study area showing sampling sites A, B, C and D

Table 3.1 Coordinates of each sampling site

Sites	Latitude	Longitude	Sample Code	Depth(cm)
Maykha (A)	25° 42.55′ N	97° 31.57′ E	MK1	60
			MK2	45
			MK3	30
			MK4	15
Malikha (B)	25° 45.42′ N	97° 29.95′ E	ML1	60
			ML2	45
			ML3	30
			ML4	15
Ayeyarwaddy 1 (C)	25° 41.57′ N	97° 29.95′ E	A 1,1	60
			A 1,2	45
			A 1,3	30
			A 1,4	15
Ayeyarwaddy 2 (D)	25° 41.23′ N	97° 31.38′ E	A 2,1	60
			A 2,2	45
			A 2,3	30
			A 2,4	15

3.3 Elemental Analysis Using EDXRF System

The X-ray fluorescence spectrometer used for heavy metal analysis is HORIBA XGT 5200 at Suranaree University of Technology, Thailand. It is a high purity Si detector and the sample is simply placed in the sample chamber and analysed at normal atmospheric pressure.

Results and Discussion

From the results, the mean concentrations of heavy metals found in the samples collected from the sampling point C: Ti, Mn, Fe and Ni were higher than in the samples from the sampling points A, B and D. The mean concentrations of heavy metals in sediments collected from the sampling point B: Cr was higher than in the samples collected from other sampling points. The mean concentrations of the heavy metals collected from the sampling point A: Ti, Cr, Mn, Fe and Ni were the lowest.

Average shale value was used as reference baseline in this study to provide elemental background concentration. Comparison of the values obtained in this study with global reference value indicates that the concentration of Ti, Cr, Mn, Fe and Ni were higher than the reference baseline of average shale shown in Fig. (4.1).

The EF was calculated for a better assessment of anthropogenic input for each metal. In sampling point A, average EF values of Ti, Cr, Fe and Ni were found to be no enriched (EF< 1) and Mn was minor enriched (EF<3). In sampling point B, average EF values of Ti, Mn, Fe and Ni were minor enriched (EF<3) and Cr was moderate enrichment (EF<5). In sampling point C, average EF values of Ti, Cr, Mn and Fe were minor enriched (EF<3) and Ni was moderate enrichment. In sampling point D, average EF values of Ti, Cr, Mn, Fe and Ni were minor enriched (EF<3).The EF value above 1.5 indicates an anthropogenic contribution and if EF is less than 1.5, the metal concentration is considered crustal or natural weathering origin. The higher the EF values is, the more severe the anthropogenic contribution. In this study, the studied heavy metals were proven to be between no enrichment and moderate enrichment. Comparison of average EF for each heavy metal in difference sites is shown in Fig.(4.2).

Based on the average values of Igeo, the ranking of intensity of heavy metal pollution of surface sediments is as follow: Ni>Cr>Mn>Ti>Fe. The average Igeo value of Cr and Mn are between zero and one (0<Igeo< 1) indicating that surface sediments are uncontaminated to moderately contaminated. The average Igeo value of Ni is between one and two (1<Igeo<2) indicating that surface sediments are moderately contaminated. Other heavy metals showed an Igeo of less than 0, indicating that the river sediments are not polluted by these metals. Therefore, the surface sediments are uncontaminated to moderately contaminated with Cr, Mn and Ni. Average Igeo values of each heavy metal in different sites is shown in Fig.(4.3).

PLI value of sampling point C was 2.79 indicating that Ayeyarwaddy River was polluted with the heavy metals. The PLI values of other sampling points were greater than 1(PLI > 1) which would indicate deterioration of site quality. The study revealed that on the basis of computed indexes, the river is classified uncontaminated to moderately contaminated. Comparison of average PLI values in difference sites is shown in Fig.(4.4).

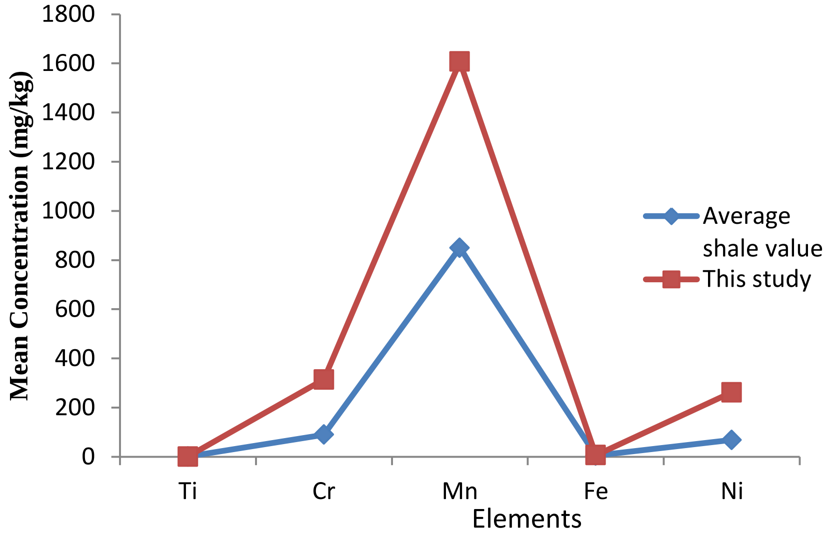

Figure 4.1 Mean concentrations of sampling sites compared with average shale values

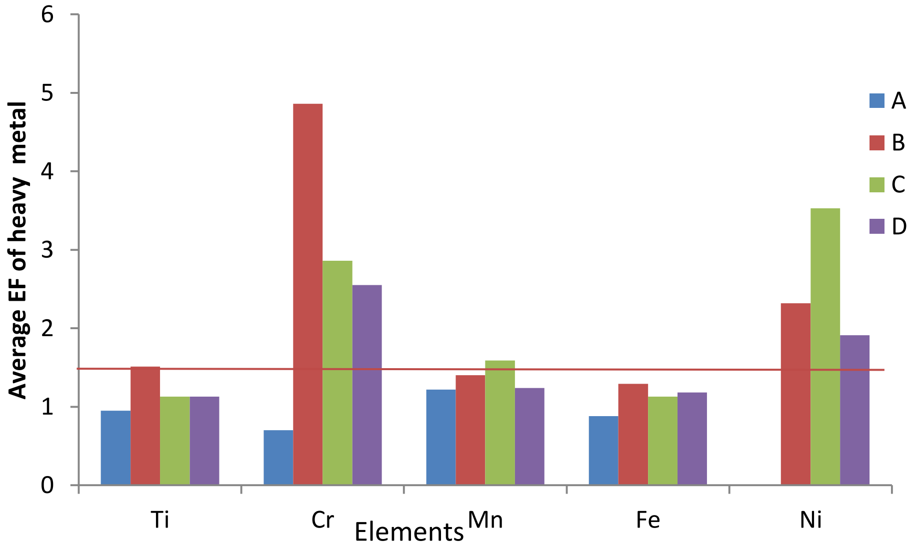

Figure 4.2 Comparison of average EF for each heavy metal in difference sites

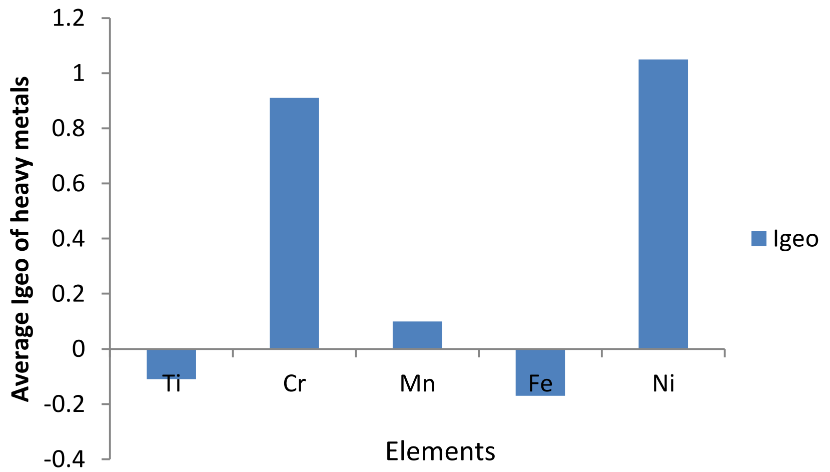

Figure 4.3 Average Igeo values of each heavy metal in different sites

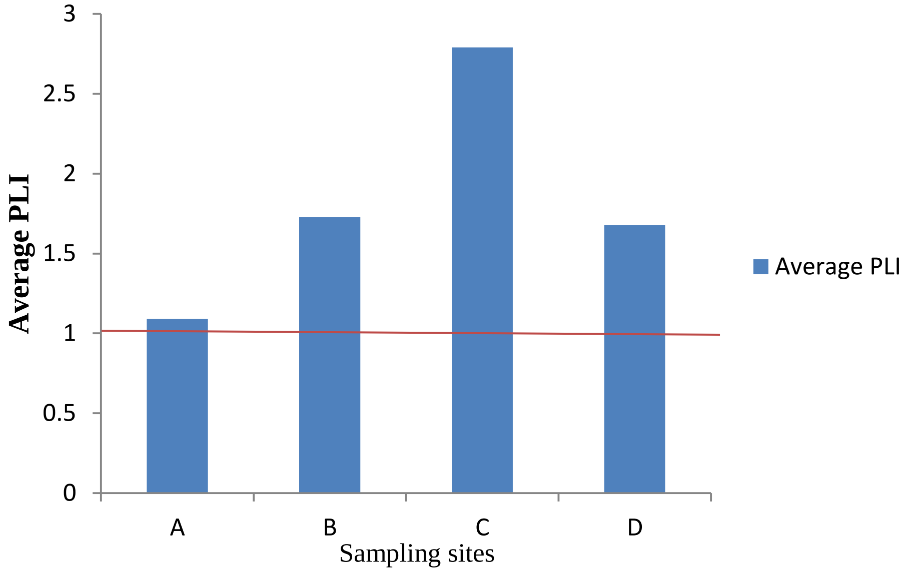

Figure 4.4 Comparison of average PLIvalues in difference sites

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