Elemental Pollution of Sediment near drain in Taungthaman Lake

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Abstract

Six sediment samples collected in 2016 from three different sites near drain in Taungthaman Lake, Amarapura, Mandalay region were examined by EDXRF method to estimate the elemental pollution of the sediments. The concentration values of toxic elements in sediment samples are compared with the recommended values of IAEA - 405 (1 August, 2000). The concentrations of Ni and As in these sediments are lower than the recommended values. The concentrations of (Cu, Cd and Hg) are higher than the recommended values. The enrichment factors of Hg in the sediments at the edge of the drain and from the deposit soil near drain are severe enrichment. The enrichment factor of Hg in the top sediment in agricultural soil around drain is moderately severe enrichment and the bottom sediment is moderate enrichment.

Introduction

Pollution of the environment is causing great damage to ecosystem that depends upon the health of this environment. Pollution levels need to be controlled all the time if we want to keep our environment safe and healthy. Without proper pollution control environment soon becomes unhealthy. Preventing introduction of pollutions into some environment is the best way to protect environment from pollution. To do so it is important to develop ecological conscience of nearby communities, and effective waste management in form of recycling. Healthy environment is prerequisite of healthy life for us and our children, and fighting pollution is definitely the best way to keep our environment healthy.

Heavy metals including both essential and non-essential elements have a particular significance in ecotaxicology, since they are highly persistent and all have the potential to the toxic to living organisms. Heavy metals such as copper, manganese, zinc, chromium and nickel are essential metals since they play an important role in biological systems, whereas Pb is non-essential metal, as it is toxic, even in trace elements. These essential metals can also produce toxic effect when the metal intake is excessively elevated.

Thus, the aim of the present study is to determine the distribution of heavy metals (Al, Cr, As, Cd, Hg, Fe, Cu, Ni, Zn and Pb) in sediments of Taungthaman Lake. This research has also been carried out on the environmental quality of sediment of the lake.

Materials and Methods

Description of Research Area

U Shwe Tun Bridge is the slop out from the factories abandons. This bridge is situated beside the Taungthaman Lake. Taungthaman Lake is located in Amarapura Township within the Mandalay Region. Taungthaman Lake has length above two miles from east to west, its width is one mile. Lake area is 231.73 acres. Taungthaman Lake is an oxbow lake in which water floods from Ayeyarwady and Datawady River during the rainy season. But water level goes down on winter and summer.

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Sample Location (Sampling Site), Collection and Preparation

In this research sediment soil samples S_1, S_2 and S_3 were taken from Taunthaman Lake at the edge of the drain, from deposit soil near drain and in agricultural soil around drain. The sediment sample location at the edge of the drain in Taungthaman Lake is shown in Figure (1). The sediment sample location from the deposit soil near the drain is also shown in Figure (2). The sediment sample location in agricultural soil around drain is shown in Figure (3). The location map of Taungthaman Lake is represented in Figure (5).

In this research sediment samples are collected from Taungthaman Lake during period in January, 2016. The fixed sampling sites S_1, S_2 and S_3 are located at (Lat 21° 53' 57.87" (N) to long 96° 04' 34.78" (E)), (Lat 21° 53' 57.07" (N) to long 96° 04' 32.92" (E)) and (Lat 21° 53' 56.85" (N) to long 96° 04' 32.81" (E)) in Amarapura Township. Three sediment samples from the research site were each collected with two inches in diameter PVC pipe which is two feet long. The sediment sample (S_1) was taken into the 1 feet depth of PVC pipe from the edge of the drain. The sediment sample (S_2) was also taken into the 1 feet depth of PVC pipe from the deposit soil near drain. And then, similarly the sediment sample (S_3) was taken into the 1 feet depth of PVC pipe from the agricultural soil around drain. The photographs of three PVC pipes for sample collection in Taungthaman Lake are shown in Figure (4).

These samples were cleaned and dried under the room temperature, avoiding the loss of any volatile radionuclides. And then it is needed to grind the soil and to get very fine powders. The soil powder samples were passed through 325 mesh sieve of the samples. After getting very fine powder, the sample was weighted nearly 5g. So the powdered samples were prepared as pellets. Binder agent is needed to obtain stable pellet. Sample 5g and binder 1g were weighed using digital balance (PW - 254). After palletizing, the pressed pellet was weighed again. Then, the meshed sediments were also transferred to plastic containers of 600g capacity for gamma spectrum analysis. The experimental Set up for SPECTRO XEPOS detection system is shown in Figure (6). Sample preparation is an important role in XRF measurement.

Experimental Procedure for SPECTRO XEPOS Spectrometer

The EDXRF machine (SPECTRO XEPOS) at the Experimental Nuclear Physics Laboratory, Mandalay University of Physics Department is used for determination of the trace elements in the six samples of interest.

Enrichment Factor

The formula to calculate enrichment factor (EF) is

$$\text{Enrichment factor (EF)} = \frac{(C_i / C_{ie})_{sample}}{(C_i / C_{ie})_{reference}}$$

where C_i = the concentration of element i in the sample of interest

C_{ie} = the concentration of immobile element in the sample of interest

C_i = the concentration of element i in the reference sample

C_{ie} = the concentration of immobile element in the reference sample

The immobile element is often taken to be Al, Li, Si, Zr, Ti and sometimes Fe or Mn have been used. The enrichment factor (EF) is used to assess the degree of pollution. A reference material is used as iron (Fe) because iron (Fe) is immobile element. Generally, the values of the enrichment factor evaluate the level of impartation of the sediment by the metals.

The advantage of using the enrichment factor (EF) analysis is that it allows establishing a contamination guideline. This technique has been well applied in several studies to assess metal contamination in marine sediments, where

$EF < 1$ indicates no enrichment

$1 < EF < 3$ indicates minor enrichment

3 < EF < 5 indicates moderate enrichment
5 < EF < 10 indicates moderately severe enrichment
10 < EF < 25 indicates severe enrichment
25 < EF < 50 indicates very severe enrichment
EF > 50 indicates extremely severe enrichment

While the geochemical background values are constant, the levels of contamination vary with time and places. The enrichment factors of heavy metal distribution in the sediments were determined from the above relation. The reference data of IAEA-405(1 August 2000) is represented in Table (1).

Figure (1) Sample location at the edge of the drain

Figure (2) Sample location from the deposit soil near drain

Figure (3) Sample location in the agricultural soil around drain

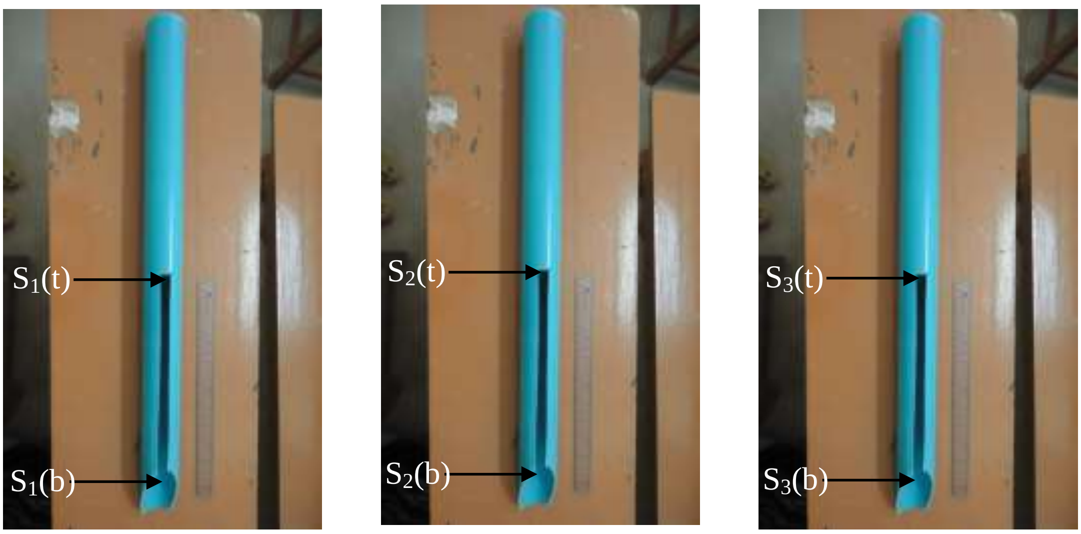

Figure (4) Photographs of PVC Pipes for the sample location

Figure (5) Location Map of Taungthaman Lake

Figure (6) Experimental Set-up for XEPOS Spectrometer Detection System

Table (1) Reference data of IAEA-405

Sr.No	Analyte	Recommended Value [mg/kg]	95% Confidence Interval [mg / kg]
1	Al	77900	(72700-83100)
2	Cr	84	(80-88)
3	Fe	37400	(36700-38100)
4	Ni	32.5	(31.1-33.9)
5	Cu	47.7	(46.5-48.9)
6	Zn	279	(272-286)
7	As	23.6	(22.9-24.3)
8	Cd	0.73	(0.68-0.78)
9	Hg	0.81	(0.77-0.85)
10	Pb	74.8	(72.6-77.0)

Results and Discussions

In the research work, recent six sediments of Taunghtaman Lake were studied by EDXRF method. The concentrations of elements in sediment sample at the edge of the drain are presented in Table (2). Variation of elements in sediment sample at the edge of the drain is shown in Figure (7). The concentrations of elements in sediment sample from the deposit soil near drain are listed in Table (3). Variation of elements in sediment sample from the deposit soil near drain is shown in Figure (8). And then, the concentrations of elements in sediment sample from the agricultural soil around drain are represented in Table (4). Variation of elements in sediment sample from the agricultural soil around drain is shown in Figure (9). These metals are aluminum (Al), Chromium (Cr), Iron (Fe), Nickel (Ni), Copper (Cu), Zinc (Zn), Arsenic (As), Cadmium (Cd), Mercury (Hg), and Lead (Pb). These concentration values are reported in ppm. The enrichment factors (EF) of the metal contaminants in the sediment at the edge of the drain are listed in Table (5). The enrichment factors (EF) of the metal contaminants in the sediment from the deposit soil near drain are presented in Table (6). The enrichment factors (EF) of the metal contaminants in the sediment from the agricultural soil around drain are represented in Table (7).

The concentrations of elements in top part sediment S1 (t) is higher than bottom part sediment S1 (b) at the edge of the drain. The concentrations of elements in bottom part sediment S2 (b) is greater than the top part sediment S2 (t) from the deposit soil near drain. Moreover, elements in top part sediment S3 (t) and bottom part sediment S3 (b) are distributed in the agricultural soil around drain. The enrichment factor (Ef) of (Al, Fe, Ni, Zn, As and Pb) shows no enrichment in the sediment. The enrichment factors (Ef) of (Cr, Cu, Cd and Hg) are higher than other elements. After many years, the cultivated area of lake can be polluted because of contamination. To be precise about the elemental distribution of the sediment samples from Taungthaman Lake, the sediment samples should be analyzed seasonally, regionally and yearly.

Table (2) Concentration of elements in sediment sample at the edge of the drain

Sr. No	Elements	Concentration (ppm)	
		S_1 (t)	S_1 (b)
1	Al	37676.4	24232.5
2	Cr	295	53.9
3	Fe	35149.3	24077.5
4	Ni	10.5	6.3
5	Cu	64.7	49.8
6	Zn	176.2	147.2
7	As	9.2	7.5
8	Cd	6.6	5.9
9	Hg	9.5	8.3
10	Pb	48.6	37.6

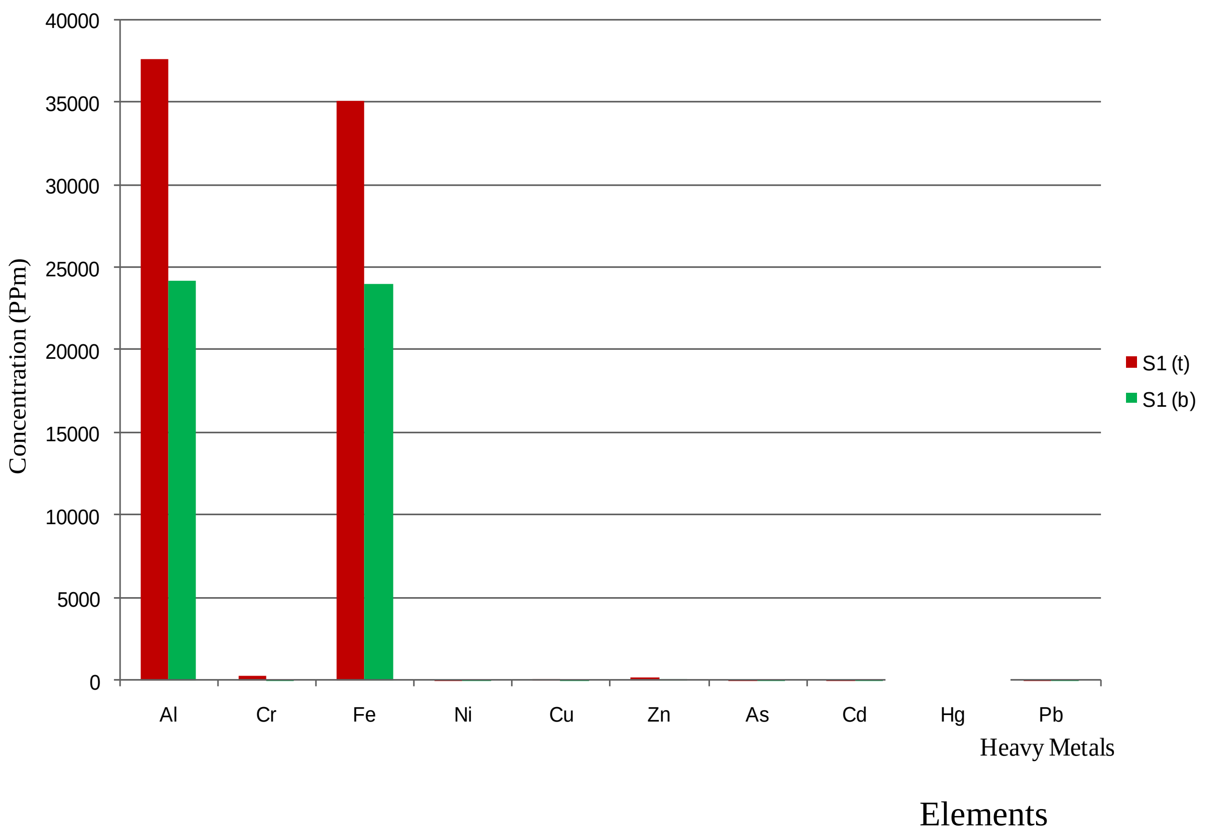

Figure (7) Variation of elements in sediment sample at the edge of the drain

Table (3) Concentration of elements in sediment sample from the deposit soil near drain

Sr. No	Elements	Concentration (ppm)	
		S_2 (t)	S_2 (b)
1	Al	40797.7	54606
2	Cr	228	774.6
3	Fe	39290.2	54527.6
4	Ni	11.6	16.9
5	Cu	60.9	90.6
6	Zn	195.4	268.9
7	As	10.7	15.3
8	Cd	4.4	7.8
9	Hg	8.8	11.4
10	Pb	50.6	63.1

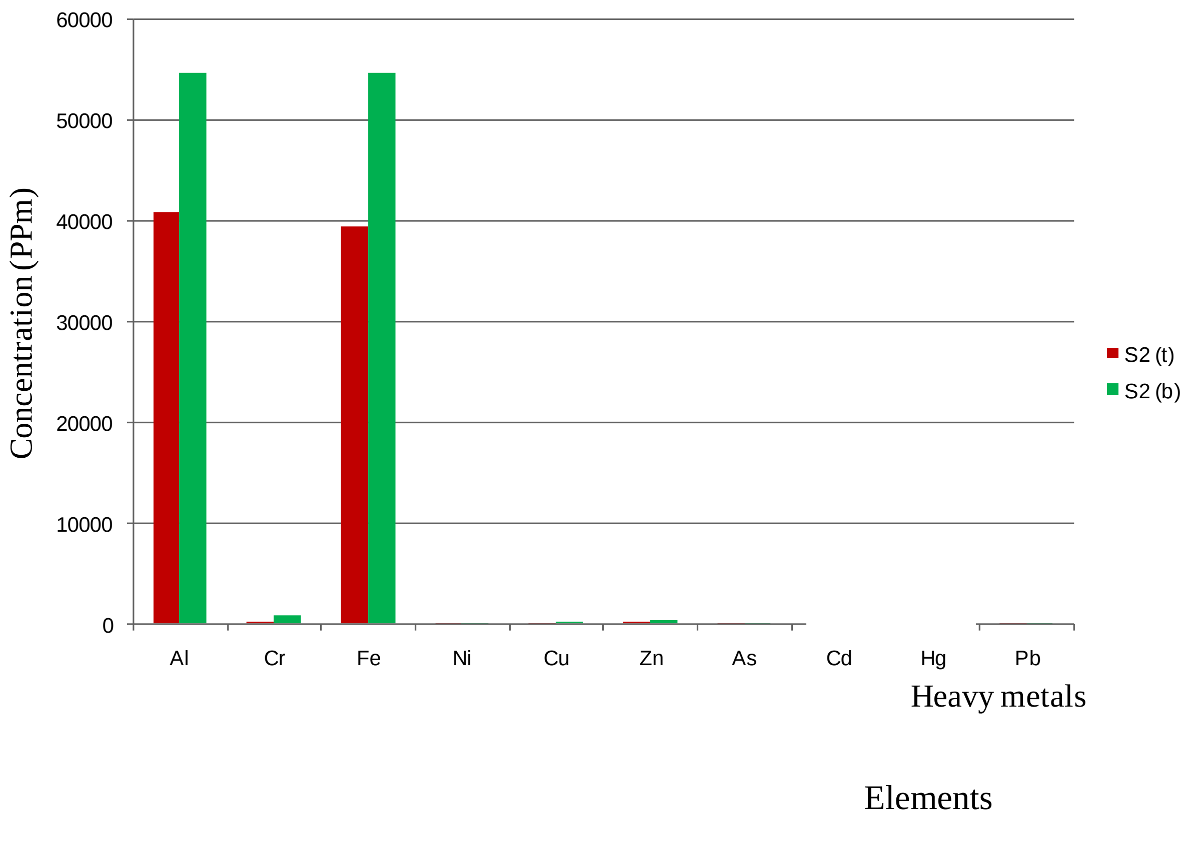

Figure (8) Variation of elements in sediment sample from the deposit soil near drain

Table (4) Concentration of elements in sediment sample from the agricultural soil around drain

Sr. No	Elements	Concentration (ppm)	
		S_3 (t)	S_3 (b)
1	Al	82133.7	102487.9
2	Cr	309.3	191.4
3	Fe	80676.9	82653.8
4	Ni	22.3	22.5
5	Cu	124.3	105.4
6	Zn	327.3	388.4
7	As	18.9	19
8	Cd	8.6	6.9
9	Hg	13.7	7.3
10	Pb	110.9	107.1

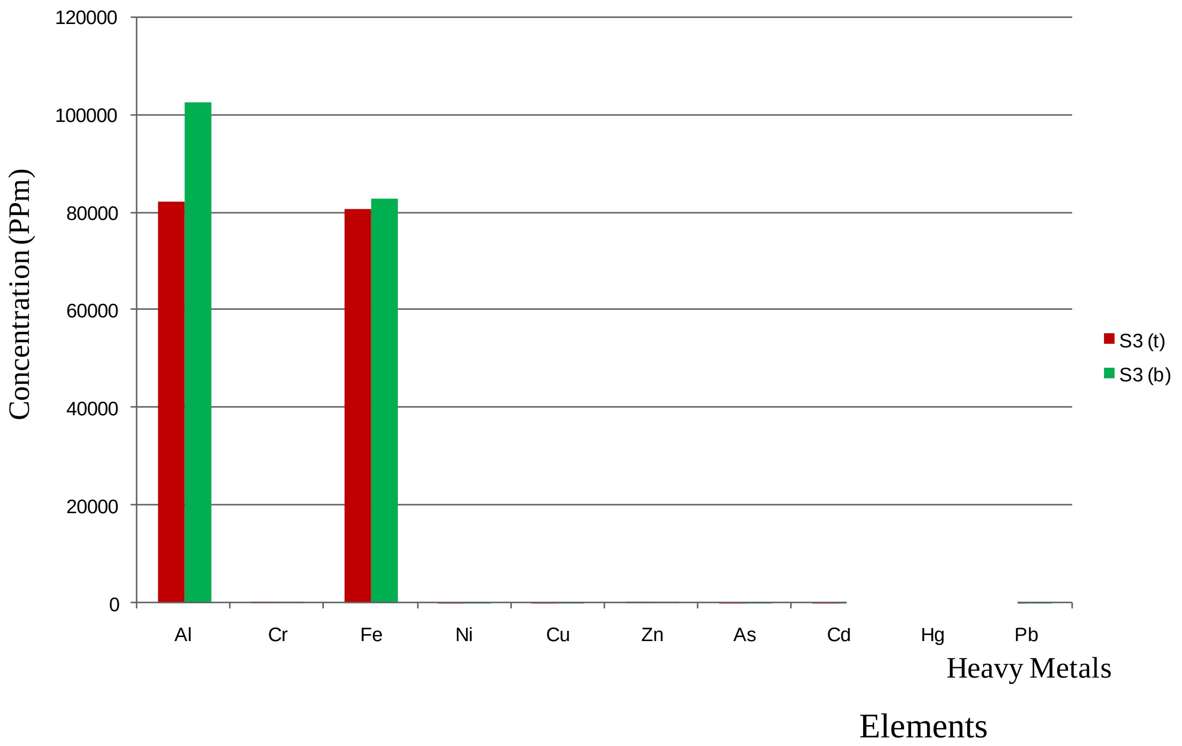

Figure (9) Variation of elements in sediment sample from the agricultural soil around drain

Table (5) The enrichment factor (EF) of the metal contaminants in the sediment at the edge of the drain

Sr. No	Elements	Enrichment factor (EF)	
		S_1 (t)	S_1 (b)
1	Al	0.515	0.483
2	Cr	3.737	0.997
3	Fe	1	1
4	Ni	0.344	0.301
5	Cu	1.443	1.622
6	Zn	0.672	0.819
7	As	0.415	0.494
8	Cd	9.62	12.554
9	Hg	12.479	15.92
10	Pb	0.691	0.781

Table (6) The enrichment factor (EF) of the metal contaminants in the sediment from the deposit soil near drain

Sr. No	Elements	Enrichment factor (EF)	
		S_2 (t)	S_2 (b)
1	Al	0.499	0.481
2	Cr	2.584	6.325
3	Fe	1	1
4	Ni	0.339	0.357
5	Cu	1.215	1.303
6	Zn	0.667	0.661
7	As	0.432	0.445
8	Cd	5.737	7.329
9	Hg	10.342	9.653
10	Pb	0.644	0.579

Table (7) The enrichment factor (EF) of the metal contaminants in the sediment from the agricultural soil around drain

Sr. No	Elements	Enrichment factor (EF)	
		S_3 (t)	S_3 (b)
1	Al	0.489	0.595
2	Cr	1.707	1.031
3	Fe	1	1
4	Ni	0.318	0.312
5	Cu	1.208	0.999
6	Zn	0.544	0.629
7	As	0.373	0.364
8	Cd	5.47	4.277
9	Hg	7.841	4.078
10	Pb	0.688	0.647

Conclusion

The SPECTRO XEPOS Spectrometer detects characteristic X-rays and determines the elements in the material quantitatively and qualitatively. According to the results obtained, it was found that the concentration of the major and some toxic heavy metals contained in these sediment sample change according to three sediment locations near drain. It was found that the concentrations of metals (Cu, Cd and Hg) are more than the recommended values of International Atomic Energy Agency (IAEA-405) ranges. The enrichment factors of Hg in the sediments at the edge of the drain and from the deposit soil near drain are severe enrichment. The enrichment factor of Hg in the top sediments in agricultural soil around drain in moderately severe enrichment and the bottom sediments is moderate enrichment. According to the results of elemental analysis, the cumulative effects of metals are believed to play a significant role in the toxicity and pollution in the soil. Therefore, further studies should be undertaken for several years to detect the status of these elements in sediment.

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