

Assessment of Heavy Metals Pollution in Freshly Deposited Sediments of Asa River, Ilorin, Kwara State, Nigeria

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ABSTRACT

Concentrations of metals such as Cu, Cr, Co, Fe, Mn, Ni, Pb, Zn and Cd were determined in freshly deposited sediments of Asa River in Ilorin. The choice of sample locations was based on the land use pattern along the Asa River with a view to determine the impact of such activities on the various levels of metal pollution. Seven locations along the river bank were selected particularly areas that receives effluents into the river. Sediment samples were collected when water level of the Asa River was low. In order to minimize the grain-size dependencies of metal concentration, a grain-size fraction <20 μ m was used for sediments in this study. Geoaccumulation index method and enrichment factor interpretations shows that Asa River sediments are highly polluted with iron and cadmium and moderately polluted with lead which suggest their anthropogenic inputs including effluents from nearby industries as well as agricultural activities such as the use of fertilizers, pesticides. Regular monitoring of sediments of the Asa River should be carried out as there is notable increase in the level of human and industrial activities along the course of the river.

Keywords: Pollution, Heavy metals, Sediments, Geoaccumulation index and Enrichment factor.

1. INTRODUCTION

The investigation of sediments from the hydrosphere has recently become a major subject of interest in research on aquatic systems, as they reflect the current quality of the system and provide information on the impact of man (Singh, Ansari, Muller 1997). The study of the sediments plays an important role, as they have a long residence time. River sediments, therefore, are important sources for the assessment of man-made contamination in rivers (Forstner and Wittman 1983; Muller 1979). The sediments are increasingly recognized as carriers and possible sources of contaminants in the system. Human activities (urbanization, industrialization and mining) promote the accumulation of polluted sediments in the nearby river system, which is considered to be a safe disposal site for contaminated sediments (Singh et al., 1997). The contaminants in the river systems can be investigated by analyzing either the water and the suspended material or the sediments.

Asa River supplies the basic water needs of the Ilorin city and its environs after treatment at Asa Dam treatment plant. Shortage of sufficient potable water has led many people to depend on this river not only for drinking but also, for other domestic and industrial uses, therefore, its pollution status is thus of serious concerns that worth investigation and assessment. Some geochemical studies have been carried out in the last few years on the geochemistry of water and sediments of Asa River (Alao and Ige 2003, Eleta et al., 2005). The present study deals with the heavy metal pollution in freshly deposited sediments along Asa River in Ilorin.

2. PHYSICAL AND GEOLOGICAL SETTINGS OF STUDY AREA

Asa River originate from Oyo state and flows through Ilorin in a South-North direction forming a dividing boundary between Eastern and Western Ilorin. The Asa River flowing almost South- North divides the city of Ilorin almost to two equal halves (Fig.1). The river and its banks have been turned in to refuse/ waste dump sites by the inhabitants of the flood plain (Ige and Alao 2003). The tributaries of Asa in Ilorin include river Agba, Aluko, Atikeke, Mitile, Odota, Okun, and Osere.

The study area is situated on the Precambrian Basement Complex rocks that include granite, granitic gneiss and migmatites (Annor et al., 1996). The rock form part regional north –western Island running northwest-southeast parallel to the River Niger (Offodile1987, Annor et al., 1996). These represent the deeper fractured aquifer which is partly overlain by a shallow porous aquifer within the lateritic soil cover (Alao, 1983).

3. RESEARCH METHODOLOGY

A 20-km long stretch of the Asa River was selected for the present study. The choice of sample locations was based on the land use pattern along the Asa River with a view to determining the impact of such activities on the various levels of metal pollution. Seven (7) locations along the river bank have been selected particularly areas that receives effluents into the river (Table 1). The sediment samples were collected at each site. All samples were collected when water level of the Asa river was low. The sediment samples were collected in black polythene sacks. Sediment samples were obtained from the field with the aid of grab sampler into black polythene sacks. In order to minimize the grain-size dependencies of metal concentration, a grain-size fraction <20 μ m was used for sediments in this study.



Plate1: Heap of refuse dumped at the Bank of Asa River in Amilegbe Bridge, Ilorin



Plate 2: Refuse dumpsite, under the Bridge at Railway station, Ilorin



Plate 3: Effluent of Soap and Detergent Industries at Asa Dam

4. SAMPLES PREPARATION AND ANALYSIS

Sediment samples were air-dried in the laboratory for about seven days to avoid loss of volatile substances that may accompany drying in the oven. The sediment samples were digested in a mixture of perchloric nitric and hydrochloric acids. All chemicals used were of reagent grades. The digested solutions were then analysed for Cd, Cr, Co, Cu, Fe, Pb, Mn, Ni, and Zn by Atomic Absorption Spectrophotometric technique.

TABLE 1: Description of the Sampling Locations.

S/N	Description	Coordinate
1	Afon water treatment station in Asa Local Government Area of Kwara State. Taken as control being the closest accessible site to the source and also as a result of low level of human activities in the area.	N08° 20' 18.8" E004° 31' 28.0"
2	Laduba Village where farming activities are taken place.	N08° 23' 0.82" E004° 33' 23.0"
3	Behind a soap and detergent company around Asa Dam in Ilorin.	N08° 26' 15.3" E004° 33' 40.5"
4	Behind a pharmaceutical company in Ilorin.	N08° 27' 41.6" E004° 33' 30.6"
5	Behind a bottling company around Unity road, Ilorin.	N08° 28' 01.8" E004° 33' 28.9"
6	Receives effluents from a major hospital and a huge dump site beside it with a busy road across the river.	N08° 29' 48.7" E004° 34' 02.4"
7	Sobi along Shao in Moro Local Government Area of Kwara state. It is far from the activities of Ilorin but also involves some farming activities.	N08° 32' 10.7" E004° 34' 05.9"

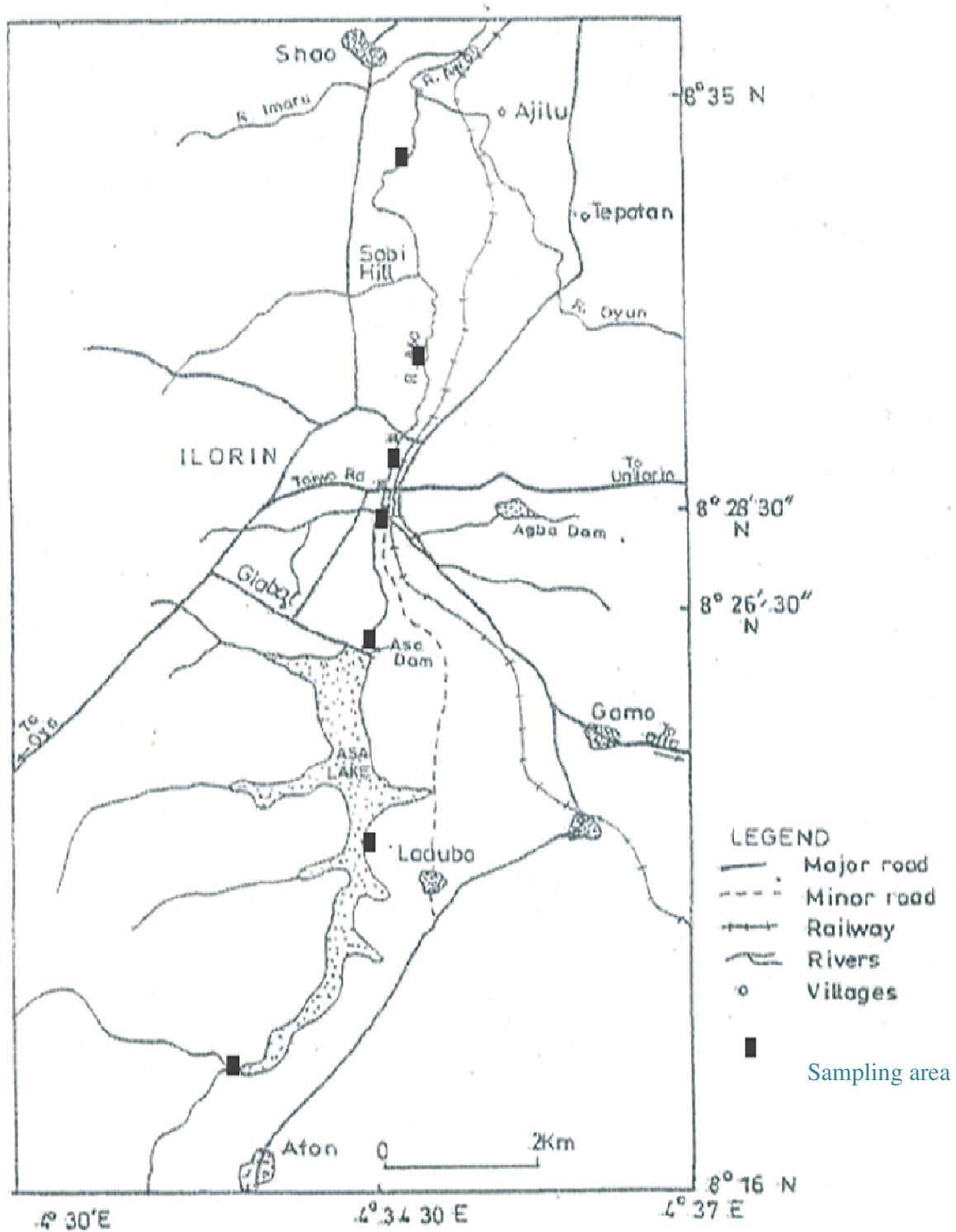


Fig.1. Map of Ilorin and environs showing flow of Asa River and sampling Locations (Modified from Eleta et al., 2005).

5. RESULTS AND INTERPRETATION

Heavy metals concentration in the Asa River sediments show varying and different behaviour influenced by urbanization. The results of the chemical analysis of the samples are presented in Table 2. Figure 2 shows the concentration of each metal across the locations.

TABLE 2: HEAVY METAL CONCENTRATIONS (ppm) OF ASA RIVER SEDIMENTS (<20µm fraction)

Soil Sample	Cadmium	Iron	Chromium	Maganese	Cobalt	Lead	Zinc	Nickel	Copper
1	3.90	120.0	7.20	6.30	76.3	1.00	6.20	4.90	14.6
2	5.40	46.4	9.40	10.2	26.5	53.1	0.50	1.90	24.3
3	2.60	33.9	3.90	6.40	14.0	49.5	5.30	5.80	18.8
4	16.3	641.6	16.4	5.80	6.30	2.00	1.20	23.4	20.3
5	4.30	76.70	3.80	16.0	4.30	24.7	4.90	19.4	13.5
6	11.2	152.2	2.30	60.5	16.4	139.2	74.9	17.5	68.4
7	0.60	140.3	18.4	16.3	17.0	3.60	3.80	5.30	7.90

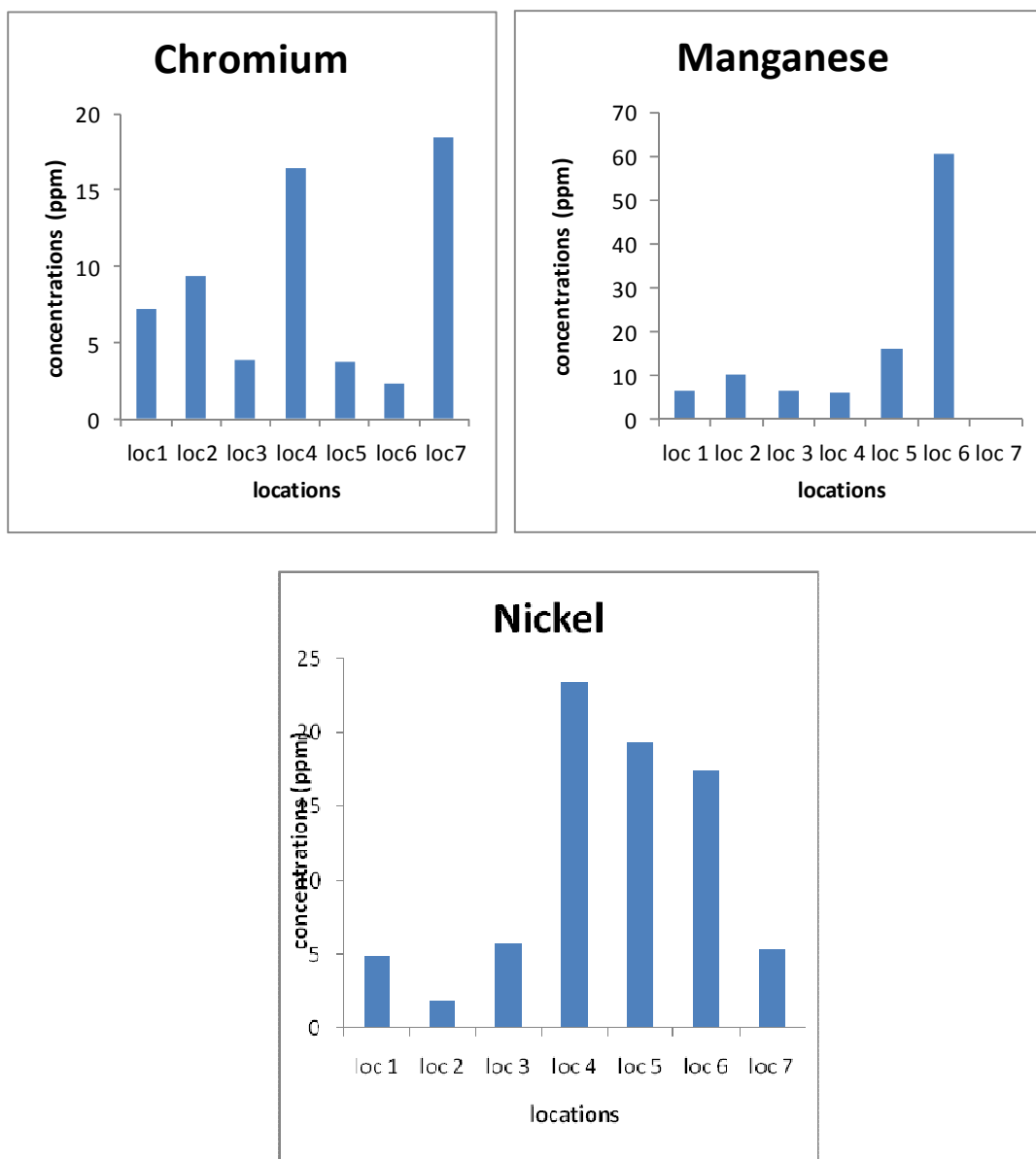


Fig.2.1: Concentration of metal across Locations.

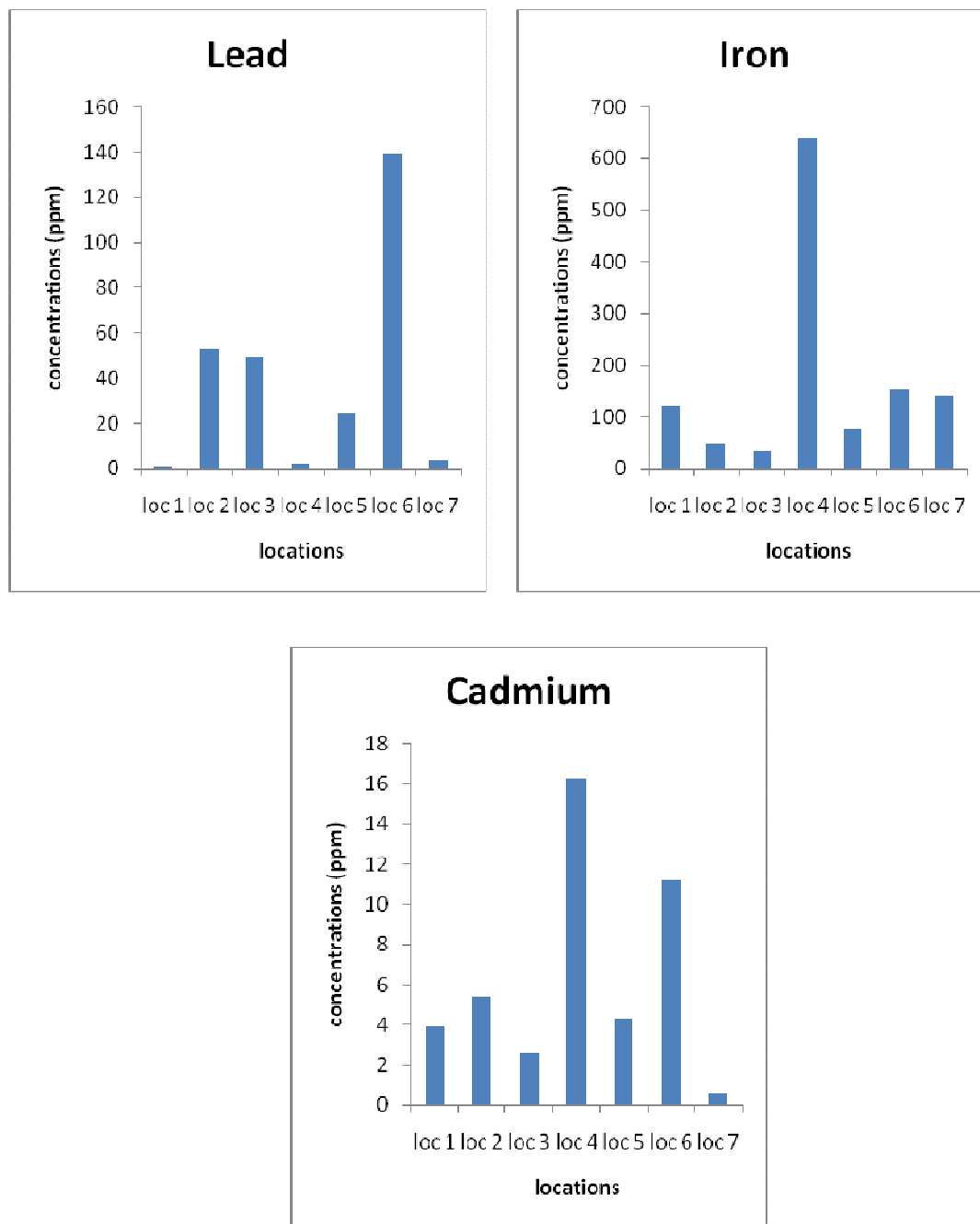


Fig.2.2: Concentration of metal across Locations.

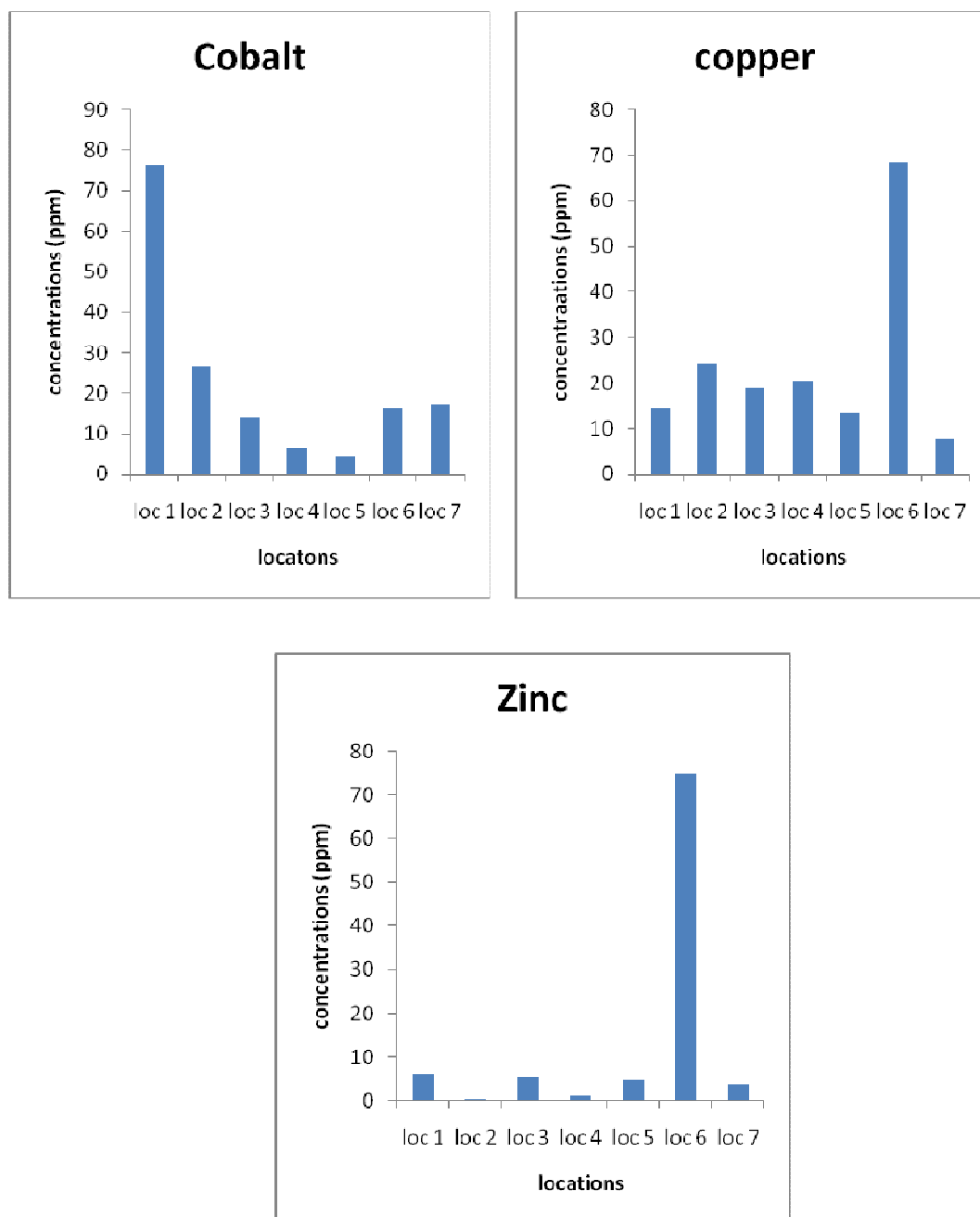


Fig.2.3: Concentration of metal across Locations.

6. QUANTIFICATION OF SEDIMENT POLLUTION

Many authors prefer to express the metal ratio with respect to average shale to represent the degree of quantification of pollution (Forstner and Muller 1973; Muller 1979). Metal ratios with respect to average shale for the Asa River in Ilorin show various degrees of enrichment (Table 3).

In the present study, enrichment factor was used to assess the level of contamination and the possible anthropogenic impact in sediments of Asa River. Ergin et al., 1991 defined metal enrichment factor as;

$$\text{Enrichment factor} = \frac{\text{concentration in sediment}}{\text{concentration in reference material}}$$

Also, according to Zhang and Liu (2002), enrichment factor values between 0.5 and 1.5 indicate the metal is entirely from crustal material or natural processes, whereas enrichment factor values greater than 1.5 suggest that the sources are more likely to be anthropogenic. The results of present study show that cadmium, iron and lead were significantly enriched in sediments of Asa River since enrichment factor of these three metals are greater than 1.5. The highest average EF is seen for iron with a value of 38 confirming its anthropogenic source and also its natural source could be confirmed by the fact that the level of iron is naturally high in soil of Kwara State (Ogunwale and Adesoye, 1994). The anthropogenic source can be attributed to the significant contribution from the deposit of particulate emissions from nearby industries such as the silicate plant coupled with aqueous effluent discharges from chemical based industries.

For example, a nearby soap and detergent plant uses ferric chloride as coagulant for the effluent treatment (Eleta et al., 2005). Indiscriminate dumping of scrap metals may also contribute to the elevated iron load sediments. Cadmium has the second highest EF with an average value of 21 and lead with 2. This suggests that cadmium, lead are from anthropogenic inputs including fertilizers and pesticides used in agricultural activities and the effluent of Soap and Detergent Industries treatment plant. The difference in EF values may be due to the difference in the magnitude of input for each metal in the sediments and/or the difference in the removal rate of each metal from the sediments.

TABLE 3: Maximum, Minimum, Mean concentrations, Average shale and Enrichment factor of heavy metals in sediments of Asa River, Ilorin.

METAL	MAXIMUM	MINIMUM	MEAN	AVERAGE SHALE	ENRICHMENT FACTOR.
Cd	16.3	0.60	6.30	0.30	21.0
Cr	18.4	2.30	8.80	90.0	0.10
Fe	641.6	33.9	173	4.60	38.0
Pb	139.2	1.00	39.0	20.0	2.00
Zn	74.9	0.50	14.0	95.0	0.10
Ni	23.4	1.90	11.2	68.0	0.20
Cu	68.4	7.90	24.0	45.0	0.50
Mn	60.5	5.80	17.4	850	0.00
Co	76.3	4.30	23.0	19.0	1.20

7. Geoaccumulation index (I_{geo}) method

The geoaccumulation index (I_{geo}) method introduced by Muller (1979) was also used to assess metal pollution in sediments of Asa River. Geoaccumulation index is expressed as follow:

$$I_{geo} = \log_2 \left(\frac{C_n}{1.5 B_n} \right)$$

Where C_n is the measured concentration of the heavy metal(n) in the $<20\mu m$ fraction of sediments, B_n is the geochemical background value in average shale (Turekian and Wed-epohl, 1961) of element n and 1.5 is the background matrix correction factor due to lithogenic effects. The geoaccumulation index consists of seven grades ranging from unpolluted to very highly polluted (Table 4).

TABLE 4: I_{geo} classes with respect to sediment quality (Muller 1979)

I_{geo}	SEDIMENT QUALITY
0	Unpolluted
1	Unpolluted to moderately polluted
2	Moderately polluted
3	Moderately to highly polluted
4	Highly polluted
5	Highly to very highly polluted
6	Very highly polluted

Table 5 presents the geoaccumulation index for the quantification of heavy metal accumulation in the river sediments. The I_{geo} class for the sediments of Asa river shows that Mn, Zn, Cr, Cu, Ni remain in class 0 whereas Co decreases from 2 to 0 and Pb increases from 1 to 3 while Cd attains a value of 6 and Fe with highest value of 7.

Based on the geoaccumulation indices, the sediments of Asa River particularly in those areas selected for this study are considered to be unpolluted with respect to Mn, Zn, Cr, Cu, Ni and Co, moderately polluted with Pb but very highly polluted with Fe and Cd.

TABLE 5: Geoaccumulation index of Asa River sediments (After Muller, 1979)

LOCATION	Cd	Co	Cr	Cu	FE	Mn
1	3	2	0	0	5	0
2	4	0	0	0	3	0
3	3	0	0	0	3	0
4	6	0	0	0	7	0
5	4	0	0	0	4	0
6	5	0	0	0	5	0
7	1	0	0	0	5	0

8. DISCUSSION AND RECOMMENDATIONS

Analyses of the sediment samples in the Asa River are said to be polluted with iron, lead and cadmium and that the Soap and Detergent industries, bottling companies and heaps of refuse dump into/ along the river are the capital source of pollution. Also, indiscriminate use of fertilizers, pesticides by the river side farmers also facilitates pollution.

The state government is advised to organize a health team which shall monitor and ensure that industrial effluents from industries concerned are seriously pre-disinfected, tested and certified by these “ non compromising” team if fish and other aqua-products from the river are to be dependable for consumption. It is also recommended that dumping of refuse along the river channel should be forcefully discouraged and that the government should help in providing household disposal sites for the inhabitants of the town. Finally, it is also recommended that regular monitoring of the sediments of the Asa River be carried out as there is notable increase in the level of human and industrial activities along the course of the river.

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