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Assessment of trace element concentrations in freshwater, sediment and fish (*Clarias gariepinus*) samples from three mining locations in South-eastern, Nigeria

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ABSTRACT

This paper is aimed at assessing the trace elements pollution levels at these sampled sites. Pearson's correlation model showed distinguished statistical relationships between some of the trace elements at ($p \geq 0.05$). Two-factor analysis of variance with replication model showed there were no significant differences in concentrations of trace elements in the individual samples and their interactions at 95 % confidence interval ($p > 0.05$). On the basis of the available data, it is suggested that the concentrations of the trace elements in the three compartments were influenced mainly by the geochemistry of the water sediments, mining, agricultural activities and environmental processes.

Keywords: Trace elements, water, sediments, fish, multivariate analysis

INTRODUCTION

There has been growing concern about the health and environmental risks associated with high levels of metal deposits in our environment. This is because metals are persistent environmental pollutant [1]; [2] and their presence is a major threat to human health due to their bio-accumulating tendency and toxicity [3]. Metal pollution of the water bodies is also a serious environmental concern because of accumulations in fish and other organisms, which could serve as transfer pathways of metal accumulation in that organism to the higher trophic levels [4].

Mining operations and mine waste materials has been recognised as major contributors of metal influx to soils, plants, waters and sediments [5]. Abandoned mine pits in Nigeria are usually converted by villagers as ponds for their daily water needs [6]. Analysis of sediments from such ponds is particularly useful in detecting metal pollution since metals discharged to surface waters do not remain solubilised but are rapidly adsorbed by pariculate matter and may thus escape detection in water samples [7].

This paper is aimed at assessing the trace elements pollution levels at three sampled sites and to study sources, similarities, association, bioaccumulation and bioconcentration of trace elements at the sampled sites.

Sampling and sampling procedure

Sediments, fresh water and fish samples from the three locations (Ekwe-Agbaja, Enyigba, and Ikwo-Ihie) were randomly collected at four different points in each area. Sterile plastic bottles were used to collect the fresh water samples, while sterile plastic bags were used to collect the sediment samples. The water samples were taken below the water surface and the sediment samples were collected from the same water areas. Freshwater fish (*Clarias gariepinus*) were sampled using the fisherman's net. The water and fish samples were

delivered in an ice box filled with ice and brought to the laboratory for further treatment. The samples were collected weekly between the month of November and December, 2014. A total of 8 samples each were collected from the three sampling locations.

Sample pre-treatment and analysis

Trace elements in sediment samples were determined using a strong acids extractable method. A small portion of each sample (1 g) was collected and placed in a measuring cylinder and 20 mL of 1: 1 nitric acid. The mixture was boiled gently on a hotplate until the volume of nitric acid was reduced to about 5 mL. DDW (20 mL) was then added and the mixture was boiled gently again until the volume was approximately 10 mL. The suspension was cooled and filtered through Whatman no. 540 filter paper and the filtrate was diluted to 25 mL with DDW. The filtrate was transferred to a 50 mL graduated flask and made up to mark with DDW. Water samples were acidified with nitric acid (0.05 *M*) (Battey and Gardner, 1977). The samples were kept in the refrigerator upon return to the laboratory and analysed within one hour of collection and maximum of 24 h. Concentrations of Cd, Pb, Fe, Mn, Cr, Ni, Co, Zn and Cu were determined using atomic absorption spectrometer, while the concentrations of K were determined using flame photometer.

RESULTS AND DISCUSSION

Trace element concentration in the compartments

The trace element concentrations in the three compartments of water, sediments and fish from Enyigba, Ekwe-Agbaja and Ikwo-Ihie are presented in Figures 1, 2 and 3 respectively. The results showed that the elements were found at varying amounts in these compartments in the three locations. The concentrations of Fe in sediment (6.47 mg/kg) and water (5.34 mg/L) at Enyigba were higher than any other element in the three locations. Similarly, Fe showed high concentration in fish (3.0 mg/kg) at Ekwe-Agbaja. The concentration of Cu in water (1.33 mg/L) at Enyigba was higher when compared with concentrations in the other compartments at the three locations. At Ikwo-Ihie, the concentrations of Ni in water (0.78 mg/L), sediment (0.51 mg/kg) and fish (0.48 mg/kg) were observed to be higher than the concentrations of Ni in the three compartments at Enyigba and Ekwe-Agbaja. The observed concentration of Pb in fish at Ikwo-Ihie was higher compared the concentration of Pb in fish from the two other locations. Highest concentration of Mn (0.74 mg/L) was observed in water at Enyigba, while Cd, Co, Cr and Zn showed similarly lower concentrations in the three compartments at the three locations, although the highest concentration of Zn (0.71 mg/L) was observed in water at Ekwe-Agbaja. Similar concentrations of K were observed in sediment (0.34 mg/kg) at Enyigba and in water (0.34 mg/L) at Ikwo-Ihie.

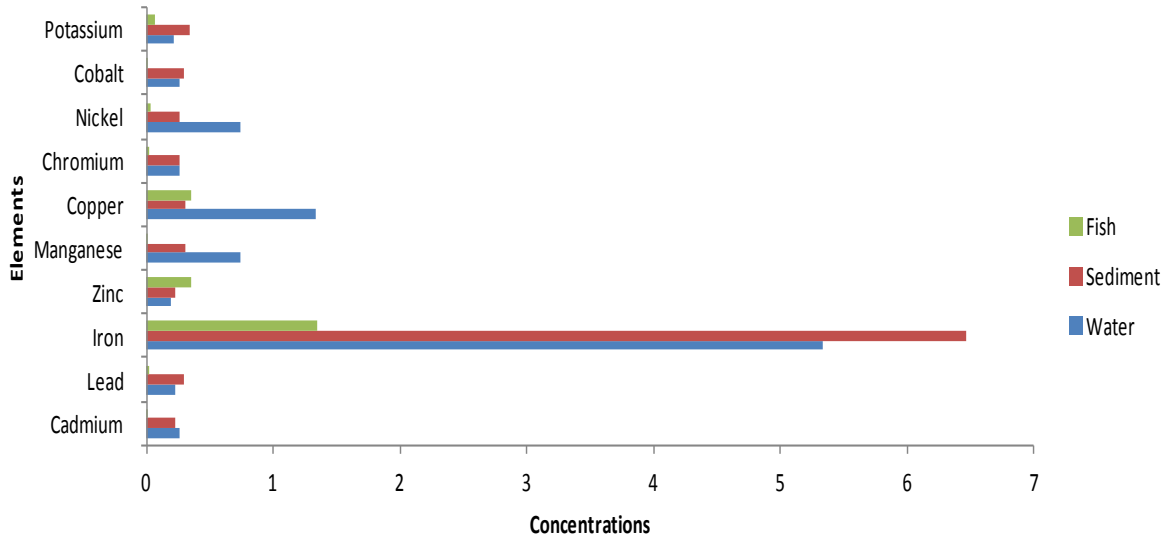

Figure 1: Mean values (n = 8) of trace elements concentrations in the three compartments at Enyigba

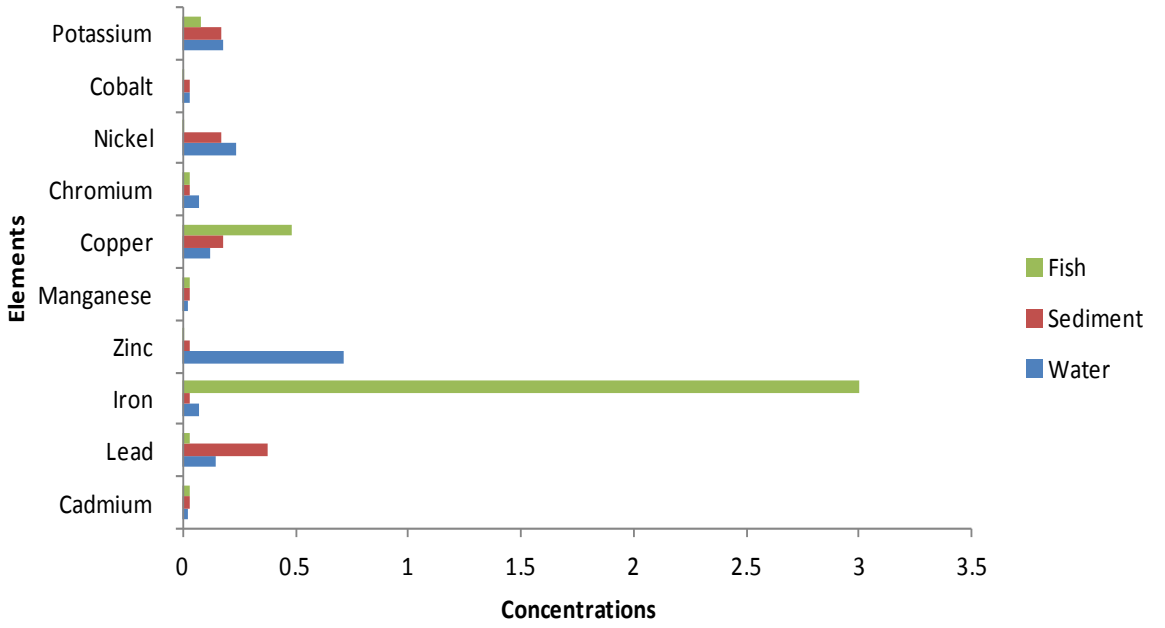

Figure 2: Mean values (n = 8) of trace elements concentrations in the three compartments at Ekwe-Agbaja

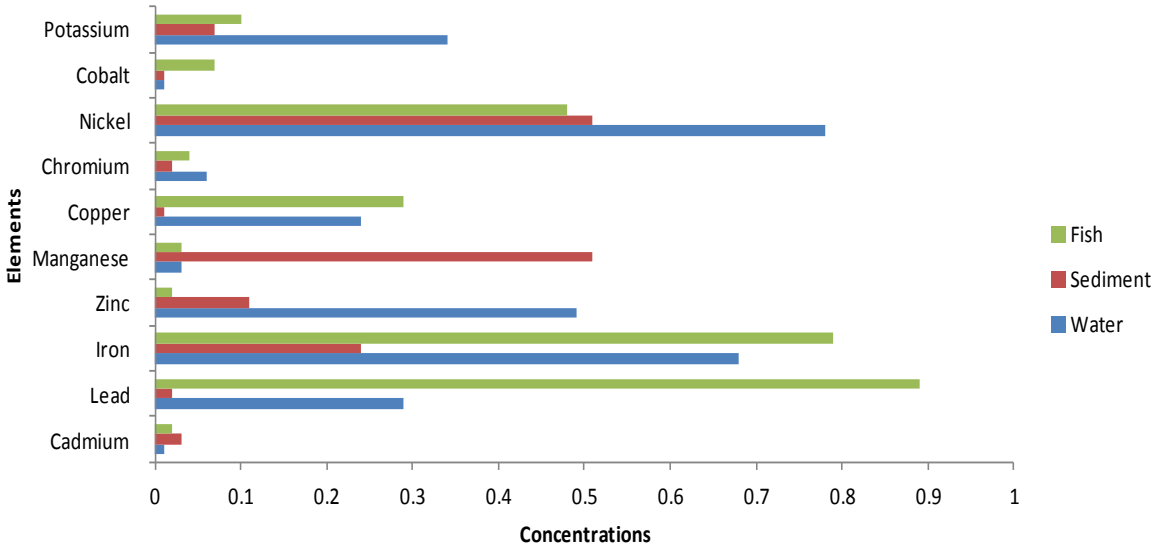

Figure 3: Mean values (n = 8) of trace elements concentrations in the three compartments at Ikwo-Ihie

Association between elements in the compartments: correlation matrix, cluster analysis model and analysis of variance

Pearson's correlation matrix and cluster analysis model were used to study the level of relationship or association (similarities) between the concentrations of the trace elements in each of the compartments at each location. Two-factor ANOVA was used to study the level of differences between the concentrations of the trace elements in each of the compartments at each location.

Pearson's correlation analysis was used to calculate correlation coefficient between two measurement variables (*e.g.* Fe and Ni) when measurements on each variable are observed for each compartment in the three locations. Tables 1, 2 and 3 show the correlation coefficients between the trace elements in the three compartments at each location. Based on the Pearson's correlation, there is significant and positive correlation (for values ≥0.5) between the two variables marked in bold. This implies that there is relationship or an association between the elements in each case.

Comparisons with results other studies

Previous studies on the concentrations of trace elements in water, sediment and fish samples were compared. [8], found mean concentrations (ug/g) of Cu (0.297), Cd (0.011), Fe (0.371) and Pb (0.008) in fish samples; mean concentrations (ug/g) of Fe (0.009), Cu (0.015), Pb (0.0002) Cd (0.0006) and Zn (0.0036) in water samples as well as mean concentrations (ug/g) of Fe (0.057), Cu (0.043), Pb (0.0006), Co (0.0002), Cd (0.0009) and Zn (0.099) in sediment samples. Similarly, mean concentrations (ug/g) of Cd (0.08–0.12), Zn (8.82–76.98), Pb (0.64–2.44), Fe (7.16–16.5) and Cu (0.55–0.82) were found in muscle tissue of fish (*S. aurata*) sampled during autumn, spring and winter seasons of November 2000 to December 2001 from the Tuzla Lagoon in Turkey [4].

CONCLUSION

This study has shown that trace elements in water, sediment and fish samples from Enyigba, Ekwe-Agbaja and Ikwo-Ihie can be clustered into similar groups based on their Euclidean distance. Results suggested that the trace elements concentrations were influenced by the geochemistry of the

water sediments, mining, agricultural activities and environmental processes. However, there was no evidence of significant differences in concentrations of trace elements from the three sampled locations. Bioaccumulation and bioconcentration factors were calculated which showed an indication of probable accumulation of some of the elements in muscle tissues of fish used as bioindicators.

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