

Seasonal Variation and Determination of Some Heavy Metals in the Sediment from Ureje River in Ado-Ekiti, Nigeria

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Abstract

This study investigated the level of contamination of four heavy metals (chromium, cadmium, nickel, lead) in the sediment collected from Ureje River, Ado Ekiti, Nigeria and compared their seasonal variation (Wet and Dry seasons). The sediments were collected, digested and analyzed using Atomic Absorption Spectrophotometer (AAS). Two of the metals namely cadmium and nickel were not detected. During the dry season, it was observed that the mean concentrations for chromium were 0.36 ± 0.08 mg/kg, 0.33 ± 0.08 mg/kg and 0.30 ± 0.04 mg/kg for Sites 1, 2 and 3 respectively. The mean concentration for lead during dry season at Site 1 was 0.33 ± 0.23 mg/kg while those of Sites 2 and 3 were 0.35 ± 0.10 mg/kg and 0.34 ± 0.04 mg/kg respectively. During the wet season, chromium levels were 0.23 ± 0.06 mg/kg, 0.25 ± 0.06 mg/kg and 0.21 ± 0.03 mg/kg for Sites 1, 2 and 3 respectively. For lead, the values recorded for Sites 1, 2 and 3 were 0.22 ± 0.11 mg/kg, 0.30 ± 0.10 mg/kg and 0.26 ± 0.03 mg/kg respectively. Comparing the two seasons, the concentration of chromium was observed to be lower than that of lead in the dry season while the reverse was the case during the wet season. Although the concentration of the metals is unlikely to pose any risk, the presence of chromium and lead in the area calls for proper monitoring to safeguard the health of human and aquatic lives around the area.

Keywords: Heavy metals, sediments, Ureje River, AAS, contaminant.

1.0 Introduction

The presence of toxic metals such as chromium, cadmium and lead in the environment has been a source of concern to many environmentalist, government agencies and health practitioners. This is mainly due to their health implication since they are non-essential metals of no significant benefit to humans [1–3]. The presence of the metals in the aquatic eco-system has a far reaching implication on the biota and indirectly to man. Heavy metals have been referred to as common pollutant, which are widely distributed in the environment with sources mainly from the weathering of minerals and soils [4]. Taking into consideration the type of occupation practised on the site where the samples were collected which are car washing and farming, it was found that metals are present both in the detergent and the fertilizer used which can cause contamination when they are washed into the river. Farming and commercial car washing has been source of heavy metals present in soils and sediment over the years.

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Heavy metals such as lead, cadmium, nickel and chromium are micro-pollutants and of special interest as they have both health and environmental significance due to their persistence, high toxicity and bio-accumulation characteristics. Lead for example is a highly poisonous metal (regardless if inhaled or swallowed), affecting almost every organ and system in the body [5]. The main target for lead toxicity is the nervous system, both in adults and children. Long-term exposure of adults can result in decreased performance in some tests that measure functions of the nervous system. Long-term exposure to lead or its salts (especially soluble salts or the strong oxidant PbO_2) can cause nephropathy, and colic-like abdominal pains. It may also cause weakness in fingers, wrists or ankles [6].

Lead exposure also causes small increases in blood pressure, particularly in middle-aged and older people and can cause anaemia. Exposure to high lead levels can severely damage the brain and kidneys in adults or children and ultimately cause death. In pregnant women, high levels of exposure to lead may cause miscarriage. Chronic, high-level exposure has shown to reduce fertility in males [5]. Cadmium is one of the most toxic elements with reported carcinogenic effects in humans. It accumulates mainly in the kidney and liver and high concentrations have been found to lead to chronic kidney dysfunction. It induces cell injury and death by interfering with calcium regulation in biological systems. It has been found to be toxic to fish and other aquatic organisms [7]. Cadmium has been found to cause endocrine disruption which could pose serious health problems. Apart from the health implication, the metal (Cd), together with other elements, e.g. Zn form a toxic "soup" that often acts synergistically. Cadmium in the body is known to affect several enzymes.

Nickel is an element that occurs in the environment only at very low levels and is essential in small doses, but it can be dangerous when the maximum tolerable amounts are exceeded. This can cause various kinds of cancer on different sites within the bodies of animals, mainly of those that live near refineries. The most common application of nickel is an ingredient of steel and other metal products. The major sources of nickel contamination in the soil and sediment are metal plating industries, combustion of fossil fuels, and nickel mining and electroplating. It is released into the air by power plants and trash incinerators and settles to the ground after undergoing precipitation reactions. It usually takes a long time for nickel to be removed from air. Nickel can also end up in surface water when it is a part of wastewater streams. Chromium salts (chromates) are also the cause of allergic reactions in some people. Chromates are often used to manufacture, amongst other things, leather products, paints, cement, mortar and anti-corrosives. Contact with products containing chromates can lead to allergic contact dermatitis and irritant dermatitis, resulting in ulceration of the skin, sometimes referred to as "chrome ulcers". This condition is often found in workers that have been exposed to strong chromate solutions in electroplating, tanning and chrome-producing manufacturers [8].

The environment of Ureje River has over the years faced adverse natural and anthropogenic challenges such as rapid loss of biodiversity and waste management. Deposition of waste and washing of contaminated soil into the river has also increased rapidly which in turn contaminates the river, thereby destroying the aquatic- ecosystem and even renders the river unusable for proper domestic purposes. This research seeks to establish a possible fact concerning the level of heavy metal contamination in the Ureje River, compare the concentrations in each location and also determine the seasonal effect with respect to their location or site.

2.0 Materials and Methods

2.1 Study Area

The study area is Ureje River in Ado-Ekiti, Nigeria which flows through three different land use areas (Fig. 1). The three locations are Polytechnic, Ureje which is located on the southern part of Ado-Ekiti between longitudes $7^{\circ}35'55.20N$ and latitude $5^{\circ}18'12.91E$; Omisanjana with a longitude of $7^{\circ}36'49.29 N$ and latitude $5^{\circ}12'36.00 E$; and Holy Child Catholic School, Ureje with a longitude of $7^{\circ}34'53.80$ and latitude $5^{\circ}15'41.37 E$. In location 3, there is a mini-abattoir that produces cow bones which are dumped into the river. In all the sampling locations, cars are washed as commercial ventures which involve the use of detergent while the waste water is directed into the river.

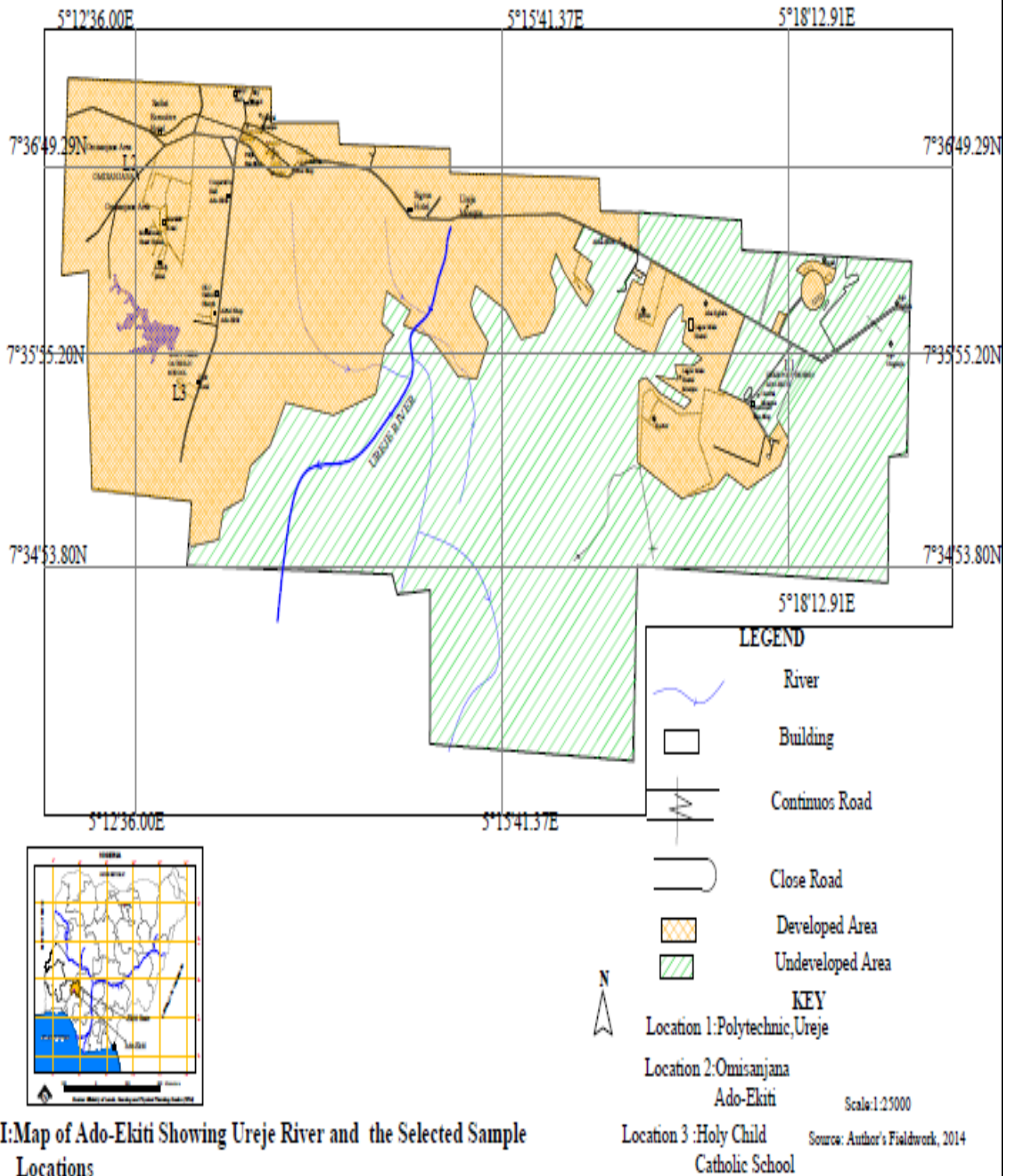


Fig I: Map of Ado-Ekiti Showing Ureje River and the Selected Sample Locations

Figure 1: Map of Ado- Ekiti showing Ureje River and the selected sample locations

2.2 Collection of Sample

Sediments were collected from the designated locations in triplicates. Due to the large study area, Global Positioning System device was used to determine the coordinates of the sampling sites. The sediments were collected using a scooper and placed in well labelled plastic bags according to the site of collection. The sediments were stored in a cooler box with ice bags while being transported to the laboratory for analysis. On getting to the laboratory, the sediments were air-dried for seven days after which they were grinded using mortar and pestle. The resulting powder was passed through 2 mm aluminium mesh filter and stored in polyethylene bags at room temperature [9, 10].

2.3 Experimental procedure

The sediment (1 g) was poured in a beaker followed by the addition of 7.5 ml hydrochloric acid and 2.5 ml nitric acid (aqua regia ratio). The mixture was then placed on a hot plate and allowed to heat to near dryness. The digest was allowed to cool before 2 ml HNO₃ was added and heated to near dryness. The mixture was cooled again then 0.5 ml hydrogen peroxide was added and heated to near dryness. After cooling, the solution was filtered to remove suspended matter. To the digest, 10 ml of deionized water was added and poured into 50 ml standard flask and made up to the mark with deionized water. The resulting solution was analysed for heavy metals using Atomic Absorption Spectrophotometer (Buck Scientific Model 210).

2.4 Statistical Analysis of Data

The analysis was determined in triplicates and expressed as mean \pm SEM. Statistical Package for Social Sciences, version 18.0 (SPSS Inc., Chicago, IL, USA) was used to carry out the statistical analysis.

3.0 Results

The concentrations of heavy metals in the sediment collected for Ureje River during the dry season is presented in Table 1. The concentration of chromium was 0.36 mg/kg for Location 1, while for Locations 2 and 3, the values recorded were 0.33 and 0.30 mg/kg respectively. The concentration of lead at Locations 1, 2 and 3 were 0.33, 0.35 and 0.34 mg/kg respectively. Both cadmium and nickel were not detected in the sediments. During the rainy season, the concentration of Chromium was 0.23, 0.25 and 0.21 mg/kg for Locations 1, 2, and 3 (Table 2). For lead, the concentration was 0.22, 0.30 and 0.26 mg/kg for Locations 1, 2 and 3. Just as obtained during the dry season, both cadmium and nickel were not detected in the sediments analysed.

Table 1: Concentration of heavy metals present in the sediment collected from Ureje River during the dry season

Locations	Metal ion concentration (mg/kg)			
	Cr	Ni	Cd	Pb
Location 1	0.36 \pm 0.08	ND	ND	0.33 \pm 0.23
Location 2	0.33 \pm 0.08	ND	ND	0.35 \pm 0.10
Location 3	0.30 \pm 0.04	ND	ND	0.34 \pm 0.04

Table 2: Concentration of heavy metals present in the sediment collected from Ureje River during the rainy season

Locations	Metal ion concentration (mg/kg)			
	Cr	Ni	Cd	Pb
Location 1	0.23 \pm 0.06	ND	ND	0.22 \pm 0.11
Location 2	0.25 \pm 0.06	ND	ND	0.30 \pm 0.09
Location 3	0.21 \pm 0.03	ND	ND	0.26 \pm 0.02

4.0 Discussion

Findings from this study revealed that variations exist in the concentrations of the heavy analysed with changes in season. However, the concentrations obtained in the sediment samples compared favourably with sediment quality guidelines, which is an indication that the concentrations did not exceed the probable effect concentrations (PEC) levels. On the contrary, the results were not compatible with those reported earlier in a study conducted on the Tigris River in Diyarbakir Province [11]. The authors observed that iron was the most abundant in the element examined while cadmium and lead were not detected. In another study on Okumeshi River [12], the heavy metal concentrations in sediment samples decreased in the sequence Mn>Cd>Ni>Cr>Pb which corresponds with the data obtained in the dry season (Cr > Pb) although Ni and Cd were not detected.

Comparing these results with those obtained from Owena Dam sediment and Ijana River sediment during the dry season, it was observed that the levels of heavy metals during the dry season were fairly low. The reduced concentration of heavy metals in Ureje River during rainy season could be attributed to dilution effect caused by the rise in water level. The heavy metal concentration for the sediment from Owena Dam varied and could be attributed to the fact that Owena River which feeds the dam, transverses through Owena town; hence exposing the river to more influx of run-off. It could also be a result of industrial activities, atmospheric emission and deposition from around the river [13]. Furthermore, there were similarities in the concentration of heavy metals in Ijana River and Owena Dam during the rainy season. The high level of metal concentration in these two water bodies was attributed to rural and urban effluents along the course of the river.

Higher concentrations of heavy metals were observed in the dry season when compared with wet season in Ureje River. However, reverse was the case with respect to concentration of heavy metals in Owena Dam [13] and Ijana River [14]. In a related study carried out on coal sediments from River Ekulu in Enugu [15], the value recorded for Cr is similar to what is obtained in this study except for rainy season while a slight increase in concentration was obtained during the dry season. The slight increase observed during the rainy season could be presumably due to dilution effects of the rainwater on the river [2, 16, 17]. When compared with Trigris, Danlibe and South Platte River, the extent of metal pollution in Ureje River was similar with respect to heavy metal concentration [18]. Apparently, comparison of metal concentration with sediment quality guidelines, the levels of chromium and lead at the studied locations are likely to results in harmful effects on sediments-dwelling organisms, if proper checks are not put in place. Predominant of more concentration of chromium and lead into the river are derived from anthropogenic sources particularly metallic discharges.

5.0 Conclusion

From the present study, it can be concluded that variation in seasons has little effect on metal concentration in the three sampling locations employed. Therefore, aquatic eco-system is unlikely to be at any risk of heavy metal pollution. However, monitoring of the River in the future is of immense importance.

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Reference

- [1]. Tyler, T.G. (1999). Heavy metals in soil biology and biochemistry. In: Paul, E.A. and Ladd, J.N. (eds.) Soil Biochemistry. Marcel Dekker, New York, pp. 33.
- [2]. Fatoki, O.S., Okoro, H.K., Adekola, F.A., Ximba, B.J. and Synman, R.G. (2012). Bioaccumulation of metals in black mussels (*Mytillus galloprovincialis*) in Cape Town Harbour South Africa. The Environmentalist, Vol. 32, pp. 48-57.

- [3]. Okoro, H.K., Fatoki, O.S., Adekola, F.A., Ximba, B.J. and Snyman, R.G. (2014). Fractionation, Mobility and Multivariate Statistical Evaluation of Heavy Metals in Marine Sediments of Cape Town Harbour. *Chemical Speciation & Bioavailability*, Vol. 26, No. 3, pp.126–138.
- [4]. Merian, E. (1991). *Metals and their compounds in the environment. Occurrence, analysis and biological relevance*. UCH Weinheim-New York-Basel-Cambridge.
- [5]. Golub, Mari, S., ed. (2005). *Summary, Metals, fertility, and reproductive toxicity*. Boca Raton, Fla.: Taylor and Francis. pp. 153.
- [6]. Lide, D. R. (2004). *CRC Handbook of Chemistry and Physics (84th Ed.)*. Boca Raton (FL): CRC.
- [7]. Woodworth, J.C. and Pascoe, V. (1982). Cadmium toxicity to rainbow trout, salmon Gardner Richardson. A study of eggs and alevins. *Journal of Fish Biology*, Vol. 1, No. 21, pp. 47-57.
- [8]. Basketry, D., Horev, L., Slodovnik, D., Merimes, S., Trattner, A. and Ingber, A. (2000). Investigation of the threshold for allergic reactivity to chromium. *Contact Dermatitis*, Vol. 44, No. 2, pp. 70–74.
- [9]. Nomeda Sabiene, Dalia Marija Brazauskiene. Lithuanian University Of Agriculture, Department Of Chemistry, Universiteto 10, Akademija, Lt-53361 Kaunas Distr., Lithuania.
- [10]. Okoro, H.K., Fatoki, O.S., Adekola, F.A., Ximba, B.J., Snyman, R.G. and Mdokwana, B.W. (2013). The Effect of Particle Sizes on Metal Accumulation in the Marine Sediments of Cape Town Harbour, South Africa. *Journal of the North Carolina Academy of Science*, Vol. 129, No. 3, pp. 115–125.
- [11]. Karadede-Akin, H. and Ünlü, E. (2007). Heavy metal concentrations in water, sediment, fish and some benthic organisms from Tigris River, Turkey. *Environmental Monitoring and Assessment*, Vol. 131, pp. 323–337.
- [12]. Ekeanyanwu, C.R., Ogbuinyi, C.A. and Etienajirhevwe, O.F. (2012). Trace Metals Distribution in Fish Tissues, Bottom Sediments and Water from Okumeshi River in Delta State, Nigeria. *Ethiopian Journal of Environmental Studies and Management*, Vol.3, No. 3, pp. 12-17.
- [13]. Oyakhilome, G.I., Aiyesanmi, A.F., Adefemi, S.O., and Asaolu, S.S. (2013). Heavy Metal concentration in sediment and fish samples from Owena multi-purpose Dam, Ondo State, southern Nigeria. *British Journal of Applied Science and Technology*, Vol. 3, No. 1, pp. 65-76.
- [14]. Emoyan, O.O., Ogan, F.E. and Akarah, E. (2006). Evaluation of heavy metals loading of River Ijana in Ekpan–Warri, Nigeria. *Journal of Applied Sciences and Environmental Management*, Vol. 10, No. 2, pp. 121–127.
- [15]. Adaikphoh, E.O., Nwajei, G.E. and Ogala, J.E. (2005). Heavy Metals Concentrations in Coal and Sediments from River Ekulu in Enugu, Coal City of Nigeria. *Journal of Applied Science and Environmental Management*, Vol. 9, No. 2, pp. 5-8.
- [16]. Okoro, H.K., Fatoki, O.S., Adekola, F.A., Ximba, B.J. and Snyman, R.G. (2013). Physico-chemical characteristics and one year monitoring of heavy metal pollution in Seawater from Cape Town Harbour and their Seasonal Variation. *Fresenius Environmental Bulletin Germany*, Vol. 22, No. 10, pp. 2855-2866.
- [17]. Fatoki, O.S and Mathabata, S. (2001). An assessment of heavy metals pollution in the East London and Port Elizabeth Harbours. *Water SA*, Vol. 27, No. 2, pp. 233-240.
- [18]. Varol, M. and Sen, B. (2012). Assessment of nutrient and heavy metal contaminations in surface water and sediments of the upper Tigris River, Turkey. *Catena*, Vol. 92, pp.1-10.