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Assessment of Seasonal Concentration of Heavy Metals in Water and Sediments of Lapai /Agaie Reservoir

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Abstract
The concentrations of ten heavy metals (Mn, Fe, Cu, Cr, Co, Cd, Ni, Pb, Hg and Zn) were investigated from the water and sediments samples of Lapai/Agaie reservoir during the dry and rainy seasons so as to monitor seasonal effects. Atomic absorption spectrometry was used due to its advantage of being highly specific, availability and selectivity. The results obtained showed that concentrations of Mn, Cr, Cd, Ni, Hg and Pb in the samples during the periods of investigation slightly exceeded the WHO recommended limits but mostly within limits of sub-lethal effect. However, the concentrations of Zn, Cu, Co and Fe in the samples were below the recommended maximum permissible levels. Samples of sediments generally recorded the highest concentrations of heavy metals for both dry and rainy season as compared to water samples. Constant monitoring of heavy metals and control program should be instituted in the reservoir to protect the people using the dam as a source of water for domestic and agricultural purposes.

Keywords*: Heavy metals, concentration, seasonal variation, Lapai/Agaie reservoir.*

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I. Introduction

The existence of heavy metals in aquatic environments has raised much concern over their influence on plant and animal life in those communities and indeed on man's need for water. The accumulation of these elements which are highly toxic, has direct and indirect consequences on man. Major factors affecting microbiological quality of surface waters are discharges from sewage works and runoff from informal settlements. Indicator organisms are commonly used to assess the microbiological quality of surface water and faecal coli forms commonly used bacterial indicator of faecal pollution (Quality of Domestic Water Supplies, 1998).

Sediments are sinks for pollutants such as pesticides and heavy metals, and they play a major role in the remobilization of contaminants in aquatic systems (Öztürk *el al*., 2009). Sediments and water are often used as pointers for the nature of pollution of the ecosystem (Opaluwa et al., 2012). Because of the importance of sediments to the overall quality of aquatic systems, sediment analyses are often included in environmental assessment studies (Adekola and Eletta, 2007; Li et al.,2006; Jain et al.,2005; Horsfall and Spiff, 2002). Heavy metals are introduced into the aquatic environment through diverse sources and are absorbed onto inorganic and organic particulates, incorporated into sediment, thus resulting in elevated levels of heavy metals in bottom sediment (Liu *et al.*, 2009, Yang and Rose 2003; Heyvart et al. 2000, Keke et al 2015). These metals are fixed by the sediments but some of the sediment-bound metals could re-mobilize and be released back to water through the variation of environmental conditions such as acidification, redox potential conditions, and cause harmful effects on living organisms (Liu *et al*., 2009). Mining of *Copper, Gold, Granite, Casseterite, Columbite, Iron* and *Silver* usually by artisanal miners occurs in the neighboring Muye and Kafin-koro of Paikoro Local Government Area which is also a threat to the quality of water for domestic use in the study area (Asubiojo, 2016).

According to Izah et al., (2016), these heavy metals are also found in beverages and drinks. Geochemical characteristics of the sediments can be used to understand the trends and the sources of the pollution. Due to the large absorption capillaries, fine grained sediments represent a major repository or trace metals and a record of the temporal changes in contamination. Heavy metal contamination of soil can occur by a variety of processes. It can be stated that in areas of active aerial contamination the metal profile in soil tends to show highest concentrations in the upper layers of the soil profile. Areas with contamination resulting from past mining activities tend to show disturbed profiles according to the past historical record of contamination and disturbance, while mineralized areas often show higher metal concentrations in both upper and lower levels of

the soil profile. Higher concentrations of heavy metals are found in the fine-grained than the sand-sized fractions of the sediment mostly in mangrove swamps. However, the differences between these two fractions becomes less significant when the swamp is more contaminated. Different heavy metal concentrations reflect the degree of anthropogenic pollution.

Although more metals are retained in the fine-grained sediments in most samples, metals would be accumulated in the sand-sized fraction if the swamp received heavy metals from anthropogenic sources. The accumulation of the heavy metals in water and sediments eventually reaches human and other living organisms through the aquatic ecosystem, since heavy metals can be transferred through the food chain. Singh *et al.*, (2011) asserted that the accumulation of heavy metals in human's body cause adverse health problems. For instance, they inhibit the biological function of the essential nutritional minerals by replacing their position. In plants, the accumulation of heavy metals could damage the cellular components (Singh *et al.*, 2011). Therefore, the study of heavy metals in water and sediments of rivers and reservoirs had been conducted continuously in order to investigate their status in the environment.

The Study Area

Lapai/Agaie reservoir is located at Bakajeba village between latitude $9^0$11'N, 9^0 15'N and longitude $6^0$33'E, 6^0 40'E across Jatau River, South East of Minna. It has a reservoir capacity of 38 million cubic meters and a dam crest length of 1,600 meters. The reservoir is shallow at the inlet about 1.64 meters and increases progressively inward to an average depth of 10.8m. The lake shore lines are swampy and inaccessible especially during the rainy season. There are three inlets and a large spillway on the side of the bank which are seasonally flooded downstream during the raining season. The western end of the reservoir drains into a broad swampy area and gradually narrows for a small stream referred to as River Jatau. The river is a major source of water to the community and is used for irrigation, fish farming and domestic uses.

Figure 1(a) is the map of Agaie and Lapai local government areas showing the location of the dam and the three rivers that flow directly into the reservoir. Figure 1 (b) shows the enhanced map of the dam indicating the rivers elaborately. They are Rivers Chain from Eastern direction, Jatau from southwest and Jimada from the northeast (Ojitiku, Kolo and Yakubu, 2016).

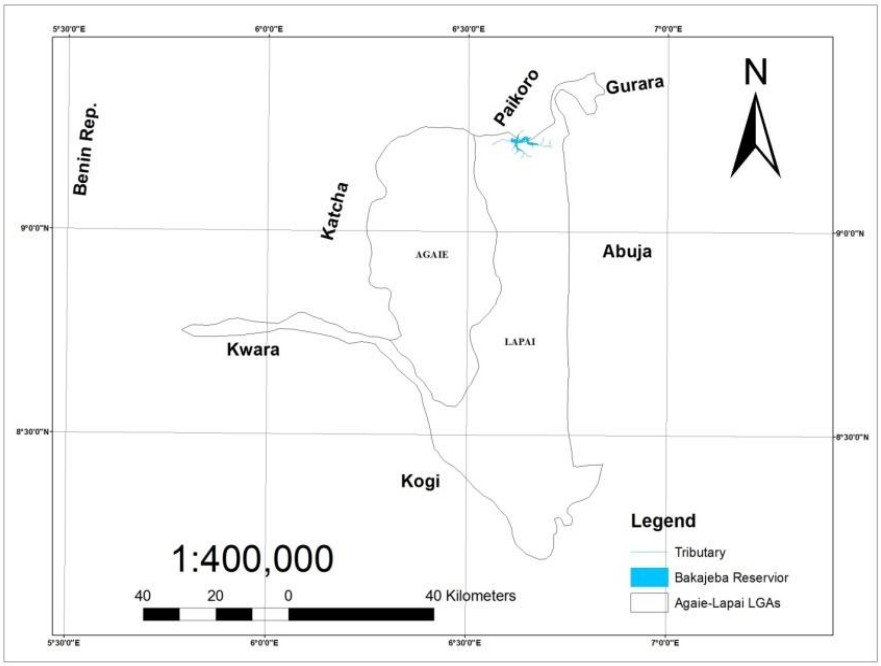

Figure 1(a). Map of Agaie and Lapai local government areas showing the dam

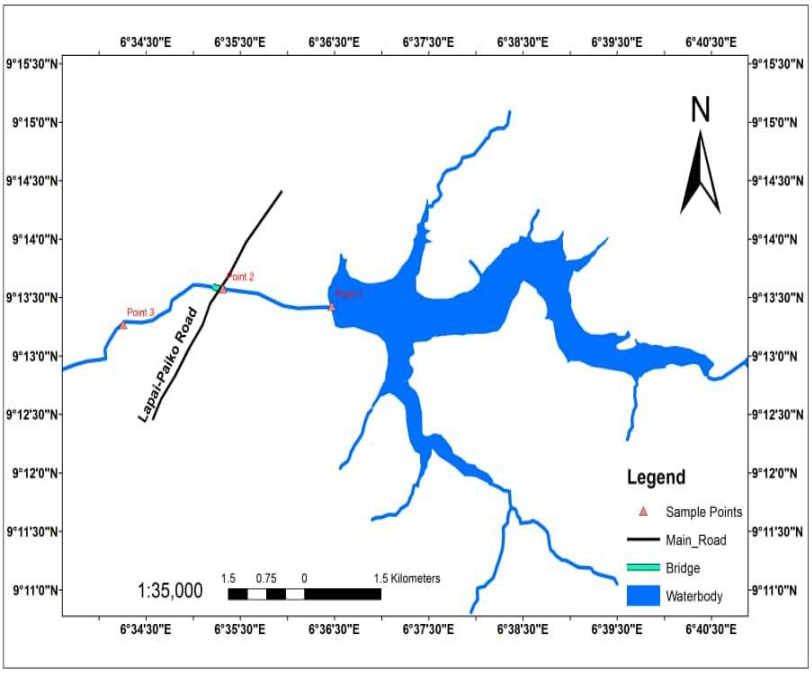

Fig. 1(b): Lapai/Agaie dam site showing the rivers that flow into it.

The spillway of the reservoir form the outlet westward which is systematically graduated into 50 meters interval along the river channel as point 1, 2 and 3 as shown in Figure 1(b).

Geology of the study area

The area is underlain by the basement rocks of the Nigerian basement complex. Within the basement complex of Nigeria three major petro-lithological units are distinguishable, namely: Migmatite – Gneisses, Schists, and Older Granites (differentiating them from the Younger Granites concentrated around Jos).

The Migmatite – Gneiss Complex is generally considered as the basement complex *sensu stricto* (Rahaman, 1988; Dada, 2006) and it is the most widespread of the component units in the Nigerian basement complex. It has a heterogeneous assemblage comprising migmatites, gneises, and a series of basic and ultra-basic metamorphosed rocks. They generally occur intricately associated with the Older Granites intruding into them and in some places along with schist belts, but chronologically the Migmatite-Gneiss complexes are oldest (older than Schist Belts older than Older Granites). Older Granites dominate the bedrock cover from Lapai central to the north on Lapai – Paiko road where Bakajeba is located. Migmatite-Gneisses and Schistose rocks are very abundant within the vicinity of the area. Figure 2 shows the geologic map of Nigeria indicating the basement complex and the sedimentary parts.

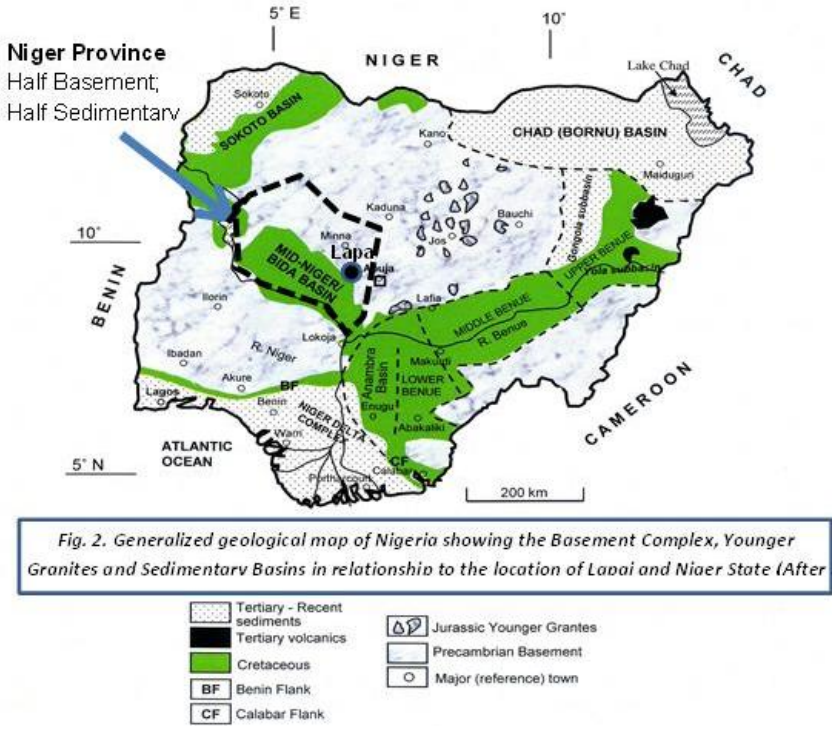

Fig. 2. Generalized geological map of Nigeria showing the Basement Complex, Younger Granites and Sedimentary Basins in relationship to the location of Lapai and Niger State (After

II. Materials and Methods

The materials used in the work were Polyethylene water bottles, Plastic hand trowel, Sterilized polyethylene bags, 250ml capacity beakers, 250ml conical flasks, Deionized water, Analytical grade Hydrochloric acid (HCl), Analytical grade HNO_3, Atomic Absorption Spectrophotometer (AAS), Heating Mantel and SPSS software.

Samples were collected twice a month. The first week of April, 2018 on-set of the raining season, twice a month to the end of raining season in October 2018, and twice a month from the onset of dry season in November, 2018 to the end of dry season in March, 2019. All samples were stored in the refrigerator before taken to the laboratory for analysis at a temperature of 4°C. Method of sample storage and preservation were done in accordance with descriptions by APHA, (2005).

Sediment samples were obtained from three (3) sampling stations along River Bakajeba. During the two seasons, all the heavy metals under study were detected in the water samples. The concentrations of heavy metals in the water samples varied from one sampling station to the other with no general trend down the river.

Water samples were collected using polyethylene sampling bottles that were pre-cleaned with 10% HCl acid in order to stabilize the metal ions and prevent precipitation and also pre-rinsed with de-ionized water to avoid any contamination from metal and non-metal ions. The bottle was lowered into the water body at mid-depth below the surface (approximately 30cm) from the various sampling sites at a specified distance of 50m apart; upstream, mid-stream and downstream points of the rivers at each point apart.

Samples were collected at the three separate sampling sites. While sediment samples were collected systematically along the points identified for sampling collection along the river channel. Three sediment samples were collected in each season twice a month from a depth of 10 cm under the river bed in plastic container from the three different locations of the rivers (the upstream, mid-stream and downstream). Sediment samples were scooped using a plastic hand trowel and transferred immediately into clean sterilized polyethylene plastic containers and stored at a temperature of 4°C before taken to the laboratory for analysis.

The digestion of sediment samples was done by dissolving 1g of dried powdered sediment samples in a clean 100ml beaker. This was followed by the addition of 20ml concentrated HCl in small portions, 5ml of concentrated HNO_3 and 2ml of HF. The mixture was covered with watch glasses and heated for an hour. It was filtered hot and made up to the mark using de-ionized water in a 100ml volumetric flask and kept for AAS analysis (Mendham et al, 2002).

For selected elements in this study, Atomic absorption spectrometry was used due to its advantage of being highly specific, availability and selectivity (García and Báez, 2012). The Atomic absorption spectrophotometer of model A.A 500 England was used to analyze ten metallic elements of the samples: Mn, Fe, Cu, Cr, Co, Cd, Ni, Pb, Hg and Zn. It requires a standard with known analytic content to establish the

relation between the measured and the analyzed concentrations and relies on Beer Lambert's law (Skoog *et al*., 2005; Christian, 2005).

The sample was converted into atomic vapors in the process of atomization. The precision and accuracy of this method depends on the atomization step and therefore, a good choice of the atomization method was required. This technique has been widely employed for elemental analysis in a number of matrices such as soils, water, nuts, wine and wine products (Navin *et al.*, 2000). Commonly used detectors are photocells and photo multiplier tubes process as indicated in Fig. 3.

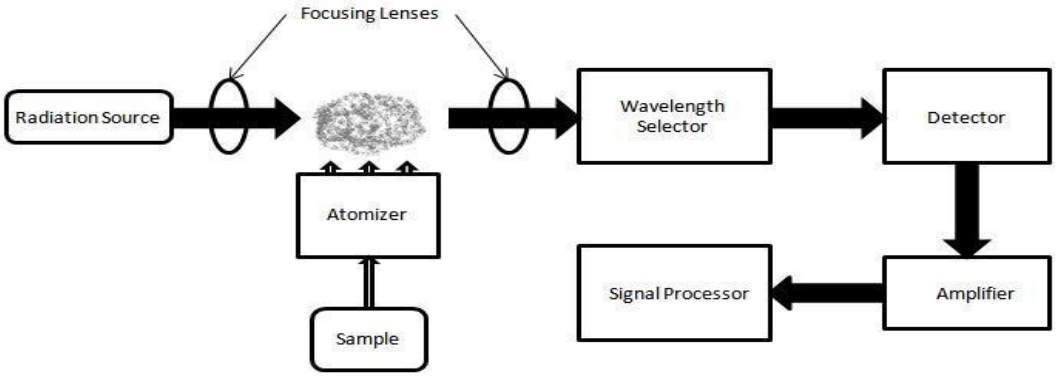

Fig. 3: Schematic diagram of AAS equipment (*Mwangi, 2009)* :

One-Way Analysis of variance ANOVA was used as a statistical inference for the comparison of results obtained from each sample at different seasons. The Pearson correlation matrix and Duncan multiple range tests were used for the identification of the relationship. The samples were analyzed using ANOVA test Statistical Package for Social Science (SPSS) software. The 95% confidence interval ($P < 0.05$) was used to determine error margin and also significant differences between the different sampling points and settlements for accuracy of the data analysis. The correlation analysis was also carried out to determine the relationship between the concentration of metal ions in water and sediment.

III. Results and Discussions

Concentration of heavy metals in water and sediments during dry and rainy seasons

During the dry and rainy seasons, all the heavy metals under investigation were detected in the water and sediments samples. The concentrations of heavy metals in the samples varied from one sampling station to the other with no general trend down the river. The presence of these heavy metals in the samples could be attributed to discharge of domestic wastes, unlawful and harsh agricultural practices, geology of river bed and the effects of androgenic catchment area activities (Kar *et al*., 2008; Obasohan, 2008). Tables 1 and 2 show the cumulative concentration of heavy metals in water during the dry and rainy seasons respectively. Tables 3 and 4 show the respective concentration of heavy metals in sediments during the dry and rainy seasons.

Table 1: Cumulative Concentration of heavy metals in water during the dry season:

Elements	**SAMPLING STATIONS**		
	Concentration (mg/L) for Sample A1 (Oct-Nov)	**Concentration (mg/L) for Sample A2 (Dec-Jan)**	**Concentration (mg/L) for Sample A3 (Feb-March)**
	Concentration (x±Sd)		
Manganese (Mn)	0.200± 0.0007	0.200± 0.0003	0.311±0.0005
Iron (Fe)	0.167±0.0008	0.500±0.0010	0.167±0.0011
Copper (Cu)	0.278±0.0032	0.611±0.0038	0.278±0.0026
Chromium (Cr)	0.238±0.0008	0.238±0.0008	0.392±0.0006
Cobalt (Co)	0.243±0.0000	0.243±0.0000	0.156±0.0095
Cadmium (Cd)	0.020±0.0079	0.030±0.0157	0.073±0.0008
Nickel (Ni)	0.0428±0.0000	0.0151±0.0010	0.0428±0.0000
Lead (Pb)	0.0050±0.0001	0.015±0.0014	0.026±0.0012
Mercury (Hg)	0.0012±0.0028	0.0014±0.0048	0.0012±0.0007
Zinc (Zn)	0.072±0.0002	0.078±0.0010	0.189±0.0002

Source: Research fieldwork, 2018 and 2019

Table 2: Cumulative concentration of heavy metals in water during the rainy season

Elements	SAMPLING STATIONS		
	Concentration (mg/L) for Sample B1 (April-June)	Concentration (mg/L) for Sample B2 (July-Aug)	Concentration (mg/L) for Sample B3 (Sept-Oct)
	Concentration (x±Sd)		
Manganese (Mn)	0.352± 0.0002	0.465±0.0018	0.577±0.0004
Iron (Fe)	0.263±0.0006	0.596±0.0011	0.485±0.0002
Copper (Cu)	0.520±0.0033	0.739±0.0057	0.129±0.0115
Chromium (Cr)	0.157±0.0007	0.157±0.0011	0.157±0.0005
Cobalt (Co)	0.550±0.0007	0.550±0.0006	0.300±0.0004
Cadmium(Cd)	0.028±0.0011	0.051±0.0006	0.043±0.0008
Nickel (Ni)	0.068±0.0107	0.068±0.0136	0.010±0.002
Lead (Pb)	0.0070±0.0011	0.0036±0.0010	0.033±0.0010
Mercury Hg)	0.0032±0.0076	0.0036±0.0028	0.0017±0.0036
Zinc (Zn)	0.0535±0.0009	0.0712±0.0008	0.0594±0.0006

Source: Research fieldwork, 2018 and 2019

Table 3: Mean concentration (mg/kg DW) of heavy metals in sediments during the dry season

Elements	SAMPLING STATIONS		
	Concentration (mg/L) for Sample A1	Concentration (mg/L) for Sample A2	Concentration (mg/L) for Sample A3
	Concentration (x±Sd)		
Manganese (Mn)	0.200± 0.0005	0.533± 0.0010	0.367±0.0006
Iron (Fe)	0.167±0.0010	0.500±0.0021	1.500±0.0004
Copper (Cu)	0.167±0.0026	0.500±0.0024	0.278±0.0023
Chromium (Cr)	0.315±0.0008	0.315±0.0008	0.469±0.0009
Cobalt (Co)	0.368±0.0087	0.421±0.0173	0.207±0.0043
Cadmium (Cd)	0.0428±0.0189	0.080±0.0000	0.081±0.0090
Nickel (Ni)	0.428±0.0000	0.151±0.0010	0.428±0.0000
Lead (Pb)	0.0151±0.0076	0.0428±0.0000	0.030±0.0099
Mercury (Hg)	0.0044±0.0036	0.0031±0.0031	0.0060±0.0073
Zinc (Zn)	0.0300±0.0013	0.0411±0.0019	0.078±0.0029

Table 4. Mean concentration (mg/kg DW) of heavy metals in water during the rainiy season

Elements	SAMPLING STATIONS		
	Concentration (mg/L) for Sample B1	Concentration (mg/L) for Sample B2	Concentration (mg/L) for Sample B3
	Concentration (x±Sd)		
Manganese (Mn)	0.577±0.0004	0.486±0.0004	0.739± 0.0004
Iron (Fe)	0.411±0.0006	0.485±0.0004	0.485±0.0002
Copper (Cu)	0.129±0.0115	0.324±0.0111	0.666±0.0196
Chromium (Cr)	0.157±0.0003	0.157±0.0009	0.157±0.0005
Cobalt (Co)	0.550±0.0002	0.550±0.0011	0.300±0.0004
Cadmium (Cd)	0.028±0.0011	0.056±0.0009	0.063±0.0008
Nickel (Ni)	0.629±0.0050	0.410±0.0000	0.100±0.0024
Lead (Pb)	0.0330±0.0013	0.0330±0.0013	0.0330±0.0010
Mercury (Hg)	0.0017±0.0036	0.0019±0.0078	0.0024±0.0014
Zinc (Zn)	0.0653±0.0002	0.0535±0.0007	0.0594±0.0066

Key: A1, B1- Source Point Water ± = SD of three result
A2, B2- Middle Point Water
A3, B3- Terminal Point Water

Concentration of Heavy Metals in Water and Sediments

Ten elements of heavy metals (Mn, Fe, Cu, Cr, Co, Cd, Ni, Pb, Hg and Zn) were analyzed from the water and sediments samples to determine their level of concentration in the river from the mouth of the reservoir down the stream in 50m intervals.

Concentration of Manganese (Mn) in Water and Sediments

Manganese in the life of living organism forms an essential part of enzyme that metabolizes proteins and energy. *Manganese* is also essential in muco- polysacharides needed for healthy joint membranes (Soetan, et al., 2010). Its concentration in fish tissue has been found to be higher in liver and gill tissue than in muscle tissue (Rajeshkumar and Li, 2018). In humans, *Manganese* is involved in the digestion and absorption of food through peptidase activity, in the synthesis of cholesterol and fatty acid in glucose metabolism. The permissible limit for *Manganese* for drinking is about 0.05mg/l (USEPA). Exposure to toxic levels of manganese may lead to complications that include psychiatric and motor disturbances, termed *manganism* which has occurred in persons involved in the production and processing of *Mn* alloys (Nussey *et al.*, 2000).

The Manganese level of the water sample from the source, mid- and terminal points were 0.200± 0.0007, 0.200± 0.0003 and 0.311±0.0005mg/L respectively for dry season and 0.352± 0.0002, 0.465±0.0018 and 0.577±0.0004 respectively for the rainy season. The result indicates the highest concentration of manganese for water samples was recorded at the terminal end of the river for the wet season. The sediments recorded manganese concentration of 0.577±0.0004mg/l, 0.486±0.0004 and 0.739± 0.0004mg/l for source, middle and terminal points respectively during the rainy season and 0.200±0.0005mg/l, 0.533±0.0010 and 0.367± 0.0006mg/l respectively during the dry season. It was observed that the Manganese of sediments samples was higher at the terminal for rainy season, an indication that the water downstream had higher manganese content. On the other hand, the manganese content at the middle point in the sediment during the dry season was higher than the terminal and source points. This may be due to the manganese content from rocks and soils directly exposed at the reservoir surface. The increase in concentration along the river is probably due to higher anthropogenic activities downstream of the river. The permissible limit for Manganese for drinking water is about 0.05mg/l (USEPA). Therefore, the water in the reservoir is deemed unsafe.

Iron (Fe) concentration in water and Sediments

When pipes are seeped into the water and exposed to oxygen, they produce rust and thereby free up iron particles which are being absorbed by the water. The tiny particles could host bacteria that are dangerous for human consumption. If someone's skin is exposed to water with high iron content, they risk suffering acne and other skin conditions. The iron could clog up pores resulting in breakouts and damage the skin. The body also needs iron for certain biological processes such as transportation of oxygen in the blood but if too high, it can damage the internal organs. The body do store iron in organs including the heart, pancreas and liver but if it is too much, it can cause iron body poisoning. Iron within the permissible range acts as a catalyst in water and will promote the dissociation of oxygen molecules in water to form free radicals.

Iron concentration in the reservoir water amounted to 0.167±0.0008 between October – November, 0.500±0.0010 December – January and 0.167±0.0011 between February – March in dry season while during the raining season, the concentration was observed to be 0.263±0.0006 between April - June, 0.596±0.0011 between July - August and 0.485±0.0002 between September - October.

The Iron content of the sediment sample for the rainy season was 0.411±0.0006mg/l, 0.485±0.0004 mg/l and 0.485±0.0002mg/l for the source, middle and terminating point while the Iron content of the sediment sample for the dry season at the source, middle and terminal point was recorded as 0.167±0.0010 mg/l, 0.500±0.0021mg/l and 1.580±0.0004mg/l. It is observed that much of iron concentration was during the raining season. This could be as a result of increased cation exchange during the raining season. According to WHO, the taste and appearance of drinking water affected by iron below the concentration of 1- 3mg/litre are acceptable. Hence the Fe concentration in the water from the reservoir was below the maximum permissible level.

Copper (Cu) concentration in water and Sediments

Copper particulates are released into the atmosphere by wind-blown dust, volcanic eruptions and anthropogenic sources (Ruqia et al, 2015); copper is an essential trace element necessary for growth and metabolism of all living organisms, humans need approximately 1.25mg daily (Nodberg et al, 2007). However, copper in higher concentrations 44mg/l is toxic to humans as it can cause gastrointestinal distress, nausea, vomiting and dizziness (Nodberg et al, 2007). According to USEPA, more than 1.30mg/L of copper in domestic water can be of health risk.

Copper content of water in the rainy season had the highest concentration at the mid-point of 0.739mg/L, while for the sediment the highest concentration of 0.666mg/L was found at the terminal point. In the dry season, the highest copper content recorded for water and sediments were 0.611±0.0038mg/l and 0.500±0.0024mg/l respectively. The presence of copper elements in water could be influenced by the presence of oxidizing agents and chelation compounds or ions. Concentration of copper in all samples fell below the maximum permissible limits of 2mg/l (WHO) and 1.3mg/l (USEPA) for drinking water but above the limits for use in irrigation (0.2mg/l).

Chromium (Cr) concentration in water and Sediments

Chromium comes in forms like Sodium chromate; ferrochrome dichromate which are used in commercial scale (Kakuschke et al, 2005). Chromium above the acceptable level of 36mg/l in African cat fish affects the embryo survival and decreases the larvae growth (Arunkumar et al, 2000). This effect on fish makes it suspend feeding behavior and may equally trigger structural changes like hypertrophy and paraplegia at gill epithelium and weaken body immune system (Arunkumar et al, 2000). Long exposure can cause damage to liver, kidney circulatory and nerve tissues, as well as skin irritation (Dayan and Paine, 2001).

Chromium levels in both water and sediments during the rainy season showed similar values of 0.157mg/l for the three points. The samples collected during the dry season showed the Cr concentration of 0.238±0.0008mg/l, 0.238±0.0008mg/l and 0.392±0.0006mg/l showing the highest concentration in February – March. The highest Cr concentration in sediments was also obtained during the same period to be 0.492±0.0009mg/l. Minimum concentrations of chromium were observed in samples collected between Sep. – October. It could be observed that both water and sediments have Cr concentrations above the recommended level by WHO (0.05 mg/l) and USEPA (0.1mg/l) (WHO, 2008; USEPA, 1996) for drinking water and this portrays some danger.

This means that consumption of water from the Bakajeba River is still risky since hexavalent Cr is very toxic and mutagenic when consumed and is a known human carcinogen, where long term exposure can cause damage to liver, kidney circulatory and nerve tissues, as well as skin irritation (Dayan and Paine, 2001).

Concentration of Cobalt (Co) in water and Sediments

Cobalt is not normally a raw water contaminant, usually from corrosion of copper plumbing. It stains laundry at a concentration of 1mg/l and taste problems are noticed at a concentration of 5mg/l (WHO, 2008). Cobalt above permissible limits of 2mg/l in the body leads to gastrointestinal diseases like lung cancer (Guideline for drinking water quality, 1996); cobalt concentration in aquatic life will pose danger when levels exceed 4µg/l.

The highest level of the metal in both water and sediments was obtained during the months of April to August as 0.550mg/L which is below the 5mg/L for taste problems and 2mg/L which could cause gastrointestinal diseases. This value however exceeds the recommended level for aquatic animals and might pose some danger to them.

Concentration of Cadmium (Cd) in water and Sediments

Cadmium has been reported to have effects on target organs including liver, placenta, kidneys, lungs, brain and bones (Reilly, 2002). It had a concentration in water ranging from 0.020mg/L in October – November samples to 0.073mg/L in February - March samples. The concentration in sediments varied from 0.028mg/L in samples collected in rainy season to 0.081mg/L in samples collected in dry season. These values exceed the WHO limits of 0.003mg/l permissible limits in drinking water but within permissible limits for irrigation use and aquatic life of 0.01mg/l. The slightly high values might be due to heavy traffic along the route and washing of cars as observed around the river. The element is toxic even at low levels which can result to feelings of nausea, vomiting, abdominal cramp and headache, as well as diarrhea, renal failure and shock (Bandara et al, 2008). The biomagnifications could occur from one link in the food chain to another which includes human eating fish of any kind that has high accumulation of cadmium in it.

Concentration of Nickel (Ni) in water and Sediments

Nickel applied as fungicide is found to enhance plant growth and increased yield, but could accumulate due to improper disposal of residential waste. The Concentration of the metal in water samples was highest in samples collected during the rainy season from April to August with 0.068±0.0107mg/l. The least value was observed in samples collected from Sep. to October with a concentration of 0.010±0.002mg/l. In the sediments, the concentration of the metal varied from 0.1000mg/L to 0.629mg/L as observed in the samples collected in April – June. Generally, the concentration of Nickel in these samples is above the permissible limit of 0.02mg/l as recommended by WHO.

Studies of the heavy metal in water from some rivers have indicated varying profiles in Ni concentrations compared to this study (Mwangi, 2009; Oguzie and Izevbigie, 2009). Concentrations of 0.01 mg/l were reported from Ikpoba Rivers which compares the minimum value reported in this work.

Concentration of Lead (Pb) in water and Sediments

Lead and Lead compounds at high level of exposure could attack the brain and the Central nervous system of humans, leading to anaemia, high blood pressure and even death especially in children (WHO, 2019).

The Lead concentrations in water samples in the rainy season for the three points were recorded as 0.0070±0.0011mg/l, 0.0036±0.0010mg/l and 0.033±0.0010mg/l while the concentration in sediments within the season was 0.0330mg/L across the samples. The value of lead concentrations recorded during the dry season were 0.0050±0.0001mg/l, 0.015±0.0014mg/l and 0.026±0.0012mg/l for water and 0.0150±0.0076mg/l, 0.0428±0.0000mg/l and 0.030±0.0099mg/l for sediments.

WHO (2008) has a maximum permissible limit of 0.01mg/l. The results obtained for both water and sediments samples were above the permissible limit for drinking water except for water samples collected from April to August. These high levels could be attributed to the discharge of untreated agricultural and rural effluent to the

river. This indicates a pending threat to the river water due to bio-accumulation and its use poses a high health risk of Pb poisoning as the element is known to be toxic even at low levels (Mwegoha and Kihampa, 2010).

Concentration of Mercury (Hg) in water and Sediments

Mercury concentration above the human health guideline of 0.500mg/l can be dangerous to both aquatic life and humans because the body temperature of a fish is the same as water temperature. Hence, the metabolic rate will increase when temperature increases. Mercury is known be more accumulated in fishes than humans (Wright and Wellbourn, 2002). The standard limit for Mercury in drinking water is 0.001-0.002mg/L (WHO, 2018, USEPA), above which it is termed hazardous, causing damage to the kidneys. The least concentration of the metal in water samples was obtained in the months of October to November and February to March to be 0.0012mg/L while the maximum value of 0.0036mg/L was obtained around July to August. The concentration in sediments varied from 0.0024mg/L in samples collected in rainy season to 0.0060mg/L for samples collected between February and March. These values are slightly above the recommended safety values by WHO and USEPA and might be dangerous to human health.

Concentration of Zinc (Zn) in water and Sediments

The concentration of Zinc in the water samples delineated the minimum and maximum values as: 0.0535±0.0009mg/l for samples collected between April and June and 0.189±0.0002mg/l for samples collected between February and March. For sediments samples, the concentration varied from 0.0300±0.0013mg/l to 0.078±0.0029mg/l. It is observed that there is an increase in zinc concentration in the dry season in both water and sediment as compared to the results in rainy season.

All the sampling points recorded Zn mean levels that were within the recommended limit of 3 mg/l in drinking water for both water and sediments (WHO, 2008) and 5mg/l as described by Brenner and Hoeskstra, (2012) for irrigation purposes.

IV. Conclusion

An assessment of heavy metal concentrations in water and sediments of Lapai/Agaie reservoir was conducted during the dry and rainy season so as to monitor seasonal effects. The results indicated that the concentrations of *Mn, Cr, Cd, Ni, Hg* and *Pb* in the samples during the periods of investigation slightly exceeded the WHO recommended limits but mostly within limits of sub-lethal effect. On the other hand, the concentrations of Zn, Cu, Co and Fe in the samples were below the recommended maximum permissible levels. The heavy metals concentration in sediments generally showed the highest concentrations of heavy metals for both dry and rainy season as compared to water samples. Samples of sediments generally recorded the highest concentrations of heavy metals for both dry and wet season as compared to water samples. The concentration of the metals in water also showed different levels.

The mean levels of Mn, Co, Cr and Cu were higher than those of the other elements in the samples both during dry and rainy season, while Hg and Pb recorded the lowest concentrations both in water and sediments for the two seasons.

V. Recommendations

Constant monitoring of heavy metals and control program should be instituted in the reservoir to protect the high population down the river using this water as the dam is a major source of water for domestic and agricultural purposes.

The concentration of heavy metals in Fishes and other aquatic animals harvested from the river for consumption from the river should also be investigated as the river

Other physico-chemical analysis such as Alkanity, pH, Nitrate, Chloride and Conductivity tests should be carried out on the water, sediments and agricultural produce obtained from the river to ascertain their level and compare with world standards.

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