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Research Article

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Assessment of Some Heavy Metals in Water and Sediments of Kiri Reservoir, Adamawa State, Nigeria

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Abstract

Heavy metals of Kiri Reservoir, Adamawa State, Nigeria were assess from March, 2017 - August, 2018. Water and sediments samples were collected from three (3) different sites monthly and were analysed using standard methods for heavy metals analysis. Six heavy metals (Fe, Mn, Zn, Cu, Cr, Ni) were investigated in water and sediments, but Cr and Ni were beyond detection for the period of this study. The monthly mean of heavy metals (Fe, Mn, Zn, Cu) in water ranged from 1.40 ± 0.50mg/l-30.65 ± 0.83mg/l, 0.04 ± 0.075mg/l-0.60 ± 0.129mg/l, 0.01 ± 0.012mg/l-0.42 ± 0.508mg/l and 0.15 ± 0.051mg/l-0.73 ± 0.201mg/l, while in sediments the values recorded ranged from 54 ± 5.11mg/kg - 67.33 ± 3.12mg/kg, 1.07 ± 0.58mg/kg - 11.99 ± 2.39mg/kg, 0.13 ± 0.10mg/kg-1.68 ± 0.66mg/kg, 0.57 ± 0.08mg/kg-1.81 ± 0.99mg/kg respectively. Fe and Mn were above recommended safety limits of 0.3mg/l and 0.4mg/l in water, while Zn and Cu in water and all the values in sediments were within the recommended safety limits as recommended by World Health Organization (WHO) and Nigerian Industrial Standard (NIS). The trend of the concentration of heavy metals in the samples investigated were sediments> water.

Key words: *Heavy Metals, Kiri; Reservoir; Sediments; Water*

Introduction

Heavy metals are ubiquitous in the environment (Pohl et al., 2011), readily dissolved in and transported by water and can be taken up by aquatic organism due to bioaccumulation and bio-magnifications in the food chain, either as such or their metabolites thus causing concern on the animal at the top of the food chain (Obasohan et al., 2010). Heavy metals are stable and persist in environmental contaminants of aquatic environments and their organisms. The U. S. Environmental Protection Agency "USEPA" (2007), conducted a national study of accumulated toxins, and observed that heavy metal contamination in water might arise in many ways. Heavy metals in ecosystems have received extensive attention because they are toxic, non-biodegradable in the environment and are easy to accumulate and magnify in organisms (Wen and Xuelu, 2014). With a combined action of adsorption, hydrolysis and co-precipitation, only a small part of free metal ions stay dissolved in water, and a large quantity of them get deposited in the sediment (Zubaidah et al., 2013).

However, when environmental conditions change, sediments might transform from the main sink of heavy metals to sources of them for the overlying waters (Krishna et al., 2009). Exposure to heavy metals has been linked to developmental retardation, various types of cancer, kidney damage, autoimmunity and even death in some instances of exposure to very high concentrations (Rai, 2009). Heavy metals such as Copper, Lead, Mercury, and Selenium, get into water from many sources, including industries, automobile exhaust, mines, and natural soil. Like pesticides, heavy metals become more concentrated as animals feed on plants and are consumed in turn by other animals. When they reach high levels in the body, heavy metals can be immediately poisonous, or can result in long-term health problems similar to those caused by pesticides, insecticides and herbicides (Hart, 2008). For example, manganese in fertilizer, pesticides and those that are derived from lithological process can be absorbed by crops. If these crops are eaten by humans in sufficient amounts, the metal can cause diarrhoea and, over time, liver and kidney damage. Lead can get into water from lead pipes and solder in older water systems; children exposed to lead in water can suffer mental retardation. The pollution of aquatic ecosystem by heavy metals is an important environmental problem, as heavy metals constitute some of the most hazardous substances that can bioaccumulate in various biotic systems (El-Sayed et al., 2011). With changing environmental conditions under increasing anthropogenic influences (application of chemical for fishing, used of treated net, open defecation, used of pesticides, herbicides, insecticides, damming, transportation, runoff from the domestic waste, washing of plates, pots, clothing, hunting of Hippopotamus and destruction of breeding sites of fish species by cutting down the grass in search for catches), these activities might also affect the nature of Kiri Reservoir and might lead to drastic changes in it biological productivity.

Materials and Methods

Study Area

Kiri reservoir is located on floodplain of lower Gongola River basin, about 25km upstream of its confluence with River Benue at Numan (Zemba, et al., 2016). It was reported to have formed as a rift phase due to lithospheric peak thinning which caused long narrow depression that developed in some places filled with variety of sedimentary environment. Kiri Reservoir is on coordinate's 9°40′47″N 12°00′51″E on the southern part of Adamawa State, Nigeria.

Digestion of water samples for heavy metal determination

The samples were transported to the laboratory, store in the refrigerator at 4^0C prior to analysis. 100cm^3 of the sample was transfer into a beaker and 5mls of concentrated HNO_3 was added. The beaker with the content was placed on a hot plate and evaporation was at about 20mls. The beaker cool and another 5mls of concentrated HNO_3 was added. The beaker was cover with a watch glass and return to the hot plate. The heating continues, and then small portion (1mls) of concentrated HNO_3 was added until the solutions appear light colour and clear. The beaker and watch glass were washed with distilled water and the sample was filter to remove some insoluble materials that could clog the atomizer. The volume was made up to 100cm^3 with distilled water. Determination of Zinc (Zn), Copper (Cu), Chromium (Cr), Nickel (Ni) and Iron (Fe) were done directly on each final solution using Atomic Absorption Spectrophotometer (AAS, Model: VGP 210) (El-Sayed et al., 2011).

Determination of heavy metals in sediments

Sediments sample were collected using a sediments sampler. Sample solution for metal analysis was prepared by treating 1g sediments sample with 10mls of concentrated nitric acid and 5mls of 60% perchloric acid in 100mls Kjeldahl flask. The mixture was heated with moderate heat using a hot plate for about 15 minutes until white fumes appear. The digest was cooled, then filtered (No. 44 whatman paper) into 50mls volumetric flask with rinsing in deionized water and made up to mark with de-ionized water (Akubugwo et al., 2007).

Results

Concentration of Heavy Metals in Water Samples

The monthly mean variation ranged from 1.40 ± 0.50mg/l in the month of March, 2017 to 30.65 ± 0.83mg/l in the month of September, 2017. Showing significance differences in the seasonal variation of Iron in seasons ($p<0.05$). The monthly mean concentration ranged from 0.04 ± 0.075mg/l in the month of August, 2017 to 0.60 ± 0.129mg/l in the month of August, 2018. Showing significance differences in the monthly variation of manganese in seasons ($p<0.05$). The mean monthly ranged from 0.01 ± 0.012mg/l in the month of February, 2018 and 0.42 ± 0.508mg/l in the month of August, 2018. Showing significant difference in seasons ($p<0.05$). The monthly mean concentration ranged from 0.15 ± 0.051mg/l in the month of November, 2017 to 0.73 ± 0.201mg/l in the month of August, 2017. Showing significance difference in the monthly variation of copper in seasons ($p<0.05$).

Heavy Metals in the Sediments

The monthly mean variation of iron ranged from 54 ± 5.11mg/kg in the month of May, 2018 and 67.33 ± 3.12mg/kg in the month of September, 2017. Showing significance differences in the monthly variation of Iron in seasons ($p<0.05$). The monthly mean concentration ranged from 1.07 ± 0.58mg/kg in the month of November, 2017 to 11.99 ± 2.39mg/kg in the month of March, 2018. Showing significance differences in the variation of manganese in seasons ($p<0.05$). The mean monthly value ranged from 0.13 ± 0.10mg/kg in the month of August, 2018 to 1.68 ± 0.66mg/kg in the month of February, 2018. Showing significant differences in seasons ($p<0.05$). The monthly mean concentration ranged from 0.57 ± 0.08 mg/kg in the month of December, 2017 to 1.81 ± 0.99 mg/kg in the month of March, 2018. Showing significance differences in the monthly variation of copper in seasons ($p<0.05$).

Months	Iron (Fe)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)
March, 2017	1.40 ± 0.504	0.08 ± 0.144	0.05 ± 0.010	0.64 ± 0.084
April	4.73 ± 1.317	0.23 ± 0.614	0.07 ± 0.017	0.47 ± 0.266
May	7.17 ± 2.233	0.05 ± 0.283	0.05 ± 0.023	0.37 ± 0.667
June	11.91 ± 8.070	0.13 ± 0.399	0.10 ± 0.047	0.43 ± 0.110
July	24.98 ± 19.47	0.09 ± 0.273	0.07 ± 0.006	0.63 ± 0.190
August	30.65 ± 0.832	0.04 ± 0.075	0.07 ± 0.021	0.73 ± 0.201
September	9.63 ± 7.886	0.09 ± 0.081	0.07 ± 0.064	0.62 ± 0.190
October	8.00 ± 3.331	0.14 ± 0.015	0.05 ± 0.032	0.49 ± 0.251
November	5.61 ± 2.070	0.21 ± 0.025	0.04 ± 0.006	0.15 ± 0.051
December	9.85 ± 2.556	0.18 ± 0.021	0.03 ± 0.010	0.54 ± 0.125
January, 2018	8.19 ± 4.411	0.16 ± 0.052	0.03 ± 0.037	0.46 ± 0.125
February	3.84 ± 0.629	0.13 ± 0.125	0.01 ± 0.012	0.56 ± 0.038
March	3.91 ± 0.849	0.24 ± 0.123	0.04 ± 0.044	0.65 ± 0.051
April	3.22 ± 1.038	0.39 ± 0.285	0.05 ± 0.042	0.48 ± 0.061
May	22.14 ± 7.666	0.34 ± 0.192	0.08 ± 0.010	0.48 ± 0.100
June	19.07 ± 8.547	0.36 ± 0.128	0.10 ± 0.083	0.58 ± 0.382
July	4.93 ± 0.147	0.47 ± 0.117	0.21 ± 0.212	0.53 ± 0.120
August	5.13 ± 0.194	0.60 ± 0.129	0.42 ± 0.508	0.60 ± 0.070

Source: Experimentation, March, 2017 – August, 2018

Table 1: *Monthly Mean Variation of Heavy Metals in Water (Mg/l).*

Months	Iron (Fe)	Manganese (Mn)	Zinc (Zn)	Copper (Cu)
March, 2017	65.33 ± 4.148	3.54 ± 2.792	0.18 ± 0.025	1.18 ± 0.247
April	63.33 ± 7.269	2.06 ± 1.131	0.18 ± 0.000	1.59 ± 0.538
May	58.67 ± 10.11	1.25 ± 0.988	0.20 ± 0.091	1.68 ± 0.908
June	63.33 ± 10.36	3.75 ± 4.719	0.25 ± 0.119	0.88 ± 0.140
July	62 ± 7.732	2.23 ± 1.112	0.18 ± 0.025	0.90 ± 0.216
August	62.33 ± 3.099	2 ± 1.060	0.14 ± 0.031	0.58 ± 0.145
September	67.33 ± 3.122	3.88 ± 1.451	0.22 ± 0.076	0.72 ± 0.085
October	65.33 ± 0.656	1.8 ± 0.823	0.15 ± 0.042	0.64 ± 0.064
November	62.33 ± 8.515	1.07 ± 0.582	0.13 ± 0.085	0.64 ± 0.114
December	60.33 ± 8.019	2.15 ± 1.364	0.18 ± 0.081	0.57 ± 0.078
January, 2018	67 ± 6.246	10.86 ± 3.699	0.19 ± 0.125	0.82 ± 0.178

February	65.33 ± 12.78	10.37 ± 2.762	1.68 ± 0.656	1.11 ± 0.256
March	67 ± 4.305	11.99 ± 2.395	0.21 ± 0.065	1.81 ± 0.988
April	57 ± 7.692	2.87 ± 2.113	0.25 ± 0.150	1.08 ± 0.243
May	54 ± 5.113	3.54 ± 4.043	0.37 ± 0.183	0.83 ± 0.139
June	58 ± 4.272	3.83 ± 3.141	1.20 ± 0.396	0.69 ± 0.165
July	59.67 ± 7.561	4.01 ± 3.843	1.26 ± 0.281	0.64 ± 0.067
August	64.67 ± 2.318	5.94 ± 3.155	0.13 ± 0.101	0.79 ± 0.342

Source: Experimentation, March, 2017 – August, 2018

Table 2: *Monthly Mean Variation of Heavy Metals in Sediments (Mg/kg).*

Discussion

The concentration of metals such as Iron (Fe), Manganese (Mn), Zinc (Zn), Copper (Cu), Chromium (Cr) and Nickel (Ni) were investigated in water throughout the period of this studies. Chromium (Cr) and Nickel (Ni) was not detected in the water sample throughout the period of the study. The concentrations of heavy metals (Fe, Mn, Zn and Cu) in water differ significantly ($p<0.05$) during the period of this study across seasons, but showed no different across sites. The highest concentrations were recorded during the rainy season (47.46 ± 19.47mg/l, 0.71 ± 0.13mg/l 1.01 ± 0.51mg/l, and 1.01 ± 0.38mg/l) for Fe, Mn, Zn and Cu respectively, and this could be attributed to dilution, anthropogenic activities and runoff from the environment which might increase the concentration of metals in the water during this period. This varied with Oyakhilome et al. (2013), who recorded higher concentrations of metals during the dry season from Owena Multi-Purpose Dam, Ondo state due to combination of water dilution, precipitation and adsorption of some metals in soil sediment during the wet season; and most importantly local concentration of metals via water evaporation from water body during the dry season. Similar result was obtained from Upper Benue River, Adamawa State (Edward et al., 2016). Similar observation were also been made (El-Sayed et al., 2011), who attributed it to the phytoplankton growth which was higher in summer and autumn seasons that can absorb large quantities of heavy metals from water. This revealed that, the current results of metals concentration in the water correlated with the higher phytoplankton dynamics during the dry season, which might lead to the absorption of heavy metals by the planktons.

The sequences of metals concentration were as follow; Fe (47.46 ± 19.47mg/l) > Zn (1.01 ± 0.51mg/l) >Cu (1.01 ± 0.38mg/l) >Mn (0.71 ± 0.13mg/l) as shown on table 1. This result varied with Samir and Ibrahim, (2008); Edward et al. (2016), who reported a sequence of Fe>Mn>Zn>Cu and Cu>Zn>Ni>Pb in their separates studies. The obtained results showed that the average values of Fe in water samples were higher than the respective values of Zn, Mn and Cu from the reservoir. The maximum values of the measured metals (Fe, Mn and Zn) were recorded at site III as well as (Mn, Cu) at site II. This might be as a result of intensive agricultural activities (through fertilizer), runoff from tributaries, used of prohibited (chemical treated) nets for fishing and waste discharge experience at the two sites both during dry and rainy season. Comparison of mean concentrations of the metals in the reservoir with guideline values for drinking water (WHO, 2008), showed that Fe, and Mn recorded higher concentrations than their guideline values (0.3mg/L and 0.4mg/L) while Zn and Cu was within the guideline values of 5mg/L and 2mg/L. But Fe, Mn and Cu were within recommended permissible limits of 3mg/L [Nigeria Industrial Standard (NIS), 2007]. Although some of the metals measured are essential elements in human nutrition, there presence in elevated concentration in water, possess serious health challenges and pollution to both plants and animals. More especially, toxicity of iron (Fe), Copper (Cu) and Zinc (Zn) to human and plants has been found to bring about vomiting, cardiovascular collapse, diarrhea, anaemia, liver and kidney damage, stomach and intestinal irritation, lead to phytotoxicity as it is a weed killer, while the deficiency of metals such as iron might lead to failure of blood clothing in human (Joseph et al., 2012). Other heavy metals such as zinc can cause changes in behaviours of fish including deficiency of balance, restless swimming, air guzzling, periods of dormancy and death (Kori and Ubogu, 2008). Besides, it also leads to development of certain degree of anaemia in fish. Copper toxicity is also the main cause of the Wilson's disease (Patil and Ahmad, 2011).

The results obtained for heavy metals in sediments are shown on table 2. The metals concentration in the sediments varied and exhibit fluctuations between season and sites especially in the values of Iron (Fe), Manganese (Mn), Zinc (Zn) and Copper (Cu). Chromium (Cr) and Nickel (Ni) was not detected in sediments for the period of this study as they remained beyond detectable limit of AAS machine. Fe (75.44 ± 12.78 mg/kg) recorded higher concentration, while Mn (14.88 ± 3.70 mg/kg), Zn (2.32 ± 0.66 mg/kg) and Cu (2.84 ± 0.99 mg/kg) for the period of this studies. Sediments accumulated more metals (high concentration) than water. This agreed with Maitera et al. (2011), who reported that there is high concentration of heavy metals in sediments samples as compare to water and fish, in some cases holding up to 99% of the total amount of metals present in the system. Higher concentration of heavy metals in sediments might be due to sedimentation, sediments been a sink to heavy metals and the inability of the metals to dissolve in water and thereby got deposited into the sediments. The sequence of heavy metals in sediments for the period of this research was Fe>Mn>Cu>Zn. Similar observation was made by Ayeku et al. (2015). But varied with the observation of Edward, et al. (2016), who reported a trend of Cu>Ni>Zn>Pb>Cr>Cd from Upper Benue River.

Conclusion

Chromium (Cr) and Nickel (Ni) were below detection level in water and sediments. Fe and Mn in water exceeded the permissible limits, while Zn and Cu were within the maximum permissible limits. All the heavy metals recorded in sediments were within the permissible limits.

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