Tropical Freshwater Biology, ***29*** *(1) (2020) 123-131* 123
http://www.ajol.info/index.php/tfb; DOI: https://dx.doi.org/10.4314/tfb.v29i1.9

SPATIO-TEMPORAL VARIATION LEVEL OF HEAVY METALS IN SURFACE WATER AND SEDIMENT IN TAGWAI LAKE, MINNA, NIGERIA

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ABSTRACT

The high contamination of aquatic systems with toxic heavy metals is of major concern since the elements are not biodegradable. Heavy metals often get into the water through runoff from farmlands and dumping of effluents from industries into the water bodies. The toxicity of these heavy metals can cause harmful and even lethal effects on the human health. The objective of this study was to investigate the level of Pb, Cu, Mn, and Fe in both surface water and sediment of Tagwai Lake. Atomic Absorption Spectrometry investigation was carried out on the collected and digested water and sediment samples to determine the extent of these heavy metals contamination in the water. The results showed that the average concentration of heavy metals ranked in the following order: Pb>Mn>Cu>Fe with higher concentration in sediment compared to the water. The correspondence of the mean concentrations of heavy metals in water and sediment of the Tagwai Lake with the WHO standard suggests that the mean concentration of Pb, Cu, and Fe lies within the standard range while Mn exceeds the standard range in both the water and sediments. We therefore advocate regular surveillance as a tool for monitoring impacts of anthropogenic activities in the lake to ensure safety of the general populace who depend on it for their livelihood.

Keywords: spatio-temporal, heavy metals, sediments, Tagwai Lake

INTRODUCTION

Environmental pollution is a significant problem in society due to industrialization and urbanization (Brraich, O. S., & Jangu, S, 2015). Monitoring metals in the aquatic environment is essential for the safety assessment of the environment. Heavy metals are inorganic elements essential for plant growth in traces or minute quantities, toxic and poisonous in relatively higher concentration, biologically non-degradable but easily assimilated and bio-accumulated in the protoplasm of aquatic organisms (Butu and Ati 2013). Heavy metals in water and sediment pose potential threats to the environment. They can damage human health through food chains. However, at low concentration, some heavy metals are essential for average healthy growth and reproduction of plants, other animals and human, all heavy metals are toxic to plants and animals at excessive concentration. Out of the various kinds of pollution, the high contamination of aquatic systems with toxic heavy metals is of major concern since these elements are not biodegradable (Barakat *et al.,* 2012). Industrialization, population growth, and technological developments in recent years have led to a considerable increase and accumulation of heavy metals in the environment (Liu *et al.*, 2009). Heavy metals, such as Cd, Cr, and Pb, are highly toxic even at minute quantities; these metals enter the environment mainly through human activities. However, some heavy metals, such as Cu, Fe, and Mn, are important plant micronutrients for plant growth and development but their higher concentrations can result in different toxicological effects on the environment (Alsaffar *et al.,* 2016). They enter the environment through various means, including the weathering of rocks and soil, the discharge of urban and industrial waste into bodies of water, and anthropogenic activities (Alkarkhi *et al.*, 2008). Heavy metals are pollutants of the aquatic environment because of their capability to poison humans and build-up in marine organisms (El-Zokm *et al.,* 2012). The toxicity effects of these heavy metals have public health implications due to their absorption into the food chain and bioaccumulation processes (Sanayei *et al.,* 2009; Tabari *et al.,* 2010). In recent years, anthropogenic activities have created ecological pressure in natural habitats and have seriously increased the atmospheric deposition of heavy metal pollutant even in places far away from close human impact (Pandey *et al.,* 2010; El-Zokm *et al.,* 2012).

Tagwai Lake is one of the essential aquatic ecosystems in Minna. It is the major source of water supply in Minna metropolis, Niger state. Several other activities such as fishing, irrigation, farming and other anthropogenic activities, take place in the lake (Chukwuemeka *et al*., 2019). Due to these activities going on within and around the lake, there is need to identify and evaluate the presence of heavy metals, its status and to compare the outcome with the standard set aside by regulatory organizations and to see whether they are within or above the permissible limits. This study was undertaken to investigate heavy metals concentrations in water and sediment of the Lake. The result will be of great help to the host community and also the government to take proactive steps in addressing any resulting issue.

MATERIALS AND METHODS

Study Area

The study was carried out in Minna, Niger State, located within longitude 6°33'E and latitude 9°37'N, covering a land area of 88 km^2 (Fig 1). The area has a tropical climate with mean annual temperature, relative humidity and rainfall of 30°C, 61.00% and 1334.00 mm, respectively. The climate presents two distinct seasons, a rainy season (between April to October), and a dry season (between November and March). The vegetation in the area is typically grass-dominated savannah with scattered tree species. Tagwai Lake is about 10 km away from Minna town. Mean maximum temperature remains high throughout the year having about 30°C, particularly in March and June. The vegetative cover is characterised by woodland and tall grasses inter spread with tall, dense species. In some areas, traces of rain forest species can be seen of Sudan Savannah alongside the plain of the River. (NSPC, 2011). The secondary benefits from this dam include fishing, recreation and wildlife

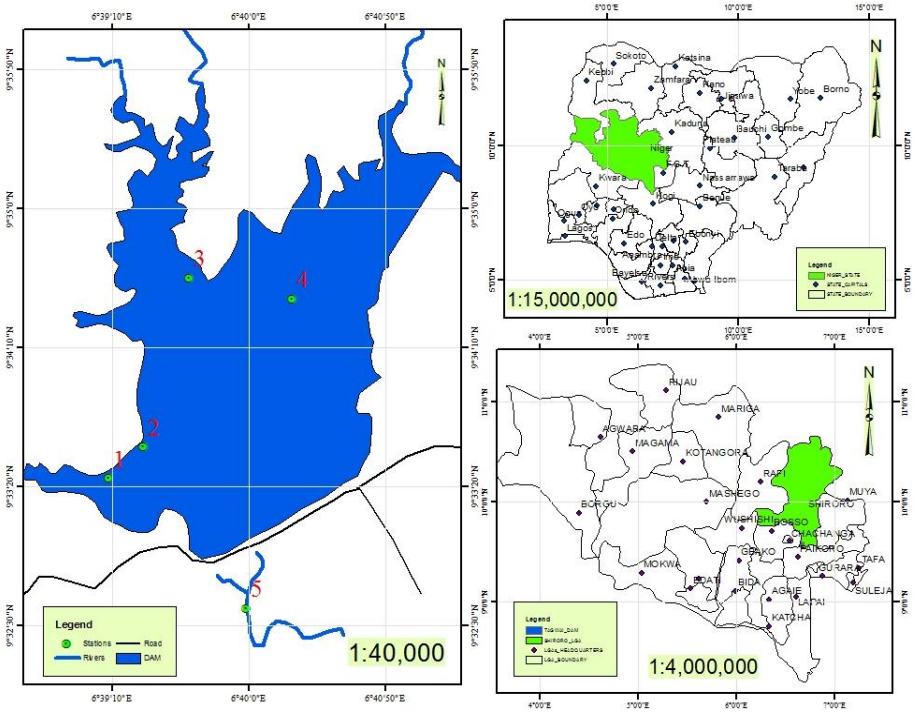

Fig. 1: Map of the study site (Tagwai Lake) in Niger State, Nigeria

Source: The Department of Geography, FUT, Minna. Centre for Remote Sensing (2018).

conservation. The occupation of the people of the area is fish farming. Different fishing gears characterise the study sites. Tagwai settlement is dominated by Nupe and Gwari people (Alkali, 1994; Chukwuemeka 2019).

Collection of samples

Water samples were collected from five different stations based on their entry points of various tributaries into the Lake. Samples were collected on a monthly basis from February to July 2018 using pre-cleaned plastic bottles. The bottles were appropriately labeled accordingly.

Sediment samples from the surface bed were also collected on monthly basis with a stainless-steel Ekman grab sampler and stored in a clean polythene bag.

Digestion of samples

A total of 30 water samples were collected and investigated. 10ml of each water sample was measured with a measuring cylinder, and 10ml of concentrated hydrochloric acid (HCl) was added to it. The solution was then transferred into a conical flask and heated on a water bath for some time. It was then transferred into 100ml volumetric flask where it was filtered using a funnel, and a filter paper and distilled water was added to fill up to the mark where it was transferred into the pre-cleaned sample bottle and taken for further Atomic Adsorption Spectrophotometer (AAS) analysis according to the method of APHA (1998).

A total of 30 sediment samples were collected and investigated. 2g of each sediment sample was weighed and poured into a beaker, 10ml of concentrated hydrogen trioxonitrate (v) acid (HNO3) was added together with 10ml of hydrochloric acid (HCl) was added and heated for some time. After proper digestion, the sample was allowed to cool down, and it was filtered. The filtrate was transferred into 100ml volumetric flask and made up to mark with distilled water. Heavy metals analyzed included zinc, manganese, lead, copper, and iron. Analyses for heavy metals were conducted in accordance with standard procedures (APHA, 1998). The prepared sample solution was transferred into the pre-cleaned labelled sample bottles for Atomic Adsorption Spectrophotometer (AAS) analysis using Bulk scientific AAS model Accusys 211, manufactured in USA.

Dats Analysis

The data generated were analyzed to get the mean and standard error which was then subjected to statistical test of difference by one-way Analysis of Variance (ANOVA) using Statistical Package for Social Sciences (SPSS) version 21.

RESULTS

Table 1 show the mean value for heavy metals in surface water in Tagwai Lake, Minna from February to July, 2018. The result showed that Lead was not present throughout the sampling period. The value of copper ranged between 0.24±0.08 and 0.27±0.07 in stations 1, 3, 4 and 5. There was no significant difference, whereas in station 2 the value was significantly different (0.19±0.06). The value for Iron in all five stations for surface water was not significantly different. It ranged between 2.15±1.64 to 2.81±2.12. The value for manganese ranged between 0.01 to 0.05 in all five stations.

TABLE 1

Heavy metals in surface water collected from Tagwai Lake between February to July, 2018

Metals						WHO 2011	P-value
	Station 1	Station 2	Station 3	Station 4	Station 5		
Pb(mg/l)	0±0	0±0	0±0	0±0	0±0	0.01	-
Cu(mg/l)	0.24±0.08[a]	0.19±0.06[b]	0.25±0.07[a]	0.27±0.7[a]	0.25±0.07[a]	2	0.17
	(0.02-0.57)	(0.07-0.39)	(0.13-0.52)	(0.12-0.55)	(0.08-0.54)		
Fe(mg/l)	2.81±2.12[a]	2.42±1.85[a]	2.15±1.64[b]	2.23±1.68[a]	2.29±1.79[a]	0.3	0.17
	(0.17-13.25)	(0.09-11.55)	(0.17-10.28)	(0.09-10.54)	(0.15-11.2)		
Mn(mg/l)	0.05±0.03[b]	0.01±0.01[a]	0.02±0.02[a]	0.02±0.01[a]	0.05±0.03[b]	0.5	0.231
	(0-0.14)	(0-03)	(0-09)	(0-08)	(0-19)		

Data are the means ± SE with minimum and maximum values in range. Values are followed by same superscript alphabet at P>0.05 (probability) value detected by ANOVA.

Table 2 shows the Mean value concentration of heavy metals in sediment in Tagwai Lake from February to July 2018. The results obtained revealed that in the five stations analyzed, lead was absent. The highest mean concentration level of copper (cu) was 3.54 ± 3.15 mg/l recorded in station 4. Station 2 and station 3 have very close values to station 4. Station 2, 3 and 4 showed significant difference (P>0.05). The result also revealed that the highest mean concentration level for iron (Fe) was 195.48 ± 43.43mg/l recorded in station 1. There was no significant difference between stations3 and station 4 at P>0.05. The highest mean concentration level for manganese was 3.45 ± 0.53 mg/l in station 1. This in comparison to the rest stations shows significance difference (P>0.05).

TABLE 2

Heavy metals in sediment from different stations in Tagwai Lake between February to July, 2018

Metals	Station 1	Station 2	Station 3	Station 4	Station 5	P-value
Pb(mg/l)	0±0	0±0	0±0	0±0	0±0	-
Cu(mg/l)	2.66±2.35[b]	3.29±2.96[a]	3.07±2.75[a]	3.54±3.15[a]	2.89±2.58[b]	0.35
	(0.08-14.42)	(0.23-18.68)	(0.12-16.80)	(0.11-19.3)	(0.14-15.8)	
Fe(mg/l)	195.48±43.43[a]	186.92±24.01[b]	195.32±37.37[a]	191.93±36.43[a]	185.78±33.59[b]	0.98
	(104.2-353.3)	(112.5-262.5)	(114.4-327.1)	(105.7-320.5)	(110.23-315.8)	
Mn(mg/l)	3.45±0.53[b]	2.98±0.48[a]	2.54±0.49[a]	2.55±0.48[a]	2.65±0.46[a]	0.01
	(2.04-4.85)	(2.12-4.74)	(1.29-3.95)	(1.21-3.88)	(1.42-4.12)	

Data are the means ± SE with minimum and maximum values in range. Values are followed by same superscript alphabet at P>0.05 (probability) value detected by ANOVA

DISCUSSION

The results obtained in this study revealed the ratio of the selected heavy metals in the water and sediment of Tagwai Lake as Pb>Mn>Cu>Fe. The result in Table 1 and Table 2 shows that Lead (Pb) was not detected in the entire study both in the surface water and sediment, which indicates that there is no pollution by Lead (Pb) in Tagwai Lake. This finding conforms with the work of Omozokpia *et al*. (2015) who worked on two fishing settlement along river Kaduna in Niger state and reported that Lead (Pb) was below detection limits in both the water and sediment samples. Opaluwa *et al.,* (2012) who worked at Uke River in Nasarawa State, reported Pb value in the stream to be 0.04mg/l. This value is in contrast with the results generated from this study. The high value could be as a result of location and the nature of industries located around the study site.

The mean concentrations of manganese (Mn) in the sediment is highest at station 1 (3.45mg/l), and the lowest mean value is 2.54mg/l recorded at station 3 shown in Table 2. A high concentration of manganese can cause genotoxic damage in fish that are bottom dwellers such as *Auchenoglanis occidentalis, Clarias gariepinus,* and *Oreochromis niloticus* which is present in Tagwai Lake (Chukwuemeka *et al*., 2019). Mn is introduced into aquatic environments mainly through anthropogenic sources, such as sewage sludge, emissions from alloy, iron, and steel industries, municipal wastewater discharges, and mining and mineral processing (Abidemi, 2013). The mean Mn concentrations observed in the five locations exceeded those values reported by Nwajei, 2002; Iwegbue *et al.,* 2012; and Ekeanyanwu *et al.,* (2010).

The mean concentration value recorded for Cu in the water ranged from 0.19 to 0.27 mg/l. This value was far below the WHO (2011) of 2 mg/l. This indicates that

there is currently no copper (Cu) pollution in Tagwai Lake. Copper (Cu) is an essential substance to human life, but chronic when present in high level (Gaetke *et al., 2003).* In the sediment, the concentration of copper (Cu) was highest in station 3 (3.54mg/l) and lowest at station 1 (2.66 mg/l) in the sediment. This could be due to anthropogenic wastes and industrial activities around the study area. The mean Cu concentrations in this study were above the target of 1.3mg/l set by USEPA (2004) and those values reported by Shomar *et al.,* (2005) and Vukovic *et al.,* (2011). This result is in accordance with the work of Oguh *et al.,* (2019), who analyzed River Chanchaga in Minna, Niger State. Their work recorded Cu value of 2.69 mg/l in fish and attributed it to the food intake from the sediment. In contrast to this, Edward *et al.,* (2013) worked on Odo-Ayo River in Ado Ekiti and recorded a low Cu value of 0.84 mg/l.

The concentration of Iron (Fe) in the water and sediments of the present study showed a high amount of Fe, which can be attributed to the anthropogenic activities around the Lake such as disposal of waste, farming activities, and washing. The concentration value recorded for iron (Fe) in the study which ranged from 2.51 to 2.81mg/l which exceeded the set standard of 0.3mg/l and 1.3mg/l by WHO (2011) and USEPA (2004) respectively. The mean concentration was highest in station 1, and this could be as a result of more farming activities in the upper region of the Lake close to station 1. The mean concentrations of Fe in the five locations were lower than those concentrations reported by Iwegbue *et al*., (2012). The high concentrations of Fe in the sediment had no identifiable point source discharge but rather of lithological or crustal origin.

CONCLUSION

Tagwai Lake has shown evidence of metal pollution which could pose a severe risk to inhabitants that depend on the Lake, and the fish in the Lake. There is a need for proper monitoring of this water body for effective sustainability and elimination of any health risk from the Lake.

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