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Research Article

Assessment of Heavy Metal Pollution in Water Collected From River Yobe Nigeria

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Abstract: Dumpsites exist throughout the developing countries present a threat to human's health and the natural ecosystems. This study is aimed at investigating the effect of dumping site at the bank of river Yobe on the river water quality in north eastern part of Nigeria. The water samples were collected from four different points (P1, P2, P3 and P4) and were analysed for physicochemical parameters and some heavy metals. The pH of the water samples were found to be within the range of 6.47 ± 0.05 – 6.85 ± 0.13. The EC, Alkalinity, chloride, hardness, TDS and turbidity of the water samples were in the ranges of 2.12 ± 0.27 – 2.67 ± 0.35 ds/m; 67.23 ± 0.43 – 92.33 ± 0.58 mg/L; 0.73 ± 0.02 – 0.89 ± 0.08 mg/L; 26.67 ± 2.31 – 35.67 ± 0.58 mg/L; 1357 ± 1.08 – 1708 ± 1.99 mg/L and 2.23 ± 0.77 – 164.20 ± 0.32 FTU respectively. The study found out that in the water samples EC, TDS, Cr, Fe and Pb had higher values than the permissible limit set by NSDWQ. The findings of this research work proved that the samples collected were polluted by some the parameters under study and these may be attributed to the availability of metal-containing wastes at the dumpsite which leached into the underlying soil and the river water.

Keywords: Dumpsite, Heavy metals, River, Water, Waste, Pollution.

INTRODUCTION

Poor waste management poses a great challenge to the well-being of city residents, particularly those living adjacent to dumpsites due to the potential of the waste to pollute water, food, land, air and vegetation. The poor disposal and handling of waste thus leads to environmental degradation, destruction of the ecosystem and may cause great risks to public health. The resultant accumulation of waste poses a health hazard to urban and also threatens the surrounding environment (UNDP, 2006).

Pollution of water bodies with heavy metals from a variety of sources is a matter of global concern because many water resources have been rendered hazardous to man and other living systems as a result of indiscriminate dumping of refuse. Studies have shown municipal waste contain heavy metals which end up in soils and water as they are leached out of the dumpsite (Okoronkwo *et al.*, 2005; Bilos *et al.*,, 2001).

The contamination of surface water by heavy metals is a serious ecological problem as some of them like Hg and Pb are toxic even at low concentrations, are non-degradable and can bio-accumulate through food chain. Though some metals like Fe, Cu and Zn are essential micronutrients, they can be detrimental to the physiology of the living organisms at higher concentrations (Nair *et al.*, 2010; Kar *et al.*,, 2008). Rivers are the major source of surface water for drinking, domestic, irrigation and industrial purposes which are of tremendous benefits to humans. Monitoring of water quality of rivers regularly is quite necessary for the assessment of water quality for beneficial purposes (Ipeaiyeda and Obaje, 2017). Pollution of fresh water bodies, especially the rivers is no longer within safe limits for human consumption as well as aquatic fauna.

One of the major causes of river water pollution is the disposal of waste materials directly into the land surface or using the river bank as dumping site. Dumping of wastes into rivers and run-off from roads during the rainy season contributes largely to water pollution. Used chemical containers are most often carelessly dumped into the river, all these can cause serious damage to the aquatic environment and subsequent hazards to human health (Obaroh *et al.*, 2015), for example an estimated 2 million tons of sewage and other effluents are discharged into the world water every day (Azizullah *et al.*, 2011).

The concentrations of some heavy metals observed in Nigerian water bodies such as lead, copper, zinc, nickel, chromium, cadmium and iron had been reported to be well above acceptable and permissible levels (Essoka and Umaru, 2006).

The human activities that are ongoing around river Yobe are dumping of refuse, washing and rearing of animals are on the increase along the river bank. This study is aimed at determining the levels of the toxic metals and physical parameters in river water obtained from river Yobe in order to ascertain the portability of the water for human and animals use.

Description of the study area

The Yobe River, also known as the Komadougou Yobe or the Komadougou Yobe (French: *Komadougou Yobé*), is a river in West Africa that flows into Lake Chad through Nigeria and Niger.Its tributaries include the Hadejia River,the Jama'are River and the Komadugu Gana River. River Yobe is situated in the Sudan Sahel zone of the Northeast of Nigeria.

It covers a total area of 148,000km^2 (Appolinaire, 2012) and the river meets around Nguru-Gashua wetland area about 250km north of Damaturu, the Yobe State capital. The river is located in Gashua, Bade local government of Yobe State, the town lies near Nguru-Gashua wetland economic and ecological system (Badejo *et al.,* 2017).

Sampling Design

A systematic sampling technique (equal probability method) was used in selecting the sampling sites. The samples were gotten from four different locations including the control: near the dumpsite (river bank) P1, away from the dumpsite (50 m) P2, away from the dumpsite (> 100 m) P3 and the control (> 100 m away from P3) P4. The experimental design consist of 4 samples and 3 replicates.

Sample collection

About 1.0 litre of water sample were collected from River Yobe (in a clean plastic bottles) in triplicate from all sample sites. A total of 12 water samples were collected from 4 different locations into plastic containers, the samples were clearly labelled and dated.

Sample analysis

The physicochemical parameters of the water samples were determined. The pH and EC of the samples were determined using pH meter (PHS – 3C). Total hardness (TH), turbidity, chloride, total dissolve solid (TDS) and alkalinity were determined using LaMotte calorimeter. Samples of water, soil and plants were subjected to atomic absorption spectrophotometry (BUCK scientific AAS) for being analyzed for metals like Cr, Cu, Fe, Pb and Zn. The instrument setting and operational conditions were done in accordance with the manufacturer's specifications.

RESULTS AND DISCUSSIONS

Table 1: illustrates the physicochemical properties of River water samples in the sampling sites P1 - P4.

Parameter	Unit	P1	P2	P3	P4	NSDWQ
pH		6.47 ± 0.05	6.62 ± 0.14	6.85 ± 0.13	6.74 ± 1.51	6.5-8.5
EC	dS/m	2.50 ± 0.20	2.67 ± 0.35	2.43 ± 0.25	2.12. ± 0.27	1
Alkalinity	mg/L	91.67 ± 0.58	92.33 ± 0.58	79.33 ± 0.58	67.23 ± 0.43	500
Chloride	mg/L	0.89 ± 0.08	0.87 ± 0.03	0.73 ± 0.02	0.73 ± 0.12	250
Hardness	mg/L	32.33 ± 0.58	35.67 ± 0.58	27.67 ± 0.58	26.67 ± 2.31	150
TDS	mg/L	1600 ± 2.17	1708 ± 1.99	1555 ± 2.05	1357 ± 1.08	500
Turbidity	FTU	164.06 ± 1.00	164.20 ± 0.32	145.46 ± 15.20	2.23 ± 0.77	5

NSDWQ: Nigerian standard for drinking water quality, 554: 2007, TDS: Total dissolved solid, EC: Electrical conductivity, P1 - P4: Sampling sites 1 – 4.

Physicochemical parameters of the water

Table 1 shows the physicochemical parameters of the water samples from different sampling points. The test for pH of the water was carried out to determine whether it was acidic or alkaline in nature. A pH reading below 6.5 generally considered as being acidic may cause problems of heavy metal toxicity. The mean pH values obtained from the river were within the range of 6.47 – 6.85 for the four sampling locations. The pH values of samples fell within the acceptable range of Nigerian standard for drinking water quality NSDWQ, (2007) except P1 which is found to be slightly below the lower limits. The pH values of this study were in concordance with the findings of Badejo *et al.,* (2017), Nazir *et al.,* (2015) and Seiyaboh *et al.*, (2016) with the values of 7.49 – 7.66, 7.22 – 8.32 and 6.73 – 6.87 mg/L respectively. The obtained results indicate that the water sample from P1 is slightly acidic. Metals like Chromium and Zinc are most likely to have increased detrimental environmental effect as a result of pH lower than 6.5 (Davies *et al.,* 2005).

Electrical conductivity gives an idea about the concentration of electrolytes in water. Electrical conductivity (EC) which is a measure of water's ability to conduct an electrical current is related to the amount of dissolved mineral in water, but it does not give an indication of which element is present but the higher value of EC is a good indicator of the presence of contaminants such as sodium, potassium, chloride etc. The EC values of this study ranged from 2.12 - 2.67 dS/m. The value of EC confirmed to be above the recommended limit set by NSDWQ. The findings were in agreement with that reported by Nazir *et al.*, (2015) of 1.03 – 1.49 dS/m and Seiyaboh *et al.*, (2016) of 2.03 dS/m. In all the collected water samples the values of Alkalinity ranges from 67.23 - 92.33 mg/L and the values were also within the normal range of NSDWQ.

The chloride of the water samples were within the minimum standard set by NSDWQ of 250 mg/l. The obtained values range from 0.73 - 0.89 mg/L and less than the findings reported by Omotayo *et al.*, (2017) of 8.36 mg/L.

The hardness of water is defined as the measures of concentration of dissolved calcium and magnesium ions in water. The Hardness of water is a very important property of water and is very important for life processes. Hardness obtained in the samples ranged from 26.67 - 35.67 mg/L which is within the NSDWQ limits of 150 mg/L. These results were less than 216 – 245 mg/L reported by Rai (2012) and also less than 46.90 mg/L reported by Yisa and Jimoh (2010).

Turbidity is mostly caused by the presence of suspended particles such as clay, silt, finely divided organic and inorganic matters make water to become muddy. Also industrial waste and growth of algae may affect water turbidity. The turbidity value obtained from this research work ranges from 2.23 -164.20 FTU. Except P4 but all the values exceeded the NSDWQ of 5 FTU. This could be attributed to the presence of organic matter pollution, other effluents, run-off with a high suspended matter content and heavy rainfall (Yisa and Jimoh, 2010).

TDS represents the total concentration of dissolved substances in water. TDS is made up of inorganic salts, as well as a small amount of organic matter. Common inorganic salts that can be found in water include calcium, magnesium, potassium and sodium, which are all cation, and carbonates, nitrates, bicarbonates, chlorides and sulfates, which are all anions. The cation is positively charged ions and anions are negatively charged ions. The TDS values obtained in this study were between 1357 - 1708 mg/L. All the TDS values exceed the NSDWQ limit of 500 mg/L. The water samples having high TDS value cannot be used for drinking as well as construction purposes. The observed high concentration of TDS in the water samples is a pointer to the fact that there are intense anthropogenic activities along the course of the river and run-off with high suspended matter content (Anyanwu, 2015). When compared with other researches the findings are in agreement with what was reported by Yisa and Jimoh (2010) of 520 mg/L and 712.5 mg/L reported by Hong *et al.*, (2014) from river Benue water in Jimeta/Yola metropolitan, Adamawa State, North Eastern Nigeria.

Determination of heavy metals in river water

The figures below showed the distribution of heavy metals in river water obtained from the sampling sites P1 - P4.

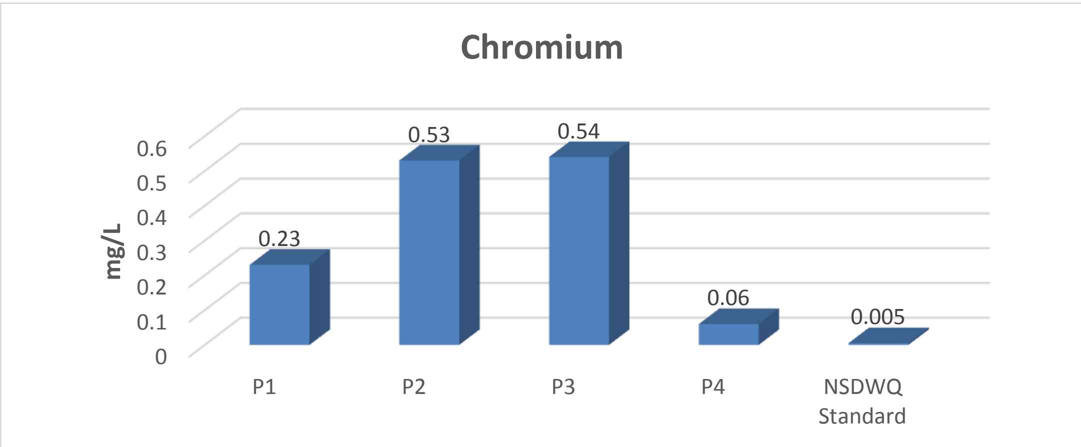

Figure 1: Chromium values obtain from river water at different sampling points and NSDWQ standard.

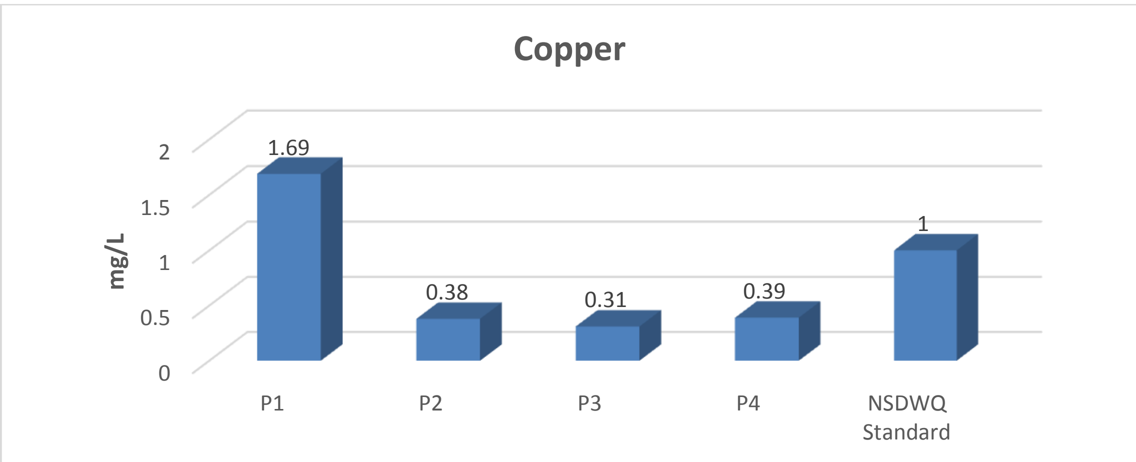

Figure 2: Copper values obtain from river water at different sampling points and NSDWQ standard.

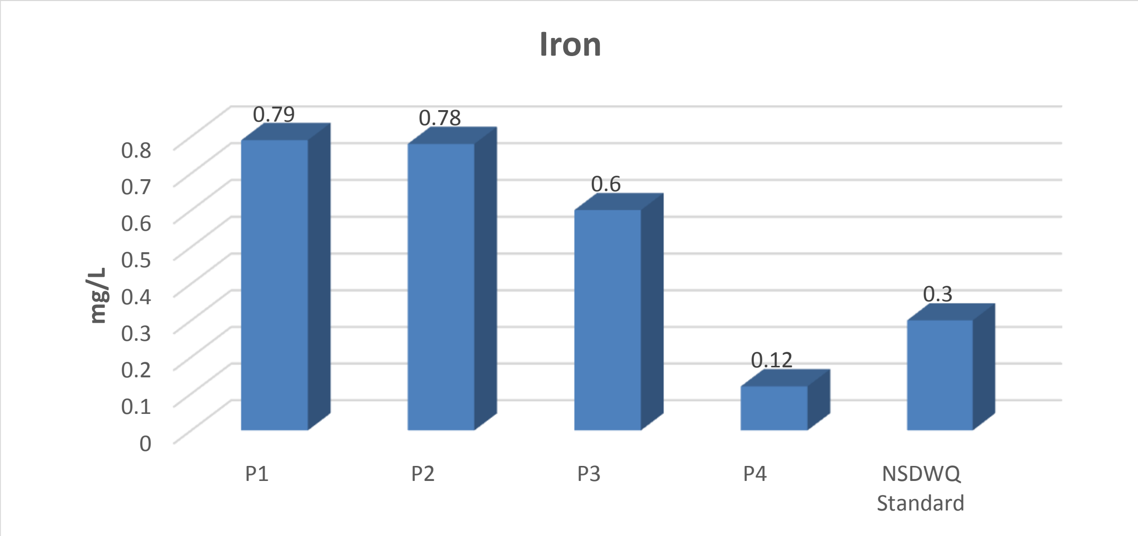

Figure 3: Iron values obtain from river water at different sampling points and NSDWQ standard.

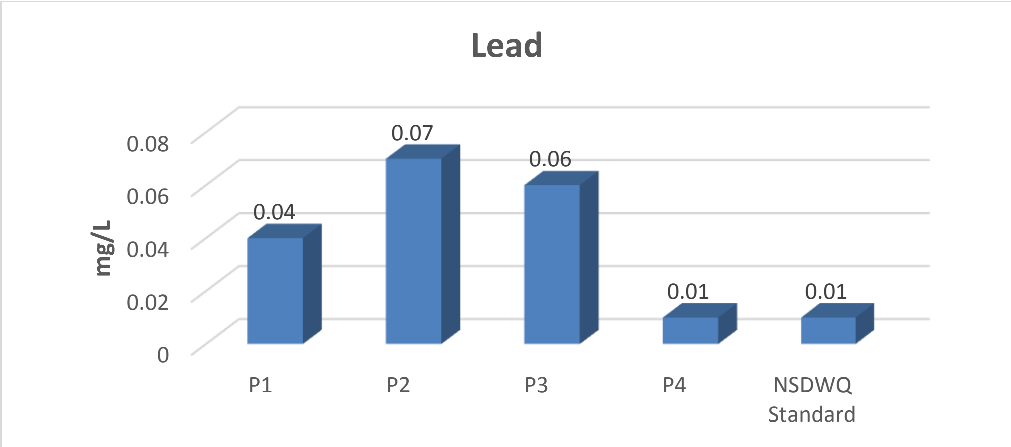

Figure 4: Lead values obtain from river water at different sampling points and NSDWQ standard.

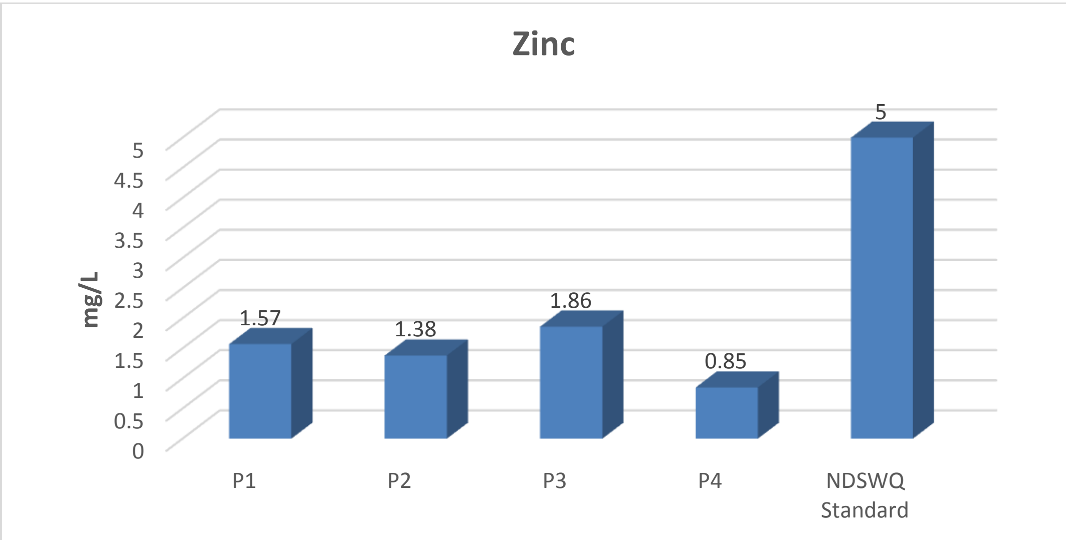

Figure 5: Zinc values obtain from river water at different sampling points and NSDWQ standard.

The concentrations of chromium in the water samples ranged from 0.06 to 0.54 mg/L which were higher than the 0.05 mg/L limit recommended by NSDWQ. Point 4, which is the control, has a minimum value of 0.06 mg/L which is slightly above the permissible limit. P3 and P2 have the highest values of 0.53 and 0.54 mg/L respectively and P1 had 0.23 mg/L. The results followed the order of P3 > P2 > P1 > P4. The values obtained constitute a health hazard as they were not within the NSDWQ permissible level. This may be from the chromium discharged into the environment through the disposal of wastes from industries like leather tanning and metallurgical, leading to contamination of river water and sediment. This must be removed from water because they are carcinogenic (Otukunefor and Biukwu, 2005). The results in the present study were in line with 0.14 mg/L reported by Omotayo *et al.*, (2017) and 0.32 mg/L reported by Yisa and Jimoh (2010) obtained from river Landzu, Bida, Niger State, Nigeria.

The NSDWQ permissible limit of Copper in water is 1 mg/L.

The concentrations of copper were between 0.31 - 1.69 mg/L with P3 having the lowest value of 0.31 mg/L, P2 and P4 having the values of 0.38 and 0.39 mg/L respectively. All the samples were below the NSDWQ standard except P1 which had the highest value of 1.69 mg/L and this may be attributed to the dumpsites which are very close to the point. The results followed the order of P1 > P4 > P2 > P3. The results obtained from this study agreed with the findings of 0.258 – 0.659 mg/L by Nazir *et al.*, (2015).

The concentration of iron in water samples varied from 0.12 to 0.79 mg/L. Except P4 which had 0.12 mg/L, all the other samples of water collected the results recorded were above the NSDWQ limits of 0.3 mg/L. The results agreed with 3.16 mg/L reported by Omotayo *et al.*, (2017) and 3.05 mg/L reported by Yisa and Jimoh (2010). The highest values recorded were from P1 0.79 mg/l, P2 0.78 and P3 0.60 mg/L. The results followed the order of P1 > P2 > P3 > P4. The concentration of lead in water samples ranged from 0.01 to 0.07 mg/L. In all the water samples the level of lead concentration were higher than the recommended limits of 0.01 mg/L set by NSDWQ, except P4 which had the same value with the standard.

The highest values of lead concentrations was in P2 (0.07 mg/L) and the lowest was found in P4 (0.01 mg/L). P1 and P3 had 0.04 and 0.06 mg/L respectively. Lead is one of the oldest metals known to man and is discharged in the surface water through paints, solders, pipes, building material, gasoline etc. Lead is also capable of disturbing the central nervous system. Children and pregnant women are most at risk of lead contamination.

The result of this study found to be in line with 1.16 mg/L reported by Akinbile and Yusoff (2011).

Zinc is one of the essential trace elements that play a vital role in the physiological and metabolic process of many organisms. But, higher absorptions of zinc can be toxic to the organism. The concentration of zinc in this study extended between 0.85 to 1.86 mg/L. According to NSDWQ the approved limit of zinc in drinking water is 5 mg/L. In all the samples collected the concentration of zinc were recorded below the permissible limit which also agreed with the result of 0.211 – 0.256 mg/L reported by Nazir *et al.*, (2015) and 1.3 mg/L reported by Akinbile and Yusoff (2011).

CONCLUSION

The results of the physicochemical parameters showed that pH, alkalinity, chloride and hardness were within the NSDWQ limit while EC was found above the standard. Except in site P4, TDS and turbidity were found to be above the allowable limit. High level of turbidity and TDS may be attributed to the presence of organic matter pollution, other effluents, run-off with a high suspended matter content and heavy rainfall (Yisa and Jimoh 2010). Toxic heavy metals are found naturally in the earth but they become concentrated as a result of human activities. Among the five heavy metals analyzed chromium and iron were found to be above the permissible limit while copper and zinc were observed to be above the acceptable limit as stipulated by NSDWQ, The high concentrations of some of the heavy metals observed during this study could be as a result of run-off during the rainy season in addition to leaching from household utensils and also human activities observed to be concentrated around the river banks, human activities observed along the river bank include, washing of vehicles, dumping of refuse and small cottage block making industry, thus posing a threat to human life and the aquatic organisms.

Human activities have been reported to be a contributing factor to high increase in heavy metal concentration of rivers (Obaroh *et al.,* 2012). Industrial and public education programs are required on awareness of health risks associated with heavy metals polluted waters. Conclusively, dumping of refuse should be prohibited along the river bank.

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