ASSESSMENT OF SOME PHYSICO-CHEMICAL PARAMETERS OF NUKKAI RIVER TRIBUTARIES, JALINGO, NIGERIA

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Abstract: This study aimed to assess the current status of physico-chemical characteristics of Nukkai River and its tributaries as it relates to human activities. Triplicate samples were collected from four sampling points. Triplicate samples were collected within two months (September and October, 2015) within the span of the rivers along the municipality. Physico-chemical and trace metal analyses of the samples were carried out using standard methods. The physico-chemical values recorded were within World Health Organization limits compared with drinking water standards of Nigeria Industrial Standard, (NIS 554:2007) for portability except Dissolved Oxygen (D.O), TDS along river Lamurde, and turbidity. The mean concentrations of the trace metals that include chromium (0.08 mg/l) and copper (0.0075 mg/l) in the surface water samples are well below WHO permissible limits for portability. The study shows that the river water may be suitable for drinking and other domestic purposes with treatment along the River Lamurde. The compromised water quality could be influenced by anthropogenic activities such as human activities which include laundry, bathing, irrigation farming and solid waste disposal by the riverside that has increased the concentration of pollutants in the samples with mostly (95.5%) of solid waste encountered to be recyclable. The quality of river water can be improved if monitoring authorities' step-up their activities.

Keywords: Anthropogenic, physico-chemical, quality, solid waste, standard, tributaries

Introduction

Water resources are of critical importance to both natural ecosystem and human development. The healthy aquatic ecosystem is dependent on the physico-chemical and biological characteristics (Venkatesharaju *et al*., 2010). The quality of water in any ecosystem provides significant information about the available resources for supporting life in that ecosystem (Thirupathaiah *et al.,* 2012). Rivers are open dynamic ecosystems whose physical and chemical properties are greatly influenced by anthropogenic activities taking place within their drainage basins (Mokaya *et al.,* 2004). A number of rivers and streams flow through urbanized areas across the world and are profoundly impacted by chances associated with urbanization (Bernhardt and Palmer, 2007).

In many metropolitan cities, open, uncontrolled and poorly managed dumping is commonly practiced, giving rise to serious environmental degradation (Ramaiah *et al.,* 2014). Nearly all human activities generate waste, and the way in which this is handled, stored, collected and disposed off, can pose risks to the environment and to public health (Zhu *et al.,* 2008). It is estimated that between one-third to one-half of solid waste generated in most towns in low and middle-income countries is left uncollected due to lack of capacity (Xiao *et al.,* 2006) and usually ends up as illegal dumps on streets and open spaces, thus polluting the nearby water bodies (UNEP, 2002; UN-Habitat, 2008). Excessive loading of domestic waste into rivers can alter the physical, chemical and biological characteristics of the aquatic system beyond their natural self-purification capacity. Higher levels of turbidity, nutrients, suspended and dissolved solids as well as coliform bacteria in rivers are all indicative of compromised system attributed to increased pollutant load, resulting largely from anthropogenic activities (Adams and Papa, 2000).

Virtually all urban centers in Nigeria are bedeviled by problems of waste management including Jalingo, and are characterized by non-existent recycling facilities and sewage treatment plants, poor urban planning, haphazard waste dumping, limited amenities and poor sanitation is no exception. The two tributaries of Nukkai River; Emir Palace River and Mayo-Gwoi River which passes through the metropolis provides a major source of water and drainage for industrial, domestic and agricultural wastes.

Materials and Methods

Study area

The city of Jalingo (centre of Muri Emirate) is located between latitude 8°47' to 9°01'N and longitude 11°09' to 11°30'E. It is bounded to the north by Lau Local Government Area (LGA), to the East by Yorro L.G.A, to the south and west by Ardo-Kola LGA (Fig. 1). It has a total land area of about 195.071 km^2. Jalingo L.G.A has a population of 139,845 people according to the 2006 population census, with a projected growth rate of 3% (Oruonye and Abbas, 2010; Tsunatu and Abdullahi, 2013). Presently, it has a projected population (2015) of 167,548 based on the 2006 population census figure of 139, 845 at 2.83% annual growth rate. Solid waste management is administered through city cleansing section department of Environmental Health Service, which is a subsection of the Taraba State Ministry of Environmental and Urban Development (ME & UD). The elevation rises from 1,351 to 1,550 m above mean sea level; the area is well drain by ephemeral rivers and streams which gather most of the runoff from the hills. The drainage system exhibits a dentritic drainage pattern and it is dominated by the River Lamurde which flows from northwest to southeast of the town (Fig. 1).

Sample design

This study was carried out in October, 2015 along Nukkai River and it two tributaries; Mayo-Gwoi River and Emir Palace River (Lamurde). Three major sites 1, 2 and 3 on the main Nukkai River, (NR), (each site about 100 metres apart) were chosen and four samples were collected from each respective site. The same was carried out for the two Tributaries, Emirs Palace River, (ER) and Mayo-Gwoi River, (MR). At the respective sites, solid wastes deposited along the stretch of the river bank were collected and analysed at the point of their disposal, and characterized by hand sorting based on their characteristics (Tsunatu and Abdullahi, 2013). The physico-chemical parameters were determined using standard methods (WHO, 1999). The water samples were collected in plastic bottles of 1 Litre capacity on the main river and its two tributaries and were well stoppered. The samples thus collected were transported to the laboratory by observing all precautions laid down in the standard methods (BIS – 10500:1991)

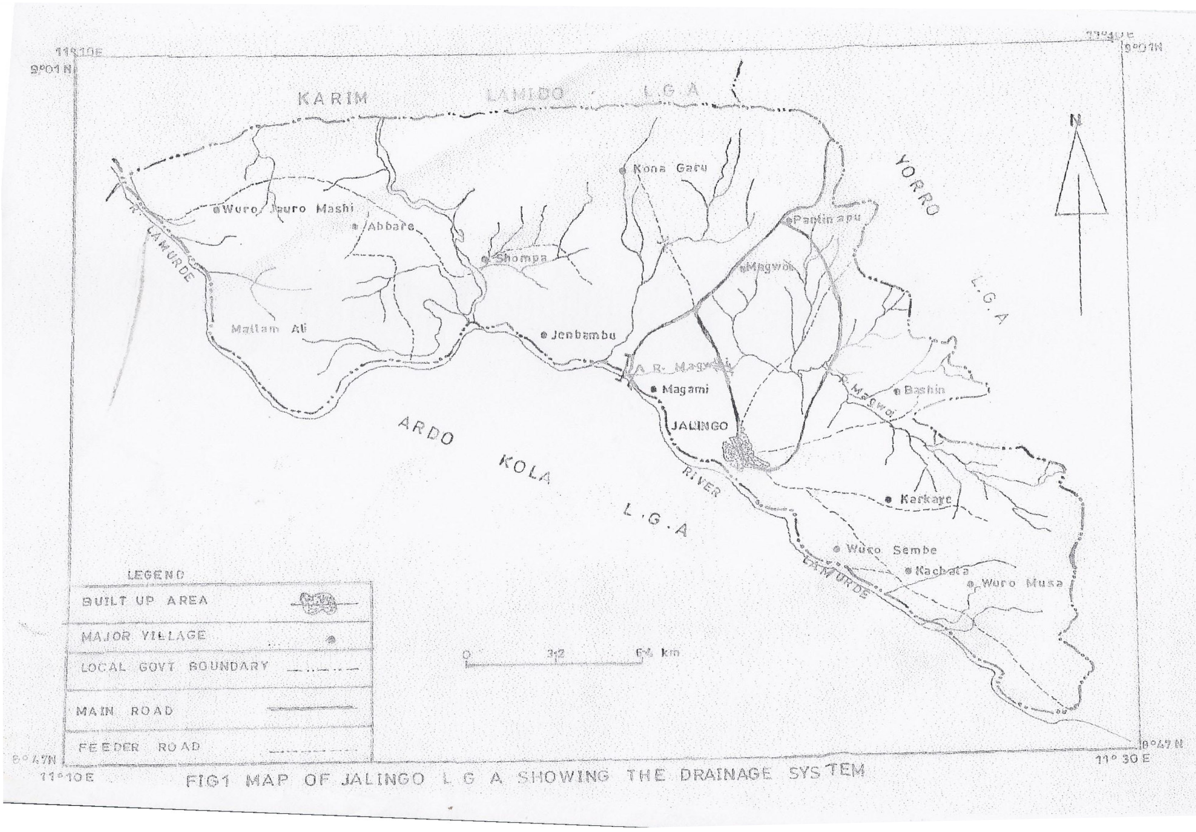

Fig. 1: Topographic map of Jalingo Metropolis showing drainage system

Results and Discussion

Anthropogenic activities

From the three rivers chosen for this research work, at the point of sampling, observation shows that, there were various activities being embarked upon especially along the river bank which is a little bit urbanized with high impact. Among these activities washing, fetching of water by inhabitants for domestic and commercial purposes along River Nukkai and Lamurde, bathing, swimming, irrigation agriculture and collection of sand for building e.t.c, are all seen along the river banks as shown in Figure 2 and 3.

Fig. 2: Anthropogenic activities along River Nukkai

Fig. 3: Anthropogenic activities along Lamurde River

Solid waste disposal

During the study, it was observed that, the composition of solid waste along the three river banks (NR, ER and MR) has 53% wooden materials (saw dust) along Nukkai River due the siting of Timber Shed close to the river, 25% leather along Lamurde (Emir) river with no waste deposit along Mayo-gwoi river bank within the span of the study site. From Fig. 4 and 5, it clearly shows that, the solid wastes along the two river banks have an appreciable amount of biodegradable materials. The percentage of non-biodegradable materials like leather, metals, rubber, and plastics is appreciably high with good opportunity for recyclable materials.

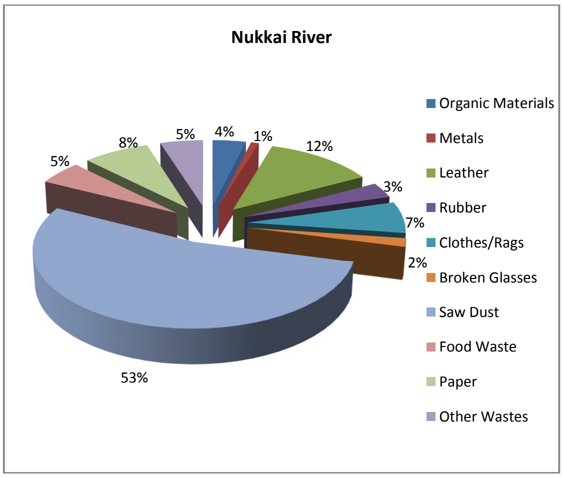

Fig. 4: Percentage composition of solid waste deposited along Nukkai River

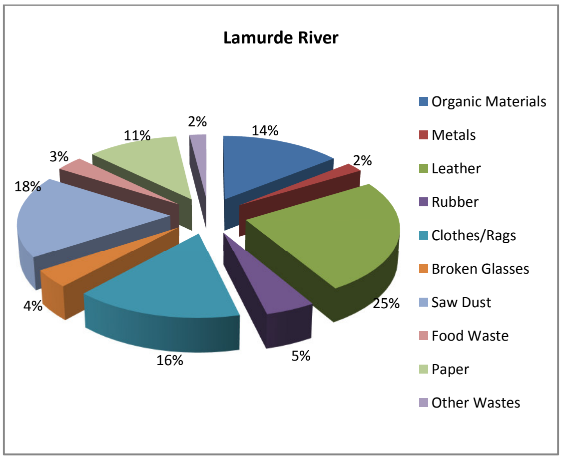

Fig. 5: Percentage composition of solid waste deposited along Lamurde River

Physico-chemical parameters for the surface water at the three rivers

The result obtained for the physico-chemical analysis of the samples collected from the three (3) rivers at the selected locations and the sites were presented in Table 1 and Fig. 6 – 18. From Table 1, the variation of pH for all the waste water samples were between the range of 4.60 to 6.80 which by implication are lower than World Health Organization standards as shown in Fig. 6. Dissolved Oxygen (D.O) levels ranged between 3.80 mg/L to 7.30 mg/L for the three rivers, Fig. 7 shows that, the values are above WHO standard. The temperature of the surface water from the three sources varied from 27 to 32^{o}C as depicted in Fig. 8.

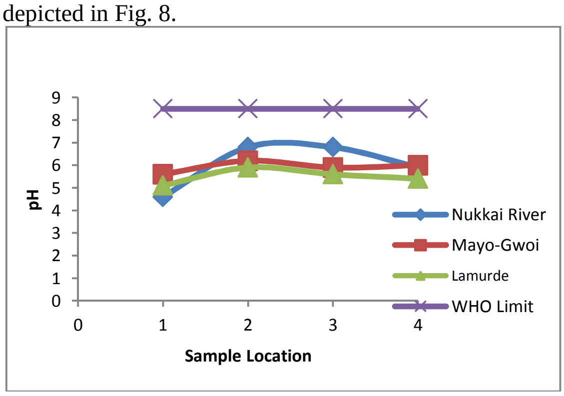

Fig. 6: Variation of pH along the three rivers

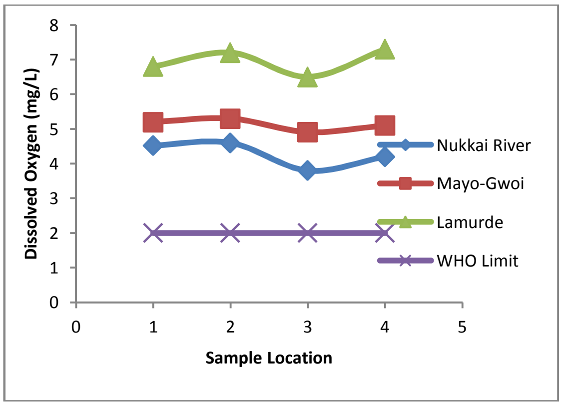

Fig. 7: Variation of Dissolved Oxygen (D.O) along the three rivers

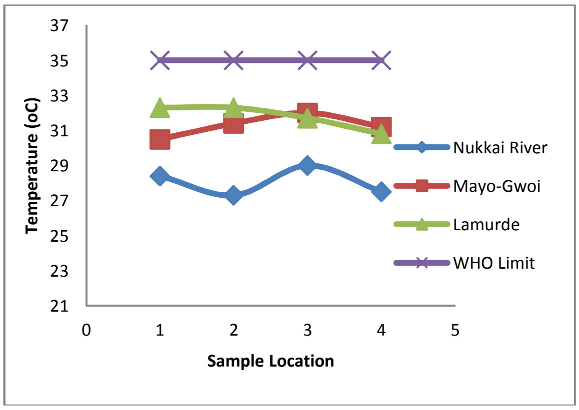

Fig. 8: Variation of temperature along the three rivers

Figure 9 shows the variations of Total Dissolved Solid (TDS). It was observed that the value varied from 357 to 731 mg/L, which is far above the acceptable limits of surface water (300 mg/L). The highest value was obtained at Lamurde River, and this is as a result of refuse dumped by the river bank and a lot of domestic washing and other activities which can be seen in Fig. 10. With high concentration, it may decrease the suitability for drinking and may cause gastrointestinal problems and laxative to the nearby inhibitants (WHO, 1997).

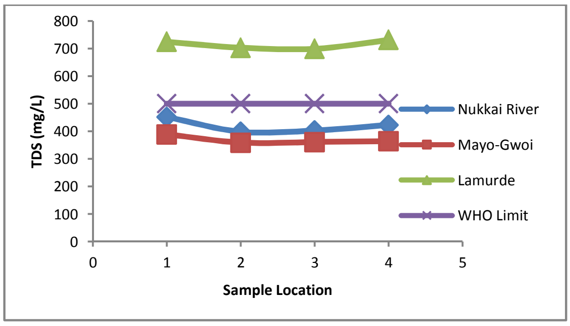

Fig. 9: Variation of TDS along the three rivers

Fig. 10: Refuse Dumping along River Lamurde within Jalingo Metropolis

Turbidity values ranges from 117.42 to 163.84 NTU for the three rivers within Jalingo Metropolis. From Fig. 11, one can depict that the values exceeded the allowable turbidity limits of between 5-10 NTU (WHO, 2004). The resultant high values may be attributed to the fact that, most of the sample sites were located within the highly turbulence regions within the urbanized section of the town due to silt, clay and other suspended particles which may contribute to the high values as the samples were collected during the wet season. Hardness of water mainly depends upon the amount of magnesium (Mg^{2+}) or calcium (Ca^{2+}) salts or both. The total hardness values of the present study area ranges from 130.14 to 245.16 mg/L as shown in Fig. 12. This total hardness was obtained based on calcium hardness which is slightly higher than the acceptable limits of World Health Organization. Also, the hardness may be attributed mainly to indiscriminate dumping or disposal of Municipal Solid Wastes (MSW) along the river bank especially along river Lamurde, depicted in Fig. 10.

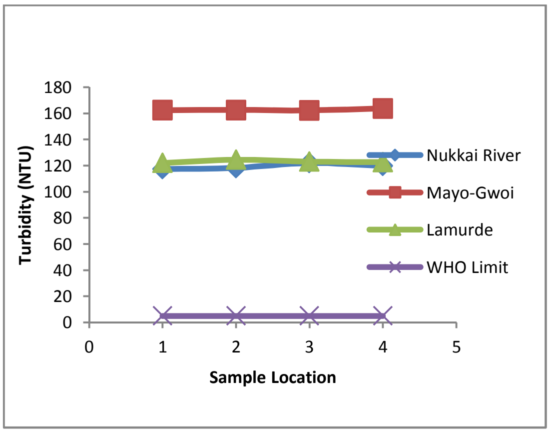

Fig. 11: Variation of turbidity along the three rivers

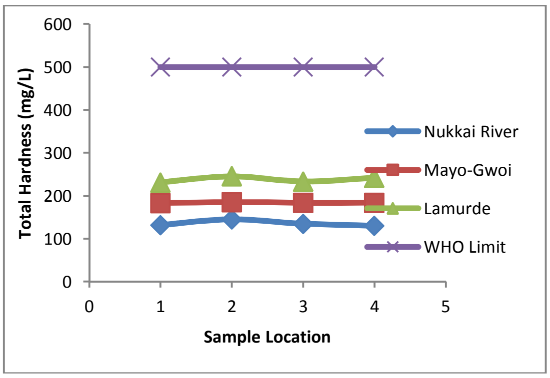

Fig. 12: Variation of total hardness along the three rivers

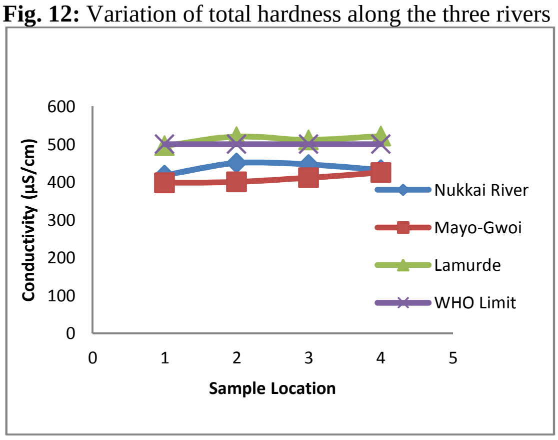

Fig. 13: Variation of conductivity along the three rivers

The conductivity is a good measure of salinity hazard to crops; excess salinity reduces the osmotic activity of plant and thus interferes with the absorption of water and nutrients from the soil (Saleh *et al.*, 1999). The conductivity values ranged from 398 to 521 µS/cm with mean value of 452.33 µS/cm as shown in Fig. 13. The values are within the range that supports good quality water for irrigation practice (Vasanthavigar *et al.*, 2010). Free cyanide (CN^{-}) from the water samples ranged from 0.10 to 0.21 mg/L with the highest value discovered at Nukkai river which is slightly above the recommended limit of 0.2 mg/L of WHO (1984). Chloride concentration ranged from 38.16 to 132.15 mg/L with a mean value of 71.03 mg/L which is below the recommended limit of WHO (2012). Sulphate varies from 20.00 to 29.15 mg/L with mean value of 23.13 mg/L, which is within the acceptable limit of 250 mg/L of WHO (2012). Heavy metals such as chromium and copper and other ions were determined and found to be present in the rivers under study; the results are presented in Figure 14 – 18.

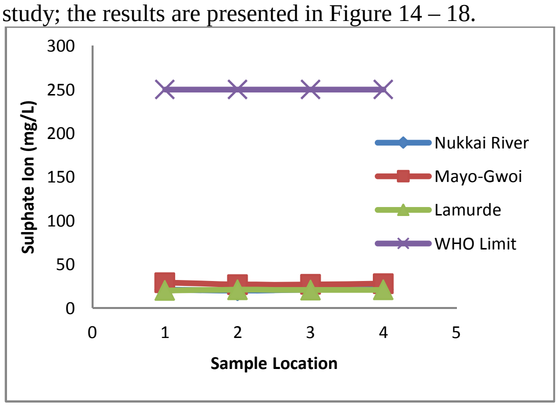

Fig. 14: Variation of sulphate ion concentrations along the three rivers

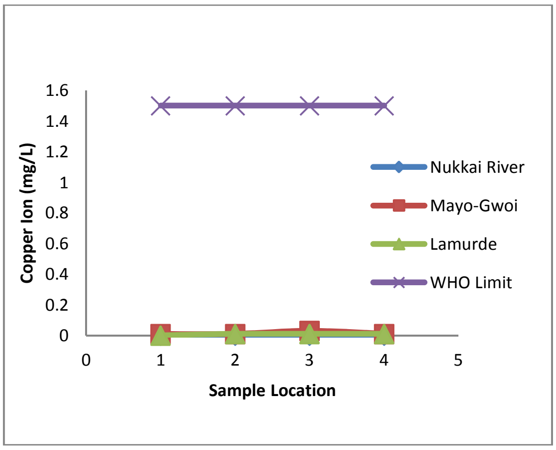

Fig. 15: Variation of copper ion concentrations along the three rivers

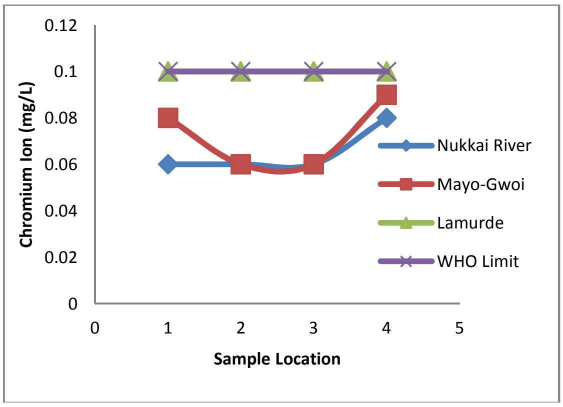

Fig. 16: Variation of chromium ion concentrations along the three rivers

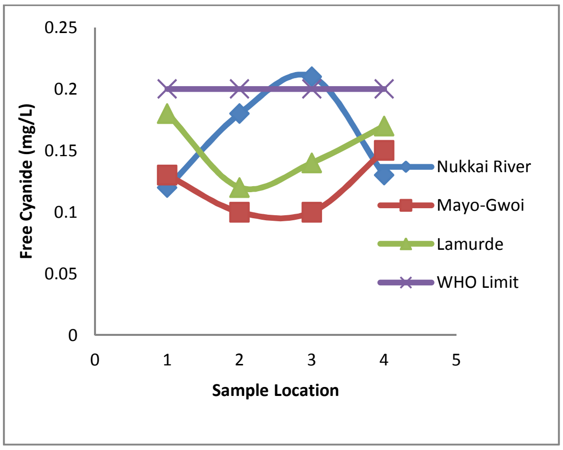

Fig. 17: Variation of free cyanide ion concentrations along the three rivers

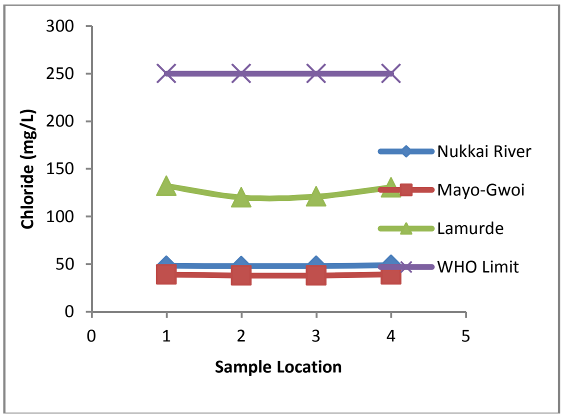

Fig. 18: Variation of chloride ion concentrations along the three rivers

Water for industrial usage is expected to be odourless, colourless, and free from micro-organism and suspended particles with low concentrations of metallic contents (Okafor and Adamu, 1994). Table 1 shows that, chromium and copper concentrations ranges from 0.06 to 0.10 mg/L and 0.00 to 0.03 mg/L, respectively. Based on these data, about 97.30% of the water samples show low concentrations of chromium and copper ions. Also, total hardness ranges from 130.14 to 245.16 mg/L with an average of 185.79 mg/L. Based on the above, hardness classification of water by Vasanthavigar (2010), all water samples are classified by soft water, so the water is suitable for industrial usage and irrigation agriculture, which is evidenced by series of irrigation farming along Nukkai and Lamurde river banks.

Table 1: Summary of surface water quality for the three rivers within Jalingo metropolis

Parameter	Minimum	Maximum	Mean	Standard Deviation	WHO (2012)
Temperature (^oC)	27.3	32.3	30.37	1.84	30 – 35
pH	4.6	6.8	5.82	0.63	6.5 – 8.5
DO (mg/L)	3.80	7.30	5.45	1.20	2.00***
TDS (mg/L)	357	731	500.33	160.23	500
Turbidity (NTU)*	117.42	163.84	135.07	20.57	5.00
Total Hardness (mg/L)	130.14	245.16	185.77	43.94	500
Chloride (mg/L)	38.16	132.15	71.03	40.91	250
Conductivity (μS/cm)	398	521	452.33	47.12	500
Free Cyanide (mg/L)	0.10	0.21	0.14	0.03	0.2**
Chromium (mg/L)	0.06	0.10	0.08	0.02	0.1
Copper (mg/L)	0.00	0.03	0.0075	0.01	1.5
Sulphate (mg/L)	20.00	29.15	23.13	3.53	250

* NTU (Nephelometric Turbidity Unit); ** WHO (1984); *** Nigerian Drinking Water Standard (2007)

Table 2: Correlation coefficient (R) among physico-chemical parameters of the three rivers within Jalingo metropolis

	Temp	pH	D.O	TDS	Turbidity	Total Hardness	Chloride	Conductivity	Free Cyanide	Chromium	Copper	Sulphate
Temperature	1.00											
pH	-0.25	1.00										
Dissolved Oxygen	0.71	-0.40	1.00									
TDS	0.45	-0.44	0.88	1.00								
Turbidity	0.44	0.13	-0.13	-0.55	1.00							
Total Hardness	0.84	-0.30	0.97	0.79	0.05	1.00						
Chloride	0.48	-0.38	0.89	0.99	-0.52	0.82	1.00					
Conductivity	0.33	-0.16	0.79	0.94	-0.62	0.72	0.95	1.00				
Free Cyanide	-0.28	0.31	-0.04	0.22	-0.50	-0.07	0.26	0.38	1.00			
Chromium	0.51	-0.40	0.85	0.87	-0.27	0.82	0.87	0.80	0.13	1.00		
Copper	0.60	0.01	0.20	-0.12	0.66	0.36	-0.09	-0.14	-0.57	-0.03	1.00	
Sulphate	0.31	0.08	-0.23	-0.61	0.98	-0.07	-0.60	-0.70	-0.51	-0.30	0.59	1.00

Conclusion

From the present study, it was concluded that, the assessment of water quality index on the three rivers within Jalingo Metropolis was carried out. It is evident that the Lamurde and Nukkai rivers are highly affected by increased anthropogenic activities along the river banks, hence contributing to release of waste discharged into the water body, thereby degrading the water quality. It was found that some parameters like Dissolved Oxygen (DO), TDS of Lamurde, Turbidity, Conductivity of Lamurde, and Free Cyanide of Nukkai are slightly above the acceptable limits of WHO Standard for drinking water. The higher value of TDS in Lamurde River is as a result of large quantity of solid waste deposited along the river bank while that of Free Cyanide along river Nukkai may be due to the presence of cassava plantations along the river bank and some related anthropogenic activities. These compromised decreases in water quality not only inhibits important ecological processes such as natural bioremediation of the rivers but also puts the health of the residents depending on waters at increased risk of water borne diseases. The physico-chemical characteristics of the river water suggested that their usage will not harm pisciculture, irrigation and domestic activities.

Conflict of Interest

The authors declare that they have no conflict of interest.

References

Adams BJ & Papa F 2000. Urban Storm Water Management Planning with Analytical Probabilistic Models. Wiley, Toronto, Ontario, Canada

Bernhardt ES & Palmer MA 2007. Restoring Streams in an Urbanizing World. *Fresh Water Biology*, 52: 738-751.

Mokaya SK, Mathooko JM & Leichtfried M 2004. Influence of anthropogenic activities of water quality of a tropical stream ecosystem, *Afr. J. Ecol.* 42: 281-288.

NIS 2007. *Nigerian Standard for Drinking Water Quality*. Nigeria Industrial Standard, 554, 14.

Okafor DU & Adamu EA 1994. Aspect of the geology and hydrogeology of the river bakoji catchments areas of Niger State, Nigeria. *J. Min. Geo.*, 2: 9.

Oruonye ED & Abbas B 2011. The Geography of Taraba State, Nigeria. LAP Publishing Company, Germany.

Saleh A, Al-Ruwait F & Shehata M 1999. Hydrogeochemical processes operating within the main aquifers of Kuwait. *J. Arid & Envt.*, 42: 195-209.

Thirupathaiah M, Samatha C & Sammaiah C 2012. Analysis of water quality using physico-chemical parameters in lower manair reservior of Karimnagar District, Andhra Pradesh. *Int. J. Envtal. Sci.*, 3(1): 172-180.

Tsunatu DY & Abdullahi AM 2013. Municipal solid waste and pollution management in Jalingo metropolis: Problems, challenges and strategies. *J. Envt. Scientific J.*, 2(5): 125 – 133.

UNEP 2002. *Global Environment Outlook 3: Past, Present and Future Perspectives*. United Nations Environment Programme, Earthscan, London.

UN-Habitat 2008. The State of the World's Cities 2008/2009, UN-Habitat, Nairobi.

Vasanthavigar MKS, Gantha RR, Vijayaraghavan K & Sarma VS 2010. Characterization and Quality Assessment of Groundwater with Special Emphasis on Irrigation Utility.

Venkatesharaju K, Ravikumar P & Somashekar RK 2010. Physico-chemical and bacteriological investigation on the River Cauvery of Kollegal Stretch in Karnataka. *J. Sci. Engin. & Techn.*, 6(1): 50 – 59.

WHO 1999. *Guidelines for Drinking Water Supply Quality* (2nd edn.), Vol. 2. World Health Organization, Geneva.

WHO 2004. *Guidelines for Drinking Water Quality: Recommendations, Vol. 1*. World Health Organization, Geneva.

WHO 2012. *Guidelines for Drinking Water Quality*. World Health Organization, Geneva.

WHO1984. Cyanide. In: *Guidelines for Drinking Water Quality. Vol. 2.* Health Creteria and Other Supporting Information; World Health Organization, Geneva, p. 97.

Xiao Q, McPherson EG, Simpson JR & Ustin SL 2006. Hydrologic processes at the urban residential scale. *Hydrological Processes*, 21(16): 2174 – 2188.