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Research Article

The Physicochemical Characteristics of Ibiekuma River Ekpoma, Nigeria

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Abstract

The Ibiekuma River is an important source of livelihood to its catchment. It contributes enormously to research success and living standard of students and staffs of the Ambrose Alli University Ekpoma, Nigeria. The aim of the study was to determine the impact of anthropogenic activities on the physicochemical properties of Ibiekuma River. Twenty seven water samples were collected at four stations during the study period and analyzed accordingly. The results obtained shows that the physicochemical parameters of the river were in conformity with the World Health Organization (WHO), National Agency for Food, Drug Administration and Control (NAFDAC) and Nigerian Industrial Standard (NIS) safe limits, except for *p*H values which ranged from 4.69 to 4.81. The heavy metal concentrations were found to be within the limit of the guidelines prescribed by WHO and NAFDAC. Also, there was no significant difference ($P > 0.05$) in the concentrations of the physicochemical parameters across the four stations sampled along the Ibiekuma River. Water obtained from Ibiekuma River will be fit for domestic use, only if purified.

***Key words**: Ibiekuma River, Physicochemical, Pollution, Nigeria*

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INTRODUCTION

Water is one of the most precious natural resources that exist on our planet. Its requirement for use domestically, agriculturally and industrially, especially in transportation of goods and services and production of hydroelectricity (GESAMP 1988), has improved the standard of living and local economy of many communities and nations of the world. Even though, all forms of water uses, contribute specific impact on water quality (Ajayi and Osibanjo 1981; Kings 1998), the provision of safe drinking water, free from both microbiological and chemical contaminants, is an essential demand for protecting public health (Gray 2008; Parathaman 2010). Water plays important roles in supporting human life and biodiversity; it also possesses great potential for transmitting diseases especially when contaminated, also, the assurance of drinking-water safety is a foundation for the prevention and control of water-borne diseases. Hence, the quality of water is a powerful environmental determinant of health status.

Unfortunately, man in his ambivalent relationship with water has treated it with more contempt than respect. The socio-economic implications of water mismanagement are costly and avoidable (Orimoogunje 2010); as unsustainanble use could lead to degradation of water quality (Ajayi and Osibanjo 1981; Kings 1998). Besides the high demand for water, the rapid depreciation of water worldwide is exacerbated by the increasing human population, urbanization and industrial activities (Ajaiye and Adeleye 1977; Dike *et al.* 2004; Igbinosa and Okoh 2009). Water pollution heightens the threshold of heavy metals and this usually poses serious threat to human health, natural and semi-natural ecosystems (Gopal and Sharma 1990; Fan 1996; Battagglia *et al*. 2005). Non-essential heavy metal such as lead (Pb) and cadmium (Cd) are emitted and globally distributed mainly through industry, road traffic and fossil fuels consumption; and their effects on animals' health have been clearly established. For example, lead poisoning and high lead exposure in humans and animals have been a concern for more than a century (Grinnell 1894; Wayland *et al.* 1999). Cadmium has been described as one of the most dangerous trace elements in food and the environment, not only for its high toxicity but for its high persistence in the environment (Battagglia *et al.* 2005). Although, other heavy metals, including zinc (Zn), iron (Fe) are essentially required for supporting biological processes, their environmental concentration beyond the acceptable limit constitutes serious toxicological problems (Pérez-López 2006). It has been ascertained that human-related inputs are generally more significant than natural sources in their biogeochemical cycles.

Ibiekuma River is important for recreation, domestic water supply, transportation and agricultural purposes particularly cassava processing for the production of cassava flour and other products. The academic research pursuit of some personnel and students welfare of the Ambrose Alli University Ekpoma depends on it. As a precautionary measure, we hypothesized that River Ibiekuma was subjected to pollutants of concern to human health. Thus, the acute societal and global need to monitor the quality and characteristics of water bodies, upon which many rural and urban communities depend for survival, cannot be neglected.

This study determined the impact of anthropogenic activities on the physicochemical properties of Ibiekuma River It is expected that the findings of this research work will assist in the understanding of the water quality parameter of Ibiekuma River and how the water resource could be managed sustainably.

MATERIAL AND METHODS

Study Area

The study was conducted on Ibiekuma River at Ebute village about 10 km from Ambrose Alli University Ekpoma, Nigeria (06˚ 44΄N, 06˚ 07΄E). The River flows in the direction of south-east through several communities among which are Abudu, Egono, Ologbo and several communities in Uhunmwode Local Government Area in Edo State. The embankment and general vicinity at the points of study comprise of bamboo plants, raffia palms, palm trees, coconut trees, rubber trees and banana plants. Aquatic plants such as water lettuce *Pistia stratiotes*, water lily *Nymphaea lotus*, sessile joy weed *Alternanjera sessile*, and *Ponotodon pentandru* are also common at the bank. The topography of the area seems to influence variation in the velocity of flow.

Sampling Stations

Four stations A, B, C and D were chosen along the river course based on disturbance level. Station A (the upper course) constitutes the stream point of origin. The width and depth were 6.0 m and 1.5 m respectively. Due to lack of frequent accessibility, station A was considerably chosen as undisturbed while the others: B, C and D were regarded as disturbed. Station B (the zone with the highest human impact) was devoid of trees and the busy nature of this station warranted the construction of hunts and other relaxation structures. Commercial tanker operators with their water-lifting machines alongside cassava (*Manihot esculenta*) processing activities for flour production by indigenous people were common activities around this station. Therefore, the likelihood of hydrogen cyanide (a toxic compound from cassava) and hydrocarbon (by-products of petroleum products) pollutants was high, and of importance to the study. The width and depth of the river at this station were 7.3 m and 1.0 m respectively. Station C equally witness frequent disturbance, however, its level of disturbance was less than station B. The vegetation at this area was dense; the surrounding landmass was waterlogged and slippery. Station D had similar levels of disturbance with station C and only differs in width. Similar organisms found in other stations were also present here. The width and depth of the river at this point were 7.9 m and 0.66 m respectively. The distances between sampling stations were 45 m (station A to B), 75.8 m (station B to C), and 30.5 m (station C to D). Therefore, water sampling was over a length of 160.3 m along the water course.

Collection of water samples

Water samples were collected once in every two weeks on three occasions. All samples were collected at the same time of the day. The sampling was in the dry season, since disturbance was usually at its peak during this period. The shoreline sampling procedure described by Milne (1989) was adopted for collection of water samples. Sampling jars were thoroughly washed with detergent, rinsed with distilled water before soaking in 5% HNO_3 for 24hours. Thereafter, they were rinsed with distilled water before being used for sampling. Twelve samples were collected for the analysis of biological oxygen demand (BOD) and another 12, for the measurement of physicochemical parameters, while three samples were collected for the analysis of heavy metals on three sampling occasions (i.e. a total of 27 samples were collected from the four stations). Samples were collected using sterile 250 ml Winchester bottles. Samples for BOD determination were fixed accordingly using Winkler's reagent. Labeled samples were appropriately stored in a portable cooler after collection on sampling days, before transportation to the Laboratory.

Physico-chemical parameters determination

Water samples for physicochemical analyses were collected directly into clean 1-litre plastic bottles. Temperature and *p*H were measured *in situ*, using mercury-in-glass thermometer and portable *p*H meter, respectively. For dissolved oxygen (DO) determinations in the laboratory, separate samples were collected into plain glass bottles and the DO fixed, using the Azide modification of the Winkler's method (for rationale, see APHA 1998). Samples for biochemical oxygen demand (BOD) were collected into dark painted glass bottles and were incubated at 20 ºC for 5 days before the remaining DO determined. All samples were stored in cold boxes and, on return to the laboratory, tested for physicochemical constituents. Physico-chemical parameters determined at the sites and on collected water samples formed the basis of assessing the quality of the water. The laboratory analyses were undertaken according to procedures outlined in the *Standard Methods for the Examination of Water and Wastewater* (for rationale, see APHA 1998) and EDTA Titrations standard methods. The velocity was determined on the site using the following materials, a light tennis ball, steel tape rule, stops watch and a pair of pegs. Two points A and B were chosen along the course of the river at each station. The pegs were fixed firmly at these points so that the distance between the points was measure using the tape rule, the light tennis ball was then released at a point A and the time taken to reach point B was recorded using the stop watch. This process was repeated twice and the average velocity was calculated. Velocity was calculated as follows.

$$\text{Velocity, V} = \frac{\textbf{Distance}}{\textbf{Time Taken}}\ (\text{ms}^{-1})$$

The concentrations of heavy metal were determined using the Atomic Absorption Photo-spectrometer named Buck Scientific (model 210VGP). All analysis, except as otherwise stated in the test were conducted at the Edo State Environmental Laboratory, Palm House Annex, Sapele Road, Benin City, Nigeria.

RESULTS AND DISCUSSION

The results show variations of the physicochemical parameters of the water samples (Table 1). The highest mean of *p*H values recorded during the period of study was 4.81 (station A), while station C had the lowest *p*H values of 4.69. Both stations A and B had same temperature values of 25^{o}C whereas stations C and D had a temperature of 24^{o}C. There was a significant correlation between temperature and BOD (R^2 = 0.752; p = 0.01). The velocities of flow were 0.14 ms^{-1}, 0.41 ms^{-1}, 0.37 ms^{-1} and 0.48 ms^{-1} for station A, B, C and D respectively. Conductivity was observed to have uniform values of 0.018µScm^{-1} across the four stations. However, turbidity was highest at station C (5.3 NTU) but lower at other stations. No coefficient of variability (CV) was found at 0.0 NTU of turbidity. Salinity recorded were 0.00‰, 0.00‰, 0.01‰ and 0.01‰ for stations A, B, C and D respectively. For total hardness, highest mean of 27.2 mg/l with a CV of 0.95% was recorded at station D. The lowest was 9.20 mg/l at station B. Alkalinity range from 27.3 mg/l to 30.7 mg/l. Total Dissolved Solids (TDS) mean range from 8.30 mg/l to 9.8 mg/l while that of TSS was from 0.00 mg/l to 0.006 mg/l. Total Hardness was higher in station D with a value of 27.2 mg/l. BOD has a range of 2.70 mg/l to 3.80 mg/l. Calcium level ranged from 0.01 mg/l to 0.07 mg/l while magnesium ranged from 0.00 mg/l to 0.07 mg/l. Maximum mean value of 1.47 mg/l was recorded for phosphate at station C while a minimum of 0.00 mg/l was recorded at station A. Nitrate values ranged from 0.10 mg/l to 23.0 mg/l while that of nitrite ranged from 0.011 mg/l to 0.0027 mg/l. There was no observed significant difference in the physicochemical parameters between the four stations (Kruskal-Wallis H, X^2 =1.068, df = 3, p = 0.785). Heavy metals also showed no significant difference (Kruskal-Wallis H, X^2 = 0.930, df = 2, p = 0.930) with respect to sampling occasions.

Table 1 Means of concentration and coefficient of variability (CV) of the physicochemical parameters obtained from Ibiekuma River, Edo State Nigeria

Parameters	Station A		Station B		Station C		Station D	
	Mean	CV	Mean	CV	Mean	CV	Mean	CV
*p*H	4.81	0	4.73	0	4.69	0	4.71	0
Conductivity (µScm^1)	0.018	3.5	0.017	4.16	0.018	5.6	0.018	3.92
Turbidity (NTU)	3	0	0	0	5.3	10.99	0	0
Salinity ($^0/_{00}$)	0	0	0	0	0.01	47.12	0.01	0
Total Alkalinity (mg/l)	30.7	1.89	27.3	2.12	28.7	2.02	27.7	2.09
Total Dissolved Solids (mg/l)	9.3	6.22	9.8	3	8.97	0.52	8.3	6.97
Total Suspended Solid (mg/l)	0.003	0	0.006	0	0.003	0	0.007	0
Total Hardness (mg/l)	13	0	9.2	2.2	11	0	27.2	0.95
Temperature	25	0	25	0	24	0	24	0
Biological Oxygen Demand (mg/l)	3.8	0	3	0	2.7	0	2.8	0
Calcium (mg/l)	0.001	0	0.007	82.7	0.01	82.7	0.003	192.9
Magnesium (mg/l)	0.01	0	0	0	0	0	0.007	82.7
Phosphate (mg/l)	0	0	0	233.3	0	0	1.47	1.08
Nitrate (mg/l)	0.1	7.07	0.23	8.7	0.18	0	0.21	4.8
Nitrite (mg/l)	0.011	6.43	0.026	7.69	0.027	23.4	0.024	45.7
Sulphate (mg/l)	0.01	0	0.04	0	0.023	25.2	0.037	15.6

The Ibiekuma River may probably be subjected to various contaminants capable of initiating the impairment of the water quality. The effect may be unnoticed because of dilution; however, there might be a lot to tell at the point of settlement. This research shows that the *p*H values (4.69 to 4.81) obtained from Ibiekuma River was not in accordance with WHO specified *p*H values (6.5 - 8.0) for drinking water WHO (1993). Consequently, the water tends to be acidic at *p*H values of 4.69 and 4.81 across the stations. In that, the indigenous people do depend on this water body for domestic uses including drinking, it will suffice to say that such water is unfit for consumption. The reason for the difference in temperature across the sampling stations is the amount of solar radiation received. Since stations A and B were exposed, temperatures were one degree (1^{o}C) higher than those of other stations which were shaded from the sun radiation. Joy (1989) recorded temperature values of 24.5 ^{o}C to 34.8 ^{o}C for Periyar River, while Igbinosa *et al*. (2012) recorded temperature range of between 26.0 and 27.7 ^{o}C for Shanomi Creek (Warri River) in Nigeria. There was a correlation between temperature and BOD (R^2 = 0.752), suggesting a dependence of BOD on temperature. Turbidity was higher at station C (5.3 NTU) compared to other stations. The conductivity obtained, ranged from 0.017 µScm^{-1} to 0.018 µScm^{-1}. Egborge and Fagade (1999) reported a decrease in conductivity along sampling stations due to dilution effect. The salinity of analyzed sample ranged from 0.00‰ to 0.01‰ and these values were anticipated since salinity of freshwater is not expected to be higher than 0.5‰. This agrees with findings of Joseph *et al* (1984) on Periyar River. Total dissolved solids (TDS) ranged from 8.30mg/l to 9.8mg/l across the four stations. Values were lower than the recommended standard of 500 mg/l (WHO 1993a; NAFDAC 2000; NIS 2007). The sources of hardness could be from calcium and magnesium in the form of limestone ($CaCO_3$), some industrial products and common food constituents. The range of values obtained for total hardness was 9.20 mg/l to 27.2 mg/l. this is lower when compared to WHO (1993b) recommended standard for total hardness of 200 mg/l to 500 mg/l. Ekudayo (1977) and Imevbore (1983) reported that the contamination of water with faeces increases the BOD level because it contains mainly organic matter, which make oxygen less available to desirable organisms. Ekhaise and Anyansi (2005) reported high and low values of 685 mg/l and 1.00 mg/l respectively for Ikpoba River.

Table 2 Concentrations of heavy metals in the Ibiekuma River

Heavy metal	1st Week	3rd Week	6th Week
Iron (mg/l)	0.37	0.34	0.3
Lead (mg/l)	0.08	0.08	0.08
Zinc (mg/l)	0.272	0.07	0.027
Cadmium (mg/l)	0.04	0.04	0.04
Nikel (mg/l)	0.05	0.05	0.05
Copper (mg/l)	0.04	0.03	0.03
Maganese (mg/l)	0.03	0.03	0.03

Generally, there was no significant difference in values obtained for parameters across the sampling stations ($p > 0.05$). Nitrate levels was similar to the global recommended average of 0.1 mg/l for nitrate in fresh water (Meybeck and Helmer 1989) and this conformed to WHO (1994) and NAFDAC (2000) recommendations. Ekhaise and Anyasi (2005) reported nitrate values to range from 0.59 mg/l to 6.13 mg/l for Ikpoba River in the same State as the study area. Concentration of phosphate was highest in station C with values of 1.47 mg/l compared to other stations. Obire *et al* (2003) reported that high concentration of phosphate entering any water body could be from component of domestic waste and excreta. Therefore, the higher concentration of phosphate in station C may have been due to the inflow of phosphate-rich waste and /or materials. Ekhaise and Anyansi (2005) reported low trend of phosphate values ranging from 0.04 mg/l to 0.36 mg/l. In general, a correlation exist among temperature and BOD ($p = 0.001$, $R^2 = 0.0752$), conductivity and nitrite ($p = 0.001$, $R^2 = 0.998$), TSS and turbidity ($p = 0.05$, $R^2 = 0.965$), total hardness and BOD ($p = 0.05$, $R^2 = 0.981$), total alkalinity and nitrate ($p = 0.05$, $R^2 = 0.989$) and, alkalinity and sulphate ($p = 0.05$, $R^2 = 0.960$), suggesting high levels of inter-dependency of some of these parameters. Heavy metals show no significant difference ($F_{1,\ 3} = 0.015$, $p = 0.986$) with respect to sampling occasions. A comparison of the values of heavy metals recorded with WHO (1993b) guidelines showed that these values were within safe limits. Over concentration of heavy metals had been associated with unpalatable taste, stain in laundry and health problems.

CONCLUSION AND RECOMMENDATIONS

Although, the Ibiekuma River at Ebute is experiencing heavy anthropogenic impact, its quality is not at variance with the recommended standards of WHO, NAFDAC and NIS. Our findings strongly suggest that all the physicochemical parameters, except *p*H, are in conformity with the drinking water quality guidelines. Nevertheless, the relatively acidic *p*H values are a source of public health concern considering its utilization by the indigenous people. Several consequences are associated with acidic water and these include skin and eye irritation; the domino effect can also affect the gastro-intestinal system. Besides, it also causes leaching of heavy metals from plumbing facilities; the attendant effect might result to neurological and reproductive problems, such as seizures, hearing loss and miscarriages. Over-ingestion of zinc, copper and lead-laden water result to nausea, vomiting and diarrhea. In addition, extreme *p*H could also have adverse impact on aquatic wildlife. The mortality of aquatic organisms (e.g. fish) due to extreme *p*H also increases the possibility of other toxic effects caused by high ammonia levels, disease-causing bacteria and parasites. Therefore, to safeguard the health of communities, especially staff and students of Ambrose Alli University, who receive supply from this river; it is important that water from the river be purified before usage. Intervention measures such as creating awareness and educating the populace on the need for proper hygiene and sanitation should be implemented. We recommend that further studies should identify specific sources of pollution, monitor seasonal changes in bacterial incidences and correlate this to outbreaks of water-borne diseases in the community.

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