



Assessment of levels of some physico-chemical parameters and heavy metals of Orisa River, Omu-Aran, Nigeria

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Abstract

The loss of water quality in rivers has been extremely serious in developing countries due to the concentrated human activities along the rivers; this could have negative impact on sustainable development. Little or no information about river water quality is available in Nigeria with no exception to Omu-Aran. Levels of the physicochemical and heavy metals parameters of River Orisa, Omu-Aran, Nigeria were assessed. Thirty water samples were collected from five different points along the River with three water samples taken twice a month between September 2018 and January 2019. The samples were analyzed for twelve physicochemical parameters in the Laboratory while the heavy metals were determined using atomic absorption spectroscopy. Standard methods were used to determine the physicochemical characteristics of the water. The analysis of data was performed using descriptive statistics and MANOVA at $\alpha_0.05$. The mean values of parameters in the water samples from various points varied from 29.72 ± 1.66 to 74.06 ± 22.44 $\mu\text{s/cm}$, 0.13 ± 0.06 to 1.05 ± 0.86 mg/L and 0.43 ± 0.47 to 2.21 ± 2.19 mg/L for electrical conductivity, chromium and nickel, respectively. The values of the water quality parameters differed significantly except that of total hardness, calcium, magnesium, sulphate, lead, copper, nickel and iron. Findings reveal the tendency of bioaccumulation in the river as all the heavy metals except Zn were above the WHO Standards. There is therefore the need for constant observation of heavy metal parameters in the river course for the preservation of marine and human lives.

Keywords

River Orisa, Water Quality, Heavy metals.

1. Introduction

Water is the most available commodity on the surface of the earth which is crucial for the existence of every form of life. Next to air which is essential for respiration, water is humanity most essential element (Lawson,

2011). Water is a limited resource which is important for the existence of humanity, cultivation, manufacturing etc. The fact remains that lack of water in sufficient quantity and quality have serious effect on sustainable development (Taiwo et al., 2012). The two major sources which water can be obtained in its natural form are: surface water such as fresh water, lakes, rivers, streams, etc. and ground water such as deep and shallow wells (Mendie, 2005). Rivers are important and susceptible freshwater systems worldwide, responsible for the provision of main water resources for the purpose of domestic, industrial, and agricultural activities (Malmqvist and Rundle, 2002). They are susceptible to active ecosystems whose physical, chemical and biotic features can significantly be affected by human activities occurring within their drainage basins. The quality of water of any precise area or source can be evaluated with the use of physical, chemical and biological parameters. The values of these parameters are dangerous to the wellbeing of man if they are available above the desirable limits (WHO, 2012). The quality of water influences its biology as it has the capacity to influence the species configuration, variety, stability, production and physiological conditions of the native populace (APHA, 1995). The adulteration by heavy metals in water can occur in variety of ways. Some heavy metals are released by mankind to the air and water at proportions in comparison and at times beyond those created by weathering process. Contamination of rivers and streams by lethal substances and eutrophication of rivers and lakes with surplus nutrients are of enormous ecological concerns across the world. Major sources of nutrients and toxic substances to aquatic life include among others; agrarian, manufacturing, and municipal activities, while chemical components such as mercury and nitrogen could be sourced from atmospheric deposition. Today, a number of rivers and streams flow-through urbanized areas across the world, were profoundly impact by changes associated with urbanization (Tadesse *et al.*, 2018). Continuous economic development, expansion and high population growth rate are some of the contributors to the speedy upsurge in the quantity and types of both industrial and household waste produced in many quickly growing urban centers, particularly in emerging nations (Tadesse *et al.*, 2018). Pollutants flowing into a watercourse usually results from numerous conveyance conduits including storm water runoff, release from channels and streams, groundwater outflow, and atmospheric deposition. These conveyance conduits are affected by the seasons. River Orisa is one of the rivers found around Omu-Aran town. The River has its source from Osun State and the river

runs from other towns such as Rore and Aran-Orin, passing through the Landmark University and along the side of the town, before it leaves the town to finally flow into the River Niger. It could be fed with contaminants brought by run-off from the upload into the river at the peak of the floods, discharge from municipal wastes, and industrial wastes from activities of roadside mechanics and local garri producers. Since there is no municipal water supply for the local communities living around the river, they are dependent on the untreated water for consumption, irrigation and other household purposes. The environmental damage caused by anthropogenic activities on Orisa River has not been investigated yet. The assessment of the water quality along the various sampling points would assist in the anticipation of the effects on the well-being of inhabitants whose source of water for consumption and other household uses is the river. The study, therefore, assessed the water quality parameters of water in the river Orisa to determine its potability.

2. Materials and Methods

2.1 The Study Area

Omu-Aran is located in the southern part of Kwara State, Nigeria. It is situated at latitude 8°8'00"N, longitude 5°6'00"E and altitude 564 m above mean sea level (Elemile *et al.*, 2019). The population of Omu-Aran as documented by the 2006 census is 148,610 on a land area of 73.7 km² (Elemile *et al.*, 2019). The climate of Omu-Aran is tropical with the rainy season having a good deal of rainfall, while the dry season have very little amount of rainfall. In Omu-Aran, the wet season is warm, hostile, and cloudy while the dry season has high temperature, wet, and partly cloudy. As the year progresses, the temperature typically fluctuates from 16.7°C to 33.3°C and does not get below 13.7°C or above 33.3°C. About 1273 mm of precipitation falls annually and this most of the time occurs during the raining season. Hence, there are more runoffs into the river during the raining season than the dry season (Raphael *et al.*, 2018).

2.2 River Water Samples Collection

Thirty water samples, which consist of six samples, were taken from five locations namely Landmark University, Aran Orin, Rore, FRSC Area, Omu-Aran and BOVAS Area, Omu-Aran during the months of September 2018 and January 2019. This is to take in consideration the effects of seasonal variations on water quality. The sampling points are shown in Plates 1 to 5 respectively while the sampling points on the map of the river are shown in

figure 1. Clean, sterilized 750 mL plastic bottles were used to collect water samples which were appropriately labelled. 5% v/v nitric acid was used to preserve the water samples before reaching the laboratory, where the samples were analysed for the selected heavy metals. The American Public Health Association (APHA) Standard Methods (APHA, 2005) was used to determine the physicochemical parameters of the water samples. These parameters included: pH, total hardness (TH), electrical conductivity (EC), total dissolved solids (TDS), calcium (Ca), magnesium (Mg), sulphate (SO₄), nitrate (NO₃), and chloride (Cl). The heavy metal analysis was carried out using hydrochloric acid digestion. Concentrations of metal ions were determined by the use of an atomic absorption spectrometer (model Philips PU 9100). The parameters analyzed included zinc (Zn), Iron (Fe), nickel (Ni), copper (Cu), chromium (Cr) and lead (Pb). The water samples were obtained in the evenings of the first working day of the first and last weeks in the months of September and December respectively.



Plate 1: Landmark University Sampling Point



Plate 2: Aran Orin Sampling Point



Plate 3: Rore Sampling



Plate 4: Aran Orin Sampling Point



Plate 5: Bovas Area Sampling Point, Omu-Aran

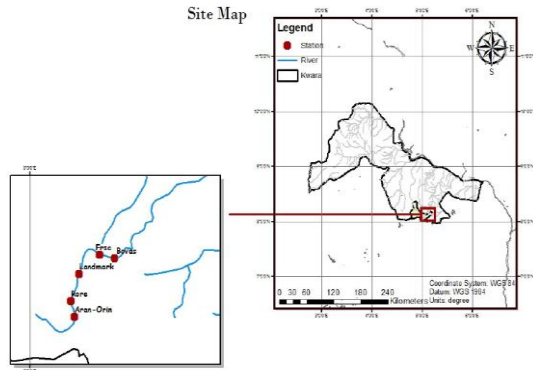


Figure 1: Map Showing Sampling Points on River Orisa

2.3 Data analysis and management

The analysis of data was done with the use of SPSS software Version 23.0 and the parameters of all the water samples from all the sampling points were compared using MANOVA. To establish the difference between the average values of parameters measured at various sampling points, Duncan's multiple range comparison tests were utilized at 5% significance level ($p < 0.05$). The presentation of all data collected was done by descriptive statistics. The data were compared with the national guideline limits set by the Nigerian Standard for Drinking Water Quality (NSDWQ) and the World Health Organization (WHO).

3. Results and Discussion

3.1 Physical analysis of water samples

The results of the physical analysis are presented in Table 1.

Table 1: Physical analysis of water samples from the sampling points

| Parameters | Units | Sampling Points | | | | | WHO |
|-------------------------|-------|-------------------------|--------------------------|---------------------------|--------------------------|--------------------------|---------|
| | | Aran-Orin | Omu-Aran | | | Rore | |
| | | | Bovas Area | FRSC Area | LMU | | |
| pH | | 6.35±0.34 ^a | 7.19±0.24 ^b | 6.88±0.68 ^{ab} | 6.46±0.17 ^a | 6.39±0.35 ^a | 6.5-8.5 |
| Electrical Conductivity | µs/cm | 29.72±1.66 ^a | 74.07±22.44 ^c | 54.60±20.81 ^{bc} | 52.93±5.87 ^a | 44.80±3.96 ^{ab} | 1000 |
| TDS | mg/L | 15.33±1.36 ^a | 36.25±10.47 ^d | 30.83±0.34 ^{cd} | 26.19±3.27 ^{bc} | 22.37±0.34 ^{ab} | 500 |

*For each parameter, means with the different letters (superscripts) are significantly different ($p < 0.05$), using Duncan's multiple range test

pH

The values of the pH were between 6.35 ± 0.34 and 7.19 ± 0.24 with the maximum and minimum values at Bovas Area and Rore respectively. The values were higher in comparison with those of 5.76–6.01 documented in another study (Ikhuorah & Oronsaye, 2016). The values of the pH differed significantly; however, the values were within the tolerable limits of the WHO. This is adequate because of the unlikelihood of the water causing diseases such as acidosis (Asamoah and Amarin, 2011). The pH is a pointer of the activities of man such as washing of clothes (Ikhuorah & Oronsaye, 2016). The increase in pH could be because of increase of anthropogenic activities like bathing, washing of clothes especially downstream of the River in the Bovas Area of OmuAran.

Electrical conductivity (EC)

The values of the electrical conductivity were between 29.72 ± 1.66 and 74.07 ± 22.44 $\mu\text{s}/\text{cm}$ with the maximum and minimum values at Bovas Area and Aran Orin respectively. This might be due to the anthropogenic activities such as swimming and washing of clothes in the downstream of the river at the Bovas area of Omu-Aran. EC is an indicator of dissolved ionic component of sodium and magnesium and total dissolved substitution in water (Yilmaz and Koc, 2014). The values of the EC differed significantly; however, the values were within the tolerable limits of 1000 $\mu\text{s}/\text{cm}$ of the WHO. The values revealed that the concentration of dissolved salts in the water samples were very minimum. There will be no harmful effect due to the intake of the water by humans.

Total dissolved solids (TDS)

The values of the dissolved solids were between 15.33 ± 1.36 and 36.25 ± 10.47 mg/L with the maximum and minimum values at Bovas Area and Aran Orin respectively. The values of the TDS differed significantly; however, the values were within the tolerable limits of 500 mg/L . An elevated level of TDS, by itself, does not indicate that the water presents a health risk. However, elevated levels of specific ions included in the TDS measurement, such as nitrate, arsenic, aluminum, copper, or lead, could present health risks (Ward et al., 2018).

3.2 Chemical analysis of water samples

The results of the chemical analysis are presented in Table 2

Total hardness

The values of the total hardness for the water samples differed significantly. The values were between 15.83 ± 10.99 and 34.65 ± 22.62 with the maximum and minimum values at LMU and FRSC respectively. All the values were within the WHO tolerable limits of 150 mg/L . which confirmed that the water from the river could be used for domestic activities. It is reported that high values of hardness on the wellbeing of man have no harmful effects. Water with values higher than of 200 mg/L has the tendency of depositing scales in the water supply system and leads to the consumption of more soap (Rawway et al., 2016).

Calcium and Magnesium

The values of the calcium were between 7.20 ± 4.52 and 16.18 ± 1.93 mg/L with the maximum and minimum values from Landmark University

and FRSC area, Omu-Aran respectively. The values for the magnesium were also between 7.25 ± 4.45 and 12.24 ± 4.38 mg/L with the highest and lowest values from Landmark University and Rore, respectively. The values of the calcium and magnesium differed significantly; however, the values were within the tolerable limits of 75 and 50 mg/L for calcium and magnesium respectively. Ca and Mg found in natural waters are from different kinds of rocks, industrial waste and sewage. It has been documented that hard water could be responsible for cardiovascular ailments (Gupta et al, 2013).

Table 2: Chemical Analysis of water samples from the sampling points

| Parameters | Units | Sampling Points | | | | WHO | |
|----------------|-------|--------------------------|---------------------------|--------------------------|--------------------------|--------------------------|-----|
| | | Aran-Orin | Omu-Aran | | Rore | | |
| | | | Bovas Area | FRSC Area | | | LMU |
| Total Hardness | mg/L | 20.44±6.03 ^{ab} | 21.85±10.55 ^{ab} | 15.83±10.99 ^a | 34.65±12.52 ^b | 16.48±6.61 ^{ab} | 150 |
| Calcium | mg/L | 11.24±3.40 ^{ab} | 11.19±5.25 ^{ab} | 7.20±4.52 ^a | 16.18±1.93 ^b | 10.22±4.54 ^a | 75 |
| Magnesium | mg/L | 8.02±6.47 ^{ab} | 8.24±4.26 ^b | 8.10±4.47 ^{ab} | 12.24±4.38 ^c | 7.25±2.45 ^a | 50 |
| Chloride | mg/L | 14.80±4.55 ^a | 19.35±3.10 ^b | 15.94±6.07 ^a | 36.07±12.25 ^d | 23.18±8.88 ^c | 250 |
| Sulphate | mg/L | 11.26±4.72 ^a | 18.35±0.52 ^c | 15.40±2.53 ^b | 23.25±16.08 ^d | 18.95±6.78 ^c | 100 |
| Nitrate | Mg/L | 0.57±0.55 ^a | 0.79±0.57 ^b | 0.65±0.63 ^a | 1.02±0.20 ^c | 0.87±0.34 ^b | 50 |

*For each parameter, means with the different letters (superscripts) are significantly different ($p < 0.05$), using Duncan's multiple range test

Chlorides

The values of the chlorides were between 36.07 ± 21.90 and 14.80 ± 4.55 mg/L with the maximum and minimum values from Landmark University and Aran Orin respectively. Chlorides are good indicators of the pollution of water by sewage. Contamination of water by chlorides could be from runoff of water comprising road salts, the application of synthetic fertilizers and landfill leachates, (Igbiosa & Uwadia, 2018). The values of chlorides differed significantly; however, the values were within the tolerable limits of 250 mg/L. It has been reported that though water with low ions of chloride is not harmful, but at high concentrations, chloride ions could destroy floras if applied for horticultural or agricultural purposes. It could also be responsible for nasty taste for consumption of water (WHO, 2004). The high concentrations of chloride in the various sampling points along the river water could be due to the activities of that people in the river such as sweating and urinating.

Sulphates

The values for sulphates were between 23.25 ± 16.05 and 11.25 ± 6.72 mg/L with the maximum and minimum values from Landmark University

and Rore respectively. The values of sulphates did not differ significantly, although reports showed that there is no standard value with respect to man's wellbeing; however, WHO has recommended that any value greater than the tolerable limits of 100 mg/L is taken as not hygienic (Yogendra & Puttaiah, 2008).

Nitrates

The values for nitrates were between 0.57 ± 0.55 and 1.02 ± 0.20 mg/L with the maximum and minimum values from Landmark University and Aran-Orin respectively. The values of nitrates did not differ significantly; however, the values were within the WHO tolerable limits of 50 mg/L. Speijers, 1996 reported that high concentrations of nitrates could lead to blue-eye syndrome in kids and expectant women. High values of nitrate could result in eutrophication (Adeolu *et al.*, 2016).

3.3 Chemical analysis of water samples

The results of the heavy metals analysis are presented in Figure 2.

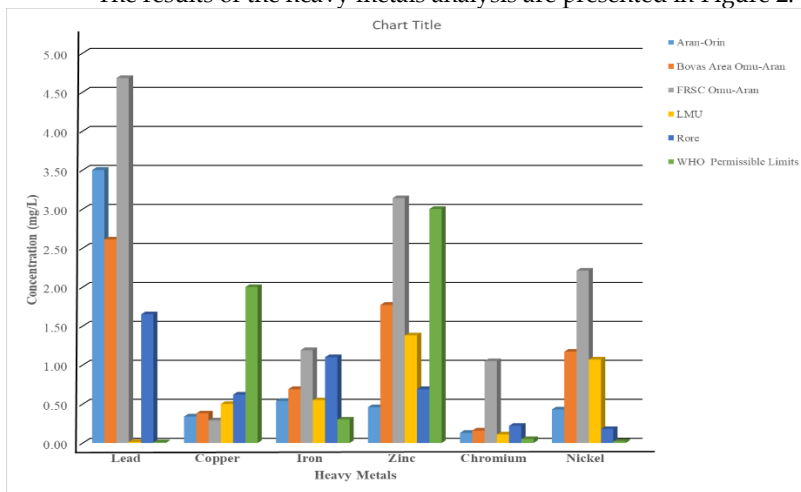


Figure 2: Heavy metal analysis of water samples collected from the sampling points

Lead

The values for the lead were between 4.68 ± 2.65 and 0.01 ± 0.00 mg/L with the maximum and minimum values from FRSC Area and Rore

respectively. The values were higher than the WHO tolerable limits of 0.015 mg/L except the samples at Rore. The high value at FRSC area could be as a result of the presence of a mechanic workshop and car wash in the area. The values of lead were greater than the ones from the research work conducted by (Jonah et al, 2015). The values of lead differed significantly. Lead is one of the most poisonous heavy metals because of its impact on the kidneys and central nervous system (Yusif et al., 2018).

Copper

The values for the copper were between 0.62 ± 0.53 and 0.29 ± 0.11 mg/L with the maximum and minimum values from Rore and FRSC Area respectively. The values were within the WHO tolerable limits of 2.0 mg/L. The values of copper differed significantly and a study reported that high values of copper could lead to the development of chronic anemia (Iqbal et al., 2011). Contamination of drinking water by copper could be by either directly polluting water sources or through rusting of copper pipes and materials.

Iron

The values for Iron were between 1.19 ± 0.53 and 0.54 ± 0.22 mg/L with the maximum and minimum values from FRSC Area and Aran-Orin respectively. The values were higher than the WHO tolerable limits of 0.3 mg/L. The values of iron differed significantly with the high values probably due to the stacking of iron at the mechanic workshop and coupled with availability of iron in the earth crust. High concentrations of iron could result in hemochromatosis which is characterized by tiredness, pains in the joints and abdomen (Jonah *et al.*, 2015).

Zinc

The values for zinc were between 3.14 ± 2.19 and 0.46 ± 0.28 mg/L with the maximum and minimum values from FRSC area and Aran-Orin respectively. Values of zinc in all sampling points except that of FRSC area are within the WHO tolerable limits of 3.0 mg/L. The values of zinc differed significantly. Zinc may have amassed from runoff of water over zinc plates along the sampling points. Studies have documented that the harmful effects of zinc on people include nausea, lack of moisture, tiredness, pains in the abdomen, lack of coordination of the muscles, and kidney failure. Although a normal dose of zinc is essential to prevent zinc deficiency (Nagdev et al., 2018), protracted dosages of zinc could trigger the development of deformed blood cells and the impairment of the pancreas (Vaishaly et al., 2015).

Chromium

The values for chromium were between 1.05 ± 0.86 and 0.11 ± 0.04 mg/L with the maximum and minimum values from FRSC and Landmark University respectively. The values were higher than the WHO tolerable limits of 0.05 mg/L. The values of chromium differed significantly. The contamination of surface water by chromium could be as a result of exposure to wastes from chromate-processing facilities which are indiscriminately disposed into open dumps. Incidentally, there is a mechanic workshop and a car wash where the wastes of vehicle parts are dumped. Chromium in its hexavalent form has been associated with the injurious effects of chromium to mankind. Harmful effects of chromium include liver necrosis and membrane ulcers (Elemile et al., 2019).

Nickel

The values for nickel were between 2.21 ± 2.19 and 0.43 ± 0.46 mg/L with the maximum and minimum values from FRSC area and Aran-Orin respectively. The values were higher than the WHO tolerable limits of 0.02 mg/L. The values of nickel differed significantly. Although nickel has been identified as a vital trace metal, it could also be highly poisonous at higher doses. Hair loss, lung fibrosis, allergies of the skin, eczema, and various degrees of kidney and heart poisoning have been associated with humans exposed to high concentrations (Anake *et al*, 2014)). Nickel also has the propensity of replacing iron and zinc in the body, thus interfering in the normal biochemistry (Akpoveta *et al.*, 2011).

4. Conclusion

The levels of all the tested physicochemical parameters in the water were within the WHO standards while all the heavy metals except Zn were above the WHO Standards. There was an increase in the heavy metal parameters due to anthropogenic activities such as mechanic workshop etc. However, the high levels of heavy metals in the water samples can lead to bioaccumulation and long-term adverse effects on the aquatic lives and humans. There is therefore, the need for constant observation of the heavy metal parameters in the river course for the preservation of marine and human lives.

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