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# COMPARATIVE EVALUATION OF THE PHYSICOCHEMICAL PARAMETERS OF MAJOR RIVERS IN ENUGU URBAN, NIGERIA

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**ABSTRACT**

The natural waters are being contaminated as the quality of water is increasingly being affected by anthropogenic activities especially in developing countries such as Nigeria. This increased contamination of surface water has resulted from the recent urbanization and industrialization trend. The physicochemical analysis of surface water from Ekulu and Nyaba rivers were carried out using standard methods to determine their suitability for domestic consumption as rivers are vital freshwater systems that are critical for the sustenance of life. River water samples were collected in the period November, 2015 to April, 2016 from different parts of the rivers. The comparative results showed a mean value range of temperature (25.50°C ± 0.87°C to 29.25°C ± 0.63°C), colour (26.20 Hz ± 4.0 Hz to 36.0 Hz ± 2.0 Hz), odour (unobjectionable), total dissolved solids (253 mg/l ± 6.21 mg/l to 283 mg/l ± 3.22 mg/l), conductivity (64 µs/cm ± 4.20 µs/cm to 66 µs/cm ± 3.20 µs/cm), pH (6.21 ± 0.42 to 7.33 ± 0.36), potassium (0.22 mg/l ± 0.01 mg/l to 0.43 mg/l ± 0.02 mg/l), sodium (0.28 mg/l ± 0.04 mg/l to 0.45 mg/l ± 0.017 mg/l), calcium (6.41 mg/l ± 0.02 mg/l to 8.34 mg/l ± 0.002 mg/l), iron (5.51 ± 0.02 to 6.53 ± 0.09), copper (2.34 ± 0.41 to 4.29 ± 0.21), zinc (3.14 ± 0.11 to 5.22 ± 0.01), total hardness (85.75 ± 5.87 to 102.20 ± 6.10), sulphate (264.21 ± 6.70 to 276.32 ± 6.40), phosphate (24.27 mg/l ± 0.06 mg/l to 32.16 mg/l ± 0.04 mg/l), nitrate (6.62 mg/l ± 0.08 mg/l to 7.25 mg/l ± 0.37 mg/l) and biochemical oxygen demand (BOD) (42 mg/l ± 6.2 mg/l to 56.60 mg/l ± 5.8 mg/l) for both rivers. Although, the result of the study recorded some parameters which were above WHO permissible limits while others fall within the limits but the obtained values of the physicochemical in the water samples showed a significant difference ($P<0.05$) when compared with WHO permissible limits for those physicochemical. Comparatively, Nyaba river was more polluted than Ekulu river. This study would help to create and develop awareness among the people to help maintain the quality of the river waters. The river waters should not be used for drinking and domestic purposes without treatment.

## INTRODUCTION

Our health, life style and economic well-being can be affected by water, which have several uses and support all forms of life (Rajiv, *et al.,* 2012). In developing countries such as Nigeria, there has been high demand of urban utility due to increasing growth and concentration of population in the urban areas (Ubani, *et al.,* 2014). As a result of this, natural waters are being contaminated as the quality of water is increasingly being affected by anthropogenic activities (Salami, *et al.,* 2003; Giwa, *et al.,* 2008). This increased contamination of surface water has resulted from the recent urbanization and industrialization trend. There is a problem of water scarcity in Enugu metropolis due to inadequate urban water supply from the state water cooperation and facing the populace is serious problem considering the geometric increase of urban population (Ubani, *et al.,* 2014). Rivers can be polluted by industrial wastes containing several pollutants, domestic and municipal sewage which contains decomposable organic matter, agricultural effluent and urban run-offs among others. Drinking contaminated water has caused many diseases in developing countries (Tar, *et al.,* 2009). A variety of water related diseases

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such as typhoid, hepatitis, cholera, diarrhea, schistosomaiasis and guinea worm can result from the use of contaminated surface water (UNESCO, 1994). Run offs carries leachates from solid waste dumps, leaching of rocks, sewage, industrial wastes and agricultural chemicals to rivers (Ademola, 2008). River waters have been made impure due to human activities and other natural factors (Nsi, 2007). As reported by Tar, *et al*., over one billion people in the world lack access to safe drinking water and 2.5 billion people do not have access to proper sanitation services. This study was aimed at comparatively evaluating the physicochemical parameters of major rivers (Ekulu river and Nyaba river) in Enugu urban.

## MATERIALS AND METHODS

### Study area

Enugu urban is made up of about twenty (20) distinct neighborhoods that may be broadly categorize as low, medium and high-density areas. There exist mixed densities, probably due to the influences of spread effects (Ubani, *et al.,* 2014). Enugu urban lies approximately on latitude 06° 21' N and 06° 30° and longitude 07° 26'E and 07° 37'E. It has an estimated land area of about $72.8^2$/km. Enugu urban has a total land area of about 12,831 km and is the state capital of Enugu state of Nigeria. Residential land use account for the highest land use comprising about 54.3% of total urban area in Enugu. The population Fig. 1 for Enugu urban in 2006 stands as 722, 664 (NPC, 2006). Due to varied topography and expansive area, the water distribution system in Enugu urban is a complex one. Rivers in Enugu urban are somewhat linked to another across some neighborhoods (Ubani, *et al*., 2014). However, there are up to ten rivers in Enugu urban but in line with design of this study, only Ekulu and Nyaba rivers were considered. From the geological map of Enugu urban, Ekulu river is the largest river that cuts across Enugu urban seconded by Nyaba river. Some of the rivers are tributaries of others as they move along neighbourhoods. Ekulu river has Abakpa river (Ava) as one of its tributaries and Idaw river among others is a tributary of Nyaba river.

### Sample collection

The samples were collected during the month of November 2015 to April, 2016 at two different sampling locations in each of the rivers with screw caped one litre plastic containers using sterile hand gloves. The containers were washed with detergent, leached with concentrated $HNO_3$, rinsed thoroughly with distilled water and finally with the respective river waters. The sampling was done in the evening when human activities were least against water flow. The sampling locations were labeled as upstream and downstream locations in each river. Six composite samples were collected from different points and pooled together at each sampling location. 250 ml BOD (biochemical oxygen demand) glass bottles were used to collect samples for BOD determination

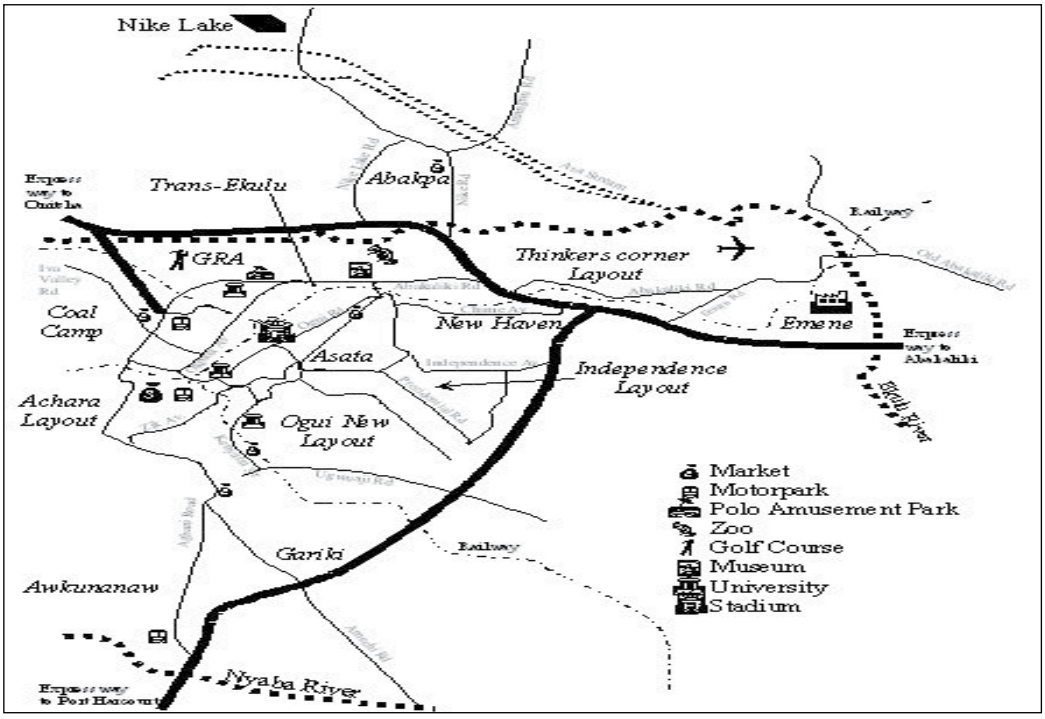


**Fig. 1** Map of Enugu urban.

**Table 1.** Mean values of physicochemical parameters in the river waters

| Physicochemical | Ekulu River | Nyaba River | WHO |
|---|---|---|---|
| Temperature (°C) | 29.25 ± 0.63 | 25.50 ± 0.87 | 25-30 |
| Colour (Hz) | 26.20 ±4.0 | 36.0 ± 2.0 | 6-15 |
| Odour | Unobjectionable | Unobjectionable | Unobjectionable |
| Total Dissolved Solid (mg/l) | 253 ± 6.21 | 283 ± 3.22 | 250 |
| Conductivity (µs/cm) | 64 ± 4.20 | 66± 3.20 | 100 |
| pH | 6.21 ± 0.42 | 7.33 ± 0.36 | 6.5-8.5 |
| Potassium (K) (mg/l) | 0.22 ± 0.01 | 0.43 ± 0.02 | 0.1 |
| Sodium (Na) (mg/l) | 0.28 ± 0.04 | 0.45 ±0.017 | 0.1 |
| Calcium (Ca) (mg/l) | 6.41 ± 0.02 | 8.34 ± 0.002 | 65 |
| Iron (Fe) (mg/l) | 5.51 ± 0.02 | 6.53 ± 0.09 | 0.3 |
| Copper (Cu) (mg/l) | 2.34 ± 0.41 | 4.29 ± 0.21 | 1.0 |
| Zinc (Zn) (mg/l) | 3.14 ± 0.11 | 5.22 ± 0.01 | 0.5 |
| Total Hardness (mg/l) | 85.75 ± 5.87 | 102.20 ± 6.10 | 500 |
| Sulphate (mg/l) | 264.21 ± 6.70 | 276.32 ± 6.40 | 250 |
| Phosphate (mg/l) | 24.27 ± 0.06 | 32.16 ± 0.04 | 100 |
| Nitrate (mg/l) | 6.62 ± 0.08 | 7.25 ± 0.37 | 10 |
| Biochemical oxygen demand (BOD) (mg/l) | 42 ± 6.2 | 56.60 ± 5.8 | 40 |

to prevent loss or gain of oxygen. Samples were transported to the laboratory where it was preserved in the refrigerator at 4°C prior analysis.

**Physicochemical analysis**

The American public health association (APHA) analytical methods for the examination of water were used to determine the physicochemical parameters of the river waters. In order to prevent natural interference and unnecessary reactions, analyses of the pH and dissolved oxygen was done immediately while others were determined within 48 hrs. sodium and potassium were measured by flame emission photometry, trace metals (iron, copper and zinc) by atomic absorption spectrophotometer (model VGB210) at specific wavelengths. The standard solution for each tested element was prepared according to its concentration and used to calibrate the system before analyzing each water sample.

**Statistical analysis**

Statistical package for social science (SPSS version 4.0) was used to test the formulated hypotheses for this study using one way analysis of variance (ANOVA).

## RESULTS AND DISCUSSION

The result of physicochemical analyses of the river waters are presented in Table 1 below. The obtained values for each physicochemical was compared with WHO permissible limits in order to determine whether the parameters are still within the acceptable limits, The physicochemical parameters determined in this study included temperature, colour, odour, total dissolved solids, conductivity, pH, potassium, sodium, calcium, iron, copper, zinc, total hardness, sulphate, phosphate, nitrate and BOD. The obtained temperature values of the rivers were within WHO acceptable limit although Ekulu river recorded higher temperature value (29.25°C ± 0.63°C) than Nyaba river (25.50°C ± 0.87°C). High temperature can make water bodies unattractive for recreational activities and can be unsafe for domestic uses (Ubani, *et al.,* 2014). The rivers had unobjectionable odours and fell within WHO acceptable limit. Nyaba river recorded higher value of colour (36.0 Hz ± 2.0 Hz) than Ekulu river (26.20 Hz ± 4.0 Hz). The obtained value was above WHO acceptable limit for colour. Colour is an important physical property of water and the need to reduce it to acceptable levels by water treatment is highly recommended. Although the pH values of the rivers were found to be within the acceptable limit set by WHO, Nyaba river was found to have a higher pH value (7.733 ± 0.36) than Ekulu river (6.21 ± 0.42). An increase or decrease in the toxicity of poisons in the water bodies can be attributed to fluctuations in the optimum pH of water (Ali, 1991). The pH obtained in the river was within the ranges suitable for aquatic life (Chapman, 1996). The pH of both water bodies would not adversely affect its use for domestic and recreational purposes. Comparative study of the total dissolved oxygen showed that Ekulu river had the highest amount (283 mg/l ± 6.21 mg/l) than Nyaba river (253 mg/l ± 3.22 mg/l) and fell within the acceptable limit by WHO. According to (Olorode, *et al.,* 2015), the non-filterable or dissolved substances in water that have formed an aqueous, non-colloidal mixture are referred to as total dissolved solids. They include inorganic salts in unsaturated solutions which may impart inferior palatability, colour and tastes to the receiving aquatic system (Olorode, *et al.,* 2015).

Although rainfall, soil erosion and surface run-off may contribute to these observations but it may be suggested that people activities at the different locations might have contributed more (Olorode, *et al.,* 2015). The conductivity values of the water bodies obtained in this study fell below WHO acceptable limit for conductivity although Nyaba river recorded a higher conductivity value (66 µs/cm ± 3.20 µs/cm) than the Ekulu river (64 µs/cm ± 4.20 µs/cm). This may be attributed to high concentrations of trace metals and total dissolved solids obtained in Nyaba river. Conductivity values reflect the chemical richness of any water. Comparatively, higher values of potassium (0.43 mg/l ± 0.02 mg/l), sodium (0.45 mg/l ± 0.017 mg/l), calcium (8.34 mg/l ± 0.002 mg/l), iron (6.53 mg/l ± 0.09 mg/l), copper (4.29 mg/l ± 0.21 mg/l), zinc (5.22 mg/l ± 0.01 mg/l), total hardness (102.20 mg/l ± 6.10 mg/l), sulphate (276.32 mg/l ± 6.40 mg/l), phosphate (32.16 mg/l ± 0.04 mg/l), nitrate (7.25 mg/l ± 0.37 mg/l) and BOD (56.60 ± 5.8) were recorded in Nyaba river than the Ekulu river (0.22 ± 0.01), (0.28 ± 0.04), (6.41 ± 0.02), (5.51 ± 0.02), (2.34 ± 0.41) (3.14 ± 0.11), (85.75 ± 5.87), (264.21 ± 6.70), (24.27 ± 0.06), (6.62 ± 0.08) and (42 ± 6.2) respectively. These values as obtained in both Nyaba and Ekulu rivers were above WHO permissible limit except for total hardness, sulphate, phosphate and nitrate. Given that these trace elements are continuously accumulated in the water bodies, exposed living organisms are likely to suffer some degree of toxicity when their respective tolerance threshold is exceeded. In an ecosystem, the concentration of sulphate present depends on the amount of oxygen in water (Mento de l'exploitant de leau et de I'assainissesment, 1986). Higher value of total hardness obtained in Nyaba river may probably be due to the mixing of sewage effluents observed at the sampling location (Rajiv, *et al.,* 2012). The concentrations of calcium as obtained in this study might be as a result of the entry of calcium by leaching process of the rocks into the water bodies. It is a common practice for people living along the river catchments to discharge their domestic and agricultural wastes into the rivers. Further to using the rivers as source for drinking water, people use it for recreational purposes, bathing and washing clothes among others. By defecting and urinating on the water bodies, animals seeking drinking water do contaminate the rivers. The obtained values of physicochemical in the river waters showed a significant difference ($P<0.05$) when compared with WHO permissible limits for those physicochemical.

Conclusively, the physicochemical analysis revealed the distinct nature of the two rivers and obtained result showed significant variations between their qualities. Comparatively, Nyaba river was more polluted than Ekulu river. There is need to improve the quality of the river waters by maintaining better sustainable management. However, the assessment of the quality of water before use is of utmost importance. This study would help to create and develop awareness among the people to help maintain the quality of the river waters. Authorities responsible for water pollution control in Nigeria requires adequate and comprehensive control mechanism and database on the sources, quantity and types of pollutants released into the water bodies because without such information, water pollution monitoring, control and prevention would not be achieved.

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