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Water Quality Indices and Potability Assessment of Three Streams in Akwa North and South Local Government Areas, Anambra State, Nigeria

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ABSTRACT: The management of water quality, control of water pollution and environmental protection for preservation of living conditions of fresh water bodies for the future necessitated careful routine monitoring. Therefore, the objective of this paper is to assess the water quality indices and anthropological suitability of three streams in Akwa North and South Local Government Areas, Anambra State, Nigeria. Water samples were collected and analyzed for physicochemical properties using standard procedures and the quality assessed using water quality index model. The result results revealed that the water samples from the three sampling sites were acidic to alkalinity in pH, moderate in temperature. The dissolved oxygen (DO), biological oxygen demand (BOD_5), chemical oxygen demand (COD), ammoniacal nitrogen and phosphate levels were found to be above World Health Organization (2011) standard limits except total suspended solids values. Water quality index value for all sampling sites ranged from 31.41 to 52.49, respectively revealing the three streams were moderately polluted with different industrial influents. Statistically, there were significant ($p < 0.05$) differences detected among the means of pathogenic groups, physicochemical parameters and sampling points but non – significant ($p > 0.05$) differences detected among the means of sampling sites. Thus, the physico- chemical baseline data from this study suggest the public health danger of the three streams to the inhabitants utilizing them as sources of water. Strict preventive measures and awareness campaigns should be put in place by government and water environmental policy makers to guarantee the public health safety of these fresh water resources.

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Water is a vital substance for the survival of all lives and one of the indispensable resources needed for the continued existence of man. It constitutes a sizeable amount of food intake by humans and supply is not reserved in the human body (Agboli *et al*., 2017). Besides, where water is available, it's quality is also a serous source of concern and this is more so, against the backdrop that the quality of water anywhere in the world is subject to natural, geographical, human-anthropological, and environmental factors and activities (UNDSEA, 2001). Potable water is one that is free from pathogens, low in compounds that are acutely toxic and have grave long-term effects on human health. It is the primary need of every human being (Onuorah *et al*., 2017). The provision of potable water to rural and urban population is necessary to prevent health hazards. A primary concern of people living in developing countries is that of obtaining clean drinking water (Onuora *et al*., 2017). Physicochemical indices are based on the values of various physicochemical qualities in a water sample. These are vital for water quality monitoring (Atiku *et al*., 2017). Physicochemical parameters such as turbidity, pH, temperature, nitrate and others with respect to water quality are widely accepted as water quality parameters. These parameters either directly

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influence microbiological quality or they may influence disinfection efficiencies or with their direct effect on health (Shukla *et al*., 2017). Hence, they affect the drinking water quality, if their values are in higher concentrations than the safe limits set by the World Health Organization (WHO) and other regulatory bodies (WHO, 2011). Water quality index (WQI) is a mathematical instrument used to transform large quantities of water data into a single number that expresses overall water quality at a certain location on several water variables which turns complex water quality data into information understandable and useable by the masses (Rumman *et al*., 2012). The index improves the comprehension of general water quality issues, communicates water quality status and illustrates the need for and the effectiveness of protective practices (Gorde and Jadhav, 2013). The unpredictability of water supplies in Mgbakwu, Obibia and Urum in Awka North and South has forced the inhabitants to depend on stream surface waters as source of water for agricultural, domestic and even industrial purposes. Although, literatures abound mostly in water quality studies of Awka Metropolis, there are paucity of information especially with regards to water quality indices of these other areas as good in-depth knowledge of the physico – chemical properties of these waters will improve the conditions of these water resources and proper management of any possible public health danger. The objective of this paper is to assess the water quality indices and potability of three streams in Akwa North and South Local Government Areas, Anambra State, Nigeria.

MATERIALS AND METHODS

Description of Study Area: The selected study areas in this study include: Mgbakwu stream, Obibia Stream, and Urum Stream both in Awka South and North Local Government Area, Anambra State Nigeria. The coordinates of the sampling points were determined using a hand-held Global Positioning System (GPS) with coordinate of Mgbakwu latitude 6° 16' 28.90" MN and longitude 7° 4' 37.55" ME, Obibia latitude 6° 11' 23.69" MN and longitude 7° 5' 36.55" ME and Urum latitude 6° 17' 11.88" MN and longitude 7° 0' 35.69" ME, respectively.

Collection of Water Sample: The samples were collected at four different points (5 m from apart) in the three sampling sites above as previously described by Ike *et al*. (2021).

Physicochemical Analysis: The following physicochemical parameters: temperature, pH, dissolved oxygen, biochemical oxygen demand (BOD_5), chemical oxygen demand (COD), total suspended solid, Ammoniacal nitrogen (NH_3) and phosphate were determined using standard procedures of APHA (2012) as described by Hanafiah *et al.* (2018) and Oladeji *et al*. (2016).

Water Quality Classification: Classification in water quality index (WQI) was determined based on the water quality index as expressed below (Hanafiah *et al*., 2018):
WQI = 0.22 x SIDO + 0.19 x SIBOD + 0.16 x SICOD + 0.15 x SIAN + 0.16 x SITSS + 0.12 x SIpH where: SIDO = Sublndex DO (% saturation), SIBOD = Sublndex BOD, SICOD = Sublndex COD, SIAN = Sublndex NH_3-N, SISS = Sublndex SS and SipH = Sublndex pH.

Fig 1: High resolution satellite image showing location of Mgbakwu, Obibia and Urum sampling sites at Awka North and South LGA, Anambra State, Nigeria

Statistical Analysis: The results of the data generated were expressed in charts as mean ± standard deviation (SD). The data means were analyzed by two-way Analysis of Variance (ANOVA) followed by Tukey's to compare differences in the physiochemical contents of the three sampling sites and different sampling points. Probability values less than 5 % ($p < 0.05$) were considered statistically significant at 95 % confidence interval using GraphPad Prism version 8.0.2.

RESULTS AND DISCUSSION

The result of physicochemical profile of the three - sampling sites as shown in Figures 2 - 9 revealed that Obibia sample point C had the highest pH of 7.7 while Mgbakwu sample point D had the lowest pH of 5.3, respectively. Mgbakwu sample point C had the highest temperature value of 28.3 °C while Urum sample point D had the lowest temperature of 27.3 °C, respectively. Urum sample point D had the highest dissolved oxygen of 42 mg/L while Mgbakwu sample point B had the lowest dissolved oxygen of 20 mg/L, respectively. Urum point D had the highest biochemical oxygen demand of 13.8 mg/L while Mgbakwu point C had the lowest biochemical oxygen demand of 3.1 mg/L, respectively. Urum point C had the highest chemical oxygen demand of 272 mg/L while Urum point A had lowest chemical oxygen demand of 96 mg/L, respectively. Urum point D had the highest total suspended solid of 0.4 mg/L while Mgbakwu point D had lowest total suspended solid of 0.0 mg/L, respectively. Urum point A had the highest ammoniacal nitrogen content of 48.35 µg/L while Obibia point A had the lowest ammoniacal nitrogen content of 6.85 µg/L, respectively. Mgbakwu sample point B had the highest phosphate value of 6.5 mg/L and Obibia sample point C had the lowest phosphate value of 0.87 mg/L, respectively. Statistically, there were significant ($p < 0.05$) differences detected among the means of physicochemical parameters but non - significant ($p > 0.05$) differences detected among the means of sampling points and sites.

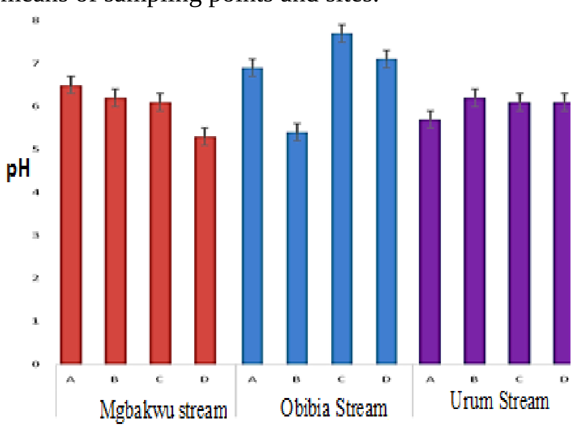

Fig 2: pH profile of the three-sampling site
Key: Error bar = Mean standard deviation

Monitoring and assessment of water quality parameters of different fresh water bodies require many different parameters to be sampled. In this present study, the physicochemical analysis such as pH of water sample is a measure of the concentration of hydrogen ions (Tank and Chippa, 2013). The pH values ranged between 5.3 to 7.7. The pH value of 5.3 showed the water sample is acidicity, 6.5 showed slightly acidic while 7.1 showed is alkalinity. Mgbakwu sample point A (6.5), Obibia sample point A (6.9), C (7.7) and D (7.1) respectively fall within WHO standard (6.5 - 8.5). Temperature is one of the physicochemical parameters used to evaluate quality of potable water. It affects many phenomena including the rate of chemical reactions in the water body, reduction in solubility of gases and amplification of taste and colour of water. The highest temperature value obtained was 28 °C and lowest was 27.6 °C, respectively which showed moderate temperature. Temperature values were above WHO recommended level (< 15 °C).

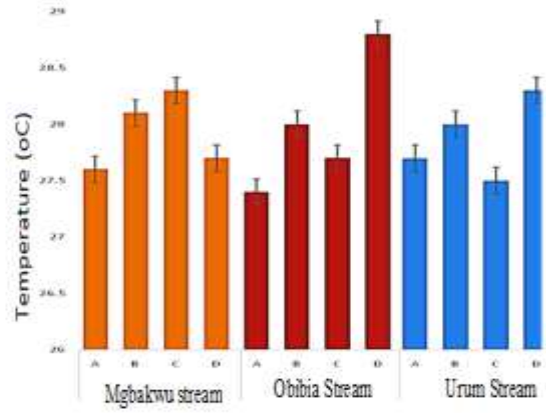

Fig 3: Temperature profile of the three-sampling site
Key: Error bar = Mean standard deviation

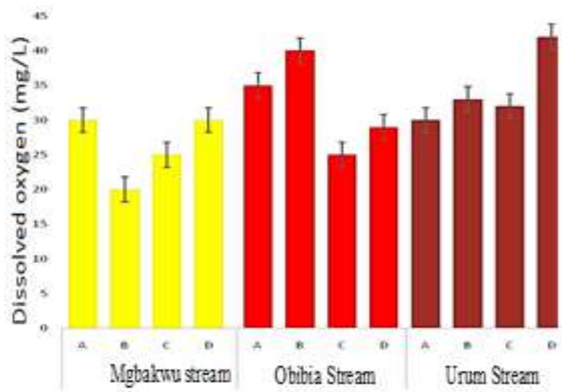

Fig 4: Dissolved oxygen profile of the three-sampling site
Key: Error bar = Mean standard deviation

Dissolved oxygen (DO) measures the amount of gaseous oxygen dissolved in aqueous solution. Oxygen gets into water by diffusion from the surrounding air, by aeration and as a waste product of photosynthesis from phytoplankton, algae, seaweed and other aquatic plants (Othman *et al*., 2012). The amount of dissolved oxygen varies depending on temperature, pressure and salinity. Solubility of oxygen decreases as temperature increases. This is due to the fact that warmer surface water requires less dissolved oxygen to reach 100 % air saturation compared to cooler water. In freshwater systems such as lakes, rivers and streams, dissolved oxygen concentrations will vary by season, location and water depth and it will decrease with higher temperature, salinity and elevation (Beale *et al*., 2000). The DO from this study ranged between (20 - 42 mg/L). The result was above the WHO (2011) standard (10 – 12 mg/L) for dissolved oxygen in fresh water.

Biochemical oxygen demand after 5 days (BOD_5) is a measurement of the amount of dissolved oxygen used by aerobic microorganisms when decomposing organic matter in water. Microorganisms such as bacteria are responsible for decomposing organic waste. When organic matter such as dead plants, leaves, grass clippings, manure, sewage or even food waste is present in a water supply, the bacteria will begin the process of breaking down this waste. When this happens, much of the available dissolved oxygen is consumed by aerobic bacteria, affecting oxygen level needed for other aquatic organisms. Although no guideline set for the maximum tolerable limit of BOD_5 in drinking water, for fisheries and aquatic life, European Union and Ethiopia recommend 3 - 6 mg/L and less than 5 mg/L, respectively. The BOD_5 values ranged from 3.1 to 13.8 mg/L, respectively.

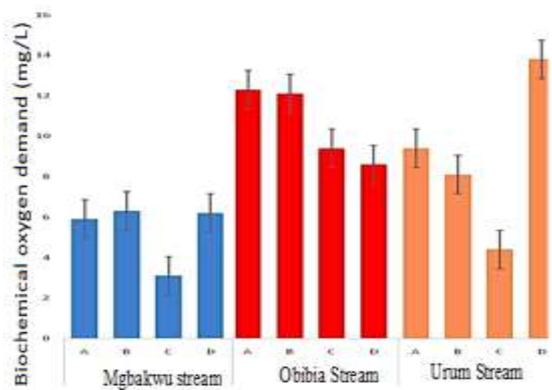

Fig 5: Biochemical oxygen demand profile of the three-sampling site
Key: Error bar = Mean standard deviation

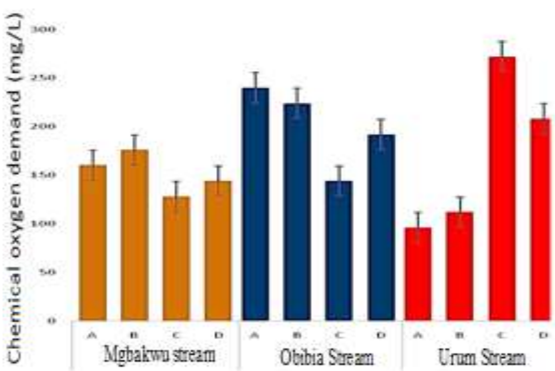

Fig 6: Chemical oxygen demand profile of the three-sampling site
Key: Error bar = Mean standard deviation

The observed results were partly acceptable although some of the result obtained fall out of the range. This suggests that stream water sources were polluted by organic matter. Chemical Oxygen Demand (COD) is a measurement of the oxygen required to oxidize soluble and particulate organic matter in water. It is used to measure the total quantity of oxygen-consuming substances in the complete chemical breakdown of organic substances in water. It does not differentiate between biologically available and inert organic matter. COD measurements can be made in a few hours while BOD_5 measurements take five days. Generally, the lower COD level indicates a low level of pollution, while the high level of COD points out the high level of pollution of water in the study area (Hanafiah *et al*., 2018). The COD value obtained in this study varied from (96 - 272 mg/L) which showed high level of pollution.

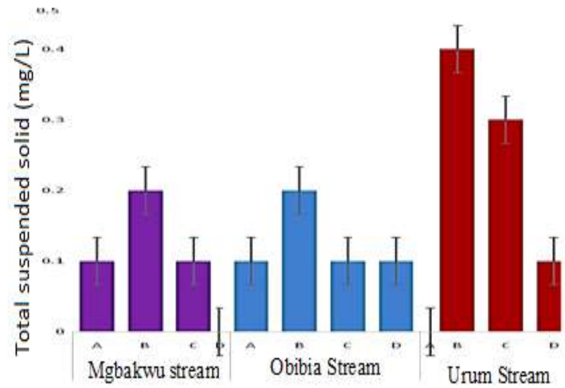

Fig 7: Total suspended solid profile of the three-sampling site
Key: Error bar = Mean standard deviation

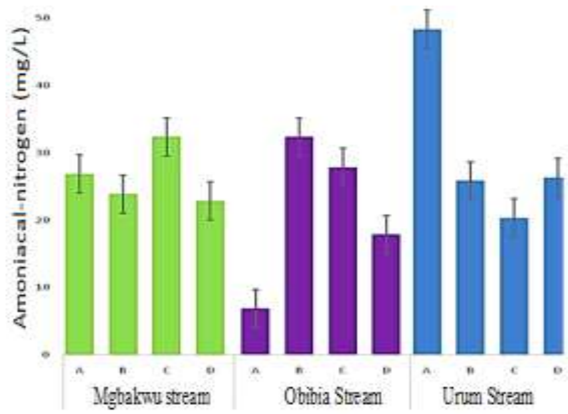

Fig 8: Ammoniacal nitrogen profile of the three-sampling site
Key: Error bar = Mean standard deviation

Total suspended solid (TSS) include a wide variety of material, such as silt, decaying plant animal matter, industrial waste and sewage. High concentrations of suspended solids can cause many problems for stream health and aquatic life (Bilotta and Brazier, 2008). The maximum threshold limit of TSS for Malaysian rivers which support aquatic life is 150 mg/L (Al-Badaii *et al*., 2013). TSS values recorded in this study are within the range of the limit. Ammoniacal nitrogen (NH_3) is common pollutant in freshwater ecosystem is associated with organic compound or sometimes from industrial effluents (Magdalena *et al*., 2015). Abdel-Raouf (2012) stated that the presence of NH_3 in the water is mainly originated from the domestic sewage and waste water from certain types of industries. Ammoniacal nitrogen indicates nutrient status, organic enrichment and health of water body (Radojevic *et al*., 2007). Higher NH_3 value can be toxic to fish, but in small concentrations, it could serve as nutrients for excessive growth of algae (Al-Badaii *et al*., 2013). The maximum threshold level of ammonia is 0.9 µg/L, the value of ammonia nitrogen obtained from this study ranged from 6.85 to 48.35 µg/L and was above the maximum range. The detection of phosphate in water sources indicates contamination of water source by runoff from agricultural farms using inorganic fertilizers. In this study, Mgbakwu point B (6.5 mg/L), C (6.1 mg/L) and Urum sample point B (6.5 mg/L) were above the maximum permissible level (5 mg/L) set by WHO (2011). Statistically, there were significant ($p < 0.05$) among the means of physicochemical parameters but non - significant ($p > 0.05$) among the means of sampling points and sites.

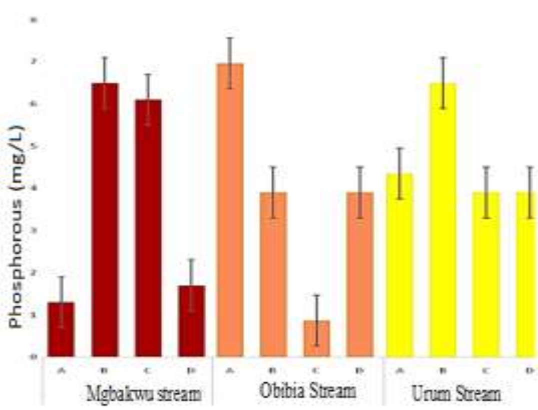

Fig 9: Phosphate profile of the three-sampling site
Key: Error bar = Mean standard deviation

In water quality index (WQI) result of the three sampling sites as shown in Figure 10 revealed that Urum sample point C had the highest WQI value of 55.23 and Mgbakwu point C had the lowest WQI value of 32.17, respectively. Water quality index (WQI) provides relative indication of quality of water. A river/stream with WQI value of 0 to 59 is considered polluted and falls under class III category, 60 to 80 is slightly polluted and fall under class II category and 81 to 100 is considered the water body is clean and falls under class I category. A higher value indicates a better quality of water (Hanafiah *et al*., 2018). The results obtained from this study of three sampling sites showed WQI falls under class III category (polluted category) and contradicts the report of Otene and Alfred – Ackiya, (2019) who stated the WQI of the three locations were found to be 31.269, 29.050 and 26.429, respectively.

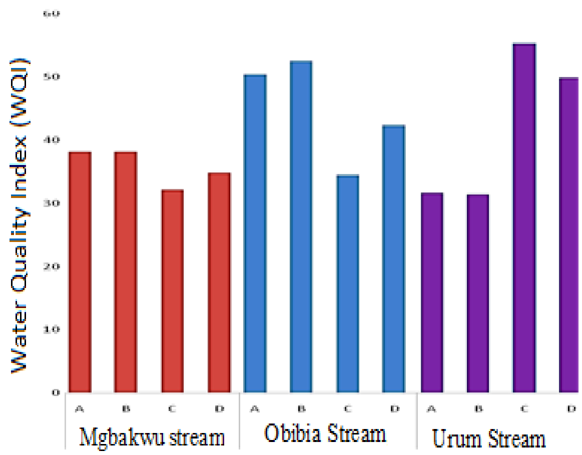

Fig 10: Water quality profile of the three-sampling site

Conclusion: The present study indicated that water samples from the three studied areas were contaminated with various organic and inorganic substances. These sites were subjected to industrial and human activities and resulted in the deterioration of water quality as reveled by the WQI values. Hence, stringent environmental actions should be enacted by government, non – government and policy makers to prevent the indiscriminate release of untreated solid and liquid wastes into these fresh water bodies. Also, in-house treatment of the raw water before use is highly recommended.

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