WATER QUALITY PARAMETERS OF RIVER ETHIOPE IN DELTA STATE, NIGERIA

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Abstract

The study assessed the water quality of River Ethiope at three stations: Umuaja, Abraka and Amukpe, Delta State, Nigeria between November, 2018 and October, 2019 with a view to establishing the parameters relative to the standard of world bodies like World Health Organisation (WHO) and Food and Agricultural Organisation (FAO). The parameters determined were water temperature, air temperature, water level, speed, transparency, pH, conductivity, total dissolved solids (TDs), dissolved oxygen (DO), total alkalinity, nitrate, phosphorus, calcium and magnesium following quality control and assurance procedures and using ANALAR grade reagents. The results indicated that minimal monthly variations in physicochemical parameters existed in the three locations. The speed was higher at Abraka and lowest at Amukpe. The pH was generally low across locations throughout the study period. Dissolved oxygen was higher at Abraka location followed by Amukpe while Umuaja had the least amount of Dissolved Oxygen. The level of alkalinity was high during the period of study in the three locations. No significant ($P \leq 0.05$) differences were observed in the three locations but the level of phosphorus was higher in Abraka location followed by Umuaja and Amukpe locations. The levels of calcium were significantly lower at Umuaja locations when compared with values obtained at Abraka and Amukpe locations. The levels of magnesium followed the same trend as those of calcium, but the values are however higher than those of calcium when compared with world water standards using FAO. The study buttressed earlier claims that the water met world standard in terms of water quality. The present study has contributed to water resources development; a necessity in the health sector. The present study also has the advantage of providing opportunity for monitoring changes in the physical and chemical properties of the river water system thus influencing the socio economic activities of communities found in the immediate vicinity of the river and beyond.

Keyword: Physicochemical parameters, River Ethiope, Delta State, Nigeria

Introduction

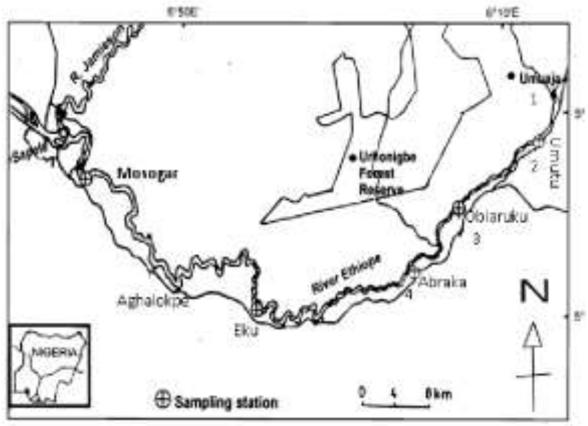
Water qualities both physical and chemical are vital to man and his many industries. Rivers play pivotal roles in the sustenance of life and fresh water habitats including rivers are reserviours of biodiversity worldwide besides helping to maintain ecosystems for a variety of species (Agbogidi, 2019). The importance of rivers in the social economic benefits of rural inhabitants such as fishing, agriculture, management of waterways and as an ecosystem service cannot be overemphasized (Agbogidi, 2022; Agbogidi *et al*., 2022a). River Ethiope believed to be the clearest, cleanest and deepest and fastest flowing waterway in Africa also serves as sacred place for many outside communities relying on them for bathing, fishing, medicine, leisure and drinking (Okumagba and Ozabor, 2014; Agbogidi, *et al*., 2022b). These uses notwithstanding, the river has been contaminated through oil spills, agricultural by-products, waste disposal and overuse among others. The present study is an attempt to assess the water physicochemical parameters of River Ethiope in Delta State with a view to documenting them both as baseline information and their relation with world standard bodies including World Health Organisation and Food and Agricultural Organisation of the United Nations. Besides, Monitoring of water quality is a growing challenge in recent times due to urban, agricultural and industrial waste discharges. The study assessed the water quality of River Ethiope in Delta State, Nigeria in relation to WHO standards.

Materials and Methods

The study area

River Ethiope

River Ethiope is situated at latitude 5°54'3" N and longitude 5°41'0" E, it is characterized by rapid flowing clear fresh water in Delta State. It covers an area of about 103km and flows into the Atlantic Ocean through the Benin River. It has its source (water shed) at Umuaja in Ukwuani Local Government Area of Delta State. At the upper course, the river channel is narrow and flows very fast but widens, deepens and flows less swiftly at the middle course. The vegetation type is that of rain forests. The region is having a well demarcated rainy and dry season. The rainy period starts in May and ends in October while the dry season starts from November to April. The river bed is made up of white sand, pepples and polished rock surfaces. The river becomes characteristically turbid due mainly to materials either in solution or suspension and meanders all along its course. The river is about 50km long and it is outstanding and unique in beauty. It flows through five Local Government Areas of Delta State starting from Ukwuani through Ethiope East, Okpe, Ethiope West and Sapele where it emptied into the River Jemison and discharges into Benin River. At the source, it is highly revered. The map of River Ethiope is shown in Figure 1.



Source: Efe and Aruegodore (2003).

Figure 1: The map of River Ethiope at the three study locations.

Determination of physicochemical parameters

The following parameters were determined using the following procedures.

Water temperature: Digital thermometer was used to determine the water temperature *in situ*.

Air temperature: This was determined *in situ* using Hanna pH meter using
Water level: The water level was determined in situ using Hanna conducive meter.
Speed: This was determined using APHA method.
Transparency: This was determined using the Secchi disk.
Conductivity: This was measured *in situ* using Hanna pH meter.
Total dissolved solid (TDs): This was measured using APHA method (2006).
Dissolved oxygen (DO): The amount of dissolved oxygen by Azide Modification method
Total alkalinity: This was determined using the APHA method (2006)
Nitrate: This was measured using the Turbid metric method
Phosphorus: This was determined using the Tin (II) colorimetric method
Calcium: This was determined using APHA method (2006)
Magnesium: This was determined using APHA method (2006)

Parameters	**Methods of measurement/determination**
Water temperature ^{0}C	Digital Thermometer *in-situ*
Ambient temperature ^{0}C	Insitu using Hanna pH meter
Water level	Insitu using Hanna conductive meter
Speed	APHA method (2006)
Transparency	Secchi disk
pH	Measured in insitu using Hanna pH meter
Conductivity	Measured in insitu using Hanna pH meter
Total Dissolved solids (TDs)	APHA method (2006)
Dissolved Oxygen (DO)	Azide modification method
Total Alkalinity	APHA method (2006)
Nitrate	Turbid metric method
Phosphorus	Tin(11) colorimetric method
Calcium	APHA method (2006)
Magnesium	APHA method (2006)

Quality control and assurance

Quality control and assurance procedures were strictly followed to obtain accurate results. Each analysis was done in triplicates. All reagents used were of ANALAR grade. All sampling containers and apparati were washed with detergent and rinsed with distilled water before use. All these ensured monitoring of water quality as it is a growing challenge in recent times due to urban, agricultural and industrial discharges.

Results and Discussion

Results

Physicochemical properties

Minimal monthly variations in physicochemical parameters existed in the three locations. Varying levels of surface and air temperatures were observed in this study. Levels of temperature varied significantly ($P<0.05$) in all three stations of study except in March and June 2019 which had temperature levels that were not significantly ($P>0.05$). Temperature levels were generally higher ($P<0.05$) in Amukpe (Station 3) than in Stations 1 and 2. Air temperatures were higher than surface water temperatures. Though air temperature was low in August, surface temperature was significantly ($P<0.05$) lower in Station 3.

Figures 1 and 2 show the variations in temperature readings in the three stations during the period of study. Figure 3 shows that water level was significantly ($P<0.05$) higher in Station 3. Station 1 is up stream and the source of River Ethiope, while Station 2 is mid-stream and Station 3, downstream close to the mouth of the river were it deposits into a bigger water body.

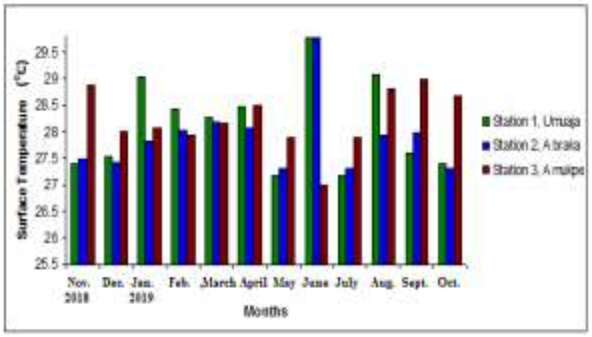


Figure 1. Monthly variations in Surface Temperature in study stations

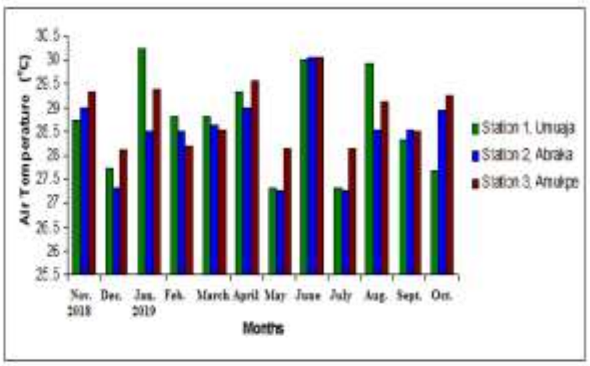


Figure 2. Monthly variations in Air Temperature in study stations

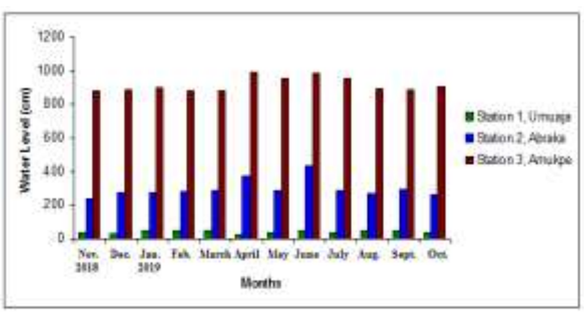


Figure 3. Monthly variations in Water Level in study stations.

Figure 4 shows that the speed of Ethiope River was higher in Station 2, Abraka. Speed was lowest in Station 3 in a few months, particularly in November, 2018. Transparency was significantly ($P<0.05$) lowest in Station 3, Amukpe ranging from 0.29 cm to 1.57 cm. River Ethiope at Station 2, Abraka had highest ($P<0.05$) level of transparency ranging from 231.67 cm to 431.33 cm. Levels of transparency of River Ethiope is presented in Figure 5. Significant differences ($P<0.05$) were observed in water level, speed and transparency in the three study stations along River Ethiope. Hydrogen ion concentration varied from station to station. Station 3 had the highest pH level while Station 1 had the lowest level (Figure 6).

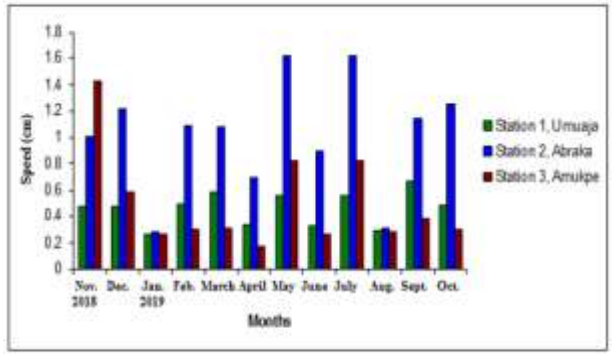


Figure 4. Monthly variations in Speed in study stations

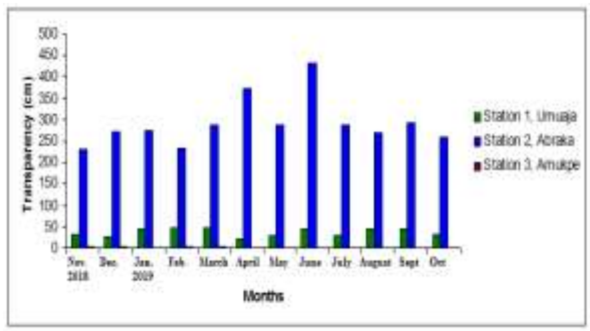


Figure 5. Monthly variations in Transparency in study stations

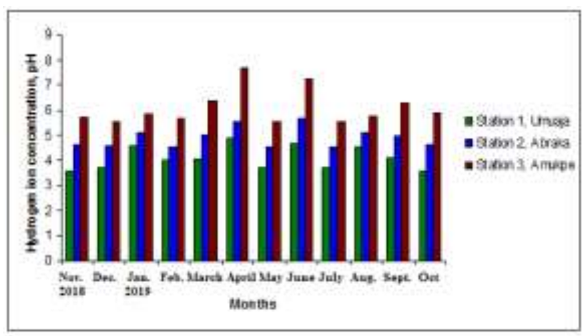


Figure 6. Monthly variations in Hydrogen ion concentration, pH in study stations

Conductivity levels were low throughout the study period in all three study stations. In most of the months, the level of conductivity was not detectable. Values were however, higher in Station 3, Amukpe (Figure 7). Levels of total dissolved solids were high in the months of June and August, 2019. Levels were generally low in other months particularly in Stations 1 and 2. Levels ranged from 0.00 ± 0.00 mg/L to 1.84 ± 0.07 mg/L (Figure 8). Dissolved oxygen levels were higher in Station 2, followed by Station 1 and lowest in Station 3. Mean dissolved oxygen level ranged from 2.13 mg/L to 8.03 mg/L (Figure 9). Level of total alkalinity was high during the period of study in all three stations. Mean total alkalinity obtained was 357.58 ± 6.19 mg/L in Station 1 (Umuaja), 475.03 ± 2.87 mg /L in Station 2 (Abraka) and 550.44 ± 13.91 mg /L in Station 3 (Amukpe). Figure 10 shows the monthly variation in dissolved oxygen in study stations. The levels of total alkalinity obtained in the study stations are presented in Figure 10. Nitrate concentrations obtained in this study, with a mean of 0.84mg/L for all Stations, was not significantly (P>0.05) different in all stations surveyed (Figure 11).

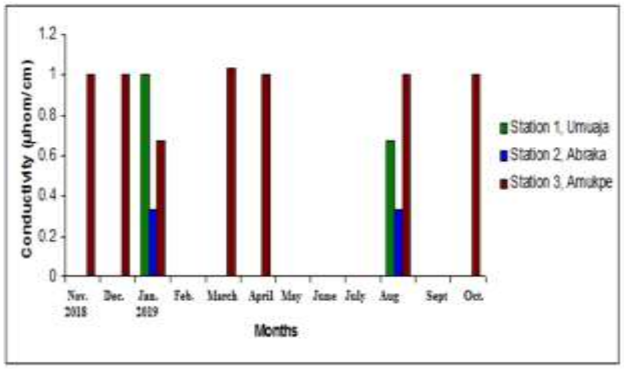


Figure 7. Monthly variations in Conductivity in study stations

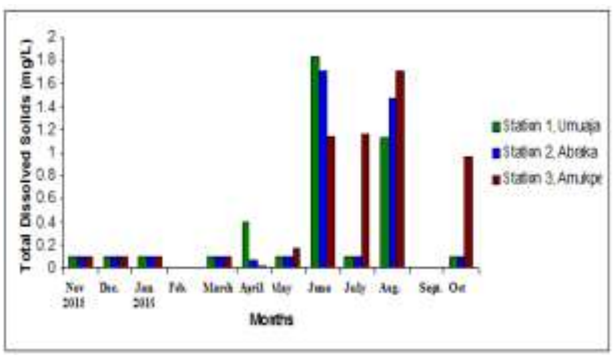


Figure 8. Monthly variations in Total Dissolved Solids in study stations

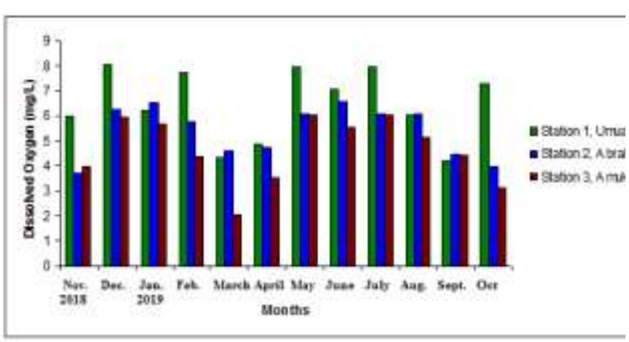


Figure 9. Monthly variations in Dissolved Oxygen in study stations

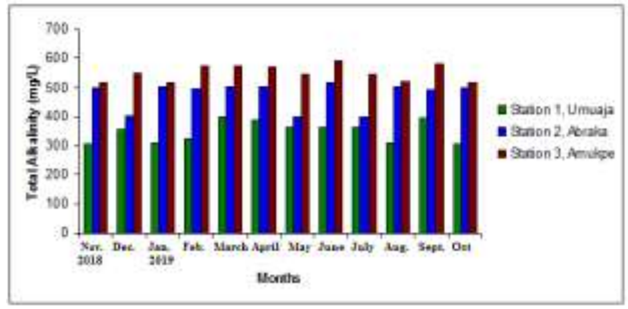


Figure 10. Monthly variations in Total Alkalinity in study stations

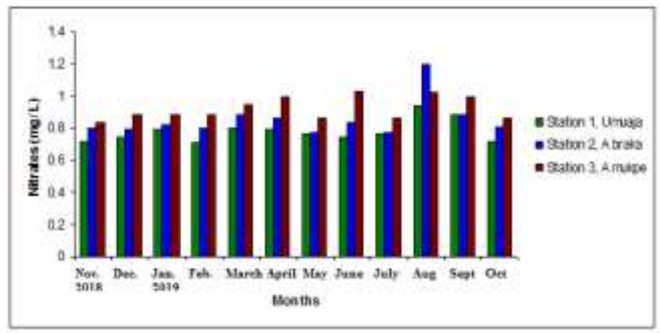


Figure 11. Monthly variations in Nitrates in study stations

The level of phosphorus was higher in Station 2, followed by Station 1 and then Station 3 throughout during the period of study (Figure 12). The concentrations of calcium in water column were significantly lower in Station 1 than in the other stations. Levels of ranged between 5.11 mg/L and 10.87 mg/L. Comparable levels were obtained for Stations 2 an 3 (Figure 13). The levels of Magnesium obtained in this study are presented in Figure 14. Though the levels of magnesium followed the same trend as the levels of calcium, magnesium levels were lower than calcium levels. Levels of magnesium in water column was significantly lower in Station 1 than in the other stations.

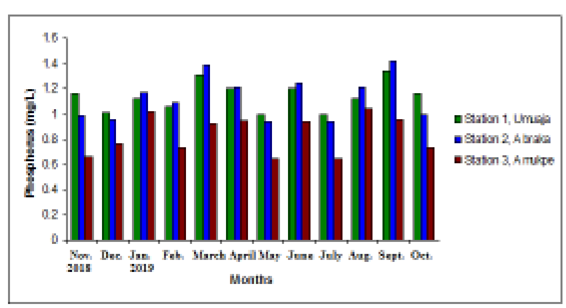


Figure 12. Monthly variations in Phosphorus in study stations

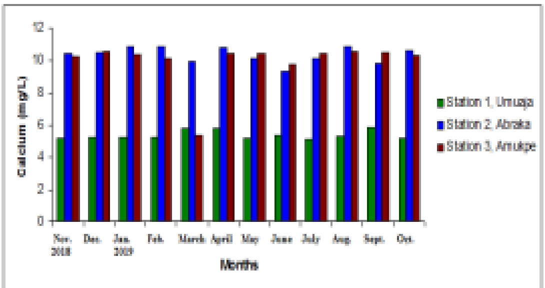


Figure 13. Monthly variations in Calcium in study stations

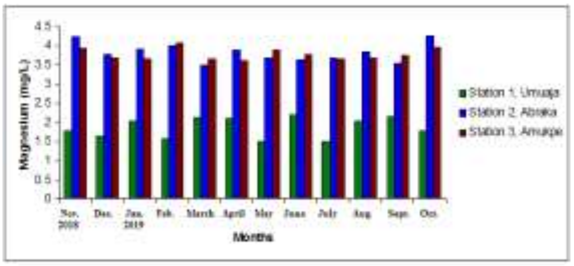


Figure 14. Monthly variations in Magnesium in study stations

The source of River Ethiope is located at Umuaja; Delta State is believed to be the deepest inland waterway in Africa. It originates from the foot of a giant silk cotton tree. The river has the depth of 100ft and it is a fresh water body which holds the undisputed record as the deepest river in West Africa.

Discussions

Physicochemical parameters

Variations in physicochemical parameters were observed during the study. According to Adeyemi *et al.* (2009), a change in physicochemical aspect of a water body can bring about a corresponding change in relative composition and abundance of the organism in the water. Variations in temperature have been reported. Folland *et al.* (2018) reported irregularities in global mean surface temperatures. Low temperatures have been reported by Khan *et al.* (2019) and by Hadi *et al*. (2019) in relation to heat waves and the unidirectional trend in temperatures as a bioclimate indicator respectively. Increases in temperatures of tropical rivers have been reported to impact on tolerance levels of fishes to fluctuations in temperatures (Kaushal *et al*. 2010; Akra, 2013). The higher surface and air temperatures observed in Station 3 may be due to the fact that Stations 3 is more urban with a few industries unlike the other stations which are located in villages. Yue and Xi (2013) noted that thermal environment had an effect of urban water. Air temperatures were in most cases higher than the surface water temperatures. Harvey *et al.* (2011) observed that air temperatures have an effect on surface water temperatures. The source of the river had smaller volume of water compared to the other stations.

At Station 2, high volume of water encouraged higher flow of water. However, Station 3 with larger volume of water had a reduced flow probably due to heavier loads as it approaches the point of deposition into a bigger water body. Bucak *et al*. (2012) and Dong *et al.* (2014) reported that water level has great influence on macrophyte community growth and trophic interactions. Flow velocity affects the swimming of fish in the water column. It also affects feeding behaviour and other activities of fish. Silva *et al.* (2011) reported that water flow in rivers has effect on fish swimming performance. Transparency was observed to be low in Station 3, Amukpe. Low transparency has been reported to affect the feeding ability of fish due to poor vision probably requiring a diet shift for fish to survive (Jönsson *et al.*, 2012). The high pH observed in Station 3 could be due to the higher organic matter load. According to Chambers *et al.* (2012), the chemical constituent of water can have an effect on the pH of water. The level of pH could also be affected by respiratory and photosynthetic activities of aquatic organisms in the river (Zaprudnova and Kamshilov, 2010).

Conductivity levels are a reflection of the amount of metal elements and chloride ions in the water column. The low level of conductivity observed could be attributed to low level of elements in the water. Oyem *et al.* (2014) while working on physicochemical properties of groundwater noted that electrical conductivity is a measure of elements in dissolution in the water column. Perlman (2014) also reported on the ability of water to conduct electricity. The levels of total dissolved solids obtained in this study were lower than levels obtained by Eze and Ogbaran (2010). The low levels obtained could be due to low effluent discharges into the water body as since upstream and mid- stream were devoid of any point source of industrial discharges. The levels of dissolved oxygen obtained were slightly lower than levels obtained in the same river (Nwabueze, 2015). Station 3 had the lowest level of dissolved oxygen. This low level could be as a result of high amount of suspended matter, evidenced by the low level of transparency obtained in Station 3. According to Bhatnagar and Devi (2013) optimum alkalinity for fish productivity is between 25 to 100 mg/L. Though values obtained in this study were above this range, the values are suitable for fish farming. Pellegrin *et al.* (2019) reported that alkaline water improves growth and antioxidant responses in juvenile fish.

The low level obtained in this study is good for fish production. It is important that the level of nitrate in a pond be controlled to avoid eutrophication. Nitrates are however not harmful to fish. Pedersen *et al*. (2012) reported the need for a balance in nitrogen level for good fish performance in aquaculture systems. High levels of nitrate could be detrimental to fish health and may affect fish production (Van Bussel *et al*., 2012). Levels of phosphorus were also generally low and comparable to levels obtained for the river in earlier studies (Nwabueze, 2015). Şahin *et al.* (2012) reported that phosphorus is gradually released from sediments in fractions. High level of calcium hardens water. The dietary requirements of fish for successful hatching of eggs have been studied (Van Bussel *et al.*, 2012). The level of magnesium obtained was good for fish production. Van Dam *et al*. (2010) opined that high level of magnesium sulphate was toxic to aquatics. Nwabueze (2015) also noted that K+, Ca2+, and Mg^{2+} could affect fish sperm motility.

Correlation analysis shows that varying degrees of correlation of physicochemical parameters existed. Values of correlation is normally between -1 and +1, depicting varying degrees of strong and weak positive and negative correlations. Values other than within these ranges show no correlation. No correlations were observed for total dissolved solids and conductivity during the study. These could be attributed to the very low and probably negligible levels of both parameters recorded during the study. Perlman (2014) reported that the level of total dissolved solids is related to electrical conductivity since conductivity is based on the total dissolved solids in the water body.

Though the levels of Calcium and Magnesium obtained in this study were low, levels were within the typical range of 4 - 100mg/L in freshwater bodies as reported by Fella *et al.* (2013), who observed similar concentration of calcium in freshwater. Freshwater has been known to have a lot of calcium than magnesium due to abundant calcium in the earth crust and so calcium is one of the major inorganic cations or positive ion in salt and freshwater. Ekelemu and Zelibe (2006) reported a magnesium ion concentration range between 3.40mg/l and 3.89mg/L and opined that magnesium is a dietary mineral for any organism. The average value of magnesium in water particulates has been given as 1.2%. Inspite of the minimum monthly variation in physicochemical parameter that existed in the three locations, no significant variation were observed in the levels of the water quality and values given by World Health Organization (WHO) (FAO, 2013).

Conclusion and recommendation

The research assessed the water quality parameters of River Ethiope, Delta State, Nigeria and observed that all the physicchemical parameters are within the recommended values for rivers as recommended by FEPA (2014) and WHO (2015). The study also recorded no significant seasonal variations in all the parameters studied at Umuaja, Abraka and Amukpe. The study has helped to generate baseline information on aspects of the physicochemical parameters of River Ethiope, Umutu, Abraka and Amukpe. The research is useful for the continued assessment and monitoring of the physicochemical properties of River Ethiope as it affects life of organisms in the River. Further studies are recommended in other locations along River Ethiope

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