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Seasonal Variation in Physicochemical Parameter of River Okpokwu

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ABSTRACT

The study investigated the physicochemical parameter of River Okpokwu in dry and rainy season. The DO was highest at station C (9.03±0.14 and 7.80±0.30) while it was lowest at station a (8.99±0.16 and 7.72±0.28) for dry and rainy season respectively. The highest BOD was recorded at station B (3.19±0.13 in dry season) and A (2.62±0.19) in rainy season)while the lowest (3.09±0.15 and 2.53±0.13 respectively) was recorded at station C. The highest pH (7.10±0.10 and 6.85±0.85) was recorded at station C and B in dry and rainy season respectively while the lowest (6.95±0.10 and 6.81±0.19) was recorded at station A for both seasons, Alkalinity was highest at station B (59.69±1.12) and A (46.03±1.84) while it is lowest at station A (58.68±1.30) and C (45.70±1.72) in dry and rainy season respectively. Hardness recorded the highest at station B (26.28±0.76) and C (22.20±0.68) in dry and rainy season respectively while its lowest at station A (26.23±0.75 and 22.06±0.64) for both season. Phosphate was highest (0.19±0.00) at station A in rainy season and was lowest (0.14±0.01) was recorded at station A in dry season. However, there was no significant difference ($p>0.05$) between Chloride and Nitrate in the dry and rainy seasons while there was significant difference ($p<0.05$) between the other parameters in both seasons during the period of study. It was concluded that Physicochemical parameters of water collected from River Okpokwu were within the normal range according to WHO which indicates that water of River Okpokwu is convenient for both aquatic life and domestic use. There was significant difference in both seasons ($p<0.05$) of Dissolved oxygen, BOD, Free carbon-dioxide, air temperature, water temperature, total dissolved solid, transparency, pH, alkalinity, hardness and phosphate, But there was no significant difference for chloride and nitrate in both seasons ($p>0.05$).

INTRODUCTION

Rivers are water ways that provide water resources for domestic, industrial and agricultural purposes. Thus, the importance of rivers to both artisanal and culture fisheries cannot be overemphasized as many fish farmers depend on them for sustained production. However, the extent to which rivers can play this important role depends largely on the qualities of water that support growth of plants and animals. Thus, the supply of adequate and quality water is a limiting factor in successful fisheries production and management (Ngwenya, 2006). According to Raj and Azeez (2009), natural factors such as rainfall, temperature and weathering of rocks and anthropogenic changes that curtail natural flow of river or alter its hydrochemistry influence the quantity and quality of surface water in the river basin. Suffices to note therefore that the water environment contributes to a large extent to the quantity and quality of catch achieved in a water body substantial knowledge of the water environment could enhance the benefits derivable from the river by those depending on it either directly or indirectly to support their livelihood. Delince (1992) reported that the qualities of water depend on the kind of soils they travel over in addition to physical, chemical and biological factors.

Human activities, including the acts of disposal of dead bodies, discharge of industrial and sewage wastes and agricultural runoffs which are major causes of ecological damage and pose serious health hazards, are major contributors to the problem of water quality deterioration (Meitei et al., 2004). Broadly speaking, there are three common types of pollution. These include air pollution, soil pollution and water pollution. They include the discharge of noxious gases into the air, disposal of wastes and effluents into water bodies, damage of soils by fertilizers and pesticides applications, over grazing of lands etc. most water from industries are polluted by by-products of the manufacturing process and other materials use relating to human activities in the industries concerned (Hodges, 1973).

Limnology or water quality assessment provides data that are useful in the development of fisheries resources, and control of vectors of water borne diseases (Haruna, 1992). Studying water quality of a river is helping to protect and maintain the aquatic eco-system and other resources the river provides to the society. Productivity studies are concerned with the evaluation of the capacity of an ecosystem, to build up, at the expense of external energy (radiant and chemical); fish yields are strongly correlated with primary production (Melack, 1976; Ogblesby, 1977). Water quality generally refers to the parameters of water which are to be present at optimum levels for suitable growth of plants and animals (Kumar et al., 2011). A good water condition is a necessity for the survival and growth of fish since the entire life process of the fish wholly depends on the quality of its environment. The physical, chemical and biological qualities of water should be closely monitored by fish farmers when raising fish in artificial ponds because availability of good quality water is an indispensable feature for improving quality of life as well as preventing diseases and deaths of humans and aquatic organisms (Adefemi and Awokunmi, 2010). The objective of this study therefore is to determine physicochemical parameter River Okpokwu with a view to providing information on the water quality of the river and plan management strategies accordingly.

MATERIALS AND METHODS

Description of Study Area

River Okpokwu transverses Ogbadibo, Okpokwu, Ado Local Government Areas of Benue State to Cross River State. There is a coal deposit in Owukpa, Ogbadibo Local Government Area which is upstream of River Okpokwu in Igumale, Ado Local Government Area of Benue where the sampling sites are located. The river is used for irrigation, recreation, sewage disposal, fishing etc.
The study area is the only portion of the river where there are true riparian communities, with settlements on both banks of the river. The area is located between latitude 6o 48' 0" N and longitude 7o 58' 0" E. It contains mineral and natural resources in commercial quantities such as limestone, kaolin, petroleum and coal. The river covers about 76.76km. The climate is characterized by two distinct seasons, the dry season (November – April) and Wet season (May – October).

The three sampling stations (figure 1) were located at Igumale (Station A, known as Madam Ori side, Station B, known as Ogbe side and station C known as Igede side), all in Ado Local Government Area of Benue State. These stations were selected considering the riparian nature and activities of the settlements.

Physicochemical Parameter Analysis

Temperature was determined on the field by using a PHT-027 Multi-parameter water quality checker, the degree of transparency of sampling points was obtained using a secchi disk with graduated rope. The transparency of the water body was computed as follows:

$$\frac{d1+d2}{2}$$

Where d1 = depth at which secchi disc disappears, d2 = depth at which secchi disc reappears.

Hydrogen ion concentration (pH) was determined on the field using a PHT-027 Multi-parameter water quality checker, Dissolved oxygen was determined on the field using dissolved oxygen meter model: DO-5509, Biological oxygen demand was determined using a dissolved oxygen meter model: DO-5509 and Freshwater aquaculture test kit (MODEL AQ-2). Sampling bottle was rinsed with water

was determined by using a Freshwater aquaculture test kit (MODEL AQ-2), Total dissolved solids were determined in situ using a PHT-027 Multi-parameter water quality checker, Free carbon-oxide was determined by using a Freshwater aquaculture test kit (MODEL AQ-2), Nitrate was determined using APHA (1985), Total hardness was determined using a Freshwater aquaculture test kit (MODEL AQ-2), Chloride was determined by using a Freshwater aquaculture test kit (MODEL AQ-2) while phosphate was determined according to according to APHA (1985) using spectrophotometer (spectromi 21D) at wavelength of 882 mm.

RESULTS

Results of the mean water quality parameters in dry season from the three stations are presented in Table 1 while Table 2 shows the results of the mean water quality parameters from the three stations in rainy season.

In dry season, DO was highest (9.03±0.14) at station C while it was lowest (8.99±0.16) at station A, the highest BOD (3.19±0.13) was recorded at station B while the lowest (3.09±0.15) was recorded at station C, the highest CO2 (17.06±0.24) was recorded at station C while the lowest (16.66±0.31) was recorded at station B, Air temperature was highest (21.81±0.46) at station C and lowest (21.54±0.47) at station A, the highest water temperature (24.99±0.47) was recorded at station C while the lowest (24.33±0.39) was recorded at station A, the highest TDS (46.48±2.36) was recorded at station B while the lowest (44.56±1.46) was recorded at station C, Transparency was highest (51.51±3.75) at station A and lowest (51.04±3.91) at station C, the highest pH (7.10±0.10) was recorded at station C while the lowest (6.95±0.10) was recorded at station A, Alkalinity was highest (59.69±1.12) at station B and lowest (58.68±1.30) at station A, Hardness recorded the highest (26.28±0.76) at station B and lowest (26.23±0.75) at station A, the highest Chloride (12.08±0.18) was recorded at station C while the lowest (12.03±0.12) was recorded at station A , Nitrate was highest (0.82±0.02) at station C and lowest (0.80±0.01) at station A, and Phosphate was highest (0.15±0.01) at stations C and B respectively and the lowest (0.14±0.01) was recorded at station A.

Whereas in rainy season, DO was highest (7.80±0.30) at station C while the lowest (7.72±0.28) was recorded at station A, the highest BOD (2.62±0.09) was recorded at station A while the lowest (2.53±0.13) was recorded at station C, the highest CO2 (17.35±0.22) was recorded at station C while the lowest (17.15±0.23) was recorded at station A, Air temperature was highest (23.51±0.46) at station B and lowest (23.14±0.47) at station A, the highest Water temperature (26.52±0.48) was recorded at station C while the lowest (26.08±0.44) was recorded at station A, the highest TDS (33.43±2.03) was recorded at station A while the lowest (23.03±1.92) was recorded at station C, Transparency was highest (27.06±1.75) at station B and lowest (26.62±1.70 at station A, the highest pH (6.85±0.08) was recorded at station B while the lowest (6.81±0.09) was recorded at station A, Alkalinity was highest (46.03±0.84) at station A and lowest (45.70±1.72) at station C, Hardness recorded the highest (22.20±0.68) at station C and lowest (22.06±0.64) at station A, the highest Chloride (11.55±0.22) was recorded at station C while the lowest (11.50±0.17) was recorded at station A, Nitrate was highest (0.85±0.03) at station A and lowest (0.84±0.03 each) at stations C and B respectively , and Phosphate was highest (0.19±0.00) at station A and the lowest (0.18±0.00 each) was recorded at stations C and B respectively.

Table 1: Mean water quality parameters by stations in the dry season.

PARAMETERS	STATION A	STATION B	STATION C	P Value
DO	8.99 ± 0.16^{a}	8.99 ± 0.19^{a}	9.03 ± 0.14^{a}	0.98
BOD	3.14 ± 0.14^{a}	3.19 ± 0.13^{a}	3.09 ± 0.15^{a}	0.87
CO_2	16.80 ± 0.19^{a}	16.66 ± 0.31^{a}	17.06 ± 0.24^{a}	0.52
Air Temp.	21.54 ± 0.47^{a}	21.64 ± 0.45^{a}	21.81 ± 0.46^{a}	0.91
Water Temp.	24.33 ± 0.39^{a}	24.82 ± 0.46^{a}	24.99 ± 0.43^{a}	0.53
TDS	44.63 ± 1.42^{a}	46.48 ± 2.36^{a}	44.56 ± 1.46^{a}	0.70
Transparency	51.51 ± 3.75^{a}	50.38 ± 3.54^{a}	51.04 ± 3.91^{a}	0.98
pH	6.95 ± 0.10^{a}	7.10 ± 0.08^{a}	7.10 ± 0.10^{a}	0.41
Alkalinity	58.68 ± 1.30^{a}	59.69 ± 1.12^{a}	59.66 ± 1.10^{a}	0.79
Hardness	26.23 ± 0.75^{a}	26.28 ± 0.76^{a}	26.27 ± 0.73^{a}	1.00
Chlorine	12.03 ± 0.12^{a}	12.05 ± 0.20^{a}	12.08 ± 0.18^{a}	0.37
Nitrate	0.80 ± 0.01^{a}	0.81 ± 0.02^{a}	0.82 ± 0.02^{a}	0.87
Phosphate	0.14 ± 0.01^{a}	0.15 ± 0.01^{a}	0.15 ± 0.01^{a}	0.97

Mean values with different superscript within rows differed significantly ($p<0.05$)

Table 2: Mean water quality parameters by stations in the rainy season

PARAMETERS	STATION A	STATION B	STATION C	P Value
DO	7.72 ± 0.28^{a}	7.77 ± 0.31^{a}	7.80 ± 0.30^{a}	0.98
BOD	2.57 ± 0.09^{a}	2.62 ± 0.09^{a}	2.53 ± 0.13^{a}	0.84
CO_2	17.15 ± 0.23^{a}	17.30 ± 0.22^{a}	17.35 ± 0.22^{a}	0.81
Air Temp.	23.14 ± 0.47^{a}	23.51 ± 0.46^{a}	24.31 ± 0.59^{a}	0.27
Water Temp.	26.08 ± 0.44^{a}	26.23 ± 0.49^{a}	26.52 ± 0.48^{a}	0.79
TDS	33.43 ± 2.03^{a}	31.86 ± 2.09^{a}	23.03 ± 1.92^{a}	0.85
Transparency	26.62 ± 1.70^{a}	27.06 ± 1.75^{a}	27.01 ± 1.73^{a}	0.98
Ph	6.81 ± 0.09^{a}	6.85 ± 0.08^{a}	6.82 ± 0.09^{a}	0.95
Alkalinity	46.03 ± 1.84^{a}	45.85 ± 1.72^{a}	45.70 ± 1.72^{a}	0.99
Hardness	22.06 ± 0.64^{a}	22.15 ± 0.67^{a}	22.20 ± 0.68^{a}	0.99
Chlorine	11.50 ± 0.17^{a}	11.54 ± 0.12^{a}	11.55 ± 0.22^{a}	0.97
Nitrate	0.85 ± 0.03^{a}	0.84 ± 0.03^{a}	0.84 ± 0.03^{a}	0.95
Phosphate	0.19 ± 0.00^{a}	0.18 ± 0.00^{a}	0.18 ± 0.00^{a}	0.94

Mean values with different superscript within rows differed significantly ($p<0.0$).

Table 3: Mean seasonal water quality parameters during the study period

PARAMETERS	SEASON	MEAN	P Value
DO	DRY	----	0.00
	RAINY	7.77±0.17	
BOD	DRY	3.14±0.08	0.00
	RAINY	2.57±0.06	
CO_2	DRY	16.84±0.15	0.03
	RAINY	17.27±0.13	
AIR TEMP	DRY	21.66±0.26	0.00
	RAINY	23.65±0.30	
WATER TEMP	DRY	24.71±0.25	0.00
	RAINY	26.28±0.27	
TDS	DRY	45.22±1.03	0.00
	RAINY	32.78±1.15	
TRANSPARENCY	DRY	50.98±2.13	0.00
	RAINY	26.90±0.98	
pH	DRY	7.05±0.05	0.00
	RAINY	6.83±0.05	
ALKALINITY	DRY	59.35±0.67	0.00
	RAINY	45.86±1.00	
HARDNESS	DRY	26.26±0.42	0.00
	RAINY	22.14±0.38	
CHLORIDE	DRY	30.02±17.99	0.31
	RAINY	11.53±0.10	
NITRATE	DRY	0.81±0.01	0.60
	RAINY	0.85±0.02	
PHOSPHATE	DRY	0.15±0.00	0.00
	RAINY	0.18±0.00	

Results of the mean seasonal water quality parameters during the study period are presented in Table 3. DO was higher (9.00±0.09) in dry season but lower (7.77±0.17) in rainy season, BOD was higher (3.14±0.08) in dry season but lower (2.57±0.06) in rainy season, CO2 was higher (17.27±0.13) in rainy season but lower (16.84±0.15) in dry season, Air temperature was also higher (23.65±0.30) in rainy season but lower (21.66±0.26) in dry season, Water temperature was higher (26.28±0.27) in rainy season but lower (24.71±0.25) in dry season, TDS was higher (45.22±1.03) in dry season but lower (26.28±0.27) in rainy season, Transparency was higher (50.98±2.13) in dry season than in the rainy season (26.90±0.98), pH recorded was higher (7.05±0.05) in dry season than in rainy season (6.83±0.05), Alkalinity was higher (59.35±0.67) in dry season but lower (45.86±1.00) in rainy season, Hardness was higher (26.26±0.42) in dry season but lower (22.14±0.38) in rainy season, Chloride was higher (30.02±17.99) in dry season but lower (11.53±0.10) in rainy season, Nitrate was higher (0.85±0.02) in rainy season but lower (0.81±0.01) in dry season, and Phosphate was higher (0.18±0.00) in rainy season but lower (0.15±0.00) in dry season.

However, there was no significant difference ($p>0.05$) between Chloride and Nitrate in the dry and rainy seasons while there was significant difference ($p<0.05$) between the other parameters in both seasons during the period of study.

DISCUSSION

Oxygen concentration was highest during the dry season as a result of photosynthetic activity by plants, which contributed in oxygenating the water column and at the same time reducing respiration by aquatic organisms and decomposition processes in the river. The low oxygen content of the water body during the rainy season could be as a result of Low transparency and low nutrient load during the season. The Dissolved oxygen concentrations in River Okpokwu were above the value of 5.0 mg L-1 recommended by FEPA (2003). The higher values of Dissolved oxygen concentrations in the river may be due to change in season, and rainfall pattern.

Temperature is an important limiting factor, which regulates the biogeochemical activities and exerts great control over aquatic communities. If the overall water body temperature of a system is altered, an aquatic community shift can be expected. It was found that in the dry season, water and air temperature were lower than wet season values. The lower water and air temperature values in dry season than the wet season values could be due to time of sampling. This is in agreement with the work of Abubakar et al. (2013) who reported lower water temperature (25.90C) in the dry season compared with 28.750C in the rainy season in Sokoto-Rima river, Nigeria, a finding which was consisted with that of Onaji et al. (2005) The surface water temperature is influenced by the intensity of solar radiation, evaporation and runoffs. According to Medudhula et al., (2012), high water and air temperature was due to low water level, high atmospheric temperature and clean atmosphere. According to Waziri et al., (2015), low water and air temperatures in the dry season were due to the cool dry North East trade wind effect. The assertion in this present work agrees with the reported work of Waziri et al., (2015). Any increase in temperature decreases the DO (Vincy et al., 2012). The range of values recorded for temperature in River Okpokwu falls within the range recommended by the Federal Environmental Protection Agency (FEPA, 2003) in an aquatic environment or ecosystem.

Water pH is important indicator of water quality. It determines the suitability of water for various purposes, including toxicity to animals and plants. Acidic pH will affect the aquatic ecosystem. pH of rivers, dams and other water bodies are significant parameters which determine distribution of aquatic organisms particularly fish (Altaf et al., 2013). Seasonal variation in the pH revealed higher values for the dry season than wet. The pH in rainy season was significantly lower than in dry season. The lower pH recorded in rainy season than the dry season could be due to increase in temperature and decreased amount of nitrates, phosphates and ultimately eutrophication in rainy season. According to WHO normal range of pH for water is 6.5-8.5 (Zaigham et al., 2012). The range of value recorded for pH in River Okpokwu agrees with the range recommended by the World Health Organization (2008) for the culture of fish but disagrees with the reported work of Altaf et al., (2013) who reported low pH values in their work. According to them, low pH was indicative of the presence of weak acids, high concentration of carbon (iv) oxide, oligotrophic water body, and stirring effect of incoming water in stagnant water of the flood plain.

Alkalinity represents the buffering capacities of water. The solubility of various substances directly depends on the levels of alkalinity in the water. Similar findings were observed by Emmanuel and Godwin, (2014) in Aiba Reservoir Headwater Streams, Iwo, Nigeria. It was observed in the present study, that low total alkalinity was recorded during the wet season. The findings are in conformity with Sani (2015) who reported low values during the wet season in Challawa River and Wassai Dam in Kano State, Nigeria. Low values recorded during the rains was due to low photosynthetic activity, water with low alkalinity less than 75 mgl-1 especially surface water and rain fall is subject to changes in pH due to dissolved gasses that may be corrosive to metallic materials. The mean total alkalinity value for dry season was higher than the wet season. This could be that during dry season, there was evaporation and high concentration of bi-carbonate ions in the water. The result of the present study is in agreement with findings of Oyhakilome, (2012) who reported higher concentration of total alkalinity during the dry season in Owena multi-purpose Dam, Ondo State, Southwest Nigeria. High alkalinity values are indicative of the entropic nature of the water bodies, and unsafe for ecosystem as well as for potable use. Total alkalinity in River Okpokwu was within the values recommended by (FEPA, 2003).

Total dissolved solids were higher in the wet season than the dry season. The higher total dissolved solids in the wet season than the dry season could be as a result of inputs from both natural and anthropogenic sources. In addition, the higher total dissolved solids in the wet season than the dry season could be attributed to the rising water level of the river because of increased inflow from point and non point discharges during the rainy season, increase in colloidal suspension from effluent discharged into the river may have increased the total dissolved solids and in turn raised turbidity and reduce transparency of the water. This assertion agrees with the reported work of Ajit and Padmaker, (2013).

High value of total dissolved solids was due to the presence of large quantity of solid matters carried by flood and erosion caused by heavy rain. Low concentrations of total dissolved solids in dry season could be as a result of limited growth of aquatic organisms due to nutrient deficiencies such as little amount of potassium, chloride and sodium. This could also be attributed to the low water level in the river due to low flow of drainage water from the drains into the river. In various water bodies in Nigeria, the total dissolved solids are variable. Similar observation had been made by EPA (2012). Total dissolved solids in River Okpokwu were below the values recommended by FEPA (2003).

High concentrations of carbon (iv) oxide may be due to high pH, and decomposition of organic matter which lead to pollution. Low concentrations of carbon (iv) oxide in this study could be due to photosynthetic activity by aquatic plants which release oxygen to the water during photosynthesis. The result of this study is in agreement with the findings of (Ikongbeh et al., 2013) who reported free carbon dioxide of Akata Lake. The dry season carbon-dioxide values were higher than wet season values. There was significant differences in carbon-dioxide in the both seasons ($p<0.05$).

Biological Oxygen Demand (BOD) is a measure of the biological activities of a water body, an indication of the organic load and it is a pollution index especially for water bodies receiving organic effluent. When the biochemical oxygen demand concentration falls below 5 mg L-1, fish species intolerant of low oxygen levels become stressed. The lower the oxygen values in aquatic environment, the greater the stress. According to the rankings of World Health Organization (WHO, 2005) water bodies with BOD levels between 1.0 and 2.0mg/l are considered clean, 3.0mg/l, fairly clean; 5.0mg/l doubtful, and 10.0mg/l definitely bad and polluted. The dry season Biological oxygen demand values were higher than Wet season values. High BOD values indicate high concentration of biodegradable matter, higher pollution load and high oxygen consumption by heterotrophic organism, which could be detrimental to aquatic life. Seasonal changes in BOD with low values during wet seasons (rainy) may be due to increased surface run-offs, soil erosions and effluents discharge into the receiving water bodies (Sani, 2015). The BOD value in River Okpokwu was below 7.0 mg L-1 value recommended by World Health Organization.

The dry season transparency values were higher than wet season values. Altaf et al., (2013) reported that dry season was characterized by absence of flow velocity, flood, surface runoff, settling effect of suspended particles, non-tidal waves and non- organic/detrital transport which gave rise to high transparency, increased food abundance, and high photosynthetic activity. The lowest transparency recorded in the present study during the wet season, may be attributed to high turbidity, erosion of soil, debris, organic matter by precipitation and the transport of silt particles into flood plain through run off, impeded light penetration, moderate phytoplankton generation, and high decomposition, which resulted in decrease in oxygen concentration, The findings are in conformity with (Mirza et al., 2013).

The concentration of nitrates is indication of level of micronutrients in water bodies and has ability to support plant growth. High concentration of nitrate in drinking water is toxic (Lianthuamluaia et al., 2013). A seasonal increase in the concentration of (ammonia, nitrate, and nitrite) was associated with inflow from water drainage during the rains (Deepa et al., 2016). The wet season nitrate values were higher than dry season values. Prabhakar et al. (2012) reported seasonal pattern of nitrates from a lake in Krishnagiri. The high level of nitrate in this study could be attributed to nitrogenous effluents from agricultural activities around the river. However, high concentration of nitrite-nitrogen during the wet was due to influx of nutrients from the watershed areas along with runoff water, nitrite-nitrogen could be low due to less decomposition of organic matter and low water temperature. The pattern of nitrite-nitrogen concentration in this river was quite similar to that which was observed by Prabhakar et al. (2012). The range of value recorded for nitrate in River Okpokwu falls below that recommended by the World Health Organization for the culture of fish.

Chloride increased during the wet season following inputs from both natural and anthropogenic sources. This may be attributed to the rising water level in the lake because of increased inflow from point and non point discharges during the rainy season, increase in colloidal suspension from effluent discharge into the river may have increased chloride (Ajit and Padmaker, 2013). However, high chloride contents might be attributed to the presence of large amount of organic matter of both allochthonous and

autochthonousions of chloride can result in limited growth of aquatic organisms due to nutrient deficiencies such as little amount of potassium, chloride and sodium. This may be attributed to the low water level in the river due to low flow of drainage water from the drains into the river. In various water bodies in Nigeria, the chlorides are variable. Chloride in River Okpokwu was below the values recommended by (FEPA, 2003).

Total hardness is the total soluble magnesium and calcium salts present in the water expressed as its CaCo3 equivalent. Water containing hardness concentration up to 60 mg/l are called 'soft' water and those containing 120-180mgL-1 as 'hard' water. Total hardness also includes the sulphate, chlorides of calcium and magnesium. In this study the values obtained is lower when compared to that reported by (Rafiullah et al., 2012). The dry season hardness was higher than wet season values. The result of this study is in agreement with the findings of Imaobong et al. (2102) who revealed that total hardness was high during dry season than wet season. These high values in the dry season may be due to the addition of calcium and magnesium salts. The increase in hardness in dry season can be attributed to the decrease in water volume and increase in the rate of evaporation at high temperature. Total hardness in River Okpokwu was below the values recommended by (FEPA, 2003).

CONCLUSION

From the result of this study, it can be concluded that Physicochemical parameters of water collected from River Okpokwu were within the normal range according to WHO which indicates that water of River Okpokwu is convenient for both aquatic life and domestic use. There was significant difference in both seasons ($p<0.05$) of Dissolved oxygen, BOD, Free carbon-dioxide, air temperature, water temperature, total dissolved solid, transparency, pH, alkalinity, hardness and phosphate, But there was no significant difference for chloride and nitrate in both seasons ($p>0.05$).

Recommendations

Proper maintenance of the water bodies is necessary; proper sanitation measures and environmental education to the public are essential to keep these water bodies clean and safe. However, continuous monitoring of water quality and stricter conservation measures are needed to maintain and healthy aquatic environment.

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