



Spatial evaluation of physicochemical properties of River Benue concerning the habitat requirements of Manatee

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Abstract

Spatial evaluation of the physicochemical parameters of River Benue in relation to the habitat requirements of west African Manatee was conducted. The River was divided into four segments; Makurdi, Abinsi, Gbajimba, and Gbaji. In each segment, ten (10) sample points were randomly selected and the following parameters; Temperature, Dissolved Oxygen (DO), pH, Total dissolved solids, (TDS), Electrical conductivity (EC), and Biological oxygen demand (BOD) were measured. Data collected were subjected to statistical analysis. The result indicated that there were significant differences in the pH, Electrical conductivity, and Biological oxygen demand (BOD) among the four study areas. The result also indicated significant differences between the rainy season and dry season conditions of the water body. The result indicated that Manatees were highly adaptable to the physicochemical differences between the rainy season and the dry season.

Keywords: Habitat, Manatee, physicochemical properties, River Benue, spatial modeling

Introduction

Habitat quality has been defined as the resources and conditions present in an area that produce occupancy- including survival and reproduction by a given organism (Verma *et al.* 2012). Smitha and Shivashankar (2013) described water quality parameters to include temperature, pH, Turbidity,



conductivity, dissolved oxygen, nitrates, and phosphates. The physicochemical properties of aquatic habitats are known to affect the biotic component of the environment in various ways (Yadav *et al.*, 2013). An organism's capacity and ability to survive and reproduce successfully in any habitat is a function of how healthy its environment is. In related work, Okayi *et al.* (2013) reported that the record of the Physico-chemical characteristics of Manatees in French Guiana was important in establishing the preferred condition for the species, and therefore inference on their areas of distribution. Furthermore, this allows us to evaluate the conservation status of the ecosystem.

According to Patil *et al.* (2015) EC correlates with ten other parameters such pH value, alkalinity, total hardness, calcium, Total dissolved solids, chemical oxygen demand, chloride, and iron concentration in water. Human activities can affect the amount of DO through the introduction of phosphates, nitrates, ammonia, nitrates as runoff from farm fertilizers and industrial effluents. (Qureshimatva *et al.* 2015). Premlata (2009) reported that dissolved oxygen gives direct and indirect information on water activities such as microbial activities, photosynthesis, available nutrients, and stratification. Patel *et al.*, (2012) reported that as summer progress, DO decreases due to an increase in temperature and an increase in microbial activities. But that at the height of summer, DO increases due to the prolonged period of sunlight and hence temperature. Tiwari (2015) reported that DO is essential to aquatic life and that a low DO of less than 2Mg/L would indicate a poor water quality unable to sustain life. Gorde *et al.*, (2013) also report that excessive algal growth can oversaturate the water with DO when the photosynthesis rate is greater than the rate at which oxygen dissolves in the water. pH describes the water's acidity or alkalinity and represents the balance between hydrogen ions (H^+) and hydroxyl ions (OH^-) in water. The higher or low PH will adversely affect the availability of certain chemicals or nutrients on the water for use by plants. (Qureshimatva *et al.* 2015). Patil *et al.* (2012) reported that the reduced rate of photosynthetic activity and assimilation of carbon dioxide and bicarbonates are ultimately related to an increase in pH. They also said higher pH values suggest that carbon, carbonate-bicarbonate equilibrium is affected due to physicochemical conditions. Tiwari (2015) reported that pH is an indication of biological life as most of them strive under a narrow range of pH values. Gordi *et al.* (2013) also reported that pH directly affects organisms and the toxicity of other pollutants in the water and that the buffering capacity is of importance to the water quality. Water temperature is important because it affects the rates of biological processes and chemical processes. Temperature is measured in degrees Fahrenheit (180^0 between the freezing and boiling point of water) or degrees Celsius 100^0 between the freezing and boiling points of water. The optimal health of aquatic organisms from microbes to larger organisms depends on temperature. If temperatures are outside the optimal range for a prolonged period, organisms are stressed and can die. For fishes, the reproductive stage (including sprawling and embryo development) is the most temperature-sensitive period. Macro-invertebrate such as crayfish, worms, clams, and snails will move about in the stream's bed to find their optimal temperature. Water temperature is also affected by the amount of dissolved oxygen (DO). The water's ability to contain oxygen decreases as the water temperature rises, the form of ammonia/harmful or harmless to aquatic life, the rate of photosynthesis by aquatic plants, metabolic rates of marine organisms, and the sensitivity of the organism to pollution. Water temperature is affected by the seasons and can also be affected by weather, removal or shading streams, bank vegetation, building dams on rivers, discharging cooling water, discharging stormwater and groundwater influx. The distribution and abundance of manatees are affected by water temperature



and aquatic vegetation availability (Deustch *et al.*, 2003). Antonio *et al.* (2003) reported that manatees are restricted to rivers and estuaries with a temperature of 24⁰ C while Perrin *et al.* (2001) reported that the African manatees are limited to the water of 18⁰ C and 27⁰ C. Furthermore, Deustch *et al.* (2003) also reported that increase in salinity greatly influence the distribution of manatees and also reproduction, feeding and calving Lefebvre *et al.* (2000) also reported that Manatee limited to water temperature value of 27⁰ C will eat properly increase in weight and become nourished and mature fast. Esenowo *et al.* (2014) reported that the PH range for the African Manatee tended towards alkalinity and that dissolved oxygen value was high, attributing to aquatic macrophytes' exposure to enough sunlight and atmosphere air. According to Tiwari (2015) Total Dissolved Solids (TDS) consist of inorganic salts and dissolved materials. In natural waters, salts are chemical compounds comprised of anions such as carbonates, chlorides, sulfates, and nitrates (primarily in groundwater), and cations such as potassium (K), magnesium (Mg), calcium (Ca), and sodium (Na). In ambient conditions, these compounds are present in proportions that create a balanced solution. If there are additional inputs of dissolved solids to the system, the balance is altered, and detrimental effects may be seen. Inputs include both natural and anthropogenic sources.

Materials and methods

Study Area

The study covers a section of the River Benue system stretching 462km in length from Gbajimba town in Guma Local Government Area of Benue State to Lokoja in Kogi State Nigeria. (Fig. 2). The area lies within latitude 07⁰ 49¹N and 07⁰ 52¹N and longitude 08⁰ 36¹E and 08⁰ 40¹E. The River Benue's major tributaries along this area include Rivers Guma, Katsina-Ala, Mu, and Gwer. Several settlements are found all along this area, the major ones being, Gbajimba, Makurdi Abinsi.

The River Benue takes its origin from the Adamawa highlands in the Western Cameron, and it is the largest tributary to the River Niger, which its confluences with at Lokoja, Kogi State. River Benue enters Nigerian a few kilometers East of Yola in Adamawa State, flowing westwards for about 780km before joining River Niger at Lokoja. It flows through Adamawa, Taraba, Benue, and Kogi State and has several tributaries. Unlike other major African Rivers, the River Benue flows free of rapids and waterfalls (Udoh 1981).

Climate

The study area has distinct dry and wet seasons of the tropical climate. The Tropical maritime air mass blows across the Atlantic brings rain to the area. The rainy season lasts from April to October and is between 1,250m-1440m. The tropical Continental air mass blows through the Sahara Desert brings dry harm tan winds. The dry season is from November to March of the next year. The monthly temperature is between 28.5⁰C to 36⁰C and may rise to as high as 38⁰ from March to April.

Topography

The area generally lies at about 100 above sea level and experiences annual flooding (Udoh 1981). The banks of the Benue River is thus filled with rich alluvial soils, which is now utilized for dry season farming of vegetables, fruits and rice.



Figure 1: Map showing River Benue, Nigeria
Source : Geological survey office Makurdi (2017)

Data Collection

During the two years of the survey, 40 transects were laid in the 120Km stretch of the River Benue. To facilitate the selection of suitable sites for laying the transects, the sampled area was divided into four zones of similar length viz: Gbajimba, Abinsi, Makurdi, and Gbaji. The selected sites gave a wide spatial coverage and reflected the range of habitats in each zone.



To determine the water quality parameters along the River, a total of 400 water samples were drawn in a plastic water container. In each of the four zones, ten (10) transects measuring 500metres each were drawn. And in each transect, Ten (10) stations were randomly selected and water samples collected. The following water parameters were measured; pH, Dissolved O₂(DO). Total dissolved solids (TDS)s, Electrical conductivity(EC), and temperature using electronic water testing kits Lutron DO5509 and electronic Oxygen meter. (plates15&16) This measurement was carried out once every month for twelve months covering both wet season and dry season.

Result

The variation of water quality analysis in the four sampling stations shows significant differences in the values of pH, Electrical conductivity, and Total dissolved solid. At the same time, Dissolved Oxygen and Temperature did not indicate any significant differences.

Table 1: Variation in Water Quality Parameter in sampling stations along River Benue

Sampling Stations	Water Quality Parameters				
	pH	EC (µS/cm)	DO (Mg/L)	Temp (°C)	TDS (Mg/L)
Abinsi	6.79±0.05 ^{ab}	37.16±1.82 ^b	8.97±0.29	28.10±0.25	39.59±1.11 ^a
Gbaji	6.89±0.03 ^a	43.20±0.98 ^a	9.62±0.32	27.57±0.24	35.84±1.52 ^b
Gbajimba	6.76±0.05 ^{ab}	43.92±0.83 ^a	9.19±0.28	28.04±0.31	40.55±0.83 ^a
Makurdi	6.67±0.05 ^b	39.28±1.63 ^b	9.09±0.35	27.42±0.27	35.30±1.06 ^b
P-Value	0.02	0.01	0.48 ^{ns}	0.21 ^{ns}	<0.01

Means on the same column with different superscript are statistically significant (p<0.05); ns = not significant

Table2: Correlations analysis among parameters in sampling stations

	pH	EC (µS/cm)	DO (Mg/L)	Temp (°C)	TDS (Mg/L)
pH	-				
EC	0.51**	-			
DO	0.29**	0.32**	-		
Temp	0.50**	0.49**	0.35**	-	
TDS	0.54**	0.54**	0.27**	0.62**	-

** indicates statistical significance at 0.01%; * indicates statistical significance at 0.05%.

The relationship of the water quality parameters indicates strong positive correlations between pH and Electrical conductivity, Dissolved oxygen and pH, and electrical conductivity. Temperature also correlates positively with pH and Electrical conductivity as well as Dissolved Oxygen. Total dissolved solid correlates positively with pH, Electrical conductivity, Dissolved oxygen, and temperature.

The seasonal variation in water quality parameters indicates significant differences between the dry and wet periods.

The fluctuation trend in the pH during the study period indicate general high values in the four sampling stations during the rainy season and a gradual drop during the dry season.



Table 3: Seasonal Variation in water quality parameters in sampling stations

Water Quality Parameters	Season		Df	T-Value	P-Value
	Dry	Rainy			
pH	6.49±0.03	7.06±0.02	386	-12.99	<0.01**
EC	29.70±0.72	52.06±0.63	469	-23.26	<0.01**
DO	8.10±0.18	10.34±0.23	452	-7.57	<0.01**
Temp	26.15±0.17	29.42±0.16	476	-14.26	<0.01**
TDS	28.80±0.70	46.83±0.45	406	-21.58	<0.01**

** indicates statistical significance at 0.01%

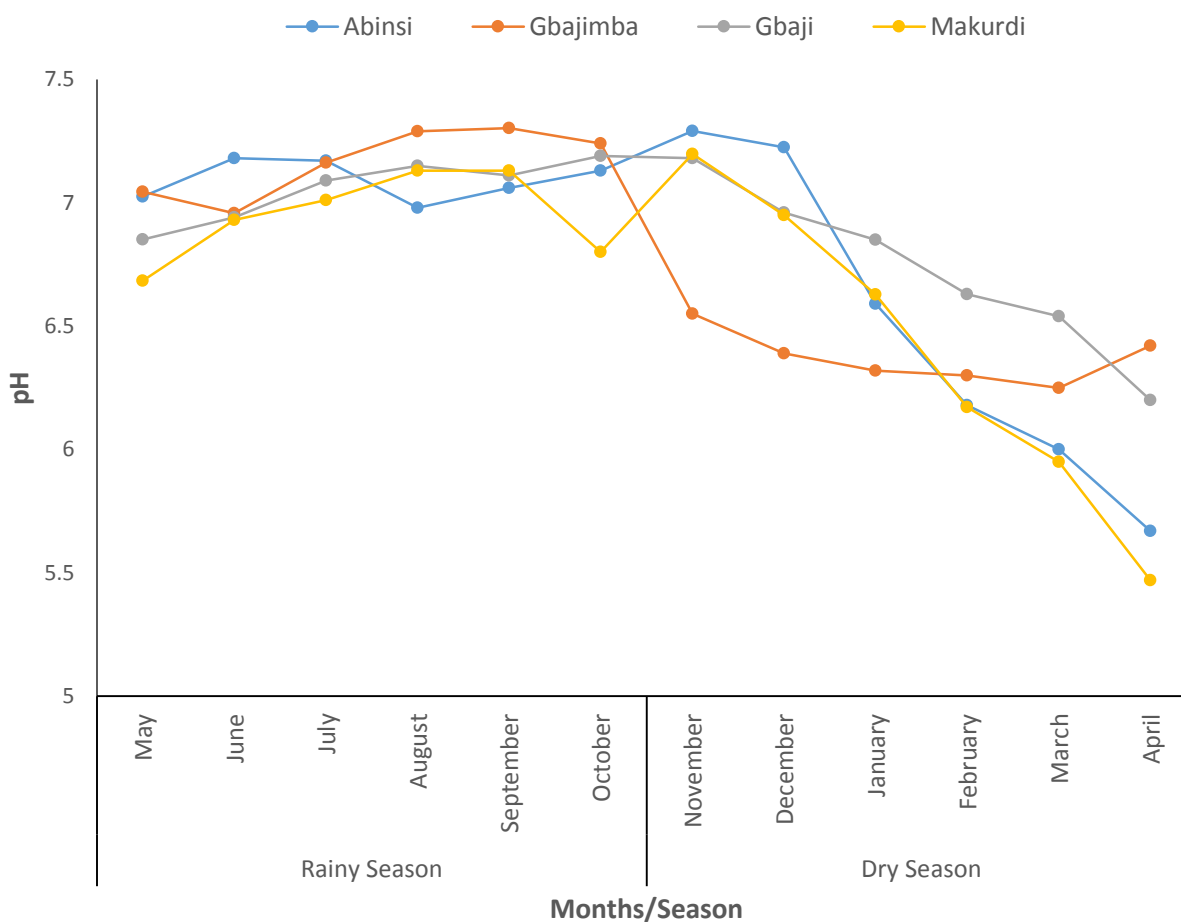


Figure 2: Fluctuation in pH along River Benue during the study period

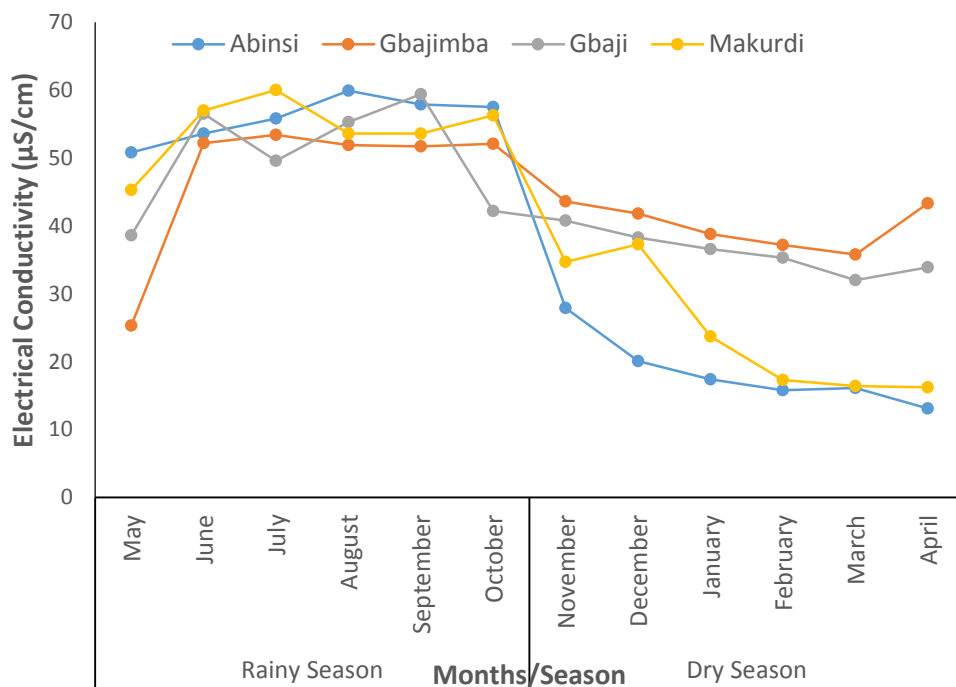


Figure3. The trend of Electrical conductivity along the River Benue during the study period

The four sampled stations' electrical conductivity values rose sharply from May, remained relatively constant during the rainy season, and then gradually dropped during the dry season.

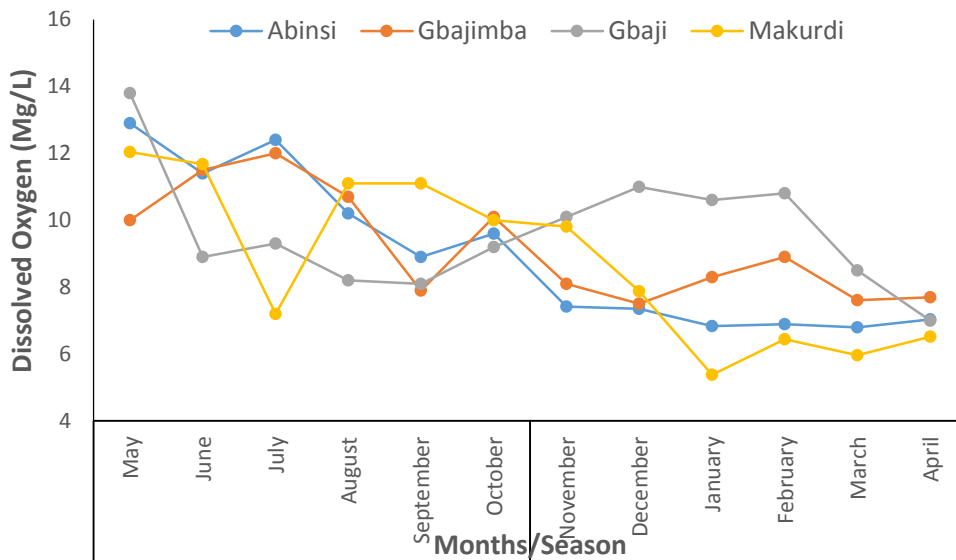


Figure4. Trend in Dissolved oxygen(DO) along River Benue during the study period



The trend in the values for dissolved Oxygen values in the four sampling stations indicate wide fluctuations, generally higher during the rainy season and drops during the dry season.

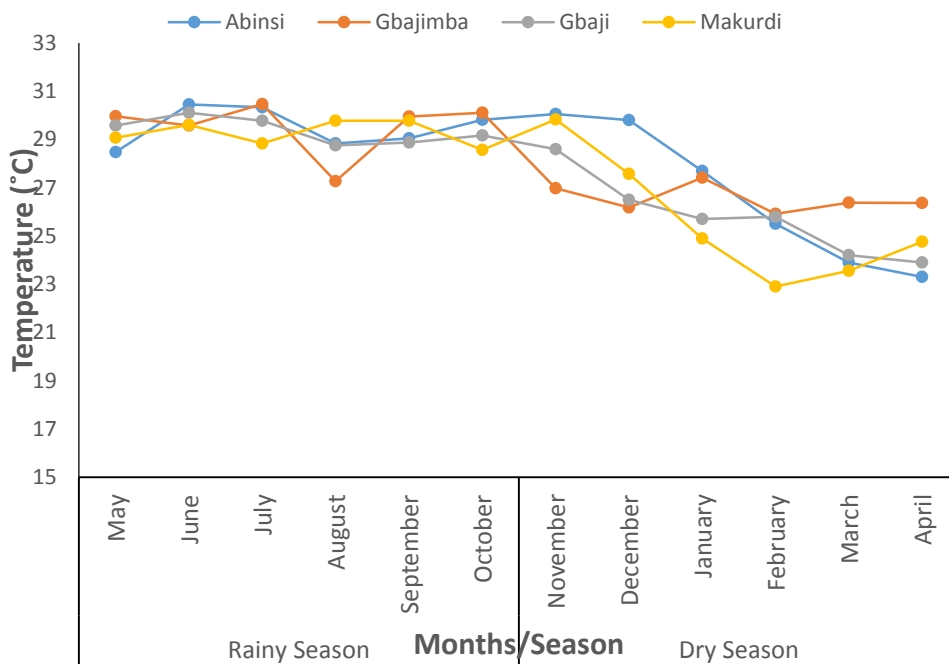


Figure5. Trend in Temperature along River Benue during the study period

The Temperature trend fluctuates between 29-30C during the rainy season and then dropped to between 23-29C during the dry season.

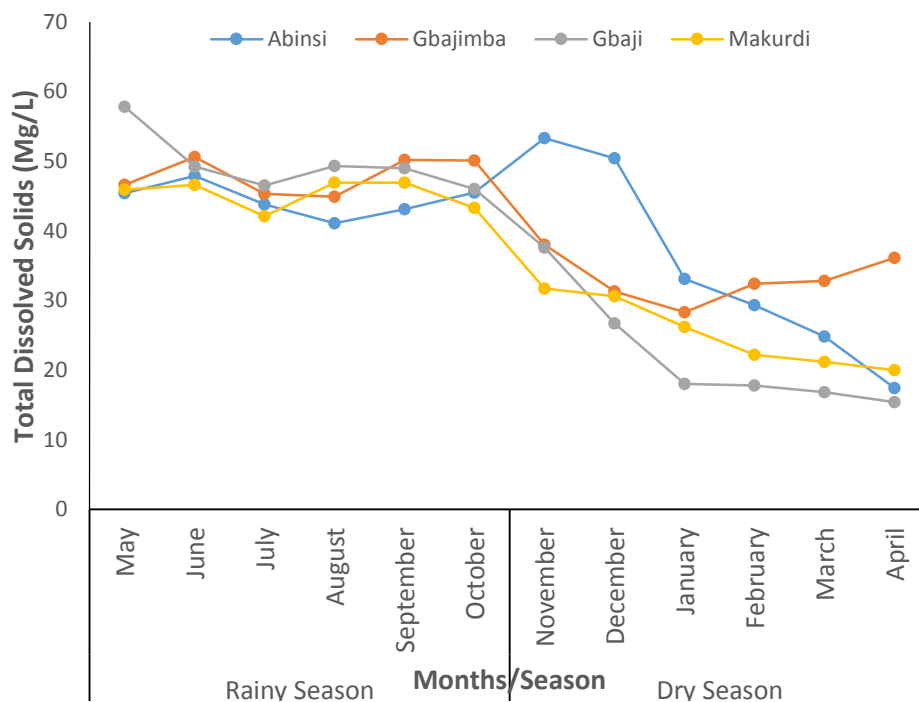


Figure 6. Trend in Total dissolved solids(TDS) along River Benue during the study period

The Total dissolved solid trend in the four sampling stations indicate higher values during the rainy season and a drop during the dry season.

Discussion

Water quality is a term used to express the suitability of water to sustain various uses or processes. It will have specific values for the physical, chemical or biological characteristics of water. This agrees with the report of Megan (2016). Water quality is usually affected by a wide range of natural and human influences. The pH (Hydrogen ion concentration) along the River Benue in the four (4) sampling stations indicates significant differences. The pH value in Gbaji was 6.89, which was significantly different from those of makurdi at 6.67 while those of Abinsi (6.79) and Gbajimba (6.76) were lies between those of Gbaji and Makurdi. These values closely agree with those of Esenowo *et al.* (2018) in their studies of West African Manatee. Spiegelgerber and Gangslosser (2005) also reported a pH value of between 5.6 to 6.8 for the Antillean Manatee in French Guiana. The pH in manatee water habitats tended towards alkalinity. The result indicated that pH did not correlate with any other Physico-chemical properties of the water. The pH revealed significant differences between the dry (4.49) and rainy (7.06) seasons. This wide margin in pH indicates that Manatees are highly adaptable to variation in pH.

The values of the electrical conductivity indicated significant differences among the four sampling stations. The values for Abinsi (37.16 μ s/cm) and Gbajimba (43.92 μ s/cm). Electrical Conductivity is a measurement of water's ability to conduct an electrical current and is related to Total dissolved solids (TDS) in the water. The electrical conductivity positively correlated with the pH, which indicates that the higher the pH, the more water's ability to conduct electrical current and verse visa. There were also significant differences in the electrical conductivity between dry (29.70 μ s/cm) and rainy (52.06 μ s/cm)



season. During the dry season, the number of solid particles is far less and hence the low conductivity value, while the water has higher solid particles during the rainy season.

The Dissolved Oxygen (DO) in the four sampling stations did not indicate any significant differences. However, there exists a positive correlation between dissolved oxygen with pH and Electrical conductivity. The value of dissolved oxygen (8.10) during the dry season also indicates a significant difference with those of the rainy season (10.34) as shown in Table 4. Temperature values in the four sampling stations did not indicate any significant differences (Table 1). It ranged from 27.426⁰C in Makurdi to 28.10⁰ C in Abinsi. According to Lefebvre *et al.* (2000), manatees are limited to a water temperature value of 27⁰C to eat properly, increase weight, and become nourished and mature fast. The result agrees with those of Spiegelberger and Ganslosser (2005), who reported a temperature range f 28.40C to 300C, and Egwali *et al.* (2018) reported a temperature range of 26⁰C - 27⁰C for the West African Manatee. The water temperature positively correlated with the pH, electrical conductivity, and dissolved oxygen. The result also indicates significant differences in temperature values between the dry season and the rainy season. While the mean temperature during the dry season was 26⁰C, the rainy season's value was 29.42⁰C. The trend in water temperature in the four sampling stations is shown in Fig. 5. Between May and October, the temperature fluctuated within 29⁰C - 30⁰C for all the stations except 27⁰C in July. From November (dry season), there was a sharp drop in temperature value in all the sampling stations.

The total dissolved solids in the four sampling stations are reflected in table1. This indicated significant differences among the four stations. The value for Abinsi (39.59Mg/L) and Gbajimba (40.55Mg/L) were significantly different from those of Gbaji (35.84Mg/L) and Makurdi (35.30Mg/L). Total dissolved solid is positively correlated with pH, Electrical Conductivity, Dissolved Oxygen, and Temperature (Table 3). The Total dissolved solid is also significantly different between the dry season and the rainy season. While the dry season's value is 28.80 mg/L, the value for the rainy season was 46.83/Mg/L.

The trend in the value of Total dissolved solids in the four sampling stations fluctuated between the dry season and the rainy seasons. The value was as high as 60Mg/L in Gbaji in May, while Gbajimba, Makurdi, and Abinsi were at 45Mg/L. It remained relatively stable from June to October during the rainy season. However, as the dry season commenced in November to April of the following year, the values fluctuated downwards in all the four stations between 20Mg/L in Abinsi, Makurdi and Gbaji to 44Mg/L in Gbajimba.

Conclusion

Much of the information concerning the ecological component of west African Manatee was gathered to identify the threat to their population better. This research tries to provide an overview of existing scientific knowledge on the water health of the Manatee. It is baseline information. It is suggested that continuous monitoring of water parameters be sustained to evaluate changes that may negatively affect the species and other aquatic species along the River Benue.

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