



Determination of Physicochemical Parameters at Selected Sites of River Benue, Adamawa State, Nigeria

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Abstract

The present study assessed the physicochemical parameters of Benue River, Adamawa state. Studies were conducted for a period of nine months, from December, 2017 to August, 2018 using standard methods of water analysis. The monthly variation of physicochemical parameters (temperature, pH, conductivity, dissolved oxygen (DO), alkalinity, free carbon dioxide (CO₂), transparency, ammonia and phosphorus (PO₂) ranged from, 22-31^oc, 6.23-10.56, 93-1272 μ S, 1.1-14.1mg/l, 3.6-36.5mg/L, 0.3-2.1mg/l, 5.4-23.9cm, 0.002-0.682mg/L, 0.064-0.673mg/L respectively. The results showed significant ($p < 0.05$) differences across month and some were not significant ($P > 0.05$) across Site. The results revealed that Benue River has phosphorus and temperature above the maximum permissible limit set by WHO, while other parameters recorded were within the recommended range for drinking and aquaculture tolerable limits for water production.

Key words: Determination, Physicochemical, Parameters, Tolerable limits, River Benue

Introduction

Water is an essential resource for sustainability of life on earth. It is a vital requirement after oxygen, as its constant supply is needed to replenish the fluids lost through normal physiological activities such as respiration, perspiration and urination (Shalom *et al.*, 2011). Water is inevitable for all living organism as it has a great social and economic value ultimately affecting man's health. It is essentially required for industrial development, fisheries, irrigation, hydroelectric power generation, human survival and domestic use (Keshere *et al.*, 2007). The importance of water as a resource is not only tied to its quantity and availability, but also its quality which is important, because in natural water bodies, the quality of water determines and supports its biological and physico-chemical composition (Versari *et al.*, 2002). The River Benue is a source of drinking water, irrigation, transportation, washing of cloths and vehicles, and fishing

among others. The quality of water is primarily based upon its physical, chemical, and biological characteristics. Monitoring of biological and physicochemical characteristics of a water body is important for both short and long term trends. Water quality influences each stage of the life cycle of the individual and plays a major role in the structure of the community (Ezra and Nwankwo, 2001). Its quality affects species abundance, composition, stability, productivity, as well as the physiological condition of indigenous population of aquatic organisms (Ahmed and Indabawa, 2015). It is important in accessing the health of a watershed and could be used to make necessary management decision to control current and future pollution of receiving water bodies (Behbaninia *et al.*, 2009). Thus, a change in the physicochemical aspect of a water body brings about a corresponding change in the relative composition and abundance of the organisms in that water (Adeyemi *et al.*, 2009). The physicochemical

and biological composition of water and its properties in a particular region is basically governed by natural processes and human activities which can either be point or non-point sources such as urbanization, industrial as well as agricultural activities. The variations in physicochemical and biological composition of aquatic environment depend mainly on the type and nature of the water as well as on the man-made addition or runoff of mineral and chemical from agriculture soils (Fathi and Flower, 2005). Physical, chemical and biological factors frequently affect the flora and fauna which leads to the altering of their diversity including pressure, density, buoyancy, temperature, light, oxygen content, carbon dioxide content, pH or hydrogen ion concentration (Achionye-Nzeh and Isimaikaiye, 2010).

Human activities have been implicated in water quality, sometimes to unacceptable limits (Oyema, 2007; Chai *et al.*, 2011). Human activities impact serious reduction in freshwater quality, characterized by abundance of organic compounds, toxic chemicals and nitrites in water may cause unfavourable effects on human health. Activities such as pond fertilization, obnoxious fishing practices, fertilizer application, and pesticides and herbicides, used in the community ecosystem (Mustapha, 2006; Garg *et al.*, 2006b; Chai *et al.*, 2011). Such activities are major factors determining the quality of surface water through atmospheric pollution, effluent discharge and eroded soils. Human activity is another factor that contribute to the addition of nutrient into the water body. Generally, rivers are known to have multiple uses in every sector of development like agriculture, industry, transportation, public water supply. Conversely, they are used as sites for waste disposal. Waste from industries, domestic sewage and agriculture practices find their way into river and result in large scale deterioration of the water quality. The growing problem of degradation of river

ecosystem due to human activities has made it important for continuous monitoring of water quality of rivers to evaluate their state of pollution. Therefore, the aim of this study was to determine the physicochemical parameters of River Benue

Materials and Methods

Study Area

River Benue is a freshwater flowing through Nigeria and it is the second largest river in the country, which is located on Longitude 12°25' and between Latitudes 9°81'N and 9°17'. The river originates from the Adamawa mountains of Cameroun, some bounding the Nigeria frontier and flows eastward through Nigeria before joining the River Niger at Lokoja, Kogi State, Nigeria (Okayi *et al.*, 2001).

Determinations of Physicochemical Parameters

Determination of water temperature

This was determined at the in-situ using mercury-in glass thermometer (Glaswekwertein model) by dipping it into the water and allowing it to stabilize for two (2) minutes, removed and the reading taken immediately (APHA, 2005).

Determination of conductivity

Conductivity was determined at the site (*in situ*) using conductivity meter (model: Large display conductivity pen-850037). Electrolyte conductivity of the water body was determined as described by Wetzel, (2000). The observed conductivity was corrected by multiplying by factor given in standard table of conversion.

Determination of transparency

The transparency was measured using Secchi disk as described by Stirling, (1985). Secchi disk was dipped into the water till the disk disappears and the depth was recorded (d_1). Then withdrawn gently and the depth at which it became visible was recorded (d_2). Actual reading was obtained by the average of the two readings ($(d_1 + d_2)/2$) (APHA, 2005).

Determination of dissolved oxygen (DO)

A Hanna Dissolved Oxygen microprocessor HI 98186 was used to determine the dissolved oxygen. It was calibrated according to the instruction manual provided by the manufacturer. Sample of the water was collected in 100ml beaker; the electrode of dissolved oxygen microprocessor was dipped into the beaker for about 2-3 minutes. The readings were recorded in mg l^{-1} (APHA, 1999; Mahar, 2003).

Determination of hydrogen ion concentration (pH)

The pH was determined directly *in-situ* using pH meter (model: Pen type pH meter). The electrode of the meter was first standardized using buffer solution. After calibration of the electrode in the solution, it was washed in distilled water before dipping into the water for 2 minutes for equilibrium (Ali, *et al.*, 2000).

Determination of total ammonia

Total ammonia was determined as described by Phillips, (1985). Sample of water collected was immediately filtered through pre-rinsed whatman GF/C filter paper. The phenol-hypochloride method was adopted for freshwater samples. Phenol-nitropruside reagent was added to 25ml of sample. It was then mix and alkaline hypochloride reagent added. The flask was covered and the mixtures were left to stand in the dark for 1 hour at room temperature. The absorbance of standards of ammonia stock was serially diluted with the same procedure used for sample and reagent and calibration curve prepared. The result was recorded as milligram per liter (mg/l).

Determination of total phosphorus

Total Phosphorus was determined as described by AOAC (1990). Sample of water was measured into a test tube. Ammonium Molybdate solution was added and allowed to stand for 20 seconds. Hydroquinone solution was added, and the flask was rotated

to mix and 1ml of Na_2SO_4 solution was added. 2ml of distilled water was added. The test tube was stopped by thumb and shaken to mix thoroughly. The mixture was allowed to stand for 30 minutes and then measure with spectrophotometer set at 650nm, alongside blank. A calibration curve was prepared using standard phosphorus concentration.

Determination of total alkalinity

Total alkalinity was determined as described by Stirling (1985). Water sample was measured and transferred into a conical flask and 3 drop of methyl orange indicator was added. The sample was titrated with standard H_2SO_4 or HCL from a 10ml burette with continuous shaking until the colour changed from blue to pale pink.

Determination of free carbon dioxide

Free Carbon dioxide was determined by titration in the laboratory as described by Saxena, (1990). Water sample was put into a flask and 3 drops of phenolphthalein indicator (reagent) was added. If the colour turned pink free CO_2 is absent in the sample, but if the sample remains colourless, it was titrated against sodium hydroxide solution (reagent) until pink colour appeared (end point).

Data analysis

All data obtained were subjected to descriptive statistics.

Results and Discussion

Table 1 shows the monthly water temperature for the four sites. The study revealed that the observed temperature was within the range of 22-31 $^{\circ}\text{C}$. The values reported in this work were outside the range (30 $^{\circ}\text{C}$) recommended by WHO (2004), but within the range of National Guideline and Standards for Water Quality (20 $^{\circ}\text{C}$ -33 $^{\circ}\text{C}$) in Nigeria for aquatic life, industrial and agricultural uses (FMEnv. 1992). This result was higher than those of Haruna (1992) in Jakara Lake Kano, who reported a temperature range of 17-28 $^{\circ}\text{C}$ as recommended or desirable. The difference in

temperature might be due to the wet season that prevailed from the month of June to its peak in August when atmospheric temperature was low. A similar observation was made by Jidauna *et al.* (2009) in Michika. The influence of temperature on the aquatic system is emphasized by Duggan *et al.* (2002) who reported that temperature is one of the important environmental parameters having a

profound influence on the life cycle of an organism, as it exerts a direct lethal and controlling effect on it. Temperature influences the determination of other factors like pH, conductivity, dissolved gases and various forms of alkalinity (N'Diaye *et al.*, 2013). Cooler waters have higher dissolved oxygen.

Table 1: Monthly Mean Water Temperature (°C) December, 2017 – August, 2018 at four Sites

Months	Site A	Site B	Site C	Site D	Mean	SEM
December, 2017	24	23	23	23	23.25	0.25
January, 2018	23	22	24	24	23.25	0.48
February	26	25	26	27	26	0.41
March	28	27	29	27	27.75	0.48
April	30	29	30	30	29.75	0.25
May	31	30	29	29	29.75	0.48
June	30	31	27	28	29	0.91
July	29	27	28	27	27.75	0.48
August	28	29	28	26	27.75	0.63
Mean	27.67	27	27.11	26.78		

Table 2: Monthly Water pH December, 2017 – August, 2018 across the four Sites

Months	Site A	Site B	Site C	Site D	Mean	SEM
December, 2017	6.53	7.67	6.4	6.29	6.87	0.40
January, 2018	6.71	7.44	6.87	6.53	7.01	0.22
February	7.04	7.62	6.34	6.24	7.00	0.37
March	6.78	7.35	6.54	6.23	6.89	0.24
April	7.11	7.65	7.37	7.00	7.38	0.16
May	7.41	7.51	7.43	7.24	7.45	0.03
June	8.34	9.22	8.16	7.81	8.57	0.31
July	9.40	10.56	8.82	8.11	9.59	0.51
August	10.0	9.82	9.74	10.0	9.85	0.08
Mean	7.70	8.32	7.52	7.27		

Table 2 shows the monthly mean value of pH. The highest value (10.56) was recorded in August and the lowest value (6.23) was recorded in November. The mean monthly values ranged from 6.71-9.85 in March, 2018 and August, 2018 respectively showing significance difference across month. The

monthly mean values across Sites A, B, C and D showed no significant difference ($p < 0.05$). The test for pH of water was carried out to determine whether it is acidic or alkaline in nature. The mean values obtained for the river was outside the range of 6.5-8.9, recommended by WHO (1996) for drinking

water. Although the values indicate that the water was slightly basic, it is in agreement with what was reported by other researchers in similar studies (Edimeh *et al.*, 2011; Aremu *et al.*, 2011). Abubakar (2006) reported that low pH allows toxic elements

Table 3 shows the result of monthly mean of conductivity for the period of the study (December 2017-August, 2018). The monthly mean ranged from 93 μ S in June at site C and 1272 μ S in May at site D showing significance difference across month and site ($p < 0.05$). The monthly mean conductivity for Site I (184 μ S/cm), Site II (127 μ S/cm), Site III (115.11 μ S/cm) and Site IV (894.33 μ S/cm) fall within the recommended WHO (1996) values of maximum permissible limits (8-10,000 μ S/cm) for drinking water and 10-1000 μ S/cm recommended by ACTFR (2002). However, the values obtained in this study

compound to become mobile and available for uptake by plants and animals. The increase in pH value in the Month of August might be due increased in the volume water that might lead to dilution, thereby reducing the acidic contents of the water.

were higher than those reported by Dass, Kaltungo and Langtang (38.70 \pm 0.30, 30.20 \pm 0.56, 38.80 \pm 0.40) respectively, in Nigeria by Ezeribe *et al.* (2012) and were also higher than values reported in the streams, wells and bore-hole water in Eggon Local Government Area of Nasarawa State, Nigeria by Aremu *et al.* (2011). The observed high conductivity value may be due to the fluctuation of pH values above the neutral point of 7 in the river. High conductivity may cause high condition factor and fecundity of fish (Jidauna *et al.*, 2009). The result of conductivity revealed that, it does influence the distributions of planktons throughout the period of this study.

Table 3: Monthly Water Conductivity (μ S/cm) December, 2017 – August, 2018 at four Sites

Months	Site A	Site B	Site C	Site D	Mean	SEM
December, 2017	200	104	107	769	295	159
January, 2018	201	124	110	812	311	167
February	193	107	126	756	295	154
March	156	125	134	698	278	140
April	187	141	124	768	305	154
May	177	123	112	1272	421	284
June	181	124	93	826	306	174
July	172	155	103	1211	410	267
August	189	140	127	937	348	196
Mean	184	127	115.11	894.3		

There was wide variation in dissolved oxygen (DO) during the period of this study. The highest value (14.3 mg/l) was recorded in the month of May, 2018 at Site D, while the lowest value (1.1mg/l) was recorded in the month of May, 2018 at Site C. The monthly mean value of dissolved oxygen (DO) ranged between 5.12 mg/l in August, 2018 and 11 mg/l in December, 2017 (Table 4) showing large difference at both site and month throughout the study period ($p < 0.05$). Dissolved Oxygen is an important

environmental parameter that decides ecological health of a stream or river and protects aquatic life (Chang, 2002). Concentrations of monthly mean of dissolved oxygen in water along the studied Benue river reach ranged from 1.1 to 14.1mg/l. The observed range is below 15.78-17.26mg/l reported by Jidauna *et al.* (2009) in Lughu reservoir Michika, Adamawa State. Boyd and Lichkoppler (1979) recorded that temperature has profound effect on solubility of Oxygen. The highest DO₂ value observed in the month

of February in this study might be attributed to reduced turbidity and active photosynthetic process during the dry season from phytoplanktons in the Benue River. This is good for shallow water fish that require highest levels of DO₂ of 4-15mg/L. Absalom *et al.* (2002) reported that high DO₂ values during wet season are due to the prevailing cool wind action. The lower DO₂ concentration in the month of April to August was as a result of reduced photosynthetic activities in the Benue River during the rainy season.

May, while December, 2017 recorded the lowest value of 3.6mg/l showing significance difference at both site and month throughout the period of this study (p<0.05). Monthly mean value of alkalinity was 8.278mg/L for Site I, 6.2mg/L for Site II, 6.822 for Site III and 21.022mg/L for Site IV. Values obtained were within the maximum permissible level of WHO (2003) (150 mg/L). This may be due to the absence of carbonates and bicarbonates in the river water because they contribute to the hardness of the water (Magit, 2002). Sexena (1990) reported that in high productive water, the alkalinity values increase the toxicity of heavy metal ions such as copper and Zinc to fish and invertebrates.

Table 5 present the monthly mean variation of Alkalinity from the study area. The highest mean recorded were 36.5mg/l in the month of

Table 4: Monthly Mean Water Dissolved Oxygen (mg/l) December, 2017 – August, 2018 at four Sites

Months	Site A	Site B	Site C	Site D	Mean	SEM
December, 2017	10.1	13.5	9.2	11.21	11.0	0.93
January, 2018	9.56	12.4	10.2	10.24	10.6	0.62
February	7.23	14.1	9.10	12.11	10.6	1.53
March	8.0	7.5	6.2	9.3	7.75	0.64
April	5.2	8.1	4.6	7.7	6.4	0.88
May	4.7	6.1	1.1	14.3	6.55	2.79
June	3.1	6.0	1.3	10.3	5.17	1.96
July	4.6	5.2	3.4	8.1	5.32	1.00
August	5.8	6.5	2.1	6.1	5.12	1.02
Mean	6.477	8.822	5.244	9.929		

Table 5: Monthly Mean Water Alkalinity (mg/l) at the four Sites from December, 2017 – August, 2018

Months	Site A	Site B	Site C	Site D	Mean	SEM
December, 2017	9.0	3.6	4.9	19.6	9.27	3.63
January, 2018	8.2	4.3	7.3	18.3	9.52	3.04
February	11.0	3.8	6.2	21.0	10.5	3.81
March	8.4	6.2	7.3	12.5	8.6	1.38
April	6.7	7.6	6.1	20.4	10.2	3.41
May	7.1	7.1	6.5	36.5	14.3	7.40
June	8.2	7.8	7.9	26.1	12.5	4.53
July	6.4	6.6	6.8	10.8	7.65	1.05
August	9.5	8.8	8.4	24.0	12.6	3.78
Mean	8.278	6.2	6.822	21.02		

The monthly mean concentration of Carbon Dioxide (CO₂) is presented in Fig 6. The highest mean value recorded were 2.1mg/l in

the month of January, while the lowest value were recorded in the month of January, February and July which was 0.3mg/l

showing significance difference at both site and month throughout the period of this study ($p < 0.05$). The observed ranged of free CO_2 is less than 0.3 to 2.1mg/l mean monthly ranged reported by Abubakar (2006) in Lake Geriyo. The lowest values of CO_2 may be due to higher alkalinity of the river and it also implies loss of some aquatic macrophyte. The value also falls below the recommended safety limit of 10mg/l as reported by Haruna (2003). The values recorded in this study were lower than what was recorded (6.5mg/l) for Delimi River (Anadu and Akpan, 1986). The values of 3 to 2.1mg/l recorded throughout the period of study were an indication that river benue is good for fishery production. This is because a good fishery is correlated with low free carbon dioxide and at high concentration it is vice versa (Adeniji and Ovie, 1990).

The monthly mean value of transparency is presented in Figure 7. The monthly mean ranged between 5.4cm in August at site A and 23.9cm in May at site D showing significance

difference at both site and month throughout the period of this study ($p < 0.05$). The observed values of mean monthly variations in transparency fall within 5.4cm to 23.9cm. This result varies with the work of Moody and Folorunsho (2006) in Kigera fish farm, who reported 19cm to 25cm variations. The river reached its highest depth between the months of July and August which indicate the impact of rainfall on the water level because this period is regarded as the rainy season; same was reported by Ude, (2012). Francis *et al.* (2006) reported that low transparency implies low photosynthetic activities and therefore low productivity. The period of greatest light penetration was in November. This may be as a result of sedimentation due to high evaporation (Ude, 2012). Increase in water turbidity increases water temperature because suspended particles absorb more heat. This in turn reduces the concentration of dissolved oxygen (DO) (warm water holds less dissolved oxygen than cold water) (Abubakar, 2006).

Table 6: Monthly Mean Water Free CO_2 (mg/l) December, 2017 – August, 2018 at four Sites

Months	Site A	Site B	Site C	Site D	Mean	SEM
December, 2017	1.0	0.5	0.4	1.8	0.92	0.32
January, 2018	0.9	0.7	0.3	2.1	1	0.39
February	2.0	0.4	0.3	1.7	1.1	0.44
March	1.3	0.8	0.7	1.2	1	0.15
April	0.9	0.6	0.5	0.9	0.72	0.10
May	1.2	0.9	0.6	0.6	0.82	0.14
June	0.8	0.4	0.8	1.1	0.77	0.14
July	1.4	0.3	0.9	0.7	0.82	0.23
August	0.7	0.4	0.7	0.8	0.65	0.09
Mean	1.133	0.556	0.578	1.211		

The value of monthly concentration of Ammonia is presented in Fig. 8. The monthly mean ranged between 0.002mg/l in August at site B and 0.682mg/l in May at sit D showing significance difference at both site and month throughout the period of this study ($p < 0.05$). The mean monthly variation of Ammonia ranged between 0.002 to 0.682mg/l

throughout the period of this study. This result is higher than 0.025 reported by Alasbaster and Llyod (1982). ACTFR, (2002) reported that Ammonia is the nitrogen form that is most readily used by aquatic plants, high concentration of the toxic form is known to produce a lethal effect while lower concentration inhibit growth rate. Khanna

and Singh (2003) reported that growth rate of fish slows down if total ammonia values recorded in the reservoir is high. Haruna

(2003) also concluded that high ammonia level cause susceptibility to disease and eventually death.

Table 7: Monthly Mean Water Transparency (cm) December, 2017 – August, 2018 at four Sites

Months	Site A	Site B	Site C	Site D	Mean	SEM
December, 2017	15	16.5	18	18	16.8	2.06
January, 2018	18.5	17.1	20.3	16.3	18.0	3.08
February	21	19	23.2	20	20.8	3.23
March	22	18.7	21.2	19.7	20.4	2.19
April	16.4	17.6	21.3	18.9	18.5	4.40
May	8.7	11.5	14.6	23.9	14.6	3.30
June	7.7	9.6	12.6	20.6	12.6	2.84
July	6.5	8.1	11	14.3	9.97	1.72
August	5.4	6.3	8.6	10.1	7.6	1.07
Mean	13.467	13.822	16.756	17.98		

Table 8: Monthly Mean Water Ammonia (mg/l) December, 2017 – August, 2018 at four Sites

Months	Site A	Site B	Site C	Site D	Mean	SEM
December, 2017	0.041	0.201	0.320	0.005	0.141	0.073
January, 2018	0.004	0.054	0.301	0.004	0.090	0.071
February	0.086	0.076	0.014	0.071	0.061	0.016
March	0.125	0.231	0.075	0.003	0.108	0.048
April	0.365	0.093	0.121	0.006	0.146	0.077
May	0.510	0.132	0.421	0.682	0.436	0.115
June	0.345	0.421	0.453	0.153	0.343	0.067
July	0.217	0.303	0.078	0.056	0.163	0.059
August	0.056	0.002	0.213	0.123	0.098	0.046
Mean	0.194	0.168	0.222	0.123		

The monthly mean concentration of Phosphorus is presented in Fig 8. The highest mean value recorded were 0.673mg/l in the month of August at site B while the lowest value were recorded in the month of June which was 0.064mg/l at site A showing significant difference in the month of October and other months ($p < 0.05$). The monthly mean across sites I, II, III and IV showed no significant difference ($p > 0.05$). The monthly mean of phosphorus concentrations of each of the three locations were lower than the limits

set by WHO (2004) (6.5mg/l). The observation is also in agreement with the findings of other workers in similar studies (Ezeribe *et al.*, 2012). The result is also high than 0.04 to 0.050mg/l recorded by Kolo and Yisa (2000) in river Suka. Jidauna *et al.* (2009) reported that the high value of Phosphorus could be attributed to lock in nutrient phenomenon. Anonymous (1972) observed that in a well oxygenated water body, nutrient element form bond with bottom sediment that prevent their recycling.

Table 9: Monthly Mean Water Phosphorus (mg/l) December, 2017 – August, 2018 at four Sites

Months	Site A	Site B	Site C	Site D	Mean	SEM
December, 2017	0.324	0.234	0.610	0.167	0.333	0.098
January, 2018	0.532	0.572	0.123	0.532	0.439	0.106
February	0.234	0.432	0.254	0.347	0.316	0.046
March	0.432	0.214	0.356	0.126	0.282	0.069
April	0.267	0.175	0.267	0.402	0.277	0.047
May	0.087	0.110	0.210	0.125	0.133	0.027
June	0.064	0.0673	0.111	0.084	0.081	0.011
July	0.164	0.133	0.178	0.104	0.144	0.017
August	0.456	0.673	0.512	0.301	0.485	0.077
Mean	0.284	0.290	0.291	0.243		

Conclusion

In conclusion, the results revealed that, the value of conductivity, transparency, dissolved oxygen (DO₂), pH, ammonia, phosphorus (PO₂), free carbon dioxide (CO₂) were found to be within the recommended ranges for water, while alkalinity, phosphorus and temperature were found to be above WHO maximum permissible levels.

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