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Physicochemical Parameters and Plankton Diversity From Lower River Benue, Makurdi.

[1]Shima .N Judith, [2]Odo Joel Inya [3]Ode Omenka Samuel and [4]Lois Igba Ali

[1]Department of Biological Science, Benue State University Makurdi, Nigeria
[2]Depertment of Fisheries and Aquaculture, University of Agriculture Makurdi, Nigeria
[3]Depertment of Physics, Benue State University Makurdi, Nigeria.
[4]Department of Biological Science, Benue State University Makurdi, Nigeria

ABSTRACT

Plankton biodiversity serves as ecological indicator of aquatic environment due to their response to environmental changes. This study was conducted with the aim of investigating the abundance and diversity of plankton as well as physicochemical properties of the Lower Benue River. The survey was carried out at different sites along the River both at Wadata and BSU Water Board. Samples collected using plankton net into bottles preserve in 5% formalin then transported to the laboratory for identification, counting and for further analysis. A total of 39 plankton were observed out of which 28 (71.79%) were obtained at Wadata and 11 (28.21%) at BSU Water Board. The most abundant of all the species was Arthrospira plantensis which was observed 16 times. The least occurring Plankton was the Paramecium species which was observed only once. The specie's richness at the Wadata location was 7 with the Shannon-Weinner Diversity Index of 1.383 and Evenness of 0.711. The species richness at the BSU Water Board on the other hand was 3 species with the Shannon-Weinner Diversity Index (H) of 0.935 and an Evenness of 0.851. A significant relationship between plankton abundance and sampling location was overserved ($\chi^2 = 19.360$; df = 1; P = 0.000). The Physicochemical properties of the Lower Benue River at the respective sampling locations revealed that Air, Water temperature and Dissolved oxygen, had no significant difference observed between them (P > 0.05). While $_{p}$H of the water, Electrical conductivity, Turbidity and Total dissolved solid had significant difference observed between them (P > 0.05). A fairly strong non-significant positive relationship was observed between plankton abundance and the $_{p}$H (r = 0.502; P = 0.389). Electrical conductivity (r = 0.629; P = 0.069) and Total dissolved solid (r = 0.461; P = 0.298). On the other hand, a very strong non-significant negative relationship between plankton abundance and Air temperature was observed (r = 0.819; P = 0.090). The relationship with turbidity was also negative and strong but they were significantly associated (r = 0.720; P = 0.029). The Pearson's correlation coefficient (r) further revealed a very weak non-significant relationship between plankton abundance and dissolved oxygen (r = 0.137; P = 0.747), while it showed no significant relationship with temperature (r = 0.047; P = 0.904).

KEYWORDS: Plankton diversity, plankton abundance, River, Physiochemical and Aquatic organism.

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1. INTRODUCTION

Water is the most important natural resource and is essential for survival and the development of modern technology. 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 although the extent to which rivers can play this important role depends largely on the qualities of water that support growth of plants and animals. Freshwater environments are subjected to increasing degradation. In addition to the extensive range of natural stresses encountered by organisms in their habitats, human activities can generate other environmental stresses. Such harmful alteration, disruption, or destruction of freshwater environments could become irreversible. Improving our understanding of freshwater ecology is therefore very important not only because of its biological implications, but also because the proper management of freshwater is of practical interest to mankind (Crossetti et al, 2013).

Plankton serves as food for larger aquatic organisms like insects, worms and molluscs which are in turn eaten by fish. Phytoplankton are the plantlike organisms that are found in aquatic environments, they are the primary producers which serves as food majorly for zooplankton which in turn serves as an important source of food to crustaceans and fish. They therefore, serve as a major source of organic carbon in rivers and may represent an important source of oxygen in low-gradient aquatic ecosystem. An assessment of phytoplankton community and abundance will enhance the understanding of biological productivity and fish population dynamics as they are known to serve as the food base that supports aquatic life. Although phytoplankton distribution and abundance are largely influenced by the light and nutrient, alteration of their natural environment by man can greatly distort this equilibrium. These may explain why plankters are used as bio-indicators to monitor aquatic pollution. The species assemblages of the zooplankton are indications of environmental quality and ecological changes as they respond to disturbances such as nutrient load, sediment input, contaminant densities and acidification. Zooplankton are not only useful as bio-indicators to help detect pollution load, but they are also helpful in ameliorating polluted waters. Relative species abundance describes how common or rare a species is relative to other species in a given community and usually described for single trophic level (Crossetti et al, 2013).

Physico-Chemical Characteristics Of Water

The most commonly used physico-chemical parameters for water quality measurement of rivers were Physical measurements like temperature, and Chemical measurements such as nutrients (nitrates and phosphate), total dissolved solids (TDS), pH, and conductivity. Other parameters include Water Temperature (^{0}C), Water Transparency (cm) Dissolved Oxygen (mg/l), Biological Oxygen Demand (mg/l), Conductivity (µS/cm), Hydrogen Ion Concentration (pH) and Plankton Diversity (FAO, 2006, Wurts and Messer, 2009, Jaji *et al.,* 2007, Abowei, 2010, Gupta, 2009).

Significant of Plankton Diversification

Diversity indicates the degree of complexity of community structure. It is the function of the number of species and abundance. Diversity has often been related to environmental characteristics of water mass and energy within the community (Badejo *et al*., 2014). Plankton communities serve as a base for the food chain that supports the commercial fisheries and they are also very useful as biological indicators in pollution management (Tweddle *et al*., 2018). The knowledge of phytoplankton distribution concerning spatial pattern is important to determine the status of the ecosystem structure and functioning and they equally reflect the nutrient status of the environment (Crossetti *et al*., 2013).

2. MATERIALS AND METHODS

Study Area

River Benue is a freshwater flowing through Nigeria and the second largest river in the country after River Niger. River Benue has features of a matured river with plains stretching for several kilometers. The greater of this plain is flooded during the rainy season and forms breeding ground for many fish species, most especially if its bank is full. Makurdi, the capital of Benue State, North Central Nigeria, is a town that lies between Latitude 7 o44'N and Longitude 8 o32'E covering an area of 820 km2 with an estimated population of 348,990 people (National Population Commission of Nigeria, 2011).

The vegetation type in Makurdi is guinea savannah with annual rainfall between 150 -180m and temperature of 26 ^{o}C - 40 ^{o}C. Three sampling stations were selected along lower River Benue at Makurdi. The sampling was done at multiple sites along the Wadata river axis and the Benue State University Water Board axis both within Makurdi. In all the sites sampled, there are enormous human impacts on the river which may favour the growth and survival of zooplankton and phytoplankton and consequently fish abundance which justified the selection of the sites for this study.

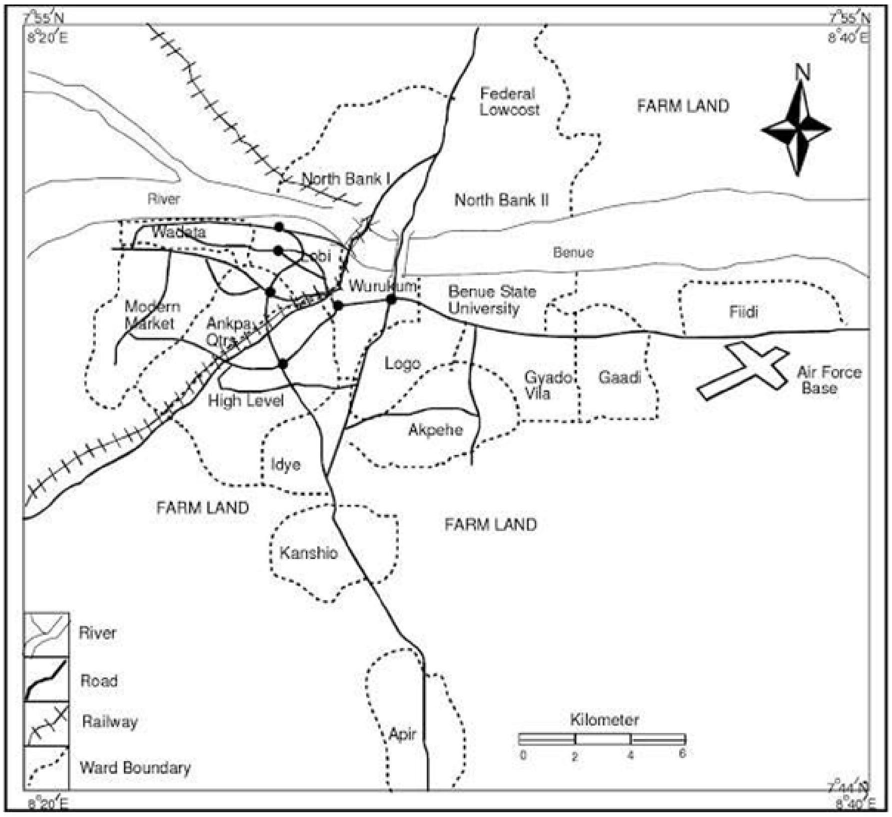

Figure 1: Map of Makurdi showing the study locations.

Source: (Ministry of lands and survey Makurdi, 2012)

Sample Collection

Samples were collected for a duration of 2 months, fortnightly early in the morning from 7:00 am – 8:00am. Water samples were collected from two selected sites, at five sample points each (at Wadata and BSU Water Board respectively). The 10 samples collected (5 from each site) weekly were transported to the Department of Fisheries and Aquaculture Laboratory, Joseph Sarwuan Tarka University Makurdi, for Chemical and Biological analysis.

Plankton sampling was carried out by using plankton net of mesh size 55µm by hauling horizontally at a distance of 5meters for 3minutes at a constant speed according to the method described by Hassan et al. (2019). Filtered water samples were stored in sample sterile bottle labelled with identification code of each sampling unit and preserved with 4% formalin which serves as fixative and Lugol's solution of 10%. Samples were immediately transferred to Microbiology Laboratory of Benue State University, Makurdi for further analysis.

Sample Identification

Fixed samples were allowed to settle in the Laboratory for 24 hours and the supernatant was carefully discarded. Sediments were dropped on a clean, grease-free microscope slide using a pipette and covered with a microscope cover slip and examined microscopically using Olympus Compound Light Microscope. Identification of the Zooplankton species was according to the identification method descried by Aniche and John,(2019) and Xiong et al. (2020). While phytoplankton species were identified on the Basis of their morphological characteristics with the aid of Standard Identification Keys of Huynh and Serediak, (2006).

Physico-Chemical Parameter Analysis

The physico-chemical parameters determined were: Total Dissolved Solids, Electrical conductivity, pH, Water Temperature (in OC) were measured using HANNA® Multiparameter water tester Model H198129, Dissolved Oxygen using HANNA® Dissolved Oxygen (DO) Meter Model H193246, Turbidity using SPER Scientific Turbidity Meter Model L87652 and Air Temperature using Alcohol in glass Thermometer.

Dissolved Oxygen

Dissolved oxygen was determined using HANNA® Dissolved Oxygen (DO) Meter Model H193246. This was done insitu by immersing the probe of the meter into the water and reading on the LCD taken when it stabilized.

Air and Water Temperature

Water Temperature was measured using HANNA® Multiparameter water tester Model H198129, the probe was immersed in the water sample and the mode to read temperature was by using the MODE keypad. The reading was taken after the sample was left to stabilize for about five (5) minutes. While Air Temperature was determined using Alcohol in glass Thermometer, with results read after 7 to 10minutes.

Total Dissolved Solids

Total Dissolved Solids was determined using HANNA® Multiparameter water tester Model H198129. The probe was immersed in the water sample and the mode to read TDS was using the MODE keypad. The reading was taken after the sample was left to stabilize for about five (5) minutes.

Water pH (Hydrogen ion concentration)

The pH of the water samples was determined using HANNA® Multiparameter water tester Model H198129. This was done by inserting the probe of the meter into the water sample and setting the mode to read pH using the MODE keypad.

Turbidity

Turbidity of water was conducted using SPER Scientific Turbidity Meter Model L87652. This was determined in a laboratory by taking 10ml of the water sample into the glass vial using adjustable micropipette. The sample was inserted into the well of the equipment after been cleaned and the lid closed. The test button was turned on and the results displayed on the Liquid Crystal Display (LCD).

Electrical Conductivity

Electrical Conductivity was determined using HANNA® Multiparameter water tester Model H198129. The probe was immersed in water sample and the mode to read EC was using the MODE keypad. The reading was taken after it was left to stabilize for about five (5) minutes

Statistical Analysis

Shannon Wiener diversity index was used to determine the plankton species composition and their diversity across the different sites sampled. Physicochemical parameters and Plankton parameters were analyzed using one-way ANOVA and Post-hoc comparisons using Duncan test ($P>0.05$) while Pearson's Correlation coefficient was used to determine the association between abundance and physicochemical parameters.

3. RESULTS

This study was conducted with the aim of investigating the abundance and diversity of plankton as well as physicochemical properties of the Lower Benue River. The survey was carried out at different sites along the River both at Wadata and BSU Water Board.

The abundance and distribution of Phyto and Zooplanktons in the Lower Benue River is presented in Table 1. A total of 39 planktons were observed out of which 28 (71.79%) were obtained at

Wadata and 11 (28.21%) at BSU Water Board. The most abundant of all the species was Arthrospira plantensis which was observed 16 times. This was followed by Closterium specie with an abundance of 8 and Melosira specie with an abundance of 6. The least occurring Plankton was the Paramecium specie which was observed only once. The species richness at the Wadata location was 7 with the Shannon-Weinner Diversity Index of 1.383 and Evenness of 0.711. The species richness at the BSU Water Board on the other hand was 3 species with the Shannon-Weinner Diversity Index (H) of 0.935 and an Evenness of 0.851. A significant relationship between plankton abundance and sampling location was overserved ($\chi2 = 19.360$; df = 1; P = 0.000).

Table 2 shows the physicochemical properties of the Lower Benue River at the respective sampling locations. The air and water temperature at the BSU Water Board area was observed to be slightly higher than the ones at Wadata however, no significant difference was observed between them ($P > 0.05$). The dissolved oxygen was however slightly higher at Wadata than BSU Water Board but no significant difference was observed ($P > 0.05$). The PH of the water, electrical conductivity and the total dissolved solid were observed to be significantly higher at Wadata when compared to the ones at the BSU Water Board. The turbidity on the other hand was significantly higher at BSU Water Board compared to the Wadata area (P = 0.044).

The effect of the physicochemical parameters on the abundance and diversity of plankton species was also studied. A fairly strong non-significant positive relationship was observed between plankton abundance and the PH (r = 0.502; P = 0.389). Electrical conductivity (r = 0.629; P = 0.069) and Total dissolved solid (r = 0.461; P = 0.298). On the other hand, a very strong non-significant negative relationship between plankton abundance and Air temperature was observed (r = 0.819; P = 0.090). The relationship with turbidity was also negative and strong but they were significantly associated (r = 0.720; P = 0.029). The Pearson's correlation coefficient (r) further revealed a very weak non-significant relationship between plankton abundance and dissolved oxygen (r = 0.137; P = 0.747), while it showed no significant relationship with temperature (r = 0.047; P = 0.904). (See figure 1 – 7).

Table 1: Diversity, abundance and distribution of Planktons in the Lower Benue River

S/No.	Planktons	Abundance		Total
		Wadata	BSU Water Board	
	Phytoplanktons			

1	Melosira species	1	5	6
2	Arthrospira platensis	16	-	16
3	Ulothrix species	1	1	2
4	Closterium species	3	5	8
	Zooplanktons			
5	Copepod species	2	-	2
6	Cyclopoid copepod	4	-	4
7	Paramecium species	1	-	1
	Total (%)	28(71.79)	11(28.21)	39(100)
	Shannon-Weinner Index (H)	1.383	0.935	
	Evenness (E)	0.711	0.851	

$\chi 2 = 19.360$; df = 1; P = 0.000

Table 2: Some Physicochemical properties of the Lower Benue River.

Physicochemical parameters	Mean value		P – value
	Wadata	BSU Water Board	
Temperature (0C)	26.54±0.49	26.78±0.42	0.429
Dissolved Oxygen (ppm)	4.18±0.49	4.16±0.29	0.939
$_{P}$H	7.38±0.08	7.16±0.05	0.001
Electrical conductivity (µs/cm)	81.80±12.89	68.00±2.12	0.046
Total Dissolved Solid (mg/L)	39.80±5.45	33.80±0.84	0.041
Turbidity (NTU)	59.40±4.72	98.60±36.29	0.044
Air Temperature (0C)	32.42±0.94	33.90±1.44	0.091

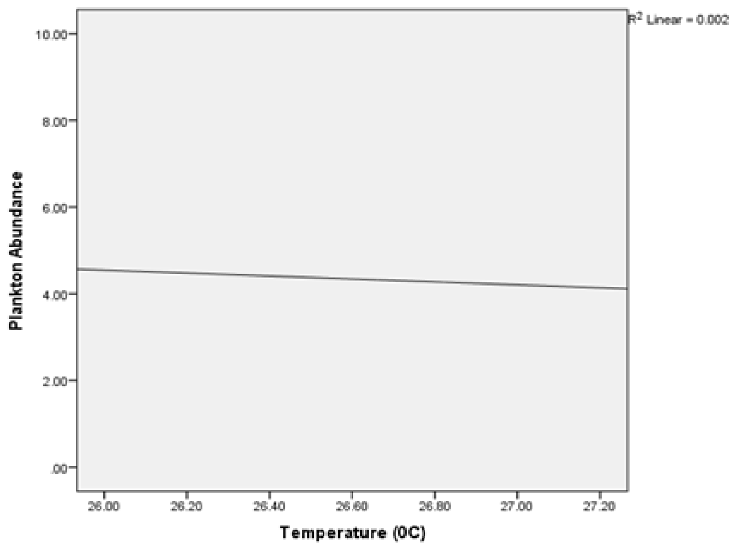

Fig. 1 Effect of temperature on the abundance of plankton in the Lower Benue River using the Pearson’s correlation

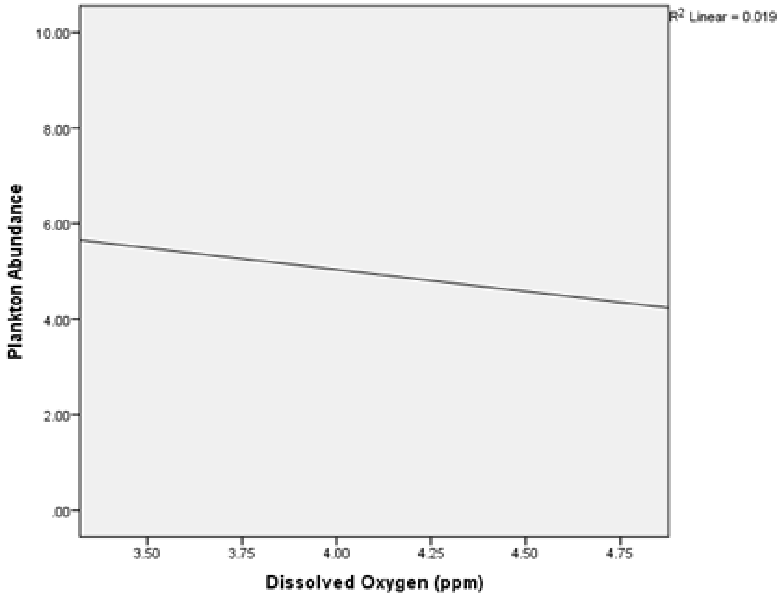

Fig. 2 Effect of dissolved Oxygen on the abundance of plankton in the Lower Benue River using the Pearson's correlation

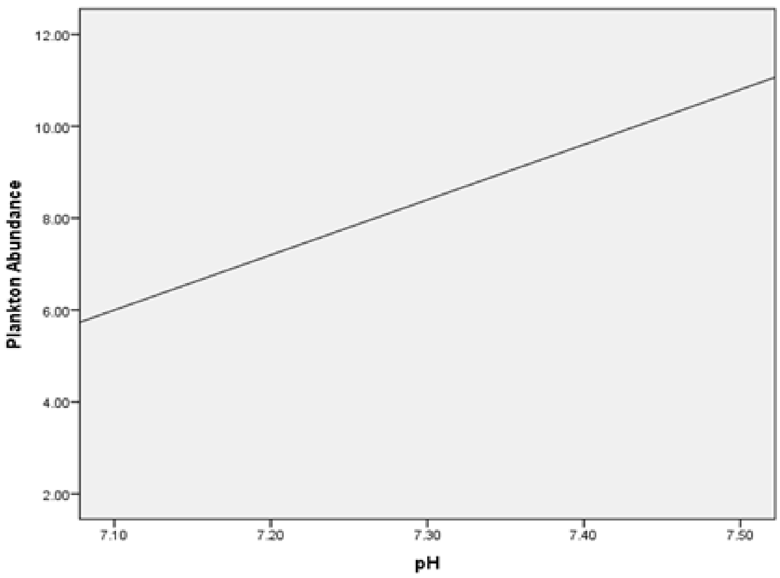

Fig. 3 Effect of PH on the abundance of plankton in the Lower Benue River using the Pearson's correlation

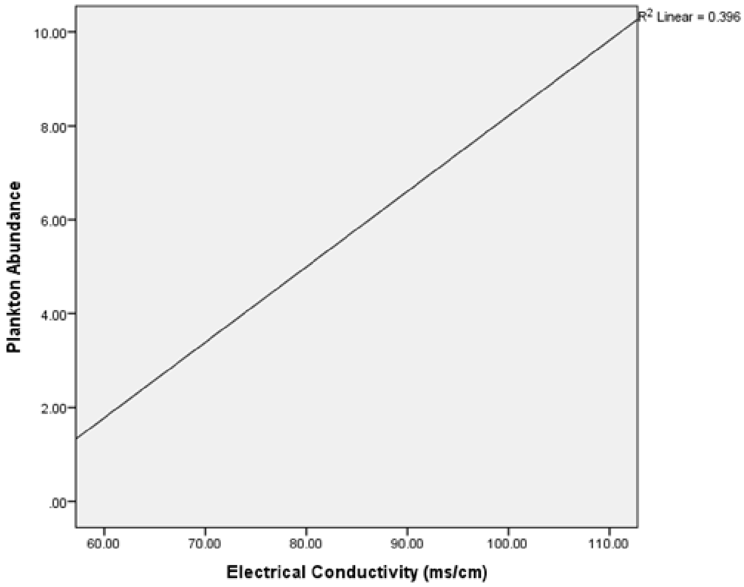

Fig. 4 Effect of electrical conductivity on the abundance of plankton in the Lower Benue River using the Pearson's correlation

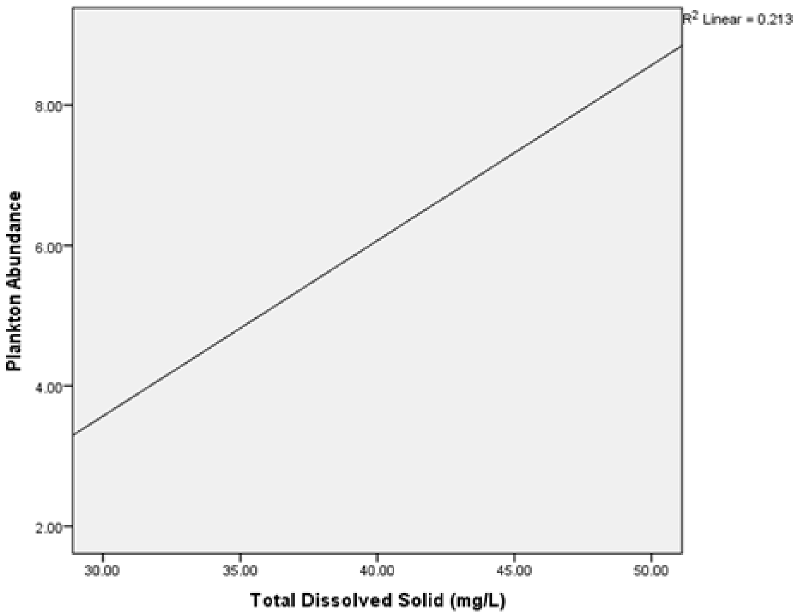

Fig. 5 Effect of total dissolved solids on the abundance of plankton in the Lower Benue River using the Pearson's correlation

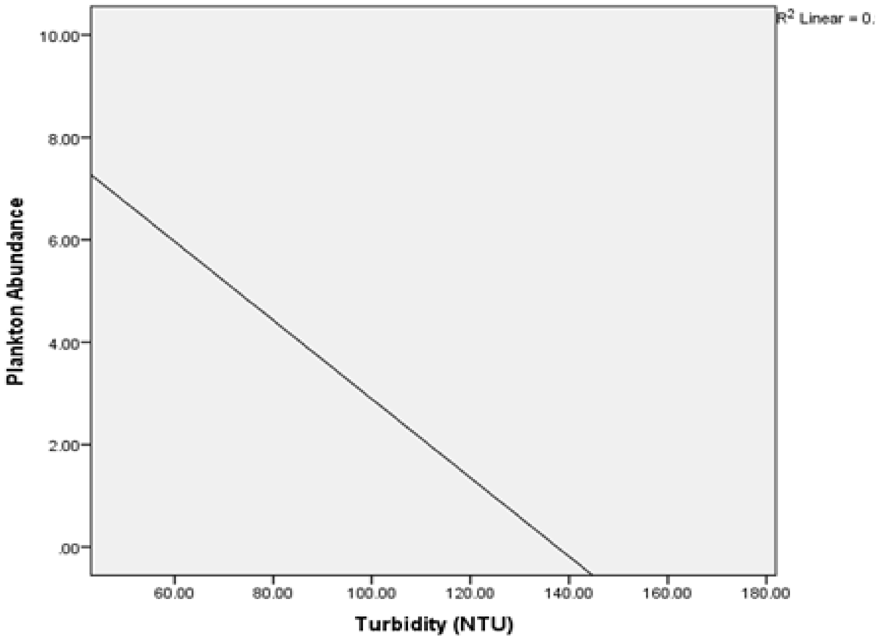

Fig. 6 Effect of turbidity on the abundance of plankton in the Lower Benue River using the Pearson's correlation

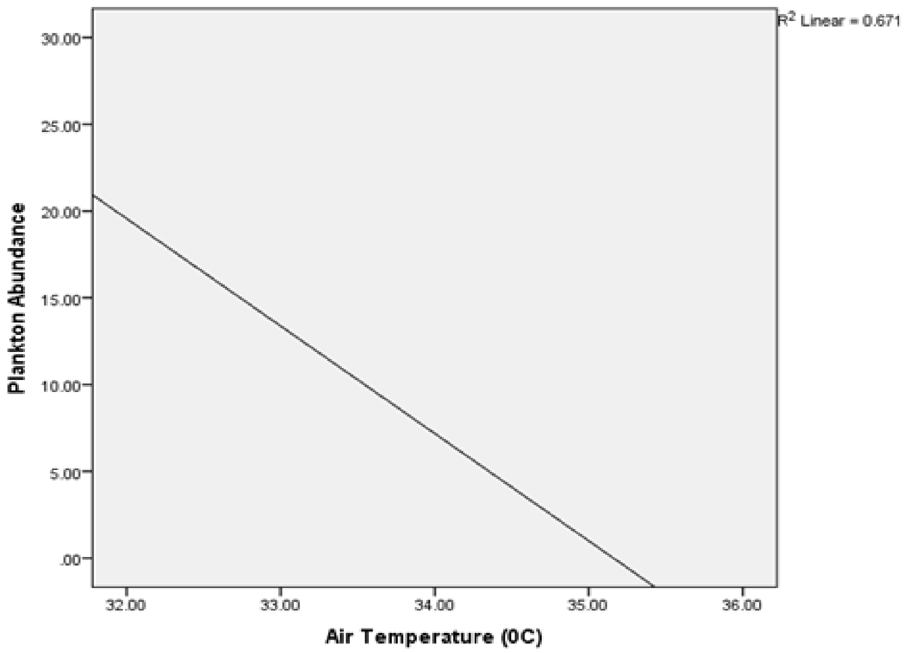

Fig. 7 Effect of Air temperature on the abundance of plankton in the Lower Benue River using the Pearson's correlation

4. Discussion

This survey was carried out at different sites along the River both at Wadata and BSU Water Board. The study showed that a total of 39 planktons were observed, constituting four Phytoplankton families and three Zooplankton families (with 28 (71.79%) obtained at Wadata). This result is similar with the findings of Musa et al. (2021) where they also recorded higher abundance of Phytoplankton species than the Zooplankton species (5 and 4 respectively). The high number of phytoplankton species recorded in this study could be due to available nutrients and other physical and chemical factors which promote growth of phytoplankton.

With the most abundant of all the species was Arthrospira plantensis and the least occurring Plankton was the Paramecium species which was observed only once, this disagree with Musa et al. (2021) where the family Bacillariophyceae was the most dominant.

Findings from the Physicochemical properties of the Lower Benue River at the respective sampling locations revealed that Air, Water temperature and Dissolved oxygen, had no significant difference observed between them ($P > 0.05$). This disagrees with the findings of Musa et al. (2021), where there was a significant difference in the results. The values of Dissolved oxygen concentrations in the river may be due to change in season, and rainfall pattern. Also, the range of values recorded for temperature (Air and Water) in the river falls within the range recommended by the Federal Environmental Protection Agency (FEPA, 2003) in an aquatic environment or ecosystem.

While PH of the water, Electrical conductivity, Turbidity and Total dissolved solid had significant difference observed between them ($P > 0.05$). This is similar with the findings of Musa et al. (2021), where there was a significant difference in these variables. It was also observed that these physico-chemical parameters show a fairly strong non-significant positive relationship and have tendencies to affect distribution, occurrence and diversity of the plankton. This agrees with the findings of Agouru and Audu (2012) who worked on river Benue.

5. Conclusion

Plankton are seen to serve as food for larger aquatic organisms like insects, worms and molluscs which are in turn eaten by fish and in this study, it can be stated that Plankton diversity and macrophytes can be used as tools for the assessment of water quality state in small and shallow water bodies with taxa's including Melosira species, Arthrospira platensis, Ulothrix species, Closterium species, Zooplanktons, Copepod species, Cyclopoid copepod, Paramecium species.

Also shown in this study is a plankton community that is more diverse and abundant in phytoplankton than zooplankton. The study also revealed the absence of pollution tolerant genera such as Euglena, Oscillatoria, Scenedesmus, Chlamydomonas etc. signifying the water studied is suitable of hosting an abundant diversity of Plankton. In any aquatic ecosystem, phytoplankton composition, community structure and species diversity are influenced, to a large extent, by human activities and physico-chemical parameters such as temperature, dissolved oxygen, pH, salinity, dissolved solids, turbidity and nutrient.

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