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ASSESSMENT OF PLANKTON AND BENTHOS DISTRIBUTION OF THE LOWER RIVER BENUE, IBI AXIS, TARABA STATE, NIGERIA

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Abstract

A four month research work was carried out to assess the distribution, abundance; diversity of plankton and benthos in the Lower River Benue at the Ibi axis, Taraba State. The objectives of the study was to identify the plankton and benthos, to assess the composition of the plankton and benthos, and to assess the abundance and diversity of the plankton and benthos species of the Lower River Benue, Ibi axis, in order to evaluate the ecological status of the river and determine the influence of physicochemical parameters on the aquatic organisms. Plankton net and van veen grab sampler were used to sample the three stations (A, B, and C), followed by laboratory identification, classification and enumeration using standard procedures, while water temperature, power of Hydrogen, dissolved oxygen, turbidity, electrical conductivity, total dissolved solid were measured in-situ. Results showed a total number of 32 individual species were identified from 755 harvested species, comprising of 350 phytoplankton (46.36%), 276 zooplankton (36.56%), and 138 benthos (18.28%). The phytoplankton species consist of 15 individual species belonging to 15 families and 13 orders, dominated by Euglenales, Naviculales, Bacillariales, and Chroococcales, the most species were *Euglena gracilis* and *Navicula cuspidata*. Zooplankton species were represented by 10 individual species, 8 families and 5 orders, mainly Cladocera, Copepoda, Rotifera, and Protozoa, with *Daphnia pulex* as the dominant species. The benthic macro-invertebrate assemblage comprised of 7 individual species, 7 families and 7 orders, including Diptera, Oligochaeta, Tricladida, and Amphipoda, with *Anopheles* larvae, *Dugesia* sp., and *Gammarus roeseli* being prominent. Margalef species richness indices indicated moderate biodiversity across the sampled stations, while physicochemical parameters showed no significant spatial variation and remained within ranges suitable for aquatic life, suggesting that the Lower River Benue at the Ibi axis is a moderately productive freshwater ecosystem capable of supporting diverse plankton and benthic species, hence, it is recommended that there is a need for continuous monitoring and regulation of anthropogenic activities to ensure sustainable management and conservation of the river's aquatic resources.

Keywords: Aquatic Ecology, Liminology, Aquatic Organisms, Aquatic Bio-indicator, River Productivity

INTRODUCTION

Rivers are important systems of biodiversity and are among the most productive ecological systems on the earth because of the favourable conditions that support number of flora and fauna. They play a vital role in productivity as they are home to a variety of flora and fauna including planktons (Komala *et al.*, 2013). The productivity of any water body is determined by the amount of plankton it contains as they are the major primary and secondary producers of the aquatic environment (Azrina *et al.*, 2005). Planktons are very sensitive to the environment they live in, any alteration in the environment leads to the change in the plankton communities in terms of tolerance, abundance, diversity and dominance in the habitat (Mathivanan & Jayakumar, 2007). Plankton organisms occur in open waters and move primarily with general water motions (Ovie *et al.*, 2009).

The plankton and benthos species composition could be used to evaluate the ecological status of aquatic habitats because of their quick response to environmental changes (Onyema *et al.*, 2007). These organisms are very good indicators of water qualities due to possessing a narrow range of tolerance to environmental perturbations. Plankton are any drifting or wandering organisms (plants and animals) that spend either part or all of their life in a drifting state and have little or no ability to swim. They are usually found in the surface and upper layers of water where sunlight and nutrients are readily available (Peg *et al.*, 2012). They can also be classified in different ways; these include whether they are true or false plankton, nutritional Requirements, size, environment and their life History (Akomeah *et al.*, 2010). Diversity and composition of plankton does not occur only in different depth, but also at different hours and in Years in the same place and depth and constitutes the main producer in any given water body (Kusuma *et al.*, 1988). Phytoplanktons are microscopic aquatic plants, occurring as unicellular colonial or filamentous Forms without any resistant to current and are free-floating or suspended in the open water (Ali *et al.*, 2013). They are important water quality indicators, Because of the short life cycles and ability to respond to environmental changes. The amount of Phytoplankton present in water depends on the light availability and the relative proportions of nutrients (nitrogen and phosphorous) and the temperature. Phytoplankton organism is one of the initial Biological component from which the energy is transferred to higher organisms through food chain (Tas & Gonolol, 2007). The density and the Diversity of phytoplankton are biological indicator for evaluating water quality and degree of eutrophication (Shekhar, *et al.*, 2008). The existence of Phytoplankton in the waters can be seen on the basis of their abundance, influenced by several Environmental and the physiological characteristics (Bellinger & Siege, 2010).

Zooplanktons occupy an important source of food for many species of aquatic ecosystem as they constitute the most important link in energy Transfer between phytoplankton and higher aquatic Fauna (Iloba, 2002). The organisms are identified as important component of aquatic ecosystems, help in regulating algal microbial productivity through grazing and in the transfer of primary productivity to fish and other consumers (Okogwu, 2010; Dejen *et al.*, 2004). By grazing on phytoplankton and Bacteria, Zooplankton helps in improving water quality and the amount of zooplankton in water Depends generally on the amount of phytoplankton And detritus available to feed on (Okogwu, 2010; Hassan *et al.*, 2010). It's an ecologically important group of

aquatic organisms that occupy a wide Range of habitats and they constitute essential biotic Component which influences the efficiency of an aquatic ecosystem such as energy flow through various trophic interactions (Park & Shin, 2007). The Zooplankton are so closely linked to the environment and they tend to change more rapidly than do larger aquatic animal such as fish, thus these organisms have proved valuable indicator of apparent and subtle alterations in the quality of aquatic environment (MBO. 2007). With the increased in human activities around River Benue, which might eventually led to pollution, it is imperative to assess the planktons composition and distributions since they have been used as bio-indicator of pollution (water quality) over-time so as to determine the Pollution level of the River.

Plankton and benthos serve as bio-indicators, reflecting the ecological status of river systems. Plankton as Indicators of Water Quality: Variations in the diversity and abundance of plankton represent pollution, eutrophication, and climate-driven alterations in water quality (Hecky & Kilham, 1988). Some phytoplankton species dominate harmful algal blooms (HABs), an indicator of excessive nutrient input and possible damage of the ecosystem (Paerl *et al.*, 2001). Environmental Stressors: Pollution, habitat deterioration, and oxygen deprivation are among the environmental stressors that might affect benthic macroinvertebrates (Rosenberg and Resh, 1993). According to Barbour *et al.* (1999), delicate species like mayflies and stoneflies exhibit high water quality, while pollution-tolerant species like oligochaete worms indicate organic contamination. Conservation and Long-Term Monitoring: Consistent evaluations of benthic and planktonic ecosystems aid in monitoring environmental changes and directing conservation initiatives (Edegbene *et al.*, 2019). For river systems to continue to support biodiversity, ecological resilience, and ecosystem services, these communities must be preserved. For the food web, nutrient cycling, and water quality regulation, plankton and benthos are essential components of river ecosystems. Their research sheds light on the effects of human activity and ecological stability as markers of environmental health. Monitoring these creatures should be a top priority in conservation and management plans to guarantee the long-term viability of riverine ecosystems.

Aim and Objectives of the Study

Aim of the Study

The aim of this study was to assess the plankton and benthos species distribution of the Lower River Benue at Ibi axis, Taraba state.

Objectives of the Study

The specific objectives of this research work was to:

1. identify the plankton and benthos of the Lower River Benue,
2. assess the composition of the plankton and benthos of the Lower River Benue;
3. assess the abundance and diversity of the plankton and benthos of the Lower River Benue, Taraba State, Nigeria.

Agouru & Audu (2012), researched on the range of plankton in River Benue, North Central, Nigeria, and Western Africa. They reported that two major types of plankton were identified. They recorded thirty five (35) species of Plankton, Phytoplanktons were nineteen (19) species (54.29%) and zooplanktons were sixteen (16)

species (45.71%), They also stated a total of twelve (12) taxa of which phytoplankton recorded seven (7) which were Chlorophyta 49.32%, Bacillariophyta 2.783%, Cyanophyta 0.18%, Dinophyta 62%, Euglenophyta 1.8%, Chrysophyta 0.185% and Rodophyta 0.09%, while zooplankton in an increasing dominance were five (5) Rotifera 52.75%, Cladocera 31.41%, Copepoda 6.84%, Ostracoda 5.40% and Decapoda 3.6%. They stated that the abundance and diversity of plankton in River Benue is affected by human activities along the shores and offshore of the river.

Igbani & Ikponmwen (2023) researched on the plankton and benthos distribution of river Donga, Taraba State, Northeast, Nigeria. They recorded a total of thirty three (33) individual species of plankton and benthos; sixteen (16) individual species belonging to phytoplankton were harvested, eleven (11) individual species belonging to zooplanktons were harvested, while six (6) individual species belonging to benthos were also harvested in stations A, B and C respectively. They comprised of 31 families and 26 orders; they recorded highest harvested individual species of *C. radiates* (100 species); the least individual species harvested was *A. lumbricoide* (1 species). They reported a total of 881 species of plankton and benthos were harvested, 524 species (59.48%) belonging to phytoplankton; 299 species (33.94%) belonging to zooplanktons were recorded, while 58 species (6.58%) belonging to benthos were also recorded. They recorded highest temperature value ($29.0 \pm 1.36^\circ\text{C}$) in Station A; the least ($27.9 \pm 0.6^\circ\text{C}$) in station B. The highest Dissolved Oxygen ($8.08 \pm 0.22\text{mg/L}$) in station B; the least ($7.32 \pm 0.5\text{mg/L}$) in station A. The mean pH values were slightly acidic; the highest value (6.71 ± 0.62) in station A; the least value (6.27 ± 0.27) in station C. Electrical conductivity, though, the highest value ($16.07 \pm 0.25\mu\text{S/cm}$) in Station C; the least ($15.58 \pm 0.52\mu\text{S/cm}$) in station A. The highest turbidity value ($33.25 \pm 6.15\text{cm}$) in station A; the least value ($32.08 \pm 4.54\text{cm}$) in station B. The highest total dissolved solid value ($0.36 \pm 0.38\text{ppm}$) in Station C; the least ($0.24 \pm 0.32\text{ppm}$) in station A. The river was highly productive in terms of its plankton and benthos richness; it was recommended that the physicochemical characteristics of the researched ecosystem will aid the culture of edible frogs and fish. They advised that monitoring of anthropogenic activities and the conservation of its natural resources is key to a sustainable biodiversity for food sovereignty and security to better lives as climate change doubles.

Igbani *et al* (2024) researched on the aquatic weed species diversity, abundance and their nutrients value in the Lower River Benue, Ibi Local Government Area, Northeast, Taraba State, Nigeria. They identified a total of thirty-five (35) individual aquatic weeds, nine (9) rooted weed species, ten (10) emergent weed species, ten (10) free floating weed species and six (6) submerged weed species amongst stations. They comprise of fifteen (15) families and fifteen (15) orders; the highest harvested individual species was *L. minor* (1627) while the least individual species was *M. pigra* (917); a total of 41447 species of aquatic weed were recorded. They reported highest temperature values ($27.87 \pm 1.00^\circ\text{C}$) in station A, while the least ($27.33 \pm 0.75^\circ\text{C}$) in station B; the highest dissolve oxygen ($4.77 \pm 0.23\text{mg/l}$) in station A, while the least ($4.40 \pm 0.46\text{mg/l}$) in station C; the highest pH value (8.37 ± 0.31) in station B, while the least (8.00 ± 0.46) in station A; the highest total dissolved solid (0.28 ± 0.20) in station B, while the least (0.27 ± 0.05) in station A. The proximate analysis of the samples/aquatic weeds were very promising for man and livestock consumption. They reported that *P. stratiotes* is the

richest in crude protein content (17%) and carbohydrate content (13%) and least in fat and moisture contents, (8%) and (2%) respectively. Hence, *P. stratiotes* is highly recommended for animal (fish and livestock) feed formulation inclusion of its (16.63%) approximately (17%) crude protein with crude fiber (36%) and (13%) carbohydrate contents.

Usman *et al.* (2019), researched on the survey of zooplankton diversity and abundance and its relationship with physicochemical parameters in river Kashimbila Takum, Taraba state, Nigeria. They identified a total of twenty one (21) species of zooplanktons, which was dominated by Ciliophora (34.61%), followed by Rotifera (32.92%) and the least being Cnidaria (0.02%). They concluded that based on the zooplankton diversity and abundance, the rivers holds high possible impact on fish production.

Andrew *et al.* (2017), researched on the seasonal analysis of water quality in two settlements of Wukari local government area, Taraba state, Nigeria. They investigated on temperature, turbidity, suspended solids, total dissolved solids (TDS), conductivity, pH, phosphate, chloride, alkalinity, hardness, chemical oxygen demand (COD), dissolved oxygen (DO) and biological oxygen demand (BOD). Nwagba *et al.* (2022), worked on the seasonal variation and Plankton physico-chemical characteristics of Omeremaduche River, Abia state, Niger delta, Nigeria. They reported that the mean values for pH, water-temperature, DO, BOD, phosphate and nitrate during the wet season were 6.91, 27.3, 5.86mg/l, 7.24mg/l, 0.38 and 4.18 respectively, while mean values of the physico-chemical characteristics during the dry season were 6.68, 26.8, 7.22mg/l, 5.44mg/l, 0.25mg/l and 3.09mg/l respectively. They also stated that, there was a significant difference in seasonal variation in DO, BOD, Nitrate and Phosphate, while no significant difference in pH and Water-temperature.

MATERIALS AND METHODS

Study Area

The research was carried out in the Lower River Benue, Ibi axis, Taraba State, North-eastern Nigeria. Ibi is located at latitude $8^\circ 38' 00''$ North and longitude $10^\circ 46' 00''$ East. The vegetative area is mainly comprised of secondary forest, forbs re-growth and swamp. There are two seasons, April to October is raining (wet) season, while November to March is sunny (dry) season. The annual rainfall ranges from 130 cm to 266.30 cm/annum with temperature between 32°C and 36°C . The area has a population over 244,749 with a scattered settlement of many small to large village settlements throughout the area and is mainly drained by the Tela River (into the Atlantic Ocean) in Gassol Local Government. The majority of the people are agricultural farmers and fisher folks (Flourizel *et al.*, 2024).

Sample Location

The study area was design to have three (3) sampling stations along the river. The selected stations were numbered, thus: Station A-Baruwana, Station B-Bisibi and Station C-Gugu abduhahi. The river was sampled twice per month for four (4) Months, from November to February; sampling was done by interval of two (2) weeks, that is, 1st and 3rd weeks of each month to consider disturbances.

Plankton Sample Collection

Plankton samples were collected from undisturbed water areas of the River. The sampling were carried out two (2) times per month

for 4 months, that is first and third weeks of each month, making it two (2) weeks interval. The sampling was carried out using the quantitative method. A composite sample of 100 litres of water was filtered through 55 um plankton net (with the aid of a 10 litres of bucket drawn 10 times at each station). The net content was washed out into plankton bottles of 250 ml size and preserved in 4% formalin solution after a proper labelling (Anene, 2003). In the laboratory, 1 ml of the preserved sample was taken as a sub sample using a pipette. The collected sample was put on the Sedgwick-rafter counting chamber and viewed under a light binocular microscope (Nikon 400 binocular microscope) using a low magnification of x10 and x40. Planktons were sorted into different groups and the cells per millimetre were counted. Species identification was done using key literatures (Vuuren *et al.*, 2006).

Benthos Sample Collection

Sediment samples were collected two (2) times per month for 16 weeks (4months), that is, the first and the third weeks of each month, were sampled making it two (2) weeks interval. At each station, soil samples were scooped using Van Veen grab from the bottom directly at the sampling points due to shallowness of the sites. Each sediment sample was diluted with water and sieved throughout 0.5 mm mesh size, then put inside a plastic container and labelled. Species identification was made using appropriate keys (Atobatele *et al.*, 2005; APHA. 2005).

Determination of Plankton and Benthos Abundance

Plankton and benthos abundance can be determine using a formula as follows;

$$\text{Abundance: } d = (S - 1) / \ln N$$

Where; d = Margalef richness index or species abundance index, S = Number of species in the population, N = Total number of individuals in species, $\ln$ = Logarithm (Antai & Joseph 2015).

Determination of Physicochemical Characteristics

The following physicochemical characteristics, such as Water Temperature, Dissolved Oxygen, Power of Hydrogen, Electrical Conductivity, Turbidity; Total Dissolved Solid were determined in-situ by lowering its measuring meter into the water below for about 3 to 5 minutes and taking its stable reading (APHA. 2005).

Statistical Analysis

Analysis of variance (ANOVA: $P < 0.05$) was used to test for significant difference occurring in various physicochemical parameters between stations. Turkey's HSD was used to separate the mean difference. Pearson's Correlation was used to test the relationship between physicochemical parameters and plankton composition of the river at $P < 0.01$ significant level.

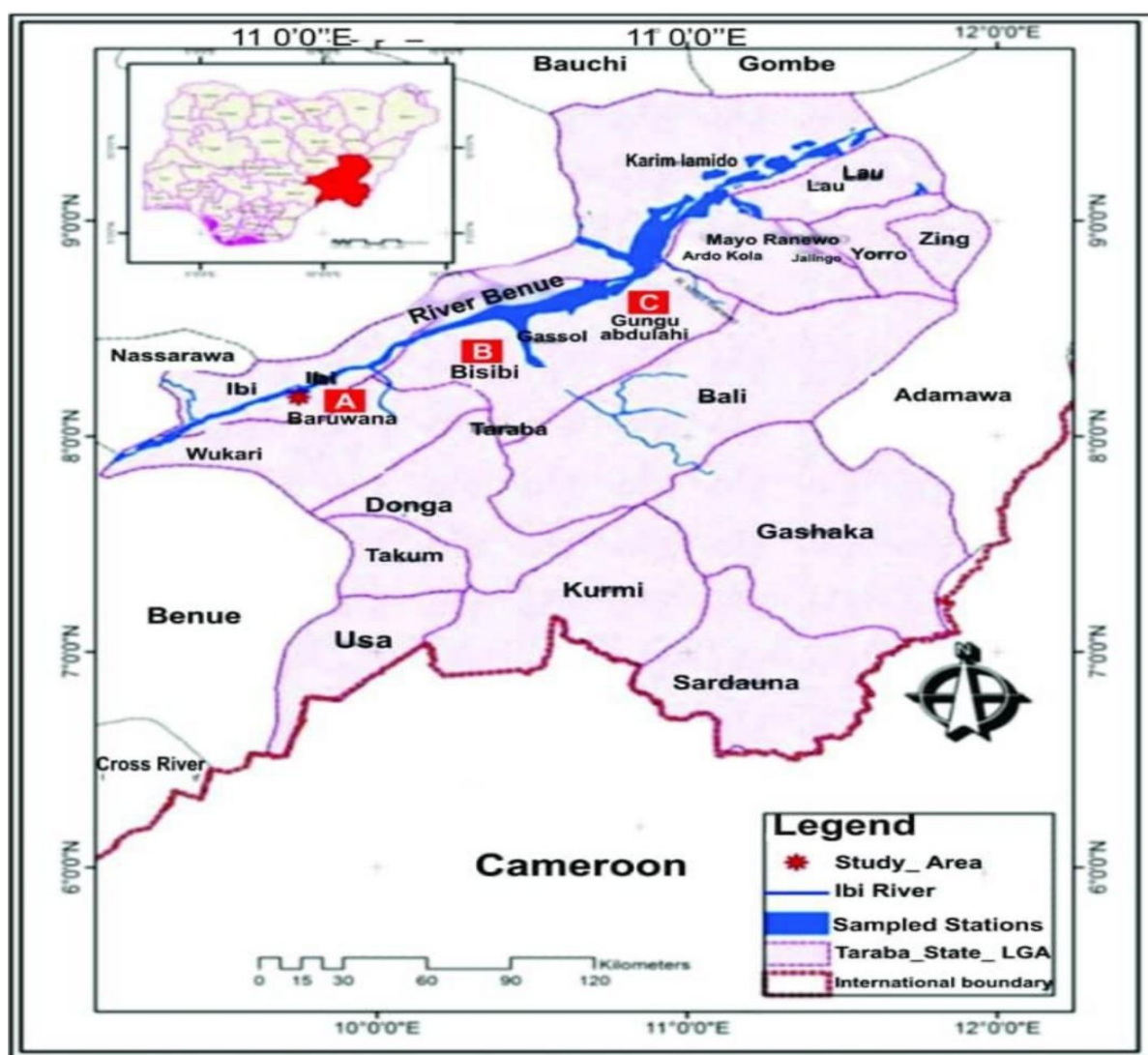


Figure 1: Map of Taraba State showing sampled stations in the Lower River Benue, Ibi Axis.

RESULTS AND DISCUSSION

Results

Table 1 presents the phytoplankton, zooplankton, and benthic macroinvertebrate; 32 individual species, 30 families and 25 orders were identified in the Lower River Benue at Ibi axis. The table reveals a diverse assemblage of aquatic organisms, indicating a biologically productive freshwater ecosystem. The phytoplankton community was composed mainly of green algae, diatoms, cyanobacteria, and euglenoids. Among the phytoplankton, *Euglena gracilis* recorded the highest abundance (51), followed closely by *Navicula cuspidata* (50), *Microcystis flos-aquae* (42), and *Spirogyra* sp. (41). The dominance of these species suggests favourable environmental conditions characterized by adequate nutrient availability and light penetration. This observation supports the role of phytoplankton as primary producers and reliable indicators of water quality in freshwater ecosystems. Diatom species such as *Nitzschia gracilis* and *Melosira varians* were also well represented, indicating good water circulation and sufficient silica content. The presence of cyanobacteria (*Microcystis flos-aquae* and *Nostoc* sp.) suggests moderate nutrient enrichment of the river, although their abundance does not indicate excessive eutrophication.

Zooplankton species recorded in the study area included copepods, cladocerans, rotifers, and protozoans. *Daphnia pulex* was the most abundant zooplankton species (62 count), followed by *calanoid copepods* (41), *Brachionus calyciflorus* (41), and *Paramecium caudatum* (40). The dominance of these taxa indicates efficient grazing on phytoplankton and effective transfer of energy to higher trophic levels, particularly fish. The occurrence of *copepod larvae* further reflects active reproductive processes and a stable aquatic environment.

The benthic macroinvertebrate community comprised oligochaetes, gastropods, insect larvae, annelids, and crustaceans. *Anopheles gambae* were the most abundant benthic organisms (41), followed by *Dugesia* sp. (24), *Gammarus roeseli* (16), and *Potamopyrgus* sp. (15). The presence of oligochaetes such as *Lumbricus terrestris* and *Eisenia foetida* indicates organic matter availability in the sediment, while the occurrence of *Gammarus roeseli* suggests that the substrate can support moderately sensitive benthic fauna.

The overall composition and abundance of phytoplankton, zooplankton, and benthos recorded in Table 1, indicates that the Lower River Benue at Ibi axis is a moderately productive freshwater ecosystem with stable environmental conditions capable of supporting diverse aquatic life and sustaining fisheries resource.

Table 2 shows the abundance and spatial distribution of phytoplankton across Stations A, B, and C. The total phytoplankton abundance varied among stations, with Station A generally recording higher values for most species, followed by Station B and Station C. *Euglena gracilis* (51) and *Navicula cuspidata* (50) were the most abundant phytoplankton species, indicating favourable environmental conditions such as adequate nutrients and light availability. The least abundant species was *Coscinodiscus radiates* (3), which occurred sparsely across the stations. The variation in phytoplankton abundance among stations may be attributed to differences in physicochemical parameters, water flow, and local anthropogenic activities. The dominance of diatoms and green invertebrate life, though some species reflect environmental disturbance.

Table 5 presents the mean values of physicochemical parameters across the three stations. Water temperature showed no significant algae suggests good primary productivity within the river.

Table 3 presents the abundance and distribution of zooplankton species across the three sampling stations. A total of ten (10) individual zooplankton species were recorded, with *Daphnia pulex* being the most abundant species (62), followed by *Brachionus calyciflorus* and *Calanoid copepods* (41 each). Zooplankton abundance was generally higher at Station B, indicating better feeding conditions likely resulting from higher phytoplankton availability. Species such as *Moina belli* and *Bosmina* sp. occurred in low numbers, suggesting selective environmental tolerance. The presence of diverse zooplankton taxa indicates efficient energy transfer between phytoplankton and higher trophic levels, particularly fish.

Table 4 shows the abundance and distribution of benthic macroinvertebrates across Stations A, B, and C. *Anopheles gambae* were the most abundant benthic organisms (43), followed by *Dugesia subtentaculata* (26) and *Potamopyrgus* sp. (17). Station B recorded the highest abundance of benthos, which may be linked to sediment quality and organic matter availability. The presence of pollution-tolerant species such as *Anopheles gambae* and oligochaetes suggests moderate organic enrichment of the river bottom. In the overall data, the benthic fauna composition indicates a substrate capable of sustaining macro-variation among stations, remaining within a narrow range suitable for aquatic organisms. pH values ranged from slightly neutral to mildly alkaline, indicating favourable conditions for plankton growth. Dissolved oxygen levels were moderate across all stations, suggesting adequate oxygen availability for aquatic life. Turbidity, electrical conductivity, and total dissolved solids showed significant variations among stations, reflecting differences in sediment load, dissolved ions, and possible anthropogenic influences.

Table 6 shows the results of the one-way ANOVA analysis. The results indicate that no significant differences ($P < 0.05$) existed among stations for temperature, dissolved oxygen, pH, electrical conductivity, turbidity, and total dissolved solids. This suggests that the physicochemical parameters of the river were relatively uniform across the sample stations during the study period.

Table 7 presents the mean abundance of plankton and benthos in relation to physicochemical parameters across the stations. Station C recorded the highest overall abundance, followed by Station-A and Station-B. The observed pattern suggests that slight variations in temperature, dissolved oxygen, and turbidity may influence the distribution and abundance of aquatic organisms in the river.

Table 8 presents the Pearson's correlation coefficients showing the relationship between benthos abundance and selected physicochemical parameters, as well as the interrelationships among the physicochemical variables in the Lower River Benue at Ibi axis. Benthos abundance exhibited weak correlations with all measured physicochemical parameters. Specifically, benthos showed weak positive relationships with dissolved oxygen ($r = 0.297$), pH ($r = 0.093$), and total dissolved solids ($r = 0.302$), while weak negative relationships were observed with temperature ($r = -0.083$), electrical conductivity ($r = -0.173$), and turbidity ($r = -0.031$). None of these relationships were statistically significant ($P < 0.01$), indicating that benthic organism abundance was not strongly controlled by any single physicochemical parameter. This suggests that benthos distribution in the study area is likely

influenced by a combination of factors such as sediment quality, organic matter availability, and habitat structure rather than water chemistry alone. Among the physicochemical parameters, a significant positive correlation was observed between temperature and dissolved oxygen ($r = 0.503$, $P < 0.01$), indicating that increases in temperature during the study period were associated with increases in dissolved oxygen. Although this pattern differs from the commonly reported inverse relationship between temperature and dissolved oxygen, it may reflect site-specific conditions such as water mixing, flow dynamics, or sampling time.

Other correlations among physicochemical variables were weak and not statistically significant ($P < 0.01$). This implies that the physicochemical conditions of the river were relatively stable and did not vary drastically in ways that would strongly influence each other or benthic abundance. The results from Table 8 indicate that benthos abundance in the Lower River Benue at Ibi axis is regulated by multiple interacting environmental factors rather than a single dominant physicochemical variable, reflecting a moderately stable freshwater ecosystem.

Table 9 shows the Pearson's correlation between physicochemical parameters and plankton abundance. A significant positive correlation ($r=0.503$, $P<0.01$) was observed between temperature and dissolved oxygen, indicating that increases in temperature were associated with increased dissolved oxygen during the study period. Other parameters showed weak positive or negative correlations with plankton abundance, and these relationships were not statistically significant. This suggests that plankton abundance in the Lower River Benue is influenced by a combination of environmental factors rather than a single physicochemical parameter.

Discussion

The present study assessed the plankton and benthos distribution of the Lower River Benue at Ibi axis, Taraba State, with a view to understanding the ecological status of the river system. The findings from this study reveal important patterns in species composition, distribution, abundance, and their relationship with physicochemical parameters, which are discussed in relation to previous studies as reviewed in this research work.

The phytoplankton community of the Lower River Benue was dominated by *Euglena gracilis*, *Navicula cuspidata*, *Microcystis flos-aquae*, and *Spirogyra* sp. This dominance suggests that the river is nutrient-enrich and moderately productive in the aquatic ecosystem; this result aligns with the findings of Komala *et al.* (2013) and Azrina *et al.* (2005), they reported that phytoplankton abundance and dominance of diatoms and green algae are indicative of favourable nutrient conditions in freshwater ecosystems. Similarly, Onyema *et al.* (2007) reported that phytoplankton communities respond rapidly to environmental conditions, making them reliable indicators of water quality. The presence of *Microcystis flos-aquae*, a cyanobacterium often associated with nutrient-rich waters, further supports the assertion that the Lower River Benue possesses adequate nutrient availability.

The observed spatial variation in phytoplankton abundance across stations, with Station-A, recording relatively higher values for several species may be attributed to localized environmental conditions such as water movement and nutrient distribution. This observation agrees with Kusuma *et al.* (1988) and Tas & Gonulol

(2007), they noted that plankton distribution varies spatially even within the same water body due to differences in depth, flow rate, and nutrient availability. However, the relatively uniform physicochemical conditions recorded across stations suggest that these variations are subtle rather than drastic. Zooplankton distribution in the study area revealed that *Daphnia pulex* was the most abundant species, followed by *Brachionus calyciflorus* and copepods. This finding is consistent with Iloba (2002) and Okogwu (2010), they reported that Cladocerans and Rotifers often dominate tropical freshwater systems due to their adaptability and efficient feeding on phytoplankton. The relatively higher abundance of zooplankton at Station B suggests greater food availability, likely resulting from phytoplankton presence/abundance, which supports the trophic linkage described by Dejen *et al.* (2004); this result therefore aligns with earlier studies that emphasize the role of zooplankton as a critical link between primary producers and higher trophic levels.

The benthic macroinvertebrate assemblage was dominated by *Anopheles gambiae*, *Dugesia* sp, *Lumbricus terrestris*, and *Gammarus roeseli*. The presence of *oligochaetes* and insect larvae suggests moderate organic enrichment of the river substrate. This observation is in agreement with Atobate *et al.* (2005) and Azrina *et al.* (2005), they reported that benthic macroinvertebrates are sensitive indicators of sediment quality and organic matter content. However, the coexistence of both tolerant and moderately sensitive species indicates that the river is not severely polluted but rather maintains conditions capable of supporting diverse benthic fauna. This aligns with the findings of Igbani & Ikponmwon (2023) in River Donga, they reported similar benthic compositions under moderately productive conditions.

The physicochemical parameters measured across the three sample stations showed relatively narrow ranges, with no statistically significant differences observed among stations. Water temperature, pH, and dissolved oxygen values were within ranges considered suitable for plankton growth and aquatic life: plants and animals. These findings support the assertions of APHA. (2005) and Bellingier & Sigee (2010), they stated that stable physicochemical conditions promote biological productivity in freshwater ecosystems. The lack of significant variation among stations suggests a relatively uniform water quality during the study period, which may be attributed to similar hydrological and seasonal conditions across the study area/ecosystem.

Correlation analysis revealed a significant positive relationship between temperature and dissolved oxygen. Although, this relationship is statistically significant, it deviates from the commonly reported inverse relationship between temperature and dissolved oxygen in natural waters. This deviation may be attributed to localized mixing, flow dynamics, or sampled period effects, as suggested by MBO. (2007). Other physicochemical parameters showed weak and non-significant relationships with plankton abundance, indicating that plankton distribution in the Lower River Benue is influenced by a combination of interacting environmental factors rather than a single controlling variable. This observation agrees with Mathivanan & Jayakumar (2007), they emphasized on the multifactorial nature of plankton dynamics in freshwater ecosystem.

The overall results of this study largely align with previous findings reviewed in related research works, particularly those conducted in similar tropical river ecosystems within Nigeria. The observed plankton and benthos diversity, coupled with stable

physicochemical conditions, suggest that the Lower River Benue at Ibi axis is a moderately productive ecosystem capable of

supporting aquatic biodiversity and fisheries resource.

Table 1: Phytoplankton, Zooplankton and Benthos Species Identified in Ibi Axis

S/N	Species	Families	Orders	Number of Species Cropped
1	<i>Spirogyra maxima</i>	Zygnemataceae	Zygnematales	41
2	<i>Oscillatoria princeps</i>	Oscillatoriaceae	Oscillatoriales	26
3	<i>Euglena gracilis</i>	Euglenaceae	Euglenales	51
4	<i>Nitzschia gracilis</i>	Bacillariaceae	Bacillariales	35
5	<i>Coscinodiscus radiates</i>	Coscinodiscaceae	Coscinodiscales	3
6	<i>Nostoc sp.</i>	Nostocaceae	Nostocales	6
7	<i>Volvox carti</i>	Volvocaceae	Chlamydomonadales	24
8	<i>Microcystis flos-aguae</i>	Microcystaceae	Chroococcales	42
9	<i>Chlorella vulgaris</i>	Chlorellaceae	Chlorellales	9
10	<i>Chlamydomonas reinhardtii</i>	Chlamydomonada-ceae	//	26
11	<i>Navicula cuspidate</i>	Naviculaceae	Naviculales	50
12	<i>Melosira varians</i>	Melosiraceae	Melosirales	13
13	<i>Pediastrum duplex</i>	Hydrodictyaceae	Sphacropleales	9
14	<i>Closterium gracile</i>	Closteriaceae	Desmidiales	6
15	<i>Cyclopoid copepod</i>	Cyclopoidae	Cyclopoida	38
16	<i>Daphnia pulex</i>	Daphniidae	Anomopoda	62
17	<i>Brachionus calyciflorus</i>	Brachionidae	Ploima	41
18	<i>Copepod larvae</i>	//	//	4
19	<i>Moina belli</i>	Moinadae	//	2
20	<i>Keratella valga</i>	//	//	36
21	<i>Paramecium caudatum</i>	Parameciidae	Peniculida	40
22	<i>Calanoid copepod</i>	Calanoidae	Calanoida	41
23	<i>Bosmina sp.</i>	Bosminidae	//	4
24	<i>Euchlanis sp.</i>	Euchlanidae	//	8
25	<i>Lumbricus terrestris</i>	Lumbriculidae	Haplotaxida	17
26	<i>Potamopyrgus sp.</i>	Tateidae	Littorinimorpha	15
27	<i>Anopheles gambiae</i>	Culicidae	Diptera	41
28	<i>Glossiphonia complanate</i>	Glossiphoniidae	Rhynchobdellida	4
29	<i>Pleurosigma cuspidatum</i>	Pleurosigmataceae	//	9
30	<i>Dugesia subtentaculata</i>	Dugesiidae	Tricladida	24
31	<i>Eisenia foetida</i>	Oligochaeta	Opisthopora	12
32	<i>Gammarus roeseli</i>	Gammaridae	Amphipoda	16
Total	Individual Species Cropped			755

Identification of Plankton and Benthos Species

Phytoplankton Species:



Plate 1: Scientific Name: *Spirogyra Maxima* (Nees, 1820)

Common Name: Blanket weed



Pate 4: Scientific Name: *Nitzschia gracilis* (Hassall, 1845)

Common Name: Diatom

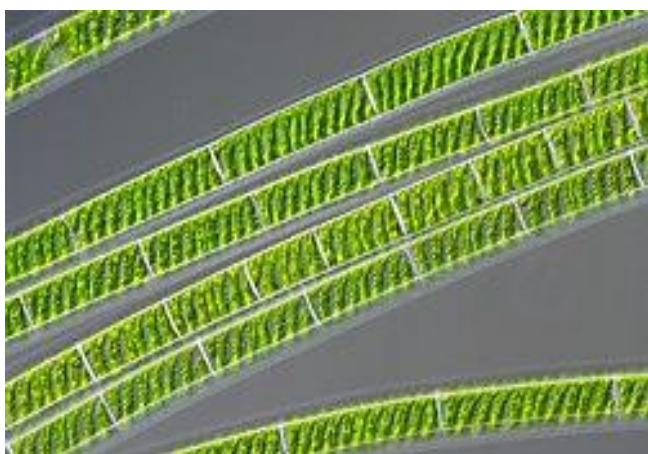


Plate 2: Scientific Name: *Oscillatoria princeps* (Vaucler, 1822)

Common Name: Filamentous blue-green algae

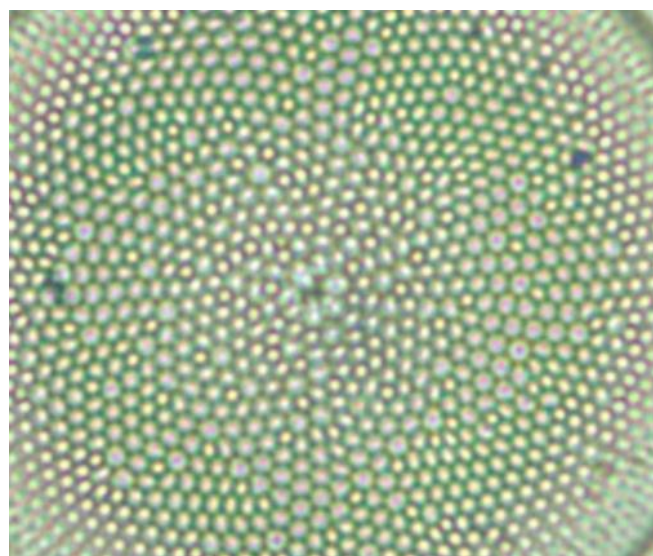


Plate 5: Scientific Name: *Coscinodiscus radiates* (Ehrenberg, 1840)

Common Name: Giant disc wheel

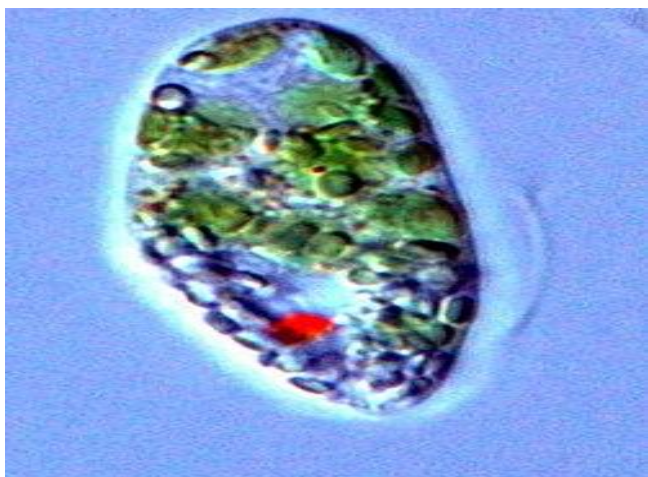


Plate 3: Scientific Name: *Euglena gracilis* (Ehrenberg, 1830)

Common Name: Green euglena

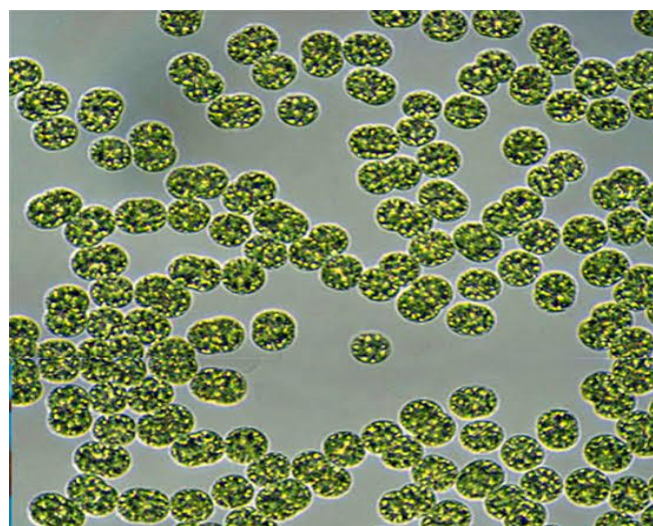


Plate 6: Scientific Name: *Nostoc microtis* (Montagne, 1839)

Common Name: Stay Jerry

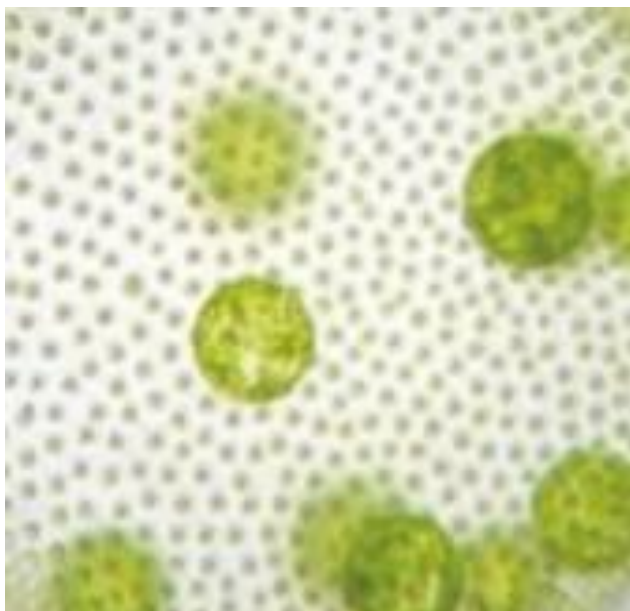


Plate 7: Scientific Name: *Volvox carti* (Stein, 1878)

Common Name: Green algae



Plate 8: Scientific Name: *Microcystis flos-aquae* (Lemmemann, 1907)

Common Name: Blue-green algae



Plate 9: Scientific Name: *Chlorella vulgaris* (Beijerinck, 1890)

Common Name: Chlorella

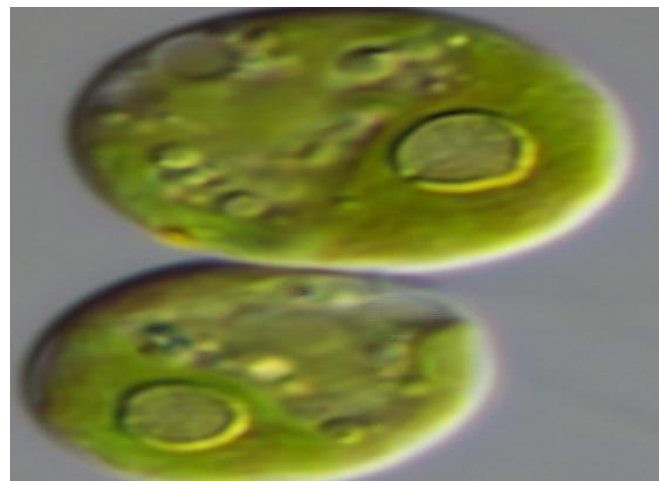


Plate 10: Scientific Name: *Chlamydomonas reinhardtii* (Dang, 1862)

Common Name: Chlamy green algae



Plate 11: Scientific Name: *Navicula cuspidate* (Bory, 1822)

Common Name: Boat-cusped tooth diatom

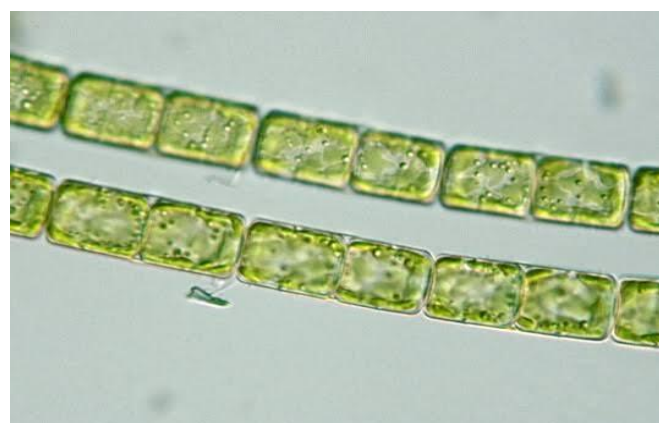


Plate 12: Scientific Name: *Melosira varians* (Agardh, 1824)

Common Name: Fringed water silk/Melosira

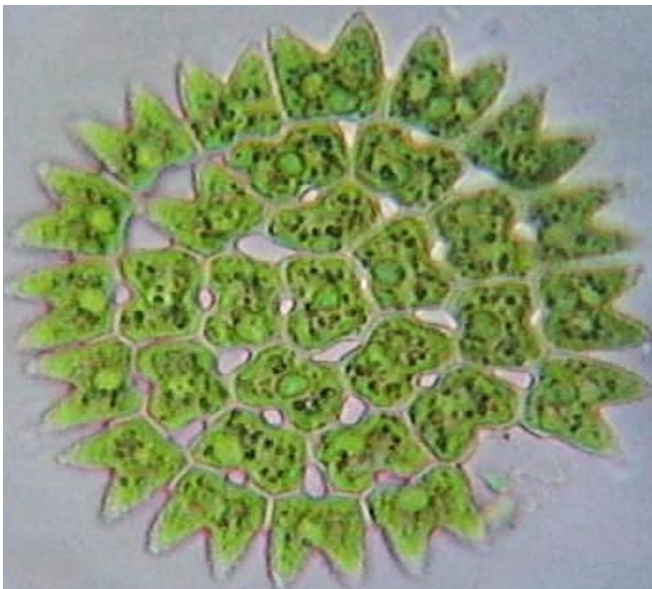


Plate 13: Scientific Name: *Pediatrium duplex* (Meyen, 1829)

Common Name: Star algae



Plate 14: Scientific Name: *Closterium gracile* (Ehrenberg, 1848).

Common Name: Closterium



Plate 15: Scientific Name: *Pleurosigma cuspidatum* (Peragallo, 1891)

Common Name: Pleurosigma diatom

Zooplankton Species:

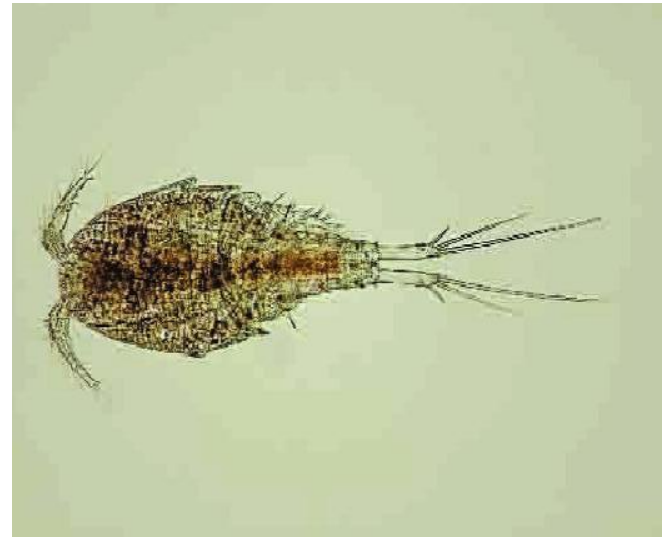


Plate 16: Scientific Name: *Cyclopoid copepod* (Burmeister, 1834)

Common Name: Drumroll Cyclops



Plate 17: Scientific Name: *Daphnia pulex* (Leydig, 1860)

Common Name: Water flea

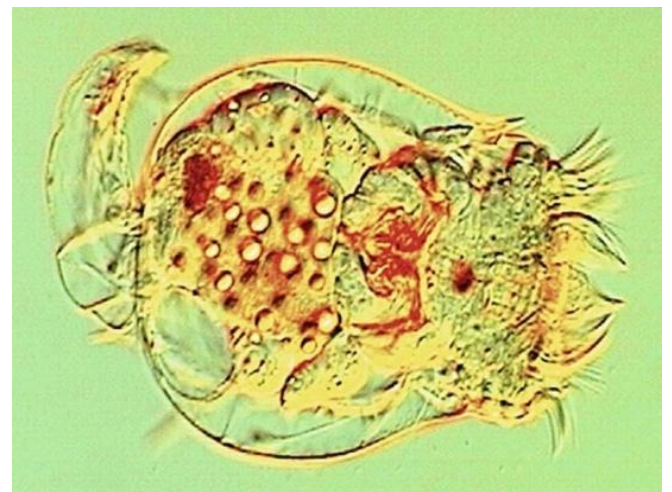


Plate 18: Scientific Name: *Brachionus calyciflorus* (Pallas, 1766)

Common Name: Box-like rotifer



Plate 19: Scientific Name: *Copepod larvae* (Milne-Edwards, 1840)

Common Name: Nauplius



Plate 20: Scientific Name: *Keratella valga* (Vincent, 1822)

Common Name: Loricata rotifer



Plate 21: Scientific Name: *Paramecium caudatum* (Ehrenberg, 1833)

Common Name: Slipper animalcules



Plate 22: Scientific Name: *Calanoid copepod* (Sars, 1903)

Common Name: Copepod



Plate 23: Scientific Name: *Bosmina longirostris* (Baird, 1845)

Common Name: Bosmina water flea



Plate 24: Scientific Name: *Euchlanis sp.* (Braun, 1884)

Common Name: Wheel Animalcules



Plate 25: Scientific Name: *Moina belli* (Gurney, 1904)

Common Name: Water flea crustacean

Benthos Species:



Plate 26: Scientific Name: *Lumbricus terrestris* (Micheal, 1930)

Common Name: Common earthworm



Plate 27: Scientific Name: *Potamopyrgus* sp. (Stimpson, 1865)

Common Name: Mud snail



Plate 28: Scientific Name: *Anopheles gambiae* (Giles, 1902)

Common Name: Mosquito larvae



Plate 29: Scientific Name: *Glossiphonia complanata* (Linnaeus, 1758)

Common Name: Snail leech



Plate 30: Scientific Name: *Eisenia foetida* (Savigny, 1826)

Common Name: Red wiggler worm



Plate 31: Scientific Name: *Gammarus roeseli* (Gervais, 1835)

Common Name: Freshwater shrimp



Plate 32: Scientific Name: *Dugesia subtentaculata* (Lang, 1884)

Common Name: Freshwater planarians

Table 2: Abundance and Distribution of Phytoplankton at Ibi Axis

S/N	Species	Families	Orders	Stations			Total Species
				A	B	C	
1	<i>Spirogyra maxima</i>	Zygnemataceae	Zygnematales	15	10	16	41
2	<i>Oscillatoria princeps</i>	Oscillatoriaceae	Oscillatoriales	11	9	6	26
3	<i>Euglena gracilis</i>	Euglenaceae	Euglenales	21	17	13	51
4	<i>Nitzschia gracilis</i>	Bacillariaceae	Bacillariales	12	15	8	35
5	<i>Coscinodiscus radiates</i>	Coscinodiscaceae	Coscinodiscales	1	0	2	3
6	<i>Nostoc sp.</i>	Nostocaceae	Nostocales	3	2	1	6
7	<i>Volvox carti</i>	Volvocaceae	Chlamydomonadales	8	4	12	24
8	<i>Microcystis flos-aquae</i>	Microcystaceae	Chroococcales	15	17	10	42
9	<i>Chlorella vulgaris</i>	Chlorellaceae	Chlorellales	4	2	3	9
10	<i>Chlamydomonas reinhardtii</i>	Chlamydomonadaceae	Zygnematales	12	5	9	26
11	<i>Navicula cuspidate</i>	Naviculaceae	Naviculales	20	16	14	50
12	<i>Melosira varians</i>	Melosiraceae	Melosirales	7	3	3	13
13	<i>Pediastrum duplex</i>	Hydrodictyaceae	Sphacroleales	4	2	3	9
14	<i>Closterium gracile</i>	Closteriaceae	Desmidiiales	2	1	3	6
15	<i>Pleurosigma cuspidatum</i>	Pleurosigmataceae	Naviculales	4	4	1	9
	Total Abundance			139	107	104	350
	Total Number of Species			15	14	15	
	Total Number of Individual Species			139	107	104	
Margalef species richness index				2.84	2.78	3.01	

Table 3: Abundance and Distribution of Zooplankton at Ibi Axis

S/N	Species	Families	Orders	Stations			Total Species Cropped
				A	B	C	
1	<i>Cyclopoid copepod</i>	Cyclopoidae	Cyclopoida	12	17	9	38
2	<i>Daphnia pulex</i>	Daphniidae	Anomopoda	23	19	20	62
3	<i>Brachionus calyciflorus</i>	Brachionidae	Ploima	16	13	12	41
4	<i>Copepod larvae</i>	cyclopoidae	Cyclopoida	2	1	1	4
5	<i>Moina belli</i>	Moinadae	Anomopods	1	0	1	2
6	<i>Keratella valga</i>	Brachionidae	Ploima	11	18	7	36
7	<i>Paramecium caudatum</i>	Parameciidae	Peniculida	12	16	12	40
8	<i>Calanoid copepod</i>	Calanoidae	Calanoida	18	10	13	41
9	<i>Bosmina sp.</i>	Bosminidae	Anomopoda	0	1	3	4
10	<i>Euchlanis sp.</i>	Euchlanidae	Ploima	3	4	1	8
	Total abundance			98	99	79	276

	Total number of species			9	9	10	
	Total number of individual species			98	99	79	
Margalef species richness index				1.74	1.74	2.06	

Table 4: Abundance and Distribution of Benthos at Ibi Axis

S/N	Species	Families	Orders	Stations			Total Species Cropped
				A	B	C	
1	<i>Potamopyrgus sp.</i>	Tateidae	Littorinimorpha	6	9	2	17
2	<i>Anopheles gambiae</i>	Culicidae	Dipteria	14	17	12	43
3	<i>Glossiphonia complanate</i>	Glossiphoniidae	Rhynchobdellida	0	5	1	6
4	<i>Lumbricus terrestris</i>	Lumbriculidae	Haplotaxida	8	2	6	16
5	<i>Dugesia sp.</i>	Dugesiidae	Tricladida	10	9	7	26
6	<i>Eisenia foetida</i>	Oligochaeta	Opisthopora	5	1	8	14
7	<i>Gammarus roeseli</i>	Gammaridae	Amphipoda	7	6	3	16
	Total abundance			50	49	39	138
	Total Number of Species			6	7	7	
	Total Number of Individual Species			50	49	39	
Margalef Species Richness Index				1.28	1.54	1.64	

Figure 2: Pie Chart Showing the Distribution of Plankton and Benthos at Ibi Axis

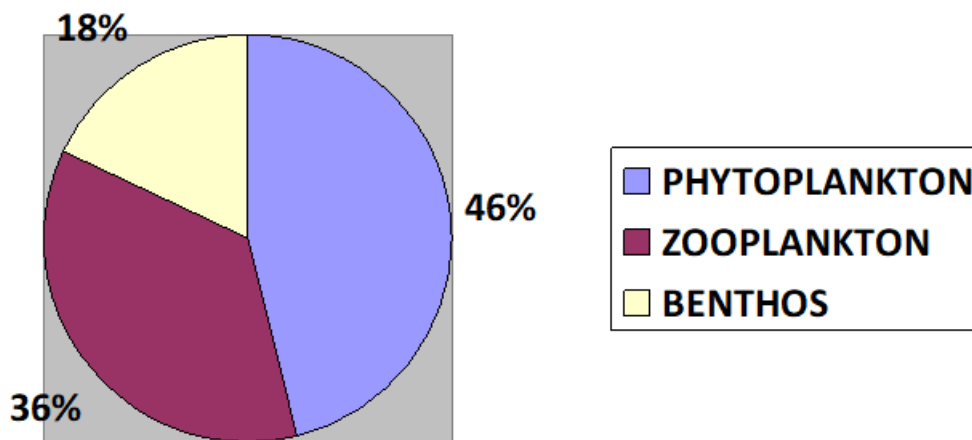


Table 5: Mean ($\pm$ SD) of Physicochemical Parameters Across Sampled Stations

	Physicochemical Parameters					
Stations	Temperature ($^{\circ}$ C)	pH	DO (mg/L)	Turbidity (cm)	EC(μ s/cm)	TDS(ppm)
A	27.36 $\pm$ 0.89 ^a	7.55 $\pm$ 0.86 ^a	5.69 $\pm$ 0.95 ^a	48.04 $\pm$ 13.70 ^a	211.48 $\pm$ 55.20 ^a	235.82 $\pm$ 110.12 ^a
B	27.26 $\pm$ 1.43 ^a	7.11 $\pm$ 0.61 ^b	5.57 $\pm$ 0.90 ^a	57.16 $\pm$ 6.33 ^{bc}	195.27 $\pm$ 45.00 ^b	295.60 $\pm$ 62.20 ^b
C	27.81 $\pm$ 0.92 ^a	7.27 $\pm$ 0.79 ^a	5.60 $\pm$ 0.70 ^b	54.78 $\pm$ 7.98 ^b	218.59 $\pm$ 36.14 ^c	241.90 $\pm$ 61.12 ^b

Values are in mean standard deviation; Means with different superscripts (^{abc}) differ significantly using Turkey's HSD test at $P < 0.05$

Table 8: Pearson's Correlation Between Physicochemical Parameters and Benthos Abundance

	Benthos	Temp	DO	pH	EC	Turbidity	TDS
Benthos	1	-.083	.297	.093	-.173	-.031	.302

Temp	-.083	1	.503**	-.272	.208	.114	-.054
DO	.297	.503**	1	-.343	.245	.146	.085
Ph	.093	-.272	-.343	1	.067	-.072	-.149
EC	-.173	.208	.245	.067	1	-.009	-.241
Turbidity	-.031	.114	.146	-.072	-.009	1	.169
TDS	.302	-.054	.085	-.149	-.241	.169	1

**=correlation is significant at P<0.01

Table 9: Pearson's Correlation Between Physicochemical Parameters and Plankton Abundance

	Temp	DO	pH	EC	Turbidity	TDS
Temp	1	0.503**	-0.272	0.208	0.114	-0.054
DO	0.503**	1	-0.343	0.245	0.146	0.085
pH	-0.272	-0.343	1	0.067	-0.072	-0.149
EC	0.208	0.245	0.067	1	-0.009	-0.241
Turbidity	0.114	0.146	-0.072	-0.009	1	0.169
TDS	-0.054	0.085	-0.149	-0.241	0.169	1

**=correlation is significant at P<0.01

CONCLUSION AND RECOMMENDATIONS

Conclusion

This study successfully identified and documented the plankton and benthos assemblages of the Lower River Benue at the Ibi axis, Taraba State. A total of 755 harvested organisms were recorded, comprising phytoplankton, zooplankton, and benthic macro-invertebrates. The phytoplankton community consisted of 15 species belonging to 15 families and 13 orders, with dominant orders including Euglenida, Naviculales, Bacillariales, and Chroococcales. Zooplankton diversity was represented by 10 species distributed across 8 families and 5 orders, notably Anomopoda, Cyclopoida, Calanoida, and Ploima. The benthic macro-invertebrate assemblage comprised 7 species belonging to 7 families and 7 orders, including ecologically important orders such as Diptera, Tricladida, Amphipoda, and Haplotaxida. The presence and distribution of these species across multiple families and orders indicate a moderately diverse and productive freshwater ecosystem, reflecting favourable environmental conditions capable of supporting varied aquatic life. The composition and richness of plankton and benthos reflect a healthy aquatic environment with adequate nutrient availability and favourable physicochemical conditions, including neutral to slightly alkaline pH, moderate dissolved oxygen, and suitable temperature ranges. Seasonal and spatial variations in species abundance were observed but did not indicate significant ecological disturbance. The findings indicate that the Lower River Benue at Ibi axis supports a wide range of aquatic ecosystem thrive; biodiversity sustainability and fisheries resource livelihood availability.

Recommendations

The identified phytoplankton, zooplankton and benthos species could be used by zoology, microbiology, biochemistry, agriculture, aquaculture, water science, hydrology, fisheries students and graduates. The results on the physicochemical parameters could be used as a base line data for aquatic threshold and stress water

culture indicator. The plankton and benthos species identified in the study area should be considered for further studies by zoologists, biologists, water scientists, hydrologists, microbiologists, agriculturalists, biochemists, aquaculturists; fisheries experts. And, it is necessary for the local communities to be informed on environmental stewardship and sustainability amongst climate change.

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18. Ehrenberg, C. G. (1848). *Closterium gracile* was a German naturalist, zoologist, comparative anatomist, geologist, and microscopist. Ehrenberg was an evangelist and was considered to be of the most famous and productive scientists of his time.
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