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The Plankton Assemblage and Water Quality of Otamiri River Owerri West Local Government Area, Imo State Nigeria.

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Abstract

This Research work on the Plankton Assemblage and Water Quality of Otamiri River, Owerri, Imo State, Nigeria was carried out between August and January, 2024.The aim of the study is to identify the plankton assemblage in Otamiri River and to determine how they are affected by water quality for National recognition and scientific recommendation, the specific objectives include: to determine the physico- chemical parameters of the river; evaluate phytoplankton and zooplankton species composition, abundance, richness and diversity; evaluate the effect of the physico-chemical parameters on the phytoplankton and zooplankton population. Samples and data were taken from the three stations along the river using standard methods, procedures and instruments. Biostatistical evaluation was carried out using ANOVA, Duncan Multiple Range Test and Pearson's correlation to test the relationship between various parameters at significance level of $p < 0.05$. The mean of some parameters studied were temperature 24.10± 0.88°C, depth 5.21 ± 2.10 m, turbidity 97.03 ± 4.10 cm, pH 7.10 ± 0.10, electrical conductivity 127.38 ± 0.66 µS/cm, total dissolved solids 17.78 ± 0.11 mg/l, hardness 90.40 ± 0.17 mg/l $CaCO_3$, dissolved oxygen 6.37 ± 0.17 mg/l, biochemical oxygen demand 2.92 ± 0.41 mg/l. Temperature, electrical conductivity, pH and total dissolved solids varied significantly across the stations. Temperature, pH, electrical conductivity and hardness were significantly higher during the dry months. The result obtained indicated phytoplankton percentage composition as; Chlorophyta (368, 43.09%), Bacillariophyta (242, 28.34%), Cyanophyta (138, 16.16%), and Dinophyta (106, 12.41%) while Zooplankton percentage composition were Arthropoda (256, 42.31%), Rotifera (198, 32.73%), Ciliopora (73, 12.07%), and Cnidaria (78, 12.89%). In summary therefore, the higher number of phytoplankton obtained during the study can be used to access the biological integrity of the river as phytoplankton reflect the nutrient status of the environment. Farming activities contribute to nutrient enrichment of the river as nitrates and phosphates from fertilizers are washed into the river. Water quality of the river is influenced by anthropogenic activities such as runoffs of inorganic fertilizers and pesticides; the river water is suitable for irrigational and domestic purposes in terms of most of the physico-chemical and biological parameters analyzed. Hence, there is need for stringent regulatory policies and effective anthropogenic inputs control program in the water to enhance productivity of the river.

Keywords: Phytoplanktons, Zooplanktons, Physicochemical parameters, Otamiri River

INTRODUCTION

Plankton are the diverse collection of organisms found in water (or air) that are unable to propel themselves against a current (or wind) (Lalli and Parsons, 1993). The individual organisms constituting planktons are called Plankters. In the aquatic environment, they provide a crucial source of food to many small and large organisms, such as bivales, fish and baleen whales. Though many planktonic species are microscopic in size, plankton includes organisms over a wide range of sizes, including large organisms such as jellyfish. This is because planktons are defined by their ecological niche and level of motility rather than by any phylogenetic or taxonomic classification. The plankton category differentiates these organisms from those that float on the water's surface called Neuston, those that can swim against a current called Nekton, and those that live in the deep sea floor called Benthos (Dolan and John, 2012). Within the plankton, holoplankton spend their entire life cycle as plankton. (eg. Most algae, copepod, salps and some jellyfish). By contrast, meroplankton are only planktic for part of their lives (usually the larval stage), and then graduate to either a nektic (swimming) or benthic (sea floor) existence. Examples of meroplankton include the sea urchins, starfish, crustaceans, marine worms and most fish (Karleskint and James, 2013). The amount and distribution of plankton depends on available nutrient, the state of water and a large amount of other plankton (Agrawai and Krishna, 2013). Phytoplankton are microscopic organisms that live in watery environments both salty and freshwater. Thus, the plankton are at the mercy of currents more so than fish and other larger organisms. It is composed of organisms with chlorophyll (phytoplankton) and animals (zooplankton). Phytoplankton is the primary producer community and consists of mainly algal such as diatoms, dinoflagellate, and a variety of forms from other division of the plant kingdom. Planktons are very sensitive to the environment they live in, any alteration in the change in the abundance, diversity and dominance in habitat will affect the plankton distribution. Therefore, plankton population observation may be used as a reliable tool for biomonitoring studies to assess the population status of aquatic bodies (Mathivanan and Jayakumar, 1995). The study of plankton as an index of water quality with respect to industrial, municipal and domestic pollution has been reported earlier (Acharjee *et al.*, 1995). Water, is a liquid that is composed of two atoms of hydrogen and one atom of oxygen. Its chemical formula is H_2O. The hydrogen atoms are bonded to the oxygen atom by covalent bond. It is the second to air as the most essential commodity to survival of life. Human life depends to a large extent on water, it is used for an array of activities; chief among these being for drinking, food preparation as well as for sanitation purpose. Water provides habitat for several aquatic organisms such as plankton. The growing demands for adequate quality water resources create an urgent need to link research with improved water management, better monitoring, assessment, and forecasting of water resources and the sanitation issues with much emphasis on the community (Yamaguchi and Wesselink, 2000). Rivers provide much of drinking water supplied to a community and plankton can greatly influence the water quality of these

rivers. Uncontrolled growth of certain species of phytoplankton can increase toxicity levels in the water (Watson, 2004; Waya and Mwambungu, 2004). This can lead to unpleasant taste, especially if these toxins are produced in drinking water and if poor filtration system exist (Watson, 2004; Waya and Mwambungu, 2004). Similarly, disease can be spread through zooplankton that supports the growth of vibrocholera, the infectious agent of cholera, and can aid in its spread through unfiltered or poorly filtered drinking water (Hug *et al.,* 1996). It has been observed that cholera outbreaks are rampant after plankton bloom (Hug *et al.,* 1996). Predation by fish determines the abundance of herbivorous zooplankton which in turn regulates the level of phytoplankton (Carpenter *et al.,* 1985). A recent study (Sarvala*et al.,* 1998) revealed that changes in the abundance of planktivorous fish do affect both the phytoplankton and zooplankton. However, most of the available information comes from experimental enclosures and much less is known about trophic interactions in large ponds (Brett and Goldman, 1996). Planktivorous fish have a major influence on the structure of the whole plankton where they modify the density and size structure of communities (Carpenter *et al.,* 1985).According to Akomeah*et al*. (2010), planktons are usually categorized according to their feeding mode or life cycle thus, 1) feeding mode: Phytoplankton = autotrophs, Zooplankton = heterotrophs, or 2) life cycle: holoplankton (entire life cycle in water column as plankton), meroplankton (part of life cycle as plankton). The amount of phytoplankton in water depends on light availability, the amount of nutrients available, and the relative proportions of nutrients available (with nitrogen and phosphorous usually as limiting nutrients) and the temperature of the water. The amount of zooplankton in water depends generally on the amount of phytoplankton and detritus available to feed on, detritus can be food for primary consumers, (Hassan *et al.,* 2001). Phytoplankton in a river is an important biological indicator of waterquality (Yakubu *et al.,* 2000). While phytoplankton are important primary producers and are at the base of the food chain in open water, some species on the other hand can be harmful to human and other animals by releasing toxic substances (hepatoxins or neurotoxins, etc.) into the water (Witty and Potts, 1999). Phytoplankton and zooplankton are considered the main natural food for fish culture especially during the early stages. Semour (1980) stated that the carrying capacity and production of fish ponds could be increased by fertilization that encourages growth of phytoplankton and in turn zooplankton that is required as natural food for fish. Touliabah (1992) evaluated the impacts of fish production and fertilization on managing plankton in fish farm. Nigeria is richly blessed with a vast area of inland waters. The total surface area of water bodies in Nigeria is estimated to be 550,000 hectares (13,000 km^2) and this constitutes about 15.9% of the total area of Nigeria (Ekiye, 2010). These include both natural and man-made lakes, reservoirs, Floodplains and cattle ponds, rivers and streams; but exclude deltas, estuarine and miscellaneous wetlands suitable for rice cultivation. The composition and density of aquatic organisms depends on the geographical and water quality of the aquatic which habitat can be adversely affected by human activities (Oben, 2000; Atobatele and Ugwumba, 2008).Rivers are considered favourable

environments to the development of plankton communities, because they establish diverse assemblages in relatively short periods of time (Rocha *et al.*, 2008). Several factors usually contribute to the establishment of plankton communities in a river, among which are good water quality, presence of nutrients, physicochemical factors of water, hydrological characteristics of the river and ageing of the river. Phytoplankton are usually at the base of aquatic food web and are the most important factor for production of organic matter in aquatic ecosystem. Most rivers will require significant amount of plankton to have productive and sustainable fisheries. The interplay of physical, chemical and biological properties of water most often lead to the production of phytoplankton, while their assemblages are structured by these factors.

MATERIALS AND METHODS

Description of the Study Area

River Otamiri where this study was carried out is a slow flowing stream having a Land Mass of 10,000 sq.m. (Ministry of Land and Survey, 2015) The river is one of the main rivers in Imo State, Nigeria. It takes its name from Ota Miri, a deity who owns all the waters that are called by his name, and who is often the dominating god of Mbari houses. Otamiri River lies between Latitude $5^{o}20'$ N and $5^{o}28'$ N, and Longitude $6^{o}56'$ E and $7^{o}40'$ E of the equator (Ministry of Land and Survey, 2015) (Figure 1). It is located in Owerri West Local Government Area of Imo State. Otamiri River runs south from Egbu pass Owerri and through Nekede, Ihiagwa, Eziobodo, Olokwu, Umuisi, Mgbirichi and Umuagwo to Uzuzu in Etche, in the River State, from where it flows to the Atlantic Ocean. The length of the river from its source to its confluence at Emeabiam with the Uramiriukwa River is 30 kilometres (Wikipedia). The Otamiri is joined by the Nworie River at Nekede in Owerri, a river about 9.2 kilometers (5.7 mi) long. (Ministry of Land and Survey, 2015). Station I is located at Nekede, the velocity of the water is high and light penetrates the station. At this station there is a pool of water for processing cassava (i.e for soaking and sieving of cassava). Other human activities that takes place in this station include washing of clothes, watering and cultivation of vegetables, washing of breadfruit, bathing, deforestation, farming along the banks. Station II is located at Ihiagwa, the velocity of water at this station is slow. It has canopies of trees such as bamboos, and the leaves are good source of nutrients to the water. The substratum is a mixture of mud, organic matter and sand. As a result, light penetrate this station. Among the human activities that occurs in this station is bush clearing, lumbering, and bathing whileStation III is located at Mgbirichi, the velocity of water at this station is very high. The substratum is mixture of pebbles and sand. Human activities in this station include cultivation, dredging of sand, lumbering, bathing and watering of vegetables along banks. Along the banks are aquatic plant such as Treculiaafricana “Breadfruit” (Moraceae), Alchorneacordifolia “Xmas bush” (Euphorbiaceae).

Duration of Study

Study was carried out during the dry and rainy months. August- October (rainy month) and November-January (Dry month).

Experimental Design

The experimental design used in the research study is the factorial experiment in complete randomized design. Locations were the replicates while months were the treatments.

Water sample collection

Water samples for physico-chemical analysis were collected using a clear sterilized oxygen titre bottle for the period of study. Oxygen bottles were used to collect water from each study station in each visit. Manganoussulphate (1ml) and potassium iodide (1ml) were used to fix dissolved oxygen in the sample prior to transportation to laboratory for analysis.

Collection of plankton samples

The sample of planktons (zooplankton and phytoplankton) were collected between 7am – 9 am twice in a week for six months. Plankton net with mesh size 70µm, collection bottle, 200ml plastic bottles and a five-liter (5l) plastic bucket were used for collection of the plankton samples. The plastic bucket was used to collect water up to its brim gradually at each study station. The water collected was transferred into three 200 ml plastic bottles and labelled Station I, Station II and Station III and preserved in 4% formalin. Both water and plankton samples were transported in collection bottles from the study stations to the research laboratory of Imo State University Owerri. In the laboratory, the water samples were analysed while the plankton samples were stored for 24 hours before observation and identification were made.

Plankton observation and identification

Plankton observation was made with a binocular dissecting microscope while identification was made by referring to the key of Thorp and Rogers (2011), Egborge (1993) and Fernando (1986). Planktons were identified up to species level.

Determination of physico-chemical parameters of the River

Determination of temperature

Temperature (°C) of the water was measured by dipping a mercury in glass thermometer into the water at each station for about 1-2 minutes then the readings were recorded (APHA, 1999)

Determination of depth

The depth of the river was determined using a weighted line. The material required include sounding line or a measuring tape. The weighted line or tape was lowered into the water until it touches the bottom. The length of the line from the water surface to the point where it touches the bottom was measured.

Determination of turbidity

The determination of turbidity of water at the study stations was conducted using a 20 cm diameter secchi disc attached to a calibrated line. The disc painted in alternate white and black colour was lowered gradually into the river by means of the calibrated line. The arithmetical mean of the distance at which the disc disappeared from view in descent and that at which the disc reappeared in ascent was given as the secchi disc turbidity (Reid and wood, 2015). Value was recorded in centimeters (cm).

Determination of pH

pH was measured with Hanna 420 pH meter. It was calibrated according to instructional manual provided by the manufacturer. The electrode of the pH meter was dipped into the water sample for 2-3 minutes and readings were recorded (APHA, 1999).

Determination of electrical conductivity

The conductivity of water samples from each station was determined in the field using a battery operated conductivity meter. At each study station, a beaker of 350 ml capacity was filled with water sample. The probe was placed directly into the water sample (rinsing the probe with distilled water after each dipping). The readings were taking from the display on the meter and values were recorded in micromhos per centimeter (µS/cm) (APHA, 2005). At the end of conductivity determination, the instrument was turned off and the probe was rinsed with distilled water and stored air dry.

Determination of Total dissolved solids

Total dissolved solids (TDS) represent the concentration of dissolved substances in water, which includes salts, minerals and organic matter. The material required to determine TDS include clean, dry beakers or evaporating dishes, water sample, Analytical balance (precision of 0.01 mg), Filtration apparatus (filter paper or membrane filter), oven or drying oven, desiccator.

Determination of Hardness

Hardness was determined by titrating 100 ml of water sample with 0.01 M EDTA solution using Eriochrome Black T as indicator. The total hardness was calculated as: Total hardness (mg/l $CaCO_3$) = (volume of EDTA) (M) (100) / (volume of water sample, where M = molarity of EDTA (APHA, 1999).

Determination of dissolved oxygen (DO)

Hanna Dissolved Oxygen microprocessor HI 98186 was used to determine the dissolved oxygen, Plate II (b). It was calibrated according to the instruction manual provided by the manufacturer. Sample of the water was collected in 100 ml beaker; the electrode of dissolved oxygen microprocessor was dipped into the beaker that contains the sample water for about 2-3 minutes. The readings were recorded in mgl^{-1}. For biochemical oxygen demand; 100ml part of the sample was incubated for five days in dark cupboard at room temperature and dissolved oxygen was determined after five of incubation, the difference between the initial value of dissolved oxygen and the value after five days of incubation was used as value of biochemical oxygen demand in the water sample (APHA, 1999; Mahar, 2003).

Determination of Biochemical oxygen demand (BOD)

Biochemical Oxygen Demand (BOD) is a measure of the amount of oxygen required by microorganisms to decompose organic matter in water. It is an important parameter for assessing water quality. The material required include BOD bottle (300 ml capacity), water samples, incubator (maintained at 20 ^{0}C, Dissolved oxygen (DO) meter or winkler titration apparatus, nutrient buffer solutions (phosphate buffer, magnesium sulfate, calcium chloride, ferric chloride. (APHA, 1999; Mahar, 2003).

Determination of phosphate-phosphorus

This was determined using the Deniges method (APHA, 1999). Some 1ml of Deniges reagent and 5 drops of stannous chloride was added to 100ml water sample. Absorbance at 690nm was measured with spectrometer, model S101 using distilled water as the blank. The phosphate-phosphorus concentration of water sample was read from the calibration curve in mgl^{-1}.

Determination of nitrate-nitrogen

One hundred (100) ml of water sample was poured into a crucible, evaporated to dryness, and cooled. Two (2) ml of phenol disulphoric acid was added and smeared around the crucible, after 10minutes, 10ml of distilled water was added followed by 5 ml of strong ammonia solution. Setting the spectrophotometer at the wave length of 430nm, absorbance of the sample treated was obtained, using distilled water as blank. The concentration of nitrate-nitrogen was obtained from the Calibration curve in mgl^{-1} (APHA, 1999).

Statistical analysis

One way analysis of variance (ANOVA) was used to compare the means of various parameters between months, when difference occurred. Duncan Multiple Range Test was used to separate the means.

Pearson's correlation was used to test the relationship between various parameters. Significant level was taken as $P < 0.05$. All the analyses were carried out using SAS software (20.0) version.

RESULTS

Variations of Physico-chemical Parameters in Relation to Stations.

The result showed that the Physico-Chemical Parameters of Otamiri River varied at the study stations (Table1)

Temperature (º C)

Temperature varied significantly at the study stations ($p< 0.05$) being highest in Station I and lowest in Station III. The least temperature was recorded in station II.

Depth (m)

The highest mean value (6.00 ± 0.30 m) was obtained in Station III. This was followed with Station I (5.30 ± 0.80 m). The lowest mean value occurred in station II (4.33 ± 0.55m).

Turbidity (cm)

The overall mean turbidity value of 97.03± 4.10 cm was recorded over the study period. The highest mean value of 108.70 ± 2.10 cm occurred in Station III while the lowest mean value occurred in Station I (92.80 ± 0.12 cm). Station II had the lowest mean value of 89.60 ± 4.00 cm. These values were significantly different at $p < 0.05$.

pH

pH varied significantly at the study stations with overall mean value of 7.10 ± 0-10. The highest mean value occurred in Station III while the lowest mean value occurred in Station I (Table1)

Electrical conductivity (µS/cm)

Electrical conductivity varied significantly at the study stations ($p<0.05$). Station III had the highest conductivity mean value (140.65 ± 0.50 µS/cm). This was followed by station II. Station I had the lowest mean conductivity of 107.80 ± 0.40µS/cm.

Total dissolved solids (mg/l)

There was significant variation in the total dissolved solids at the study stations. Station I had maximum mean value of 22.50 ± 0.10 mg/l. The minimum mean value of 14.77 ± 0.70 mg/l was obtained in Station II.

Hardness (mg/l $CaCO_3$)

Hardness varied significantly at the study stations. The overall mean value recorded was 90.40 ± 0.17. The highest mean value of 92.33 ± 0.1 mg/l $CaCO_3$ occurred in Station I while lowest mean value of 88.00 ± 0.90 mg/l $CaCO_3$ occurred in Station III.

Dissolved oxygen (mg/l)

There was significant variation in dissolved oxygen at the study stations. Station II had maximum mean value of 7.80 ± 0.90 mg/l. The minimum mean value of 5.60 ± 0.10 mg/l $CaCO_3$ was recorded in Station III.

Biochemical oxygen demand (mg/l)

Biochemical oxygen demand varied significantly at the study stations. The overall mean value of 2.92 ± 0.41 mg/l was recorded. The highest mean value of 3.60 ± 0.10 was recorded in Station II while the lowest mean value of 2.16 ± 0.10 mg/l was recorded in Station I.

Phosphate- phosphorus (mg/l)

The overall mean Phosphate- phosphorus value of 3.09 ± 2.00 mg/l was recorded over the study period. The maximum mean value of 3.24 ± 0.10 mg/l was recorded in Station III. The minimum mean value of 2.88 ± 0.30 mg/l was recorded in Station I.

Nitrate- Nitrogen (mg/l)

Nitrate- nitrogen varied significantly at the study stations. The overall mean value of 6.15 ± 0.11 µg/l. The highest mean value of 6.50 ±0.10 µg/l was recorded in Station I while the lowest mean value of 5.89 ± 0.20 µg/l was recorded in station I.

Table 1: Summary of Physico-chemical Parameters in Otamiri River in relation to stations

Parameters	Station I	Station II	Station III	Annual mean
Temperature (℃)	**24.70±4.1** [a]	**24.60±4.0** [b]	**24.00±0.1** [c]	**24.10±0.88**
Depth (m)	**5.30±0.80** [b]	**4.33±0.55** [c]	**6.00±0.30** [a]	**5.21±2.10**
Turbidity(cm)	**92.80±0.12** [b]	**89.60±4.0** [c]	**108.70±2.10** [a]	**97.03±4.1**
pH	**6.90±1.1** [c]	**7.00±0.1** [b]	**7.40±1.1** [a]	**7.10±0.10**
Conductivity (µS/cm)	**107.80±0.40** [c]	**133.70±2.1** [b]	**140.65±0.5** [a]	**127.38±0.66**
Total dissolved solid (mg/l	**22.50±0.1** [a]	**14.77±0.7** [c]	**16.07±0.4** [b]	**17.78±0.11**

Hardness (mg/l $CaCO_3$)	**92.33±0.1** [a]	**90.87±0.4** [b]	**88.00±0.9** [c]	**90.40±0.17**
Dissolved oxygen (mg/l)	**5.70±0.1** [b]	**7.80±0.90** [a]	**5.60±0.1** [c]	**6.37±0.17**
BOD (mg/l)	**2.16±0.1** [c]	**3.60±0.1** [a]	**3.00±0.9** [b]	**2.92±0.41**
Phosphate-Phosphorus (mg/l)	**2.88±0.3** [c]	**3.15±0.1** [b]	**3.24±0.1** [b]	**3.09±2.00**
Nitrate-Nitrogen (mg/l^{-1})	**6.50±0.1** [a]	**5.89±0.20** [c]	**6.06±0.70** [b]	**6.15±0.11**

Key: Temperature (Temp.), Nephelometric Turbidity Unit (NTU), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Electrical conductivity (EC), Phosphate Phosphorus (PO_4-P), Nitrogen-Nitrite (NO_3-N).
Note: Columns with same superscript are not significantly different from each other at $p > 0.05$

Composition and abundance of phytoplankton in relation to stations

The overall percentage abundance of phytoplankton was maximum in station 1. (414, 28.5%), this was followed by station II (255, 29.9%), and station III (185, 21.7%). Phytoplankton abundance varied significantly ($P<0.05$) at the study stations. Out of a total of 27 species taxon encountered in the study, 25 individual species occurred in station I and III while 23 individual species occurred in station II. Major taxonomic group varied greatly among the study stations (Figure 4.3). Bacillariophyta occurred most in station I (155, 37.44%). This was followed by station II (55, 21.57%). Station III had the least abundance of 37(20.00%). It had 6 representative taxa most of which were ubiquitous in distribution. Only *Epithemia*sp was restricted in distribution being absent in station II. It is *Cyclotella*sp that was the most abundant taxon and dominated in all the stations. *Anomoness* sp. was the least taxon. Chlorophyta was the most abundant and the most diversified phylum. It dominated across the stations. *Oocystis* sp. was the most abundant taxon. It occurred most in station III (21, 11.35%) and least in station II (8, 3.14%). *Volvox*sp the least representative taxon of the phylum chlorophyta was encountered most in station III (10, 5.41%) and least in station I (3, 0.72%). Cyanobacteria was ubiquitous and occurred in all the study stations. It occurred most in station II and least in station III. *Chroococcus*sp was the most abundant taxon. It was encountered in all the stations being abundant in station II and least in station III with respective percentage abundance of 7.06% and 2.16% respectively. *Nostoc* sp. was the only taxon that was restricted in distribution. It was absent in station I. The least phylum was Dinophyta. *Ostreopsis*sp was the most abundant taxon. It was encountered in all stations being dominant in station I. Dinophyta was represented by 3 taxon namely *ostreopsis*sp, *ceratium*sp and *peridinum*sp which were restricted in distribution. It occurred most in station III (44, 23.78%) and least in station II (17, 6.67%).

Table 2 : Composition and Abundance of Phytoplanktons in Otamiri River in relation to station (August 2023 - January 2024)

Phylum	Class	Order	Family	Species	Station I	Station II	Station III
Bacillariophy							
	Coscinodiscophyceae	Thalassiosirales	Stephanodiscaceae	*Cyclotella*sp	30(7.25)	16(6.27)	14(7.57)
	Coscinodiscophyceae	Thalassiosirales	Stephanodiscaceae	*Diatomella*sp	25(6.04)	5(1.96)	9(4.86)
	Bacillariophyceae	Cymbellalles	Cymbellaceae	*Cymbella*sp	18(4.35)	13(5.10)	6(3.24)
	Bacillariophyceae	Cymbellalles	Cymbellaceae	*Anomoeis*sp	7(1.69)	16(6.27)	2(1.08)
	Bacillariophyceae	Naviculales	Pleurosigmataceae	*Gyrosigama*sp	35(8.45)	5(1.96)	4(2.16)
	Bacillariophyceae	Rhopalodiales	Rhopalodiaceae	*Epithemia*sp	40(9.66)	0(0.00)	2(1.08)
					155(37.44)	55(21.57)	37(20.00)
Chlorophyta							
	Chlorophyceae	Chlamydomonodales	Oocystaceae	*Oocystis*sp	16(3.86)	8(3.14)	21(11.35)
	Chlorophycea	Sphaeropleales	Scenedesmaceae	*Scenedesmus*sp	30(7.25)	7(2.75)	0(0.00)

	Chlorophycea	Sphaeropleales	Hydrodictyaceae	*Pediastrum*sp			
	Chlorophycea	Chlorococcales	Chlorococcaceae	*Dictyochloris*sp	31(7.49)	12(4.71)	1(0.54)
	Chlorophycea	Chlorococcales	*Tetraedron*aceae	*Tetraedron*sp	25(6.04)	5(1.96)	3(1.62)
	Chlorophycea	Ulotrichales	Ulotrichaceae	*Ulothrix*sp	7(1.69)	17(6.67)	1(0.54)
	Chlorophycea	Volvocales	Volvocaceae	*Volvox*sp	6(1.45)	17(6.67)	3(1.62)
	Zygnematophyceae	Desmidiales	Desmidiaceae	*Closterium*sp	3(0.72)	7(2.75)	10(5.41)
	Zygnematophyceae	Desmidiales	Desmidiaceae	*Euastrum*sp	6(1.45)	17(6.67)	5(2.70)
	Zygnematophyceae	Zygnematales	Zygnemataceae	*Spirogyra* sp	3(0.72)	15(5.88)	10(5.41)
	Zygnematophyceae	Zygnematales	Zygnemataceae	*Zygnema*sp	14(3.38)	9(3.53)	4(2.16)
	Ulvophyceae	Oedogoniales	Oedogoniaceae	*Oedegonium*sp	9(2.17)	18(7.06)	3(1.62)
Cyanophyta					25(6.04)	0(0.00)	3(1.62)
					175(42.27)	132(51.76)	64(34.59)

	Cyanophyceae	Chroococcales	Chroococcaceae	*Chroococcus*sp	12(1.93)	22(7.06)	4(2.16)
	Cyanophyceae	Chroococcales	Microcystaceae	*Microcystis*sp	7(1.69)	14(5.49)	3(1.62)
	Cyanophyceae	Oscillatoriales	Oscillatoriaceae	*Gomphosphaeria*sp	8(1.69)	3(5.10)	13(7.03)
	Cyanophyceae	Oscillatoriales	Oscillatoriaceae	*Oscillatoria*sp	7(1.69)	6(2.35)	7(3.78)
	Cyanophyceae	Nostocales	Nostocaceae	*Anabaena* sp	14(3.38)	0(0.00)	7(3.78)
	Cyanophyceae	Nostocales	Nostocaceae	*Nostoc*sp	0(0.00)	6(2.35)	6(3.24)
					48(11.59)	51(20.00)	40(21.62)
Dinophyta							
	Dinophyceae	Gonyaulacales	Ceratiaceae	*Ceratium*sp	0(0.00)	0(0.00)	16(8.65)
	Dinophyceae	Gonyaulacales	Ostreopsidaceae	*Ostreopsis*sp	30(7.25)	15(5.88)	28(15.13)
	Dinophyceae	Peridiniales	Peridiniaceae	*Peridinium*sp	6(1.45)	2(0.78)	0(0.00)
					36(8.70)	17(6.67)	44(23.78)
	Total			*27*	414(100)	255(100)	185(100)

Variations of Physico-chemical Parameters in Relation to Months

The result shows that Physico-Chemical Parameters of Otamiri River varied in relation to months.

Temperature (º C)

The mean temperature value of 24.0 ± 0.87 ^{0} C was recorded over the study period. The highest temperature was recorded in January this was closely followed by December, then November, October and September. The lowest mean temperature value occurred in August (18 ^{o} C). The temperature values obtained varied significantly ($p < 0.05$).

Depth (m)

Depth was highest in September with mean value of 7.5 m. This was followed by the mean values of 6.4 m and 6.1 m recorded in August and October respectively. These values were not significantly different ($p > 0.05$) from each other and from the mean values of all other months. The least mean value of 5.3 m was recorded in December and January (Table 2).

Turbidity (cm)

Turbidity varied in relation to months. The highest value occurred in September with mean value of 128.3 cm. This value which varied significantly ($p < 0.05$) with the mean turbidity values of all other months, did not vary significantly ($p > 0.05$) with the mean value of 101.3 cm obtained in December. January had the least mean value.

pH

The highest mean pH value occurred in January (7.8). This value did not vary significantly ($p > 0.05$) with the values recorded from September to December. It was significantly different ($p < 0.05$) from the least mean value of 6.5 obtained in August.

Electrical conductivity (µs/cm)

Electrical conductivity varied in relation to months. The highest value occurred in January with mean value of 140 µs/cm. This value which was not significantly different ($p > 0.05$) from the mean values of 136.60 µs/cm and 133.30 µs/cm obtained in November and December respectively was significantly different $p < 0.05$ from the values of all other months. The least mean value occurred in August 122.00 µs/cm.

Total dissolved solids (mg/l)

The highest mean of total dissolved solid was recorded in December (23.8 mg/l). This value was significantly different ($p < 0.05$) from the mean values recorded from August to October but did not vary significantly ($p > 0.05$) from the mean values of other months. The least mean value was recorded in August.

Hardness (mg/l $CaCO_3$)

Hardness varied in relation to months. The highest mean value was recorded in January 90.90 mg/l $CaCO_3$. However, this value did not vary significantly ($p > 0.05$) with the mean values obtained from August to December. The least mean value (84.3 m/l) was recorded in October.

Dissolved oxygen (mg/l)

Dissolved oxygen was highest in October with mean value of 7.8 mg/l. This value did not vary significantly ($p > 0.05$) from August to November but varied with the mean values recorded in other months. The least mean value of 5.7 mg/l was recorded in January (Table 2).

Biochemical oxygen demand (mg/l)

The highest mean value of biochemical oxygen demand occurred in December 4.00 mg/l. This meanvalue did not vary significantly ($p > 0.05$) from the mean valuesof August to November. However it varied significantly with the least mean value of 2.30 mg/l recorded in January

Phosphate –phosphorus (mg/l)

Phosphate- phosphorus varied in relation to months. The highest mean value of 3.80 mg/l was recorded in October. This was followed by the mean value of 3.6 mg/l obtained in September and then 3.1 mg/l recorded in August. These values were not significantly different $p > 0.05$ from each other. However, they were significantly different ($p < 0.05$) from the values of all other months. The least mean value of Phosphate- phosphorus was recorded in November and January. (Table 2)

Nitrate- nitrogen (mg/l)

Nitrate- nitrogen was highest in September with a mean value of 7.20 mg/l. This value did not vary significantly ($p > 0.05$) with the mean values obtained in August, October and November. However, thesevalues varied significantly ($p < 0.05$) from the mean values of December and January.The least mean value of 4.20mg/l was obtained in January.

Table 3: Summary of Physico-chemical Parameters in Otamiri River in relation to months

Months	Temp. (°C)	Depth (m)	Turbidity (cm)	pH	EC (µS/cm)	TDS (mg/l)	Hardness (mg/lCaC0)	DO (mg/l)	BOD (mg/l)	PO_4- P (mg/l)	NO_3-N (mg/l)
Aug.	18.0^{f}	6.4^{a}	88.6^{bc}	6.5^{c}	122.0^{bc}	10.2^{cd}	87.9^{a}	7.1^{ab}	3.6^{ab}	3.1^{a}	7.1^{a}
Sept.	20.0^{e}	7.5^{a}	128.3^{a}	6.9^{ab}	122.7^{bc}	13.4^{bc}	88.6^{a}	7.5^{a}	3.6^{ab}	3.6^{a}	7.2^{a}
Oct.	22.6^{d}	6.1^{a}	95.7^{bc}	6.8^{ab}	129.7^{b}	17.0^{bc}	84.3^{a}	7.8^{a}	3.8^{a}	3.8^{a}	6.5^{a}
Nov.	23.7^{c}	5.7^{ab}	98.3^{bc}	6.8^{ab}	133.3^{ab}	19.3^{ab}	87.3^{a}	7.7^{a}	3.9^{a}	2.4^{bc}	6.6^{a}
Dec.	28.3^{b}	5.3^{ab}	101.3^{ab}	6.9^{ab}	136.6^{ab}	23.8^{a}	90.7^{a}	$6.9^{, b}$	4.0^{a}	2.7^{bc}	5.3^{bc}
Jan.	28.6^{a}	5.3^{ab}	88.0^{bc}	7.8^{a}	140.3^{a}	23.5^{a}	90.9^{a}	5.7^{ab}	2.3^{bc}	2.4^{bc}	4.2^{c}
Annual mean	24.0±0.8	7.15±0.1	96.95±3.6	6.4±0.3	2.90±0.4	136.07±4.	15.8±1.5	5.4 ±0.3	3.29±0.2	5.98±0.3	88.8±01.4

Key: Temperature (Temp.), Turbidity (T), Dissolved Oxygen (DO), Biochemical oxygen demand (BOD), Electrical conductivity (EC), Phosphate-phosphorus (PO_4-P), Nitrogen-nitrite (NO_3-N).

Note: Columns with same superscript are not significantly different at $p > 0.05$

DISCUSSION

The studies on the Plankton assemblage and water quality of Otamiri River; Imo State, Nigeria was conducted with the view to contribute some knowledge about the physico-chemical parameters and biological status of the river for National recognition and scientific recommendation. The investigation was based on physico-chemical factors such as temperature, turbidity, conductivity, total dissolved solids, pH, hardness, water depth, dissolved oxygen, biochemical oxygen demand, Nitrate-nitrogen, phosphate-phosphorus and biological parameters such as, phytoplankton and zooplankton.The water temperature of the river fluctuated with months, which was between 18°C and 28°C in all the three sampling stations. High water temperature was recorded in the river during the dry months, which could be as a result of changes in air temperatures associated with the cool dry North-East winds. Changes in temperature in dry months could according to Indabawa (2009) be attributed to intensified heat radiation and effect of harmattan. The water pH in the river was within 6.5 to 7.8, which makes the water of the river to be circum-neutral during the study. This was similar with the results of Ibrahim *et al.,* (2009) which reported that hydrogen ion concentration (pH) was nearly neutral and it was within the range for inland water pH 6.5 - 8.5 in Kontagora River, Niger State, Nigeria; which makes it suitable for optimal biological activity.The turbidity of the river was high during the dry months; the higher values of turbidity in September may be due to settling effect of surface run-offs and suspended materials that followed the cessation of rainfall. Ayoade*et al.* (2006) observed the onset of rain decreased the Secchi-disc visibility in two mine lakes around Jos.The high dissolved oxygen concentration obtained in October (7.8 mg/l) corresponds with report of Araoye (2008) which reported high oxygen concentration (8.2 mg/l) recorded during the dry season was due to an enhanced photosynthetic activities during the dry season.The river revealed higher values of biochemical oxygen demand recorded during the dry month of December (4.0 mg/l) may be due to reduction of phytoplankton and decomposition of other living organisms in the river. Mahar (2003) made similar observation and suggested the reason was due to the depletion of oxygen in the water during decomposition in dry season.The highest value of electrical conductivity recorded in the dry month of January (140.3 µS/cm) may be due to the reduction in the water level and increases in nutrients due to run off of inorganic fertilizer from nearby farm lands. The least concentration recorded in August (122.0 µS/cm) corresponds with the suggestion of Atobatele and Ugwumba (2008) who reported that

decrease in conductivity values might be due to dilution by rainwater.The lower values of Phosphate-phosphorus in the river during the dry month may be due to reduced water volume, intensive agricultural activities around the river involving the use of fertilizers and pesticides to produce dry season crops like vegetables and maize, this corresponds with the work of Ibrahim *et al.* (2009) who reported that the low value of Phosphate-phosphorus (PO_4-P) could be due to concentration effect of reduced water volume in KwantagoraRiver.Nitrate-nitrogen was found to exhibit variation. The higher values were recorded in rainy months than in dry months. These values range from (4.2 – 7.1 mg/l). The reason for the peaked in nitrate-nitrogen in the rainy months may be due to excessive influx of nutrients from farmlands where fertilizer is used to boost crop production particularly around the river, as well as input through runoff into the river. The results tallies with that of Balogun*et al.* (2005). A total of eight hundred and fifty four (854) phytoplanktons were identified into 4 phyla, 7 classes, 17 orders, 21 families, and 27 species. (Table 4.3). The phytoplankton belonged to four groups of algae, Bacillariophyta, Cyanobacteria, Chlorophyta, and Dinophyta (Pyrrophyta). In general, green (Chlorophyta) algae have higher abundance (368, 43.09%) over other kinds of algae and revealed positive correlation with dissolved oxygen, biochemical oxygen demand, phosphate phosphorus and nitrate nitrogen which indicated the productivity of the river especially during rainy months. Mahar (2003) also observed, that phytoplankton community was affected by strong seasonal influence. The monthly variation of composition and abundance of phytoplankton may be due to the fluctuations of dwater and physico-chemical parameters in the river. Chlorophta species was obtained more in the rainy month of August (86, 45.50%) and September (76, 44.97%) and decreases drastically towards the dry months. Abubakar (2009) made similar observation in which he reported that; in tropical regions the dry and rainy seasons show distinct fluctuations with abundance of phytoplankton.The higher abundance during rainy months could be due to the presence of more nutrients and water level in the river during the months. The higher phytoplankton count during the rainy months indicated that the river was more productive during the rainy season because phytoplankton being the primary producers in freshwater and determines the link of feeding relationship in the aquatic ecosystem. This corresponds to the observation of Tisser*et al.* (2008) which reported that; phytoplankton forms the vital source of energy in the fresh water environment, they initiate the fresh water food chain by serving as food to primary consumers which include zooplankton, fish and others. Phytoplankton shown

positive relation with dissolved oxygen, biochemical oxygen demand, nitrate-nitrogen, and phosphate-phosphorus; Abubakar (2009) made similar observation in Sabke Lake Imo State. The high concentration of nutrients like nitrate-nitrogen and phosphate-phosphorus results into blooming of algae that is sign of eutrophication but the concentration of both nitrogen and phosphates in the river was within the acceptable range. Nutrient limitation is also an important factor for phytoplankton abundance in shallow freshwater (Araoye and Owolabi, 2005). The high phytoplankton abundance in this study could be attributed to nutrient enrichment and low zooplankton abundance. Lehman (2008) reported that zooplankton are major recyclers of nitrogen and phosphorus which frequently limit phytoplankton growth rate, therefore low zooplankton abundance contribute to increased enrichment and phytoplankton development.A total of six hundred and five (605) individuals belonging to four phyla namely Arthropoda, Rotifera, Ciliophoria and Cnidaria were encountered. Zooplanktons composition in Otamiri River was dominated by Arthropoda, and then Rotifers, which were followed by Ciliophora and Cnidarians. The zooplankton composition and abundance varied significantly in number due to predation by fish which determines the abundance of herbivorous zooplankton which in turn regulate the level of phytoplankton. Mahar (2003) reported factors such as light intensity; food availability, dissolved oxygen, and predation affect the population composition of zooplankton. Otamiri River had higher zooplankton composition and abundance during the rainy season. This observation coincides with that of Edward and Ugwumba (2010) in which they reported that the increased number of zooplankton during the rainy season could be linked to the influx of nutrient.The Arthropoda had the highest species abundance in the river that indicates the water was productive and of good quality. Mahar (2003) reported Arthropoda appear to be sensitive indicators of changes in water quality. The positive correlation ofArthropoda with dissolved oxygen and biochemical oxygen demand was an indication the river was unpolluted; Balogun*et al.* (2005) in Makwaye (Ahmadu Bello University Farm) made similar observation. Ciliophora in Otamiri River, also indicates monthly variation in abundance that may be due to variations of physico-chemical parameters. Ciliophora indicated positive correlation with nitrogen, dissolved oxygen, biochemical oxygen demand, and Phosphate. The result was similar with that of Syuhei (1994) which reported that Ciliophora had positive correlation with dissolved oxygen, nitrogen and temperature. The individual growth rate of Arthropoda may depend on temperature alone in a global viewpoint; food condition is still considered an important factor affecting

growth and reproduction of Arthropoda in nature, especially in closed environment such as rivers and lakes (Mahar, 2003). The Arthropoda exhibited monthly variation in abundance and positive correlation with nitrate-nitrogen, dissolved oxygen, biochemical oxygen demand and phosphate-phosphorus in Otamiri River. The positive correlation with dissolve oxygen was an indication the river was unpolluted and productive. The Cnidarians also indicated variation in population abundance and composition within months but no significant between stations. The representatives of the group identified are AcanthometronspandAuritasp.Cnidarians show positive relation with temperature, dissolvedoxygen, pH, nitrate-nitrogen, and phosphate-phosphorus.

Conclusion

The Chlorophyta, Bacillariophyta, Cyanophyta, and Dinophyta encountered during the period of this study all varied significantly in months and stations, likewise Arthropoda, Rotifers, Ciliophora, and Cnidarians which were influenced by the physicochemical parameters of the river, this is because the physico-chemical qualities of the water played an important role in the life processes of aquatic organisms particularly planktons. Zooplankton and Phytoplankton composition and abundance were increased during rainy months and decreased with dry months.Water quality of the river is influenced by anthropogenic activities as runoffs of inorganic fertilizers and pesticides; similar observation was made by (Abdullahi, 2016) who reported that Otamiri River has become repository for variety of pollutant due to rapid industrialization, urbanization and intensified agricultural activities which contribute to the rivers deteriorating water quality. The river water is suitable for irrigational and domestic purposes in terms of most of the physico-chemical and biological parameters analyzed, this is supported by Ludwig et al. (2017) who conducted a comprehensive study on the self purification potential of the river and revealed that it possesses moderate self purification capability which is however being overwhelmed by the scale and intensity of pollution. However, considering that the river is a source of drinking water, the potential of the anthropogenic inputs gains significance. Hence, there is need for stringent regulatory policies and effective anthropogenic inputs control p[20] ı to reduce and protect the rivers health.

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