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WATER QUALITY AND PHYTOPLANKTON AS INDICATORS OF POLLUTION IN IBUYA RIVER

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ABSTRACT: *Ibuya River runs across the Old Oyo National Park and there is paucity of information on the limnology of the river. In order to assess the status of the river, phytoplankton and water quality were examined during the study period of September 2012 to February 2014 at four sampling stations. A total of 45 species of phytoplankton belonging to four families were identified. The most representative family in terms of species richness was Bacillariophyceae (25 species), followed by Chlorophyceae (9 species) and Euglenophyceae (8 species) and the least dominant is Cyanophyceae with 3 species. Water temperature was 24.73 ± 0.21°C, pH was 7.57 ± 0.04 and dissolved oxygen (DO) was 4.43 ± 0.15 mg/L, conductivity was 140.83 ± 5.60 µS/cm, TDS was 98.11 ± 3.80 m/L. Cadmium (Cd), Lead (Pb) and Phosphate (PO_4^{3-}) exceeded the permissible limits for surface water (0.003, 0.01 and 3.5 mg/L) respectively. The water quality and phytoplankton species composition of the river showed that allochthonous input from activities within and outside the park has subjected the ecosystem to pollution pressure.*

KEY WORDS: Ibuya River, Phytoplankton, water quality, anthropogenic activities, pollution indicators

INTRODUCTION

Human society relies on freshwater for domestic, industrial, agricultural and other services. These needs have subjected the ecosystems which include rivers, streams, lakes and ponds to increasing contamination by a variety of mineral, agrochemicals and organic pollutants due to higher frequency of allochthonous input from anthropogenic activities (Nwonunara, 2018). Some of the pollutants such as fertilizers, herbicides (Singh, and Mathur 2005), are frequently used in land preparation for agriculture. They gain entrance into aquatic ecosystems through terrestrial runoff, direct application and aerial spray, frequently causing impairment of the water quality for other uses and the production of the ecosystem (Carter, 2000). However, the major degrading factors arising from the stressors may include excessive eutrophication due to nutrient (inorganic and organic) matter loading, sewage from sewers, siltation due to inadequate erosion control at agricultural lands, logging and mining activities and pesticides (Anna-lissa and Galina, 1999). Since water bodies serve as habitat to a variety of organisms, response to the stressors may vary among the producers and consumers. The phytoplankton community structure might change in line with the nutrient status and other regulating factors, which may affect the animal community in either way or could lead general loss of biodiversity (Nwonunara, 2018). Water pollution is of grave consequences because both terrestrial and aquatic life may be affected. It may cause disease due to the presence of some hazardous substances, with distortion of the water quality, impose physiological stress on biotic community, add odour and significantly hinder economic activities (Asonye et al. 2007). Inputs from within and outside the park as a result of human and wildlife activities enter the Ibuya River. These inputs can render the water unsafe for human consumption and also adversely affect the resident biota. Despite these, there is paucity of information on the limnology of the Ibuya River. The objective of this study was to determine the pollution index of Ibuya River by assessing the water quality and phytoplankton structure of the ecosystem. The study therefore provides vital information that can help to identify the negative impacts of human activities on such ecosystem. The information can serve as the necessary baseline data on the ecological status and as tool for advocacy of policies to protect the ecological system for sustainable management.

METHODOLOGY

Study area

Ibuya River is located in the Old Oyo National Park. The park is in Sepeteri, Oyo State, South-western Nigeria. It lies between latitude 8^0.10' - 9^0.05'N and longitude 3^0.00' - 4^0.20'E. A sizeable portion of the park is the Ibuya River and is well drained by two river systems; the Ogun River discharging into Atlantic Ocean and the Tessi River discharging into the River Niger. Several tributaries flow to join these two main rivers respectively. The park has diverse wildlife and cultural/historical settings. Other activities around and outside the park include cultivation and processing of cassava, farming, block industry and filling station (fuel station). The abundance of cultural features both within and outside the park makes it a combination of an ecological, cultural/historical park.

Sample collection

Physicochemical Variables

Water samples were collected for the period of 18 months from September 2012 to February 2014 in the morning hours between 7 and 10 am covering the wet and dry season at four different locations at regular interval. The physico-chemical parameters (Temperature, pH, Conductivity and Dissolved Oxygen) were measured in-situ using mercury in glass thermometer (in Celsius), pH meter, TDS/conductivity meter and DO meter model ExStik DO600 while samples for turbidity, iron, cadmium, lead, phosphate, sulphate and nitrate were analyzed in the laboratory according to standard methods (APHA 2005 and AOAC 2010). All the parameters were measured in triplicate.

Phytoplankton Sample

Plankton net of mesh size 55µm was used to collect plankton samples just below the water surface. The collected sample was poured immediately into a liter plastic container holding 4% of buffered formalin and transported to the laboratory for analysis (Onyema 2007). Samples collected for plankton studies were allowed to stand for at least 24 hours in the laboratory before the supernatant was pipetted to concentrate the samples. The concentrated sample was agitated to homogenize before pipetting 1 mL sub sample with sample pipette. The content was placed on a slide and examined with Olympus binocular microscope at different magnification X100 and X400 (APHA et al. 1998). The plankton was identified and total number per species was recorded using keys and checklists of Hutchinson (1967), Prescott (1954), Botes (2003), Nwankwo (2004), Jeje and Fernando (1980) and Nguetsop (1990). The drop count method described by NIO (2004) was used for plankton calculation. Diversity indices: H′ was used in estimating phytoplankton diversity and enumeration of plankton was done on natural unit count and reported as units or organisms per milliliter (mL) (APHA et al. 1998).

Data Analysis
Microsoft Excel was used for graphical illustrations. Shannon-Wiener diversity index and evenness were determined (Shannon and Wiener 1949). Genstat_Discovery 4.103 was used for descriptive statistics and student t-test was used to compare mean. Spatial and seasonal variations in physicochemical parameters and phytoplankton abundance were determined using Analysis of Variance (ANOVA). Values were considered significant at $p < 0.05$ levels.

RESULTS

Physicochemical Variables
The result of the physico-chemical parameters showing the range, mean and standard errors of water samples from Ibuya River are presented in Table 1. The mean water temperature for the wet season 24.69±0.47 °C was lower than the dry season value 24.76±0.43 °C (Table 2). The pH for the wet season 7.56±0.09 was lower than the dry season value of 7.58±0.15. The mean dissolved oxygen concentration (4.53 ± 0.12 mg/L) for the wet season was higher than the dry season (4.36±0.14 mg/L). Mean conductivity (163.00±8.89 µS/cm) and TDS (112.60±6.83 mg/L) were higher in the dry season. However, transparency (10.40±0.89 cm) was least in the wet season and turbidity was higher (24.36±1.11 FTU) in the wet season. The mean Fe value for the wet season (3.16±0.37 mg/L) was higher than the dry season value of 1.25±0.17 mg/L. The mean Cd for the wet season 0.29±0.01 mg/L was higher than the dry season value 0.20±0.01 mg/L. The mean Pb for the wet season (0.70±0.16 mg/L) was higher than the dry season value 0.67±0.14 mg/L. The mean value for PO_4^{3-} in the wet season 29.8±2.65 mg/L was higher than the dry season 19.8±0.02 mg/L. The mean value for NO_3^- during the wet season (26.80±5.10 mg/L) 3 was lower than the dry season (36.1±4.68 mg/L). The mean value for SO_4^{2-} in the wet season 45.20±4.17 mg/L was higher than the dry season value of 21.10±3.81 mg/L. ANOVA result showed that conductivity, TDS, transparency, turbidity, Fe and sulphate varied significantly ($p< 0.001$) between seasons (Table 2).

Phytoplankton Species Composition

Four phytoplankton families including Bacillariophyceae (25 species), Chlorophyceae (9 species), Euglenophyceae (8 species) and Cyanophyceae (3 species) were identified in Ibuya River during the period of study. Some of the phytoplankton species identified among the divisions that were indicators of pollution include *Aulacoseira granulate*, *Fragilaria construens*, *F. oceanica*, *Merismopedia punctate*, *Nitzschia spp.*, *Oscillatoria princeps*, *Prorocentrum gracile*, *Closterium acerosum*, *Synedra acus* (Table 3). The most dominant among the pollution indicators were *Aulacoseira granulate* (43,978 cells/ml), *Fragilaria construens* (33,332 cells/ml), *F. oceanica* (23166 cells/ml), *Merismopedia punctata* (159744 cells/ml), *Oscillatoria princeps* (11710 cells/ml) (Table 3). The variation in total count of phytoplankton and the number of species in each of the sampled stations is presented in Figure 1 and the percentage distribution of phytoplankton groups was shown in Figure 2.

Phytoplankton Diversity

The Shannon wiener diversity index (H) (2.63) and evenness (E) (0.91) for Bacillariophyceae was highest in station 4. However, the diversity for Euglenophyceae was lowest in station 2 (2.47) while evenness (E) is highest in station 4 (1.01). Chlorophyceae diversity (3.75) and evenness (1.3) was highest in station 2. Divesity (H) for Cyanophyceae was highest in station 3 (1.66) while evenness was highest in station 3 (0.69) (Table 4).

Table 1. Physico-chemical parameters in Ibuya River

Parameters	Range	Mean ± Standard error
Water temperature (°C)	20.30 - 29.70	24.73 ± 0.21
pH	6.88 - 8.39	7.57 ± 0.04
DO (mg/L)	2.68 - 8.89	4.43 ± 0.15
Conductivity (µS/cm)	69.90 - 272.00	140.83 ± 5.60
TDS (mg/L)	48.80 - 188.00	98.11 ± 3.80
Transparency (cm)	5.50 - 56.00	16.02 ± 1.28
Turbidity (FTU)	6.55 - 36.20	19.36 ± 0.91
Fe (mg/L)	0.03 - 8.32	2.10 ± 0.21
Cd (mg/L)	0.00 - 1.64	0.24 ± 0.05
Pb (mg/L)	0.00 - 2.11	0.68 ± 0.07
PO_4^{3-} (mg/L)	0.00 - 68.50	24.25 ± 2.84
SO_4^{2-} (mg/L)	0.00 - 96.45	31.80 ± 3.06
NO_3^{-} (mg/L)	0.00 - 97.60	32.00 ± 3.60

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Table 2. Analysis of variance of the physico-chemical parameters in Ibuya River

PARAMETERS	SEASON		STATIONS					SEASONS*STATIONS							
Season/Station	**Dry**	**Wet**	**1**	**2**	**3**	**4**	**LSD**	**Dry*Wet**							
								1	2	3	4	1	2	3	4
Water temp (^{0}c)	24.76	24.69	24.63	24.98	24.70	24.61		24.57	25.22	24.62	24.63	24.70	24.67	24.79	24.59
pH	7.58	7.56	7.41*	7.58	7.59	7.69*	0.19	7.41	7.63	7.61	7.66	7.416	7.52	7.57	7.73
DO (mg/L)	4.36	4.53	4.29	4.59	4.47	4.38		4.01	4.53	4.50	4.39	4.65	4.67	4.43	4.36
Cond (µS/cm)	163.00***	113.10***	143.70	144.00	142.00	133.60		166.30	161.10	167.60	157.00	115.5	122.70	109.90	104.30
TDS (mg/L)	112.60***	80.00***	99.70	100.00	98.80	94.00		115.90	110.70	115.00	108.60	79.4	86.50	78.50	75.70
Trans (cm)	20.50***	10.40***	15.10	15.60	15.50	17.90		19.60	19.70	19.20	23.50	9.5	10.40	11.00	10.80
Turb (FTU)	15.35***	24.36***	20.14	19.02	17.88	20.38		17.40	15.32	12.58	16.10	23.57	23.65	24.49	25.74
Fe (mg/L)	1.25***	3.16***	2.44	2.27	2.08	1.62		1.81	1.32	1.01	0.86	3.22	3.46	3.42	2.56
Cd (mg/L)	0.20	0.29	0.17	0.24	0.27	0.27		0.19	0.20	0.19	0.21	0.161	0.28	0.36	0.36
Pb (mg/L)	0.67	0.70	0.71	0.74	0.61	0.67		0.65	0.76	0.62	0.63	0.78	0.72	0.60	0.72
Po_4^{3-} (mg/L)	19.80	29.80	22.00	23.00	26.20	25.80		17.30	19.80	20.00	22.20	27.8	27.00	34.10	30.30
So_4^{2-} (mg/L)	21.10***	45.20***	30.20	32.00	35.90	29.10		21.80	22.40	21.50	18.70	40.8	43.90	53.80	42.20
No_3^- (mg/L)	36.10	26.80	35.80	25.50	34.20	32.40		43.80	29.60	35.90	35.20	25.8	20.30	32.10	29.00

* Significant P<0.05 level, **Significant P<0.01 level, ***Significant P<0.001 level

Key: Water temp = Water Temperature, Cond = Conductivity, Trans = Transparency, Turb = Turbidity, Fe = Iron, Cd = Cadmium, Pb = Lead, Po_4^3 = Phosphate, So_4^{2-} = Sulphate, No_3^- = Nitrate, LSD = Least significant difference.

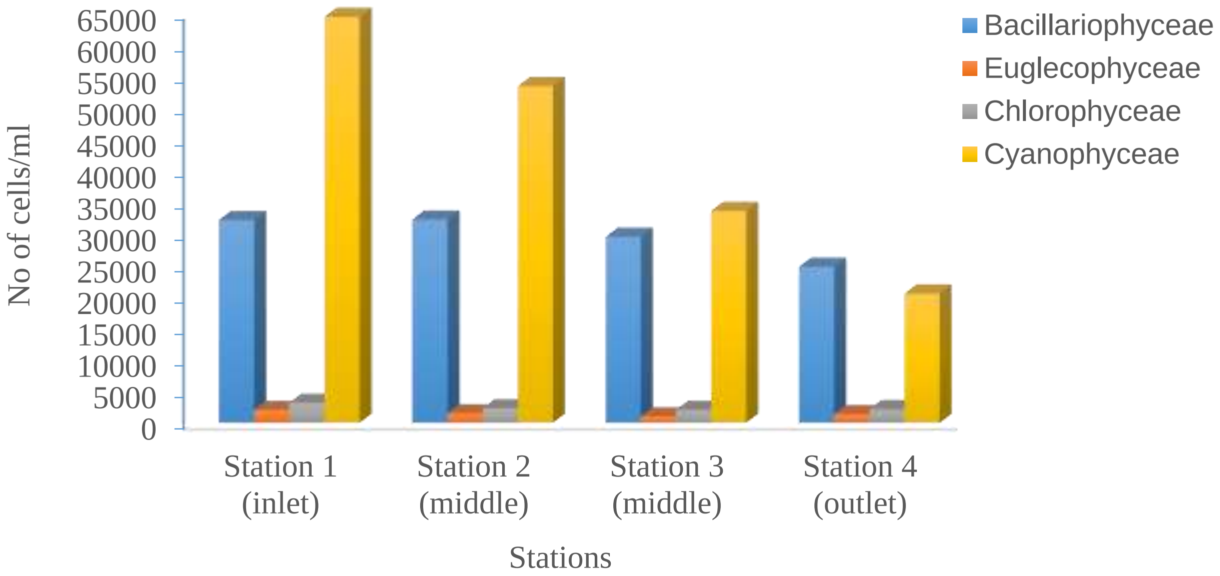

Figure 1. Spatial variation of Phytoplankton abundance in Ibuya River

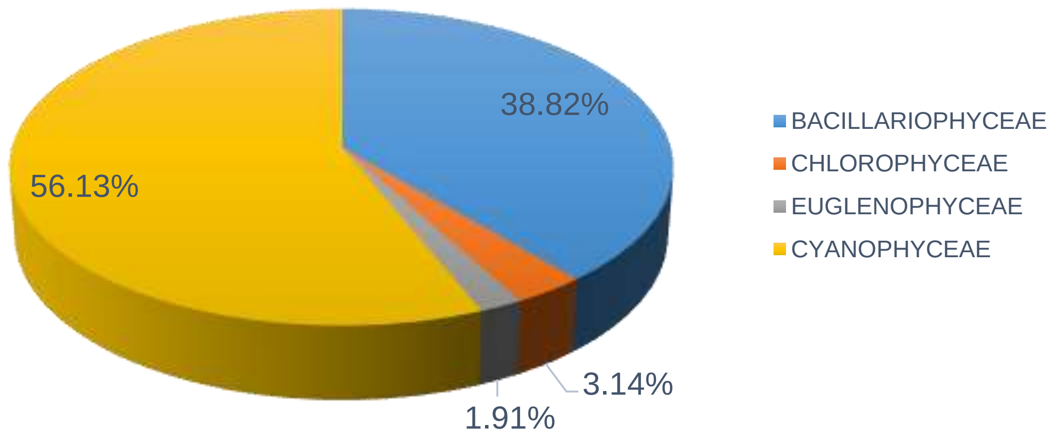

Figure 2. Percentage distribution of phytoplankton groups

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Table 3. Relative Abundance of Phytoplankton organisms in Ibuya River.

BACILLARIOPHYCEAE	**No of cells/ml**	**Percentage (%) number of phytoplankton**
**Aulacoseira granulata*	43978	14.35
**Coscinodiscus lineatus*	1235	0.40
**Cymbella sp.*	338	0.11
**Cyclotella stelligera*	429	0.14
Diatoma elongatum	676	0.22
Ditylum brightwellii	325	0.11
**Fragilaria construens*	33332	10.87
**F. oceanica*	23166	7.56
**Frustulia rhomboides*	442	0.14
**F. weinholdii*	585	0.19
**Gomphonema dubravicense*	741	0.24
Gyrosigma fasciola	507	0.17
**Navicula mutica*	507	0.17
Nitzschia sigmoidea	1079	0.35
Nitzschia sp.	1535	0.50
N. spiculum	1995	0.65
Peridinium sp.	533	0.17
**Pinnularia biceps*	403	0.13
**P. cardinalis*	1326	0.43
**P. gibba*	494	0.16
P. nobilis*	364	0.12
**Synedra acus*	1456	0.48
**S. crystallina*	794	0.26
**S. ulna*	1612	0.53
Tabellaria fenestrata	1144	0.37
Subtotal	**118996**	**38.82**
CHLOROPHYCEAE		
**Closterium acerosum var. elongatum*	702	0.23
**C. ehrenbergii menegh*	351	0.11
**C. lineatum var. africanum*	468	0.15
**Cosmarium granatum var. concavum*	390	0.13
Pandorina morum	286	0.09
**Pediastrum duplex*	442	0.14
Scenedesmus opoliensis	611	0.20
S. protuberans	949	0.24

Spirogyra dubra	5421	1.77
Subtotal	**9620**	**3.12**
EUGLENOPHYCEAE		
Euglena ehrenbergii	1066	0.35
E. oxyuris	624	0.20
E. spirogyra ehrenbergii	1235	0.40
E. tripteris dujardin	533	0.17
**Phacus longicauda var. torta*	520	0.17
**P. pleuronectes*	598	0.20
**Prorocentrum gracile*	910	0.30
**Trachelomonas planctonia*	364	0.12
Subtotal	**5850**	**1.91**
CYANOPHYCEAE		
**Microcystis aeruginosa*	600	0.20
**Merismopedia punctata*	159744	52.12
**Oscillatoria princeps*	11710	3.82
Subtotal	**172054**	**56.13**

NB: Species with asterisks are pollution indicator.

Table 4. Diversity and evenness of phytoplankton in the different sampling stations in Ibuya River

Stations	Bacillariophyceae		Euglecophyceae		Chlorophyceae		Cyanophyceae	
	Diversity (H)	Evenness	Diversity (H)	Evenness	Diversity (H)	Evenness	Diversity (H)	Evenness
1	2.60	0.90	2.73	0.94	2.68	0.93	0.47	0.34
2	2.57	0.89	2.47	0.85	3.75	1.30	0.03	0.02
3	2.49	0.86	2.74	0.95	2.44	0.84	1.66	0.69
4	2.63	0.91	2.92	1.01	2.38	0.82	1.54	0.67

DISCUSSION

Physicochemical variables

Temporal variation in water temperature observed could be attributed to seasonal changes in weather condition since the variable was directly linked to season. Temperature was an important ecological factor as it directly affected the behaviour and productivity of organisms and dissolution of gases in water (Dixit and Tawari, 2007). The water temperatures ranged from 20.30 °C to 29.70 °C during the study period. This variation could be due to the flow condition, especially in the rainy season when flow velocity was high. The pH of the river was mostly in the neutral/alkaline range of 6.88 to 8.39 and is within the acceptable level for culturing tropical fish species (Huet, 1977). This range may be conducive for fish since they usually live at pH levels between 6.0 and 9.0, although they may not tolerate a sudden change within this range (Adefemi et al., 2007). Dissolved Oxygen fluctuated between 2.68 mg/L and 8.89 mg/L throughout the study period. DO is one of the most important factors used in determining the quality of water and in this study, the fluctuation in the DO concentration could be attributed to anthropogenic activities from surrounding towns into the water during the period of collection. Higher conductivity and TDS was observed in the dry season and could be due to higher concentrations of dissolved ions in the water bodies at that period. This could be linked to higher water temperature recorded in the dry season which Dixit and Tawari (2007) suggested that it enhances the solubility of salt. Nwonumara, et al. (2016) recorded higher conductivity at Idumayo River in the dry season in their previous study at the same site. According to Koning and Ross (1999) long dry period, low flow condition and high temperature can contribute to high conductivity and these features were typical of the observations made at the study sites in the dry season. The conductivity values recorded in the dry season was above that of unpolluted river according to Koning and Ross (1999), which was an indication that the river is under pollution pressure. Water turbidity, which reflects transparency, is an important criterion for assessing the quality of water. Turbidity values obtained for the Ibuya River was higher than the 5 NTU standards recommended by WHO (2008) which indicates that the entire river generally contains pollutant and could pose problems to aquatic lives. This might be due to surface runoff and wastewater from different anthropogenic activities. Similar higher turbidity values were also recorded by some researchers as compared to the limit set by WHO (Akan et al., 2008; Mebrahtu and Zerabruk 2011; Pal et al., 2013). The levels of cadmium in the water samples were above the standard values of 0.003 mg/L for the survival of aquatic organism (USEPA, 2010). The high levels of Cd obtained in this study might be due to runoff from agricultural lands from surrounding towns. Similarly, a higher concentration of cadmium ranging from 0 to 0.39 mg/L was reported for Warri River, Nigeria by Ayenimo et al. (2005). The value of Pb obtained in this study was above the permissible limit of 0.01 mg/L set by WHO for water quality. Similarly, Apeh and Ekenta (2012) reported mean Pb of 0.03 ± 0.02 mg/L for water obtained from River Benue. Phosphate is the key nutrient also causing eutrophication leading to extensive algal growth (Davies et al., 2009). The results of the present study showed that the maximum phosphate concentration was 68.50 mg/L. The high concentration of phosphate is an indication of pollution since it was above the standard limit of 3.50 mg/L in natural aquatic bodies. This could be as a result of flood water from farmland surrounding the river which brought in soil component associated with fertilizer, detergents and animal faeces which are washed into the river. The value for Nitrate in Ibuya River fluctuated throughout the study period and the high concentration recorded during the dry season might be due to the influx of nitrogen rich flood water that brings about large amount of sewage (Anderson et al., 2006). Comin et al. (1983), stated that high nitrate concentrations in lake is related to inputs from agricultural lands. Generally, in this study, the fluctuations of the physico-chemical factors were influenced by the environment and other anthropogenic inputs.

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Phytoplankton Species Composition
Cyanophyceae dominated with 56.13%, followed by Bacillariophyceae, Chlorophyceae, and Euglenophyceae with 38.82 %, 3.14 % and 1.91 % respectively of the relative abundance of Phytoplankton. However, the phytoplankton species composition was dominated by Bacillariophceae with 25 species, followed by Chlorophyceae with 9 species, Euglenophyceae with 8 species and Cyanophyceae with 3 species. The dominance of Cyanophyceae in this river is similar to the findings by Sekadende et al. (2004), Dimowo (2013), and Shakila and Natarajan (2012). There has been report of dominance of blue-green algae in tropical freshwaters despite the greater number of taxa of the diatoms (Gonzalez et al., 2004 and Atobatele et al., 2007). Gonzalez et al. (2004) reported that blue-green algae in a tropical reservoir accounted for more than 75 % of the total plankton. The reservoir was regarded as hypereutrophic, which was as a result of high level of nutrients and biological production. *Merismopedia punctata* recorded the highest relative abundance (52.12 %) followed by *Oscillatoria sp*. (3.82 %) and *Microcystis sp*. (0.2 %). *Merismopedia* and *Microcystis* are colonial forms while *Oscillatoria* is a filamentous form of the blue-green algae. Station 1 and 2 had the highest percentage abundance of blue-green algae (65.40 % and 33.24 %) respectively while station 3 had the lowest value of (0.62 %). Cyanophyta showing more dominance in these stations, was a clear indication of deterioration of water quality. Cyanophyceae recorded no significant difference between seasons though the dry season value was higher compared with the wet season. Oduwole (1997) gave a similar report that among the phytoplankton of Ogunpa and Ona Rivers, the Cyanophyceae were dominant in the dry season. Oben (2000) and Atobatele et al. (2007) opined that the high relative abundance of blue-green algae and their presence either in colonial or filamentous form may be indicative of the influence of organic pollution of the water body.

Bacillariophyceae dominated the species composition of phytoplankton community with 25 species. The result of this study, however, varies considerably from some other studies in Nigeria. Yakubu et al. (2000) recorded 17, 20 and 34 species from Rivers Nun, Orashi and Nkisa respectively while Erondu and Chindah (1991) reported 27 species from New Calabar River. The dominance of diatoms species in the study sites confirms the statement that diatoms are predominant in natural lotic water bodies in the tropics (Chindah and Braide, 2004; Ibiebele and Braide, 1984). *Aulacoseira granulata* dominated the diatoms with 14.35 % followed by *Fragilaria construens* and *F. oceanica* with 10.87 % and 7.56 % respectively in relative abundance. *Aulacoseira* is an R – strategist widespread diatom that can dominate in reservoirs under turbid conditions (Péréz et al., 1999). *Aulacoseira* sp. has been attested to be a cosmopolitan species and is prevalent in prominent water bodies of Nigeria such as Eleiyele reservoir (Imevbore, 1967), River Osun (Egborge, 1973; 1974), Warri River (Opute, 1990), and in the coastal waters of Nigeria extending from Lagos to Cross River (Kadiri, 1999). The composition of diatoms varied across the different sampling stations in Ibuya River. Higher percentage abundance was recorded in station 1 while station 4 had lower percentage abundance. This could be attributed to organic waste, agricultural runoffs and anthropogenic inputs. The presence of these diatoms; *Navicula*, *Euglena*, *Nitzschia* and *Synedra* indicates organic pollution in Ibuya River. These species have been known to tolerate organic pollution (Nwankwo and Akinsoji, 1988; Nwankwo and Amuda, 1993; Passy et al., 2004).

For Chlorophyceae, *Spirogyra dubra* dominated the green algae followed by *Scenedesmus protuberans*. The highest percentage abundance of green algae was recorded in station 1 while the lowest value was recorded in station 3. This suggest that the green algae are mostly freshwater forms that may not tolerate eutrophic or polluted condition. Chlorophyceae fluctuated between seasons and the fluctuations were not significantly different but recorded a higher value during the dry season. Oduwole (1997) reported that among the phytoplankton of Ogunpa and Ona rivers, the Chlorophyceae were dominant in the rainy season. For Euglenophyceae, *Euglena spirogyra* dominated the euglenoids in Ibuya River followed by *E. ehrenbergii* and *Prorocentrum gracile.* The presence of species such as *Euglena, Phacus* and *Trachelomonas* is an indication that the water is tending towards pollution. Abubakar (2007) indicated that Euglenophyceae were common in environments rich in decaying organic matter, and large populations of *Euglena* were favored by the presence of high levels of dissolved organic compounds and high temperatures. Kim and Boo (2001) in their study on temporal changes of euglenoids and their relationships to environmental variables referred to green eugleniods as eutrophic species that are abundant in locations rich in organic and inorganic matter. Euglenoids such as *Phacus* have been reported in polluted waters; however, small species like *Trachelomonas* having high surface to volume ratio, are favoured in oligotrophic waters compared to large sized planktonic algae (Kim and Boo, 2001).

CONCLUSION

The effects of anthropogenic stress of aquatic ecosystem can be identified through water quality assessment and the phytoplankton structure. Some physico-chemical (conductivity, TDS, turbidity, Pb, Cd, phosphate and nitrate) variable was above that of unpolluted sites while some phytoplankton species that are indicators of pollution were recorded. Hence, low diversity of most phytoplankton families recorded shows that the river is on the verge of being polluted. Hence, anthropogenic activities around the river should be regulated to ensure its protection and conservation. This might contribute to national development through provision of good water for domestic use and food.

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