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Original Article

Plankton and Macrobiota Composition and Diversity of Three Tropical Freshwaters Rivers in Ogun and Ondo States, Southwest Nigeria

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Abstract

Three different rivers in Ogun and Ondo states were investigated for both micro and macro-biota of the water bodies. Several physical and chemical properties of these rivers were determined. The pH value of the studied water bodies was essentially neutral with salinity values between 0.02 - 4.0‰. Microalgae communities were represented by three divisions: Cyanophyta, Bacillariophyta and Chlorophyta at Oluwa and Ifara Rivers (Ondo state), while at Ibefun River (Ogun state), five divisions: Cyanophyta, Bacillariophyta, Chlorophyta, Euglenophyta and Pyrrhophyta were identified. Diatoms dominated these water bodies, with *Navicula radiosa* Kutz. at Ifara River, *Fragilaria* sp. in Oluwa River, while out of 90 algal taxa identified in Ibefun river, 64 were diatoms species belonging to 26 genera, with *Melosira* sp. and *Synedra* sp. recording the highest numbers of cell count. Dinoflagellates recorded only *Peridinium* sp. while *Phacus orbicularis* Hubner and *Trachelomonas* sp. dominated the euglenoids. For the zooplankton composition at Ibefun, rotifers (75.95%) were represented by *Brachionus* sp., which recorded 62.03%, and *Gastropus* sp. with 13.92% of the total zooplankton, thus dominated the spectrum, while the copepod recorded 22.78% of the total organisms, with *Copilia* sp. and *Euchirella* sp. having 8.86% each. The macrobenthic invertebrates were represented by 3 taxa, belonging to 3 groups, with the dominant group Insecta accounted for 57% of the total individuals (7 individuals/m^2), while Oligochaeta and Hirudinea accounted for 29% and 14% respectively of the total individuals at Oluwa and Ifara Rivers. At Ibefun River, the macrobenthic invertebrates were represented by 5 taxa, belonging to 3 groups, Bivalves, Oligochaeta and Insecta, with bivalves being the dominant group (51.7% of the total individuals, as 64 individuals/m^2), while Oligochaeta and Insecta accounted for 26.6% and 21.9% respectively of the total individuals. The dominant taxon, *Macoma cumana*, accounted for 42.2%. A total of seventeen (17) finfish and shellfish species comprised of thirteen (13) finfish and four (4) shellfish species were recorded, being representative of freshwater and brackish water species; *Clarias anguillaris* (Clariidae), *Tilapia zilli* (Cichlidae), *Chrysichthys nigrodigitatus* (Bagridae), *Alestes* spp. and *Macrobrachium vollenhovenii* (Palaemonidae) were the most common species observed.

Keywords: algae, benthos, fish, plankton, rivers, water chemistry

Introduction

Algae are one of the most important primary producers in almost every aquatic ecosystem. They are not only the nutrition source of themselves and the other living organisms in water, they also cause increases in the dissolved oxygen rate. That is why phytoplankton is greatly affected by environmental pollution and changes in the aquatic ecosystem. Plankton plays a major role in the determination of the biological productivity of water bodies. It represents a common component in ponds and lakes of various sizes, rivers, estuaries and world oceans. Plankton is a major food source associated with numerous fauna in these aquatic habitats which they in turn are linked to other predators, including those leading to the higher trophic levels. Through the process of photosynthesis, they are capable of harvesting solar energy in their transformation of basic substances in the water, being able to multiply and thus represent a food and energy product for various animal species. In addition, a major bi-product of their photosynthesis is oxygen, which is released into the water as another essential commodity for biota in these habitats. Like all plants, phytoplankton has the ability to fix carbon by photosynthesis (Nwankwo, 1996). Reports from Boney (1989) described phytoplankton as being predominantly autotrophs and therefore form the base of the food chain in an aquatic environment. They perform more than 95% of photosynthesis in the ocean, which amounts to nearly half of the world's primary production and are responsible for the release of nearly half the oxygen in the atmosphere (Castro and Huber, 2005).

They are used as indicators of environmental conditions within the aquatic environment because their populations are especially sensitive to changes in nutrient levels and other water quality conditions. Ecologically, algae are the widespread of the photosynthetic plants, forming bulk of the carbon assimilating, floating microscopic cells in the sea and fresh water. Macrobenthic invertebrates are useful bio-indicators providing

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a more accurate understanding of changing aquatic conditions than chemical and microbiological data, which at least give short-term fluctuations (Ravera, 2000; Ikomi *et al*., 2005). The composition, abundance and distribution of benthic macroinvertebrates can be influenced by water quality and differences in the local environmental conditions (Haslam, 1990; Odiete, 1999). Chironomidae and lumbriculidae have been reported to dominate aquatic benthic invertebrates' communities (Victor and Ogbeibu, 1985; Hynes, 1998) as they hardly show any habitat restriction (Victor and Ogbeibu, 1991) and are known to replace other invertebrate taxa in streams perturbed by human activities.

Nigerian aquatic systems are subjected to pollution pressures associated with urbanization and population growth (Nkwoji *et al*., 2010). Many of the rivers and creeks are used for irrigation, flood control, fisheries development and provision of potable water to towns and the surrounding rural areas. Along the approximately 853 km coastline of Nigeria there are estuaries and lagoons receiving effluents from many rivers and creeks most of which are routes for the introduction of pollutants. Benthological studies in Nigeria include Ajao and Fagade (1990), Brown (2000) and Edokpayi *et al.* (2004), who have focused majorly on general species composition and distribution.

Therefore, the authors consider that this study will contribute greatly to the freshwater microalgae, macro invertebrates and fishes database of the study sites. In this regard, the study aimed to make a contribution to the knowledge of the diversity of microalgae, macro invertebrates and fish communities in these rivers.

Materials and Methods

Description of study sites

Ondo state: The stations are within Omotosho/Agodo power plant transmission line which covers a distance of 50 km (from Omotosho Power station in Ondostate to Agodo, Ogun waterside, Ogun state). The Omotosho/Agodo power plant transmission line passes through the communities like Faji, Oloruntedo (where the transmission line tease off to Agodo), Agirifon, Araromi, Ilusin and Agodo. The vegetation along these communities includes *Cola nitida, Ficus sur, Elaeis guineesis, Anthocleista vogelii* and *Hevea brasiliensis* (Plantation). Two shallow and rocky rivers (Oluwa and Ifara) were analysed for their biota in this state. Three sampling stations were chosen for each of the two rivers, with Oluwa River having Station 1 (N06° 43′16.8′′E004° 42′49.1′′), Station 2 (N06° 43′53.8′′E004° 42′46.2′′) and Station 3 (N06°43′42.3′′E004°42′22.9′′), while Ifara River coordinates were N06° 43′41.3′′E004° 37′00.5′′ (Station 1), N06°43′30.7′′E004° 36′56.3′′ (Station 2) and N06° 43′13.3′′E004° 36′55.3′′ (Station 3).

Table 1. Coordinates of different stations at Ibefun

Station	Latitude	Longitude
1	N06^0 37. 225'	E003^0 48.442'
2	N06^0 37. 604'	E003^0 48.233'
3	N06^0 37. 964'	E003^0 48.011'
4	N06^0 38.380'	E003^0 47.936'
5	N06^0 38.700'	E003^0 47.812'
6	N06^0 39.095'	E003^0 47.792'
7	N06^0 39.226'	E003^0 47.457'
8	N06^0 39.340'	E003^0 46.647'
9	N06^0 39.796'	E003^0 46.425'
10	N06^0 40.412'	E003^0 46.495'

Ibefun (Ogun state): Ibefun River falls within the lowland rainforest zone where there is high humidity and predominance of herbs, shrubs and tree species. Generally, the ecosystems encountered included secondary regenerating forests and freshwater swamp. Within these, bush fallow of different ages and farmlands were also recorded in the area. The most conspicuous economic plants observed were *Cola* spp. (Kolanut), *Discorea* spp. (Yam), *Elaeis guineensis* (Oil Palm), *Mangifera indica* (Mango), *Musa* spp. (Plantain and Banana), *Manihot esculenta* (Cassava), *Theoborma cacao* (Cocoa), *Zea mays* (Maize), *Mangifera indica* (Mango), *Anacardium occidentale* (Cashew), *Rauvolfia vomitoria* (Swizzle stick), *Colocasia esculenta* (Cocoyam), *Talinum triangulare* (Water leaf) among others. The study site has riparian vegetation and freshwater swamp vegetation like *Raphia hookeri* and macrophytes like *Eichornia crassipes* (Mart) Solm. and *Ceratophyllum demersum*. Ten sampling stations were chosen to reflect the differences in biological characteristics which exist in the same body of water using Global Positioning System (GPS) (Table 1). This river enters into the Lagos lagoon.

Collection of biological samples

Plankton: For plankton collection, duplicate water samples were collected; surface water samples were collected directly into already labelled 500 ml plastic bottles; plankton net was also towed at low speed for 5 minutes and both sample types s were fixed with 4% unbuffered formalin. This method was used in order to have record of all plankton, including nanoplankton that may be present in water bodies. Samples were then taken into the laboratory where they were allowed to settle for 24 h and then decanted to a known volume in appropriately labelled plastic containers. In the laboratory, the plankton samples were concentrated to 10 ml.

For analysis, five drops of each concentrated sample (10 ml) were investigated at different magnifications (X100 and X400) using Olympus XSZ-N107 photomicroscope. Taxonomic keys employed in the identification of plankton taxa included Hustedt (1930-1937), Atrick and Reimer (1966), Whitford and Schumacher (1973), Krammer and Large-Bertalot (1986), Patrick and Reimer (1975), Prescott (1962), Wimpenny (1966), Olaniyan (1975), Nwankwo (1984), Davis (1955), Desikachary (1959), Wiafe and Frid (2001).

Macro invertebrates: Benthos sampling was carried out with Van Veen grab of sediments, except for some locations where direct collection of sediments was made. Each location was geo- referenced using geographic position system. Grab samples and direct sediments samples were initially washed on deck through sieves of 0.5 mm mesh and the retained materials were preserved in 4% formalin for further sorting in the laboratory. The identification of the species was according to taxonomic keys provided in Quigley (1977), Atobatele *et al.* (2005) and Ibemenuga and Inyang (2006).

Fish and Fisheries study: The investigation of fish and fisheries of the study area was carried out based on oral interview of the local fishermen, physical observation of the fishing methods and processing of landings. Some of the fishing gear

used in the study area was gillnet, cast net and fish trap. The finfish and shellfish recorded in the study area included both freshwater and brackish water species. Fish samples were bought from the fishermen and then taken to the laboratory for further processing. The condition factor (K) was determined using Bannister (1976) method.

Physico-chemical analysis

Surface water samples were analyzed *in-situ* for some of the parameters. The pH was determined with Electronic Cole-Parmer Testr3, while the salinity was measured using a handheld refractometer. Dissolved oxygen and chemical oxygen demand were determined using titrimetric method. Winkler's method was applied for the determination of biological oxygen demand.

Statistical analysis

To obtain the estimates of species diversity, three community structure indices Margalef's diversity index (d), Shannon-Weaner index (H^1) (Shannon and Weaver, 1963) and Species equitability (j) or Evenness (Pielou, 1975) were used. For benthic analysis, bio-statistical methods used were according to Ogbeibu (2005).

Results

Physico-chemical analysis

The pH value ranged between 7.07 and 7.54 for the sampled stations, while the salinity was between 0.02 - 0.03‰. The sulphates, phosphate-phosphorus and nitrate-nitrogen ranged between 2.0 and 3.0, 0.003 and 0.005, 0.138 and 0.210 mg/L respectively. Dissolved oxygen value was high, with 5.1 mg/L and 4.5 mg/L recorded, while biological oxygen demand and chemical oxygen demand ranged between 4.0 - 6.0 mg/L for the sites.

Plankton

Microalgae at Ifara and Oluwa Rivers: Three classes- Bacillariophyceae, Cyanophyceae and Chlorophyceae were recorded for both rivers. Diatoms dominated both samples, with frequent taxa being *Navicula radiosa* Kutz. at Ifara River and Oluwa River, whereas *Fragilaria* sp. recorded the highest frequency; blue green algae recorded *Oscillatoria* sp. which was rear in the samples and *Stigeoclonium* ably represented the green algae (Table 2).

Community structure analysis recorded highest species evenness (0.86 and 0.72) at Stations 1 and 3 in Ifara and Oluwa Rivers respectively, while the lowest diversity value (1.69) was recorded at Station 1 in Oluwa River (Fig. 1). Zooplankton samples were not diverse, as only two species were recorded for the sample.

Microalgae at Ibefun River

The total microalgae (cells count) and species composition is presented in Table 3. Five different divisions- Bacillariophyta, Chlorophyta, Cyanophyta, Euglenophyta and Pyrrophyta were represented. Out of the 90 algal taxa identified, 64 were diatoms species, belonging to 26 genera, with *Melosira* sp. and *Synedra* sp. recording the highest number of cell count. The green algae were represented by many species out of which *Crucigenia irregularis* Wille, *Desmodesmus abundans* var. *brevicauda* G. M Smith and *Scenedesmus quadricauda* var. *maxima* W&G.S.West were frequently encountered. The cyanophyta was ably represented by five genera, with *Spirulina* sp. being the most frequent species. Dinoflagellates recorded only *Peridinium* sp., while *Phacus orbicularis* Hubner and *Trachelomonas* sp. dominated the euglenoids (Table 3). Community structure analysis recorded highest value (0.91) of species evenness (j) at Stations 9 and 10, while the lowest diversity value (4.67) was recorded at Station 4, whereas Shannon-Weaner index highest value (3.17) corresponded to highest species evenness (j) at Station 9 (Fig. 2).

Zooplankton

The zooplankton composition at Ibefun was dominated by rotifers (75.95%) represented by *Brachionus* sp. which recorded 62.03% and *Gastropus* sp. with 13.92% of the total zooplankton observed. The copepod recorded 22.78% of the total organisms, with *Copilia* sp. and *Euchirella* sp. having 8.86% each, while *Scolecithrix* sp. had 5.06%. The lowest percentage occurrence (1.27%) was recorded by *Brachyuran* sp. (Decapoda) (Table 4). The presence of *Copillia* and *Euchirella* spp. in zooplankton composition might be an indicator of sea water incursion to the Ibefun River. The community structure analysis as compared with that of microalgae (Fig. 4) showed a diverse ecosystem in terms of microalgae which invariably supports the growth of few species of zooplankton recorded hereby, showing in the species evenness that slightly followed the same pattern in plankton (Fig. 3).

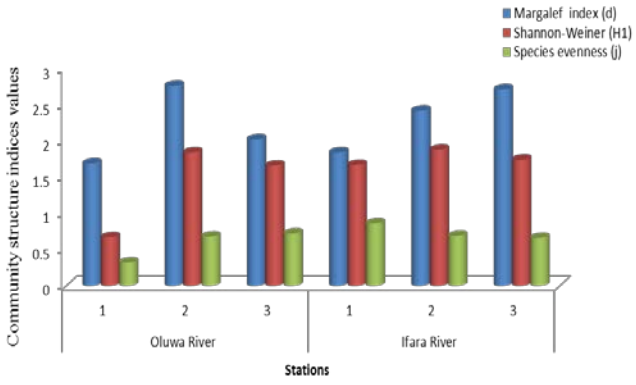

Fig. 1. Comparison of microalgal community structure indices at Oluwa and Ifara Rivers, Ondo State

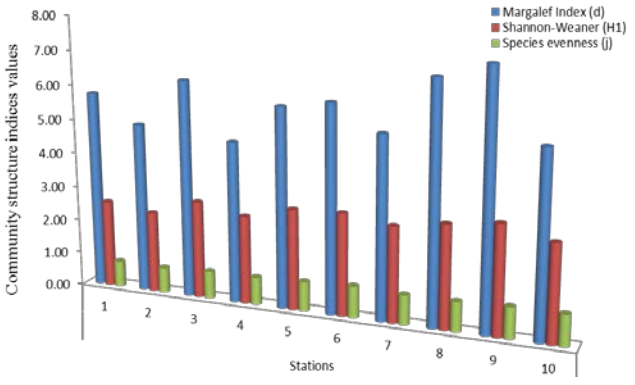

Fig. 2. Comparison of microalgal community structure indices at Ibefun River, Ogun State

Table 2. Microalgae composition and abundance (cells/mL) at Oluwa and Ifara Rivers, Ondo state

Microalge composition	Oluwa River			Ifara River		
	Stations			Stations		
	1	2	3	1	2	3
Division: Bacillariophyta						
Class: Bacillariophyceae						
Order: Achnanthales						
Cocconeis scutelum Ehr.	_	3	1	_	_	1
Order: Coscinodiscales						
Coscinodiscus sp.				_	3	_
Order: Thallassiophysales						
Amphora sp.	_	2	_	_	3	1
Order: Cymbellales						
Cymbella sp.	_	_	1			
Gomphonema angustum Agardh	1	_	_	3	36	_
G. clavatum Ehrenberg	_	1	_	1	_	_
G. gracile Ehr.				_	46	_
Gomphonema sp.	_	1	_			
Order: Eunotiales						
Eunotia sp.				_	1	_
Order: Fragillariales						
Fragilaria capucina Desmarziers	_	_	1	4	1	_
Fragilaria sp.	54	50	_	5	_	32
Frustulia vulgaris Thwaites				_	_	2
Surirella sp.				_	_	1
Synedra sp.	3	19	3	_	93	42
Terpsinoe americana (Bail.) Ralfs			18	_	_	2
Ulnaria ulna (Nitzsch.) Ehrenberg				_	17	1
Order: Tabellariales						
Tabellaria fenestrata (Lyng.) Kutzing	_	2	_	_	2	22
Order: Mastogloiales						
Mastogloia sp.	_	_	2	1	_	_
Meridion sp.	1	_	_			
Order: Naviculales						
Diatoma sp.				_	_	1
Navicula cryptocephala Kutz.				_	1	_
Navicula decussis Oestrup	_	1	_			
N. exigua (Greg.) O. Muller	1	2	_			
Navicula mutica Kutzing	1	_	_			
N. radiosa Kutz.	1	10	7	10	78	12
Neidium sp.	_	1	_			
Pinnularia abaujensis (Plant) Ross				_	3	_
P. legumen Ehr.				_	1	_
P. maior Kutzing				_	_	1
Order: Nitzschiales						
Nitzschia sublinearis Hustedt	_	1	_			
Pinnularia sp.	1	_	_	_	_	2
Division: Cyanophyta						
Class: Cyanophyceae						
Order: Hormogonales						
Chroococcus sp.	_	_	22			
Oscillatoria proboscidea Gom.	_	20	_			
Oscillatoria sp.	_	45	_	2		
Spirulina sp.				_	1	_
Division: Chlorophyta						
Class: Chlorophyceae					_	_
Order:						
Closterium moniliferum Ehrenb.	_	_	1			
Cosmarium sp.	_	1				
Stigeoclonium sp.	_	_	30	_	42	1
Total number of species	8	15	10	7	15	14
Total number of individuals	63	159	86	26	328	121
Margalef index (d)	1.69	2.76	2.02	1.84	2.42	2.71
Shannon-Weaver (H^1)	0.67	1.84	1.66	1.67	1.88	1.74
Species evenness (j)	0.32	0.68	0.72	0.86	0.69	0.66

Macrobenthic invertebrates

Oluwa and Ifara Rivers: The macrobenthic invertebrates were represented by 3 taxa belonging to 3 groups (Table 5). The dominant group was the Insecta, accounting for 57% of the total individuals (7 individuals/m^2), while Oligochaeta and Hirudinea accounted for 29% and 14% respectively of the total individuals. The dominant taxon was *Chironomus* spp. accounting for 57%, while *Glossiphonia* spp. was the least represented, with 14% of the total individuals (7 individuals/m^2) recorded. The general diversity (H^1) and species richness (d) were the highest at Stations 1 and 2 with corresponding values of 0.30 and 1.45 respectively (Fig. 4). At Station 3, the lowest values of 0.28 and 0.91 were recorded for the diversity and species richness respectively.

Ibefun River: The macrobenthic invertebrates were represented by 5 taxa belonging to 3 groups (Table 6). Bivalve was the dominant group accounting for 51.7% of the total individuals (64 individuals/m^2), while Oligochaeta and Insecta accounted for 26.6% and 21.9% respectively of the total individuals. The dominant taxon, *Macoma cumana*, accounted

Table 3. Microalgae composition and abundance (cells/mL) at Ibefun River (Ogun state)

	Microalge composition	Stations									
		1	2	3	4	5	6	7	8	9	10
	Division: Bacillariophyta										
	Class: Bacillariophyceae										
1	*Achanthes* sp.	_	_	_	_	_	_	_	_	_	3
2	*Amphora coffeaeformis* (Agardh) Kutzing	_	_	_	_	_	_	_	_	1	_
3	*A. holstica* Hustedt	1	_	_	_	_	_	_	_	_	_
4	*Amphora* sp.	_	_	3	_	_	_	_	_	4	_
5	*Asterionella formosa* Hassal	_	_	_	_	_	_	_	_	_	1
6	*Bacillaria paxillifera* (O.F. Muller) Hendey	2	2	_	_	_	_	_	5	_	6
7	*Cocconeis scutellum* Ehr.	2	1	_	_	4	_	_	1	3	3
8	*Cyclotella* sp.	_	_	6	1	4	1	6	10	1	1
9	*Cymbella affinis* Kutzing	_	_	_	_	_	_	1	_	_	_
10	*C. brehmii* Hustedt	_	_	_	_	2	_	_	_	_	_
11	*C. prostrata* (Berkely) Cleve	2	_	_	_	_	_	_	_	_	_
12	*Cymbella* sp.	_	_	_	_	_	_	_	_	_	1
13	*Diatomella balfouriana* Greville	4	_	2	_	_	_	3	1	_	_
14	*Eunotia* sp.	_	_	_	_	1	_	_	_	_	_
15	*Fragilaria capucina* Desmarziers	_	_	_	_	_	_	_	_	1	_
16	*F. crotonensis* Kitton	_	_	_	_	_	4	_	_	2	_
17	*Fragilaria* sp.	30	_	_	_	_	_	_	5	_	_
18	*Frustulia nobilis* Schumard	_	_	_	_	_	_	_	_	_	2
19	*F. rhomboids* (Ehr.) de Toni	_	_	_	_	1	_	_	_	_	_
20	*F. vulgaris* Thwaites	_	_	_	_	_	_	_	_	_	1
21	*Gomphonema angustum* Agardh.	_	_	_	_	_	_	_	_	2	1
22	*G. clavatum* Ehrenberg	_	_	_	_	1	_	_	1	_	_
23	*G. gracile* Ehrenberg	_	_	_	_	_	_	_	_	2	2
24	*G. lanceolatum* Ehr.	_	_	_	_	_	_	_	_	1	_
25	*G. subclavatum* (Grunow)	1	_	_	_	_	_	_	_	1	_
26	*Gomphonema* sp.	2	_	1	_	_	_	_	_	_	_
27	*Gyrosigma acuminatum* (Kutzing) Rabenhorst	_	_	_	_	_	_	_	_	1	5
28	*G. nodiferum* (Grunow) Reimer	_	_	1	_	_	_	_	_	_	_
29	*G. obscurum* (W.Smith) Griffith &Henfrey	_	_	_	_	_	_	_	1	2	_
30	*G. scalproides* (Rabenhorst) Cleve	1	_	_	_	_	_	1	_	2	1
31	*G. spencerii* (Quekett) Griffith &Henfrey	_	_	_	_	3	_	_	_	_	_
32	*Mastogloia* sp.	_	_	_	_	1	_	_	_	1	_
33	*Melosira* sp.	9	45	37	34	22	1	12	10	_	_
34	*Navicula angusta* Grunow	_	_	_	_	_	2	_	_	_	_
35	*N. contenta* (Grunow)	_	2	_	_	_	_	_	_	_	_
36	*N. decussis* Oestrup	_	_	1	_	_	_	1	1	_	_
37	*N. exigua* (Greg) O. Muller	2	2	1	_	_	_	_	_	_	2
38	*N. muralis* Grun	_	_	1	_	_	_	_	_	_	_
39	*N. mutica* Kutzing	1	6	1	3	4	1	_	_	_	_
40	*N. radiosa* (Kutz.)	1	_	1	1	_	2	1	1	1	3
41	*N. rhynchocephala* Kutz.	_	_	2	_	_	_	_	_	_	_
42	*Navicula* sp.	1	_	1	1	_	_	5	1	1	1
43	*Neidium* sp.	_	_	_	_	1	_	1	_	_	_
44	*Nitzschia acicularis* W. Smith	1	2	1	_	3	2	_	2	1	_
45	*N. acuminate* Gomont	_	1	_	_	_	_	_	_	_	_
46	*N. gracilis* Hantzsch.	_	1	_	_	_	_	_	_	1	_
47	*N. ignorata* Krasske	_	_	_	_	_	_	_	_	1	_
48	*N. obtuse* W. Sm	_	1	_	_	_	1	_	1	_	_
49	*N. palea* (Kutz) W. Sm	_	_	1	_	_	_	2	_	_	_
50	*N. sublinearis* Hustedt	3	_	_	_	_	_	_	_	_	1
51	*N. sublitis* Grun	_	1	_	_	_	_	1	_	_	_
52	*Nitzschia* sp.	3	_	2	_	6	_	3	1	2	_
53	*Pinnularia acrosphaeria* Brebisson	_	_	_	_	1	_	_	_	_	_
54	*P. braunii* (Grunow) Cleve	_	_	_	_	_	1	_	2	_	5
55	*P. gibba* Ehrenberg	_	_	_	_	_	_	_	_	1	_
56	*P. stomatophora* (Grunow) Cleve	_	_	_	_	_	_	1	1	_	_
57	*Pinnularia* sp.	1	_	_	_	_	_	_	_	_	_
58	*Pleurosigma salinarum* Grunow	_	_	_	_	_	_	1	_	_	_
59	*Stauroneis salina* W. Smith	_	_	_	_	_	_	_	1	_	_
60	*Synedra* sp.	14	14	12	11	9	2	10	9	10	1
61	*Tabellaria fenestrate* (Lyng.) Kutzing	2	3	5	3	_	1	1	5	3	2
62	*Terpsinoe americana* (Bail) Ralfs	_	_	_	_	_	_	_	_	_	8
63	*Ulnaria ulna* var. *amphirynchus* (Ehr.) Grun.	1	1	4	_	_	_	3	_	_	_
64	*U. ulna* var. *danica* (Ehr.) van Huerck.	5	_	4	4	4	1	_	1	1	_
	Division: Cyanophyta										
	Class: Cyanophyceae										
65	*Chroococcus* sp.	_	1	2	1	3	_	_	_	_	_
66	*Oscillatoria acuminata* Gomont	_	_	3	5	8	4	_	_	2	_
67	*O. tenuis* Ag.	1	_	_	_	_	_	_	_	_	_
68	*Phormidium* sp.	_	1	_	_	1	_	_	1	_	_
69	*Polycystis* sp.	34	_	_	_	_	_	_	_	_	_

70	*Spirulina* sp.	1	21	1	14	1	1	_	2	_	_
	Division: Chlorophyta										
	Class: Chlorophyceae										
71	*Chlorella* sp.	_	_	6	23	_	_	_	_	6	_
72	*Chlorosarcina consociate* (Klebs) G. M. Smith	_	_	_	_	_	_	_	1	_	_
73	*Closterium abruptum* (Lyngb.) Breb	_	_	_	_	_	_	_	1	_	_
74	*C. kutzingii* f. *sigmoides* Irenee-Marie	1	1	1	3	1	1	1	1	_	1
75	*C. moniliferum* Ehrenb.	_	_	_	_	_	1	_	_	_	_
76	*Cosmarium* sp.	_	1	3	1	_	_	_	_	_	_
77	*Crucigenia irregularis*Wille	_	_	_	7	20	9	4	_	6	_
78	*Desmodesmus abundans* var. *brevicauda* G. M Smith	3	1	7	8	3	5	5	1	2	_
79	*Eudorina* sp.	_	6	9	2	1	2	_	_	_	_
80	*Gonatozygon aculeatum* Hastings	_	_	1	3	2	1	_	1	_	1
81	*Microspora floccose* (Vauch.) Lagerheim	_	_	_	1	_	_	_	_	_	_
82	*Microspora* sp.	3	_	_	_	_	3	2	_	1	_
83	*Pandorina* sp.	_	_	_	_	_	_	_	1	_	_
84	*Scenedesmus quadricauda* var. *maxima* W&G.S.West	_	3	4	4	10	2	5	1	1	_
	Division: Euglenophyta										
	Class: Euglenophyceae										
85	*Euglena proxima* Dang	_	_	2	_	_	_	_	_	_	_
86	*Euglena* sp.	_	2	_	2	7	_	_	_	_	_
87	*Phacus orbicularis* Hubner	_	3	25	1	8	1	5	1	_	_
88	*Trachelomonas* sp.	1	9	28	2	16	3	18	6	1	_
89	**Division: Pyrrhophyta**										
	Class: Dinophyceae										
90	*Peridinium* sp.	_	_	9	2	1	2	1	_	3	_
	Total number of species	29	25	34	24	30	25	25	31	32	22
	Total number of individuals	133	131	188	137	149	54	94	77	68	52
	Margalef index (d)	5.73	4.92	6.30	4.67	5.80	6.02	5.28	6.91	7.35	5.31

Table 4. Zooplankton composition and abundance at Ibefun River (Ogun state) during sampling period

	Microalge composition	Stations									
		1	2	3	4	5	6	7	8	9	10
	Rotifera										
1	*Brachionus* sp.	_	_	_	_	3	_	1	14	29	2
2	*Gastropus* sp.	3	2	_	_	3	2	_	_	1	_
	Decapoda										
3	*Brachyuran* sp.	_	_	1	_	_	_	_	_	_	_
	Copepoda										
4	*Copilia*sp.	2	1	1	1	1	1	_	_	_	_
5	*Euchirella* sp.	1	1	_	_	_	_	3	1	_	1
6	*Scolecithrix* sp.	_	_	1	1	2	_	_	_	_	_
	Total number of species	3	3	3	2	4	2	2	2	2	2
	Total number of individuals	6	4	3	2	9	3	4	15	30	3
	Margalef index	1.12	1.44	1.82	1.44	1.37	0.91	0.72	0.37	0.29	0.91
	Shannon-Weaner (H^1)	1.01	1.04	1.1	0.69	1.31	0.64	0.56	0.25	0.15	0.64
	Species evenness (j)	0.92	0.95	1.00	1.00	0.94	0.92	0.81	0.36	0.22	0.92

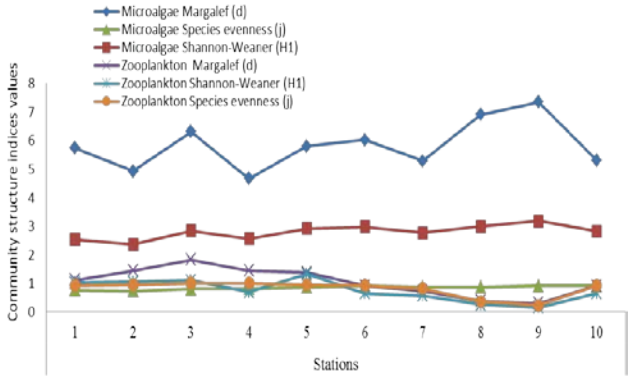

Fig. 3. Comparison of plankton community structure indices at Ibefun River, Ogun State

for 42.2%, while *Nais* spp. and *Perna perna* were the least represented, with 9.4% each of the total individuals (64 individuals/m^2) recorded (Fig. 5). The general diversity (H) was the highest at Station 1 (0.52), while the least value (0.18) was recorded at Station 2. The species richness (d) and evenness (j) highest values (1.45 and 1.00) were recorded at Station 8, while Station 2 recorded the lowest values (0.52 and 0.60) respectively (Fig. 6).

Fish and Fisheries study at Ibefun stations, Ogun state

A total of seventeen (17) finfish and shellfish species comprised of thirteen (13) finfish and four (4) shellfish species were recorded. The finfish and shellfish recorded are representative of freshwater and brackish water species, as shown in Table 7. The dominant species observed were *Clarias anguillaris (*Clariidae*), Tilapia zilli (*Cichlidae*), Chrysichthys nigrodigitatus* (Bagridae), *Alestes* spp. and *Macrobrachium vollenhovenii* (Palaemonidae) among others. Condition factor (k) which is an index of condition and degree of wellbeing of the fish varied by size for fish species recorded at the study area, with values that ranged from 1.17-2.96 (Table 7).

Discussions

Information on variation in physico-chemical factors of the studied area, especially within Ibefun River, were in agreement with earlier observations made in the Lagos lagoon that two dominant factors, fresh water discharge and tidal sea water incursions govern the physical, chemical and biological characteristics of the areas (Nwankwo, 1984, 1996; Brown, 2000).

Table 5. The distribution, occurrence and diversity indices of macrobenthic invertebrates' community at Oluwa and Ifara Rivers

Macrobenthic invertebrate	Oluwa River			Ifara River		
	Stations			Stations		
	1	2	3	1	2	3
Hirudinea						
Glossiphonia spp.	1	1	2	-	-	1
Insecta						
Chironomus spp.	-	2	-	1	1	2
Oligochaeta						
Lumbriculus spp.	2	2	1	1	1	-
Number of species (s)	2	3	2	2	2	2
Number of individual (N)	3	5	3	2	2	3
Margalef index (d)	0.91	1.24	0.91	1.44	1.44	0.91
Shannon-Weaner (H^1)	0.63	1.05	0.63	0.69	0.7	0.63
Species evenness (j)	0.91	0.96	0.91	1.00	1.00	0.91

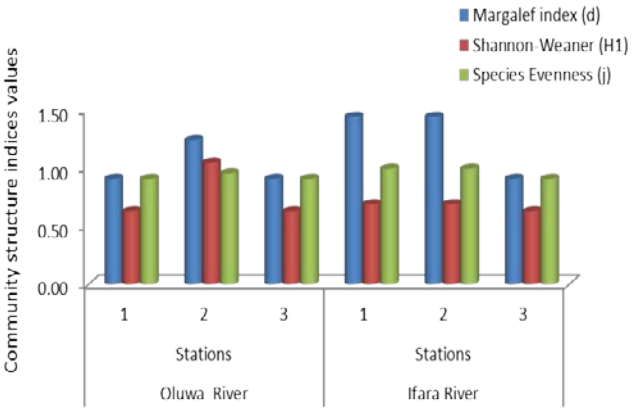

Fig. 4. Comparison of macrobenthic invertebrate community structure indices at Oluwa and Ifara Rivers, Ondo State

Table 6. The distribution, occurrence and diversity indices of macrobenthic invertebrate community at Ibefun River study stations

Macrobenthic invertebrate	Stations									
	1	2	3	4	5	6	7	8	9	10
Oligochaeta										
Lumbriculus spp.	3		4				2		2	
Nais spp.			2			1		1		2
Bivalvia										
Pernaperna (L)	2	1			1	2				
Macoma cumana (C)	8	6	1	3	4		2			3
Insecta										
Chironomus spp.	2			1	2		7	1	1	
Number of taxa	4	2	3	2	3	2	3	2	2	2
Number of individual	15	7	7	4	7	3	11	2	3	5
General diversity (H)	0.52	0.18	0.41	0.24	0.42	0.28	0.39	0.30	0.28	0.29
Maximum diversity (Hmax)	0.60	0.30	0.48	0.30	0.48	0.30	0.48	0.30	0.30	0.30
Species richness (d)	1.11	0.52	1.03	0.72	1.03	0.91	0.83	1.45	0.91	0.62
Species evenness (j)	0.87	0.60	0.85	0.80	0.88	0.93	0.81	1.00	0.93	0.97

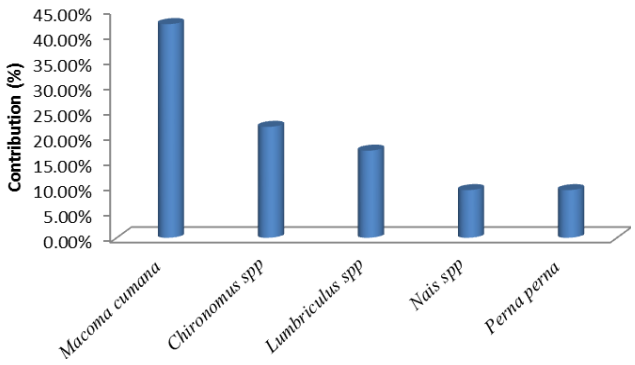

Fig. 5. The percentage contribution of the major macrobenthic invertebrates' taxa at Ibefun, Ogun state

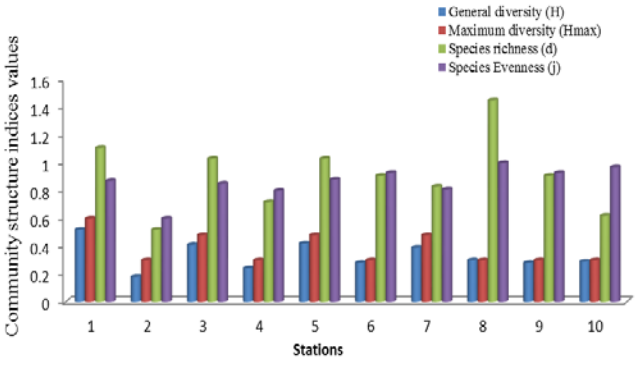

Fig. 6. Comparison of macrobenthic invertebrates community structure indices at Ibefun River, Ogun State

The presence and dominance of diatoms in the sampling areas conformed with observation made by Nwadiaro (1990) in the chanomi creek system of the Niger Delta, Chindah and Pudo (1991) in Bonny River, Erondu and Chindah (1991) in the new Calabar River, Niger Delta, Adesalu and Nwankwo (2005, 2008) in Olero and Abule-Eledu creek respectively, Adesalu *et al.* (2008) in Ogbe creek and Adesalu and Kunrunmi (2012) in the Lagoons of South-Western Nigeria.

The presence and abundance of *Oscillatoria* sp. among the blue-green algae supported Nwankwo (2004) who stated that the blue green algal forms found in the creek were mostly filamentous forms and could be opportunistic forms which by bio-modification of physical processes usually proliferate to advantages of other species.

The dominant of rotifer species in rivers comparative to the cladocerans and copepods is characteristic of tropical lakes and rivers and this has been reported in the studies of Akinbuwa and Adeniyi (1996), Neves *et al.* (2003), Mwebaza-Nadwula *et al.* (2005), Imoobe and Akoma (2009).

Table 7. The checklist and condition factor (K) of fish species at Ibefun River, Ogun state

	Family	Species name	Standard length (cm)	Weight (g)	K - value
1	Channidae	*Parachanna obscura*	25.5	225.3	1.36
2	Clariidae	*Clarias anguillaris*	26.3	250.2	1.38
3	Bagridae	*Chrysichthys nigrodigitatus* (Lacepede)	28.9	295.3	1.22
4	Cichlidae	*Tilapia guineensi* (Bleeke)	12.6	67.2	1.5
		Tilapia zilli	16.0	105.4	2.57
		Oreochromis aureus	22.7	260.3	2.23
5	Mormyridae	*Hyperopisus bebe*	38.0	710.1	1.29
6	Sphyranae	*Sphyraena sphyraena*	44.0	998.4	1.17
7	Cyprinidae	*Labeo coubie*	12.0	48.2	2.79
8	Palaemonidae	*Macrobrachium vollenhovenii* (Herklots)	6.0	6.4	2.96
9	Ocypodidae	*Ocypoda africana*	NS	NS	NS
10	Gecarcinidae	*Cardiosoma armatum*	NS	NS	NS
11	Characidae	*Alestes macrolepidotus* (Valenciennes)	16.5	85.1	1.89
		Alestes longipinni (Hubrecht)	8.2	45.2	1.00
12	Hepsetidae	*Hepsetus odoe*	14.7	56.3	1.25
13	Citharinidae	*Citharinus citharus* (Geoffrey Saint Hilaire)	10.0	47.3	1.05
14	Clupeidae	*Pellonula afzeliusi*(Johnels)	17.0	59.1	1.32

NS: Not sampled for K-factor analysis

The abundance and distribution of benthic fauna in a given community is affected by the water quality conditions (Bunn and Davies, 1992; Camargo, 1992). Lumbriculidae and Chironomidae have been reported to dominate aquatic benthic invertebrates' communities (Victor and Ogbeibu, 1985; Hynes, 1998) because they hardly show any habitat restriction (Victor and Ogbeibu, 1991) and are known to replace other members of invertebrate community in water bodies under human stressors.

The high load of organic matter in the sediment at the study sites was probably responsible for the prevalence of the bivalves, oligochaetes and the chironomids recorded at some stations. The dominance of bivalve, especially *Macoma cumana* at Ibefun stations, could be attributed to the suspended small food particles, that seldom settle out of organic matter deposit, which are trapped from the sediment with their feeding apparatus (Yankson and Kendall, 2001). According to Awachie (1981) chironomids usually have no habitat restrictions, while Edokpayi and Osimen (2001) stated that they are known to replace other invertebrate taxa in water bodies polluted by agricultural and domestic activities. *Lumbriculus* spp. and *Nais* spp. have been reported in polluted tropical waters (Victor and Ogbeibu, 1985; Atobatele *et al*., 2005) and prefer soft sediments rich in organic content (Crothers, 1997; Edokpayi *et al*., 2004), a feature characteristic of the study sites.

The relatively low diversity of benthic macro-invertebrates recorded in this study could be attributed to the resultant effect of anthropogenic impacts on the studied environment (Edokpayi *et. al*., 2010). However, one of the most important effects of anthropogenic activities such as motorcycle washing, laundering of clothes, farming land nearby, water transportation and sand mining which are prevalent at Ibefun sites were stated by Ogbeibu and Victor (1989) and Edokpayi *et al*. (2004) as the resultant destabilization of the substratum and increased silt formation in the environment.

The general composition of fish species recorded was similar to those reported for the freshwater and brackish water of West Africa (Schneider, 1990; Holden and Reed, 1991; Olaosebikan and Raji, 1998) probably an indicator of sea water incursion at Ibefun River. The overall community structure at the study sites stretch exhibited low taxa richness. Determining the precise contribution of each factor influencing the abundance of a particular taxon is difficult (Atobatele *et al*., 2005).

Conclusions

The low diversity in the zooplankton identified from Oluwa, Ifara and Ibefun Rivers was a clear indication of unstable aquatic communities with negative effect on the aquatic fauna. Among zooplankton, the rotifers were the most diverse, while copepods were the most evenly distributed. Despite the greatest diversity exhibited by diatoms, the euglenoids were the most evenly distributed. According to Lagler (1986), a fish is said to be in good condition when the value of K is higher than one, therefore the fishes from the water in the study areas were healthy, as indicated by the condition factors observed in the study.

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