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Relative Abundance, Distribution and Species Diversity of Phytoplantonic Algae of a Lotic Freshwater, North-Eastern Nigeria

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Abstract: The phytoplankton and physico-chemical characteristics of Shadawanka river Nigeria were monitored to determine the impact of change of some parameters on the distribution, species richness, relative abundance and diversity of phytoplankton composition. Water was sampled and analysed for both Biological and physico-chemical characteristics of the river. Three major components were identified that influence the physico-chemistry of the water, namely: rainfall, dissolved, oxygen and ionic composition. However, the result revealed that, the Bacillariophyceae (pinnate diatoms) had the highest abundance in all the stations, seasons and communities followed by Chlorophyceae which tended to decline with increase in flow and with reduction in nutrients and few species of Euglenophyceae dominated the total algal biomass. Correlation analysis showed that, harmful algal biomass increased with increase in total algal biomass. Total Dissolved Solids (TDS), Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD) and pH were generally high during the dry season. pH increases with increase in electrical conductivity and rainfall. DO increases with increase in rainfall and BOD.

INTRODUCTION

Phytoplankton are increasingly being used to monitor the ecological quality and health of the water environment and also to measure the effectiveness of management or restoration programmes or regulatory actions, it is the most common biological parameters collected because they form the base of the aquatic food web and influence other aspects of the lake including color and clarity of the water and fish production. Phytoplanktons (algae) are microscopic plants that are an integral part of the aquatic ecosystem which use nutrients in the water and sunlight to grow and are the base of the aquatic food web. Chlorophyll-a is the primary photosynthetic pigment contained in algae In addition to light and Oxygen (O_2), they require basic simple inorganic chemical nutrients, such as Phosphate (PO_4) and Nitrate (NO_3). They also require carbon in the form of Carbon dioxide (CO_2). Some phytoplankton, the diatoms, also requires a form of silicon (silicate, SiO_4); this makes them have a "glass-like" shell? Because chlorophyll-*a* concentration can be easily measured in a water sample, it is a common way to estimate the phytoplankton biomass in the water (Verlecar and Desai, 2004).

These microscopic plants range in size from 1/1000 of a millimeter to 2 mm and float or swim in the upper 100 m of the ocean where they are dependent on sunlight for photosynthesis.

Studies on the structure and functioning of planktonic communities in reservoir ecosystems provide opportunities to investigate patterns of responses to cyclical variations and episodic disturbances. The understanding of plankton dynamics in reservoirs can also be useful to evaluate the resilience of this kind of ecosystem which can present deep changes in limnological conditions in relatively short periods.

This dynamic is generated by short-term variations in the water retention time, flux regime, outflow and level and by interactions with other aquatic and terrestrial ecosystems in the catchment area. The heterogeneity frequently observed in the distribution of zooplankton in reservoirs is caused by interactions between physical and biological processes (Jafari and Gunale, 2007). This variability is related to water movements and to the quality and quantity of resources brought into the system by tributary rivers (Threlkeld and Choinsk, 1985; Marzolf, 1990; Betsil and Van Den Avyle, 1994). During periods of high flux, the structure of the plankton can be strongly influenced by differential loss of organisms as a consequence of their vertical position in the water column, swimming capacity and reproductive rates. However, the interference can also be indirect, through modifications in the physical and chemical conditions of the environment. In addition to typical longitudinal gradients generally observed in reservoirs, lateral components such as arms and bays can contribute significantly to the maintenance of heterogeneous patterns in the zooplankton distribution (Brink *et al*., 2007).

The spatio-temporal ranges of phytoplankton species has led to the habitat-template approach which proposes that algal attributes are matched to opportunities provided by the environment and that there is an encouraging fit of phytoplankton species to the range of habitats described by the trophic spectrum. Certain assemblages are thus referred to as oligotrophic species (desmids, chrysophytes and diatoms) or eutrophic indicators (cyanobacteria, euglenoids) (Reynolds, 1998). The excessive abundance or blooming of eutrophic species has detrimental effects on the domestic, industrial and recreational uses of water and is in many cases a direct motivation for restorative measures (Bryant, 1994). However, it is not valid to ascribe phyla or classes exclusively to one part of the trophic range as diatoms, chlorophyta and cyanophytes occur right across the width of the spectrum from ultra-oligotrophy to hyper-Eutrophy. Rather what is needed is a basis for relating the differing arrays of adaptive attributes and tradeoffs of individual species of phytoplankton and how these might interact with the totality of processes which together determine their pelagic environments.

MATERIALS AND METHODS

Shadawanka river is situated in the Shadawanka military barracks, 2 km, off Jos road, East of Wuntin dada village, South of Shadawanka village. It resulted from two confluence rivers namely: Lafiyari and Zamfara rivers. Shadawanka river serves majorly as a source of water for livestock watering and irrigation purposes for both the dry and wet seasons. Aquatic macrophytes common in the river are: *Nymphia lotus* L. *Pennesetum* sp. *Andropogon* sp. and *heteropogon* sp. The dry season usually ranges between the months of November to March while the wet season last from April to October (Table 1).

Collection of samples: Water samples for physicochemical analysis were collected monthly for a period of eight months (February-September, 2007) between 7 and 8 h from four stations namely: Stations A, B, C and D (Fig. 1) in 1litre acid rinsed polyethene bottles and transferred to the laboratory in a cooler packed with ice prior to analysis. Samples for biological analysis was obtained as thus: Phytoplankton were collected using a plankton net of mesh size 55µm towed at low speed for 10 min and immediately collected in screw capped bottles and immediately fixed with 4% formalin. Epiphytic algae were sampled by carefully removing aquatic macrophytes with a sharp razor blade and transferred into polythene bags. Distilled water was then poured into it and agitated vigorously to remove algal materials as suggested by Foester and Schlichting (1965). The algal material was then transferred into 250 mL bottles and preserved in 4% unbuffered formalin solution prior to identification. Epilithic algae were sampled following the method suggested by Douglas (2006). In this method, stones surfaces from the bank of the river were measured with a ruler and algal materials scrapped using razor blade. These were collected, transferred into sampling bottles. Distilled water and drops of 4% formalin were added and agitated to preserve it for identification.

Physicochemical attributes such as temperature, pH and transparency were measured in situ using an ordinary mercury bulb thermometer, a portable Cyber Scan pH meter, model pH 20 and a 12 cm diameter Secchi disc, respectively. Electrical conductivity using a combo conductivity meter model, H1-98129, total dissolved solids by evaporation method as described by APHA. Dissolved Oxygen titrimetrically using Wrinkler's method, nutrients were determined spectrophotometrically using an atomic absorption spectrophotometer model VGP 210 and Biochemical oxygen demand by Hunts method.

Table 2: Summary of physico-chemical data analysis of physico-chemical attributes of Shadawanka river

	Station A			Station B			Station C			Station D		
Parameters	Mean±SE	Min.	Max.	Mean±SE	Min.	Max.	Mean±SE	Min.	Max.	Mean±SE	Min.	Max.
Tempt (ºC)	24.2±3.59	20.2	28.6	23.7±2.87	20.6	27.2	24.5±2.09	20	27.3	23.6±3.34	20	28.1
Transp (m)	0.22±0.15	0.11	0.33	0.36±0.12	0.22	0.64	0.33±0.06	0.20	0.43	0.40±0.09	0.25	0.55
pH	7.06±0.15	6.8	7.30	6.90±0.45	6.1	7.3	7.11±0.28	6.9	7.7	7.05±0.27	6.5	7.5
NO_3-N (mg L^{-1})	6.65±0.52	6.01	7.15	7.13±0.68	6.33	8.0	6.71±0.37	6.24	7.02	6.42±0.38	6.0	6.88
PO_4-P (mg L^{-1})	0.32±0.06	0.22	0.44	0.26±0.06	0.22	0.53	0.20±0.07	0.1	0.28	0.23±0.08	0.1	0.32
DO (mg L^{-1})	12.73±2.12	10.0	15.8	12.18±1.57	10.2	15.9	11.96±1.35	9.8	13.4	10.97±0.87	9.8	11.9
TDS (mg L^{-1})	0.85±0.24	0.5	1.2	2.86±4.32	0.3	14.3	3.02±4.16	1.0	12.1	3.35±4.23	0.2	11.7
BOD (mg L^{-1})	4.79±0.97	4.8	6.4	4.68±1.17	3.1	6.0	4.38±0.42	3.9	4.2	3.84±0.42	2.1	5.0
EC (µmSc^{-1})	450.6±211.46	210	920	449.6±192.6	230	780	412.6±82.83	204	580	415.2±92.56	245	840

SE = Standard Error; Min = Minimum; Max = Maximum; DO = Dissolved Oxygen; TDS = Total Dissolved Solid; BOD = Biochemical Oxygen Demand; EC = Electrical Conductivity

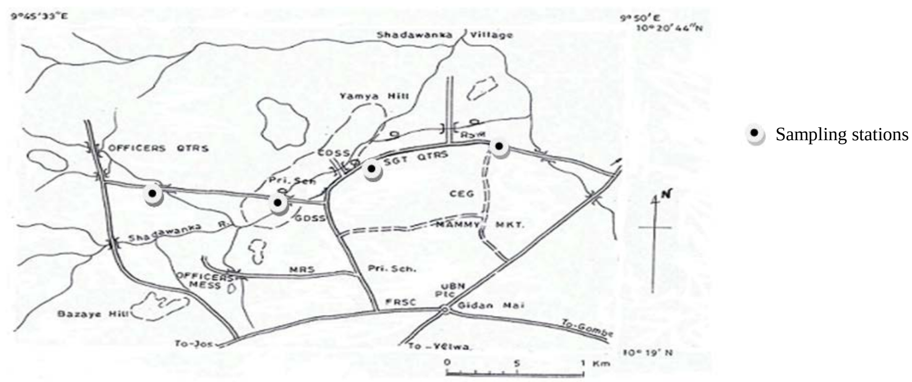

Fig. 1: Map of Shadawanka military barracks showing Shadawanka river analysis of samples

RESULTS AND DISCUSSION

A total of 481species of phytoplantonic algae was sampled out of which 274 were diatoms (237 pennales and 39 species of centrales). About 123 species of Chlorophyceae 34 species of Cyanophyceae, 45 species of Euglenophyceae, 3 species of Phaeophyceae and 4 of Xanthophyceae monthly variations in the physicochemical attributes of the river Shadawanka. Temperatures were virtually same in September but generally lower temperatures fall within the months of July at stations B, C and D. Station A in August. Lower transparency was observed at station C in June, it varied greatly among all the stations. Transparency was generally low among stations B, C and D, in the months of April to September. The highest transparency recorded was at station A. There was no definite pattern among the stations, this could be due to time it was determined. pH is invariably same among all the stations. As a general trend, there were no much variations from acidity to alkalinity in station A and B. A vivid variation was observed in September where acidity was maintained at stations C and D probably due to deposits of waste and domestic inputs like detergents and fertilizers. Nitrate and phosphate varied greatly among all the stations, this could be as a result of increase and decrease in levels of eutrification. Dissolved oxygen, however, did not vary much among the stations, it had almost same trend of change of change within each station throughout the period of study. Total dissolved solids had a great variation through both seasons and among stations with the greatest variation at station D in the dry season and station B in the wet season. Electrical conductivity varied greatly among all the stations, it increased with the wet season. Biochemical oxygen demand, however, did not vary significantly among the stations in both seasons.

Physico-chemical characteristics, however, revealed that temperatures were higher in the dry season and lower in the wet season which was attributed to variations in season and sunlight intensity. Transparency was significantly higher ($p<0.01$) in the dry season than the wet season. This could have been as a result of inflow of silt particles eroded into the river in the wet season. pH values were within the inland water expected range (pH 6.5-8.5) as reported by Ezra. Nitrates and phosphates (Nutrients) during the wet season and the dry season varied significantly ($p<0.05$). It was lower during the dry season and higher during the wet season. This might have resulted, due to surface run-off from farmlands, domestic inputs as well as from animal wastes. Dissolved Oxygen (DO) had higher values in the dry season which might been as a result of the high photosynthetic processes by the algae due to higher amount of sunlight (Solar radiation). Higher amount of Total Dissolved Solids

(TDS) and electrical conductivity in the wet season could be attributed to inflow of debris through erosion into the river channel; higher depth in the wet season could be as a result of the increased in flow of water as a result of rainfall. Biochemical Oxygen Demand (BOD), however was higher during the wet season. This could be attributed to the increased productivity of the algae in the river.

The variations in both Phytoplantonic and physico-chemical attributes of the river seems to reflect the effect of the change in season in all the stations high temperature in the dry season could be attributed to low depth of the river due to reduced volume of water and sunlight intensity. Similar findings observed and reported by Ezra and Nayaya (1999), Ezra and Nwankwo (2001) and Ezra *et al*. (2008). High transparency in the dry season was also attributed to low depth and settlement of silt and debris because of sink mechanism of aquatic systems. This agrees with the work of Hallock, etc. The phytoplantonic algae relative abundance and species composition assumes the indicators of nutrient enrichment and tolerant to extreme conditions serving as water cleaners. These can be employed in aquatic ecosystems that have been affected by aquatic pollution.

List of Planktonic algae in Shadawanka river:
Class Bacillariophyceae:
Order Pennales:

- *Achnanthes convergens*, H. Kobayensi
- *A. delicatula* . (Kutz) Grun.
- *A. inflata*. Boyer
- *A. lanceolata*. Breb.
- *A. lanceolatum.* Wyoming
- *A. levenderi* (Breb) Grun.
- *A. linearis.* (W. Smith) Grun.
- *A. microcephela*.(Kutz)Grun
- *A. minutissima.* Kutzing.
- *Achnanthes* sp
- *Actinastrum hanstzchii.* Lagerh.
- *Actinaceum wollei.* Agardh.
- *Ammoensis constata.* Boyer.
- *Ammoensis sphearophora*.(Ehrenb) Pfizer
- *Amphora calumetrica.* Kutz
- *A.coffeafformis* (Ag) Kutz
- *A.cuspidata.* Kutz.
- *A.ovalis* Kutz.
- *A . submontana.* Kutzing
- *Amphyphora ornata.* Nitzch.
- *Aphanotheca stagnina* (Spreng) A. Braun
- *Asterionella formossa.*Hassall.
- *Asterionella* sp
- *Cocconeis disculus.*(Schum) Cl.
- *C.pedulus.* Ehr.
- *C. placentula.* Ehr.
- *C. speciosa.* Ehr
- *C. sublittoralis.* Hendy.
- *Cymbella affinis.* Kutzing.
- *C. linearis.* Grun.
- *C. lunata.* W.Smith.
- *C. minuta.*Rabh
- *C. minuta.* Wyoming.
- *C. ocellata.* Ehr.
- *C. striata.* (Kg)Grun.
- *C. turgidula.* Cleve.
- *C.turgidula.* Ehr.
- *C. tumidula.* Greg
- *C. ventralis.* Kutz.
- *C. ventricosa.* Kutz.
- *Cuscinodiscus lacustris*. Grun.
- *Diatoma elongata.* Bory
- *Diatoma* sp.
- *D.vulgaris.* Bory
- *Diplonies ovalis*(Naeg) Cleve
- *D. ovalis*(Hilse*)* Cleve.
- *Echinospernum* sp.
- *Echinophosphearella luminetica.* G. M.Smith.
- *Entzia acuta*. Labour.
- *Eucampia zoodiacus.* Ehr.
- *Eunatia exigua.* Grun.
- *E. flexuosa.* Wyoming.
- *E. gracilis*(M. Perag)Herib.
- *E. nagaeli.* Hustedt.
- *E. pectinalis.* A. Boyer.
- *E. pectinalis.* Ehrenberg
- *E. solieritti.* A. Boyer.
- *Eunotia* sp.
- *E. sudetica.* Ehr.
- *E. venetris.* (Kg) O.Mull.
- *Fragillaria acus.* Grun
- *F. brevistrata.* Grun.
- *F. fenestrata*. Kutzing.
- *F. pinnata.* Ehr.
- *Fragillaria* sp.
- *Frustulia rhomboides* Cleve.
- *Frustulia* sp.
- *F. vulgaris*(Thwaites). De Toni.
- *Genecularis* sp.
- *Gomphoneis herculeana.* Cleve
- *Gomphonema abbreviatum* (Ag) Kutz.
- *G.appicatum* (Kutz) Grun.
- *G.brasilensis.* Huntsmann.
- *G. graciles.* Ehr.
- *G. grovei.* Kutz.
- *G. ingulatum.* Hust.
- *G. olivaecum*(Lynb)Kutzing
- *G. rubusta.* O.Mull.
- *Gomphonema* sp.
- *G subclavatum.* Kutz
- *G. subtilis.* Ehr.
- *G. tetrastigmatum.*Horikawa et Okuno.
- *Hantzschia dakarensis.* Ehr.

- *Melosira granulate.* Ehr.
- *M. solida.* Eulenstein.
- *Melosira* sp.
- *Meridion circulare.* Agardh.
- *Mesotaenium Kranstai.* Ehrenberg
- *Monoraphidium arcuatum.* Hindak.
- *M. contorium.*(Thur) Kom-legh
- *M. graffi* (Berk) Komle-legh
- *Navicula americana.* Ehr.
- *N. arvensis.* Hustedt.
- *N.baccillum.* Wyoming.
- *N.confervecea.*(Kg)Grun.
- *N. contenta.* Kutz.
- *N. capitata.* Hust.
- *N. explanata.* Hust.
- *N. gysingensis.* Grun.
- *N. menisculus.* Hust.
- *N. mutica.* Kutz.
- *Navicula oppurtuna.* Hust.
- *N. radiosa.* Kutz.
- *Navicula* sp.
- *Nitzschia acicularia*. W. Smith.
- *N. filiformis.* Kutz.
- *N. linearis*(Agardh)W.Smith
- *N. sigmoidea* (Kutz) W.Smith.
- *N. venecularis* (Kg) Grun.
- *Peronia fibule*. Hust.
- *Pinnularia bisepts.* Gregory.
- *P.gibba.* Ehr.
- *P. parvular.* A. Boyer.
- *P. pinnata.* A. Boyer.
- *Pinnularia* sp.
- *P. subcapitata.* Hust
- *Rhiocospheria curvata* (Kutz) Grunow
- *Surirella ovata.* Kutz
- *S.robusta.* Ehr.
- *Surirella* sp.
- *Synedra cyclopum.* W.Smith.
- *S. nana.* (Nitzsch) Ehr.
- *S. pulchella.* Kg.
- *S. rumpens.* Kg
- *Synedra* sp.
- *S.ulna.*Kutz
- *Taballeria fenestrata*. Wyoming.
- *T. flocullosa.* (Roth) Kutzing
- *Taballeria* sp.

Class: Baccillariophyceae
Order: Centrales:

- *Coscinodiscus* sp.
- *Cyclotella comta.* Kutz.
- *C.glomerulata* (Kutz) Cleve.
- *C.michiganiana.* Kutzing
- *C.ocellata.* William.
- *C. ovata.* Kutzing.
- *Cyclotella* sp.
- *C.superb.* Fricke.

Class: Chlorophyceae
Order: Chlorococcales:

- *Ankistrodesmus braunii.*(Naeg) Brauner
- *A.falcatus(Chod)* Ralfs.
- *A.fractus*. (West and West)Brun.
- *A.fusiformis*(Corda) Sensukors.
- *A.graciles.* Korshikov.
- *Ankistrodesmus* sp.
- *Botryococcus proturberans* G. S. West
- *Chara* sp.
- *Characium accuminatum*. A.Braun
- *C.gracilipes.* Lambert.
- *Characium* sp.
- *Characium vacualatum.* Lee et Bold.
- *Chlorella vulgaris.* Beig.
- *Chroococcus minutes.* (Kutz) Naegeli.
- *Chlorocytium lemnecum.* Williams.
- *Crucigenia rectangularis.* (Naeg) Kom-legh
- *C.tetrapodia* (Kirk) West and West.
- *Kirchneriella elongata.* G. M. Smith.
- *K.linearis.* G. M. Smith.
- *K. obesa*. (Bernard) G. M.Smith.
- *Kirchenerialla* sp.
- *Oocystis biospora*. Kg.
- *O. solitaria.* Wittrock.
- *Pediastrum botroanum*. Meneghii
- *P. biradinum.* Meyen.
- *P. duplex*. West and West.
- *P. lestyanum.*Meneghii
- *Scenedesmus accuminatus* (Lagerh) Chod.
- *S. arcus.* Meyen.
- *S.arvensis.* Chodat.

Class: Chlorophyceae. Order: Chlorococcales:

- *S. calyptratus.* Comas.
- *S. curvicaudal.* Brebbisson.
- *S. incrassatulus.* G.M. Smith.
- *S. intermediates.* Chod.
- *S.opoliensis.* P. Richter.
- *S. perforatus* Lemmermann.
- *S. quadracaudal.* Grun.
- *Scenedesmus* sp.
- *S. spinosus.* Chod.
- *S. ventralis.* Kom-legh.
- *Tetraedron biforcatum* (Wolle) Lagerh.
- *T. minimum.* Hansgirg
- *T. regulare.* Kutz.
- *T.tumidulum.* Riemsh.
- *T.trigonum.* Hansgwg
- *Tetrastrum elegans.* Playf
- *T. heterocanthum.* Chod
- *T. triangulare.* Komareck

- *Westella butryoides.* (W. West) De Wild.
- *W. linearis.* G. M. Smith.
- *Wolle soccata* (Wolle) Bornet and Flahault.

Order: Zegnematales:

- *Euastrum* sp.
- *E. sobordinata.* Kutzing.
- *Closterium biclavatum* (Borges) Scott & Prescott.
- *C.cynthia*. Cynthia
- *C. dianae.* Kutzing.
- *C. giganteum.* Breb.
- *C. graciles.* Grun
- *C. incurvum.* Breb.
- *C. infractum.* T. West.
- *C. jeneri.* Ralfs.
- *C. lanula.* Stein.
- *C. moniliferum.* G. S. West.
- *C. pseudolanula*. Breb.
- *Closterium* sp.
- *Closterium toxo*. Lemmermann
- *Cosmarium rodum.* Gutw.
- *Oedogonium incospicuum.* Hirn.
- *Spirogyra angulare*. Transeau.
- *S.porticalis.* Cleve.
- *Spirogyra* sp.
- *Staurastrum cerates.* Krieg.
- *Staurastrum* sp.

Class:Chlorophyceae
Order: Volvocales:

- *Asterococcus superbus.* Scherffel

Class: Cyanophyceae Order: Chroococcales:

- *Anabaena minutissima.* Kutz.
- *A.spiroides.*
- *Anabaena* sp.
- *Aphanocapsa* sp.
- *Calothrix fusca*(Kutz) Bornet and Flahault.
- *C. stagnalis.* Gomont.

Class: Cyanophyceae
Order: Chroococcales:

- *C. stellaris.* Bornet and Flahault.
- *Chariopsis cylindrical*. (Lambert) Lemmermann
- *Chroococcus disperses* (Kiessl) Lemmermannn
- *C.minutus* (Kutz) Nagaeli
- *Cylindrospernum muscicola.* Clark and Jensen
- *Gloecystis major.* Gerneck
- *Gleocapsa aeruginosa.* Kuetzing
- *Microcystis aeruginosa.* Kutzing
- *M. complanata.* Hust
- *M. protocystis.* Kutzing
- *Rhombocystis complanata.* Chod
- *Stignonema mimillosum* (Lynb) Agardh ex Flah et Borne

Order: Nostocales:

- *Oscillatoria agardii.* Gormont.
- *O. baccillum.* Stein.
- *O.granular.* Gardner.
- *O. homelii.* Lemmermann.
- *O. Tanganyika.* Grun.
- *Pleurotaeneum coronatum.* Ehr.

Class: Euglenophyceae
Order: Euglenales:

- *Euglena acus.* Ehrenberg.
- *E. acculeata.* Christiux.
- *E. accuminatum*. Skvortzow.
- *E. allorgii.* Deflande.
- *E. oxyuris*.(Minor)Prescott.
- *E. proxima.* Dang.
- *Euglena* sp.
- *Lepocinclis acuta.* Prescott.
- *L. playfairiana.* Deflande.
- *Phacus acuta.* Prescott.
- *Phacus accumminatum.* Skvortzow.
- *P. caudata.* Hubner.
- *P. chloroplastes.* Prescott.
- *P. nordstedii.* Lemmermann
- *P. Pseudoswirenkoi.* Prescott.
- *Phacus* sp.
- *P. triqueter.* Dijadin.
- *Trachelomonas armata*(Playf) Deflande
- *T. baccillifera.* Stein.
- *T. girardiana.* Playf
- *T. hexangulata.* Swirenko.
- *T. hispida.* Stokes.
- *T. leferri*. Prescott.
- *T. similis.* Stokes.
- *Trachelomonas* sp.

Class: Phaeophyceae
Order: Laminariales:

- *Saccorhiza polyschides.* Norton &Burrows

Class: Xanthophyceae. Order: Heterococcales:

- *Ophiocytium capitatum.* Lee Dale & Hibberd
- *Ophiocytium* sp.

CONCLUSION

There was a total absence of Phaeophyceae during the rainy season. This suggests that they were being highly influenced by high levels of nutrients, low temperature and higher flow rate of the river and attest that the river is not polluted.

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