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Autecology of microalgae in Nsit Ubium river

Abstract

Analysis of water such as river and lakes can provide an insight into their composition and potential impact on the environment. Nsit Ubium River is a fresh water body that flows through urban areas in Akwa Ibom state. The locals attached a lot of socio-economic importance to the river, as a result of this a lot of humans generated pollutants find their way into it. Researching on the autecology of microalgae in the river, water and algae sample were collected from the river for the period of four months (October 2021 to January 2022) and analyzed for physiochemical parameters and species diversity using standard procedures. Water samples were collected using 1 litre transparent bottle while microalgae samples were collected by scrapping the attached plants on the river bank into a transparent bottle and preserved with a drop of a mixture of formaldehyde and lugol iodine. pH ranged between (4.1 and 5.8), conductivity between (15 and 153), alkalinity between (5.0 and 5.8), Nitrate between (0.5 and 0.80Mg/L), phosphate between (5.01 and 7.8Mg/L) and dissolve oxygen between (6.27 and 9.22mg/l) were determined. Five divisions of algae comprising of 92 taxa were identified during this study. The division, Bacillariophyta was the most represented division accounting for 80% occurrence and a total of 72 species, this was followed by Chlorophyta with 10%, Euglenophyta (7%), Cyanophyta (2%) which were accounted for 9, 6 and 2 taxa respectively. Dinophyta was the least represented with (1%) and contributed only one taxon. The month of November has the highest number of species with total of 54 taxa while December has the least occurrence (31 taxa). The composition of microalgae in Nsit Ubium River were dominated by diatoms (Bacillariophyta) which are good pollution bio-indicators. The Cyanophyta indicates higher nutrient enrichment which could have been due to runoff from agricultural land or waste water discharge. Therefore, the documented algae in the river could be usedful as a pollutant indicator in assessing pollution status of rivers.

Keywords: periphyte algae, biofuel, lotic ecosystem, anthropogenic

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Introduction

Autecological data has been used individually as indicators of trophic and organic enrichment conditions in streams and rivers. And algal indices as biological integrity. Since the late 18th century with the description and naming of ecklonia maxima,[1] phycology (scientific study of algae as a research field has undergone several stages. The first stage as report[2] was from the late 18th century to late 19th century with descriptive work of scholars such as carl Adolph agardh (1785 – 1859) who firstly emphasized the importance of the reproductive characters of algae and the use of these to distinguish different genera and families (Papenfu second stage started from the late 19th century when phycology became a recognized research filed of its own. Scholars such as Friedrich Traugott kitting (1807-1893) continued the descriptive work with systematic recordings, extensive distribution mapping and development of identification keys.[3]The third stage was from the early 20th century up to date. In this stage a rapid progress have made and numerous key books have been published. Two important new research areas were also initiated during this late stage including investigation of freshwater algae and the use of algae in bio-assessment, warranted by decreased water quality of freshwater ecosystems due to intensive human disturbances. During the last decades the concepts and tools for assessing ecosystems health and diagnosing causes of impairment in streams and rivers have been developed rapidly. Phytoplankton developed mostly in slowly moving waters.[4] Christi[5] states that microalgae are unicellular microscopic plants, heterotrophic or autotrophic photosynthesizing organisms that grow in fresh water and marine systems. Chang Y[6] reported that microalgae normally grow in suspension within a body of water. They commonly double every 24 hours during the peak growth phase, each microalgae can double every 3.5hours, they are classified as the most primitive form of plants, Christi[7], EI Karim[8] reported that the mechanism of photosynthesis in microalgae is similar to that in higher plants but they are usually more efficient converters of solar energy because of their simple cellular structure. Microalgae contain large amount of lipid within their cell structure and so they are increasingly becoming an interest as a biofuels feedstock.[9]

Periphytic algae communities contribute immensely to the biodiversity associated with lotic ecosystems, they grow on pebbles, stones, boulder and bedrocks in rivers and other ecosystems.[10] These algae proliferate when high concentration of nutrients occur in the water and velocities are low; they can also provide habitat for many other organisms especially rotifers.[11] They are very responsive to degradation of water quality (often changing in both taxonomic composition and biomass where even slight contamination occurs.[12] They serve as micro environmental indicators of physical, chemical and biological disturbances that occur in lotic ecosystems[13] and hence serve as indicators of biological integrity of freshwater bodies.[14]Algae form the basis of the aquatic food and acts as natural purification agents of fresh water bodies since they absorb nutrients and other pollutants. In lotic ecosystems, due to the main unidirectional flow of water, the first signs of eutrophication may be detected by changes in the periphytic community because the signs of change often occur in attached communities.[15] The biological monitoring of periphyton has been deemed a useful tool in the detection of anthropogenic impacts on rivers and streams.

They have many different species with varying composition and live as single cells or colonies without any specialization. Although this makes their cultivation easier and more controllable, their small size makes subsequent harvesting more complicated. Algae grown

in pond can be far more efficient than higher plants in capturing solar energy especially when grown in bioreactors. According to Kroger M et al.,[9] Biomass is a viable renewable energy feedstock that promotes production of sustainable energy and reduction in green house gas emissions. Among the various types of biomass, microalgae are promising candidates because of their high biomass yields, high lipid contents, low cultivation costs, and non competition with agricultural land.[16] In addition, microalgae fix carbon (IV) oxide thereby reducing net carbon addition to the atmosphere. These benefit gives microalgae unique status as an environmentally friendly resources for large scale production of biofuels. Rivers carry drifting and insitu produced organic matter as a result of physiochemical conditions and the corresponding biological responses. Porter,[17] Ibola[18] mentioned that Planktonic organisms are produced insitu but their occurrence is mostly restricted through rivers or sheltered areas. In the middle course of large rivers, the water residence there is critical to allow substantial phytoplankton development.

Little is known about the ecology of algae in sea beach deposits as compared with the rocky coasts, although Chapman[19] reported a variation in the algae communities of salt marsh areas from those of other zones.[20] The most recent report on the algal communities of Nigerian waters is an investigation into the physiochemical conditions and planktonic organisms of the lower reaches of the Nun river located within the Niger Delta.[18] More so, Cowell et al.,[21] reported that algae are heterogeneous autotrophs distributed heterogeneously in space and time via the creation of distinct habitats, a product of the interactions between the river flow with the sediment. Therefore algae distribution in water bodies is naturally temporal and spatial in relatively calm environment.[22] Algae distribution, diversity and richness are tools for detecting disturbances impacts in any aquatic ecosystems. Since they have lifestyles associated with habitats and are also highly sensitive to habitat ecological stressors.[8] Thus, algal species richness, composition and abundance speaks of river systems productivity and trophic dynamics,[23] specific niche quality and characteristics of the ecological habitat[24] regardless of whether pelagic or benthic and not underestimated.[25]

Study area

Nsit Ubium river is a fresh water body that flows through urban areas in Akwa Ibom state. The locals derived a lot of importance from the river.In addition to natural attributes, the river at the middle experiences several impacts from small scaled industrial and traditional sand dredging as well as other anthropogenic activities along its course. Nsit Ubium river lies within the Niger Delta basin in Akwa Ibom State, the southern part of Nigeria with (Ibeno beach) Qua Iboe river estuary as its major tributary. It is located at about 60km east of Eket, Okobo, Nsit Ibom, Ibesikpo Asutan and Nsit Atai local government areas. It's coordinates in Nigeria is 4° 46 '0" N,7°56 '0" E.

Water and sample collection

Water and microalgae samples from the sampling area were collected for the period of four months starting from October 2021 to January 2022. The water samples from the surface were collected using 1 litre transparent bottle and taken to the laboratory for analysis. Microalgae samples were collected by pressing the attached plants on the river bank into a bucket and then transferred to a transparent bottle thus preserved with a drop of lugol iodine before taken to the laboratory. The algal samples were viewed at 400x magnification using an Olympus compound microscope. Taxonomic denominations and identifications were made by consulting (AHPA, 1989).

Phytoplankton identification and enumeration

Phytoplankton identification and enumeration were donein laboratory. Five drops of each concentrated sample (10 ml) were examined ×400 magnifications after mounting on a glass slide and covering with a cover slip each time. Thorough investigation was then carried out, observing all fields within the cover slip border using an Olympus universal wide field research compound microscope. The average of 5 mounts was then taken. Since each drop amounted to 0.1 ml the results on density of species (i.e. averages) were multiplied by 10 to give values as numbers of cell per ml. Appropriate text such as Prescott,[26] Adesakin,[27] Adeyemin[28] were used for identification.

Analysis of water sample

Temperature : Air and water temperature was taking in the field bymeans of mercury-in-class bulb thermometer with a range of 0□0 – 100□0 with an accuracy of 0±0.1□

Turbidity : Turbidity of the water was measured using HACH DR 2000 Model spectrophotometer at a wavelength of 45.

Chemical parameter

pH (Potential hydrogen ion): The pH of water samples was determined in the field using a pH meter previously calibrated with appropriate buffer of pH 4 and pH 9.

Conductivity : Conductivity of water samples was determined using HACH Co 150 total dissolved solid and conductivity meter.

Dissolved oxygen (DO) (mg/l) : Azide modification of Winkler method was used to determine dissolved oxygen content of the water samples. The fixed samples were dissolved in the laboratory by adding 2 ml of concentrated sulphuric acid (H_2SO_4). Fifty (50) ml of this solution was then poured in a conical flask and titrated with 0.2 N sodium thiosulphate as titrant till apale yellow colour was observed. Three (3) drops of 1%aqueous starch solution indicator was then added to the sample, and the resulting blue-black colour which was finally titrated till a colourless end point was reached. Dissolved oxygen was calculated as follows;

DO (mg/l) = number of digits on digital titrator x digit multiplier (0.04)

Biochemical oxygen demand (BOD) (mg/l) : Azide modification of Winkler method was used to determine BOD content of the water samples. Thesamples were fixed after five days using one ml of Winkler A followed by addition of 1 ml of Winkler B. Dissolution of the precipitate formed was done using 2 ml concentrated sulphuric acid and the sample was titrated as outlined above, Biochemical oxygen demand was calculated as follows;

DO5 (mg/l) = number of digits on digital titrator x digit multiplier (0.04)

BOD = Initial DO – DO5 at day five (DO5)

Alkalinity : Alkalinity was estimated by titrimetric method, (APHA, 1998). Three drops of Méthyl orange was added to 20 ml of water samples as indicator and titrated against a 0.01 N H_2SO_4 from yellow to pink. The value for alkalinity was calculated from the formula below:

Total Alkalinity (mg/l) = (A x N x 500)/(ml of sample used)

Where A = Total volume of acid used for titration of sample

N = Normality of acid (H_2SO_4) used for titration.

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Nitrate-Nitrogen (NO3- -N) (mg/l) : Nitrate was determined using HACH ER 2000 spectrophotometer. Thirty (30) ml of sample was measured into acid washed glass beakers after rinsing thoroughly with water. The contents of NitraVer 6 nitrate powder pillow was added to the measured sample and shaken continually for three minutes and then allowed to settle for 2 minutes allowed to stand for 2 minutes. Twenty-five (25) ml of the settled sample was then poured into cuvette. Then the content of one NitriVer 3 nitrite reagent powder was poured into the 25 ml cuvette and left for 10 minutes for the colour development. The sample was then read at 507 nm after blanking with the original sample.

Nitrate NO3- (mg/l): Nitrate NO_3- (mg/l) = Nitrogen × 4.4

Phosphate PO43- (mg/l) : This was determined using a HACH DR 2000 spectrophotometer. Twenty five (25) ml of sample was measured into acid washed glass beakers after rinsing thoroughly with water. The contents of PhosVer 3 phosphate powder pillow was added to the measured sample and allowed to stand for 2 minutes, for full colour development. Another 25 ml of the sample was measured and poured into a cuvette and used to zero the equipment. The developed sample was thereafter transferred into a cuvette and read at a wavelength of 890 nm.

Results

Phytoplankton community composition

A total number of 92 taxa belonging to 5 divisions (Figure 1 & 2) namely, *Bacillariophyta* (Diatoms), *Chlorophyta* (green algae), *Cyanophyta* (Blue-green algae/Cyanobacteria), *Dinophyta (Dinoflagellates)* and *Eulenophyta (Euglenoid*) were identified from the phytoplankton samples examined. The phytoplankton taxa were mainly of the division *Bacillariophyta*, which accounted for 74 taxa of the 92 taxa recorded. *Chlorophyta*, *Euglenophyta* and *Cyanophyta* accounted for 9, 6 and 2 taxa respectively, while *Dinophyta* contributed ony one taxon.

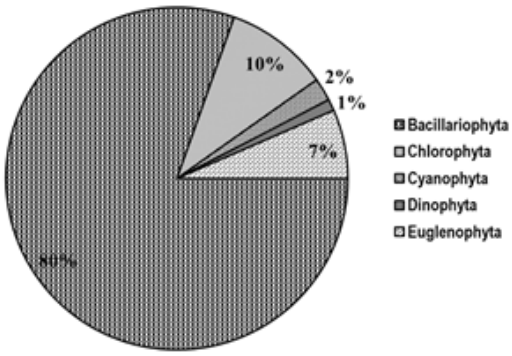

Figure 1 Total species distributed in each month.

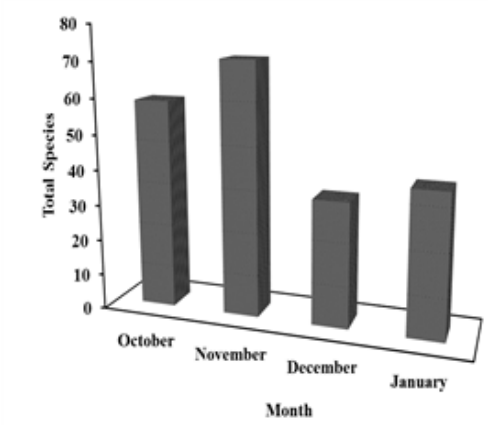

Figure 2 Shows the total number of species distributed in each month. Overall, November has the highest number of species. This was closely followed by the month of October while December recorded the lowest number of species.

Conclusion

In conclusion, the periphytic algae of Nsit Ubium river have been successfully analyzed and a total number of 92 taxa belonging to five divisions (Table 1) of *Bacillariophyta* (Diatoms), *Chlorophyta* (Green algae), *Cyanophyta* (Blue-green algae/*Cyanobacteria*), *Dinophyta* (*Dinoflagellates*) and *Eulenophyta* (*Euglenoid*) were identified. Among the five divisions *Bacillariophyta* was the most dominance with a total of 74 species while *Dinophyta* was the least occurrence with only one species.[29–49] The physicochemical parameters of the river were carefully analyzed using standard procedures. The interaction between the water body and the algae species were much impressed as large number of species were recorded. In addition, various species of phytoplankton found in the river contributes to the river richness as it supports natural development and healthy living of the locals through consumption of water and aquatics plants. Due to the species abundance of Nsit Ubium river, it is therefore concluded that, the identified species of *phytoplankton* are pollution tolerant and if the river is controlled of certain disturbances and other anthropogenic activities, it will greatly harbour more aquatic life as well as large algae species than the recorded ones.[50–57]

Table 1 Phytoplankton composition and distribution across the months

S/N	Division/Species	October	November	December	January
	Cyanophyta				
1	*Glaucocystis sp.*	+	-	+	+
2	*Calothrix sp*	-	+	-	-
	Euglenophyta				
1	*Phacus pleuronectes*	+	+	+	-
2	*Phacus orbicularis*	+	+	-	-
3	*Phacus acuminatus*	-	+	+	+
4	*Phacus curvicauda*	-	-	+	+
5	*Phacus sp.*	+	+	-	-
6	*Euglena gracilis*	+	+	-	+
	Chlorophyta				

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Table Continued...

S/N	Division/Species	October	November	December	January
1	*Cladophora glomerata*	+	+	+	-
2	*Closterium limneticum*	-	-	+	+
3	*Closterium moniliferum*	-	+	+	-
4	*Cosmarium per maculatum*	-	+	-	+
5	*Euastrum sp.*	-	-	+	-
6	*Geminella sp.*	-	-	+	+
7	*Spirogyra sp.*	+	+	-	-
8	*Spirogyra sp.*	+	-	-	+
9	*Spirogyra sp.*	+	+	+	-
	Bacillariophyta				
1	*Achnanthes sp.*	+	+	+	-
2	*Achnanthidium exiguum*	+	-	-	+
3	*Actinella brasiliensi*	+	+	+	-
4	*Actinella punctate*	-	+	-	-
5	*Asterionella Formosa*	+	-	-	+
6	*Brachysira neoexilis*	+	+	-	-
7	*Brachysira sp.*	-	+	+	+
8	*Brachysira sp.*	-	-	+	+
9	*Brachysira wygaschii*	+	+	-	-
10	*Climacosphenia moniligera*	+	+	-	-
11	*Cocconeis placentula*	+	+	+	-
12	*Diadesmis confervacea*	-	+	-	+
13	*Diatoma vulgaris*	+	+	-	-
14	*Diploneis sp.*	-	+	+	+
15	*Diploneis sp.*	-	-	+	+
16	*Eunotia bilunaris*	+	+	-	-
17	*Eunotia flexuosa*	+	+	-	-
18	*Eunotia incise*	+	+	+	-
19	*Eunotia paludosa*	-	+	-	+
20	*Eunotia pectinalis*	-	-	+	-
21	*Eunotia praerupta*	-	+	+	-
22	*Eunotia serpentine*	+	+	-	-
23	*Eunotia sp.*	+	+	-	+
24	*Fragilaria sp.*	+	+	-	-
25	*Fragilariform sp.*	-	+	+	+
26	*Frustulia crassinervia*	+	+	-	+
27	*Frustulia magaliesmontana*	+	+	-	-
28	*Frustulia quadrissinuata*	+	+	-	-
29	*Frustulia rhomboids*	+	+	+	+
30	*Frustulia saxonica*	+	+	-	-
31	*Frustulia undosa*	+	+	-	-
32	*Frustulia vulgaris*	+	+	-	-
33	*Gomphonema productum*	-	+	+	+
34	*Gomphonema sp.*	-	+	+	-
35	*Gomphonema sp.*	+	-	-	+
36	*Gomphonema venusta*	+	+	-	-
37	*Kobayasiella parasubtilissima*	+	+	-	-
38	*Navicula digitoradiata*	-	+	+	+
38	*Navicula lanceolata*	-	+	-	-
40	*Navicula radiosa*	-	+	-	+
41	*Navicula sp.*	+	+	-	-
42	*Navicula sp.*	+	+	-	-
43	*Navicula tripunctata*	-	+	+	+
44	*Nitzschia angustata*	+	-	-	+
45	*Nitzschia gracilis*	+	+	-	-

Present = +

Absent = -

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None.

Conflicts of interest

Authors declare that there is no conflict of interest.

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