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Phytoplankton as indicators of pollution of an urban stream, Zaria, Nigeria

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ABSTRACT: Phytoplankton samples were collected monthly for a period of two years (July, 1997 – June, 1999) from an urban stream using standard methods. The collections made from each sweep were identified in the laboratory using published keys. Relative abundance and abundance of the various taxa were calculated using the formulae: $N = \frac{a}{b} n$ and $D = \frac{N}{V}$ respectively.

A total of sixty two (62) taxa, comprising a total of 2100 individuals were collected. Many of the phytoplankton species (*Fragillaria sp.*, *Tabellaria sp.*, *Melosira sp.*, *Cyclotella sp.*, *Pinularia sp.*, *Euglena sp.*, *Phacus sp.*, *Oscillatoria sp.*, *Phormidium sp.*, *Cladophora sp.*, *Anabaena sp.*, *Oscillatoria sp.*, *Phormidium sp.*, *Cladophora sp.*, and *Anabaena sp.* etc.) were observed to be either restricted in their distribution or associated with waters of particular quality. While these biological indices do not reveal the particular types of pollution causing particular damage to the various stations on Bindare stream, they were useful in monitoring the environmental changes.

Key words: Stream, Water quality; Phytoplankton; Restriction; Indicator species.

Introduction

It has been shown conclusively that certain species of algae have wide range of tolerance, whereas other species have very narrow ranges of tolerance (1,2 and 3). Several tolerant algae, such as *Nitschia plalea*, *Cyclotela meneghiniana, Gomphonema parvulum, Anacystis cyanae* and *Stigeoclonium lubricum* have their best development in the presence of certain kinds of pollution, and therefore, if they are abundant, they truly indicate the presence of a given type of pollution. However, it is important to use a variety of parameters in diagnosing the water quality by the use of algae (4).

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One should consider the structure of a community, that is, the numbers of species, the relative abundance of species, the kinds of species and the total biomass present. Adakole and Oladimeji (3) investigated the effects of pollution on phytoplankton on a stretch of River Kubanni (Nigeria) and reported that the various phytoplankton species they encountered were zones according to the degree of pollution. (5) observed that the distribution of phytoplankton in River Delimi was regulated by the level of suspended particles and the heavy metals on the growth of primary producers of eighteen monospecific strains of marine alga. Their results indicated growth inhibition was due to cadmium, copper, mercury and lead levels in the water. The herbicide 2,4-D Dichlorophenyl acetic acid which is widely used in the control of aquatic weeds has been found to be toxic to many aquatic phytoplankton (7). Other papers that reported effects of pesticides, herbicides and other pollution on algae include (8), (9) and (10). Specific list of water quality indicator species compiled for one section of the country or world may be of little value in another region, because many aquatic organisms are very restricted in their distribution (11). The present paper presents information on some phytoplankton species that could be used as water quality indicators of an urban stream in Northern Nigeria.

Materials and Methods

Study Area

Bindare stream (Fig. 1) flows in a West – East direction along a gully situated to the east of Sabon-Gari and the Chikaji industrial area, Zaria. Most part of the gully contains water throughout the year probably because it cut through a perched water table. Also the gully receives various effluents. Bindare stream which is about 6km long takes its source from Kwangila Hills and empties into River Galma. The nature of Bindare stream valley varies considerably both from station to station and from time to time. Attempts to conserve the stream water include construction of earth-sand barrages and artificially enlarging and deepening of pools. Heaps of refuse, human faeces and cattle dungs were found on the slopes of the valley. Municipal and industrial effluents are channelled into the same drains and subsequently into the stream irrespective of their quality.

Five sampling stations (four on Bindare stream and one on river Galma) were chosen for the study. Station 1 is located upstream before Chikaji Industrial Estate. Station 2 is about 20m after Bindare stream had received all the effluents from Chikaji Industrial Estate (it is about 1.3km from station 1). Station 3 (about 1.1km from station 2) is located just after the stream had begun to receive domestic effluents. Station 4 (about 1.1km from station 3) is located after the stream had received most of the municipal effluents. Station 5, on river Galma, is 20m after the stream had joined the river.

Sample collection

Samples were collected monthly for a period of two years (July, 1997 – June, 1999). For qualitative examination, a plankton net with a conical bag (net mesh size of 0.01mm) 25cm long, attached to 50ml bottle and with a square opening measuring 15cm by 15cm, was lowered just beneath the water surface and towed to a distance of about 5.0 meters at a rowing speed. The collections were then transferred to small plastic vials and preserved in 4.0% neutral formalin as suggested by (12). The collections made from each sweep were identified in the laboratory using published keys (13-19).

For quantitative estimation, 1.0ml of the 50.0ml water collected was counted under the microscope and the number of algal cells expressed per liter. Relative abundance of the various taxa were calculated using the formula:

$$N = \frac{a}{b} n \quad 3.$$

Where N = estimated number of species per sample; n = number of species in sub-sample; a = volume of water (ml) (50.0ml) and b = volume (ml) of sub-sample (1.0ml).

The abundance of taxa in each sample calculated using the formula:

$$D = \frac{N}{V}$$

Where D = abundance of species (individuals per liter); N = estimated number of species per sample and V = volume (liters) of water originally filtered.

Statistical analysis was carried out using Genstat release 4.03 package.

Results and Discussion

The phytoplankton encountered belonged to the class: *Bacillariophyceae, Cyanophyceae, Chlorophyceae, Euglenophyceae* and *Rhodophyceae*. Sixty two (62) taxa, comprising a total of 2100 individuals were collected. 29.28% and 54.69% of *Cyanophyceae* population were collected from stations 3 and 4 respectively. *Rhodophyceae* were found at stations 2 and 4 only. The mean composition, distribution and abundance of phytoplankton along Bindare stream and River Galma are shown in Table 1. *Phacus* sp. was found at station 4 only (Figure 2). *Euglena* sp.; *Anabaena sp., Zygnema sp., Vaucheria sp., Oedogonium sp., Chlamydomonas sp., Cladophora sp., Nostoc sp.* and *Oscillatoria sp.* were almost exclusively found at stations 3 and 4 while *Anomoeonies sp., Asterionella sp., Fragillaria sp., Opephora sp., Stauronies phoenucentron, Tabellaria sp., Ankistrodesmus sp., Closteriopsis sp.* and *Euastrum sp.* were collected mainly from stations 1,2 and 5 (Figures 3a and 3b). The figures also revealed that there were high variation in both phytoplankton taxon and population during the study period. Phytoplankton population were higher during the rainy season than during the dry season. The highest population of 277 individuals per liter was obtained in station 4 in September of the first study year. Generally, there was a decline of phytoplankton population during the second study year. However, a mean of six phytoplankton taxon were collected during each of the seasons. Significant variation ($P < 0.05$) of phytoplankton taxon exists between stations. Analysis of variance for phytoplankton population showed that the interaction between station by season was not significant ($P > 0.05$).

The predominance of the various phytoplankton classes is in this order of magnitude: Chlorophyceae>Bacillariophyceae>Cyanophyceae>Euglenophyceae>Rhodophyceae. Based on classification of general associations of phytoplankton communities with waters of low and high fertility (20,21,22): the preponderance of *Fragillaria sp., Tabellaria sp., Melosira sp., Cyclotella sp.* and *Pinularia sp.* at stations 1, 2 and 5 is an indication of an infertile water (oligotrophic); the preponderance of *Euglena sp., Phacus sp., Oscillatoria sp., Phormidium sp., Cladophora sp.* and *Anabaena sp.* in stations 3 and 4 indicates highly fertilized water (hypertrophic). The hypertrophic status of stations 3 and 4 is attributed to domestic wastes received by the stream at these stations. According to (21), blue-green algae are tolerant of low oxygen concentrations of anaerobic waters due to their ability to use H_2S as well as H_2O as a hydrogen donor for photosynthesis. While these biological indices do not reveal the particular types of pollution causing particular damage to the various stations on Bindare stream, they were very useful in monitoring the environmental changes that occurred during the study period. The effect of slight pollution of Bindare stream in increasing the growth of certain algae species has also been noted in other water bodies. (2) showed this stimulation effect of mild pollution on some planktonic lake algae (*Fragillaria crotonensis, Melosira islandica, M. granulata* and *Rhizosolenia criensis*).

Conclusion

The algal populations increased or decreased in response to changes in nutrient of the stream. When the African environmental requirements of aquatic phytoplankton become known, and the biological communities associated with waters of particular quality are better established, biological indices could become very useful for detecting changes in water quality and in establishing sound standards for protecting beneficial uses of our aquatic resources.

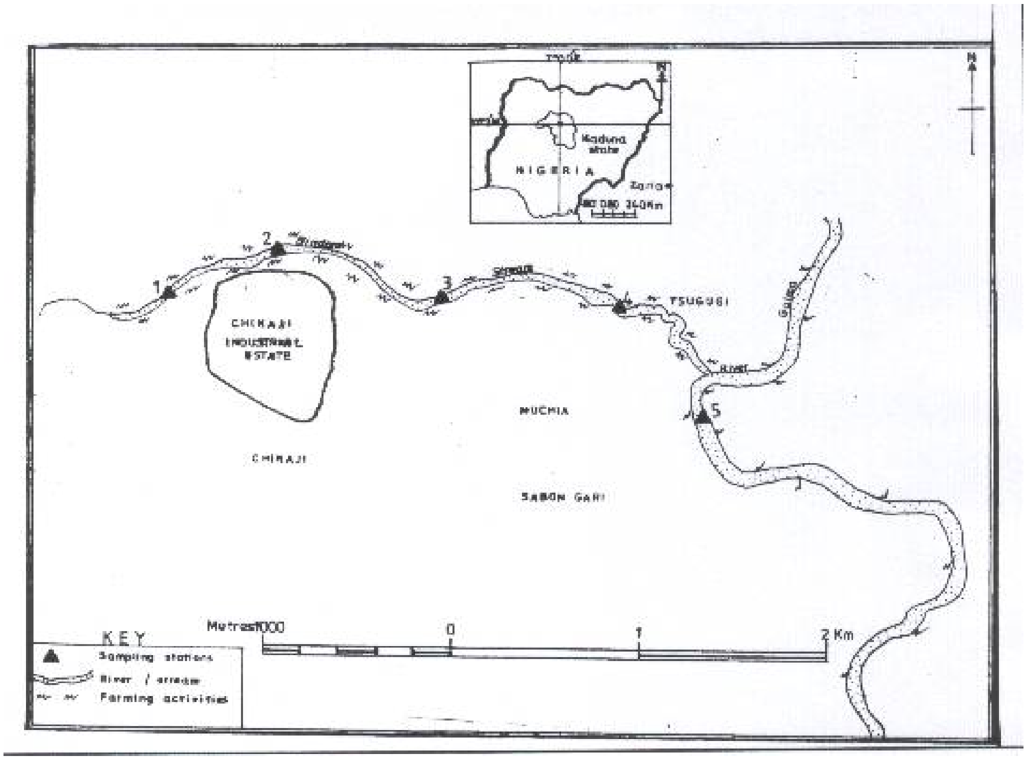

Fig. 1: Sabon Gari Zaria showing study area and location of sampling stations.

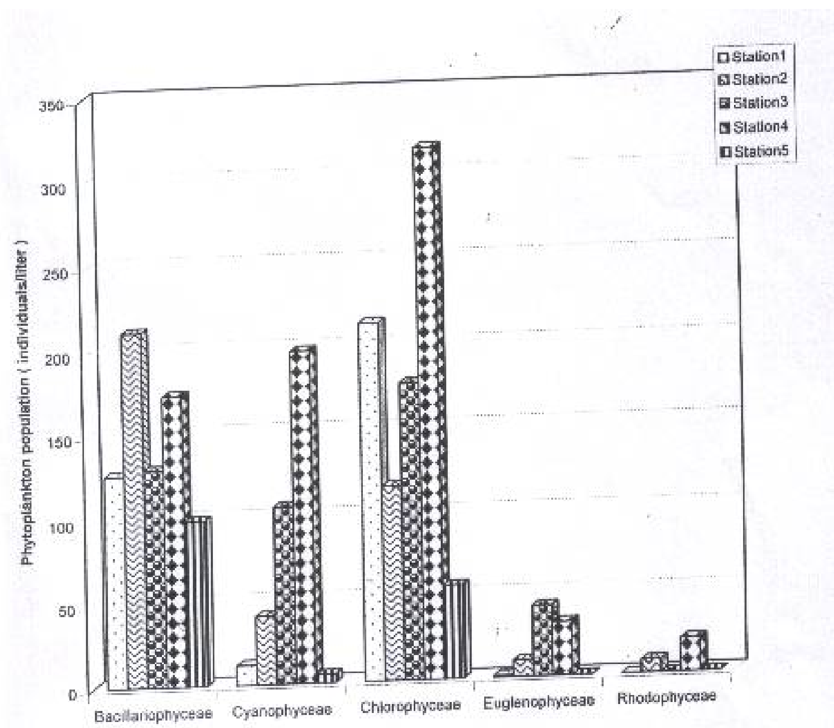

Fig. 2: Distribution of major phytoplankton taxa (individuals/litre) along Bindare stream and River Galma.

Table 1 : Mean composition , distribution and abundance of Phytoplankton population(Individuals/ liter) along Bindare stream and River Galma.

Taxon	Stations					Total
	1	2	3	4	5	
BACILLARIOPHCEAE						
Anomoeoneis sp	2	0	0	0	0	2
Asterionella sp	0	0	0	0	16	16
Cyclotella sp	10	8	4	2	40	64
Cylindrotheca sp	2	2	0	0	0	4
Cymbella gastroides	0	2	6	0	0	8
Cymbella sp	14	20	4	8	0	46
Diatoma balfouriana	0	0	6	0	0	6
Diatoma sp	0	214	26	10	14	264
Epithemia sp	0	0	2	0	0	2
Fragilaria sp	38	10	2	0	44	94
Gomphonema sp	0	0	0	6	0	6
Melosira sp	6	0	0	0	0	6
Navicula sp	34	82	26	36	16	194
Nitzschia sp	18	10	144	192	6	370
Opephora sp	10	0	2	0	0	12
Pinnularia sp	8	14	8	0	6	36
Pleurosigma attenuatum	0	2	0	0	0	2
Pleurosigma sp	0	0	6	0	0	6
Stauronies phonucentron	4	16	0	0	0	20
Stauronies sp	2	6	0	30	0	38
Stephanodiscus sp	0	0	0	26	0	26
Surirella sp	14	0	0	0	0	14
Synedra sp	36	0	22	36	16	110
Taberllaria fenestrata	14	0	0	0	0	14
Taberllaria sp	40	36	0	0	40	116
CYANOPHYCEAE						
Anabaena sp	8	30	126	82	2	248
Anacystis sp	0	0	0	22	6	28
Microcystis sp	2	2	0	0	0	4
Nostoc sp	0	2	0	6	0	8
Oscillatoria sp	14	48	86	220	2	370
Phormidium sp	0	0	0	66	0	66
CHLOROPHYCEAE						
Ankistrodesmus sp	32	8	0	0	18	58
Binuclearia sp	0	2	0	0	0	2
Chlamydomonas sp	0	2	38	16	0	56
Cladophora sp	0	0	40	88	0	128
Closteriopsis longissima	0	2	0	0	0	2
Closteriopsis sp	10	10	0	0	0	20
Closterium sp	220	122	188	230	62	822
Cosmarium sp	0	2	2	0	2	6
Desmidium sp	0	0	0	6	0	6
Dinobryon sp	0	6	2	0	0	8
Draparnaldia sp	0	0	0	2	0	2
Euastrum sp	8	2	0	0	0	10
Microspora sp	0	12	0	6	2	20
Mougeotia sp	0	0	0	0	6	6
Netrium sp	0	2	0	0	0	2
Oedogonium sp	2	4	8	22	2	38
Pediastrum sp	0	0	0	0	2	2
Phacotus sp	2	0	0	0	0	2
Rhizoclonium sp	0	6	0	0	0	6
Sirogonium sticticum	0	2	0	0	0	2
Spirogyra sp	96	40	0	100	0	236
Stigeoclonium sp	8	0	2	4	0	14
Tetmemorus sp	2	0	0	0	0	2
Ulothrix sp	46	6	28	102	0	182
Ulothrix zonata	0	0	10	0	0	10
Vaucheria sp	0	0	2	0	0	2
zygnema sp	0	4	34	54	18	110
EUGLENOPHYCEAE						
Euglena sp	2	10	76	64	0	152
Euglenopsis sp	0	10	0	0	0	10
Phacus sp	0	0	8	0	0	8
RHODOPHYCEAE						
Batrachospermum sp	0	16	0	40	0	56
	704	772	908	1476	320	4180

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