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PHYTOPLANKTON-BASED BIOMONITORING IN ASSESSING THE POLLUTION LEVEL OF A LENTIC FRESHWATER BODY IN HOOGHLY DISTRICT, WEST BENGAL, INDIA

© 2020 S. Pore[1], S. Ghosh[2], J. P. Keshri[3], S. S. Barinova[4]*

[1]Bandel Vidyamandir High School, India
[2]Mahadevananda Mahavidyalaya of the West Bengal State University, India
[3]CAS, The University of Burdwan, India
[4]Institute of Evolution, University of Haifa, Haifa 3498838, Israel
**E-mail: sophia@evo.haifa.ac.il*

Abstract. Phytoplankton is the base of every aquatic food web. During the assessment of the trophic status of the investigated lentic water body (within Lake City Housing Complex, Mankundu, Hooghly, West Bengal, India), phytoplankton composition and its temporal variation are proved to be the most important. In this study, 30 phytoplankton taxa have been recorded in various arrangements throughout the season. The maximum number of phytoplankton species with the highest Shannon–Weaver diversity index value represented the pre-monsoon season, whereas the least number of phytoplankton taxa and the lowest diversity indicators characterized the post-monsoon season. The development of algal bloom by one specific taxon, *Botryococcus braunii*, in the post-monsoon season indicates the change in the trophic status of this particular water body. As a criterion for the beginning of the algal bloom, an exceedance of 1 mg/L in nitrate concentration can be considered. The phytoplankton composition, values of various diversity indices, its density and species distribution pattern, and selected environmental parameters have been investigated, as well as the results of the analysis of rank abundance curves, which allowed for evaluation of the ecological status of this lentic water body. This study describes the change or shift in the ecosystem of the investigated water body towards eutrophication and establishes its pollution level as moderate to light.

Keywords: phytoplankton, diversity, biomonitoring, climatic seasons, West Bengal, India

БИОМОНИТОРИНГ НА ОСНОВЕ ФИТОПЛАНКТОНА В ОПРЕДЕЛЕНИИ СОСТОЯНИЯ ЗАГРЯЗНЕНИЯ ПРЕСНОВОДНОГО НЕПРОТОЧНОГО ВОДОЕМА В РАЙОНЕ ХУГЛИ, ЗАПАДНАЯ БЕНГАЛИЯ, ИНДИЯ

С. Пор[1], С. Гош[2], Дж. П. Кешри[3], С. С. Баринова[4]*

[1]Средняя школа Бандель Видьямандира, Индия
[2]Колледж Махадевананда Махавидьялая Западно-Бенгальского государственного университета, Индия
[3]Центр перспективных исследований, Университет Бурдвана, Индия
[4]Институт эволюции, Университет Хайфы, Хайфа 3498838, Израиль
**E-mail: sophia@evo.haifa.ac.il*

Аннотация. Фитопланктон является базовой единицей каждой водной пищевой сети. Для изучения трофического статуса исследованного непроточного водоема (в жилищном комплексе Лейк-Сити, Манкунду, район Хугли, Западная Бенгалия, Индия) наиболее важны состав фитопланктона и его изменение во временном масштабе. В настоящем исследовании в течение сезона были зарегистрированы 30 таксонов фитопланктона в различных комбинациях. Предмуссонный сезон был представлен максимальным количеством видов фитопланктона с наивысшим значением разнообразия Шеннона–Уивера, а постмуссонный сезон характеризовался наименьшим количеством таксонов фитопланктона и самыми низкими показателями разнообразия. Развитие цветения одного из таксонов, а именно *Botryococcus braunii*, в постмуссонный сезон указывает на изменение трофического статуса этого водоема. Критерием начала цветения можно считать повышение концентрации нитратов выше 1 мг/л. Нами были изучены состав фитопланктона, значения различных индексов разнообразия, его плотность и структура распределения видов, выбранные параметры окружающей среды, а также результаты анализа ранговых кривых численности, что позволило расшифровать экологический статус этого непроточного водоема. В этом исследовании показано изменение или сдвиг экосистемы исследуемого водного объекта в сторону эвтрофикации и определено состояние загрязнения на уровне от умеренного до легкого.

Ключевые слова: фитопланктон, разнообразие, биомониторинг, климатические сезоны, Западная Бенгалия, Индия

INTRODUCTION

Phytoplankton is formed by microscopic organisms with the photosynthetic ability and is present in almost every water body. It plays many important roles related to the production of food, oxygen supply, and climate regulation. The existence of phytoplankton within a water body actually establishes the fine regulating mechanism mostly through the biotic and abiotic factors. Phytoplankton establishes its immense importance as a primary producer in aquatic ecosystems and as a basic representative of the first level of a trophic pyramid. Phytoplankton is represented by the free-floating photosynthetic organisms, including photosynthetic cyanobacteria. These organisms are capable of generating oxygen by photosynthesis that can help them fix carbon to build significant biomass for the next generation and for the next trophic level. The biological monitoring uses various biological organisms to describe the ecological situation in a water body.

Phytoplankton is a very efficient component of biological monitoring study due to the rapid reproduction rate and short life span of plankters, and its adequate indication of minute environmental changes [1–9]. In this context, we have to understand that the alteration of a phytoplankton community mostly results from changes in the water quality. Initially, changes in the water quality show quantitative or numerical deviation in the phytoplankton community composition. The density of the phytoplankton changes under the impact of the regulating factor. The qualitative alterations can be caused either by the introduction of some new species or by the disappearance of some common ones. According to the mentioned studies, nutrient enrichment and other regulating or modifying factors result in bloom formation. For water quality assessment, both qualitative and quantitative methods can be effectively used for phytoplankton. It is known that a healthy or non-polluted water body is characterized by higher diversity than a deteriorated one [10]. Multivariate analysis establishes the correlation between phytoplankton accumulations and environmental data. A few selected biomonitoring approaches with their specific attributes are described in terms of species indicators and environmental variables [1, 2, 11–13].

Various autogenic and allogenic regulatory changes lead to the alteration of species composition. In this study, we consider both qualitative characteristics (e.g. species composition) and some quantitative attributes (phytoplankton density and diversity) [14, 15]. The objective of the present investigation was to evaluate a particular lentic water body, typical for the region, based on phytoplankton variables; for that purpose, easily accessible and available tools have been utilized for a detailed investigation of the community structure with the purpose to find markers for the ecosystem changes under the climatic impact.

MATERIALS AND METHODS

A lentic water body (22°50'41.8524'' N, 88°20'57.7428" E) within Lake City Housing Complex, Mankundu, Hooghly, was selected for biomonitoring studies and analysis (fig. 1). Despite its location in an urbanized area, it is of a natural origin; it is 90 m long, 75 m wide and about 5 m deep. After the construction of the Housing Complex, this water body was partially influenced by controlled anthropogenic pressure.

The samples were collected by scooping water from four sampling points in four different parts of the lake during the pre-monsoon (March–May), monsoon (June–August) and post-monsoon (September–November) periods between 10 and 11 a.m. in November 2018, March 2018, and July 2018, respectively. The samples were collected in 500 ml amber-colored bottles. Lugol's iodine solution was used as a fixative in 1:100 ratio. The samples were kept overnight for sedimentation purposes. The supernatant part was pipetted, and the sample was concentrated to 5 ml volume for analysis. Storage of water samples in amber-colored bottles prevents the discoloration of algae. For the quantitative estimation of phytoplankton, we followed the “Drop Count Method” [16]. In this particular method, one drop of the concentrated phytoplankton sample is placed on a glass slide and the phytoplankton cells are counted in strips [17]. The phytoplankton density was expressed as cells/L. The geographic coordinates of the lake under investigation were determined by the GARMIN GPS eTrex® H device.

Fig. 1. Investigated lentic water body in Lake City, Mankundu, Hooghly, West Bengal, India

Рис. 1. Исследованный непроточный водоем в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия, Индия

Zeiss Axiostar Plus microscope and Axio vision software for numerical studies of phytoplankton, as well as its photomicrographs, were used for the phytoplankton taxa identification and counting of its cells according to the standards in [18–24]. The revealed taxa were recorded in compliance with their valid names at algaebase.org [25].

Physical and chemical variables, such as water temperature, pH, TDS, and conductivity were measured by means of Oakton PCSTestr 35 Waterproof Tester. The water transparency was identified with a Secchi disk. Dissolved oxygen, nitrates, and phosphates were analyzed in the Burdwan University laboratory using standard methods [26, 27]. During the investigation, PAST (V3.19) and BioDiversity Pro software [28] was used in order to calculate various diversity indices and other ecological characteristics (species distribution, rank abundance curve). The calculation of species similarity was made as the network analysis in JASP 0.9.0.0 on the botnet package in R-Statistica [29]. JASP plot was created as a calculation result on the 50 % similarity level and was significant only when $p < 0.05$.

The calculated diversity indices were compared with the known system of the pollution level [30] and complicity of the community structure according to Wilhm and Dorris (a) and Staub et al. (b) [31, 32] (table 1).

The saprobity index (SI) and WESI toxic pollution index [1, 2, 33, 34] were calculated using the formula: WESI = Rank Index SI/Rank $N\text{-}NO_3$ to assess the toxic pollution influence on the aquatic ecosystems of the investigated water body. The index values vary from 0.1 to 9. If the index values are less than 1, then the ecosystem is exposed to toxic pollution, which inhibits photosynthesis.

RESULTS AND DISCUSSION

Chemical and physical characteristics of the water in the Lake City pond during three climatic seasons are represented in table 2. It is shown that water temperature and dissolved oxygen as well as water pH and the water transparency values decreased after the monsoon period. On the contrary, such variables as nitrates and phosphates synchronously increased with the TDS.

Table 1. Shannon diversity index in relation to pollution level according to Wilhm and Dorris (a) and Staub et al. (b) [31, 32]

Таблица 1. Индекс разнообразия Шеннона в зависимости от загрязнения согласно Wilhm и Dorris (a) и Staub et al. (b) [31, 32]

a)

Species diversity, Shannon index Видовое разнообразие, индекс Шеннона	Pollution level Уровень загрязнения
>3.0	Clean water Чистая вода
1.0–3.0	Moderately polluted Среднезагрязненная
<1.0	Heavily polluted Сильнозагрязненная

b)

Species diversity, Shannon index Видовое разнообразие, индекс Шеннона	Pollution level Уровень загрязнения
3.0–4.5	Slight pollution Условно чистая вода
2.0–3.0	Light pollution Слабое загрязнение
1.0–2.0	Moderate pollution Среднее загрязнение
0.0–1.0	Heavy pollution Сильное загрязнение

It should be noted that the phytoplankton density was minimal during the intermediate monsoon season, whereas before and after it the abundance of organisms was higher, which gives us a reason for a detailed investigation of the community structure with the purpose to find markers for monitoring.

In this study, a total of 30 phytoplankton taxa were recorded and showed prominent fluctuations during the season (table 3). Pre-monsoon season was represented by the maximum abundance of phytoplankton with the highest Shannon-Weaver biodiversity value, whereas post-monsoon season was characterized by the least representation by both abundance and diversity criteria. The diversity value slightly decreased in the monsoon season due to the dilution effect of the rain; this pattern was also recorded in the post-monsoon season. During this study, we identified phytoplankton species belonging to six classes: Chlorophyceae (8), Cyanophyceae (10), Bacillariophyceae (4), Zygnematophyceae (4), Euglenophyceae (2), and Trebouxiophyceae (2). Cyanophycean representatives prevailed during the period of the study, mostly because of their ability to withstand a wide range of environmental conditions and their vast habitat preferences (fig. 2, table 4).

Calculation of the data similarity for each of the studied seasons is represented on the JASP plot (fig. 3). The figure indicates that the communities of pre- and monsoon seasons are the most similar (fig. 3a), whereas the post-monsoon community contains different species, which have different density. At the same time, the abundance of each species helps define the communities that have no similarity in between for each season individually; and the most negative it was for pre- and post-monsoon seasons (fig. 3b).

Biodiversity can be represented in various ways. The calculation of similarity of the species abundance in seasonal communities is shown in fig. 4. It is obvious from the figure that algal and cyanobacterial communities were rather different during the studied seasons (especially during the post-monsoon period) when compared to nonparametric statistics in BioDiversity Pro. Many diversity indices can also be calculated in order to reveal dissimilarity between community composition or its changes caused by seasonal variations of weather. Normally biodiversity is expressed by species richness or by species diversity indices. All the while, we have to consider that no particular index is the best. However, we can use them depending upon the specific representation under consideration. Here some alpha diversity indices (table 5), which can express the diversity within a specific area or ecosystem under study are used. Among all

Table 2. Investigated limnological characteristics with environmental variables and phytoplankton abundance in Lake City, Mankundu, Hooghly, West Bengal in 2018

Таблица 2. Изученные лимнологические показатели с гидрохимическими данными и численностью фитопланктона в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г.

Variable Переменная	Pre-monsoon Предмуссонный	Monsoon Муссонный	Post-monsoon Постмуссонный
Water temperature (°C) Температура воды (°C)	31	27	23
Water pH pH воды	8.2	9.5	8.34
Dissolved oxygen, mg/L Растворенный кислород, мг/л	8.3	7.6	5.6
Nitrates, mg/L Нитраты, мг/л	0.41	0.31	1.66
Phosphates, mg/L Фосфаты, мг/л	0.33	0.28	1.08
Transparency, Secchi depth, m Прозрачность по диску Секки, м	4.3	2.3	1.1
TDS, mg/L Общая минерализация, мг/л	90	75	210
Phytoplankton abundance (ths. cells/L) Численность фитопланктона (тыс. кл./л)	360	205	350

represented indices, the Shannon Diversity Index is the most important as it indicates changes in the trophic status of the investigated water body.

Species distribution or dispersion study shows the details of the arrangement of individuals under particular spatial considerations. Behavioral and ecological factors, at micro- or macrolevels, can influence the dispersion. Normally, three types of dispersion patterns can be encountered in nature: uniform, clumped, and random. In this study, the

Table 3. Time profile of the number of thousand phytoplankton cells per liter in the context of seasonal observations in Lake City, Mankundu, Hooghly, West Bengal in 2018

Таблица 3. Календарь количества тысяч клеток фитопланктона на литр при сезонных наблюдениях в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г.

Phytoplankton taxa Таксоны фитопланктона	Pre-monsoon Предмуссонный	Monsoon Муссонный	Post-monsoon Постмуссонный
Bacillariophyceae			
Meridion circulare (Greville) C. Agardh	2	0	0
Nitzschia palea (Kützing) W. Smith	1	0	17
Pinnularia major (Kützing) Rabenhorst	2	0	3
Ulnaria capitata (Ehrenberg) Compère	11	5	0
Trebouxiophyceae			
Botryococcus braunii Kützing	0	0	200
Oocystis lacustris Chodat	32	6	0
Chlorophyceae			
Monoraphidium minutum (Nägeli) Komárková-Legnerová	22	0	0
Ankistrodesmus falcatus (Corda) Ralfs	22	0	0
Coelastrum microporum Nägeli	0	33	0
Kirchneriella obesa (West) West & G.S. West	11	0	8
Stauridium tetras (Ehrenberg) E. Hegewald	16	0	0
Tetradesmus obliquus (Turpin) M.J. Wynne	64	16	0
Tetraëdron trigonum (Nägeli) Hansgirg	16	32	0
Volvox aureus Ehrenberg	0	64	0
Zygnematophyceae			
Closterium parvulum Nägeli	1	0	0
Cosmarium angulatum (Perty) Rabenhorst	6	18	0
Micrasterias alata Wallich	8	0	0
Spondylosium sp.	0	0	16
Cyanophyceae			
Aphanocapsa biformis A. Braun	12	8	0
Aphanocapsa incerta (Lemmermann) G. Cronberg & Komárek	8	3	20
Arthrospira gigantea (Schmidle) Anagnostidis	12	0	0
Aulosira fritschii Bharadwaja	8	2	0
Cylindrospermum sp.	25	0	12
Dolichospermum circinale (Rabenhorst ex Bornet & Flahault) P. Wacklin, L. Hoffmann & J. Komárek	12	2	0
Gloeotrichia echinulata P.G. Richter	22	0	0
Kamptonema formosum (Bory ex Gomont) Strunecký, Komárek & J. Smarda	6	1	0
Merismopedia glauca (Ehrenberg) Kützing	32	0	0
Microcystis aeruginosa (Kützing) Kützing	0	13	66
Euglenophyceae			
Euglena viridis (O.F. Müller) Ehrenberg	1	2	8
Trachelomonas hispida (Perty) F. Stein	8	0	0

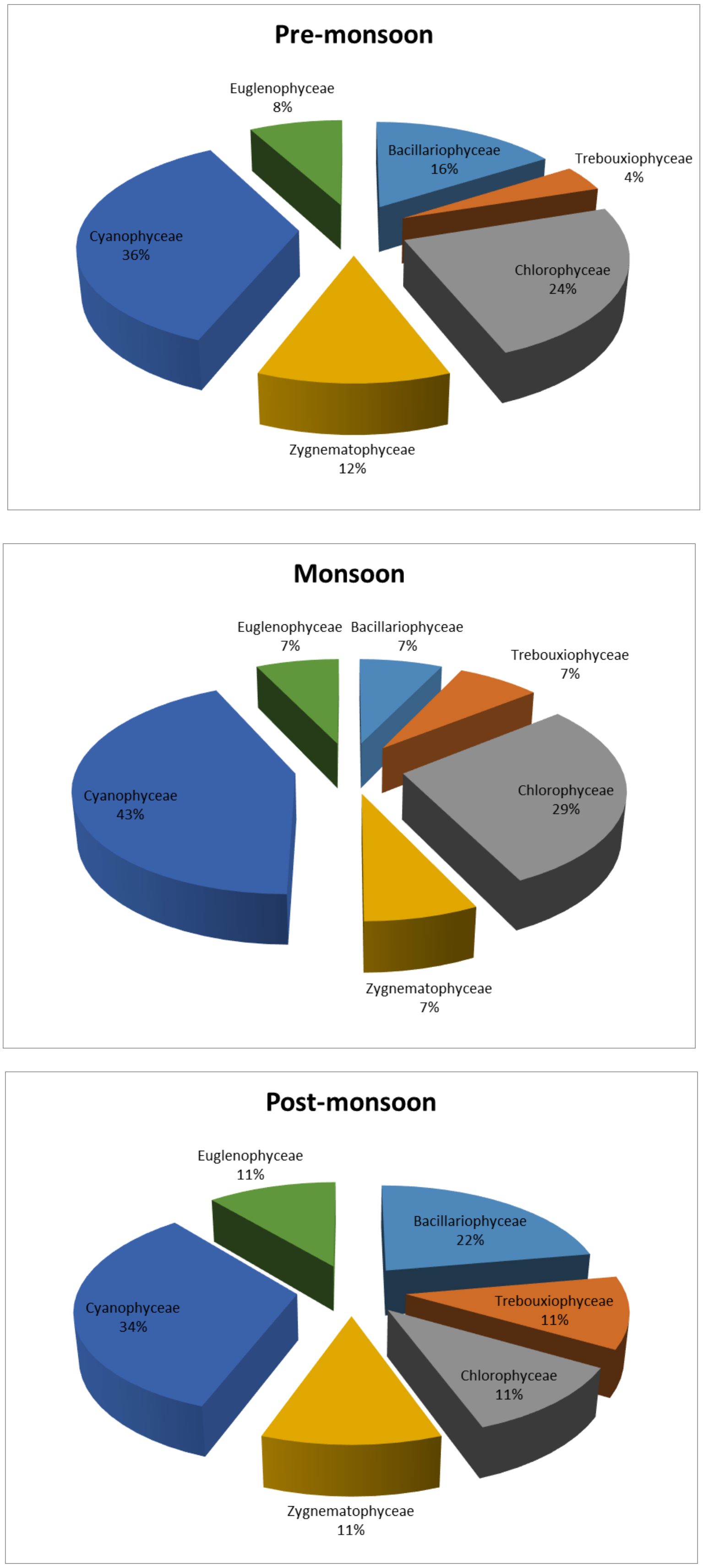

Fig. 2. Pie charts representing percentage of the phytoplankton composition for three seasons in classes in Lake City, Mankundu, Hooghly, West Bengal in 2018

Рис. 2. Круговые диаграммы, представляющие процентный состав фитопланктона в классах за три сезона в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г.

Table 4. Number of species in the phytoplankton taxonomic classes in climatic seasons in Lake City, Mankundu, Hooghly, West Bengal in 2018

Таблица 4. Число видов в классах сообществ фитопланктона в климатические сезоны в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г.

Phytoplankton classes Классы фитопланктона	Pre-monsoon Предмуссонный	Monsoon Муссонный	Post-monsoon Постмуссонный
Bacillariophyceae	4	1	2
Trebouxiophyceae	1	1	1
Chlorophyceae	6	4	1
Zygnematophyceae	3	1	1
Cyanophyceae	9	6	3
Euglenophyceae	2	1	1

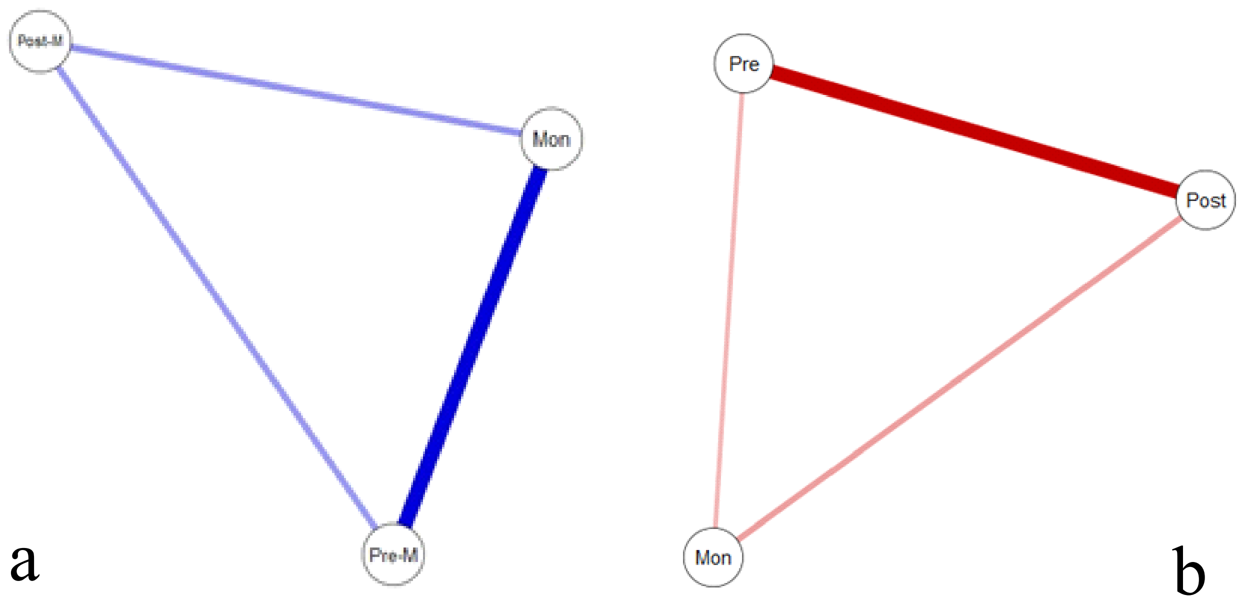

Fig. 3. The JASP network plot of the similarity (in R-statistics) of the composition of the planktonic algae and cyanobacteria by species (a) and cell abundance (b) in Lake City, Mankundu, Hooghly, West Bengal for three seasons in 2018. Abbreviations: Pre-M — pre-monsoon season, Mon — monsoon, Post-M — post-monsoon. The line thickness between the nodes reflects the correlation value: blue is positive, red is negative (it has not been found).

Рис. 3. Сетевой график JASP (в R-статистике) сходства состава планктонных водорослей и цианобактерий по числу видов (a) и по численности клеток (b) за три сезона в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г. Сокращения: Pre-M — предмуссонный сезон, Mon — муссонный, Post-M — постмуссонный. Толщина линии между узлами сети отражает значение корреляции: синий — положительная, красный — отрицательная (не обнаружена)

clumped distribution was found to be the most common (fig. 5). Some environmental gradients that are most suitable for phytoplankton are localized, which can lead to such a clumped pattern.

Analysis of the rank abundance curve (fig. 5a) provides the distribution of species abundance for a specific community by proportional abundance against its rank of abundance. The abundance of the most common species is shown on the extreme left side of the diagram, and the least abundant ones are given on the extreme right side of it. The rank abundance diagram represents the diversity in terms of richness and evenness. The width of the horizontal axis indicates the species richness, whereas a wider curve is indicative of a higher species richness value. The shape of the curve represents the evenness pattern. The rank abundance curve for the specific community expresses its intricate structure and can be correlated with the diversity curve form. The species uniqueness in the studied seasonality of phytoplankton was highest in the

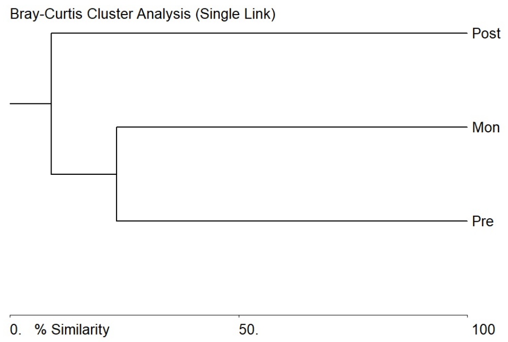

Fig. 4. Bray–Curtis dissimilarity analysis of the species abundance in seasonal communities of algae and cyanobacteria (in BioDiversity Pro) in Lake City, Mankundu, Hooghly, West Bengal in 2018. Abbreviations: Pre — pre-monsoon season, Mon — monsoon, Post — post-monsoon

Рис. 4. Анализ сходства по Брей–Кертису численности видов в сезонных сообществах водорослей и цианобактерий (в BioDiversity Pro) в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г. Сокращения: Pre — предмуссонный сезон, Mon — муссонный, Post — постмуссонный

pre-monsoon communities (fig. 5b) and decreased with time to zero. It means that the species in the post-monsoon community had all been recorded in the communities before it as well. This result has been confirmed by the rank abundance curve of phytoplankton community (fig. 6). It is shown that the curve for the post-monsoon community is shorter and its abundance is higher. This pattern demonstrates a community with low species richness and a wide fluctuation of species density [35–38].

In the present study, the phytoplankton community in the pre-monsoon season is represented by 25 taxa, which is followed by 14 taxa in monsoon and 9 in the post-monsoon seasons. It has been found out that members of Cyanophyceae mostly prevailed in the seasonal pattern followed by Chlorophyceae and other phytoplankton classes with diminishing representation.

For the diversity study here, we used a dominance index (in this case, Simpson's Diversity Index), which is biased to dominant or common species. Other information statistic indices, such as Shannon and Brillouin indices, provide information about low-abundant species. Various indices under observation depict slightly different values but they are positively connected to express the diversity scenario.

Variation of the population of living organisms as a measure of water quality is based on the principle that community diversity is high in clean water, while in polluted water it is low [31, 2, 35]. There is a close relationship between the Shannon diversity value and pollution status [36, 37] (table 1), and it indicates light to moderate pollution level in the investigated water body (table 5) with pollution increasing during the studied period seasonally from pre- to post-monsoon season.

It has been revealed that almost all phytoplankton showed clumped or aggregated dispersion patterns. In this case, it can be attributed to concentration of the resources in a specific area within the lake, which leads to group formation by the members of phytoplankton community where may exist a preference of one member of the community over the others. This

Table 5. Values of various indices of phytoplankton species diversity in Lake City, Mankundu, Hooghly, West Bengal in 2018

Таблица 5. Значения различных показателей видового разнообразия фитопланктона в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г.

Ecological indices Экологические индексы	Pre-monsoon Предмуссонный	Monsoon Муссонный	Post-monsoon Постмуссонный
Dominance (D) Доминирования (D)	0.075	0.169	0.372
Simpson (1-D) Симпсона (1-D)	0.924	0.830	0.627
Shannon (H′) Шеннона (H′)	2.847	2.079	1.415
Evenness (e^H/S) Выравненности (e^H/S)	0.689	0.571	0.457
Brillouin (H_B) Бриллюэна (H_B)	2.716	1.964	1.365

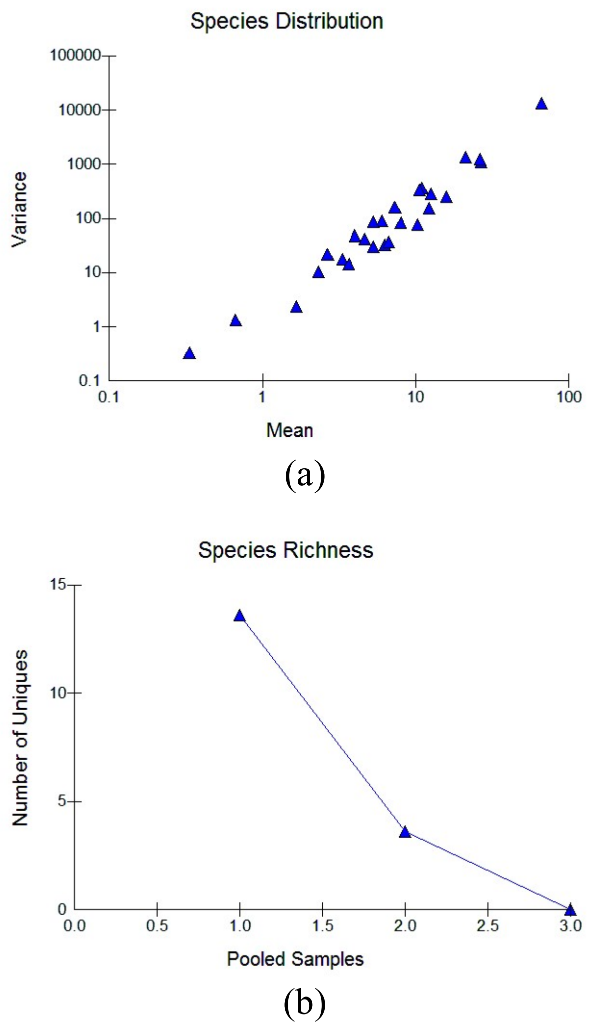

Fig. 5. Distribution patterns of phytoplankton species in Lake City, Mankundu, Hooghly, West Bengal in 2018. Dispersion of species density (a); unique species (b)

Рис. 5. Распределение видов фитопланктона в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г. Дисперсия численности (a); уникальные виды (b)

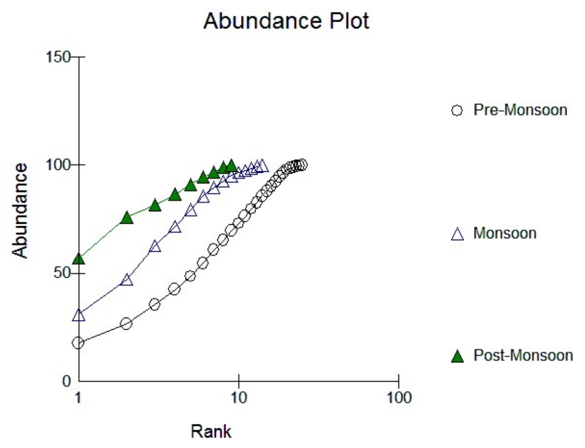

Fig. 6. Rank curve for the abundance of phytoplankton seasonal community in Lake City, Mankundu, Hooghly, West Bengal in 2018

Рис. 6. Ранговая кривая численности сообщества фитопланктона в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г.

preference may have developed due to various interactions like competition, territoriality, etc.

The rank abundance diagram can express a more complete description of the investigated community under the abundance dynamics. In this case, the pre-monsoon season is represented by the wider curve, i. e. the most diverse community along with the maximum evenness among all three seasons. The monsoon season community is characterized by lower richness and evenness than the former case. The algal community showed the least richness, i. e. the lowest diversity, and the least evenness during the post-monsoon season. A massive bloom event of *Botrycoccus braunii* in the post-monsoon season can explain the decrease in the species diversity, which was revealed in the other water bodies under a wide range of succession stages of the phytoplankton community [32, 35].

As the final step of the analysis, saprobity indices (SI), which are based on the species-specific index value and abundance of each indicator species, were calculated. Table 6 represents values of the SI dynamics with the highest value during the monsoon season. However, classification rank for each season is the same and reflects low organically polluted water during the studied period. Thus, saprobity index alone cannot define the changes in the ecological situation of this water body. In order to clarify this dynamics, the WESI index was calculated based on the SI and nitric-nitrogen concentration as demonstrated in table 6. It can be seen that the WESI index is higher than 1.0 in the pre-monsoon and monsoon ecosystems but in the post-monsoon one it is lower than 1.0, which reflects low toxic impact on the photosynthesis of planktonic autotrophs after the monsoon. The nature of pollution cannot be defined in the current analysis but it can call for further monitoring of the variables for which it can be specified in respect of the climatic season features [39]. Quantitative variables of phytoplankton from the small typical water bodies with the diversity indices calculated can be used as an effective monitoring tool that has proved itself useful in a few example ecosystems of this region [40, 41].

Table 6. Table of calculation of the WESI index based on saprobity index (SI), ranks of nitrate content and phytoplankton abundance in Lake City, Mankundu, Hooghly, West Bengal in 2018

Таблица 6. Таблица расчета индекса состояния водной экосистемы WESI на основе индекса сапробности SI, рангов концентрации нитратов и численности фитопланктона в Лейк-Сити, Манкунду, Хугли, Западная Бенгалия в 2018 г.

Ecological indices Экологические показатели	Pre-monsoon Предмуссонный	Monsoon Муссонный	Post-monsoon Постмуссонный
Abundance, ths. cells/L Численность, тыс. кл./л	360.00	205.00	350.00
Saprobity index SI Индекс сапробности SI	1.58	1.86	1.65
SI index rank Ранг индекса сапробности SI	4	4	4
Nitrates, mg/L Нитраты, мг/л	0.41	0.31	1.66
Rank $N\text{-}NO_3$ Ранг нитратного азота	3	3	6
Index WESI Индекс состояния водной экосистемы WESI	1.33	1.33	0.67
Risk Риск	no нет	no нет	risk риск

CONCLUSIONS

Maximum phytoplankton abundance was recorded in the pre-monsoon season, being accompanied by the high diversity value, i. e. various forms of phytoplankton were found in that instance, which probably represented the oligotrophic condition of the lake. On the other hand, the lowest phytoplankton representation (species richness) associated with the bloom event, where one specific taxon, *Botryococcus braunii*, prevailed, may be indicative of the shift in a trophic status towards eutrophic nature. In this case, despite showing the values similar to those of the pre-monsoon season, the phytoplankton abundance slightly increased as compared to the monsoon season due to bloom formation. This actually represents the paradox of enrichment, i. e. high density with low diversity. In other words, a typical algal bloom condition develops. The criterion of the algal bloom start can be the nitrate content when it exceeds the level of 1 mg/L. This is the limit of the trophic level increase with the weather change in this area. These environmental changes lead not only to alterations of species composition and abundance but also to significant changes in the structure of the plankton community as confirmed by the current analysis. The study of species dispersion, supported by the similarity tree and rank abundance curve analysis, reinforces the analysis of the community species. We have to consider all these factors and take necessary steps to maintain both the aesthetic and ecological balance of this water body, which is important for the nature and culture of this urbanized area.

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