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Identification and Ecological Study of Algal Species in the Polluted Stretch of Bharalu River, Guwahati, Assam, India

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ABSTRACT

Guwahati city, the gateway of the Northeastern India has been facing major environmental threats due to various anthropogenic pressures, thus making the city prone to water hazard especially in the form of water pollution and flash floods. The Bharalu river, flowing through the Guwahati city is notoriously known for its critically polluted water quality as reported by the Central Pollution Control Board. Although the river is highly polluted, still a few organisms including microbes, such as algae are found to thrive in it. The purpose of the present research is to study and identify the pollution tolerant algal species present in the polluted water of Bharalu river, so that their bioremediation potential can be explored subsequently. During the study, altogether 33 species of phytoplankton distributed in four different families were recorded. Chlorophyceae has been represented by 20 species followed by Bacillariophyceae, Cyanophyceae and Euglenaceae with 8, 3 and 2 species, respectively. *Scenedesmus* was the most dominant genera with a total of 11 species. Phytoplankton peaks were observed during Jan- Feb (19×10^3 units/l).

Key words: Water pollution, Water quality, Anthropogenic pressure, Pollution tolerant, Phytoplankton, Bioremediation

INTRODUCTION

The Bharalu River, a small tributary of the river Brahmaputra, traverses through the densely populated Guwahati city of Assam to finally meet the mighty Brahmaputra River at a location known as Bharalumukh. The water quality of Bharalu River in Guwahati, Assam, has been a matter of concern due to pollution from various sources such as sewage discharge, industrial effluents, and solid waste dumping. Over the years, the river has faced significant degradation in water quality, leading to environmental and health hazards for the surrounding communities and ecosystems. The Bharalu River in its downstream after entering the Guwahati city acts as a sewage drain carrying large portion of the city's municipal as well as other wastes. It also serves as a natural drainage for storm water runoff apart from being treated as a sewage channel by the city dwellers. Besides, all the major industrial and refinery drains open up into the Bharalu River. Majority of the time the water quality parameters of the river is observed to obtain absurd values with elevated level of Biochemical Oxygen Demand (BOD) and depleted Dissolved Oxygen (DO) level in the river water signifying the organically polluted status of the river (Girija et al. 2007). According to a report of the Central Pollution Control Board (CPCB), Bharalu river has been identified as one of the critically polluted rivers stretch in India and is place in Priority I category i.e., water samples with highly degraded BOD levels (Anonymous 2018). More alarming is the fact that the Bharalu River directly without any treatment is flowing into the Brahmaputra River, water from which is directly been used for municipal supply water after some primary treatments.

Sewage and organic wastes from different factories like milk, slaughterhouses, starch factories and food processing factories greatly increase the productivity of water and a good number of algae grow and sometimes dominate the flora. Free-floating planktonic algae are autotrophic unicellular microscopic suspended plants residing in the limnetic zone of any water body. Phytoplankton are an important water quality monitoring factor which is an indicator of the status of the water in which they thrive. Phytoremediation involves the rearing and use of certain plant species in order to reduce eliminate, break down, or restrict the movement of environmental toxins, primarily those of anthropogenic origin, so as to attain a restored treated site. While algal bioremediation shows promise as a sustainable and cost-effective method for environmental cleanup, it also faces challenges such as the selection of suitable algal species, optimization of growth conditions, and management of algal blooms. Research in this field continues to explore new strategies and technologies to enhance the effectiveness of algal bioremediation in addressing various types of pollution. Research highlighting the significance of algal bioremediation was done from time to time by various workers (Case et al. 2008, Sakset and Chankaew 2013, Suresh et al. 2013, Shukla et al. 2015, Sarmah and Rout 2017, Malik et al. 2018, Kumari and Kumar 2019, Kumar et al. 2020).

Efforts have been made by local authorities and environmental organizations to monitor and improve the water quality of Bharalu River. This includes initiatives such as setting up sewage treatment plants, implementing pollution control measures for industries, and promoting public awareness about the importance of preserving water bodies. However, despite these efforts, challenges remain in effectively managing and restoring the water quality of Bharalu River. Therefore, the study of the Bharalu River water quality and the potent algal groups demands necessary attention with further focus on phytoremediation of the river water. Although, water quality of the Bharalu River has been widely explored by numerous workers (Girija et al. 2007, Borah et al. 2020, Bhuyan et al. 2023) but research in the field of identification of potent algal species are very scanty and therefore this pioneering study is of utmost significance.

Implementing algal bioremediation in the Bharalu River would require careful selection of suitable algal species, monitoring of water parameters, and management of algal growth to prevent unintended ecological consequences such as algal blooms. Additionally, community involvement and support from local authorities would be essential for the success of such a project. Algal bioremediation could be integrated with other water management strategies to achieve comprehensive and sustainable improvements in the water quality of the Bharalu River.

MATERIALS AND METHODS

Overview of the study area

Bharalu a perennial river flowing through the heart of Guwahati city of Assam, is a small yet important tributary of the Brahmaputra River. Having its origin at Khasi Hills of Meghalaya, the river traverses a distance of about 30 km before its confluence with Brahmaputra River. During its course, the river passes through the urban hub of Guwahati city having various landuses ranging from commercial, residential to industrial agglomerations. The study area falls under typical monsoon type of climate experiencing torrential rainfall during the monsoon months of June to September. The geographic extent of the Bharalu River at Bharalumukh is 26°10’29.9" N and 91°43’47.1" E (Fig. 1).

Sampling and analytical procedures

The present study was conducted for a period of six months i.e., from January 2022 to June 2022. The samples were collected from four different sampling stations starting from upstream to downstream viz. S_1 (Jonali), S_2 (Bhangarh), S_3 (Rajgarh) and S_4 (Bharalumukh) at about 15 cm depth from the surface and about 60 cm away from the bank of the river at bi-monthly intervals in morning hours in between 7 to 10 A.M. The sampling sites were selected mainly from the polluted river stretch within the Guwahati City. The experiments were performed in 250 ml Erlenmeyer flask each containing 100 ml of Modified Chu 10 culture media at 25°C in an orbital shaker set to 120 rpm (revolutions per minute) for 15 days. Pre-sterilization of the glassware and the growth media was done in an autoclave (20 min at 121°C) in order to avoid any contamination. Periodic mechanical stirring and mixing were done to ensure sufficient aeration of the culture media. After proper incubation and growth, identification was done under appropriate microscopic viewing following standard literature viz., Desikachary (1959), Fritch (1961), Chapman and Chapman (1962) and Devi (1981). Photographs of the species were also taken under proper magnification.

Algal count and phytoplankton density were determined following standard protocol (Kamat 1982). Sedgwick rafter plankton counting cell was used for counting the algal samples following Kamat

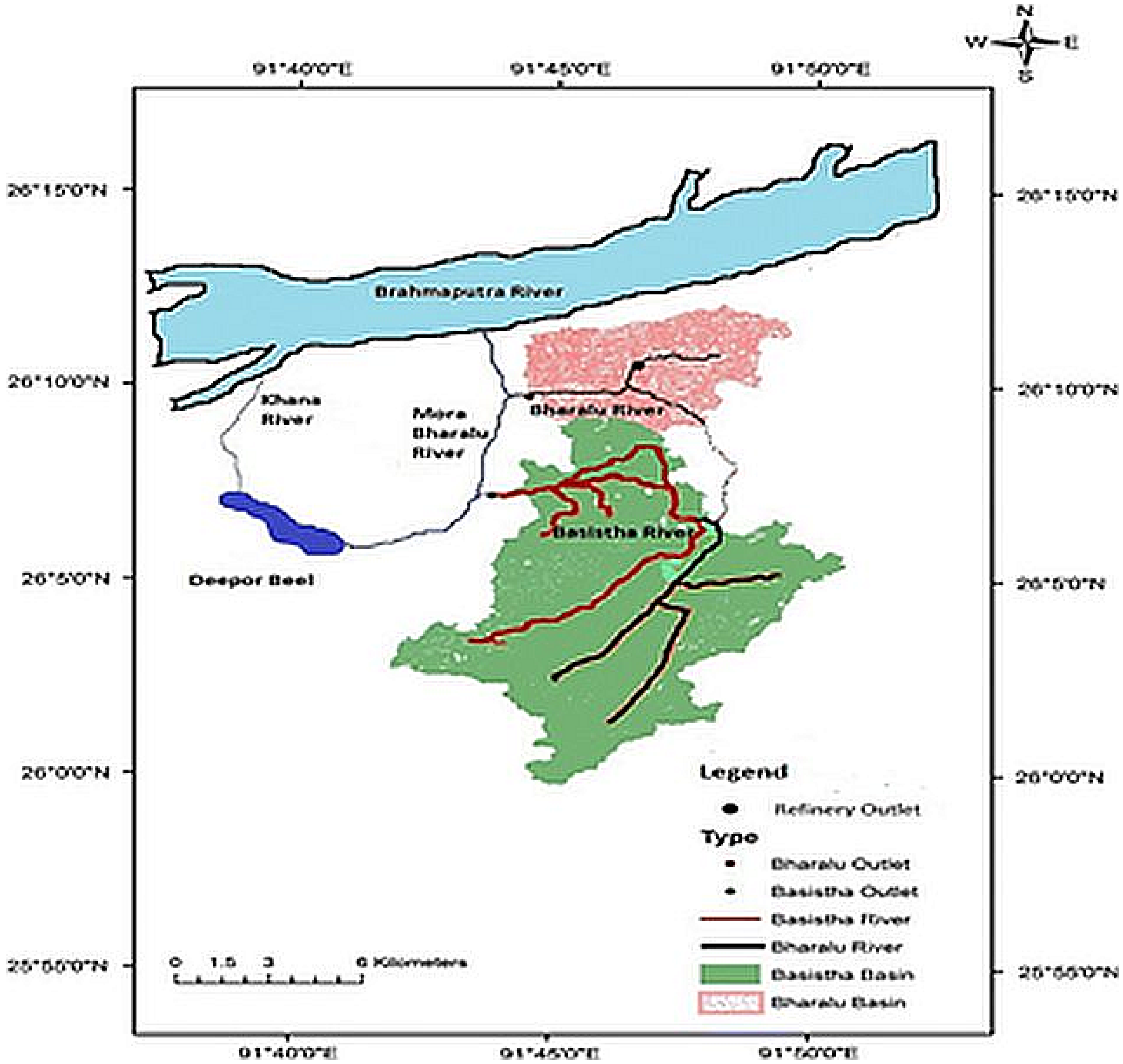

Figure 1. Catchment area map of Bharalu basin (Source: Saharia and Sarma 2018)

(1982). For quantitative estimation, standard measures of 1 ml well-mixed water sample from each sampling site were pippeted out into the measuring cell and then were carefully covered with cover slip. Thereafter, the planktons were counted under microscope. As a standard protocol at least three replicates were done for each sample and then average is calculated out. Phytoplankton density (units/liter) was then estimated as the ratio of number of algal counts per volume of sample. Moreover, ecological indices such as Similarity index (S_s) (Sorensen 1948), Diversity index (H) (Nolan and Callahan 2006) and Evenness index (J) (Pielou 1966) were also computed.

RESULTS AND DISCUSSION

Algal growth was noticed within 10-15 days after the water samples were provided with Modified Chu 10 media and kept in optimal incubation conditions of light and temperature. LED lights kept at a distance of about 40 cm from the cultures were used for illumination while the temperature was maintained within a range of 20 to 30°C. After proper incubation

Table 1. Phytoplankton composition of Bharalu River

Family/Species	S_1	S_2	S_3	S_4
Chlorophyceae				
1. *Chlorella vulgaris* Beij.	+	+	+	+
2. *Closterium dianae*	+	+	_	_
3. *Closterium eboracense*	+	_	+	_
4. *Closterium venus*	+	_	+	+
5. *Cosmerium moniliforme* var. *subpyriforme*	_	_	+	_
6. *Cosmerium moniliforme* var. *punctata*	+	+	_	+
7. *Myxosarcia* sp.	+	_	+	+
8. *Scenedesmus acuminatus*	+	+	+	+
9. *Scenedesmus armatus*	+	+	+	+
10. *Scenedesmus bijugatus*	+	+	+	+
11. *Scenedesmus brasiliensis*	+	+	+	+
12. *Scenedesmus communis*	+	+	+	+
13. *Scenedesmus decorus*	+	_	_	+
14. *Scenedesmus denticulatus*	+	_	+	_
15. *Scenedesmus dimorphus*	+	+	+	+
16. *Scenedesmus incrassalatus*	_	+	_	+
17. *Scenedesmus ornatus* Hortob.	_	+	+	_
18. *Scenedesmus quadricauda*	+	+	_	+
19. *Selenastrum gracile*	_	+	+	_
20. *Selenastrum* sp.	+	_	_	_
Bacillariophyceae				
21 *Cyclotella* sp.	+	_	_	+
22 *Fragillaria crotonensis*	+	+	+	+
23 *Pinnuleria viridis*	+	+	+	+
24 *Pinnuleria meisteri* A cl var *Scandica*	+	_	+	_
25 *Navicula cryptocephaloids* Hustedt.	+	_	+	+
26 *Navicula* sp.	+	+	_	_
27 *Nitzschia* sp.	+	+	_	+
28 *Synendra* sp.	_	+	+	_
Cyanophyceae				
29. *Chroococus montanus* Hansging.	+	+	+	+
30. *Merismopedia gluca*	+	_	_	_
31. *Microcystis aeruginosa*	+	+	+	+
Euglenophyceae				
32. *Euglena acus* Her.	+	_	+	+
33. *Euglena viridis*	_	+	_	_
TOTAL	27	21	22	21

N.B: += present and _ = absent

and microscopic viewing, a total of 33 algal species belonging to 4 families viz., Chlorophyceae, Bacillariophyceae, Cyanophyceae and Eglenophyceae were recorded during the study period. Although, the anoxic condition of the river does not support any major aquatic population in the river (Girija et al. 2007), however, on the contrary the existence of algae is indeed a good indication and provides wide prospects for bio-monitoring of the pollution condition.

Phytoplankton composition

With the observation of 33 algal species, the water samples of Bharalu River exhibit quite a good bio-diversity of planktons as reported in other organically polluted river like that of Damodar River, a major tributary of Ganga River (Dora et al. 2015). A maximum of 20 species belongs to Chlorophyceae followed by Bacillariophyceae, Cyanophyceae and Euglenaceae with 8, 3 and 2 species, respectively. *Scenedesmus* is observed to be the most dominant genera with a total of 11 species. Algal genera of *Euglena, Oscillatoria, Scenedesmus, Navicula, Nitzschia* and *Microcystis* were very common in the study sites (Table 1) which is in conformity with Nandan and Aher (2005) in organically polluted waters. Similarly, it has been reported that excessive growth of certain algal genera, viz., *Chlorella*, *Scenedesmus* and *Microcystis* indicate nutrient enrichment of aquatic bodies Zargar and Ghosh (2006) which also points out the organically degraded status of the Bharalu river water.

Phytoplankton count and density calculation

The results of station wise monthly variation of phytoplankton density demonstrate maximum algal count during the months of Jan - Feb and minimum during the months of May - June at all the four sampling stations (Table 2). This may be because generally during January and February the river contains minimum amount of flow and hence algal load is more which gets diluted once rainfall starts. Reduced flow often leads to higher concentrations of nutrients in the water, particularly in stagnant areas or slow-moving sections of the river (Giller and Malmqvist 1998). As with less water flow, pollutants and excess nutrients from sources like agriculture, urban runoff, and wastewater discharge also becomes more concentrated in the river, providing additional nutrients for algal growth. These nutrients, such as nitrogen and phosphorus, act as fertilizers for algal growth. Overall, reduced flow conditions in rivers create favorable conditions for algal growth (Kim et al. 2021).

Similarity and diversity indices

In the present study, the similarity index of algal species between stations ranges from 0.65 to 0.83. The water samples of S_1 and S_4 are the most similar ones with a similarity index value of 0.83. Community activities and human interference in the form of municipal solid waste dumping is maximum near S_1 and S_4 sites (i.e., Jonali and Bharalumukh sites) indicating most similar samples (Bora 2022). Least similar samples are those of S_2 and S_3 having a similarity index value of 0.65. Similar results indicating the fact that water samples with identical environmental conditions exhibits almost similar

Table 3. Similarity index of different sampling stations

Sampling stations	S_1	S_2	S_3	S_4
S_1	1	0.66	0.747	0.830
S_2		1	0.651	0.714
S_3			1	0.697
S_4				1

Table 2. Monthly variation of phytoplankton density

Sampling sites	Phytoplankton density (units/l)		
	Jan – Feb	Mar – Apr	May – June
S_1	19.00×10^3 (± 1.826)	16.25×10^3 (± 1.71)	14.25×10^3 (± 1.5)
S_2	17.00×10^3 (± 2.217)	13.00×10^3 (± 1.633)	11.75×10^3 (± 1.732)
S_3	16.75×10^3 (± 2.217)	16.00×10^3 (± 2.160)	15.00×10^3 (± 1.414)
S_4	15.25×10^3 (± 1.707)	14.75×10^3(± 1.258)	13.25×10^3 (± 2.217)

species composition had been reported by earlier workers (Nasir et al. 2023). The similarity index values among different samples collected from different sampling stations are given in Table 3.

According to Shannon and Weiner diversity index, >4 is clean water; between 3 and 4 is mildly polluted water; between 2 and 3 is moderately polluted water and <2 is heavily polluted water (Albueajee et al. 2020). The Shannon-Weiner diversity index thus proposed that lower the value of diversity index, higher will be the pollution level of water. The species diversity indices computed in the present analysis showed that phytoplankton species diversity ranged between a minimum value of 1.627 (during Jan-Feb at S_4) to a maximum value of 2.620 (during Mar-Apr at S_2), indicating heavy to moderately polluted water.

The average diversity index value was observed to be minimum i.e., 1.822 (indicating highly polluted water) during the months of January and February signifying the lean season when water flow is meager as compared to the other studied months (Table 4). In nut-shell it can be summarised that although algal count is more during the dry seasons however, species are less diverse during those season. Therefore, diversity index provides a valuable insight regarding the water quality of the river water samples.

Likewise, evenness index is also a valuable tool for assessing biodiversity and ecosystem health. High evenness index value suggests a balanced distribution of resources and a robust ecosystem, while low evenness may indicate vulnerability to disturbances or environmental changes. The month wise average values of evenness index ranges between 0.491 (Jan-Feb) to 0.6 (Mar-April). The evenness index of the Bharalu River indicates more or less equal distribution of species along all the sampling sites and suggests that all the recorded algal species can survive extreme pollution levels (Table 4).

Both diversity index as well as evenness index shows minimum values during the months of January and February which is mainly because of the fact that these months belong to lean season when there is scanty flow in the rivers of this region. Similar results were also reported by Nwinyimagu et al. (2021) and Pokhrel et al. (2021). However, as the months proceeds there is the occurrence of periodic rainfall events with the onset of *Nor-wester* or Kal-Baishakhi and thereby diluting the water and reducing the pollution level and hence resulting in the increase in the diversity as well as evenness index values.

CONCLUSIONS

Water pollution has become a major environmental threat throughout the world including India. Besides chemical pollutants, organic pollutants under the impact of uncontrolled population growth and urbanization are now-a-days turning out to be the chief cause of concern. Although, the prospect of water quality degradation is widely explored in case of Bharalu river, however, the biological aspect of the river is hardly addressed by any worker. The present investigation has therefore been undertaken to identify the pollution tolerant phytoplankton species of River Bharalu which is disgraced for its pollution status. The diversity indices values of phytoplankton below 2 indicate heavy pollution in the river. Still, it harbors around 33 species of phytoplankton belonging to four different classes. It

Table 4. Station wise diversity index and evenness index

Sampling sites	Jan – Feb		Mar – Apr		May – June	
	Diversity Index	**Evenness Index**	**Diversity Index**	**Evenness Index**	**Diversity Index**	**Evenness Index**
S_1	1.873	0.510	2.492	0.610	1.925	0.512
S_2	1.828	0.547	2.620	0.590	2.242	0.490
S_3	1.961	0.457	2.580	0.610	2.001	0.570
S_4	1.627	0.450	2.314	0.560	1.871	0.500
Average	**1.822**	**0.491**	**2.5**	**0.6**	**2.01**	**0.518**

has been observed that the presence and abundance of algal species in the Bharalu River vary seasonally.

The existence of phytoplankton species in such a polluted river rightly signifies the scope of algal bioremediation in river water. The observed pollution tolerant species can be grown as pure culture and their bio-remediation potential can be explored which can come out as an effective pollution abetment strategy for organically polluted rivers in the long run. Therefore, based upon this study it can be concluded that organically polluted river with completely anoxic conditions can also support some forms of planktonic life and if they can be efficiently exploited for bioremediation purpose than a broad spectrum can be achieved in this domain. However, it's important to note that while algal bioremediation shows promise, it is not a standalone solution and should be part of a broader watershed management strategy. Additionally, proper planning, monitoring, and maintenance are crucial for the long-term success of algal bioremediation projects in rivers like Bharalu. Continuous monitoring, strict enforcement of regulations, community participation, and sustainable urban planning are also essential for ensuring the long-term health and sustainability of the river ecosystem.

Conflict of interest*:* The author declares no competing interests

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