

ORIGINAL ARTICLE

Correlation between Physico-chemical Parameters & Inorganic Ions with Microalgal Diversity of Damodar and Kopai River Ecosystems during 2024 - 2025

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ABSTRACT

The present study stress on the correlation between physicochemical parameters, significant inorganic ions and microalgal diversity in the Damodar and Kopai river ecosystems during 2024-2025. Physicochemical parameters and biologically inorganic ions are crucial for the survival, growth, and diversity of microalgae in any aquatic ecosystems. They act as essential nutrients, play an important role in osmotic balance, and influence various physiological processes such as photosynthesis, respiration, metabolism, and enzyme activity etc. in microalgal organisms. The present survey revealed the variations of physicochemical parameters like temperature, pH, TDS, conductance, salinity, DO, turbidity, BOD, hardness and inorganic ions like Na^+ , K^+ , Ca^{2+} , NO_3^- , CO_3^{2-} , HCO_3^- , total alkalinity, carbonate alkalinity, and bicarbonate alkalinity in the Damodar and Kopai rivers. The Damodar river is a rain-fed river, shallow, wide, and flashy. It originates near Khamarpat hill on the Chotanagpur plateau in the Palamau district of Jharkhand, and its mouth is the Hooghly river in the Howrah district of West Bengal. The Damodar river was earlier known as the "river of sorrow" because it used to flood many areas of Bardhaman, Hooghly, Howrah, and Medinipur districts. The length of the river is 592 km. The Kopai river is the smallest in West Bengal, flowing across the Rarh Bengal region. This river is a tributary of the Bakreshwar river. The Kopai river originates from the foothills of the Chotanagpur plateau in Jharkhand state, India, and ultimately merges with the Mayurakshi river. The length of this river is 176.4 km. Results revealed that 25 species of algal genera from the Damodar river and 21 algal species from the Kopai River were observed during the period from 2024 to 2025. Fluctuations of these physicochemical parameters and inorganic ions significantly affect the growth and diversity of microalgae in the river ecosystems.

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KEYWORDS

- Ecosystem • Physicochemical parameters • Inorganic ions • Temperature
- Damodar • Kopai

INTRODUCTION

A river ecosystems are always lotic ecosystem. A freshwater aquatic ecosystem consists of Physicochemical parameters and Inorganic ions dissolved in water, and aquatic plants and animals. Algae are a vast group of prokaryotic and eukaryotic organisms and also have diverse forms of thallus organisation like unbranched filamentous, branched filamentous, unicellular, colonial and siphonacious forms, etc. They are a large group of plant organisms and are cosmopolitan in nature. Algae are vital for the primary productivity of river ecology and also a rich source of protein, carbohydrates and fatty acids. On the other hand, algae respond promptly with respect to the environmental changes related to other plants and animals. The dominance of diatoms and green algae in river water indicates clean and oligotrophic water quality and an aquatic ecosystem. In contrast, the formation of blue-green algal bloom indicates that the water quality and aquatic ecosystem are polluted or eutrophic (Debnath, T. *et al.*, 2024). The Damodar River is a rain-fed river, shallow, wide, and flashy. It originates near Khamarpat hill on the Chotanagpur plateau in the Palamau district of Jharkhand, and its mouth is the Hooghly river in the Howrah district of West Bengal. The Damodar river flows through the industrial towns of Chandrapura, Ramgarh, Bokaro, Jharia, Sindri, Dhanbad, Asansol, Andal, Durgapur, Burdwan, and Howrah before joining the lower Ganga at Shayampur, 55 km downstream of Howrah. This river is one of the important rivers of India that flows across the Indian states of Jharkhand and West Bengal (Mondal, G. C. *et al.*, 2018). The Damodar river was earlier known as the “river of sorrow” because it used to flood many areas of Bardhaman, Hooghly, Howrah, and Medinipur districts. The length of the river is 592 km (368 miles). During the monsoon season, heavy rain causes the river to flood the adjoining areas, while in summer, the sand beds are almost always dry. The

Damodar river has several tributaries and sub-tributaries, including Barakar, Konar, Bokaro, Haharo, Jamunia, Ghari, Guaia, Khadia, and Bhera (Bhattacharyya, K., 2011). The Kopai River is the smallest in West Bengal, flowing across the Rarh Bengal region. This river is a tributary of the Bakreshwar river and passes through Santiniketan, Bolpur, Kankalitala, Kirnagar, and Labhpur in the Birbhum district of the Indian state of West Bengal. Though it is a small river in the dry season, it overflows its banks during the monsoon. The towns and surrounding villages like Chhora, Nichinta, Rupuspur, and Perua depend on this river (Ghosal, J., 2018). The Kopai river originates from the foothills of the Chotanagpur plateau in Jharkhand state, India, and ultimately merges with the Mayurakshi river. The length of this river is 176.4 km. Fluctuations of these physicochemical parameters and inorganic ions significantly affect the growth and diversity of microalgae in both rivers.

METHODS

Study area

The present work was the outcome of the extensive survey of the three different points or ghats of the Damodar and Kopai rivers during 2024-2025 in different months of the year to cover the variation of algae in all the seasons of the year. With the algae, physicochemical parameters of river water (Damodar and Kopai) will also be analysed during 2024-2025 in different months of the year.

Table 1: Location

Damodar River	Kopai River
Sadarghat Park (Lat. 23.1615° & Long. 88.0167°)	Kankalitala (Lat. 23.715375° & Long. 87.710334°)
Chanchai Ghat (Lat. 23.2290° & Long. 87.8316°)	Kopai River View Point (Lat. 23.708481° & Long. 87.670715°)
Fakirpur Ghat (Lat. 23.2290° & Long. 87.8316°)	Kopai River Railway Bridge (Lat. 23.711592° & Long. 87.693262°)

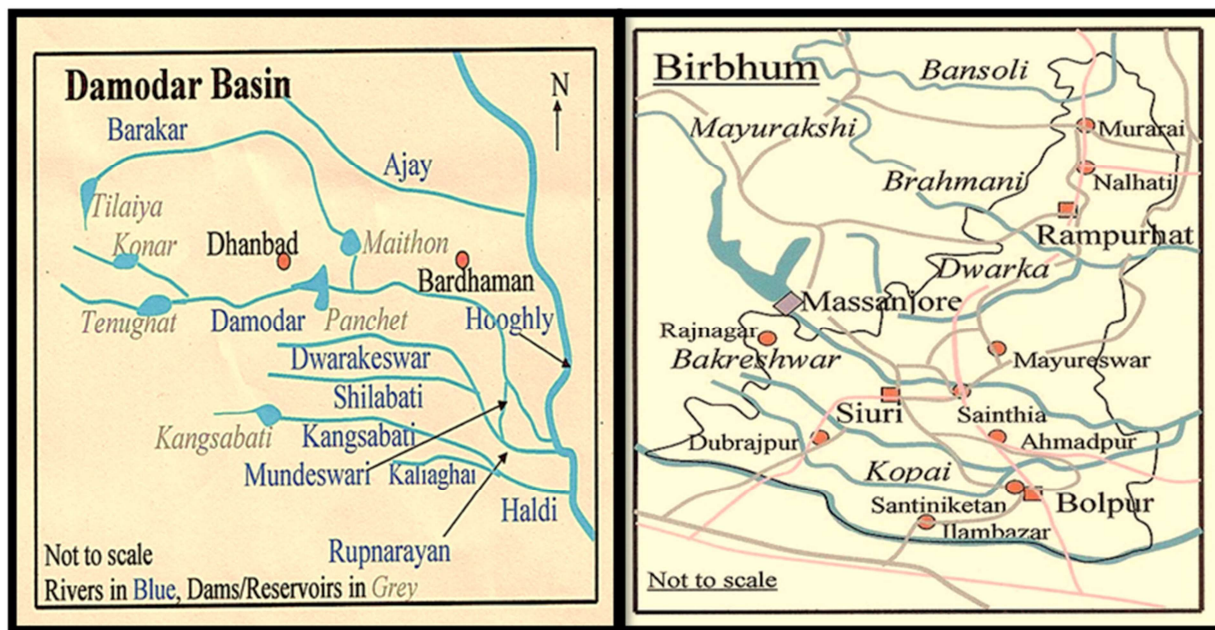


Figure 1: Damodar and Kopai rivers basin (source: Google).

METHODS

Study of microalgae

Sterilised PVC sampling bottles were used to collect water and algae samples from different depths of the river. For algal blooms near the riverbank, bottles and a plankton net were used directly (Debnath, T. *et al.*, 2024). In some cases, expert swimmers and boats were employed to collect algae from deeper waters. After collection, the samples were preserved using suitable fixatives and preservatives for further analysis. Microscopic observations were performed using standard methods. Identification of various algal taxa was conducted using standard literature while following a proper classification system. Finally, algal samples were observed and documented. For the study of the Similarity

Coefficient, we used Sorenson's Similarity Index (SSI) (Sorenson, P. A., 1948) and Jaccard's Similarity Index (JSI) (Jaccard, P., 1912).

Study of physicochemical parameters and inorganic ions of water samples

On-site measurements of physicochemical parameters, including pH, conductivity, total dissolved solids, salinity, and temperature, were conducted using appropriate scientific instruments. The hardness, carbonate ions, bicarbonate ions, and alkalinity were determined using the Titrimetric method. Sodium, calcium, and potassium ion concentrations were measured with a flame photometer. Phosphate and nitrate ion concentrations were analysed using a Systronics ion meter (Ray, M. *et al.*, 2021).

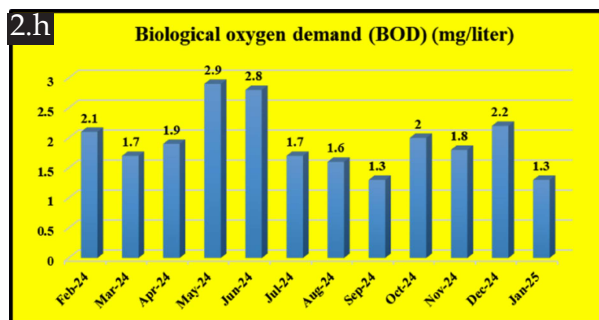
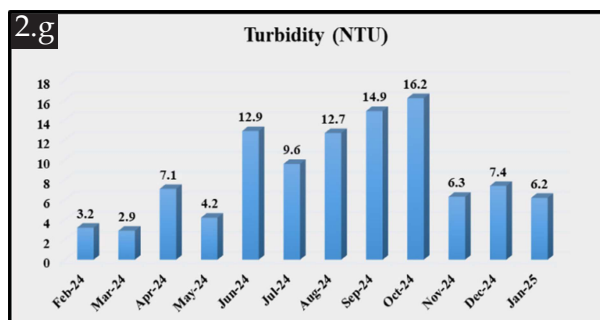
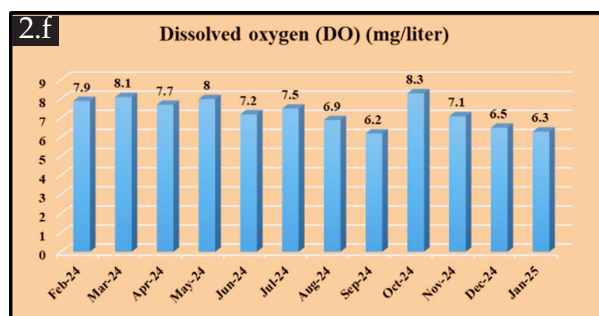
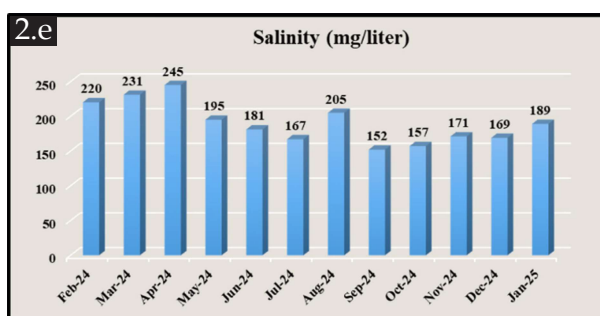
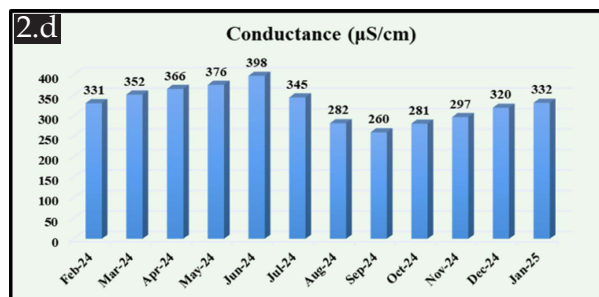
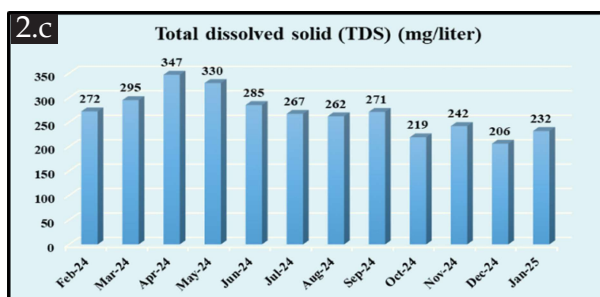
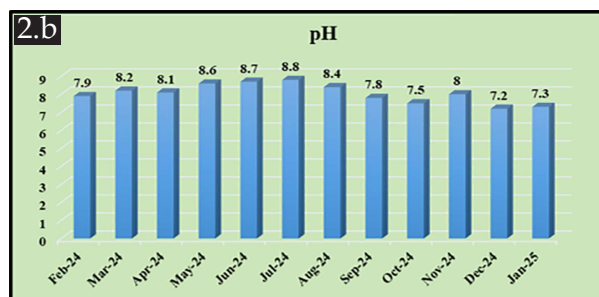
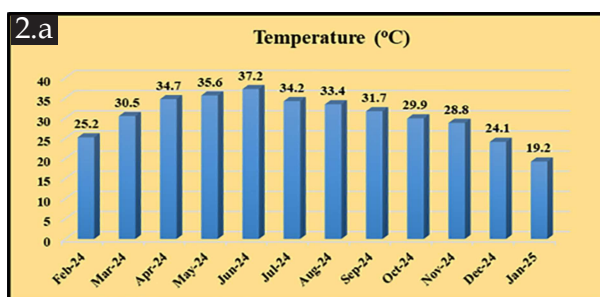
RESULTS

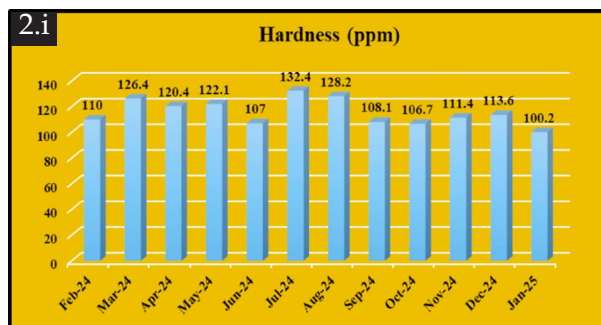
Table 2: Monthly variation of the physicochemical parameters of the Damodar River water throughout the year 2024 to 2025:

Month	Temperature (oC)	pH	TDS (mg/liter)	Conductance (µS/cm)	Salinity (mg/liter)	DO (mg/liter)	Turbidity (NTU)	BOD (mg/liter)	Hardness (ppm)
February 2024	25.2	7.9	272	331	220	7.9	3.2	2.1	110
March 2024	30.5	8.2	295	352	231	8.1	2.9	1.7	126.4
April 2024	34.7	8.1	347	366	245	7.7	7.1	1.9	120.4
May 2024	35.6	8.6	330	376	195	8.0	4.2	2.9	122.1

table cont....

Month	Temperature (oC)	pH	TDS (mg/liter)	Conductance (μ S/cm)	Salinity (mg/liter)	DO (mg/liter)	Turbidity (NTU)	BOD (mg/liter)	Hardness (ppm)
June 2024	37.2	8.7	285	398	181	7.2	12.9	2.8	107
July 2024	34.2	8.8	267	345	167	7.5	9.6	1.7	132.4
August 2024	33.4	8.4	262	282	205	6.9	12.7	1.6	128.2
September 2024	31.7	7.8	271	260	152	6.2	14.9	1.3	108.1
October 2024	29.9	7.5	219	281	157	8.3	16.2	2.0	106.7
November 2024	28.8	8.0	242	297	171	7.1	6.3	1.8	111.4
December 2024	24.1	7.2	206	320	169	6.5	7.4	2.2	113.6
January 2025	19.2	7.3	232	332	189	6.3	6.2	1.3	100.2



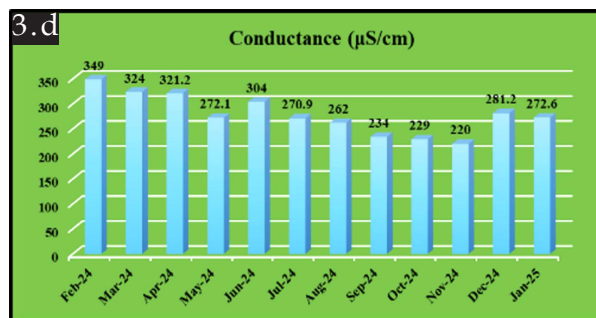
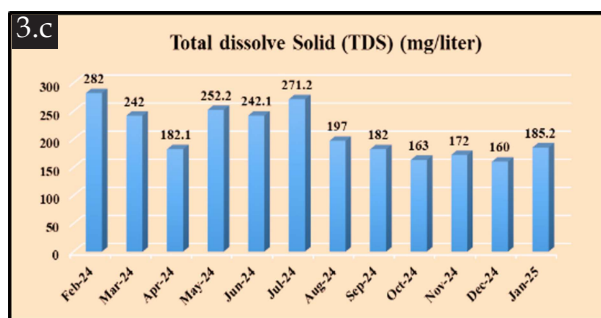
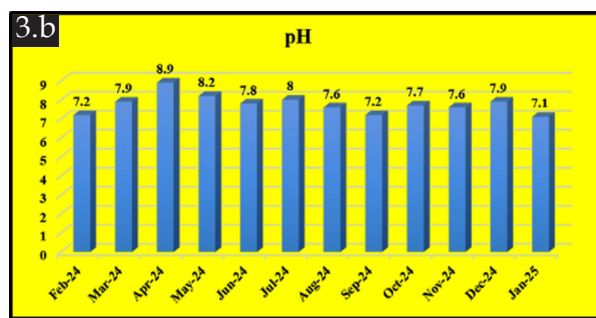
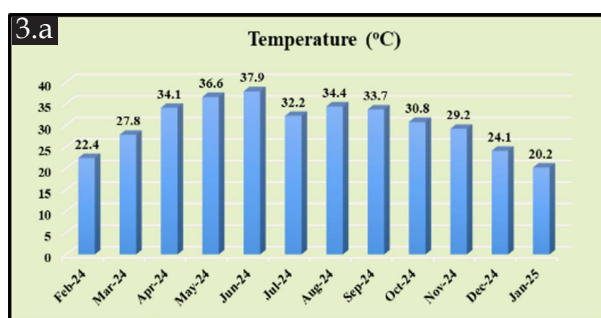


- 2.a. Temperature (°C)
- 2.b. pH
- 2.c. Total Dissolved Solid (mg/liter)
- 2.d. Conductance (µS/cm)
- 2.e. Salinity (mg/liter)
- 2.f. Dissolved Oxygen (mg/liter)
- 2.g. Turbidity (NTU)
- 2.h. Biological Oxygen Demand (mg/liter)
- 2.i. Hardness (ppm)

Plate I: Graphical representation of the monthly variation of the physicochemical parameters of the Damodar River water throughout the year 2024 to 2025

Table 3: Monthly variation of the physicochemical parameters of the Kopai River water throughout the year 2024 to 2025:

Month	Temperature (oC)	pH	TDS (mg/liter)	Conductance (µS/cm)	Salinity (mg/liter)	DO (mg/liter)	Turbidity (NTU)	BOD (mg/liter)	Hardness (ppm)
February 2024	22.4	7.2	282	349	162	7.2	3.2	1.6	132.4
March 2024	27.8	7.9	242	324	170	7.1	3.1	1.8	136.0
April 2024	34.1	8.9	182.1	321.2	174	7.3	3.5	2.1	142.2
May 2024	36.6	8.2	252.2	272.1	163	6.7	1.7	2.0	130.1
June 2024	37.9	7.8	242.1	304	130.2	6.8	1.6	1.8	123.4
July 2024	32.2	8.0	271.2	270.9	146.6	6.6	12.9	2.9	102.4
August 2024	34.4	7.6	197	262	121.2	7.0	18.6	1.9	104.3
September 2024	33.7	7.2	182	234	173	7.3	4.2	1.6	107.4
October 2024	30.8	7.7	163	229	112	6.7	6.7	1.7	121.4
November 2024	29.2	7.6	172	220	142	7.2	12.4	2.1	120.7
December 2024	24.1	7.9	160	281.2	152.2	6.6	9.2	1.6	116.9
January 2025	20.2	7.1	185.2	272.6	163	6.7	10.1	1.3	111.4



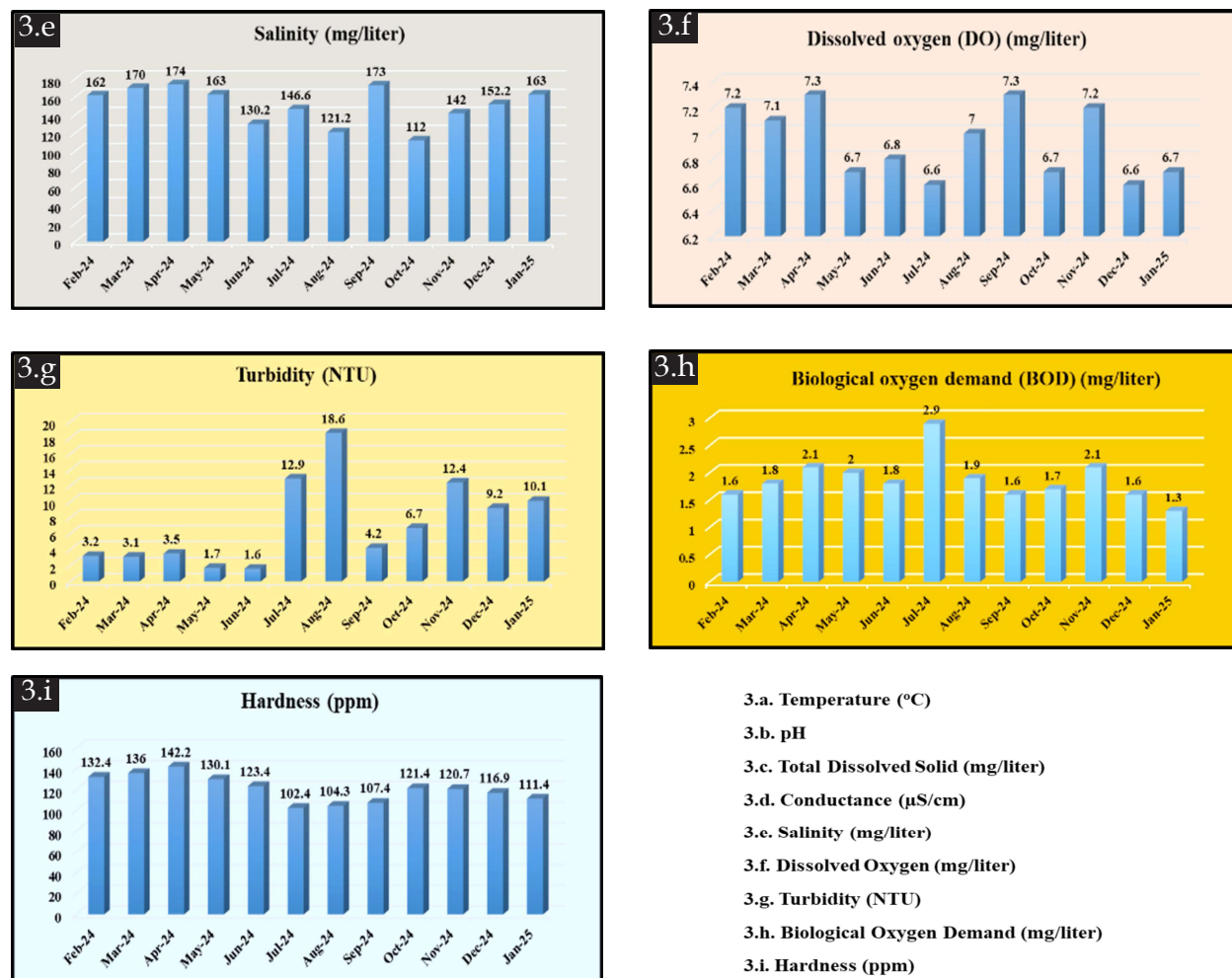
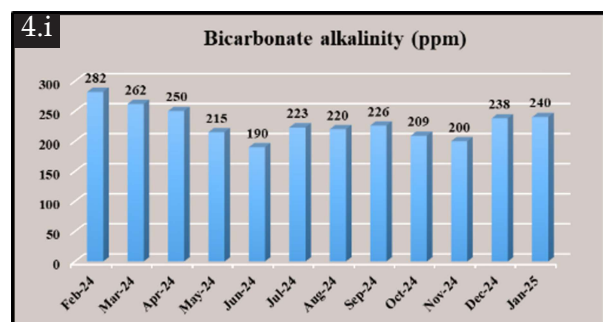
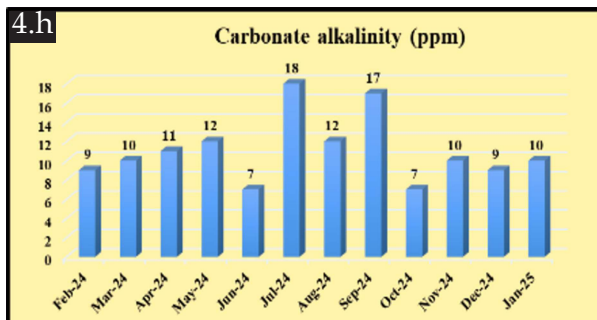
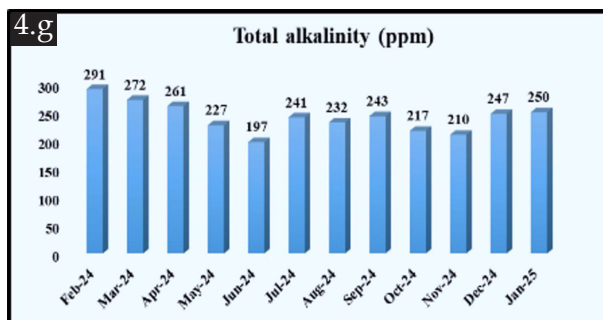
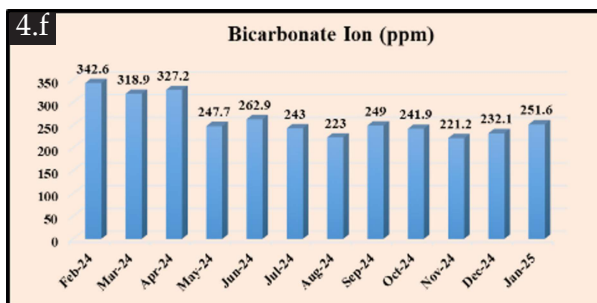
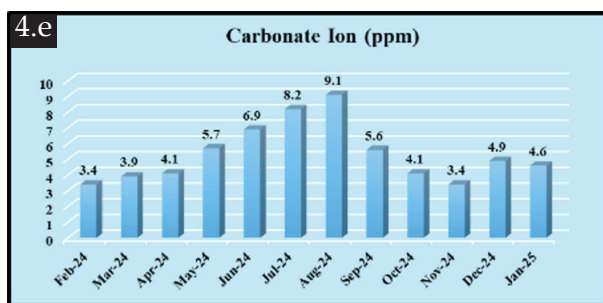
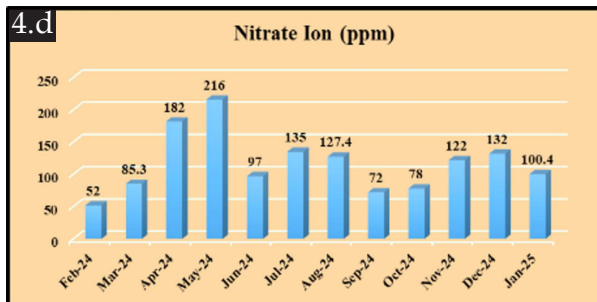
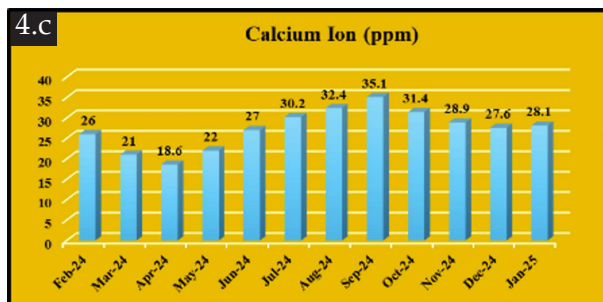
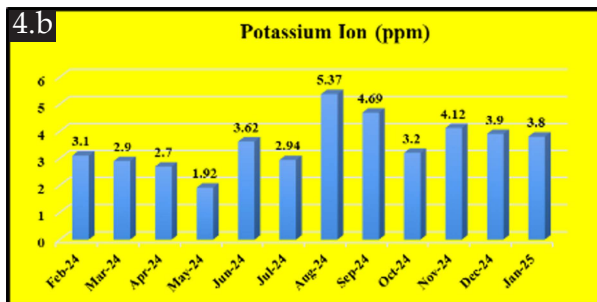
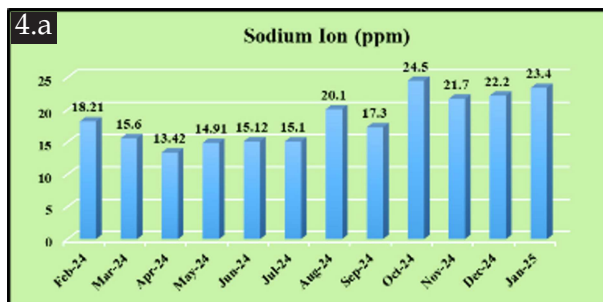


Plate II: Graphical representation of the monthly variation of the physicochemical parameters of the Kopai River water throughout the year 2024 to 2025

Table 4: Monthly variation of the Inorganic ions of the Damodar River water throughout the year 2024 to 2025:

Month	Sodium ion (Na ⁺) (ppm)	Potassium ion (K ⁺) (ppm)	Calcium ion (Ca ²⁺) (ppm)	Nitrate ion (NO ₃ ⁻) (ppm)	Carbonate ion (CO ₃ ⁼) (ppm)	Bicarbonate ion (HCO ₃ ⁻) (ppm)	Total alkalinity (ppm)	Carbonate alkalinity (ppm)	Bicarbonate alkalinity (ppm)
February 2024	18.21	3.1	26	52	3.4	342.6	291	9	282
March 2024	15.60	2.9	21	85.3	3.9	318.9	272	10	262
April 2024	13.42	2.7	18.6	182	4.1	327.2	261	11	250
May 2024	14.91	1.92	22	216	5.7	247.7	227	12	215
June 2024	15.12	3.62	27	97	6.9	262.9	197	7	190
July 2024	15.10	2.94	30.2	135	8.2	243	241	18	223
August 2024	20.1	5.37	32.4	127.4	9.1	223	232	12	220
September 2024	17.3	4.69	35.1	72	5.6	249	243	17	226
October 2024	24.5	3.2	31.4	78	4.1	241.9	217	7	209
November 2024	21.7	4.12	28.9	122	3.4	221.2	210	10	200
December 2024	22.2	3.9	27.6	132	4.9	232.1	247	9	238
January 2025	23.4	3.8	28.1	100.4	4.6	251.6	250	10	240

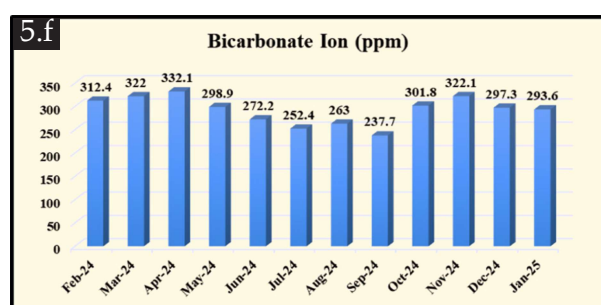
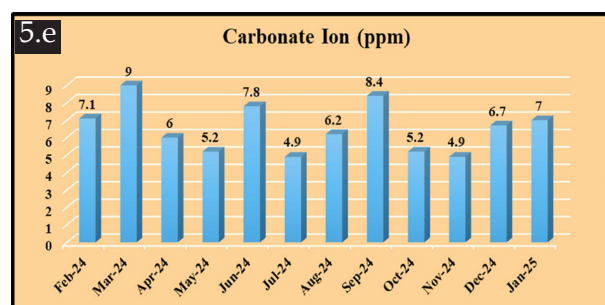
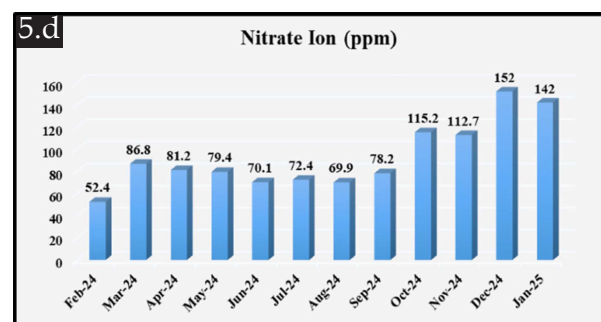
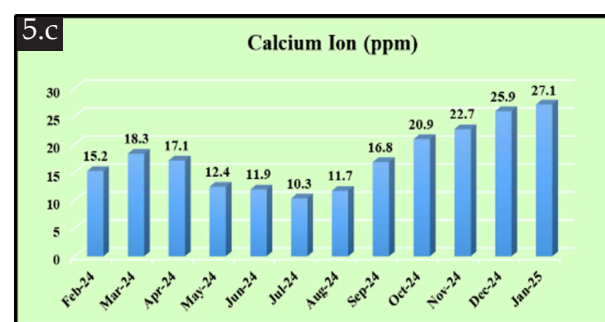
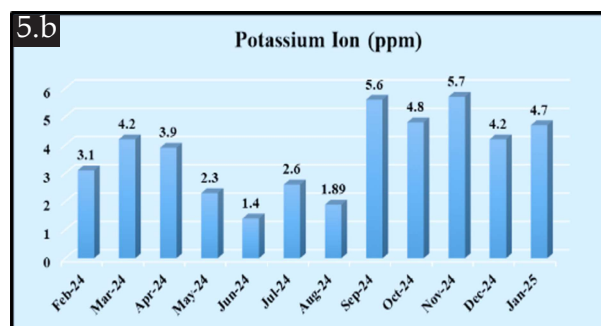
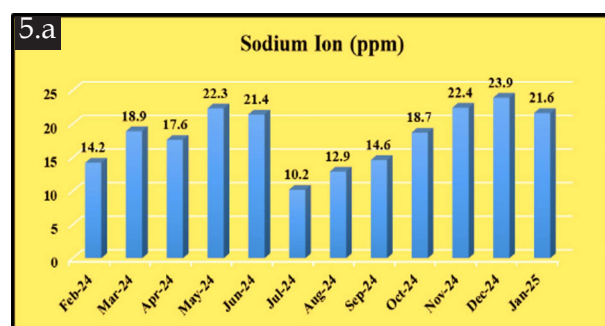


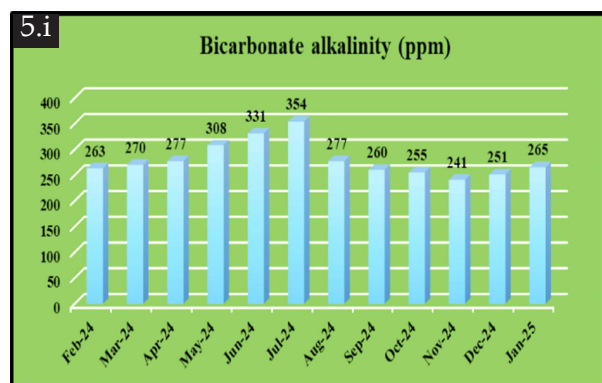
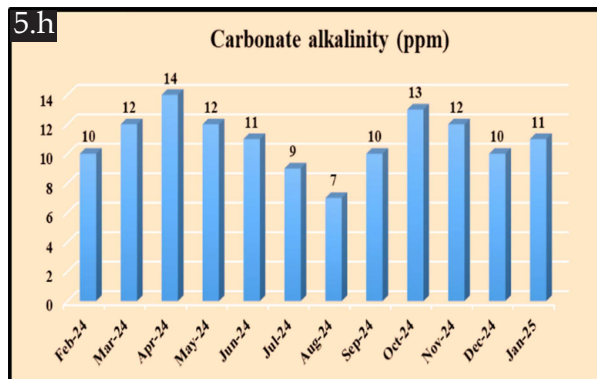
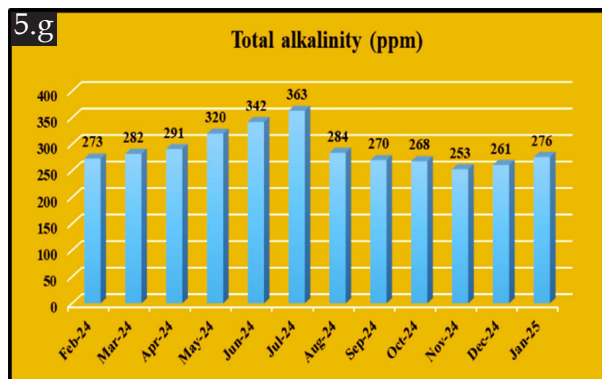
- 4.a. Sodium ion concentration (Na^+) (ppm)
- 4.b. Potassium ion concentration (K^+) (ppm)
- 4.c. Calcium ion concentration (Ca^{2+}) (ppm)
- 4.d. Nitrate ion concentration (NO_3^-) (ppm)
- 4.e. Carbonate ion concentration (CO_3^{2-}) (ppm)
- 4.f. Bicarbonate ion concentration (HCO_3^-) (ppm)
- 4.g. Total alkalinity (ppm)
- 4.h. Carbonate alkalinity (ppm)
- 4.i. Bicarbonate alkalinity (ppm)

Plate III: Graphical representation of the monthly variation of the inorganic ions of the Damodar River water throughout the year 2024 to 2025

Table 5: Monthly variation of the Inorganic ions of the Kopai River water throughout the year 2024 to 2025:

Month	Sodium ion (Na ⁺) (ppm)	Potassium ion (K ⁺) (ppm)	Calcium ion (Ca ²⁺) (ppm)	Nitrate ion (NO ₃ ⁻) (ppm)	Carbonate ion (CO ₃ ⁼) (ppm)	Bicarbonate ion (HCO ₃ ⁻) (ppm)	Total alkalinity (ppm)	Carbonate alkalinity (ppm)	Bicarbonate alkalinity (ppm)
February 2024	14.2	3.1	15.2	52.4	7.1	312.4	273	10	263
March 2024	18.9	4.2	18.3	86.8	9	322	282	12	270
April 2024	17.6	3.9	17.1	81.2	6	332.1	291	14	277
May 2024	22.3	2.3	12.4	79.4	5.2	298.9	320	12	308
June 2024	21.4	1.4	11.9	70.1	7.8	272.2	342	11	331
July 2024	10.2	2.6	10.3	72.4	4.9	252.4	363	9	354
August 2024	12.9	1.89	11.7	69.9	6.2	263	284	7	277
September 2024	14.6	5.6	16.8	78.2	8.4	237.7	270	10	260
October 2024	18.7	4.8	20.9	115.2	5.2	301.8	268	13	255
November 2024	22.4	5.7	22.7	112.7	4.9	322.1	253	12	241
December 2024	23.9	4.2	25.9	152	6.7	297.3	261	10	251
January 2025	21.6	4.7	27.1	142	7	293.6	276	11	265





- 5.a. Sodium ion concentration (Na⁺) (ppm)
- 5.b. Potassium ion concentration (K⁺) (ppm)
- 5.c. Calcium ion concentration (Ca²⁺) (ppm)
- 5.d. Nitrate ion concentration (NO₃⁻) (ppm)
- 5.e. Carbonate ion concentration (CO₃⁼) (ppm)
- 5.f. Bicarbonate ion concentration (HCO₃⁻) (ppm)
- 5.g. Total alkalinity (ppm)
- 5.h. Carbonate alkalinity (ppm)
- 5.i. Bicarbonate alkalinity (ppm)

Plate IV: Graphical representation of the monthly variation of the inorganic ions of the Kopai River water throughout the year 2024 to 2025

Table 6: Presence and absence of microalga species of the Damodar and Kopai River throughout the year 2024 to 2025:

Name of the microalgal species	Damodar River	Kopai River
<i>Anabaena sp.</i>	+	+
<i>Gloeocapsa sp.</i>	+	-
<i>Lyngbya ceylanica</i> Wille.	+	+
<i>Microcystis sp.</i>	+	+
<i>Oscillatoria amoena</i> (Kutz) G.omont.	+	+
<i>Phormidium sp.</i>	+	+
<i>Rivularia sp.</i>	+	-
<i>Scytonema simplex</i> Bharadwaja, nom. illeg.	-	+
<i>Cladophora glomerata</i> Kutz.	+	+
<i>Hydrodictyon indicum</i> M.O.P.Iyengar	+	-
<i>Hydrodictyon reticulatum</i> (Linnaeus) Bory	+	-
<i>Oedogonium oblongum</i> Witttr.	+	+

Name of the microalgal species	Damodar River	Kopai River
<i>Oedogonium vulgare</i> Kirch.	+	+
<i>Scenedesmus denticulatus</i> Lag.	+	+
<i>Aulacoseira granulate</i> (Ehrenb.) Simonsen	+	+
<i>Cymbella acuta</i> C. Agardh.	+	+
<i>Cymbella aculeate</i> C.Agardh.	+	+
<i>Gomphonema parvulum</i> (Hantz)	+	+
<i>Melosira sp.</i>	+	+
<i>Navicula sp.</i>	+	+
<i>Synedra ulna</i> Nitz.	+	+
<i>Ulothrix zonata</i> (F.Weber & Mohr) Kutzing.	+	+
<i>Vaucheria amphibian</i> Randhawa.	+	+
<i>Closterium sp.</i>	+	+
<i>Spirogyra sp.</i>	+	+
<i>Zygnema sp.</i>	+	-

Table 7: Similarity Coefficient of microalgae of the Damodar and Kopai Rivers:

Plant type	Sorenson's Similarity Index (SSI)	Jaccard's Similarity Index (JSI)
Microalgae	0.8696	0.7692

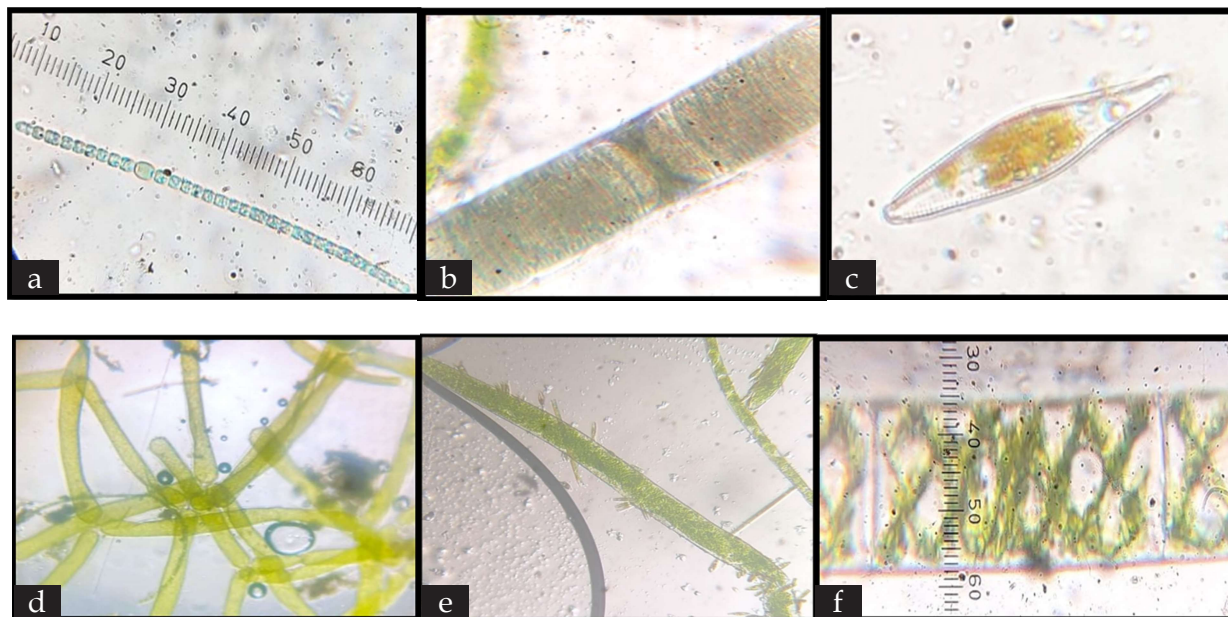


Plate V: Some microalgae from the study area (microscopic view), a. *Anabaena* sp., b. *Lyngbya ceylanica* Wille., c. *Navicula* sp., d. *Hydrodictyon reticulatum* (Linnaeus) Bory, e. *Cladophora glomerata* Kutz., f. *Spirogyra* sp.

DISCUSSION

The detailed analysis of physicochemical parameters reveals that both the damodar and kopai rivers follow similar seasonal patterns, particularly in water temperature, which peaked in June (in case of damodar 37.2°C and river kopai 37.9°C) and reached its low in January (damodar 19.2°C, kopai 20.2°C). Both rivers consistently maintained a slightly alkaline pH (damodar 7.2-8.8; kopai 7.1-8.9) and exhibited low Biological Oxygen Demand (BOD) levels, with an identical range of 1.3-2.9 mg/liter (Table 2 & 3). This low BOD suggests that organic pollution is not a primary stressor in either system. However, significant differences are evident in other parameters. Specifically, the damodar river, for instance, recorded considerably higher Total Dissolved Solids (TDS), peaking at 347 mg/liter, compared to the kopai's maximum of 282 mg/liter. Turbidity was also highly variable and peaked during the monsoon and post-monsoon months in both rivers, notably reaching 16.2 NTU in the damodar in October and 18.6 NTU in the kopai in August.

A critical finding of this study is the significant nutrient loading observed in both rivers, where the damodar river exhibited extremely high levels of nitrate ions (NO_3^-), reaching around 216 ppm in the month of May 2024. While the kopai river also showed elevated nitrate concentrations, its

peak was substantially lower and 152 ppm in December 2024. These high nitrate levels are a strong indicator of eutrophic conditions, likely stemming from agricultural runoff or industrial discharge, which directly promotes algal proliferation. Furthermore, both rivers displayed high total alkalinity, primarily driven by bicarbonate ions (HCO_3^-). This high buffering capacity explains the stable, alkaline pH observed in both systems, creating a favourable environment for microalgal growth (Debnath, T. and Ray, M., 2023 & Ray, M. and Sk, S., 2023).

This present study identified 25 microalgal species in the damodar river and 21 in the kopai river. Despite the differences in specific parameters like TDS and nitrate peaks, the overall algal communities are remarkably similar.

The physicochemical and inorganic ion data strongly correlate with the observed microalgal composition. The presence of several species of Cyanobacteria (Blue-Green Algae), such as *Anabaena* sp., *Lyngbya ceylanica*, and *Microcystis* sp. (Table 6) in both rivers, is a direct ecological response to the nutrient-rich, eutrophic conditions indicated by the high nitrate levels. According to established ecological principles, the formation of blue-green algal bloom indicates that the water quality is polluted or eutrophic (Debnath, T., 2024, 2025). The prevalence of these species, known for their

tolerance to a wide range of environmental stressors, suggests a moderate level of pollution stress in both river ecosystems. Conversely, the presence of various Diatoms (e.g., *Aulacoseira*, *Cymbella*, *Navicula*) and Green Algae (e.g., *Cladophora*, *Spirogyra*, *Ulothrix*) indicates that sections of the river maintain sufficient water quality for these groups, whose dominance typically indicates cleaner, oligotrophic water. Therefore, the microalgal diversity in both rivers reflects a complex environment, characterized by seasonal fluctuations and significant nutrient enrichment from nitrate ions, ultimately affecting the survival, growth, and diversity of microalgae (Ray, M. and Sengupta, K., 2015).

This is quantitatively confirmed by the high Sorenson's Similarity Index (0.8696) and Jaccard's Similarity Index (0.7692) (Table 7). This high degree of similarity suggests that the prevailing environmental conditions, especially the eutrophic nature of both rivers, are selecting for a comparable set of hardy, nutrient-tolerant species. The presence of numerous blue-green algae (Cyanobacteria) such as *Anabaena sp.*, *Lyngbya ceylanica*, *Microcystis sp.*, and *Oscillatoria amoena* in both rivers directly correlates with the high nitrate concentrations. These genera are well-established indicators of nutrient-polluted water, confirming the central hypothesis that the high levels of inorganic ions are a dominant factor shaping the microalgal diversity in both ecosystems.

CONCLUSION

The Damodar and Kopai rivers, despite being different in size, face similar ecological stresses, as evidenced by the comparable fluctuations in their water chemistry and the high similarity of their microalgal flora. The data underscore that the water quality in both river ecosystems is influenced by significant nutrient loading, which directly promotes the growth and diversity of microalgae, particularly species associated with enriched aquatic environments. Further monitoring and correlation studies are recommended to fully understand the long-term impact of these parameters on the health and biodiversity of these vital aquatic resources.

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