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ORIGINAL ARTICLE

Diversity of Microalgae and Aquatic Macrophytes of Damodar: Effect of Physico-chemical Parameters and Inorganic Ions

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ABSTRACT

The present study is conducted to analyse the present status of the effect of physico-chemical parameters and inorganic nutrient ions on the diversity of microalgae and aquatic macrophytes of the Damodar River. This study observed growth, diversity, and distribution of aquatic plants are related to the variation of physico-chemical parameters and inorganic nutrient ions of river water. The extensive and exclusive study on the five different spots of Damodar River during 2022-2024 in different months of the year identified many species of aquatic flowering plants, aquatic fern, and algae. The Presence of many *aquatic flora and algae indicates that the river Damodar is suitable for aquatic floral diversity. It was also observed that* river water pollution inversely affected the floral and algal diversity at Damodar River. Pollutants are released from different industries located near both banks of this river. As a result of that water quality also deteriorated. Damodar river water can be characterized as slightly alkaline throughout the year. This preliminary observation identifies the status of the effect of physico-chemical parameters and inorganic nutrient ions on the biodiversity of the Damodar River.

KEYWORDS

• Physico-chemical parameters • Damodar river • Biodiversity • Aquatic • Flora.

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INTRODUCTION

Rivers are the veins of the earth and hold a large number of aquatic floral and faunal species to form a rich and diverse aquatic ecosystem. They behave as a composite aquatic biodiversity[1]. Generally, the flowing river ecosystem is always lotic. Damodar is a rain-fed river and it is shallow, wide, and flashy. The river originated near the Khamarpat hill on the Chotanagpur Plateau in the Palamau district of Jharkhand and its mouth is Hooghly River, Howrah district, West Bengal. 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[7]. Damodar is one of the important rivers in India that flows across the Indian states of Jharkhand and West Bengal. The length of the river is 592 km. In the monsoon season due to heavy rain, the river is flooded the adjoining area and in summer the sand beds are almost always dry. Damodar River has several tributaries and sub-tributaries. The Damodar Valley is one of the most important and diverse river valleys in India and also one of the most industrialized parts of India[7-8]. The diversity of aquatic flora and fauna of river ecosystems is totally dependent on physico-chemical parameters and inorganic nutrient ions of river water. Microalgae are important parts of the river ecosystem. They are a large group of plant organisms and they are cosmopolitan found everywhere viz. fresh water, Saline water, estuarine water, and also moist surface area. They play an important role as primary producers of river ecosystems for various consumers of aquatic fauna and also rich sources of protein, carbohydrates, and fatty acids[10]. On the other hand, algae are helpful indicators of water quality due to their rapid response to environmental changes related to other plants and animals. The dominance of diatoms and green algae presence in river water indicates clean and oligotrophic water quality and aquatic ecosystem, whereas the formation of blue green algal bloom indicates that the water quality and aquatic ecosystem is polluted or eutrophic[11]. With the microalgae, other aquatic macrophytes have an important role in the river ecosystem. Floral groups are the autotrophic components and play an important role in the aquatic food chain. They serve as indicators of water quality and are also a key part of the ocean and freshwater ecosystem. Different kinds of microalgae and macrophytes belonging to different families are available in the water of the Damodar River. The floral diversity of any river is related to the amount and the variation of physicochemical parameters and inorganic ions like Temperature, pH, conductance, salinity, turbidity, dissolved oxygen, biological oxygen demand, total dissolved solids, hardness; Sodium, Potassium, Calcium, Nitrate, Carbonate, and Bicarbonate ions; Total alkalinity, Carbonate alkalinity and Bicarbonate alkalinity of that river water[4-5]. Variation of physico-chemical parameters and inorganic nutrient ions of river water shows the great impact on the growth and diversity of microalgae and macrophytic plants found in that river water.

METHODS

Study Area

The present work was the outcome of the extensive field study of the five different points or ghats of Damodar River during 2022-2024 in different months of the year.

Table 1: Geographical Location of Study Area

Sites	Latitude	Longitude
Chanchai Ghat	23.1615°	88.0167°
Fakirpur Ghat	23.2290°	87.8316°
Sadarghat Park	23.211597°	87.849481°
Chaitrapurjotoram	23.191432°	87.922021°
Khejurna Ghat (Chaitrapur, East Burdwan)	23.191723°	87.922122°

Sampling, preserving, studying, and identifying microalgae and aquatic macrophytes, along with phytosociological analysis

Sterilized 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. In some cases, expert swimmers and boats were used to collect algae from deeper waters. After collection, the samples were preserved using appropriate fixatives and preservatives for further study. Microscopic observations were conducted using standard methods. Identification of different algal taxa



Figure 1: Damodar river and map of its basin area (***source:*** Google & GPS map camera)

was carried out using standard literature while adhering to a proper classification system. Finally, algal samples were observed and documented. During the time of spots visit or field trips the different aquatic plant species were collected. Plant samples were collected from five spots of Damodar river. Then herbarium specimens were prepared by the collected plants samples and the specimens were primarily examined and identified.

Analysis of physico-chemical parameters and inorganic nutrient ions of water samples

On-site measurements of physicochemical parameters including pH, conductivity, total dissolved solids, salinity, and temperature were measured using proper scientific instruments. The hardness, carbonate ions, bicarbonate ions, and alkalinity were assessed using the Titrimetric method. Sodium, calcium, and potassium ion concentrations were measured using a flame photometer. Phosphate and nitrate ion concentrations were analyzed using a Systronics ion meter at the Environmental Chemistry Research Laboratory of Barrackpore Rastraguru Surendranath College.

RESULTS

Table 2: Seasonal variation of Physico-chemical parameters & Inorganic ions

Physio-chemical parameters and Biological significance ions	Seasons				
	Spring	Summer	Monsoon	Autumn	Winter
Temperature (°C)	28.2±0.4	34.3±0.6	32.4±0.2	28.4±0.5	23.4±0.4
pH	8.7±0.2	8.12±0.4	8.4±0.5	7.8±0.1	8.06±0.2
TDS (mg/litre)	270±5.1	228±7.2	196±4.8	253±5.4	286±6.4
Conductance (µS/cm)	409±11.1	327±7.3	277±7.8	357±10.2	318±8.1
Salinity (mg/litre)	194±3.5	158±4.8	162±3.9	172±2.1	153±5.6
DO (mg/litre)	8.6±0.4	5.9±0.7	7.1±0.2	7.8±0.7	8.2±0.5
Turbidity (NTU)	1.6±0.1	1.4±0.1	10.4±0.4	16.1±0.8	12.3±0.6
BOD (mg/litre)	1.9±0.1	2.3±0.3	1.8±0.1	2.1±0.4	1.7±0.5
Hardness (ppm)	132.08±3.4	116.58±5.6	102.75±7.1	128.44±7.5	126.7±4.2
Sodium (ppm)	13.83±1.1	13.83±0.9	19.31±0.7	22.2±1.4	46±2.3
Potassium (ppm)	2.0±0.4	2.03±0.2	3.9±0.7	4.6±0.3	8.5±0.6
Calcium (ppm)	23±1.2	26±2.4	18±2.2	38±3.1	57±3.8
Nitrate (ppm)	183±3.3	213±4.1	81±2.1	144±2.8	550.3±6.2
Carbonate ion (ppm)	3.6±0.6	4.8±0.4	8.4±0.4	4.8±0.5	3.6±0.1
Bicarbonate ion (ppm)	345.3±4.1	322.08±3.7	247.7±3.8	266±2.4	112.24±1.7
Total alkalinity (ppm)	289±4.1	272±3.1	217±2.5	226±3.7	92±1.4
Carbonate alkalinity (ppm)	6±0.2	8±0.4	14±1.0	8±0.7	6±0.4
Bicarbonate alkalinity (ppm)	283±2.7	264±5.5	203±4.1	218±3.1	86±2.2

Table 3: Phytosociological measurement of aquatic Macrophytes found in Damodar

Plant taxa	Density	Relative Density	Frequency	Relative Frequency	Abundance	Relative Abundance
Sagittaria sagittifolia	6.71	3.20	100.00	4.000032	6.71	1.97
Sagittaria trifolia	6.00	2.87	100.00	4.000032	6.00	1.76
Alisma sp.	3.86	1.84	85.71	3.43	4.5	1.32
Lemna minor	26.29	12.56	85.71	3.43	30.67	9.00
Pistia stratiotes	11.14	5.32	71.43	2.86	15.6	4.58
Spirodela polyrhiza	3.86	1.84	71.43	2.86	5.4	1.59
Wolffia globose	21.71	10.37	28.57	1.14	76.00	22.32
Hydrocotyle vulgaris	12.00	5.73	57.14	2.29	21.00	6.17
Ceratophyllumdemersum	1.71	0.81	71.43	2.86	2.4	0.70
Schoenoplectiella juncoides	4.43	2.11	85.71	3.43	5.17	1.52
Eleocharis dulcis	4.86	2.32	71.43	2.86	6.8	1.98
Cyperus articulates	7.29	3.48	85.71	3.43	8.5	2.50

Plant taxa	Density	Relative Density	Frequency	Relative Frequency	Abundance	Relative Abundance
Bolboschoenus maritimus	1.43	0.68	57.14	2.29	2.5	0.73
Eichhornia crassipes	1.86	0.88	71.43	2.86	2.6	0.76
Monochoria hastate	6.29	3.00	85.71	3.43	7.33	2.15
Potamogeton crispus	1.71	0.81	71.43	2.86	2.4	0.70
Potamogeton natans	2	0.95	100.00	4.000032	2.00	0.59
Stuckenia pectinata	2.43	1.16	100.00	4.000032	2.43	0.71
Potamogeton distinctus	1.86	0.88	85.71	3.43	2.17	0.64
Perscaria hydropiperoides	3.71	1.77	100.00	4.000032	3.71	1.09
Persicaria glabra	1.71	0.81	71.43	2.86	2.4	0.70
Persicaria amphibian	2.57	1.23	71.43	2.86	3.6	1.06
Hydrilla verticillata	4.14	1.98	85.71	3.43	4.83	1.42
Vallisneria americana	9.71	4.64	71.43	2.86	13.6	3.99
Vallisneria spiralis	6.57	3.14	57.14	2.29	11.5	3.37
Elodea canadensis	4.57	2.18	71.43	2.86	6.4	1.88
Nymphoides peltata	2.43	1.16	71.43	2.86	3.4	0.99
Saccharum spontaneum	6.57	3.14	57.14	2.29	11.5	3.37
Leptochloa virgate	3.43	1.64	71.43	2.86	4.8	1.40
Phragmites sp.	6.00	2.87	71.43	2.86	8.4	2.47
Typha latifolia	2.57	1.23	71.43	2.86	3.6	1.06
Marsilea minuta	2.43	1.16	42.86	1.71	5.67	1.67
Azolla pinnata	21.29	10.17	57.14	2.29	37.25	10.94
Salvinia natans	4.14	1.98	42.86	1.71	9.67	2.84

Table 4. Seasonal diversity of Micro algae found in Damodar River

Algal taxa	Abundance due to seasonal variation														
	Spring			Summer			Monsoon			Autumn			Winter		
	Do	Co	Ra	Do	Co	Ra	Do	Co	Ra	Do	Co	Ra	Do	Co	Ra
Lyngbya ceylanica	-	++	-	+++	-	-	+++	-	-	+++	-	-	+++	-	-
Lyngbya majuscule	-	++	-	+++	-	-	+++	-	-	+++	-	-	+++	-	-
Phormidium sp.	-	++	-	+++	-	-	+++	-	-	-	++	-	-	-	+
Oscillatoria amoena	-	-	+	-	++	-	+++	-	-	+++	-	-	-	-	+
Gloeocapsa sp.	+++	-	-	-	-	+	+++	-	-	+++	-	-	+++	-	-
Microcystis sp.	-	++	-	-	-	+	-	++	-	-	++	-	-	++	-
Anabaena sp.	-	++	-	-	-	+	-	++	-	-	-	+	-	++	-
Dinobryon sp.	-	++	-	+++	-	-	-	++	-	-	++	-	+++	-	-
Ulothrix zonata	-	++	-	+++	-	-	-	++		-	-	+	+++	-	-

Algal taxa	Abundance due to seasonal variation														
	Spring			Summer			Monsoon			Autumn			Winter		
	Do	Co	Ra	Do	Co	Ra	Do	Co	Ra	Do	Co	Ra	Do	Co	Ra
Oedogonium amphulum	-	++	-	-	++	-	+++	-	-	-	++	-	+++	-	-
Oedogonium grands	-	++	-	-	++	-	+++	-	-	-	++	-	+++	-	-
Oedogonium oblongum	-	++	-	-	-	+	-	++	-	+++	-	-	-	++	-
Oedogonium vulgaris	-	++	-	-	-	+	-	++	-	+++	-	-	-	++	-
Oedogonium varians	-	++	-	-	-	+	-	-	+	-	++	-	-	++	-
Hydrodictyon indicum	-	-	+	-	++	-	-	++	-	-	-	+	-	-	+
Hydrodictyon reticulatum	-	-	+	-	++	-	-	++	-	-	-	+	-	-	+
Stigeoclonium lubricum	-	++	-	+++	-	-	+++	-	-	-	++	-	-	++	-
Scenedesmus obliqus	-	++	-	-	++	-	+++	-	-	-	-	+	-	-	+
Scenedesmus denticulate	-	++	-	+++	-	-	-	-	+	-	++	-	+++	-	-
Cladophora glomerata	+++	-	-	+++	-	-	-	++	-	+++	-	-	-	++	-
Vaucheria amphibian	+++	-	-	+++	-	-	-	++	-	+++	-	-	-	++	-
Nitzschia sp.	+++	-	-	+++	-	-	-	-	+	+++	-	-	+++	-	-
Synedra ulna	-	++	-	-	++	-	-	-	+	+++	-	-	+++	-	-
Melosira sp.	-	++	-	-	++	-	-	-	+	+++	-	-	+++	-	-
Cymbella acuta	-	++	-	-	++	-	-	-	+	+++	-	-	+++	-	-
Cymbella aculeate	+++	-	-	+++	-	-	+++	-	-	-	++	-	-	++	-
Navicula sp.	+++	-	-	+++	-	-	+++	-	-	-	-	+	-	-	+
Gomphonema parvulum	+++	-	-	+++	-	-	+++	-	-	-	-	+	-	-	+
Aulacoseira granulate	-	++	-	-	++	-	+++	-	-	-	++	-	-	-	+
Spirogyra sp.	-	++	-	-	++	-	+++	-	-	-	++	-	-	-	+
Zygnema sp.	-	++	-	-	++	-	+++	-	-	-	++	-	-	-	+
Closterium sp.	-	-	+	-	++	-	+++	-	-	-	-	+	-	-	+

Do (+++): Dominant; Co (++): Common; Ra (+): Rare

DISCUSSION

Average temperature of the river remained 23.4 to 34.3˚C throughout the years creating ideal ecosystem for algal and aquatic floral diversity[3]. The pH of Damodar River ranges between 7.8 to 8.7 which suggest river water is slightly alkaline and the present study suggest this range is suitable for algal growth. The conductance of Damodar river water lied between 277-409 µS/cm throughout the year. Damodar river water is slightly hard and ranges between 102.75 – 132.08 ppm.Total Dissolved Solids(TDS) remains between 196 – 253 mg/lt around the year which indicate that pollutants mix in the river water.Dissolve Oxygen plays important role in Biological process of aquatic ecosystem[2]. DO of Damodar river lied between 5.9 mg/lt to 8.6 mg/lt resulting healthy aquatic ecosystem. The salinity lied between 153 mg/lt to 194 mg/lt throughout the year which suggest the river water is fresh. Species diversity depends on salinity. Low salinity of river Damodar water indicates the presence of wide spectrum flora and fauna. Turbidity lied between 1.4 to 16.1 NTU during study time. Low turbidity reflects more penetration of

sunlight, denoting more primary productivity. Biological Oxygen Demand or BOD is an important parameter often useas an index of the degree of organic pollution in water. In present study BOD ranges between 1.7 to 2.3 mg/ lt that indicate river water has less organic pollution.

During study period Sodium ion concentration of river water were found between 13.83 to 46 mg/lt which is helpful for Cyanophycean algae[8] and Potassium ion concentration lied between 2.0 to 8.5 mg/lt. Study found Bicarbonate ion concentration between 112.24 to 345.3 ppm and carbonate ion concentration between 3.6 to 8.4 ppm which indicate river water is suitable for algal diversity[4].

The present study identified rich variety of algal species and other aquatic plants. This study identified 6 genera of Blue-green algae, 9 genera of green algae, 1 yellow green algae, 1 golden algae, and 7 genera of diatoms belonging to the group Cyanophyta, Chlorophyta, Charophyta and Bacillariophyta. From table 6 it is clear most of the algae are dominant during rainy season and summer but most are common in spring. Diatoms are dominant in winter. Green algae are dominant in monsoon.

This study identified 5 genera of invasive plants. Table 3 of the present study indicate that emergent flora are dominant having 50% population followed by floating species having 23.52% population then submerged species having 14.70% of population and least population of submerged floating occurring 11.76% in Damodar river. Table 4 indicate that some species have 100% frequency in Damodar river such as *Sagittariasagittifolia*, *Sagittariatrifolia*, *Potamogeton natans*, *Stuckenia pectinata*, *Perscariahydropiperoides*.

CONCLUSION

The present study concluded that the aquatic ecosystem of river Damodar is suitable for algal and floral diversity. All the physicochemical parameters have an impact on the diversity of microalgae and aquatic macrophytes. Inorganic ion concentration is also an important factor for the growth of algae and macrophytes. River water is slightly polluted in the summer and winter seasons due to a mix of pollutants from riverside localities and industry. It is also concluded that the dominancy of algal species differs in different seasons but the present observation reported that accordingly 37.5% belongs to Chlorophyceae, 29.16% belongs to Bacillariophyceae and 25% belongs to the Cyanophyceae group.

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