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Phytoplankton diversity and physico-chemical features of Narmada River district Dindori (M.P.) India

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Abstract
The focus of this study is on the diversity of phytoplankton and the physical and chemical characteristics of the Narmada River during the post monsoon season. In the morning, water samples were collected and phytoplankton were collected using a plankton net with a mesh size of 20 µm. A total of forty-three different genera of phytoplankton were identified in the study area, belonging to four main classes: Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Euglenophyceae. The study also analyzed various physico-chemical parameters, including temperature, pH, dissolved oxygen, carbon dioxide, alkalinity, calcium content, water hardness, nitrate and silicate levels, and productivity. The results revealed significant variations in phytoplankton diversity and physico-chemical parameters across different study sites.

Keywords: Phytoplankton, physico-chemical parameters, Narmada river

Introduction
The remarkably diverse and captivating world of phytoplankton, those microscopic single-celled organisms that thrive in water, both marine and freshwater, cannot be overstated. Serving as the essential building blocks of aquatic ecosystems, they exhibit a remarkable array of sizes and shapes. These remarkable creatures not only hold the key to the intricate food webs that exist beneath the water's surface but also perform the crucial role of primary producers. Through the awe-inspiring process of photosynthesis, phytoplankton consume vast amounts of carbon dioxide, rivaling even the most majestic of forests and land plants. Their significance extends beyond this, as they serve as the vital link between the atmosphere and the ocean, facilitating the transfer of carbon dioxide and generating a staggering amount of atmospheric oxygen, comparable to that produced by their terrestrial counterparts. Furthermore, these extraordinary organisms form the very foundation of virtually every aquatic food web, playing an irreplaceable role in the intricate tapestry of global ecology and the functioning of ecosystems. As primary producers, they contribute a staggering fifty percent of the planet's primary production and play a vital role in the global nutrient cycles that sustain life on Earth, making them an unparalleled force within any body of water they inhabit (Biddanda and Benner, 1997) [1].

The composition and abundance of phytoplankton populations are primarily regulated by inorganic nutrients such as nitrogen, phosphorus, and silica, particularly in the form of nitrate, nitrite, ammonia, and soluble orthophosphate (USEPA, 2000) [2]. The distribution and fluctuations of phytoplankton in freshwater environments are dependent on their physical and chemical characteristics (Cetin and Sen, 2004) [3]. Phytoplankton is commonly used as an indicator of ecological health and the impact of chemical pollutants on aquatic ecosystems (Yu *et al.*, 2014) [4]. Changes in water quality can be observed through alterations in the structure of the biotic community, including phytoplankton, with more delicate species acting as indicators of pollution. To maintain a suitable habitat for aquatic organisms, regular monitoring of physical and chemical factors is necessary. The activity of living organisms is influenced by seasonal and daily variations in these parameters (Akinyeye, 2011) [5]. This study focuses on examining the diversity of phytoplankton populations and the physico-chemical parameters of the Narmada River during the post-monsoon season.

Materials and Methods

The Narmada River, previously also known as *Narbada* or anglicised as *Nerbudda*, is the 5th longest river and overall longest west-flowing river in India. It is also the largest flowing river in the state of Madhya Pradesh. This river flows through the states of Madhya Pradesh and Gujarat in India. It is also known as the "Life Line of Madhya Pradesh and Gujarat" due to its huge contribution to the two states in many ways. The Narmada River rises from the Amarkantak Plateau in Anuppur district Madhya Pradesh. It forms the traditional boundary between North India and South India and flows westwards over a length of 1,312 km (815.2 mi) before draining through the Gulf of Khambhat into the Arabian Sea, 30 km (18.6 mi) west of Bharuch city of Gujarat.

The upstream region consist of Narmada river at Dindori district, Sati ghat and Dam ghat (upstream), Jogi Tikariya ghat (midstream) and shiv ghat (downstream) comprises top and down regions. Water samples were collected during the post monsoon season *i.e.*, October 2021 to January 2022. Samples were collected during the early morning time before the outbreak of sunlight. Phytoplankton was collected by plankton net Number-20 silk bolting cloth having a mesh of 20 µm in size. The samples were collected and stored in a plastic containers and preserved using 4% formalin and Lugol's iodine for better settlement. Microscopic observations were conducted by Magnus (MX 2li clinical) light compound microscope and phytoplankton identified with the help of Fresh water algal identification key established by Desikachary (1959) [6], Prescott (1982) [7] and Philipose (1967) [8]. Physico-chemical characteristics such as temperature, pH, dissolved oxygen, carbon dioxide, alkalinity, amount of calcium, hardness of water, content of nitrate and silicate and productivity were analyzed according to standard procedures (APHA, 2001) [9].

Results and Discussion

In the aftermath of the monsoon season, a remarkable array of phytoplankton diversity was documented in the study's observations. A grand total of forty-three genera were identified, with four prominent families making their presence known. Leading the pack was Chlorophyceae, boasting the highest number of representatives, followed closely by Bacillariophyceae, Cyanophyceae, and Euglenophyceae, the latter having the fewest members. Notably, the river exhibited a preponderance of eighteen Chlorophyceae species, while Euglenophyceae trailed behind with a modest count of three. (Table 1).

The intricate interplay between the vast array of phytoplankton species and the physico-chemical characteristics of aquatic environments is undeniably profound. The flourishing of phytoplankton, whether as a consequence of direct or indirect influences, is intricately entwined with the prevailing physicochemical conditions. The presence of *Navicula*, *Cymbella*, *Nitzchia* and *Oscillatoria* serves as a telltale sign of water contamination, acting as steadfast indicators thereof. Overall, the broader phytoplankton communities can be judiciously employed as invaluable barometers of pollution, facilitating an accurate assessment of water quality (Usman, 2016) [10]. The occurrence of *Ocillatoria* in the present study also indicates pollutants of biological origin (Altaf and Saltanat, 2014) [11]. It is evident from the results that the river is progressing from the oligotrophic to the mesotrophic state (Sharma *et al.* 2017) [12]. In the downstream, the water temperature reached its peak at a balmy 26 °C. The concentration of hydrogen ions, a crucial factor, plays a vital role in the biological functions of all aquatic creatures (Wetzel, 1975) [13]. In the current analysis, the pH levels spanned from 6.97 to 7.88, signifying a delicate balance in the aquatic ecosystem. The presence of dissolved oxygen emerges as a pivotal element crucial for the survival of underwater organisms, a notion well-expounded upon by Namdeo and Singh (2021b) [14]. Interestingly, the highest concentration of dissolved oxygen was detected in the upstream area. Notably, the levels of nutrients such as nitrate, phosphate, and silicate displayed noteworthy fluctuations across distinct regions. A comprehensive compilation of the findings concerning physico-chemical aspects can be found in Table 2.

Table 1: Phytoplankton diversity in Narmada River at Dindori during post monsoon season

S.No.	Class	S.No.	Phytoplankton	Upstream	Midstream	Downstream
1.	Chlorophyceae	1.	*Chlorella*	+	+	+
		2.	*Closterium*	+	-	+
		3.	*Cloteriopsis*	+	+	+
		4.	*Coelastrum*	-	+	+
		5.	*Cosmarium*	+	+	+
		6.	*Euastrum*	+	-	+
		7.	*Kirchneriella*	-	+	+
		8.	*Micrasterias*	+	-	+
		9.	*Microspora*	+	-	-
		10.	*Oedogonium*	-	+	-
		11.	*Onychonema*	-	-	+
		12.	*Pediastrum*	+	+	+
		13.	*Scenedesmus*	+	+	+
		14.	*Spirogyra*	+	+	-
		15.	*Spondylosium*	-	-	+
		16.	*Staurodesmus*	+	+	+
		17.	*Volvox*	-	-	+
		18.	*Xanthidium*	+	-	+
2.	Bacillariophyceae	19.	*Amphora*	+	-	-
		20.	*Aulacoseira*	+	-	+
		21.	*Cocconeis*	+	+	-
		22.	*Cyclotella*	+	-	+

		23.	*Cymbella*	+	+	+
		24.	*Diadesmis*	-	-	+
		25.	*Fragilaria*	+	-	+
		26.	*Gomphonema*	+	+	+
		27.	*Gyrosigma*	+	-	+
		28.	*Melosira*	-	+	+
		29.	*Navicula*	+	+	+
		30.	*Nitzschia*	+	+	+
		31.	*Pinnularia*	+	+	+
		32.	*Stephanodiscus*	+	-	-
		33.	*Surirella*	+	+	+
		34.	*Synedra*	+	+	+
		35.	*Tabellaria*	+	+	+
3.	Cyanophyceae	36.	*Anabaena*	-	+	+
		37.	*Lyngbya*	+	+	-
		38.	*Merismopedia*	+	-	-
		39.	*Oscillatoria*	-	+	+
		40.	*Spirulina*	+	+	-
4.	Euglenophyceae	41.	*Euglena*	+	+	+
		42.	*Phacus*	-	+	+
		43.	*Trachelomonas*	-	-	+

Table 2: Physico-chemical qualities of the water samples

S.No.	Parameters	Upstream	Midstream	Downstream
1.	Temperature (°C)	26	28	30
2.	PH	6.6	7.88	6.97
3.	Dissolved oxygen (mg/l)	5.7	4.3	3.6
4.	CO_2 (mg/l)	5	7	10
5.	Alkalinity (mg/l)	11	18	26
6.	Calcium (mg/l)	5.12	3.88	4.34
7.	Hardness of water (mg/l)	15	19	20
8.	Nitrate (mg/l)	0.121	0.094	0.167
9.	Phosphate (mg/l)	0.132	0.088	0.036
10.	Silicate (mg/l)	0.186	0.201	0.262
11.	Productivity of the water (mg/C/l/hr)	0.532	0.462	0.235

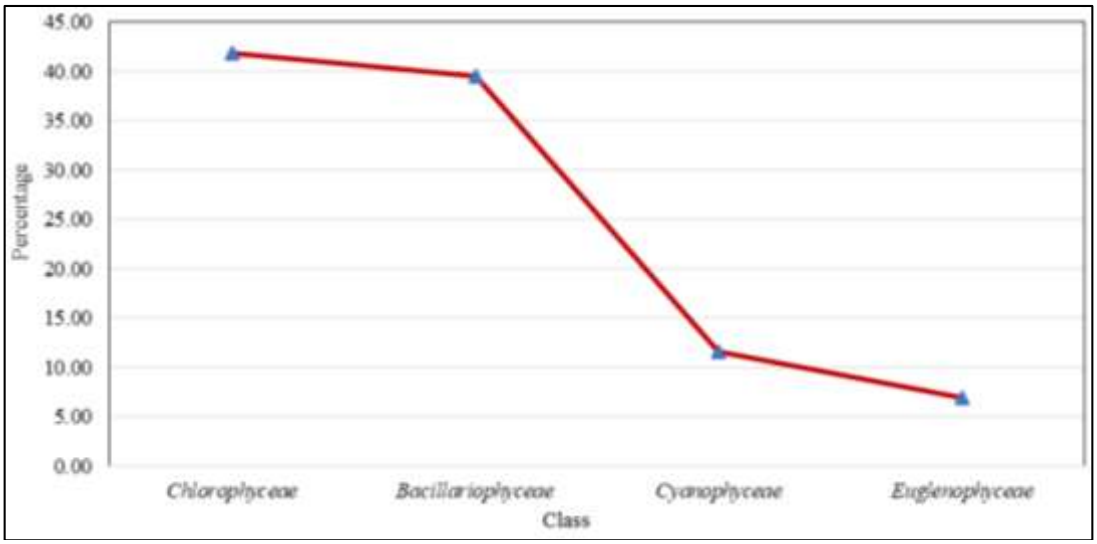

Fig 1: Graph analysis of class %age presentation of phytoplaktonic diversity.

Conclusion

In the post-monsoon period, the Narmada river at Dindori displays a remarkable correlation between the diversity of phytoplankton and physico-chemical factors. The presence of chlorophyceae is notably more prevalent compared to other categories, making them valuable indicators for evaluating water quality. Additionally, the physico-chemical parameters exhibit variations across different locations along the river.

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