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Seasonal variability of phytoplankton (Bacillariophyceae) population in the Brahmani River of Odisha, India

RP Mishra, SK Das, TS Nagesh and S Behera

Abstract
This study was conducted from March 2020 to November 2022 along the Brahmani River. The population of phytoplankton, pH, Temperature, Transparency and DO were investigated based on the samples that were obtained from nine locations. Seasonal fluctuation affects phytoplankton abundance. Present study consists of phytoplankton (Bacillariophyceae) community of Brahmani river in pre-monsoon, monsoon and post-monsoon season. Hydrographical parameters like water temperature, transparency, pH, DO have shown significant seasonal variation in Brahmani river. Water temperature; DO have shown significant variation (p<0.01) among seasons while *p*H has shown significant variation (p<0.01) among both seasons and stations. Transparency of the water decreased much in monsoon season due to inflow of turbid rain water. But the variation in transparency among seasons and stations were found not to be significant. *p*H show significant variation among seasons and stations. Phytoplankton density have shown significant variation (p<0.01) among seasons and stations during the study period. During our study, phytoplankton belonging to class Bacillariophyceae dominated over other classes of phytoplanktons at all the 9 stations in the whole year. The numbers of phytoplankton genus under these classes are identified as Bacillariophyceae 21 genus and several species, 7 genus of Chlorophyceae and 3 genus of Myxophyceae. The dominant species recorded at different sampling stations belonged to the genera *Coscinodiscus*, *Skeletonema*, *Nitzschia*, *Navicula*, *Thallasiothrix*, *Triceratium*, *Ceratium*, *Rhizosolenia*, *Thallasionema*, *Chaetocerous*, *Melosira*, *Trichodesmium*, *Pleurosigma* etc.

Keywords: Seasonal, phytoplankton, Bacillariophyceae and Brahmani River

Introduction
In Rivers, phytoplankton form the foundation of pelagic food webs and are crucial to the worldwide cycling of elements such as phosphorus, nitrogen, and carbon as well as the control of Earth's temperature. The diversity and dynamics of phytoplankton communities are greatly varied, as they are multispecies communities. The main cause of successive shifts in the structure of phytoplankton communities is variations in the physico-chemical and environmental variables that affect the distribution and abundance of plankton communities in rivers, such as nutrients (Ferreira *et al*., 2005; Madhu *et al*., 2007) [7, 12].
The distribution of biomass and species makeup in phytoplankton have a significant impact on the rates of carbon fixation and energy transfer within food webs. Thus, research on the quantity, location, and makeup of phytoplankton communities makes a significant addition to our comprehension of the composition and dynamics of riverine ecosystems. So the present study attempted to determine the seasonal variation in the phytoplankton (Bacillariophyceae) community with its related physicochemical parameters.

Materials and Methods
The current investigation was conducted on the Brahamani River between March 2020 and November 2022. The trial was further divided into three seasons: the pre-monsoon (March-June), the monsoon (July-October), and the post-monsoon (November--February). Nine sampling sites were used during the study, *viz*; Ramachandrapur (S1), Panaspal (S2), Radhanagar (S3), Sanapatuli (S4), Ballipasi (S5), Beusahi (S6), Kasnipura (S7), Indupur (S8) & Gaurapal (S9). Water samples were collected from the selected river sites in the morning before 9.00 am on a monthly basis in 2 litre plastic cans and transported to the laboratories of Krishi Vigyan Kendra, Angul and Central Institute of Freshwater Aquaculture, Bhubaneswar using ice boxes for the estimation of physicochemical parameters.

Water samples were taken from the subsurface layer at the sampling locations.

Laboratory analysis

The pH was measured with a digital pH metre, the water temperature were recorded with a thermometer (Cystronics model 335) and calculation of dissolved oxygen using Winkler's method by standard techniques (APHA, 2008) [2]. DO was analyzed by Winkler's titration method (Naik *et al*., 2009) [15]. Phytoplankton samples, preserved with Lugol's iodine solution, were analyzed for phytoplankton cell density and taxonomic identification. 1 mL of the concentrated sample was placed in a Sedgwick Rafter cell and observed for identification and counting under a compound microscope. Standard literature such as Easter (Verlencar and Somshekar, 2004) [21] were referred. Analysis of variance (ANOVA) was applied to hydrographic and biological datasets obtained to see any significant variation among seasons as well as stations.

Phytoplankton Sampling

A plankton net made of conventional bolting silk fabric No. 25 (mesh size 0.03 - 0.04 mm) was used to gather the plankton. Using a plastic bucket with a 15-liter capacity, Rheoplankton were harvested from 100-liter water samples at various research stations. The plankton was then removed from the plankton net and stored in a formaldehyde solution containing 4%. Once in the lab, the material was subjected to qualitative and quantitative analysis using a sedge wick Rafter type counting cell (1 ml capacity), and the planktons were counted following Allen (1930) [1] and Fritsch (1965) [9]. Phytoplankton counts and species identification was conducted using a sedimentation method. After being treated with Lugol's iodine, samples for phytoplankton examination were kept in dark vials for storage. Through the use of a Sedgwick-R after counting cells and a microscope, phytoplankton was analyzed both qualitatively and quantitatively.

Results

It was observed that the value of Bacillariophyceae varied from a minimum of 472 no./L at station S6 in the month of August to the maximum of 1015 no. /L at station S9 in the month of May. The mean value of Bacillariophyceae in the upper stretch was 961.66±3.08, 854.75±3.01 and 873.91±3.08 (Mean±SD) during Pre-monsoon, Monsoon and Post-monsoon respectively. Such values in the middle stretch was 855.91±3.37, 477.66±3.65 and 865.50±3.53 (Mean±SD) during the period of investigation. The corresponding values in the lower stretch were 1009.91±3.58, 534.00±2.86 and 934.16±3.93. It was found that there was highly significant differences (Table no.1) shown in both stretch (f = 30778.954, p = < 0.05) and season wise (f == 24571.061, p = < 0.05) study. The Bacillariophyceae analysed was higher in summer and in rainy it was relatively lower (Table no.1 and Figure no.1).

During our study, phytoplankton belonging to class Bacillariophyceae dominated over other classes of phytoplanktons at all the 9 stations in the whole year (March-20 to Nov-22). After Bacillariophyceae, some genus of Myxophyceae and Chlorophyceae genus were observed. Phytoplankton abundance and species composition showed both spatial and seasonal variation. The dominant species recorded at different sampling stations belonged to the genera *Coscinodiscus*, *Skeletonema*, *Nitzschia*, *Navicula*, *Thallasiothrix*, *Triceratium*, *Ceratium*, *Rhizosolenia*, *Thallasionema*, *Chaetocerous*, *Melosira*, *Trichodesmium*, *Pleurosigma* etc. There was succession of different species recorded during different sampling seasons at different sampling points. The numbers of phytoplankton genus under these classes are identified as Bacillariophyceae 21 genus and several species, 7 genus of Chlorophyceae and 3 genus of Myxophyceae.

Bacillariophyceae

Table 1: Variations in Bacillariophyceae (no./L) along different stretches and in different seasons during Pre-monsoon

Seasons / Stretches	March	April	May	June	Mean±SD
U-1	959	963	964	961	961.75±2.21
U-2	956	960	968	964	962.00±5.16
U-3	961	962	963	959	961.25±1.70
Mean±SD	958.67±2.51	961.66±1.53	965.00±2.64	961.33±2.52	961.66±3.08
M-1	857	854	859	852	855.50±3.10
M-2	854	856	860	853	855.75±3.09
M-3	858	851	862	855	856.50±4.65
Mean±SD	856.33±2.08	853.67±2.52	860.33±1.53	853.33±1.52	855.91±3.37
L-1	1009	1004	1012	1005	1007.50±3.69
L-2	1012	1006	1014	1013	1011.25±3.59
L-3	1008	1011	1015	1010	1011.00±2.94
Mean±SD	1009.67±2.08	1007.00±3.60	1013.67±1.53	1009.33±4.04	1009.91±3.58

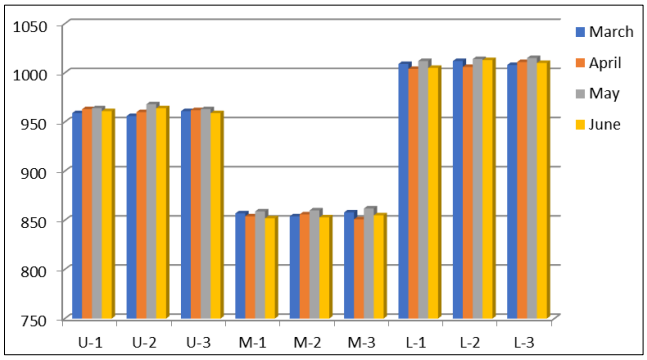

Fig 1: Variations in Bacillariophyceae (no./L) along different stretches and in different seasons during Pre-monsoon

Table 2: Variations in Bacillariophyceae (no./L) along different stretches and in different seasons during Monsoon

Seasons / Stretches	July	Aug.	Sept.	Oct.	Mean±SD
U-1	857	854	859	858	857.00±2.16
U-2	854	856	852	850	853.00±2.58
U-3	855	858	850	854	854.25±3.30
Mean±SD	855.33±1.53	856.00±2.00	853.67±4.72	854.00±4.00	854.75±3.01
M-1	475	477	474	476	475.50±1.29
M-2	480	475	480	482	479.25±2.98
M-3	476	472	481	484	478.25±5.31
Mean±SD	477.00±2.64	474.67±2.52	478.33±3.78	480.67±4.16	477.66±3.65
L-1	534	531	538	536	534.75±2.98
L-2	537	529	537	531	533.50±4.12
L-3	532	536	533	534	533.75±1.70
Mean±SD	534.33±2.51	532.00±3.60	536.00±2.64	533.67±2.51	534.00±2.86

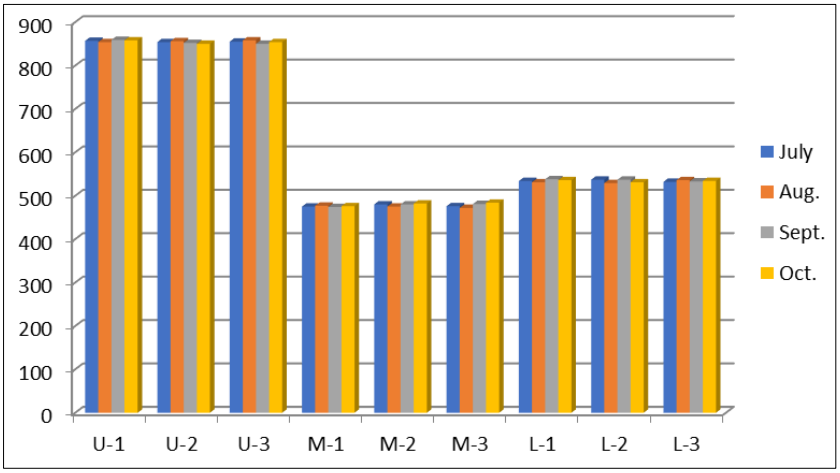

Fig 2: Variations in Bacillariophyceae (no./L) along different stretches and in different seasons during Monsoon

Table 3: Variations in Bacillariophyceae (no./L) along different stretches and in different seasons during Post-monsoon

Seasons / Stretches	Nov.	Dec.	Jan	Feb	Mean±SD
U-1	873	871	878	874	874.00±2.94
U-2	875	869	876	872	873.00±3.16
U-3	879	870	874	876	874.75±3.77
Mean±SD	875.67±3.05	870.00±1.00	876.00±2.00	874.00±2.00	873.91±3.08
M-1	864	860	865	868	864.25±3.30
M-2	867	864	868	866	866.25±1.70
M-3	862	861	869	872	866.00±5.35
Mean±SD	864.33±2.51	861.67±2.08	867.33±2.08	868.67±3.05	865.50±3.53
L-1	935	933	934	938	935.00±2.16
L-2	936	931	937	932	934.00±2.94
L-3	940	929	938	927	933.50±6.45
Mean±SD	937.00±2.64	931.00±2.00	936.33±2.08	932.33±5.51	934.16±3.93

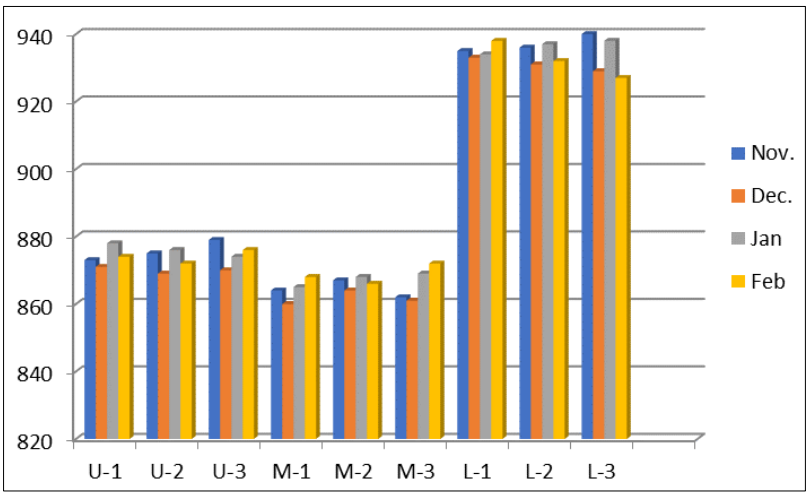

Fig 3: Variations in Bacillariophyceae (no./L) along different stretches and in different seasons during Post-monsoon

Table 4: ANOVA of Variations in Bacillariophyceae (no./L) along different stretches and in different seasons

Source	Type III Sum of Squares	df	Mean Square	F	Sig.
Season	2132222.111	11	193838.374	24571.061	.000
Stretch	485623.500	2	242811.750	30778.954	.000
Error	568.000	72	7.889		
Total	75681936.000	108			

Table 5: Range and average (avg) of hydrographic and biological parameters

	PRM			MON			POM		
Parameters	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**	**Min**	**Max**	**Avg**
Water Temp (°C)	30.5	34.82	32.79	29.26	30.76	30.09	21.26	23.06	22.31
Transparency(cm)	38.56	40.86	40.04	38.01	40.76	39.65	39.43	40.87	40.15
pH	7.22	8.79	8.06	7.22	7.48	7.35	7.3	7.88	7.57
DO (mg/L)	5.06	5.72	5.31	5.30	5.84	5.57	6.21	6.73	6.46
Phytoplankton Bacillariophyceae (Nos./L)	851	1015	941	472	859	630	860	940	893

Table 6: Two way ANOVA results of hydrographic and biological parameters Among seasons Among Stations

Parameters	F	Sig.	F	Sig.
Water Temperature	642.682	.000	.104	.901
Transparency	.202	.997	1.604	.208
*p*H	30.881	.000	61.585	.000
DO	77.811	.000	1.775	.177
Phytoplankton (Bacillariophyceae) density	24571.061	.000	30778.954	.000

[Significant values (p<0.01) are given in bold]

Discussion

In the Brahmani River, hydrographical indices such as water temperature, transparency, pH and DO have demonstrated significant seasonal fluctuations. The monsoon and post-monsoon seasons had the lowest water temperatures, which may have been brought on by gloomy weather and the input of freshwater. Because of the influx of turbid precipitation during the monsoon season, the water's transparency significantly deteriorated. However, the variation in transparency among seasons and stations was found not to be significant. Due to precipitation, temperature drops, and the breakdown of organic matter, pH varies significantly between seasons and stations (Rajasegar, 2003) [19].

During the experiment, Water temperature and DO have shown significant variation (p<0.01) among seasons while *p*H has shown significant variation (p<0.01) among both seasons and stations (Table no.6). In tropical nations such as India, monsoonal rainfall, tidal features, evaporation, and water currents all have a significant impact on the significant variance of numerous hydrographic parameters (Damotharan *et al*., 2010) [6].

Phytoplankton is the primary producer in aquatic environments and is a crucial part of the aquatic food chain. According to Xu *et al*. (2001) [23], phytoplankton is therefore an ecological indicator and essential to the upkeep of a robust aquatic ecosystem. The significance of the phytoplankton community's composition in environmental monitoring, ecosystem restoration, and management has been emphasised by Arhonditsis and Brett (2005) [3], and other scholars. The biotic organisation of a lake's phytoplankton population, which is mostly shaped by variations in environmental conditions, defines its ecological niches. Studies by Padisák *et al*. (2009) [17] and Bellinger and Sigee (2015) [4] have demonstrated this association.

The phytoplankton community structure is directly impacted by seasonal dynamics caused by climatic variability, as per the findings of (Edwards *et al*., 2016 and Mohanty *et al*., 2022) [14]. Thus, a crucial step in developing sustainable management methods for the reservoir environment is evaluating the plankton community both quantitatively and qualitatively.

Throughout the course of the research, there was a significant (p<0.01) fluctuation in phytoplankton density between seasons and stations. Seasonal variations can be attributed to the occurrence of distinct hydrographic environmental conditions at different times of the year. (Carvalho *et al*., 2013) [5]. They suggested that Phytoplankton responds to continuously changing environmental conditions, especially about temperature, light, and nutrients. Water transparency is one of the most significant abiotic elements that permit light permeability into the water, according to Fleming-Lehtinen and Laamanen (2012) [8] and Jiang *et al*. (2014) [11]. This may directly alter autotrophs' ability to photosynthesize, which in turn influences the growth and dispersal of phytoplankton across the aquatic ecosystem.

The species makeup of a certain set of phytoplankton communities is connected with the environmental conditions well (Maileht *et al*., 2013) [13], which makes them suitable for use as ecological indicators (Bellinger and Sigee, 2015; Gogoi *et al*., 2021) [4, 10]. Phytoplankton populations, which typically experience steady fluctuations over time, are greatly influenced by seasonal dynamics (Weithoff *et al*., 2015). [22]

According to Sasamal *et al*. (2004) [20], diatoms, or Bacillariophyceae, are tolerant to a broad range of temperature variations. Therefore, the current investigation confirms this finding once more with lower values for other groups in the unpredictable physicochemical and nutritional environment during the monsoon and rainy season (Naik *et al*., 2009) [15]. In comparison with other seasons, the monsoon population was lower, which is most likely because of the shift in hydrographic parameters brought about by the influx of freshwater through precipitation and the widespread stratification brought about by rainwater, high turbid water, and low temperature (Palleyi *et al*., 2008) [18]. The Bascilllariophyceae dominated the phytoplankton community during the post-monsoon, possibly as a result of the increased nutrient absorption. During the study period, the Bacillariophyceae exhibited distinct dynamics. Higher population was observed in the month if May followed by November and August had the lowest number. Bright light and high temperatures are favorable for the growth of Bacillariophyceae.

Conclusion

Using various hydrographic parameters, the species composition and relative abundance of phytoplankton were investigated in the Brahmani River throughout the pre-monsoon and post-monsoon seasons. Seasons have demonstrated a significant fluctuation in water temperature ($p<0.01$), while both seasons and stations have demonstrated a significant variance in pH ($p<0.05$). More research is needed to determine if human or natural influences are responsible for the pH change in the dam water. There has been a significant difference ($p<0.01$) in phytoplankton density between seasons and stations. However, the controlling factors of season-wise and station-wise fluctuation in phytoplankton population as well as species composition shall be further studied with relation to nutrients and anthropogenic generated factors. The state of the phytoplankton community structure at various seasons was the specific focus of this research. Nonetheless, additional research on the mechanisms influencing species composition and fluctuations in phytoplankton populations according to season and station will be necessary in light of anthropogenic causes and nutrient availability.

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