International Journal of Ecology and Environmental Sciences 49: 659-663, 2023
ISSN: 2320-5199 (Online); https://doi.org/10.55863/ijees.2023.3045

Chlorophyceae Diversity and Seasonal Variation in the River Torsa, West Bengal, India

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ABSTRACT
A survey was conducted at two sampling sites in the river Torsa for the study of Chlorophyceae from March 2014 to February 2016. A total of 12 chlorophyceae under the seven orders, such as Chlorococcales (with 4 species), Chlamydomonodales and Desmidiaceae (with 2 species) and Oedogoniales, Zyggnematales, Ulotrichales, and Zygnemales (with 1 species) were recorded. The values of the Shannon diversity index and Margalef species richness index indicate the water of the river is of good quality. The seasonal values of the number of taxa and diversity indices were at their maximum in the winter season due to favourable water quality.

Key words: Torsa, Chlorophyceae, diversity indices

INTRODUCTION

The river Torsa originates from the Chumbi Valley in Tibet, China, at an altitude of 7065 m, and it is a transboundary river. This river is known as Machu in China and Amo Chu in Bhutan. The river flows through China, Bhutan, India, and Bangladesh. The total length of the river Torsa is 358 km, of which 113 km are in China and 145 km are in Bhutan, and it then flows into North Bengal (Bandopadhyay 2002). Planktons are free-floating organisms, and their movement depends on water movement (Sommer, 1988). Phytoplankton, due to the presence of chlorophyll are the primary producers of aquatic ecosystems and are the main source of food, directly or indirectly, for various aquatic organisms (Anitha Devi et al. 2013). Algae are useful tools for assessing the degree of pollution or as an indicator of water pollution (Trivedy and Goel 1986). Phytoplankton community serves as a bioindicator for assessing the health of an aquatic ecosystem (Tiwari and Chauhan 2006). The functional classification of plankton is based on trophic level, size, and distribution. Autotrophs (primary producers) can produce their own food and constitute phytoplankton, whereas heterotrophs, i.e., consumers, constitute zooplankton. The amount of phytoplankton present influenced the productivity of the water body (Delince 1992). The aims of the present study were to assess the diversity indices of Chlorophycae and their seasonal variation.

MATERIAL AND METHODS

Two sites of the river Torsa were selected for the study. Site 1 is located at Sonapur (Latitude 26°30’22"N and longitude 89°19’38"E) and Site 2 is at Cooch Behar city (Latitude 26°30’22"N and longitude 89°19’38"E). The study was conducted for two years, from March 2014 to February 2016.

Water samples were collected monthly interval with the help of a plankton net (mesh size: 60 micron) in the early morning (between 6:00 a.m. and 9:00 a.m.). Ten litres of surface water were filtered and preserved in Lugol’s iodine solution (Trivedy and Goel 1986). In the laboratory, the water sample was then concentrated by centrifugation at 15000 rpm for ten minutes. Phytoplankton samples were identified up to the genus level with the help of standard references such as Turner (1982), Anand (1998), Presscot (1962), and APHA (2005). Diversity indices were calculated using PAST 3.0 software. March to June is considered the summer season; July to October is the monsoon season; and November to February is considered the winter season.

RESULTS AND DISCUSSION

A total of 12 chlorophyceae under the seven orders were reported during the study period. Chlorococcales was the dominant order with 4 (34%) species, followed by Chlamydomonodales and Desmidiaceae (with two species, 17%) and

Oedogoniales, Zyggnematales, Ulotrichales, and Zygnemales (with one species, 8%) (Table 1, Fig. 1). Bhanja et al. (2014) found the phytoplankton community was dominated by Chlorophyceae and Bacillariophyceae. Sarwade and Kamble (2014) recorded a total of 22 Chlorophyceae in the Krishna River, Maharashtra. Patel and Singh (2014) reported 16 Chlorophyceae from the river Beehar, Rewa (M.P.). Jafari and Gunale (2006) recorded a total of 18 Chlorophyceae in the river Mutha, Pune, India. Previous studies in different rivers of India, reported more Chlorophyceae than the present study. The phytoplankton community was dominated by Chlorophyceae and then Bacillariophyceae (Sarwade and Kamble 2014, Bhanja et al. 2014, Negi and Rajput 2011, Pyasi 2015), which concurred with our findings.

The presence of *Chlorella* sp. and *Spirogyra* sp. indicated a low level of organic and sewage pollution in this river (Gupta and Shukla1990, Shekhar et.al. 2008). *Chlorella* sp. and *Closterium* sp. are pollution tolerant genera (Palmer 1969), recorded during the survey. The number of taxa ranged from 7 (May) to 12 (November and December) and 6 (July) to 11 (November and December) at sites 1 and 2, respectively. The dominance index ranged from 0.09469 (May) to 0.1944 (December) at site 1 and 0.09631 (December) to 0.1852 (July) at site 2. Shanon diversity index varied from 1.792 (May) to 2.41 (December) at site 1 and 1.735 (July) to 2.369 (December) at site 2. 0.8571 (May) and 0.9483 (December) were the minimum and maximum evenness index recorded at site 1. At site 2 the minimum and maximum evenness indexes were

Table 1. Checklist of Chlorophyceae in two sampling sites in the river Torsa

Order	**Species**	**2014-2015**		**2015-2016**	
		S 1	**S 2**	**S 1**	**S 2**
Chlamydomonodales	*Clamydomonas* sp.	+	+	+	+
	Volvox sp.	+	+	+	+
Chlorococcales	*Chara* sp.	+	+	-	+
	Chlorella sp.	+	+	+	+
	Pediastrum sp.	+	-	+	+
	Coelastrum sp.	+	-	+	-
Oedogoniales	*Oedogonium* sp.	+	+	+	+
Zyggnematales	*Spirogyra* sp.	+	+	+	+
Desmidiaceae	*Cosmarium* sp.	+	-	+	+
	Closterium sp.	+	+	+	+
Ulotrichales	*Ulothrix* sp.	+	-	+	+
Zygnemales	*Zygonema* sp.	+	+	+	+

Table 2. Number of taxa and diversity indices of Chlorophycae in the river Torsa

		JAN	**FEB**	**MAR**	**APR**	**MAY**	**JUN**	**JUL**	**AUG**	**SEP**	**OCT**	**NOV**	**DEC**
Taxa (S)	S1	9	9	9	8	7	11	8	8	8	9	12	12
	S2	10	8	8	8	7	10	6	8	9	7	11	11
Dominance (D)	S1	0.1293	0.1229	0.1327	0.1405	0.1944	0.1073	0.1405	0.157	0.1405	0.125	0.104	0.09469
	S2	0.1563	0.128	0.1556	0.1328	0.1405	0.125	0.1361	0.1116	0.1003	0.1066	0.1122	0.1563
Shannon (H')	S1	2.112	2.14	2.107	2.02	1.792	2.313	2.02	1.972	2.02	2.138	2.367	2.41
	S2	2.197	2.014	1.992	2.02	1.906	2.243	1.735	1.979	2.138	1.864	2.276	2.369
Evenness (e^H'/S)	S1	0.9179	0.9147	0.9133	0.9421	0.8571	0.9187	0.9421	0.8984	0.9421	0.9428	0.8885	0.9483
	S2	0.9	0.9367	0.9158	0.9421	0.961	0.9421	0.8856	0.9046	0.9428	0.9211	0.9449	0.9713
Margalef	S1	2.62	2.55	3.03	2.91	2.41	3.53	2.91	2.91	2.91	3.21	3.50	3.203
	S2	3.114	2.525	2.729	2.919	2.885	3.41	2.276	2.817	3.219	2.415	3.338	2.97

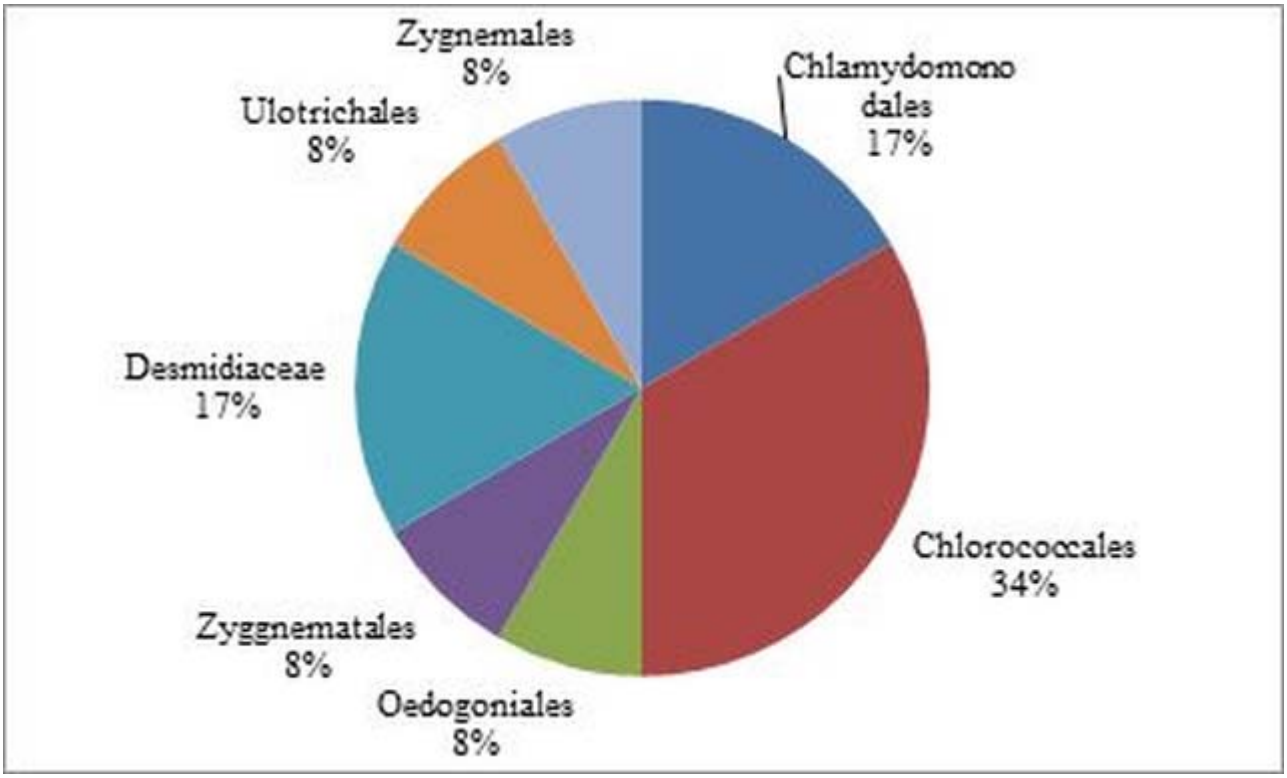

Figure 1. Composition (%) of Chlorophyceae in the river Torsa

0.8571 and 0.9713, respectively. A higher value of Shannon's diversity index in the river Torsa indicated a rich diversity of species and a longer food chain. According to Wilham and Dorris (1966), a species diversity value greater than 3 indicates clean water. So, the water quality of the river Torsa is good. Many herbivore fish dominate this river, which mostly depends on chlorophyceae for food. Chlorophyceae fluctuate in response to herbivore fish. Margalef species richness index ranged between 2.415 (May) and 3.53 (November) at site 1 and 2.276 (July) and 3.114 (November) at site 2 (Table 2). From the above study, we conclude that the diversity indices of two sampling sites are more or less the same.

The maximum number of taxa was recorded in the winter season and the lowest in the summer season at both sites. The lowest dominance index was reported in the winter season and the maximum in the summer season at all sites. The maximum Shannon diversity index was found in the winter season and the lowest in the summer season at two sites. The maximum Margalef species richness index was reported in the winter season and the minimum in the summer season. Shannon diversity index and Margalef species richness index were at their maximum in the winter season due to favourable environmental conditions (Table 3). The winter peak of Margalef's richness index recorded in this river concurred with studies by Acherjee and Barat (2013), Senapati et al. (2011), and Sharma et al. (2015). Phytoplankton genera, density, and diversity indices were at their maximum in the winter season due to the low volume of river water and high nutrient content. Similar findings were suggested by Keshri et al. (2013) and Patel (2014).

The number of chlorophyceae taxa shows a negative and significant correlation with the dominance index but a positive and significant correlation with the Shannon diversity index and the Margalef species richness index. Dominance index is negatively correlated with Shannon diversity index, evenness index, and Margalef species richness index. The Shannon diversity index is positively correlated with the Margalef species richness index but inversely correlated with the dominance index (Table 4). The Shannon diversity index (H') and Margalef species richness index (R) depend on the number of species and number of individuals in each

Table 3. Seasonal variation of the number of taxa and diversity indices of Chlorophyceae in the river Torsa

	Site 2			Site 1		
	Summer	Rainy	Winter	Summer	Rainy	Winter
Taxa (S)	8.25±0.48	8.75±0.75	10.5±0.008	7.75±0.25	8.25±0.85	9.75±0.94
Dominance (D)	0.1476±0.016	0.1363±0.0104	0.1132±0.008	0.1463±0.0037	0.1438±0.01	0.1254±0.01
Shannon (H')	2.01±0.078	2.08±0.078	2.25±0.076	1.98±0.026	2.02±0.11	2.18±0.10
Evenness (e^H'/S)	0.914±0.020	0.925±0.01	0.919±0.011	0.938±0.009	0.934±0.009	0.919±0.01
Margalef	2.73±0.15	3.07±0.15	3.14±0.18	2.76±0.089	2.93±0.25	2.96±0.19

Table 4. Pearson's correlation matrix between different diversity indices of Chlorophyceae in the river Torsa.

		Taxa (S)	Dominance (D)	Shannon (H')	Evenness (e^H'/S)	Margalef
Taxa (S)	S1	-				
	S2	-				
Dominance (D)	S1	-0.88409**	-			
	S2	-0.95974**	-			
Shannon (H)	S1	0.97402**	-0.9662**	-		
	S2	0.98707**	-0.99177**	-		
Evenness (e^H'/S)	S1	0.019481	-0.46622	0.23819	-	
	S2	-0.195	-0.028418	-0.064357	-	
Margalef	S1	0.75172*	-0.71073**	0.7572**	0.12073	-
	S2	0.80772**	-0.81374**	0.81682**	-0.15729	-

species, and so the Shannon diversity index (H') and Margalef species richness index (R) are positively correlated with density and number of individuals (Ludwig and Reynolds 1988).

CONCLUSION

Twelve chlorophyceae under the seven orders were found during the survey period. The highest diversity indices, such as the Shannon diversity index, Margalef species richness index, and evenness index, were recorded at their maximum during the winter season due to favourable water conditions. The presence of *Chlorella, Closterium,* and *Spirogyra* indicated a low level of polluted water in this river. The values of the Shannon diversity index and Margalef species richness index indicate good quality of water.

Conflict of interest: Author declare no conflict of interest

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Received:1st June 2023
Accepted: 05th August 2023