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Evaluation of the Phytoplankton Community in the Keshopur Chhumb Wetland (Ramsar Site) in District Gurdaspur, Punjab

Hargobind Singh and Syed Shabih Hassan*
Department of Fisheries Resource Management, College of Fisheries,
Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana – 141004 (Punjab), India.

(Corresponding author: Syed Shabih Hassan)*
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ABSTRACT: In aquatic ecosystems, plankton initiate energy transfer, hence the health of these organisms determines the stability of the system. Phytoplanktons are a vital component of the aquatic food chain that feeds zooplankton. The oxygen that algae make during photosynthesis is inhaled by fish and other aquatic animals. Keshopur Chhumb Wetland, a natural marsh, situated between the Ravi and Beas rivers in Gurdaspur district, includes villages Dalla, Miani, Matwa, Dhalla, and Magarmudhian, and is a Ramsar site of international importance. The study examined the phytoplankton, chlorophyceae, bacillariophyceae, cyanophyceae and euglenophyceae populations in Keshopur wetland. The population of Chlorophyceae varied between 15.0 and 62.0 × 10^6 no. per L, with December having the highest population (58.67 × 10^6 no. per L) and September having the lowest (17.67 × 10^6 no. per L). The bacillariophyceae population peaked in August (50.0 × 10^6 no. per L) and lowest in July (26.0 × 10^6 no. per L), with the postmonsoon season having the highest seasonal population and winter having the lowest. The range of the Cyanophyceae population was 30.0 to 58.0 × 10^6 no. per L, with the highest population occurring in October (56.0 × 10^6 no. per L) and the lowest occurring in January (32.0 × 10^6 no. per L). The population of euglenophyceae varied between 0.0 and 10.0 × 10^6 no. per L, with August and October having the highest populations (8.0 × 10^6 no. per L). Seasonally, the monsoon season had the highest number of euglenophyceae (5.5 × 10^6 no. per L) recorded, followed by the postmonsoon and winter. In the Keshopur Chhumb Wetland, the order of phytoplankton abundance was found to be Cyanophyceae > Bacillariophyceae > Chlorophyceae > Euglenophyceae, indicating that the water is conducive to aquatic life. This study is crucial for understanding their composition, abundance, and seasonal variations, assessing food availability, energy transfer and biodiversity maintenance, aiding protection of wetland ecology.

Keywords: Keshopur Chhumb Wetland, Ramsar Site, Evaluation, Phytoplankton population, Gurdaspur, Punjab.

INTRODUCTION

The Keshopur Chhumb Wetland is a mosaic-like natural marsh area in the Gurdaspur district, encompassing villages Dalla (152 acres), Miani (400 acres), Matwa (51 acres), Dhalla, and Magarmudhian (111 acres). It is located on the border between India and Pakistan, formerly submerged by Ravi and Beas rivers. It is a jumble of farmed wetlands, natural wetlands, and aquaculture ponds where bulk crops such as chestnut and lotus are grown (Hassan, 2015). This wetland is surrounded by rice, wheat, and sugarcane farms and is maintained by rainfall. The construction of fish ponds and the rapid spread of aquatic weeds such as lotus and trapa have had considerable negative influences on the rural economy and community involvement of the local people in the Keshopur Chhumb Wetland. The marsh also provides a livelihood for the residents of nearby communities (Hassan, 2015). An essential component of wetland production is phytoplankton which serves as the base of the food chain. Algae, small aquatic plants, are the primary link in the aquatic food chain, providing food for zooplankton and releasing oxygen into the water. According to Kadiri (2010), plankton organisms reveal the cleanliness of a body of water. Small aquatic plants and animals, called phytoplankton and zooplankton, are found in the water column. Phytoplankton are at the base of the aquatic food chain, followed by zooplankton. Algae are tiny aquatic plants that exist as single cells or colonies. They are the primary provider of food for zooplankton in the aquatic food chain. These tiny creatures are eaten by fish and other aquatic creatures. Phytoplanktons in rivers are influenced by water movement, turbidity, temperature, and nutrients, which control their abundance, as per the work of Hynes (1971). Factors like light, temperature, water current, substrate, water chemistry, and invertebrate grazing impact phytoplanktons, primary producers and food chains in water bodies, potentially influencing periphytonic populations (Whitton, 1975; Hynes, 1975; Biggs, 1996). Ellis (1937) and other studies by Canfield and Jones (1996); Khanna *et al*. (2013) found that erosive silt in rivers blocks phytoplankton photosynthesis. Rao (1975) stated that phytoplanktons, primary water producers and food sources for various animal groups, are increasingly used to evaluate riverine health, restoration and measure ecosystem management effectiveness. It determines toxic substance impact on aquatic environments (Joubert 1980). They also serve as water quality indicators in lotic and lentic water systems (Bhatt et al 1999). Research and observation on plankton aid in controlling the physical, chemical, and biological conditions of bodies of water. According to a number of scientists, phytoplankton can indicate the trophic level and water quality of wetlands/lakes. The development and composition of phytoplankton are significantly impacted by both short and long term environmental changes. To track trophic status and water pollution, systems, indices, and bioindicators have been developed through qualitative and quantitative evaluations of various organism groups. Ekwu and Sikoki (2006) state that because plankton initiate energy transmission in aquatic ecosystems, the stability of the system depends on plant well-being.

The biomonitoring of North Indian rivers has received relatively little attention, according to Jindal and Sharma (2011). Ekwu and Sikoki (2006), indicated that plankton are essential to the health of lotic and lentic ecosystems because they transfer energy throughout aquatic environments. Sharma *et al.* (2013) investigated the species diversity and dynamics of the plankton population in the River Sutlej, Punjab. Protozoa, rotifera, and crustacea were among the phytoplankton constituents, while bacillariophyceae, chlorophyceae, cyanophyceae, and euglenophyceae were among the phytoplankton. In all, Akhter and Brraich (2020) identified 43 different species of plankton from the Sutlej River. They also examined the distribution of phytoplankton at four different locations within the Ropar Wetland in Punjab. Through the use of Pearson correlation analysis, they were able to determine how strongly and seasonally phytoplankton production and density are influenced by physicochemical factors. There was evidence of greater phytoplankton density at higher temperatures and fertilizer levels. In water, the diversity of phytoplankton was more susceptible to dissolved oxygen and free CO_2, which were negatively correlated with all physio-chemical parameters across all sites. From four sampling sites in the Ropar wetland, Akhter and Brraich (2020) identified 28 phytoplankton taxa, represented by the following: dinophyceae (1), cyanophyceae (4), bacillariophyceae (14) and chlorophyceae (9). Dinophyceae were the least represented and diversified group of plankton, whereas bacillariophycean plankton were the least represented group. Compared to those in the monsoon treatment, the summertime phytoplankton population was more diversified. Akhter and Brraich (2020) used the Shannon Weiner diversity score and reported that the Ropar Wetland has a modest level of pollution in relation to its trophic status. Phytoplankton are useful bioindicators of water quality. The study was designed to evaluate the fluctuations and abundance of phytoplanktons in Keshopur Chhumb Wetland.

MATERIAL AND METHODS

Study area and location. The current studies on, phytoplankton abundance in the Keshopur Chhumb Miani

Map 1. Keshopur Chhumb Wetland.

Chart 1

Chart 2

Chart 3

Sampling Sites in Keshopur Chhumb Wetland

Wetland, at district Gurdaspur, Punjab were carried out at the College of Fisheries, Guru Angad Dev Veterinary and Animal Sciences University, Ludhiana, Punjab. The Keshopur Chhumb Miani Wetland, Gurdaspur (32° 05' 16° 3" N, 75° 24' 24° 2" E), covers total area of 850 acres and is situated at an altitude of 245-250 m. A dynamic freshwater ecosystem in the Gurdaspur district is recognised as a notified Community Reserve in India under the Wildlife Protection Act of 1972, and now it became a Ramsar site in 2019. Phytoplankton samples were collected for both qualitative and quantitative examination. Water surface phytoplankton samples were collected using 125 ml borosilicate glass bottle. The samples were preserved using Lugol's stock solution and kept upright inside the clear box or container. It was quickly transported to the laboratory and kept there for additional processing in a chilly, dark area to avoid spills. To evaluate phytoplankton productivity, the biological parameter population of phytoplankton and its groupwise relative abundance were calculated.

Plankton productivity. The primary focus of the plankton productivity assessment was phytoplankton. Samples of plankton were taken from the Keshopur Chhumb wetland in the morning hours. The drop count method was used for qualitative and quantitative analysis to estimate phytoplankton following APHA (2017).

Sample collection, fixation, preservation and identification: Using a borosilicate glass bottle, samples of water surface phytoplankton were collected. The Lugol's stock solution was used to preserve the samples. Lugol's acid solution was made by dissolving 10 g of potassium iodide in 20 mL of distilled water. To create the solution, 50 millilitres of water, five grams of sodium acetate, and five grams of iodine crystals were added. Getting a water sample and putting it in a reagent bottle was the first step in gathering and conserving the sample. 2 ml of Lugol's acid solution were added to a borosilicate glass bottle containing a water sample to fix the phytoplankton. The sample in the bottle was left unopened for a full day to ensure total sedimentation or settling of any suspended particles. After the supernatant was removed, the sediments were spun once more to extract the phytoplankton concentrate. Collected samples was placed in a graded centrifuge tube. After centrifuging the test tube, 5 ml of sample was obtained. Under a microscope, a single drop of the sample was placed over the slide and inspected. Ten fields were randomly selected, and the phytoplankton count was recorded using a 40x microscope. The following method was used to calculate the amount of phytoplankton per liter of sample:

$$\text{No. of phytoplankton/drop} = \frac{\text{Area of cover slip x total individuals counted in all field}}{\text{Area of one field x number of fields observed}} = \text{A}$$

No. of phytoplankton/ml of concentrate = A × 20 = b (1 ml = 20 drops)

$$\text{No. of phytoplankton/litre of water} = \frac{\text{b x ml of concentrate x 1000 (ml)}}{\text{Volume of water sample (ml)}}$$

(A) (B) (C) (D)

Plate 1 : Laboratory Analysis of Plankton Samples (A) Slide preparation, (B) Slide Mounting, (C) Microscopic examination, (D) Documentation of Plankton).

RESULTS AND DISCUSSION

Chlorophyceae (green algae). The population of Chlorophyceae at several sites selected inside the Keshopur Chhumb wetland during the present study ranged from 15.0 to 62.0 × 10^6 no. per L (Table 1 and Fig. 1). In the Keshopur Chhumb Wetland, the average maximum Chlorophyceae population (58.67 × 10^6 no. per L) was recorded in December, while the average lowest (17.67 × 10^6 no. per L) was recorded in September. In the water of the Keshopur Chhumb Wetland, the average population of Chlorophyceae was the highest (45.89 × 10^6 no. per L) in the winter, followed by the post monsoon (28.33 × 10^6 no. per L) and monsoon (25.75 × 10^6 no. per L) populations. A green algal bloom, according to Tas and Gonulal (2007), is a sign of an area free from pollution. It has been suggested that some phytoplankton species can be useful in addition to their functions as primary producers in food webs and keepers of ecological balance; additionally, they are indicators of the quality of water. Comparable results were recorded in the present study.

The great diversity of the green algae population following the monsoon may be explained by increased photosynthetic activity in the wetland due to moderate water flow and temperature as well as decreased turbidity of the water. The higher density is a result of the high dissolved oxygen content and high transparency following the monsoon. Thus, a variety of physical and chemical factors affect the concentration of Chlorophyceae in wetlands. These findings are consistent with earlier research showing comparable amounts of green algae in freshwater environments. On the other hand, Barwant and Sanap (2020) found chlorophycean ` in the Godavari River during late winter and summer. The December water level of chlorophyceae may be explained by moderate turbidity, pH, DO, nitrate, or temperature. According to Kaur and Singh (2020), mild temperatures and sufficient nutrients may be related to the high abundance of Chlorophyceae during the postmonsoon season. The monsoon months showed significant changes in values at every site when compared to other months ($p<0.05$).

Table 1: Monthly variations in Chlorophyceae populations (no. × 10^6 per L) at different sites in the Keshopur Chhumb Wetland.

Month	Site 1	Site 2	Site 3	Average
July	30	30.2	38	33.50 ± 2.362^{d}
August	18	21	15	18.00 ± 1.732^{f}
September	20	18	15	17.67 ± 1.452^{f}
October	26	28	30	28.00 ± 1.154^{e}
November	36	40	42	39.33 ± 1.763^{c}
December	56	58	62	58.67 ± 1.763^{a}
January	36	34	32	34.00 ± 1.154^{d}
February	41	48	46	45.00 ± 2.081^{b}

*Values (men ± standard error) with different alphabetical superscripts (a, b, c…) differ significantly between the site (in a row) and within the site (in the column)

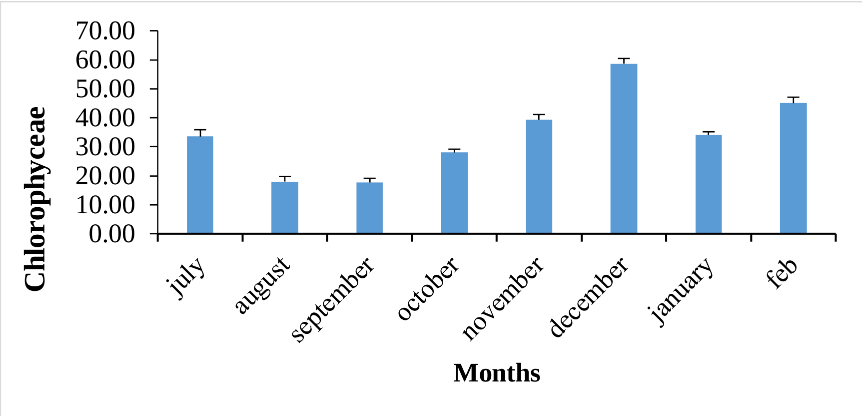

Fig. 1. Monthly variations in Chlorophyceae populations (no. × 10^6 per L) at different sites in the Keshopur Chhumb Wetland.

Bacillariophyceae (Diatoms). The amount of the bacillariophyceae population ranged between 24.0 and 52.0 × 10^6 no. per litre in the present study during the examination of various sites within the Keshopur Chhumb wetland (Table 2 and Fig. 2). In the Keshopur Chhumb Wetland, the average maximum (50.0 × 10^6 no. per L) Bacillariophyceae population was detected in August, whereas the average minimum (26.0 × 10^6 no. per L) was recorded in July. Seasonally, the postmonsoon season (38.78 × 10^6 no. per L) had the largest average bacillariophyceae population in the Keshopur Chhumb Wetland water, followed by the monsoon season (38.0 × 10^6 no. per L) and winter (31.33 × 10^6 no. per L).

In the premonsoon and monsoon seasons, when the water column stratified as a result of increased turbidity, water movement, and rainfall, the lowest number of bacillariophyceae occurred. Because of the dissolved oxygen availability and transparency, the postmonsoon density increases. Diatoms prefer the postmonsoon season, and Jagadeeshappa and Kumara (2013) state that Bacillariophyceae species are sensitive to physicochemical changes in waterbodies. Lakshminarayana (1965) achieved similar results from the Ganga River. The species showed large pollution loads since the bacillariophycean was pollutant resistant. Diatoms such as *Nitzschia* sp., *Achnanthes* sp., *Naviculas* sp., and *Gomphonema* sp., according to Venkateswarlu (1983), grow more easily in settings with low DO levels, high oxidizable materials, and elevated levels of phosphates, chlorides, and nitrates. August in the Keshopur Wetland had the highest recorded population of bacillariophyceae. The abundance of nutrients from allochthonous sources that accumulated throughout the monsoon season may also explain this difference. The breakdown of these organic nutrients in rivers increases the amount of organic nutrient matter in the water. At every site, the monsoon months exhibited considerably distinct changes compared to the other months ($p<0.05$).

Table 2: Monthly variations in Bacillariophyceae populations (nos. × 10^6 per L) at different sites in the Keshopur Chhumb Wetland.

Month	Site 1	Site 2	Site 3	Average
July	28	26	24	26.00 ± 1.154^{g}
August	48	50	52	50.00 ± 1.154^{a}
September	41	40	38	39.67 ± 0.881^{c}
October	45	48	47	46.67 ± 0.881^{b}
November	30	31	29	30.00 ± 0.577^{ef}
December	36	34	32	34.00 ± 1.154^{d}
January	30	28	26	28.00 ± 1.154^{fg}
February	32	30	34	32.00 ± 1.154^{de}

*Values (men ± standard error) with different alphabetical superscripts (a, b, c…) differ significantly between the site (in a row) and within the site (in the column)

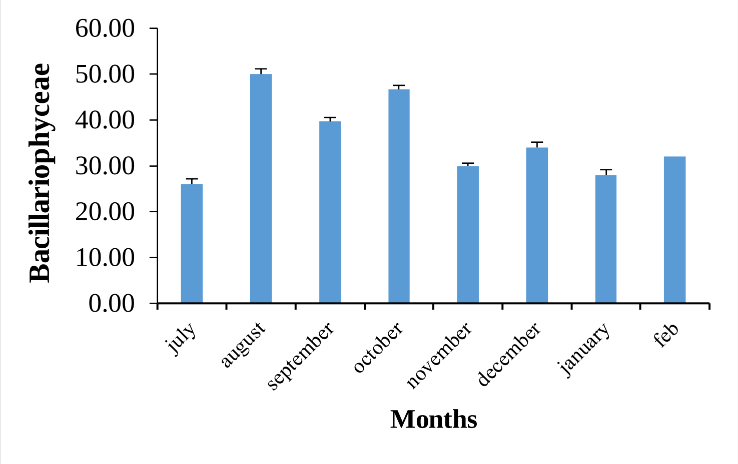

Fig. 2. Monthly variations in Bacillariophyceae populations (nos. × 10^6 per L) at different sites in the Keshopur Chhumb wetland.

Cyanophyceae (Blue–green algae). Worldwide, bluegreen algae are found at every stage of the food chain. Many live with other algae and plankton (Ramteke and Moghe, 1988). Many species, including *Anabaena*, *Microcystis*, and *Oscillitoria brevis*, were observed during the study period. Because of the moderate temperatures; free carbon dioxide, hardness, BOD, nitrate, and phosphate concentrations; and hardness in the Keshopur Chhumb Wetland in October. Cyanophyceae were abundant in both months.

At specific locations within the Keshopur Chhumb Wetland, the number of cyanophyceae varied from 30.0 × 10^6 to 58.0 × 10^6 no. per L in the present study (Table 3 and Fig. 3). In the Keshopur Chhumb Wetland, the average maximum (56.0 × 10^6 no. per L) cyanophyceae population was recorded in October, while the average minimum (32.0 × 10^6 no. per L) was recorded in January. Seasonally, the average cyanophyceae population in the water of the Keshopur Chhumb Wetland was the highest (46.66 × 10^6 no. per L) in the postmonsoon season, followed by the monsoon season (46.0 × 10^6 no. per L) and winter (37.33 × 10^6 no. per L).

The postmonsoon season occurred when the mean cyanophycean density was at its maximum. Because of the dissolved oxygen availability and transparency, the postmonsoon density increases. Shukla et al (2015) discovered *Anabaena, Oscillatoria*, and *Synedra* in the Ganga River, whereas Johnson (2006) discovered a greater population of cyanophyceae in the Banjara and Naditni Lakes as a result of eutrophication. Pawar et al. (2006) claimed that low DO concentrations, high temperature, and organic materials encourage the growth of the bluegreen algae as stated by Lakshminarayana (1965) because the growth of bluegreen algae is induced by high pH, dissolved organic matter, nitrates, and phosphates. Venkateswarlu (1969a, b, c) stated that cyanophyceae originated under conditions of high oxidizable organic matter, low DO, and low pH.

Table 3: Monthly variations in Cyanophyceae populations (nos. × 10^6 per L) at different sites in the Keshopur Chhumb Wetland.

Month	Site 1	Site 2	Site 3	Average
July	36	38	40	38.00 ± 1.15^{cd}
August	53	55	54	54.00 ± 0.58^{a}
September	50	48	46	48.00 ± 1.15^{b}
October	54	56	58	56.00 ± 1.15^{a}
November	34	36	38	36.00 ± 1.15^{d}
December	38	40	42	40.00 ± 1.15^{c}
January	30	32	34	32.00 ± 1.15^{e}
February	38	40	42	40.00 ± 1.15^{c}

*Values (men ± standard error) with different alphabetical superscripts (a, b, c…) differ significantly between the site (in a row) and within the site (in the column)

Euglenophyceae. In the present study, the population of euglenophyceae varied between 0.0 and 10.0 × 10^6 no. per lt at specific locations within the Keshopur Chhumb Wetland (Table 4 and Fig. 4). In August and October, the average maximum euglenophyceae population (8.0 × 10^6 no. per L) was observed, while in November, December, and January, no euglenophyceae were reported (0.0 × 10^6 no. per L) in the Keshopur Chhumb Wetland. Seasonally, the average population of euglenophyceae was found to be highest (5.5 × 10^6 no. per L) in the Keshopur Chhumb Wetland during the monsoon season, followed by the postmonsoon season (4.22 × 10^6 no. per L) and winter (1.33 × 10^6 no. per L).

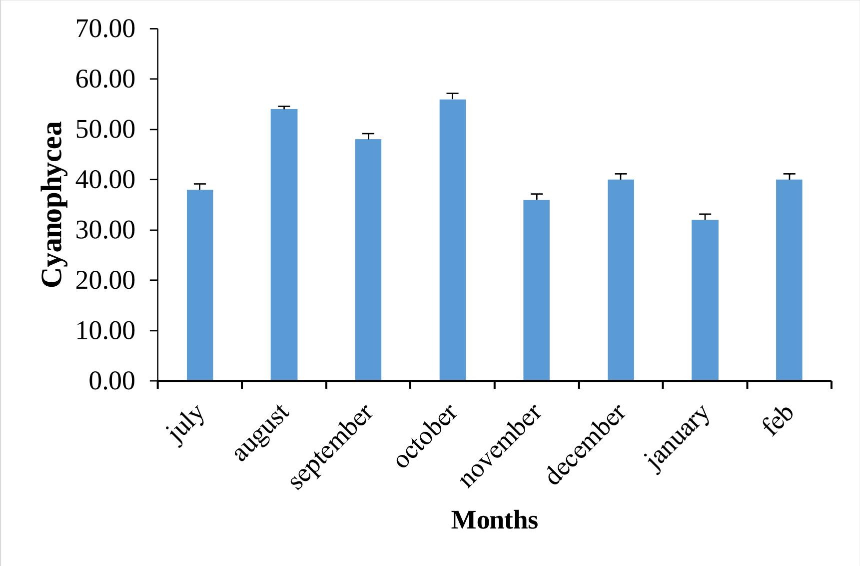

Fig. 3. Monthly variations in Cyanophyceae populations (nos. × 10^6 per L) at different sites in the Keshopur Chhumb Wetland.

Table 4: Monthly variations in Euglenophyceae populations (no. × 10^6 per L) at different sites in the Keshopur Chhumb Wetland.

Month	Site 1	Site 2	Site 3	Average
July	5	4	0	$3.00{\pm}1.527^b$
August	10	8	6	$8.00{\pm}1.154^a$
September	4	6	4	$4.67{\pm}0.666^b$
October	10	8	6	$8.00{\pm}1.154^a$
November	0	0	0	$0.00{\pm}0^c$
December	0	0	0	$0.00{\pm}0^c$
January	0	0	0	$0.00{\pm}0^c$
February	4	2	6	$4.00{\pm}1.154^b$

*Values (men ± standard error) with different alphabetical superscripts (a, b, c…) differ significantly between the site (in a row) and within the site (in the column)

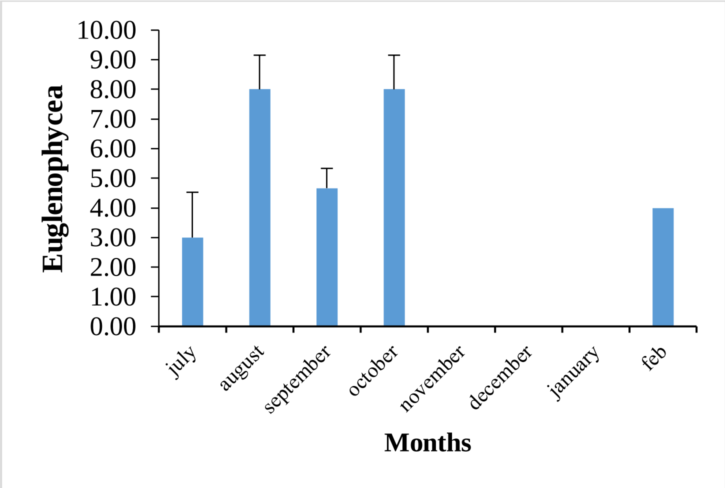

Fig. 4. Monthly variations in Euglenophyceae populations (no. × 10^6 per L) at different sites in the Keshopur Chhumb Wetland.

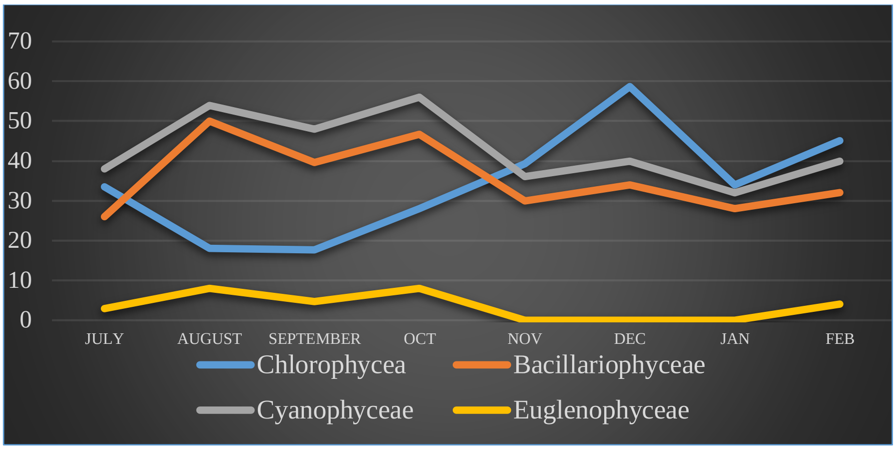

Fig. 5. Month-wise average variations of phytoplankotns in Keshopur Wetland.

Relative abundance of phytoplankton. During the present study, month-wise average variations of phytoplankotns in Keshopur Wetland are depicted in Fig. 5. Keshopur Chhumb Wetland had the highest percentage of the cyanophyceae population (36.94%), followed by the bacillariophyceae (30.75%), chlorophyceae (29.44%), and euglenophyceae (2.97%). According to the collected data, the order of phytoplankton abundance in the Keshopur Chhumb Wetland was Cyanophyceae > Bacillariophyceae > Chlorophyceae > Euglenophyceae. In Fig. 5 and 6, the relative abundance is shown.

In the Nangal wetland in Punjab, Brraich and Kaur (2015) observed changes in the phytoplankton population. According to their findings, chlorophyceae constitute 44% of the phytoplankton population, whereas bacillariophyceae constitute 43% and cyanophyceae 13%. Brraich and Kaur (2015), phytoplankton diversity follows the order of dominance, such as chlorophyceae > bacillariophyceae > cyanophyceae. The current results, however, do not concur with those of Brraich and Kaur (2015). According to reports from the Ganga and other water bodies in north India, seasonal variations in hydrological and physico-chemical parameters are known to significantly control aquatic productivity and biodiversity (Hassan *et al.*, 1998a, b; Sehgal *et al.*, 2011; Hassan, 2015; Hassan and Sinha, 2015). Plankton biomass and succession are significantly shaped by nutrient availability in the trophogenic and epilimnetic zones (Hassan *et al.*, 2015), and water quality and primary productivity may be further altered by anthropogenic inputs, organic amendments, and watershed influences (Sharma and Hassan 2016; Sharma *et al.*, 2019). The significance of phytoplankton as markers of eutrophication and ecological balance is highlighted by studies on trophic status and wetland productivity in comparable habitats as Nigeen Lake and Harike Wetland (Kaur *et al.*, 2018; Priyanka *et al.*, 2018). The necessity of incorporating planktonic assessments with more comprehensive environmental monitoring frameworks is further highlighted by worries about heavy metal contamination and microbial load in Punjab wetlands and rivers (Kaur *et al.*, 2019a, b, c; Kumar *et al.*, 2020; Maan and Hassan 2021). Therefore, Keshopur Chhumb Wetland's phytoplankton assessment not only shows its current trophic condition but also acts as a basis for conservation planning and sustainable fisheries management in Punjab.

The phytoplankton population in the Ropar wetland in Punjab was investigated by Akhter and Brraich (2020). All the Ropar wetland locations had phytoplankton identified from four distinct groups, the most prevalent of which were Bacillariophyceae (Akhter and Brraich 2020). Cyanophyceae, Dinophyceae, and Chlorophyceae are other common groups of phytoplankton. The total class wise representation and dominance hierarchy of phytoplanktonic diversity are reported as follows by Akhter and Braich (2020): Bacillariophyceae > Chlorophyceae > Cyanophyceae > Dinophyceae. Compared to those of previous researchers, somewhat different phytoplankton orders were found in the present study. Nonetheless, the results imply that aquatic life benefits from water in wetlands/dams.

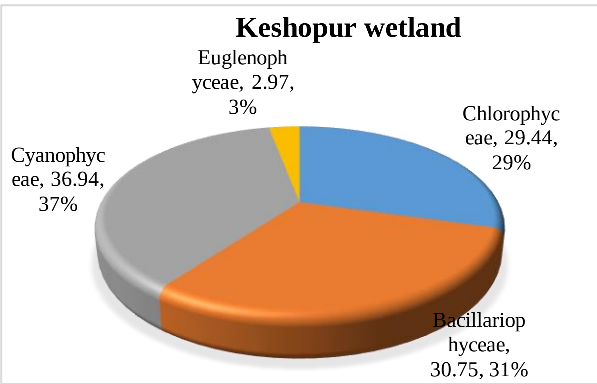

Fig. 6. Relative abundance (%) of phytoplankton in the Keshopur Chhumb Wetland.

CONCLUSION

Phytoplankton populations are crucial for the wetland food web, influencing nutrient cycling and productivity. Their abundance and community composition are greatly impacted by seasonal variations in physico-chemical features of the wetland. Phytoplankton species determine the trophic state of marshes; higher cyanobacteria levels indicate eutrophic conditions. Phytoplankton types are essential for determining the level of pollution in wetland water. Bacillariophyceae, cyanophyceae, and euglenophyceae are bioindicators of freshwater trophic status, pollution levels, and ecological changes, with bloom formation in warm, nutrient-rich waters. Understanding phytoplankton populations is necessary to evaluate the ecological and fisheries status of freshwater wetlands. Additionally, it would shed some light on the productivity and diversity of the marsh. This is advantageous for conservation, anti-pollution, planning, and exploitation efforts. The diversity and quantity of phytoplankton affect zooplankton populations and higher trophic levels, regulating the general health, ecological balance, and productivity of the wetland environment. Monitoring phytoplankton communities is a trustworthy bio-indicator for assessing the water quality and ecological integrity of wetlands.

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