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COMPARATIVE STUDY OF TWO PERENNIAL WETLANDS OF BHAGALPUR DISTRICT IN EASTERN INDIA WITH SPECIAL REFERENCE TO THEIR PHYSICO – CHEMICAL ENVIRONMENT AND PHYTOPLANKTON DIVERSITY

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ABSTRACT

In the present paper, we have examined two perennial freshwater wetlands in Bhagalpur district, Bihar (I) Jichho Pond in Pirpainti Block (Pond-I: Latitude-N 25°18'56.25"/Longitude-E 087°25'53.94"), and (II) Purandaha Pond in Shahkund Block (Pond-II: Latitude-N 25°09'35.46"/Longitude-E 086°48'22.62"). Both the wetlands provide a variety of services for the human population, which include water for drinking and irrigation, fishing, and other domestic uses. The objective of the present study was to generate baseline data on water quality and phytoplankton diversity of the above mentioned two ponds. Water parameters such as temperature, pH, electrical conductivity, dissolved oxygen, alkalinity, total hardness, chloride, nitrate-nitrogen, phosphate-phosphorus, COD and BOD for both the ponds were studied on seasonal basis (2020 – 21). Most of the water parameters were found to be well within permissible limit except that of BOD (3.1-4.8mg/L) and COD (28.8-82.3mg/L) which were in higher range crossing the permissible limit as prescribed by WHO (2017) and BIS (2012). In this study, a total of 91 species belonging to 42 genera of phytoplankton (algal taxa) have been identified from both the ponds. Phytoplankton taxa in Pond – I was found to be relatively more diverse than in Pond-II. Among the identified phytoplankton species, Chlorophyceae (38.88%) formed the dominant group followed by Bacillariophyceae (29.62%), Cyanophyceae (20.37%) and Euglenophyceae (11.11%) in Pond-I, whereas in Pond-II, Chlorophyceae (39.58%) formed the dominant group followed by Bacillariophyceae (31.25%), Euglenophyceae (20.83%) and Cyanophyceae (8.33%). Phytoplankton density was found to be maximum during summer season and minimum during monsoon season in both the ponds. Species like *Scenedesmus quadricauda, Scenedesmus obliquus, Scenedesmus dimorphus, Chlorella vulgaris, Pediastrum duplex, Coelastrum microporum, Synedra ulna, Synedra acus, Nitzschia palea, Cyclotella meneghiniana* and *Oscillatoria princeps* were recorded from both ponds. According to Palmer's (1969) pollution index, the presence of algal species like *Chlorella vulgaris, Oscillatoria princeps, Euglena gracilis, Nitzschia palea and Scenedesmus quadricauda* suggested that both the ponds under investigation were organically polluted and are advancing towards the eutrophic condition.

Keywords: Freshwater wetlands, Water quality, Phytoplankton.

INTRODUCTION

Freshwater ponds are suitable habitats for the growth of aquatic flora and fauna since it is a close microcosm. They represent great internal complexity so it is never easy to evaluate them. Ponds are smaller in size and less in-depth, therefore, they maintain a unique freshwater ecosystem service (Elton and Miller, 1954). In these habitats, phytoplankton is important for trophic dynamics as they are the chief primary producers of the aquatic environment (Wetzel, 1975) and also act as a very important biological indicator of water quality. The physical and chemical properties of freshwater bodies are characterized by climatic, geochemical, geomorphic, and pollution conditions. The pH, DO_2, alkalinity, hardness, turbidity, and dissolved nutrients are important for plankton production (Banerjea, 1967). The structure and abundance of the phytoplankton populations are mainly controlled by inorganic nutrients such as nitrogen, phosphorous, and silica (Daniel, 2001). The interplay of physical, chemical, and biological properties of water most often leads to the production of phytoplankton, while their assemblage (composition, distribution, diversity, and abundance are also structured by these factors). Several studies show that the phytoplankton community is strongly influenced by changes in physico – chemical parameters of water (Islam *et al*., 2020), the rhythm of the seasons (Dong *et al.*, 2022), and another aspect of climate change can also affect the phytoplankton community in various ways (Dashkova *et al*., 2022).

The purpose of the study was to investigate the seasonal changes in phytoplankton population with respect to water quality of two perennial freshwater ponds. The Ponds under the investigation are not well developed and also surrounded by human population. Thus, assessment of the water quality in these ponds has become extremely important for controlling water pollution. The present study was conducted in the year 2020-21 in the ponds: (i) Jichho Pond (Pond-I) located in Pirpainti Block; and (ii) Purandaha Pond (Pond-II) in Shahkund Block in the Bhagalpur district of Bihar, India. .

STUDY AREA

Pond I: (Jichho Pond): Jichho Pond is located in the River Ganga floodplains at latitude-N 25°18'56.25"/longitude-E 087°25'53.94" in the Pirpainti Block of Bhagalpur district (Figure -1). The water body has a constructed boundary of cement and bricks on one side and another side is the nearby road with a natural boundary. Various cultural events take place in/around the pond, so there are frequent chances of organic waste disposal in the pond. The most common activities seen are fishing, washing clothes, and cattle wallowing which also add nutrients and harmful components to water. The area of the pond is 0.052km^2

Pond II: (Purandaha Pond): Purandaha Pond is located 16 km south to the River Ganga at latitude-N 25°09'35.46"/longitude-E 086°48'22.62" in Shahkund Block of Bhagalpur district (Figure - 2). The Pond is surrounded by cemented stairs on two sides and the other two sides are close to the natural land area. The catchment area of the pond has various rows of dense plantations with human settlement. Various anthropogenic activities in and around the pond, such as bathing, washing clothes, cattle wallowing, rituals and agro-practices appear to have adverse impacts on the water quality of the pond. The excess water from Hanumana dam is accumulated in the pond. The area of the pond is 0.055km^2.

Fig. 1: GIS map of sampling site Jichho Pond (Pond I) under Pirpainti block

Fig. 2: GIS map of sampling site Purandaha Pond (Pond II) under Shahkund block

MATERIAL AND METHODS

For analysis of water variables, water samples from both ponds were collected between 8:00 am to 11:00 am from the pre-decided sampling points (Figs.1 and 2). The water samples were collected in pre-cleaned and acid-treated BOD bottles and 1.5 liter poly containers from the subsurface level i.e., 20-30 cm below the upper water surface. Some water parameters like temperature, pH, dissolved oxygen, free carbon dioxide, carbonate and bicarbonate alkalinity, electrical conductivity, and total dissolved solids were estimated on the spot, and for analysis of the rest of the water parameters like total hardness, chloride, phosphate-phosphorus, nitrate- nitrogen, COD and BOD, water samples were transported to the Environmental Biology Research Laboratory in the University Department of Botany, T. M. Bhagalpur University. The water parameters were analyzed following Standard Methods (APHA, 2005). Phytoplankton samples were collected in 125 ml of sample bottles from sampling stations using phytoplankton net of 65µ mesh size. The filtrate was immediately preserved in 4% formaldehyde and later observed thoroughly under the microscope and has been identified with the help of relevant literature and monographs (Turner, 1892; West and West, 1907; Gandhi, 1958, 1961, 1967; Randhawa, 1959; Desikachary, 1959; Edmondson, 1959; Ramanathan, 1964; Patrick and Reimer 1966, 1975; Philipose, 1967; Prescott, 1970; Cramer, 1984; and Trivedy and Goel, 1986).

RESULTS AND DISCUSSION

Physico – Chemical Parameters

The results obtained for water quality parameters is depicted in Table 1, whereas results of correlation among them along with total phytoplankton density have been depicted in Tables 3 and 4. Results for phytoplankton composition and density of two ponds are presented in Table 2. Figure I and II represents the GIS map of both the sampling sites.

Ambient temperature regulates various physico – chemical as well as biological activities. Temperature changes govern biological processes like growth, development, reproduction, and other life processes of the biota (Wetzel, 1983). In the Pond I ambient temperature varied from 21°C (winter) to 31°C (monsoon) whereas in Pond II ambient temperature ranged from 22°C (winter) to 30°C (monsoon). Ambient temperature was always observed more than the water temperature. In Pond I ambient temperature showed a positive correlation with FCO_2 (r = 0.63) and NO_3-N (r = 0.57) and negative correlation with conductivity (r = -0.99) while in Pond II positive correlation with NO3-N (r = 0.72) and negative correlation with total hardness(r = -0.99).

Water temperature plays an important role in the physico – chemical and biological behavior of the aquatic system (Welch, 1952). During this study water temperature of the Pond I ranged from 17.9°C (winter) to 28°C (monsoon) whereas in Pond II value ranged from 21.3°C (winter) to 27°C (summer). Water temperature fluctuated due to the presence of different algal groups. The temperature of the water may decide which group of algae is more favored in the Pond water. Wieliczko *et al.* (2018) reported that the increase in water temperature was responsible for increasing the phytoplankton structure along with nutrient contents of subtropical shallow lake. The seasonal changes in water temperature have far-reaching effects on the aquatic and biotic components of both Ponds. Water temperature showed positive correlation with NO_3-N (r = -0.52) in the Pond I and negative correlation with conductivity (r = -0.99) while, in Pond II, no significant correlation was established between water temperature and other water parameters except that of positive correlation with NO_3-N (r = 0.65) .

The hydrogen-ion concentration expressed in terms of pH depends upon the number of carbonates present in water. It is the measurement of acidic or basic nature of the water. The pH of water controls the relative predominance of FCO_2, carbonate, bicarbonate, dissolved oxygen, and dissolved solids in an aquatic ecosystem (Wetzel, 1975). Prescott (1970) and Roy (1955) think that high pH is associated with phytoplankton maxima. During the present study, the pH value of Pond I ranged from 8.1(monsoon) to 8.5 (summer) and for Pond II from 7.3 (monsoon) to 8.3 (winter). A similar result was observed by Tompe *et al.* (2017). The fluctuation in pH value was within a narrow alkaline range of 7.3 – 8.5. pH showed positive correlation with total hardness, COD and BOD in Pond I. Pond II showed positive correlation with total hardness (r = 0.76) and conductivity (r = 0.57) and negative correlation with total dissolved solids, dissolved oxygen, free carbon dioxide, total alkalinity and phosphate phosphorus.

Total Dissolved solid is a quantitative measurement of the dissolved salts in water. The high content of dissolved solids evaluates the density of water, influences osmoregulation of freshwater organisms, and reduces the solubility of gases and utility of water for drinking, irrigation, and industrial use (Saxena, 1989). In Pond I, TDS values ranged from 224 mg/L (summer) to 294 mg/L (monsoon) and in Pond II, the values ranged from 92 mg/L (summer) to 189mg/L (monsoon). The maximum value of TDS during rainy season was possibly due to mixing of domestic waste water and sewage in Pond waters. Total dissolved solids showed positive correlation with chloride (r = 0.62), nitrate- nitrogen (r = 0.60) and negative correlation with FCO_2 (r = -0.54) in Pond I, whereas no significant correlation was established between TDS and water parameters in Pond II.

Conductivity is the measure of the ability of a solution to carry electric current. As this ability is dependent upon the presence of ions in solution, a conductivity measurement is an excellent indicator of the TDS in water. The value of conductivity in the Pond I ranged from 425 µs/cm (summer) to 536 µs/cm (winter) and in Pond II ranged from 171µs/cm (monsoon) to 276µs/cm (winter). The higher value of conductivity may be due to the addition of sewage, domestic wastewater, and seepage of drains, whereas the lower value of conductivity during the monsoon season might be due to high rainfall which reduces the level of dissolved solids. Conductivity had a negative correlation with free carbon dioxide (r = -0.53) in the Pond I while in the Pond II, it had a positive correlation with free carbon dioxide (r = 0.73) and chloride (r = 0.66).

Chapman and Kimstach (1992) stated that the oxygen content of natural waters varies with temperature turbulence, the photosynthetic activity of algae and plants, etc. DO_2 is much more useful in indicating the degree of pollution of organic matter, the destruction of organic substances, and the level of self-purification of water. Dissolved oxygen fluctuated from 3.7 mg/L (winter) to 7.2 mg/L (monsoon) in the Pond I, whereas in Pond II ranged between 1.8 mg/L (winter) to 6.2 mg/L (monsoon). In both the Ponds winter values of DO_2 were lower which reflects the richness of organic matter, otherwise, they were within the permissible limit. Similar results were also reported by Bisht *et al.* (2013). No significant correlation between DO_2 and other water parameters was found in Pond I but in the Pond II, it had a positive correlation with nitrate-nitrogen (r = 0.76) and negative with free carbon dioxide (r = -0.57).

Carbon dioxide is one of the important components of the buffer system of fresh waters. In Pond I, the value of FCO_2 ranged from 1 mg/L (summer) to 12 mg/L (monsoon) and was absent in the in the winter season. In Pond II, the value of FCO_2 ranged from 1mg/L (summer) to 10 mg/L (winter). No significant correlation in between FCO2 and other water parameters was found in Pond I while in Pond II, a positive correlation was established with total hardness (r = 0.55).

Alkalinity results from the presence of hydroxides, carbonates, and bicarbonates of elements such as calcium, magnesium, sodium, potassium, or ammonia (Metcalf and Eddy, 1991). In the pond waters, alkalinity was due to carbonates and bicarbonates. The value of carbonate in Pond I was 0.8 mg/L during the winter season only due to the complete absence of free carbon dioxide. Bicarbonates value ranged from 36mg/L (summer) to 46mg/L (monsoon). In Pond II, the value of bicarbonate ranged from 8mg/L (summer) to 32mg/L (monsoon). Total alkalinity had a positive significant correlation with total hardness (r = 0.60) and negative correlation with total density of phytoplankton (r = - 0.69) in Pond I but in Pond II, no significant correlation between alkalinity and other parameters was established.

Chloride forms an important ecological factor as they are usually associated with the salt concentration and the amount of dissolved minerals in water, it also helps to regulate osmosis. Chloride is usually present in water in the form of sodium chloride which imparts a salty taste (Duggal, 2002). During the present investigation, the value of chloride in Pond I ranged from 187mg/L (monsoon) to 204mg/L (summer) whereas in Pond II from 67.98 mg/L (summer) to 130mg/L (winter). Although the maximum value of chloride was within the permissible limits of BIS (2012) and WHO (2017), the higher value of chloride in Pond II might be due to release of domestic sewage, human and animal excreta into Pond waters. Chloride showed a negative correlation with COD and BOD in Pond I but no significant correlation between chloride content and other water parameters was found in the Pond II.

Total hardness is the sum of carbonate and non-carbonate hardness. Duggal (2002) stated that hardness is due to the presence of certain salts of calcium and magnesium dissolved in it. In the present investigation, the range of total hardness for Pond I was found in the range of 100mg/L (monsoon) to 390 mg/L (winter) and for Pond II from 65 mg/L (monsoon) to 120 mg/L (winter). According to Durfor and Becker (1964), the water of both the ponds comes under the moderate to very hard category. Total hardness showed a negative correlation with nitrate-nitrogen (r = -0.72) in Pond I while no significant correlation was found in Pond II.

During the present investigation, the value of nitrate–nitrogen for the Pond I ranged from 0.028 mg/L (in winter and summer) to 0.032 mg/L (monsoon) and for Pond II from 0.028 mg/L (winter) to 0.045 mg/L (monsoon). Similar results were obtained by Gurung *et al.* (2019). The higher value of nitrate–nitrogen in Pond II during the monsoon season was due to rains, surface runoff from agricultural lands, and less phytoplankton density. Nitrate-nitrogen showed a negative correlation with COD and BOD in Pond I and positive correlation with phosphate-phosphorus (r = 0.54) in Pond II.

Phosphorous occurs in natural waters almost solely as phosphates. The usual forms of phosphorus found in aqueous solutions include orthophosphate, polyphosphate, and organic phosphate (Metcalf and Eddy, 1991). Orthophosphate is the phosphorus that is directly taken up by algae. The value of phosphate–phosphorous was found to be from 0.033 mg/L (winter) to 0.059 mg/L (monsoon) in the Pond I and from 0.037mg/L (winter) to 0.096 mg/L (summer) in the Pond II. Similar results were obtained by Bai *et al.* (2023). The higher value of phosphate - phosphorous in ponds under study might be due to inflow of domestic wastewater, particularly those containing detergents, and fertilizers runoff from nearby agricultural fields. Phosphate-phosphorus had no significant correlation with other water parameters in Pond I, but showed positive correlation with total hardness (r= 0.58) in Pond II.

Chapman and Kimstach (1992) reported that the chemical oxygen demand (COD) is a measure of the oxygen equivalent of the organic matter in a water sample that is susceptible to oxidation by a strong chemical oxidant. The range of COD was found from 67.2mg/L (monsoon) to 82.3 mg/L (summer) in Pond I and from 28.8 mg/L (winter) to 52 mg/L (monsoon) in Pond II. According to Chapman (1996) and WHO (2017), the value of COD for clean water is supposed to be below 20 mg/L. In present study, the value of COD was above the permissible limit in both the Ponds throughout the year. The high value of COD indicated the presence of organic matter in the ponds which may be due to high levels of decaying plant matter and human waste present around the pond.

Biological oxygen demand depends on aquatic life. Variation in BOD indicates dynamism in aquatic life present in the pond. Chapman and Kimstach (1992) reported that the biochemical oxygen demand (BOD) is an approximate measure of the amount of biochemically degradable organic matter present in a water sample. The value of BOD ranged from 3.1 mg/L (monsoon) to 4.8 mg/L (summer) in Pond I and from 3.1 mg/L (monsoon) to 3.4 mg/L (winter) in Pond II. High values of BOD in both the ponds have crossed the permissible limits as prescribes by BIS (2012). The higher value of BOD suggest organic pollution in both the ponds and this condition might trigger more plant growth.

Phytoplankton

The phytoplankton population largely depends on the physico – chemical characteristics of the water bodies. Phytoplankton showed variations in their density and abundance during different seasons of the year. During the present investigation (2020-2021), a total of 91 species belonging to 42 genera of phytoplankton (mainly represented by algal taxa) belonging to Chlorophyceae, Bacillariophyceae, Cyanophyceae, and Euglenophyceae were recorded in both the ponds of Bhagalpur district.

The phytoplankton density in Pond I (Jichho Pond, Pirpainti) and Pond II (Purandaha Pond, Shahkund) was maximum during the summer season with a total density count (5144.63 U/L) and (2607.26 U/L) and the minimum count was recorded during monsoon season with total density count (1899.41U/L) and (1948.72 U/L). Suslov *et al.*, (2020) also reported that the summer is the most suitable season for the growth of phytoplankton. The long duration of the sunshine period, increased salinity, and pH help in the growth of phytoplankton. Sharma *et al.* (2014) also noticed that phytoplankton grow and multiply best during summer months when the temperature is high and has longer photoperiod.

The density of Chlorophyceae was highest during the summer season in both the ponds with density in Pond I at (1408.44 U/L) and a percentage composition of (27.33%) whereas in Pond II, the density was (1108.75 U/L) with a percentage composition of (40.56%). The lowest value of Chlorophyceae was recorded during the monsoon season in the ponds I and II with densities of (770.51 U/L) and (618.21 U/L) and their percent composition of (40.56%) and (31.72%) respectively. Chlorophyceae was found to be the most significant group of phytoplankton and was mostly represented by *Spirogyra* sp., *Coelastrum* sp., *Cosmarium* sp., *Pediastrum* sp., *Scenedesmus* sp., *Chlorella* sp. *Actinastrum* sp., *Hyalotheca* sp., etc. Chlorophyceae dominates in water rich in nutrients such as nitrate and phosphate (Philipose, 1967). Rajagopal *et al.* (2010) noticed that dissolved oxygen, pH, and alkalinity play a significant role in the distribution of Chlorophyceae members in freshwater bodies.

The density of Bacillariophyceae was highest during the winter season in both the ponds with density in Pond I at (1084.11 U/L) with a percentage composition of (30.92%) whereas in Pond II the density was (819.80 U/L) with a percentage composition of (41.35%). The lowest value in Pond I was recorded during the monsoon season with a density of (542.04 U/L) and a percentage composition of (28.54 %) whereas in Pond II lowest density was during the summer season (678.69 U/L) and the percentage composition of (26.03%). The dominance of Bacillariophyceae in the aquatic environmental condition is a major indicator of water quality because they are adapted to a wide range of physico – chemical conditions (Fonge *et al.*, 2012). The group was mostly represented by *Synedra* sp., *Cymbella* sp., *Fragilaria* sp., *Navicula* sp., *Cyclotella* sp., *Pinnularia* sp., and *Surirella* sp. The presence of phosphate, nitrate, and total hardness might have promoted the growth of diatoms. Masithah *et al*., (2019) suggested that correlation ratio of nitrate and phosphate was responsible for encouraging the growth of diatoms. Harikrishnan *et al.*, (1999) stated that alkaline pH favors the abundance of the diatomic population. In the present investigation, pH was alkaline almost in all the seasons.

The density of Cyanophyceae in the Pond I was highest during the winter season (779.15 U/L) and the percentage composition was (22.22%) whereas in Pond II, the value was higher during the summer season (456.94 U/L) and the percentage composition was (17.52%). The lowest value of density in the Pond I was recorded during the monsoon season (586.84 U/L) and the percentage composition was (30.90%) whereas in Pond II the density was recorded as lowest during the winter season (275.50 U/L) with the percentage composition of (13.89%). The group was mostly represented by *Oscillatoria* sp., *Merismopedia* sp., *Anabaena* sp., *Spirulina* sp., *Nostoc* sp. and *Microcystic* sp. Higher values of TDS, dissolved oxygen, phosphate, nitrate, and BOD might be the reason for the growth of Cyanophyceae. Savadova *et al.*, (2018) showed that high temperature favors the luxuriant growth of Cyanophyceae (blue-green algae).

The density of Euglenophyceae was highest during the summer season in Ponds I and II (2062.96 U/L and 362.86 U/L) and the percentage composition was (40.09% and 31.91%) respectively. The lowest value in the Pond I was recorded during the winter season (312.02 U/L) with a percentage composition of (9.15%) whereas in Pond II it was (275.50 U/L) with a percentage composition of (14.13%). Euglenophyceae contributed to the minimum population density with the dominance of species like *Euglena* sp., *Phacus* sp., *Strombomonas* sp., and *Trachelomonas* sp. Murulidhara and Murthy (2018) reported that a temperature above 25°- 27°C was good for the growth of Euglenophyceae. The presence of chloride, total dissolved solids, and BOD also might have played important role in the growth of Euglenophyceae in the ponds under study.

Total density of phytoplankton showed positive correlation with phosphate-phosphorus ($r = 0.58$) in Pond II but have no significant correlation with water parameters in Pond I.

CONCLUSION

According to the results of the present study, it is clear that the differences in the water quality of the two Ponds might be attributed to a variety of physical and chemical factors. In Pond I (Jichho Pond), the values of water parameters like conductivity, TDS, dissolved oxygen, total hardness, chloride, carbonate, and bicarbonate alkalinity were significantly higher than that of Pond II (Purandaha Pond), indicating high contamination because of human interference. Due to the high nutrient contents, the phytoplankton density was also higher in Pond I (Jichho Pond) than that of Pond II (Purandaha Pond).The presence of algal species like *Chlorella vulgaris, Oscillatoria princeps, Euglena gracilis, Nitzschia palea, and Scenedesmus quadricauda* suggested that both the ponds were organically polluted and advancing towards eutrophication

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Table – 1 Physico – Chemical characteristics of Water variables of two perennial Ponds (Pond-I, Jichho Pond & Pond-II, Purandaha Pond) of Bhagalpur District (2020 – 2021)

Sl. No.	Water variables	Pond – I (Jichho Pond)			Pond - II (Purandaha Pond)		
		Winter	Summer	Monsoon	Winter	Summer	Monsoon
1.	Water Temp.(°C)	17.9	27.6	28	21.3	27	26.8
2.	Ambient Temp. (°C)	21	30	31	22	29.4	30
3.	pH	8.2	8.5	8.1	8.3	8.1	7.3
4.	TDS	284	224	294	147	92	186
5.	Conductivity (μs)	536	425	430	276	171	182
6.	DO_2	3.7	5.6	7.2	1.8	5.6	6.2
7.	FCO_2	NA	1	12	10	1	8
8.	CO_3--	0.8	NA	NA	NA	NA	NA
9.	HCO_3^-	52	36	46	26	8	32
10.	Cl^-	204	179.92	187	130	67.98	123
11.	T.H.	390	185	100	120	74	65
12.	NO_3-N	0.028	0.028	0.032	0.028	0.032	0.045
13.	PO_4-P	0.033	0.047	0.059	0.037	0.0963	0.087
14.	COD	71.4	82.3	67.2	28.8	45.3	52
15.	BOD	3.2	4.8	3.1	3.4	3.2	3.1

All the values of water variables expressed in mg/L except temperature, pH, and conductivity.

Table – 2 Seasonal Density and Percentage Composition of Phytoplankton Population of two perennial Ponds (Pond-I, Jichho Pond & Pond-II, Purandaha Pond) of Bhagalpur district (2020 -2021)

Year	Seasons	Total density (U/L)	Bacillariophyceae		Chlorophyceae		Cyanophyceae		Euglenophyceae	
			Density(U/L)	% composition	Density(U/L)	% composition	Density(U/L)	% composition	Density(U/L)	% composition
2020 – 2021 Pond – I	Winter	3505.64	1084.11	30.92	1330.35	37.94	779.15	22.22	312.02	9.15
	Summer	5144.63	910.52	17.70	1406.44	27.33	764.70	14.86	2062.96	40.09
	Monsoon	1899.41	542.04	28.54	770.51	40.56	586.84	30.90	-	-
2020 – 2021 Pond- II	Winter	1982.32	819.80	41.35	887	44.74	275.50	13.89	-	-
	Summer	2607.26	678.69	26.03	1108.75	42.52	456.94	17.52	362.86	13.91
	Monsoon	1948.72	698.85	35.86	618.21	31.72	356.14	18.27	275.50	14.13

Table 3 - Correlation coefficients (r) among water variables of Pond-I (Jichho Pond) (2020-21)

	Water temp (°C)	Air temp (°C)	pH	T.D.S	Conductivity	DO_2	FCO_2	Total Alkalinity	Cl^-	T.H.	NO_3N	PO_4– P	COD	BOD	Total den
Water temp (°C)	1.000														
Air temp (°C)	0.998	1.000													
pH	0.244	0.189	1.000												
T.D.S	-0.349	-0.296	-0.994	1.000											
Conductivity	-0.997	-0.991	-0.315	0.418	1.000										
DO_2	0.905	0.927	-0.192	0.083	-0.871	1.000									
FCO_2	0.592	0.636*	-0.637	0.548*	-0.530	0.879	1.000								
Total Alkalinity	-0.785	-0.749	-0.792	0.854	0.829	-0.447	0.034	1.000							
Cl^-	-0.948	-0.928	-0.541	0.629*	0.969	-0.722	-0.304	0.942	1.000						
T.H.	-0.968	-0.980	0.008	0.102	0.946	-0.983	-0.776	0.604*	0.837	1.000					
NO_3N	0.529*	0.576*	-0.693	0.609*	-0.465	0.840	0.997	0.109	-0.231	-0.726	1.000				
PO_4– P	0.903	0.926	-0.197	0.088	-0.868	1.000	0.881	-0.443	-0.718	-0.982	0.843	1.000			
COD	0.214	0.159	1.000	-0.990	-0.287	-0.222	-0.660	-0.773	-0.515	0.038	-0.715	-0.226	1.000		
BOD	0.422	0.371	0.982	-0.997	-0.489	-0.003	-0.480	-0.893	-0.690	-0.181	-0.545	-0.008	0.976	1.000	
Total den	-0.029	-0.085	0.962	-0.927	-0.046	-0.451	-0.823	-0.596	-0.292	0.279	-0.863	-0.456	0.970	0.894	1.000

*Significant at 0.05%   ** Significant at 0.01%

Table 4 -Table Correlation coefficients (r) among water variables of Pond - II (Purandaha Pond) (2020-21)

	Water temp (°C)	Air temp (°C)	pH	T.D.S	Conductivity	DO_2	FCO_2	Total Alkalinity	Cl^-	T.H.	NO_3N	PO_4– P	COD	BOD	Total density
Water temp (°C)	1														
Air temp (°C)	0.995	1.000													
pH	-0.631	-0.704	1.000												
T.D.S	-0.129	-0.031	-0.688	1.000											
Conductivity	-0.998	-0.987	0.579**	0.192	1.000										
DO_2	0.988	0.998	-0.745	0.028	-0.976	1.000									
FCO_2	-0.695	-0.621	-0.120	0.803	0.739**	-0.573	1.000								
Total Alkalinity	-0.307	-0.212	-0.545	0.983	0.368	-0.154	0.898	1.000							
Cl^-	-0.611	-0.531	-0.228	0.863	0.661**	-0.480	0.994	0.941	1.000						
T.H.	-0.983	-0.996	0.762**	-0.055	0.969	-1.000	0.551*	0.128	0.456	1.000					
NO_3N	0.659**	0.729**	-0.999	0.661	-0.609	0.768**	0.083	0.513	0.192	-0.786	1.000				
PO_4– P	0.993	0.977	-0.537	-0.242	-0.999	0.963	-0.773	-0.414	-0.698	-0.955	0.568*	1.000			
COD	0.951	0.977	-0.840	0.185	-0.929	0.987	-0.437	0.003	-0.336	-0.991	0.860	0.909	1.000		
BOD	-0.934	-0.965	0.866	-0.233	0.909	-0.979	0.392	-0.052	0.289	0.984	-0.884	-0.887	-0.999	1.000	
Total density	0.487	0.399	0.370	-0.929	-0.543	0.345	-0.967	-0.981	-0.989	-0.319	-0.335	0.584*	0.193	-0.144	1

*Significant at 0.05% ** Significant at 0.01%