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Seasonal Correlation between Physico-chemical factors and phytoplankton density in Alwara taal of Kaushambi, UP, India

Ashok Kumar Verma[1], Sunil Kumar[2] and Shri Prakash[3*]
[1]Department of Zoology, Govt. P.G. College, Saidabad, Allahabad, 221508, UP, India
[2]Department of Zoology, Ewing Christian College, Allahabad, 211007, UP, India
[3]Department of Zoology, KAPG College, Allahabad, 211001, UP, India
sriprakasht80@gmail.com

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Abstract

Present investigation is an attempt to assess the correlation between physico-chemical factors and phytoplankton density in Alwara taal of district Kaushambi, Uttar Pradesh. This taal (lake) has a vast dynamic landscape due to its wide openness, large standing water and extreme seasonal variations with huge biodiversity. The members of chlorophyceae group have been found dominant and determinative among the four classes of phytoplankton viz Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae studied. The maximum density of phytoplankton 1243.5±107.6 (1512.7 - 988.5) unitsL^{-1} was recorded during winter with low water temperature 19.2±0.73 (20.4-17.5) ^{o}C and carbon dioxide 2.3±0.06 (2.5-2.2) mgL^{-1}. The rainfall and flood water enhanced the total solids 734.9±27.94 (810.0-675.6) mgL^{-1} that resulted the minimum density 529.0±86.0 (783.5 - 418.9) unitsL^{-1} of phytoplankton in rainy season. More water temperature 26.1±2.03 (30.5-21.4) ^{o}C moderated the density 902.4±147.4 (1196.5 - 629.0 unitsL^{-1}) of phytoplankton.

Keywords: Phytoplankton, Chlorophyceae, Alwara lake, Indian sarus crane, Physico-chemical parameters.

Introduction

Investigating lake is situated in the Yamuna basin at district-Kaushambi, Uttar Pradesh. It is a part of Gangetic plain of India (northern region). The lake is a marshy riparian type wetland, covering an area of more than 400 hectares and locally called as Alwara taal. Its adjacent river Yamuna used to flood it annually and turned it into a perennial lake with a vast openness of agricultural land after rainy season during winter and summer. The climatic change therefore imparts an influence on its vast openness, landscape ecology and biodiversity. In this water ecosystem, phytoplankton is major producer which fixes energy and transfers to the land. Moreover, vast openness around the said lake provides habitat for vulnerable Indian Sarus Crane[1-3] and phytoplankton directly provides fabricating material for the nest of this bird and indirectly provides food to it as well as to other water birds.

A review of literature suggests that there had been only a few attempts[4-7] to study the limnological, zooplanktonic and phytoplanktonic properties of the said lake however this lake was studied[1-3,8,9] for different aspects of Indian sarus crane on large scale only by few Zoologists.

The ecology of a water body is directly influenced by the phytoplankton density and indirectly by the temperature, rainfall and topography of the land. Similarly these factors influence overall distribution of phytoplankton which contributes the trophic turnover.

Some workers[10-11] reported that the anthropogenic disturbance badly influences the phytoplankton diversity and increasing anthropogenic disturbance in reservoirs including the lake under exploration is a type of serious threat for ecological balance. Present exploration was concerned to assess the physico-chemical and climatic factors that determine the varied phytoplankton density in case of this Alwara lake.

Materials and Methods

Collection of samples: Water samples were collected weekly from selected sites *i.e.* four times in a month over year, 2014. The collection time was particularly late morning. Biological and physico- chemical parameters were analyzed by separate samples of water and further analysis was done in the laboratory.

Analysis of physical and chemical parameters: Physical and chemical parameters of the lake water were analyzed in accordance with the standard methods of water and waste-water analysis[12]. The samples for dissolved oxygen (DO) and Biological Oxygen Demand (BOD) were fixed at collection sites. The temperature was measured with the glass-mercury centigrade thermometer and transparency was measured with the Secchi disc at the collection site. The other parameters were analyzed in the laboratory.

Phytoplankton analysis: The assessment of phytoplankton

population of Alwara lake was done by Prakash et. al and Verma et. al.[5,7] in 2014. They studied four classes of phytoplankton namely Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglinophyceae.

Statistical analysis: The data were analyzed by using MYSTAT software[13] for the statistical interpretation. Pearson Correlation Matrix (Figure-1 and Table-2) was analyzed at confident interval on regression line 0.95, sample (*ELL*) 0.682; confidence 0.6827, confidence at centroid (Elm) p0.95 and tension at 0.05. Principle Component Analysis (Factor Loading Plot, Figure-2) was analyzed by Degree of freedom 4, Iteration at 20 and convergence at 0.001.

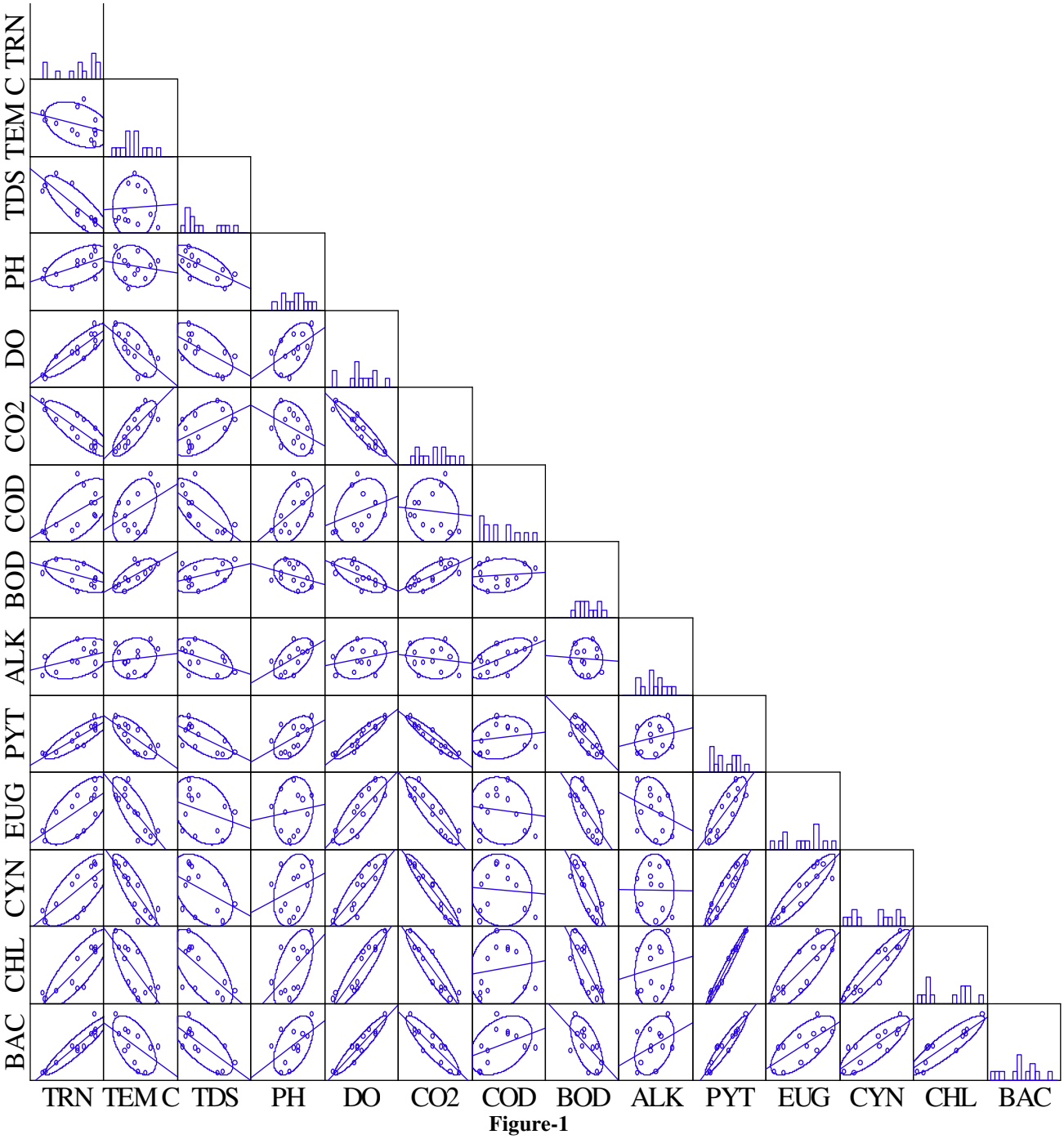

Figure-1

Pearson Correlation Matrix depicting significance of influencing physico-chemical factors on the occurrence of observed phytoplankton in Alwara lake during the year, 2014

Results and Discussion

Verma *et al*[7] recorded 43 genera of phytoplankton representing four taxonomic groups *viz*. Chlorophyceae, Bacillariophyceae, Cyanophyceae and Euglenophyceae during the period of 12 months of investigation in 2014. Relative approximate abundance of these four groups in further study showed maximum of Chlorophyceae, followed by Bacillariophyceae then Cyanophyceae and lastly Euglenophyceae. They explained that Chlorophyceae was dominant in density and diversity among all the observed phytoplanktons.

Prakash *et al* [5] worked out four groups of phytoplankton from all the sampling sites with their similar distribution. They reported overall population density of phytoplankton, 1512.7 (378.2±149.0) - 0418.9 (088.9±026.5) during the study period. The maximum density (unitsL^{-1}) was recorded in winter season (Jan., Feb., Nov. and Dec.) as 1243.5±107.6 (1512.7-988.5); moderate in summer season (Mar. to Jun.) as 902.4±147.4 (1196.5-629.0) and minimum in rainy season (Jul. to Oct.) as 529.0±86.0 (783.5-418.9). The density of Chlorophyceae 366.4±58.32 (105.0-695.0) was dominated over Bacillariophyceae 325.1±36.46 (128.6-548.5) followed by Cyanophyceae 170.1±13.48 (102.8-230.0) and then Euglinophyceae 30.0±3.35 (12.6-48.2).

The variations of physico-chemical parameters of the lake were recorded during all the 12 months of 2014 (Table-1). During winter season, the authors recorded maximum dissolved oxygen 10.1±0.45 (11.2-9.1) mgL^{-1}, *p*H 8.1±0.15 (8.3-7.6), transparency 70.9±3.65 (76.4-60.2) and minimum of Biological Oxygen Demand 2.2±0.13 (2.6-2.0) mgL^{-1}, carbon dioxide 2.3±0.06 (2.5-2.2) mgL^{-1}, temperature 19.2±0.73 (20.4-17.5)^{o}C. During summer season, we recorded maximum alkalinity 78.2±01.67 (81.4-73.4) mgL^{-1}, Chemical Oxygen Demand 19.9±0.63 (21.4-18.5) mgL^{-1}, temperature 26.1±2.03 (30.5-21.4)^{0}C and minimum Total Solids 456.2±20.31 (510.2-415.0) mgL^{-1}. During rainy season, authors recorded maximum Biological Oxygen Demand 3.0±0.20 (3.4-2.5) mgL^{-1}, carbon dioxide 3.0±0.13 (3.3-2.7) mgL^{-1}, Total Solids 734.9±27.94 (810.0-675.6) mgL^{-1} and minimum alkalinity 75.4±0.98 (77.6-73.4) mgL^{-1}, Chemical Oxygen Demand 15.8±0.180 (16.3-15.5) mgL^{-1}, dissolved oxygen 7.6±0.57 (8.7-6.5) mgL^{-1}, *p*H 7.6±0.09 (7.8-7.4), transparency 38.7±6.07 (55.2-28.6) cm.

Discussion: Prakash *et al*[5] and Verma *et al*[7] explored that Chlorophyceae group was dominant in species richness as well as in density among all the four groups of phytoplankton observed. The dominancy of chlorophyceae in the similar physiographic region has also been reported by various workers[14,15]. The maximum phytoplankton density 1243.5±107.6 (1512.7 - 988.5;[7] unitsL^{-1} was observed in winter which was supported by maximum dissolved oxygen 10.1±0.45 (11.2-9.1) mgL^{-1}, *p*H 8.1±0.15 (8.3-7.6), transparency 70.9±3.65 (60.2-76.0) and by minimum of Biological Oxygen Demand 2.2±0.13 (2.6-2.0) mgL^{-1}, carbon dioxide 2.3±0.06 (2.5-2.2) mgL^{-1}, temperature 19.2±0.73 (20.4-17.5)^{o}C (Table-1). Pearson Correlation Matrix (Figure-1 and Table-2) also substantiated that observed density varied significantly negative with water temperature (-0.943) and free carbon dioxide (-0.945) whereas positive with dissolved oxygen (0.915) and transparency (0.879). Although Biological Oxygen Demand (-0.768), Total Solids (-0.687) varied less negatively to significant whereas p*H* (0.531), Chemical Oxygen Demand (0.195) and Total Alkalinity (0.262) were not varied positive to significant (Figure-1 and Table-2). Factor loading plot (Figure-2) explains that temperature and TDS influenced separately and inversely over the other co-occurring factors (physico-chemical and phytoplankton) whereas BOD and CO_2 influenced jointly.

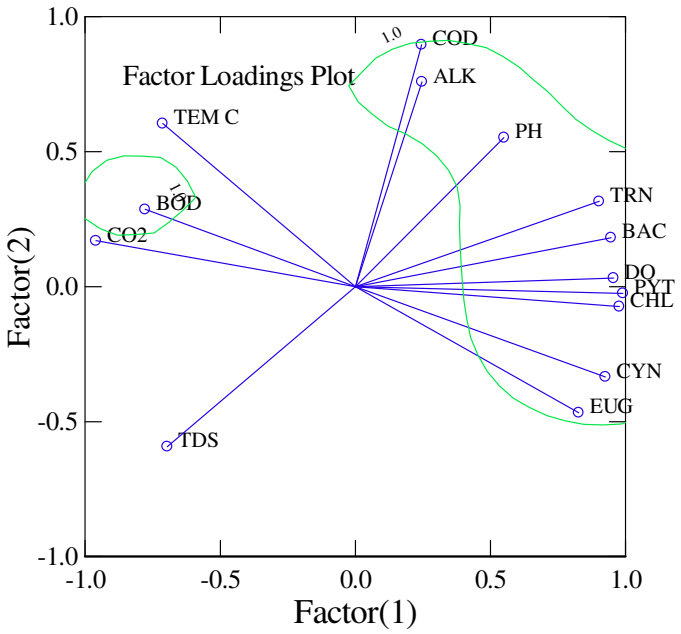

Figure-2

The Factor Loading Plot showing the significance of correlation between physico-chemical factors and phytoplankton of Alwara lake water during the year, 2014

Kumar *et al*[14] reported higher turnover of lake energy in the month of January to June (mid winter- summer) and less in July to September (rainy) for both phytoplankton and aquatic plants from the similar lake. It shows similarities with the present study having less energy turnover in sense of less phytoplankton density in the rainy season. Hossain *et al*[15] correlated phytoplankton density negative to water temperature, p*H*, ammonia-nitrogen, alkalinity and positive to dissolved oxygen from similar region. The phytoplankton density is correlated more with physical factors than chemical factors of water. The reason behind this is that chlorophyceae members can adopt any type of water environment due to their photosynthetic pigments. That is why certain phytoplankton and their density are regulated mostly by seasonal fluctuations of water temperature. Certain planktonic population apparently disappears at specified

period and reappears during other months. Such temporary disappearances are due to the fact that species concerned either become scare or occur as spores or resting eggs etc. which are not easily detectable[16,17]. Similar trend was reported by Imam and Khan (2014)[18].

Verma *et al* (2016)[7] observed minimum phytoplankton density 529.0±86.0 (783.5 - 418.9;) unitsL^{-1} in the rainy season due to maximum value of total solids 734.9±27.94 (810.0-675.6) mgL^{-1} that had to be brought by the flood of river Yamuna (Table-1). Conversely increased values of free carbon dioxide 3.0±0.13 (3.3-2.7) mgL^{-1} were resulted by decreased transparency 38.7±6.07 (55.2-28.6; Table 1) under less consumption in photosynthesis. The observed moderate density of phytoplankton 902.4±147.4 (1196.5 - 629.0) unitsL^{-1}[7] during summer season was due to the increased surface water temperature 26.1±2.03 (30.5-21.4)^oC and Chemical Oxygen Demand; 19.9±0.63 (21.4-18.5) mgL^{-1} that would had destroyed chlorophyll, hence carbon dioxide content observed moderate, 2.8±0.13 (3.0-2.4) mgL^{-1} under less exploitation by photosynthesis in the summer season (Table-1). Simultaneously, other biotic (microorganisms) and abiotic factors (wind pressure, depth of lake, light intensity and photoperiod) cannot be ignored.

Table-1
Month wise variations (Mean±SE) of physico - chemical parameters of Alwara lake water during the year, 2014

Months	ALK (mgL^{-1})	BOD (mgL^{-1})	COD (mgL^{-1})	CO_2 (mgL^{-1})	DO (mgL^{-1})	pH	TDS (mgL^{-1})	TEM (^oC)	TRN. (cm)
Jan	80.4±09.63	2.2±0.18	17.3±1.01	2.2±0.32	11.2±0.47	8.3±0.79	464.0±19.74	17.5±0.89	75.0±10.99
Feb	76.2±11.21	2.6±0.21	17.2±0.59	2.3±0.25	09.7±0.22	7.6±0.88	472.0±22.20	20.4±0.62	76.0±10.34
Mar	73.4±09.14	2.5±0.43	18.5±0.80	2.4±0.21	10.3±0.52	7.9±0.97	461.2±23.60	21.4±0.51	75.8±09.49
Apr	78.8±10.54	2.6±0.20	19.4±0.45	2.7±0.28	09.2±0.38	8.2±0.67	438.5±16.99	24.3±0.56	76.2±07.62
May	79.2±06.01	3.2±0.24	20.3±0.91	2.9±0.40	08.2±0.34	8.0±1.12	415.0±14.88	30.5±0.57	65.4±07.86
Jun	81.4±05.77	3.0±0.36	21.4±0.83	3.0±0.30	08.7±0.52	7.9±1.35	510.2±16.39	28.3±0.71	60.2±06.69
Jul	73.4±05.77	2.8±0.67	15.6±0.72	3.3±0.30	06.7±0.54	7.6±1.14	675.6±24.51	26.5±0.94	28.6±08.37
Aug	77.6±09.68	3.2±0.42	15.5±0.43	3.1±0.27	06.5±0.70	7.8±1.75	720.4±15.26	24.3±1.43	30.6±07.16
Sep	74.2±07.06	3.4±0.33	16.3±0.36	2.9±0.35	08.4±0.78	7.7±0.64	810.0±20.70	23.4±0.69	40.5±05.78
Oct	76.5±08.30	2.5±0.45	15.7±0.48	2.7±0.32	08.7±1.06	7.4±0.94	733.4±24.86	21.5±0.80	55.2±09.88
Nov	76.4±11.32	2.0±0.42	16.3±0.73	2.5±0.21	09.1±0.31	8.0±0.69	537.0±29.80	20.3±1.23	60.2±05.45
Dec	78.5±09.40	2.3±0.44	18.5±0.88	2.3±0.26	10.3±0.71	8.1±1.03	484.2±22.55	18.6±0.78	72.4±06.05
Mean (CV)	77.62 (0.04)	02.71 (0.15)	17.66 (0.11)	02.68(0.13)	09.0 (0.16)	07.87(0.04)	560.11(0.24)	23.10 (0.17)	59.7(0.30)

Table-2
Pearson Correlation matrix of physico-chemical variables and phytoplankton density in Alwara lake, Kaushambi (U.P.) during the year, 2014

	ALK	BOD	CO_2	COD	DO	pH	TDS	TEM	TRN
PYT	0.262	**-0.768	*-0.945	0.195	*0.915	0.531	-0.687	*-0.943	*0.879
BAC	0.422	-0.609	*-0.886	0.401	*0.828	0.523	**-0.733	-0.816	*0.937
CHL	0.191	-0.783	*-0.925	0.145	*0.893	0.562	-0.660	*-0.958	*0.834
CYN	0.028	-0.823	*-0.948	-0.081	**0.857	0.291	-0.453	*-0.943	**0.740
EUG	-0.272	-0.704	*-0.885	-0.124	**0.831	0.132	-0.332	-0.838	*0.660

*Correlation is significant at 0.01 level. **Correlation is significant at 0.05 level. Alk.= Total Alkalinity; BOD= Biological Oxygen Demand; COD= Chemical Oxygen Demand; $CO_{2,}$ = Free Carbon Dioxide; DO= Dissolved oxygen; TDS=Total dissolved solids; SE= Standard Error of Mean; TEM (^oC)= Surface Water Temperature; TRN= Transparency.

Conclusion

The group of chlorophyceae algae has been found dominated among observed phytoplankton density with seasonal variations. Their optimum density was observed in winter season that was resulted by minimum temperature where as their minimum density was recorded in rainy season due to higher TDS and moderate density in summer was recorded due to maximum transparency and free carbon dioxide. This pattern of seasonal phytoplankton density is more influenced by physico-chemical factors than other factors of water bodies in the lake studied.

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