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The Effect of Physico-Chemical Stress on the Population of *Chlamydomonas* Species in a permanent pond of Kanpur, (U.P.) India

***Saras[1] and Padma Saxena[2]**

[1]Department of Zoology,
D.A.V.P.G. College, KANPUR (U.P.) INDIA
[2]Department of Zoology,
T.R.K.M. ALIGARH (U.P.) INDIA
*Corresponding Author
E-mail: saras060877@gmail.com

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ABSTRACT

In permanent lentic water bodies, the chemical picture completely depends on the surroundings from where these bodies receive effluents. Planktons play an important role as primary producers of the system. The limnological study is important for water quality monitoring by which correlation has been established among different physical, chemical, and biological parameters. This statistical analysis easily represented the presence /absence of Planktons on the basis of seasonal variations. Regarding the seasonal variations, the values of pH, magnesium & calcium (Mg, Ca), dissolved oxygen & dissolved oxygen matter (DO, DOM) indicate variation in water quality which directly or indirectly influence the population of *Chlamydomonas elliptica*, *Chlamydomonas globosa*, *Chlamydomonas intermedia*, and *Chlamydomonas orbicularis*. On the basis of chemical analysis in terms of DO & DOM, the shallow water system was moderately polluted. *Chlamydomonas intermedia* showed dominant species which occurred most of the months in a year. The fluctuation in the population densities of *Chlamydomonas elliptica, Chlamydomonas globosa,* and *Chlamydomonas orbicularis* was observed greatly as they occurred in a few months in a year. *Chlamydomonas intermedia* showed positive co-relation with DO and significant negative co-relation with DOM. Mg and pH showed significant negative values. Apart from this, biological populations also showed various co-relation among other known species.

Figure : 00 References : 12 Tables : 04
KEY WORDS : Density, Limnological study, Plankton, Waste-water system

Introduction

Kanpur is an eminent city for various industries. In most of the locations of the Kanpur city, small shallow ponds and puddles are found which are filled to the brim during the rainy season. Generally, these water bodies persist throughout the year. But the water level may vary due to seasonal variation. It has been observed that in drier months their water levels were maintained by the inflow of domestic discharges and industrial effluents were frequent. Excessive usage of natural resources and an ever-increasing population have been responsible for many undesirable changes in this lentic aquatic system. Most of the freshwater systems were under the stress of urbanization and industrialization. The development of new environmental problems as a result of this has given rise to new ideas in the field of monitoring and assessment of aquatic ecosystems. Such water body has unique physico - chemical characteristics which highly influences the biological spectrum[12]. Seasonal water samples collection and their experimental studies provided information for an understanding of environmental changes which was necessary to allow for the protection and remediation of ecosystems. Ecological assessment considering all components of the ecosystem helped in giving information in plankton densities regarding with physico – chemical parameters (pH, Ca, Mg, DO & DOM). In other words, we can say that Biomonitoring is used to assess environmental quality by observations on changes in the biological responses and vice–versa[8].

Material and Methods

This permanent pond was a hypertrophic system that is situated in the Dabauli(south) towards Gujaini in Kanpur. It is a natural aquatic system as no defined built boundaries are there. It is surrounded by natural vegetation as well as an urban area near NH19. It received rainwater, solid waste dumping, and domestic wastewater discharges regularly. This is a pond in which Sunlight reached all the way to the pond, so

TABLE-1 : Monthly fluctuation in the concentration of the parameters of water quality under investigation for two years June 2021 to May 2023

Month	pH	$HCO3^-$	$CO3^{-2}$	Ca++	Mg++	DO	DOM
June 2021	8.6	165.0	34.6	18.4	46.7	4.9	48.2
June 2022	8.2	156.4	31.6	15.7	44.0	4.4	46.8
July 2021	8.4	152.0	29.5	22.0	31.4	5.7	43.7
July 2022	8.2	152.8	28.2	22.8	32.7	6.2	42.8
August 2021	8.0	172.8	24.2	26.4	17.3	10.4	29.3
August 2022	8.4	174.2	25.4	28.2	16.8	11.8	28.6
September 2021	8.3	159.0	33.8	22.8	21.6	5.6	39.9
September 2022	8.6	163	33.2	23.4	20.8	5.8	40.6
October 2021	8.7	154.2	35.4	13.9	26.0	4.8	51.3
October 2022	8.6	153.0	35.2	13.4	25.2	4.6	51.8
November 2021	8.8	152.0	36.8	10.2	27.5	4.2	58.1
November 2022	8.6	151.8	36.4	10.4	28.2	4.4	57.7
December 2021	8.7	173.2	34.4	17.2	32.7	3.9	62.4
December 2022	8.7	174.0	34.6	17.8	33.3	4.2	61.2
January 2022	8.5	208.7	26.4	26.8	17.9	4.9	53.9
January 2023	8.2	208.3	25.8	26.3	17.3	4.7	54.1
February 2022	8.6	171.5	37.8	21.4	13.4	10.4	28.4
February 2023	8.5	171.2	37.2	20.9	12.8	10.8	27.8
March 2022	8.2	197.8	21.6	35.7	45.8	8.6	45.4
March 2023	8.4	198.3	21.8	36.3	44.5	9.2	46.2
April 2022	8.5	168.8	27.8	33.2	42.7	5.1	52.6
April 2023	8.3	166.6	26.3	32.7	41.8	5.4	51.9
May 2022	8.6	156.2	32.6	23.0	49.3	4.9	56.2
May 2023	8.4	155.8	32.0	22.6	49.3	4.7	56.8

- All quantities in mg/l except pH.
- DOM as mg/l of oxygen equivalent

photosynthesis and growth of Phyto-planktons occurred throughout the water and thus the growth or productivity was higher. Planktons, particularly phytoplankton, have long been used as indicators of water quality. They flourish both in highly eutrophic waters while few others are very sensitive to organic and/or chemical wastes. Some species have also been associated with noxious blooms causing toxic conditions apart from odor problems.

For the present study, water samples were collected from a depth of 25 cm. Regular collection of water samples was taken for two years (June 2021 to May 2023). Chemical parameters are related to the solvent capabilities of water, and concern in water-quality management (Table-1). Some of the important Physico-chemical parameters (pH, Ca, Mg, DO, DOM) which are estimated in this study, are discussed[1,4].

Biological methods used for assessing the water quality included the collection, counting, and identification of aquatic organisms. The counting of individuals was done with the help of Sedgwick Rafter's counting slide (Table-2).

Chemical data measured the concentration of pollutants, *etc.* in the water body, and the ecosystem imbalances are measured by biological information. Biological and chemical data were essential in understanding the ecosystem[2,10]. Various steps have been taken for planktonic estimation. Plankton net, concentration technique, preservation of the sample, and counting methods were used for observation. The biological methods used for assessing water quality included collection, counting, and identification of aquatic organisms and processing and interpretation of biological data[7].

Observations

Water samples collected from the pond were analyzed for the Physicochemical and biological parameters. Twelve samples, for each year, were collected during the present study for two years. Statistically computed results for different above-said parameters analyses have been given in Tabular form (Table-1 and Table-2).

From both Tables, we can easily calculate and understand the correlation between the different parameters of water quality with unicellular forms of plankton mentioned in (Table-3) as well as the co-relation between different species of *Chlamydomonas* (Table-4).

Results and Discussion

This hypertrophic small shallow aquatic system received sewage and waste water effluents from rain waters, solid waste dumping, and domestic establishments. From these sources, discharges reaching to the water bodies. Both inorganic and organic materials mix with the water bodies. As a result of microbial degradation of waste nutrients like inorganic and organic nitrogen, phosphorus, and carbon dioxide increase in water, by which rapid growth of several species of Phytoplankton as well as Zooplanktons took place[6,11]. It was almost invariable growth of certain algae and raised biological demand[9]. If we compare the analysis with studies of other researchers at other places, it shows that the observed pond under the present investigation represents a relatively moderate polluted system[3,5].

Analysis of samples, it was found that the unicellular form of plankton population *Chlamydomonas intermedia* was the most dominant and the most frequent species, which was recorded in seven samples followed by *Chlamydomonas globosa* and *Chlamydomona elliptica*, which were found at three times in different months. But quantitative analysis showed another aspect that the populations of *Chlamydomonas globosa* and *Chlamydomonas elliptica* were almost equal. Some other species of *Chlamydomonas* named *Chlamydomonas orbicularis* was not dominant in nature and occurred only for two months in a year, so it was not remarkable and mentionable.

The present analysis, which included a permanent lentic water system and covered a period of two years (June 2021 to May 2023), shows the following features:

- The pond under observation represented, a moderately polluted system in which the concentration of some parameters was high while other parameters of water quality were moderate. The fluctuations in plankton population were affected by these concentrations, as these were replenished by the inflow of waste water effluent from surrounding areas. Most of the minerals were present in much more concentrations than those required for the growth of the autotrophic populations.
- Being a shallow water body, the pond had a large surface area as compared to the total volume of water. This results in enough dissolution of oxygen from air while the light was available to the sub-surface autotrophs to generate oxygen by photosynthesis.
- *Chlamydomonas intermedia was* the dominant species as it occurred most of the time in a year for July to January.
- *Chlamydomonas elliptica* occurred only 3 times in a year in the month of September to November,

TABLE-2 : Monthly fluctuation in *Chlamydomonas* species under investigation for two years June 2021 to May 2023

POND	*Chlamydomonas intermedia*	*Chlamydomonas elliptica*	*Chlamydomona-sglobosa*	*Chlamydomonas orbicularis*
June 2021	0	0	0	0
June 2022	0	0	0	0
July 2021	5600	0	0	0
July 2022	5480	0	0	0
August 2021	7080	0	260	0
August 2022	6880	0	242	0
September 2021	4600	340	480	0
September 2022	3800	310	410	0
October 2021	1380	520	660	0
October 2022	1160	460	590	0
November 2021	860	630	0	220
November 2022	820	600	0	190
December 2021	510	0	0	380
December 2022	480	0	0	340
January 2022	280	0	0	0
January 2023	260	0	0	0
February 2022	0	0	0	0
February 2023	0	0	0	0
March 2022	0	0	0	0
March 2023	0	0	0	0
April 2022	0	0	0	0
April 2023	0	0	0	0
May 2022	0	0	0	0
May2023	0	0	0	0

* Plankton densities as numbers per milliliter.

Chlamydomonas globosa for August to October, and *Chlamydomonas orbicularis* occurred in the month of November & December.

- Physical as well as chemical factors play an important role in the fluctuation in the densities of *Chlamydomonas species* as they showed +ve / -ve /no correlation with those factors.
- As *Chlamydomonas intermedia* the dominant species, it showed a significant negative correlation with pH, Mg^{++}, DOM, a less significant negative correlation with HCO_3^{-2}, CO_3^{-2}, for Ca^{++}, it showed an unremarkable correlation, and for DO, a less significant positive correlation.
- *Chlamydomonas elliptica* showed a significant positive correlation with CO_3^{-2} and a less significant positive correlation with pH, and DOM.
- *Chlamydomonas elliptica* showed significant negative correlation with Ca^{++} and less significant correlation with HCO_3^{-1}, Mg^{++}, DO.
- *Chlamydomonas globosa* showed a less significant negative correlation with pH, HCO_3^{-1}, Ca^{++}, Mg^{++}, DO & DOM and non-significant positive correlation with CO_3^{-2}.
- *Chlamydomonas orbicularis* showed a significant positive correlation with pH & DOM and a less significant positive correlation with CO_3^{-2}.
- *Chlamydomonas orbicularis* showed a significant negative correlation with Ca^{++}, DO, and unremarkable negative correlation with HCO_3^{-1} & Mg^{++}.
- *Chlamydomonas intermedia* dominant species and it showed (+) ve correlation with *Chlamydomonas globosa,* less significant (-) ve correlation with *Chlamydomonas orbicularis*, and

TABLE-3 : Co-relation coefficients between different parameters of water quality and population densities

POND	***Chlamydomonas intermedia***		***Chlamydomonas elliptica***		***Chlamydomonas globosa***		***Chlamydomonas orbicularis***	
	June21-May22	June22-May23	June21-May22	June22-May23	June21-May22	June22-May23	June21-May22	June22-May23
PH	**-0.6505**	-0.36432	0.400019	**0.636635**	-0.14204	0.406056	**0.474647**	0.198749
HCO_3^-	-0.28254	-0.20513	-0.31144	-0.451	-0.31144	-0.26392	-0.09625	-0.08471
CO_3^{-2}	-0.2528	-0.19809	**0.486483**	**0.580489**	0.163275	0.179911	0.345726	0.391897
Ca++	0.002695	0.067698	**-0.6495**	**-0.6762**	-0.25175	-0.2727	**-0.48494**	-0.39521
Mg++	-0.43012	-0.34239	-0.24982	-0.26447	-0.36268	-0.37903	-0.00885	0.013191
DO	0.318679	0.257448	-0.34787	-0.34491	-0.00057	-0.01811	-0.40751	-0.40144
DOM	**-0.53411**	**-0.51832**	0.22346	0.160966	-0.21605	-0.27639	**0.559228**	**0.525309**

unremarkable correlation with *Chlamydomonas elliptica*.

- *Chlamydomonas elliptica showed significant (+) ve correlation with Chlamydomonas globosa and less significant (+)ve correlation with Chlamydomonas orbicularis..*
- *Chlamydomonas globosa* showed a less significant (-)ve correlation with *Chlamydomonas orbicularis.*

TABLE-4 : Co-relation coefficients between different Species of *Chlamydomonas*

Pond	***Chlamydomonas elliptica***		***Chlamydomonas globosa***		***Chlamydomonas orbicularis***	
	June21-May22	**June22-May23**	**June21-May22**	**June22-May23**	**June21-May22**	**June22-May23**
Chlamydomonas intermedia	0.046204	0.008387	**0.406324**	0.364329	-0.18571	-0.17769
Chlamydomonas elliptica			**0.569546**	**0.537436**	0.205456	0.174682
Chlamydomonas globosa					-0.22974	-0.22547

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