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CORRELATION BETWEEN PHYSICO-CHEMICAL ATTRIBUTES ANDPHYTOPLANKTONS OF FRESH WATER BODIES IN GOA

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ABSTRACT

Freshwater bodies are degraded by both natural and anthropogenic activities, which deteriorate their quality, and push them to the brink of extinction in the process of unplanned development, giving rise to the need for suitable conservation strategies. The management of natural surface water resources needs the understanding of water quality. In present study physico-chemical parameters for determining water quality and density of phytoplanktons of four water bodies was undertaken. During the period two years, seasonal variations in pH, Temperature, TDS, Turbidity, DO, Nitrates, Phosphates, and Total Chlorophyll were recorded. The statistical correlation analysis between the various physico-chemical parameters and dominant phytoplanktons belonging to Chlorophyceae, Euglenophyceae, Cyanophyceae and Bacillariophy ceae were computed. The results of this study revealed that the concentration of the analyzed parameters varied in pre monsoon, monsoon and post monsoon season. These variations influenced the density of recorded phytoplanktons. Among the selected water bodies three were euptophic and one was mesotrophic.

KEYWORDS: Physico-chemical parameters, Phytoplanktons, Correlation, Nitrates, Phosphates

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Original Article

1. INTRODUCTION

Limnological investigations are aimed to assess the water quality and its interaction with biotic and abiotic factors. Physico-chemical properties of freshwater bodies are characterized by the climatic, geochemical, geo-morphological, biological productivity and pollution conditions (Garg et al., 2006). Control of pollutant-oriented problems for providing good quality water and to protect the valuable freshwater resources to safeguard public health can be done by monitoring water quality (Bartram et al., 2002). Water contains variety of floating, dissolved, suspended, microbiological as well as bacteriological impurities. Phytoplanktons play an important role in the biosynthesis of organic matter in aquatic ecosystems, which directly or indirectly serve as food (Ozedon, 2013). They float in water and often multiply rapidly resulting in increased turbidity. Groups like blue-green algae, green algae, diatoms, desmids, euglenoids, *etc*. being important among aquatic flora, form the basic link in the food chain of all aquatic life. The changes in phytoplankton biomass are related to eutrophication and the distribution of phytoplankton apparently is related to nutritional status and selective grazing by zooplanktons (Ingole et al., 2010).

Goa is the smallest state situated in the coastal region of India. It encompasses an area of 3,702 km^2. It lies between the Latitudes 14°53′54″ N and 15°40′00″ N and Longitudes 73°40′33″ E and 74°20′13″ E. Different types of aquatic ecosystems in the state include wetlands, estuarine, marine, lakes, ponds, rivers and springs. Studies on the ecological status and pollution levels of fresh water bodies in the state are scanty. Hence in the present study pH, temperature, total dissolved solids, turbidity, DO, nitrates (NO_3), phosphates (PO_4^-) and total chlorophyll were analyzed to understand their seasonal variations. Phytoplanktons were encountered and correlations were drawn between the physico chemical parameters and phytoplankton populations; trophic status of selected water bodies was determined using biomonitoring studies.

2. MATERIALS AND METHODS

2.1 Study sites and description

Two water bodies each from North Goa (Syngenta Lake and Khandola Pond) and South Goa (Lotus Lake and Curtorim Lake) were selected for the study. Analysis of water samples was carried out on monthly basis for a period of two years.

- **Syngenta Lake** is in the premises of M/s Syngenta Agro Chemicals at Corlim in Tiswadi taluka located on the banks of Cumbarjua canal situated between 15.5º N Latitude 73.94ºE Longitudes.
- **Khandola Pond** is situated between 15.5ºN Latitude and 73.9ºE Longitude at Marcela in Ponda taluka. It is a source of irrigation to areca nut plantation existing in the surrounding areas**.**
- **Lotus lake**is situated between 15.2ºN Latitude and 73.9ºE Longitude at Benaulim in Salcete taluka. The lake is polluted and has abundant growth of aquatic weeds.
- **Curtorim Lake**is situated between 15.2ºN Latitude and 74.0ºE Longitude at Curtorim in Salcete taluka. Lake is a source of irrigation for paddy crop.

Water samples collected on monthly basis were used for analysis of physico chemical parameters for a period of two years. pH of water samples was measured using digital pH meter; Temperature was recorded using a thermometer. Total dissolved solids were analyzed by gravimetric method (APHA, 2012); Turbidity of the water samples was measured using Turbidity meter; DO was analyzed by using Winkler’s Method **(**APHA, 2012); Nitrates were determined by Spectrophotometerusing stock nitrate solution (PDA method)(Rao, 1988); Phosphates were determined by using stannous chloride method **(**APHA, 2012);Total chlorophyll was estimated by using Arnon’s method (Arnon, 1949); For phytoplankton study, one litre of water sample was collected in sterile plastic bottles and Lugol solution (0.7ml/100 ml of sample, APHA, 2012) was added immediately for sedimentation and left undisturbed for 24 hours. The phytoplanktons settled at the bottom of the container were collected and preserved in 4% formaldehyde. After decanting the supernatant, remaining sample was concentrated by centrifugation at 1500 rpm and the total volume was made to 20 or 10 ml depending on density of phytoplanktons. Precaution was taken to avoid filamentous forms (even if they were present in the centrifuged samples they were not counted for organisms per drop) and floating debris. Later, the phytoplanktons were examined immediately upon fixation using student research microscope. Dimensions were measured using micrometry and photomicrographs were obtained using Nikon DS Fi 2 camera. Counting was done by Laky drop method (Suxena, 1987). Identification was carried out using standard bibliographies and monographs (Iyengar, 1940; Desikachary, 1959; Edmondson, 1966; Prescott, 1969; Sarode and Kamath, 1984; Prasad and Misra, 1992; Gandhi, 1998; Krishnamurthy, 2000; APHA, 2012). The phytoplanktons identified were recorded as organisms per drop.

2.2 Perason’s correlation matrix

Data pertaining to physico-chemical parameters and phytoplankton count was analyzed for Pearson’s Correlation matrix, using SPSS - 19software.

3 RESULTS AND DISCUSSIONS

Correlations drawn from results of physico-chemical analysis of water samples and dominant phytoplanktons are tabulated in **Tables1 to 4.**

3.1 pH

The pH of water in the selected water bodies undertaken for the study ranged from 5.9 to 7.8. Variations in pH were recorded in all the water bodies studied. The pH in Syngenta Lake varied from 5.9 to 6.8, Khandola Pond varied from 6.0 to 7.1, Lotus Lake ranged from 5.9 to 7.8 while at Curtorim Lake it ranged from 5.5 to 7.2. The variations recorded in phytoplankton diversity may be attributed to the changing pH levels. Physico-chemical and biological characteristics of water bodies are known to influence each other. The pH range of 5.0 to 8.5 is reported to be ideal for phytoplankton growth (Robert *et al.*, 1974). In fresh waters, low pH affects the phytoplanktons due to the dissolution of salts, while high pH causes discolouration of their cells. Most natural changes occur due to interactions with surrounding rock and other materials.

3.2 Temperature

The water temperature at the study sites varied from 25ºC to 31ºC**.** Maximum temperature was recorded in May (late summer and early rainy season) and minimum in January (winter season). Water temperature plays an important role in controlling the occurrence and abundance of phytoplanktons. It has been called as 'abiotic master' factor due to its effect on aquatic organisms (Wetzel, 2001). Fluctuations in temperature can affect the behaviour of aquatic organisms, such as moving to warmer or cooler water after feeding, predator-prey responses and resting or migrating routines. Algal photosynthesis increases with temperature, although different species have different peak temperatures for optimum photosynthetic activity. Algal blooms are resulted due to increase in water temperature (Spencer and King, 1989).

3.3 Total Dissolved Solids (TDS)

The TDS were least at Khandola Pond (32.60 to 51.45 mg L^{-1}), followed by Syngenta Lake (604 to745 mg L^{-1}), Lotus Lake (616 to 1078 mg L^{-1}) and were maximum at Curtorim Lake (922 to 1389 mg L^{-1}). Beeton (1965), attributed an increase in TDS in St. Lawrence Great Lakes to cultural eutrophication and suggested the separation of Oligotrophic (TDS<100 ppm) and Eutrophic (TDS>100 ppm)lakes based on TDS values. Increase in TDS above 100 ppm in Syngenta, Lotus and Curtorim Lakes indicate cultural eutrophication. Higher values of TDS are due to contamination of domestic waste water, garbage, fertilizers, *etc*. (Verma et al., 2013). During the present study maximum amounts of TDS were recorded in monsoon and minimum in post-monsoon and pre-monsoon. Depending on the ionic properties, excessive TDS can produce toxic effects on fish. They can also affect water taste and often indicates high alkalinity or hardness. With high amounts of suspended solids water becomes aesthetically unsatisfactory for bathing and its palatability becomes inferior (Ramchandra and Solanki, 2007).

3.4 Turbidity

Turbidity measurements are used as an indicator of water quality based on clarity and estimated total suspended solids in water. Higher turbidity levels were recorded during monsoon while low values were recorded during post-monsoon. The values ranged from 22 to 53 NTU in Syngenta Lake, 15.4 to 31 NTU in Khandola Pond, 29 to 54.78 NTU in Lotus Lake and 26 to 56.7 NTU in Curtorim Lake. Increased turbidity levels in monsoon may be due to rainfall and surface runoff of water bringing sediments from the surrounding area.Similar observations have been recorded in earlier (Saxena et al., 1966). High turbidity levels can diminish visibility and often feeding behaviours, in addition to physically harming aquatic life.

3.5 Dissolved Oxygen (DO)

DO is an important parameter in assessing water quality because of its influence on the organisms living within a water body. In limnology, DO is an essential factor as high or low level can harm aquatic life and affect water quality (Wetzel, 2001). DO levels ranged between 6.01 to 12.06 mg L^{-1} at Syngenta Lake, 7.20 to 11.97 mg L^{-1} at Khandola Pond, 5.68 to 10.30 mg L^{-1} at Lotus Lake and 8.14 to 12.77 mg L^{-1} at Curtorim Lake. DO values were maximum during rainy season and minimum during summer season. These variations may be due to natural turbulence in the rainy season and higher bacterial decomposition of organic matter due to good aeration caused by rain water as observed in an earlier study (Prasad, 1991). Jitendraet al., (2008) observed low DO during summer and attributed to higher temperatures and low solubility of oxygen in water consequently affecting the BOD.

3.6 Nitrates

The nitrate levels in the water bodies varied from 0.20 to 0.54 mg L^{-1}in Syngenta Lake, 0.23 to 0.58 mg L^{-1}in Khandola Pond, 1.43 to 4.55 mg L^{-1}in Lotus Lake and 0.80 to 2.76 mg L^{-1}in Curtorim Lake. High nitrate levels were recorded during monsoon and low levels were recorded during post-monsoon season. Similar observations have been recorded earlier (Prabhakar et al., 2012). Nitrates are useful as nutrients but their entry into water resources increases the growth of nuisance algae, macrophytes and triggers eutrophication (Trivedy and Goel, 1986).

3.7 Phosphates

Phosphate is essential for growth of organisms. Discharge of raw wastewater, agricultural drainage, or industrial waste to water body stimulates the growth of photosynthetic aquatic micro- and macro-organisms in large quantities. In the present study variations in Phosphateconcentrations in different water bodies were recorded and ranged from 0.07 to 0.31 mg L^{-1} in Syngenta Lake, 0.01 to 0.30 mg L^{-1} in Khandola Pond, 0.01 to 2.41 mg L^{-1} in Lotus Lake and 0.01 to 1.72 mg L^{-1} in Curtorim Lake. Higher of concentration of Phosphate may also be due to inflow of domestic waste, washing activities and bathing of cattle(Joseph et al., 1993). Levels of phosphates and nitrates deplete DO resulting in the formation of algal blooms.

3.8Total Chlorophyll

Surface waters that have high amount of chlorophyll are typically high in nutrients like Phosphates and Nitrates. In the present study, the chlorophyll concentration varied from 10.76 to 23.43 mg m^{-3} at Syngenta Lake, 2.7 to 5.25 mg m^{-3} at Khandola Pond, 16.52 to 39.23 mg m^{-3} at Lotus Lake and 19.04 to 54.4 mg m^{-3} at Curtorim Lake. High amount of chlorophyll was observed during late summer and during October. This is due to increase in water temperature resulting in accelerating primary production(Marker et al., 1980).

3.9 Correlations

Correlations were drawn between physico-chemical parameters and frequently occurring phytoplanktons. A total of 125 phytoplanktons were identified from all the study sites. Seventy four species of chlorophyceae belonging to 26 genera were recorded during the study period. Chlorophyceae members dominated all the water bodies. Four genera of Euglenophyceae were identified with 16 species out of which only two members *i.e.Euglena minuta* and *E. oxyuries* were recorded fromKhandola Pond.

Fourteen species of Cyanophyceae belonging to seven genera were recovered from all the study sites of which *Chroococcus varius* and *Merismopedia sp.* were found growing in Khandola Pond. Twenty one species of Bacillariophyceae belonging to 12 genera were recorded from the study sites**.***Cocconeis placentula, Navicula halophila, N. radiosa, N. rhynococephala, N. mutica* and *Pinnularia dolosa* were recovered from Khandola Pond. Among the study sites, Khandola Pond showed least diversity of phytoplanktons. This could be attributed to lesser degree of pollution in this water body.

3.9.1 Correlations observed in Syngenta Lake

Cosmarium subretusiforme, Scenedesmus armatus, Chroococcus disparus, Pinnularia dolosa, Navicula halophila and pH were negatively correlated while positive correlation was seen between *Cosmarium ordinatum,Euglena minuta, Trachalomonas volvocina, Ch. disparus* and temperature. *T. volvocina* and *P. dolosa* were positively correlated with turbidity. Negative correlation was seen between *E. minuta, T. volvocina, Spirulina nordesttedii, P. dolosa* and DO whereas *C. ordinatum,T. volvocina, S. nordesttedii* and *N. halophila* showed positive correlation with BOD. *Cosmarium subretusiformae, E. minuta, T. volvocina, P. dolosa, N. halophila* and nitrates showed positive correlation while *C. ordinatum, S. armatus, E. minuta,* and *Ch. disparus* showed positive correlation with phosphates. *Cosmarium subretusiforme, E.minuta, T. volvocina, Ch. disparus, S. nordesttedii* and *N. halophila* were positively correlated with total chlorophyll. *Cosmarium ordinatum* was inversely proportional to *C. subretusiformae* while there was positive correlation between *T. volvocina, E. minuta, S. nordestedii* and*Ch. disperus* and *N. halophila* and *P. dolosa* **(Table 1)**.

3.9.2 Correlations observed in Khandola Pond

Staurastrum thienemannii, Euastrum spinulosum,Navicula mutica were inversely proportional to pH whereas positive correlation was observed between *S. thienemannii, E. spinulosum,Euglena oxyuriss, E. minuta,P. dolosa* and temperature.*Euastrum spinulosum*and*E. minuta*were positively correlated with turbidity. Negative correlation was seen between*S. thienemannii, Netrium digitus, Pediastrum obtusum, E. minuta,P. dolosa, N. mutica* and DO. BOD was below detectable level. Positive correlation was observed between *E. spinulosum,E. oxyuriss, E. minuta,P. dolosa*and nitrates.There was positive correlation between*E. spinulosum,E. oxyuriss, E. minuta* and phosphates.*Staurastrum thienemannii, E. spinulosum,E. oxyuriss, E. minuta* and *N. mutica* were positively correlated with total chlorophyll. *Euastrum spinulosum* was inversely proportional to *S. thienemannii* while there was positive correlation between *E. minuta* and *E. oxyuriss* and *N. rhynococephala,* and *P. dolosa* **(Table 2)**.

3.9.3 Correlations observed in Lotus Lake

Cosmarium contractum showed positive correlation with pH,whereas *Ankistrodesmus falcatus, Chroococcus disperses* and *Gomphonema parabolum*showed negative correlation. *Scenedesmus quadricauda, Trachalomonas volvocina, Ch. disperses Gomphosphaeria lacustris* showed positive correlation with temperature. *Cosmarium contractum* showed negative correlation with turbidity whereas *A. falcatus, Ch. disperses* showed positive correlation with turbidity. *Scenedesmus dimorphus, A. falcatus, T. volvocina,*and *Go lacustris* showed negative correlation with DO. *Cosmarium contractum, E. minuta, Ch. disperses* and *G. parabolum* showed positive correlation with BOD. Nitrates and *S. quadricauda, T. volvocina Go. lacustris, Gomphonema parabolum* were positively correlated. *Cosmarium contractum, S. quadricauda, T. volvocina, Go. lacustris* and *G. parabolum,* showed positive correlation with phosphates. *Scenedesmus quadricauda, E. minuta, Ch. disperses* and *G. parabolum* showed positive correlation with total chlorophyll. *Cosmarium contractum, S. quadriquada, G. parabolum* and *Go. lacustris* were positively correlated while *T. volvocina* and *E. minuta* were inversely proportional to each other **(Table 3)**.

3.9.4 Correlations observed in Curtorim Lake

Trachalomonas volvocina, Gomphosphaeria lacustris and *Synedra ulna* were inversely proportional to pH. Positive correlation was seen between *Cosmarium regnellii, C. obsoletum, Scenedesmus bernardii, Trachalomonas volvocina, Synedra ulna*and temperature.*Cosmarium obsoletum,Actinastrum hantzschii* and*Chroococcus disperses* were positively correlated with turbidity. Negative correlation was seen between*C. obsoletum, Scenedesmus bernardii, T. volvocina, Lepocinclis fusiformis* and *Go lacustris*with DO while these forms showed positive correlation with BOD. Positive correlation was observed between *C. regnellii, S. bernardii, T. volvocina, Go. lacustris* and nitrates.*Cosmarium regnellii, S. bernardii, Go. lacustris* and *S. ulna*were positively correlated to phosphates.*Cosmarium regnellii, S. bernardii, T. volvocina* and *Go. lacustris*were positively correlated with total chlorophyll. *Scenedesmus bernadii* and *A. hantzschii* are inversely proportional with *C. obsoletum.* Positive correlations were observed between *T. volvocina, L. fusiformis, Ch. disperus, Go. lacustris* and *S. ulna* **(Table 4)**.

4 CONCLUSIONS

With a view of understanding the quality of water and pollution status, four fresh water bodies were selected for the present study. The analyzed physico-chemical parameters governed growth of a variety of phytoplanktons. The study revealed definite relationship between physico-chemical parameters and phytoplanktons in the selected water bodies. The analyses of water quality suggest that most of the parameters are above desirable limits. The Lotus and Curtorim Lakes are influenced by domestic activities, sewage flow, cattle washing by rural communities and small scale industrial effluents, while the Syngenta Lake is affected by organic pollution. Khandola Pond however, is affected to a lesser extent by above anthropogenic stresses.Data envisaged that the current status of three lakes is eutrophic whereas the pond shows mesotrophic conditions.

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Table 1: Correlation between Physico-chemical parameters and phytoplanktons for Syngenta Lake

	1	**2**	**3**	**4**	**5**	**6**	**7**	**8**	**9**	**10**	**11**	**12**	**13**	**14**	**15**	**16**	**17**	**18**
1	1																	
2	.053	1																
3	-.169	.105	1															
4	.357	.600**	.265	1														
5	.429*	-.457*	-.398	-.122	1													
6	-.344	.459*	.274	.116	.685**	1												
7	-.068	.131	.501*	.130	.037	-.091	1											
8	.373	.349	.410*	.764**	-.069	.085	.308	1										
9	-.031	.614**	-.232	.519**	-.239	.416*	-.328	.289	1									
10	.630**	.364	.009	.172	-.448*	.221	.621**	.247	.696**	1								
11	-.241	.742**	-.026	-.075	-.370	.713**	.244	.756**	.060	.605**	1							
12	.638**	.062	-.077	-.096	-.498	.343	.447*	.897**	.561*	-.107	.717**	1						
13	.001	.717**	.027	.351	.626**	.575*	.746**	.602**	.522**	.542**	.091	.105	1					
14	-.083	.651**	.328	.509**	.540**	.738**	.624**	.178	.511**	.525*	.481*	.413*	.648**	1				
15	.697**	.584**	.107	.238	-.468*	.528*	.046	.676**	.640**	.334	.270	.051	.203	.345	1			
16	-.404	.470*	.229	.080	.542**	.721**	.555*	.681**	.510**	.189	.504*	.222	.204	.469*	.737**	1		
17	.714**	.033	.005	.506**	.670**	.566*	.652**	.793**	.201	.518**	-.044	-.010	.305	.070	.375	.223	1	
18	.602**	.148	.102	-.324	-.483*	.743**	.640**	.716**	.572**	.325	.359	.427*	.324	.379	.214	.284	.790**	1

Legend: * Significant at the 0.05 level (2-tailed); **. Significant at the 0.01 level (2-tailed);
1.pH, 2. Temperature, 3. TDS, 4. Turbidity, 5. DO, 6. BOD, 7. Nitrates, 8. Phosphates, 9. Total Chlorophyll, 10. *Cosmarium subretusiforme*, 11. *C ordinatum*, 12. *Scenedesmus armatus*, 13. *Euglena minuta*, 14. *Trachalomonas volvocina*, 15. *Chroococcus disparus*, 16. *Spirulina nordesttedii*, 17. *Pinnularia dolosa*, 18. *Navicula halophila.*

Table 2: Correlation between Physico-Chemical Parameters and phytoplanktons for Khandola Pond.

	1	2	3	4	5	6	7	8	9	10	11	12	13	**14**	**15**	**16**	**17**
1	1																
2	-.552**	1															
3	-.289	.074	1														
4	-.158	-.037	.314	1													
5	-.028	.002	.111	.317	1												
6	-.293	.532**	-.239	.043	.042	1											
7	-.022	.170	-.071	.470*	.701**	.296	1										
8	-.289	.572**	.260	-.195	-.096	.004	-.163	1									
9	-.534**	.741**	.513*	-.238	-.688**	-.008	-.238	.505**	1								
10	-.675**	.707**	.202	.513**	-.314	.624**	.638**	.630**	-.738**	1							
11	-.275	-.122	.318	.551*	-.718**	-.334	-.377	-.035	.346	.719**	1						
12	-.247	-.135	-.075	-.182	-.519**	.239	-.246	-.228	-.134	.103	.259	1					
13	-.609**	.635**	.115	-.032	-.184	.635**	.566*	.625**	-.091	-.008	.090	.036	1				
14	.122	.596**	-.130	.694**	-.639**	.568**	.565**	.653**	.218	.157	.013	.296	.691**	1			
15	-.085	.608**	.057	-.201	-.524**	.505**	.039	.009	.396	.406*	.152	.077	-.196	**.547****	1		
16	-.614**	.227	.077	-.160	-.624**	.036	-.122	.745**	.350	.380	.194	-.211	.525**	-.275	-.225	1	
17	-.024	-.076	-.155	-.585*	.020	.079	-.106	-.208	-.095	.102	.225	.503**	-.142	.396	.328	-.366	1

***Legend**: * Significant at the 0.05 level (2-tailed); **.Significant at the 0.01 level (2-tailed);*

BOD Values are eliminated as it was Below Detectable Level in this study site. 1. pH, 2.Temperature, 3.TDS, 4.

Turbidity,5. DO, 6. Nitrates, 7. Phosphates, 8.Total Chlorophyll, 9. *Staurastrum thienemannii*, 10. *Euastrum spinulosum*, 11. *Netrium digitus*, 12. *Pediastrum obtusum*, 13. *Euglena oxyuriss*, 14. *Euglena minuta,* 15. *Pinnularia dolosa,* 16. *Navicula mutica,* 17. *N. rhynococephala.*

Table 3: Correlation between Physico-Chemical Parameters and phytoplanktons for Lotus Lake.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1																	
2	.538**	1																
3	-.122	-.030	1															
4	-.432*	.261	.508*	1														
5	.052	-.110	.190	-.153	1													
6	-.120	.117	-.170	.261	.622**	1												
7	-.095	-.041	.524**	.289	.574**	-.426*	1											
8	-.066	-.163	.695**	.585**	.438*	-.303	.761**	1										
9	-.409*	.449*	-.038	.356	.645**	.661**	-.372	-.230	1									
10	-.048	.066	.093	.094	.518**	.269	-.074	.008	.340	1								
11	.582**	-.266	-.329	.540**	-.041	.601**	-.103	.797**	.089	.121	1							
12	-.460*	.633**	.003	.351	-.170	.126	.585**	.690**	.578**	-.114	.799**	1						
13	.506**	.457*	-.050	.679**	.773**	.560*	-.257	-.054	.404	.076	-.213	.418*	1					
14	-.092	.496*	-.170	-.053	-.259	.646**	-.384	-.277	.565**	.568**	.026	.536**	.542*	1				
15	-.148	.549**	-.195	.010	.607**	.158	.685**	.609**	.483*	.060	-.032	.638**	.525**	.813**	1			
16	.664**	.678**	-.063	.737**	-.020	.732**	-.174	.009	.547**	.070	-.137	.637**	.639**	.704**	.567**	1		
17	-.121	.706**	-.279	.004	.563**	.101	.674**	.762**	.318	.431*	-.240	.360	.075	.422*	.530**	.182	1	
18	.642**	.290	-.456*	.170	-.453*	.632**	.539**	.611**	.749**	.090	-.130	.339	.734**	.436*	.435*	.548**	.321	1

Legend: * Significant at the 0.05 level (2-tailed); **.Significant at the 0.01 level (2-tailed);

1.pH, 2. Temperature,3. TDS,, 4. Turbidity, 5. DO, 6. BOD,7. Nitrates, 8. Phosphates, 9. Total Chlorophyll, 10.*Scenedesmus dimorphus,* 11. *Cosmarium contractum,* 12. *Scenedesmus quadricauda,* 13. *Ankistrodesmus falcatus,* 14. *Euglena minuta,* 15. *Trachalomonas volvocina,* 16. *Chroococcus disperses,* 17.*Gomphosphaeria lacustris,* 18. *Gomphonema parabolum.*

Table 4: Correlation between Physico-Chemical Parameters and phytoplanktons for Curtorim Lake.

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	17	18
1	1																	
2	.018	1																
3	.040	.234	1															
4	-.006	.149	.641**	1														
5	.505*	-.276	-.373	-.108	1													
6	.608**	.334	.289	.179	.839**													
7	-.012	.193	.643**	.778**	-.142	.155	1											
8	.072	.082	.575**	.828**	-.171	.162	.675**											
9	.696**	.340	.302	.330	.839**	.951**	.259	.243	1									
10	.107	.789**	-.241	-.156	-.222	.293	.681**	.660**	.768**	1								
11	.779**	.659**	.059	.612**	.782**	.633**	-.059	-.268	.538*	.439*	1							
12	-.081	.680**	-.084	-.107	.552**	.610**	.569**	.699**	.788**	.805**	.708**	1						
13	.134	.119	-.198	.650**	-.081	.417	-.191	-.098	.594*	.469*	.659**	.452*	1					
14	.536**	.542**	.425*	.082	.705**	.518**	.523**	.104	.601**	.141	.251	.328	.116	1				
15	.043	.463*	.021	-.355	.650**	.708**	-.285	-.226	.100	.460*	.463*	.384	.103	.746**	1			
16	.205	.487*	.444*	.627**	-.138	.168	.059	.088	.144	.390	.278	.463*	.123	.444*	.498*	1		
17	.695**	.397	.107	-.043	.695**	.702**	.626**	.529**	.600**	.423*	.740**	.631**	.234	.352	.400	.823**	1	

18	.552**	.695**	-.177	-.234	.255	-.001	-.164	.656**	-.007	.180	.375	.441*	.059	.253	.319	.185	.633**	1

Legend: * Significant at the 0.05 level (2-tailed); **. Significant at the 0.01 level (2-tailed); 1.pH, 2. Temperature, 3. TDS, 4. Turbidity, 5. DO, 6. BOD, 7. Nitrates, 8. Phosphates, 9.Total Chlorophyll, 10. *Cosmarium regnellii*, 11. *Cosmarium obsoletum*, 12. *Scenedesmus bernardii*, 13. *Actinastrum hantzschii*,14. *Trachalomonas volvocina*,,15. *Lepocinclisfusiformis*, 16*Chroococcus disperses*, 17.*Gomphosphaeria lacustris*, 18. *Synedra ulna*.