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DIRECT AND INDIRECT EFFECTS OF VARIOUS PROPERTIES OF WATER AND BOTTOM SOIL OF PONDS ON THE PLANKTON PRODUCTION

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Interactions in nine physico-chemical properties of water were recorded through path analysis. In such cases water temperature and dissolved O_2 had almost significant correlations with other properties. The interaction in various chemical properties of bottom soil of pond (most of the correlation values among them) is insignificant in nature, except a fewer number of significant correlation values. Transparency, dissolved O_2, free CO_2, available N and exchangeable K influenced positiviely and direcly the production of plankton as well as indirectly through other physico-chemical properties of water. But temperature, pH, available P and exchangeable Ca influenced negatively and directly the plankton production as well as indirectly through the physico-chemical factors of water. Again, all the chemical factors of bottom soil influenced positively and directly the production of plankton as well as indirectly through these factors of bottom soil of ponds.

Key words: Water, Soil, Plankton.

Introduction

The interactions in various physico-chemical properties of water and bottom soil of ponds are prevailing in aquatic ecosystem [1,2]. A knowledge of interrelationship in the properties of water and bottom soil and to assess the effectiveness on plankton production of selected properties through direct and indirect effect analyses are essential. Keeping all these in view, an attempt was made to have some important informations about interrelationship and the relative contribution as direct and indirect effects of these properties of water and bottom soil on the plankton production through path coefficient correlation analysis.

Materials and Methods

Water and bottom soil samples were collected from four ponds, one situated inside the Bangladesh Agricultural University (BAU) Campus and other three situated outside the BAU Campus, for a period of 4 months from Jul. 1986 to Oct. 1986. Samples of water and bottom soil were collected from 2 ponds with bloom and 2 without bloomed condition. Three ponds (Pond 1, Pond 2 and Pond 3) were almost free from aquatic vegetations except few rooted aquatic weeds which were present in the shallower area of 4th pond (Pond 4). Samples were collected every fortnightly from 4 stations of each ponds by using earthen pot and banana raft.

(i) *Collection of bottom soil samples.* Soil samples were collected by Ekman Dredge from the area of soil-water interface (covering an area of 225 cm^2). Soil sample from each station of 4 ponds was put into individual plastic bucket of 2kg capacity and carried to the laboratory. The samples were dried at room temperature, grounded, sieved by 0.03 mm sieve and kept in plastic packet marked with date and station number of pond for chemical analyses.

(ii) *Collection of water samples.* About 2 litres of water sample from each station of every pond were collected by using a Kemmerer type water sampler. The water sample was kept in black bottle by adding 2 - 3 drops of toluene in the laboratory.

(iii) *Collection of plankton.* Ten litres of water was collected from surface, middle and bottom of the pond by Kemmerer type water sampler and filtrated through No.55 bolting silk plankton net. The plankton samples were concentrated and were kept in 5% buffered formalin for analysis.

(iv) *Analyses of physico-chemical properties of water.* The transparency and temperature were recorded by secchi disc and centigrade thermometer, respectively. The pH was determined by pH meter (Model No.420). Dissolved O_2 by azide modification of iodometric method, free CO_2 by titrimetric method using phenolphthalein indicator and N/44 NaOH, available N by phenol disulphonic acid method through colorimeter and available P by stannous chloride method through Spectronic-20 were determined. Exchangeable K and Ca were analysed through ammonium acetate extract by Eppendrof flame photometer. All the analysis were done by following the standard methods for the analysis of water and waste water [3].

(v) *Analysis of bottom soil samples.* The pH was determined by pH meter (Model No.420) in a 1:25, soil : water suspension [4]. Organic carbon by wet oxidation method [5], total N by Macrokjeldahl method [6] and available P by 0.5

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$NaHCO_3$ extraction method through Spectronic-20. Exchangeable K and Ca were analysed from ammonium acetate extract by Eppendrof flame photometer.

(vi)*Study of plankton.* The estimation was done by Sedgewick Rafter Counting Chamber Method [7]. The colonical as well as each filamentous algae was treated as a single unit. Qualitative and quantitative studies were done by using different standard keys [8 - 11]. The total plankton production was estimated as the sum of all the genera of plankton.

(vii) *Data analysis.* The simple correlation coefficients among all possible combinations of various physico-chemical properties of water and among all possible combinations of chemical properties of bottom soil of ponds were analysed through path analysis. The direct and indirect effects of various physico-chemical properties of water and chemical constituents of bottom soil on the total growth and abundance of plankton were done through path coefficient analysis. All the statistical analyses were done by following keys given by Gomez and Gomez [12] and Singh and Choudhary [13] with the help of IBM computer.

Results and Discussion

The mean value and standard error of physico-chemical properties of water as tarnsparency, temperature, pH, dissolved O_2, free CO_2 available P, exchangeable K and Ca are shown in Fig. 1. The temperature, pH, dissolved O_2, exchangable K and Ca were higher in October. The transparency and free CO_2, were maximum in September and minimum in October. The highest amount of available N and P, were recorded in July. The lowest temperature in September and pH, dissolved O_2, exchangeable K were recorded in July. But minimum transparency, avialable N, P and exchangeable Ca were recorded in October. Habib *et al.* [1] reported almost similar results like the present findings except in case of pH and exchangeable Ca. Oppenheimer *et al.* [14] reported that the dissolved O_2 is inversely correlated with free CO_2 which agrees with the present study. Ali *et al.* [15] found that due to the growth of *Microcystis*, transparency and nutrients of water decrease. Khan *et al.* [16] stated that pH, dissolved O_2, available N and P were higher in summer months. Alam *et al.* [2] reported that the concentration of available N and exchangeable Ca were lower in July and August and higher in Sept., Oct. and Nov. The analysed chemical properties of pond bottom soil as pH, organic carbon, total N, avialable P, exchangeable K and Ca are shown in Fig. 2. During the study, highest value of pH in Oct. and total N and exchangeable K in July were recoreded. Again, the amount of organic carbon and exchangeable Ca in August and available P in July were maximum. The pH and exchangeable K in Sept. total N in Oct., available P in Aug., organic carbon and exchangeable Ca in July were minimum during the study. Sondergaard and Jensen [17] reported the similar results like the present findings. Habib *et al.* [18] stated that lower amount of organic carbon, avialable N, P and exchangeable K of pond bottom soil might be due to mixing of these nutrients in water from bottom soil through bacterial activity.

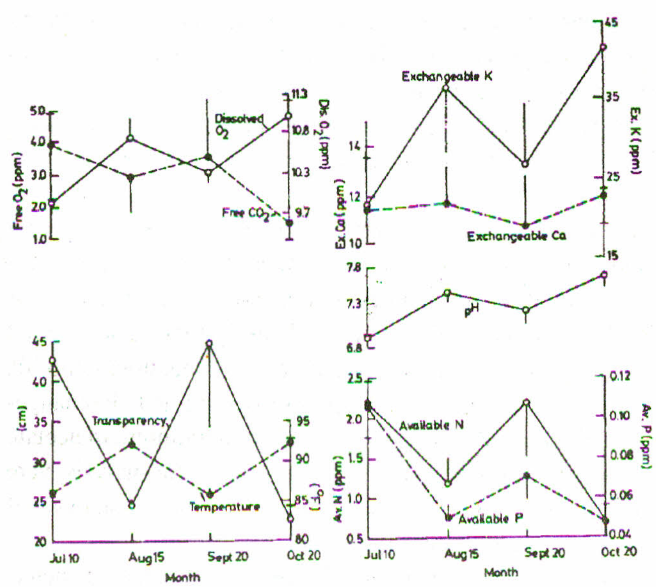

Fig. 1. The mean values and standard errors of physico-chemical factors of water of ponds (vertical bars represent the standard errors).

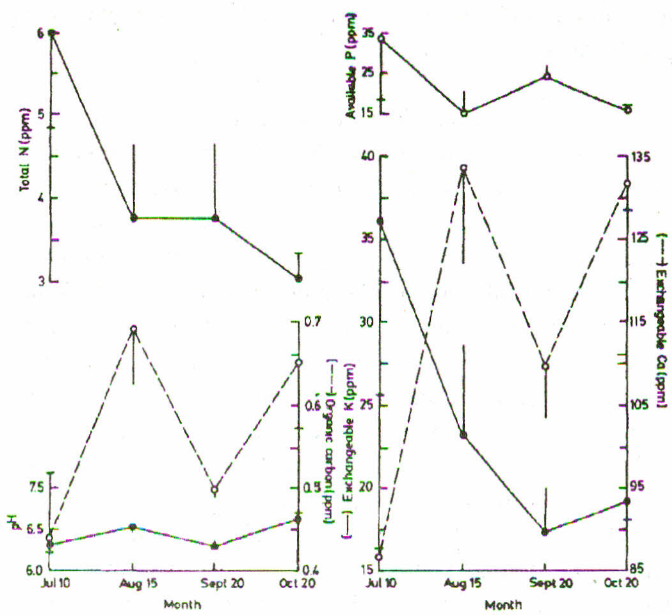

Fig. 2. The mean values and standard errors of chemical factors of bottom soil of ponds (vertical bars represent the standard errors).

TABLE 1. PATH ANALYSIS IN THE PHYSICO-CHEMICAL PROPERTIES OF WATER PONDS.

Physico-chemical properties of water	Temperature (°F)	pH	Dissolved O_2 (ppm)	Free CO_2 (ppm)	Available N (ppm)	Available P (ppm)	Ex. K (ppm)	Ex. Ca (ppm)
Transparency	-0.618***	-0.449**	-0.441*	-0.475**	0.283	0.115	-0.327	0.224
Temperature	—	-0.539***	0.725***	-0.399*	-0.719***	-0.356*	0.025	0.113
pH	—	—	0.438*	-0.212	-0.306	-0.332	0.017	0.089
Dissolved O_2	—	—	—	-0.471**	-0.727***	-0.427*	-0.143	0.374*
Free CO_2	—	—	—	—	0.366*	0.159	-0.002	0.007
Available N	—	—	—	—	—	0.402*	0.227	-0.589***
Available P	—	—	—	—	—	—	0.642***	-0.246
Exchangeable K	—	—	—	—	—	—	—	-0.212

df = 30; *P <0.05; **P <0.01; ***P <0.001 and Ex= Exchangable.

TABLE 2. PATH ANALYSIS IN THE CHEMICAL PROPERTIES OF BOTTOM SOIL OF PONDS.

Chemical properties of bottom soil	Total N (ppm)	Organic carbon (%)	Available P (ppm)	Exchangeable K (ppm)	Exchangeable Ca (ppm)
pH	-0.068	0.534*	0.002	-0.176	-0.076
Total N	—	-0.388*	-0.073	-0.180	-0.659***
Organic C	—	—	0.440	-0.166	0.416*
Available P	—	—	—	-0.233	0.161
Exchangeable K	—	—	—	—	0.001
Exchangeable Ca	—	—	—	—	—

df = 30; *P < 0.05; **P < 0.01 and ***P < 0.001.

TABLE 3. ESTIMATES OF DIRECT EFFECT PATH COEFFICIENT AND INDIRECT EFFECT PATH COEFFICIENT OF DIFFERENT PHYSICO-CHEMICAL PROPERTIES OF WATER INFLUENCING THE PLANKTON PRODUCTION.

Characters	Effect through									
	Trans-parency (cm)	Tem-perature (°C)	pH	Dissolved O_2 (ppm)	Free CO_2 (ppm)	Available N (ppm)	Available P (ppm)	Exch. K (ppm)	Exch. Ca (ppm)	Correlation coefficient (r) with plankton
Transparency	0.018	1.201	0.745	-1.808	0.535	0.302	-0.034	-0.334	-0.001	0.624
Temperature	-0.011	-0.943	0.894	2.972	-0.449	-0.767	0.106	0.026	-0.001	0.825
pH	-0.008	1.047	-1.658	1.795	-0.239	-0.327	0.099	0.017	-0.001	0.726
Dissolved O_2	-0.008	-1.409	-0.726	4.099	-0.530	-0.776	0.127	-0.146	-0.002	0.628
Free CO_2	0.009	0.775	0.352	-1.930	1.125	0.391	-0.047	-0.002	-0.001	0.672
Available N	0.005	1.397	0.507	-2.980	0.412	1.067	-0.119	0.232	0.003	0.525
Available P	0.002	0.692	0.551	-1.750	0.179	0.429	-0.297	0.655	0.001	0.462
Exchangeable K	-0.006	-0.049	-0.028	-0.586	-0.002	0.242	-0.190	1.020	1.001	0.402
Exchangeable Ca	0.004	-0.220	-0.148	1.533	0.008	-0.629	0.073	-0.216	-0.006	0.400

Underlined figures denote the direct effects; Residual effect = 0.625.

TABLE 4. ESTIMATES OF DIRECT EFFECT PATH COEFFICIENT AND INDIRECT EFFECT PATH COEFFICIENT OF DIFFERENT CHEMICAL PROPERTIES OF BOTTOM SOIL OF POND INFLUENCING THE PLANKTON PRODUCTION.

Characters	Effect through						
	pH	Total N (ppm)	Organic carbon (%)	Available P (ppm)	Exchangeable K (ppm)	Exchangeable Ca (ppm)	Correlation coefficient (r) with plankton
pH	0.933	-0.181	0.251	0.001	-0.216	-0.163	0.625
Total N	-0.063	2.660	-0.182	-0.033	-0.220	-01.413	0.748
Organic carbon	0.498	-1.032	0.470	0.197	0.203	0.892	0.821
Available P	0.002	-0.194	0.207	0.447	-0.285	0.345	0.521
Exchangeable K	-0.164	-0.479	-0.078	-0.104	1.225	0.220	0.402
Exchangeable Ca	-0.071	-1.753	0.195	0.072	0.001	2.144	0.589

Underlined figures denote direct effect; Residual effect = 0.528.

Interactions in various physico-chemical properties of water were recorded through path analysis (Table 1) where inversely correlated values were more than the directly correlated values. The strongly ($P < 0.001$) direct correlations of dissolved O_2 with temperature (r = 0.725), and available P with exchangeable K (r = 0.642) were recoreded. There were strongly ($P < 0.001$) inverse correlations of available N with temperature (r = ±0.719) and dissolved O_2 (P =–0.727), available N with exchangeable Ca (r =–0.589) and transparency with temperature (r =±0.618). There were highly ($P < 0.01$) inverse correlations of pH with transparency (r = –0.449)and temperature (r =–0.539) and free CO_2 with dissolved O_2 (r=–0..471) recorded during the study. Only free CO_2 had highly ($P < 0.01$) direct correlation with transparency (r = 0.475). Ali *et al.* [15] and Khan *et al.* [16] partially agreed with the present results. Habib *et al.* [18] recorded that available N and exchangeable K were directly correlated with most of the other chemical properties of water which disagree with the present findings. They further stated that water temperature, pH and dissolved O_2 are almost inversely correlated with other chemical properties of water which partially agree with the present reults.

In case of interactions in various chemical properties of bottom soil of pond, most of the correlation values among them were positive in nature except between exchangeable Ca and others (Table 2). Only total N was strongly ($P<0.001$) and inversely correlated with exchangeable Ca (r = -0.659). Organic carbon had highly ($P< 0.01$) direct correlation with pH (r=0.534), simply ($P = 0.05$) inverse and direct correlations with total N (r =–0.388) and exchangeable Ca (r = 0.416), respectively. Habib *et al.* [18] stated that total N and organic carbon had significant correlation with exchangeable Ca which agrees with the present findings (Table 3).

The direct and indirect effects of 9 physico-chemical properties of water on plankton production were done through path coefficient analysis (Table 3). The direct effects of transparency, temperature, pH, available P, exchangeable Ca on the fluctuations and abundance of total plankton production were not so important and negative in nature in most of the cases (Table 3). Dissolved O_2, free CO_2, available N and exchangeable K had significantly direct effect and played important role on the plankton production. Dissolved O_2 had negative effect through all the properties of water except available N on plankton production. Temperature influenced positively the abundance of plankton through pH which was relatively important but temperature, pH and dissolved O_2 decreased negatively the plankton growth through free CO_2, available N and exchangeable K. Transparency, available P, exchangeable K and Ca had either negligible positive or negative substantial effect through all the properties of water on the plankton production which are not so important. But negative indirect effects played important role to retard the fluctuation of plankton in ponds. In case of chemical properties of bottom soil of ponds, the influence of all the properties had substantially direct and positive effects on the growth and abundance of plankton directly and positively which contributed to accelerate the fluctuations of plankton production (Table 4). But their indirect effects through various factors upon the plankton growth were almost very poor and did not play important role. Habib and Rehman [20] recorded the important role of direct and indirect effects of physico-chemical properties of water on the available genera of plankton. Ali and Shaikh [19] and Jahiruddin *et al.* [21] recorded the direct and indirect effects of some important growth influencing factors on the yield where some factors had substantial contribution among each other.

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