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Ecotendency of phytoplankton: An approach for categorizing algae as bio-indicators for monitoring water quality

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Hydrobiological investigations were made in a channel of river Ganges at Bhagalpur to study the ecotendency of phytoplankton. Different inter-correlations between abiotic parameters and phytoplankton abundance were estimated. Functional relationship between NO_3 and Zygnematales showed 83% of variance. A multiple regression model of phytoplankton abundance accounted for 88% of variance. Of the abiotic parameters included in the analysis, water temperature, total alkalinity and SiO_2 increased phytoplankton population. A shift in specific algae with increase in trophicity and saprobity was clearly demarcated. This information may be useful in categorizing algae as bio-indicators for monitoring water quality.

CHANGES in ecotendency of algal taxa and their assemblage are attributed to the progression of trophic and saprobic levels in aquatic environments. For many years algae have been used as bio-indicators for monitoring water quality^{1–10}. It enables quick, easy and authentic monitoring water quality even at micro-level impurity. Importance of categorizing algae as bio-indicators of

different types of water has attracted global attention. It has been suggested to carry out such study in local conditions¹¹ for better use. Here we put forth an ecological model which depicts ecotendency of phytoplankton from a channel of river Ganges, a tropical water body.

The study was conducted during 1983 (January to November) in a channel of river Ganges at Bhagalpur (25° 14' N 86° 57' E). The characteristic features of this channel were that, it behaved as clean water body during July to October because it became a riverine system by getting deluged with the main river during floods and thereafter it assumed a separate identity like a channel, and was fed with community sewage. Community sewage was indiscriminately discharged at the rate of 0.5 MLd (million litre per day) at dry weather fall level. Sewage as an auxiliary energy input increased nutrients which subsequently enhanced phytoplankton production¹². Hydrobiological samples were collected at monthly intervals and were subsequently analysed. Data of water temperature, pH, total alkalinity, phosphate, nitrate, Fe(II), dissolved organic matter (DOM), chloride, specific conductivity, silicon dioxide and phytoplanktons were analysed. Different inter-correlations and multiple regression analyses were made between five important abiotic parameters and phytoplankton. Relation between trophicity and saprobity has been dealt with earlier²¹.

Phenomena of eutrophication and saprobication were observed accompanied with an increase in nutrients and phytoplankton. Strong positive correlation existed between total alkalinity and chloride ($r = 0.9376$), DOM ($r = 0.8089$), PO_4 ($r = 0.791$), SiO_2 ($r = 0.5824$) and NO_3 ($r = 0.4428$) (Table 1). Higher concentration of chloride was probably attributed to sewage¹³. Individual effects of temperature (X_1), total alkalinity (X_2), DOM (X_3), chloride (X_4) and SiO_2 (X_5) on total phytoplankton population (Y) were significant at 5% level (with 7 df). Multiple regression fitted to observed data was:

$$Y = -955568.0201 + 25385.4548 X_1 + \quad (3.94)$$

$$1559.5625 X_2 - 13492.8324 X_3 - 2177.0622 X_4 + \quad (3.95) \quad (4.92) \quad (2.20)$$

$$12245.1467 X_5 \quad (r^2 = 0.8851) \quad (2.25)$$

(Figures within brackets are the estimated t values to test the significance of the respective regression coefficients.)

Temperature, total alkalinity and SiO_2 were found to have positive influence on phytoplankton. Individual effects of total alkalinity (X_2) and chloride (X_4) on phytoplankton were found to be statistically significant at 5% level (with 11 df). The estimated linear regressions were:

*For correspondence.

Table 1. Correlation matrix

	Water temp	pH	Total alk.	PO ₄	NO ₃	Fe(ic)	DOM	Chloride	Sp cond	SiO ₂	Total phytoplankton	Volvocales	Chlorococcales	Zygnematales	Diatoms	Euglenoids	Myxophyceae
Water temp.	1.000	0.087	-0.553	-0.790	0.034	0.020	-0.283	-0.272	0.416	-0.774	-0.089	-0.093	-0.104	-0.279	-0.105	0.033	0.312
pH	0.087	1.000	0.518	0.087	0.384	-0.018	0.409	0.542	-0.136	-0.084	0.562	0.640	0.566	-0.393	0.556	-0.186	0.119
Total alk	-0.553	0.518	1.000	0.791	0.443	-0.002	0.809	0.938	-0.729	0.582	0.550	0.584	0.544	0.158	0.538	0.119	0.065
PO ₄	-0.790	0.087	0.791	1.000	0.311	0.083	0.463	0.656	-0.533	0.769	0.396	0.377	0.399	0.280	0.401	0.070	-0.193
NO ₃	0.034	0.384	0.443	0.311	1.000	-0.494	0.321	0.536	-0.360	-0.081	0.410	0.421	0.409	-0.611	0.409	0.431	0.024
Fe(ic)	0.020	-0.018	-0.002	0.083	-0.494	1.000	0.023	0.015	0.015	0.139	-0.094	-0.089	-0.092	0.578	-0.092	-0.150	-0.114
DOM	-0.283	0.409	0.809	0.463	0.321	0.023	1.000	0.803	-0.765	0.331	0.150	0.183	0.121	0.131	0.113	0.130	0.501
Chloride	-0.272	0.542	0.938	0.656	0.536	0.015	0.803	1.000	-0.688	0.419	0.571	0.604	0.559	0.116	0.554	0.218	0.141
Sp. cond.	0.416	-0.136	-0.729	-0.533	-0.360	0.015	-0.765	-0.688	1.000	-0.307	-0.208	-0.214	-0.189	-0.212	-0.186	-0.323	-0.220
SiO ₂	-0.774	-0.084	0.582	0.769	-0.081	0.139	0.331	0.419	-0.307	1.000	0.346	0.334	0.349	0.398	0.350	-0.250	-0.134
Total phyto-plankton	-0.089	0.562	0.550	0.396	0.410	-0.094	0.150	0.571	-0.208	0.346	1.000	0.986	0.998	-0.099	0.998	-0.127	-0.032
Volvocales	-0.093	0.640	0.584	0.377	0.421	-0.089	0.183	0.604	-0.214	0.334	0.986	1.000	0.991	-0.119	0.989	-0.149	-0.099
Chlorococcales	-0.104	0.566	0.544	0.399	0.409	-0.092	0.121	0.559	-0.189	0.349	0.998	0.991	1.000	-0.106	1.000	-0.134	-0.092
Zygnematales	-0.279	-0.393	0.158	0.280	-0.611	0.578	0.131	0.116	-0.212	0.398	-0.099	-0.119	-0.106	1.000	-0.104	-0.013	-0.107
Diatoms	-0.105	0.033	0.556	0.401	0.409	-0.150	0.113	0.130	-0.092	0.554	0.998	0.989	1.000	-0.104	1.000	-0.129	-0.091
Euglenoids	0.033	-0.186	0.119	0.070	0.431	-0.150	0.130	0.218	-0.323	-0.250	-0.127	-0.149	-0.134	-0.013	-0.129	1.000	-0.098
Myxophyceae	0.312	0.119	0.065	-0.193	0.024	-0.114	0.501	0.141	-0.220	-0.134	-0.032	-0.099	-0.092	-0.107	-0.091	-0.098	1.000

$$Y = -55137.0017 + 241.2358 X_2 \quad (r^2 = 0.3025),$$

$$(2.184)$$

$$Y = -47163.2181 + 756.5942 X_4 \quad (r^2 = 0.3262).$$

$$(2.307)$$

Variations in trophic and saprobic conditions due to environmental factors influenced species composition, succession and abundance of phytoplankton. Correlation of total biomass of phytoplankton to chemical parameters is well-established⁸. *Eudorina indica*, a member of Volvocales significantly correlated with pH ($r = 0.648$), total alkalinity ($r = 0.584$) and chloride ($r = 0.689$) (Table 1) and confirmed that alkaline water with higher chloride is good for *Eudorina*^{15, 16, 18}. Amongst Chlorococcales, *Chlorella vulgaris* was dominant (40,000 cells l⁻¹) followed by *Scenedesmus quadricauda*, *S. acuminatus* and *S. opoliensis* (1500 cells l⁻¹). Chlorococcales' members significantly correlated with pH ($r = 0.566$) and chloride ($r = 0.559$), indicating that polluted water due to sewage offers conducive conditions for Chlorococcales. *Chlorella vulgaris*, *Scenedesmus* spp. have been recorded in higher number from polluted water earlier^{17, 18, 20-22}. Diatoms significantly correlated with pH ($r = 0.556$) and chloride ($r = 0.554$) (Table 1). *Fragilaria longiseta* and *Navicula radiosa* showed affinity towards eutrophic/mesosaprobic and hypereutrophic/polysaprobic water bodies^{21, 23}. Amongst Zygnematales, *Gonatozygon kinhani* was dominant both in frequency of occurrence and abundance. Correlation coefficient between Zygnematales and NO₃ ($r = -0.6111$) (Table 1) was significant at 5% level. To find out the relationship between them, polynomial regression also fitted, which was as follows:

$$Y = 4730.17 - 40925 X + 80862.65 X^2$$

$$(r = 0.82996),$$

where $X = \text{NO}_3$, $Y = \text{Zygnematales}$. This indicates that NO₃ is not favourable for Zygnematales, particularly for *Gonatozygon kinhani* and hence may be used as bio-indicator for oligotrophic/oligosaprobic water^{19, 21}, Eugleneids represented by *Euglena acus*, *E. viridis* and *Phacus longicauda*. On the basis of their periodicity and abundance, it may be concluded that *E. acus* prefers hypereutrophic/polysaprobic water^{12, 16, 18, 20, 21}. Myxophycean members, viz. *Microcystis aeruginosa*, *Oscillatoria* spp. and *Spirulina princeps* were available during summer, probably attributed to increase in organic matter.

Correlation of NO₃ and PO₄ with Myxophyceae indicated that phosphate is negatively correlated (Table 1). Excess of phosphate has probably inhibitory effect on blue-green algae^{2, 4}. This information may be useful in categorizing algae as bio-indicators for monitoring different types of water.

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