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Trophic Evaluation of an Urban Wetland of Ajmer, Rajasthan

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ABSTRACT

Role of phytoplankton diversity and nutrient release potentials of dominant macrophytes in trophic evaluation of Lake Anasagar, an urban wetland of Ajmer, was assessed. Out of 120 phytoplanktons, Chlorella vulgaris, Chlorococcum infusionum, Pediastrum tetras, Stiqeoclonium, species of Navicula, Euglena, Microcystis aeruginosa and Oscillatoria were recorded as indicators of nutrient-rich conditions. Trophic State Indices showed that even comparatively unpolluted zone of the lake is weak eutrophic and may switch over to a high level of eutrophication estimated for the site influenced by sewage-wate disposal. Besides human activities, macrophyte species i.e. Azolla pinnata, Trapa bispinosa as floating and Potamogeton crispus, Vallisneria spiralis as submerged, release nutrients (N, P, Ca and Mg) in lake waters and form a natural culture medium for phytoplanktons. It was estimated that comparatively more amount of nitrogen and phosphorus added to the nutrient pool is released by Azolla and Trapa respectively. Floating species contribute much to the nutrient-enrichment than submerged macrophytes. It has been emphasised that alongwith algal diversity and characteristic vegetation dynamics, values of decomposition constants (k), nutrient losses and biomass may be utilised for trophic evaluations of shallow urban wetlands in semi-arid regions.

Key words: *Phytoplankton, Diversity, Macrophytes, Eutrophication, Nitrogen, Phosphorus, Decomposition, Trophic evaluation.*

INTRODUCTION

The wetlands of tropical and sub-tropical regions like India are characterised by large seasonal fluctuations in water level which has been recognised as a component of the normal environment for the vegetation adapted to such habitats (Gopal 1986). Numerous small and large, natural and man-made waterbodies experience both hydrosere and xerosere operating in the same area at different times of the year (Misra 1946). However, in wetlands of arid and semi-arid regions of Rajasthan, such a dynamic series in communal units is clearly demarcated due to very low precipitation largely confined to rainy season and extremely high temperatures. These wetlands are characterised by very low water level during peak summers and excessive phytoplankton and macrophyte production throughout the year.

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For trophic evaluation of wetlands in semi-arid region, biological parameters such as algal diversity (Venkateswarlu 1981) and macrophytes (Melzer 1981, Wiegleb 1984) provide valuable information pertaining to the trophic state and cycles which involve complex interactions between phytoplankton, macrophytes and nutrients. Therefore, the objectives of this study were to (1) enumerate the phytoplanktons, (2) determine the Trophic State Indices and (3) decay rates and nutrient release potentials of dominant macrophytes of the Lake Anasagar, a shallow urban wetland of Ajmer, Rajasthan, India.

STUDY AREA

Ajmer, a centrally located city in Rajasthan $25^0$38' and $26^0$58' north latitude and $73^0$52' and $75^0$22' east longitude) lies in the central Aravalli region – an oldest mountain range in the world. The region assumes to be ecologically significant as it provides a zone of confluence between north-west desert part and south-east comparatively humid region. The region is semi-arid which enjoys a monsoonal climate with strong seasonality of rainfall. The summer season (April-June) experiences high temperatures (max. 31.7^0 C), while in peak winters (December-January) it goes down very low (min. 15.2^0 C). More than 79% of the 784.4 mm annual precipitation occurs during July-September.

The study was conducted for Lake Anasagar, a shallow fresh waterbody situated in the heart of Ajmer city. The total area of the lake is 384 ha while maximum depth ranges from 1.0 to 6.0 m. This wetland is dominated by *Azolla pinnata*, *Hydrilla verticillata*, *Paspalidium, geminatum*, *Potamogeton*, *crispus*, *Trapa bispinosa* and *Vallisneria spiralis*. Due to multifold pressure of pollutants from various sources like urban sewage-waste, cloth-washing activities, agricultural practices, construction of housing colonies on a major part of its margin, it has become one of the most threatened wetland of the central Aravalli region. At some distances it is surrounded by hillocks and during the rainy season, surface flow adds water into the lake which also carry urban waste-water from catchment area and agricultural fields. In the present study, two sides i.e. North-East part of the lake is enriched by sewage-waste (site I) and Western part is comparatively unpolluted (site II) were identified.

MATERIALS AND METHODS

Algal samples were collected from site I and site II. These were preserved in 5% formalin and various phytoplanktons were identified with the help of references mentioned elsewhere (Sharma, 1991). Nygaard Trophic State Indices were calculated from total number of species belonging to various algal classes (Nygaard, 1949).

Four macrophytes viz. *Azolla pinnata* and *Trapa bispinosa* as floating and *Potamogeton crispus* and *Vallisneria spiralis* as submerged were selected for the study of decomposition. They were collected from different spots and brought to the laboratory. Loas in weight at various stages of decomposition was estimated by the litter bag technique (Bocock and Gilbert, 1957). 20 g oven dried plant sample (at 80^0 C) of each species was placed in 1 mm mesh bags separately. Total 15 bags for each macrophyte were suspended in a concrete-cement tank (75 x 45 x 60 cm) filled ¾ with lake water. Three bags were retrieved at each interval of 5, 10, 20, 40 and 60 days and remaining material was dried at 80^0 C in oven for the estimation of loss in weight. Decomposition constant (k) and time required for 50% and 95% decay were calculated with the help of exponential equation given by Olson (1963).

$X/Xo = e^{-kt}$

(X = weight of remaining at time t, Xo = initial weight, e= base of natural logarithms and k = decomposition consant). In initial and remaining material at each interval, nutrients were determined : ash content by ashing the remaining in muffle furnace at 550^0 C, nitrogen by micro-kjeldahl method,

phosphorus by colorimetry using ammonium molybdate, and calcium and magnesium by EDTA titration method. The amount of each nutrient in remaining (as a percentage of the initial amount) was also calculated as described by Kok *et al.* (1990). For the computation of total nutrient release, biomass of each species was estimated by taking twenty 1 x 1 m quadrats during the period of occurrence in the Lake Anasagar and mean annual values were estimated.

RESULTS AND DISCUSSION

Algal diversity

Algal species belonging to Chlorophyceae, Bacillariophyceae, Euglenineae and Cyanophyceae were recorded for site I and site II (Table 1). Out of total 120 species of 59 genera, 112 species belonging to 55 genera and 74 species belonging to 48 genera were categorised for site I and site II respectively. Species were found to be more in number at polluted site.

In the present study, it was observed that *Chlorella vulgaris, Chlorococcum infusionum, Pediastrum tetras* and *Stigeoclonium tenue* are represented throughout the year in polluted waters and may be regarded as indicators of nutrient-enrichment of the site. It has been reported that *Chlorella* is a dominant form in waters rich in nitrogenous compounds (Kumar et al. 1974). Similarly, *Stigeoclonium tenue* has also been reported as indicator of eutrophic conditions (Gunale and Balakrishnan 1979).

Bacillariophyceae was found to be dominant in sewage-polluted water as reported earlier by Sreenivasan (1981). *Navicula* with its seven species is a dominant genus at polluted site. Diatoms showed no continuous periodicity at both the sites. Species such as *Navicula cryptocephala, N. cuspidata, N. simplex, Nitzschia palea* were recorded from polluted site while *Cycotella meneghiniana, Cymbella cymbiformis, Navicula cryptocephala, N. cuspidata, Nitzschia palea, N. recta and Pinnularia viridis* were found to be dominant species from comparatively unpolluted site.

Euglenineae represented by *Euglena* and *Phacus* was also found to be dominant and showed continuous periodicity in polluted waters. It was reported that *Euglena* and *Phacus* species occur in waterbodies rich in organic matter (Hutchinson 1957). At the polluted site phosphates are being added in the form of detergents from cloth-washing activities near the water margin. High levels of phosphates in water favours the growth of Euglenoids (Munawar 1970). Besides this, domestic-sewage being dumped regularly into the lake is also rich in phosphates.

Cyanophyceae was represented by 31 species of 12 genera at polluted and 15 species of 10 genera at comparatively unpolluted site. *Microcystis aeruginosa* was found to be a dominant blue-green algae in polluted waters throughout the year. Seven species of *Oscillatoria* alongwith four species of *Spirulina* and *Microcystis* showed regular occurrence in polluted waters. It has been reported that *Oscillatoria* is a tolerant genus to water pollution (Rai and Kumar 1976). At polluted site more Cyanophyceae members may be due to high phosphates and low calcium content in the waterbody (Singh and Swarup 1979).

Trophic State Indices

Algal species recorded for different sites were used to calculate the Nygaard's Trophic State Indices. Mean annual values of different indices are presented in Table 2. The trophic nature of the polluted and unpolluted sites may be assessed by comparison of values of various indices with the range of indices for oligotrophic and eutrophic conditions as mentioned by Gunale and Balakrishnan (1981). Values of indices indicate that the polluted site is highly eutrophic while comparatively unpolluted site is weak eutrophic. It has been observed that Diatoms and Euglenophyte are least sensitive to polluted waters as compared with

Cyanophyceae and Chlorophyceae members (Sharma and Sharma 1991).

Decomposition

Data on percent remaining dry weight show rapid loss in dry weight within 5-10 days of decomposition (Table 3). On tenth day the weight loss was less than 50 percent except for *Azolla pinnata* in which it was about 60 percent. Further loss in dry weight continued at a slower rate in *Azolla pinnata* and at a rapid rate in *Potamogeton crispus* and *Trapa bispinosa*. Most rapid loss was observed for *Vallisneria spiralis* in which it remained only about 2 percent on 60th day as compared to about 11 percent in *Potamogeton* and *Trapa* and about 48 percent in *Azolla*. Slow rate in weight loss of *Azolla* and rapid rate of *Potamogeton* and *Trapa* followed by *Vallisneria* is clear from decomposition constant (k) and days required for 50% and 95% decay of these macrophyte species.

Analysis of remaining at different stages of decay showed that significant amounts of nitrogen and phosphorus were lost during decomposition (Fig. 1-2). A rapid loss of P occurred within the first five days where more than 50% of initial P was lost from all the species. On 10th and 20th day P was greater in *Azolla* and *Trapa* while on 60th day it was 15% in *Azolla* followed by 5-6% in *Potamogeton* and *Trapa*, and only 1% in *Vallisneria*.

A rapid loss of N was observed from *Potamogeton* and *Vallisneria* where about 80% nitrogen was lost within first ten days. Percent N was found to be increased from the initial content in *Azolla* and *Trapa* within first five days and the same was lost at a slow rate in *Azolla* and at a rapid rate in *Trapa*. Analysis of remaining at 60th day showed that more than 40% N loss occurred from *Azolla* while it was more than 90% from other three species.

The total biomass production and its nutrient content computed for different macrophyte species are presented in Table 4. Based on total annual biomass production per ha and total content of N, P, Ca and Mg in individual macrophyte, floating species i.e. *Trapa* and *Azolla* contribute much to the nutrient-enrichment than *Potamogeton* and *Vallisneria* (submerged species). Total nutrient output (if plant material is completely decomposed) from floating species is about 6-10 times more than submerged plants. Among the macrophytes studied, greater amount of nitrogen and phosphorus are released from decay of *Azolla* and *Trapa* respectively.

A large amount of total nutrients are added either by leakage from macrophyte shoots (Twilley et al. 1977) or released through decomposition of dead parts (Godshalk and Wetzel 1978, Carpenter 1980). In the shallow wetlands of Aravalli region the total biomass production during the peak growing period is converted into dead matter due to exposed sediment of peripheral zone of waterbody during the summers. Van der Velde (1979) has emphasised that initial decomposition can be of a physiological nature controlled by external factors. However, the decomposition is more a physical in case of Lake Anasagar. During the peak summers, biomass is converted into dead matter and its decay starts immediately and continued till moisture is available. A greater amount of nutrients are released during this initial decomposition. In extreme dry period (May-June) decomposition is postponed till water is available in the preceding rainy months (July-August). Later part of decomposition is initiated in the rainy season and continued throughout the year even for longer time in species like *Azolla* where it requires comparatively longer time for complete decomposition (576 d for 95% decay).

Among macrophytes, *Azolla* contributes more to the nutrient-enrichment of water as compared to other macrophytes. Contribution by *Trapa* is even more than *Azolla* but confined to zones where it is being cultivated by farmers.

Table 1: List of Algae of Site I and Site II of Lake Anasagar, Ajmer

S.No.	Name of Algae	Site I	Site II
	Chlorophyceae		
1.	*Actinastrum hantzschii*	+	+
2.	*Ankistrodesmus* falcatus	+	+
3.	*A. falcatus* var. *tumidus*	+	+
4.	*Chaetophora eleqans*	+	+
5.	*Chara corallina*	-	+
6.	*Characium* ambiqumm	+	+
7.	*C. apiculatum*	-	+
8.	*Chlamydomonas qlobosa*	+	+
9.	*Chlorella vulqaris*	+	+
10.	*Chlorococcum infusionum*	+	-
11.	*Closterium lanceolatum*	+	+
12.	*C. limneticum*	+	-
13.	*C. moniliferum*	+	+
14.	*C. parvulum*	+	+
15.	*Coleochaete pulvinata*	+	+
16.	*C. scutata*	+	+
17.	*Cosmarium apertum*	+	+
18.	*C. ctenoidum*	+	+
19.	*C. marqaritiferum* var. *exsertum*	+	+
20.	*C. trachyplerum*	+	+
21.	*Dinobryon sertularia*	+	-
22.	*Euastrum verrucosum*	+	+
23.	*Gloeocystis planktonica*	+	-
24.	*Hydrodictyon reticulatum*	+	+
25.	*Microspora* sp	+	+
26.	*Mouqeotia maltae*	+	+
27.	*M. punctata*	+	+
28.	*Nitella transilis*	-	+
29.	*Oedoqonium inconspicuum*	-	+
30.	*O. lotuminarum*	+	+
31.	*O. patulum*	+	-
32.	*O. vulgare*	+	+
33.	*Pandorina morum*	+	+
34.	*Pediastrum obtusum*	+	+
35.	*P. tetras*	+	+
36.	*P. tetras* var. *tetradom*	-	+
37.	*Pithophora mooreana*	+	+

S.No.	Name of Algae	Site I	Site II
38.	*Protococcus viridis*	+	+
39.	*Rhizoclonium hieroqlyphicum*	+	+
40.	*Scenedesmus acuminatus*	+	-
41.	*S. armatus* var. *bicaudatus*	+	-
42.	*S. bijuga* var. *alternans*	+	+
43.	*S. obliquus*	+	-
44.	*S. quadricauda* var. *longispina*	+	+
45.	*S. quadricauda* var. *Westii*	+	+
46.	*Spirogyra crassa*	+	+
47.	*S. ellipsospora*	+	+
48.	*S. protecta*	+	-
49.	*S. rectanqularis*	+	+
50.	*S. triplicata*	+	-
51.	*S. weberi*	+	-
52.	*Stiqeoclonium lubricum,*	-	+
53.	*S. tenue*	+	+
54.	*Ulothrix subtilissima*	+	+
	Bacillariophyceae		
55.	*Achnanthes hunqarica*	+	+
56.	*Amphora ovalis*	+	-
57.	*Anomoeoneis sphaerophora*	+	+
58.	*Cycotella meneqheniana*	+	+
59.	*Cymbella cymbiformis*	+	+
60.	*Diatoma vulgare*	+	-
61.	*Fraqilaria intermedia*	+	+
62.	*Navicula affine*	+	-
63.	*N. cryptocephala*	+	-
64.	*N. cuspidata*	+	+
65.	*N. lineola*	+	-
66.	*N. pupula* var. *capitata*	+	-
67.	*N. simplex*	+	-
68.	*N. viridula*	+	-
69.	*Nitzschia palea*	+	+
70.	*N. recta*	+	+
71.	*Pinnularia viridis*	+	+
72.	*Placoneis* sp	+	-
73.	*Stephanodiscus* sp	+	-
74.	*Stauroneis* sp	+	+
75.	*Synedra ulna*	+	+

S.No.	Name of Algae	Site I	Site II
76.	*Tabellaria* sp	+	+
	Euglenineae		
77.	*Euqlena acus*	+	-
78.	*E. convoluta*	+	-
79.	*E. polymorpha*	+	+
80.	*E. stellata*	+	-
81.	*E. viridis*	+	-
82.	*Phacus caudatus*	+	+
83.	*P. curvicauda*	+	+
84.	*P. lonqicauda*	+	-
85.	*P.* Uorbicularis	+	+
86.	*P. pyrum*	+	-
87.	*P. swirenkoi*	+	-
	Cyanophyceae		
88.	*Aqmenellum* sp	+	+
89.	*Anabaena flos-aquae*	+	-
90.	*A. orientalis*	+	+
91.	*A. oryzae*	+	-
92.	*Aphanocapsa roseana*	-	+
93.	*Arthrospira intermedia*	+	+
94.	*A. jenneri*	+	-
95.	*Chroococcus minutus*	+	+
96.	*C. macrococcus*	+	+
97.	*Gloeocapsa aeruginosa*	+	-
98.	*G. livida*	+	-
99.	*Gloeotrichia ghosei*	+	-
100.	*Lynqbya borqerti*	+	-
101.	*Merismopedia elegans*	+	-
102.	*M. glauca*	+	+
103.	*M. punctata*	+	+
104.	*Microcystis aeruqinosa*	+	-
105.	*M. benqalensis*	+	-
106.	*M. flos-aquae*	+	-
107.	*M. marqinata*	+	-
108.	*Oscillatoria amphibia*	+	+
109.	*O. articulata*	+	-
110.	*O. chlorina*	+	-
111.	*O. obscura*	+	+
112.	*O. simplicissima*	+	-

S.No.	Name of Algae	Site I	Site II
113.	*O. subbrevis*	+	+
114.	*O. tenuis*	+	+
115.	*Phormidium ambiquum*	+	+
116.	*Rivularia aquatica*	-	+
117.	*Spirulina labyrinthiformis*	+	-
118.	*S. major*	+	-
119.	*S. meneqhiana*	+	-
120.	*S. subsalsa*	+	+

Abbreviations : (+) present, (-) absent

Table 1

Changes in dry weight during leaching (% remaining), decomposition constant (k) and day required for 50% and 95% decay of various macrophyte species

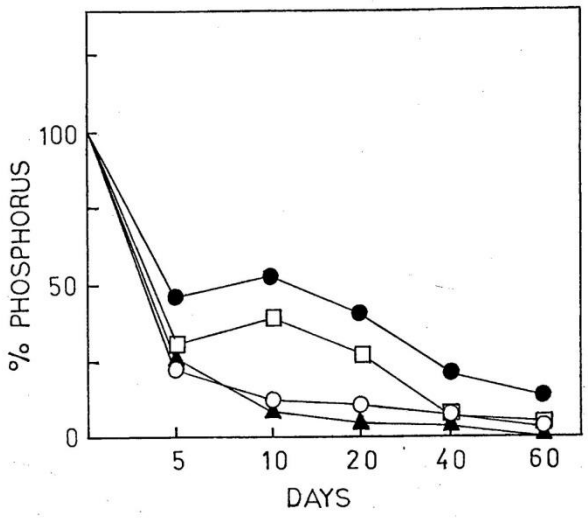
Species	% remaining dry weight						Days required	
	5	10	20	40	60	k	50%	95%
A. pinnata	71.7	60.2	53.7	50.4	48.6	0.005	133	576
P. crispus	53.2	27.6	22.0	13.3	11.6	0.015	44	193
T. bispinosa	60.6	47.4	31.2	17.5	11.3	0.015	44	191
V. spiralis	44.5	19.4	11.8	2.3	2.2	0.027	25	108

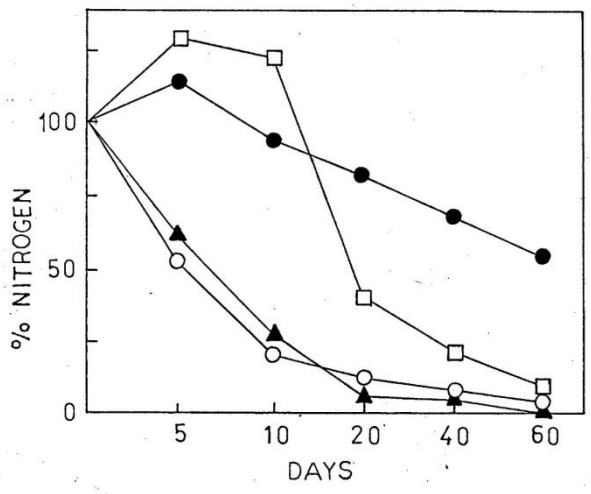
Table 2: Nygaard's Trophic State Indices of polluted site (1) and comparatively unpolluted site (II) of Lake Anasagar

Index	Range of Index for		Trophic Index	
	Oligotrophic	Eutrophic	Site I	Site II
Cyanophycean	0.0 – 0.4	0.1 – 3.0	3.66	1.85
Chlorophycean	0.0 – 0.7	0.2 – 9.0	1.88	1.62
Diatoms	0.1 – 0.3	0.0 – 1.0	0.10	0.09
Euglenophycean	0.0 – 1.2	0.0 – 1.0	0.22	0.10
Compound	0.0 – 1.0	1.2 – 2.5	1.44	0.50
Compound Quotient (CQ)	<2	>6	9.22	5.37

Table 3: Computed values of biomass and nutrients (Kg ha^{-1} Yr^{-1}) of various macrophytes

Species	Biomass	N	P	Ca	Mg	Total
A. pinnata	2970	136.65	3.80	52.28	85.26	277.99
P. crispus	338	21.64	0.69	5.41	3.61	31.35
T. bispinosa	3390	88.15	5.45	108.50	97.31	299.41
V. spiralis	812	30.89	1.30	13.00	10.64	55.83





CONCLUSION

The present study show that macrophyte production in various zones, their decay rates, nutrient release potentials alongwith climatic factors and physical characteristics of the wetland serve as potent sets for modelling and evaluating the trophic status.

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