EVALUATION OF NUTRIENT LOADINGS AND CARRYING CAPACITY OF BHOJ WETLAND ECOSYSTEM

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ABSTRACT

Sustainable lake management approach involves estimation of nutrient loadings from point and non-point sources. In the present study nutrient loadings from eleven sub-watersheds of Bhoj wetland were estimated on seasonal basis. The maximum input of nutrients was observed during monsoon season in comparison to other seasons. Loading of NO_3- N ranged between 0.032–64.10 tons and TP between 0.016–24.10 tons. The higher residence time of nutrients in the present investigation indicates the lower nutrient carrying capacity. Nutrient input from sub-watersheds II and I are mostly of urban in nature, while input from sub-watersheds III, IV and a part of II and IX were mostly of cattle and agricultural.

INTRODUCTION

Growing concern for preserving water quality in lakes and controlling the adverse effects of eutrophication has highlighted the need for quantitative information concerning the nutrient budgets of lakes. It is generally agreed that the most desirable long-term lake management approach is to control, insofar as is possible, the influx of nutrients, although there is considerable disagreement regarding the selection of nutrient sources which should be controlled, the method for control, and the benefit which is to be gained. Nutrient loading rates in lakes are determined on yearly basis because lakes tend to accumulate nutrients as well as algal and macrophyte biomass over long time periods compared to rivers, which constantly flush components downstream. Nutrients in lakes can be released from the sediments into the bottom waters during the winter and summer and circulated to the surface during mixing events.

The watershed approach for the development of aquatic ecosystems appears very promising as it has the holistic nature with the component of conservation and management of the prevalent ecosystem. Opening up of the terrestrial ecosystem may be one of the important causes responsible for the shrinkage of a water body having geological slope towards its basin, as such watershed plays an important role in developing natural linkages between terrestrial and aquatic ecosystems which finally controls the bio-geochemical cycle and metabolic activity of the water body. For example the increase of nutrient load such as nitrogen and phosphorus to the lake due to changes in watershed area has been one of the major cause of water pollution or eutrophication. Monitoring influent nutrient load from the lake basin to the lake through watershed discharges is now crucial for the management of lake environment (Oki et al., 1998).

STUDY AREA

The present study area, Bhoj wetland (a tropical water body), is located about 5 km away from the main Bhopal railway station, at an altitude of 494 meters above mean sea level within the

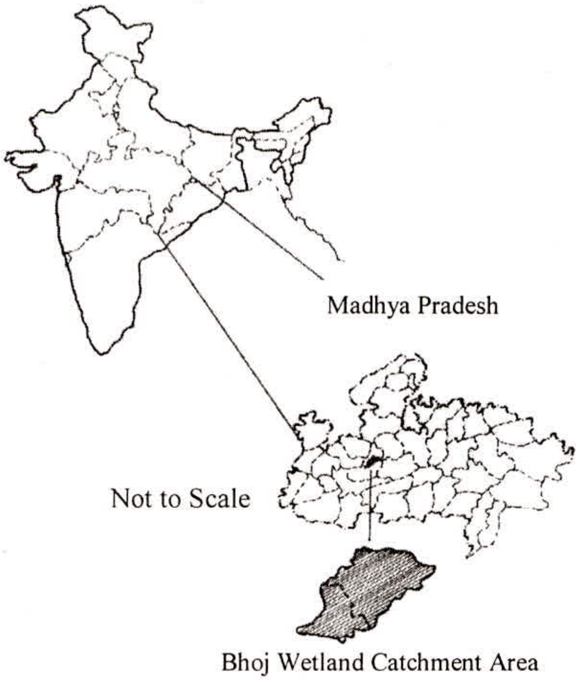

Figure 1. Location of the Study Area

geographical coordinates of $23^0 10' - 23^0 20'$ N and $77^0 15' - 77^0 25'$ E (Fig.1). Bhoj wetland is a Ramsar site formed by constructing an earthen dam across "Kolans" river in the 11th century to supply potable water to Bhopal city. It is providing tremendous benefits to the local habitants through fish production and economically and commercially viable plants. The cultivation of *Trapa bispinosa* and *Nelumbo nucifera* in the shoreline and the fish (major carps) available in this wetland have direct impact on the economic condition of local people. In addition, the wetland is supplying adequate drinking water (27 MGD) to many parts of Bhopal city. Further it provides a critical habitat for waterfowl and other birds as well as countless mammals, reptiles, amphibians and invertebrate species. The southeast zone of the wetland has been transformed into a tourist zone. It is observed that, the wetland catchment (about 336.81 Sq.Km) has been threatened to greater extent, due mainly to accelerated drainage, land reclamation and increase in human activities.

Geologically the area is covered by deccan trap basalts and vindhyan sandstones cover the catchment area. The study area experiences tropical climate due to the fact that tropic of cancer is passing through the state of Madhya Pradesh. The climatic conditions are quite variable with hot summers and mild winters. The annual average rainfall of the area is about 1100 mm. In the present study the whole catchment area has been divided into 11 sub-watersheds (based on the drainage pattern) for the estimation of nutrient loadings (Fig. 2). The landscape of each watershed is of different in nature. Though area wise sub-watershed I (2.425 Sq.Km) is smaller out of eleven, yet it supports maximum human population followed by sub-watersheds II, III and XI. On the other hand sub-watersheds III and IV recorded maximum animal population. Magnitude of both human and animal population in these areas is significant from the point of view of nutrient load into the system. Slope nature of eleven sub-watersheds reveal very gentle to moderately steep nature resulting in moderate runoff from most of the watershed areas except sub-watershed XI, which experienced rapid rate of runoff on account of its slope nature and presence of vindhyan sandstone.

METHODOLOGY

In order to evaluate the nutrient loads from eleven sub-watersheds the mean concentrations of nitrogen and phosphorus on seasonal basis were calculated based on the data collected from the regular monitoring during the year 2003. Area velocity method (Subramanya, 1984: Goudie, 1970) is adopted to calculate the hydraulic discharges of each sub-watershed. Nutrient loads transported were calculated by multiplying the hydraulic discharges of each watershed by the concentration of the particular nutrient (Cullen et al., 1988).

RESULTS AND DISCUSSION

In order to give future generations freedom of choice in their water requirements, it is essential to maintain the existing level of quality of water resources and ensure that their carrying capacity with respect to nutrients is no way diminished beyond their self-purification capability. High hydraulic inputs from the surrounding catchment area have been bringing with it lot of colloidal material in the form of silt etc., due to the degradation in its land use land cover pattern.

Hydraulic input from sub-watersheds of the wetland were calculated on seasonal basis for the year 2003 (Table 1). Maximum hydraulic input is from sub-watershed VI (64.244 $m^3 \times 10^6$) followed by IX (11.74 $m^3 \times 10^6$) and II (5.9 $m^3 \times 10^6$). Area wise also sub-watersheds VI and

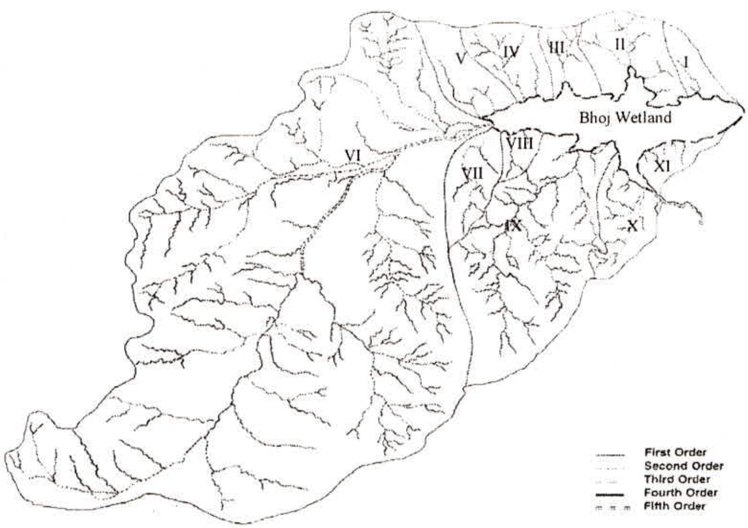

Figure 2. Catchment Area and eleven sub-watersheds of Bhoj Wetland

IX are larger and their hydraulic contribution is maximum, while sub-watershed II, which is small in area but it contributes considerably high due to its urban nature. Almost all watersheds recorded high hydraulic input during monsoon. In summer no flow was observed in many of the watersheds except sub-watersheds I, II and XI. During the winter the contribution from the watershed is comparatively low. The sub-watersheds I, II and XI recorded a continuous input in almost all seasons into the wetland due to urban nature.

Table 1. Seasonal Hydraulic Input ($m^3 \times 10^6$) from sub-watersheds

Watershed	Summer	Monsoon	Post Monsoon	Winter
I	0.344	0.99	0.41	0.12
II	0.697	3.693	1.27	0.238
III	NF	0.89	NF	NF
IV	NF	1.25	0.064	NF
V	NF	0.709	NF	NF
VI	NF	55.17	9.064	NF
VII	NF	1.404	NF	NF
VIII	NF	0.36	NF	NF
IX	NF	11.47	0.271	NF
X	NF	1.55	NF	NF
XI	0.182	0.556	0.09	0.182

NF: No Flow

Total Phosphorus (TP) and Nitrate Nitrogen (NO_3-N) concentrations from all the sub-watersheds were calculated on seasonal basis (Fig. 3 and 4). Similarly nutrient loadings of TP and NO_3-N were also computed (Table 2 and 3). In summer TP recorded a maximum concentration of 0.795 mg/l or 0.27 tons (sub-watershed I) and a minimum of 0.489 mg/l or 0.068 (sub-watershed XI). Monsoon concentrations of TP ranged from 0.134 mg/l or 0.11

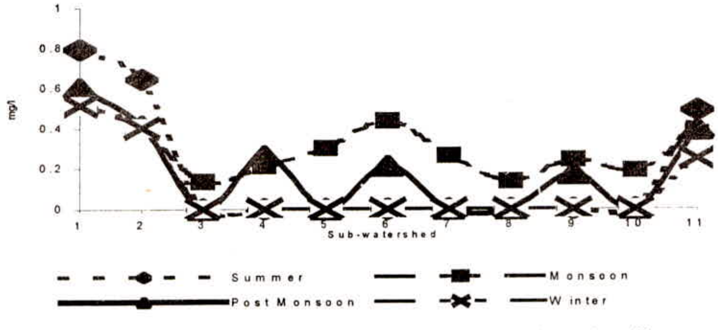

Figure 2. Seasonal variation of TP concentrations (mg/l)

tons to 0.537 mg/l or 0.53 tons. A maximum total input of 30. 366 tons was observed during this season.

The sub-watershed IX recorded minimum TP value (0.172 mg/l or 0.106 tons while the maximum (0.604 mg/l or 0.24 tons) was observed in sub-watershed I during post monsoon season. Winter values of TP ranged from 0.24 mg/l or 0.045 tons (sub-watershed XI) to 0.516

mg/l or 0.061 tons (sub-watershed VII). During their urban nature the sub-watersheds I, II and XI recorded continuous discharges.

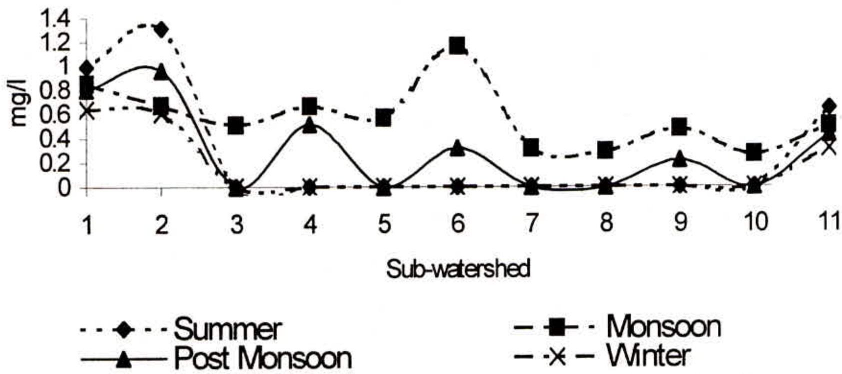

Figure 2. Seasonal variation of concentrations NO_3-N (mg/l)

Table 2. Loading of Total Phosphorous (tons) from sub-watersheds

Watershed	Summer	Monsoon	Post Monsoon	Winter
I	0.270	0.530	0.240	0.061
II	0.450	1.460	0.529	0.096
III	NF	0.110	NF	NF
IV	NF	0.260	0.016	NF
V	NF	0.213	NF	NF
VI	NF	24.10	1.930	NF
VII	NF	0.367	NF	NF
VIII	NF	0.048	NF	NF
IX	NF	2.780	0.106	NF
X	NF	0.291	NF	NF
XI	0.068	0.207	0.035	0.045

NF : No Flow

Sub-watersheds II and XI contributed the maximum (1.312 mg/l) or 0.914 tons) and minimum (0.637 mg/l or 0.115 tons) NO_3-N respectively. A total contribution of 1.368 tons was recorded from the whole drainage basin during this season. Monsoon recorded a maximum NO_3-N value of 0.894 mg/l or 0.840 tons (sub-watershed I) and a minimum value (0.264 mg/l or 0.409 tons) from sub-watershed X. The total input recorded from all the eleven watersheds in this season amounted to 75.83 tons. A total input of 4.857 tons of NO_3-N during post monsoon season was recorded from the whole catchment area. A maximum concentration of 0.962 mg/l or 1.22 tons was contributed by sub-watershed II and a minimum concentration of 0.218 mg/l or 0.059 tons from (sub-watershed IX). During winter season sub-watersheds I and XI contributed the maximum (0.638 mg/l or 0.076 tons) and minimum (0.311 mg/l or 0.056 tons) respectively. A total input of 0.276 was recorded throughout the season. Monsoon is the major contributor among other seasons. Due to their urban nature the watershed no.s I, II and XI contributed the maximum NO_3-N to this wetland.

It has been observed that maximum input of phosphorus was from urban sub-watershed I, which is an urban watershed. On seasonal basis maximum input of phosphorus has been recorded during monsoon season as during winter and summer months most of the inlet channels dry up. Due to the paucity of data from tropical water bodies, the present work was compared with that of temperate regions where in maximum input of phosphorus has also been recorded during precipitation time. This is further supported by the findings of Meyer and Links (1979) and Baker (1980) who conducted that up to 50% of the annual transport of phosphorus occurs during 5% of the time with the highest fluxes. In the case of NO_3-N, monsoon recorded maximum in comparison to other seasons from the incoming waters. This is probably due to the rainwater runoff through which huge amounts of NO_3-N is entering into the system.

Table 3. Loading of NO_3-N (tons) from sub-watersheds

Watershed	Summer	Monsoon	Post Monsoon	Winter
I	0.339	0.840	0.328	0.076
II	0.914	2.485	1.220	0.144
III	NF	0.455	NF	NF
IV	NF	0.832	0.032	NF
V	NF	0.403	NF	NF
VI	NF	64.10	2.910	NF
VII	NF	0.443	NF	NF
VIII	NF	0.105	NF	NF
IX	NF	5.490	0.059	NF
X	NF	0.409	NF	NF
XI	0.115	0.274	0.038	0.056

NF : No Flow

The addition of chemical fertilizers and farmyard manures in the agricultural fields of watershed areas help in discharging high nitrogen concentration through runoff. The mineralizable N in soil receiving farmyard manure was much greater than in soils without it, although applying fertilizer N in spring as ammonium sulphate also tended to increase the mineralizable N (Gower, 1980). On comparing NO_3-N from urban runoff's with that of other workers (Borman et al 1968; Sylvester 1961) almost similar observations were recorded in the present study. Sub-watershed I contributed maximum nitrogen in comparison to others. Nutrient inputs from sub-watersheds II and I were mostly of urban in nature and while nutrients from sub-watersheds III, IV and a part of sub-watersheds II and IX were of cattle and agricultural.

The maximum export of nutrients from the present wetland experienced during monsoon period when the sluice gates situated on Bhadbhada outlet are opened for maintating the hydralulic budget. The opening of the sluice gates is totally dependent upon the amount of precipitation and evaporation. Though some amount of nutrient does pass out the system through the pumping water treatment plants and a small quantity of nutrients are lost by way of seepage yet the output from Bhadbhada sluice gates play a major role. It is observed that flushing rate and retention coefficient are two important parameters, which will have a direct bearing on the nutrient carrying capacity.

ACKNOWLEDGEMENT

Authors are thankful to the Director, Regional Research Laboratory (CSIR), Bhopal for according permission to publish this paper.

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