Seasonal Assessment of Trophic State of a Palustrine Water Body

Amit Yadav, Atul Kataria, Kapil Singh,
Karamveer Mathur*, Sagar Goswami, A. K. Haritash
Department of Environmental Engineering
Delhi Technological University, Bawana Road,
Shahbad, Delhi (110 042)

Abstract- **− Most of the water bodies around human habitations are observed to be moderately to severely polluted. Inflow of sewage, addition of domestic waste water, and run off from neighbouring areas has resulted in increase in dissolved solids, salinity, and eutophication of most of the Palustrine water bodies. Therefore, the present study was undertaken to determine the nutrient status and trophic state of a sacred groove village pond. It is observed that the water body is eutrophic with an increasing Carlson's Trophic State Index (CTSI) with time. The concentration of Total Phosphate (TP) increased from 14.6mg/l to 17.3mg/l within six months of time. It resulted in more than 4 times increase in Gross Primary Productivity (GPP) (12.7mg/l/day-54.7mg/l/day), which was also confirmed by an increase in Chlorophyll concentration from 2.88mg/l to 3.25mg/l. Although, the secchi depth decreased from 26 cm to 21 cm resulting in decreased penetration of sunlight and limiting the photic Zone. The dissolved oxygen too decreased from 7.3mg/l to 2.1mg/l, although the variation in average temperature of surface water was negligible. The concentration of Total Dissolved Solids (TDS) and Salinity increased during the period confirming to addition of nutrient/pollutants and a gradual deterioration of water quality. In the light of above mentioned facts it is important to monitor the health of pond water ecosystems; restrict the discharge of waste water without pre treatment; and to adopt suitable interventions and management practices to improve the health of water bodies.**

Keywords: Palustrine, Eutrophication, CTSI, GPP

I. INTRODUCTION

Palustrine ecosystems are micro environments having significant ecological, environmental, social, and economic benefits particularly in rural areas of developing countries. These are not only the storage reservoirs but are also the systems to recharge ground water, sources to drinking water and irrigation, conserve soil quality, and maintain aquatic diversity. Since most of the rural and remote areas lack proper drainage system most of the domestic waste water, agricultural and storm water run off finds its way into the ponds. During the process a considerable amount of nutrients like carbon, nitrogen, and phosphorus (CNP), and pollutants like dissolved metals, pesticides, organic matter, and other dissolved impurities are carried to the ponds. Most of the village ponds, therefore, suffer from the problem of excessive algal growth, intensive weed proliferation, reduced dissolved oxygen (DO) levels, production of obnoxious odour, and reduced aesthetics resulting in overall degradation of environmental quality [1]. Excess of nutrients leach through the soil and may contaminate ground water, and indirectly affect health, agricultural production, and soil quality as well. High concentration of organic impurities (specifically carbonaceous and nitrogenous) results in decreased DO particularly in bottom layers [2], and increased levels of nitrate and phosphate in sediments. Excess of anions like chloride (Cl^-), sulphate (SO_4^{2-}), nitrate (NO_3^-), and phosphate (PO_4^{3-}) may also interfere with the DO levels in hypolimnion [3]. Formation of reducing or anoxic conditions in bottom sediments may render the insoluble phosphate soluble and further increase the intensity of eutrophication [4]. Turbidity of lakes and ponds is an important parameter to determine the water quality, and most of the eutrophicated lakes have low transparency because of algal growth and dead and decomposing organic matter this reduces sunlight penetration, reduced photosynthesis, and low productivity of the lake. Such water bodies are prone to stratification during summer and winter, whereas spring and fall may coincide with algal bloom [5]. There have been number of studies to determine water quality of lakes and rivers [6-10], but the studies on monitoring of ponds are limited. Though the size and volume of ponds is smaller compared to lakes but the number is considerably high. Monitoring and management of pond ecosystems at local level can result in significant improvement in soil and water quality of the region. Owing to lack of awareness, and disposal of waste water, such water bodies are gradually turning useless with more frequent algal blooms. In order to meet the water demand, dependence on ground water has increased and ground water table in such areas is gradually depleting. Realizing their importance, village ponds have been restored and declared as sacred grooves in many villages. The present study is an attempt to monitor the water quality of a sacred groove declared village pond; identification of major sources and parameters of concern; and classify the water body based on its trophic status.

II. MATERIALS AND METHODS

A. Study Area and sample collection

The study area is located at 28º44′20″ N longitude and 77º2′6″ E latitude in Karala village of North-west district of Delhi (Fig. 1). It is a natural depression having an area of around 10 acres. The source to the pond is domestic wastewater, agricultural runoff, and rainfall. It has an average depth of 5 feet in summer and winter, and 8 feet during monsoon. It is surrounded by agricultural fields on North and village temples in southern direction. It has been declared as a sacred groove for more than 50 years. It was exclusively used for bathing, irrigation, and cattle earlier. But in the past two decades the village has registered significant growth in population, and a few industries. Since then it is receiving domestic waste water and industrial effluent resulting in an increase in concentration of nutrients as well as pollutants in order to determine the water quality the study area was divided into 10 grids of equal size, and representative water sample was collected from each grid in the month of September 2014 and February 2015 representing an interval of 6 months. Temperature, pH, Electrical conductivity (EC), Total Dissolved Solids (TDS), and Dissolved Oxygen (DO), were measured on the site using Orion make Star A329 model multiparameter meter. The gross primary productivity (GPP), and transparency were determined using DO levels under light and dark conditions, and sechhi-disc depth, respectively. Other parameters were determined within 24 hours after transporting the preserved samples to laboratory using standard methods of APHA [11]. Total phosphate (TP), sulfate (SO_4^{2-}), and nitrate (NO_3^-) were determined spectrophotometrically, and sodium (Na), potassium (K), calcium (Ca), and lithium (Li) were determined on Systronics make 128□□C model flame photometer. The statistical analysis of values obtained was done on MS-Excel software. The eutrophication status of a wetland is usually measured using one of several trophic state indexes (TSI) of algal weight (biomass): water transparency (Secchi Depth, TSI-SD), algal chlorophyll (TSI-Chl), and total phosphorus (TSI-TP) [12]. The following equations can be used to compute the Carlson's TSI.

$$TSI\ (SD) = 60 - 14.41 \ln(SD)$$

$$TSI\ (CHL) = 9.81 \ln(Chl) + 30.6$$

$$TSI\ (TP) = 14.42 \ln(TP) + 4.15$$

Where, SD is sechhi depth (m), Chl is chlorophyll (mg/L), and TP is total phosphorus (mg/L).

$$CTSI = \{(TSI\text{-}SD)+(TSI\text{-}Chl)+(TSI\text{-}TP)\}/3$$

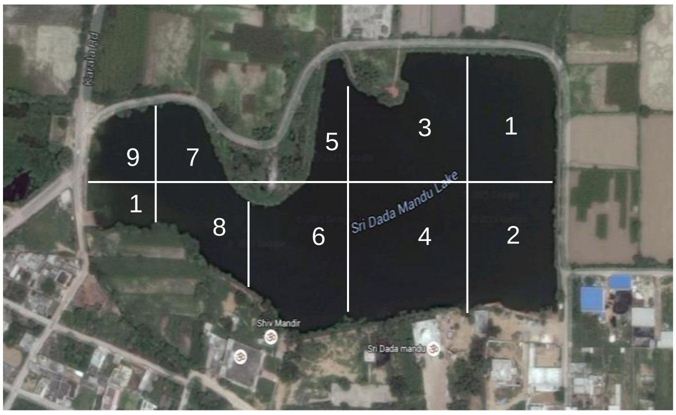

Fig. 1. Sampling locations in the village pond

III. RESULTS AND DISCUSSION

Based on the analysis of samples, there were slight spatial variations except at the inlet, but the temporal variations represented a significant increase in concentration of pollutants (Table 1). The pH of water was observed to slightly alkaline in range during September 2014 (post-monsoon), whereas it was slightly acidic with an average value of 6.3 during February, 2015 (winter). It shows significant variation of chemical composition and the chemical stress the water body goes through. The acidic pH may be correlated to anoxic and reducing conditions formed in the pond during winter, apart from the possibility of addition of some acidic waste into the water body. The later period of winter represented higher concentration of dissolved solids (TDS) and electrical conductivity (EC) owing to higher import of pollutants and reduced volume of water during winter. The difference in temperature in the two seasons was marginal with average values of 24.1˚**C** and 26.8˚**C.** Although the temperature difference is marginal, there was significant difference of DO with average values of 7.0 mg/L and 2.0 mg/L during post-monsoon and winter, respectively. Reduced DO in winter further strengthens the assumption that reducing conditions in bottom layer had resulted in formation of acids, thus leading to lowering of pH. Another important aspect related to DO is survival of fish and other aquatic life. Most of the sensitive species fail to survive at DO level of 2.0 mg/L; low temperature and reduced photoperiod during winter decreases overall productivity resulting in death of flora and fauna of the pond. This further adds dead biomass resulting in increased oxygen demand and reduced DO levels. The lowering of pH in water reverses carbonate cycle. The same is confirmed in our study with the absence of carbonates in winter since the average pH had dropped to 6.3 resulting in conversion of carbonate to bicarbonate. An increase in bicarbonate concentration was also reported which supports the results. High concentration of anions like chloride and sulphate is an indication of addition of domestic wastewater in a water body. In the present study, average chloride concentration was 1245.5 and 563.0 mg/l in post monsoon and winter, respectively. Concurrent trend for sulphate was observed in the seasons. Higher levels during post monsoon may be correlated to higher water demand and more wastewater production compared to winter. Phosphate and nitrate are important parameters to regulate algal growth in a water body. Average concentration of phosphate was 15.5 mg/L initially, and increased to 17.3 mg/L in a period of six months.

TABLE 1. RANGE (MIN.-MAX.), MEAN, AND STANDARD DEVIATION OF CONCENTRATION OF VARIOUS PARAMETERS

Parameter	**September 2014**				**February 2015**			
	Range		**Mean**	**SD (±)**	**Range**		**Mean**	**SD (±)**
	Min.	**Max.**			**Min.**	**Max.**		
pH	8.1	8.5	8.3	0.12	6.1	6.7	6.3	0.18
EC (mS/cm)	3.0	3.51	3.45	0.16	3.5	3.6	3.5	0.05
Temp (°C)	23.5	24.8	24.1	0.45	25.5	27.7	26.8	0.69
DO (mg/L)	3.0	13.0	7.0	3.35	1.0	4.0	2.0	0.96
TDS (mg/L)	1460	1720	1690	90	1750	1770	1760	10
HCO_3^- (mg/L)	384.3	683.2	503.3	82.7	414.8	610.0	502.6	61.9
CO_3^{2-} (mg/L)	BDL	78.0	41.0	16.6	BDL (*Below the detection limit*)			
Cl^- (mg/L)	1050.0	1345.0	1245.5	80.7	490.0	660.0	563.0	56.8
SO_4^{2-} (mg/L)	138.5	163.7	150.8	8.93	112.8	144.9	132.4	10.8
PO_4^{3-} (mg/L)	14.5	18.4	15.5	1.15	11.8	27.8	17.3	14.5
NO_3^- (mg/L)	2.4	24.5	16.5	7.43	0.77	4.7	2.9	1.2
Na (mg/L)	227.4	438.4	336.9	86.6	373.6	463.5	401.6	29.0
K (mg/L)	97.7	163.5	128.8	24.9	145.2	193.6	157.5	17.0
Ca (mg/L)	35.4	42.9	38.7	1.98	150.8	177	158.5	9.13
CTSI	87.0				92.0			
GPP (mgO_2/L/day)	12.65				54.65			

As discussed earlier, formation of reducing/acidic conditions result in mobilization of phosphate, which otherwise remains in bound form with sediments. The calcium and ferric-ion bound inorganic phosphate gets mobilized/soluble in water with the lowering of pH, and reduction of ferric ions to ferrous, respectively. Dissolution of calcium carbonate sediments increases calcium concentration as observed in our study, representing an increase of average calcium concentration from 38.7 to 158.5 mg/L, thus confirming our speculation. Similar increase in concentration of other cations (Na, K) was observed. An increase in dissolved solids, phosphate, and nitrate results in increased frequency and intensity of eutrophication. The trophic status of the water body was calculated based on Carlson's Trophic State Index (CTSI) to classify the water body. CTSI was 87.0 during post-monsoon and 92.0 during winter classifying the lake as a hypereutrophic water body [13], which is heading towards more frequent and intense cycles of eutrophication. In order to confirm it, the productivity of water body was also calculated. With an increase in CTSI value, the gross primary productivity (GPP) increased from 12.65 mgO_2/L/day to 54.65 12.65 mgO_2/L/day from post monsoon to winter season. Significant increase in GPP confirms that the water body is going through increased intensity of algal bloom. Based on the results obtained, it is concluded that discharge of domestic wastewater in village ponds may result in eutrophication and poor state of health of the water body. There is an urgent need to regularly monitor the status of palustrine water-bodies, and take necessary measures to restore the already eutrophicated ponds.

IV. REFRENCES

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