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Physico-chemical Status of Upper Lake (Bhopal, India) Water Quality with Special Reference to Phosphate and Nitrate Concentration and Their Impact on Lake Ecosystem

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Abstract : The physico-chemical status of Upper Lake (Bhopal, India) with special reference to phosphate and nitrate has been investigated during the year 2003-2004. The phosphate and nitrate are two important nutrients in the lake loading through point and non-point pollution sources such as washing, bathing, agricultural activities in fringe area, joining of domestic raw sewage, cultivation of trapa and huge growth of aquatic macrophytes. These nutrients support the fast growth of the aquatic plants (mainly *Eichhornia crassipes*, *Hydrilla*, *Ceratophyllum* etc.) as a result these plants lead to gradual shrinking of wetland area along with other complications like low light penetration, reduces oxygen concentration, clogging of water channels, lowers entertainment value of lake and some time the level of oxygen depletes so that it can lead to fish mortality also.

Keywords : Nutrients, Lake-limnology, Upper lake Bhopal, Phosphate, Nitrate

Introduction :

Lake, a large body of water surrounded by land and inhabited by various aquatic life forms, is subjected to various natural processes taking place in the environment and anthropogenic activities. Humans are responsible for choking several lakes to death due to a consequence of unprecedented development. Eutrophication is accelerated as a result of human activities near or in a body of water that generate residential wastes, untreated or partially treated sewage, agricultural runoff, urban pollutants, and so forth. Sewage or residential waste, consisting largely of phosphate-containing detergents, is a major source of nutrients in bodies of water. The flow of nutrients in the water may over-stimulate the growth of algae. This creates conditions that interfere with the recreational use of lakes and adversely affect the diversity of indigenous fish, plant and animal populations. The concept of nutrient overloading has a great impact on all subsequent eutrophication research and lake management (Vollenweider, 1976). It is fair to state that nitrates and phosphates are probably the key nutrients in controlling aquatic plant growth.

The nitrate and phosphate are two important constituents that immensely help in the growth of the plants where they present. If they are present in lake and ponds they are excessively promote the growth of aquatic weeds and polluting our aquatic resources. International studies on the nitrates and phosphates in the surface waters of various bodies of water have expressed their concern and drawn the attention of scientists around the globe. These constituents are immensely help in the growth of the macrophytes like water hyacinth (*Eichhornia crassipes*) which is the

most troublesome aquatic weed in the world. The major sources of nitrate in lakes and ponds are from the catchment area by rainfall, sewage effluents, agro waste, suspended organic matter when algae and other suspended micro-organisms die and settle down to the bottom. They carry their nitrogen and phosphorous with them, during decomposition. This nitrogen is released and becomes available for subsequent growth of aquatic biota (Singh, 1987). Presence of nitrate in water indicates the final stage of mineralization (Nema *et al.*, 1984). Phosphorous is present in many forms among them orthophosphate plays important role in the aquatic ecosystem. Orthophosphate is the soluble reactive phosphorous which is also termed as inorganic phosphate. It plays a dynamic role in aquatic ecosystem which is taken up widely by phytoplankton (Goldman, 1965).

Material and Method :

The Upper Lake Bhopal has been selected for present investigation. This lake is an east westerly elongated shallow lake with irregular margins and has dense growth of aquatic macrophytes and algae. The catchment area of this lake is 370 sq km, maximum water area is 3105 ha, storage capacity 100.8 million cubic meters with water spread area 12.2 sq miles and maximum depth is 6 meters. Monthly samples were collected from Behtagaon (Bairagarh) Bhopal and analysed as per Standard Methods for the Examination of Water & Waste Water. 14th Edn (1983) AWWA-APHA-WPCF, Washington and laboratory manual on water analysis (NEERI, 1987).

Result and Discussion :

As shown in Table-1, seasonal variations are evident in all the physico-chemical parameters examined. A direct relationship of the temperature and nitrate contents has been noticed. The maximum value of nitrate was recorded as 0.315 mg/l on surface and 0.123 mg/l at bottom in the month of June 2004 whereas minimum value was recorded as 0.048 mg/l on surface and 0.019 mg/l at bottom of the lake in the month of December 2003. A rise in nitrate content is therefore has been noticed from April to July, 2004 (Fig. 1 and 2). During the period under study higher values of nitrate were observed in summer months. This may be due to decreased water level or concentration of water, high density of phytoplankton and high rate of organic decomposition. The lower values of nitrate were recorded during winter months as the temperature remains quite low during winters. As the rate of decomposition declines, it results into uptake of nitrate by higher density of algal blooms during the season. As shown in the Table 1. A rise in nitrate content of water from indicates the increasing anthropogenic influence on the lake.

The concentration of nitrates in the water was within the acceptable limits although it tends to increase considerably in one year's time. The deterioration in the quality of lake water has contributed to the decline in the biological diversity of the flora, fauna and productivity of the wetland systems (Ramachandra, 2001). The raw sewage is the source of nitrates and phosphates in the water (Aggarwal *et al.*,

Table 1 : Showing physico chemical parameters of water sample of Behta village area (Bairagarh).

	Water Temp in ^oC	Trans P.	Free CO_2	Ph	D.O.	BOD	COD	P Alka Linity	Hard-ness	Nitr-ate	Pho-sphate	At. Temp in ^oC
Nov. 03	S 17.6 B 13.8	171.5	S 3.81 B 4.81	S 7.5 B 7.4	S 8.4 B 5.2	S 2.5 B 1.5	S 18.2 B 21.3	S Nil B Nil	S 58.8 B 66.3	S 0.063 B 0.034	S 0.130 B 0.142	20.0
Dec. 03	S 17.4 B 12.5	170.0	S 3.66 B 4.8	S 7.3 B 7.2	S 8.8 B 6.3	S 1.5 B 1.1	S 17.4 B 20.6	S Nil B Nil	S 70.4 B 78.9	S 0.048 B 0.019	S 0.121 B 0.136	20.5
Jan. 04	S 19.5 B 13.0	170.3	S 2.76 B 3.79	S 7.8 B 7.4	S 7.8 B 7.4	S 1.7 B 1.2	S 17.8 B 21.2	S Nil B Nil	S 67.9 B 76.5	S 0.049 B 0.023	S 0.094 B 0.11	22.0
Fab.	S 21.0 B 14.5	166.0	S 1.62 B 2.89	S 8.5 B 8.1	S 7.3 B 4.8	S 1.9 B 1.4	S 16.3 B 19.0	S Nil B Nil	S 65.7 B 74.9	S 0.059 B 0.028	S 0.073 B 0.091	22.4
Mar. 04	S 25.7 B 17.2	168.0	S Nil B Nil	S 7.6 B 7.4	S 7.1 B 4.6	S 2.5 B 1.6	S 20.8 B 23.4	S 22.4 B 18.2	S 53.4 B 61.7	S 0.085 B 0.047	S 0.051 B 0.068	26.6
Apr. 04	S 27.2 B 19.7	94.5	S Nil B Nil	S 8.8 B 8.1	S 6.7 B 4.5	S 2.9 B 2.0	S 29.6 B 32.6	S 25.2 B 20.4	S 48.7 B 56.4	S 0.173 B 0.076	S 0.043 B 0.057	31.0
May 04	S 28.0 B 21.0	64.0	S Nil B Nil	S 9.2 B 8.8	S 8.3 B 6.3	S 3.6 B 2.6	S 29.2 B 33.6	S 28.0 B 22.5	S 37.8 B 48.2	S 0.231 B 0.105	S 0.039 B 0.052	32.5
June 04	S 29.6 B 22.5	55.3	S Nil B Nil	S 8.6 B 7.1	S 8.3 B 6.3	S 4.8 B 2.8	S 27.6 B 30.4	S 24.3 B 21.0	S 35.2 B 48.6	S 0.315 B 0.123	S 0.041 B 0.058	31.8
July 04	S 25.5 B 13.5	47.0	S 1.89 B 3.83	S 7.9 B 7.6	S 8.1 B 6.5	S 5.9 B 2.4	S 20.2 B 23.8	S Nil B Nil	S 50.6 B 58.9	S 0.209 B 0.097	S 0.073 B 0.089	27.6
Aug. 04	S 26.0 B 15.0	43.0	S 2.12 B 3.46	S 7.8 B 7.4	S 9.8 B 6.8	S 5.6 B 2.7	S 18.3 B 21.0	S Nil B Nil	S 47.4 B 56.2	S 0.123 B 0.051	S 0.129 B 0.143	27.0
Sep. 04	S 26.0 B 19.3	57.0	S 2.82 B 3.17	S 7.5 B 7.3	S 9.7 B 7.9	S 4.8S B 2.3	S 16.8 B 19.7	S Nil B Nil	S 52.2 B 60.9	S 0.1117 B 0.048	S 0.158 B 0.170	26.7
Oct. 04	S 25.0 B 18.5	88.6	S 3.27 B 4.59	S 7.7 B 7.5	S 9.3 B 7.4	S 3.4 B 2.0	S 16.8 B 19.7	S Nil B Nil	S 59.6 B 69.5	S 0.087 B 0.047	S 0.147 B 0.161	26.0

All values in mg/l otherwise given S = Surface B = Bottom

2000). The standard drinking water quality guideline for nitrates is 40 ppm (APHA, 1985). Early monsoon runoff has been shown to be an important contributor of nitrate-nitrogen in reservoir (Hannan and Young, 1975).

However, an inverse relation seems to appear with temperature and phosphate and these both are the most important ecological features acting as limiting factors for the growth and distribution of flora and fauna in any aquatic ecosystem. High phosphate content in the Lake water indicates the prevailing hyper-eutrophic conditions. The phosphate concentration in the water body was very high as compared to the standard guidelines. This condition is accompanied by a gradual filling up of the water body, which becomes shallower from the accumulation of plants and sediments on the bottom and also becomes smaller due to the invasion of shore vegetation. The extinction of the lake can result because of enrichment, productivity, decay and sedimentation.

Phosphate is also one of the major macronutrients responsible for biological productivity and eutrophication of the water body. During the period under study higher values of phosphate were observed in rainy season. This may be attributed to surface runoff during rainy season receiving huge quantity of domestic sewage, cattle dung, detergents, and agricultural fertilizers from surrounding catchment area. Catchment area activities are enriching PO_4^{-3} in the lake.

The lower values of phosphate in summer months may be due to more uptake of phosphate for luxuriant growth of macrophytes. During the period under study maximum value of phosphate was recorded as 0.158 mg/l on surface and 0.170 mg/l at bottom in the month of September 2004 whereas minimum value was recorded 0.039 mg/l on surface and 0.052 mg/l at bottom of the lake in the month of May 2004.

The Shahpura Lake of Bhopal was also found to be highly eutrophic. The phosphate content of the lake water studied was found in the range of 6.05 to 9.21 ppm. The nitrate content of the water was found to be in the range 2.02 to 15.22 ppm (Dixit *et al.*, 2005). The phosphate content in the lake water is alarming. The values are comparatively lower in the first half the year 2004.It appears due to lake's feeding sources where a high concentration of phosphates from the manure and chemical fertilizers used in an adjacent garden drains into the lake. For phosphates, the U.S. Environmental Protection Agency (1976) suggested that 0.08 ppm was the critical level for the occurrence of eutrophication in lakes and reservoirs.

In the present study the higher values were noted from August, 2004 and November, December, 2003 (Fig. 3 and 4). There are various sources of phosphate to the lake water, such as firm rock deposit, runoff from surface catchments, and interaction between the water and sediment from dead plant and animal remains at the bottom of the lake.

Phosphate is considered to be the most significant among the nutrients responsible for

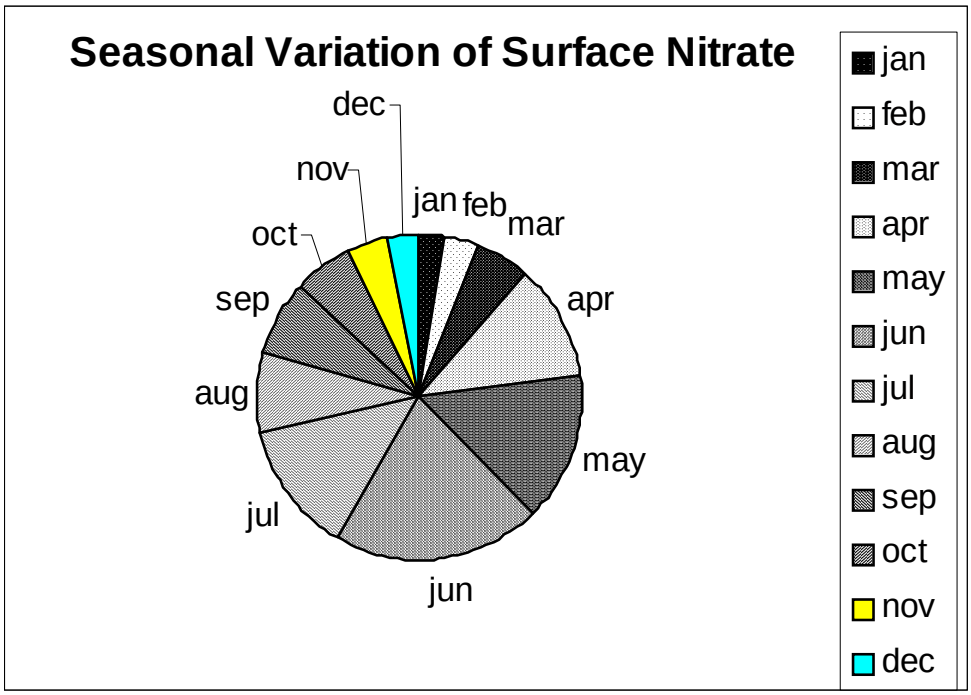

Fig. 1 : Seasonal Variation of Surface Nitrate

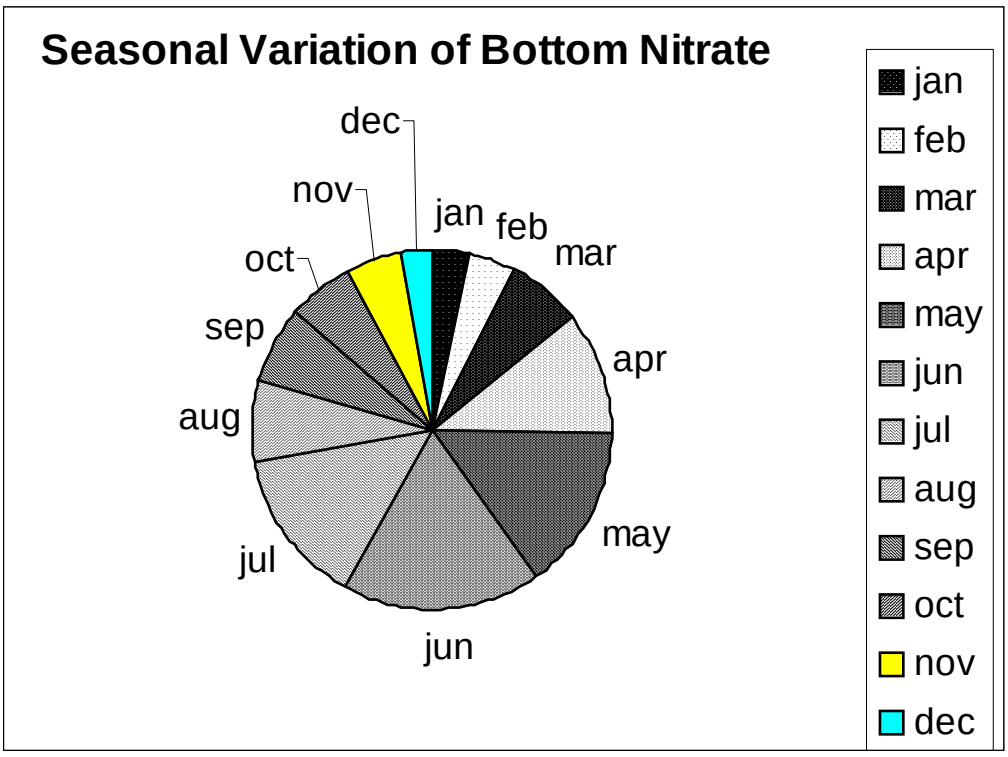

Fig. 2 : Seasonal Variation of Buttom Nitrate

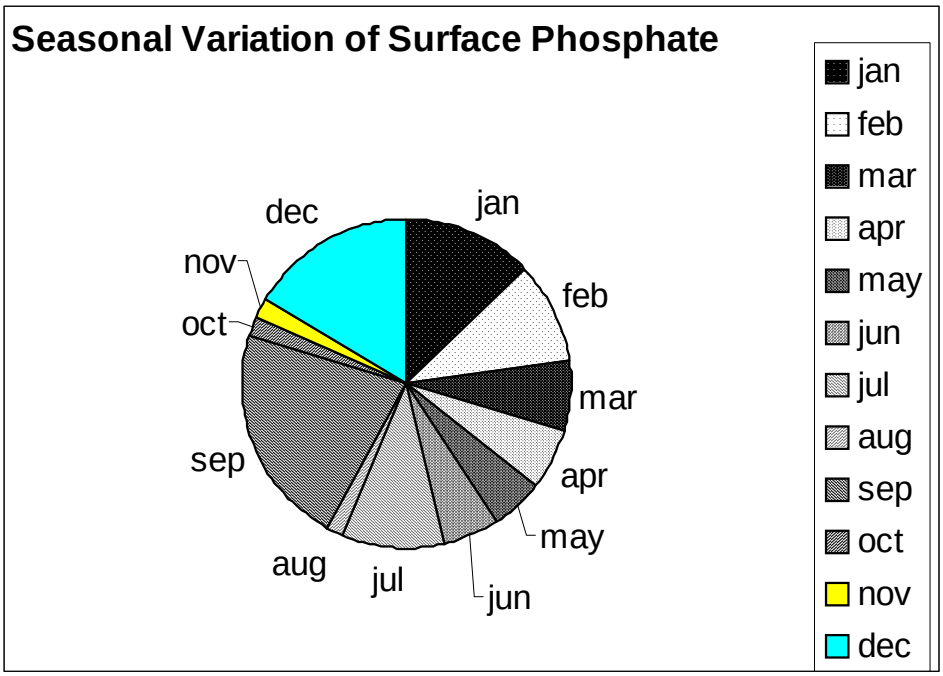

Fig. 3 : Seasonal Variation of Surface Phosphate

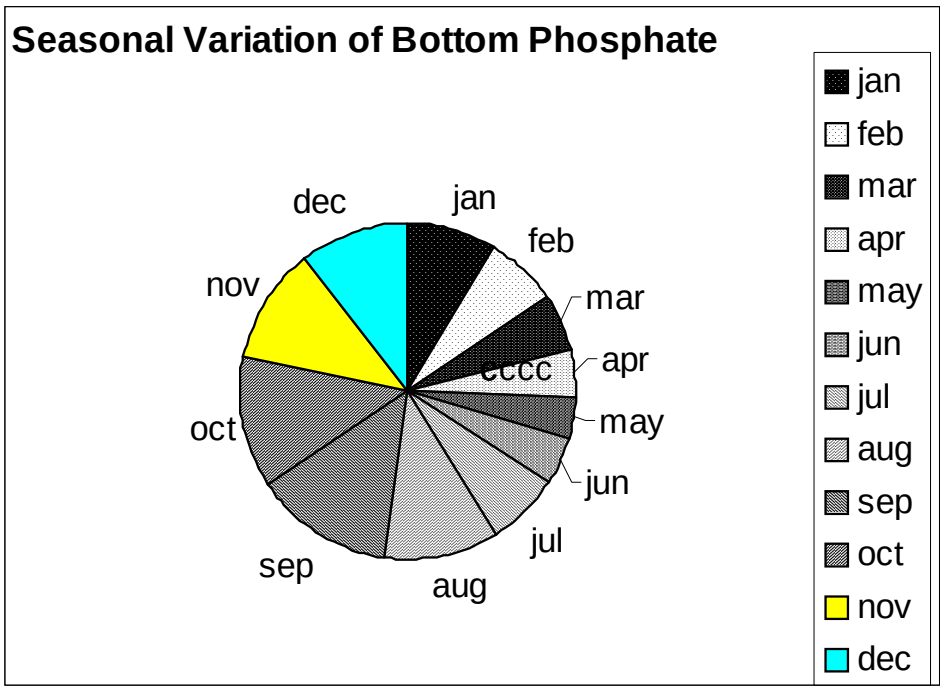

Fig. 4 : Seasonal Variation of Bottom Phosphate

eutrophication of lakes, as it is the primary initiating factor. Phosphate enters the lakes in domestic wastewater, accounting for the condition of eutrophication. Atmospheric input, as well, may account for a significant proportion of the influx of nutrients to the lake.

Storm water runoff and discharge of sewage into the lakes are two common ways that various nutrients enter the aquatic ecosystems resulting in the death of those systems (Sudhira & Kumar, 2000). The washing of large amounts of clothes by *dhobis*, laundry workers, and the continued entry of domestic sewage in some areas are posing pollution problems (Benjamin et al, 1996). Of all the water quality issues regarding lakes everywhere, eutrophication is of great concern. Eutrophication of a water body signifies the aging of a lake. It is caused by the accumulation of nutrients, sediments, silt and organic matter in the lake from the surrounding watershed. Eutrophication describes the variations in aquatic systems due to nutrient enrichment; the eventual consequence of that enrichment is the growth of primary production to nuisance proportions (Marsden, 1989). The main cause is excessive loading into the system of phosphorus and nitrogen, resulting in high algal biomass, dominance by cyanobacteria, and loss of macrophytes (Jana & Das, 1995). Although eutrophication is a natural process of aging of lakes and water bodies, human activities can greatly accelerate eutrophication by increasing the rate at which nutrients and organic substances enter aquatic ecosystems from their surrounding watersheds.

Negative impact of higher nutrient concentration in lake ecosystem

Higher nutrient concentration can lead to following conditions.
Higher growth and decay of algal bloom.
Lowers dissolve oxygen level.
Can lead fish mortality.
Enhance macrophyte growth.
Growth of pathogenic microbes like protozoa, viruses and bacteria enhances as these grow in anaerobic conditions.
Algae and diatoms attain high degree of dominance due to over fertilization.
Some phytoplankton species eliminated at higher nutrient concentration and die.
Nutrients like nitrate and sulphate on decomposition produce foul smell, which lower the aesthetic value of the water body.
During eutrophication the algal bloom release the toxins and chemical which kill fishes, birds and other aquatic animals causing water to sink.

The deterioration in the quality of Upper Lake (Bhopal, India) water and rise in the nutrient level is alarming, and periodic monitoring and preventative measures are required to save the lake from eutrophication.

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