ABSTRACT

Phosphorus is abundant in the sediments but its movement to the overlying water is largely governed by the physico-chemical conditions and under anaerobic state the equilibrium is towards the sediment side. Total Phosphorus in fresh water comprises of soluble reactive phosphate, poly phosphate, soluble and insoluble phosphorus. In recent times, increased use of detergents with long chain poly-phosphate compounds and the use of water bodies as receptacles for waste disposal have resulted in excessive phosphorus loading of aquatic systems, causing Eutrophication. The present paper deals with distribution of phosphorus in Lower lake of Bhopal (India) which is a sewage pulled waterbody.

Key Words: Orthophosphate, Total Phosphorus, Eutrophication, Lower lake, Sewage Pollution

INTRODUCTION

No other element in Limnology has been as intensively studied as phosphorus. Ecological interest in phosphorus stems for its major role in biological metabolism and the relatively small amount of phosphorus in the hydrosphere. In comparison to the biota (carbon, hydrogen, nitrogen, oxygen and sulphur) phosphorus is least abundant and yet most commonly limits to biological productivity.

Phosphate is found in the dissolved form in natural water as a result of the natural weathering and solution of phosphate minerals, soil erosion and transport, soil fertilization and resultant phosphorus transport and biological transfer (assimilation and dissimilation process involving phosphorus in agriculture etc.) and use of soluble phosphate compounds in detergent manufacturer and water treatment industry (domestic and industrial waste water).

Contrary to the numerous forms of phosphorus in the lake systems, the only significant form of inorganic phosphorus is ortho phosphate. A very large proportion greater than 90% of the phosphorus of lake water is bound organically in organic phosphate and cellular constituents in the living particulate matter of the system or variously associated with or adsorbed to inorganic and dead particulate organic materials. The most important quantity, in view of the metabolic characteristics within a lake, is the total phosphorus content of unfiltered water consists of the phosphorus in suspension in particulate matter and the phosphorus in dissolved forms.

Total phosphorus in fresh water comprises of soluble reactive phosphate, poly-phosphate, soluble and insoluble organic phosphorus. In recent times, increased use of detergents with long chain poly-phosphate compounds and the use of water bodies as
receptacles for waste disposal have resulted in excessive phosphorus loading of aquatic systems, causing Eutrophication.

Phosphorus is abundant in the sediments. The exchange of phosphorus between the sediments and overlying water is a major component of the phosphorus cycle in natural water. Its importance in an apparent net movement of phosphorus into the sediments in most of the lakes.

Because of the fundamental importance of phosphorus as a nutrient and major cellular constituent, much emphasis has been placed on analytical evaluation of its change in concentration with time.

Study Site

Lower lake of Bhopal is situated in a thickly populated area of the city. Major portion of the shoreline of this man made lake is natural except from north-eastern part and western corner, where dams are constructed. The western dam separates the lower lake from the other lake called upper lake. The lake receives sewage and run off from catchments area through a number of inlets.

MATERIAL AND METHODS

Water and sediment samples were collected monthly for a period of 12 months (Jan. 1996 to Dec. 1996) from 4 different stations. All the four sampling stations are situated near the inlets. Water samples were collected with the help of Ruttner’s sampler whereas the sediment samples were collected by Lenz bottom sampler. Physico-chemical parameters like temperatures and pH were estimated in the field using pH meter with built in thermometer and for D.O. and free CO₂ methods were followed by Standard Methods(1985). Total phosphorus was estimated by Ascorbic Acid method. All the forms of phosphorus were converted to orthophosphate by digestion and oxidation which was then measured spectrophotometrically. 25 ml. of sample is evaporated and residue was dissolved in 1 ml. Perchloric Acid (70%). The residue was heated till it became cultureless. 10 ml. distilled water was added followed by a drop of phenolphthalein indicator. This was titrated with Sodium Hydroxide solution to slight pink end point. Now the volume was made up to 25 ml. by adding 1 ml. of ethyl alcohol + 24 ml. of combined reagent. After mixing thoroughly there was a blue color developed. This blue colored residue was analyzed spectrophotometrically at 880 nm.

RESULTS AND DISCUSSION

All the results given below are the average of all the 4 stations.

1. Temperature

The temperature of surface water was highest 29.8°C in June and lowest 19.4°C in January. The temperature of bottom water was highest 24.8°C in July and lowest 17.8°C in January.

2. pH

The pH of surface water was highest 9.75 in October and lowest 7.86 in January. The pH of bottom water was highest 7.98 in October and lowest was 6.97 in November.

3. Dissolved Oxygen (D.O.)

Highest surface D.O. was 12 mg/L in April and lowest was 5.2 mg/L in August. D.O. values of bottom water was highest 4.4 mg/L in April and lowest 1.2 mg/L in July.

4. Free Carbon Dioxide (CO₂)

Highest surface Free CO₂ value was 5 mg/L in November and lowest zero for most of the year. However free CO₂ value is comparatively higher in bottom water than surface water. Free CO₂ value of bottom water was highest 14 mg/L in December and lowest 8.8 mg/L in October.

5. Total Phosphorus in Water

Maximum total phosphorus value of surface water was 1.76 mg/L in January at station 1 and lowest 0.92 mg/L in September at station 4. While maximum value of total phosphorus in bottom water was 2.8 mg/L in January at station 1 and lowest 1.72 mg/L in August at station 3.
6. Total phosphorus in sediments

In lake sediments, values of total phosphorus is much higher than in water. Maximum value of total phosphorus was 30 mg/gm in January at station 1 and minimum 16 mg/gm in August at station 3.

In aquatic systems no other factor has so much influence as temperature. The temperature not only effects physiological processes, but also the density and sedimentation of water. It has also been observed that water temperature as expected higher in summer months and lowest in winter other workers have also found the same type of results. H+ ion concentration controls the chemical state of many nutrients including free carbon dioxide, phosphate etc. In the present study, higher pH values of surface water were explained on the basis of increased photosynthetic activity of the algal bloom, the carbonates of Calcium and Magnesium are precipitated from Bicarbonates and water becomes more alkaline. Dissolved Oxygen is required for the metabolism of all aquatic organisms. It acts as an indication of the magnitude of Eutrophication. Highest D.O. was recorded during summer months, may be due to high photosynthetic activity, increased density of phytoplankton and surface water movement by wind action. Some workers have found that the low values of dissolved oxygen and anoxic conditions at the bottom depicted the high rates of oxygen consumption as a result of increased decomposition of autochthonous organic matter produced and introduced through continuous sewage loading. The utilization of phosphorus in photosynthetic activity may also be due to permanent algal bloom at the lower lake.

There are various sources of phosphorus intake such as rock deposits, by surface run off from catchment, sediment water interaction at the bottom of the lake from dead plants and animals remains. Phosphorus is considered to be the most important among responsible for Eutrophication of lakes, phosphorus being the main initiating factor.

The total phosphorus level gradually increases with the increases of depth. The total phosphorus value in water in this lake ranged from 0.92 mg/L to 2.59 mg/L indicating hypereutrophic state of the lake and according to studies total phosphorus values exceeding 0.05 mg/L creates biological nuisance. In the present study total phosphorus was found to be generally high in winter months and this may be due to anthropogenic influences and growth of dense free floating and floating leaved plants. The low total phosphorus values was found in monsoon months. The total phosphorus values were always high at the bottom as compared to the surface water in the present study. This was due to decomposition at the bottom of the lake, there is a high release of phosphorus at the bottom.

There is little correlation between the amount of phosphorus in the sediments and the productivity of the overlying water. The phosphorus content of the sediments can be several orders of magnitude greater than of water. The important factors are the ability of the sediments to retain phosphorus, and the conditions of the overlying water and the biota within the sediments that alter exchange equilibrium and affect phosphorus transport back to the water. The exchange of phosphorus across the sediment influence are regulated by mechanisms associated with mineral water equilibria, sorption processes, redox interactions and the activities of bacteria, fungi, plankton and invertebrates.

The ability of sediments to retain phosphorus at the interface is related to several interacting factors. Much of the organic phosphorus reaching the sediments by sedimentation is decomposed and hydrolysed.

Lake sediments contain much higher concentration of phosphorus, than the water.
Fig. 1. Concentration of Total Phosphorus at Station 1

Fig. 2. Concentration of Total Phosphorus at Station 2
Fig. 3. Concentration of Total Phosphorus at Station 3

Fig. 4. Concentration of Total Phosphorus at Station 4
Under aerobic conditions, it is clear that the exchange of phosphorus is largely unidirectional towards the sediments. Under aerobic condition, exchange mechanism is strongly influenced by redox conditions and under anaerobic state, the equilibrium is towards the sediment side. The depth of the sediments involved in active migration of phosphorus to the water is considerable. In undisturbed anoxic sediments, given sufficient time (2 to 3 months), phosphorus moved upward readily from at least a depth of 10 cm. to the overlying water.

CONCLUSION

The waterbody under present study is seriously polluted and receiving high amount of nutrients from various sources. The earlier studies suggest that the phosphorus values exceeding 0.05 mg/L can cause biological nuisance. The present water comes under this category and leading towards the state of eutrophy.

REFERENCES