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RESEARCH ARTICLE

PHYSICO-CHEMICAL CHARACTERISITICS OF HAUZ KHAS LAKE, NEW DELHI, INDIA

[1]Disha Jain and *,[2]Dr. Jakir Hussain

[1]Department of Environment Sciences, Maharshi Dayanand University, Rohtak, Haryana, India
[2]National River Water Quality Laboratory, Central Water Commission, New Delhi-110016, India

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ABSTRACT

In India, urban water bodies commonly become cesspools due to lack of sanitation facilities. Delhi is continually urbanizing at a rapid pace that has affected the condition of water bodies. Hauz khas is an area which is located in South Delhi and the lake inside it is 700 year old. The pH in zone 2 was 9.6 and in zone 3 was 9.7 which showed the lake water is not suitable for irrigation, fish culture, outdoor bathing. It is very clear that the sewage effluent is the major source of nutrients in the lake and it was concluded that the current situation is not sustainable. The pH in two zones found maximum permissible limit. Turbidity also found maximum in all zone it may affect the ability of fish gills to absorb dissolved oxygen. Whereas, remaining parameters like ammonia, fluoride, chloride, total hardness, nitrate and boron all these parameters found within the limit as per IS: 2296: 1992 except DO and BOD. DO level in zone 3 and 4 was 9.45 mg/L and 7.93mg/L it showed the presence of high algal growth. BOD ranged from 10 to 64.9 mg/L. As results showed that the two zones of lake i.e. zone 3 and zone 4 is not suitable for bathing, irrigation purposes. Also, it is not suitable for aquatic life.

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INTRODUCTION

Water is one of the most important natural resource available to mankind. Knowing the importance of water for sustenance of life, the need for conservation of water bodies especially the fresh water bodies is being realized everywhere in the world. Lakes, rivers and reservoirs are most important water resources and used for several purposes like hydroelectric power generation, irrigational supply through canals, prevent wide damage from floods in the downstream, recreational purpose like boating, swimming etc. Due to the fast urbanization and industrialization in India is leading to steep increase in waste generation. The waste management is not adequately addressed resulting in large part of uncollected and untreated wastes getting into the water bodies. This situation coupled with steep increase in water demand leading to degradation of water quality. Therefore, it is necessary to assess the quality of the water bodies before it can be safely utilized for various purposes.

Lakes are of special concern with regard to the retention of certain constituents, especially nutrients including forms of nitrogen and phosphorous which promote eutrophication. Eutrophication is a natural ageing process in which the water content becomes organically enriched, leading to the domination of undesirable aquatic growth, such as algal, water hyacinth and so on. The eutrophic process tends to decrease aquatic life and has detrimental dissolved oxygen effect. The Hauz Khas Lake has the potential of providing tangible and intangible benefits to the people of the region, though no scientific study has yet been reported on this aspect of the lake. So, the present study deals with the water quality assessment of the Hauz Khas Lake of Delhi City of India and its pollutional status.

**Corresponding author: Dr. Jakir Hussain,*
National River Water Quality Laboratory, Central Water Commission, New Delhi-110016, India.

Study area

The etymology of the name Hauz Khas in urdu language is derived from the words "Hauz": *"water tank" or "lake"* and "Khas" : "royal" – the *"Royal Tank"*. This tank was built by Sultan Alauddin Khalji in 1295 to provide water for the residents of Siri , and was called Hauz Alai. Later on, the hauz became dry. During the reign of Firoz Shah Tughlaq, it was excavated and named Hauz Khas. In 1916, excavations revealed that the original flight of steps are of local grey stone. Several buildings (Mosque and madrasa) and tombs were built overlooking the water tank or lake. Firoz shah's tomb pivots the L-shaped building complex which overlooks the tank. The lake is originally known as *HAUZ –E-ALAI.* Hauz khas is a historic place and the lake inside it is 700 year old. The latitude is *28.55□ N* and longitude is *77.19□ E.* Hauz khas tank is *26 km* far from Yamuna river which is in delhi. The lake is *1.5 km long*. The tank was originally of about *50ha (123.6 acres)* area with dimensions of *600 m (1968.5 ft)* width and *700 m (2296.6 ft)* length with *4m (13.1 ft) depth of water*. The area lies *225 m* *above sea level*. The area of a lake surrounded by RK Puram is also known as Deer Park, Safdarjung enclave, Green park.

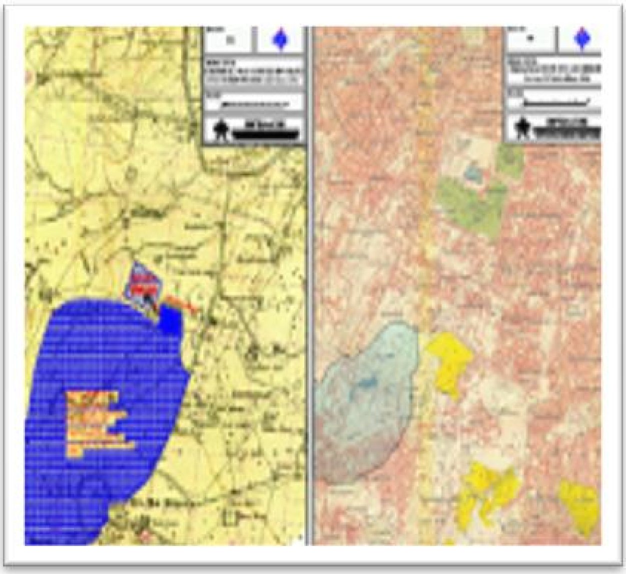

Fig. 2. Sampling points of Lake

Sampling points

In Hauz Khas Lake samples collected from the sampling points. Lake is approximately 1.5km long so, we divided the lake into four zones are as follows:

MATERIALS AND METHODS

The water quality of Hauz Khas Lake is monitored by collecting the water samples from four zones/ locations. The sampling sites are selected in a grid pattern keeping in view the path of water flow in the lake from inflow channels to the outflow point. Various water quality tests were conducted in the field as well as in the laboratory to determine the physico-chemical and biological properties of the lake water using the standard methods (APHA 2012). The physical parameters and chemical parameters such as pH, electrical conductivity (EC) and dissolved oxygen (DO) were determined in the field at the time of sample collection using portable water testing kit. Chloride concentration was determined by argentometric method in the form of silver chloride. Alkalinity was determined by the titrimetric method with the aid of phenolphthalein and methyl orange indicators. Calcium, magnesium and total hardness were analysed by complexometric titration. Fluoride, nitrate and ammonia concentration were determined by ion selective electrode method. Phosphate, boron, nitrite concentrations were determined using UV– VIS Spectrophotometer. Biochemical oxygen demand was analysed by titration method.

Quality criteria

As it is a well-known fact that the sources of usable water on the earth are limited, any kind of pollution in them will further reduce its availability. Polluted water cannot be utilized for drinking because of its inherent health risk.

Fig 2. Sampling points of Lake

Water with high salt contents is not suitable for agriculture and most industries. The quality of water also interferes with the aesthetic and economic pursuits of water bodies by affecting marine and fresh water life. However, the water, which is not suitable for irrigation, may be quite suitable for industrial cooling. Every use of water requires a certain minimum quality standards with regards to the presence of dissolved and suspended materials of both chemical and biological nature. The desirable quality of water ensures no harm to the user.

To maintain the minimum quality standard for diverse user has led to the formulation of water quality criteria, and water quality standards. Water quality criteria can be considered as specific requirements on which a decision or judgment to support a particular use will be based. The criteria for the various uses are developed based on the experimental data and our current knowledge of the health, ecology and other issues and assessing its overall economical effect these are not a set of fixed values, but subject to modification as the scientific data get updated and more and more knowledge is gathered. The term standard applies to any definite principle or measure established by an authority by limiting concentration of different constituents in water to ensure the safe use of water and safeguard the environment.

standard IS 2,296:1992. Important water quality standards of IS code are shown in Table 1.

The water quality criterion for each of the designated best use given by BIS is as under:

A = Drinking water source with conventional treatment but after disinfection
B = Outdoor bathing
C = Drinking water source with conventional treatment followed
D = Propagation of Wildlife and fisheries
E = Irrigation, Industrial Cooling and Controlled Waste Disposal

RESULT AND DISCUSSION

pH

The pH is a measure of the intensity of acidity or alkalinity and measures the concentration of hydrogen ions in water. It has no direct adverse affect on health, however, a low value, below 4.0 will produce sour taste and higher value above 8.5 shows alkaline taste. A pH range of 6.5 – 8.5 is normally acceptable as per guidelines suggested by BIS.

Table 1. Designated Best Use (IS:2296: 1992)

Parameters	A	B	C	D	E
pH	6.5-8.5	6.5-8.5	6.0 – 9.0	6.5-8.5	6.0-8.0
EC(µmhos/cm)	-	-	-	-	2.250
Total Dissolved Solids (mg/L , max)	500	-	1500	-	2100
Total Hardness(as $CaCO_3$) (mg/L , max)	300	-	-	-	-
Calcium hardness, (mg/L , max)	200	-	-	-	-
Magnesium hardness, (mg/L , max)	100	-	-	-	-
Chloride (mg/L , max)	250	-	600	-	600
Sulphate (mg/L , max)	400	-	400	-	1000
Nitrate (mg/L , max)	20	-	50	-	-
Fluoride (mg/L , max)	1.5	1.5	1.5	-	-
Boron (mg/L , max)	-	-	-	-	2
Ammonia (mg/L , max)	-	-	-	1.2	-
Dissolved Oxygen (mg/L , max)	6	5	4	4	-
Biochemical Oxygen Demand (mg/L , max)	2	3	3	-	-

Designated Best Use

For any water body to function adequately in satisfying the desired use, it must have corresponding degree of purity. Drinking water should be of highest purity. As the magnitude of demand for water is fast approaching the available supply, the concept of management of the quality of water is becoming as important as its quantity. Each water use has specific quality need. Therefore, to set the standard for the desire quality of a water body, it is essential to identify the uses of water in that water body. In India, the Central Pollution Control Board (CPCB) has developed a concept of *designated best use*. According to this, out of the several uses of water of a particular body, the use which demands highest quality is termed its designated best use. Five designated best uses have been identified. This classification helps the water quality managers and planners to set water quality targets and design suitable restoration programs for various water bodies. In India, CPCB has identified water quality requirements in terms of a few chemical characteristics, known as primary water quality criteria. Further, Bureau of Indian Standards has also recommended water quality parameters for different uses in the

In the present study, the fluctuation of pH in the lake samples is from 7.98 to 9.70. In zone 1, the value of pH is 7.98 and in zone 4 is 8.12 which showing a little basicity in the sample. But in zone 2 and zone 4 the value of pH is 9.66 and 9.70. It is higher than the normal; it may be due to photosynthesis uses up dissolved carbon dioxide, which acts like carbonic acid (H_2CO_3) in water. CO_2 removal, in effect, reduces the acidity of the water and so pH increases. For this reason, pH may be higher during daylight hours and during the growing season, when photosynthesis is at a maximum. And may be, when pollution results in higher algal and plant growth (e.g., from increased temperature or excess nutrients), pH levels may increase, as allowed by the buffering capacity of the lake. Although these small changes in pH are not likely to have a direct impact on aquatic life, they greatly influence the availability and solubility of all chemical forms in the lake and may aggravate nutrient problems.

Electrical Conductivity and Total Dissolved Solids

Conductivity is a measure of the ability of water to pass an electrical current. Conductivity in water is affected by the presence of inorganic dissolved solids such as chloride, nitrate, sulfate, and phosphate anions or sodium, magnesium, calcium, iron, and aluminum cations. Conductivity is also affected by temperature: the warmer the water, the higher conductivity. A failing sewage system would raise the conductivity because of the presence of chloride, phosphate, and nitrate; an oil spill would lower the conductivity. The conductivity of Hauz Khas lake of all zones around 758.3, 745.7, 797.2, 760.3 in µS/cm which is higher than normal. Studies of inland fresh waters indicate that streams supporting good mixed fisheries have a range between 150 and 500 µmhos/cm. Conductivity outside this range could indicate that the water is not suitable for certain species of fish or macro invertebrates. Total dissolved solids and specific conductivity of water has a high degree of correlation (>0.95) as both parameters indicate the amount of dissolved solid. The values of TDS of different zones are within the limit as per IS:2296: 1992. In the study, TDS found in zone 1 is 440 mg/L, zone 2 is 420 mg/L, zone 3 is 460 mg/L and in zone 4 are 500 mg/L. According to class E of designated best use (IS:2296: 1992), the water can be used for irrigation.

Turbidity

Turbidity is the cloudiness or haziness of a fluid caused by large numbers of individual particles that are generally invisible to the naked eye, similar to smoke in air. The measurement of turbidity is a key test of water quality. In natural water, it is caused by clay, silt, organic matter and other microscopic organisms. But in lake samples it is ranged from 164.5 - 180.8 NTU which is higher than the prescribed limit, reason behind it may be due to caused by growth of phytoplankton. Human activities that disturb land, such as construction, mining and agriculture, can lead to high sediment levels entering water bodies during rain storms due to storm water runoff. In water bodies such as lakes, high turbidity levels can reduce the amount of light reaching lower depths, which can inhibit growth of submerged aquatic plants and consequently affect species which are dependent on them, such as fish and shellfish. High turbidity levels can also affect the ability of fish gills to absorb dissolved oxygen.

Hardness

Total hardness is defined as the sum of the calcium and magnesium concentration, both expressed as $CaCO_3$, in mg/L. Water hardness is a traditional measure of the capacity of water to precipitate soap. Hardness of water is not a specific constituent but is a variable and complex mixture of cations and anions. It is caused by dissolved polyvalent metallic ions. In fresh water, the principal hardness causing ions are calcium and magnesium which precipitate soap. In the present investigation, the value of total hardness found in zone1 was 110.26, in zone 2 was 106.19, in zone 3 was 211.64mg/L and in zone 4 was 129.13 (all are in mg/L). Calcium hardness was recorded in zone 1 was 107.3, in zone 2 was 85.1, in zone 3 was 105.82 and in zone 4 was 75.11mg/L. Magnesium hardness found maximum in zone 3 was 105.82mg/L and minimum in zone 1 was 2.96mg/L, in zone 2 was 21.09 and in zone 4 was 54.02mg/L. Only magnesium hardness in zone 3 found maximum as per IS: 10500, 2012. The values of total hardness, calcium and magnesium are within the limit as per IS: 2296:1992

Sodium and Potassium

Sodium and potassium are naturally occurring elements of groundwater. It is one of the major contributors to salinity of water. Sodium concentration plays an important role in evaluating the groundwater quality for irrigation because sodium causes an increase in the hardness of soil as well as a reduction in its permeability (Tijani 1994). The values for sodium and potassium are not mentioned in Indian standards. But in the study the values for sodium ranged from 109.63 to 113.32mg/L. For potassium, the values ranged from 36.16 to 39.59mg/L.

Sulphate

The sulphate concentration in lake water ranged from 146.2 - 163.6 mg/L. In zone 1, the concentration of sulphate is 146.2 mg/L, in zone 2 is 154.5 mg/L, in zone 3 is 132.9 mg/L and in zone 4 is 163.6 mg/L The values found within the permissible limit as per (IS:2296: 1992). This lake water may be suitable for irrigation.

Chloride

Excess of chloride in inland water is usually taken as index of pollution. The salts of sodium, potassium and calcium contribute chlorides in water. Large contents of chloride in water are an indicator of pollution. According to Indian standards, the concentration of chloride should be 250mg/L for drinking water source with conventional treatment but after disinfection. For irrigation, it should be 600mg/L. But in the study, we found the concentration of chloride in lake water ranged from 139.09 to 164.87mg/L. On the basis of study, the water may be used for irrigation purposes as well as for drinking purposes with conventional treatment but after disinfection.

Phosphate

Phosphate occurs in natural water in low quantity as many aquatic plant absorb and store phosphate many times their actual immediate needs. In the study, the concentration of phosphate ranged from 0.24 to 0.52mg/L. Limits not mentioned in the Indian standards.

Fluoride

Fluoride is considered beneficial to human health if taken in limited quantity (0.5 to 1.5 mg/l). Fluoride prevents tooth decay by enhancing the remineralization of enamel that is under attack, as well as inhibiting the production of acid by decay causing bacteria in dental plaque. Fluoride is also a normal constituent of the enamel itself, incorporated into the crystalline structure of the developing tooth and enhancing its resistance to acid dissolution. But it is also known to cause dental, skeletal fluorosis, osteosclerosis, thyroid, kidney changes and cardiovascular, gastrointestinal, endocrine, neurological, reproductive, developmental, molecular level, immunity effects, if concentration is higher than 1.5 mg/l in drinking water. In the study, the concentration of fluoride was found in zone 1 is 0.46, in zone 2 0.45, in zone 3 0.45 and in zone 4 0.38. The values are within the permissible limit as per (IS:2296: 1992). According to the study, the water may be used for bathing purposes.

Nitrate and Ammonia

The presence of normal levels of nitrates usually does not have a direct effect on aquatic insects or fish. However, excess levels of nitrates in water can create conditions that make it difficult for aquatic insects or fish to survive. Algae and other plants use nitrates as a source of food. Nitrates are not utilized by aquatic organisms such as fish and aquatic insects, but nitrates are used by aquatic plants. All aquatic organisms excrete wastes and aquatic plants and organisms eventually die. These activities create ammonia. Some bacteria in the water change this ammonia to produce nitrite which is then converted by other bacteria to nitrate. Nitrates (NO_3^-) are an oxidized form of nitrogen and are formed by combining oxygen and nitrogen. In the study, the values of nitrate and ammonia are within the limit as per (IS:2296: 1992). The values of nitrate ranged from 9.71 to 14.6 mg/L. The values for ammonia ranged from 0.07 to 0.21mg/L.

Nitrite

Nitrates and nitrites are nitrogen-oxygen chemical units which combine with various organic and inorganic compounds. Denitrification in Eutrophic (Nutrient Rich) Lakes Denitrification only occurs at low oxygen levels, and hence is typically restricted to sediments, although it also occurs in the deoxygenated hypolimnia of some lakes. In eutrophic lakes that are stratified, concentrations of N_2 may decline in the epilimnion because of reduced solubility as temperatures rise and increase in the hypolimnion from de-nitrification of nitrate (NO_3) to nitrite (NO_2) to inorganic nitrogen (N_2). Concentrations of nitrite in lakes are usually very low unless organic pollution is high. In the study, the nitrite in zone 1 and zone 2 is 0.01 and in zone 3 is 0.28 and in zone 4 is 0.02 (all are in mg/L). The limits are not mentioned in Indian Standards.

Dissolved Oxygen and Biochemical Oxygen Demand

Dissolved oxygen is defined as how much oxygen is dissolved in water. BOD is how much oxygen is consumed by microorganisms. DO and BOD are opposite each other. Like terrestrial animals, fish and other aquatic organisms need oxygen to live. Oxygen can be present in the water, but at too low a concentration to sustain aquatic life. Oxygen also is needed by virtually all algae and all macrophytes, and for many chemical reactions that are important to lake functioning. DO always varies with temperature. Photosynthesis is the primary process affecting the dissolved-oxygen/temperature relation; water clarity and strength and duration of sunlight, in turn, affect the rate of photosynthesis. Dissolved-oxygen concentrations fluctuate with water temperature seasonally as well as diurnally (daily). In the present study, DO in zone 1 is 5.9 mg/L, in zone 2 is 6.08 mg/L, in zone 3 is 9.45 mg/L and in zone 4 is 7.93 mg/L. The maximum DO is found in zone 3 and zone 4 it shows the presence of high algal growth. The values of zone 1 and zone 2 within the limit as per IS:2296: 1992. According to designated best use (IS:2296: 1992), zone 1 and zone 2 may be good for drinking water source with conventional treatment but after disinfection. Biological Oxygen Demand (BOD) is a measure of the oxygen used by microorganisms to decompose this waste. If there is a large quantity of organic waste in the water supply, there will also be a lot of bacteria present working to decompose this waste. In this case, the demand for oxygen will be high (due to all the bacteria) so the BOD level will be high. As the waste is consumed or dispersed through the water, BOD levels will begin to decline.

Reason of high BOD may be nitrates and phosphates in a body of water can contribute to high BOD levels. Nitrates and phosphates are plant nutrients and can cause plant life and algae to grow quickly. When plants grow quickly, they also die quickly. This contributes to the organic waste in the water, which is then decomposed by bacteria. This results in a high BOD level. When BOD levels are high, dissolved oxygen (DO) levels decrease because the oxygen that is available in the water is being consumed by the bacteria. Since less dissolved oxygen is available in the water, fish and other aquatic organisms may not survive. In the study, the levels of BOD found high in all zones. It shows that the organic pollution is very high in lake. High organic pollution contaminates the lake water and harms aquatic life. In zone 1 is 10.5 mg/L, zone 2 is 24 mg/L, zone 3 is 64.9 mg/L and in zone 4 is 54 mg/L.

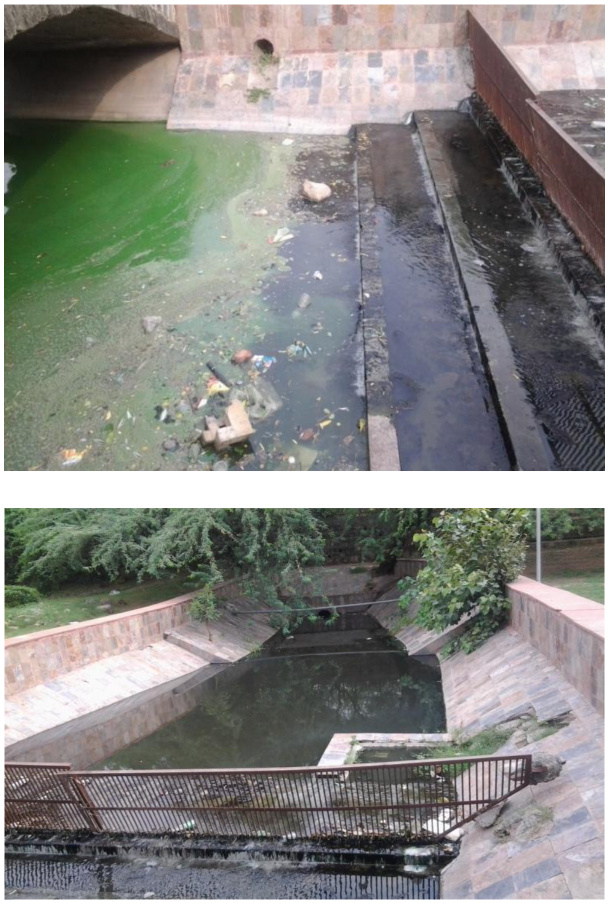

Figure 3. Pollutants enter in the Lake

BOD found highest in zone 3, 4 and 2 it may be due to urbanization because the lake is surrounded by many houses and restaurants they may be discharged their waste into the lake with the help of some channel through which lake is *eutrophicated* now. The color of lake is green due to *high algal growth.*

Table 2. Chemical and Biological analysis result of Hauz Khas Lake

S. No.	Parameters	Unit	Zone1	Zone 2	Zone 3	Zone 4
1	pH		7.98	9.6	9.7	8.1
2	Electrical Conductivity	µmhos/cm	758	745	797	760
3	Total Dissolved Solids	mg/L	440	420	460	500
4	Total Hardness(as $CaCO_3$)		110.26	106.19	211.64	129.13
5	Calcium Hardness		107.3	85.1	105.8	75.1
6	Magnesium Hardness		2.96	21	105.8	54
7	Chloride		145.9	164.87	139.09	160.98
8	Sulphate		146.2	154.5	132.9	163.6
9	Nitrate		14.6	12.7	11.6	9.71
10	Fluoride		0.46	0.45	0.45	0.38
11	Boron		0	1.22	0.25	1.42
12	Ammonia		0.14	0.21	0.11	0.07
13	Dissolved Oxygen		5.9	6.0	9.4	7.9
14	Biochemical Oxygen Demand		10	24	64.9	54

Boron

In the present study, boron found in zone 1 was 0 mg/L, in zone 2 was 1.22 mg/L, in zone 3 was 0.25 mg/L and in zone 4 was 1.42 mg/L. In most natural waters boron is rarely found in concentrations greater than 1mg/L, but even this low concentration can have deleterious effect on agriculture crops. Boron is essential for plant growth, but at high concentration it becomes deleterious. At high concentration, it affects the CNS, while extended consumption may lead to a condition known as borism.

Conclusion

It is concluded from the present study the concentration of pH in zone 2 was 9.6 and in zone 3 was 9.7 which showed the lake water in zone 2 and 3 is not suitable for irrigation, fish culture, outdoor bathing. But the pH in zone 1 and 4 was 7.9 and 8.1 that area may be suitable for outdoor bathing, fish culture and may source for drinking water with conventional treatment but after disinfection. But the pH in zone 4 was 8.1 which showed that the area is only suitable for irrigation purposes. Electrical conductivity in all zones were higher than the prescribed limit it ranged from 745 to 797 µS/cm it showed that the lake water is not suitable for certain species of fish. Turbidity also found maximum in all zone it may affect the ability of fish gills to absorb dissolved oxygen. High turbidity levels can reduce the amount of light reaching lower depths, which can inhibit growth of submerged aquatic plants and consequently affect species which are dependent on them, such as fish and shellfish. Whereas, remaining parameters like ammonia, fluoride, chloride, total hardness, nitrate and boron all these parameters found within the limit as per IS:2296: 1992 except DO and BOD. DO recorded in zone 1 was 5.9 mg/L which may be suitable for outdoor bathing and DO in zone 2 was 6mg/L that area of lake may be suitable for drinking purpose but with conventional treatment but after disinfection and DO found in zone 3 and 4 was 9.45 mg/L and 7.93mg/L it showed the presence of high algal growth and BOD in all zones found higher than the prescribed limit as per IS:2296: 1992. We concluded that the reason of high BOD it may be effect of rapid urbanization. Because the Hauz Khas lake comes under an urban area and it is surrounded by many houses and restaurants. It is clear that the lake is eutrophic completely but the highly polluted zone is zone 3 and 4 which is not suitable for bathing, irrigation and very dangerous for aquatic life. It is also clear that the reason of eutrophication in lake that an untreated sewage is released into the lake. By this way, it harms the aquatic life.

Conservation and Restoration

Water is not only the most vital requirement of all living organisms but provides the habitat to a significant proportion of the earth's biodiversity, representing practically all groups of plants and animals, ranging from the primitive microorganisms to large mammals which pass some or all stages in their life cycle in water. These water – dwelling organisms, through their interactions, confer upon the water bodies their characteristics attributes leading to the provision of specific goods and services. On the other hand, humans depend upon water not only for their biological needs but also for food production and all social and cultural activities such as industrial production, energy generation, microclimate regulation, waste disposal, navigation, recreation, aesthetics etc. therefore, humans use water bodies not only for abstracting water and their plant and and animal resources but also for a variety of in-situ activities. These activities in and around the water bodies result in the degradation of water quality changes in the aquatic plant and animal communities and gradually the loss of ecosystem goods and services provided by the water bodies. Further, all human activities on land throughout the catchment of the water bodies- such as clearing of natural vegetation, agriculture, settlements, mining and overgrazing, also impinge upon the water bodies directly or indirectly, often resulting in their shrinkage or total loss due to siltation, besides the changes in water quality.

Conservation of lakes and wetlands requires several actions to be taken together. It is necessary to first assess the current state of the water body in terms of its physical, chemical, hydrological and biological characteristics and then determine the objectives and goals for which the water body is to be conserved. These may relate to the conservation of water quality and for the conservation of biodiversity depending upon the services required from the water body. The catchment (drainage basin) of the lake has to be considered an integral part of the lake for any conservation or restoration effort. If the catchment has been degraded irreversibly (eg, complete urbanization), or the hydrology has been altered greatly or large amounts of toxic substances have accumulated in the lake and biodiversity has been affected considerably. It may be nearly impossible to restore the lake. In India, there are several thousand lakes and a majority of them needs restoration to varying extents. Too many problems and causative factors have to be addressed and obviously, no amount of money or time can be enough to undertake restoration of these lakes individually. Conservation and management of the water bodies accordingly involves bringing together a large array of stake holders and the difficult ion and task of resolution of the conflicts between their interests. It requires coordination between different user organizations and stake holders. A participatory approach to the preparation and implementation of all management action plans. It further requires the support by way of appropriate policies that consider water bodies in an integrated holistic manner. Adequate and appropriate institutional arrangements are required to ensure the implementation of policies and management plans (MoEF, 2010).

Ministry of environment and forests has developed two programmes for the conservation of water bodies. The National Wetland Conservation Programme was initiated as early as 1983. Both lakes and wetlands were considered for conservation under this programme until 1989. However, considering the difference in the nature of activities required for the conservation of lakes, which were mostly in urban areas and hence required greater attention for pollution abatement, a separate National Lake Conservation Plan (NLCP) was initiated in 2011.

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