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Original Research Paper

Impact of Three Different Types of Aeration Units on Limnology and Fish Fauna in a Eutrophic Tropical Wetland, Lower Lake, Bhopal, India

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ABSTRACT

In Bhopal, more than twenty five water bodies are present in and around the city, most of which are under great environmental stress due to multiple anthropogenic activities. The Upper Lake and Lower Lake, jointly known as Bhoj-Wetland (Ramsar Site), are situated in heart of the city and also the lifeline for the citizens of Bhopal. Lower Lake is eutrophicated due to mixing of domestic raw sewage, slums and human intervention in fringe areas, huge growth of aquatic macrophytes, idol immersion and removal of oxygenated surface water through waste weir etc. Due to these anthropogenic activities, sometimes anaerobic conditions were also reported in hypolimnion region causing mass mortality of fish fauna before installation of aeration units. The catchment area of Lower Lake is 9.6 km^2 with water spread area 1.3 km^2. For improving water quality and oxygenation of lake water three types of aeration units were installed under Bhoj Wetland Conservation and Management Programme: they are (i) Floating Fountain (ii) Ozoniser and (iii) Floating Fountain cum ozoniser. For performance and evaluation of these different types of aeration units various parameters such as pH, alkalinity, free carbon dioxide, dissolved oxygen, biochemical oxygen demand, nitrate and fish fauna were taken. On basis of the observations all three types of aeration units are effective for management of Eutrophication and improving water quality, however, floating fountain cum ozoniser is most effective for over all improvement in water quality of the lake and creating better environment for fish survival and fish growth.

INTRODUCTION

The Upper and Lower lakes, popularly called Bhoj wetland (Ramsar Site) are ecological landmark on the map of Bhopal city of Madhya Pradesh, India. The Upper lake, situated on the south-west side of the city, is lifeline for the citizens of the city whereas the Lower lake is surrounded by urban agglomeration and gives a panoramic view maintaining climate of the city and also the dividing line between old and new city. The twin impoundments have made Bhopal "the city of lakes".

Unfortunately, Bhopal has no river system and thus, the lakes and reservoirs are vital for meeting water demand of ever-growing population of the city. The population of the city is more than 17 lakhs. In the past, water from the Upper lake was adequate to meet the water demand of the city, but due to increasing population in the past three decades, the lake water became insufficient, therefore, Kolar water supply (35 km from city) has been installed to meet growing water demands. In the present scenario even both these water bodies are insufficient to meet the growing water needs. Finally, Government of Madhya Pradesh is going to bring Narmada river water (80 km from city) to bridge the gap between demand and the supply of the drinking water. Therefore it is necessary to conserve and manage the available aquatic resources in and around the city for future.

The Lower lake is badly managed and under great environmental stress due to multiple anthropogenic activities. As a result, water quality of the lake is getting deteriorated day by day and also gradually getting filled up leading to eutrophication.

With the financial assistance from Japan Bank for International Co-operation (JBIC), State Government and Government of India executed a major Project on conservation and management of Bhoj wetland amounting to Rs. 247 crores. The project is comprised of 21 sub-projects, of which the main are: (i) desilting and deweeding, (ii) afforestation, (iii) catchment area treatment, (iv) solid waste treatment, (v) shifting of Dhobi-ghat, (vi) sewage collection diversion and treatment, (vii) deepening and widening of spill channel, (viii) aquaculture, (ix) construction of physical barrier (road) between habitation and lake, (x) public awareness, (xi) lake view promenade at lake shore, (xii) water quality monitoring, (xiii) strengthening of earthen dam, and (xiv) installation of aeration units, etc.

Under this sub-project, three different types of aeration units have been installed to oxygenate the lake water especially in hypolimnion zone. This activity has not only improved the water quality but also increased the scenic beauty and became a tourist attraction and provide better environment and water quality for survival of aquatic fauna

especially fish. There is a significant difference between fountains and aerators. The primary function of an aerator is to add oxygen and induce circulation in the water. The primary function of a fountain is to create an aesthetic effect.

The other major advantages of aeration units are: (i) reduction of growth of algal blooms by converting soluble phosphorus into non-soluble form, (ii) increase of fish growth, (iii) increased living space for fish to increase their production, (iv) reduction of organic bottom sediment (muck), (v) prevention of summer/winter kill of fish, and (vi) overcoming of taste and odour problems. Due to vertical water movement and mixing of lake water, overall dissolved oxygen level increases in water column.

The present study focused on the impact of different types of aeration units: (i) floating fountain, (ii) ozoniser, and (iii) floating fountains cum ozoniser on the lake water.

Morphometric features of Lower lake: Some of the important morphometric and other features of the Lower lake are as below.

1. Period of Lake formation	:	1794 by Nawab Chhote Khan
2. Type of the dam	:	Earthen dam
3. Location: (Longitude)	:	77°24'-77°26'E
(Latitude)	:	23°14'-23°15'N
4. Catchment area	:	9.6 km^2
5. Water spread area	:	1.3 km^2
6. Shoreline length	:	6.16 km
7. Maximum length	:	1.6 km
8. Maximum width	:	0.9 km
9. Maximum depth	:	9.4 m
10. Discharge of wastewater	:	7.3 M.G.D. (Million Gallons per Day)
11. Source of water	:	Rain water, seepage from Upper lake and domestic raw sewage
12. Main use of water	:	Washing, boating and aquaculture

Associated problems of Lower lake: Following are the important facts which are responsible for the deterioration of the water quality as well as degradation of the environmental status of the lake:

a. Siltation of the lake due to mixing of untreated domestic sewage, garbage, etc. The inflow of approximately 7.3 M.G.D.
b. Washing activities.
c. Human intervention in fringe area of the lake.
d. Huge quantity of nutrient input in the lake ecosystem due to death and decay of aquatic macrophytes.
e. Removal of oxygenated surface water through waste weir at Pul-Pukhta.
f. Unmanaged aquaculture.
g. Pollution from point and non-point sources.
h. Idol immersion
i. Algal blooms.

MATERIALS AND METHODS

For impact of different types of aeration units on the lake limnology, samples were collected near the aeration units, before 6-10 hours prior to the functioning of units and during the functioning of aeration units from surface and bottom of the lake during year 2009 for comparative study.

Assessment of different physical, chemical and biological parameters was made by the methods of APHA (1995) and NEERI (1986).

The aeration units: The main objective of installation of floating fountain was to oxygenate the lake water through aeration. The desirable oxygen level in water is essential for biotic life of the lake. The three types of aeration units were installed under Bhoj Wetland programme and these floating units can be moved in the radius of 500 meter to cover maximum water area of the lake. They are as:

a. Floating fountains: Units are simple type of floating fountains which take water from hypolimnion/ metalimnion with higher quantity and the height of jet fountain is about 80 feet approximately (Fig. 1).

b. Ozoniser: Units convert oxygen into ozone and pump to deeper zone of the lake. These units have no fountain (Fig. 2).

c. Floating fountain cum ozoniser: Units have both the systems, fountain as well as conversion of the oxygen in to the ozone. Height of the jet fountain is comparatively lower (Fig. 3).

RESULTS AND DISCUSSION

Lake aeration system was first described by Wand & Foley (1919). Shuler (1972) reported that taste and odour problems can also be overcome to some extent by legation through oxidation of reduced organic and inorganic compounds. Chern & Cheng (1997) worked on oxygen transfer modelling of diffused aeration system. Rusan (1971) emphasized use of ozone application for wastewater treatment. Al-Ahmady (2006) analysed oxygen transfer performance on sub-surface aeration systems. Bhuyar et al. (2009) studied design characteristics of curved blade aerator with respect to aeration efficiency and overall oxygen transfer coefficient and comparison with CFD modelling.

Impact of different aeration units on different physico-chemical conditions during pre-operation and during operation on surface and bottom waters is shown in Fig. 4. The

Fig. 1: Floating fountain

Fig. 2: Ozoniser

Fig. 3: Floating Fountain cum Ozoniser

lake water was found to be of alkaline nature and its pH varied from 7.2-8.4. Slight reduction in pH value was noticed during operational period of aeration units. The alkalinity is the sum total of carbonate and bicarbonate. According to Spence (1967) if the alkalinity is more than 60 mg/L the lake is nutrient rich. In the present investigation, the range of total alkalinity varied from 140-220 mg/L. On the basis of the alkalinity values, Lower lake can be considered nutrient rich. Significant reduction was noted during operation period of aeration units.

Most of the time free carbon dioxide was absent on surface, which may be due to its utilization in photosynthetic activities of algal blooms and aquatic macrophytes, whereas higher values were detected at bottom, which may be due to high rate of organic decomposition with low or no photosynthesis. Aeration units play significant role in reduction of carbon dioxide especially in hypolimnion region.

Dissolved oxygen in water is of great importance to all aquatic organisms and indicator of water quality especially the magnitude of eutrophication. Tamot (1998) reported lower range of dissolved oxygen in hypolimnion zone of Lower lake, Bhopal. Eutrophicated water bodies have wide range of dissolved oxygen in which oxygen is more at surface and depletes fast with the depth. In the present investigation wide range of dissolved oxygen was noted from 3.4 to 14.0 mg/L. Floating fountain cum ozoniser and ozoniser are most effective aeration units for increasing dissolved oxygen level in water column. Due to lack of oxygen/anaerobic condition especially in cloudy weather, mass fish mortality was reported before installation of these aeration units. After installation of the aeration units, sufficient oxygen was recorded in water column, which supports better environment and water quality for survival and faster growth of fish.

Biochemical oxygen demand is a good indicator for presence of organic pollution. Kaushal & Sharma (2000) stated that high BOD may cause indirect harm by reducing dissolved oxygen inimical to fish life and other beneficial aquatic organisms. In the present investigation, its range varied from 6.2 to 22.0 mg/L with higher values recorded in hypolimnion zone. Floating fountain cum ozoniser and ozoniser play significant role for reduction in BOD.

Nitrate is an important plant nutrient. It is one of the most oxidized forms of nitrogen and occur in varying amount in the lake water depending upon the nature of the water shade, season, degree of pollution and abundance of planktonic life (Rodhe 1969, Sommer 1989). Its range varied from 0.3 to 1.6 mg/L. Reduction in nitrate value was noted during operation of aeration units. Bengtssen & Gelin (1975) reported that aeration can be an effective method to reduce the nutrient concentration of the lake and improve overall water quality.

Cowell et al. (1987) supported the present findings. He worked on impact of lake aeration on the limnology of a hyper-eutrophic lake in central Florida and found significant increase in dissolved oxygen at bottom and decline in pH and alkalinity values, and reduction in the density of blue green algal blooms.

In Lower lake more than 20 fish species were reported, most fish were: *Ctenopharygodon idella, Catla catla, Labeo*

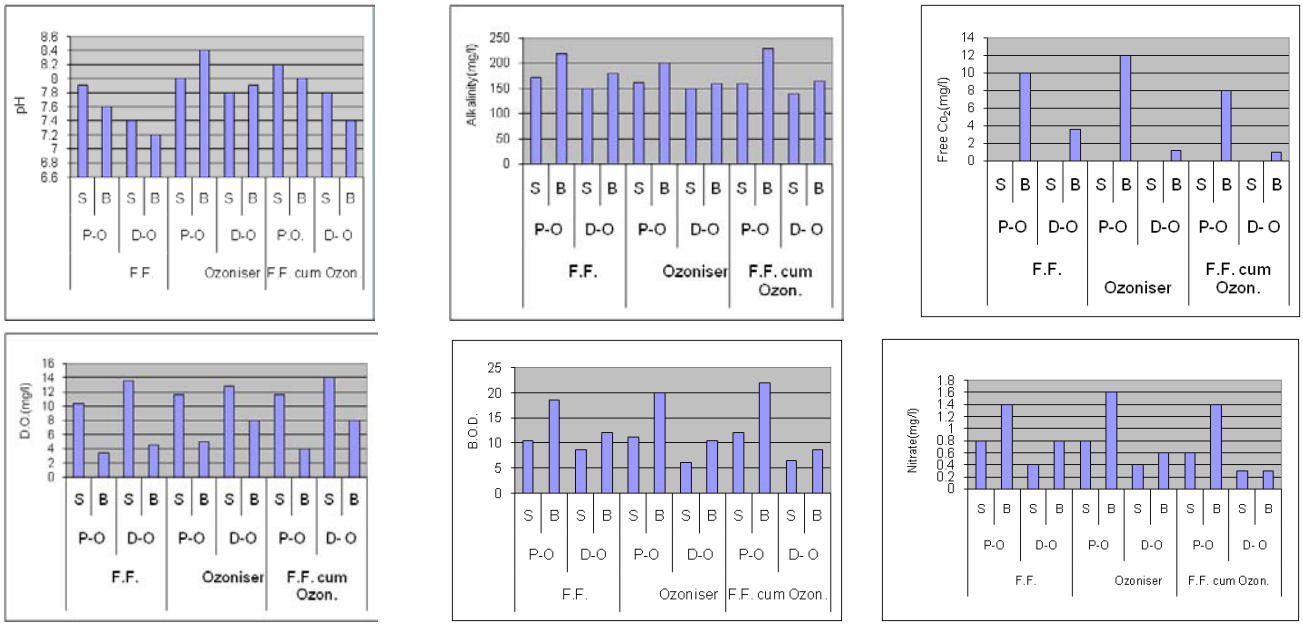

Fig.4: Impact of aeration units (Floating Fountain: FF, Ozoniser and Floating Fountain cum Ozoniser on different physical and chemical parameters during pre-operation (P-O) and during operation (D-O) in surface (S) and bottom (B) waters.

rohita, *Chana punctatus*, *Mastacembelus armatus*, *Mystus seenghala* and *Wallago attu.* Due to installation of aeration units, dissolved oxygen level in water column was found satisfactory and no mass fish mortality recorded.

CONCLUSION

On the basis of the present observations, all three types of aeration units play a significant role in lake limnology. But, Floating fountain cum ozoniser has given the best results in reduction of the BOD, free carbon dioxide and total alkalinity, and increasing dissolved oxygen and nutrient loading. Ozoniser unit was most effective for controlling the growth of bacteria. Floating fountain is also effective for increasing dissolved oxygen level and also the scenic beauty of the lake.

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