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Original Research Paper

Assessment of Water Quality for Aquaculture - A Case Study of Madhavara Lake in Bangalore

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ABSTRACT

Periodical physicochemical analysis of Madhavara lake, a freshwater body, in Bangalore, was carried out from July, 2005 to June, 2006. Water quality for aquaculture was estimated with the parameters such as temperature, pH, conductivity, dissolved oxygen (DO), biochemical oxygen demand (BOD), chemical oxygen demand (COD), chlorides, hardness, nitrate, phosphate, sulphate and ammonical nitrogen. Results indicate severe deterioration of the water quality in this lake. The study suggests the water quality of Madhavara lake to be highly polluted, and hence, unfit for aquaculture.

INTRODUCTION

Fish are totally dependent upon water to breathe, feed and grow, excrete wastes, maintain a salt balance and reproduce. Hence, understanding the physical and chemical qualities of water is critical to successful aquaculture. The quality of water not only determines growth of fish in aquaculture operation, but also their survival. Fish perform all their bodily functions in water. Thus, to a great extent water determines the success or failure of an aquaculture operation. Fish influence water quality through processes like nitrogen metabolism and respiration. While, some water quality factors such as dissolved oxygen, temperature and ammonia are involved with fish kill, others, such as pH, alkalinity, hardness and clarity, though affect fish, are not usually directly toxic (Joseph et al. 1993). A detailed study of the water quality of any water body is of importance as it provides information about the water quality status necessary for effective management of water bodies. It is with this background that the present study was taken up.

Madhavara lake, located north of Bangalore, is subjected to severe stress from people living around the lake and the urban community as the populace is releasing domestic sewage directly into it and making the lake polluted. Therefore, it is necessary to protect this lake, which is deteriorated by cultural pollution. The present study will help in more effective management of sustainable fisheries in this lake.

MATERIALS AND METHODS

Water samples from Madhavara lake were collected periodically from July, 2005 to June, 2006 (8 a.m. to 10 a.m.) in polythene bottles at five sites avoiding bubbling, and brought to the laboratory and preserved for further analysis. Physicochemical parameters like pH, conductivity, DO, BOD, COD, chlorides, hardness, nitrate, phosphate, sulphate and ammonical nitrogen were estimated employing standard methods (APHA, AWWA 1985 and Trivedy & Goel 1986). Temperature was measured at the collection site.

RESULTS AND DISCUSSION

The average values of water quality parameters are shown in Table 1. Temperature is one of the most important physical factors which control the biological characters of any ecosystem. In the present study the highest temperature was recorded in the month of September (24°C), and lowest in the month of January (18°C). It corresponds to the prevailing climatic condition. At temperatures above or below optimum, fish growth is reduced, and if extremes, fish mortalities occur (Joseph et al. 1993).

pH values of the lake water varied between 7.28 (July) and 9.15 (January) indicating an alkaline nature of water. Lake water exhibited more or less similar pH and showed highly alkaline nature of water body. Higher value of pH can be attributed to higher growth rate of algal population which utilized CO_2 through photosynthetic activities (Chaterjee & Raziuddin 2006).

The electrical conductivity value is an index to represent the total concentration of soluble salts in water. In the lake variation from 1.70 mS (April) to 2.98 mS (September) were observed. The higher values recorded during summer months may be due to accumulation of ions owing to evaporation, biological turnover and interaction with sediments. These findings are in agreement with statement of Payne (1986).

Dissolved oxygen (DO) is probably the most critical water quality variable in freshwater aquaculture. It was found to be in the range of 3.72 mg/L (November) to 5.96 mg/L (December). Diffusion of oxygen from air into water, production through photosynthesis and consumption by biota, all affect the solubility and availability of many nutrients and thereby productivity of aquatic ecosystem (Wetzel 1983). Low content of DO, a sign of organic pollution, is also due to inorganic reductants like hydrogen sulphide, ammonia, nitrates, ferrous iron and other such oxidisable substances (Khatavkar et al. 1989, Ara et al. 2003).

Biochemical oxygen demand (BOD) values vary between 6.15 mg/L (June) and 10.95 mg/L (January). Greater the BOD values, the more rapidly oxygen is depleted in the water. The level of

Table 1: Physicochemical characteristics of Madhavara lake in various months during 2005-2006.

Parameter/ Month	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb	Mar	Apl	May	Jun
Temperature	23	23.5	24	20	20.5	18	18	20	21.5	22.5	22.5	22.5
pH	7.28	7.87	7.96	8.12	8.23	8.27	9.15	8.36	8.32	7.77	7.52	7.81
Conductivity	2.26	2.04	1.29	1.38	1.70	2.30	2.26	2.40	1.52	2.98	2.55	2.41
DO	5.52	5.8	5.6	5.88	5.96	3.72	4.08	3.96	4.36	3.86	4.26	3.86
BOD	6.87	7.25	7.7	8.7	8.55	9.35	10.95	10.4	6.71	7.75	7.5	6.15
COD	67.4	65.7	52.6	57.74	70.866	75.16	109.56	129.95	154.09	139.47	24.71	102.04
Hardness	596.2	463	316.4	366	476.4	595.2	678.8	557.6	487.6	526.4	498	462.4
Calcium	139.2	97.4	72.24	80.32	111.36	139.04	151.04	119.2	95.2	95.68	100	104.32
Magnesium	55.03	53.3	35.2	40.144	48.114	60.167	73.192	63.083	60.652	90.489	60.264	48.988
Chloride	519.2	362.	355.2	264.8	456	508	894	753.2	672.4	703.2	629.2	612
Fluoride	0.47	0.16	0.59	0.27	0.412	0.286	0.144	0.433	0.43	0.408	ND	0.11
Nitrate	18.36	13.7	1.876	0.801	3.08	2.24	0.99	0.99	0.058	0.139	0.45	0.394
Phosphate	1.167	0.86	0.95	0.28	0.653	1.1656	0.854	1.26	1.018	0.704	1.798	1.8
Sulphate	39.532	23.1	25.6	49.44	34.88	58.44	65.36	45.76	76.8	63.2	56.64	30.88
Amm-N	0.02	0.01	0.01	0.08	0.701	0.96	1.55	1.12	1.3	0.67	1.178	2.76

N.B. All the values are in mg/L expect temperature (°C), pH and conductivity (mS).

BOD may be increased by domestic sewage due to enhanced organic pollution into the water body. The chemical oxygen demand (COD) was found to be in the range of 24.71 mg/L (May) to 154.09 mg/L (March), which is beyond the permissible limit of standards prescribed by ISI and WHO (1984). The high COD could be attributed to addition of dissolved and suspended solids from nearby surroundings. It represents oxidisable load of organic matter in water.

Water hardness ranges from 316.4 mg/L (September) to 596.2 mg/L (July). Maximum hardness in water in July can be attributed to low water level and high rate of evaporation due to higher atmospheric temperature. Calcium is a dominant cation which ranges from 72.24 mg/L (September) to 139.2 mg/L (July). The level was low in September probably due to its utilization by the biotic community. Increase in summer is due to the decomposition of plants and fall off of marl that coats the shoots of submerged macrophytes as observed by Purohit (1989) in other lakes. Magnesium is an essential micronutrient for both autotrophs and heterotrophs, which fluctuates between 35.2 mg/L (September) and 90.489 mg/L (April). The higher values of Mg may be due to its release from the bottom sediment and due to decomposition of biota.

The presence of chloride in the lake water was mainly due to domestic sewage and its value ranged from 519.2 mg/L (July) to 894 mg/L (January). The presence of chloride concentration in the water is used as an indicator of organic pollution by domestic sewage (NEERI 1979). High chloride values may be due to organic wastes of animal origin and domestic wastes, the higher concentration of chloride during summer months may be associated with reduced water level and frequent runoff loaded with contaminated water from the surrounding settlement. Higher values of chloride also reflect the magnitude of organic pollution (Vass & Zutshi 1983). The presence of fluoride was found to be 0.388 mg/L. This may be due to the excessive use of fertilizers. Rise in the fluoride content in the water bodies is of great concern for the surrounding environment, and it is suggested that discriminate and excess use of the fertilizers may be avoided.

Nitrate is an important parameter to determine the extent of organic pollution in a water body as several species of diatoms, green and blue green algae use either nitrate or ammonia directly for their growth. In the present study nitrate showed a variation from 0.394 mg/L (June) to 18.36 mg/L (July). The main source of nitrate in a water body is decomposition of organic nitrogenous matter. There exists a direct relation between the degree of pollution and concentration of nitrate (Agrawal et al. 1976). The low values noticed in June are due to the utilization of nitrate by phytoplankton. Similar results were noticed by Khatavkar et al. (1989) in different lentic water bodies of India.

Inorganic phosphorus or orthophosphate plays a dynamic role in water bodies as it is readily taken up by phytoplankton (Heron 1961). The major reason of increased concentration is the use of detergents with long chain phosphate compounds and use of the pond as receptacle for the waste disposal. According to Golterman (1975), the increased application of fertilizers, use of detergents and domestic sewage play major roles in the contribution of heavy loading of phosphorus in water.

The concentration of sulphate was in the range of 23.1 mg/L (August) to 76.8 mg/L (March). A few studies have reported sulphate toxicity to some aquatic organisms, including some fish and aquatic mosses at concentrations at or below 100 mg/L. Sulphate (SO_4^{2-}) pollution of surface water and groundwater is known to influence eutrophication in freshwater water bodies (Boström et al. 1982, Caraco et al. 1989, Roelofs 1983, Murray 1995, Lamers et al. 1998, Beltman et al. 2000).

Ammonia is present in two forms in water, as gas (NH_3) or as ammonium ion (NH_4^+) and fluctuates from 0.01 mg/L (August to September) to 2.76 mg/L (June). Ammonia is toxic to culture

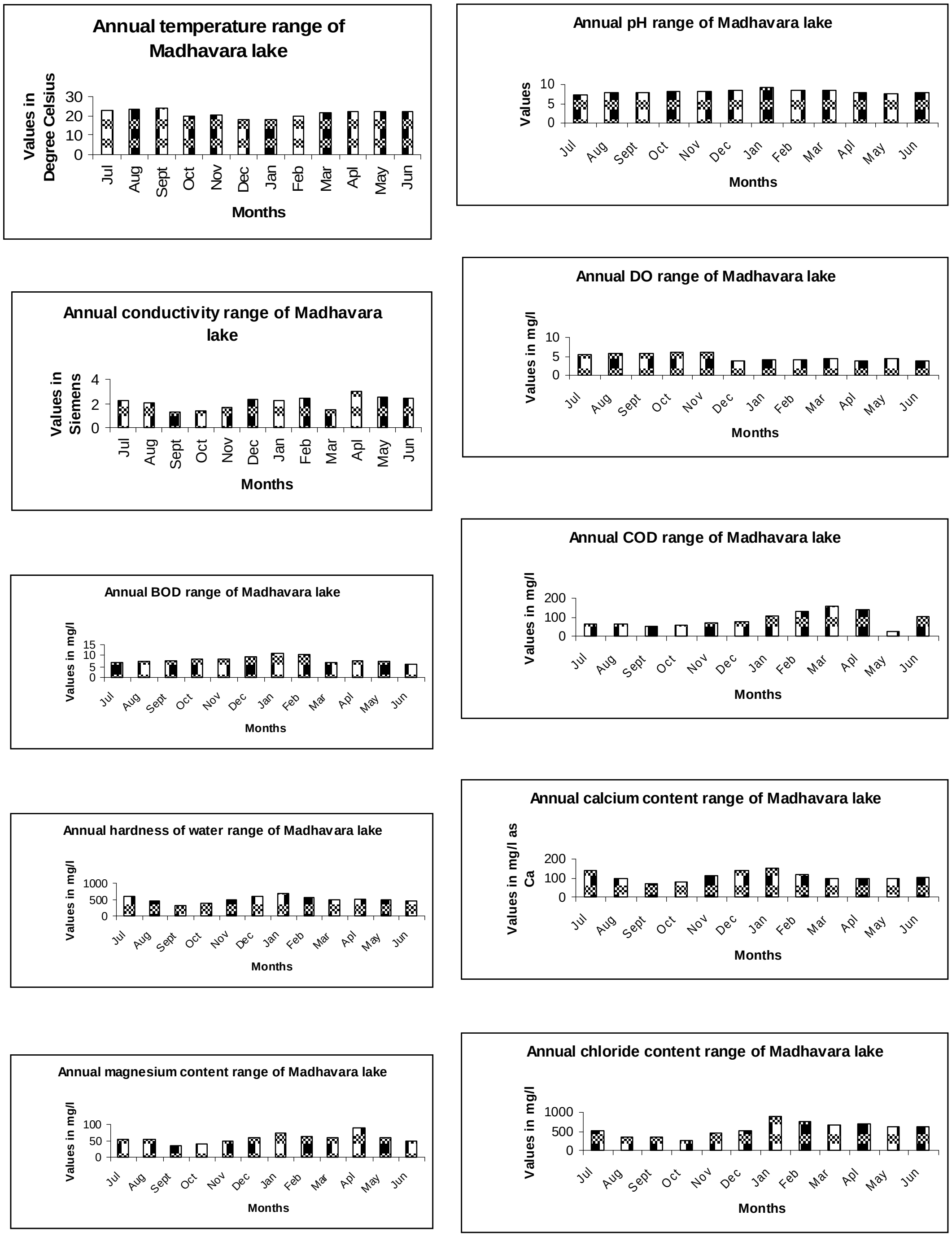
Annual temperature range of Madhavara lake
Values in Degree Celsius
30
20
10
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months
Annual pH range of Madhavara lake
Values
10
5
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months
Annual DO range of Madhavara lake
Values in mg/l
10
5
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months
Annual conductivity range of Madhavara lake
Values in Siemens
4
2
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months
Annual COD range of Madhavara lake
Values in mg/l
200
100
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months
Annual BOD range of Madhavara lake
Values in mg/l
15
10
5
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months
Annual calcium content range of Madhavara lake
Values in mg/l as Ca
200
100
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months
Annual hardness of water range of Madhavara lake
Values in mg/l
1000
500
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months
Annual magnesium content range of Madhavara lake
Values in mg/l
100
50
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months
Annual chloride content range of Madhavara lake
Values in mg/l
1000
500
0
Jul Aug Sept Oct Nov Dec Jan Feb Mar Apl May Jun
Months

Fig. 1 Cont....

Cont. Fig. 1...

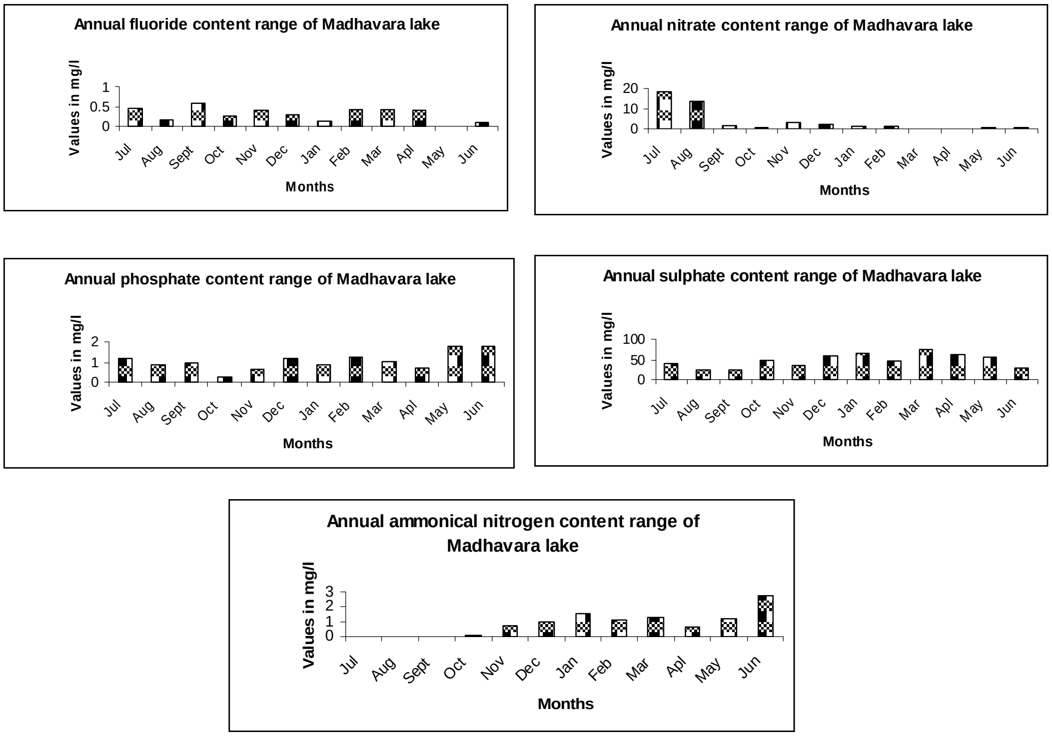

Fig. 1: Monthly variations in physicochemical characteristics of Madhavara lake during 2005-2006.

animals in the gaseous form and can cause gill irritation and respiratory problems. Ammonia levels will depend on the temperature of the lake water and its pH. For example at a higher temperature and pH, a greater number of ammonium ions are converted into ammonia gas, thus, causing an increase in toxic ammonia levels within the freshwater lake.

From the present study it may be concluded that Madhavara lake is not ecologically conducive for aquaculture as most water quality parameters for aquaculture are above permissible limits. It appears that release of domestic sewage without treatment is one of the reasons for pollution. Further, there is a need to increase the DO content for reducing the turbidity, BOD as well as total suspended solids of lake water. If Madhavara lake, an ecologically important lake, is to be used for aquaculture then effective management measures must be taken up.

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