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Geochemical Assessment of Fort Lake, Belagavi: A Comparative Study of Physico-Chemical Parameters

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Abstract—

Fort Lake (Kote Kere) is an urban lake in the heart of Belagavi, Karnataka, that received sewage until remedial measures began in 2005. This paper compares the monthly physico-chemical data of the lake for 2004, 2006 and 2010 taken from published research papers. Eight parameters are considered: pH, hardness, total dissolved solids (TDS), chloride, electrical conductivity, biochemical oxygen demand (BOD), dissolved oxygen (DO) and nitrate. Mean BOD falls from 14.18 mg/L in 2004 to 5.79 mg/L in 2006 and 1.44 mg/L in 2010 (July–September only). Mean chloride falls from 121.4 to 61.2 and then 48.4 mg/L, and mean DO rises from 4.66 to 6.25 mg/L between 2004 and 2006. Chloride and nitrate stay far below the limits of IS 10500:1991 in all years, and pH is within 6.5–8.5 in 34 of 36 months. The data show a clear improvement in organic pollution after the remedial measures reported in the literature. They do not cover recent years, and several parameters are missing for 2010.

Index Terms—Fort Lake, Belagavi, water quality, physico-chemical parameters, BOD, dissolved oxygen, lake pollution.

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I. INTRODUCTION

Water is a vital natural resource, and it is under growing pressure from population growth and indiscriminate use. Urban lakes are especially exposed. Domestic sewage, agricultural run-off, laundering and rapid urbanisation raise the pollution load and change the physico-chemical properties of the water, which in turn affect the distribution and richness of aquatic life. The nutrients that enter cause eutrophication and excess algae, silt settles on the bed, and the lake becomes shallower and smaller. Water quality is assessed through physico-chemical parameters, and their study shows the severity of pollution and helps protect the lake in future.

A. Study area

Fort Lake (Kote Kere, also called Killa Lake) lies in the heart of Belagavi and takes its name from the historic fort in front of it. It covers 66 acres, of which 43 acres are water spread (about 27 ha), with a depth of 6 m, a catchment of 2.27 km² and a command area of 573 acres [1]. It lies in the Krishna basin and the Ghataprabha sub-basin. The lake is a prime tourist spot, used for boating, walking, a food plaza and sightseeing (Fig. 1). The land irrigated from it has fallen from 570 to 340 acres because of urbanisation.



Fig. 1. Fort Lake, Belagavi: (a) aerial view, (b) after development.

B. Status of the lake

Three main sewage inlets drained into the lake: a drain from the circuit house corner, a drain from the Shivaji Nagar area, and a masonry channel near the BUDA corner through a pipe culvert [2]. Storm water is the major inflow, and there is no continuous outflow. The outlet works only when the level exceeds the sill during the monsoon, from June to September. Sludge accumulated through the inlets to about 85,000 m³ at an average depth of 0.31 m. Remedial measures from 2005 desilted the basin, bypassed the sewage through the underground drainage, stopped washing of clothes, cattle and vehicles, fenced the border and added a garden along the road [2]. An aeration fountain was installed to raise the oxygen level (Fig. 2).



Fig. 2. (a) Entry of sewage into the lake, (b) aeration fountain.

C. Climate

Belagavi has a tropical climate with almost continuous monsoon rain from June to September. Winter (November–February) is the coldest period, with temperatures falling to 7 °C, and April is the hottest month, reaching about 38 °C.

II. OBJECTIVES OF THE PROJECT

The objectives of the project are: (i) to study the water pollution status of Fort Lake, Belagavi, and (ii) to carry out a comparative study of the lake from published research papers. To meet them, the monthly values of eight physico-chemical parameters for 2004, 2006 and 2010 are compared with each other and with the limits cited in the report.

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III. Literature Review

Nagraj and Patil [2] collected water samples from Killa Lake at two places and found the lake polluted by the entry of sewage. After the basin was desilted, the city sewage bypassed and only storm water allowed in, the physico-chemical parameters of the lake improved.

Giriyappanavar and Patil [3] studied the seasonal water quality index of the lake. The lake was more affected in summer than in winter, because low temperature reduces microbial activity and keeps DO at a satisfactory level through winter. Most parameters were slightly higher in the wet season than in summer, and a total ban on polluting activities was suggested.

Bhattacharya and Shandilya [4] studied the Upper Lake of Bhopal, the main source of potable water for half the city. They measured pH, colour, turbidity, BOD, hardness, TDS, chloride, carbon dioxide, COD and bacteriological parameters before and after treatment, to judge the water supplied. Physico-chemical studies of other tanks and lakes have also been reported [5]–[7].

IV. Methodology

A. Data collection

The present study uses the data of previous journal papers on Fort Lake and compares them (Fig. 3). The monthly values for 2004, 2006 and 2010 are taken from these papers. The tests reported and their methods follow standard practice [8] and are listed in Table I. DO, turbidity and temperature were measured on the spot, and the other parameters were tested in the laboratory with standard methods [8].

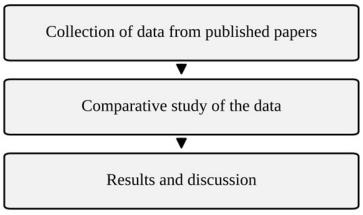


Fig. 3. Methodology of the study.

Table I
Parameters and Test Methods

Parameter	Method
pH	pH meter
Hardness	EDTA titrimetric
Chloride	Mohr's titrimetric
Electrical conductivity	Conductivity meter
Nitrate	UV-visible spectrophotometer
Total dissolved solids	Gravimetric
Biochemical oxygen demand	Titrimetric
Dissolved oxygen	Titrimetric

B. Parameters

pH reflects the chemical condition of the water and controls the availability of nutrients, biological function and microbial activity. BOD is the oxygen used by aerobic micro-organisms in oxidising organic matter, and it is a sensitive indicator of organic pollution. Hardness is the property that prevents water from forming lather with soap. TDS is measured gravimetrically by evaporating the water and weighing the residue. Chloride is found in all natural waters and rises with pollution from organic waste. Electrical conductivity measures the ability of the water to conduct electricity and depends on the concentration and type of ions and on temperature. DO is essential for aquatic life and comes from diffusion from air and photosynthesis. Nitrate is the most oxidised form of nitrogen and results from aerobic decomposition of organic nitrogen.

V. Results and Discussion

A. Annual summary

Table II gives the range and mean of each parameter for the three years, and Figs. 4 and 5 show the monthly values. The 2010 data cover all twelve months for pH, hardness, TDS, chloride and nitrate, but only July–September for BOD and conductivity, and none for DO.

Table II
Range (Mean) of Parameters by Year

Parameter	2004	2006	2010
pH	7.50–8.16 (7.88)	6.61–8.56 (7.85)	6.30–8.00 (7.53)
Hardness, mg/L	97–174 (133)	44–148 (107)	84–136 (100)
TDS, mg/L	320–680 (447)	220–460 (293)	140–640 (279)
Chloride, mg/L	80–148 (121.4)	28–88 (61.2)	37.2–73.3 (48.4)
BOD, mg/L	7.50–20.20 (14.18)	2.80–8.80 (5.79)	0.25–2.09 (1.44)
EC, µS/cm	465–865 (684)	350–645 (475)	640–720 (681)
DO, mg/L	3.95–6.05 (4.66)	4.90–8.70 (6.25)	—
Nitrate, mg/L	1.13–7.44 (4.02)	1.17–9.64 (4.13)	0.00–0.37 (0.15)

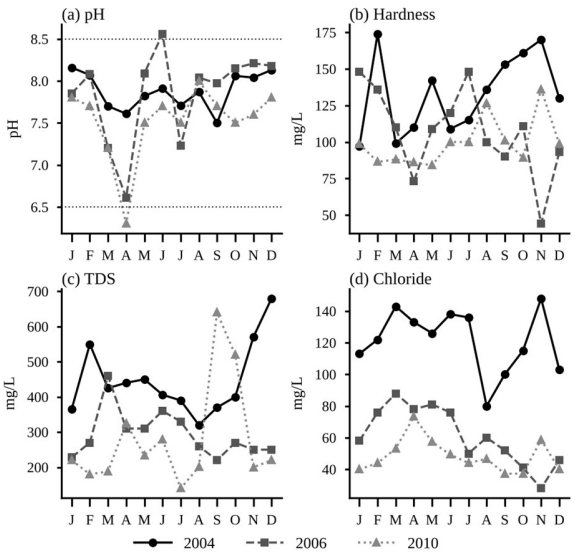


Fig. 4. Monthly pH, hardness, TDS and chloride in 2004, 2006 and 2010. Dotted lines in (a) mark 6.5 and 8.5.

B. pH and hardness

The pH lies between 6.3 and 8.56, which shows an alkaline water body with high buffering capacity. Only two of the 36 monthly values fall outside the 6.5–8.5 range permitted for public supplies by IS 10500:1991 [9]: 8.56 in June 2006 and 6.3 in April 2010. The water is hard. Using the classes 0–60 mg/L

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soft, 61–120 moderately hard, 121–160 hard and above 160 very hard, 7 months in 2004 were hard or very hard, against 3 in 2006 and 2 in 2010. Mean hardness fell from 133 mg/L in 2004 to 107 mg/L in 2006 and 100 mg/L in 2010, which the literature attributes to fresh storm water added after the improvement works.

C. TDS, chloride and conductivity

Mean TDS fell from 447 mg/L in 2004 to 293 mg/L in 2006 and 279 mg/L in 2010, although it reached 640 mg/L in September 2010. Chloride fell from 80–148 mg/L in 2004 to 28–88 mg/L in 2006 and 37–73 mg/L in 2010. It is well below the 250 mg/L limit of IS 10500:1991 [9] in all years, but it is directly related to the pollution level, so the 2004 values were slightly high. Conductivity fell from a mean of 684 µS/cm in 2004 to 475 µS/cm in 2006. The three 2010 values (July–September, mean 681 µS/cm) are higher than the same months in 2004 (558 µS/cm) and 2006 (442 µS/cm), which the data do not explain. All values are far below the 2,250 µS/cm criterion for irrigation [10].

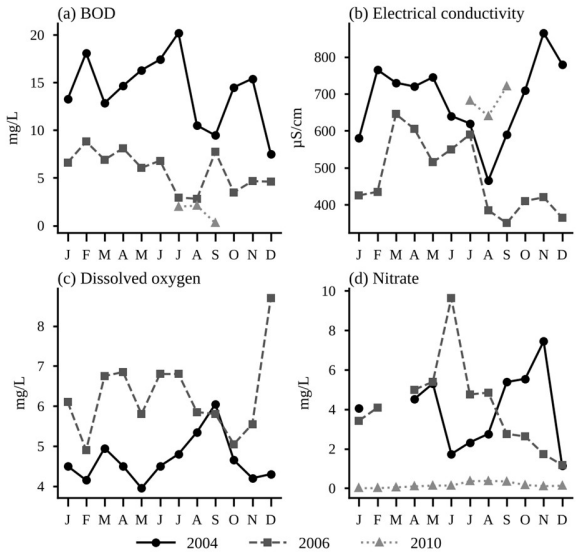


Fig. 5. Monthly BOD, electrical conductivity, DO and nitrate in 2004, 2006 and 2010. Months with no value are blank.

D. BOD, dissolved oxygen and nitrate

BOD is the clearest indicator. In 2004 it ranged from 7.5 to 20.2 mg/L (mean 14.18 mg/L), which shows heavy organic pollution. In 2006 it ranged from 2.8 to 8.8 mg/L (mean 5.79 mg/L), and in 2010 it was 0.25–2.09 mg/L in July–September. For the same three months the means are 13.38 mg/L in 2004, 4.49 mg/L in 2006 and 1.44 mg/L in 2010, so the improvement is not an artefact of the missing months. DO rose from 3.95–6.05 mg/L in 2004 to 4.9–8.7 mg/L in 2006. Nitrate was 1.13–7.44 mg/L in 2004 and 1.17–9.64 mg/L in 2006 (months reported as below the detection limit are not plotted), and it was no more than 0.37 mg/L in 2010. All values are far below the 45 mg/L limit of IS 10500:1991 [9].

E. Overall status and limitations

The data show that organic pollution (BOD, chloride, TDS) fell sharply between 2004 and 2010, and that oxygen improved between 2004 and 2006. This is consistent with the desilting, the sewage diversion and the other measures reported in the literature [2], although the data alone cannot prove the cause. The abstract of the source report calls the lake polluted and unfit for drinking. The values here show that the water meets the IS 10500:1991 limits for chloride and nitrate, but drinking suitability needs bacteriological and other tests that are not in these data, so the lake should be treated as a recreational and irrigation water body. The study uses secondary data for three years only, 2010 lacks DO and most BOD and conductivity values, and no sampling was done by the authors. The present condition of the lake is not known, so fresh sampling is needed.

VI. Conclusion

The monthly physico-chemical data of Fort Lake, Belagavi, for 2004, 2006 and 2010 show a clear improvement after the remedial measures begun in 2005. Mean BOD fell from 14.18 to 5.79 and then 1.44 mg/L, mean chloride from 121.4 to 61.2 and then 48.4 mg/L, and mean DO rose from 4.66 to 6.25 mg/L between 2004 and 2006. Chloride and nitrate are far below the IS 10500:1991 limits, and pH is within 6.5–8.5 in 34 of 36 months. The measures that helped are desilting, bypassing the sewage, allowing only storm water, stopping washing in the lake, fencing and gardening. Future work should include fresh sampling to establish the present status, bacteriological tests, the missing 2010 parameters, and a water quality index for the lake.

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