# Limnology, Diatom Diversity and Conservation of Kishore Sagar Lake, Kota, Rajasthan, India

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***Abstract*** **-** Selected aspects of limnology and Diatom diversity of Kishore Sagar lake were investigated during December, 2004 to December, 2005 to assess the water quality status with respect to management and conservation needs of this manmade lake. Based on limnological investigations, Kishore Sagar lake is considered a typical lake of tropics. The pH value of this water body was found to be on the alkaline side. Electrical conductance was found above 0.20 mS whereas the dissolved oxygen contents were found below 5 mg/l on seven occasions. This is indicator of distressed conditions of ecosystem for aquatic life and fish in particular. Free $CO_2$ varied between 2.0 to 36 mg/l whereas carbonate alkalinity was altogether absent during the study period. Total alkalinity in Kishore Sagar ranged between 80.0 to 172.0 mg/l and Total Hardness varied between 64.0 to 100.0 mg/l; Orthophosphate varied between 0.35 to 1.28 mg/l and Nitrate–nitrogen ranged between 0.0 to 0.106 mg/l.

The Diatom community of Kishore Sagar was diverse as evident from presence of forty two species representing 8 centric forms and 34 pennate types. Among the notable diatoms recorded from this wetland were *Melosira granulata, Cocconies placentula, Diatoma elongatum, Fragilaria crotoneinsis, Ghomphonema olivaceum, Ghomphoneis herculeanum, Nitzschia sp. Navicula radios* and *Synedra ulna* which appeared as the most dominant species and considered flourished well under poor water quality conditions.

***Keywords*** **-** Kishore Sagar, Diatom, limnology, lake conservation

## I. INTRODUCTION

The state of Rajasthan is the largest state in Republic of India covering an area of 3, 42,239 sq.km which is more than 10 % of the total geographical area of the country. The temporal and spatial availability of water in the state is very critical issue in general and aquatic life in particular as the state is supporting more than 5.5 % of the human population & almost same number of the livestock of country. Contrary to this, the state is endowed with only 1.16% of the total surface water resources available in the country. Moreover, 2/3 region of the state is part of the Great Thar desert. The total surface water available in the State is 21.71 BCM, out of which 16.05 BCM is economically utilizable. State has so far harnessed 11.84 BCM which is 72% of economically utilizable portion.

The importance of water in the State has had been recognized even during the pre independence period and there is rich tradition of water conservation and management which is exemplified from occurrence of numerous old water harvesting structures in the form of Tankas, Khadins, Johads, Ponds, Lakes etc. These structures are used conventionally to cater various needs of drinking water, irrigation and ground water recharge. For this purpose these resources are managed and conserved in a traditional manner. In the present scenario, many of the fresh water resources are under stress due to natural and manmade pollution which is clearly depicted in alterations in the physic-chemical and biological characteristics. Therefore, there is need for a scientific approach of management.

Kishore Sagar Lake is situated in the centre of city of Kota, Rajasthan, India. It is one of the freshwater structure facing pollution problems from nearby areas. This water body can be an important source of drinking water and other multipurpose uses for the nearby areas besides adding as beauty to Kota city. Considering the need scientific comprehensive and integrated planning for surface and groundwater resources this study was carried out from December, 2004 to December, 2005 to evaluate selected physicochemical characteristics along with diatom diversity of Kishore Sagar Lake.

## II. STUDY AREA

Kishore Sagar Lake is situated in the centre of Kota city. It is also known as Bara Talao (Fig.1). This artificial lake was constructed in 1946 by Prince Dher Deh of Bundi. Presently, water of this lake is being used for irrigation, fisheries and domestic uses such as bathing and washing purposes. The catchment of Kishore Sagar is semi-hilly and rocky and the length of the dam is 1500 m while the height of dam is 5.6 m. During monsoon and latter quarter of year the marginal area of this lake is occupied by green herbs which encourages cattles' grazing along the shores of this water body. The lake has regular inlet and outlet. The lake receives heavy influx of domestic sewage from nearby residential colonies thus

making it unfit for drinking and aquaculture uses. The morphometric features of the lake are shown in Table 1.

## III. MATERIALS AND METHODS

For the collection of water and diatom samples one location was fixed in the lake (Fig. 1). Only surface water samples were collected for analysis of selected physico-chemical parameters using one liter capacity plastic bottles during a period of thirteen months from December, 2004 to December 2005.The collected samples were immediately processed for measuring temperature, pH, alkalinity, free $CO_2$ and dissolved oxygen in the field whereas other parameters like EC, hardness, dissolved silicates, sulphate, orthophosphate and nitrate nitrogen were analysed in the laboratory as per methodology for the assessment of physicochemical parameters given in APHA (1985) and Sharma and Saini (2003).

For the study of diatom diversity of the lake, a known volume of water sample was filtered through plankton net of bolting silk no. 25 and preserved in Lugol's solution. Quantitative analyses of diatom samples were carried out in the laboratory using Sedgewick Rafter Cell. The diatoms were identified with the help of Edmondson (1959) and Weber (1971).

## IV. RESULTS AND DISCUSSION

**Physicochemical characteristics**

The observed physicochemical features of the lake showed notable variations as shown in Table -2.

**Temperature**

The annual average surface water temperature of the lake was observed 27.79$^0$C. Based on thermal classification of lakes (Das, 1989), Kishore Sagar lake belongs to 'typical lake of tropical latitude' whose water temperature varies between 25$^0$C to 30$^0$C in summer and 16$^0$C to 20$^0$C in winter.

**Hydrogen –ion – concentration**

The pH value of the investigated water body was found to be on the alkaline side with an annual average of 7.8 units. The higher value of pH may be due to increased photosynthetic activities of phytoplankton and macrophytes triggered by the decomposition of excessive organic matter and inputs of sewage (Singh and Mahajan, 1987). According to Sarwar and Wazir (1988), the Kishore Sagar Lake can be categorized as 'slightly alkaline' due to the predominance of calcium and bicarbonates. This also coincided with the results of Pearsall (1930) and Zafar (1966) who concluded that the pH of water is dependent upon the relative quantities of calcium, carbonates and bicarbonates. The water tends to be more alkaline if it possesses carbonates and it is much less alkaline when it possesses large quantity of bicarbonates, carbon dioxide and calcium. A similar situation was noticed in the investigated water body.

**Electric conductance**

The EC varied with minimum of 0.22 to the maximum of 0.34 mS. Waters are categorized eutrophic when having electrical conductance above 0.20 mS (Rawson, 1960). Thus, Kishore Sagar Lake can be assigned the status of 'Eutrophic' as per this criterion.

**Dissolved oxygen**

The annual average value of Dissolved Oxygen was observed 5.4 mg/l. Interestingly, the lower dissolved oxygen in the lake coincided with higher free $CO_2$. For supporting fish life there should be at least 3.00 ppm dissolved oxygen in water (Tarzwell, 1957). In the present water body dissolved oxygen was found below 5 mg/l on seven occasions which is indication of distressed environment for the fish life. The lower values of dissolved oxygen during post winter months can also be attributed to the fact that the rise in temperature and subsequent warming of water which can hold less amount of oxygen. High temperature also helps to increase mineralization of non-living matter which demands oxygen (Kumar *et al.*, 2005). Many workers (Streeter and Phelps, 1925; Weibe, 1927; Swale, 1964; Tsuda and Morishita, 1975) have stated that low values of oxygen are associated with high organic matter.

**Free $CO_2$**

Free $CO_2$ was found appreciably high with an annual average of 15.8 mg/l. As per Dwivedi and Pandey (2002) the main source of $CO_2$ is greater decomposition of organic matter and respiration of plants and animals. For fish life concentration from 1.5 to 10 mg/l of free $CO_2$ has been considered as the most favourable. In Kishore Sagar Lake on nine occasions free $CO_2$ was found much higher than the favorable limits prescribed above. According to Swingle (1967) free $CO_2$ concentration of more than 15 ppm may be detrimental to fish.

**Carbonate alkalinity**

In Kishore Sagar Lake carbonate alkalinity was altogether absent during study period as this absence of carbonate alkalinity coincides with presence of free $CO_2$ and bicarbonates.

**Total alkalinity**

Phillipose (1960) suggested that a water body with alkalinity values >100 mg/l is nutritionally rich. High total alkalinity values of Kishore Sagar Lake indicate its high trophic status as in the present study the annual average value of total alkalinity was 134.0 mg/l.

**Total hardness**

The hardness of water is mainly governed by the contents of calcium and magnesium which are largely combined with bicarbonates and carbonates (temporary hardness), and with sulphate, chlorides and other anions of minerals (permanent hardness). Kaur *et al.* (1996) reported that high values of hardness are probably due to the regular addition large quantities of sewage and detergents in the water body from the

nearby residential localities. Spence (1964) opined that waters with more than 60.0 ppm hardness can be designated as 'nutrient rich' waters. According to this classification, therefore, the Kishore Sagar Lake can be categorized as 'nutrient rich' where the total hardness values oscillated between 64.0 to 100.0 mg/l with an annual average of 86.8 mg/l.

**Calcium hardness**

Ohle (1934) categorized water body as 'rich' having calcium values >25 mg/l. Calcium hardness in Kishore Sagar varied between 50.0 to 74.0 mg/l with an annual average of 58.0 mg/l. The higher content of calcium in comparison to magnesium may be due to the fact that $CO_2$ reacts more rapidly with calcium salts converting large quantities of calcium into soluble bicarbonates. This is further supported from the observed high values of bicarbonates in Kishore Sagar.

**Orthophosphate**

Value of the orthophosphate above 0.5 mg/l has been considered a sign of organic pollution (Meena *et al.,* 2007) which also corroborates with the present study. From this point of view, orthophosphate values of Kishore Sagar Lake were fairly high with variation**s** between 0.35 to 1.28 mg/l and annual average of 0.71mg/l. This may be due to the rapid decomposition of organic matters in the water body. The main anthropogenic sources of phosphorus being the detergents and municipal sewage coming into the water body.

**Nitrate-nitrogen**

Nitrate generally occurs in trace quantities which is essential for many photosynthetic autotrophs and in some has also been identified as growth limiting nutrient (Prakash, 1994). Sharma *et al.* (1984) reported nitrate-N for unpolluted water (0.008 mg/l) and polluted water (0.165 mg/l) of Pichhola and Rang Sagar, respectively. In Kishore Sagar, $NO_3$-N values varied between 0.0 to 0.106 mg/l with an annual average of 0.018 mg/l, thus affirming moderate level of pollution.

**DIATOM DIVERSITY**

The diatom community of Kishore Sagar Lake was diverse and comprised of 42 species representing 8 centric forms and 34 pinnate forms. The species composition and frequency of diatom community are shown in table 3.

The predominant diatom species recorded from the investigated site were *Synedra ulna, Navicula* spp., *Gomphonema olivaceum, Diatoma elongatum, Nitzschia* spp., *Cocconies placentula and Fragilaria crotoneinsis.* The presence of these species is indicative of the enriched status of the water-body. According to Williams (1969) presence of *Fragilaria* sp. indicates the sewage pollution while Benson (1967) and Vollenweider (1968) consider *Fragilaria crotoneinsis* to indicate eutrophy. Lowe (1972) considers *Synedra ulna* as eutrophic species. According to Dickman (1975) *Cymbella, Fragilaria capucina, Diatoma elongatum, Gomphonema olivaceum* and *Cocconies placentula* are commonly found in organically polluted waters. Richardson (1968) considers *Nitzschia* spp. to be characteristics of organically rich waters and Sommerfeld *et al.* (1975) consider it to be a typical eutorphic species. Lowe (1974) reported that *Melosira granulata* is favoured by sewage effluents. Further, considering the observed numbers of Centric and Pinnate diatoms Nygaard's trophic State Index was found to be 0.235 which is approaching the upper limit of oligotrophy. However, apparently Kishore sagar is eutophic as evident from water quality and recorded species of diatoms.

**SUGGESTED MEASURES FOR LAKE PROTECTION**

- Catchment area protection to stop the inflow of domestic sewage in to the lake.
- To stop open defecation in and around the lake.
- To stop bathing, washing of cloths and vehicles on Ghats and banks of the lake.
- Dilution and flushing for adding low nutrient water.
- Phosphorus inactivation by aeration using bottom set aerators.
- Food web management to control algal growth (Biomanipulation).
- Pretreatment of effluents using constructed wetlands.
- Regular water quality monitoring and scientific fisheries management.

## V. CONCLUSION

Based on the characteristics of physicochemical parameters studied and presence of nutrient favoured Diatom species, it shall be appropriate to mention that the water quality of the lake has been deteriorated and is potential threat to human health as well as aquatic flora and fauna. The water body needs more attention towards its scientific management, restoration and conservation so that it can be utilized for multipurpose water uses and revenue generation.

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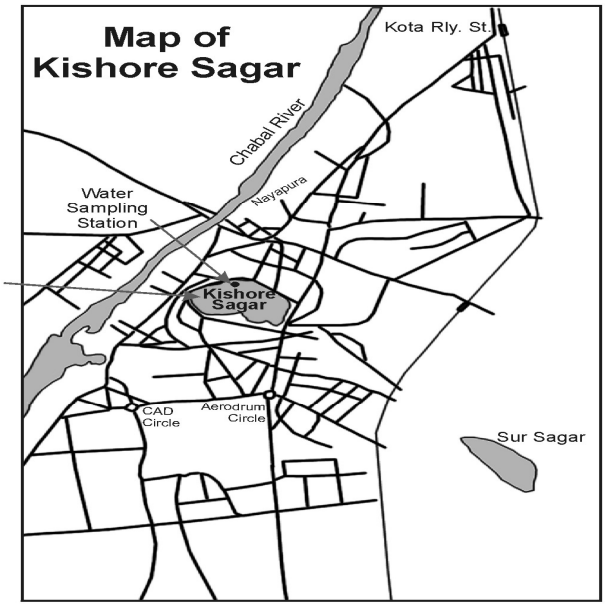


**Fig. 1 Outline map of Kishore Sagar**

Table 1. Morphometric features of Kishore Sagar Lake

| S. No. | Items | Kishore Sagar |
|---|---|---|
| 1. | Locations:<br>Latitude<br>Longitude | <br>24°25.675N<br>76°37.348E |
| 2. | Maximum depth (m) | 5.0 |
| 3. | Mean depth (m) | 3.0 |
| 4. | Length of dam (m) | 1500.0 |
| 5. | Height of dam (m) | 5.60 |
| 6. | Nature of dam | Stone masonry |
| 7. | Year of impoundment | 1946 |
| 8. | Purpose | Irrigation and agriculture |
| 9. | Village / Town / City | Centre of Kota city |
| 10. | Tehsil and district | Kota |

**Table-2 Monthly values, minima, maxima and annual average of physicochemical parameters of Kishore Sagar during December 2004 to December 2005**

| S. No. | Parameter | Dec. | Jan. | Feb. | Mar. | Apr. | May | Jun. | Jul. | Aug. | Sept. | Oct. | Nov. | Dec. | Minima | Maxima | Annual average |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1 | Temperature (°C) | 23 | 18 | 22 | 26 | 29 | 32 | 34 | 33 | 32 | 29 | 29.5 | 26 | 24 | 18 | 34 | 27.79 |
| 2 | PH (Units) | 7.9 | 7.2 | 8.5 | 7.9 | 7.9 | 8 | 7.6 | 8.2 | 7.8 | 7.4 | 8.3 | 7.4 | 7.8 | 7.2 | 8.5 | 7.8 |
| 3 | Ec (mS) | 0.224 | 0.226 | 0.236 | 0.289 | 0.291 | 0.31 | 0.312 | 0.342 | 0.257 | 0.271 | 0.238 | 0.237 | 0.254 | 0.22 | 0.34 | 0.27 |
| 4 | D. O. (mg/l) | 5.2 | 8 | 9.2 | 7.2 | 3.6 | 5.6 | 3.2 | 4.8 | 5.6 | 2.4 | 4.4 | 6 | 5.2 | 2.4 | 9.2 | 5.4 |
| 5 | Free CO2 (mg/l) | 12 | 26 | 14 | 16 | 14 | 36 | 18 | 20 | 8 | 20 | 4 | 2 | 4 | 2 | 36 | 15.8 |
| 6 | Car. Alkalinity (mg/l) | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 | 0 |
| 7 | Bicar. Alkalinity (mg/l) | 110 | 84 | 144 | 146 | 172 | 166 | 154 | 128 | 120 | 140 | 164 | 80 | 96 | 80 | 172 | 134 |
| 8 | Total Alkalinity (mg/l) | 110 | 84 | 144 | 146 | 172 | 166 | 154 | 128 | 120 | 140 | 164 | 80 | 96 | 80 | 172 | 134 |
| 9 | Total Hardness (mg/l) | 90 | 90 | 98 | 94 | 94 | 94 | 100 | 92 | 80 | 78 | 68 | 64 | 72 | 64 | 100 | 86.8 |
| 10 | Cal. Hardness (mg/l) | 62 | 56 | 60 | 56 | 60 | 56 | 60 | 74 | 54 | 50 | 52 | 56 | 54 | 50 | 74 | 58 |
| 11 | Orthophosphate (mg/l) | 0.35 | 1.09 | 0.7 | 1.24 | 1.16 | 1.28 | 1.43 | 0.84 | 0.81 | 0.99 | 0.87 | 1.1 | 0.09 | 0.35 | 1.28 | 0.71 |
| 12 | Nitrate-Nitrogen (mg/l) | 0.002 | 0.001 | 0.006 | 0 | 0.106 | 0.035 | 0.032 | 0.009 | 0.005 | 0.018 | 0.001 | 0.002 | 0.002 | 0 | 0.106 | 0.018 |

Table 3. Species composition and relative abundance of diatoms in Kishore Sagar Lake during December 2004 to November 2005

| | **A. Centric forms** | **Relative Abundance** |
|---|---|---|
| 1 | *Cyclotella michiganaina* | + |
| 2 | *Chaetocerus elmorei* | + |
| 3 | *Cyclotella atomtus* | + |
| 4 | *Cyclotella glomerata* | ++ |
| 5 | *Cyclotella bodanica* | + |
| 6 | *Melosira varians* | + |
| 7 | *Melosira granulata* | +++ |
| 8 | *Melosira herozogii* | ++ |
| | **B. Pennate forms** | |
| 1 | *Amphora ovalis* | + |
| 2 | *Caloneis amphisbaena* | + |

| | | |
|---|---|---|
| 3 | *Cocconeis placentula* | ++ |
| 4 | *Cocconeis pediculus* | + |
| 5 | *Cymbella affinis* | ++ |
| 6 | *Cymbella turgida* | + |
| 7 | *Cymbella tumida* | + |
| 8 | *Diatoma anceps* | ++ |
| 9 | *Diatoma elongatum* | +++ |
| 10 | *Diatoma vulgare* | ++ |
| 11 | *Fragilaria crotoneinsis* | ++ |
| 12 | *Fragilaria capucina* | + |
| 13 | *Ghomphonema olivaceum* | +++ |
| 14 | *Ghomphonema angustatum* | ++ |
| 15 | *Ghomphonema constricticum* | + |
| 16 | *Ghomphoneis herculeanum* | ++ |
| 17 | *Nitzschia apiculata* | + |
| 18 | *Nitzschia acicularis* | + |
| 19 | *Nitzschia holsatica* | + |
| 20 | *Nitzschia elliptica* | + |
| 21 | *Nitzschia dissipata* | ++ |
| 22 | *Nitzschia angustata* | + |
| 23 | *Nitzschia denticulata* | ++ |
| 24 | *Nitzschia paradoxa* | + |
| 25 | *Navicula radiosa* | ++ |
| 26 | *Navicula canalis* | +++ |
| 27 | *Navicula bacillum* | + |
| 28 | *Navicula pupula* | + |
| 29 | *Navicula hungarica* | + |
| 30 | *Neidium dubium* | + |
| 31 | *Synedra ulna* | +++ |
| 32 | *Synedra acus* | ++ |
| 33 | *Synedra palchella* | + |
| 34 | *Surirella angustata* | + |
| | | |
| | + Present ++ Abundant<br>++ + Dominant | |