Eutrophication: A Case Study of Highly Eutrophicated Lake Udaisagar, Udaipur (Raj.), India with regards to its Nutrient Enrichment and Emerging Consequences

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ABSTRACT

Present paper embodies a broad limnological investigation of lake Udaisagar of Udaipur (Raj.) with regard to nutrient enrichment and its consequences. In most of the cases the lotic ecosystem have been used thoughtlessly as repositories for disposal of domestic sewage, industrial effluents and agricultural run-off etc., which leads to nutrient enrichment, growth of micro & macrophytic vegetation and ultimately cause eutrophication.

World famous highly eutrophicated lake Udaisagar is approximately 20 Km away from Udaipur, the city of the Lakes & Fountains and popularly known as 'Kashmir of Rajasthan'. Lake Udaisagar receives city sewage, industrial wastes of certain industries of Mewar industrial area and run-off of agricultural field through river Ahar.

At times heavy algal blooms have been observed which pose serious problem in the water supply of Debari Zinc Smelter, a factory of Hindustan Zinc Ltd. In view of the above, an attempt was made to study certain limnological parameters with special reference to eutrophication and its correlated phenomena.

Standard methods for the examination of water and waste water of American Public Health Association (APHA) and American Water Works Association (AWWA), (1980) and Mackereth (1963) were followed.

Results have been discussed with reference to eutrophication and emerging challenges which may cause drastic effect for well being of human society. The flowering of water in Lake Udaisagar by Cyanobacteria, Microcystis aeruginosa as one of the dominant plant species indicated the high degree of eutrophication.

Present research work concludes that Udaisagar is highly eutrophicated and polluted lentic water body. Ahar river which flows near the ancient ruins of Ahar culture and civilization receives Udaipur city untreated sewage, industrial effluent of certain industries of Mewar Industrial Area and agricultural run-off from nearby agricultural fields is a main source of eutrophication in lake Udaisagar.

High concentration of nitrates, phosphates, chlorides, high total alkalinity, high organic matter contents, total dissolved solids and high temperature greatly contribute to the present deteriorated situations of world famous beautiful fresh water Udaisagar lake and enhance the process of eutrophication and correlated phenomena i.e. flowering of water, fish mortality foul odour, blue-green colouration of water and overall decrease in the recreational values.

Key words: Trophic Status, Sewage, Water Bloom, Fish Mortality, Foul Odour, Blue-Green Colouration, Decline Recreational Value.

INTRODUCTION

Lakes are not only a significant source of precious water but also provide valuable habitats to the biological world.

Eutrophication and deterioration in water quality, siltation and consequent shallowing and shrinking of lakes are major problems and are assuming alarming proportion in India due to various anthropogenic activities.

The term eutrophication can popularly be attributed to weber (1907) who used 'eutrophic' and 'oligotrophic' to describe the conditions of water and soil solution in German bogs. Eutrophic water is nutrient rich and oligotrophic water is nutrient poor. Eutrophication refers to continuous enrichment of water by the addition of substances that provide for the increasing growth of aquatic life.

For undisturbed lakes, eutrophication is considered by most to be a natural process, characterized by gradual filling in of the lake basin, the appearance of 'nuisance' algal blooms, discolouration of water, fish kills and with geological time, emergence of marsh land or swamp. Bodies of water experiencing acceleration of the natural aging process are often said to be in a state of natural eutrophication (Hasler,1974).

The excessive amount of nutrients favours the growth of algae and weeds leading to eutrophication (Thilaga et al., 2005).

The nutrient enrichment results in diminishing economic as well as recreational values of rivers (Chatterjee & Raziuddin, 2001).

Anthropogenic nutrient enrichment causes serious alteration in aquatic ecosystems (Ansari and
Eutrophy is the consequence of a lake's nutrient enrichment (Saxena, 2007).

Hydrobiological studies of many inland water bodies of India including lakes of Udaipur have been conducted by several workers. No systematic work, however, has been done on eutrophication of various water bodies of other states of India and those of foreign countries (Fruth, 1966; Sreenivasan, 1969; Pant et al., 1980; Zadanowski et al., 1982; Arumugam and Furtado, 1980; Prat and Daroca, 1983; Marshall and Falconer, 1973). Lake Udaisagar (Udaipur) is the main source of water supply to the Zinc Smelter, a factory of Hindusthan Zinc Limited, created at a cost of more than 100 crore. This lake is getting polluted by drainage of river Ahar which carries the domestic, sewage and industrial wastes of Mewar Industrial area. Deterioration of water quality and interruption in industrial water supply has caused great concern to the authorities. Udaisagar lake is now highly eutrophicated as indicated by water bloom formation and fish mortality in this lake.

The most serious aspect of the eutrophication of Udaisagar lake is water bloom formation by Microcystis aeruginosa in summer and rainy months. The problem is of great national and local importance as the study will provide basic information required to deal with the increasing problem of eutrophication in many of water bodies of India. In view of the above present investigation was carried out with special reference to nutrient enrichment and emerging consequences from Jan.1986 to Dec.1986 under the C.S.I.R., New Delhi research project entitled, "Eutrophication Trends in and around lakes of Udaipur (Raj). The Lake Udaisagar was reinvestigated in the year 2006 to study the current state of nutrient enrichment with the view to know eutrophication trend since 1986.

MATERIAL AND METHODS

Standard methods for the examination of water and waste water of American Public Health Association (APHA) and American water works Association (AWWA) 1980 and Mackereth (1963) were followed. As a regular feature, the samples were collected during morning hours (8-11 AM.) in the 2nd week of every month.

RESULT & DISCUSSION

Seasonal variations in the water characteristics of lake Udaisagar are presented in Tables I and II for the year 1986 and 2006 respectively while the consequences of nutrient enrichment are presented in Table-III. A close perusal of water characteristics and consequences reveals that the lake Udaisagar is towards an increasing state of eutrophy and of much more deteriorated water quality.

Table I. Seasonal variation in water characteristics of lake Udaisagar during the year 1986.

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Water Characteristics</th>
<th>Summer (Mar.-Jun.)</th>
<th>Rainy (Jul.-Oct.)</th>
<th>Winter (Nov.-Feb.)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Temperature (°C)</td>
<td>27.12</td>
<td>27.80</td>
<td>19.07</td>
</tr>
<tr>
<td>2</td>
<td>Transparency (meter)</td>
<td>0.44</td>
<td>0.45</td>
<td>0.82</td>
</tr>
<tr>
<td>3</td>
<td>T.D.S.</td>
<td>587.50</td>
<td>957.50</td>
<td>610.00</td>
</tr>
<tr>
<td>4</td>
<td>Chlorides</td>
<td>129.22</td>
<td>125.31</td>
<td>121.76</td>
</tr>
<tr>
<td>5</td>
<td>Total alkalinity</td>
<td>342.50</td>
<td>257.50</td>
<td>313.75</td>
</tr>
<tr>
<td>6</td>
<td>Dissolved Oxygen</td>
<td>4.45</td>
<td>5.28</td>
<td>4.68</td>
</tr>
<tr>
<td>7</td>
<td>Nitrate</td>
<td>0.45</td>
<td>0.74</td>
<td>0.58</td>
</tr>
<tr>
<td>8</td>
<td>Phosphati</td>
<td>0.40</td>
<td>0.86</td>
<td>0.58</td>
</tr>
</tbody>
</table>

All results except Temperature and Transparency are expressed in ppm (Table-I & II)
**Table-III. Consequences of Nutrient enrichment.**

<table>
<thead>
<tr>
<th>S. No.</th>
<th>Consequences</th>
<th>Summer</th>
<th>Rainy</th>
<th>Winter</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Water Bloom</td>
<td>Maximum</td>
<td>Medium</td>
<td>Low</td>
</tr>
<tr>
<td>2</td>
<td>Fish Mortality occurred</td>
<td>NiL</td>
<td>NiL</td>
<td>NiL</td>
</tr>
<tr>
<td>3</td>
<td>Blue green colouration</td>
<td>Maximum</td>
<td>Minimum</td>
<td>Medium</td>
</tr>
<tr>
<td>4</td>
<td>Foul Odour</td>
<td>Maximum</td>
<td>Not observed</td>
<td>Not observed</td>
</tr>
<tr>
<td>5</td>
<td>Mosquito Production</td>
<td>Frequent</td>
<td>Medium</td>
<td>Not observed</td>
</tr>
<tr>
<td>6</td>
<td>Decrease in Recreational value</td>
<td>To the greatest extent</td>
<td>NiL</td>
<td>NiL</td>
</tr>
</tbody>
</table>

**Temperature**

The excessive amount of nutrients in the water bodies along with higher temperature favours the growth of algae and aquatic weeds. Nutrients vary with the seasons and are also affected by overturning of the water, which brings about decomposed bottom materials to the photosynthetic zone.

**Transparency**

Transparency determines the photic conditions of the lake. Summer season was observed to show the minimum value of transparency for both the year i.e. 1986 and 2006 while winter was the season showing the maximum transparency. The higher values very clearly speaks the high level of turbidity of lake water specially during summer and early monsoon period.

**Total Dissolved solids (TDS)**

Beeton (1965) attributed an increase in T.D.S. in some Laurention Great Lakes over the past 50-60 years to cultural eutrophication and suggested the separation of oligotrophic and eutrophic lakes on the basis of T.D.S. values. Oligotrophic lakes have less than 100 ppm TDS and eutrophic more than 100 ppm. Thus, on the basis of presently observed values of TDS, Udaisagar lake is of eutrophic type. Increasing trends of TDS in present study indicates cultural eutrophication in the lake.

**Chlorides**

Sreenivasan (1965) is of the opinion that the chloride concentration between 4 and 10 ppm indicates purity of water. Chlorides are not utilized for plant growth and their presence in large amount in the lake water is regarded as suggestive of pollution by organic matter.

The high concentration of Chlorides in the lake Udaisagar suggested heavy pollution of its water. In the present study chlorides in greater amount in summer, probably because of the fact that due to evaporation of water the concentration of chlorides increases.

Khan et al (1978) indicated in their studies that an increase in the chloride values may be due to run off from surrounding catchment area and discharge of sewage. The pollution in Udaisagar lake is largely due to organic matter of animal origin and human sewage brought by the Ahar river.

**Total alkalinity**

Moyle (1949) recorded 40 mg L⁻¹ total alkalinity as a natural separation point between soft and hard waters and thus the presently investigated lake has become almost a hardwater body. Extraordinary high alkalinity of lake water clearly speaks of its role in the increasing trend of eutrophication.

**Dissolved oxygen**

Determination of dissolved oxygen is a most common limnological parameter. The lower concentration of DO in summer in both the years (1986 & 2006) explain its quick utilization in the oxidation processes of the lake.

**Nitrates & Phosphates**

Nitrates and phosphates are better indicator of eutrophication and a host of workers (Prescott, 1948 and George, 1962) have emphasized the role of high nitrate and phosphate contents in the formation of water bloom in impoundments studied by them. In the present investigation higher values of nitrate and phosphate in the rainy season in both the year (1986 and 2006) might be responsible for the development of water bloom by *Microcystis aeruginosa* and may have accelerated the process of eutrophication.

The perennial occurrence of *Microcystis aeruginosa* in Udaisagar lake might have adverse effect with regard to clogging of gills and toxic effect on fish life though there are no such report from India but it will be worth while to study this problem in a lake like Udaisagar considering the fish mortality during water bloom formation. Hughes et al. (1958) who studied the toxicity of *M. aeruginosa* on mice were able to distinguish two distinct lethal factors, one slow death factor and other a fast death factor.

Blue green colouration of lake water, foul odour and massive production of mosquitoes are certain co-related phenomena which were frequently observed in summer season and high light the much more deteriorated water quality and high degree of entrophication.
The increasing trend of eutrophication as observed in present investigation may adversely affect the recreational value of the lake as well as the aquaculture practices which are operated regularly. Phosphorus along with nitrogen causes explosive growth of algal species that leads to eutrophication (Dwivedi & Pandey 2001).

The role of phosphorus in algal growth and eutrophication has been studied by Peterson et al. (1974).

CONCLUSION

From the result obtained, it can be concluded that the lake Udaisagar is a polluted fresh water body due to the continuous discharge of municipal sewage, run off from agricultural fields and industrial effluent of Mewar industrial estate. Higher amount of nutrient leads to an increasing trend of eutrophication. Nutrient enrichment in the lake changes the conductive environment of the lake Udaisagar and water has become almost unfit for drinking & aqua culture. The periodical survey of the lake is the need of present day time to find out the water quality and carry out abatement programs, to check further deterioration of water quality. The increasing trend of entrophication may further deteriorate the water quality to greater extent and may affect the recreational values of lake Udaisagar.

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