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Effect of anthropogenic activities on Indian pilgrimage sites–A case study of Pushkar Lake

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ABSTRACT

Water is the source of life for all living beings. About two-thirds of the Earth is covered by water. Among many water bodies, Lakes are the most fertile, diversified and productive of all the ecosystems in the world. A variety of environmental goods and services are bestowed upon us by Lakes which makes them vulnerable to human exploitation. The fresh water Pushkar Lake is situated in the gap of the Aravallis and was used as the area of research for the present study. History claims that in the 20th century, this Lake and its catchment area were a rich source of wildlife as well as a source of water for the railways for over 70 years, till 2004. The society's demand for economic gains has resulted in the deterioration of its water quality. Two main reasons for this loss are – high rate of sedimentation due to sand-fall from the nearby sand dunes and anthropogenic practices followed in the periphery of the Lake. The water of the Lake is getting dried up because of reversal of hydraulic gradient from Lake to groundwater, leading to rapid decline in the groundwater level of the surrounding areas also. Eutrophication and various anthropogenic activities including holy rituals and tourism are the major contributing effects of water pollution. So the present study deals with a comparative analysis of the physic-chemical analysis of the Lake water before, during and after the annual Pushkar fair. Some of the remedial measures for water conservation are increasing the water level of the Lake, increasing the groundwater level, improving the water quality, checking soil erosion, desilting the banks of the Lake, establishing a water treatment plant nearby and creating public awareness to revive the aesthetic importance of the sacred Pushkar Lake.

Keywords: Pushkar Lake, physico-chemical analysis, water pollution, siltation, water shed conservation

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INTRODUCTION

Water is the most important natural resource gifted by God for the existence of life on earth. Lakes and reservoirs in arid and semi-arid areas are very essential for the inhabitants of such regions. Water that is present naturally in ponds, rivers or Lakes for a considerable period of time is called stored water. The interaction of man with water bodies during the last few decades has been of concern largely due to the rapid population growth, which resulted in degradation of such water by domestic, industrial sewage, agricultural run-off containing fertilizers and pesticides [4]. Hydrological conditions such as amount of precipitation, water loss due to high heat indices and man-induced perturbances can modify chemical and physical characteristics of the water and these changes in the physico-chemical environment have direct impact on the biotic component of the water body [6]. Water pollution is a major worldwide problem and the quality of drinking water is vitally important to civilization. The quality of water is determined by its physico-chemical characteristics. It is a well established fact that domestic-sewage and industrial

effluent discharged into natural waters results in deterioration of water quality and cultural eutrophication. The other important sources of water pollution include mass bathing, disposal of dead bodies, rural and urban waste matters and solid waste disposal. The Lakes and reservoirs all over the country are in vary ing degrees of environmental degradation [5]. In our country 70% of the water is polluted and 75% of illness and 80% of the child mortality is attributed to water pollution.

Area of Study:

Rajasthan is the largest state of India and is famous for the 'Thar Desert'. Therefore, in this region, water is the most precious commodity since the dawn of civilization. One such stagnant fresh-water body located in the gap of the Aravallis is the Pushkar Lake. Pushkar lies on the eastern fringe of the Thar desert. Pushkar city is situated 12 kms North West of Ajmer and is located at latitude 26˚29'14"N and longitude 74˚33'18"E, at an elevation of 530 meters above mean sea level (mamsl).

Fig 1.1 Image showing Pushkar Lake surrounded by Pushkar City.

The total catchment area of the Lake is 36.71 sq. km. the total capacity of the Lake is more than 150 milli cubic feet and its depth is approximately 8.3m. This semicircular Lake is surrounded by hills on three sides (*Nag Pahari* and *Savitri Pahari*) and sand dunes on the fourth side. *Ghori Nadi*, *Savitri Nadi* and *Gomukh nallah* drain this area. The ground water is about 10 feet deep from the surface of the Lake and is westerly, i.e., towards *Saraswati* river. The climate is semi-arid to arid type. The temperature of this area is high during the summer (May-June) and reaches 44-46˚C, while the temperature goes down to 5˚C during winter (December-January). The rate of evapo-transpiration is comparatively higher than in the south-eastern region of Rajasthan. The average annual rainfall is 520 mm (Ajmer station) with 20 rainy days, 90% of which is being received in between months of June and September (uncertain rainfall pattern). The wind speed during summer is 40-60 kmph and leads to sand shifting and sedimentation into the Lake. This area is a part of the Aravalli range with undulating hills and sand deposition on older alluvium, surrounding hills and valleys have moderate to poor vegetation cover. The area under investigation represents different soil types ranging from sandy loom to sandy clay and yellowish brown to dark brown in color.

Anthropogenic activities:

This Lake is considered sacred as it has mythological significance and is a famous tourist destination. A Lake as a tourist destination is generally a functionally compact regional whole with clear geographical limits. Easy access to Pushkar increases the floating population day by day all the year around. Because of the aesthetic importance of this Lake, there is a steady flow of tourists and pilgrims throughout the year to Pushkar. Natural drainage from surrounding hills has been obstructed due to accumulation of shifting sands in its course and also been disturbed because of agricultural activities and encroachments in the catchment areas. Moreover presence of cattle in the

catchment area of the Lake also deals with great damage. Cattle defecate in the periphery of the Lake which comes through waterways and deteriorates the water quality. Pushkar Lake is transformed into a bustling fair-ground in the month of *Kartik* (October-November) when the annual Pushkar Fair and Cattle Fair are held simultaneously. In recent years, these anthropogenic activities and environmental stresses have surpassed the carrying capacity of Pushkar Lake and ultimately deteriorated the water quality rendering it unfit for use of any kind. Thus, keeping in mind the religious, economic and social importance of this Lake, as well as the effect of this water on the health of the local community, the study of the physico-chemical and biological parameters of the Lake and its appropriate restoration methods towards conservation and management have been deduced.

MATERIALS AND METHODS

The entire study was conducted within a period of six months (August 2012 to January 2013), including the festival of *Kartik Poornima* and the annual cattle fair held from 20th to 28th November 2012. Physico-chemical analysis of water samples was done on 3 selected sites of the Pushkar Lake in the following steps:-

Step 1- Selection of sites and Sample collection:
The three sampling sites were selected (site 1, site 2, site 3) on the Pushkar Lake depending on the nature of disturbance, such as, pollution load, pilgrim activities, cattle occurrence and sewage in the water. These water samples were collected from the surface zone at a depth of 0.3m early in the morning between 9:00-10:00 am. Sampling was done on a monthly basis.

Fig.1.2 Image of Sampling Sites (1,2 and 3) around Pushkar Lake.

Step 2- Physico-chemical analysis of samples:
Water samples were collected in triplicate in PET bottles of two liter capacity with necessary precautions. The temperature, pH, electrical conductivity and DO were determined on the field itself. Rest of the samples were refrigerated at 4˚C to be analyzed later in the laboratory. All the collected samples were analyzed within 24 hrs, except the BOD, which required 5 days for estimation following standard methods [1], [7] and [3].

Step 3- Biological analysis of samples:
Fecal indicator bacteria remain the preferred way of assessing the hygienic quality of water. Freedom from contamination with fecal matter is the most important parameter of water quality because fecal matter is generally considered to be a greater risk to human health as it is more likely to contain human enteric pathogens. Thus,

monitoring the biological water quality of surface water plays an important role in environment related research. Coliform bacteria were used as microbiological indicators for water quality as the last step.

RESULTS AND DISCUSSION

The results obtained by physico-chemical analysis of all the samples are given in detail in table 1.1. Marked differences in various parameters were observed due to the climatic conditions and pressure of anthropogenic activities.

Table 1.1- The monthly average of physico-chemical parameters of samples collected from 3 sites at Pushkar Lake (August 2012 to January 2013) including Kartik Poornima held from 20th to 28th November 2012.

S. No.	Parameter	Units	15thAug	15th Sept	15th Oct	15th Nov	30th Nov	15th Dec	15th Jan
1	Temperature	˚C	25.4	27.6	26.2	22.3	20.1	18	17.3
2	pH		7.9	8.1	8.3	8.9	9.4	8.5	7.8
3	DO	mg/L	7.3	6.75	5.9	5.13	4.86	5.5	6.1
4	EC	µmohs/cm	252.67	238.1	227.55	218.62	237.3	225.2	223.35
5	BOD	mg/L	5.1	5.5	6.8	7.4	15.3	12.6	9.4
6	Chlorides	mg/L	25.1	28.6	36.4	39.29	42.43	39.40	36.7
7	Sulphate	mg/L	30.37	32.58	33.17	35.28	38.66	37.54	33.47
8	Total Alkalinity	mg/L	128	134	145	149	167	153	140
9	Fluoride	mg/L	0.04	0.07	0.09	0.10	0.17	0.13	0.09
10	Phosphate	mg/L	2	9	6	8	25	20	11
11	Total Hardness	mg/L	52.4	74.3	96.9	100.3	115.7	102.3	97.8
12	TDS	mg/L	106.2	125.3	172.8	214.5	412.7	396.9	326.3
13	COD	mg/L	32.5	39.1	40.7	41.3	46.2	42.7	31.8

Data was collected twice in the month of November 2012 (15th and 30th Nov 2012).

Temperature of Water is one of the most important factors in an aquatic ecosystem. During the investigation the temperature varied from 17.3 to 27.6 °C. The decrease in temperature during and after the fair (20.1˚C) may be due to change in weather, winter season starts in November after Kartik Poornima.

pH regulates most of the biochemical reactions. Fluctuation in pH depends on foreign input in water bodies. In the present investigation, pH varied from 7.8 – 9.1. The pH of a typical Eutrophic Lake ranges from 7.7 – 9.6, therefore Pushkar Lake is Eutrophic. High pH value (9.4) on Kartik Poornima may be due to mass bathing, holy rituals, over feeding to fishes, etc.

Dissolved Oxygen in water is considered to be the factor which reflects physical and biological processes taking place. Concentration of DO depends on photosynthetic activity of aquatic plants, surface agitation due to temperature, respiration rate of living organisms and decomposition of dead organic matter. In the present investigation DO concentrations varied from 4.86 to 7.3 mg/L due to which many fish die of suffocation.

Electrical Conductivity values mainly depend on ionic concentration or dissolved inorganic substances. In the present study the value of EC of Pushkar Lake fluctuated from 218.61 – 252.67 µmohs/cm. The highest EC was recorded in the month of August during rainy season, while during the Pushkar fair EC value was 237.3 because organic matter was introduced by anthropogenic activities.

Biological Oxygen Demand determines the amount of oxygen required for biological oxidation of organic matter by microbial activity in the water. BOD can be used as a measure of waste strength. In the present study BOD values ranged between 5.1 – 15.3 mg/L with maximum value recorded on Kartik Poornima. This may be due to over loaded input of flowers, garlands and other religious matters offering food for fishes, birds and cows as well as mass bathing.

Chloride status in water indicates pollution of animal origin. In the present study chloride concentration was found between 25.1 to 42.43 mg/L with highest value (42.43) observed on Kartik Poornima. This may be due to large

amount of organic matter, mass bathing urination and defecation by animals. These results were also recorded before [9] where they stated that high chloride value is indicative of bathing activity and urination in the Dal Lake.

Sulphate concentration in water changes due to accumulation of soluble salts. In the present study sulphate concentration ranged between 30.37 - 38.66 mg/L with maximum concentration (38.66) on Kartik Poornima.

Total Alkalinity of water is the quality and kind of bicarbonates, carbonates and hydroxide present in water. According to previous work done on freshwater lakes, withdrawal of CO_2 from bicarbonates for photosynthesis by phytoplankton increases total alkalinity. In the present study the values ranged between 128 – 167 mg/L with highest value (167 mg/L) on Kartik Poornima. Therefore Pushkar Lake can be broadly considered as a nutrient rich Lake due to bathing and washing of cloths by the people during the fair.

Fluoride content in water bodies of Rajasthan is comparatively higher than in other parts of India. In the present study, fluoride content ranged between 0.04 to 0.17 mg/L and highest value (0.17mg/L) was recorded on the day of Kartik Poornima. There was no significant rise in fluoride content because externally added water from ground water source did not let the values alter much.

Phosphate determines the productivity of lake water. Major sources of Phosphate are domestic sewage, detergents, agricultural effluents with fertilizers and industrial waste water. In the present study Phosphate concentration was between 2-25 mg/L. Lakes with phosphate concentration more than 10, 10-20 and more than 20 mg/L are Oligotrophic, Mesotrophic and Eutrophic respectively. Thus we say that Pushkar Lake is Eutrophic with the highest value recorded on Kartik Poornima due to immersion of ash and dead bones as well as high rate of decomposition of organic matter.

Total Hardness of Pushkar Lake varied from 52.4 - 115.7 mg/L. The source of hardness in Pushkar Lake is mainly due to addition of calcium and magnesium through increased influx of various chemicals used in religious activities. In the study maximum hardness was seen during Kartik Poornima and decreased after the fair in order to acquire its previous state.

Total Dissolved Solids are simply the sum of cations and anions concentration expressed in mg/L. TDS in this Lake fluctuated between 106.2 - 412.7, with highest value (412.7 mg/L) observed on Kartik Poornima due to mass bathing, offering food, flowers, garlands, lamps and other religious matter.

Chemical Oxygen Demand is the oxygen required by organic substances in water to oxidize them by a strong chemical oxidant. In the present investigation value of COD ranged between 31.8- 46.2 mg/L with the maximum value (46.2 mg/L) on Kartik Poornima, this is due to input of domestic drains and use of soap and detergents for washing and bathing. Toxins and micro organisms may vary the value of COD also.

In general, data on water quality is indicative of water pollution status, which leads to eutrophic condition. Extreme seasonal temperature variation is due to differential amount of light incidence over the water surface in different seasons, which is an important factor in arid and semi-arid regions [8],[2].

The quality of water is typically determined by monitoring microbial presence of coliforms in large numbers. These indicate changing conditions in the water which affect the internal factors between and within bacterial population in the water body.

Biological analysis of water samples showed the following results:

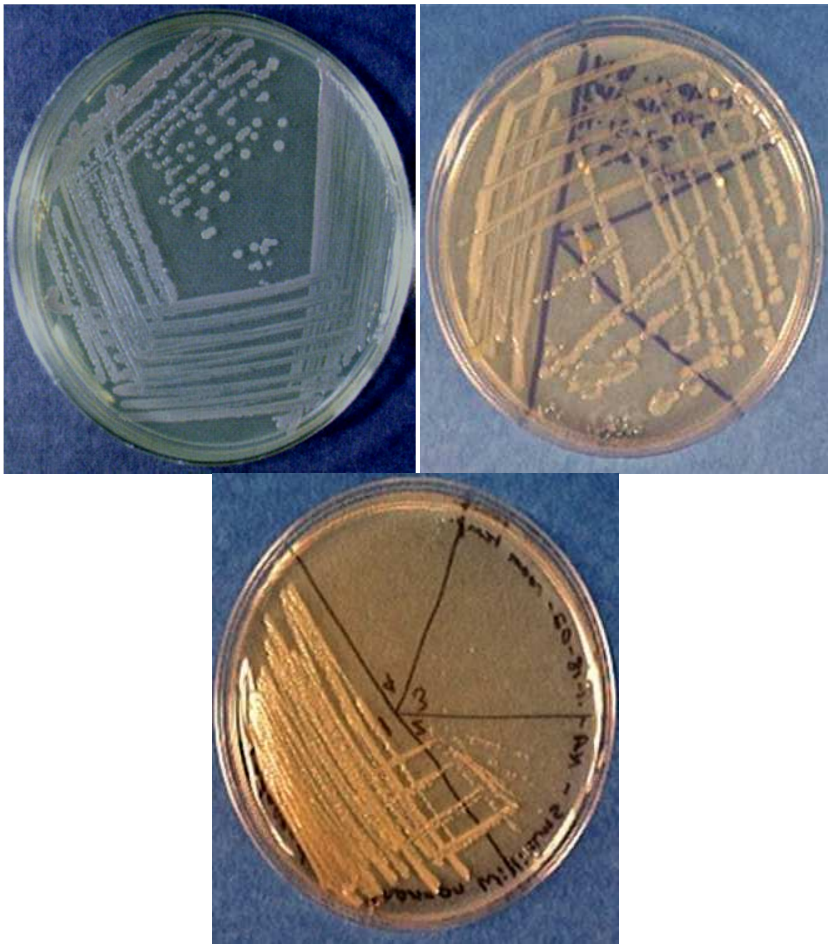

Fig 1.3- Pure colonies of isolated coliform bacteria from 3 selected sites.

Fecal coliforms (*E. coli, Enterobacter, Klebsiella, Citrobacter,* etc) are gram-negative, non-spore forming rods (Fig 1.3). They are associated with fecal materials of warm-blooded animals and their presence indicates the possible presence of pathogenic bacteria. The use of bacteria as water quality indicators specifies fecal contamination and thus can be used as a signal to determine why such contamination is present, how serious it is and what steps can be taken to eliminate it.

Recommendations for water conservation and management:

There is urgent need for restoration and rejuvenation of this prestigious lake with the following suggestions.

1. Channelization of streams, feeders to increase water storage in the lake. Complete lining of streams to minimize seepage and leakage of run-off.
2. Construction of check dams at appropriate intervals and regular clearance of accumulated materials from the periphery of the lake.
3. The drain network should be strengthened to enhance water storage capacity.
4. Removal of sediments upto 5 meters from the bottom of the lake should be undertaken to increase the depth of the lake and remove materials leading to Eutrophication.
5. Feeding fishes, birds and cows should be discouraged because this increases the amount of organic material which results in decrease of DO.
6. For ashes and dead bones immersion a specific 'Ghat' must be marked and the amount of ashes should be limited for this purpose.
7. Regular pollution monitoring to note down environmental status of the lake should be done and a water treatment plant (using aquatic plants like *Eichhornia, Salvinia, Nelumbo, Hydrilla*) should be established.

8. Huge inflow of tourists in a short time puts tremendous pressure on the lake. Therefore regulations regarding proper town planning to maintain high tourist flow as well as providing quality services needs to be enforced as early as possible.
9. Conservation of 'Ghats' and improvement of catchment area through afforestation in order to stabilize the active sand dunes in the area should be taken up.
10. Maintenance, conservation, regular cleaning, weeding and treatment and screening of Pushkar lake water should be done on a regular basis by the local government.

CONCLUSION

In arid and semi-arid regions, lakes are being threatened by environmental stresses like soil erosion, siltation, and anthropogenic activities like over exploitation of surface water and ground water for irrigation and domestic use, agricultural practices in the catchment area and religious activities in the periphery of the lake. The study shows that Pushkar lake is Eutrophic because of high concentration of various physico-chemical parameters and high degree of siltation. The remarkable point is that water pollution load is significantly high during Pushkar fair especially on the day of Kartik Poornima.

REFERENCES

[1] APHA, (**1992**). Standard methods for the examination of water and waste water, 18th Ed. American Public Health Association, Washington D.C.
[2] Kumar, A., (**1996**). *Journal of Ecobiology*, 8: 117-122.
[3] Maiti, S. K. (**2001**). Handbook of methods in environmental studies. Vol 1. *Water and waste water analysis*. ABD Publishers, Jaipur, India.
[4] Prasad, S. N., T. V. Ramachandra, N. Ahalya, T. Sengupta, Alok Kumar, A. K. Tiwari, V. S. Vijayan and Lalitha Vijayan., (**2002**). *Tropical Ecology*, 43(1): 173-186.
[5] Reddy M. S. and Char M. V., (**2004**). *Management of lakes in India*.
[6] Sharma R. and K. C. Sharma (**1993**). *Geobios New Report* 10:158-159.
[7] Trivedi, R. K., P. K. Goel and C. L. Trisal., (**1998**). *Practical methods in Ecology and Environmental sciences*, Enviromedia Publications, Karad, India.
[8] Vyas, L. N. (**1968**). Studies in phytoplankton ecology of Picchola lake, Udaipur. *Proc. Symp. Recent. Adv. Trop.* Ecol. 334-337.
[9] Zutshi, D. P. and K. K. Vass (**1978**). *Indian J. Ecol*. 5:90-97.