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Impact of Mass Bathing on Water Quality

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ABSTRACT: One of the sacred water tank Brahmsarovar, at Kurukshetra in India was studied to assess the impact of mass bathing during new moon day (called as Amavasya in India) in terms of physico-chemical and biological characteristics. Overall water quality index was calculated using online calculator. Results have revealed significant ($P<0.05$) increase in organic pollution indicating parameters *viz.* Biochemical Oxygen Demand (BOD), total solids, chlorides, alkalinity and decline in dissolved oxygen (DO) which may be attributed to organic, domestic waste , their microbial decomposition , addition of soaps ,detergents and their absorption by aquatic flora. A sharp and significant increase in ammonia concentration was also observed which is again due to high organic matter of animal origin. No significant variation in plankton population was observed, however, numerical value of species diversity index showed a decrease indicating the elimination of sensitive taxa. Since the conditions are not beyond the limit so proper legislative efforts to disinfect the water regularly and to educate the pilgrims can improve it. Since fish netting is banned in such holy tanks so it is recommended to use it for the conservation of wild stocks of important fish species

Key words: Mass bathing, Amavasya, Water quality, Solar eclipse, Dissolved oxygen, Species diversity index

INTRODUCTION

At present, world's water resources are under pressure and are in danger because of potential pollution and contamination due to rapid industrialization, increasing population pressure, urbanization, modern agricultural activities and other anthropogenic activities (Hatcher& McGillivary, 1979; Hutley, 1990; Agarwal *et al.*, 2006 and Singh *et al.*, 2007). But these alone can not be blamed for ruining the aquatic systems, 'Mass bathing' which is an age old ritual in India, has also a big hand in it. It is sheer irony that though scriptures prohibit mass bathing and throwing used floral offerings into the water body, but all of this is done with unparallel zeal. Mass bathing increases the organic matter in the water body, apart from impurities like soaps, detergents and a lot of clothes. Several studies have been done on the impact of mass bathing on different water bodies (Sinha *et al.*, 1991; Lal, 1996; Dhote *et al.*, 2001; Chandra and Prasad, 2005; Kulshreshtha and Sharma, 2006, BBWQ, 2007).

Dip in the 'Brahmsarovar' has remained the most sanctifying event for Hindu community of the country. Dip in the tank on the day of '*Amavasya*' (1st of new moon) and on 'Solar eclipse' are given highest merit and it is believed that this will absolve all the sins. On solar eclipse millions of pilgrims take holy bath in the tank. Such a huge bathing can definitely deteriorate the water quality of the tank. Some pilgrims also carry skin and other diseases, so there is a risk of cholera, typhoid, rashes and more, that affect human health. Keeping all these facts in mind, present study had been designed to detect changes in the water quality status of Brahmsarovar.

MATERIALS & METHODS

The Kurukshetra district lies between latitude 29°-52' to 30°- 12' and longitude 76°-26' to 77°-04' in the North Eastern part of Haryana State in India approximately 250m above sea level. Usually there are three recognized seasons- winter, summer, and Monsoon. Climate of the district is very hot in summer up to 47°C and cold in winter

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down to 1^{0}C. 'Brahmsarovar' is the holiest of the water tank on the revered land of Kurukshetra used for mass bathing. Water and plankton samples were collected monthly from February to August 2007, two days before every *amavas*ya and one day after *amavas*ya, from selected three stations- S1, S-2, S-3 divided on the basis of mass of pilgrims taking bath in the Sarovar (S-1: where minimum bathing occur, S-2: where maximum bathing occur and S-3: where intermediate bathing takes place), in triplicate in polythene bottles and plastic tubes respectively. Physico-chemical parameters were analyzed using Standard procedures (Golterman *et al.*, 1978 and APHA, 1998). Planktons were identified according to Ward and Whipple (1959), Needham and Needham (1962) and APHA (1998) and counted using Sedgewick-rafter cell method. Species diversity index was calculated after Shannon and Weaver (1963) and Washington (1984) according to following formula:

$d = -\sum (ni/N) \log_2 ni/N$
d = Species diversity
ni = Number of individuals of ith species.
N = Total number of individuals in the sample

Coefficient of Correlation between different water quality parameters was determined using SPSS packages while Group means were compared by students' "t" test (Snedecor and Cochran, 1967). Water quality index was calculated according to Mr. Brian Oram's WQI Index- Consumer Support Group Online Calculator (Oram, 2007).

RESULTS & DISCUSSION

Mean values of different physico-chemical and biological characteristics (Mean + SE) before and after amavasya from February to August, 2007 are shown in Table 1. No significant variations have been observed in the values of temperature, conductivity and magnesium after the dip. Total alkalinity, hardness and calcium showed slight increase whereas total solids (TS), free CO_2, Biochemical oxygen demand (BOD), phosphate (PO_4)and ammonia values revealed considerable increase after the dip and it was found maximum at station S-2 (where maximum bathing occur). Dissolved oxygen (DO) and pH depicted significant decrease in the values after bathing and it was also highest at S-2.

Among biological factors, no significant variations have been reported in the total population of plankton, phytoplankton and zooplankton. But a general decline in the species diversity index (SDI) of both phytoplankton and zooplankton has been reported after the pilgrims dip. Water quality index value has been found to be 88 before amavasya and was 74 after amavasya.

Impact of mass bathing was clearly depicted in the values of different water quality characteristics revealing that water quality is deteriorating.The purpose of present investigations is not to draw a picture of horror and discourage religious activities but to develop base line data on physical and biological aspects of this sacred ecological unit that may need attention for its upkeep in near future. Among various physico-chemical characteristics studied water temperature closely followed the trend of atmospheric temperature and pH showed the alkaline nature of the tank indicating that waters are well buffered and in high trophic status, however, decrease in the pH was noticed after the dip, it may be due to increase in the phosphate level after bathing, which may shifts the pH towards acidic side but electrical conductivity showed no significant variations after the dip. According to report of WQAE (2001) when phosphate level are low 0.004 -0.2 mg/L and algae is low, the DO contents meet the standards and thus water body has no eutrophication problems. In the present studies phosphate levels were in the range of 0.04 -0.12 mg/L and the phytoplankton population moderately high 1876-2176/L. Thus the tank water seems to be in moderately eutrophic condition.An increase in the free CO_2, BOD and decrease in the DO was found after mass bathing may be due to entry of organic, domestic and biodegradable wastes by pilgrims and their microbial decomposition that utilize oxygen for their respiration and release CO_2 in turn(Fig.1).

The decrease in DO further explained due to activities of pilgrims like adding soaps, detergents and absorption of these pollutants by aquatic flora. Hence a significant ($P<0.01$) correlation has been reported between CO_2 and BOD ($r = 0.696$) and a significant ($P<0.01$) negative correlation of DO with CO_2 ($r = -0.614$) and BOD ($r = -0.431$). The increase in the free CO_2 after mass bathing also increased the total alkalinity and the phosphate level of the tank and this is further conformed by a positive correlation of phosphate with free CO_2 (r = 0.467, P<0.01). Presence of free CO_2, may be responsible for releasing of phosphate ions into surroundings from its insoluble compounds like ferric sulphate as supported by Wezel (2000) and may be clear with the following equation:

Table 1.Mean values of physico-hemical and biological characteristics (Mean ±S.E. of Mean) of Brahm sarovar water from February to August 2007

Sr No	Parameter	S-1		S-2		S-3	
		Before amavasya	**After amavasya**	**Before amavasya**	**After amavasya**	**Before amavasya**	**After amavasya**
1.	Temperature °C	26.69± 3.53	26.52± 3.39	26.55± 3.51	26.55± 3.46	26.85±3.53	26.69±3.49
2.	pH	7.58±0.10	7.35±0.08	8.02±0.11	7.34±0.14	7.76±0.05	7.35±0.22
3.	Conductivity µ mhos/ cm	274.4±9.88	277.5±6.62	254.2±4.87	252.6±5.18	247.4±3.48	252.3±5.97
4.	Total solids mg/L	210.7±16.5	231.3±23.7	217.2±26.7	302.2±20.8	186.5±13.5	255.5±17.0
5.	Free CO_2 mg/L	1.44±0.43	3.38±0.45	1.22±0.37	4.77±2.74	1.11±0.40	4.00±1.71
6.	DO mg/L	6.55±0.73	4.88±0.74	6.59±0.56	4.53±0.72	6.61±0.69	4.75±0.77
7.	BOD mg/L	1.26±0.15	2.60±0.26	1.25±0.11	2.76±0.47	1.36±0.07	2.61±0.33
8.	Total Alkalinity mg/L	55.8±2.75	57.4±4.52	66.8±3.72	72.5±4.15	63.8±4.08	71.7±4.36
9.	Chlorides mg/L	13.19±1.23	14.03±1.44	12.97±1.33	14.80±1.46	12.97±1.37	14.36±1.47
10.	Hardness mg/L	97.3±3.14	100.5±2.28	94.7±4.00	99.4±3.98	92.4±2.11	97.1±1.90
11.	Calcium mg/L	29.85±0.36	32.28±1.10	27.86±0.89	29.34±0.53	27.65±0.59	28.96±0.86
12.	Magnesium mg/L	5.96±1.05	5.11±0.88	6.08±0.92	6.14±0.67	5.70±0.63	6.04±0.62
13.	Phosphate mg/L	0.054±0.005	0.089±0.015	0.066±0.013	0.120±0.039	0.047±0.007	0.107±0.03
14.	Ammonia mg/L	0.086±0.036	0.245±0.075	0.116±0.057	0.409±0.074	0.102±0.032	0.189±0.034
15.	NPP g C/ $m^{3/}$ d	0.57±0.37	0.79±0.19	0.88±0.09	0.75±0.12	1.06±0.17	0.88±0.15
16.	GPP g C/ $m^{3/}$ d	1.01±0.45	1.97±0.12	1.55±0.58	1.38±0.51	2.17±0.06	1.90±0.03
17.	Total Plankton/L	2366±263	2336±135	2303±133	2651±369	2433±115	2350±232
18.	Total Phytoplankton/ L	1940±255	1926±171	1863±117	2176±372	1953±127	1876±276
19.	SDI Phytoplankton	2.49±0.04	2.49±0.056	2.35±0.18	2.23±0.25	2.65±0.09	2.25±0.18
20.	Total Zooplankton/L	413±24	413±64	440±23	473±37	453±28	473±65
21.	SDI Zooplankton	2.43±0.07	2.23±1.40	2.52±0.07	2.42±0.09	2.60±0.13	2.48±0.17

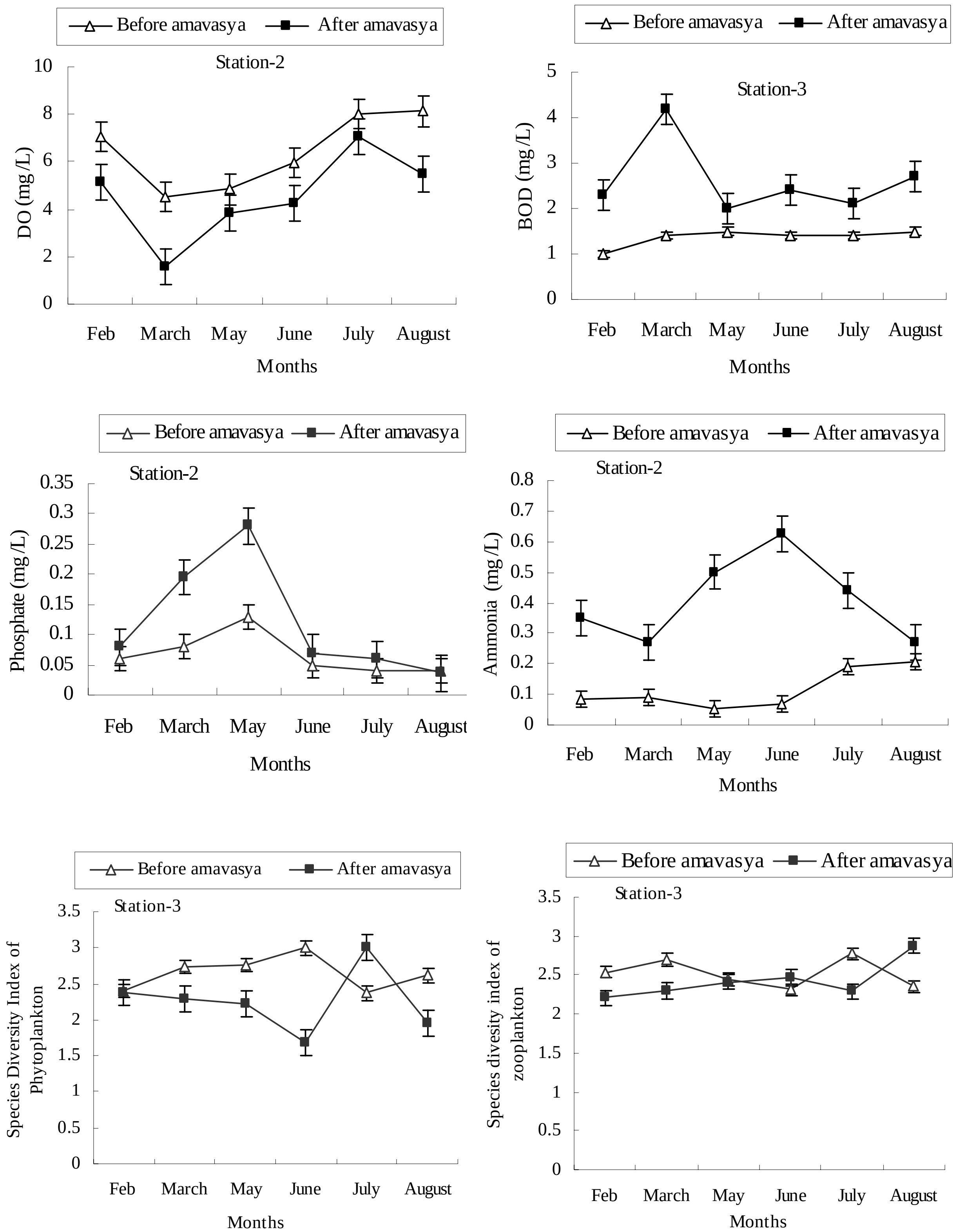


Fig.1. Variations in different water quality parameters (Mean ± S.E.) before and after Amavasya at different stations during February to August 2007

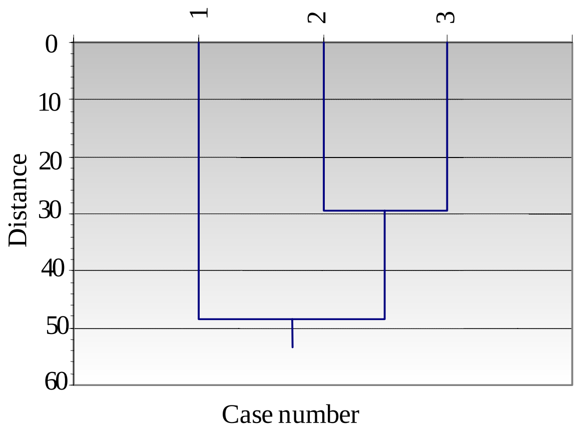
$$\textbf{Fe (III) PO}_4\textbf{ (Insoluble)} \xrightarrow{\boxed{\text{Free CO}_2}} \textbf{Fe (II) (PO}_4)_2\textbf{ (Soluble)} \longrightarrow \textbf{Fe}^{2+}\textbf{ (free)} + \textbf{PO}_4^{3-}\textbf{ (free)}$$

Another reason for increase of phosphate level after bathing may be the addition of soaps and detergents by the pilgrims. Phosphate was found quite opposite in relation to DO (r = -0.434, P<0.01) may be due to inverse relationship of CO_2 and DO. This may also responsible for increase in hardness after bathing. These results further depict that the tank was well under tropic status showing moderately eutrophic condition (Kulshrestha *et al.*,1992).

The high organic matter and pollution due to animal origin like bathing, adding ashes and urination in water increased the chloride and ammonia contents of water. Chloride also showed a significant (P<0.01) positive correlation with hardness (r = 0.469) may be attributed to presence of chlorides of sodium, calcium and magnesium that may contributed to the hardness and with total solids (r = 0.312) may be due to presence of organic matter that also increased the chloride contents of water. Hence, increased chlorides are also responsible for increase of total solids and hardness after mass bathing and on the basis of Kannan's observations water of the tank can safely be included in the range of moderately hard (61-120 mg/L).

Significant variations have not been observed in the population of phytoplankton as well as zooplankton after mass bathing, however, phytoplankton showed a significant positive correlation with DO (r = 0.321, P<0.01), hardness (r = 0.351, P<0.01) and a negative correlation with BOD (r = -0.328, P<0.01)and PO_4 (r = -0.362, P<0.01; r = -0.352, P,0.01). These correlation values indicates that DO is the promoting factor and BOD and PO_4 are the limiting factors for the plankton population. Plankton also showed a positive correlation with conductivity along with hardness, it may be attributed to more the dissolved nutrients in water, more will be the conductivity and hardness hence more will be the plankton population whereas zooplankton showed a positive correlation with chloride (r = 0.278, P<0.05) that is also in conformation with Sadguru et al. (2001).

It may be attributed to the presence of organic matter of animal origin and this organic matter may serve as a food for the zooplankton. Decrease in the species diversity index of phytoplankton was noticed after the dip may be due to their positive correlation with pH (r = 0.364, P<0.01) because decrease in the pH has been recorded after bathing. A decrease in the SDI of zooplankton has also been noticed it may be due to their inverse relationship with PO_4 (r = -0.324, P<0.01) that has been found to be increased after bathing. Water quality index value has been found to be 88 before amavasya. Hence, the water of the tank is good in water quality status according to Oram (2007) but after mass bathing; it was found to be decreased *i.e.* 74, which tell us about the deterioration of the water quality after mass bathing. Dendogram (Fig.2) based on cluster analysis (MVSP) showed the station wise complete linkage between different parameters clearly revealing the values at station S-1 where minimum or less bathing occurs.



joining		with		
Cluster 1	Size 1	Cluster 2	Size 2	Distance
2	1	3	1	29.44741266
1	1	2	2	48.42704447

Fig. 2. Dendogram showing the cluster analysis of various physico-chemical and Biological characteristics with respect to stations

CONCLUSION

The study clearly depicted that the mass bathing during amavasya, tends to change the overall ecology of the tank by significantly decreasing DO and water quality index, increasing ammonia, BOD, hardness, total solids and available phosphates. The effects were further clear by showing a decline in species diversity of indwelling planktons. The conditions are not worst, so the proper legislative efforts can improve it, therefore it is recommended:

- •To disinfect the water time to time.
- •To educate the rural pilgrims to prohibit the acts which deteriorate the water quality.
- •To construct more toilets in the vicinity of the Sarovar.
- •To use such temple ponds as conservation site for wild stock of important vulnerable fish species.

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