International Journal of Multidisciplinary Research and Development

Volume: 2, Issue: 9, 25-30
Sep 2015
www.allsubjectjournal.com
e-ISSN: 2349-4182
p-ISSN: 2349-5979
Impact Factor: 4.342

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Analysis of water quality in Polluted Sagar Lake by investigating different physico-chemical parameters

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Abstract
Sagar Lake is located in the centre of Sagar city in Madhya Pradesh. This lake is surrounded by agricultural fields, industries, hospital, bus stand and slums. The waste from the industries and surrounding localities is directly discarded into the lake. To evaluate the water quality of this lake, study was carried out for the period of one year from January to December 2014. Monthly water samples were collected to analyze different physico-chemical parameters and obtained results were compared with standard values. The pollution status was investigated on the basis of obtained results of physico-chemical parameters of water. High level of variation was recorded during analysis, as a result of human activity and discharge of waste water to the lake. If similar condition will be continued for longer period of time, then very soon Sagar Lake will becomes biologically inactive.

Keywords: Pollution, Sagar Lake, Physico-chemical.

Introduction
Sagar Lake is situated in the heart of Sagar city (23º 50'N: 78º 45'E and 517 MSL) with an area of 82 hectares. It is a shallow, rained lake with a small catchment (588 hectares), and its north westward drainage agrees well with the general north westward drainage pattern of the district (Mishra, 1969) [19]. The entire lake can be divided into two parts; the main lake occupying an area 68 hectares and a small lake of 14 hectares. The main lake is well protected by a large number of ghats, houses, roads and a stone fencing wall all around, except on the southern open side which ultimately terminates in the small lake which is connected to the main lake by a narrow passage of cemented bridge. The lake improved and deepened during the famine of 1900 at a cost of about Rs. 7000. Due to topography of the region and the existence of the Sagar Lake very little improvement was effected in the old parts of the town. Sagar Lake is the biggest lake. The rain water from the south-western side enters in the small lake through the feeder canal in the west, whereas the outflow is through Mongha weir in the main lake situated at the back of the Ganga Mandir. This weir regulates the outflow and helps to maintain the water level. The main lake is shallower on the north-eastern, eastern and south-western sides, with its deepest point (5.5m) near the fort side and the average depth is around 2 meters. The lake is used for bathing, washing clothes, recreation, navigation, Trapa cultivation etc. A large number of cattle may be seen stumbling specially at the southern side, disturbing and churning the sediments. Aquatic environment of water bodies was disturbed due to mismanagement and unawareness of people. Here, an investigation was done to asses present water quality of the lake as, the monitoring and assessment provides the basic information on the condition of a water bodies.

Material and Methods
The present study was carried out for Sagar Lake, located in Sagar, Madhya Pradesh. In the present study the sampling was done during morning hour from 7.00 a.m to 10.00 a.m. in third week of every month. The water samples were collected in collection bottle, from eight different sites. From the time of sample collection to the time of actually analysis, many physico-chemical reactions would occurs which changes the quality of the water sample; therefore to minimize this change the sample were preserved soon after the collection. The water samples were preserved by adding chemical preservatives and by lowering the temperature. The water Temperature, pH, TDS and DO were analyzed immediately at the site, whereas the analysis of remaining parameters were done in the laboratory. The collected water samples were brought to the laboratory and relevant analysis was performed. pH was determined electrometrically using digital pH meter, Dissolved Oxygen is measured by modified Wrinkler's method, Total Dissolve Solid was measured by using TDS meter and similarly Alkalinity, Chloride, Hardness, Nitrate and Phosphate were determined by method suggested by Adoni *et al*. (1999), Trivedy and Goel

(1984), APHA (1995) [2]. The mean value of the monthly data was calculated as site wise and Statistical analysis such as standard deviation, standard error and correlation coefficient (r) was calculated by using Origin pro-8.6

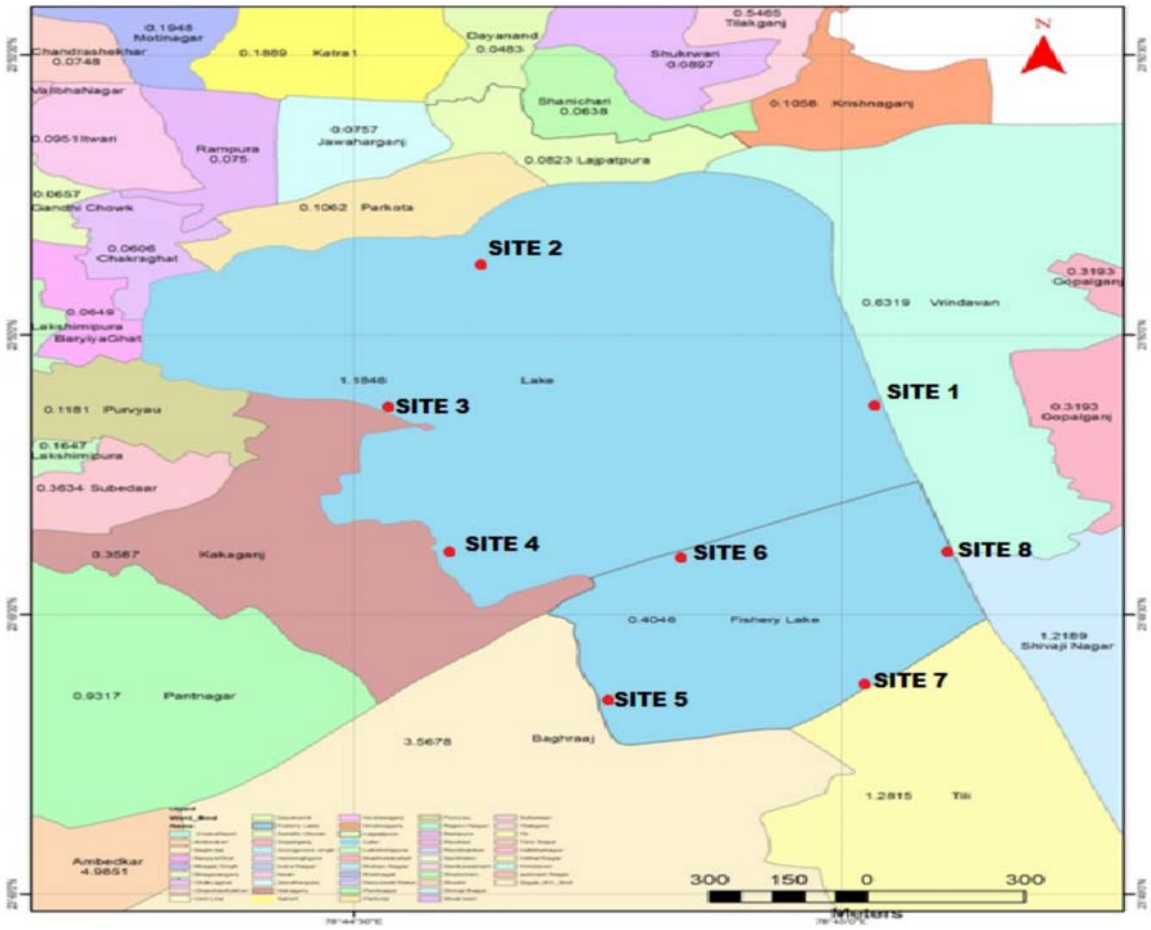

Fig 1: Showing collection sites at the Sagar Lake

Results and Discussion

pH: In India water bodies are generally alkaline in nature (Ranu, 2001; Gupta and Sharma, 2004) [25]. pH means H+ ions are compensated with OH ions (Sharma and Darve, 1991) [26]. The pH value of Sagar Lake ranges between 6.8 to 8.2 (Figure 2). The maximum pH was recorded during summer season and the minimum pH was recorded during rainy season. Alkaline state of pH might be due to the chemical buffering and release of bicarbonate and carbonate ions or salts (Sharma and Gupta, 2004) [27]. High pH in summer is due to high decomposition activities. Similar result was observed in Yammuna River at Faridabad and in mini Mahi River (Chaudhary, Anuradha and Sastry, 2004; Solanki, 2007). The factors like photosynthesis, respiratory activity, temperature exposure to air, disposal of industries wastes etc. bring out changes in the pH (Swarnlatha and Narsingrao, 1998) [31]. The low value of pH could be due to accumulated organic matters which reduces the pH. According to (Sreenivasan, 1976) [30] variation in pH of water indicates highly productive nature of water body.

Temperature: Temperature is an important factor, which regulates the biogeochemical activities in the aquatic environment. The temperature of Sagar Lake ranges between 15.12 °C to 31.5 °C (Figure 3). The maximum temperature was recorded during the summer season and the minimum was recorded during winter season. The maximum temperature during summer was due to greater solar radiation, low water level, clear atmosphere and higher atmospheric temperature. Similar observation was found in the studies of Dahikhura reservoirs, and in lake at Nainital (Garg, *et al*., 2000b and Hujare, 2008) [12, 14]. During higher temperature if there is excessive amount of nutrients in water body it causes growth of algae and aquatic weeds. During winter the temperature remain low due to cold low ambient temperature and shorter photoperiod (Kadam, *et al*., 2007) [16].

Total Dissolve Solid: Total dissolved solids denote mainly the various kinds of mineral present in the water. The amount of Total Dissolve Solid in Sagar Lake ranges between 160 to 291 ppm (Figure 4). The maximum amount of Total Dissolve Solid was recorded during summer season and minimum was recorded during winter. Due to contamination of domestic waste water, garbage, fertilizer, etc in the natural surface water body the value of TDS was reported to be high. Indeed, high concentration of TDS enriches the nutrient status of water body which were resulted into eutrophication of aquatic ecosystem Similar result was observed in some Laurention Great Lakes (Beeton,1965) [3].

Dissolved Oxygen: Dissolved Oxygen is a primary physico-chemical parameter in pollution studies. Lakes with good aquatic life had high Dissolve oxygen value (Vijayan *et al*., 1980-91) [32]. The amount of Dissolved Oxygen recorded in Sagar Lake ranges between 4.0 to 8.2 mg/l (Figure 5). The minimum amount of Dissolved Oxygen in Sagar Lake was

recorded during summer season, whereas the maximum amount of Dissolved Oxygen in Sagar Lake was recorded during winter season. Dissolved Oxygen in water is often attributed to the fact that the oxygen is dissolved more during the period of active photosynthesis (Sreenivasan, 1972) [29]. In summer season Dissolved Oxygen was decreased due to increase temperature of water (Naz, and Turkmen, 2005). Depletion of dissolve oxygen in water is due to high temperature and increased microbial activity (Kataria, *et al*., 2006) [17].

Biochemical Oxygen Demand: Biochemical oxygen demand depends on aquatic life,variation in BOD indicates dynamism in aquatic life present in the pond. BOD refers the oxygen used by the microorganism in the aerobic oxidation of organic matter. Therefore with the increase in the amount of organic matter in the water the BOD increases. The BOD value in Sagar Lake ranges between 12 to 31.4 mg/l (Figure 6). The minimum demand of oxygen in the water was recorded during winter season, whereas the maximum demand was recorded during rainy season. The higher value of BOD during rainy season was due to input of organic wastes. Similar result was observed by (Garg, Rao and Saksena, 2008) in Ramsagar reservoir of Datia and by (Devaraju, *et al*., 2005) [9] in Maddur Lake.

Chemical Oxygen Demand: It is a measure of various chemically oxidizable organic substance of different nature entering in water body. COD ranges from 12.3 to 14.6 mg/l (Figure 7). The minimum COD was recorded in winter, whereas the maximum in summer. COD was high due to high temperature. COD increases with increasing concentration of organic matter (Boyd, 1981) [6]. The continuous flow of sewage from different sources into the Lake results in increased COD level.

Chloride: The COD increase with increasing concentration of chlorides in lake water from different sources like disposal of sewage and industrial waste (Sirsath, *et al*., 2012). The amount of Chloride recorded in Sagar Lake ranges between 55.27 to 134.86 mg/l (Figure 8). The minimum amount of chloride in lake water was recorded during the rainy season and the maximum amount was recorded during summer season. The high chloride concentration of the lake water may be due to high rate of evaporation or due to organic waste of animal origin (Prasad, *et al*., 1985; Purohit, and Saxena, 1990) [23, 24]. Similar variations was also observed by many workers (Fokmare and Musaddiq, 2002; Chatterjee and Raziuddin; 2003, Garg, Rao, and Saksena, 2009) [11, 8, 13].

Total Alkalinity: Total Alkalinity in water is due to salts of weak acids and bicarbonates of highly alkaline water (Kataria, *et al*., 2006) [17]. The amount of total alkalinity recorded in Sagar lake ranges between 114 to 178 mg/l (Figure 9). The minimum value of alkalinity was recorded during summer season and the maximum value of alkalinity was recorded rainy season. The addition of large amount of sewage waste and organic pollutant in the lake due to rain water results in high Alkalinity that makes the water body nutrient rich and highly productive (Munawar, 1970) [21]. The degradation of plants, living organism and organic waste might also be one of the reasons for increase in a carbonate and bicarbonate resulting in increase of alkalinity value (Jain, *et al*., 1997, and Chaurasia, *et al*., 2007) [15, 7].

Total Hardness: In water, the principle hardness causing ions are calcium and magnesium. The Total Hardness recorded in the water of Sagar Lake ranges between 170 to 254 mg/l (Figure 10). The maximum amount of total hardness in the water of Sagar Lake was recorded during winter season and the minimum amount of total hardness was recorded during summer season. The high value of hardness may be due to addition of calcium and magnesium salts by mean of plants and living organism. High values of hardness are probably due to regular addition of large quantities of sewage and detergent into lakes from the nearby residential localities (Kaur, *et al*., 1996 and Mohanta, *et al*., 2000) [18, 20]. High Hardness of water body points towards eutrophication (Pandey, 2008) [22].

Nitrate: Nitrates are contributed to freshwater through discharge of sewage and industrial wastes and run off from agricultural fields.The amount of nitrate recorded in the water of Sagar Lake ranges between 3.72 to 9.62 mg/l (Figure 11). The minimum amount of nitrate in the water of Sagar Lake was recorded during winter season, whereas the maximum amount of nitrate in water was recorded during rainy season. The high nitrate concentration during rainy season might be due to influx of nitrogen rich flood water that brings about large amount of contaminated sewage water. Similar results were observed by (Vijayvergia, 2008) [33] in Udaisagar Lake.

Phosphate: Phosphorus along with Nitrogen causes explosive growth of algal species that leads to eutrophication (Dwivedi and Panday, 2001) [10]
. The amount of phosphate recorded in the water of Sagar Lake ranges between 0.61 to 0.84 mg/l (Figure 12). The minimum amount of phosphate recorded in the water of the lake was during rainy season and the maximum amount was recorded during winter season. The washing of large amount of clothes by dhobis and laundry worker, as well as continuous entry of domestic sewage in some area are responsible for increase in amount of phosphate (Benjamin *et al*., 1996) [4].

Table 1: Showing Statistical Characteristics and Seasonal Mean from January to December 2014 in Sagar Lake

	Winter	Summer	Rainy	Min	Max	Mean	SD	SE
pH	7.2	7.6	7.1	6.8	8.2	7.35	0.1237	0.0154
Temperature	20.49	27.59	25.87	15.12	31.5	24.65	1.3965	0.1745
TDS	230.96	265.71	239.59	160	291	245.42	1.4849	1.8561
DO	6.45	4.61	5.17	4.0	8.2	5.4125	0.17677	0.0220
BOD	20.85	26.4	26.85	12	31.4	24.70	1.2727	0.1590
COD	17.465	30.393	28.737	12.3	41.6	25.53	2.1213	0.2651
Chloride	103.69	114.20	82.243	55.27	134.86	101.05	20.678	2.5848
Alkalinity	138.18	130.87	162.31	114	178	143.78	2.8284	0.3535
Hardness	196.64	190.07	195.58	170	254	194.10	40.7806	5.0975
Nitrate	5.904	6.1718	7.556	3.72	9.62	6.544	0.8326	0.1040
Phosphate	0.80	0.73	0.72	0.61	0.84	0.757	0.0300	0.0037

Correlation Coefficient (r) between Different Physico-chemical parameters

Correlation coefficient (r) between every parameters of Sagar Lake is calculated by taking average of values shown in Table 2. The degree of line association between any two water parameter which are measured as correlation coefficient (r) is presented in Table 2 as 11X 11 correlation matrix. pH shows positive correlation with Temperature, TDS, BOD, COD, Chloride, and Phosphate, while negative correlation with DO, Alkalinity, Hardness and Nitrate. Water Temperature shows positive correlation with TDS, BOD, COD and Nitrate, while negative correlation with DO, Chloride, Alkalinity, Hardness and Phosphate. TDS shows positive correlation with BOD, COD, Chloride, Hardness, Nitrate and Phosphate, while negative correlation with DO and Alkalinity. DO show positive correlation with Hardness and Phosphate, while negative correlation with BOD, COD, Chloride, Alkalinity and Nitrate. BOD shows positive correlation with COD, Alkalinity and Nitrate, while negative correlation with Chloride, Hardness and Phosphate. COD shows positive correlation with Chloride, Alkalinity and Nitrate, while negative correlation with Hardness and Phosphate. Chloride shows Positive correlation with Hardness and Phosphate, while negative correlation with Alkalinity and Nitrate. Alkalinity shows positive correlation with Hardness and Nitrate, while negative correlation with Phosphate. Hardness shows positive correlation with Nitrate and Phosphate. Nitrate shows positive correlation with Phosphate. There is a strong positive correlation r = 0.78154 between Temperature and COD. Temperature and Phosphate shows highly significant negative correlation r = -0.6983. The values (r) ranged from -0.42467 to -0.79734 are significant at $P < 0.05$ and $P < 0.01$ respectively.

Table 2: Correlation Coefficient (r) between Different Physico-chemical parameters in Sagar Lake

	1	2	3	4	5	6	7	8	9	10	11
1	1										
2	0.43385	1									
3	0.75448	0.41266	1								
4	-0.53331	-0.7863	-0.6899	1							
5	0.22979	0.741814	0.36489	-0.79734	1						
6	0.47799	0.78154	0.62663	-0.92675	0.767777	1					
7	0.54818	-0.06696	0.634887	-0.33286	-0.10578	0.19458	1				
8	-0.63056	-0.08181	-0.30282	-0.03071	0.411022	0.11677	-0.36273	1			
9	-0.02879	-0.20869	0.05465	0.157732	-0.23322	-0.1513	0.158389	0.02418	1		
10	-0.15629	0.36480	0.106334	-0.27407	0.334439	0.36789	-0.23751	0.42710	0.070448	1	
11	0.083432	-0.6983	0.210929	0.41085	-0.42467	-0.4246	0.474052	-0.1301	0.33126	0.016078	1

(1) pH
(2) Temperature
(3) TDS
(4) DO
(5) BOD
(6) COD
(7) Chloride
(8) Total Alkalinity
(9) Total Hardness
(10) Nitrate
(11) Phosphate

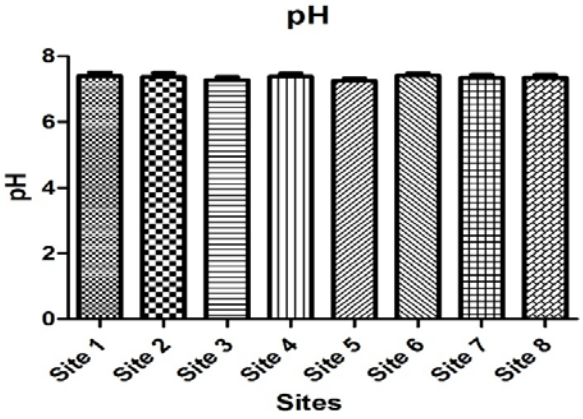

Fig 2: Monthly variation in pH

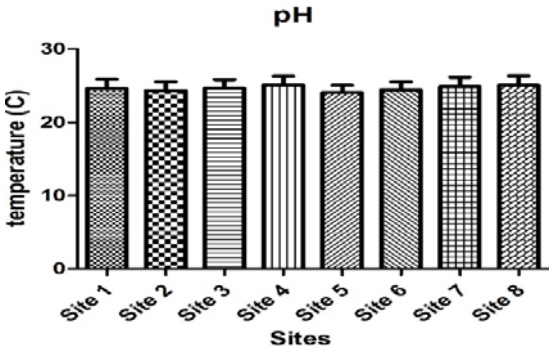

Fig 3: Monthly variation in Temperature

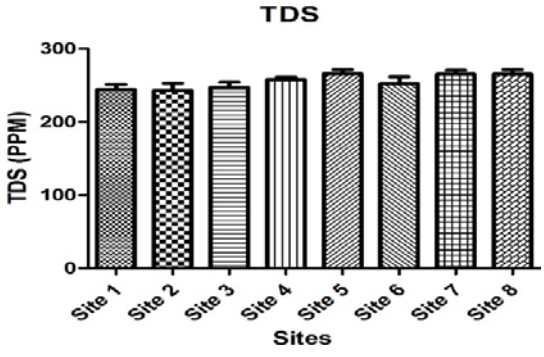

Fig 4: Monthly variation in TDS

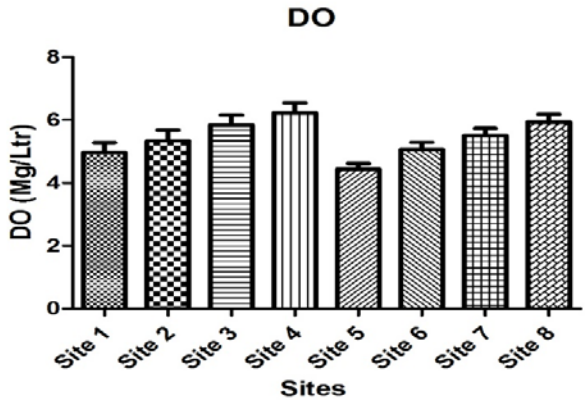

Fig 5: Monthly variation in DO

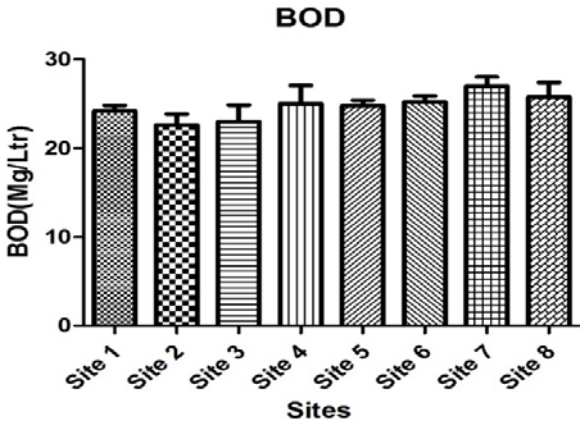

Fig 6: Monthly variation in BOD

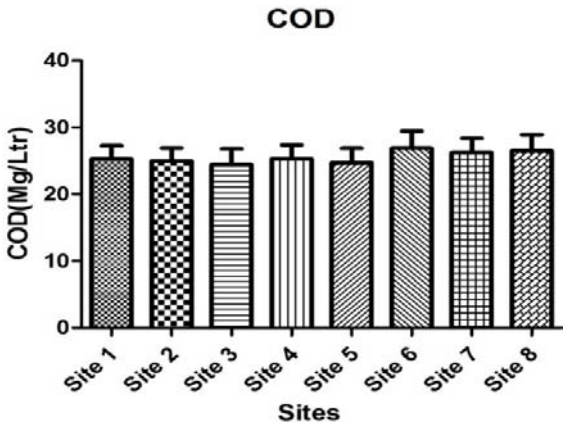

Fig 7: Monthly variation in COD

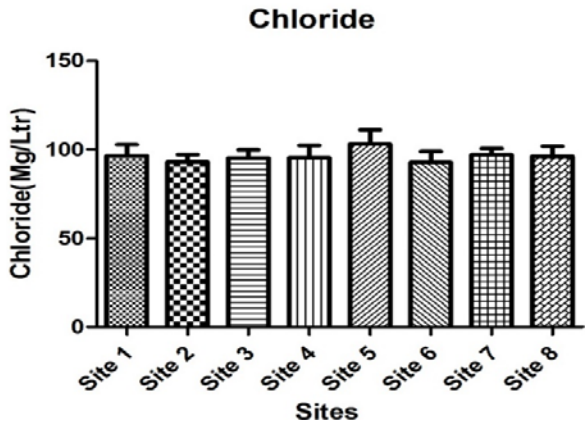

Fig 8: Monthly variation in Chloride

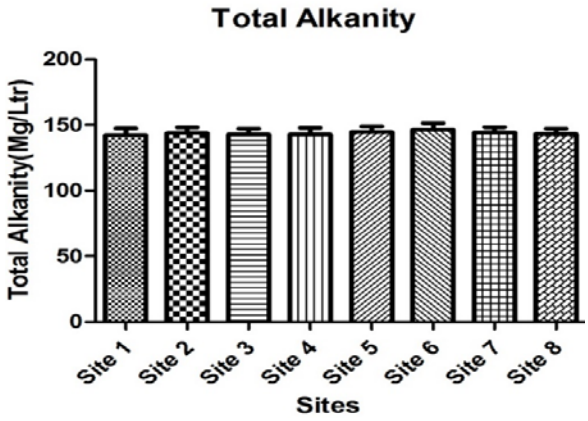

Fig 9: Monthly variation in Total Alkalinity

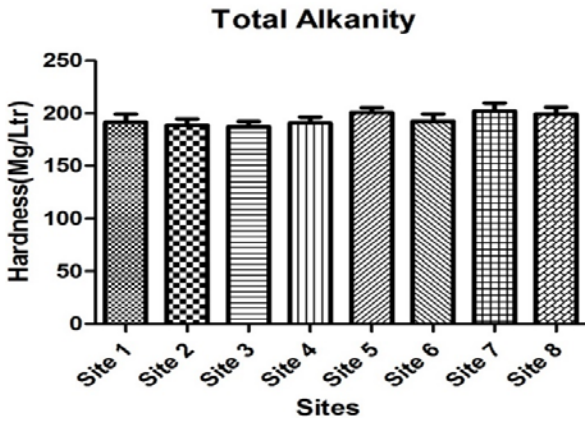

Fig 10: Monthly variation in Total Hardness

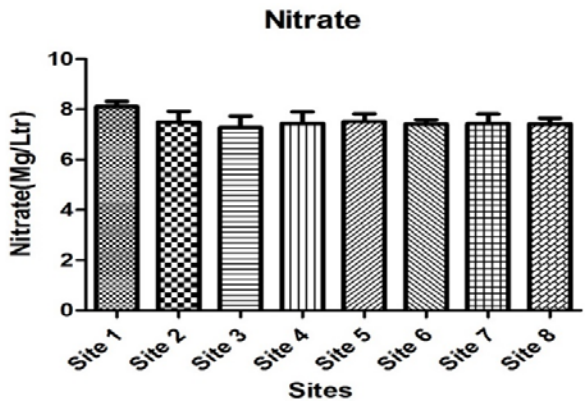

Fig 11: Monthly variation in Nitrate

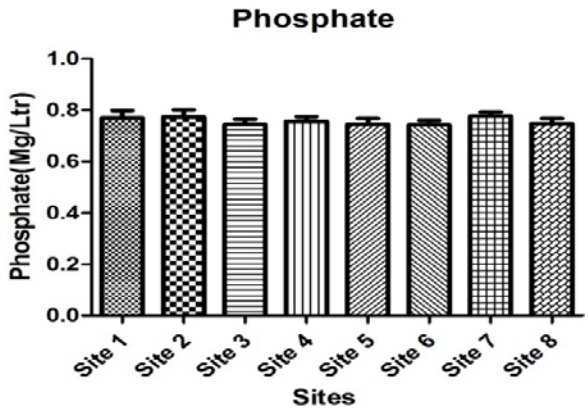

Fig 12: Monthly variation in Phosphate

Conclusion

The result obtained during study was compared with WHO and BIS standards and it was found that maximum number of parameters in Sagar lake were above desirable limit in all the eight sites. This result shows that the Sagar Lake receives very high amount of pollution from the surrounding and the water of lake is highly contaminated. If similar condition continue for the longer period, Sagar Lake may soon become ecological inactive.

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