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To study the variations in Chemical parameters of water during the pre – monsoon and the post monsoon seasons – A case study of Upper Lake, Bhopal

Ranjana Talwar*[1], Swasati Bhattacharya[2], Amit Chowdhury[3], Avinash Bajpai[4], Suman Malik[5]

[1]*Extol Faculty of Life Sciences, Bhopal, India*
[2,3]*Dept of Zoology, East Calcutta Girls College, Laketown, Kolkata*
[4]*Makhanlal Chaturvedi University, Bhopal, India*
[5]*Head of Dept. of Chemistry Sadhu Vaswani College Bhopal, India*

A B S T R A C T

Upper Lake of Bhopal is the chief source of potable water for the people of Bhopal. To assess the quality of water of the Lake samples from ten different stations with varying catchment area activities were collected. The catchment area activities ranged from rural to semi urban and urban. The study was carried out for a period of two years during the pre-monsoon and the post-monsoon seasons so as to depict the effect of rainfall upon concentration of various parameters. The various physic-chemical parameters studied were temperature, pH, conductivity, chloride, nitrate, phosphate, sulphate, carbonate, potassium and sodium. It was observed from the study that most of the parameters were found to have a higher level during the post monsoon season due to surface runoff from the nearby areas. Also it was observed that concentration of various parameters depended on the rural and the urban activities being carried out in the catchment area.

Keywords: *potable, catchment area activities, physic-chemical parameters, surface runoff,*

A R T I C L E I N F O

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***Corresponding Author**
Ranjana Talwar
Extol Faculty of Life Sciences,
Bhopal, India
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1. Introduction

A lake is a body of water that is surrounded by land. There are millions of lakes in the world and are important **ecosystems.** They may be sources of water supply in certain regions. Lakes are extremely varied in

terms of origin, occurrence, size, shape, depth, water chemistry, and other features. Lakes may be Fresh water or Saline water. Fresh Water is essential to existence of life. Water of acceptable quality is essential not only for drinking and domestic purposes but also for agriculture, industrial and commercial uses. The availability of water is an important factor in the establishment of the earliest settled communities and even today, the evolution of public water supply systems is tied directly to the growth of cities and towns.

Lakes are important sources of fresh water also in the city of Bhopal, the capital of Madhya Pradesh. They supply the communities with water for various purposes including domestic, agricultural and industrial. Besides acting as a source of potable water and attracting tourists for its scenic beauty it also provides occupation to many fishermen families. The catchment area of the lake displays a complete range of urban and rural activity with varying intensities. The lake also serves as the source of water for irrigating a large area. There are 87 villages in its catchment area in the Bhopal as well as Sehore districts. Agriculture is the main source of livelihood for people in these areas and most farmers have livestock as well. The urban catchment area comes under the Bhopal settlement. The settled area has variety of land use consisting of housing, business, institutions, parks, playgrounds, recreational sites, worshipping and open places.

These developments have generated anthropogenic pressures on the lake, thus accelerating its eutrophication and microbial contamination. To meet the increased demand for potable water and subsequent pressure of the Upper lake resources, the storage capacity of the lake was increased by raising the height of the spillway. Although this has resulted in an increased water supply, the increased anthropogenic activities and urbanization in the catchment also have caused an increased inflow of the silt, untreated domestic sewage from the nearby areas, nutrients, pesticides and other agricultural wastes from the rural areas, industrial wastes from the urban areas, and an overall deterioration of the water quality. With the increasing rate of human exploitation and modification of the environment, the quality of water is fast degrading.

2. Materials and Methods

In order to assess the quality of water and to study the impact of various urban and semi urban activities of the catchment areas on the lake ecosystem of the Upper Lake - the chief source of water for the people of Bhopal, ten different sampling stations were selected. These sampling stations were selected because of the various different types of activities in these catchment areas and to study the influence of these activities on the water quality. The samples from these different stations were collected twice a year during the Pre – monsoon and Post – monsoon seasons. The study was carried out for a period of two years i.e. 2011 and 2012. The water samples to be analyzed were collected in different well labeled and clean plastic bottles for analysis of physico-chemical parameters. The bottles were tightly capped and were immediately transported to the laboratory for analysis to avoid any unpredictable changes in the parameters being tested. The method of analysis of various water samples was as per the standard methods of APHA (1995).

Sampling Stations:

The various sampling stations selected for analysis of water samples are as under:

Sampling station near Borban [S1]

This sampling station is situated near the Bairagarh township. It is less affected by human interventions and is thus comparatively less polluted.

Sampling station Khanugaon [S2]

This part of the Upper Lake is also affected due to human interventions. Domestic sewage from the adjoining slums and nearby residential areas enters into the lake. It is also affected by cattle activities especially galloping of buffaloes.

Sampling station near Vardhaman Park [S3]

Vardhaman Park is located at a distance of 2.5 kms from Bhopal city center. The park has a rose garden and a well landscaped walk way with a fantastic view of the Upper Lake. It basically has a tourist attraction.

Sampling station near PHE Pumphouse [S4]

Raw water from the Upper Lake is abstracted for municipal supply at seven different points around the lake and pumped to an equal number of independent water treatment plants. After treatment, the water is pumped to the service reservoirs.

Sampling station near Yatch Club [S5]

This station is basically used for stocking of fish fingerlings. This site is comparatively less affected due to anthropogenic pressure than the other sites at southern region.

Sampling station near Vanvihar [S6]

This station represents the area that comes under protected forest. It is comparatively free from human interventions and other anthropogenic activities. This is an ideal spot for fish growth.

Sampling station near Kotra Nallah [S7]

This station receives main untreated drainage from Kotra. It is the confluence point of drainage nallah from Charimli area behind and Kotra.

Sampling station near Goragaon [S8]

This area of the Upper Lake is situated in the remote areas away from human interventions and the quality of water is affected by discharge from agricultural fields.

Sampling station near Gora Bisenkhedi [S9]

This station is situated near Gora Bisenkheri village that is the southern part of Upper Lake. Agricultural fields have been observed near this station.

Sampling station near Kaliasote [S10]

This sampling station is situated near the Kaliasote dam and also has agricultural practices going on in the nearby areas. The parameters that were tested on the collected water samples were Temperature, pH, Conductivity, Chloride, Nitrate, Phosphate, Sulphates, Carbonate, Sodium and Potassium.

Table 1A: Seasonal variations of Chemical parameters observed in various water samples in the catchment areas of Upper Lake, Bhopal in the year 2011

Sampling Station	Sampling Season	Temperature	pH	Conductivity	Chloride	Nitrate
S1	**Pre-monsoon**	32.4	6.9	0.2	14.2	2.09
	Post-monsoon	23.5	7.3	0.2	17.6	2.41
S2	**Pre-monsoon**	31.4	7.5	0.3	30.7	2.27
	Post-monsoon	22.2	7.4	0.3	28.9	2.76
S3	**Pre-monsoon**	32.8	7.5	0.2	34.9	1.62
	Post-monsoon	24.4	7.9	0.2	40.7	2.38
S4	**Pre-monsoon**	31.4	7.5	0.2	36.6	1.42
	Post-monsoon	21.6	7.5	0.3	39.4	2.25
S5	**Pre-monsoon**	34.1	7.3	0.1	28.2	1.78
	Post-monsoon	23.4	7.6	0.3	32.1	2.21
S6	**Pre-monsoon**	30.7	8.9	0.2	14.9	2.49
	Post-monsoon	20.3	7.9	0.2	18.7	3.37
S7	**Pre-monsoon**	33.4	6.5	0.8	78.8	2.23
	Post-monsoon	22.5	6.7	1.0	71.6	2.65
S8	**Pre-monsoon**	32.2	6.8	0.3	21.2	3.36
	Post-monsoon	21.1	7.1	0.2	30.8	3.72
S9	**Pre-monsoon**	34.3	7.7	0.2	24.1	2.84
	Post-monsoon	23.2	7.5	0.3	34.0	3.54
S10	**Pre-monsoon**	32.1	8.8	0.1	24.6	2.69
	Post-monsoon	23.1	8.1	0.2	34.2	3.55

Table 1B: Seasonal variations of Chemical parameters observed in various water samples in the catchment areas of Upper Lake, Bhopal in the year 2011

Sampling Station	Sampling Season	Phosphate	Sulphate	Carbonate	Sodium	Potassium
S1	**Pre-monsoon**	1.85	16.4	4	16	14
	Post-monsoon	2.03	23.6	8	19	17
S2	**Pre-monsoon**	3.53	16.2	2	21	17
	Post-monsoon	3.78	21.9	6	27	22
S3	**Pre-monsoon**	1.93	30.6	8	22	16
	Post-monsoon	1.59	34.5	18	28	23
S4	**Pre-monsoon**	2.21	29.4	2	13	8
	Post-monsoon	2.57	28.6	0	17	14
S5	**Pre-monsoon**	1.26	19.2	2	14	10
	Post-monsoon	1.74	21.6	2	21	17
S6	**Pre-monsoon**	2.65	21.9	14	10	9
	Post-monsoon	3.18	24.9	26	13	15
S7	**Pre-monsoon**	2.15	45.3	2	37	31
	Post-monsoon	2.67	48.7	0	47	36
S8	**Pre-monsoon**	3.36	26.9	2	19	13
	Post-monsoon	3.79	24.4	2	25	18
S9	**Pre-monsoon**	4.82	27.3	2	23	13
	Post-monsoon	4.37	32.8	4	25	15
S10	**Pre-monsoon**	2.15	23.5	6	15	9
	Post-monsoon	2.72	27.6	10	23	16

Table 2A: Seasonal variations of Chemical parameters observed in various water samples in the catchment areas of Upper Lake, Bhopal in the year 2012

Sampling Station	Sampling Season	Temperature	pH	Conductivity	Chloride	Nitrate
S1	**Pre-monsoon**	30.3	7.1	0.1	16.4	1.88
	Post-monsoon	22.6	6.9	0.3	26	2.45
S2	**Pre-monsoon**	29.5	7.6	0.2	37.4	2.47
	Post-monsoon	22.9	7.3	0.3	39.2	4.36
S3	**Pre-monsoon**	30.2	7.3	0.2	35.9	2.46
	Post-monsoon	22.5	7.6	0.3	47.6	2.07
S4	**Pre-monsoon**	28.8	7.7	0.1	32.3	1.77
	Post-monsoon	22.4	7.6	0.2	45.8	2.36
S5	**Pre-monsoon**	29.3	7.4	0.2	21.2	2.16
	Post-monsoon	22.2	7.1	0.2	32.6	2.58
S6	**Pre-monsoon**	27.5	8.1	0.1	15.8	2.91
	Post-monsoon	22.0	7.6	0.2	21.4	3.66
S7	**Pre-monsoon**	28.3	7.1	0.9	84.6	2.86
	Post-monsoon	20.9	7.3	1.3	75.7	3.44
S8	**Pre-monsoon**	27.4	7.3	0.3	20.9	3.57
	Post-monsoon	20.1	7.0	0.4	34.3	4.32
S9	**Pre-monsoon**	29.1	7.2	0.2	26.7	3.27
	Post-monsoon	19.8	6.9	0.3	39.4	4.72
S10	**Pre-monsoon**	30.5	7.5	0.2	28.4	2.83
	Post-monsoon	22.0	7.8	0.3	37.7	3.64

Table 2B: Seasonal variations of Chemical parameters observed in various water samples in the catchment areas of Upper Lake, Bhopal in the year 2012

Sampling Station	Sampling Season	Phosphate	Sulphate	Carbonate	Sodium	Potassium
S1	**Pre-monsoon**	1.64	19.8	4	13	15
	Post-monsoon	2.27	23.1	12	23	19
S2	**Pre-monsoon**	3.36	21.8	4	26	28
	Post-monsoon	3.74	25.7	2	29	16
S3	**Pre-monsoon**	2.22	33.4	10	21	18
	Post-monsoon	1.76	37.8	24	25	14
S4	**Pre-monsoon**	2.32	31.9	0	11	9
	Post-monsoon	2.61	34.2	0	18	16
S5	**Pre-monsoon**	1.39	24.7	4	12	13
	Post-monsoon	2.12	26.3	2	23	18
S6	**Pre-monsoon**	2.85	16.4	18	12	10
	Post-monsoon	3.46	25.6	22	17	15
S7	**Pre-monsoon**	2.36	52.6	0	42	39
	Post-monsoon	2.93	54.5	0	54	44
S8	**Pre-monsoon**	3.31	21.9	0	23	17
	Post-monsoon	3.98	27.3	2	31	23
S9	**Pre-monsoon**	5.22	23.7	6	28	18
	Post-monsoon	5.12	37.9	6	26	16
S10	**Pre-monsoon**	2.31	22.1	10	19	15
	Post-monsoon	3.08	33.3	16	25	17

3.

3. Results and Discussion

The variations in the different chemical parameters observed in the various water samples collected from the catchment areas of the Upper Lake, Bhopal have been depicted in Table 1 and 2 in the year 2011 and 2012 respectively. During the study it was observed that the activities being carried out in the catchment areas have a direct influence on the quality of water. Temperature is an important factor that affects the physical characteristics of a lake. It may vary from lake to lake depending upon the depth of the lake, plant growth, dissolved materials, time of day and season. Sunlight warms the water, and wind cools it down. During the period of study a higher temperature was observed in the pre monsoon season while a lower temperature was observed in the post monsoon season. Similar results were also observed by **Tiwari (2005)** and **Jinwal *et al.* (2010).** pH maintenance is one of the most important attributes of any aquatic system since all the biochemical activities depend on pH of the surrounding water. Any alteration in water pH is accompanied by a change in the physico-chemical characteristics. The study revealed that the nature of water samples was found to be alkaline in most of the times. High value of pH is attributed to the presence of sufficient quantities of carbonates in the water samples. This type of observation has also been reported by **Das and Srivastava (2003)**. A general trend of a higher pH value was observed during the post monsoon season than in the pre monsoon season. Conductivity of water depends on the presence of ions, their total concentration and temperature variations. Chemically pure water has low electrical conductivity. The presence of ions in solution increases the conductivity of water. During the current investigation it was found that the value of Conductivity increased during the post – monsoon period probably due to the increase in the inflow of industrial inflow from urban areas and large inflow of silt. Chloride ion is essential for the electrolytic balance in our bodies. Because there is a continuous intake and excretion of chloride from all animals, it is one of the more abundant anions found in wastewater and are good indicator ion for pollution sources. Lower values of Chloride content indicated in the pre – monsoon season during the study may be due to concentration of the salts in the lake water whereas higher chloride content indicates the presence of organic matter of animal origin that has undergone oxidation. Similar findings were reported by **Bajpai (1994).** He stated that higher values of Chloride may be due to input of organic matter of animal origin. The major sources of nitrates in lakes are from the catchment area by rainfall, sewage effluents, agro wastes, suspended organic matter when algae and other suspended micro-organisms die and settle down to the bottom. During the study it was observed that higher nitrate concentration was observed in agricultural catchment areas and also during the post monsoon season. **Anu *et al.* (2010)** studied water quality of Kaliasote Dam and also found higher nitrate values in the rainy season. Phosphate enters water from human and animal wastes, wastes from laundries, cleaning and industrial processes and farm fertilizers. During the present investigation maximum value of phosphate concentration was recorded at station **S9 i**ndicating agricultural activities in its catchment areas. The higher values of phosphate concentration was also observed during the post – monsoon period indicating greater inflow of soil from the rural catchments along with the rain water. **Sujitha *et al.* (2012)** observed that the total phosphate value at Pallichal area of Karamana river of Trivandrum showed the deposition of nutrients during monsoon season. A general trend of an increase in the sulphate value was recorded in the post – monsoon season. **Choubey *et al.* (2008)** found higher concentration of sulphate at a few sites in the water samples collected from Upper Lake, Bhopal and also in the post monsoon season. This may be attributed to domestic sewage that enters into these sites and minerals from catchment areas along with surface run-off. During the present study it was observed that higher values of Carbonate were observed in the post – monsoon period. The high availability of sodium and potassium was observed during the post – monsoon season in Upper Lake. High values of potassium may be because of excessive use of chemical fertilizers in these catchment areas. The intensive agricultural activities carried out in the catchment areas results in increased level of unutilized potassium. This potassium gets accumulated in the lake water through runoff. Similar types of observations were also recorded by **Bajpai *et al.* (2002).**

4. Conclusion

It can be concluded from the above study that pollution in terms of nitrate and phosphate concentration, sulphate and a few others were specifically due to agricultural practices chiefly being carried out in the catchment areas. The extensive use of chemical fertilizers and pesticides has lead to an increase in their concentration during the post monsoon season as a result of agricultural runoff and sediments from the nearby fields. On the other hand pollution in the urban catchment is contributed by the sewage inflow, domestic and industrial wastes, anthropogenic activities, religious practices etc.

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