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Seasonal variations of physico-chemical parameters in Lower Lake of Bhopal

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Abstract
Water quality is considered to be a key contributor to both health and state of disease for humans. The quality of water is largely disturbed and influenced by both natural as well as by anthropogenic activities. The surface water quality is mainly impacted by human activities through effluent discharges, the use of agricultural chemicals and increased exploitation of water resources. The aquatic ecosystems are greatly affected by these factors, resulting in decrease of quality of water, depletion of biodiversity, habitat and in overall decreasing the quality of life for local inhabitants. It is therefore important to prevent and control water pollution and to implement regular monitoring programs. The analysis of various physico-chemical was done for understanding water quality of Lake.

Keywords: Water, physico-chemical parameters, Water quality, Lake

Introduction
Water has been used since ancient times as a symbol by which to express devotion and purity. Some cultures, like the ancient Greeks, went as far as to worship Gods who were thought to live in and command the waters. It is the most precious gift to mankind and is no possibility of life on earth without it. It is the nature's soul and a vital resource used for various activities such as drinking, irrigation, fish production, industrial cooling, power generation and many others (Sathe *et al*., 2001) [11]. It is an essential element for all living beings which are present on earth and is the primary source of food for root levelled producers in all food web on earth.
Water quality refers to chemical, physical, biological and radiological characteristics of water (Diercing, 2009). It is a measure of the condition of water relative to the requirements of one or more biotic species and to any human need or purpose (Johnson *et al.*, 1997) [8] and is determined by various physico-chemical, biological variables and changes generally due to many factors like source of water, type of pollution, seasonal fluctuations and adjacent human intervention that directly or indirectly affect its quality and consequently its suitability for the distribution and production of fish and other aquatic animals (Tiwari, 1992) [22]. It is most frequently used by reference to a set of standards against which compliance can be assessed and most common standards used to assess water quality relate to health of ecosystem, safety of human contact and drinking water. It has been the subject of many recent studies (Magesh and Chandrasekar, 2013; Pandey *et al.*, 2012) [13, 15] mainly because of the scarcity of water and its poor distribution which is increasing challenge and has gained increased research interest due to anthropogenic pressure on water bodies (Espejo *et al.*, 2012) [6]. Its degradation can be associated with changes in physical and chemical variables such as sediment load, concentration of nutrients, temperature, dissolved oxygen levels, pH (Swamee and Tyagi, 2007) [20] and biological indicators at the individual, population and community levels (Abbasi and Abbasi, 2012) [2].
Water quality studies of any aquatic ecosystem are fundamental to understand the water resource and one of the important features of the water body is the way in which they interact with the surrounding land, particularly due to the agricultural activities of man, construction of dams, deforestation and domestic as well as the industrial inputs. Since the quality of water affect aquatic lives in several ways, water must be of good quality for the health of all organisms.

Materials and Methods
The investigation was carried out during the period from Jan. 2016 to Dec. 2016. Three Sampling stations were selected based on different human activities such as washing, bathing

etc. The other factors like inlets, outlets, macrophytic population and morphometric features are also considered during the selection of sampling stations.

Station L1 (Neelam Park) This station is situated near Jehangirabad. The raw sewage from Jehangirabad, Police Headquaters, residential colonies and other surrounding densely populated areas make its way to this water body. It has moderate macrophytic population due to shallow area, sandy bottom.

Station L2 (Kali Mandir) This sampling station is situated near Kali Mandir. At this station lake has maximum depth of near about 10-11 meter. The main source of pollution for this station is sewage and solid waste from surrounding area.

Station L3 (P.H.Q.) This station is near the bathing ghat adjacent to Kathalapura temple. The sewage from police Headquaters enters in the lake from this point.

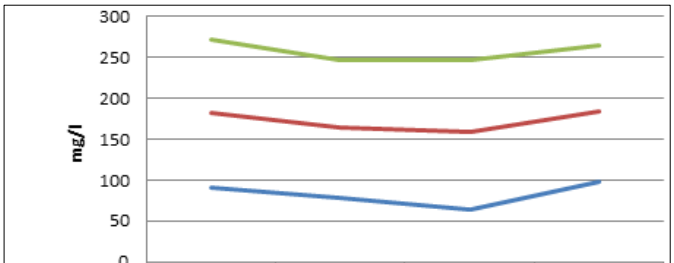
Water samples were collected seasonally at the selected sampling sites in 1-liter plastic cane between 8.30 AM to 12.30 PM. At the sampling stations analysis of some of the physico-chemical parameters was carried out immediately, which included air and water temperature, pH, Electrical Conductivity, Total dissolved solids. Free carbon dioxide, Transparency, fixing of sample for dissolved oxygen, Alkalinity, Total hardness. For estimation of dissolved oxygen, samples were fixed at the sampling site in accordance with modified Wrinkler method. Water sample for other Physico-Chemical and parameters were stored and carried to the laboratory and then immediately analysed within 4-6 hrs. The analysis of water samples was done by adopting standard methods of (Adoni, 1985) [3] and (APHA, 1998) [1].

Result and Discussion

In order to define a particular freshwater body, it is important to analyze accurately as many physical and chemical characteristics of water as possible. The measurements of these characteristics provide valuable information about the aquatic environment.

Air temperature (^{0}C)

It is an important factor which regulates biogeochemical activities. Air temperature shows a fluctuation in different seasons of study period as it ranges from 21.9 ^{0}C to 40.1 ^{0}C. The minimum air temperature 21.9 ^{0}C was observed at station L3 in winter where as maximum 40.1 ^{0}C in summer season at sampling station L1. (Fig. 1). Spatial fluctuations in air temperature experienced during a particular season might be due to the timing of collection and the influence of weather, which quite fluctuate diurnally and seasonally in the Lakes (Welch, 1952) [25]. Wanganeo (1998) [24] and Khan *et al.*, (2015) [11] reported that temperature of Bhoj wetland varied from 22.2 ^{0}C to 33.8 ^{0}C and 21 ^{0}C to 40 ^{0}C respectively which coincides with present study.

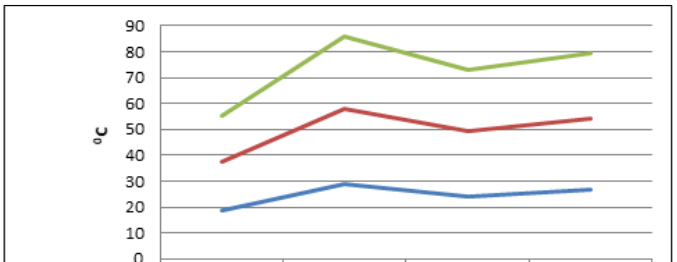


	Winter	Summer	Monsoon	Post – monsoon
Station L3	89.6	82.7	87.6	80
Station L2	91.4	85.3	94.4	85.2
Station L1	90.4	79	64.6	98.9

Fig 1: Seasonal variation in air temperature (^{0}C)

Water temperature (^{0}C)

Water temperature of lake varies from season to season and in different selected stations. The minimum water temperature was recorded in winter season at sampling station L3, where as maximum value of 29.1 ^{0}C was registered in summer season at sampling station L1. (Fig. 2). The rising of water temperature particularly in summer in the present study can be attributed to overall increasing trend in atmospheric temperature in addition to exothermic chemical process of the human activities prevail all along the lakes. Narasimha and Jaya (2001) [14] observed that rise in temperature can be resulted in high rate of evaporation, may cause decline in water level during summer months.

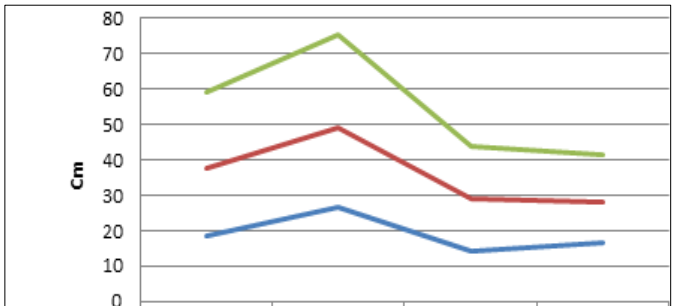


	Winter	Summer	Monsoon	Post-monsoon
Station L3	17.8	27.8	23.6	25.6
Station L2	18.9	28.8	24.8	27.4
Station L1	18.5	29.1	24.3	26.6

Fig 2: Seasonal variation in water temperature (^{0}C)

Transparency (cm)

During the year 2016 of study period the transparency value are given (Fig. 3) for three stations in different seasons of the year. The lowest value 11.6 cm of Secchi disc reading was found in post-monsoon season at sampling station L2 while as highest value 26.5 cm was recorded in summer season at station L1. However, high values of transparency in summer may be due to clear atmosphere and high light penetration. Similar observations have been reported by (Gaur and Devendra, 2009; Kadam *et al.*, 2007) [7, 9]. Khan *et al.*, (2015) [11] observed a same trend in Upper Lake, Bhopal. Similar findings were observed in the present study.

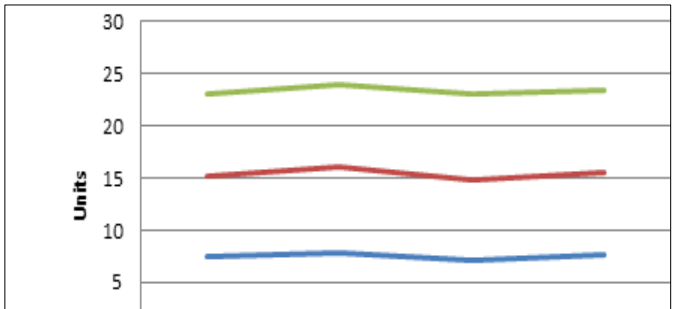


	Winter	Summer	Monsoon	Post-monsoon
Station L3	21.6	26.3	14.6	13.4
Station L2	18.8	22.6	14.8	11.6
Station L1	18.6	26.5	14.4	16.6

Fig 3: Seasonal variation in transparency (Cm)

Hydrogen ion concentration (pH)

pH of any aquatic system is suggestive of acid-base equilibrium achieved by various dissolved compounds The minimum pH value 7.2 have been noted at station L1 in monsoon season, whereas the maximum pH 8.2 was observed L2, L3 during summer and monsoon respectively. (Fig. 4). In monsoon months, heavy rains caused higher turbidity and so photosynthetic rate is also decreased because of low transparency and reduced intensity of light causing decrease in pH value. A fall in pH during monsoon of investigated period in Lower Lake is supported by (Shardendu and Ambasht 1988; Kaushik *et al.*, 1989 and Khan and Chaudhary, 1994) [12, 18, 10]. The high pH values during summer may be due to high photosynthesis of micro and macro vegetation resulting in high production of free carbon dioxide, shifting the equilibrium towards alkaline side (Trivedi, 1989) [23] or due to low water levels and concentration of nutrients in water.

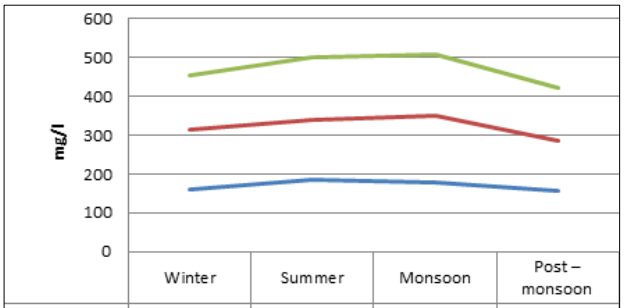


	Winter	Summer	Monsoon	Post – monsoon
Station L3	7.9	7.9	8.2	7.8
Station L2	7.7	8.2	7.7	8
Station L1	7.5	7.8	7.2	7.6

Fig 4: Seasonal variation in pH (Units)

Total dissolved solids (mg l^{-1})

Total dissolved solids content also showed fluctuations on seasonal basis. The lowest total dissolved 126.7 mg l^{-1} solids was recorded at sampling station L2 in post-monsoon season where as the maximum value 185.5 mg l^{-1} was observed at station at L1 in summer season (Fig. 5).

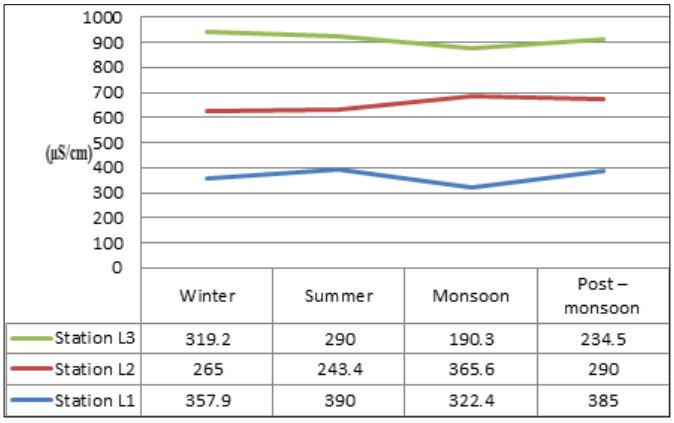


	Winter	Summer	Monsoon	Post – monsoon
Station L3	141.6	162.5	158.5	138.4
Station L2	155.6	153.6	170	126.7
Station L1	158.6	185.5	178.8	157.8

Fig 5: Seasonal variation in total dissolved solids (mg/l)

Electrical conductivity (µS/cm)

Electrical conductivity of water followed a seasonal pattern in lake water. During monsoon the minimum value 190.3 µS/cm was observed at station, where as the maximum 390 µS/cm was noted at station L1 in summer season. (Fig. 6). The higher conductivity was observed during summer season this may be due to the evaporation of water in summer season similar result was noted by (Reddy, 2009 and Solanki and Acharya, 2016) [16, 19].

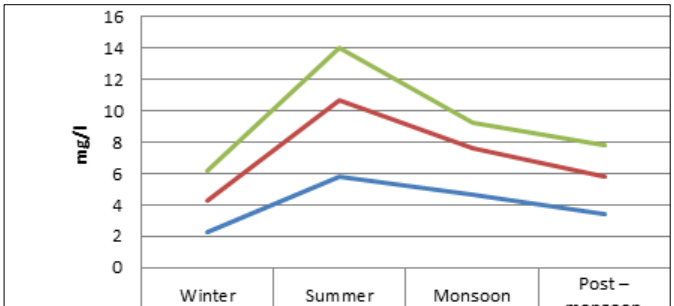


	Winter	Summer	Monsoon	Post – monsoon
Station L3	319.2	290	190.3	234.5
Station L2	265	243.4	365.6	290
Station L1	357.9	390	322.4	385

Fig 6: Seasonal variation in electrical conductivity (µS/cm)

Free carbon dioxide (mg l^{-1})

On seasonal basis the maximum free carbon dioxide was recorded to be 5.8 mg l^{-1} at sampling station Ll in summer season, whereas the minimum free carbon dioxide 1.6 mg l^{-1} which was observed at station L3 in season monsoon (Fig. 7).

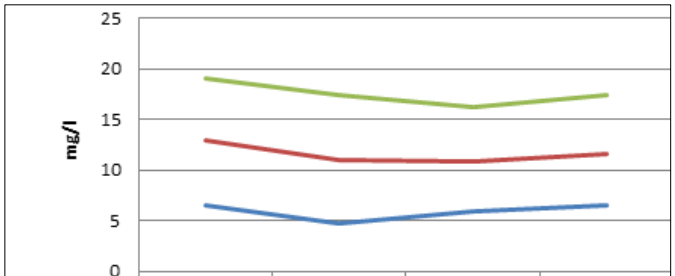


	Winter	Summer	Monsoon	Post – monsoon
Station L3	1.9	3.3	1.6	2
Station L2	2	4.9	2.9	2.4
Station L1	2.3	5.8	4.7	3.4

Fig 7: Seasonal variation in free carbon dioxide (mg/l)

Dissolved oxygen (mg l^{-1})

During the study period in lake the dissolved oxygen content fluctuates from season to season and it was observed that range of dissolved oxygen was from 4.8 mg l^{-1} to 6.6 mg l^{-1}. On seasonal basis the maximum dissolved oxygen was found to be 6.6 at station L1 during winter and post-monsoon, whereas the minimum 4.8 mg l^{-1} at station L1 (summer) and station L2 during monsoon. (Fig. 8). The oxygen concentration showed decreasing trend from summer onwards. Low oxygen during the peak summer months as also reported by (Tian *et al*., 2012) [21] may be attributed to the temperature rise and stratification which leads to the increased bacterial consumption of oxygen

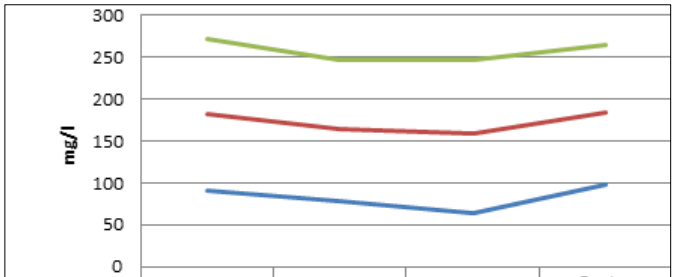


	Winter	Summer	Monsoon	Post – monsoon
Station L3	6.2	6.5	5.4	5.8
Station L2	6.3	6.2	4.8	5
Station L1	6.6	4.8	6	6.6

Fig 8: Seasonal variation in dissolved oxygen (mg/l)

Total alkalinity (mg l^{-1})

During the investigated period the variation in total alkalinity in different seasons is much different. It was noted that its values ranges from 64.6 mg l^{-1} to 98.9 mg l^{-1}. The minimum total alkalinity was recorded to be 64.6 mg l^{-1} in monsoon season at station L1, while as the maximum value of 98.9 mg l^{-1} in post-monsoon season at sampling station L1. (Fig. 9). As per the Bureau of Indian standards the desirable level of total alkalinity for drinking water is below 200 mg^{-1} and permissible level in the absence of alternate source is 600 mg^{-1} (BIS, 1992).

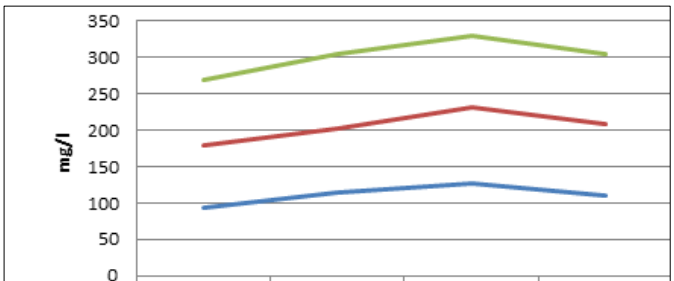


	Winter	Summer	Monsoon	Post – monsoon
Station L3	89.6	82.7	87.6	80
Station L2	91.4	85.3	94.4	85.2
Station L1	90.4	79	64.6	98.9

Fig 9: Seasonal variation in total alkalinity (mg/l)

Total hardness (mg l^{-1})

During the investigation period, it was observed that the total hardness ranges from 65.3 mg l^{-1} to 126.9 mg l^{-1} which fluctuates in different seasons. The minimum value 87.4 mg l^{-1} was found at station L2 in season winter, whereas maximum 126.9 mg l^{-1} in season monsoon at sampling station L1. (Fig. 10). High concentration of total hardness recorded during monsoon may be attributed to the decline and decomposition in submerged macrophytes.



	Winter	Summer	Monsoon	Post – monsoon
Station L3	88.9	102	98	94.7
Station L2	87.4	89.2	104.3	100
Station L1	92.6	113.4	126.9	109.5

Fig 10: Seasonal variation in total hardness (mg/l)

Conclusion

The present study revealed that the physicochemical parameters such as temperature, pH, dissolved oxygen and nutrients influence the biological systems to varying degrees. By scrutinization of these parameters it is inferred that the values observed during the present investigation follows the flip flop pattern. Hence, Lower Lake represents disturbed ecological status and deteriorated water quality. Oxygen level gets reduced in summer season and comparatively remains lower and shows anorexia condition in summer when temperature approaches 40 ^{0}C as is evident from death of fauna mostly fishes and frogs. The deterioration in the water quality of Lower Lake Bhopal increases and its nutrient level is alarming, needs periodic monitoring and preventative measures are required to save the lake from eutrophication.

Water quality results showed clearly that most of the physico-chemical characteristics are above the permissible limits. Measures suggested to improve the water quality including the ban on activities that are responsible for pollution.

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