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ABSTRACT
Upper Lake is a freshwater lake, which is the major source of drinking water in the city of Bhopal, the capital city of M.P., the central province of India, but due to anthropogenic activities this lake is being polluted. During the investigation physicochemical parameters were analyzed to determine the water quality of Upper Lake monthly in the year 2010.

Keywords: Upper Lake, drinking, anthropogenic, physicochemical.

1. INTRODUCTION
The physico-chemical properties of water play important role in the distribution and abundance of aquatic flora and fauna. The physical properties of water, in any aquatic ecosystem, are largely dependent on the existing meteorological conditions of the area and chemical properties of the water. The effect of physical features like light and heat is of great limnological significance, as they are solely responsible for many of the phenomena like thermal stratification, chemical stratification, diurnal and seasonal variations in the number and distribution of plankton. Chemical characteristics of water not only alter the physical properties of the medium but also exert significant influence on the distribution and metabolic activities of organisms, which in turn tend to change the chemical qualities of the water in due course of time. The other characteristics such as the place of origin of stream, water temperature, substratum, biotic communities are some of the principal ones, interacting with one another; thus, affecting the number and abundance of aquatic flora and fauna of the aquatic ecosystem. All of these parameters obviously influence the yield potential of fishery water. In the light of above consideration, it is essential to record the
important parameters of the water bodies. A lot of work has been carried out on the physico-chemical and biological conditions of the different aquatic habitats. Important contributions in this field are those of Sunil (1990), Veena (1990), Joshi (1994), Jyoti et al. (2004) and Romana and Jyoti (2007).

2. MATERIAL AND METHODS

Upper Lake is one of the largest fresh water lakes of India. Upper lake is a shallow tropical lake located between Longitude 77-180 to 77-23°E and Latitude 23-120 to 23-16°N at the heart of Bhopal, the capital city of Madhya Pradesh, a central province of India. This city has a subtropical moderate climate where the temperature ranges 07°C to 45°C. Its catchments area is 361 km² and water spread area is 31 km² (Dixit et al., 2005).

Monthly samples of water were collected from the selected sites of the stream for a period of one year i.e. from January, 2010 to December 2010. The air temperature, water temperature, depth, transparency, pH, dissolved oxygen and free carbon dioxide were measured at the field station itself. The other parameters like total dissolved solids, alkalinity, chloride, calcium, total hardness and magnesium were measured in the laboratory. All the parameters were analysed according to the methods given by Welch (1948), Adoni (1985) and APHA (1995).

3. RESULTS & DISCUSSION

Temperature is considered as to be one of the most important factors in an aquatic ecosystem (Welch, 1952). During the present study, the mean values of atmospheric temperature have been found to vary between 18.3°C to 41.3°C. The maximum air temperature was recorded in summer, while the minimum was recorded in the winter. The maximum value of air temperature was recorded in the month of May and the minimum in the month of January. The water temperature was always less than air temperature and followed same trend as that of air temperature. Water temperature too showed its maximum and minimum values in the month of may and January, respectively. As is evident from the data recorded, there is steady rise in water temperature with the increase day length and the angle of incidence of sun rays. These observations get support from the findings of Vyas and Kumar (1968), Seghal (1980) and Harshey et al. (1982) who have also advocated similar view for the different water bodies studied by them.

Water, the universal solvent has large number of salts dissolved in it, which largely govern the physico-chemical properties and in turn have an indirect effect on the aquatic organisms (Table 1). An available limit of total dissolved solids in a water body is a useful parameter in describing the chemical density as a fitness factor and as a general measure of edaphic relationship that contributes to the productivity of water. During the period of investigation, the mean values of total dissolved solids have been found to vary between 9.63 mg/l to 137.25 mg/l, being maximum in June and minimum in January. It has been observed that as a result of increase of total dissolved solids the transparency of water decreases. The pH of natural water is governed to the extent by the interaction of H⁺ released as a result of the dissociation of H₂CO₃ and OH⁻ produced the hydrolysis of bicarbonates. The pH of the most natural water generally ranges between 2.00 to 12.00 and provides useful indirect information about the alkalinity and photosynthetic activity (Welch, 1952).

During the investigation of present study, the mean values of pH h ave been found to vary between 7.05 to 7.42. The pH was observed to decline during winter and increase during the summer as is evident from the mean values. Studies on pH under present investigation did not reveal much variation. The present investigation revealed that there has been direct relationship between pH and carbonate and indirect relationship with free carbon dioxide. This observation gets support from the earlier findings of Welch (1952) and Sunil (1990).
Oxygen is present in water in a dissolved state. The oxygen content of freshwater varies with the season and also during the day and light. The level of oxygen contents in an aquatic environment is dependent on the temperature, photosynthesis of autotrophs, respiration of biotic communities and organic load etc. During the investigation of present study, the mean values of dissolved oxygen content have been found to vary between 5.49 mg/l to 10.70 mg/l. According to Banerjee (1976) for average and good productive water bodies should have dissolved oxygen concentration more than 5 mg/l. No doubt, the dissolved oxygen content in the stream under investigation was always more than 5 mg/l, but the occurrence of flora and fauna was not so abundant because the flora and fauna inhabiting the stream is always in great stress of water currents and alternating floods and droughts.

The alkalinity in water is usually caused by the carbonate, bicarbonate and hydroxyl ions and less frequent by the borates, silicates and phosphates (APHA, 1995). During the investigation of present study, the mean values of carbonate have been found to vary between nil to 7.61 mg/l. The carbonate in the water samples were recorded during the summer and was absent during the winter. It has been observed that the carbonate was present in water samples only when the free carbon dioxide was absent. An inverse relationship between the carbonate and free carbon dioxide has earlier been recorded by Welch (1952) and Puri (1989).

Carbon dioxide content of freshwater varies like that of other parameters. During the period of investigation, the mean values of free carbon dioxide have been found to vary between nil to 2.00 mg/l. In line to the suggestions of Vaishya (1990), the present observations also regard the very low quantity of decomposing organic matter and less metabolic activities as a contributory factor for absence of free carbon dioxide during the summer season. Reid (1961) noted that free carbon dioxide is usually absent when the pH is higher than 8.0.

The alkalinity in water is usually caused by the carbonate, bicarbonate and hydroxyl ions and less frequently by the borates, silicates and phosphates (APHA, 1995). During the investigation of present study, the mean values of carbonate have been found to vary between nil to 7.61 mg/l. The carbonate in the water samples were recorded during the summer and was absent during the winter. It has been observed that the carbonate was present in water samples only when the free carbon dioxide was absent. An inverse relationship between the carbonate and free carbon dioxide has earlier been recorded by Welch (1952) and Puri (1989).

During the investigation of present study, the mean values of bicarbonate have been found to vary between 38.61 mg/l to 57.99 mg/l. Seasonal fluctuations in bicarbonate content, being maximum in winter and minimum in July and August seem to be due to its uptake by photosynthesis by phytoplankton. Negi (1989) also recorded the winter peak in bicarbonate alkalinity at the bottom of river Alakananda due to low dilution of river during winter.

During the investigation of present study, mean values of total alkalinity have been found to vary between 43.93 mg/l to 57.99 mg/l. Overall, it has been observed that the total alkalinity was maximum in winter and minimum in summer. A decline in alkalinity as observed during summer may be due to increase in the volume of water by monsoon rains. Similar observations were made by Pahwa and Mehrotra (1966), Singh and Srivastava (1988) and Kant and Raina (1990).

The mean values of chloride have been found to vary between 32.12 mg/l to 84.27 mg/l. The little pulse during the summer may be associated with high temperature, which enhances the evaporation, reducing the volume of water, thus, resulting in the concentration of salts. Chloride enrichment due to excreta has earlier been reported by Dutta (1978), Sehgal (1980) and Malhotra et al. (1986). There was no appreciable seasonal difference in chloride concentration, although it was slightly higher in summer.

### Table 1
Monthly Variations in Physico-Chemical Parameters of Upper Lake, Bhopal (2010)

<table>
<thead>
<tr>
<th>PARAMETERS</th>
<th>JAN.</th>
<th>FEB.</th>
<th>MAR.</th>
<th>APR.</th>
<th>MAY.</th>
<th>JUN.</th>
<th>JUL.</th>
<th>AUG.</th>
<th>SEP.</th>
<th>OCT.</th>
<th>NOV.</th>
<th>DEC.</th>
</tr>
</thead>
<tbody>
<tr>
<td>Air Temp. (°C)</td>
<td>18.3</td>
<td>25.2</td>
<td>31.4</td>
<td>36.6</td>
<td>41.3</td>
<td>37.3</td>
<td>29.08</td>
<td>25.10</td>
<td>31.5</td>
<td>29.7</td>
<td>27.5</td>
<td>21.7</td>
</tr>
<tr>
<td>Water Temp. (°C)</td>
<td>16.1</td>
<td>22.5</td>
<td>29.7</td>
<td>33.9</td>
<td>37.7</td>
<td>34.8</td>
<td>27.1</td>
<td>23.0</td>
<td>28.9</td>
<td>26.9</td>
<td>25.1</td>
<td>19.0</td>
</tr>
<tr>
<td>Transp. (Cms)</td>
<td>36.50</td>
<td>39.75</td>
<td>30.50</td>
<td>32.00</td>
<td>26.50</td>
<td>25.50</td>
<td>22.25</td>
<td>25.50</td>
<td>24.50</td>
<td>25.25</td>
<td>24.00</td>
<td>22.75</td>
</tr>
<tr>
<td>T.D.S. (mg/l)</td>
<td>9.63</td>
<td>11.93</td>
<td>62.08</td>
<td>34.20</td>
<td>17.00</td>
<td>137.25</td>
<td>73.73</td>
<td>68.79</td>
<td>61.81</td>
<td>42.00</td>
<td>20.58</td>
<td>10.57</td>
</tr>
<tr>
<td>pH</td>
<td>7.05</td>
<td>7.07</td>
<td>7.14</td>
<td>7.15</td>
<td>7.18</td>
<td>7.42</td>
<td>7.35</td>
<td>7.32</td>
<td>7.21</td>
<td>7.06</td>
<td>7.06</td>
<td>7.07</td>
</tr>
<tr>
<td>D. O. (mg/l)</td>
<td>6.04</td>
<td>7.78</td>
<td>6.62</td>
<td>8.52</td>
<td>7.62</td>
<td>7.49</td>
<td>6.69</td>
<td>5.38</td>
<td>6.15</td>
<td>6.70</td>
<td>5.55</td>
<td>5.79</td>
</tr>
<tr>
<td>F. CO2 (mg/l)</td>
<td>1.43</td>
<td>1.78</td>
<td>0.58</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>--</td>
<td>0.87</td>
<td>2.00</td>
<td></td>
</tr>
<tr>
<td>Carbonate (mg/l)</td>
<td>--</td>
<td>--</td>
<td>1.36</td>
<td>2.17</td>
<td>6.38</td>
<td>7.61</td>
<td>5.32</td>
<td>6.32</td>
<td>1.37</td>
<td>0.99</td>
<td>--</td>
<td>--</td>
</tr>
<tr>
<td>Bicarb. (mg/l)</td>
<td>57.99</td>
<td>53.60</td>
<td>50.93</td>
<td>46.78</td>
<td>45.09</td>
<td>40.87</td>
<td>38.61</td>
<td>44.89</td>
<td>47.28</td>
<td>50.05</td>
<td>53.54</td>
<td>56.8</td>
</tr>
<tr>
<td>T. Alka. (mg/l)</td>
<td>57.99</td>
<td>53.60</td>
<td>52.29</td>
<td>48.95</td>
<td>51.47</td>
<td>48.48</td>
<td>43.93</td>
<td>52.21</td>
<td>48.65</td>
<td>51.04</td>
<td>53.54</td>
<td>56.8</td>
</tr>
<tr>
<td>Chloride (mg/l)</td>
<td>51.89</td>
<td>51.86</td>
<td>62.02</td>
<td>73.12</td>
<td>73.67</td>
<td>84.27</td>
<td>64.49</td>
<td>59.43</td>
<td>44.12</td>
<td>38.65</td>
<td>35.79</td>
<td>32.12</td>
</tr>
</tbody>
</table>
4. CONCLUSION
The study clearly indicates that some of the physicochemical and heavy metal parameters undertaken to assess the water quality of upper lake were found below the prescribed limit, while some were found above the prescribed limit. During the investigation period results reveal that upper lake is partially polluted. All physicochemical parameters were below the permissible limit.

CONFLICT OF INTEREST
The authors have no conflict of interest.

REFERENCES