Water quality index and abundance of total zooplankton in Varuna, Madappa and Giribettethe lakes of Mysore, Karnataka State, India

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ABSTRACT

Water Quality Index (WQI) is a dimensionless number that combines multiple water quality factors into a single number to define the quality of water (e.g., good, moderate or bad). Conventionally, it has been used for evaluating the quality of rivers, streams and lake waters. The WQI of Varuna, Madappa and Giribettethe lakes was studied with the help of 21 Physico-chemical parameters obtained for two years (June 2009-May 2011). The study revealed that Varuna lake is moderately polluted with a WQI of 69, while Madappa lake and Giribettethe lake were severely polluted with a WQI of 83 and 93, respectively. The first year study revealed that all the three lakes were severely polluted during summer season and were least polluted during winter season. During second year of study Madappa and Giribettethe lakes showed high value of WQI during summer season and least value during winter season. However, Varuna lake showed a high WQI during rainy season. Zooplanktons can also be used as bioindicators for water pollution. The study on the abundance of total zooplankton in all the three lakes revealed that the abundance was maximum during summer season and least during rainy season. These findings have been discussed in the light of recent literature published.

Keywords: Water Quality Index, Varuna, Madappa, Giribettethe, abundance, total zooplankton.

1. Introduction

Physico-chemical analysis is the prime consideration to assess the quality of water for its utilization like drinking, irrigation, domestic and helpful in understanding the complex interaction between the climatic and biological process in the water (Kulkarni and Tapase, 2011). Water pollution is a phenomenon that is characterized by the deterioration of its quality as a result of various human activities. Rapid industrialization and indiscriminate use of chemical fertilizers and pesticides in agriculture are causing heavy and varied pollution in aquatic environment leading to deterioration of water quality and hence depletion of aquatic biota (Khan et al., 2012). Surface water quality depends not only on natural processes like precipitation inputs, erosion, and weathering of crustal material, etc., but also on anthropogenic influences like urban, industrial, and agricultural activities (Ravikumar et al., 2013). Therefore, scientific study needs to review strategies for conservation and better utilization of lakes (Nikitaraj, 2012).

A well-known method of expressing water quality that offers a simple stable and reproducible unit of measurement is the Water Quality Index (WQI) which responds to changes in the principal characteristics of water (Brown et al., 1970). WQI is defined as a rating reflecting the composite influence of different water quality parameters. WQI is a
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single number that expresses the quality of water by integrating the water quality variables. The objective of an index is to turn complex water quality data into information that is understandable and useable by the public.

Fresh water zooplankton is an important biological component in aquatic ecosystems, whose main function is to act as a primary and secondary links in the food chain and they play a vital role in energy transfer of aquatic ecosystems (Altaff, 2004). Zooplanktons are the most valuable indicator of trophic status than generally has been realized, since they are larger and easier to identify than phytoplankton (Kovalev, et al., 1999). Zooplanktons can also be used as “bioindicators” for water pollution studies, because their occurrence, vitality and responses, change under adverse environmental conditions (Oliver, 1996).

Water quality and the abundance of total zooplankton of some lakes which are under threat of being polluted are investigated by various workers. For example, Yogendra and Puttaiah (2008) made some investigative studies on the determination of WQI on the basis of various physicochemical parameters in Gopishettykere, Shimoga, Karnataka and reported this as a useful tool in the overall assessment of water quality. Kulkarni & Tapase (2011) studied on the water quality of Gandhisagar Lake of Nagpur in Maharashtra and reported that the quality of water is poor for drinking purpose but it is good after purification and also good for irrigation and other domestic purpose. Sinha and Biswas (2011) observed a high WQI value and hence a higher degree of pollution in Kalyani lake of West Bengal. Thakor et al (2011) calculated the water quality index of Pariyed lake in Gujarat and reported that the water quality is poor and not safe for human consumption. Khan et al (2012) studied on the physicochemical parameters of Triveni lake of Amravati in Maharashtra and reported that there was significant seasonal variation in some physicochemical parameters and the water is best for drinking purpose in winter and summer seasons.

Zooplankton abundance was also studied by various workers. For example, Das et al (2005) reported a higher premonsoon population than postmonsoon population in two freshwater wetlands of Goa. Dhembare (2011) observed seasonal variations in the density of zooplankton in Mula Dam, Maharashtra and also found that the overall variation was high during rainy and least during winter season. Joshi (2011) made qualitative and quantitative studies of zooplankton in Rajura Lake of Buldhana, Maharashtra and reported a minimum density during rainy season and maximum density during summer season. Sitre (2012) studied on the seasonal variation of zooplankton in Ambazari lake of Nagpur city, Maharashtra and they noticed a high number during summer and winter seasons.

Very few studies are available on the water quality and the abundance of total zooplankton of different lakes in Mysore district. For example, Hosamani et al (1995) investigated the ecological significance of biochemical parameters in certain freshwater lakes (Kukkarahalli and Yenahole) of Mysore. Govindappa et al (1982) studied hydrobiology of Kukkarahalli lake and found that nutrient enrichment in the lake lead to eutrophication. Padmanabha and Belagalli (2007) made a comparative study on population dynamics of rotifers and WQI of Kamana, Kukkarahalli, Karanji and Dalvoy lakes of Mysore. Their study revealed a highest WQI and population density of rotifers during summer and least during winter. In our laboratory, Koorosh et al (2008) studied the abundance of zooplankton in three contrasting lakes (Bannur, Lingambudhi and Hebbal) of Mysore and reported a low abundance during rainy season and high abundance during summer season. Beenamma Joseph and Yamakanamardi (2011) observed a negative relationship between the total zooplankton and
concentration of phosphate and also reported that eutrophication has led to the deterioration of the water quality of Kukkarahalli Lake.

Savitha and Yamakanamardi (2012) made investigative studies on the abundance of zooplankton and reported that Kalale lake was less polluted with less abundance of zooplankton compared to Dalvoy and Alanahalli lakes. Jomet and Yamakanamardi (2013) while reporting on the WQI of Kapila, Cauvery and at their confluence sites found that Kapila river and confluence sites were severely polluted with a WQI of 91 and 78 respectively, but Cauvery river was moderately polluted with a WQI of 59. To the best of our knowledge, WQI and the abundance of total zooplankton of Varuna, Madappa and Giribettothe lakes has not been studied so far. Hence, this investigation was taken up to find monthly and seasonal (winter, rainy and summer) changes in the WQI and the abundance of total zooplankton of these lakes.

2. Material and methods

The location of three sampling site is shown in Figur 1. The first sampling site was on Varuna Lake at Chikkhalli village, Mysore. The lake is situated at latitude of 76°44’ E, longitude of 12°16’N at an elevation of 719 meters above the Mean Sea Level (MSL) and with a total area of about 0.8 sq.kms. The second sampling site was Madappa Lake at Chornahalli village. This Lake is situated at latitude of 76°43’ E and a longitude of 12°17’N at an elevation of about 706 meters above MSL and a total area of about 0.3 sq. kms. The third sampling site was on Giribettothe Lake at Duddagere village. The Lake is situated at a latitude of 76°46’ E and a longitude of 12°15’N and at an elevation of about 688 meters above MSL having a length of about 3 kms and the boundaries are 3 acres.

Surface water samples were collected fortnightly for two years (June 2009 to May 2011) and 21 Physico- Chemical parameters (Air temperature, Water temperature, Field pH, Lab pH, Conductivity, Turbidity, Carbon -di –oxide (CO2), Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Alkalinity, Hardness, Calcium, Chloride, Phosphate, Sulphate, Nitrate, TASA (Total Anions of The Strong Acids), TSS (Total Suspended Solids), POM (Particulate Organic Matter), Chlorophyll-a) were analyzed.
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as per the standard methods given in APHA (1992) and Trivedy and Goel (1986). Monthly values of each physico-Chemical parameters were calculated from fortnightly sample data and all the 21 physico-Chemical parameters were taken for calculation of WQI (Jindal and Sharma, 2011), using the following formula

\[
\text{Water quality index (WQI)} = \sum q_i w_i
\]

Where \( q_i \) = (water quality rating) \( 100 \times (V_a - V_i) / (V_s - V_i) \)

Where \( V_a \) = Actual value present in the water sample,

\( V_i = \) Ideal value (0 for all parameters except pH and DO which are 7.0 and 14.6 mgL\(^{-1}\), respectively).

\( V_s = \) Standard value

\( W_i = \) (Unit weight) = \( K/S_n \)

Where, \( K = (\text{constant}) \times 1/V_s_1 + 1/V_s_2 + \ldots + 1/V_s_n \)

\( S_n = \) Standard value.

Based on the analysis, the water quality was classified as excellent (if the WQI value is 0 to 25), good (26 to 50), moderately polluted (51 to 75), severely polluted (76 to 100), and unfit for drinking (above 100) (Nageswara Rao, et al., 2007). For the study of abundance of different groups of zooplankton, one hundred liters of water sample was collected from each sampling site and filtered through 60μm mesh size net and the concentrated zooplankton was fixed and preserved using 4% formalin. For enumeration of zooplankton abundance, the modified Sedgwick Rafter method as given in Kamaladasa (2007) was followed. One ml from the concentrated sample from each sampling site was transferred into one ml Sedgwick Rafter counting chamber and observed under Olympus binocular microscope. Abundance of Total Zooplankton [Org/L] is the sum total of all the four (Rotifers, Cladocerans, Cyclopoids and Ostracods) zooplankton groups counted. Abundance of four groups of zooplankton was carried out using the following formula as given in APHA (1992),

\[
\text{No: of Organisms/m}^3 = \frac{C \times V_1}{V_2 \times V_3}
\]

Were,

C= Number of organisms counted

\( V_1 = \) Volume of concentrated sample (50 ml)

\( V_2 = \) Volume of sample counted (1 ml)

\( V_3 = \) Volume of grab sample (0.1m\(^3\))

Finally, to obtain organisms/L, the No: of organisms per m\(^3\) was divided by 1000.

3. Result and discussion

The mean WQI of Varuna, Madappa and Giribettethe lakes for a period of two years is given in Table1. The mean WQI value (69) of Varuna was within the range of 51-75, thus showing that the lake is moderately polluted. The mean WQI of Madappa (83) and Giribettethe lakes (93) falls in the range of 76-100 indicating that surface waters of these lakes are severely polluted. The graph (Figure 2) also clearly indicates that the WQI values of Varuna lake ranges between 60 and 80 (moderately polluted), Madappa lake between 65 and 90 (severely polluted) and the Giribettethe lake (severely polluted) between 80 and 100.

Table1 indicates the Coefficient of Variation (CV) in the WQI and the abundance of total zooplankton of the three lakes for a period of two years, June 2009 to May 2011. The table
clearly indicates that a high variation of 48% in the WQI is shown by Madappa lake and a least variation of 16% is shown by Varuna lake. But a moderate variation of 27% in the WQI is observed in Giribetethe lake. The abundance of total zooplankton showed a high variation of 30% in Varuna lake followed by Madappa (18%) and Giribetethe (16%) lakes.

Monthly fluctuations of WQI values and the abundance of total zooplankton from June 2009 to May 2011 of Varuna, Madappa and Giribetethe lakes are shown in Fig. 2. From the table, it is evident that Varuna lake showed a maximum WQI value of 72 during the month of April 2010 while Madappa and Giribetethe lakes showed a high WQI value of 88 and 97 respectively during the month of March 2011. The minimum WQI value was observed during the month of November 2010 in Varuna lake (61), January 2011 in Madappa lake (64) and December 2010 in Giribetethe lake (83) respectively.

The study on the abundance of total zooplankton revealed that the maximum abundance of total zooplankton was observed during the month of April 2010 in Varuna (44 Org/L) and Giribetethe (69 Org/L) lakes and March 2010 in Madappa lake (52Org/L) respectively. The abundance of total zooplankton was found to be least during the month of July 2009 in Varuna lake (15 Org/L), November 2010 in Madappa lake (26 Org/L) and December 2010 in Giribetethe lake (41 Org/L) respectively.

Since the two year monthly study of WQI and the abundance of total zooplankton do not give a clear picture of the exact variations, the data for four months each was grouped into three different (rainy, winter and summer) seasons for further statistical analysis by ANOVA (Table 2). Madappa lake showed significant difference in the WQI during rainy season when compared to summer and winter seasons. But Giribetethe Lake showed significant difference in the WQI during winter when compared to rainy and summer seasons. Interestingly, Varuna lake did not showed any significant difference between all the three seasons. Season wise grouped data for the abundance of total zooplankton (Table 3) for two years revealed that Varuna and Madappa lakes showed a significant difference during summer season when compared to rainy and winter seasons. But Giribetethe lake showed significant difference in the abundance of total zooplankton during winter season when compared to rainy and summer seasons.

Thus it can be concluded that when the WQI value increases, total zooplankton value also increases. In Giribetethe lake, there is a close association between the WQI and total zooplankton values. But the association is found to be moderate in Madappa lake and minimum in Varuna lake (Fig.2).

**Table 1:** Mean Water Quality Index (WQI), abundance of total zooplankton, percentage of coefficient of variation (%) in the WQI and abundance of total zooplankton of Varuna, Madappa and Giribetethe lakes, June 2009 to May 2011

<table>
<thead>
<tr>
<th>Lakes</th>
<th>WQI</th>
<th>CV (%) in the WQI</th>
<th>Total Zooplankton</th>
<th>CV (%) in the Total Zooplankton</th>
</tr>
</thead>
<tbody>
<tr>
<td>Varuna</td>
<td>69</td>
<td>16</td>
<td>29</td>
<td>30</td>
</tr>
</tbody>
</table>
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<table>
<thead>
<tr>
<th></th>
<th>Rainy</th>
<th>Winter</th>
<th>Summer</th>
<th>F-Value</th>
<th>P-Value</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>WQI</td>
<td>WQI</td>
<td>WQI</td>
<td>TZP</td>
<td>TZP</td>
</tr>
<tr>
<td>Varuna</td>
<td>68.15&lt;sup&gt;a&lt;/sup&gt;</td>
<td>27.3&lt;sup&gt;a&lt;/sup&gt;</td>
<td>64.02&lt;sup&gt;a&lt;/sup&gt;</td>
<td>24.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>65.59&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Madappa</td>
<td>67.18&lt;sup&gt;b&lt;/sup&gt;</td>
<td>27.0&lt;sup&gt;a&lt;/sup&gt;</td>
<td>75.39&lt;sup&gt;a&lt;/sup&gt;</td>
<td>29.8&lt;sup&gt;a&lt;/sup&gt;</td>
<td>73.72&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
<tr>
<td>Giribettethe</td>
<td>90.49&lt;sup&gt;a&lt;/sup&gt;</td>
<td>52.1&lt;sup&gt;a&lt;/sup&gt;</td>
<td>82.45&lt;sup&gt;b&lt;/sup&gt;</td>
<td>35.5&lt;sup&gt;b&lt;/sup&gt;</td>
<td>93.51&lt;sup&gt;a&lt;/sup&gt;</td>
</tr>
</tbody>
</table>

Values are obtained from ANOVA post hoc nonparametric test. * = Significant, P <0.05. Mean values with different superscripts are significantly different (Student – Newman Kuels Test).

The results obtained clearly revealed that all the three lakes were severely polluted during summer season and were least polluted during winter season. The pollution load is relatively high during summer season when compared to rainy and winter season, which may be due to high conductivity, pH, TSS and higher concentration of chlorides (Yogendra and Puttaiah., 2008). Kulkarni and Tapase (2011) reported that increase in temperature accelerates the chemical reactions in water thereby reducing solubility of gases and imparts odour to water. Highest WQI value during summer season may be due to higher values of alkalinity registered during the season (Thakor et al., 2011). Sisodiya and Moundiotiya (2006) also reported on high alkalinity values during summer in their studies on WQI on Kalakho lake in Rajasthan. They suggested that the high alkalinity value is due to presence of excess free Carbon-di-Oxide product as a result of decomposition process and high photosynthetic rate. Our investigation also showed high level of alkalinity in Madappa lake (432 mg/L) and Giribettethe lake (492 mg/L) during summer season. Elevation in hardness is another reason for the high WQI values. Higher values of hardness during summer can be attributed to low water level and high rate of evaporation of water and addition of calcium and magnesium salts (Khursid 1998). Mohanta and Patru (2000) also suggested that large scale use of detergents and addition of sewage might be the cause for elevation of hardness. This report supports the results obtained in the present study from Madappa (270 mg/L) and Giribettethe (225 mg/L) lakes. Higher values of conductivity are indicators of deteriorating water quality. According to Pandey (2003) less flow during summer and more anthropogenic activities are
responsible for the increase in ionic content which might have resulted in increased level of conductivity during summer season. Increased conductivity is regarded as pollution indicator in shallow lakes as reported by Sinha and Biswas (2011). Giribettethe (1334 µScm⁻¹) and Madappa (867 µScm⁻¹) lakes showed a mean high conductivity throughout the study period and hence these lakes can be classified under the heavily polluted lakes and Varuna with a low value of 405 µScm⁻¹ the least polluted one.

Figure 2: Monthly variation in the WQI and the abundance of total zooplankton in Varuna, Madappa, Giribettethe lakes, June 2009 to May 2011.

The study on the abundance of total zooplankton clearly reveals that the abundance was maximum during summer season and minimum during winter season. The summer maxima of zooplankton were co-related with higher temperatures, lower transparency, and a high standing crop of primary producers leading to greater availability of food (Joshi, 2011). The study indicates that temperature has important role in the distribution of zooplanktons in a fresh water habitat. Sitre (2012) reported that, during summer season, increase in temperature enhances the rate of decomposition due to which the water becomes nutrient rich. Similarly, due to concentration followed by evaporation in summer season the nutrient concentration increases and abundant food is present in the form of phytoplankton and micro-organisms to zooplankton which inturn causes a high zooplankton population density during the summer.
season could be related to stable hydrological factors and low water level. According to Sharma and Singh (2012), the total number of zooplankton was highest during summer and lowest during winter. Same findings were expressed by Salve and Hiware (2010). Das et al., (2005) in their study on the zooplankton diversity of wetland ecosystems of Goa also reported that premonsoon (summer) population of zooplankton is higher than postmonsoon (winter) population in freshwater wetlands. Similar findings were shown by Bais and Agrawal (1995). Normally the monsoon climate is associated with lower population densities due to its dilutional effect and decreased photosynthetic activity by primary producers, similarly Bais and Agrawal (1993) showed that the abundance of zooplankton has been governed by the cumulative effect of physico-chemical and biological parameters. Kumar et al., (2011), made some investigative studies on the assessment of zooplankton diversity of a tropical wetland system and reported that the net zooplankton abundance increased during summer, probably corresponding to the water quality, decaying vegetation, increased levels of organic matter in the sediment and higher abundance of bacteria in the wetlands. Sudden reduction in the zooplankton population during the rainy season could be due to sudden fall of temperature and dilution in concentration of minerals and salts in wetland water. Thus it is evident from the observations recorded in this work as well as other documented literature that the water quality of lentic ecosystems plays a significant role in seasonal variations in the density or abundance of zooplankton.

Hence, from the two year study on WQI and the abundance of total zooplankton, we can conclude that Varuna lake is moderately polluted, while Madappa and Giribettethe lakes are highly polluted. Since the WQI and the total abundance of zooplankton of Giribettethe lake was very high, there is contamination of water with reference to almost all the water quality parameters studied which is likely to cross the limit easily to become unsuitable for human consumption. Thus the water quality is at risk and the vulnerability to contamination must be taken care of for optimization since the water is more polluted. So special attention has to be given to control the pollution load of Giribettethe lake.

4. Conclusion

Overall comparison between the three lakes showed high variation in WQI and the abundance of total zooplankton in both the years. Finally, we conclude by saying that Varuna lake is moderately polluted while Madappa and Giribettethe lakes are highly polluted. Both Madappa and Giribettethe lakes come under the same category (severely polluted) but the pollution load of Giribettethe lake was much more than Madappa lake.

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5. References


