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# Insight into limnological regime of Mandya lakes, Karnataka

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## Abstract

In the present study physico-chemical quality of seven lakes of Mandya district were determined in four seasons *i.e*., Post Monsoon, Winter, Pre Monsoon and Monsoon from October 2011 to July 2013, with an objective estimate their impact on quality of lake water. Water samples were analyzed for various physical parameters like temperature, pH, turbidity, conductivity and total dissolved solids; chemical parameters like total hardness, calcium, magnesium, nitrate, sulphate, phosphate, iron, fluoride, alkalinity, carbonate, bicarbonate, COD, DO and BOD. Two way ANOVA and the distance similarity matrix of cluster analysis were carried out. Statistical analysis between the sampling spots, showed significant variation in temperature followed by the nitrate, chloride, magnesium, phosphate, COD and iron. A significant relation between the total alkalinity and conductivity followed by magnesium with total hardness, conductivity with total dissolved solids and sulphate with total alkalinity were also established.

**Keywords** : Limnological regime, Mandya lakes, Physico-chemical parameters, turbidity, conductivity, BOD and COD

## Introduction

Mandya district lies between North latitudes 12° 13′ to 13° 04′ and East longitudes 76° 19′ to 77° 20′ falling in the survey of India degree sheet Nos - 57 H and 57D and has seven taluks (Anonymous, 2008). The study area, Mandya district comprises Srirangapattana, K.R. Pet, Maddur, Malavalli Nagamangala, Mandya and Pandavapura taluks. The present study tries to provide detailed information on the physico-chemical status of lakes one from each taluk *viz.*, Ballekere lake (SI), Doddakere / Bookanakere lake (S II), Doddaarasinakere lake (S III), Malavalli lake (S IV), Raghurampura lake (S V), Thaggalli lake (S VI) and Thonnur lake (S VII) respectively (Fig.- 1).

Water is the most vital resources for all kinds of life on this planet and it is adversely affected both qualitatively and quantitatively by all kinds of human activities (Gupta and Shukla, 2004). The availability of good quality water is a necessary feature for preventing diseases and improving quality of life (Oluduro and Aderiye, 2007). The American Academy of Microbiology has opined that the quality of drinking water is declining all over the world, mainly because of bacteriological contamination (Conboy and Goss, 2001; Gupta and Shukla, 2004). Lakes, rivers and streams have important multi – usage components, such as sources of drinking water, irrigation, fishery and energy production (Iscen *et al*., 2008).

Manjare *et al*. (2010) studied on the physico-chemical parameters of the Tamadalge water tank in Kalhapur District of Maharastra. All parameters were within the permissible limits. The results indicated

potability of tank water. Various physico-chemical parameters in Nagpur lakes showed distinct, temporal and spatial variations throughout the study period. Lake water quality parameters undergo seasonal changes and values are generally higher during the summer season (Puri *et al*., 2010; Mukhtar *et al*., 2014). Comparative analysis of physico-chemical properties of Kankaria (site I) and Malav (site II) lakes of Ahmedabad city, showed that Sites II had some sort of vegetation in the water body and more polluted compared to site I (Hardikar and Acharya, 2013). The study of physico-chemical and biological characteristics of lakes from Shivaji University Campus, Kolhapur, showed that all parameters were within the permissible limits except BOD, COD and phosphates (Shilpa *et al.*, 2011). Assessment of physico-chemical characteristics of Pushkar lake of Ajmer, Rajasthan showed that water was more alkaline and polluted and measures were suggested to control this (Mathur *et al.*, 2008).

The lake water samples used for the present study were utilized by the people for irrigation, bathing, swimming, washing of utensils, clothes, animals and their vehicles. Usually the villages near the sampling spots had the provision of bore well water for drinking purpose which was usually treated by chlorination. But in case of emergency, people use the water for cooking after filtration or rarely by boiling. Domestic animals are fed with the lake water. WHO suggest that water quality should be maintained in a particular range that is used for different purpose like washing, swimming and recreation. As people depend on lake water for different purpose, it is essential to know the physico-chemical characteristics of water.

## Materials and Methods

### Sample collection

Water samples were collected from different lakes in pre-sterilized aseptic bottles. All precautionary measures were taken to prevent contamination during sampling process. The samples were properly labelled and transported immediately to the laboratory. They were stored in a refrigerator and analyzed.

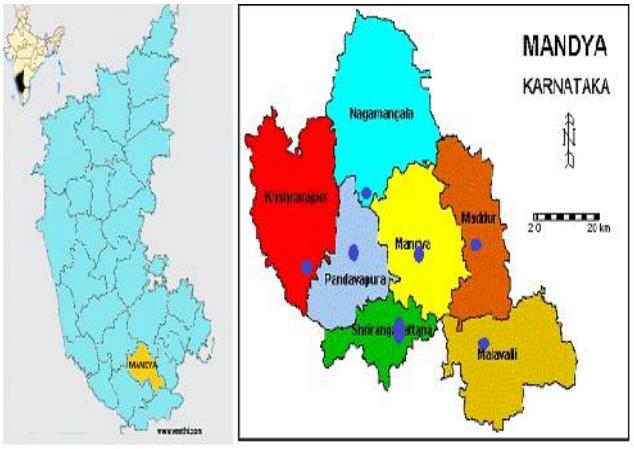


**Fig – 1. Water sampling spots in Mandya district**

### Methodology

Water samplings were done from October 2011 to July 2013. In two years of the sampling period, sampling was done in four seasons of the year *viz.*, post monsoon (October 2011 - Season 1), winter (January 2012 - Season 2), pre monsoon (April 2012 - Season 3) and monsoon (July 2012 - Season 4). The same pattern of sampling was followed in the next year (October 2012 - July 2013). The water samples were collected from each site and brought to the laboratory as per standard methods prescribed by APHA (1998). Analysis of physico-chemical parameters in the water samples help to determine the type of pollution that may be affecting a waterway and can provide some clues as to the sources. In the present investigation, the physico-chemical parameters used to analyze the water are pH, Temperature (°C), Electrical conductivity (µmho $cm^{-1}$), Turbidity (NTU), Alkalinity (mg/L), Total Hardness (mg/L), Total dissolved solids (mg/L), Calcium (mg/L), Magnesium (mg/L), Chloride (mg/L),

Fluoride (mg/L), Nitrate (mg/L), Sulphate (mg/L), Phosphate (mg/L), Iron (mg/L), Dissolved oxygen (mg/L), Biological oxygen demand (mg/L) and Chemical oxygen demand (mg/L). The standard methods prescribed by Trivedy and Goel (1986), APHA (1995) and AWWA (1995) were followed.

The pH and temperature were recorded at the sampling site by using a digital thermometer and pH meter. For the estimation of DO samples were collected in separate sterilized 300 ml BOD bottles at each site and fixed immediately using Winkler's reagent and later analyzed in the laboratory. In addition to this raw sample, samples acidified with $H_2SO_4$ and nitric acid were collected in three separate sterile polythene bottles (50 ml). The acidified samples were used for the analysis of the BOD and the raw samples for immediate analysis in the laboratory for acidity, alkalinity and inorganic ions. All the samples were properly labeled and transported in an ice box to the laboratory for further analysis. TDS values were estimated by evaporation method, turbidity by Nephelometer and conductivity by Conductivity meter. Total hardness, calcium, magnesium, total alkalinity, chloride, DO (Azide method), BOD (Winkler) and COD were estimated by volumetric method. Nitrate, phosphate, sulphate and fluoride by UV spectrophotometer and finally iron by colorimetric- phenanthroline method. The parameters were analyzed as per APHA (1995).

**Results and Discussion**

The results of the physico-chemical analysis of the water samples collected from October 2011 to July 2013 are mentioned in Table 1 and graphically represented in figures 2a-q. Accordingly, two-way ANOVA and dendrogram (Fig.- 3) were applied for statistical analysis for the physico-chemical parameters. Monitoring of water quality is important to detect and control contamination in surface and underground water as suggested by Gray (1999).

**Physico-chemical parameters**

No significant seasonal changes were observed in the water samples collected. Comparatively, there was an increase in pH and sulphate in winter. There was also an increase in turbidity, conductivity, total hardness, calcium, phosphate, COD and BOD during monsoon. The total alkalinity, total dissolved solids, magnesium and nitrate increased in the summer. The iron and fluorine content was very less or below detectable level and if present, it showed a constant values.

**Temperature**: In season 1, temperature ranged from 21.5°C to 32°C. Lowest was observed in S I and the highest was seen in S VI. In season 2 temperature ranged between 21.5°C and 24.1°C. Lowest was observed in S IV and highest observed in S V. In season 3 range was between 29.6°C and 32°C. Lowest was observed in S I and highest in S II. In season 4, temperature ranged between 27.4°C and 32°C. In S III 27.4°C was lowest and highest 32°C was observed in S II. Overall temperature throughout the sampling period ranged between 21.5°C and 32°C (Fig. - 2a) There was a slight difference in the temperature recorded from different sampling sites and that might be due to differences in turbidity values, which absorb sunlight. Similar results were also noticed by Dey and Hazra (2005).

**pH** : In season 1 pH ranged between 7.1 and 7.7. Lowest was seen in S III and highest in S I. In season 2 the range was between 7 and 8, lowest in S IV and highest in S II, respectively. In season 3 pH range was 7.4 to 7.8, lowest observed in S III and highest in S V. In season 4 the range of pH was between 6.8 and 7.3; lowest in S IV and highest in S III. Range observed in the sampling period was 6.8 to 8.0 (Fig.-2b) Most of the Indian waters are alkaline (pH more than 7.0) (CWC, 2006).

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**Table – 1a. Physico-chemical parameters of water samples from October 2011 to July 2013**

| Samples | Season | Temp | $P^H$ | Turb | EC | TA | TDS | TH | Ca | Mg |
|---|---|---|---|---|---|---|---|---|---|---|
| S I | Post Monsoon | 24.1 | 7.7 | 0.7 | 471.4 | 140.5 | 334.0 | 182.0 | 145.0 | 37.0 |
| | Winter | 22.8 | 7.4 | 1.1 | 506.0 | 127.5 | 351.5 | 237.0 | 148.0 | 89.0 |
| | Pre Monsoon | 29.7 | 7.6 | 5.3 | 559.0 | 132.5 | 478.5 | 182.0 | 113.0 | 69.0 |
| | Monsoon | 28.2 | 7.3 | 4.9 | 549.0 | 75.0 | 474.0 | 160.0 | 130.0 | 30.0 |
| S II | Post Monsoon | 26.4 | 7.3 | 1.4 | 443.0 | 134.0 | 324.5 | 136.0 | 108.0 | 28.0 |
| | Winter | 24.0 | 8.1 | 1.5 | 513.0 | 125.0 | 340.0 | 176.0 | 120.0 | 56.0 |
| | Pre Monsoon | 32.0 | 7.6 | 2.7 | 697.0 | 151.5 | 607.0 | 226.0 | 174.0 | 52.0 |
| | Monsoon | 32.2 | 7.2 | 3.3 | 839.5 | 60.5 | 603.5 | 288.0 | 223.0 | 65.0 |
| S III | Post Monsoon | 25.3 | 7.2 | 2.2 | 608.0 | 160.0 | 374.5 | 200.0 | 167.5 | 32.5 |
| | Winter | 23.8 | 8.0 | 1.5 | 742.5 | 110.0 | 491.5 | 193.0 | 143.0 | 50.0 |
| | Pre Monsoon | 30.3 | 7.4 | 1.7 | 777.0 | 189.0 | 665.5 | 264.0 | 199.0 | 65.0 |
| | Monsoon | 27.4 | 7.4 | 1.8 | 751.0 | 51.5 | 644.0 | 327.0 | 260.0 | 67.0 |
| S IV | Post Monsoon | 25.7 | 7.5 | 2.0 | 799.0 | 132.0 | 583.0 | 248.0 | 191.5 | 56.5 |
| | Winter | 21.5 | 7.0 | 2.1 | 610.5 | 117.0 | 468.5 | 211.0 | 170.0 | 41.0 |
| | Pre Monsoon | 31.6 | 7.8 | 3.6 | 858.5 | 197.5 | 712.0 | 238.0 | 156.0 | 82.0 |
| | Monsoon | 31.0 | 6.9 | 4.3 | 688.5 | 62.0 | 556.0 | 221.0 | 180.0 | 41.0 |
| SV | Post Monsoon | 26.7 | 7.4 | 1.1 | 560.8 | 124.5 | 316.5 | 200.0 | 153.0 | 47.0 |
| | Winter | 24.2 | 8.0 | 4.8 | 662.0 | 112.5 | 413.5 | 191.0 | 155.0 | 38.5 |
| | Pre Monsoon | 31.9 | 7.9 | 4.5 | 536.0 | 138.5 | 485.5 | 170.0 | 123.0 | 47.0 |
| | Monsoon | 30.7 | 6.9 | 4.3 | 574.0 | 59.0 | 500.5 | 192.0 | 169.5 | 22.5 |
| SVI | Post Monsoon | 30.2 | 7.4 | 0.8 | 632.5 | 150.5 | 367.7 | 216.0 | 184.0 | 32.0 |
| | Winter | 23.0 | 7.3 | 4.7 | 727.5 | 127.5 | 470.0 | 304.5 | 228.0 | 76.5 |
| | Pre Monsoon | 31.1 | 7.6 | 5.2 | 924.0 | 175.0 | 622.5 | 368.0 | 291.0 | 77.0 |
| | Monsoon | 31.2 | 7.0 | 5.9 | 951.0 | 58.5 | 667.0 | 437.5 | 363.5 | 74.0 |
| SVII | Post Monsoon | 25.4 | 7.7 | 0.8 | 458.7 | 127.5 | 309.5 | 192.0 | 152.0 | 40.0 |
| | Winter | 22.0 | 7.2 | 0.8 | 532.7 | 133.0 | 376.5 | 171.0 | 124.5 | 46.5 |
| | Pre Monsoon | 31.3 | 7.9 | 0.7 | 552.1 | 202.5 | 444.0 | 282.0 | 155.0 | 77.0 |
| | Monsoon | 31.0 | 7.4 | 0.6 | 332.6 | 56.0 | 289.5 | 190.0 | 147.0 | 43.0 |

Temp- Temperature, Turb- Turbidity EC- Electrical Conductivity TA- Total Alkalinity, TDS- Total Dissolved Solids TH- Total Hardness, Ca- Calcium, Mg- Magnesium. Sample I - Ballekere lake, Sample II - Doddakere / Bookanakere lake, Sample III- Doddaarasinakere lake, Sample IV- Malavalli lake, Sample V- Raghurampura lake, Sample VI- Thaggalli lake and Sample VII- Thonnur lake.

**Table – 1b. Physico-chemical parameters of water samples from October 2011 to July 2013**

| Samples | Season | $NO_3$ | $SO_4$ | Cl | $PO_4$ | Fe | Fl | COD | DO | BOD |
|---|---|---|---|---|---|---|---|---|---|---|
| S I | Post Monsoon | 0.8 | 11.8 | 38.0 | 0.1 | 0 | 0.20 | 121.5 | 7.0 | 1.1 |
| | Winter | 2.3 | 11.3 | 22.0 | 0.8 | 0 | 0.20 | 128.5 | 7.0 | 0.9 |
| | Pre Monsoon | 2.9 | 9.1 | 58.0 | 1.6 | 0.0005 | 0.20 | 83.0 | 4.5 | 1.1 |
| | Monsoon | 1.1 | 7.9 | 40.0 | 0.8 | 0 | 0.20 | 110.0 | 6.8 | 0.7 |
| S II | Post Monsoon | 0.0 | 11.0 | 25.5 | 0.1 | 0.0005 | 0.23 | 146.0 | 6.7 | 1.3 |
| | Winter | 0.8 | 7.8 | 56.0 | 0.1 | 0 | 0.20 | 119.0 | 6.9 | 1.2 |
| | Pre Monsoon | 2.9 | 6.1 | 81.0 | 0.6 | 0.0015 | 0.20 | 71.0 | 4.8 | 1.2 |
| | Monsoon | 1.1 | 11.9 | 80.5 | 0.6 | 0.0005 | 0.20 | 81.0 | 5.6 | 1.3 |

| Samples | Season | $NO_3$ | $SO_4$ | Cl | $PO_4$ | Fe | Fl | COD | DO | BOD |
|---|---|---|---|---|---|---|---|---|---|---|
| S III | Post Monsoon | 0.0 | 12.2 | 38.9 | 0.0 | 0 | 0.20 | 136.0 | 6.9 | 1.1 |
| | Winter | 2.4 | 9.9 | 52.5 | 0.1 | 0 | 0.20 | 130.0 | 7.1 | 1.3 |
| | Pre Monsoon | 3.0 | 8.3 | 79.0 | 1.2 | 0.0015 | 0.20 | 99.0 | 5.2 | 1.4 |
| | Monsoon | 2.6 | 7.8 | 78.5 | 1.6 | 0.0005 | 0.20 | 122.0 | 5.4 | 1.4 |
| S IV | Post Monsoon | 0.7 | 13.6 | 26.0 | 0.1 | 0 | 0.20 | 141.5 | 6.8 | 1.2 |
| | Winter | 1.7 | 10.9 | 36.5 | 0.1 | 0 | 0.20 | 146.0 | 6.9 | 1.2 |
| | Pre Monsoon | 2.2 | 6.3 | 77.0 | 1.3 | 0.0015 | 0.20 | 112.0 | 5.6 | 1.0 |
| | Monsoon | 2.0 | 5.6 | 65.5 | 1.9 | 0 | 0.20 | 129.0 | 6.2 | 1.1 |
| SV | Post Monsoon | 0.4 | 9.3 | 35.0 | 0.1 | 0.0025 | 0.20 | 118.5 | 6.9 | 1.1 |
| | Winter | 3.1 | 14.9 | 47.5 | 1.2 | 0.0005 | 0.23 | 171.0 | 6.4 | 1.3 |
| | Pre Monsoon | 3.4 | 12.4 | 66.5 | 1.8 | 0.003 | 0.20 | 151.5 | 4.5 | 1.8 |
| | Monsoon | 3.2 | 11.3 | 70.5 | 2.3 | 0.003 | 0.20 | 167.0 | 5.1 | 2.0 |
| SVI | Post Monsoon | 0.3 | 13.0 | 28.5 | 0.0 | 0.001 | 0.25 | 119.0 | 6.8 | 1.1 |
| | Winter | 1.2 | 13.1 | 47.5 | 0.6 | 0 | 0.20 | 165.0 | 5.9 | 1.6 |
| | Pre Monsoon | 2.8 | 10.7 | 81.0 | 0.7 | 0.0025 | 0.20 | 158.5 | 5.1 | 2.0 |
| | Monsoon | 2.8 | 9.4 | 73.5 | 1.4 | 0.0005 | 0.20 | 179.0 | 6.1 | 2.3 |
| SVII | Post Monsoon | 0.1 | 10.1 | 23.5 | 0.2 | 0.0005 | 0.23 | 142.5 | 6.8 | 1.3 |
| | Winter | 1.6 | 10.1 | 30.8 | 0.1 | 0.0005 | 0.25 | 115.0 | 6.8 | 1.0 |
| | Pre Monsoon | 1.3 | 7.4 | 77.0 | 0.0 | 0.0035 | 0.20 | 77.5 | 6.4 | 0.9 |
| | Monsoon | 0.6 | 3.8 | 61.5 | 0.8 | 0 | 0.20 | 120.0 | 6.8 | 1.2 |

$NO_3$ - Nitrate, $SO_4$ - Sulphate, Cl- Chloride, $PO_4$ - Phosphate, Fe- Iron, Fl- Fluoride, COD- Chemical Oxygen Demand, DO- Dissolved Oxygen and BOD- Biological Oxygen Demand. Sample I- Ballekere lake, Sample II- Doddakere /Bookanakere lake, Sample III- Doddaarasinakere lake, Sample IV- Malavalli lake, Sample V- Raghurampura lake, Sample VI - Thaggalli lake and Sample VII- Thonnur lake.

**Turbidity** : In the season 1 turbidity range was between 0.6 NTU and 2.2 NTU; lowest was seen in S I and highest in S III. In the season 2 turbidity range was from 0.8 NTU to 4.7 NTU; lowest in S VII and highest in S V. In season 3 range of turbidity was 0.6 NTU to 5.2 NTU; the lowest was in S VII and highest was in S I. In season 4 the range was 0.5 NTU to 5.8 NTU; lowest was seen in S VII and the highest turbidity in S VI. The overall range in sampling period is between 0.5 NTU and 5.8 NTU (Fig.-2c) The high turbidity may also be due to oxidation of iron in its lower oxidation state (Sinha and Rastogi, 2007).

**Electrical conductivity** : In season 1 the range of conductivity was 443 µmho $cm^{-1}$ to 799 µmho $cm^{-1}$; lowest valve was observed in S II and highest in S IV. In season 2 the range was between 506 µmho $cm^{-1}$ and 742.5 µmho $cm^{-1}$; lowest was seen in S I and highest in S III. In season 3 the range was 536 µmho $cm^{-1}$ to 924 µmho $cm^{-1}$; lowest was seen in S V and highest in S VI. In season 4 the conductivity range is 332 µmho $cm^{-1}$ to 951 µmho $cm^{-1}$; lowest in S VII and highest in S VI. The overall range in sampling period is 332 µmho $cm^{-1}$ to 951 µmho $cm^{-1}$ (Fig.-2d). High conductivity shows the presence of ionic solids in water. EC of water is related to the amount of dissolved solids. It increases due to minerals and produces a salty taste in water (Jain *et al.*, 2006).

**Total alkalinity**: In season 1 alkalinity range was between 124.5 mg/L and 160mg/L; lowest alkalinity was seen in S V and highest in S III. In season 2 the range was 110 mg/L to 133 mg/L; lowest in S III and highest in S VII. In season 3 the alkalinity range was

between 132 mg/L and 202 mg/L; lowest in S I and highest in S VII. In season 4 range was between 51.5 mg/L and 75 mg/L; lowest in S III and highest in S I. The overall range in sampling period is 51.5 mg/L to 202 mg/L (Fig. -2e). Studies conducted by Pawar and Mane (2006) also showed same seasonal low and high fluctuations in Sadatpur lake, Maharashtra.

**Total dissolved solids:** In season 1 TDS range was between 309.5 mg/L and 583 mg/L; lowest was seen in S VII and highest in S IV. In season 2 TDS range was from 340 mg/L to 491.5 mg/L; lowest in S II and highest in S III. In season 3 range of TDS was 444 mg/L to 712 mg/L; lowest was observed in S VII and highest in S IV. In season 4 the range was 289.5 mg/L to 667 mg/L; lowest was seen in S VII and highest TDS in S VI. The overall range in sampling period is between 289.5 mg/L and 712 mg/L (Fig. -2f). Higher values obtained in the present study may be due to the decrease of water level and disturbances by various activities. The same opinion was expressed by Rajurkar *et al*. (2003) in river Umshyripi at Shillong.

**Total hardness** : In season 1 total hardness range was between 136 mg/L and 248 mg/L; lowest total hardness was seen in S II and highest in S IV. In season 2 the range was 171 mg/L to 304.5 mg/L; lowest in S VII and highest in S VI. In season 3 the total hardness range was between 170 mg/L and 368 mg/L; lowest in S V and highest in S VI. In season 4 range was between 160 mg/L and 437.5 mg/L; lowest in S I and highest in S VI (Fig. -2g). The overall range in sampling period is 136 mg/L to 437.5 mg/L. The results of the present study also corroborate the work of Aparecida *et al*. (2003).

**Calcium** : In season 1 the range of calcium was 108 mg/L to 191.5 mg/L; lowest valve was observed in S II and highest in S IV. In season 2 the range was between 120 mg/L and 228 mg/L; lowest was seen in S II and highest in S VI. In season 3 the range was 113 mg/L to 291 mg/L; lowest was seen in S I and highest in S VI. In season 4 the calcium range was 140 mg/L to 363.5 mg/L; lowest in S I and highest in S VI (Fig. -2h). The overall range in sampling period is 108 mg/L to 363.5 mg/L. Similar observations were made by Tassaduque *et al*. (2003) and Mathivanan *et al*. (2005).

**Magnesium** : In the season 1 magnesium range was between 28 mg/L and 56.5 mg/L. Lowest was seen in S II and highest in S IV. In the season 2 magnesium range was from 19 mg/L to 52.5 mg/L; lowest in S II and highest in S IV. In season 3 range of magnesium was 47 mg/L to 82 mg/L; lowest was observed in S V and highest in S IV. In season 4 the range was 31 mg/L to 57 mg/L; the lowest was seen in S II and highest magnesium in S IV. The overall range in sampling period is between 19 mg/L and 82 mg/L (Fig. -2i). Many investigators are of the opinion that magnesium always occurs in lower concentration than calcium (Mehta, 2003; Tassaduque *et al*., 2003).

**Nitrate** : In season 1 the range of nitrate was 0.0 mg/L to 0.7 mg/L; lowest value was observed in S II and S III and highest in S I. In season 2 the range was between 0.8 mg/L and 3.0 mg/L; lowest was seen in S II and highest in S V. In season 3 the range was 1.2 mg/L to 3.3 mg/L; lowest was seen in S VII and highest in S V. In season 4 the nitrate range was 0.6 mg/L to 3.2 mg/L; lowest in S VII and highest in S V. The overall range in sampling period is 0 mg/L to 3.3 mg/L (Fig. -2j). In the present study, nitrate concentrations were well below the permissible limit of 10 mg $L^{-1}$ prescribed by BIS (1998) in all the samples. Perhaps the high concentration of nitrates is harmful, but nitrate is an essential nutrient for plants and planktons, which convert into cell protein (Maiti, 2001; Jain *et al*., 2006).

**Sulphate** : In the season 1 sulphate range was between 9.3 mg/L and 13.5 mg/L; lowest sulphate was seen in S V and highest in S IV. In season 2 the range was 7.8 mg/L to 14.9 mg/L; lowest in S II and highest in S V. In season 3 the sulphate range was between 6.0 mg/L

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and 12.4 mg/L; lowest in S II and highest in S V. In season 4 range was between 3.7 mg/L and 11.8 mg/L; lowest in S VII and highest in S II. The overall range in sampling period is 3.7 mg/L to 14.9mg/L (Fig.-2k). Pawar and Mane (2006) also recorded sulphate concentrations which were low in monsoon and high in winter season.

**Chloride** : In the season 1 chloride range was between 23.4 mg/L and 38.9 mg/L; lowest chloride was seen in S VII and highest in S III. In season 2 the range was 22 mg/L to 56 mg/L; lowest in S I and highest in S II. In season 3 the chloride range was between 58 mg/L and 81 mg/L; lowest in S I and highest in S II. In season 4 range was between 40 mg/L and 80 mg/L; lowest in S I and highest in S II. The overall range in sampling period is 22 mg/L to 81 mg/L (Fig. -2l). Unni (1985) stated that the chloride concentration largely depends on domestic wastes, rainfall, humidity of climate and evaporation.

**Phosphate** : In season 1 the range of phosphate was 0 mg/L to 0.17 mg/L; lowest valve was observed in S III and S VI and highest in S VII. In season 2 the range was between 0.06 mg/L and 1.2 mg/L; lowest was seen in S IV and highest in S V. In season 3 the range was 0 mg/L to 1.8 mg/L; lowest was seen in S VII and highest in S V. In season 4 the phosphate range is 0.6 mg/L to 2.3mg/L; lowest in S II and highest in S V. The overall range of phosphate in the sampling period was 0 mg/L to 2.3 mg/L (Fig. -2m). The Bureau of Indian Standard (BIS) suggested the limit of phosphate is 0.1 mg $L^{-1}$. Higher concentration in the monsoon season may be attributed to its influx with rainwater (Sunkad and Patil, 2003; Pandey and Verma, 2004).

**Iron** : In season 1 iron range was between 0 mg/L and 0.005 mg/L; lowest iron content was seen in S I, S III and S IV and highest in S II. In season 2 the range was 0 mg/L to 0.0005 mg/L. The presence of iron was observed in S V and S VII and rest showed zero valve. In the season 3 the iron range was between 0.0005 mg/L and 0.035 mg/L; lowest in S I and highest in S VII. In season 4 range was between 0.0 mg/L and 0.005 mg/L (Fig.-2n). Presence of iron was observed in S II and absent in S I, S IV and S VII. The overall range of iron in sampling period was 0 mg/L to 0.005 mg/L. The iron concentration estimated to be more in monsoon season and is due to the heavy runoff of water in. Earlier studies support to present findings Aparecida *et al*. (2003).

**Chemical oxygen demand** : In season 1 the range of COD was 118.5 mg/L to 146 mg/L; lowest valve was observed in S V and highest in S II. In season 2 the range was between 115 mg/L to 171 mg/L; lowest was seen in S VII and highest in S V. In season 3 the range was 71 mg/L to 158.5 mg/L; lowest was seen in S II and highest in S VI. In season 4 the COD range was 81 mg/L to 179 mg/L; lowest in S II and highest in S VI. The overall range in sampling period was 71 mg/L to 179 mg/L (Fig. -2O). Usually COD values remain higher than the BOD values. This may be high due to the anthropogenic activities, domestic and industrial effluents (Sawant *et al*., 1996; De, 1999).

**Dissolved oxygen**: In season 1 DO range was between 6.7 mg/L and 7 mg/L; lowest DO was seen in S II and S IV and highest in S I. In season 2 the range was 5.8 mg/L to 7.0 mg/L; lowest in S VI and highest in S I. In season 3 the DO range was between 4.5 mg/L and 6.3 mg/L; lowest in S I and S V and highest in S VII. In season 4 range was between 5.0 mg/L and 6.7 mg/L; lowest in S V and highest in S I and S VII. The overall range in sampling period was 4.5 mg/L to 7.0 mg/L (Fig.-2p). DO in natural and waste water depends on the physical, chemical and biological activities in the water body. Sabata and Nair (1995) have concluded that the solubility of DO decreases with increase in temperature. Generally, the value of DO was lowest during summer due to higher temperature and higher

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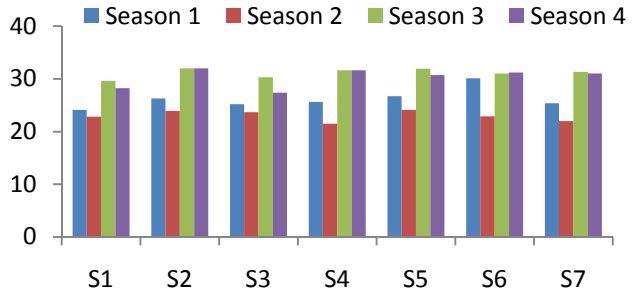


**Fig. - 2a. Temperature (îC)**

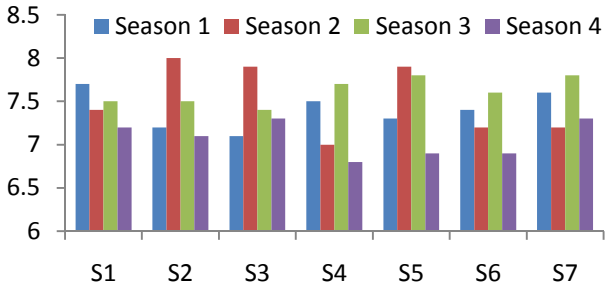


**Fig.- 2b. pH**

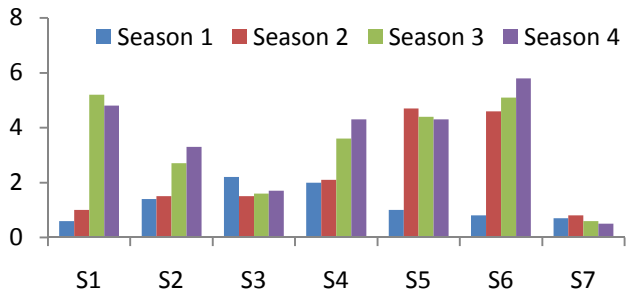


**Fig. -2c. Turbidity (NTU)**

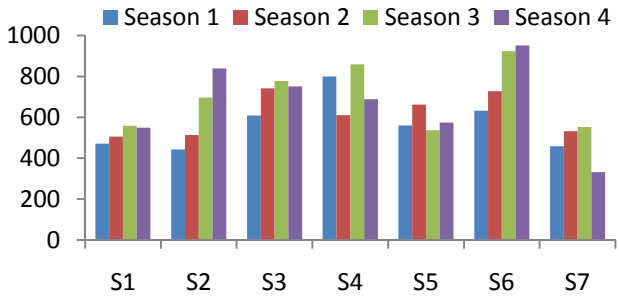


**Fig.- 2d. Electric conductivity (µmho cm-1)**

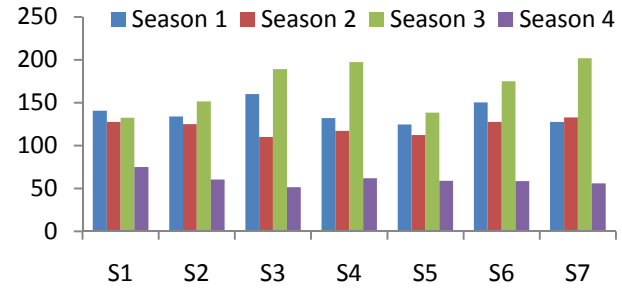


**Fig. -2e. Total Alkalinity (mg/L)**

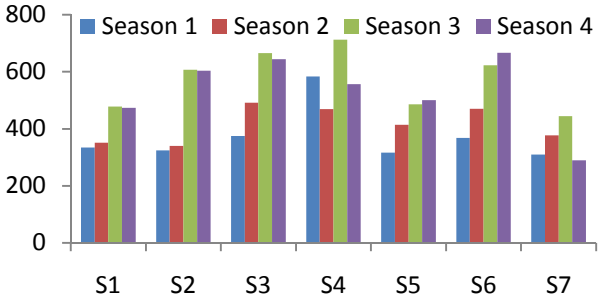


**Fig.- 2f. Total dissolved solids (mg/L)**

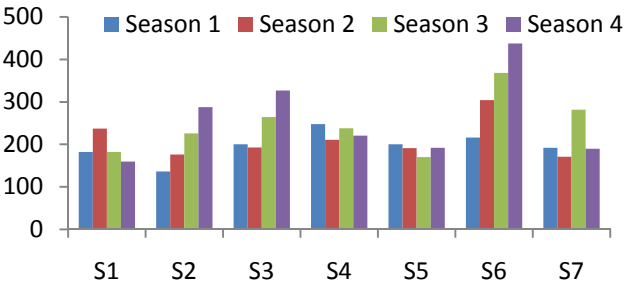


**Fig. -2g. Total hardness (mg/L)**

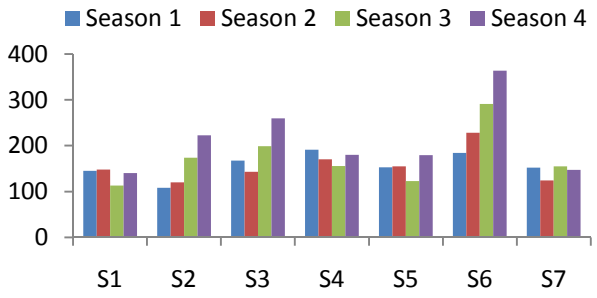


**Fig.- 2h. Calcium (mg/L)**

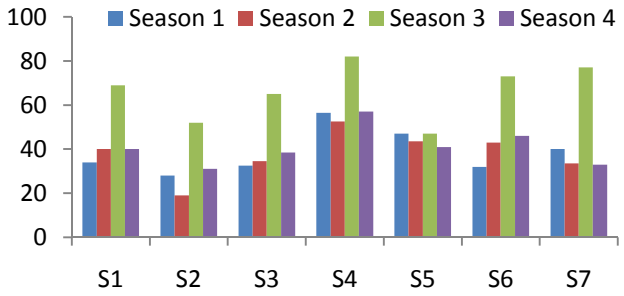


**Fig. – 2i. Magnesium (mg/L)**

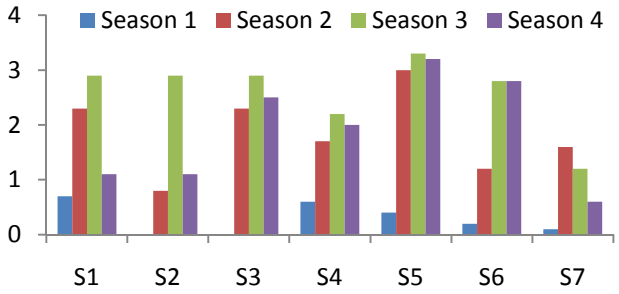


**Fig.- 2j. Nitrate (mg/L)**

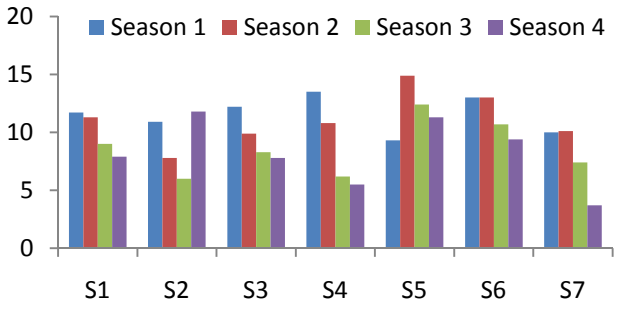


**Fig. -2k. Sulphate (mg/L)**

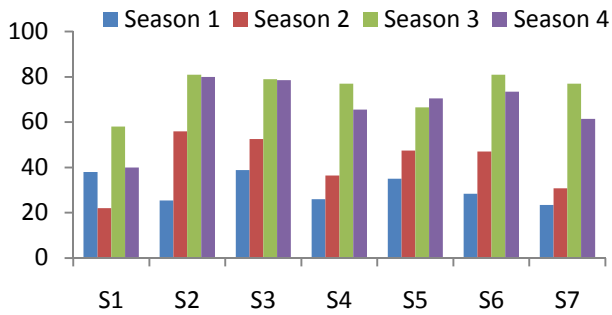


**Fig.- 2l. Chloride (mg/L)**

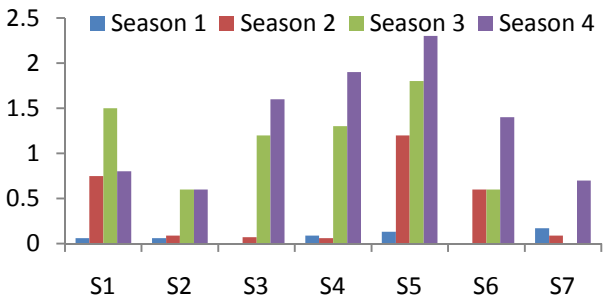


**Fig. -2m. Phosphate (mg/L)**

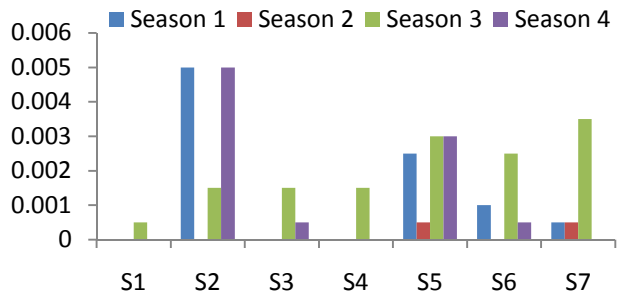


**Fig.- 2n. Iron (mg/L)**

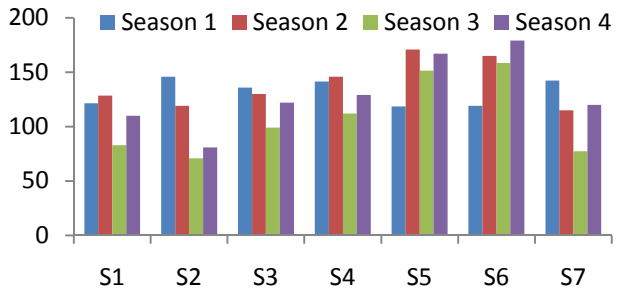


**Fig. -2o. Chemcial Oxygen Demand (COD) (mg/L)**

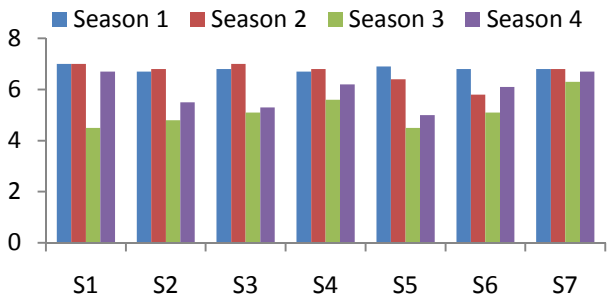


**Fig.- 2p. Dissolved Oxygen (DO) (mg/L)**

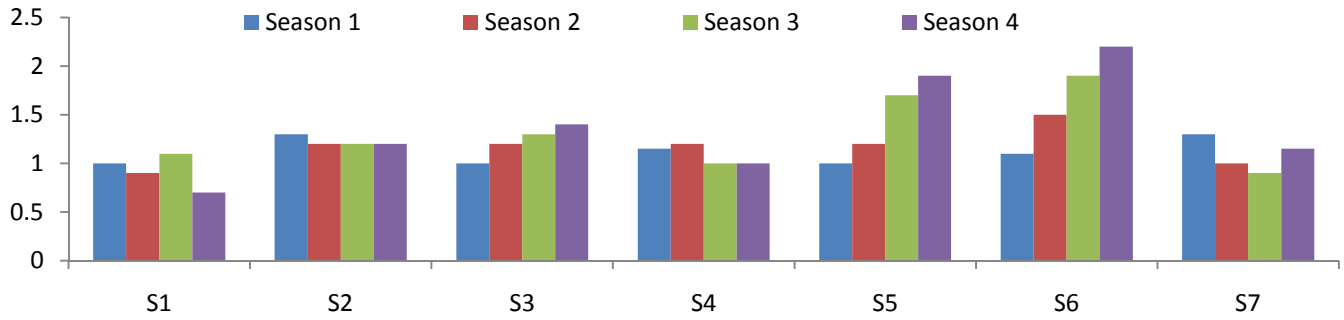


**Fig.- 2q. Biological Oxygen Demand (BOD) (mg/L)**

**Fig. - 2a-2q. Seasonal variations of 18 different physico-chemical parameters of water samples**

rate of microbial decomposition of the organic matter (Pandey and Verma, 2004).

**Biological oxygen demand** : In season 1 the range of BOD was 0.8 mg/L to 1.3 mg/L; lowest value was observed in S I and highest in S III. In season 2 the range was between 0.5 mg/L and 1.6 mg/L. Lowest was seen in S VII and highest in S I. In season 3 the range was 0.9 mg/L to 1.7 mg/L; the lowest was seen in S VII and highest in S VI. In season 4 the BOD range was 0.7 mg/L to 1.9 mg/L; lowest in S II and highest in S VI. The overall range in sampling period was 0.7 mg/L to 1.9 mg/L (Fig. -2q). According to BIS standards the drinking water should not contain any BOD at all. However a value of 3 mg/L is tolerable. If this is considered on an average basis, then all the sampling spots in the present investigation contain lesser BOD.

**Fluoride**: It was found constant throughout the sampling period in almost all the samples and the value was around 0.2 mg/L. Fluoride is ubiquitous in nature the and is present in rocks, soil, water, plants and even air (Thakare *et al.*, 2006; Mali, 2007). In the present study fluoride is under permissible limit (BIS, 1998).

According to statistical analysis between the sampling spots, temperature showed the significant variation followed by the nitrate, chloride, magnesium, phosphate, COD and iron. The Dendrogram using average linkage (Between Groups) for physico-chemical

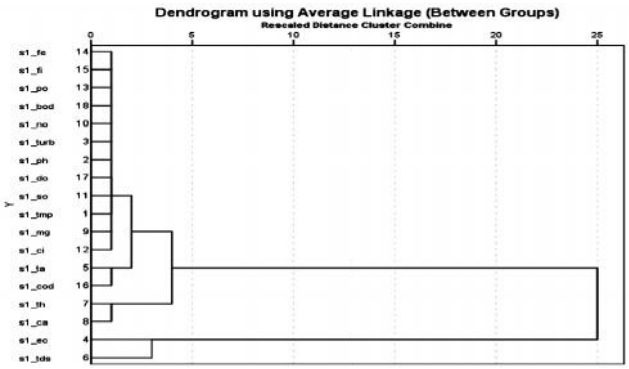


**Fig. - 3. Statistical representation (dendrogram) of different physico-chemical parameters of water samples**

parameters revealed that total alkalinity and electrical conductivity are highly related and showed a significant role in the study. This was followed by relatedness between magnesium and total hardness, electrical conductivity and total dissolved solids and sulphate and total hardness. Other parameters linkages were at low a level.

**Conclusion**

The lake water analysis of Mandya district showed highest correlation between total alkalinity and electrical conductivity followed by magnesium and total hardness. The rest of the parameters showed lowest correlation. The parameters like pH, total hardness, total dissolved solids, chloride, magnesium, iron and sulphate were within the range, chemical

oxygen demand, and calcium were above the range mentioned by WHO. The water quality of lakes was either average or below average as per the standards. It is important to monitor the quality of lake water to know the degree of pollution and its effect on surrounding humans and flora and fauna. The local residents should be educated regarding the measures to decrease lake water pollution and to maintain ecological balance.

**References**

Anonymous. 2008. Ground water information booklet, Mandya district, Karnataka. Government of India, Ministry of Water Resources, Central Ground Water Board, South Western Region, Bangalore.

Aparecida, P., Rodrigus, L. and Aurelio, T. 2003. Spatial variation of phytoplankton and some abiotic variables in the Pirapo river (Brazil) in August 1999: a preliminary study. *Acta. Scient. Biol. Sci*., 25:1 - 8.

APHA, 1998. Standard methods for the examination of water and waste water. American Public Health Association, Washington DC, USA.

American Water Work Association (AWWA). 1995. Standard Method for the Examination of Water and Wastewater, 19th ed. American Public Health Association, Washington DC, USA.

Behera, B.C., Mishra, R.R., Patra, J.K., Dutta, S.K. and Thatoi, H.N. 2014. Physico chemical properties of water sample collected from mangrove ecosystem of Mahanadi River Delta, Odisha, India. *Am. J. Mar. Sci*., 2: 19 - 24.

BIS, Bureau of Indian Standards, 1996. Standards for water for drinking and other purposes, India.

Conboy, M.J. and Goss, M.J. 2001. Identification of an assemblage of indicator organisms to assess timing and source of bacterial contamination in groundwater. *Water Air Soil Pollut*., 129: 101 - 118.

CWC. 2006. Integrated Hydrobiological Data Book (non-classified river basins). Hydrological data directorate information systems organization, water planning and projects wing, Central Water Commission, New Delhi.

De, M.K. 1999. Environmental Chemistry, New Age International Limited, Publication, New Delhi. pp. 364.

Gray, N.F. 1999. Water Technology: An Introduction for Environmental Students. Elsevier Science and Technology Books, New York. 133-189 pp.

Gupta, G.K. and Shukla, R. 2004. Physico-chemical and bacteriological quality in various sources of drinking water from Auriya district (UP) industrial area. *Pollut. Res*., 23: 205 - 209.

Hardikar, R.S. and Acharya, C.A. 2013. Comparative analysis of physico-chemical properties of two fresh water bodies of Ahmedabad city, Gujarat. *Life Sci. Leaflets*., 4: 81 - 84.

Iscen, C.F., Emiroglu, O., Ilhan, S., Arslan, N., Yilmaz, V. and Ahiska, S. 2008. Application of multivariate statistical techniques in the assessment of surface water quality in Uluabat lake. *Turk. Environ. Monit. Assess*., 144: 269 - 276.

Jain, N., Saxena, S., Singh, A.N. and Shrivastava, R.K. 2006. Studies on the underground water quality of earthquake affected Kosamghat region of Jabalpur district, M.P. *Nat. Environ. Pollut. Technol*., 5: 123 - 127.

Maiti, S.K. 2001. Hand book of Methods in Environmental Studies, Vol. 1. Water and Waste Water Analysis. ABD Publishers, Jaipur, India.

Mali, D.S. 2007. Prevalence of fluorosis and defluoridation of water: An overview. *Indian J. Environ. Prot*., 27: 459 - 466.

Manjare, S.A., Vhanlakar, S.A. and Muley, D.V. 2010. Physico-chemical parameters of Tamadalge water

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tank in Kalahapur District, Maharastra. *Int. J. Adv. Biotechnol. Res.*, 1: 115 - 119.

Mathivanan, V., Kayalvizhi, A. and Selvisabhanayakam. 2005. An assessment of physico-chemical parameters of fish culture ponds at Vishakapatanam, Cuddalore district, Tamilnadu. *J. Curr. Sci.*, 7: 253 - 258.

Mathur, P., Agarwal, S. and Nag, M. 2008. Assesment of physico-chemical characteristics and suggested restoration measures for Pushkar lake, Ajmer Rajasthan (India). Sengupta, M. and R. Dalwani (eds). Proceedings of Taal 2007: The 12th World Lake Conference: 1518-1529.

Mehta, M.B. 2003. Drinking water quality of ground water from selected sample points around Thane district of Maharashtra. *J. Indus. Pollut. Control.*, 19: 53 - 157.

Mirza, M.A., Arain, G.M. and Khuhawar, M.Y. 2006. Comparative study of physico-chemical characteristics of five main ponds of District, Bhimber, Azad, Jammu and Kashmir. *J. Chem. Soc. Pak.*, 28: 322 - 330.

Mukhtar, F., Bhat, M.A., Bashir, R. and Chisti, H. 2014. Assessment of surface water quality by evaluating the physico-chemical parameters and by checking the water quality index of Nigeen basin and Brari Nambal lagoon of Dal lake, Kashmir. *J. Mater. Environ. Sci.*, 5: 1178 - 1187.

Oluduro, A.O and Adewoye, B.I. 2007. Efficiency of *Moringa oleifera* seed extract on the microflora of surface and ground water. *J. plant Sci.*, 6: 453 - 438.

Pandey, J. and Verma, A. 2004. The influence of catchment on chemical and biological characteristics of two fresh water tropical lakes of southern Rajasthan. *J. Environ. Biol.*, 25: 81 - 87.

Pawar, B.A. and Mane, U.H. 2006. Hydrography of a Sadatpur lake near Pravaranagar, Ahmednagar district, Maharashtra. *J. Aqua. Biol.*, 21: 101 - 104.

Puri, P.J., Yenkie, M.K.N., Battalwar, D.G., Gandhare, N.V. and Dhanorkar, D.B. 2010. Study and interpretation of physico-chemical characteristic of lake water quality in Nagpur city (India). 3: 800 - 810.

Sabata, B.C. and Nair, M.P. 1995. River pollution in India: A case study of Ganga river. APH Publishing Corporation, New Delhi. pp. 223.

Sawant, C.P., Shrivastava, V.S. and Saxena, G.C. 1996. Metals in well water samples collected from tribal area of Satpura valley. *Indian J. Environ. Prot.*, 16: 906 - 908.

Shilpa, G.P., Goroba, C.S., Suhas, J.A. and Raut, P.D. 2011. Study of physico-chemical and biological characteristics of lakes from Shivaji University Campus, Kolhapur, Maharashtra. *Adv. Appl. Sci. Res.*, 2: 505 - 519.

Sinha, D.K. and Rastogi, G.K. 2007. Physico-chemical characteristics of underground drinking water at Moradabad. *Pollut. Res.*, 26: 345 - 349.

Sood, A., Singh, K.D., Pandey, P. and Sharma, S. 2008. Assessment of bacterial indicators and physico-chemical parameters to investigate pollution status of Gangetic river system of Uttarakhand (India). *Ecol. Indicator.*, 8: 709 - 717.

Sunkad, B.N. and Patil, H.S. 2003. Water quality assessment of Rakasakoppa reservoir of Belgaum, Karnataka. *Indian J. Ecol.*, 30: 106 - 109.

Tassaduque, K., Ali, M., Salam, A., Latif, M. and Zahar, T. 2003. Studies on the seasonal variations in the physico-chemical and biological aspects of Indus river, Pakistan. *Pak. J. Biol. Sci.*, 6: 1795 - 1801.

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Thakare, S.B., Parwater, A.V. and Rao, M. 2006. Status of fluoride and study of endemic fluorosis - An overview. *Environ. Pollut. Control. J*., 9: 1 - 3.

Trivedy, R.K. and Goel, P.K. 1986. Chemical and biological methods for water pollution studies. *Environ. Publ*., 15: 342 - 346.

Unni, K.S. 1985. Comparative limnology of several reservoirs in Central India. *Int. Rev. Gensanteh. Hydrobiologia.*, 70: 845 - 856.

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