Lake Water Quality Characterization in Hyderabad, Telangana State, India

V. Hema Sailaja, Centre for Environment, Institute of Science and Technology, JNTUH, Hyderabad, Telangana, India
P. Suman Babu, Department of Civil Engg., CVSR Engg. College, Anurag Group of Institutes, Gatkesar, R.R. Dist., Telangana, India
M. Anji Reddy, Centre for Environment, Institute of Science and Technology JNTUH, Hyderabad, Telangana, India

ABSTRACT

The three P's (Population, pollution and protection) had been globally significant with regard to the inland water bodies been unfit for portability. This is due to the disregard by people of their responsibility towards the environment in which their survive. This paper reveals the trend of the water quality in Shamirpet lake, situated in Hyderabad metro city from 2010 to 2014. The analysed values of the chemical parameters signify the deterioration of the water quality through the study period as the three P's go uncontrolled and unconcerned. The quantification of the quality of the lake water is done through calculating the indices like WQI and TSI. The spatio-temporal variability is exhibited by the distribution maps which help the planners to act on the scenario for restoration. The water quality standards, Indian standard:10500 and APHA methods are considered for the assessments. The values compared with the standards are observed to exceed the permissible limit showing considerable variations during the pre and post monsoon seasons altering the composition and leading the lake to eutrophic state. This is mainly due to the nutrient input and sewage & industrial effluents. The results notify that the water quality is bad from WQI and is proceeding towards Hypereutrophic from CTSI.

Keywords

Water Quality, Lake, WQI, TSI and Pollution

INTRODUCTION

Being the major natural resource supporting Life (Basavaraja Simpi et al., 2011), water plays vital role in sustainable development of the ecosystem. The exaggerated metro developments leading to pronounced urban sprawl, has a substantial impact on water quality. The quality of water affects the life forms surviving in the aquatic environment. The water quality is affected by the substances, their concentrations and the source of their origin. The point sources such as agriculture, aquaculture, municipalities, industries and commercial activities cause adverse effect on the receiving water bodies ((McGwire et al., 2000), if the contaminants exceed the desirable limits, the water quality deteriorate leading to eutrophication thereby posing threat to the aquatic ecosystem. The major contributor for the quality distress of the water bodies can be indisputably be assigned to anthropogenic sources. The major developmental activities with disregard to the environmental consequences are causing havoc to the water resources.

The metro city Hyderabad is no exception to this state of deterioration of lake water quality. Located in the Deccan plateau the

city is dotted with scattered lakes throughout its extent numbering to few hundreds. Expansion of the city due to rapid urbanization, industrialization, commercialization and urban sprawl, the inland water bodies replicate gutters and the climax ecological succession lead to their disappearance and paved way to encroachments, eventually leading to reduction in their number and worsened water quality, upsetting the ecosystem as a whole. Thus water quality assessment is vital for monitoring, management and restoring of the lake waters.

Remote sensing and GIS are the proven technologies in resource management with large scale observation spatially and temporally having continuous monitoring possibility. Remote sensing has the advantage of

measuring the location with a synoptic coverage and receptivity is easy on a target. Lillesand et al. 1983, Cox et al. 1998 and many referred Remote sensing and GIS as successful tools in estimating and establishing water quality parameters.

STUDY AREA

The study area is Hyderabad, the fifth largest metropolis in the country and the capital of state Telangana. Situated at an average height of 515m above mean sea level and located at 17°22"N latitude and 70°22"E longitudes, Hyderabad carry its legacy of fame as the city of lakes. The city lies on the Deccan plateau covering an area of 778 km^2. Fig:1 exhibit the location map of the lake Shamirpet area under study.

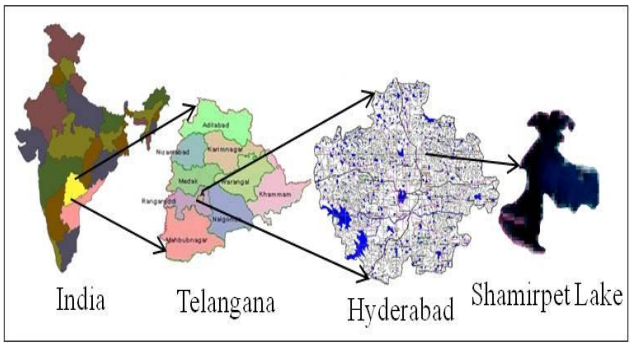


Fig. 1 Location map of the study area.

Description of the Lake: Shamirpet lake is 27kms from Secunderabad is an artificial lake dug by Jagirdar of that area 50 years ago. Jawahar deer park is adjacent to the lake. Many exotic species of birds visit this lake attracting bird watchers. The water holding capacity of the lake declined from 469.25 ha in1986 to 208.65 ha in 2009 (Source: Anjal Prakash, SaciWATERs 2014). The lake acts as a source of irrigation for about 10 villages in surrounding areas. The nearby industrial waste dumps and the residential discharges and solid wastes are polluting the water and made it unfit for portability.

METHODOLOGY

The water quality Index presents the overall quality of the lake. The nutrient load is expressed in terms of the lakes trophic state index. Analytical procedure are used to calculate the water quality index (NSFWQI) and Trophic state index (Carlson TSI) of the lakes in the study area. The water quality parameters viz., pH, temperature, dissolved oxygen, turbidity, total phosphorus, nitrates, total dissolved solids, Biological oxygen demand, faecal coliforms, total suspended solids, chlorophyll-a and secchi depth are investigated to find both indices of the lakes over five years of the study period. Premonsoon and post monsoon seasonal data is collected from the sampling locations of the lake. Fig:2 illustrate the sampling locations in Shamirpet lake.

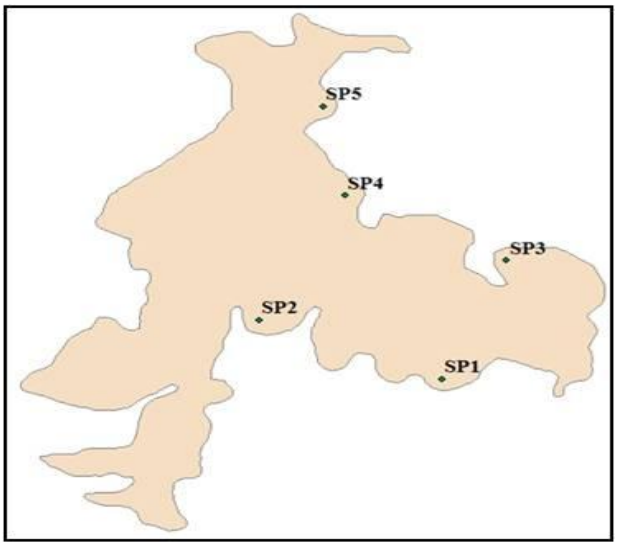


Fig. 2 Sampling points in Lake Shamirpet

The Following are the five GCP's of the sampling locations description.

SP1	South side of the lake pointing Shamirpet bus station
SP2	SW side of the lake opposite to Shamirpet deer park
SP3	East side towards Hyd-Mancherial road
SP4	NE corner pointing towards Ratnalayam
SP5	North side along the direction of Majeedpur

Rainfall and temperature data were collected from the Indian meteorological department, Hyderabad. The water samples were analysed in the laboratory for the targeted quality parameters as per the procedures of Indian standard: 10500 and APHA methods (1989 & 2005). After tabulating the results twice in each year of the five years study period, the results are interpreted statistically. The water quality indices present a combined symptomatic value from the complex individual data's which otherwise may not present an comprehensive quality trends over time and across geographic areas. The indices values

would give a concise meaning that indicates the health of the water body and provide for measurement and assessment of the water quality of the lakes by incorporating the data of different quality parameters into an mathematical equation. The number would be compared with the rating scale and the range categorizes the quality.

In case of the NSFWQI (Brown et al,1970) the scale of rating is from 0 to 100 scale and graded from very bad to excellent. Each parameter sub-indices are calculated by a rating curve after which they are averaged to get the overall WQI value to denote the lake's condition.

The NSFWQI is expressed as the following equation:

$$WQI = \sum_{i=1}^{n} Q_i W_i$$

Where,

Q_i = sub-index for ith water quality parameter;

W_i = weight associated with ith water quality parameter;

n = number of water quality parameters.

The Trophic state index (TSI)(Carlson, 1977) on the other hand provides an index number for the three parameters, Chlorophyll-a, Secchi Depth and Total Phosphorus. The TSI ranges from a scale of 0 to 100 and the classification range from oligotrophic to hypereutrophic state of the lakes.

The formulas for calculating the TSI values are as follows:

For Secchi Depth: TSI (SD) = 60 - 14.41 ln(SD)

For Total Phosphorus: TSI (TP) = 14.42 ln(TP) + 4.15

For Chlorophyll a: TSI (CHL) = 9.81 ln(CHL a) + 30.6

where, ln is the natural logarithm.

CTSI = [TSI (SD) + TSI (TP) + TSI (CHL a)]/3

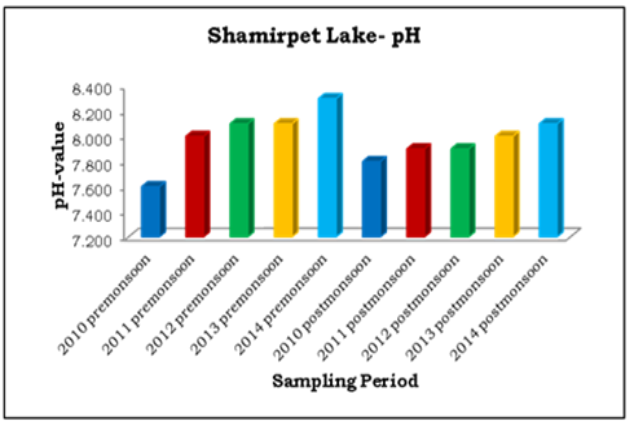
The final concentrations were utilised in preparing spatial distribution of each parameter under study emphasizing the water quality estimated in the selected lake using GIS.

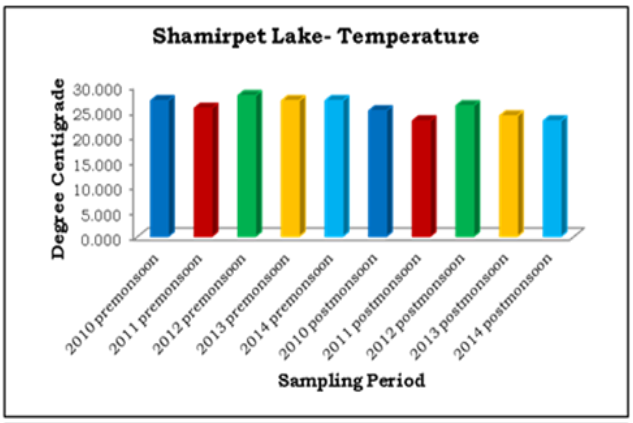
RESULTS

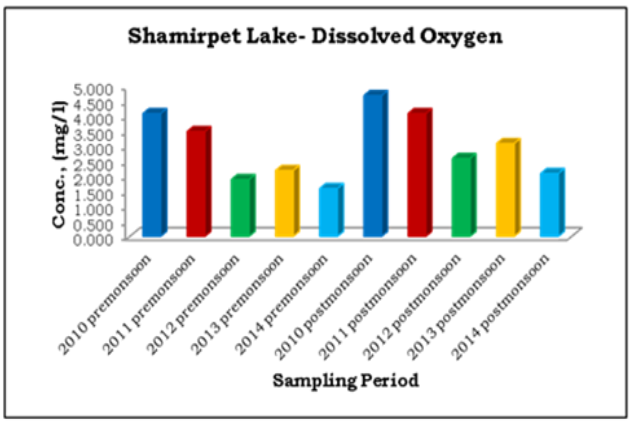
The investigation was carried in Shamirpet lake located at 78° 33' 47" E, 17° 36' 36" N covering an area of 46.8 hectares / 0.47 Sqkm in Hyderabad. The water quality interpretation can be done in an appropriate manner with the help of the indices like water quality index and Trophic state index of any water body like lakes. The water samples were subjected to the analysis of the following parameters like pH, temperature, dissolved oxygen, turbidity, total phosphorus, nitrates, total dissolved solids, Biological oxygen demand, faecal coliforms, total suspended solids, chlorophyll-a and secchi depth and their concentrations were tabulated in their appropriate units.

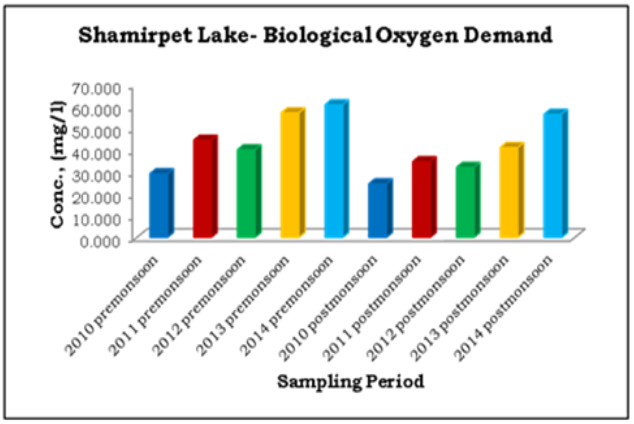
Statistical Analysis: The Mean values of the parameter viz., pH, temperature, dissolved oxygen, turbidity, total phosphorus, nitrates, total dissolved solids, Biological oxygen demand, faecal coliforms, total suspended solids, chlorophyll-a and secchi depth are calculated and illustrated in Fig:3. The descriptive statistics of the lake in during the five year study period 2010 to 2014 for both the seasons premonsoon and post monsoon is also premeditated (Table:1 and Table:2 show data only for the year 2010). The values of each parameter show specific seasonal based behaviour emphasizing the prevailing quality having impact on the water body.

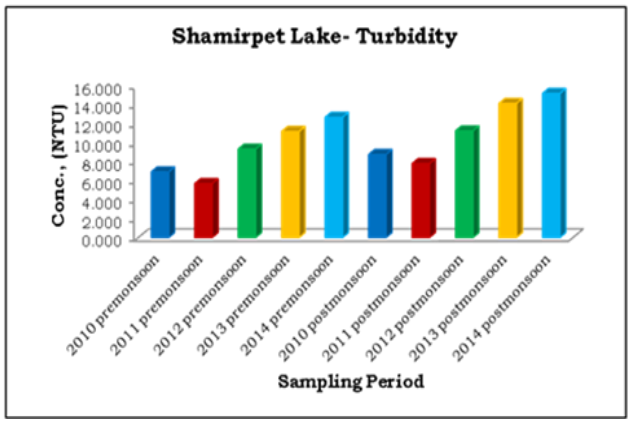
To achieve a better visualization of the raw data and allow simpler interpretation descriptive statistics are very important in the analysis of any data. Low variance show the relatively low difference of the data around the mean value and the descriptive statistics exemplify the variability of the different water quality parameters with each other. Skewness and kurtosis assist in deciding the normality. The spread of the data can be measured by the range, quartiles, variance and standard deviation. Therefore, these descriptive statistics are calculated for the data analyzed for summarizing and improving the interpretation of the water quality data. It is observed that a clear variation is present from the premonsoon to post monsoon seasonal change on the parameter behaviours' in the lake.

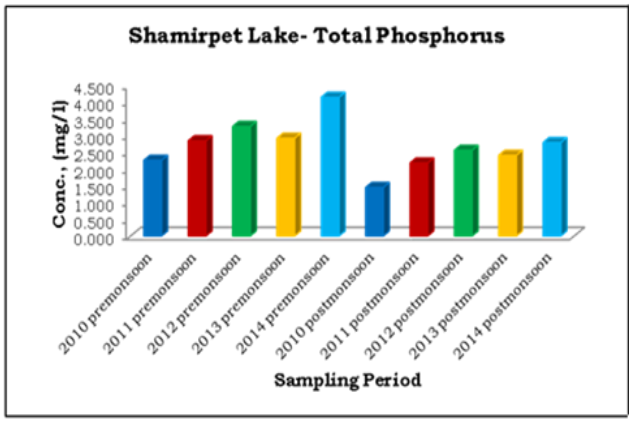

Shamirpet Lake- pH
pH-value
8.400
8.200
8.000
7.800
7.600
7.400
7.200
2010 premonsoon
2011 premonsoon
2012 premonsoon
2013 premonsoon
2014 premonsoon
2010 postmonsoon
2011 postmonsoon
2012 postmonsoon
2013 postmonsoon
2014 postmonsoon
Sampling Period

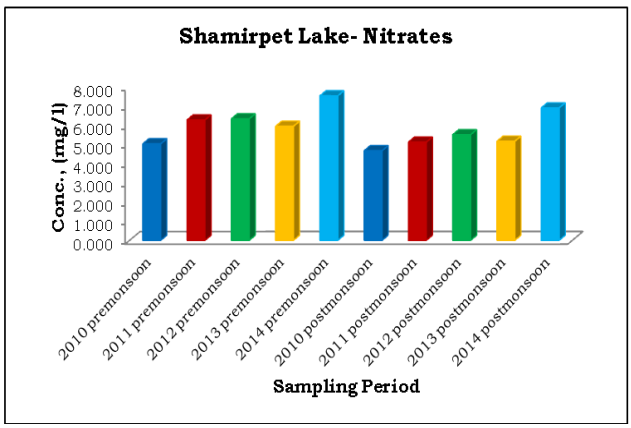

Shamirpet Lake- Temperature
Degree Centigrade
30.000
25.000
20.000
15.000
10.000
5.000
0.000
2010 premonsoon
2011 premonsoon
2012 premonsoon
2013 premonsoon
2014 premonsoon
2010 postmonsoon
2011 postmonsoon
2012 postmonsoon
2013 postmonsoon
2014 postmonsoon
Sampling Period

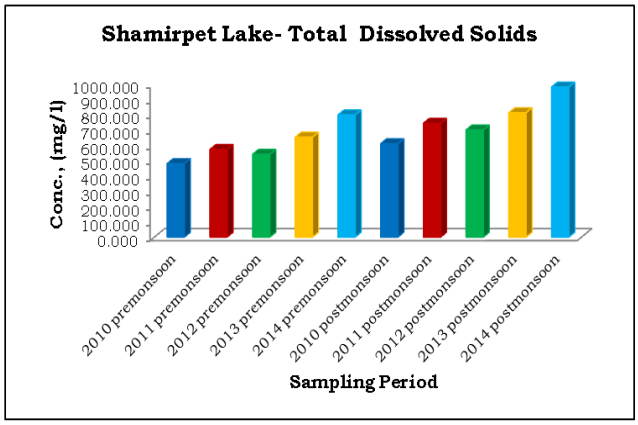

Shamirpet Lake- Dissolved Oxygen
Conc., (mg/l)
5.000
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
2010 premonsoon
2011 premonsoon
2012 premonsoon
2013 premonsoon
2014 premonsoon
2010 postmonsoon
2011 postmonsoon
2012 postmonsoon
2013 postmonsoon
2014 postmonsoon
Sampling Period


Shamirpet Lake- Biological Oxygen Demand
Conc., (mg/l)
70.000
60.000
50.000
40.000
30.000
20.000
10.000
0.000
2010 premonsoon
2011 premonsoon
2012 premonsoon
2013 premonsoon
2014 premonsoon
2010 postmonsoon
2011 postmonsoon
2012 postmonsoon
2013 postmonsoon
2014 postmonsoon
Sampling Period


Shamirpet Lake- Turbidity
Conc., (NTU)
16.000
14.000
12.000
10.000
8.000
6.000
4.000
2.000
0.000
2010 premonsoon
2011 premonsoon
2012 premonsoon
2013 premonsoon
2014 premonsoon
2010 postmonsoon
2011 postmonsoon
2012 postmonsoon
2013 postmonsoon
2014 postmonsoon
Sampling Period


Shamirpet Lake- Total Phosphorus
Conc., (mg/l)
4.500
4.000
3.500
3.000
2.500
2.000
1.500
1.000
0.500
0.000
2010 premonsoon
2011 premonsoon
2012 premonsoon
2013 premonsoon
2014 premonsoon
2010 postmonsoon
2011 postmonsoon
2012 postmonsoon
2013 postmonsoon
2014 postmonsoon
Sampling Period


Shamirpet Lake- Nitrates
Conc., (mg/l)
8.000
7.000
6.000
5.000
4.000
3.000
2.000
1.000
0.000
2010 premonsoon
2011 premonsoon
2012 premonsoon
2013 premonsoon
2014 premonsoon
2010 postmonsoon
2011 postmonsoon
2012 postmonsoon
2013 postmonsoon
2014 postmonsoon
Sampling Period


Shamirpet Lake- Total Dissolved Solids
Conc., (mg/l)
1000.000
900.000
800.000
700.000
600.000
500.000
400.000
300.000
200.000
100.000
0.000
2010 premonsoon
2011 premonsoon
2012 premonsoon
2013 premonsoon
2014 premonsoon
2010 postmonsoon
2011 postmonsoon
2012 postmonsoon
2013 postmonsoon
2014 postmonsoon
Sampling Period

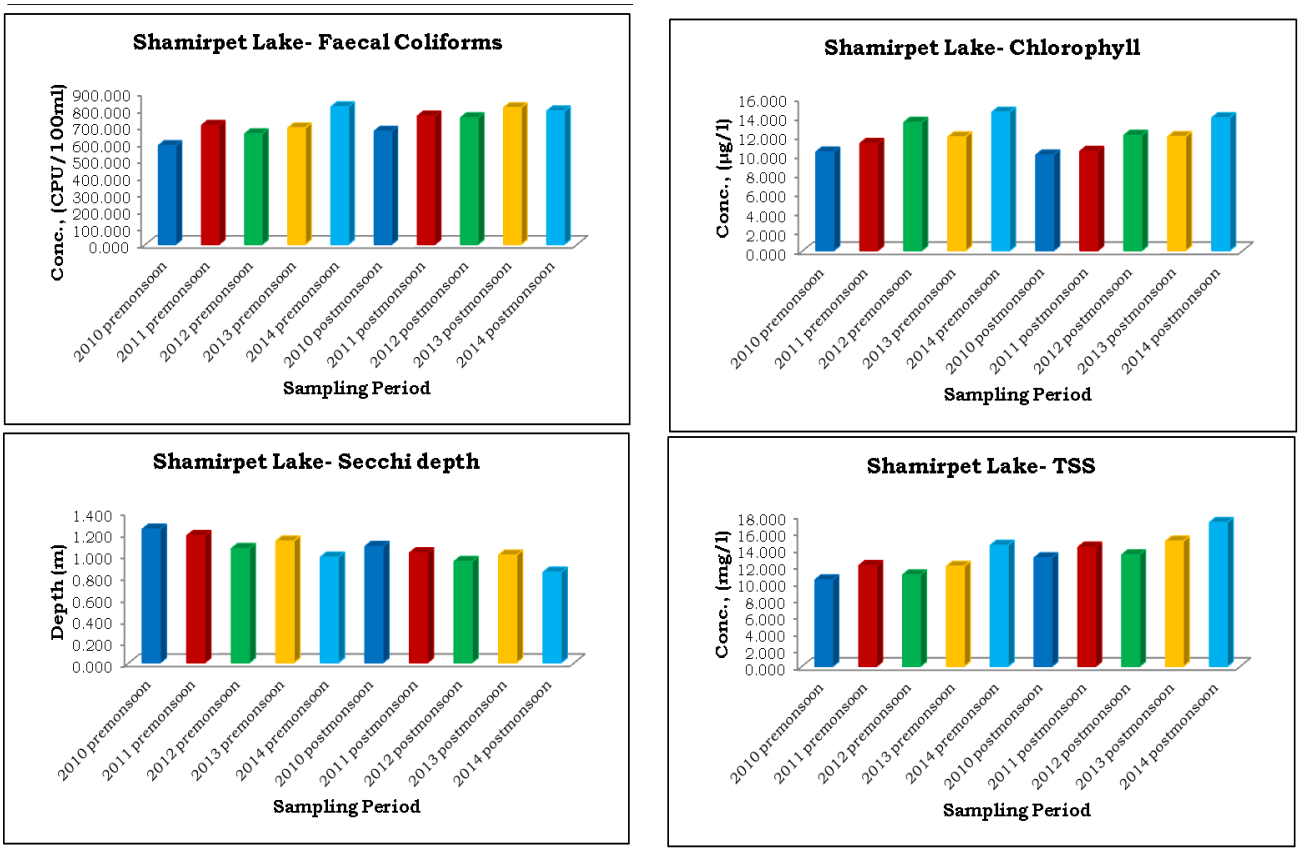


Fig. 3 Illustrate Shamirpet Lake water quality parameters mean concentration during the study period

Table 1 Descriptive statistics of the water quality parameters during 2010 premonsoon in Shamirpet lake

SHAMIRPET 2010 premonsoon									
Parameters	**STDEV**	**Variance**	**Kurt**	**Skew**	**Range**	**Q1**	**Median**	**Q3**	**IQR**
pH	0.60	0.36	0.74	0.71	1.60	7.30	7.50	7.80	0.50
Temperature	2.74	7.50	0.13	0.61	7.00	26.00	27.00	29.00	3.00
DO	0.47	0.23	1.20	0.00	1.20	3.80	4.10	4.40	0.60
BOD	9.10	82.87	0.92	0.78	21.95	24.00	32.00	36.00	12.00
Turbidity	0.98	0.97	0.79	0.55	2.50	6.40	6.60	7.50	1.10
Total Phosphorus	0.23	0.05	1.13	1.03	0.60	2.20	2.30	2.40	0.20
Nitrate Nitrogen	0.36	0.13	1.63	0.14	0.90	4.80	5.00	5.30	0.50
TDS	118.51	14044.55	3.08	0.54	246.00	365.00	539.50	573.00	208.00
Faecal Coliforms*	82.09	6738.50	1.08	0.45	202.00	542.00	588.00	651.00	109.00
Chlorophyll	0.74	0.55	1.62	0.08	1.80	9.70	10.50	10.70	1.00
Secchi depth	0.56	0.31	3.49	1.80	1.40	0.90	1.10	1.20	0.30
TSS	0.68	0.46	1.22	0.02	1.70	9.80	10.50	10.60	0.80

Table 2 Descriptive statistics of the water quality parameters during 2010 postmonsoon in Shamirpet lake

SHAMIRPET 2010 postmonsoon									
Parameters	**STDEV**	**Variance**	**Kurt**	**Skew**	**Range**	**Q1**	**Median**	**Q3**	**IQR**
pH	0.61	0.38	1.49	0.38	1.70	7.60	7.80	7.90	0.30
Temperature	3.16	10.00	1.05	1.19	8.00	23.00	24.00	26.00	3.00
DO	0.58	0.33	1.04	0.97	1.50	4.60	4.70	5.10	0.50
BOD	4.31	18.58	2.86	1.68	10.70	22.00	23.00	25.00	3.00
Turbidity	1.62	2.62	0.62	0.13	4.40	8.20	8.70	9.45	1.25
Total Phosphorus	0.41	0.17	2.36	0.36	0.95	1.10	1.60	1.70	0.60
Nitrate Nitrogen	0.79	0.62	0.12	0.19	2.10	4.30	4.80	5.00	0.70
TDS	78.45	6154.58	1.05	0.08	200.00	560.00	620.00	655.00	95.00
Faecal Coliforms*	111.59	12452.00	2.51	0.54	248.00	577.00	712.00	759.00	182.00
Chlorophyll	2.12	4.48	1.94	0.35	5.10	8.40	10.60	11.40	3.00
Secchi depth	0.22	0.05	2.37	0.56	0.50	0.90	1.20	1.20	0.30
TSS	1.03	1.06	1.40	0.09	2.55	12.50	12.70	13.80	1.30

Water Quality Index Results: The water quality index gives a single value representing the quantity of different parameters which determine the pollution load in the water body. The National Sanitation Foundation Water Quality Index (NSFWQI) presents the general water quality disregarding the type of water consumption within the method of analysis. This type is developed by Brown et al., using method Delphi assigning weights to the parameters on common scale. This single digit value resolve the multi parameter data of the water quality analysis and significantly assess the quality of the water body. The water quality index is calculated for each sampling location point and also the overall mean WQI is also calculated based on the mean values of the lakes individually and seasonally. The parameters considered for the index are as follows: pH, Temperature, Dissolved oxygen, BOD, turbidity, Total phosphates, Nitrates, TDS and Faecal Coliforms. The NSFWQI calculated is ranked based on the scale rating from 0 to 100 and graded accordingly from very bad to excellent denoting the quality of water.

Lake Shamirpet water quality index at the sampling locations during the Pre and Post monsoon seasons is shown in Fig:4 and Fig:5. It is observed that the quality of all the locations in the lake is bad ranging between 25 to 50 scale. In 2014 premonsoon at SP1 location the quality happens to be very bad with 23.990. In 2010 postmonsoon period the WQI was found the highest 35.554 at SP4 location. Overall, Shamirpet lake water quality during the five year study period is found to be Bad in quality.

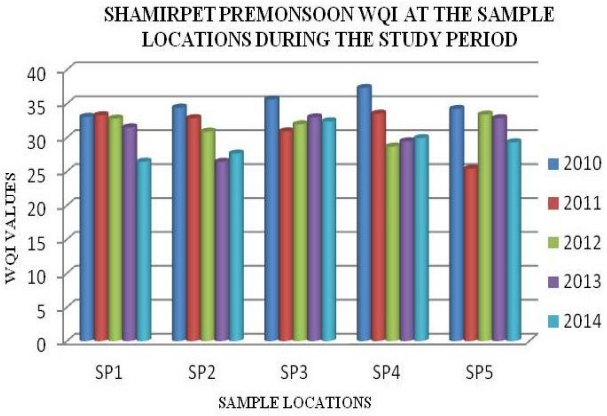


Fig. 4 Illustrate the Water Quality Index values at the sampling locations during Premonsoon period

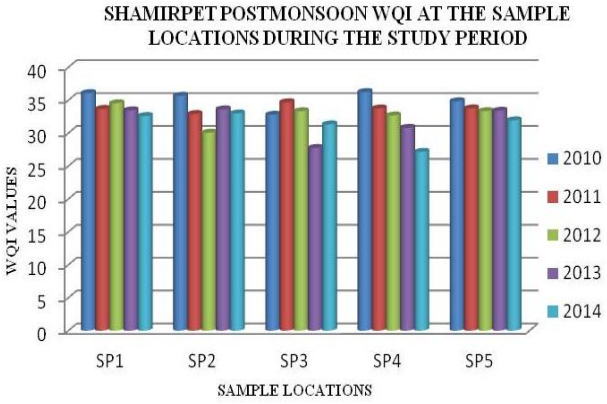


Fig. 5 Illustrate the Water Quality Index values at the sampling locations during Post-monsoon period

Based on the exhibited lake water quality it is essential to address the problem of pollution load into the lake for restoration.

CTSI Results: The Carlson's Trophic State Index (CTSI) for all the four lakes under investigation during the five year study period is tabulated below. The lake exhibit Eutrophic to hyper Eutrophic trophic status. The increase in the TSI value indicate the increasing productivity of the lake waters thereby attributing to the escalating algal growth and deteriorating state of existence. The biological productivity referred by the TSI shows the nutritional load on the lake waters. This is measured by estimating the parameters Chlorophyll-a, Total Phosphorus and Secchi depth of the water. The average of these three parameters TSI values result in the Carlson's trophic state index. The index ranges from 0 to 100 and range from oligotrophic to hypereutrophic state accordingly. Oligotrophic being the clear waters with dissolved oxygen content in the Hypolimnion throughout the year and Hypereutrophic is waters with algal scum, very few macrophytes are left and the fish are killed in summer due to anoxia.

Thus the values help to classify the water bodies useful in monitoring programs, predicting algal biomass, nutrient load, etc., presenting the perception of the quality by the trophic spectrum.

Fig: 6 and Fig:7 shows the CTSI values at the sampling points of each season in Shamirpet lake. It is found that the values ranges between 70 and above 80 which signify the eutrophic/hypereutrophic nature of the lake. The overall index values exemplify that the lake is converting from eutrophic to hypereutrophic condition which is alarming and demand immediate attention to decrease the productivity of the lake by abatement measures.

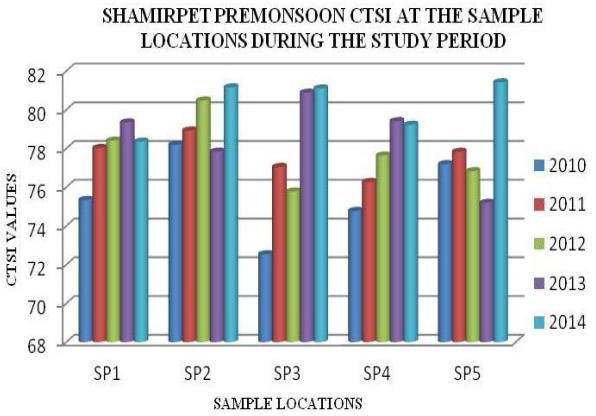


Fig. 6 Illustrate the CTSI values at the sampling locations during Premonsoon period

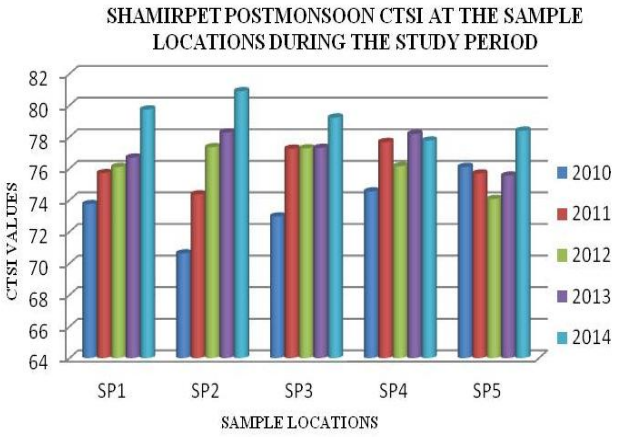


Fig. 7 Illustrate the CTSI values at the sampling locations during Post-monsoon period

Spatial distribution maps for all the TSI parameters, for both the seasons for all the five years were prepared using ArcGIS10 version. In Fig:8 shows only 2010 results of the parameters in both the seasons.

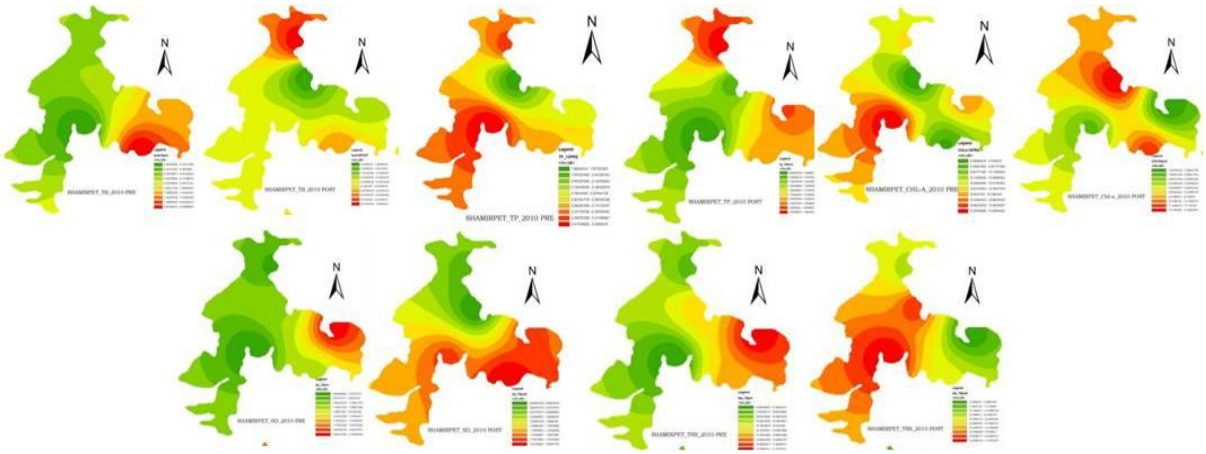


Fig. 8 Turbidity, TP, Chlorophyll-a, Secchi Depth and TSS Concentration in Shamirpet lake during pre and post monsoon seasons respectively during the study period 2010

The trophic state of the lake is majorly Eutrophic leading to hyper-Eutrophic state in the lakes notifying threat of deterioration. Even the NSF water quality index show the bad quality of the lake waters and their declining numbers.

CONCLUSION

The results indicate that the parameters were beyond the permissible limits in lakes, which indicate the pollution from the point and non-point sources mainly from the nearby densely residential and industrial out puts. There is no mechanism of regulation on regular basis or stringent actions on the violation of the norms of waste water disposal and other waste dumps into the lake waters. Both the WQI and CTSI indices results show the fading water quality of the lake Shamirpet. It is therefore suggested that every inlet should be provided with STPs along with the primary treatment for grit and other solid waste removal. The boundaries of the lakes need to be re-established in view of their shrinkage due to encroachments and restored for recreation and preservation of the lake ecosystem. Restoring the surface water quality will have a great impact on the ground water quality. The lake reclamation should be taken up as part of the conservative measures of the lake environment. The point ad non point sources need to be addressed with proper policies and strict prohibition of pollution into the lake waters.

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