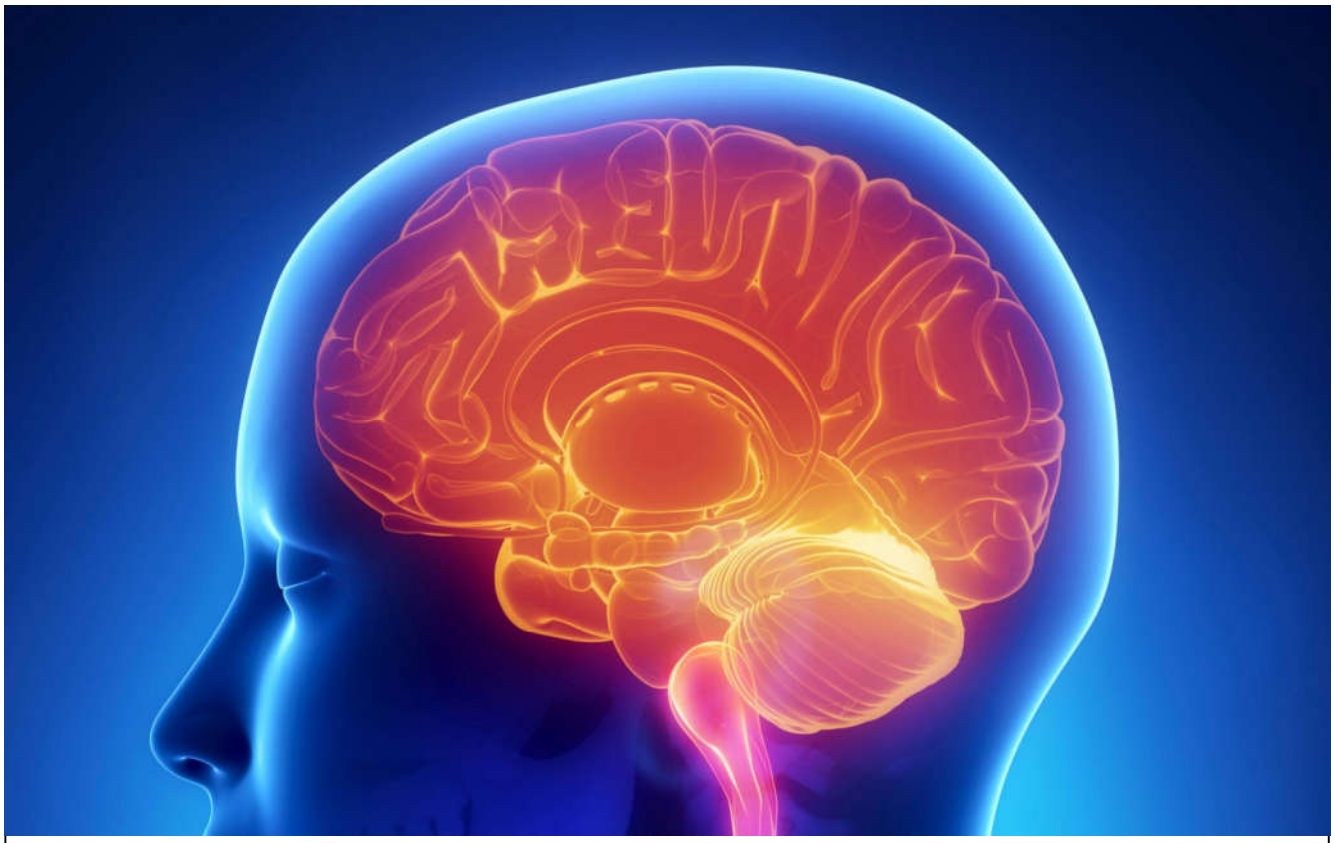

International Journal Of

Recent Scientific Research

ISSN: 0976-3031

Volume: 6(11) November -2015

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THE OFFICIAL PUBLICATION OF
INTERNATIONAL JOURNAL OF RECENT SCIENTIFIC RESEARCH (IJRSR)
http://www.recentscientific.com/ recentscientific@gmail.com

ISSN: 0976-3031

Available Online at http://www.recentscientific.com

International Journal of Recent Scientific Research
Vol. 6, Issue, 11, pp. 7536-7540, November, 2015

International Journal of Recent Scientific Research

RESEARCH ARTICLE

ASSESSMENT OF WATER QUALITY IN SAROORNAGAR LAKE, HYDERABAD

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ARTICLE INFO

Article History:
Received 05th August, 2015
Received in revised form 08th September, 2015
Accepted 10th October, 2015
Published online 28st November, 2015

Key words:
Water Quality Index, Physico- chemical parameters, Eutrophication, Drinking Water Quality Standards

ABSTRACT

The present investigation was undertaken to assess the Water Quality Index (WQI) of Saroornagar lake, Hyderabad. This 400 year old lake was to provide water for irrigation of farm lands and domestic water purposes. With rapid urbanization in the catchment as well as command areas of the lake and population explosion the lake is heavily polluted recent years, it is essential to assess the quality of water. Samples were collected from four sampling stations for a period of two years and comprehensive physico-chemical analysis was carried out to determine pH, alkalinity, chlorides, DO, BOD, total hardness, calcium, magnesium, nitrates, sulphates and total dissolved solids for evaluating Water Quality Index. The lake quality was calculated from the WQI. The water quality index levels of the lake and all the four stations were manifold higher, indicating water is highly polluted and unsuitable for drinking, domestic and recreational purpose.

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INTRODUCTION

For any country fresh water lakes are vital resources. They regulate the urban climate (Benjamin, 1996) and also have a prominent effect on ground water quality and ground water table (Ravikumar, 2013). Water bodies like lakes, ponds, rivers and streams are polluted to a lesser extent by natural sources but are highly polluted by anthropogenic sources such as urbanization, industrialization, various human developmental activities and improper management of water resources. This has led to severe water quality impairment. Enormous consumption of world's water reserves is the result of huge increase in population (Ho, 2003). Population growth, urban run offs, sewage discharge and improper agricultural practices can disturb or disrupt aquatic ecosystems leading to eutrophication of inland water bodies (Suresh, 2015)causing the deterioration of water quality, which in turn interferes with most of its beneficial uses (Ahangar, 2012).

Water Quality Index (WQI) is a rating system which reflects the complex influence of different water quality parameters (Sahu 2008). It is one of the most constructive and potent tool (Tiwari 1985, Singh 1992, Naik 2001, Mishra 2001,Yogendra 2008 and Ravi kumar 2013)through which the water quality information can be communicated to concerned authorities, public and policy makers. Saroornagar lake is also an urban lake which is under stress. Hence it is important to evaluate its Water Quality Index to assess quality of lake water which calls for immediate setting up of well designed environmental monitoring systems.

Study Area

Hyderabad is the capital of Telangana which is the southern Indian State. It occupies 625 square kilometers (241 mi^2) along the banks of the Musi River. The Metropolis Hyderabad is situated between 17° 22' 31" N latitude and 78° 28' 27" E longitudes at an average elevation of 542 meters (1,778 ft) above the mean sea level. Saroornagar lake is one of the bigger lakes of Hyderabad, and is situated to the east of the city. Saroornagar lake is believed to have been built in 1626 during the reign of Quli Qutubshah to provide water for irrigation of farm lands and domestic water purposes. This 400 year old lake is one of the major water-bodies of Hyderabad. It lies in the coordinates of 17.35584°N latitude and 78.52714°E longitudes and it has the maximum depth of 6.1 meters (20 ft).

Saroornagar lake originally occupied about 180 acres of land. However with the onset of modern life leading to land encroachment, urbanization and the subsequent pumping of sewage and waste into the lake, the submergence area has been reduced to 99 acres and to 63 acres. Recent years though, there have been efforts to beautify the lake and its surroundings. Dredging efforts started in 2000 and Hyderabad Urban Development Authority (HUDA) restored the lake in 2003. Improper functioning of filtration unit of sewage treatment plant in the later years, lake is heavily polluted by domestic and sewage waste leading to deterioration of lake water quality.

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MATERIALS AND METHODS

The water samples were collected monthly intervals for a period of two years (September 2013 to August 2015) at four sampling stations in the lake. Station I is situated near Priyadarshini park, station II is near Pochamma temple, Station III is situated near Singareni colony and station IV is near Green park colony. The samples were analysed for eleven physico-chemical parameters as per the standard procedures of APHA (1995). pH, alkalinity, chlorides, dissolved oxygen, biological oxygen demand, total hardness, calcium, magnesium, total dissolved solids and sulphates were the parameters considered for the calculation of Water Quality Index.

Based on their relative importance in the overall quality of water for drinking purposes and considerable effects on primary health each of the chemical parameters was assigned a weight (*wi*) (Table 1).

Table 1 The weight and relative weight of each of the physico-chemical parameters used for WQI determination

S.No	Parameters	BSI Desirable limit	Weight (*wi)*	Relative Weight *(Wi)*
1.	pH	8.5	3	0.083
2.	Alkalinity	200	2	0.055
3.	Chlorides	250	3	0.083
4.	DO	6	5	0.138
5.	BOD	3	3	0.083
6.	Total Hardness	300	3	0.083
7.	Calcium	75	2	0.055
8.	Magnesium	30	2	0.055
9.	Nitrate	45	5	0.138
10	Sulphate	200	3	0.083
11.	Total Dissolved Solids	1000	5	0.138

5 was the maximum weight assigned to the parameters which are important in maintaining water quality and have prominent effect on water quality. The parameters which exhibit considerably low harmful effects were assigned a weight of 2. Computing the relative weight (*Wi*) of each parameter Eq. 1. Table 1. present the weight (*wi*) and calculated relative weight (*Wi*) values for each parameter. The concentration of each parameter was divided by its respective standard according to the guidelines laid down by BSI (1998) for computing a quality rating scale (*qi*).This result was multiplied by 100 using Eq. 2. For WQI computation, the water quality sub-index *(SIi)* for each chemical parameter is first determined, which is then used to determine the WQI as per the Eqs. 3 and 4.

$$W\,i = w_i / \sum_{n=1}^{n} Wi \qquad (1)$$

Where *Wi* is the relative weight, *wi* is the weight of each parameter and n is the number of parameters.

$$q_i = (Ci|Si)\,100 \qquad (2)$$

Where *qi* = quality rating, *Ci* = concentration of each chemical parameter in each water sample in mg/L, Si = Indian drinking water standard (BIS 1998) for each chemical parameter in mg/L except for conductivity (lS/cm) and pH.

$$SI = Wiqi \qquad (3)$$

$$WQI = \sum_{i=1}^{n} SI_i \text{Type equation here.} \qquad (4)$$

Where SI_i is the sub-index of ith parameter; *qi* is the rating based on concentration of i^{th} parameter and *n* is the number of parameters.

RESULTS

Table 2 Ranges and average values of Physico-chemical parameters all values are expressed in mg/L except p^H and Temp (^{o} C)

S.No	Parameters	Station-I			Station-II			Station-III			Station-IV		
		Average	Range		Average	Range		Average	Range		Average	Range	
			Min	Max		Min	Max		Min	Max		Min	Max
1.	pH	8.37	7.46	9.27	8.37	7.36	9.31	8.37	7.48	9.35	8.36	7.32	9.38
2.	Alkalinity	761.2	545.0	922.7	757.5	574.1	890.3	815.6	577.1	935.8	777.1	636.1	883.8
3.	Chlorides	781.1	674.5	850.0	759.5	597.6	887.0	756.3	639.0	850.9	759.8	674.5	887.0
4.	DO	0.6	0.2	2.4	0.5	0.2	2.4	0.5	0.2	2.6	0.3	0.2	2.4
5.	BOD	238.7	140.0	300.0	192.0	30.0	300.0	218.3	300.0	120.0	226.6	90.0	300.0
6.	Total Hardness	648.0	552.0	832.0	602.4	500.0	750..0	605.5	520.0	830.0	615.8	520.0	810.0
7.	Calcium	145.2	100.0	192.0	154.3	31.8	288.0	136.9	52.6	192.0	133.6	34.4	192.0
8.	Magnesium	51.7	17.0	94.8	53.2	14.1	102.1	57.8	29.2	99.8	60.8	29.2	126
9.	Nitrates	16.5	14.6	19.3	19.8	18.0	22.7	19.6	17.8	22.5	17.4	15.6	20.3
10.	TDS	2615	2582	2648	2521	2491	2638	2556	2531	2584	2606	2584	2638
11.	Sulphates	247.7	238.0	260.0	257.7	248.0	270.0	255.7	246.0	268.0	252.9	243.0	265.0

Table 3 Calculation of Water Quality Index at Station I

S.NO	Parameters	Concentration of each parameter(Ci)	BSI Desirable limit (Si)	Weight *(wi)*	Relative Weight *(Wi)*	Qi	*SI (Wiqi)*
1.	pH	8.37	8.5	3	0.083	98.47	8.20
2.	Alkalinity	761.2	200	2	0.055	380.6	21.14
3.	Chlorides	781.1	250	3	0.083	312.44	26.03
4.	DO	0.6	6	5	0.138	10	1.38
5.	BOD	238.7	3	3	0.083	7956.66	663.05
6.	Total Hardness	648	300	3	0.083	216	18
7.	Calcium	145.2	75	2	0.055	193.6	10.75
8.	Magnesium	51.7	30	2	0.055	172.33	9.57
9.	Nitrate	16.5	45	5	0.138	36.66	5.09
10.	Sulphate	247.7	200	3	0.083	123.85	10.32
11.	Total Dissolved Solids	2615.04	1000	5	0.138	261.50	36.32
				$\sum wi$ =36	$\sum Wi$ =1		$\sum$SI = 809.89

Water Quality Index=$WQI = \sum_{i=1}^{n} SIi$ = 809.89

Table 4 Calculation of Water Quality Index at Station II

S.NO	Parameters	Concentration of each parameter(Ci)	BSI Desirable limit (Si)	Weight *(wi)*	Relative Weight *(Wi)*	*Qi*	*SI (Wiqi)*
1.	pH	8.37	8.5	3	0.083	98.47	8.20
2.	Alkalinity	757.5	200	2	0.055	378.75	21.04
3.	Chlorides	759.5	250	3	0.083	303.8	25.31
4.	DO	0.5	6	5	0.138	8.33	1.15
5.	BOD	192	3	3	0.083	6400	533.33
6.	Total Hardness	602.4	300	3	0.083	200.8	16.73
7.	Calcium	154.3	75	2	0.055	205.73	11.42
8.	Magnesium	53.2	30	2	0.055	177.33	9.85
9.	Nitrate	19.85	45	5	0.138	44.11	6.12
10.	Sulphate	257.7	200	3	0.083	128.85	10.73
11.	Total Dissolved Solids	2521	1000	5	0.138	252.1	35.01
				$\sum wi = 36$	$\sum Wi = 1$		$\sum SI = 678.94$

Water Quality Index=$WQI = \sum_{i=1}^{n} SIi = 678.94$

Table 5 Calculation of Water Quality Index at Station III

S.NO	Parameters	Concentration of each parameter(Ci)	BSI Desirable limit (Si)	Weight *(wi)*	Relative Weight *(Wi)*	*Qi*	*SI (Wiqi)*
1.	pH	8.37	8.5	3	0.083	98.47	8.20
2.	Alkalinity	815.6	200	2	0.055	407.8	22.65
3.	Chlorides	756.3	250	3	0.083	302.52	25.21
4.	DO	0.5	6	5	0.138	8.33	1.15
5.	BOD	218.3	3	3	0.083	7276.66	606.38
6.	Total Hardness	605.9	300	3	0.083	201.96	16.83
7.	Calcium	136.9	75	2	0.055	182.53	10.14
8.	Magnesium	57.8	30	2	0.055	192.66	10.70
9.	Nitrate	19.6	45	5	0.138	43.55	6.04
10.	Sulphate	255.7	200	3	0.083	127.85	10.65
11.	Total Dissolved Solids	2556	1000	5	0.138	255.6	35.5
				$\sum wi = 36$	$\sum Wi = 1$		$\sum SI = 753.49$

Water Quality Index=$WQI = \sum_{i=1}^{n} SIi = 753.49$

Table 6 Calculation of Water Quality Index at Station IV

S.NO	Parameters	Concentration of each parameter(Ci)	BSI Desirable limit (Si)	Weight *(wi)*	Relative Weight *(Wi)*	*Qi*	*SI (Wiqi)*
1.	pH	8.36	8.5	3	0.083	98.35	8.19
2.	Alkalinity	777.1	200	2	0.055	388.55	21.58
3.	Chlorides	759.8	250	3	0.083	303.92	25.32
4.	DO	0.3	6	5	0.138	5	0.69
5.	BOD	226.6	3	3	0.083	7553.33	629.44
6.	Total Hardness	615.8	300	3	0.083	205.26	17.10
7.	Calcium	133.6	75	2	0.055	178.13	9.89
8.	Magnesium	60.8	30	2	0.055	202.66	11.25
9.	Nitrate	17.4	45	5	0.138	38.66	5.37
10.	Sulphate	252.9	200	3	0.083	126.45	10.53
11.	Total Dissolved Solids	2606	1000	5	0.138	260.6	36.19
				$\sum wi = 36$	$\sum Wi = 1$		$\sum SI = 775.61$

Water Quality Index=$WQI = \sum_{i=1}^{n} SIi = 775.61$

Table 7 Average Water Quality Index of the lake

Sample station	WQI
Station I	809.8
Station II	678.9
Station III	753.4
Station IV	775.6
Average WQI of the lake =Sum of WQI/No.of stations =754.4	

Table 8 Water Quality Index and status of water quality (Chattterji and Raziuddin 2002)

Water Quality Index	Water quality status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking

DISCUSSION

The samples were collected and analysed from the four sampling stations within the Saroornagar Lake on monthly intervals for a period of two years from September 2013 to August 2015. The average, maximum and minimum analytic results of each parameter during the period of investigation are summarized Table 3. Station wise Water Quality Index calculations are depicted in the Table 3, 4, 5 and 6. The result of the present investigation exhibited the Water Quality Index values 809.8, 678.9, 753.4 and 775.6 at station I, II, III and IV respectively. From these results the average water quality index

of the lake was found to be 754.4 (Tb 7).

The water quality ratings clearly indicates that the lake is highly polluted and unsuitable for drinking purposes (Table 8).This quality rating study indicates eutrophic condition of the lake with severe pollution load and not suggestible for human utilization. This was supported by the evaluation results of physico-chemical parameters observed during the investigation period.

pH is an important parameter by which survival and nourishment of biological life is influenced (Airsang 2013). The pH of the lake is 8.37. The observed minimum and maximum values of total alkalinity are 757.5 mg/L at station II and 815.6 mg/L at station III respectively (Table 2), representing alkaline nature of the lake. This was in accordance to Cynthia (2014), who reported the alkaline nature of Saroornagar lake waters from past three decades. Amin Hossaini (2013), Altaf H. Ganai (2014) and John Mohammad (2015) reported alkaline nature of ponds and lakes in India.

Chlorides play a very important role to determine the quality of water. The concentration of chlorides were very high and recorded The average values were 781.1 mg/L at station I, 759.5 mg/L at station II, 756.3 mg/L at station III and 759.8 mg/L at station IV respectively. Similarly the highest chloride concentration has also been observed by Das (2002) and Shiddamallayya (2008). Higher concentration of chlorides associated with higher degree of pollution (Ravish verma 2012, Ameetha Sinha 2014 and John Mohammad 2015).

DO is the most important parameter to assess water quality. The DO values in the lake were too low. The minimum and maximum DO values observed were 0.3 mg/L at station IV and 0.6 mg/L at station I. According to drinking water standards of WHO, BOD should be lower than 6 mg/L (De, 2003). Very high values of BOD were recorded at all stations.238.7 mg/L,192 mg/L,218.3 mg/L,226.6 mg/L were BOD values recorded at station I,II,III and IV respectively. Higher BOD values indicate organic contamination (Siraj, 2010) and high nutrient loading or respiration, decomposition and mineralization of organic matter losses the oxygen to atmosphere (Suresh, 2015). Minimum DO and maximum BOD values were noted Station IV.

The total hardness of the lake was very high compared to their permissible limit of BSI (1998). Station I represented the maximum value of 648 mg/L , 602.4 mg/L at station II ,605.9 mg/L at station III and 615.8 mg/L at station IV. The lake water was very hard WHO (2004) standards. Very high hardness may be due to sewage contamination or addition of detergents. At station I, II, III and IV recorded concentrations of Calcium were 145.2 mg/L, 154.3 mg/L, 136.9 mg/L, and 133.6 mg/L, concentrations of magnesium were 51.7 mg/L, 53.2 mg/L, 57.8 mg/L, and 60.8 mg/L respectively. These values were also much higher.

Nitrate concentration in surface water is normally low but as a result of agricultural runoff or contamination with human or animal wastes can reach high levels (Nas and Berktay 2006). High levels of nitrates trigger eutrophication and indicate organic pollution (Dinesh K. Uchchariya 2012 and Ravish Verma 2012).16.5 mg/L ,19.8 mg/L,19.6 mg/L and 17.4 mg/L were the nitrate values recorded from station I to IV respectively.

In the present investigation the sulphates were recorded in high concentration and ranged between 238.0 to 270.0 mg/L. Major Sources of sulphur in fresh water are in the form of sewage and fertilizers (Langmuir 1971, Sudha Rani 2004 and Amin hossaini 2013). High sulphate values makes the water unfit for domestic utilities (Ameetha Sinha 2014).

Total dissolved solids may be organic or inorganic but precisely, the dissolved solids are composed mainly of carbonates, bicarbonates, chloride, sulphate, calcium, magnesium, phosphate, nitrate, sodium, potassium and iron (Trivedy 1986, Esmaeili 2005 and Suresh 2015). The average concentration of total dissolved solids recorded was 2615.04 mg/L at station I, 2521 mg/L at station II ,2556 mg/L at station III and 2606 mg/L at station IV.TDS values of Saroornagar lake were higher than BSI permissible limit of 2000 mg/L.

The present analysis reveals the physico-chemical parameters, alkalinity, chlorides, BOD, total hardness, calcium, magnesium, sulphates and total dissolved solids are in high concentration at all the stations and DO is lower than BSI (1998) permissible limits (Tab 3,4,5 and 6). Station I represented maximum Water Quality Index. At this station chlorides, BOD, total hardness and total dissolved solids were the parameters which are higher in concentrations than any other station under investigation.

Very high average Water Quality Index of lake clearly indicates that the lake water quality is severely deteriorated and exhibiting eutrophic condition. Hence, it is unsuitable for drinking, domestic and recreational Purposes.

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How to cite this article:

Padma Priya K T *et al.,* Assessment of Water Quality In Saroornagar Lake, Hyderabad. *International Journal of Recent Scientific Research Vol. 6, Issue, 11, pp. 7536-7540, November, 2015*

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ISSN 0976-3031