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Water Quality Studies of Saralasagar Reservoir with Reference to Physico–Chemical Parameters

B. Sreenivas Reddy* and K. Satya Parameshwar

Department of Zoology, Sarojini Naidu Vanitha Mahavidyalaya, Nampally, Hyderabad - 500001, Telangana, India; sreenivasreddy.buddula@yahoo.com, satyaparameshwark@gmail.com

Abstract

Objectives: Present study aims at the assessment of various organoleptic, physical and chemical parameters of Saralasagar reservoir water to check its status pertaining to the water quality and to measure the correlation among these parameters so that to generate the record of data of its water quality and suggest mitigating measures for its conservation. **Methods/ Statistical Analysis:** Sampling was carried out from two sampling sites. The samples were analysed in the laboratory as per the standard protocols. The original Winkler's iodometric method for dissolved oxygen was modified by adding sodium azide in order to avoid the interference due to organic matter and chlorides present in the sample. The annual mean values of each parameter from the two sampling sites were compared with W.H.O. and I.S. permissible limits by using one-sample t-test [2-tailed] and Pearson's correlation coefficient [r] at 0.05 and 0.01 significance levels. **Findings**: The physico-chemical parameters showed very few fluctuations and most of them were within the permissible limits of standards indicating better quality of reservoir water. The lake water was oligotrophic. However, certain parameters like pH and BOD were significant in limnological point of view. The higher pH values suggest that carbonate and bicarbonate equilibrium is affected. The high BOD values indicate the presence of plenty of organic matter, microbial richness and non-biodegradable oxygen demanding pollutants in the lake water which may lead to eutrophication. There was a strong negative correlation between pH and E.C., DO and BOD and was a positive correlation between EC and TDS, TH and chloride, water temperature and BOD, Ca – TH and Mg. Most of the parameters were minimum in monsoon and maximum in pre-monsoon periods. **Applications**: These results conclude the suitability of Saralasagar water for various human needs. However, regular monitoring for its water quality maintenance is need of the hour to prevent its further deterioration.

Keywords: Mahabubnagar, Oligotrophic Lake, Physicochemical Parameters, Saralasagar Reservoir, Telangana, Water Quality Studies

1. Introduction

Environment and development are the two sides of a coin. Developmental activities caused irreparable changes in many of the water bodies through pollution. Since the last century, mining activities affected both the ground and surface water systems[1].The hydrosphere is further classified as marine, brackish and fresh water bodies. Over 97% of the water on this earth is stored in oceans which cannot be used for our diverse needs. Just about 3% of the total water is involved in the global water cycle and most of it is locked up as polar ice caps and glaciers. Hence, our regu-

**Author for correspondence*

lar supply of water must be fresh water from rivers, lakes, reservoirs, ponds and underground aquifers. Water is an essential ecological factor of life which performs unique and indispensible activities in each ecosystem, biosphere and biogeochemical cycle[2]. The fresh water aquatic ecosystem is fortunate to be endowed with a wide range of natural ecosystems but the unfortunate thing is, it is documented poorly compared to that of marine habitats[3]. The knowledge of functional dynamics of the fresh water bodies is meagre[4]. Numerous workers have tried to examine the changes in some physical and chemical factors but knowledge about the month-wise, seasonal, vertical and diurnal fluctuations of these factors is very little. In order to recognise and predict the hazardous effects of these physico-chemical factors on aquatic biota and man, the scientific monitoring of physical, chemical and biological components of water is essential. For this purpose, the quantitative characterization of water is the pre requisite. It gives us an idea about the seriousness of the pollution problem in water. This would also help for focussing on the extent to which pollution control is required and generate real concern among policy planners. Literature is available on different aspects of pollution and environmental engineering but, literature with regard to the quantification of pollutants and on characterization of water is very rare. Many studies have been made on physico-chemical parameters of various freshwater bodies during the last few decades. In most of the studies, abiotic components were given priority but some of them were also focussed on biotic components[5]. In most of the studies the lakes were oligotrophic and showed very few fluctuations in their physico-chemical parameters[6-10]. However, in some instances the lakes were eutrophic[11,12]. High level of some parameters like total dissolved solids 9942 mg/L[13], total hardness 295 mg/L in Ganga river[14], turbidity 288 NTU in Ruti dam[15] were recorded. The organic and inorganic pollutant load in Dal lake has accelerated the macrophytic growth which in turn reduced the water quality and raised the biological oxygen demand of the lake and hence has reduced the recreational and aesthetic appeal of the lake[16]. The aquatic ecosystems are severely affected by the continuous release of various wastes[17]. Some researchers also reported the low levels of some parameters like dissolved oxygen 2.3 mg/L[18]. Reservoirs were considered the single largest inland fishery resources in India in terms of potential area of fish production and also as the reliable and sustainable drinking water and irrigation resources. Understanding the quality of water is essential since it determines the suitability of water for the use of various human activities. The study was intended to determine the trophic status of Saralasagar reservoir, to study the pollution level, if any, in the reservoir, the factors affecting reservoir water quality, to check the suitability of water for drinking, domestic, agriculture, pisciculture and industrial purposes and also to document the record of water quality data pertaining to the physico-chemical parameters. The present study was made during the period from April 2014 to March 2015 to assess the water quality of the man-made perennial reservoir, Saralasagar situated in the Mahabubnagar district of Telangana state in India. Monthly changes in physico-chemical parameters were analyzed. Present research paper deals with different parameters of water quality such as p^H, water temperature, electrical conductivity [EC], turbidity, colour, Dissolved Oxygen [DO], Biological Oxygen Demand [BOD], Total Dissolved Solids [TDS], Total Hardness [TH], Total Alkalinity [TA], Calcium [Ca^{++}], Magnesium [Mg^{++}], Sodium [Na^+], Potassium [K^+], Chlorides [Cl^-], Sulphates $[SO_4]^{2-}$, Phosphates $[PO_4]^{3-}$, Nitrates [NO_3^-], Fluoride [F] , Iron [Fe^{++}], Silica [SiO_2] and their adverse effects on aquatic biota and human being. The present study is the first effort in this direction.

2. Materials and Methods

2.1 Study Area

Present work has been conducted in Saralasagar reservoir situated in Mahabubnagar district, Telangana, India, which is endowed with wide range of littoral and limnetic habitats. Mahabubnagar is the largest district in Telangana and is situated between 16°30'-18°20'N latitudes and 77°30'-79°30'E longitudes. Climatically this district falls under the tropical region with cyclic rains and has varied habitats like rivers, streams, back waters, major, medium and minor irrigation tanks. Most of its soils are sandy, sandy loam, lateritic and red soils.

2.1.1 Saralasagar Reservoir

Saralasagar is a medium sized perennial irrigation tank

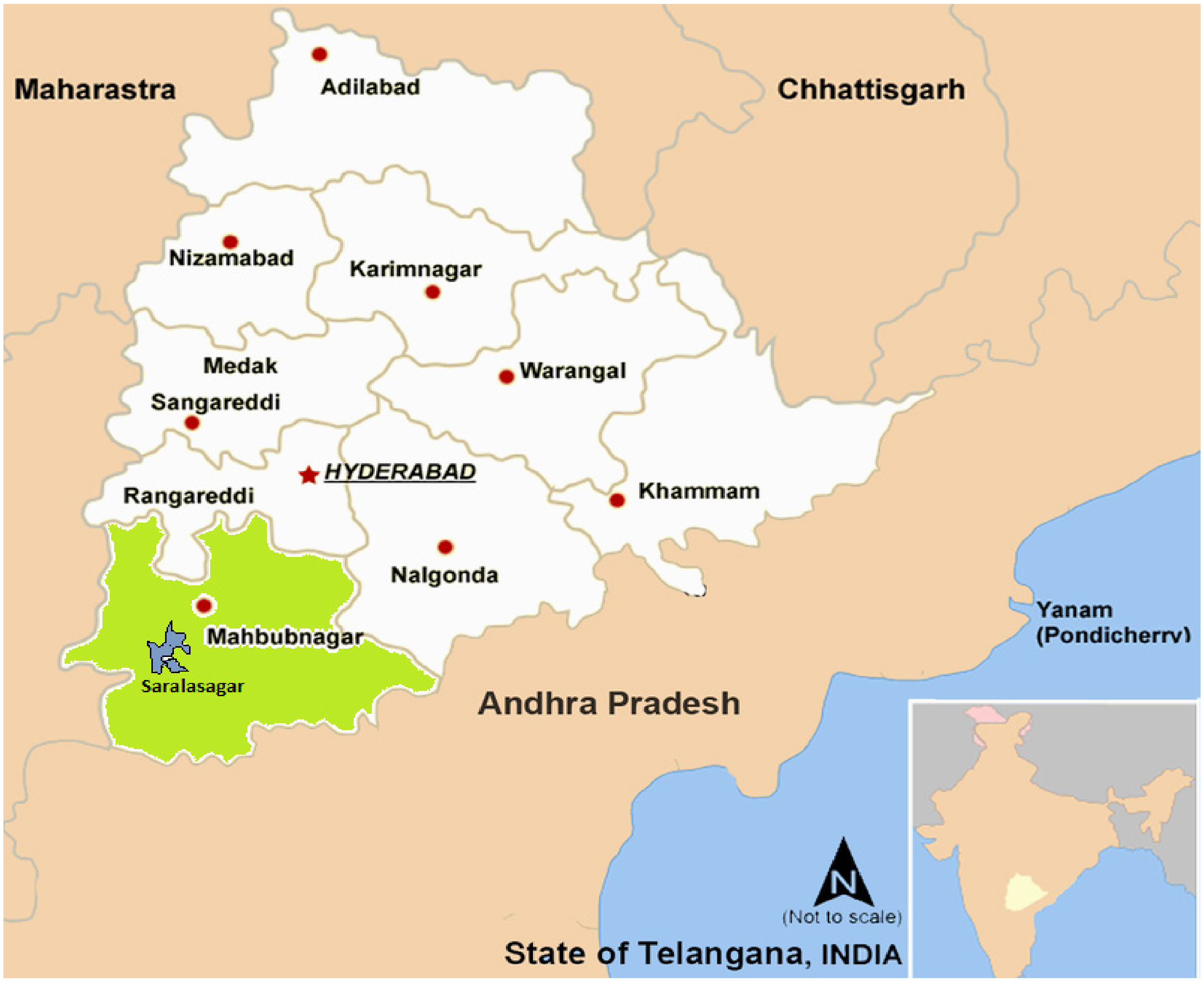


Figure 1. Location of Saralasagar reservoir in Mahabubnagar District, Telangana, India.

situated at Shankarampeta village, Kothakota mandal [Tehsil] of Mahabubnagar district, Telangana state in India. It is constructed across the Chinnavagu, a tributary of Krishna River about 48 kms away from the district headquarters and 142 kms away from the state capital Hyderabad. It is situated on 16°46' N latitude and 77°56' E longitude shown in Figure 1. The main purpose of construction of this reservoir was to uplift the economic condition of the natives and to eliminate the scarcity of food grains and water problems in the drought – prone and economically backward villages of the Kothakota mandal. Now Saralasagar reservoir has become prime importance for irrigation, supplying drinking water to Mahabubnagar town and also for aquaculture practices. About 176 fishermen families depend on this reservoir in continuing their lives. Thus, this reservoir plays a vital role in the rural economy. Saralasagar is the first siphon system dam in India as well as in Asia and second in the world.

2.2 Research Methodology

Samples were collected from two sampling sites of Sralasagar reservoir wiz, Station1 [S1] and Station 2 [S2], so that by and large the water sample may represent the totality of its water chemistry. Samples were collected from 5-8 cm depth in acid polyethylene bottles of 1L capacity. Samples were properly labelled immediately after their collection and brought to the laboratory for the physical and chemical examination. Samples were stored at 4°C prior to their assessment. The organoleptic and physico-chemical parameters of the samples were analysed in the laboratory as per the standard protocols[19-21]. The water temperature was measured by using mercury – filled Celsius thermometer of 0-50°C range and 0.2°C least count. A digital p^H meter was used to measure the p^H and the electrical conductivity was measured using a conductivity meter. Turbidometry was followed for the determination of turbidity. Total dissolved solids were calculated by drying the sample on a drying oven at

Table 1. The instruments and methods of analysis used for different water quality parameters

Parameter	Instrument used	Method used	Method Reference
p^H	p^H meter	Potentiometry	APHA (1998)
E.C.	Conductivity meter	Potentiometry	Trivedi and Goel (1986)
TDS	Drying oven	Evaporation	APHA (1998)
Turbidity	Turbidimeter	Calibration	APHA (1998)
Total Hardness	Burette	Titration(EDTA method)	Trivedi and Goel (1986)
Calcium	Burette	Titration(EDTA method)	Trivedi and Goel (1986)
Magnesium	Burette	Titration(EDTA method)	Trivedi and Goel (1986)
Total Alkalinity	Burette	Titration	APHA (1998)
Sodium	Flame Photometer	Calibration	APHA (1998)
Potassium	Flame Photometer	Calibration	APHA (1998)
Chloride	Burette	Titration (Argentometry)	APHA (1998)
Nitrate	Spectrophotometer	Brucine method	APHA (1998)
Sulphate	Turbidimeter	Calibration	APHA (1998)
Phosphate	Spectrophotometer	stannous chloride method	APHA (1998)
Fluoride	Spectrophotometer	SPADNS	APHA (1998)
Total Silica	Spectrophotometer	Molybdosilicate method	APHA (1998)
D.O	Burette	Winkler's Iodometry	APHA (1998)
BOD	Burette and Incubator	Winkler's Iodometry	APHA (1998)

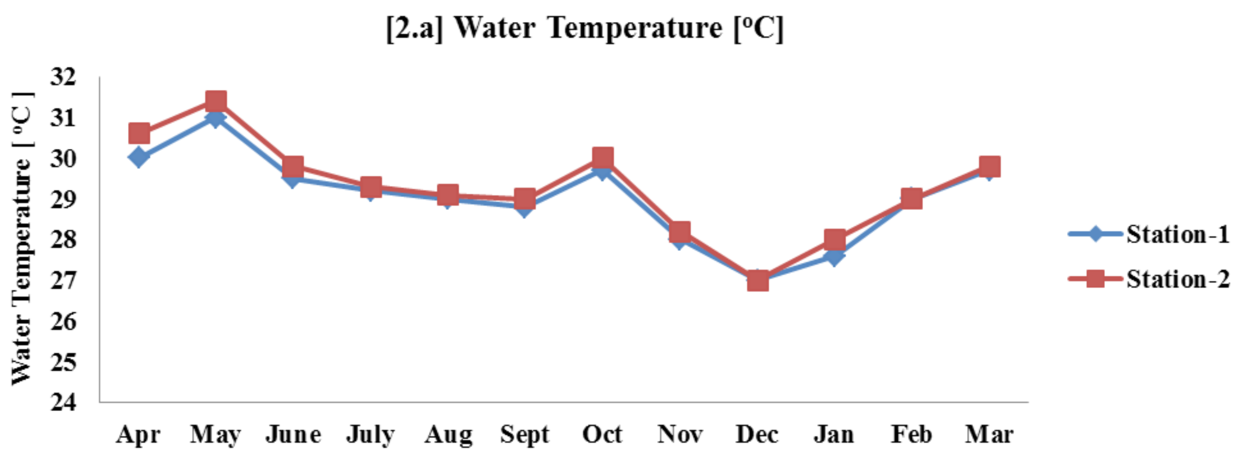
180°C. Water colour was studied by visual comparison method. The various chemical parameters of the samples collected were studied as follows. Dissolved oxygen and BOD were estimated by Winkler's iodometric method with azide modification. The carbonates and bicarbonates were determined by phenolphthalein and methyl orange methods respectively. EDTA method was followed to assess the calcium, magnesium and TH. The flame emission photometer was used to determine the sodium and potassium. Phosphate was measured by stannous chloride method and the fluoride by spectrophotometry [SPADNS] method, chloride by argentometry, nitrate by brucine method, silica by molybdosilicate method and sulphate by turbidimetric method shown in Table 1.

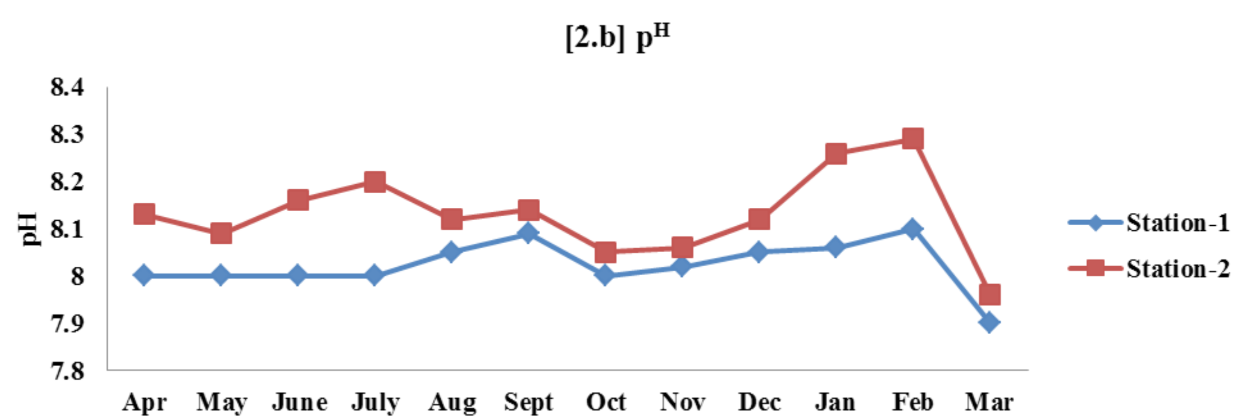
2.3 Statistical Analysis

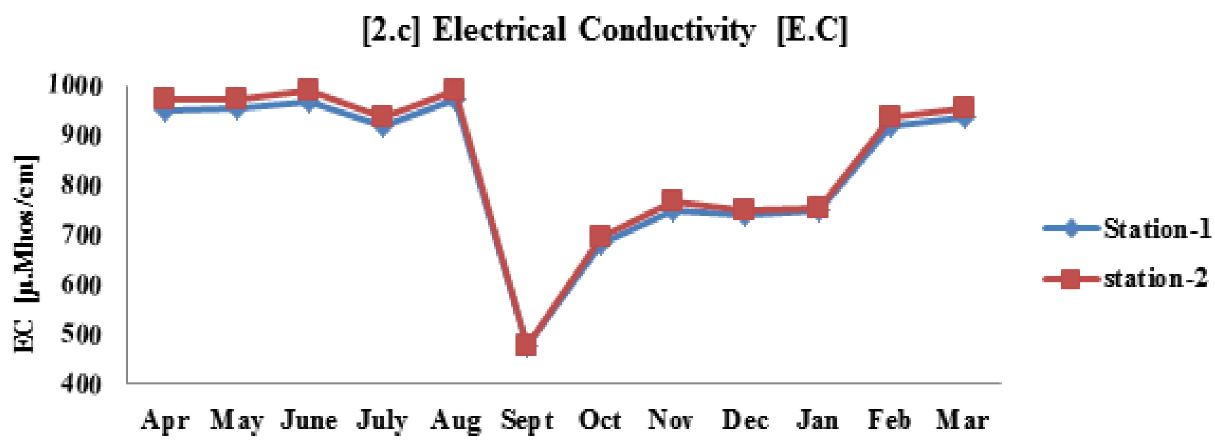
A window-based SPSS statistical package [version 20.0 IBM] was used for the statistical analyses. The annual mean values of each parameter from the two sampling sites were compared with W.H.O and IS: 10500 [2014] permissible limits by using one-sample t- test [2-tailed] and Pearson's correlation[r] at 0.05 and 0.01 significance levels.

3. Results and Discussion

Table 2 and 3 reveals the data pertaining to the organoleptic, physical and chemical parameters of Saralasagar like







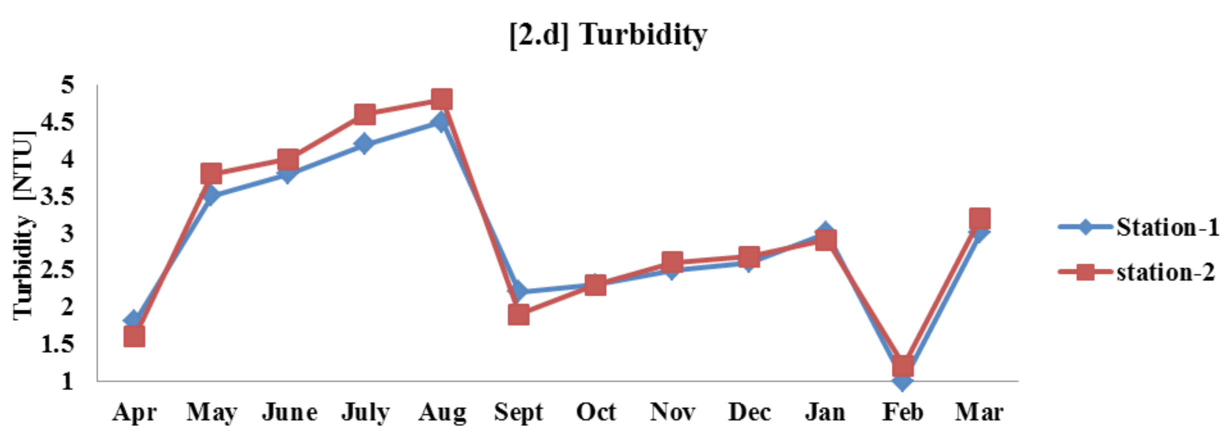
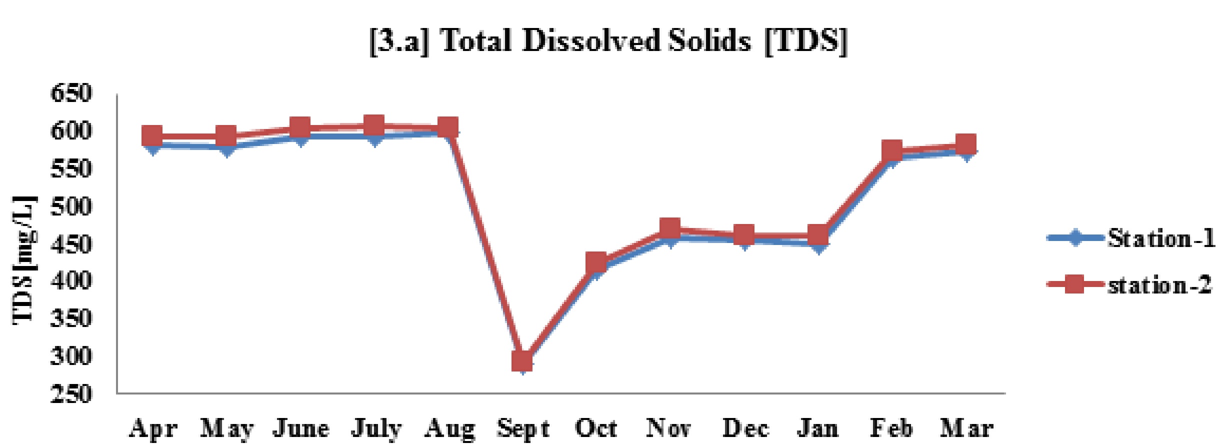


Figure 2. Monthly variations of (a) Water Temperature (b) pH (c) E. C. and (d) Turbidity at S1, S2 of Saralasagar Reservoir from April 2014 to March 2015.



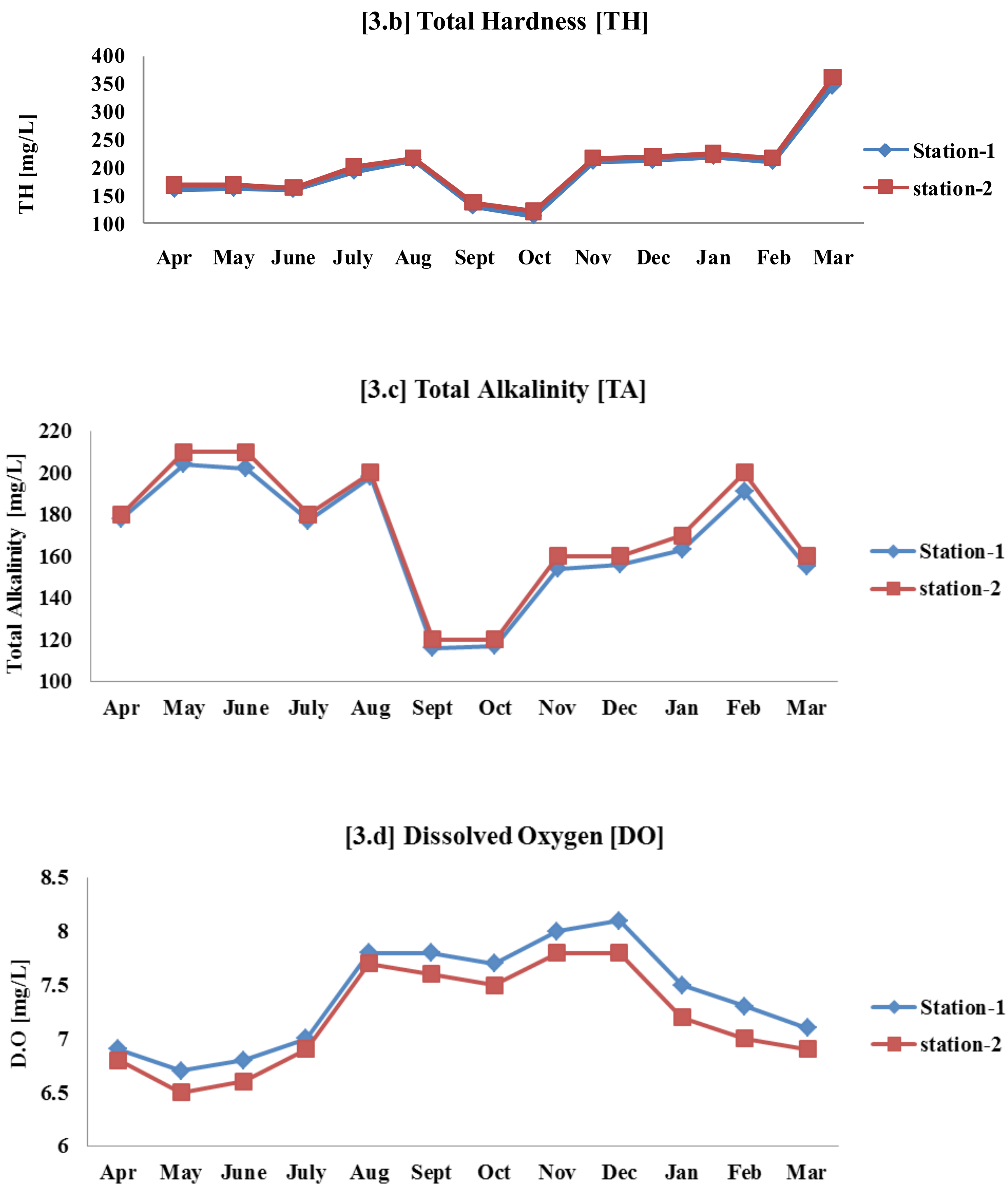
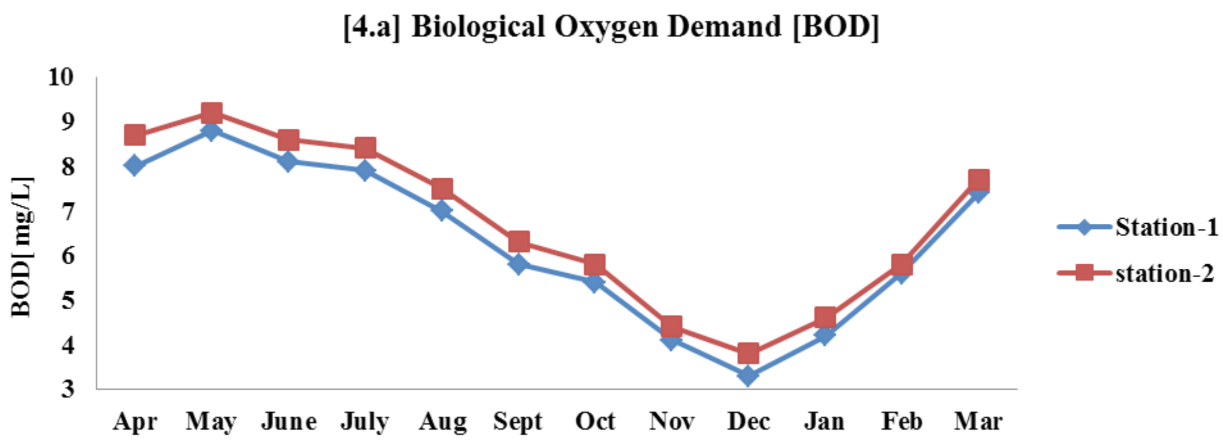
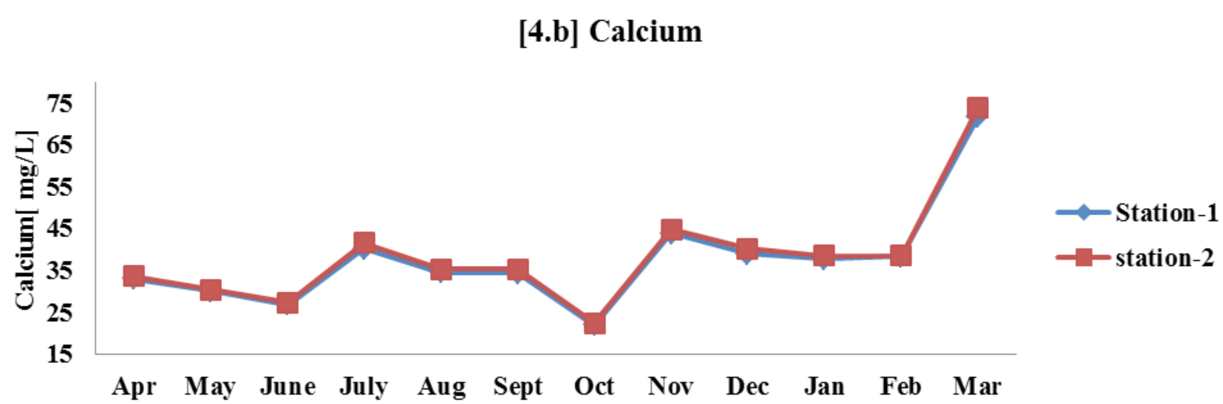
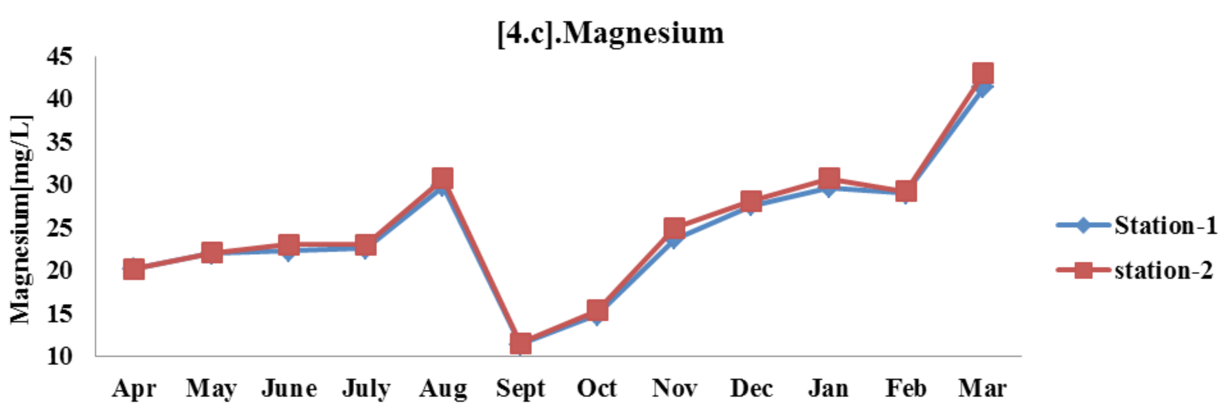


Figure 3. Monthly variations of (a) TDS (b) Total Hardness (c) Total Alkalinity and (d) Dissolved Oxygen at S1, S2 of Saralasagar Reservoir from April 2014 to March 2015.


[4.a] Biological Oxygen Demand [BOD]
BOD[mg/L]
10
9
8
7
6
5
4
3
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Station-1
station-2


[4.b] Calcium
Calcium[mg/L]
75
65
55
45
35
25
15
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec
Jan
Feb
Mar
Station-1
station-2


[4.c].Magnesium
Magnesium[mg/L]
45
40
35
30
25
20
15
10
Apr
May
June
July
Aug
Sept
Oct
Nov
Dec
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Feb
Mar
Station-1
station-2

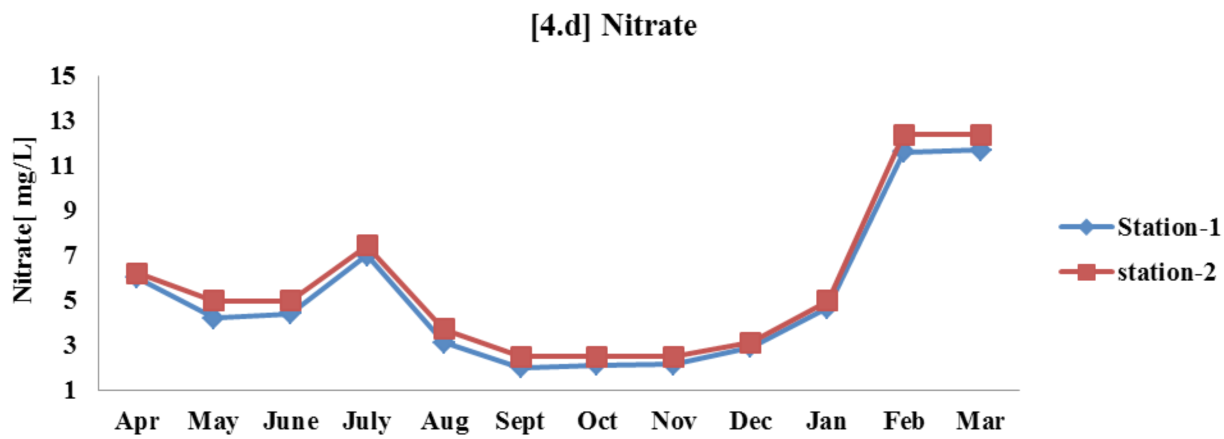
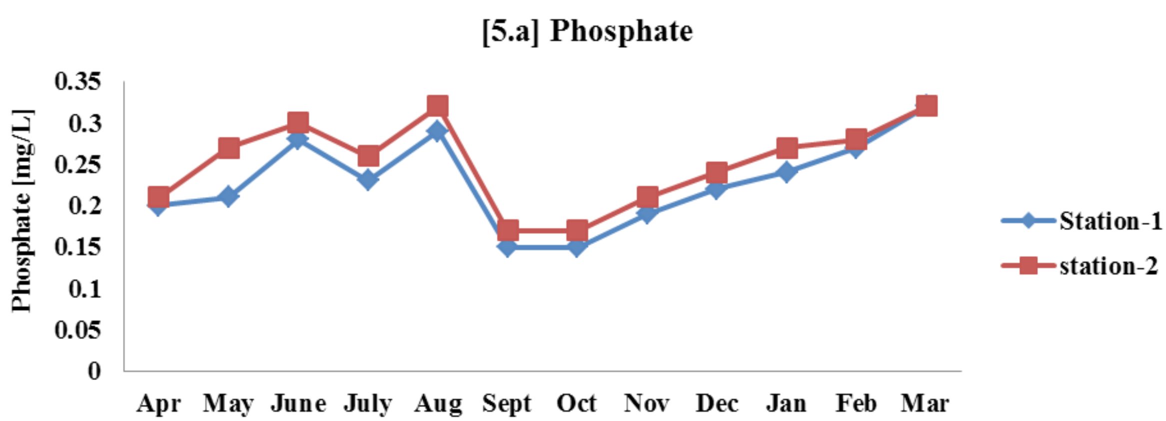
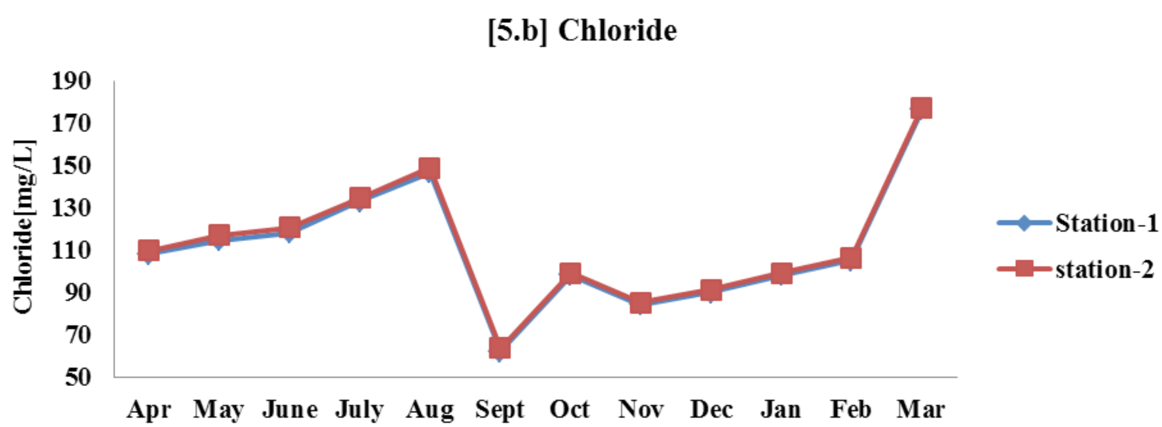
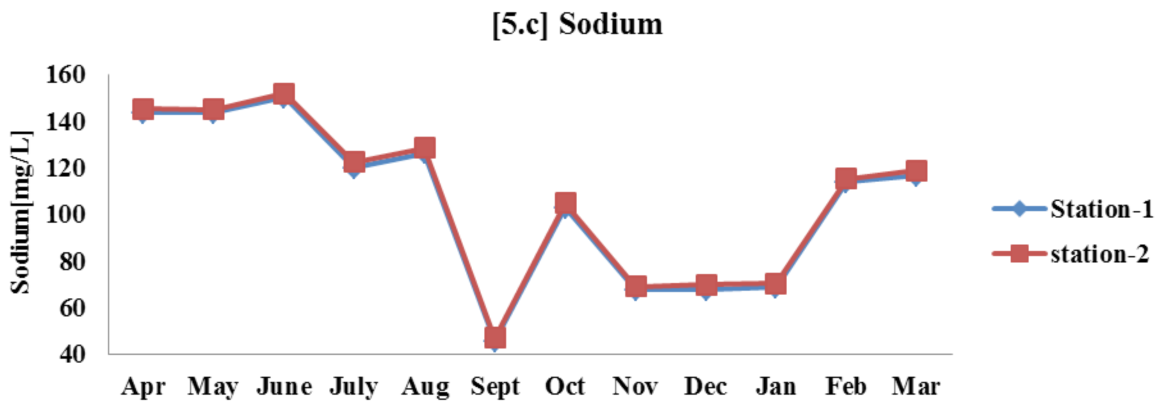


Figure 4. Monthly variations of (a) Biological Oxygen Demand (b) Calcium (c) Magnesium and (d) Nitrate at S1, S2 of Sralasagar Reservoir from April 2014 to March 2015.







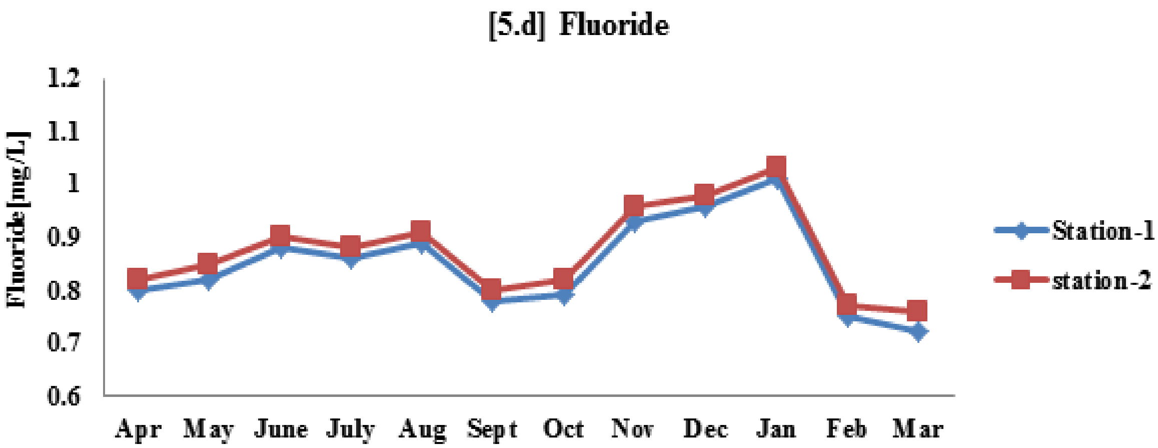


Figure 5. Monthly variations of (a) Phosphate (b) Chloride (c) Sodium and (d) Fluoride at S1 and S2 of Saralasagar from April 2014 to March 2015.

p^H, EC, water temperature, turbidity, colour, DO, BOD, TDS, TH, TA, calcium, magnesium, sodium, potassium, chloride, sulphate, nitrate, phosphate, iron, silica and fluoride of collected water samples from the S1 and S2 of Saralasagar reservoir. The monthly variations of various parameters of S1 and S2 of Saralasagar are represented graphically shown in Figure 2, 3, 4 and 5. The results obtained were compared with WHO[22] and IS standards for safe drinking water[23].

3.1 Water Temperature

The temperature in water is the most significant ecological factor which strongly affects various properties of the water body[24]. High temperature in water cause stress on aquatic biota by impairing the capacity of water to retain the vital dissolved gases like oxygen usually during the summer, which may lead to massive fish deaths. Temperature of the lake water was fluctuated between 27°C in December and 31.4°C in May shown in Figure 2(a). The annual average water temperatures were 29.04 and 29.26 for S1 and S2 respectively.

3.2 pH and E.C

p^H is used to express the chemical nature of a solution. p^H affects the aquatic biota since many of their metabolic activities are p^H sensitive[25]. Ideal p^H range for effective life

Table 2. Frequencies of various physico-chemical parameters at Saralasagar Reservoir, station-I

Parameters	N	Mean	Std. Error of Mean	Mode	Std. Deviation	Min	Max	permissible Limit WHO	permissible Limit IS:10500-2012
p^H	12	8.0225**	.01533	8.00	.05311	7.90	8.10	6.5-8.5	6.5-8.5
E.C(μ.mhos/cm)	12	835.166**	44.9480	920.00	155.70475	476.00	974.00	1500	-
Turbidity(NTU)	12	2.8667**	.29319	3.00	1.01564	1.00	4.50	5.0	5.0
Colour(Hazen)	12	BDL	-	-	-	-	-	5.0	5.0
WaterTemp(°C)	12	29.0417**	.31682	29.00	1.09748	27.00	31.00	30-32	-
TDS (mg/L)	12	512.333	28.1681	290.00	97.57732	290.00	598.00	500	500
TH (mg/L)	12	193.916	17.1112	160.00	59.27510	113.00	345.00	200	200
TA (mg/L)	12	167.583*	8.65978	116.00	29.99836	116.00	204.00	100	200
DO (mg/L)	12	7.3975	.14240	7.80	.49330	6.70	8.10	7.5	-
BOD (mg/L)	12	6.3000**	.28890	5.30	1.82009	3.30	8.80	30	30
Ca^{++} (mg/L)	12	37.6167**	3.56869	21.90	12.36232	21.90	71.80	75	75
Mg^{++}(mg/L)	12	24.5333*	2.24747	11.40	7.78546	11.40	41.30	50	30
Na^{+} (mg/L)	12	105.537	10.1268	45.60	35.08035	45.60	150.20	150	180
K+ (mg/L)	12	1.3083**	.13968	.73	.48388	.72	2.30	12	-
Cl^{-} (mg/L)	12	111.289**	8.71521	62.12	30.19039	62.12	176.36	200	250
$(SO_4)^{2-}$ (mg/L)	12	77.9017**	8.97370	25.60	31.08580	25.60	137.50	200	200
NO_3^{-} (mg/L)	12	5.1517**	.98459	2.00	3.41070	2.00	11.70	45	45
$(PO_4)^{3-}$ (mg/L)	12	.2292**	.01549	.15	.05368	.15	.32	0.5	-
F^{-} (mg/L)	12	.8492**	.02545	.72	.08816	.72	1.01	1.5	1.0
Fe^{++}(mg/L)	12	.1092**	.01323	.10	.04582	0.00	.20	0.1	0.3
SiO_2(mg/L)	12	11.5775	.65313	6.71	2.26250	6.71	14.00	-	-

* Correlation is significant at the 0.05 level. ** Correlation is significant at the 0.01 level.
BDL - Below Detectable Limits.

Table 3. Frequencies of various physico-chemical parameters. Saralasagar Reservoir, station II

Parameters	N	Mean	Std. Error of Mean	Mode	Std. Deviation	Min	Max	permissible Limit WHO	permissible Limit IS:10500
p^H	12	8.1317**	.02616	8.12	.09064	7.96	8.29	6.5-8.5	6.5-8.5
E.C(µ.mhos/cm)	12	850.0833**	46.30784	971.00	160.41506	479.00	992.00	1500	-
Turbidity(NTU)	12	2.9650**	.33300	1.20	1.15356	1.20	4.80	5.0	5.0
Colour(Hazen)	12	BDL	-	-	-	-	-	5.0	5.0
WaterTemp(°C)	12	29.2667**	.34252	29.00	1.18654	27.00	31.40	30-32	-
TDS (mg/L)	12	521.6667	28.77323	592.00	99.67341	292.00	606.00	500	500
TH (mg/L)	12	200.5000	17.64657	216.00	61.12952	120.00	360.00	200	200
TA (mg/L)	12	172.5000	8.88692	160.00	30.78518	120.00	210.00	100	200
DO (mg/L)	12	7.1917*	.13621	6.90	.47186	6.50	7.80	7.5	-
BOD (mg/L)	12	6.7392**	.27726	5.80	1.86856	3.80	9.20	30	30
Ca^{++} (mg/L)	12	38.4467**	3.69563	35.20	12.80205	22.40	73.89	75	75
Mg^{++}(mg/L)	12	25.7317	2.78157	23.04	9.63563	11.52	49.92	50	30
Na^{+} (mg/L)	12	107.3050	10.14693	46.92	35.15001	46.92	151.80	150	180
K+ (mg/L)	12	1.3617**	.13964	1.56	.48373	.78	2.34	12	-
Cl^{-} (mg/L)	12	112.7792**	8.73375	99.26	30.25459	63.81	177.30	200	250
$(SO_4)^{2-}$ (mg/L)	12	80.0267**	8.90792	27.84	30.85795	27.84	139.20	200	200
NO_3^{-} (mg/L)	12	5.6317**	1.01526	2.48	3.51695	2.48	12.39	45	45
$(PO_4)^{3-}$ (mg/L)	12	.2517**	.01512	.17	.05237	.17	.32	0.5	-
F^{-} (mg/L)	12	.8733**	.02472	.82	.08563	.76	1.03	1.5	1
Fe^{++}(mg/L)	12	.1125**	.01393	.10	.04827	0.00	.20	0.1	0.3
SiO_2(mg/L)	12	11.8075	.66546	12.33	2.30521	6.85	14.33	-	-

in water is 6.5-8.2[26]. The p^H of the lake water was between 7.96 in March and 8.29 in February shown in Figure 2(b). The annual p^H mean values observed were 8.02 and 8.13 at S1andS2 respectively shown in Table 2 and 3. The higher p^H values indicate the imbalance in carbonate and bicarbonate equilibrium[27].The Electrical Conductivity [EC] was found maximum in the month of August i.e. 974 µmhos/cm [S1], and in the month of June 992 µmhos/cm [S2] and minimum in the month of September at S1 [476 µmho/cm] and in the same month at S2 [479 µmho/cm] shown in Figure 2(c). The annual mean E.C. values were 835.16 and 850.08 for the S1 and S2 respectively.

3.3 Turbidity and Colour

Turbidity ranged from a minimum of 1 [NTU] in February to a maximum of 4.8 [NTU] in August Figure 2(d). Annual mean turbidity values were 2.86 and 2.96 for the S1 and S2 respectively. Monsoon generally causes high turbulence and mixing of water leading to an increase in the Suspended Particulate Matter [SPM]. Study on similar lines recorded turbidity range between 230-289 [NTU][28]. The water colour was in below detectable limits and was colourless to pale yellow.

3.4 Total Dissolved Solids [TDS]

TDS values were fluctuated between 290 mg/L in September and 606 mg/L in July shown in Figure 3(a). TDS values of Udaipur lake in 2001 were fluctuated between 202 and 724 mg/L which are greater than that of Saralasagar[29]. The high level of TDS in drinking water causes laxative effects.

3.5 Total Hardness [TH] and Total Alkalinity [TA]

The total hardness values fluctuated between 113 to 360 mg/L and were highest in March (during summer) and lowest in October (during winter) shown in Figure 3(b). The annual mean values of total hardness were 193.91 and 200.5 for the S1 and S2 respectively. Minimum values were recorded during monsoon. The total hardness in Harsal Dam was 83.8 to 178 mg/L[30]. A high TH value of 295 mg/L was recorded in Ganga river[31]. The total alkalinity also showed a remarkable seasonal variation. The values were high during summer and low during monsoon shown in Figure 3(c). The steep fall during monsoon may be attributed with the dilution of reservoir water by floods. The annual mean values of total alkalinity were 167.58 and 172.50 for the S1 and S2 respectively. The high total alkalinity may be ascribed to a high rate of organic decomposition which liberates CO_2 which in turn reacts with water to form HCO_3^- ions there by increasing the total alkalinity[32]. The water quality of Nizamsagar located in Telangana region was alkaline in nature[33].

3.6 D.O and B.O.D

The Dissolved Oxygen [DO] was varied from 6.5 to 8.1 mg/L shown in Figure 3(d). Its highest and lowest values were recorded in December and may months respectively. The annual mean values of DO were 7.39 and 7.19 for the S1 and S2 respectively. The DO is the most important factor in any aquatic ecosystem. DO can be used as an index of water quality, primary production and pollution. The minima and maxima of the concentration of DO in ponds are directly related with the minima and maxima of Phytoplankton present in the lake[34]. The main source of DO is dissolution from atmosphere and the photosynthesis. DO range was between 2.3 to 10.8 mg/L in palas Nilengaon reservoir in Osmanabad district[35]. DO less than 2.5 mg/L is described to be hypoxic condition[36]. Excessive DO in water may lead to “gas bubble disease” but, it is a rare occurrence[37]. DO and BOD were inversely related in Narmada River[38]. The Biological Oxygen Demand [BOD] values were varied from 3.30 to 9.20 mg/L shown in Figure 4(a). Its minimum and maximum values were recorded in December and May respectively. BOD denotes the amount of organic material in an aquatic solution which aids the microbial growth. The annual mean values of BOD were 6.30 and 6.73 for the S1 and S2 respectively.

3.7 Calcium and Magnesium

The minimum values of Calcium shown in Figure 4(b) and Magnesium in Figure 4(c) were 21.9 mg/L, 11.4 mg/L at S1 and 22.40 mg/L, 11.52 mg/L at S2 respectively. Similarly the maximum values of Ca and Mg were 71.80 mg/L, 41.3 mg/L at S1 and 73.89 mg/L, 42.92 mg/L at S2 respectively. The annual mean values of Ca and Mg were 37.61 mg/L, 24.53 mg/L at S1 and 38.44 mg/L, 25.7 mg/L at S2 respectively. Magnesium hardness in association with the sulphate also shows laxative effects[39].

3.8 Nitrate and Phosphate

The minimum values of nitrate observed were 2 mg/L at S1 and 2.48 mg/L at S2. The maximum values were 11.7 mg/L at S1 and 12.39 mg/L at S2 shown in Figure 4(d). The annual nitrate mean values were 5.15 at S1 and 5.63 at S2. Nitrogen is the chief constituent of organic matter. When this organic matter gets decomposed, release ammonia which in turn converted to nitrate if there is oxygen[40]. The nitrate content of Saralasagar was well within the permissible limits i.e. 45 mg/L. Excessive nitrate concentration may lead to a disease, methaemoglobinaemia in which the oxygen transport is impaired. Upgraded Soil Aquifer Treatment [SAT] method is the promising one to remove the nitrate from water bodies[41]. Phosphate in water indicates the degree of pollution. Phosphate is the A1 limiting factor in many aquatic ecosystems. Phosphate is responsible for the growth of both plankton and plants in water which in turn are used by fish as their food. The phosphate concentration in water samples varied from 0.15 mg/L–0.32 mg/L shown in Figure 5(a).

3.9 Chloride and Sulphate

The chloride also was in the permissible limits i.e. 200 mg/L shown in Figure 5(b). The annual mean values of chloride were 111.70 and 112.77 at S1 and S2 respectively. A high chloride value of 553.8 mg/L was evident from an urban lake in Telangana state[42]. The annual sulphate mean values recorded at S1 and S2 were 77.90 mg/L and 80.02 mg/L respectively.

3.10 Sodium and Potassium

Sodium in water is toxic for some crops, particularly when the sprinkler irrigation is followed[43]. The minimum values of sodium shown in Figure 5(c) and potassium were 45.6 mg/L, 0.72 mg/L at S1 and 46.92 mg/L, 0.78 mg/L at S2 respectively. Similarly the maximum values recorded were 150.2 mg/L, 2.30 mg/L at S1 and 151.8 mg/L, 2.34 mg/L at S2 respectively. Soils can hold sodium and potassium to a greater extent than phosphate, chloride or nitrate. Hence, they do not indicate the pollution unlike the phosphate and nitrate.

3.11 Iron, Silica and Fluoride

The iron concentration in Saralasagar water varied from 0.10–0.20 mg/L. Silica is an important nutrient for the growth of diatoms. It was ranged between 6.71 mg/L-14 mg/L. Fluoride is often termed as double-edged sword since; its excess as well as inadequate levels in drinking water are responsible for the disease, fluorosis[44]. The fluoride was in the permissible limits shown in Figure 5(d). The annual mean values of fluoride were 0.84 mg/L at S1 and 0.87 mg/L at S2.

3.12 Correlation [r] Between Different Parameters

Correlation studies were made to find the correlation among the parameters by calculating Pearson's correlation coefficient [r] for the parameters like p^H, E.C., turbidity, water temperature, TDS, total hardness, total alkalinity, D.O., BOD, calcium, magnesium, chloride, sulphate, nitrate and fluoride of Saralasagar reservoir. The degree of correlation between the parameters is represented in Tables 4 and 5 for S1 and S2 respectively. The p^H showed a negative correlation with chloride [r = - 0.689 at S1 and r = -0.324 at S2]. E.C. showed a strong positive correlation with TDS [r = 0.995 at S1 and S2], total alkalinity [r = 0.875 at S1 and r = 0.857 at S2] and chloride [r = 0.754 at S1 and r = 0.756 at S2]. TDS positively correlated with total alkalinity [r = 0.863 at S1 and r = 0.846 at S2] and chloride [r = 0.761 at S1 and r = 0.762 at S2]. Dissolved oxygen correlated negatively with water temperature [r = - 0.747 at S1 and r = - 0.720 at S2] whereas the BOD was correlated positively with water temperature [r = 0.878 at S1 and r = 0.772 at S2]. DO was negatively correlated with BOD [r = - 0.857 at S1 and r = -0.772 at S2]. Calcium showed a strong positive correlation with TH [r = 0.930 at S1 and r = 0.936 at S2] and magnesium [r = 0.769 at S1 and r = 0.833 at S2]. Magnesium also strongly correlated with TH [r = 0. 948 at S1 and r = 0.936 atS2], calcium [r = 0.769 at S1 and r = 0.833 at S2] and chloride [r = 0.720 at S1 and r = 0.742 at S2]. The r values from 0.579 to 0.693 were significant at the 0.05 level and the values from 0.720 to the above were significant at the 0.01 level.

Table 4. Correlations at Saralasagar Station-I

Para-meter	pH	E.C	TUR	TEM	TDS	TH	TA	DO	BOD	Ca^{++}	Mg^{++}	Cl^-	SO_4^{--}	NO_3^{--}	F^-
pH	1	-.425	-.322	-.473	-.426	-.448	-.037	.450	-.480	-.499	-.374	-.689*	-.134	-.300	.303
E.C	-.425	1	.370	.464	.995**	.362	.875**	-.672*	.641*	.157	.531	.754**	.693*	.528	-.115
TUR	-.322	.370	1	.120	.397	.121	.392	-.195	.411	.001	.176	.514	-.002	-.230	.359
TEM	-.473	.464	.120	1	.453	-.198	.308	-.747**	.878**	-.136	-.169	.398	.554	.249	-.691*
TDS	-.426	.995**	.397	.453	1	.354	.863**	-.669*	.649*	.161	.512	.761**	.682*	.533	-.117
TH	-.448	.362	.121	-.198	.354	1	.163	-.029	-.063	.930**	.948**	.667*	-.305	.643*	-.040
TA	-.037	.875**	.392	.308	.863**	.163	1	-.599*	.537	-.078	.367	.455	.640*	.319	.123
DO	.450	-.672*	-.195	-.747**	-.669*	-.029	-.599*	1	-.857**	-.013	-.095	-.459	-.691*	-.502	.376
BOD	-.480	.641*	.411	.878**	.649*	-.063	.537	-.857**	1	-.039	-.030	.560	.584*	.303	-.503
Ca^{++}	-.499	.157	.001	-.136	.161	.930**	-.078	-.013	-.039	1	.769**	.548	-.441	.619*	-.220
Mg^{++}	-.374	.531	.176	-.169	.512	.948**	.367	-.095	-.030	.769**	1	.720**	-.105	.646*	.052
Cl^-	-.689*	.754**	.514	.398	.761**	.667*	.455	-.459	.560	.548	.720**	1	.211	.596*	-.283
SO_4^{--}	-.134	.693*	-.002	.554	.682*	-.305	.640*	-.691*	.584*	-.441	-.105	.211	1	.214	-.133
NO_3^-	-.300	.528	-.230	.249	.533	.643*	.319	-.502	.303	.619*	.646*	.596*	.214	1	-.533
F^-	.303	-.115	.359	-.691*	-.117	-.040	.123	.376	-.503	-.220	.052	-.283	-.133	-.533	1

Table 5. Correlations at Saralasagar Station-II

Parameter	pH	E.C	TUR	TEM	TDS	TH	TA	DO	BOD	Ca^{++}	Mg^{++}	Cl^-	SO_4^{--}	NO_3^-	F^-
pH	1	.023	-.144	-.277	.045	-.279	.350	-.138	-.147	-.391	-.246	-.324	.274	.132	.250
E.C	.023	1	.451	.444	.995**	.352	.857**	-.633*	.630*	.146	.470	.756**	.701*	.533	-.119
TUR	-.144	.451	1	.118	.486	.164	.436	-.161	.432	.043	.224	.579*	.031	-.125	.328
TEM	-.277	.444	.118	1	.428	-.228	.279	-.720**	.856**	-.189	-.161	.351	.594*	.209	-.624*
TDS	.045	.995**	.486	.428	1	.345	.846**	-.633*	.638*	.151	.453	.762**	.693*	.534	-.108
TH	-.279	.352	.164	-.228	.345	1	.153	-.049	-.068	.936**	.970**	.665*	-.295	.646*	-.029
TA	.350	.857**	.436	.279	.846**	.153	1	-.587*	.498	-.082	.272	.442	.628*	.352	.110
DO	-.138	-.633*	-.161	-.720**	-.633*	-.049	-.587*	1	-.772**	-.002	-.122	-.422	-.673*	-.539	.367
BOD	-.147	.630*	.432	.856**	.638*	-.068	.498	-.772**	1	-.054	-.018	.557	.591*	.289	-.490
Ca^{++}	-.391	.146	.043	-.189	.151	.936**	-.082	-.002	-.054	1	.833**	.539	-.440	.603*	-.179
Mg^{++}	-.246	.470	.224	-.161	.453	.970**	.272	-.122	-.018	.833**	1	.742**	-.162	.655*	-.007
Cl^-	-.324	.756**	.579*	.351	.762**	.665*	.442	-.422	.557	.539	.742**	1	.226	.599*	-.260
SO_4^{--}	.274	.701*	.031	.594*	.693*	-.295	.628*	-.673*	.591*	-.440	-.162	.226	1	.219	-.163
NO_3^-	.132	.533	-.125	.209	.534	.646*	.352	-.539	.289	.603*	.655*	.599*	.219	1	-.544
F^-	.250	-.119	.328	-.624*	-.108	-.029	.110	.367	-.490	-.179	-.007	-.260	-.163	-.544	1

4. Conclusion

Present investigation ensures that, many of the water quality parameters like water temperature, EC, TDS, turbidity, total hardness, alkalinity, DO, phosphates, chlorides, nitrates, sulphates, sodium, potassium, calcium, magnesium, iron, silica, fluoride etc. were within the limits recommended by WHO and IS standards. It has been found that Saralasagar reservoir is non-polluted and its water is safe and can be used for various human needs in all the seasons and it can be used for irrigation and aquaculture practices and also suitable for industrial purpose. However, the higher p^H values suggest that carbonate and bicarbonate equilibrium is affected. The high BOD values indicate the presence of plenty of organic matter, microbial richness and non-biodegradable oxygen demanding pollutants in the lake water. The fish productivity of Saralasagar reservoir can be improved if the physico-chemical parameters are maintained at more accurate levels. It is also suggested that frequent examination of water quality is essential before supplying its water for house hold and agricultural purposes. Indiscriminate use of synthetic pesticides, chemical fertilizers and soil erosion must be checked strictly in the catchment area of reservoir to prevent its further deterioration thus to maintain its sustainability as a water resource. It is also suggested to include this reservoir under the "Mission Kakatiya", a recently initiated desilting scheme taken up by the government of Telangana for the restoration of irrigation tanks and lakes.

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