LIMNOLOGICAL STUDIES RELATED TO PHYSICO-CHEMICAL CHARACTERISTICS OF SHRI SHARANABASAVESHWARA LAKE WATER OF GULBARGA CITY

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Abstract
The present study deals with the seasonal limnological investigation related to physico-chemical characteristics of water of the Shri Sharanabasaveshwara Lake, Karnataka State. Besides temperature and meteorological data, 11 limnological parameters were tested following standard methods at 5 sampling sites/stations of the lake. The physico-chemical parameters (pH, DO, BOD, HCO_3, TDS, Chloride, Nitrate, TH, Ca, Mg and SO_4 etc.) showed distinct variation in the lake sites.

Keywords: Limnology, Physico-chemical parameters, Shri Sharanabasaweshwara Lake

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1. INTRODUCTION

Wetland i.e., lakes, jheels, beels etc., have a variety of linkages for energy and nutrient exchange with surrounding watersheds and air sheds. The inland freshwater ecosystem both lentic and lotic, are being increasingly subjected to greater stress form various human activities (Wood and Gibson, 1974; Hemasundaram, 2003). The eutrophication of water means enrichment with nutrients and the resulting degradation of its quality accompanied by luxuriant growth of micro and macrophytes are recognized as a major problem in the developed as well as in developing countries. The enrichment of nutrients occurs due to the disposal of domestic and farm sewage, industrial effluents and from the runoff from surrounding areas. Vollenweider (1968) pointed out that the domestic sewage is a major source of eutrophication. With the constantly increasing eutrophication of surface waters more and more attention is being paid to investigations of the bottom sediments of wetlands (Kajak, 1979; Golterman and Qude, 1991; Freeman et al., 1993; Clair et al., 1996; Dortch, 1996; Craft, 1997; Ansari and Kumar, 2003). Although considerable investigations have been made by the researchers but a little information is known about the systematic limnological studies in Gulbarga Shri. Sharanbasveshwara Lake However, it is important to note that no qualitative, quantitative or ecological study on limnology was made so far from Shri Sharanasveshwara Lake. Shri Sharanabasveshwara lake has received various types of sewage i.e., domestic sewage, cattle waste etc. Hence an attempt into the limnological investigation in relation to the different physico-chemical characteristics of water of the lake was taken up in the present investigation.

1.1 Information about Shri Sharanabasaweshwara Lake:

The Shri Sharanabasaweshwara Lake is situated in the heart of the city and is also known is Jagat Tank. The eastern, northern and southern boundaries are flanked by roads, while a part of western bank is linked through a narrow channel with the adjacent moat of the Gulbarga Fort which a part of the city. This tank spreads over an area of 0.275sq.km the mean depth is 2.2 meters with a maximum being 1.2 meters during the dry period. The tank is fully utilized by the Fisherman's Co-operative society. Shri Sharanabasaweshwara Lake exists from many many decades. Since from early days this lake is used for cattle rearing, for bathing, for fishing, and also women used to wash their household cloths. After few decades, the municipal administration joined the sewage drains from Ward A (Shahabazaar area) of Gulbarga City into this lake. That's the point from which the lake got polluted & silted up. Incidences of fish kill happened 2 to 3 times. Very recently the City administration has taken up steps to desilt the tank and added fresh water in it, apart from that they also constructed stone lining/pitching & fencing throughout the periphery of the lake. Now it is well protected from animals and anthropogenic hindrances. It is now being used for contractual recreational boating only.

1.2 Objectives of the study:
The main objectives of the current study are as following.
1. Studying the Physico-chemical characteristics of lake water.
2. Knowing the suitability of water for aquatic life, recreation etc.

2. MATERIALS AND METHODS

Study Area: Gulbarga City is a divisional head quarter of five revenue districts of, Bidar, Gulbarga, Yadgir, Raichur, Bellary, Koppal and is also having Gulbarga University, Central University and VTU regional office. It is situated on Mumbai – Chennai Section of the Central Railway and is at a distance of 640 Kms. from the capital of Karnataka, the Bangalore. It is sufficiently developed in the field of education commerce and industries. There are many educational institutes including Medical, Engineering, Arts, Science and Commerce Colleges. The city has all India Radio Broadcasting station and Television transmitting center. Gulbarga is also a pilgrimage place of two religious centers, viz., Shri Sharanabasaveshwara Temple and Hazrat Khaja Bande Nawaz Darga. The city is situated at latitude of 17°20' and longitude of 76°50'. It has a general slope of North-West to South-East.. The town lies between the contours 1570m and 1460m and the average elevation above the mean sea level is about 458m. The ground level varies from 488m to 420m. Gulbarga city falls under one of the hottest regions. The climate is usually warm during most of the year.   The maximum temperature in summer is 46°C during March to May and minimum temperature is 10°C during December average temperature is 36°C. The winds are generally light and moderate with some increase in force during the latter part of summer and monsoon. The rainy seasons occurs during June to October following by winter season from November to January. The average annual rainfall is 691.7mm. The mean annual maximum humidity observed in the morning is 60% and minimum in the evening is 40%. Geologically the area is composed of Deccan traps of tertiary period and shale and lime stones in Bhima series. Deccan traps occupy ¾ of the area as horizontal flows of Basaltic lava. Different varieties of traps are present in the study area, (1) Hard massive trap (2) Jointed weathered trap (3) Zeolitic trap. The weathering of trap varies from place to place depending on the elevation. In a few places in between two trap flows bole beds (Inter trappings) are present, these are good aquifers. The jointed Zeolitic and weathered trap also act as good aquifers in the area. The location map of Shri Sharanabasaveshwara Lake is shown in figure1. Sampling points chosen are at North-West corner S1, North-East corner S2, Centre of lake S3, South-West corner S4 and South-East corner S5. The inlet is near sampling pointS1 and the outlet is near sampling point S5. The physico-chemical characteristics are analysed as per standard procedural methods. For statistical analysis viz., Correlation coefficients and Factor analysis MINITAB software is utilised.

Correlation Coefficients (r): The degree of relationship between the variables is measured through the correlation analysis. The measure of correlation is called correlation coefficient, represented by symbol 'r'. The Karl Pearson's formula is

$$r = \frac{N\sum(X_iY_i) - (\sum X_i).(\sum Y_i)}{\sqrt{[N\sum X_i^2 - (\sum X_i)^2][N\sum Y_i^2 - (\sum Y_i)^2]}}$$

Factor Analysis: Factor analysis is a very powerful technique which provides information on the meaningful parameters which describe the whole data set rendering data reduction with minimum loss of information (Singh K. P. et. al,). FA is a quantification of the significance of variables that explain the observed grouping and patterns of the inherit properties of the individual objects (Kowalkowski T. et. al,). FA allows the explaining of related parameters by only one factor (Singh K. P. et. al, Kowalkowski T. et. al, Boyacioglu. H. et. al,). FA exposes the important factor responsible for variation in ground water quality and eventually leads to sources identification of ground water pollution. In this study, FA was applied to extract the most significant factors and to reduce the contribution of less significant variables to simplify even more of the data structure coming from factor analysis. The factors obtained were further subjected to varimax rotation according to well established rules to maximize differences between the variables and facilitate easy interpretation of the data (Singh K. P. et. al, Kowalkowski T. et. al, Boyacioglu. H. et. al,). The rotating axis defined by factor analysis generates varimax factor (Factor1, Factor2….) which can further reduce the contribution of variable with minor significance. The classification of the factor loading as 'strong', 'moderate' and 'week' corresponds to absolute loading of > 0.75, 0.75-0.50 and 0.50-0.30, respectively (Liu. C.W. et. al,).
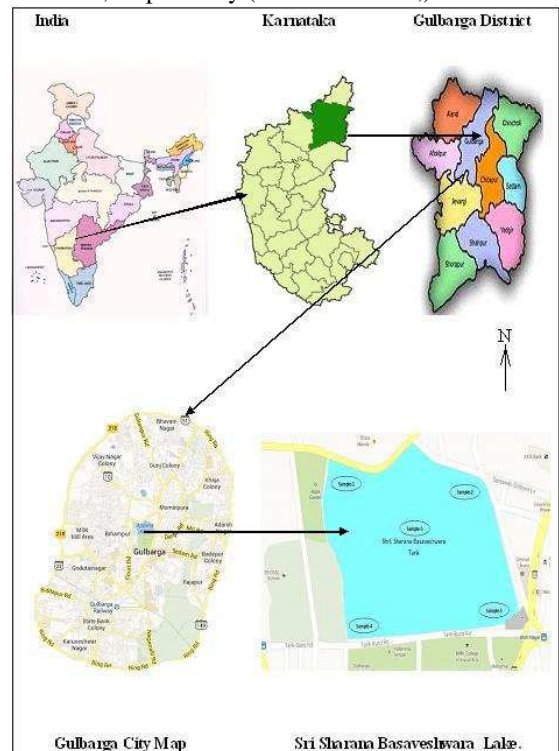

Figure1: Location Map of Shri Sharanabasaweshwara Lake

3. RESULTS AND DISCUSSIONS

The physico-chemical characteristics are analysed for all the sampling points and are presented in the table 1 to table5. Correlation coefficients are worked out for individual samples and are presented in the table 6 to table 10. Factor analysis also worked out for all the individual samples and is presented in table 11 to table 15.

Table 1: Characteristics of Lake water at sampling point 1

Date	Temperature atms	water	pH	Alkalinity	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
5-Nov	30.2	24.4	8.8	119.32	9.2	107.1	342	189.4	142.05	47.35	1.02	3.96	235
8-Nov	29.71	24.05	8.72	116.71	9.3	107.89	340	185.25	138.94	46.31	0.99	3.98	232.64
11-Nov	29.22	23.7	8.9	114.1	9.4	108.68	338	181.11	135.83	45.28	0.97	4.01	230.27
14-Nov	28.73	23.35	8.85	111.48	9.2	109.47	338	176.95	132.71	44.24	0.96	4.02	227.9
17-Nov	28.24	23	8.62	108.86	9.1	110.25	336	172.8	129.6	43.2	0.96	4.03	225.55
20-Nov	27.75	22.65	8.82	106.38	9	111.08	334	168.85	126.64	42.21	0.95	4.05	223.16
23-Nov	27.26	21.3	8.84	103.64	9.2	111.79	332	164.5	123.38	41.13	0.93	4.07	220.8
26-Nov	26.77	21.95	8.72	100.99	9.2	112.46	332	160.3	120.23	40.08	0.92	4.09	218.12
29-Nov	26.28	21.6	8.7	98.48	9.3	113.93	330	156.32	117.24	39.08	0.9	4.1	216.05
2-Dec	25.79	21.25	8.8	95.8	8.8	114.25	328	152.07	114.05	38.02	0.89	3.93	213.6
5-Dec	25.46	21.3	8.94	98.65	8.42	114.89	326	156.58	117.44	39.15	0.88	3.84	214.88
8-Dec	25.12	21.36	8.82	101.5	8.5	114.24	328	161.11	120.83	40.28	0.87	3.75	216.16
11-Dec	24.8	21.41	8.7	104.35	8.24	116.45	330	165.64	124.23	41.41	0.86	3.66	217.44
14-Dec	24.47	21.46	8.6	107.21	7.96	117.25	334	170.17	127.63	42.54	0.85	3.57	218.72
17-Dec	23.81	21.52	8.7	110.06	7.68	118.03	336	174.7	131.03	43.68	0.84	3.48	220.22
20-Dec	23.48	21.58	8.84	112.91	7.8	118.83	338	179.23	134.42	44.81	0.83	3.31	212.28
23-Dec	23.15	21.64	8.6	115.77	7.76	119.56	340	183.76	137.82	45.94	0.82	3.2	222.56
26-Dec	22.82	21.69	8.84	118.62	7.65	120.48	342	188.29	141.22	47.07	0.81	3.11	223.84
Max	30.2	24.4	8.94	119.32	9.4	120.48	342	189.4	142.05	47.35	1.02	4.1	235
Min	22.82	21.25	8.6	95.8	7.65	114.24	326	152.07	114.05	38.02	0.81	3.11	212.28
Mean	26.28	22.17	8.76	108.04	8.65	113.70	334.66	171.50	128.62	42.87	0.90	3.78	221.62
S.D	2.33	1.05	0.10	7.31	0.64	4.14	4.99	11.61	8.70	2.90	0.06	0.32	6.58
C.V	0.088	0.047	0.011	0.067	0.073	0.036	0.014	0.067	0.067	0.067	0.066	0.084	0.029

pH: Hydrogen Ion Concentration, DO: Dissolved Oxygen in mg/L, BOD: Bio-chemical Oxygen Demand in mg/L, TDS: Total Dissolved Solids in mg/L, TH: Total Hardness in mg/L, Ca: Calcium Hardness in mg/L, Mg: Magnesium Hardness in mg/L, NO3: Nitrate in mg/L, SO4: Sulphate in mg/L, Cl: Chloride in mg/L, Max: Maximum value, Min: Minimum value, SD: Standard deviation, CV: Coefficient of variation

Table 2: Characteristics of Lake water at sampling point 2

Date	Temperature atms	water	pH	Alkalinity	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
5-Nov	30.2	24.4	7.96	107.39	8.28	96.39	308	170.46	127.85	42.62	0.92	3.56	211.5
8-Nov	29.71	24.05	7.92	105.04	8.37	97.1	306	166.73	125.04	41.68	0.89	3.58	209.38
11-Nov	29.22	23.7	7.85	102.69	8.46	97.81	304	163	122.25	40.75	0.87	3.61	207.24
14-Nov	28.73	23.35	8.01	100.33	8.28	98.52	304	159.26	119.44	39.81	0.86	3.62	205.11
17-Nov	28.24	23	7.97	97.98	8.19	99.23	302	155.52	116.64	38.88	0.86	3.63	203
20-Nov	27.75	22.65	7.76	95.74	8.1	99.97	301	151.97	113.97	37.99	0.86	3.65	200.84
23-Nov	27.26	21.3	7.94	93.27	8.28	100.61	299	148.05	111.04	37.01	0.84	3.66	198.72
26-Nov	26.77	21.95	7.96	90.89	8.28	101.21	299	144.27	108.2	36.07	0.83	3.68	196.31
29-Nov	26.28	21.6	7.67	88.63	8.37	102.53	297	140.69	105.52	35.17	0.81	3.69	194.45
2-Dec	25.79	21.25	7.83	86.22	7.92	102.83	295	136.86	102.65	34.22	0.8	3.54	192.24
5-Dec	25.46	21.3	7.92	88.78	7.58	103.4	293	140.92	105.69	35.23	0.79	3.46	193.39
8-Dec	25.12	21.36	8.05	91.35	7.65	102.82	295	145	108.75	36.25	0.78	3.38	194.54
11-Dec	24.8	21.41	7.94	93.92	7.42	104.8	297	149.08	111.81	37.27	0.77	3.29	195.7
14-Dec	24.47	21.46	7.83	96.49	7.16	105.53	301	153.15	114.86	38.29	0.77	3.21	196.85
17-Dec	23.81	21.52	7.74	99.05	6.91	106.23	302	157.23	117.92	39.31	0.76	3.13	198.2
20-Dec	23.48	21.58	7.85	101.62	7.02	106.94	304	161.31	120.98	40.33	0.75	2.98	191.05
23-Dec	23.15	21.64	7.96	104.19	6.98	107.6	306	165.38	124.04	41.35	0.74	2.8	200.3
26-Dec	22.82	21.69	7.74	106.76	6.89	108.44	308	169.46	127.1	42.37	0.73	2.8	201.46
Max	30.2	24.4	8.05	107.39	8.46	108.44	308	170.46	127.85	42.62	0.92	3.69	211.5
Min	22.82	21.25	7.74	86.22	6.89	96.39	293	136.86	102.65	34.22	0.73	2.8	191.05
Mean	26.28	22.17	7.89	97.24	7.78	102.33	301.16	154.35	115.76	38.58	0.81	3.40	199.46
S.D	2.33	1.05	0.10	6.58	0.58	3.73	4.55	10.44	7.83	2.61	0.05	0.29	5.92
C.V	0.088	0.047	0.011	0.067	0.074	0.036	0.015	0.067	0.067	0.067	0.061	0.085	0.029

Table 3: Characteristics of Lake water at sampling point 3

Date	Temperature atms	water	pH	Alkalinity	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
5-Nov	30.2	24.4	7.78	105	8.1	94.25	301	166.67	125	41.67	0.9	3.48	206.8
8-Nov	29.71	24.05	7.74	102.7	8.18	94.94	299	163.02	122.27	40.76	0.87	3.5	204.72
11-Nov	29.22	23.7	7.67	100.41	8.27	95.63	297	159.38	119.53	39.84	0.85	3.53	202.64
14-Nov	28.73	23.35	7.83	98.1	8.1	96.33	297	155.72	116.79	38.93	0.84	3.54	200.55
17-Nov	28.24	23	7.79	95.8	8.01	97.02	296	152.06	114.05	38.02	0.84	3.55	198.48
20-Nov	27.75	22.65	7.59	93.61	7.92	97.75	294	148.59	111.44	37.15	0.84	3.56	196.38
23-Nov	27.26	21.3	7.76	91.2	8.1	98.38	292	144.76	108.57	36.19	0.82	3.58	194.3
26-Nov	26.77	21.95	7.78	88.87	8.1	98.96	292	141.06	105.8	35.27	0.81	3.6	191.95
29-Nov	26.28	21.6	7.67	86.66	8.18	100.25	290	137.56	103.17	34.39	0.79	3.61	190.12
2-Dec	25.79	21.25	7.66	84.31	7.74	100.54	289	133.82	100.37	33.46	0.78	3.46	187.97
5-Dec	25.46	21.3	7.74	86.81	7.41	101.1	287	137.79	103.34	34.45	0.77	3.38	189.09
8-Dec	25.12	21.36	7.87	89.32	7.48	100.53	289	141.78	106.33	35.44	0.77	3.3	190.22
11-Dec	24.8	21.41	7.67	91.83	7.25	102.47	290	145.76	109.32	36.44	0.76	3.22	191.35
14-Dec	24.47	21.46	7.66	94.34	7	103.18	294	149.75	112.31	37.44	0.75	3.14	192.47
17-Dec	23.81	21.52	7.57	96.85	6.76	103.87	296	153.74	115.3	38.43	0.74	3.06	193.79
20-Dec	23.48	21.58	7.67	99.37	6.86	104.57	297	157.72	118.29	39.43	0.73	2.91	186.81
23-Dec	23.15	21.64	7.78	101.88	6.83	105.21	299	161.71	121.28	40.43	0.72	2.82	195.85
26-Dec	22.82	21.69	7.57	104.39	6.73	106.03	301	165.7	124.27	41.42	0.71	2.74	196.98
Max	30.2	24.4	7.87	105	8.27	106.03	301	166.67	125	41.67	0.9	3.61	206.8
Min	22.82	21.25	7.57	84.31	6.73	94.25	287	133.82	100.37	33.46	0.71	2.74	186.81
Mean	26.28	22.17	7.71	95.08	7.61	100.05	294.44	150.92	113.19	37.73	0.79	3.33	195.02
S.D	2.33	1.05	0.08	6.43	0.57	3.64	4.32	10.21	7.66	2.55	0.05	0.28	5.79
C.V	0.088	0.047	0.010	0.067	0.074	0.036	0.014	0.067	0.067	0.067	0.063	0.084	0.029

Table 4: Characteristics of Lake water at sampling point 4

Date	Temperature atms	Water	pH	Alkalinity	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
5-Nov	30.2	24.4	7.87	106.2	8.19	95.32	304	168.57	126.42	42.14	0.91	3.52	209.15
8-Nov	29.71	24.05	7.83	103.87	8.28	96.02	303	164.87	123.65	41.22	0.88	3.54	207.05
11-Nov	29.22	23.7	7.76	101.55	8.37	96.72	301	161.19	120.89	40.3	0.85	3.58	204.94
14-Nov	28.73	23.35	7.92	99.22	8.19	97.42	301	157.49	118.11	39.37	0.85	3.58	202.83
17-Nov	28.24	23	7.88	96.89	8.1	98.12	299	153.79	115.34	38.45	0.85	3.59	200.74
20-Nov	27.75	22.65	7.67	94.67	8.01	98.86	297	150.28	112.71	37.57	0.85	3.6	198.61
23-Nov	27.26	21.3	7.85	92.24	8.19	99.49	295	146.41	109.8	36.6	0.83	3.62	196.51
26-Nov	26.77	21.95	7.87	89.88	8.19	100.08	295	142.67	107	35.67	0.82	3.64	194.13
29-Nov	26.28	21.6	7.76	87.65	8.28	101.39	294	139.12	104.34	34.78	0.8	3.65	192.28
2-Dec	25.79	21.25	7.74	85.27	7.83	101.69	292	135.34	101.51	33.84	0.79	3.5	190.1
5-Dec	25.46	21.3	7.83	87.79	7.49	102.25	290	139.36	104.52	34.84	0.78	3.42	191.24
8-Dec	25.12	21.36	7.96	90.33	7.57	101.67	292	143.39	107.54	35.85	0.77	3.34	192.38
11-Dec	24.8	21.41	7.85	92.87	7.33	103.64	294	147.42	110.56	36.85	0.77	3.26	193.52
14-Dec	24.47	21.46	7.74	95.41	7.08	104.35	297	151.45	113.59	37.86	0.76	3.18	194.66
17-Dec	23.81	21.52	7.65	97.95	6.84	105.05	299	155.48	116.61	38.87	0.75	3.1	196
20-Dec	23.48	21.58	7.76	100.49	6.94	105.75	301	159.51	119.64	39.88	0.74	2.95	188.93
23-Dec	23.15	21.64	7.87	103.03	6.91	106.41	303	163.55	122.66	40.89	0.72	2.85	198.08
26-Dec	22.82	21.69	7.65	105.57	6.81	107.23	304	167.58	125.68	41.89	0.72	2.77	199.22
Max	30.2	24.4	7.96	106.2	8.37	107.23	304	168.57	126.42	42.14	0.91	3.65	209.15
Min	22.82	21.25	7.65	85.27	6.81	95.32	290	135.34	101.51	33.84	0.72	2.77	188.93
Mean	26.28	22.17	7.80	96.16	7.7	101.19	297.83	152.63	114.47	38.15	0.80	3.37	197.24
S.D	2.33	1.05	0.09	6.50	0.57	3.68	4.46	10.33	7.74	2.58	0.05	0.28	5.86
C.V	0.088	0.047	0.011	0.067	0.073	0.036	0.014	0.067	0.067	0.067	0.062	0.083	0.029

Table 5: Characteristics of Lake water at sampling point 5

Date	Temperature atms	water	pH	Alkalinity	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
5-Nov	30.2	24.4	7.51	101.42	7.82	91.04	291	160.99	120.74	40.25	0.87	3.37	199.75
8-Nov	29.71	24.05	7.48	99.2	7.91	91.71	289	157.46	118.1	39.37	0.84	3.38	197.74
11-Nov	29.22	23.7	7.41	96.98	7.99	92.37	287	153.94	115.46	38.49	0.82	3.41	195.73
14-Nov	28.73	23.35	7.57	94.76	7.82	93.05	287	150.41	112.81	37.6	0.82	3.42	193.72
17-Nov	28.24	23	7.52	92.53	7.74	93.71	286	146.88	110.16	36.72	0.82	3.43	191.72
20-Nov	27.75	22.65	7.33	90.42	7.65	94.41	284	143.52	107.64	35.88	0.81	3.44	189.69
23-Nov	27.26	21.3	7.5	88.09	7.82	95.02	282	139.83	104.87	34.96	0.79	3.46	187.68
26-Nov	26.77	21.95	7.51	85.84	7.82	95.59	282	136.26	102.19	34.06	0.78	3.48	185.4
29-Nov	26.28	21.6	7.41	83.71	7.91	96.84	281	132.87	99.65	33.22	0.77	3.49	183.64
2-Dec	25.79	21.25	7.4	81.43	7.48	97.12	279	129.26	96.94	32.31	0.76	3.34	181.56
5-Dec	25.46	21.3	7.48	83.85	7.16	97.66	277	133.09	99.82	33.27	0.75	3.26	182.65
8-Dec	25.12	21.36	7.6	86.27	7.23	97.1	279	136.94	102.71	34.24	0.74	3.19	183.74
11-Dec	24.8	21.41	7.5	88.7	7	98.98	281	140.79	105.6	35.2	0.73	3.11	184.82
14-Dec	24.47	21.46	7.4	91.13	6.77	99.66	284	144.64	108.48	36.16	0.72	3.03	185.91
17-Dec	23.81	21.52	7.31	93.55	6.53	100.33	286	148.5	111.37	37.12	0.71	2.96	187.19
20-Dec	23.48	21.58	7.41	95.98	6.63	101	287	152.35	114.26	38.09	0.71	2.81	180.44
23-Dec	23.15	21.64	7.51	98.4	6.6	101.63	289	156.2	117.15	39.05	0.7	2.72	189.18
26-Dec	22.82	21.69	7.31	100.83	6.5	102.41	291	160.05	120.03	40.01	0.69	2.64	190.26
Max	30.2	24.4	7.6	101.42	7.99	102.41	291	160.99	120.74	40.25	0.87	3.49	199.75
Min	22.82	21.25	7.31	81.43	6.5	91.04	277	129.26	96.94	32.31	0.69	2.64	180.44
Mean	26.28	22.17	7.45	91.83	7.35	96.64	284.55	145.77	109.33	36.44	0.76	3.21	188.37
S.D	2.33	1.05	0.08	6.21	0.55	3.52	4.21	9.86	7.40	2.46	0.05	0.27	5.59
C.V	8.87	0.047	0.010	0.067	0.074	0.037	0.014	0.067	0.067	0.067	0.065	0.084	0.029

Table 6: Correlation Co-efficient of different parameters at sampling point 1

	pH	Alk	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
pH	-	-	-	-	-	-	-	-	-	-	-
Alk	-0.060	-	-	-	-	-	-	--	-	-	-
DO	0.179	-0.181	-	-	-	-	-	-	-	-	-
BOD	-0.216	-0.072	-0.919	-	-	-	-	-	-	-	-
TDS	-0.129	0.966	-0.102	-0.099	-	-	-	-	-	-	-
TH	-0.060	0.485	-0.181	-0.072	0.966	-	-	-	-	-	-
Ca	-0.060	0.485	-0.182	-0.072	0.966	0.485	-	-	-	-	-
Mg	-0.060	0.485	-0.181	-0.072	0.966	0.485	0.485	-	-	-	-
NO₃	0.179	0.144	0.897	-0.990	0.182	0.144	0.144	0.144	-	-	-
SO₄	0.171	-0.418	0.943	-0.857	-0.349	-0.418	-0.148	-0.418	0.824	-	-
Cl	0.001	0.733	0.440	-0.659	0.727	0.733	0.733	0.733	0.706	0.240	-

Table 7: Correlation Co-efficient of different parameters at sampling point 2

	pH	Alk	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
pH	-	-	-	-	-	-	-	-	-	-	-
Alk	-0.097	-	-	-	-	-	-	-	-	-	-
DO	0.370	-0.181	-	-	-	-	-	-	-	-	-
BOD	-0.392	-0.072	-0.919	-	-	-	-	-	-	-	-
TDS	-0.161	0.962	-0.097	-0.099	-	-	-	-	-	-	-
TH	-0.097	0.485	-0.181	-0.072	0.962	-	-	-	-	-	-
Ca	-0.097	0.485	-0.182	-0.072	0.962	0.485	-	-	-	-	-
Mg	-0.097	0.485	-0.182	-0.071	0.962	0.485	0.485	-	-	-	-
NO₃	0.307	0.153	0.889	-0.984	0.200	0.153	0.153	0.153	-	-	-
SO₄	0.327	-0.421	0.942	-0.856	-0.346	-0.421	-0.421	-0.421	0.817	-	-
Cl	0.138	0.733	0.440	-0.659	0.727	0.733	0.733	0.733	0.708	0.241	-

Table 8: Correlation Co-efficient of different parameters at sampling point 3

	pH	Alk	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
pH	-	-	-	-	-	-	-	-	-	-	-
Alk	-0.103	-	-	-	-	-	-	-	-	-	-
DO	0.366	-0.181	-	-	-	-	-	-	-	-	-
BOD	-0.388	-0.071	-0.920	-	-	-	-	-	-	-	-
TDS	-0.167	0.965	-0.117	-0.093	-	-	-	-	-	-	-
TH	-0.103	0.485	-0.181	-0.071	0.965	-	-	-	-	-	-
Ca	-0.103	0.485	-0.181	-0.072	0.965	0.485	-	-	-	-	-
Mg	-0.103	0.485	-0.180	-0.072	0.965	0.485	0.485	-	-	-	-
NO₃	0.330	0.140	0.892	-0.989	0.170	0.140	0.140	0.141	-	-	-
SO₄	0.327	-0.420	0.944	-0.856	-0.358	-0.420	-0.420	-0.420	0.822	-	-
Cl	0.135	0.733	0.441	-0.659	0.729	0.733	0.733	0.733	0.701	0.243	-

Table 9: Correlation Co-efficient of different parameters at sampling point 4

	pH	Alk	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
pH	-	-	-	-	-	-	-	-	-	-	-
Alk	-0.097	-	-	-	-	-	-	-	-	-	-
DO	0.371	-0.179	-	-	-	-	-	-	-	-	-
BOD	-0.392	-0.072	-0.919	-	-	-	-	-	-	-	-
TDS	-0.140	0.986	-0.103	-0.094	-	-	-	-	-	-	-
TH	-0.097	0.485	-0.180	-0.072	0.967	-	-	-	-	-	-
Ca	-0.097	0.485	-0.180	-0.072	0.967	0.485	-	-	-	-	-
Mg	-0.097	0.485	-0.179	-0.072	0.968	0.485	0.485	-	-	-	-
NO₃	0.135	0.149	0.889	-0.984	0.179	0.149	0.149	0.149	-	-	-
SO₄	0.329	-0.421	0.941	-0.855	-0.359	-0.422	-0.422	-0.422	0.818	-	-
Cl	0.138	0.733	0.441	-0.659	0.723	0.733	0.733	0.733	0.706	0.240	-

Table 10: Correlation Co-efficient of different parameters at sampling point 5

	pH	Alk	DO	BOD	TDS	TH	Ca	Mg	NO₃	SO₄	Cl
pH	-	-	-	-	-	-	-	-	-	-	-
Alk	-0.112	-	-	-	-	-	-	-	-	-	-
DO	0.371	-0.182	-	-	-	-	-	-	-	-	-
BOD	-0.392	-0.072	-0.919	-	-	-	-	-	-	-	-
TDS	-0.184	0.965	-0.116	-0.086	-	-	-	-	-	-	-
TH	-0.112	0.485	-0.182	-0.072	0.965	-	-	-	-	-	-
Ca	-0.112	0.485	-0.182	-0.072	0.965	0.485	-	-	-	-	-
Mg	-0.112	0.485	-0.182	-0.072	0.965	0.485	0.485	-	-	-	-
NO₃	0.340	0.139	0.898	-0.986	0.172	0.139	0.139	0.139	-	-	-
SO₄	0.336	-0.417	0.944	-0.857	-0.356	-0.417	-0.417	-0.417	0.823	-	-
Cl	0.130	0.733	0.439	-0.659	0.727	0.733	0.733	0.733	0.695	0.245	-

Correlation Coefficients (r): In all the sampling points, the highest positive correlation is found between Total dissolved solids & Alkalinity (TDS & HCO_3), Chloride & Alkalinity (Cl & HCO_3), Nitrate & Dissolved Oxygen (NO_3 & DO), Sulphate & Dissolved Oxygen (SO_4 & DO), Total hardness & Total dissolved solids (TH & TDS), Magnesium hardness & Total dissolved solids (Mg & TDS), Chloride & Total dissolved solids (Cl & TDS), Chloride & Total hardness (Cl & TH), Calcium hardness & Chloride (Ca & Cl), Magnesium hardness & Chloride (Mg & Cl), Nitrate & Chloride (NO_3 & Cl), Nitrate & Sulphate (NO_3 & SO_4).

Factor Analysis: In all the sampling points, almost following factor1 and factor2 gave the loadings.

Factor 1:

(1) Strong loading: It suggests that the quality of ground water is mainly controlled by strong loading parameters. The Strong loading on TH, Mg & Ca shows the permanent hardness of water. Alkalinity, Cl also suggests the hardness of water. High TDS shows that wash water from the water treatment are being added up in the fresh water of lake.
(2) Moderate loading: No loading at all.
(3) Weak loading: No loading at all.

Factor 2:

(1) Strong loading: Strong loading on DO suggests that water is being aerated in water treatment units of Gulbarga. NO_3, & SO_4 shows mild pollution and inherited quality of river water
(2) Moderate loading: Loading of Cl also indicates pollution & permanent hardness of water.
(3) Weak loading: No loading at all.

Table 11: Factor Analysis (Sample 1) (Rotated Factor Loadings and Communalities, Varimax Rotation)

Variable	Factor 1	Factor 2	Communality
pH	-0.076	0.246	0.066
Alkalinity	0.994	-0.091	0.997
DO	-0.092	0.970	0.950
BOD	-0.160	-0.979	0.984
TDS	0.974	-0.044	0.950
TH	0.994	-0.091	0.997
Ca	0.994	-0.091	0.997
Mg	0.994	-0.091	0.996
NO_3	0.234	0.963	0.982
SO_4	-0.332	0.934	0.982
Cl	0.797	0.545	0.982
Eigen value	5.8	4.0	-
% Variance	52.2	37.2	-
Cumulative % of Variance	52.2	89.4	-

Table 12: Factor Analysis (Sample 2) (Rotated Factor Loadings and Communalities, Varimax Rotation)

Variable	Factor 1	Factor 2	Communality
pH	-0.095	0.345	0.214
Alkalinity	0.995	-0.081	0.996
DO	-0.101	0.967	0.945
BOD	-0.15	-0.98	0.983
TDS	0.972	-0.033	0.945
TH	0.995	-0.081	0.996
Ca	0.995	-0.081	0.996
Mg	0.995	-0.082	0.996
NO_3	0.235	0.955	0.967
SO_4	-0.342	0.925	0.972
Cl	0.791	0.554	0.932
Eigen value	5.8	4.0	-
% Variance	52.2	37.2	-
Cumulative % of Variance	52.2	89.4	-

Table 13: Factor Analysis (Sample 3) (Rotated Factor Loadings and Communalities, Varimax Rotation)

Variable	Factor 1	Factor 2	Communality
pH	-0.099	0.345	0.218
Alkalinity	0.995	-0.082	0.996
DO	-0.101	0.966	0.943
BOD	-0.152	-0.98	0.983
TDS	0.974	-0.047	0.951
TH	0.995	-0.082	0.996
Ca	0.995	-0.081	0.996
Mg	0.995	-0.081	0.996
NO_3	0.222	0.96	0.97
SO_4	-0.341	0.924	0.97
Cl	0.792	0.554	0.935
Eigen value	5.8	4.2	-
% Variance	52.2	37.2	-
Cumulative % of Variance	52.2	89.4	-

Table 14: Factor Analysis (Sample 4) (Rotated Factor Loadings and Communalities, Varimax Rotation)

Variable	Factor 1	Factor 2	Communality
pH	-0.091	0.456	0.216
Alkalinity	0.995	-0.079	0.997
DO	-0.101	0.966	0.943
BOD	-0.149	-0.98	0.982
TDS	0.974	-0.039	0.951
TH	0.995	-0.079	0.997
Ca	0.995	-0.079	0.997
Mg	0.995	-0.079	0.997
NO_3	0.227	0.956	0.966
SO_4	-0.346	0.923	0.972
Cl	0.789	0.555	0.932
Eigen value	5.7	4.1	-
% Variance	52.2	38.2	-
Cumulative % of Variance	52.2	89.4	-

Table 15: Factor Analysis (Sample 5) (Rotated Factor Loadings and Communalities, Varimax Rotation)

Variable	Factor 1	Factor 2	Communality
pH	-0.11	0.349	0.227
Alkalinity	0.994	-0.083	0.996
DO	-0.099	0.967	0.944
BOD	-0.153	-0.979	0.982
TDS	0.974	-0.051	0.951
TH	0.994	-0.083	0.996
Ca	0.994	-0.083	0.996
Mg	0.994	-0.083	0.996
NO_3	0.222	0.960	0.971
SO_4	-0.336	0.925	0.968
Cl	0.973	0.551	0.933
Eigen value	5.9	4.3	-
% Variance	52.2	38.2	-
Cumulative % of Variance	52.2	89.4	-

CONCLUSIONS

The Physico-chemical characteristics are high at North-West corner (S1) where as South-East corner (S2), Centre (S3), and North-East corner (S4) are moderate & the South-West corner (S5) are low. Since the lake is receiving fresh cum treated water from Bhima River, the water quality is good. All anthropogenic activities are barred in the lake water viz., bathing, swimming, Cattle's washing etc., since the lake is well protected by pitching and fencing. The Physico-chemical Characteristics of Shri Sharanabasaveshwara lake at different sampling points were analyzed and found all the values within the permissible limits except BOD which may be because of wash water from treatment unit. The pH in Shri Sharanabasaveshwara lake is in between 7.45 to 8.77. The DO in Shri Sharanabasaveshwara lake varies from 7.35 to 8.65 mg/L. The BOD in Shri Sharanabasaveshwara lake varies from 96.65 to 113.70 mg/L. Factor analysis at all the sampling points has shown that DO is rich in water, NO3 and SO4 are present in the water is an inherent quality of Bhima river water. Factor analysis for sampling points shown moderate high value in chloride, which shows permanent hardness of water. In all the sampling points, the highest positive correlation is found between Chloride & Alkalinity (Cl & HCO3), Chloride & Total hardness (Cl & TH), Calcium hardness & Chloride (Ca & Cl), Magnesium hardness & Chloride (Mg & Cl), Nitrate & Chloride (NO3 & Cl), Nitrate & Sulphate (NO3 & SO4) this shows the permanent hardness

of water. Shri Sharanabasaveshwara lake is now being utilized only for boating, even fishing activities as been stopped by authorities.

REFERENCES

[1] Wood, R.B. and G.E. Gibson, Eutrophication and Loch Heagen. Water Res. 1974, 7, 163-287.
[2] Hemasundaram, A. K. Dhanalakshmi, B. Prasad and N.V.S. Naidu, Assessment of water quality with regard to surfactants in pilgrim town - a case study of Tirupati. Ultr. Scient. Phyl. Sci. 2003, 15(2): 189-194.
[3] Kajak, Z. Eutrofizacja jezior (Eutrophication of lakes), Warszawa, PWN, 1979, 233 p.
[4] Golterman.H.L and N.T. Qude, Eutrophication of lakes, rivers and coastal seas, The handbook of environmental chemistry (Ed. O.Hutzinger), Berlin Heidelberg, Springer-Verlag, 1991, 5(A): 70-124.
[5] Freeman.C., M.A. Lock and B. Reynolds, Climatic change and the release of immobilized nutrients from Welsh riparian wetland soils, Ecol. Eng., 1993, 2(4): 367- 373.
[6] Clair T.A., B.G. Sayer, J.R. Kramer and D.R.Eaton, Seasonal variation in the composition of aquatic organic matter in some Nova Scotion brown waters: A nuclear resonance approach, Hydrobiologia, 1996, 317(2): 141- 150.
[7] Dortch M.S., Removal of solids, nitrogen and phosphorus in the Cache River wetland, Wetlands, 1996, 16(3): 358-365.
[8] Craft C.B., 1997, Dynamics of nitrogen and phosphorus retention during wetland ecosystem succession, Wetland Ecology Management, 1997, 4(3): 177-187.
[9] Ansari A.H and S. Kumar, Effect of nitrate input on the release of phosphorus from a tropical lake sediment, Dimens. Polln., 2003, 2:120-126.
[10] Singh K.P., A. Malik, D. Mohan and S. Sinha, "Multivariate Statistical Techniques for the Evaluation of Spatial and Temporal Variations in Water Quality of Gomti River (India) - a Case Study", Water Research, 2004, 38 (18), PP 3980-3992.
[11] Kowalkowski T., R. Zbytniewski, J. Szpejna and B. Buszewski, Application of Chemo metrics in River Water Classification, Journal of Water Research, 2006, 40(4), PP. 744-752.
[12] Boyacioglu. H. and H. Boyacioglu, "Water Pollution Sources Assessment by Multivariate Statistical Methods in the Tahtali Basin, Turkey", Journal of Environmental Geology, 2006, 54(2), PP. 275-282.
[13] Liu. C.W., Lin K.H. and Kuo Y.M., Application of factor analysis in the assessment of groundwater quality in a black foot disease area in Taiwan, The Science of Total Environment, 2003, Vol. 313, pp77-89.

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