Seasonal Variations in Physico-Chemical Characteristics of Almatti Reservoir of Bijapur district, Karnataka State

S.B. Hulyal, B.B. Kaliwal [#1],

[#] *Post-Graduate Department of Studies in Biotechnology and Microbiology, Karnataka University, Dharwad – 580003, India*
[1] b_kaliwal@yahoo.com

***Abstract*- Almatti reservoir is one of the major perennial water resource located at about 63 km away from Bijapur is mainly used for drinking and irrigation. Monthly and seasonal variations of physico-chemical characteristics were studied from February, 2003 to January 2005 to study the various ecological parameters such as rainfall, humidity, air and water temperature, pH, electrical conductivity, dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, calcium, magnesium, chloride, nitrate, phosphate, sulphate, bicarbonate, total dissolved solids. The study revealed that there exists seasonal fluctuations of the factor and from data it was also apparent that various correlations between the factors could be seen. However, it is obvious that the absence of significant difference between sampling stations for all these parameters in the Almatti reservoir indicated fairly homogeneous conditions and the water quality is also found to be homogeneous. Study also in**dicated that the water is quite suitable for irrigation and pisciculture.

***Keywords*- fresh water reservoir; seasonal variations; physico-chemical parameters; Almatti reservoir**

I. INTRODUCTION

Water is one of the basic needs of the mankind and is a vital resource used for various activities such as drinking, irrigation, fish production, industrial cooling, power generation and many others. Increased human activities over the recent past years are imposing a greater stress on these ecosystems, resulting in changing their features. There is a progressive deterioration of water quality throughout the world. The causative factors responsible for degradation of water quality need to be evaluated so as to take proper steps before the situation becomes worst and uncontrollable.

tudies have been made on the limnological status of natural and man-made lakes and reservoirs in India mainly with an intention to assess the water quality ([1],[2],[3],[4],[5],[6]- [7]).

The Almatti reservoir under study is one of the major perennial reservoirs of the district located at about 63 km away from the Bijapur. It lies between 160º-19" North latitude and 75º-53'-15" East longitude. The catchment area of the reservoir is 13871 Sq. miles. The main purpose of reservoir is irrigation and power generation. Water is utilized for irrigation of 121690 Ha of land. A large number of major and minor carps are bred by fisherman and local villagers. The knowledge of a reservoir ecosystem is of considerable value in assessing the ecological nature of the reservoir, which can be studied by the assessment of the physical and chemical characters of the reservoir water. Hence, the present study is undertaken to analyse the physical and chemical nature of the reservoir water.

II. MATERIALS AND METHODS

The investigation was carried out for two years from February 2003 to January 2005. Surface water samples were collected at monthly intervals in a clean polythene container. The collected samples were brought to the laboratory for the estimation of various physico-chemical parameters as per the procedures given in standard methods [8]. Except rainfall, humidity, temperature and pH were expressed in mg/l (Table 1 and 2).

III. RESULTS

The results of the analysis of Almatti reservoir water were presented in Table 1 and Table 2.

A. Physical parameters of water

In the present investigation five physical parameters viz., rainfall, humidity, air and water

TABLE 1 MONTHLY VARIATIONS IN PHYSICO-CHEMICAL PARAMETERS OF WATER OF ALMATTI RESERVOIR FROM FEB. 2003 TO JAN. 2004

Values are mean ± standard deviation and average of five sites
All parameters except rainfall, humidity, temperature, pH and EC are expressed as mg/l

Months / Parameters	Feb. 03	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 04
Rainfall	0	7.2	23.9	0	10.4	54.9	62.7	53.3	23.4	4.5	0.5	0
Humidity	45	39	42	43	56	67	70	67	60	53	49	50
Air Temp.	26.6	29.1	31.2	31.4	28.6	26.6	25.9	26.0	26.3	27.1	24.1	23.0
Water Temp.	23.56 ± 0.37	26.16 ± 0.50	24.6 ± 1.51	24.3 ±0.44	22.4 ±0.54	24.1 ± 2.07	26.26 ± 0.48	26.88 ± 0.10	25.8 ± 0.66	23.32 ± 1.30	21.8 ± 0.57	22.34 ± 0.23
pH	7.06 ± 0.08	7.16 ± 0.03	7.16 ± 0.05	7.6 ± 0.06	7.8 ± 0.05	8.0 ± 0.06	7.7 ± 0.14	7.4 ± 0.10	7.2 ± 0.02	8.6 ± 0.06	7.24 ± 0.01	7.42 ± 0.09
Electrical conductivity	375.2 ± 3.96	377.92 ± 4.94	366.0 ± 3.80	421 ± 9.53	214.4 ± 6.94	423.0 ± 8.86	161.8 ± 13.80	210.2 ± 1.38	177.8 ± 7.66	224.0 ± 24.01	272.4 ± 19.88	257.4 ± 12.40
Dissolved oxygen	7.52 ± 0.37	7.12 ± 0.45	6.82 ± 0.54	6.36 ± 1.66	7.96 ± 0.70	6.7 ± 0.76	7.6 ± 1.38	7.38 ± 0.38	8.74 ± 0.90	7.62 ± 1.55	7.26 ± 0.71	8.36 ± 0.39
Free carbon dioxide	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Total alkalinity	136.6 ± 6.58	137.8 ± 6.14	140.0 ± 6.32	132.0 ± 2.82	78.4 ± 3.57	107.2 ± 6.57	62.4 ± 11.52	68.4 ± 9.44	60.0 ± 2.82	112.0 ± 13.5	88.0 ± 6.92	84.8 ± 3.34
Total hardness	153.8 ± 7.04	152.2 ± 8.22	149.6 ± 10.03	160.8 ± 4.38	117.6 ± 5.36	168.0 ± 10.95	80.8 ± 6.57	111.2 ± 9.47	70.4 ± 0.06	120.0 ± 23.15	105.6 ± 19.30	116.0 ± 5.65
Calcium	31.6 ± 0.70	32.64 ± 1.02	34.56 ± 1.43	35.12 ± 6.12	24.64 ± 3.68	32.5 ± 3.39	17.68 ± 2.83	17.56 ± 2.16	13.76 ± 0.87	34.64 ± 9.51	30.84 ± 3.94	20.8 ± 1.6
Magnesium	13.86 ± 1.81	14.14 ± 1.99	15.34 ± 3.02	17.47 ± 3.29	13.59 ± 2.47	21.02 ± 2.52	1.6 ± 2.39	10.15 ± 1.49	8.73 ± 1.37	6.35 ± 1.26	7.55 ± 3.55	15.53 ± 1.53
Chloride	54.04 ± 7.83	55.16 ± 7.68	56.0 ± 7.48	70.4 ± 7.26	48.8 ± 3.34	86.0 ± 2.0	48.8 ± 5.21	68.0 ± 5.61	40.8 ± 4.38	42.4 ± 5.36	36.0 ± 5.65	42.4 ± 3.57
Nitrate	4.3 ± 0.42	4.0 ± 0.36	3.8 ± 0.58	4.2 ± 0.83	2.8 ± 0.83	2.2 ± 0.83	2.6 ± 0.54	5.6 ± 1.51	7.0 ± 1.0	10.0 ± 00	3.6 ± 0.89	10.6 ± 0.89
Phosphate	00	00	00	0.004 ± 0.005	0.014 ± 0.005	0.016 ± 0.005	0.016 ± 0.005	0.052 ± 0.08	0.014 ± 0.005	0.012 ± 0.008	0.014 ± 0.005	0.014 ± 0.005
Sulphate	42.18 ± 10.40	42.64 ± 10.59	43.0 ± 10.95	31.6 ± 2.96	31.6 ± 1.67	31.6 ± 1.67	13.3 ± 1.78	13.86 ± 2.71	12.6 ± 0.54	17.0 ± 3.08	11.8 ± 1.30	13.4 ± 2.30
Bicarbonate	105.42 ± 10.87	106.52 ± 10.99	108.00 ± 11.66	79.2 ± 1.69	78.4 ± 3.57	67.2 ± 6.57	42.8 ± 20.27	45.4 ± 13.16	40.8 ± 3.34	40.6 ± 1.94	48.0 ± 6.92	70.4 ± 6.38
Total dissolved solids	24.66 ± 2.56	24.94 ± 2.50	25.24 ± 2.79	28.64 ± 0.71	16.6 ± 1.18	7.0 ± 2.73	11.66 ± 1.34	9.08 ± 1.46	2.58 ± 0.52	6.68 ± 2.74	6.04 ± 2.32	16.28 ± 0.69

temperature, pH and electrical conductivity of reservoir were studied monthly and seasonally. The average values of physico-chemical parameters are presented in the Table 1 and 2 and seasonal average values of the various parameters were given in the Table 3.

1) *Rainfall:* Bijapur region experienced moderate rainfall during the study period. Usually heavy rainfall occurs

TABLE 2 MONTHLY VARIATIONS IN PHYSICO-CHEMICAL PARAMETERS OF WATER OF ALMATTI RESERVOIR FROM FEB. 2004 TO JAN. 2005.

Months / Parameters	Feb. 04	March	April	May	June	July	Aug.	Sept.	Oct.	Nov.	Dec.	Jan. 05

Rainfall	0	0	25.3	86.3	55.8	114.4	30.3	166.4	34.2	0.4	0	1.3
Humidity	42	39	44	57	65	72	73	72	62	50	45	48
Air Temp.	25.3	29.4	30.5	28.8	26.1	25.6	24.6	25.2	25.2	30.0	22.2	23.5
Water Temp.	23.4 ± 0.41	28.5 ± 0.35	27.0 ± 0.35	28.08 ± 0.39	26.38 ± 0.30	24.84 ± 0.08	26.02 ± 0.04	26.9 ± 0.22	26.28 ± 0.89	23.34 ± 1.07	22.36 ± 0.47	22.8 ± 0.30
pH	7.33 ± 0.03	7.43 ± 0.07	7.44 ± 0.08	7.25 ± 0.07	7.52 ± 0.13	7.33 ± 0.04	7.42 ± 0.08	7.46 ± 0.07	7.65 ± 0.02	7.93 ± 0.06	7.04 ± 0.02	7.42 ± 0.04
Electrical conductivity	273.8 ± 20.43	316.8 ± 33.17	353.4 ± 17.28	315.4 ± 13.46	308.6 ± 15.67	186.6 ± 26.82	245.0 ± 60.31	220.0 ± 7.90	182.0 ± 4.47	223.2 ± 10.08	265.8 ± 14.27	267.2 ± 9.88
Dissolved oxygen	7.54 ± 0.36	7.84 ± 0.18	7.76 ± 0.15	7.66 ± 0.13	7.52 ± 0.31	7.68 ± 0.10	6.86 ± 0.05	7.3 ± 0.14	7.7 ± 0.2	7.68 ± 0.16	6.7 ± 0.76	8.1 ± 0.26
Free carbon dioxide	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil	Nil
Total alkalinity	96.0 ± 5.65	108.8 ± 1.78	104.0 ± 2.82	108.0 ± 7.48	92.8 ± 9.95	64.0 ± 8.94	58.4 ± 11.52	68.0 ± 3.08	65.0 ± 3.0	112.4 ± 2.50	107.2 ± 6.57	82.5 ± 1.0
Total hardness	116.8 ± 7.15	122.4 ± 18.24	120.0 ± 4.89	141.6 ± 6.69	100.8 ± 7.69	89.6 ± 12.83	77.6 ± 13.14	115.6 ± 3.78	87.6 ± 5.59	124.4 ± 9.44	115.0 ± 15.81	116.0 ± 3.08
Calcium	28.4 ± 2.22	13.76 ± 4.32	30.08 ± 2.62	27.84 ± 2.67	23.36 ± 3.31	18.72 ± 2.50	23.36 ± 3.50	23.38 ± 3.71	23.66 ± 3.59	24.54 ± 3.05	25.04 ± 2.12	21.36 ± 0.68
Magnesium	11.14 ± 2.30	21.36 ± 6.83	10.87 ± 1.06	17.48 ± 0.97	10.29 ± 2.62	10.38 ± 3.49	4.65 ± 3.52	10.88 ± 2.65	11.4 ± 1.22	13.34 ± 1.53	14.26 ± 1.51	15.42 ± 0.37
Chloride	42.4 ± 5.36	60.8 ± 3.34	48.8 ± 1.78	59.2 ± 6.57	42.4 ± 2.19	51.2 ± 3.34	52.0 ± 4.89	51.0 ± 4.41	57.2 ± 4.14	53.0 ± 2.44	83.6 ± 2.60	42.2 ± 1.48
Nitrate	6.4 ± 1.51	7.2 ± 2.16	6.2 ± 1.09	6.6 ± 2.30	8.4 ± 2.19	6.2 ± 1.64	6.2 ± 1.64	6.4 ± 0.54	7.0 ± 1.0	8.4 ± 0.54	2.2 ± 0.83	10.4 ± 0.54
Phosphate	0.016 ± 0.005	0.014 ± 0.005	0.016 ± 0.005	0.016 ± 0.005	0.016 ± 0.005	0.014 ± 0.005	0.016 ± 0.005	0.018 ± 0.004	0.016 ± 0.005	0.016 ± 0.005	0.016 ± 0.005	0.016 ± 0.005
Sulphate	13.2 ± 1.48	14.6 ± 0.89	15.8 ± 1.64	15.4 ± 1.14	16.6 ± 2.88	14.0 ± 2.64	12.6 ± 2.50	11.8 ± 1.92	15.4 ± 2.07	13.6 ± 2.07	11.8 ± 1.64	12.8 ± 0.83
Bicarbonate	65.6 ± 15.38	78.2 ± 7.29	98.4 ± 16.13	88.8 ± 10.35	24.4 ± 6.69	12.0 ± 16.97	41.2 ± 17.18	40.6 ± 12.48	43.2 ± 12.87	46.8 ± 13.51	42.6 ± 12.44	71.2 ± 2.28
Total dissolved solids	17.74 ± 0.57	6.56 ± 4.08	20.68 ± 0.61	25.52 ± 2.68	21.04 ± 1.07	12.72 ± 1.85	16.68 ± 3.99	17.76 ± 6.48	15.28 ± 3.39	18.02 ± 4.73	18.5 ± 1.98	15.66 ± 0.42

Values are mean ± standard deviation and average of five sites
All parameters except rainfall, humidity, temperature, pH and EC are expressed as mg/l

only in monsoon months (June to September). During the study period heavy rainfall 62.7 mm occurred in August in 2003, while in 2004 heavy rainfall was recorded from May to September except August. In the present investigation the season wise analysis showed that the rainfall in the Almatti reservoir was maximum during June to September in 2003 and 2004 respectively (Table 3). The variations in the rainfall in the different seasons of the study period had its influence on other hydrological features of the reservoir.

2) *Humidity:* The highest relative humidity 70% was observed in August and lowest 39% in March. Similarly during 2004 the relative humidity fluctuated from 39% in March to 73% in August (Table 1 and 2). Seasonally the relative humidity value was maximum during monsoon, comparatively less during winter and least during summer season of both the years of study (Table 3).

3) *Air and Water Temperature:* During 2003 the air temperature varied between 24.1ºC in December and 31.4ºC in May, while the surface water temperature ranged from 21.8ºC in December to 26.8ºC in September, whereas in 2004 the air temperature ranged from 22.2ºC in December to 30.5º in April while the water temperature ranged from 22.3ºC in December to 28.5ºC in March (Table 1 and 2). The ambient temperature was always remained higher then the water

temperature. In the present investigation the season wise analysis showed that the average air and water temperature in the reservoir was maximum during summer, comparatively less during monsoons and least during winter season (Table 3).

4) *pH:* The pH of Almatti reservoir varied between 7.06 (Feb) and 8.6 (Nov) during the first year. While during the second year, the pH ranges from 7.04 (Dec) to 7.93 (Nov). The pH of Almatti reservoir remained alkaline throughout the period of study. In the present study season wise analysis of pH in the reservoir showed maximum in monsoon and minimum in summer during 2003. While in 2004, the maximum pH was found in winter and minimum in summer (Table 3).

5) *Electrical conductivity (EC):* The EC value ranged between 161.8 µmhos/ cm (Aug) and 377.9 µmhos/ cm (march) during 2003. While in 2004, the values ranges from 182.0 µmhos/ cm (Oct) to 353.4 µmhos/ cm (April). The EC values showed marked seasonal variation being maximum during summer and minimum during winter season (Table 3).

B. . Chemical parameters of water

In the present investigation dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, calcium, magnesium, chloride, nitrate, phosphate, sulphate, bicarbonate and total dissolved solids were determined monthly and seasonally.

1) Dissolved Oxygen: The amount of dissolved oxygen varies from 6.36 mg/ l (May) to 8.7 mg/ l (Oct) and 6.7 mg/ l (Dec) to 8.1 mg/ l (Jan) during the year 2003 and 2004 respectively (Table 1 and 2). The minimum dissolved oxygen recorded during summer and maximum during winter in 2003, whereas in 2004 the minimum value was found in monsoon and maximum in summer (Table 3).

2) *Free Carbon dioxide:* The reservoir was devoid of carbon dioxide. It was absent at all the sampling stations throughout the investigation period (Table 1 and 2).

3) *Total alkalinity:* The values of total alkalinity varied from 60 mg/l (Oct) to 140 mg/l (Apr) during 2003 and 64 mg/l (July) to 112.4 mg/l (Nov) during 2004. Lower alkalinity values were recorded during monsoon and higher values were recorded during summer (Table 3).

4) *Total hardness:* The total hardness ranged between 70.4 mg/l (Oct) and 168 mg/ l (July) during 2003 and 77.6 mg/l (Aug) to 141.6 mg/ l (May) during 2004. The total hardness ranged between 70.4 mg/l (Oct) and 168 mg/l (July) during two years of study (Table. 1 and 2). The total hardness was found higher during summer months than winters and rainy seasons (Table 3).

5) Calcium: Calcium content of water ranged from 13.76 mg/ l (Oct) to 35.12 mg/ l (May) during 2003 and 13.76 mg/ l (March) to 30.08 mg/l (April) during 2004 (Table 1 and 2). It was minimum during monsoon and maximum during summer months of both the year of investigation (Tables 3).

6) Magnesium: Magnesium content in the reservoir water varied from 1.6 mg./ l (Aug) to 21.02 mg/l (July) in 2003 and 4.65 mg/ l (Aug) to 21.36 mg/ l (March) during 2004. It was minimum during winter and maximum during summer during 2003 and 2004 respectively (Table 3).

7) *Chloride:* The chloride concentration in Almatti reservoir ranged from 36.0 mg/l (Dec) to 86 mg/l (July) during 2003 and maintained the same level except December. During 2004 chloride values ranges from 42.2 mg/l (Jan) to 83.6 mg/l (Dec) (Tables 1 and2). Seasonal fluctuations have been occurred in chloride concentration during 2003, the maximum concentration of chloride was found in monsoon and minimum in winter. While in 2004 maximum values were found in winter and minimum in monsoon (Table 3).

8) *Nitrate*: The nitrate content in the reservoir ranged from 2.2 mg/ l (July) to 10.6 mg/l (Jan) in 2003 and 2.2 mg/ l (Dec) to 10.4 mg/l (Jan) during 2004. Seasonally highest values of nitrates were recorded during winter season and lowest during monsoon season for both the years of investigation period (Table 3).

9) *Phosphate:* The phosphate content in the reservoir ranged between nil (Feb to May) and 0.052 mg/l (Sept) during 2003. While in 2004 the value ranges from 0.014 mg/l (March and July) to 0.018 mg/l (Sept) (Tables 1 and 2). Highest seasonal mean values were recorded during monsoon and lowest during summer (Table 3).

10) *Sulphate :* Peak values of 43 mg/l was obtained in April and lowest value of 11.8 mg/l was in December, 2003 while

TABLE 3 SEASONAL VARIATIONS IN PHYSICO-CHEMICAL PARAMETERS OF WATER OF ALMATTI RESERVOIR FROM FEB. 2003 TO JAN. 2005.

Seasons Parameters	**Feb. 2003 to Jan. 2004**			**Feb. 2004 to Jan. 2005**		
	Summer	Monsoon	Winter	Summer	Monsoon	Winter
Rainfall	7.77 ± 11.27	45.32 ± 23.64	7.1 ± 11.05	27.90 ± 40.71	91.72 ± 60.97	8.97 ± 16.82
Humidity	42.25 ± 2.5	65.0 ± 6.16	53.0 ± 4.96	45.5 ± 7.93	70.50 ± 3.69	51.25 ± 7.45
Air Temp.	29.57 ± 2.23	26.77 ± 1.25	25.12 ± 1.90	27.05 ± 3.50	25.37 ± 0.76	25.22 ± 3.41
Water Temp.	24.65 ± 1.09	24.91 ± 2.05	23.31 ± 1.77	26.74 ± 2.31	26.03 ± 0.87	23.69 ± 1.76

pH	7.24 ± 0.24	7.72 ± 0.25	7.61 ± 0.66	7.36 ± 0.08	7.43 ± 0.07	7.51 ± 0.37
Electrical conductivity	385.03 ± 24.51	252.35 ± 116.24	232.9 ± 41.93	314.85 ± 32.53	240.05 ± 51.58	234.55 ± 40.55
Dissolved oxygen	6.95 ± 0.48	7.41 ± 0.53	7.99 ± 0.67	7.7 ± 0.12	7.34 ± 0.35	7.54 ± 0.59
Free carbon dioxide	Nil	Nil	Nil	Nil	Nil	Nil
Total alkalinity	136.60 ± 3.37	79.1 ± 19.86	86.2 ± 21.27	104.2 ± 5.85	70.8 ± 15.18	91.77 ± 22.10
Total hardness	154.10 ± 4.79	119.4 ± 36.15	103.0 ± 22.56	125.2 ± 11.17	95.9 ± 16.19	110.75 ± 15.99
Calcium	33.48 ± 1.64	23.09 ± 7.08	25.01 ± 9.50	25.02 ± 7.56	22.20 ± 2.32	23.65 ± 1.62
Magnesium	15.20 ± 1.64	11.59 ± 8.05	9.54 ± 4.10	15.21 ± 5.11	9.05 ± 2.94	13.60 ± 1.69
Chloride	58.90 ± 7.70	62.9 ± 17.86	40.4 ± 3.02	52.8 ± 8.73	49.15 ± 4.52	59.0 ± 17.5
Nitrate	4.07 ± 0.22	3.3 ± 1.55	7.8 ± 3.21	6.6 ± 0.43	6.8 ± 1.07	7.0 ± 3.49
Phosphate	0.001 ± 0.002	0.0177 ± 0.238	0.0135 ± 0.001	0.0155 ± 0.001	0.016 ± 0.001	0.016 ± 0.001
Sulphate	39.85 ± 5.51	22.59 ± 10.40	13.7 ± 2.29	14.75 ± 1.14	13.75 ± 2.10	13.4 ± 1.52
Bicarbonate	99.785 ± 13.76	58.45 ± 17.22	49.95 ± 14.06	82.75 ± 14.09	29.55 ± 14.05	50.95 ± 13.62
Total dissolved solids	25.87 ± 1.86	11.02 ± 4.03	7.89 ± 5.87	17.62 ± 8.04	17.05 ± 3.43	16.86 ± 1.63

Values are mean ± standard deviation
All parameters except rainfall, humidity, temperature, pH and EC are expressed as mg/l

during 2004 the highest value of 16.6 mg/l was obtained in June and lowest value of 11.8 mg/l was observed in September and December. SO_4 concentration was found to be fluctuated from 2003 to 2004 (Table 1 and 2). Seasonal sulphate content was more during summer followed by monsoon and less during winter in both the years (Table 3).

11) *Bicarbonate*: Bicarbonate content in the reservoir ranged from 40.6 mg/l (Nov) to 108 mg/l (April) during 2003. In 2004 values ranged between 12 mg/l (July) and 98.4 mg/ l (April). Seasonally bicarbonate in the reservoir was more in summer followed by monsoon and less value was found in winter months during 2003. While in 2004 bicarbonate level was high in summer and less in monsoon season (Table *3).*

12) Total Dissolved Solids (TDS): The maximum values of TDS during 2003 were recorded in May (28.64 mg/l) and the minimum values were observed in October (2.58 mg/l). In 2004 the values of TDS ranged from 6.56 mg/l (Mar) to 25.52 mg/l (May). Seasonally TDS values were recorded maximum in summer followed by rainy season and less during winter months of both the years of study period (Table 3).

IV. DISCUSSION

In the development of aquatic resources the ecology of the water reservoir plays an important role, since ecology determines the habitability and abundance of flora and fauna in the different seconds of the reservoir. Considerable hydrobiological investigations have been carried out on the man made lakes in and outside India. In the limnological study the physico-chemical factors must be taken into consideration in understanding the ecophysiology of the natural bodies of water. Each factor contributes in making of the specific ecosystem and thus determines the topic dynamics of the aquatic body. Therefore any change in one factor directly or indirectly alters the other factors. Hence, the study of the physico-chemical characteristics of aquatic systems is pertinent for the proper understanding of various limnological phenomena [9].

It has been pointed out in journal article in [10] that in the tropics the amount of rainfall plays a significant role in regulating the various seasonal biological rhythms and the changes in the concentration of certain chemical substances which enter with the rain water into the reservoir suggests its effects on them, which in turn influence the fluctuations in the quantity and quality of plankton. Hence, the study has been designed to understand the hydrobiological characters of the reservoirs and to identify the factors governing the water quality which determine the potability of water and the suitability for fish culture and irrigation purpose. During the present investigation five physical factors viz. rainfall, humidity, air and water temperature, pH and electrical conductivity of reservoir were studied monthly and seasonally.

A. Physical parameters of water

1) Rainfall: The present study area, Almatti which is coming under Bijapur district is characterized by high annual temperature with evaporation exceeding precipitation. The average rainfall was 20.06 mm and 42.86 mm during 2003 and 2004 respectively. Because of large amount of the radiant energy received the potential evapotranspiration was always higher than the precipitation except July, August and September. Thus the meteorological factors namely rainfall, humidity, light intensity and temperature govern the physico-chemical properties of the reservoir which in turn influence plankton production. Among the physical factors rainfall is considered important in regulating the biological rhythms in the present study rainfall exerted a very distinct impact on biotic and abiotic factors in the reservoir.

2) *Humidity:* The data on relative humidity for two years have shown that from June to November the humidity was high and remained low level during other months. Seasonally the relative humidity value was maximum during monsoon comparatively less during winter and least during summer season of both the years of study.

3) *Air and Water Temperature:* Temperature is a physical factor that alters the quality of the water and considered as an important factor in controlling the fluctuation of plankton and functioning of the aquatic ecosystem [11]. The surface water temperature confirmed to tropical character and was distinctly influenced by air temperature. Monthly fluctuation in the surface water temperature was correlated to that of ambient temperature.

The air temperature was observed to be higher than the surface water temperature which corresponded with the work of journal article in ([12], [13]-[14]). In the present investigation, the seasonwise analysis showed that the average air and water temperature in the reservoir was maximum during summers, comparatively less during monsoon and least during winter season, which is in concurrent with the reports of journal article in [15].

The results also showed that the water temperature was consistently lower than the atmospheric temperature. The pattern of fluctuation is identical with that of the steady change in the atmospheric temperature with the change in the season's results in the corresponding changes in the water temperature. A steady rise or fall in the water temperature is coincides with the rise or fall in the atmospheric temperature due to the increased or decreased solar radiations. Thermal conditions in the superficial layers of reservoir water are mainly influenced by atmospheric temperature.

4) pH : The hydrogen ion concentration of natural water is an important environmental factor. The variation in pH is linked with the species composition and life processes of animal and plant communities inhabiting them [16]. There are two general ways of regarding the limnological value of pH, 1) as a limiting factor and 2) as an index of a general environmental condition [17]. The proper determination of pH may give indirect information about free carbon dioxide content, alkalinity, dissolved oxygen content. The changes in pH of water will bring about subtle changes in the functional and structural variations in the organisms of the water body. High pH is due to very high concentration of soda in lakes, [11]. In the present study, seasonwise analysis of pH in the reservoir showed maximum in monsoon and minimum in summer during 2003. While in 2004 maximum pH was found in winter and minimum in summer. In the present study highest pH values observed during winter appeared to be influenced by water level, density of phytoplankton and increased dissolved oxygen level which are in agreement with the findings of journal article in [18], [19]. It has been reported that if the water body is neither highly alkaline nor highly acidic, the pH of water is principally governed by the carbon dioxide – bicarbonate – carbonate system [9]. Domestic waters have a pH range of 6.5 to 8.5 and at value outside this range water can be corrosive or can cause precipitation of metal salts. The pH of Almatti reservoir was found to be alkaline throughout the study period. The annual fluctuations are small, indicating good buffering capacity. It has been suggested that the high pH is normally associated with a high photosynthetic activity in water [20], [21]. The water having pH range of 6.5 to 9.0 are most suitable for pond aquaculture [16]. Thus the present water body shows higher pH values and can be used for fresh water fish culture by local fisherman. At pH below 6 or 9.5 for extended, fish will not grow well, though they may just survive. In the present study, the high pH in the reservoir may be due to an increased utilization of CO_2 in photosynthesis.

5) *Electrical Conductivity (EC):* Electrical conductivity is also an important parameter of water and it depends on the nature and concentration of ionized salts. The more conductivity of water the lesser is its resistance to electric flow, thereby indicating higher concentration of dissolved salts and higher trophic status of the system [22].The electrical conductivity of water is due to ionization of dissolved organic and inorganic solids and becomes a major of total dissolved solids. The electrical conductivity is used as an index to select the suitability of water for agricultural purpose. Journal article in [23] has classified the irrigation water according to the electrical conductivity (µmhos/ cm) as E.C. < 250 Excellent, 250-750 Good, 750-2000 Permissible, 2000-3000 doubtful, >3000 Unsuitable. Following this criteria the water of Almatti reservoir is good for irrigation purpose.

The relation of E.C. with temperature could be explained on the basis of the fact that solubility of minerals and other inorganic matter increase with increase in water temperature. Moreover the accumulation of dissolved salts due to high rate of evaporation in summer increases the electrical conductivity of water. Hence, the present water body shows high electrical conductivity value during summer and low in winter months. Journal article in [24] have reported maximum E.C. value during summer and minimum during winter which is in agreement with the present findings. The variations in electrical conductivity have been reported from one reservoir to another ([25], [26], [27]-[28]). In the present investigation chemical parameters such as dissolved oxygen, free carbon dioxide, total alkalinity, total hardness, calcium, magnesium, chloride, nitrate, phosphate, sulphate, bicarbonate and total dissolved solids were determined monthly and seasonally.

B. *Chemical Parameters of Water*

1) *Dissolved Oxygen*: Dissolved oxygen in water is of great limnological significance as it regulates many metabolic processes of aquatic organisms. The short and long term variations in dissolved oxygen in fresh water bodies give a good measure of their trophic state. Oxygen content is important for direct need of many organisms and affects the solubility of many nutrients and therefore the productivity of aquatic ecosystem [29]. In the present investigation DO concentration in the reservoir exerted a seasonal change which is in accordance with the investigation of a PhD thesis in [30]. During the winter months higher oxygen concentration in the reservoir indicated higher autotrophic activity and low organic and inorganic load during 2003-2004, this was in agreement with the reports of journal article in ([14], [31], [32]--[7]). The decrease in the amount of DO in summer may be attributed to high temperature due to which the oxygen holding capacity of water decreases [17] Whereas during 2004-2005 the DO concentration was maximum in summer and lower values in monsoon in the reservoir serve to emphasize the overriding influence exerted by factors (other than temperature) such as greater abundance of photosynthesizing organisms. Journal article in [33] reported low concentration of DO in monsoon in the Fort Lake might be due to excessive growth of bacteria which utilized oxygen for their metabolic activities. Journal article in [34] have recorded maximum DO in summers and minimum in monsoon. Journal article in [35] have reported lower DO values in monsoon months and higher values during summer, associated with high phytoplankton population.

2) *Free Carbon Dioxide*: The CO2, was absent in the water of the Almatti reservoir throughout the period of study. The absence of free CO2 in some reservoirs/ lakes located in different parts has also been reported [36], [37]. Therefore, with the absence of CO2 in non-polluted water bodies are apparently due to higher photosynthetic activity and higher pH which results in the conversion of CO2 into HCO3 and CO3. The fluctuation in free CO2 values corresponds directly with standing crop of phytoplankton. As the number of phytoplankton increases through winter and summer months the free carbon dioxide disappears because of greater utilization of free CO2 for photosynthetic activity of journal article in [38].

3) *Total Alkalinity:* Total alkalinity is used as a measure of productivity [16] and he has also reported that natural water bodies in tropics usually shows a wide range of fluctuations in total alkalinity values depending upon the location and season. Journal article in [39] have classified waters into nutrient status based on alkalinity namely 1 to 15 mg/l as nutrient poor, 16 to 60 mg/l as moderately rich and more than 60 mg/l as nutrient rich .evidently the Almatti reservoir water in the present study may be categorized as nutrient rich. Journal article in [40] alkalinity below 50 mg/l indicates low photosynthetic rate. In the present study the total alkalinity in the reservoir remained always high indicating high photosynthetic rate. Journal article in [2]has recorded 89 mg/l to 170 mg/l for Bhutanal reservoir in Bijapur district. A PhD thesis in [6] has recorded 24.2 mg/l to 34.2 mg/l total alkalinity in Rakkasakoppa reservoir at Belgaum. Journal article in [7] has recorded 131.53 mg/l to 223.96 mg/l total alkalinity in Talsande reservoir in Kolhapur district and he has also reported that the total alkalinity in Attigre reservoir was 88.2 mg/l to 166.92 mg/l suggested minimum during monsoon and maximum during summer months. The total alkalinity variations have also been reported in number of reservoirs and lakes in India. In the present study the lower alkalinity values were recorded during monsoon and higher in winter and summer. In the similar report, Journal article in [9] has observed the minimum alkalinity during monsoon and maximum in the summer. Higher alkalinity in summer may be attributed to increased rate of decomposition, during which CO2 is liberated which reacts with water to form HCO3 increasing the total alkalinity in summer. Similar suggestions have been given by a journal article in [41], [42].TN the present study 64 mg/ml the total alkalinity in monsoon may be due to dilution effect. Similar results have been reported by a journal article in [43].

4) Total Hardness: The hardness of water is mainly due to the presence of various salts of Ca and Mg and it is used to classify waters as “hard” or “soft”. Journal article in [44] has given the range of 80 to 230 mg/l and 105 to 250 mg/l from Harlike reservoir (Punjab). Journal article in [45] have reported 134 to 148 mg/l and 134 to 150 mg/l hardness for Siddhewadi and Ped reservoirs respectively. Journal article in [43] have reported the range of 18 to 134 mg/l hardness for Dahikhuta reservoir.

As per test characteristics for drinking water a standard in [46] the desirable maximum limit of hardness is 300 mg/l. The hardness beyond this limit causes encrustation of water supply structure and adversely affects on domestic use [47]. Hence, the water of Almatti reservoir was found to be suitable for drinking and irrigation purpose, after the treatment.

Higher values of total hardness during summer season of present reservoir water can be attributed to decrease in water volume and increase in the rate of evaporation at high temperature. Journal article in [48], [49] have also recorded that the higher hardness in summer and lower in winter, which is in agreement with present findings on the other hand higher hardness in summer and lower in monsoon were also reported journal article in([50],[51],[32],[42],[19]). The present findings are also in conformity with these observations.

5) *Calcium:* The present findings revealed that calcium content was higher in summer and lower in monsoon months.

The decrease of their level in the water may be due to absorption by the phytoplankton and macrophytes journal article in [52].While increase in some months could be possibly due to a low rate of uptake by these organisms, otherwise the values of Ca may be expected from macrophytic decomposition and allochthonous supply. Any value above 25 mg/l indicates calcium rich water journal article in [53].As per these criteria the water of Almatti reservoir is poor in calcium ions. The maximum desirable limit of calcium in drinking water is 75 mg/l and maximum permissible limit is 200 mg/l. The calcium is an essential constituent of human beings. The low content of calcium in drinking water may cause rickets and defective teeth. It is essential for nervous system, cardiac function and in coagulation of blood a journal article in [54]. Higher calcium content in drinking water causes encrustation in water supply structure and adversely affects on domestic use [47]. The calcium values in Almatti reservoir are found to be in desirable limit, for the domestic use.

6) *Magnesium:* Magnesium is required universally by chlorophyllous plants as the component of chlorophyll molecule. Magnesium was relatively lower than calcium in both the years of study period due to lesser occurrence of magnesium minerals in bottom strata of the reservoir. In the reservoir high value was found in summer followed by monsoon during 2003 but during 2004 highest value during summer followed by winter months. However, variation during monsoon and winter period was negligible. Similar observations have been made by several investigators. Investigations have been shown in person living in area containing water resources with higher hardness, magnesium and potassium are significantly increased in heart muscles [54]. The permissible limit of magnesium content for drinking purpose is 50 mg/l maximum limit is 150 mg/l. The maximum values are found to be below the desirable limit in Almatti reservoir.

7) Chloride: Chloride one of the anions is generally considered as a major factor to equalise cations and plays active role in the photolysis of water and photophosphorelation reactions in autotrophs a PhD thesis in [30]. The most important source of chloride in natural waters is the discharge of sewage. In very high concentration it gives a salty taste to the water. The concentration of salts in solution is critical to proper plant growth also affect taste and general suitability of drinking water. In fresh waters the manifold increase in chlorides may be largely due to industrial sources, municipal waste waters etc. [11]. In the present study, the chloride content in the reservoir was low and only slightly higher value was noticed in monsoon during 2003 that could perhaps be attributed to the increasing organic wastes of human origin with rain water and it is also showed seasonal fluctuations. The desirable limit of chloride concentration in drinking water is 250 mg/l [47]. As per these criteria in the present study, the chloride value of Almatti reservoir lies in acceptable limit.

8) Nitrate (NO3 -N): Nitrate is normally the most common form of combined inorganic and organic nitrogen in lakes and streams, it moves freely through soils along with subsurface waters. The concentration and rate of supply of nitrate is intimately connected with the land use practices of surrounding watershed. Nitrates were reported in lower quantities in Almatti reservoir, which might be due to utilization by phytoplankton and macrophytes. Though nitrates are in lower concentration they are in somewhat better quantities during post monsoon. Similar findings have been made by a journal article in [32].

9) Phosphate (PO4-P): The phosphate is one of the most important major nutrients, that is required to biota. Although needed in small amounts, it is one of the more common phytoplankton growth limiting elements, because of the geo-chemical shortage of phosphorus in many drainage basins together with the lack of phosphorus equivalent to nitrogen fixation. The living organisms carry out various vital activities in the presence of this element for the synthesis of nucleic acid and release of energy in the form of ATP etc. [55]. Hence, it has been regarded as a limiting factor.

In the present study, PO4 content in the Almatti reservoir was fluctuated between 0.004 to 0.052 mg/l and 0.014 to 0.018 mg/l in 2003 and 2004 respectively. The similar ranges of values were reported by some workers viz., PhD thesis in [7] recorded 0.058 mg/l to 0.228 mg/l in 99 and 0.051 mg/l to 0.22 mg/l during 2000 in Talsande reservoir. In the present study, highest seasonal mean values were reported during monsoon and lowest during winter which is in conformity with ([54], [7], [32],-[19]). The higher phosphate observed during monsoon months could be attributed influx through rain water and surface run off, a journal article in [12]. High PO4 during monsoon might be due to influx of rain water containing fertilizers from the fields which brings PO4 from catchment area, which is agreement with observations made by a journal article in [57].

10) *Sulphate (SO4):* Sulphate plays an important role in soft water systems where complex metal ions prevent reacting with other substances [11]. In the present study, sulphate concentration was found to be fluctuated and observed very low values of SO4 in both the years of study period. As per the WHO standard drinking water highest permissible limit is 200 mg/l. By comparing with this limit, the SO4 concentration in the Almatti reservoir is well below the permissible limit. Seasonally average peak value was noted in summer followed by winter during 2003. While in 2004 the highest value was noted in pre monsoon period followed by winter. Similar observation was made by a journal article in [58] and reported that seasonal average highest value was in monsoon months. It has been shown that 0.5 ppm of sulphate is too low for algal growth [59].However, in the present study, the high value of SO4 in summer may be due to sulphate released by the decomposition of organic matter, and low value of SO4 in winter might be due to absorption by phytoplankton population. Similar observations were made by journal article in [58], [2] - [6].s

11) *Bicarbonate:* The carbonates and bicarbonates are common chemical factors in most of the water bodies because carbonate minerals are abundant in nature and contribution to alkalinity by hydroxides is rare in nature. In the reservoir the bicarbonate alkalinity varied seasonally with definite pattern, being highest during summer and lowest during rainy season.

In the present investigation the bicarbonate alkalinity was found highest during summer season and lowest during monsoon. Lower concentration of carbonates and bicarbonates

during monsoon can be attributed to the decreased rate of evaporation coupled with influx of large volume of water resulted in to dilution of carbonates and bicarbonates. This is consistent with the findings of a journal article in [60], [61] suggested that higher temperature in summer results into increased rate of organic decomposition during which CO2 is liberated which reacts with water to form bicarbonates thereby increasing the total alkalinity of water. Journal article in [62] has recorded higher bicarbonate alkalinity during summer and lowest during monsoon. These observations are in agreement with the present findings.

12) Total Dissolved Solids (TDS): All waters in nature contain dissolved solids. As water is the universal solvent, this dissolves different types of materials as compared to other solvents [17]. The dissolved solids. Journal article in [63] reported maximum TDS during summer and minimum during winter which supports our findings.

The total dissolved solids indicate the general nature of water quality or salinity. The water containing more than 500 mg/l of TDS is not considerable for drinking water purpose. Hence, 500 mg/l is the desirable limit and 1500 mg/l is maximum permissible limit for domestic use a standard in [64].Beyond the desirable limit palatability of water decreases and may cause gastrointestinal disorders a standard in [12].It is evident that TDS values of the present reservoir water lies in the desirable limit.

V. CONCLUSION

In conclusion, the present study revealed that Almatti reservoir is of the better quality, although there is need in continuous monitoring to maintain the quality of drinking water. However, government should take necessary steps to beautify the water of the reservoir before reaching eutrophic condition. The results showed that Almatti reservoir water is suitable source for supply of water for drinking, irrigation and also useful for fish culture.

ACKNOWLEDGEMENT

The authors express their sincere thanks to Karnataka University, Dharwad for providing financial support and Chairman, Post-Graduate Department of Studies in Zoology for providing facilities.

REFERENCES

[1] P.K Goel, R.K. Trivedy, and S.V. Bhave, "Studies on the limnology of a fresh water bodies in southwestern Maharasthra", *Indian J. Environ. Prot.* 5(1), 19-25. 1985.

[2] S.M. Karikal, "Limnobiotic study on the Bhutnal reservoir from Bijapur area". Ph.D. thesis, submitted to Karnatak Univ. Dharwad, 1995.

[3] S.A. Abbasi, K.S. Bhaliya, Kunhi, A.V.M, and R.S.Soni, "Studies on limnology of Kuttadi Lake (North Kerala)", *Eco. Env. Cons*., vol 2, pp.17-27, 1996.

[4] D.N. Singh, "Seasonal variation of zooplankton in a tropical lake", *Geobios*. 27(2-3), pp.97-100, 2000.

[5] Y. Shastri, and D.C Pendse, "Hydrobiological study of Dahikhuta reservoir", *J. Environ. Biol.*, 22 (1), p.67-70, 2001.

[6] B.N. Sunkad, "Studies on biodiversity of wetlands with special reference to the physico-chemical factors", thesis, submitted to the Karnatak University, Dharwad. 2002.

[7] M.S. Hujare, "Hydrobiologial studies on some water reservoirs of Hatkanangale Tahsil (Maharashtra)", thesis, submitted to the Shivaji University, Kolhapur. 2005.

[8] APHA, "Standard Methods for the Examination of Water and Waste water", *American Public Health Association. Inc. New York*. 18th Ed, 1991.

[9] G.E. Hutchinson, "*A treatise on Limnology Vol.-I. Geography*, Physics and Chemistry. John Wiley and Sons, Inc. p. 1015, 1957.

[10] G.S Carter, "Tropical climates and Biology", *Nature (Lond.)*, 187, p.843, 1960.

[11] R.G. Wetzel, *Limnology*, W.B. Sunders Company Pub. Philadelphia, London, Toronto 740, 1975.

[12] M. Munawar, "Limnological studies on fresh water ponds of Hyderabad, India II. The Biocoenose, distribution of unicellular and colonial phytoplankton in polluted and unpolluted environments", *Hydrobiologia.*, 36, pp. 105-128, 1970.

[13] S.M. Jain, Meenaxi Sharma and Ramesh Thakur, "Seasonal variations in physico-chemical parameters of Halali reservoir of Vidisha district", *India. J. Ecobiol.* 8(3), p 181-188, 1996.

[14] B.K.Baruah, A.C. Das, S. Talukdar, and C.R Borthakur,. "Certain water quality parameters and plankton population in ponds of urban and rural areas", *Environment & Ecol.*, 16(4), p 881-884, 1998.

[15] V. Kannan, and S.V. Job, "Diurnal depth wise and seasonal changes of physicochemical factors in Sathio reservoir", *Hydrobiologia*, 70, pp 103-117.1980.

[16] V.G. Jhingran, *Fish and Fisheries of India*. Hindustan Publishing Corp. (India) Delhi, 1982.

[17] P.S Welch, *Limnology*, McGraw Hill Book Company, New York, Toronto and London, 1952.

[18] Shyam Sundar "Monitoring the water quality in a stretch of river Jhelum, Kashmir", *Ecology and Pollution of Indian rivers.* Ashish Publishing House, New Delhi, India, pp. 131-162. 1998.

[19] M.S. Nair, Rajendran, "Seasonal variations of physico-chemical factors and its impact on the ecology of a village pond at Imala (Vidisha)", *J. ecobiol* 12(1), p .21-27. 2000.

[20] D.L. King, "The roll of carbon in eutrophication", *Journal of Water Pollution Control Federation*, 42, pp. 2035-2051, 1970.

[21] P.N.Goel, A.Y. Khatavkar, A.Y. Kulkarni, and R.K. Trivedy, "Limnological studies of a few freshwater bodies in southwestern Maharasthra with special reference to their chemistry and pollution", *Poll. Res.*, 5M (2), pp. 79-84, 1986.

[22] A. Kumar, and E.N. "Siddiqui Quality of drinking water in and around Ranchi", *I.J.E.P.*, 18(5), pp. 339-345, 1997.

[23] Deo Namita and Manzoor Ali "Water quality of a mining area in Keonjhar district for drinking and agriculture", *I.J.E.P.*, 13(9), p. 652-658.1993.

[24] H.C.Kataria, S.A.Iqbal,and A.K. Shandilya, "Limno-chemical studies of Tawa reservoir", *IJEP*, 16(11), p. 841-846, 1995.

[25] L.J.Bhosale, A.B. Sabale, and N.G. Mulik, "Survey and status report on some wetlands of Maharashtra", Final report submitted to Shivaji University, Kolhapur India, 1994.

[26] Prasanth Arun, V. Subba Rao, Kothandaraman, Jothi Kumar and S. Narasimhan, "Evaluation of physico-chemical and bacteriological quality of water from temple tanks in and around Madras city", *Indian J. Env. Prot.*, 16(7), p. 494-498, 1996.

[27] H.P. Singh, "Studies on primary production in Gobindsagar reservoir, Himachal Pradesh", *J. Environment. Biol.*, 19(2), p. 167-170, 1998.

[28] Dadhich Neeru and M.M. Saxena, "Zooplankton as indicators of trophic status of some desert waters Bikaner (N-W Rajasthan)", *Journal of Environment and Pollution*, 6(4), pp. 251-254, 1999.

[29] R.G. Wetzel, *Limnology*, II. Ed. Saunders College Publ. New York, 1983.

[30] B.D.Huddar, "Hydrobiological studies in lentic fresh water bodies of Hubli", thesis, submitted to the Karnataka University, Dharwad.1995.

[31] M.B.Rao, Mukhopadhyay and E.V. Moley, "Seasonal and species of zooplanktonic organisms and their succession in two freshwater ponds at Wagholi, Poona", *Proc. Symp. Ecol. Anim. Pool. Zool. Suve. India*, 2, pp. 63-84, 1981.

[32] H. Kaur, S.S. Dhillon, K.S. Bath, and G. Mandar, "Interrelationships between physico-chemical factors at Harike wetland (Punjab-India)", *Journal of Environment and pollution*, 4(3), 237-240, 1997.
[33] B.N. Sunkad, and H.S. Patil, "Physico-chemical characteristics of Fort lake of Belgaum (Karnatak)", *Abst. Nat. Symp. Karnatak Univ. Dharwad*, pp.68, 2001.
[34] Ahmed Masood and R. Krishnamurthy, "Hydrobiological studies of Wohar reservoir, Aurangabad (Maharashtra State)" India. *J. Environ. Biol.*, 11(3), p. 335-343, 1990.
[35] R.K. Gaur A.A. Khan, and A. Alam, "Oxygen system dynamics of the pond harbouring a permanent bloom of a cyanobactyerium, *Microcystis aeruginosa*", *J. Ecotoxicol., Environ. Monit.*, 5(1), p. 71-76, 1995.
[36] M. Ali, and A.A. Khan, "Limnological studies in a sewage fed pond", *J. Zool.*, 4, pp. 341-355, 1979.
[37] Fasiuddin and Jyotsna Kumari "Seasonal variation in physico-chemical properties and plankton periodicity in a fresh water fish pond at Bhagalpur, India", *Environment & Ecol.*, 8(3), p. 929-932, 1990.
[38] Kant, Shashi and Anil Raina "Limnological studies of two ponds in Jammu II physico-chemical parameters", Journal of Environmental Biology, Muzaffarnagar-251001, India, 1990.
[39] J.B. Moyle, "Some indices of lake productivity", *Trans. Amer. Fish. Soc.* 76, p. 322-334, 1949.
[40] D.F. Jackson, "Comparative studies on phytoplankton photosynthesis in relation to total alkalinity", *Verh. Int. Ver. Limnol.*, 14, pp.125-133, 1961.
[41] D.K. Harshey, A.K. Shrivastav, and S.G. Patil, "Studies on the ecology of fresh water ostracoda part II population ecology in Balsagar tank, Jabalpur M.P", India. *J. Curr. Biosci.*, 4(4), p. 127-134, 1987.
[42] H. Kaur, K.S. Bath, G. Mandar, and N. Jerath, "Physico-chemical status of Kanjli wetland (Punjab-India)", *Journal of Environment and pollution*, 7(1), p. 39-42, 2000.
[43] Y.Shastri and D.C.Pendse, "Hydrobiological study of Dahikhuta reservoir", *J. Environ. Biol.*, 22 (1), p. 67-70, 2001.
[44] K.S. Bath and H. Kaur, "Seasonal distribution and population dynamics and rotifers in Harike reservoir (Punjab-India)", *Journal of Environment and Pollution*, 5(4), pp. 249-252, 1998.
[45] S.S. Sathe, Suresh Khabade and Milind Hujare "Hydrobiological studies on two man made reservoirs from Tasgaon Tahsil (Maharashtra) India", *Ecol. Env. And Cons.* 7(2), p. 211-217, 2001.
[46] ISI "ISI specification for drinking water IS: 10500: 1991". *Indian Standard Institution, New Delhi*, 1991
[47] K. Raghavendran, "Quality assurance for drinking water mission to village", *Ecology*, 6(8), pp.13 – 25, 1992.
[48] Saify Tayyab, S.A. Chaghtai, Parveen Alvi and Durrani, "Hydrology and periodicity of phytoplankton in the sewage fed Motia pond, Bhopal (India)", *Geobios.*, 13(5), p. 199-203,1986.
[49] Rao, Narendar and S.K. Mahmood, "Nutrient status and Biological characteristics of Hubsiguda pond", *Journal of environment and Polln.*, 2(1), p. 31-34, 1995.
[50] S. Naik, and K.M. Purohit, "Physico-chemical analysis of some community ponds of Rourkela", *I.J.E.P.*, 16(9), p. 679-684, 1996.
[51] Kumar Arvind, "Pollution in River Mayurakshi in south Bihar, India", *J. of Environment and Pollution*, 2(1), p. 21-26, 1995.
[52] A. Sreenivasan, "The limnology, primary production and fish production in a trophical pond", *Limnol. Oceanogr.*, 9(3), pp. 391-396, 1964b.
[53] C.R. Goldman, and A.J Horne, *Limnology*, Pub. McGraw Hill Inc. Japan, pp. 1-464, 1983.
[54] S.Khurshid, Zaheeruddin and A. Basheer "Pollution assessment and water quality status in parts of Cochin", *I.J.E.P.* 18(4), p. 246-249, 1997.
[55] L.C. Rai, and H.D. Kumar, "Systematic and Ecological studies on algae of some habitats polluted with fertilizer factory effluents near Shahapuri, Varanasi", India. *Nova Hedwigia*, 27, p. 807-811, 1976.
[56] L.R. Bhat, P. Laccoul, H.D. Lekhak. and P.K. Jha, "Physico-chemical characteristics and phytoplankton of Toudah lake, Kathmandu", *Poll. Res.*, 18(4), p. 353-358, 1999.
[57] B.N. Pandey, A.K. Mishra, A.K. Jha, and R.N. Lal, "Phytoplankton population of the river Mahanda, Kotihar, Bihar", *Environ. & Ecology*, 11(4), p.936-940, 1992.
[58] R.K. Sinha, "Evaluation of pollution water quality and carbon cycling from hydrobiological parameters in river Ganges in and around Patna", Doctoral thesis, Patna Univ. India, 1986.
[59] R.S.A. Beauchamp, "Sulphates in African inland waters", *Nature*, 171, p. 769-771, 1953.
[60] Pushpendra and M.N. Madhyastha, "Seasonal variation of certain chemical parameters in soil-water phases in a small pond along western India", *J. Ecobiol.*, 6(4), p. 311-313, 1994.
[61] G. Seenayya, "Ecological studies in the phytoplankton of certain freshwater ponds of Hyderabad India-II The phytoplankton", *Hydrobiologia.*, 37, p. 55-58, 1971.
[62] R.K. Gaur, A.A. Khan, and A. Alam, "Oxygen system dynamics of the pond harbouring a permanent bloom of a cyanobactyerium, *Microcystis aeruginosa*", *J. Ecotoxicol., Environ. Monit.*, 5(1), p. 71-76, 1995.
[63] Paka Swarnalatha and Rao Narsing "Interrelationships of physico-chemical factors of a pond", *J. Environ. Biol.*, 18(1), p. 67-72, 1997.
[64] ICMR, "Manual of standards of quality for drinking water supplies", *Indian Council of Medical Research Rep.*, 44, p. 27, 1975.