

Characteristics of Water Quality and Hydrophytic Community of Govindgarh Lake, Rewa (M.P.), India

D.K. Tripathi*, A. Tiwari¹ and A. Awasthi²

International Institute of Waste Management (IIWM), Bhopal (M.P.)

¹Awadhesh Pratap Singh University, Rewa (M.P.)

²Environmental Biology, Awadhesh Pratap Singh University, Rewa (M.P.)

✉ Deepak.tripathi17@rediffmail.com

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Abstract: The present work provides an ecological study on the hydrophytic community as well as physiochemical study of water body of the Govindgarh Lake, Rewa. Four sample locations were selected in the study area representing various types of water quality namely, Bathing Ghats, Gopalbag, Fort Area and Devi temple of the Govindgarh Lake. Ecologically, Govindgarh Lake has many interesting aspects. 15.6 km of northern slope of Kamore range serves as the catchment area for 330 ha large and about 10 m deep lake which stores an enormous amount of water. This paper presents characteristics of water quality and hydrophytic community of Govindgarh lake which is situated in the Rewa district, M.P.

Key words: Lake, fresh water, lentic water, lotic water body.

Introduction

Water, like air and food, is a basic human need without which no life can be sustained. Water is so important for human life that there is also strong concern about the fate of freshwater habitats. The water resource scenario of the country reveals that out of a total 400 m.ha-m of available water, 68 m.ha-m of surface water and 42 m.ha-m of ground water is utilizable giving a total of 110.4 m.ha-m. As estimated during 1985, 32 m.ha-m of surface water and 15m.ha-m ground being utilized for irrigation giving a total of 47 m.ha-m. The total volume of fresh water on the earth surface is small in relation to the catchments; only about 0.01% of the earth water is in rivers and lakes at any one time. Fresh water ecosystem is of a great economic importance as pure and clear water of multipurpose use in the society. Considerable work has been done on pure limnology of fresh water: Lentic and Lotic habitats of India in the past. The Govindgarh lake is not only an object of social pride but a great symbol

of culture heritage as it was built by the popular ruler of this land some two hundred years ago.

Rewa District is located at the north east of the Madhya Pradesh state, in central India, and covers an area of about 6,314 km² and a population of 1,972,333 (2001 census), a 27% increase from 1991. Rewa is also known as land of white tigers. Govindgarh lake which is only 7000 ha is totally converted by water body. Its catchment area is 330 ha large near about 10 m deep lake and driest period of the water level never goes below seven metres which stores enormous amount of water. Govindgarh lake is being managed jointly by state fishery and irrigation departments. This has added new dimension of fisheries culture, irrigation and tourism to this lake.

Objectives

This paper presents the characteristics of water quality and hydrophytic community of Govindgarh Lake. The prime objective of this study was to monitor lake water

*Corresponding Author

quality based on physical and chemical properties of quality parameters viz., temperature, pH, total solid, suspended solid, dissolved solid, chlorides, nitrate, phosphate, alkalinity, total hardness, dissolved oxygen (DO), biochemical oxygen demand (BOD) and chemical oxygen demand (COD) for the management of Govindgarh Lake.

Material and Methods

Monthly water samples were collected at four sampling sites as per the details given below for determination of physico-chemical characteristics of the lake:

Bathing Ghats: These are the ghats where people take baths, wash utensils and clothes regularly. Water samples were taken from these ghats to assess the impact of human activities on water quality of lake.

Gopal Bag: This site is located almost at the centre of lake along with an approach road.

Near Fort: This site is located near the Fort.

Near Temple: This sampling site is situated near the Papara towards the southern side of the lake.

The water quality analysis was carried out using standard methods (APHA, 1985).

Results and Discussion

The physico-chemical characteristics of water at four sampling sites of Govindgarh lake are given in Tables 1-4. The results are given below.

Temperature: It is recorded by spot reading made by appropriate centigrade thermometer. Result indicated minimum temperature of water during winter months and maximum during summer months. The water temperature of Govindgarh Lake observed at four sites varies between 18 and 32.1°C. An average temperature of 23.14°C, 24.78°C, 25.17°C and 24.70°C was observed at Gopal Bag, near Fort, near temple and at Bathing Ghat respectively (Table 5). Thermal changes of Govindgarh lake water during different months of the year were not so profound as typical shallow lake. This height may be the reason for narrow difference in surface water temperature if Govindgarh Lake is not sustaining richer macro vegetation.

pH: There was a narrow variation in pH value of water at four sampling sites of Govindgarh lake. The mean values of pH were observed as 7.47, 7.51, 7.46 and 7.81 for Gopal Bag, near temple, Fort and Bathing Ghat, respectively (Table 5). There was no marked seasonal

variation in pH values of Govindgarh lake water (Tables 1-4). The narrow pH range (7.21-8.12) observed for the water of Govindgarh Lake is supported by several other studies.

Total solids: Total solids of Govindgarh lake water varied between 650 to 800, 686 to 808, 670 to 807 and 732 to 1140 mg/l for Gopal Bag, near Temple, near Fort and Bathing Ghat respectively (Table 5). The mean total solids were recorded as 735, 744, 739 and 869 mg/l for the four sites respectively. Result revealed comparatively higher loads of total solids at Bathing ghats of Govindgarh lake. The higher concentration of solids at Bathing ghats may be due to human activities such as bathing, washing, utensil washing, etc.

Suspended solids: The suspended solids ranged between 89 to 199 mg/l, 88 to 198 mg/l, 87 to 195 mg/l and 122 to 340 mg/l for Gopal Bag, Temple area and at Bathing ghats, respectively (Table 5). Average concentrations for suspended solids at four sites were recorded as 149.66 mg/l and 199.75 mg/l respectively. Result (Tables 1 to 4) indicated comparatively higher concentration of suspended solids during the monsoon months and lower during the winter months. Moderate concentrations were observed during the summer months. Same interpretations can be drawn for suspended solids as were supported for total solids.

Dissolved solids: Dissolved solids under present investigation varied between 115 and 628 mg/l, 560 to 620 mg/l, 576 to 616 mg/l and 636 to 800 mg/l for Gopal Bag, Temple area, Fort area and at Bathing ghats respectively (Table 5). The Bathing ghats of Govindgarh lake again exhibited higher contents of dissolved solids in the water. The minimum concentrations were recorded at Gopal Bag area of the lake.

Chlorides: The chlorides contents of four sites were found to be ranging between 24.22 and 64.14 mg/l for Gopal Bag, Temple area, Fort area and at Bathing ghats, respectively (Table 5). Govindgarh Lake exhibited relatively higher concentration of chloride in water to be followed by temple area (48.84 mg/l), Fort area (48.81 mg/l) and Gopal Bag area (43.36 mg/l). Higher concentration of chloride in water at bathing ghats may be attributed to human activities. The water of these ghats is regularly used for bathing and washing activities.

Ammonium-Nitrogen: The ammonium contents of Govindgarh lake varied between 0.60 and 1-13 mg/l, 0.64 to 1.12 mg/l, 0.63 to 1.10 mg/l and 0.86 to 1.82 mg/l for Gopal Bag, Temple area, Fort area and Bathing ghats, respectively (Table 5). Average ammonium nitrogen

content was found to be higher at Bathing ghat (1.22 mg/l) as compared to Fort area (0.94 mg/l), and Gopal Bag area (0.93 mg/l). The Bathing ghat of Govindgarh lake are added with organic matter due to human interference.

Phosphate: The phosphate content varied between 0.45 and 1.65 mg/l at Gopal Bag, 0.48 to 1.06 mg/l at Temple area, 0.46 to 1.04 mg/l at Fort area and 1.08 to 2.06 mg/l at Bathing ghats. Bathing ghats of Govindgarh lake exhibited higher concentration of phosphate (1.60 mg/l) in water to be followed by Gopal Bag (0.90 mg/l), Temple area (0.83 mg/l) and Fort area (0.81 mg/l) (Table 5).

Alkalinity: Total alkalinity under present study varied between 149 and 198 mg/l, 148 to 196 mg/l, 147 to 194 mg/l and 180 to 236 mg/l for Gopal Bag, Temple area, Fort area and Bathing ghats, respectively (Table 5). Higher average concentration of total alkalinity was found at Bathing ghats (208.0 mg/l) as compared to Fort area (173.16 mg/l), Temple area (176.0 mg/l) and Gopal Bag (177.25 mg/l).

Total hardness: Hardness is the property of water which prevents the foam formation with soap and increases the boiling points of water. The total hardness of Govindgarh lake water was found to be varied between 216-292 mg/l Temple area, 212 to 289 mg/l Fort area, 218 to 295 mg/l Gopal Bag and 264 to 328 mg/l Bathing ghats. Total

hardness values have not varied significantly with respect to seasons. Like other parameters Bathing ghats also exhibited higher values of total hardness in water (297.33 mg/l), to be followed by Gopal Bag (263.91 mg/l), Temple area (291.22 mg/l) and Fort area (257.25 mg/l).

Calcium hardness: The calcium hardness of studied sites varied as 152 to 196 mg/l Bathing ghat, 112 to 185 mg/l Fort area, 116 to 164 mg/l Temple area and 118 to 186 mg/l Gopal Bag. The maximum values of calcium hardness were obtained for Bathing ghats (175.66 mg/l) to be followed by Gopal Bag (158.41 mg/l), Temple area (154.83 mg/l), and Fort area (152.91 mg/l).

Dissolved Oxygen: The dissolved oxygen content of Govindgarh lake varies between 6.9 and 7.7 mg/l at Temple area, 6.0 to 7.0 mg/l at Fort area, 6.3 to 7.8 mg/l at Gopal Bag and 6.4 to 7.7 mg/l at Bathing ghats. An average DO content was minimum at Bathing ghats (7.05 mg/l) as compared to Gopal Bag (7.25 mg/l), Temple area (7.29 mg/l), and Fort area (7.07 mg/l).

Biochemical oxygen demand (BOD): The BOD of water samples under present investigation varied between 3.0 and 4.3 mg/l, 4.0 to 6.4 mg/l, 3.2 to 4.6 mg/l, and 3.0 to 4.8 mg/l for Fort area, Bathing ghats, Temple area and Gopal Bag area respectively (Table 5). An average BOD at four sites was found as 3.43 mg/l Fort area, 5.39 mg/l Bathing ghat, 3.7 mg/l Temple area, and 3.78 mg/l Gopal

Table 1: Physio-chemical characteristics of water sampled at Fort area of Govindgarh lake, Rewa

Parameters (mg/l)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
Temp °C	18.1	18.3	21	23	27	32	29.1	27.6	26.3	26	25	24
pH	7.37	7.37	7.41	7.37	7.21	7.44	7.61	7.70	7.68	7.51	7.50	7.40
Total solids	670.0	670	680	706	711	750	780	790	807	780	760.0	750.0
Suspended solids	87.0	106.0	109	144	150.0	171	163.0	185.0	187.0	164.0	154.0	130.0
Dissolved solids	595.0	580.0	580.0	580.0	558.0	576	610.0	602.0	609.0	616.0	603.0	615.0
Chloride	25.45	39.41	44.33	49.26	54.10	49.3	44.31	44.32	54.10	59.12	64.03	59.12
Ammonium nitrate	0.63	0.87	0.95	0.96	0.93	1.03	1.06	1.10	1.04	1.08	0.83	0.87
Nitrate	0.22	.51	0.65	0.60	0.73	0.80	0.82	0.92	0.90	0.79	0.40	0.35
Nitrite	0.13	0.17	0.20	0.50	0.52	0.56	0.54	0.75	0.64	0.50	0.27	0.14
Phosphate	0.46	0.78	0.89	0.89	0.85	0.93	0.95	1.03	1.04	0.90	0.52	0.54
Alkalinity	147.0	147.0	158.0	170.0	176.0	184.	180.0	190.0	194.0	184	175	170.0
T. hardness	212.0	223.0	231.0	242.0	263.0	270.	271.0	280.0	289.0	275.0	270	261.0
C. hardness	112.0	126.0	145.0	143.0	150.0	153.	163.0	173.0	185.0	170.0	162.0	153.0
D.O.	7.6	7.4	7.2	7.1	6.0	6.8	7.1	7.4	7.1	7.2	7.2	7.2
B.O.D.	3.7	3.0	3.1	3.2	3.1	3.0	4.1	4.3	4.2	3.0	3.4	3.1
C.O.D.	9.7	9.7	18.2	28.31	18.2	28.3	37.73	47.0	37.72	28.30	37.73	28.30

Source: Survey

Table 2: Physio-chemical characteristics of water sampled at Bathing Ghat, Rewa

<i>Parameters (mg/l)</i>	<i>Jan</i>	<i>Feb</i>	<i>Mar</i>	<i>Apr</i>	<i>May</i>	<i>June</i>	<i>July</i>	<i>Aug</i>	<i>Sep</i>	<i>Oct</i>	<i>Nov</i>	<i>Dec</i>
Temp °C	18.0	18.5	20.0	24.0	28.0	32.0	30.0	29.0	28.0	27.0	26.0	25.0
pH	7.73	7.82	7.64	7.75	7.48	7.68	8.06	8.12	8.10	7.86	7.76	7.72
Total solids	732.2	786.0	804.0	819.0	848.0	862.0	1020.0	1140.0	980.0	820.0	816.0	802.0
Suspended solids	126.0	135.0	156.0	182.0	190.0	2.5.0	315.0	340.0	280.0	208.0	138.0	122.0
Dissolved solids	606.0	651.0	648.0	637.0	658.0	657.0	705.0	800.0	700.0	612.0	678.0	680.0
Chloride	39.20	39.20	44.34	49.27	54.22	69.34	82.0	74.4	69.34	44.34	39.20	44.04
Ammonium	.86	.94	.92	1.06	1.12	1.25	1.73	1.82	1.78	1.20	1.14	.88
Nitrate	.75	.82	.80	.95	1.09	1.18	1.52	1.64	1.33	1.10	1.06	0.54
Nitrite	.42	.38	.49	.62	.80	.90	.96	1.08	1.03	.98	.85	.32
Phosphate	1.15	1.22	1.08	1.30	1.42	1.59	1.86	1.98	2.05	2.06	1.98	1.52
Alkalinity	180.0	192.0	204.0	212.0	216.0	232.0	236.0	228.0	212.0	288.0	2.4.0	196.0
Total hardness	264.0	272.0	276.0	288.0	300.0	316.0	324.0	328.0	212.0	288.0	204.0	196.0
C. hardness	152.0	156.0	168.0	176.0	184.0	192.0	196.0	188.0	172.0	168.0	176.0	180.0
D.O.	7.6	7.4	7.3	6.9	6.8	6.4	6.9	7.7	7.2	7.0	6.8	6.7
B.O.D.	4.5	4.8	5.2	5.6	5.8	6.0	6.1	6.4	6.0	5.5	4.8	4.0

Source: Survey

Table 3: Physio-chemical characteristics of water sampled at Gopal Bag, Rewa

<i>Parameters (mg/l)</i>	<i>Jan</i>	<i>Feb</i>	<i>Mar</i>	<i>Apr</i>	<i>May</i>	<i>June</i>	<i>July</i>	<i>Aug</i>	<i>Sep</i>	<i>Oct</i>	<i>Nov</i>	<i>Dec</i>
Temp °C	18.0	18.2	22.0	21.0	26.0	31.0	29.1	27.5	26.3	25.0	24.0	22.0
pH	7.36	7.46	7.40	7.39	7.23	7.43	7.63	7.90	7.67	7.53	7.40	7.30
Total solids	650	675	680	700	703	745	778	793	800	790	760.0	750.0
Suspended solids	89	103	113	149	153	175	167	181	199	172	160.0	135.0
Dissolved solids	599	584	585	563	565	580	626	115	620	625	618.0	628.0
Chloride	24.43	39.43	44.35	49.25	24.22	49.28	44.35	44.36	54.23	59.16	64.14	59.15
Ammonium	.60	.89	.97	.90	.96	1.00	1.09	1.13	1.00	1.07	0.84	0.82
Nitrate	.31	.55	.69	.72	.77	.83	.87	.97	.94	.82	0.53	0.82
Nitrite	.15	.19	.24	.54	.55	.63	.57	.72	.67	.53	0.29	0.16
Phosphate	.45	.83	.93	.97	.90	.98	.97	1.08	1.65	.94	0.56	0.59
T. alkalinity	149	153	163	169	182	189	185	195	198	189	182.0	173.0
T. hardness	229	209	239	250	267	280	279	289	295	286	275.0	260.0
C. hardness	118	130	146	149	156	159	169	178	186	180	170.0	160.0
D.O.	7.8	7.6	7.5	7.3	7.1	6.3	6.8	7.1	7.3	7.4	7.4	7.5
B.O.D.	3.9	3.4	3.5	3.6	3.4	3.1	4.5	4.7	4.8	4.3	3.2	3.0
C.O.D.	9.9	9.9	18.5	28.34	18.5	28.36	37.77	47.4	37.78	28.40	37.81	28.37

Source: Survey

Bag area. The higher value of BOD at Bathing ghats of Govindgarh lake might be due to influx of sewage in to the lake during the rainy months. This added sewage might have offered more microorganisms for decomposition and thus resulted in the greater demand of

oxygen. The addition of phosphate due to detergent used during bathing activities might have also caused excessive growth of algae and consequently have reduced oxygen content.

Table 4: Physio-chemical characteristics of water sampled at Devi temple, Rewa

S. No.	Parameters (mg/l)	Jan	Feb	Mar	Apr	May	June	July	Aug	Sep	Oct	Nov	Dec
1.	Temp °C	18	18	20	24	28	32.1	29	27.8	26.4	27	26	25
2.	pH	7.38	7.48	7.42	7.39	7.38	7.22	7.45	7.62	7.80	7.69	7.60	7.50
3.	Total solids	686	690	694	708	712	752	786	792	808	789	764.0	752.0
4.	Suspended solids	88	108	112	148	152	174	166	180	189	170	158.0	132.0
5.	Dissolved solids	598	582	582	560	560	578	620	612	610	619	606.0	619.0
6.	Chloride	26.46	39.42	44.34	49.27	54.20	49.27	44.34	54.20	59.13	64.05	64.05	59.13
7.	Ammonium	0.64	0.88	0.96	0.98	0.95	0.1.06	1.08	1.12	1.05	1.02	0.86	0.88
8.	Nitrate	0.33	0.52	.68	0.70	0.76	0.82	0.88	0.95	0.92	0.80	0.50	0.36
9.	Nitrite	0.14	0.18	0.26	0.26	0.52	0.54	0.60	0.58	0.70	0.66	0.28	0.15
10.	Phosphate	0.48	0.80	0.90	0.95	0.88	0.96	0.98	1.06	1.00	0.92	0.54	0.58
11.	T. alkalinity	148	152	160	172	180	188	184	192	196	188	180.0	172.0
12.	T. hardness	216	228	236	248	264	272	276	184	292	280	272.0	268.0
13.	C. hardness	116	128	140	148	154	164	172	184	170	164	164.0	156.0
14.	D.O.	7.7	7.5	7.4	7.2	7.0	6.9	7.2	7.6	7.3	7.4	7.4	7.4
15.	B.O.D.	3.8	3.2	3.4	3.5	3.3	3.2	4.2	4.6	4.5	4.0	3.5	3.2
16.	C.O.D.	9.8	9.8	18.4	28.32	18.4	28.32	37.76	47.2	37.76	28.32	37.76	28.32

Source: Survey

Chemical Oxygen Demand (COD): The values of COD of studied water sample were found in the range of 9.7 to 47.0 mg/l near Fort, 9.8 to 66.08 mg/l Bathing ghat, 9.8 to 47.2 mg/l near Temple and 9.9 to 47.4 mg/l Gopal Bag. The average values of COD recorded for four sites were 26.50 mg/l, 35.35 mg/l, 27.51 mg/l and 27.58 mg/l respectively (Table 5). Result indicated relatively higher value of COD for the water of Bathing ghats.

Macrophyte Vegetation

Results given in Table 7 show that the *Azolla pinnata* was the dominant species during rainy season coming under 70-80 IVI class to be followed by *Ottelia alismoides* (50-60) and *Najas minor* (30-40). In summer season again *Azolla pinnata* dominated the community with IVI value of 51.76 followed by *Najas minor* (43.43) and *Nymphaeoides cristatum* (42.41). Almost same pattern has been observed during the winter season. After critical examination of results the macrophytes community of Govindgarh lake may be considered a community of *Azolla pinnata*, *Najas minor*, *Vallisneria spiralis* and *Hydrilla verticillata*. Winter season showed higher species diversity (4.32) followed by summer (3.28) and rainy season (2.96). It is obvious from the result that submerged species dominated the macrophytic community of Govindgarh Lake. The causes of this are unicellular but it may be due to the rather good water

quality of this lake as suggested. The result of the present investigation reveals that the colonization for macrophytes in the lake is poor. The nature of substratum may also be important in influencing the distribution of rooted vegetation. In the substratum of Govindgarh Lake, gravels are common.

Twelve species of macrophytes were recorded in the lake (Table 6). These were *Azolla pinnata*, *Nymphaeoides cristatum*, *Cerataophyllum demersum*, *Hydrilla verticillata*, *Najas minor*, *Ottelia alismoides*, *Potamogeton pectinatus*, *Limnophila heterophila*, *Marsilea quadrifolia*, *Scirpus anticalatus*, *Vallisneria spiralis* and *Eriocaulon setaceum*.

The macrophytic vegetation was limited to comparatively shallower water of lake. Three vegetation life forms—namely, floating, submerged and emergent—were characterized by the distinct assemblage of their species. Out of twelve species, two species *Azolla pinnata* and *Nymphaeoides cristatum* were free and rooted floating, respectively. Six species *Cerataophyllum demersum*, *Hydrilla verticillata*, *Najas minor*, *Ottelia alismoides*, *Potamogeton pectinatus* and *Vallisneria spiralis* belong to submerged group. Other species like *Limnophila heterophila*, *Marsilea quadrifolia*, *Scirpus anticalatus*, and *Eriocaulon setaceum* were emergent macrophytes. The submerged plants were distributed to about 1.3 m deep into water whereas emergent plants were distributed towards the margin. Floating plants were distributed at

Table 5: Average value of Physio-chemical parameters of water at four sampling sites of Govindgarh Lake, Rewa

Parameters (mg/l)	Bathing Ghat		Gopal Bag		Temple area		Fort area	
	Range	Mean \pm SD	Range	Mean \pm SD	Range	Mean \pm SD	Range	Mean \pm SD
Temp (°C)	18.32	24.70 \pm 4.61	18.0-31.0	24.14 \pm 4.0	18.2-32.1	25.177 \pm 4.38	18.1-32.0	24.78 \pm 4.1
pH	7.48-8.12	7.81 \pm 1.48	7.23-7.90	7.47 \pm 0.60	7.22-7.80	7.50 \pm 1.24	7.21-7.70	7.46 \pm 1.87
Total solids	732.0-1140	869.08 \pm 117.01	650-800	735.33 \pm 51.79	686-808	744.41 \pm 44.52	670-807	739.08 \pm 47.00
Suspended solids	122-340	199.75 \pm 78.65	89.0-199.0	149.66 \pm 33.56	88.0-198.0	148.91 \pm 32.12	87-195	146.58 \pm 32.65
Dissolved solids	636-800	669.33 \pm 51.24	115.0-628.0	558.91 \pm 141.83	560.0-620	595.5 \pm 22.35	576-616	591.83 \pm 20.89
Chloride	30.20-82.0	54.07 \pm 5.48	24.22-64.14	46.36 \pm 12.62	24.46-64.5	48.84 \pm 10.63	24.45-64.03	48.81 \pm 10.62
Ammonium	86-1.82	1.22 \pm 1.37	0.60-1.13	0.93 \pm 1.88	0.64-1.12	0.95 \pm 1.75	0.63-1.10	0.94 \pm 3.09
Nitrate	.15-1.64	1.06 \pm 1.01	0.30-0.57	0.69 \pm 3.31	0.33-0.95	0.68 \pm 1.0	0.22-0.92	0.64 \pm 1.01
Nitrite	.32-1.08	0.73 \pm 0.718	0.15-0.72	0.43 \pm 0.2	0.14-1.70	0.42 \pm 21	0.13-0.75	0.41 \pm 1.23
Phosphate	1.08-2.06	1.60 \pm 0.898	.452-1.65	0.90 \pm 1.72	0.48-1.06	0.83 \pm 1.50	0.46-1.04	0.81 \pm 1.74
T. alkalinity	180-236	208.33 \pm 17.76	149-198	177.25 \pm 15.96	148.0-196	176 \pm 15.63	147-194	173.16 \pm 14.87
T. hardness	264-328	297.33 \pm 18.71	218-295	263.91 \pm 24.96	216-292	261.33 \pm 23.93	212-289	257.25 \pm 24.39
C. hardness	152-196	175.66 \pm 13.47	118-186	158.41 \pm 20.33	116-184	154.83 \pm 19.67	112-185	152.91 \pm 20.21
D.O.	6.4-7.7	7.05 \pm 0.612	6.3-7.8	7.25 \pm 0.78	6.9-7.7	7.29 \pm 1.27	6.0-7.6	7.07 \pm 1.09
B.O.D.	4.0-6.4	5.39 \pm 732	3.0-4.8	3.78 \pm 0.63	3.2-4.6	3.7 \pm 0.35	3.0-4.3	3.43 \pm 1.03
C.O.D.	9.8-66.08	35.35 \pm 16.69	9.9-47.4	27.58 \pm 11.63	9.8-47.2	27.51 \pm 11.67	9.7-47.0	26.59 \pm 11.00

Source: Survey

Table 6: Seasonal density, abundance and frequency of different species of macrophytes

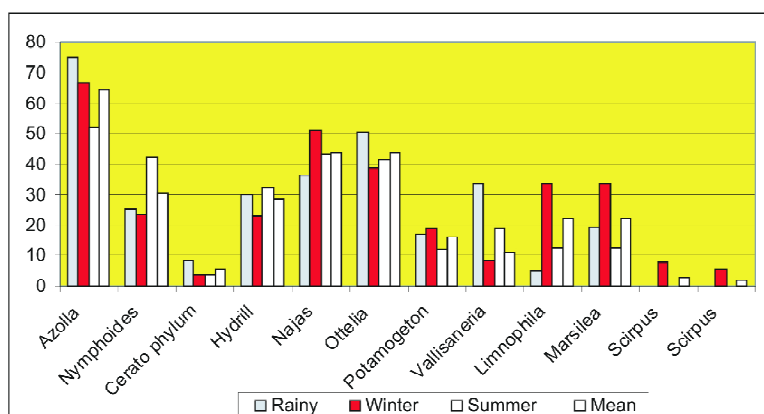
Life forms	Species	Density abundance	Rainy	Frequency	Density abundance	Winter	Frequency	Density	Summer Abundance	Frequency
Floating	<i>Azolla pinnata</i> ,	7.78	17.50	44.44	5.56	25.00	22.22	4.44	20.0	22.22
	<i>Nymphoides cristatum</i>	0.89	2.67	33.33	0.56	1.06	33.33	1.11	2.00	56.56
Submerged	<i>Ceratophyllum demersum</i> ,	1.22	5.50	22.22	0.56	5.00	11.11	0.44	4.00	11.11
	<i>Hydrilla verticillata</i> ,	6.22	11.20	55.56	4.88	11.00	44.44	5.77	8.67	66.67
	<i>Najas minor</i>	8.11	12.17	66.67	13.00	14.63	88.89	10.77	16.17	66.67
	<i>Ottelia alismoides</i> ,	2.44	7.33	33.33	1.33	6.00	22.22	1.55	7.00	22.22
	<i>Potamogeton pectinatus</i> ,	2.67	6.0	44.44	2.67	4.80	55.56	1.66	5.00	33.33
	<i>Vallisneria spiralis</i>	6.67	10.00	66.67	8.67	19.50	44.44	7.33	22.00	33.33
Emergent	<i>Linnophila heterophila</i> ,	1.00	9.00	11.11	2.23	21.00	11.11	4.11	12.33	33.33
	<i>Marsilea quadrifolia</i> ,	2.56	4.60	55.56	2.56	14.60	55.56	1.66	5.00	33.33
	<i>Scirpus anticalatus</i> ,	-	-	-	0.55	2.50	22.22	-	-	-
	<i>Eriocaulon setaceum</i>	-	-	-	1.1	10.00	11.11	-	-	-

Source: Survey

Table 7: Important Value Indices (IVI) of the different macrophytes

Life forms	Species	Rainy	Winter	Summer	Mean
Floating	<i>Azolla pinnata</i> ,	74.76	66.68	51.76	64.40
	<i>Nymphoides cristatum</i>	25.10	23.44	42.41	30.32
Submerged	<i>Cerato phylum demersum</i> ,	8.25	3.84	3.81	5.30
	<i>Hydrill verticillata</i> ,	29.89	22.97	32.19	28.35
	<i>Najas minor</i> ,	36.24	50.83	43.43	43.50
	<i>Ottelia alismodes</i> ,	50.51	38.69	41.44	43.52
	<i>Potamogeton pectinatus</i> ,	17.12	19.06	12.13	16.17
	<i>Vallisneria spirals</i>	33.51	8.35	18.99	10.85
Emergent	<i>Limnophila heterophila</i> ,	5.22	33.76	12.34	21.84
	<i>Marsilea quadrifolia</i>	19.41	33.76	12.34	21.84
	<i>Scirpus anticulatus</i> ,	-	7.74	-	2.58
	<i>Eriocaulon setaceum</i>	-	5.50	-	1.83

Source: Survey

**Figure 1: Graphical representation of the macrophytes.**

the margin and deep in the water. *Nymphoides cristatum* was not found as deep as *Azolla pinnata*.

The submerged species contributed about 50% of total vegetation to be followed by emergent (16.6%) and floating (13.3%) species. There have been marked variation in the density, frequency and abundance of the studied plants during the three seasons. Some species like *Najas minor*, *Hydrilla verticillata* and *Potamogeton pectinatus* showed comparatively higher values of density and frequency. Results in Table 7 indicated that *Azolla pinnata* was the dominant species among floating plants in all three seasons. Maximum IVI value was recorded during the rainy months (74.76) for this species to be followed by winter (66.68) and summer month (51.76). *Najas minor*, *Hydrilla verticillata* and *Vallisneria spiralis* together dominated among the submerged group.

The graphical representation of macrophytes is shown in Figure 1.

Conclusion

The study and diversity of the zooplankton are controlled by the several physico-chemical factors of water, temperature, Dissolved oxygen and organic matter are the important factors which control the zooplanktons growth. A large number of the rotifers indicate high eutropic nature of the water body. For proper environmental management of the wetlands it is imperative to undertake a systematic study involving scientific inputs from various disciplines. Therefore the present study is undertaken to assess the water quality and macrophytic vegetation of Govindgarh Lake. The study would provide important information which may be useful for management pretreatments.

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