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PHYSICO-CHEMICAL STATUS OF DIHAILA LAKE AT KARERA AS A PRIMARY DATA FOR SUSTAINABLE MANAGEMENT

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ABSTRACT

Dihaila Lake is a part of cultural, economical, irrigational and recreational life of Dihaila and Rajpur village. Dihaila Lake is one of the shelter water bodies for migratory birds in Karera Bustard Sanctuary. It is facing multifold pressure due to human interference, agricultural waste discharge, domestic waste discharge, cattle grazing, bathing and washing, agricultural practices and wetland encroachment. Different study stations at Dihaila Lake exhibited seasonal and inter-site variations in physico-chemical parameters.

INTRODUCTION

Water resources comprising of surface water (rivers and wetlands), ground water, marine water and coastal waters support all living things including human beings. Due to unplanned management, agriculture and disposal of untreated public sewage water, and other human and animal wastes in to river, lakes, reservoirs and other water bodies are continuously deteriorating their water quality and biotic resources (Venkatesan, 2007; Elmaci *et al*., 2008). Development of water resources has affected fish and wildlife resources in many wetlands (Rao, 2002). India is a signatory to Ramsar Convention and plays an important role in conservation and wise use of wetlands. Twenty-five sites from India have been designated as Ramsar sites of international importance and 6 wetlands are under process of designation (MoEF and GOI, 2007). Dihaila Lake in the Karera Bustard Sanctuary is the only water source for its inhabitants. Entirely rainfed, the size and depth of the Lake depend on the monsoons each year. Across the waters lies the Dihaila village whose inhabitants own and use the land forming the lakebed.

Study Area: Dihaila Lake is most important water body of Karera Bustard Sanctuary. It is a natural lake formed 200 years ago with 31.5 sq km spread area. It is located (N 25°38'09.6" E 078°09'33.1") at an altitude of 227 msl. The Lake is situated on the southern side of the Dihaila Rajpur village. It is surrounded by a wooded hill, rocky area on one side and the open forest, shrubs, dry deciduous forests, flat grassland and agriculture on other side. The Dihaila Lake is a natural shallow lake occupying a depression in the Karera Bustard Sanctuary at about 22 km north-west of Karera in Shivpuri District, Madhya Pradesh (fig. 1). The water spread area of the lake is about 496 ha with a depth of about 2-5 m. depending on the season and fluctuation in rain fall. The Lake provides water for wildlife, irrigation and livestock.

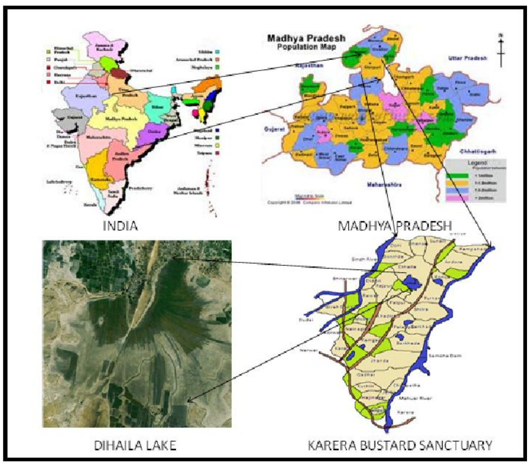

Fig. 1. Location of Dihaila Lake in Karera Bustard Sanctuary, Shivpuri, M.P.

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MATERIALS AND METHODS

The present study was conducted during August 2010-April 2011. The information on usage of water body for different purposes was collected from forest officers, local villagers, field staff of the Karera Bustard Sanctuary and other local organizations. For physico-chemical analysis, sampling was done at Dihaila Lake. Six sampling station were selected for analysis of physico-chemical characteristic of water covering whole are of the Lake. (fig. 2)

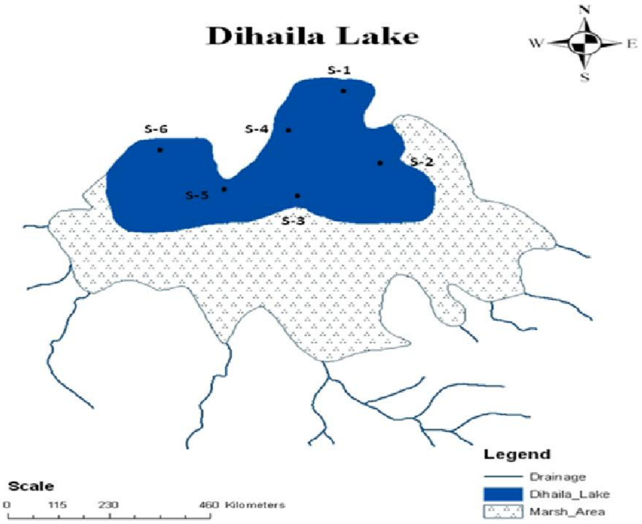

Fig. 2. Map of Dihaila Lake showing the sampling stations

The main purpose of this analysis was to determine the quality of water in the Lake at different seasons. Water samples were collected from six sampling stations from the lake between 25th and 30th (last week) of a month. Direct field measurements and sampling was started in early hours (7.00 am to 9 am) of the day during post monsoon season (October-2010), winter season (Janurary-2010) and summer season (April-2011). Grab samples were taken at various inlets, outlets and center of the lakes. Total six samples were taken from the Lake each time using polyethylene containers. The samples were then labeled and immediately transported to laboratory for analysis. The sampling design is depicted in table 1. The laboratory analysis of samples was done using standard methods (APHA, 2009).

RESULTS AND DISCUSSION

The physico-chemical characteristics of water of Dihaila Lake Karera Bustard Sanctuary (Madhya Pradesh) have been studied. The physical parameters of water of Dihaila Lake including odour, colour, transparency, ambient and water temperature and chemical parameters including electrical conductivity, total dissolved solids, pH, total suspended solids, chemical oxygen demand, biochemical oxygen demand, nitrate, phosphate, and dissolved oxygen, were analyzed. The seasonal values of physico-chemical characteristics on various water sampling stations at different sites have been given in table 2. The range of variation in various physico-chemical characteristics and their seasonal mean along with standard deviations has been given in table 3. It is estimated that freshwater wetlands alone support 20 percent of the known range of biodiversity in India (Deepa and Ramachandra, 1999). Due to increasing demand for food, freshwater, timber, fiber and fuel, the wetland ecosystem has been changed dramatically. There is a substantial loss in the diversity of life on earth, with 10-30% of the mammals, birds and amphibian species currently threatened with extinction. The fresh water populations have declined consistently with an average decline of 50% between 1970 and 2000 (Loh *et al*., 2005).

The quality of Physical, chemical and biological parameters serve as a good index in providing a complete and reliable picture of the conditions prevailing in a water body (Mishra *et al.,* 1999). Temperature is a vital parameter for growth of organism (Ram *et al.,* 2007; Manimegalai *et al.,* 2010). The water temperature increase correspondingly with increasing atmosphere temperature as found by Surve *et al*., (2005). In the present study the ambient and water temperature of Dihaila Lake have varied from October 2010 to April 2011 respectively. Highest water temperature value was recorded as 28.64^{0}C during summer season (April, 2011) while minimum value of water temperature was recorded as 19.58^{0}C during winter season (January, 2010). In Dihaila Lake water depth varied from 37.80cm to 149.05 cm during 2010-11. Maximum water level was recorded in post-monsoon period, 149.05cm cm (October, 2010) while minimum water level was recorded during winter season, 37.80cm (January, 2010) during the study period. As a rainwater-fed Lake, depth increases depending on rainfall.

Table 1. Parameters and sampling/analysis plan for Dihaila Lake

S. No.	Parameters	Sampling Bottles	Volume	Preservation	Method/ Instrument
1	Odour				Personal observation
2	Colour				
3	Transparency (cm)	Field Parameter			Secchi Disk
4	Air Temperature (°C)				Digital
5	Water Temperature (°C)				Thermometer
6	Depth (cm)				Depth Meter (GARMIN Fish Finder 60) + Sinker methods
7	pH				Digital pH Meter
8	Electrical Conductivity (µmho/cm)	Plastic	1 lit	Ice preservation	
9	Total Dissolved Solids (mg/l.)				
10	Total Suspended Solid (mg/l.)				
11	Chemical Oxygen Demand (mg/l.)				APHA, 2009
12	Biochemical Oxygen Demand (mg/l.)				
13	Phosphate (mg/l.)				
14	Nitrate (mg/l.)	Plastic wide mouth	500 ml	Conc. HNO_3	
15	Dissolved Oxygen (mg/l.)	DO Bottles	300ml	$MnSo_4$+KI+KNO_3	

Table 2. Physico-Chemical characteristics of Dihaila Lake of KBS during the post-monsoon, winter and summer season at six sample stations

S. No	Parameters	Units	Post- Monsoon Season (October)						Winter Season(January)						Summer Season (April)					
	Locations		S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6	S-1	S-2	S-3	S-4	S-5	S-6
1	Odour		OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL	OL
2	Colour		Turbid	Turbid	Turbid	Turbid	Turbid	Turbid	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	CL	Greenish
3	Transparency	Cm	82.3	53.5	49.1	55.3	90.4	114.8	99.4	37.8	18.3	36.6	98.6	82.4	96.3	71.3	37.5	63.7	104.5	108.8
4	Air Temperature	°C	29.2	29.2	29.2	29.1	29.9	28.9	17.9	17.9	17.2	17.5	17.9	16.9	31.1	31.5	31.8	30.2	30.9	29.6
5	Water Temperature	°C	26.3	26.7	26.7	26.4	26.0	25.9	25.3	25.7	25.7	25.4	25.7	24.3	27.2	28.4	28.6	28.3	28.3	26.6
6	Depth	Cm	105.5	80.5	58.8	81.4	128.9	149.0	99.4	37.8	18.3	36.6	118.9	108.5	96.3	71.3	37.5	63.7	120.7	122.5
7	pH		8.3	8.0	8.3	8.1	8.2	8.1	8.6	8.7	8.5	8.3	8.4	8.5	8.7	8.9	8.4	8.4	8.5	8.6
8	Electrical conductivity	µmho/ cm	212	260	275	233	340	226	230	272	237	242	373	240	187	203	178	187	276	190
9	TDS	mg/l	117	184	119	137	208	120	104	147	109	147	211	140	93	127	98	135	220	130
10	TSS	mg/l	57	64	49	60	69	67	46	69	42	61	76	73	93	61	33	52	60	62
11	COD	mg/l	7.6	8.12	7.54	7.6	11.9	8.4	7.8	8.4	7.8	7.8	12.2	9.4	9.5	9.9	8.4	8.3	13.6	10.4
12	BOD	mg/l	2.6	3.1	2.5	2.6	3.9	3.0	2.6	3.9	2.3	2.3	3.7	2.8	3.3	4.2	2.5	2.5	4.1	2.9
13	Dissolved Oxygen	mg/l	7.2	7.5	7.3	7.1	7.7	7.2	5.5	5.4	5.1	5.3	5.8	5.2	6.4	6.8	6.3	6.5	6.8	6.6
14	Nitrate	mg/l	0	0.01	0	0	0	0	0	0.05	0	0	0	0	0	0	0	0	0	0
15	Phosphate	mg/l	0.02	0.12	0.02	0.03	0.15	0.02	0.02	0.11	0.02	0.02	0.14	0.02	0.01	0.01	0.01	0.02	0.09	0.08

TDS=Total Dissolved Solid, TSS=Total Suspended Solid, COD = Chemical Oxygen Demand, BOD = Biochemical Oxygen Demand, OL = Odor less, CL = Colour less

Table 3. Range of variation, mean and standard deviation of water parameters of Dihaila Lake

S. No	Parameter	unit	Range of variation	Mean ± S.D.
1	Colour	-	-	-
2	Odour	-	-	-
3	Transparency	cm	18.3 - 114.8	72.5 ±28.4
4	Air Temperature	°C	16.9 - 31.8	25.9 ±5.9
5	Water Temperature	°C	24.3 - 28.6	26.5 ±1.2
6	Depth	cm	18.3 - 149.0	85.3 ±36.4
7	pH	-	8.0 - 8.9	8.4 ±0.2
8	Electrical conductivity	µmho/cm	178 – 373	242.3 ±50.3
9	Total Dissolved Solid	mg/l	93 – 211	141.4 ±37.9
10	Total Suspended Solid	mg/l	33 – 93	60.8 ±13.3
11	COD	mg/l	7.6 - 13.6	9.2 ±1.8
12	BOD	mg/l	2.3 - 4.1	3.0 ±0.6
13	Dissolved Oxygen	mg/l	5.1 - 7.7	6.4 ±0.8
14	Nitrate	mg/l	0 - 0.05	0.00 ±0.01
15	Phosphate	mg/l	0.01 - 0.15	0.05 ±0.05

COD = Chemical Oxygen Demand, BOD = Biochemical Oxygen Demand

The water is also drained for agricultural practices by the surrounding villages. So, agricultural drainage plays a major role in determining the depth of the water body. Colour in natural water occurs due to presence of suspended matter, phytoplankton, weeds, agricultural waste etc. Colour of water generally depends upon the production and degradation processes in the natural environment. Water acquires greenish colour because of the excess growth of microphyte algae (Bhalla *et al.,* 2006). The water colour of Dihaila Lake was turbid in rainy season; colourless in winter and summer season. Although at site 6 grayish colour was observed due to inflow of domestic sewage in summer season into the Lake. The transparency of water is mainly determined by biological productivity, suspended particles colour of water and due to high density of plankton inhabiting the water column (Kadam *et al.,* 2005; Kamath *et al*., 2006). The rain water brought large amount of dissolved and undissolved inorganic and organic materials into Dihaila Lake that made water turbid and cause lower transparency in rainy months. Sawant *et al.,* (2010) reported the transparency ranges between 8 to 30 cm and the minimum transparency was recorded in May and maximum in September at Atyal Pond, Maharashtra. In the present study the range of transparency varied among 36.6 cm to 114.8 cm during the study period. The data on transparency may not represent the photo depth and the tropic condition of the Lake as the depth of the water body changed very rapidly during study period.

Electrical conductivity (EC) is an index of the amount of water soluble salts present in water indicating the state of mineralization in an ecosystem (Das, 2000). The EC was found highest during winter season due to fewer intakes by aquatic vegetation and low bacterial degradation. During rainy season, the electrical conductivity values showed a gradual decline, may be due to dilution by the rain water. In summer season, it gradually decreases as the nutrient uptake by plants and bacterial degradation increase. In Dihaila Lake the electrical conductivity had a minimum range of 178 µmho/cm in summer, 2011 and maximum range was 340 µmho/cm winter, 2010. Krishnamoorti and Selvakumar (2010) found EC maximum in summer season (160 to 210 µmho/cm) and minimum in rainy season (76 to 160 µmho/cm). Water inflow from the Mohni Sagar Dam through the canal during summer may be the determining factor for low EC during that season. Total Dissolved Solids (TDS) denote mainly the various kinds of minerals present in the water. Welch (1952) stated that dissolved solids vary qualitatively and quantitatively in different waters depending upon the seasons, locations and other factors.

In freshwater ecosystem dissolved solids originate from natural sources and depend upon location, geological basin of water body, drainage, rainfall, bottom deposit and inflowing water. The pollutants from cattle grazing and human interference also contribute to the enrichment of dissolved solids (Ram *et al*., 2007). In the present study the total dissolved solids were ranging from 93 to 220 mg/l, which is on the lower side. Ramana *et al.,* (2008) recorded high dissolved solids ranging from 235.0 to 301.0 mg/l. The TDS value does not correspond to the observed pollutant input in the Lake as the water body is rejuvenated by fresh water every time during monsoon and the remaining water gets drained out during summer for agriculture. pH is the measurement of the intensity of acidity or alkalinity or measurements of the concentration of hydrogen ions in water. According to Jhingran and Sugunan, (1990) the pH range from 6.00 to 8.50 indicate medium productive nature of reservoir, more than 8.5 high productive and less than 6 as low productive reservoir. The largest varieties of aquatic animals prefer a range of 6.5 to 8.0. When pH is outside this range, diversity within the water body may decrease due to physiological stresses and reproduction (Raveen and Danil, 2010). pH in Dihaila Lake water was recorded in the range of 7.99 (October, 2010) to 8.61 (April, 2011) and will fall under medium productive reservoir. The surface runoff from adjoining areas carry heavy silt load which may cause the slightly alkaline nature of the Lake water. Dissolved Oxygen (DO) levels are impacted by water temperature, water agitation, types and numbers of aquatic plants, light penetration and amounts of dissolved or suspended solids that use oxygen such as organic matter (Jayaraju *et al.,* 1994). Dissolved Oxygen level between 5.0 and 8.0 mg/l are satisfactory for survival and growth of flora and fauna in an aquatic ecosystem (Raveen and Danil, 2010). Ramana *et al.,* (2008) reported variation of DO from 6.8 to 7.8 mg/l DO showed significant inverse relationship with water temperature. Rani *et al.,* (2004) reported lower values of DO in summer months due to higher rate of decomposition of organic matter and limited flow of water in low oxygen holding environment due to high temperature.

In the present study, DO in Dihaila Lake ranged from 5.25 to 7.65 mg/l with higher value occurring during post monsoon season (October, 2010) and lower value during winter (January, 2011). DO increased during post-monsoon may be due to agitation in the water body and fresh input of water. It decreased during winter as the water temperature drops and algal activity decreases. In summer DO increased as the atmosphere gets warmer and algal activity increased. In aquatic ecosystem, nitrogen level is regulated through precipitation, atmospheric dissolution and volatization under meteorological process, sedimentation influence, effluent and groundwater movement under geologic process, nitrogen fixation, denitrification, uptake growth, decay, hydrophytes pumping and fish and weed removal under biological process (Chavan *et al.,* 2004). High amount of nitrates in aquatic ecosystems are generally indicative of agricultural runoff. High concentrations of nitrates are useful in irrigation but their entry into the water resources increases the growth of nuisance algae and trigger eutrophication and pollution (Trivedy and Goel, 1986). In the present study nitrate level lies between 0-0.05 mg/l and found only at Site 2. Bacterial oxidation is the major contributor of nitrate in water body (Rawat and Sharma, 2005). Being low in productivity, the nitrate level is below detection at Dihaila Lake. The low level of nitrate at site 2 may be associated with agriculture in the Lake bed and bird droppings at the bird perching rock-face.

The main supply of phosphate in natural waters comes from the weathering of phosphorus bearing rocks, leaching of soils of the catchment area by rain; cattle dung (Jhingran, 1982). Eutrophication of water bodies is often correlated with the phosphates in the aquatic environment (Kaushik, 1992). Lee *et al.,* (1981) have classified the water bodies on the basis of phosphorus with mesotrophic water bodies shaving phosphorus level 0.012 mg/l to 0.027 mg/l. The phosphate concentrations in different site lies between 0.01-0.15 mg/l was measured during the study period. According to the phosphorus level this Lake can be classified as mesotrophic.

The highest value of phosphate was recorded during the post-monsoon season (October, 2010) and lowest value of phosphate was recorded in summer seasons (April, 2011). Moderate level of phosphorus in the Lake can be associated with use of pesticides, washing of clothes and cow dung.

Conclusion

In essence the physico-chemical and planktonic composition of the lake reveals that it is tending, fast towards 'eutrophism' particularly at station IV. The quality of water is deteriorating day by day due to inflow of domestic sewage, agricultural runoff and effluents of organic waste of animal and human origin into the lake. Deterioration of water quality and eutrophication are assuming alarmingin Dihaila Lake, due to casual attitude of people concerned with development of rural population. Therefore, there is an urgent need of regular monitoring of water quality to govern the status and diverting the sewage away from the lake to preserve the flora and fauna of this ecosystem. If waste input is not checked then it will severely impair water dynamics and will cause eutrophication of the entire system. Overall, coordinated efforts of various stakeholders and proper community involvement are the primary needs to restore the ecological subsystem of the lake and to make it useful for further social and economic exploration.

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