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Preliminary Investigation of the Water Quality of Wadhwana Reservoir, Gujarat, India: A Case Study

[1]*G. Sandhya Kiran, [1]Mudaliar Ashwini N., [1]Usha B. Joshi, [2]Geeta Padate, [1]Aruna G. Joshi

[1]Department of Botany, Faculty of Science, The M.S. University of Baroda, Vadodara-390002

[2]Department of Zoology, Faculty of Science, The M.S. University of Baroda, Vadodara-390002

*Email corresponding author: ecorsgis12@gmail.com

Abstract

Wetlands are the ecotones or transitional zones among permanently aquatic and dry terrestrial dynamic ecosystems. One of such wetlands, Wadhwana reservoir situated near Vadodara city is being developed into the major tourist place for bird-watching by the Gujarat State Forest department of India. The existing water body is contaminated due to agricultural, domestic and wildlife wastes/effluents. The restoration of such ecosystem requires the base line information on changes in the water composition. This paper focuses on the analysis of physico-chemical parameters of the water for the summer season. The analysis showed that the lake was slightly eutrophic with high concentrations of alkalinity. The results highlighted the need and urgency to restore the physical, chemical and biological integrity of this lake ecosystem through viable restoration and sustainable watershed management tactics. Moreover, this study will help the state forest department in developing this wetland as an eco-tourism place.

Keywords: *Physico-chemical analysis; Reservoir management; Restoration*

1 Introduction

Wetlands are the ecotones or transitional zones among permanently aquatic and dry terrestrial dynamic ecosystems. According to the Ramsar Convention the wetlands are "areas of marsh, fen, peat land or water, either natural or artificial, permanent or temporary with water that is static or flowing, fresh, brackish or salt, including areas of marine water the depth of which at low tide does not exceed six meters". They occupy eight million km² (6.4%) of the earth's surface with about five million km² in tropics and sub-tropics. According to OECD (1996), almost a 50% of the wetlands have been reduced since 1900 (Zhang et al., 2010). Statistics on wetland loss in India is not yet available; except for the information on loss of 70-80% of individual fresh water marshes and lakes in the Gangetic flood plains generated by wildlife Institute of India (Ramachandra and Rajesekara, 2002). Wetlands supply crucial human and animal needs such as drinking water, protein production, fodder, water purification, wildlife habitat, and flood storage. Direct land conversion for agricultural drainage, forestry, as well as urban construction has caused the destruction and degradation of wetlands (Yi et al., 1994; Spaling 1995; Mensing et al., 1998). Three quarters of India's population is rural, it places great demands on India's wetlands. Thus, increased appreciation of uses and decreasing area of wetlands justifies protecting them. Wetland understanding, management, and Public awareness in India must continue growing if wetland resources are to stay functional. In India around Ninety-four wetlands is identified for conservation and management under the National Programme for Conservation and Management of Wetlands. In Gujarat, eight wetlands are there under this program and Wadhwana is one of them. The State Forest department has also taken an initiative in developing this reservoir into a major wetland for migratory birds. The forest department is building up facilities like bird observation towers and tourist bungalows for the tourists. This place will soon be on the Eco-tourism map. In addition, this wetland also provides water to the local people for agricultural purposes and fulfilling needs like fishing and it is the habitat of a variety of migratory and resident birds. In this regard, it becomes very important to analyze the water quality of the Wadhwana Lake. This paper assesses the water quality of the lake in terms of its physico-chemical composition, due to the impact of various activities in this area. This research will help in formulating proper management tactics for lake water restoration and developing it, into an Eco-tourist place.

1.1 Study site

Wadhwana irrigation tank is located near Wadhwana village of Dabhoi Taluka of Vadodara district. It is about 45 km away from Vadodara city on Vadodara-Rajpipla road. Dabhoi town is approximately 15 km away from Wadhwana. It was constructed in the year 1909-10, while King Gaekwad family ruled the Vadodara State under British residency established in Vadodara city by East India Company. The location map of the study area is shown in fig. 1

1.2 Tank Wadhwana

At Full Reservoir Level (F.R.L.) capacity for tank is 12.85 Mm (3) (no dead storage), tank is 8473 m long, with top width of 3.66 m and greatest height of 8.25 m. Sill level at 46.66 m. and F.R.L at 55 Cum. Tank water is fed from Jojwa weir on river Orsang and directing the water via feeder canal. System of canal fed through five

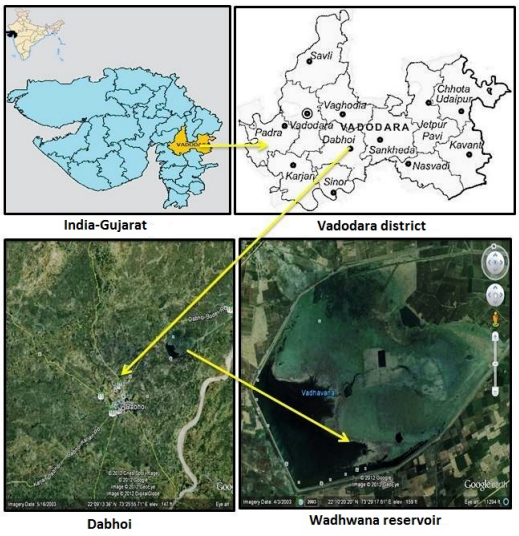

Figure 1: Location map of the study area

outlets provided at different levels, such a way, that water is used to its last drop, if any of canals breaks down or seeps the water is taken automatically to lower level canals via Canal entry (direct) or water will be collected in drain and diverted to lower level canal. This is a special feature of this tank.

1.3 Climate

The climate of the region is characterized by a hot summer and general dryness. The year is divided into three seasons. The period from March to mid-June is summer season. South-west monsoon season is from June to September and the winter is from December to February.

2 Materials and methods

Samples from various points were collected based on random sampling during the summer season. Two samples were taken from upper and lower surface from a single point. The different Physico-chemical parameters carried out for these samples were Color, Temperature, Turbidity, pH, Total solid (TS), Total suspended solid (TSS), Total dissolved solid (TDS), Total hardness, Alkanity, Acidity, Dissolved Oxygen. The water analysis followed the standard procedure by the American Public Health Association (APHA, 1998)

3 Results and discussion

The quality of water is now the concern of experts in all the countries of the world. The decision of WHO's 29th session emphasizes that water delivered to the consumer should meet the high requirements of modern hygiene and should at least be free from pathogenic organisms and toxic substances. The quality of water depends on the location of the source and the state of environmental protection in a given area. The physico-chemical aspects are considered the most important principles in the identification of the nature, quality, and type of the water (fresh, brackish, saline) for any aquatic ecosystem. The quality and the nature of water were determined by physical and chemical analysis (Voznoya, 1983). The quality of water is vital concern for humanity since it is directly linked with human welfare. The water quality analysis of Wadhwana reservoir has been carried out for Color, Temperature, Turbidity, pH, Total solid, Total suspended solid, Total dissolved solid, Total hardness, Alkalinity, Acidity and Dissolved oxygen.

3.1 Color

The color of the lake was blue due to the presence of different algal components specifically the green and the blue-green algae. The results showed that the blue colour of water was not matching with the standards of WHO, 2008.

3.2 Water temperature

The temperature of water was about 30°C at the upper surface; while lower surface showed 28.3°C. Shinde and his co-workers found that the maximum water temperature was 30.66°C in the summer season. (Shinde et al., 2011). The surface water temperature in Sabarmati River ranged between 18°C to 24°C (Kumar et al., 2012). The water temperature of ground water in Allahabad city fluctuated between 29 to 33°C. (Khan et al., 2012)

3.3 Turbidity

The turbidity was higher at upper surface as compared to lower surface. It ranged from zero to 21 NTU in the upper surface and zero to 18 NTU at the lower surface (Table-1). To meet water quality standards, turbidity levels should not be greater than 25 NTU. This lake turbidity level was under the water quality standards. The Turbidity in the cleaner water bodies of Bangalore city ranged from 1.0-25.0 NTU and 70.0-362.0 NTU in polluted water bodies, primarily due to silt, suspended and organic matter and autochthonous sources (mainly planktons). Turbidity in Chandola lake recorded ranges between 19 ± 0.41 NTU to 24 ± 1.08 NTU (Verma et al., 2012)

3.4 pH

The pH range fluctuated among 6.8 to 8.3 in the upper surface and 6.9 to 8.4 in the lower surface. The mean pH of the upper surface of water of Wadhwana reservoir was 7.81 and at the lower surface, it was 7.8. No much difference was observed in pH among the upper and the lower surface of the lake. According to the Indian Standard for Drinking Water – Specification IS 10500: 1991; the pH of the lake was within the permissible level in among 6.5 to 8.5. Several wetland studies have shown various ranges of pH values. pH values above nine (alkaline) have been recorded at Yediur, Puttenahalli and Ulsoor tanks of the Bangalore city (Chakrapani et al., 1996). In Katraj lake pH ranged between 7.3 to 8.45. (Khare et al, 2008).

Table 1: Physico-chemical parameters in Wadhwana reservoir

No	colour		TempºC		Turbidity		pH		TS		TSS		TDS		Total hardness		Alkalinity		Acidity		DO	
	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L	U	L
A.	blue	blue	30	28.3	2	0	8.01	8	27	25	18	15	9	6	114	112	510	450	50	50	12	11
B.	blue	blue	30	28.3	0	0	8.2	8.1	30	25	20	20	10	5	116	104	480	400	125	100	12	12
C.	blue	blue	30	28.3	1	0	7.8	7.5	20	18	8	7	12	11	126	106	440	350	100	90	14	13
D.	blue	blue	30	28.3	5	5	7.4	7.7	15	10	7	6	8	4	132	132	440	350	90	90	14	14
E.	blue	blue	30	28.3	12	10	6.8	6.9	6	5	4.1	4	1.9	1	240	200	700	630	70	60	12	12
F.	blue	blue	30	28.3	21	18	7	6.9	8	7	3.9	3.8	4.1	3.2	170	108	800	750	100	100	10	10
G.	blue	blue	30	28.3	20	17	7.9	7.4	8	7	4.1	4	3.9	3	170	170	850	800	50	40	7.3	7
H.	blue	blue	30	28.3	15	14	8.32	8.2	9	8	3.7	3.6	5.4	4.4	160	166	750	750	60	60	9	9
I.	blue	blue	30	28.3	17	16	6.9	6.9	7	6	4	3.8	3	2.2	180	160	850	800	125	100	10	10
J.	blue	blue	31	25.5	18	17	8.3	8.2	6	5	3.8	3.5	2.2	1.2	260	204	845	800	50	40	14	14
K.	blue	blue	31	25.5	10	10	7.3	7.2	8	6	3.9	3.5	4.1	2.5	180	180	850	800	40	40	13	13
L.	blue	blue	31	25.5	14	10	7.2	7.2	4	3	3.8	2	0.2	1	180	152	800	750	125	100	14	12
M.	blue	blue	30	28.3	18	15	8.1	8	5	5	4	3.5	1	1.5	170	160	800	750	150	125	12	11
N.	blue	blue	30	28.3	10	9	8.03	8.4	7	6	3.9	3.6	3.1	2.1	160	146	400	350	50	50	14	11
O.	blue	blue	30	28.3	14	15	8.21	8.1	7	5	4.1	3.6	2.9	1.4	167	120	400	450	100	100	15	13
P.	blue	blue	30	28.3	1	0	8.23	8.3	18	15	10	8	8	7	140	140	400	350	150	100	11	11
Q.	blue	blue	30	28.3	10	12	7.5	7.8	6	5	4	3.9	2.1	1	180	140	500	350	100	100	11	12
R.	blue	blue	30	28.3	15	10	7.7	7.9	6	5	4.5	3.9	1.5	1.1	180	180	400	450	50	50	12	13
S.	blue	blue	30	28.3	18	18	8.01	8.1	4	4	2	2	2	2	200	104	450	300	40	40	12	13
T.	blue	blue	30	28.3	20	18	8.28	8.3	6	5	4.2	3	1.8	2	167	100	400	350	100	90	13	12
U.	blue	blue	30	28.3	10	9	7.9	8.1	7	6	4.7	4.1	2.3	1.9	180	140	400	400	50	40	14	14
V.	blue	blue	30	28.3	10	9	8.2	8.3	7	5	4	3.6	3	1.4	187	160	400	350	100	100	13	16
W.	blue	blue	30	28.3	20	18	8.16	8	8	7	4.1	5	3.9	2	193	120	500	450	150	125	14	14
X.	blue	blue	30	28.3	19	18	7.98	8.1	7	6	5	4.2	2	1.8	160	152	400	350	100	90	12	14
average			30	28	13	11.2	7.81	7.8	9.83	8.3	5.78	5.2	4.1	2.9	171	144	574	522	89	78	12	12
(S.E)			±0.06	±0.19	±1.36	±1.29	±0.09	±0.09	±1.42	±1.25	±0.89	±0.83	±0.63	±0.48	±6.85	±6.26	±38.53	±38.59	±7.49	±5.88	±0.37	±0.39

3.5 Total solid and total dissolved solid

Total Solid content of the Wadhwana Lake ranged from 4 to 30 ppm in the upper surface and 3 to 25 ppm in lower surface, while the Total Dissolved Solid (TDS) values ranged from 0.2 to 12 ppm in the upper surface, and the lower surface showed variation among one to 11 ppm (Table-1). The TS and TDS levels are in the permissible level (ISI, 1991 and WHO, 2008)

3.6 Total suspended solid

The mean Total Suspended Solid of the Wadhwana Lake was 5.78±0.89 ppm for upper surface and 5.2±0.83 ppm for lower surface. The values of the Total Suspended Solid in both the layer ranged among 2 to 20 ppm (Table-1). TSS level in Sivakasi ranged between 40 to 200 ppm (Radha Krishnan et al., 2007)

3.7 Total hardness

The mean Total hardness of the lake was 171± 6.85 ppm for the upper surface and 144±6.26 ppm for the lower surface. The Total Hardness of the Wadhwana Lake ranged from 114 to 240 ppm (Table-1), while for the lower surface it varied among 104 to 204 ppm. The accepted values as according to the Indian standard for drinking water is 500 ppm. The values of the present study are within the recommended level.

3.8 Alkalinity

Alkalinity is not a pollutant. It is a total measure of the substances in water that have "acid-neutralizing" ability. Alkalinity represents the buffering capacity for water and its ability to resist a change in pH. Excessive alkalinity may cause eye irritation in humans and chlorosis in plants. Surface water with alkalinity less than 200 mg l^{-1} is potentially sensitive to heavy acid deposition. Alkalinity itself is not harmful to human beings; still water supplies with less than 100 mg l^{-1} of alkalinity are desirable for domestic use. The desirable level of total alkalinity for drinking water should be below 200 ppm (ISI, 1991). Alkalinity in excess of 300 ppm does not adversely affect fish. Here the Alkanity was above the acceptable level. The mean Alkalinity of the Wadhwana Lake was 574 ppm for upper surface and 522 ppm for lower surface (Table-1). The reason for the high amount of the alkalinity in the water is due to the discharge of Industrial wastewater, washing clothes mostly by laundries, bathing, and cleaning utensils. Similarly Srivastava et. al., 2012, found the alkalinity in the ground waters of Bathinda district ranged between 175–525 mg l^{-1}.

3.9 Acidity

Acidity in water may be caused by mineral acids such as sulphuric acid or hydrochloric acid or by dissolved carbon dioxide. Most commonly in drinking water, carbon dioxide is the principal cause of acidity. The Acidity of the lake ranged from 50 to 125 ppm in both upper and the lower surface (Table-1).

3.10 Dissolved oxygen (DO)

It is an important parameter, which affects chemical as well as biological reaction in ecosystem. Concentra-

Table 2: Correlation coefficient (r) for different parameters

	Temp.	Turbidity	pH	TS	TSS	TDS	Total hardness	Alkalinity	Acidity	DO
Temp	1									
Turbidity	-0.08	1								
pH	0.2	-0.09	1							
TS	0.22	-0.79	0.17	1						
TSS	0.19	-0.72	0.2	0.95	1					
TDS	0.23	-0.74	0.1	0.86	0.67	1				
Total hardness	-0.47	0.46	-0.23	-0.66	-0.58	-0.65	1			
Alkalinity	-0.53	0.39	-0.53	-0.27	-0.25	-0.24	0.51	1		
Acidity	0.21	-0.03	-0.01	0.1	0.12	0.1	-0.32	-0.09	1	
DO	-0.25	-0.19	0.25	-0.07	-0.05	-0.1	0.04	-0.5	0.08	1

tions below 5 ppm adversely affect the functioning and survival of biological communities and below 2 ppm lead to fish mortality. The Dissolved Oxygen (DO) in the present study area ranged from 7.3 to 14 ppm in the upper surface, while in the lower surface it ranged from 7 to 16 ppm (Table-1). These results indicate the DO of the lake water was in the permissible level. High level of DO was observed in the present condition despite of Eutrophic condition these results were found to be similar to the Motia lake of Bhopal (Dixit et al., 2012). According to Wetzel, 1973 such higher values of DO were due to the photosynthetic activity of different green planktons in the water body. Dissolved oxygen concentration more than 5.00 ppm favours good growth of flora and fauna (Das, 2000). In Ramsagar reservoir the DO ranged between 6.78 to 11.59 ppm (Garg et al., 2010).

3.11 Correlation analysis

The correlation coefficients (r^2) among various water quality parameters were calculated and the values of the correlation coefficients (r^2) are given in table 2. The turbidity is a striking characteristic of water to analyze its physical status. It was observed that Turbidity showed positive correlation with total hardness and alkalinity and negative correlation with other parameters. Mamta et al., (2011) in their findings showed similar correlation of Turbidity with total hardness, alkalinity, and dissolved oxygen. A positive correlation of turbidity with hardness implied that the increasing turbidity levels will increase hardness of water. This reduces the potability of water. Alkalinity of water showed significant negative correlation with pH, TS, TSS, TDS, and DO. Similar results were also obtained for Kosi River. On the other hand, DO showed significant positive correlation with pH, hardness and acidity and negative correlation with Temperature (Bhandari et al., 2008). A significant inverse relationship between surface water temperature and the level of DO was obtained in this study. In addition, the r^2-values for other factors such as TS, TSS, TDS, and alkalinity also exhibited the similar relationship with surface temperature. A small positive correlation between the acidity and DO inferred that slight increase in the acidity may lead to improved DO level of water.

4 Conclusion

The physico-chemical study of the Wadhwana reservoir revealed degrading quality of wetland water due to various anthropogenic activities. The wetland was found to be in eutrophic condition. It is necessary to convert this eutrophic wetland in the oligotrophic wetland for developing it into an eco-tourism place for recreational purpose for which different constructive efforts in form of proper care and management practices by different government and non-government agencies are required.

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