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Assessment of Surface Water Quality of Wadhwana Irrigation Reservoir, Gujarat, India

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Abstract

Assessment of seasonal variation in surface water quality is important for evaluating the limnological changes in a reservoir. The present study was carried out in Wadhwana irrigation reservoir for understanding changes in different physico-chemical parameters of water quality from July 2016 to May 2017. The values of selected physico- chemical parameters were observed to vary considerably as per the seasons for pH (7.02-8.85),Temperature (12.80 ºC -33.00ºC),Electrical Conductivity (0.29 mS-14.15 mS), Dissolved Oxygen (4.30 mg/l-8.71 mg/l),Turbidity (3.70 NTU-91 NTU), Acidity (20 mg/l as $CaCO_3$-80 mg/l as $CaCO_3$), Alkalinity (80 mg/l as $CaCO_3$-280 mg/l as $CaCO_3$), Chlorides (1.2 ppt -10 ppt), Salinity (0.04 ppt-18.06 ppt), Total hardness (200 mg/l as $CaCO_3$-600 mg/l as $CaCO_3$), Calcium hardness (21 mg/l as $CaCO_3$-105 mg/l as $CaCO_3$), Magnesium hardness (104 mg/l as $CaCO_3$-600 mg/l as $CaCO_3$) and Nitrates (0 mg/l -42.30 mg/l) on other hand, seasonal variations were observed to be insignificant for the nutrients like Nitrites (0.01 mg/l -0.18 mg/l) and Phosphates (0.03mg/l -2.90mg/l). Temperature and Electrical Conductivity were found to be high during summer season; Turbidity, Acidity, Alkalinity, Total hardness, Magnesium hardness, Nitrates and Nitrites were high during monsoon season whereas pH, Dissolved Oxygen, Calcium hardness, Chlorides and Salinity were high during winter season. The present study revealed that water of Wadhwana Irrigation Reservoir is suitable for fisheries, irrigation and drinking purposes.

Keywords: *Physico-chemical parameters, seasonal variations, Wadhwana irrigation reservoir, water quality*

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INTRODUCTION

Wetlands provide numerous ecological, environmental and socio-economic services [1] such as provisioning of drinking water, fish and fodder, water for agricultural practices, recycling of nutrients, purification of water, provisioning of habitat for a large number of migratory and resident birds, controlling the rate of runoffs in urban area, buffering shorelines against erosion and recreation to the society [2].The interaction of humans with wetlands during the last few decades have been of concern largely due to the rapid population growth accompanied by intensified industrial, commercial and residential development further leading to encroachment and pollution of wetlands by domestic sewage, industrial effluents, and pesticide/fertilizer laden agricultural run-offs. The fact that wetland values are overlooked has resulted in threat to the source of these benefits. Natural processes and anthropogenic activities have an undesirable impacts on the water quality, causing degradation in surface water and groundwater leading to degradation and alteration of numerous hydrological functions, resulting into increase in nutrients and sediment load, and spread of invasive and exotic species and affecting their potential use for human and animal consumption, agriculture, recreation, industry and others [3] .These factors have resulted in large undesirable losses of wetlands, which have had a high social cost. The physical and chemical characters of the wetland water can be used to assess the ecological nature of the wetlands. Due to the socio-economical, ecological and environmental services that

many wetlands provide, it is essential to maintain the quality of the wetlands that also include man-made wetlands like irrigation reservoir. With this background, the present study was undertaken to assess the seasonal variations in physico-chemical characteristics of water of Wadhwana Irrigation Reservoir in Gujarat State (India) for a period of one year from July 2016 to May 2017.

Study area

Wadhwana Irrigation Reservoir is located in the semi-arid zone in Central Gujarat (22^o 10′ N, 73^o 29′ E). Besides providing irrigation waters to many agricultural fields of Vadodara district, this reservoir is also famous for providing support to a large population of resident and migratory waterbirds. It is situated about 50 km south-east of Vadodara city at Wadhwana village in Dabhoi Taluka of Vadodara District (Figure 1). The reservoir is spread over an area of 5.75 sq.km and its water spread is surrounded by an earthen dam (8.2 kilometers). The reservoir earlier received water from the Jojwa dam on Orsang River, but after the construction of the famous Sardar Sarovar Dam on Narmada River the water from this dam is also diverted to it making it an almost a perennial water body. It irrigates about 88.15 sq.km land of 25 villages in its vicinity. On the basis of the waterbird assemblages supported by this wetland, it was declared as a wetland of National Importance by MoEF & CC, Government of India in 2005. It has also got a recognition of Important Bird and Biodiversity area (IBA). The climate in the area is characteristic hot - dry with the precipitation during south-west monsoon i.e. June to September. The average temperature in the area varies between 12 °C to 33 °C with the hot summer's temperature reaching above 40 °C and moderate winters when it drops around 10 °C. The rainfall in the area ranges between 500 mm to 1000 mm, mostly received during the south-west monsoon. The relative humidity ranges from about 40% in the summer to 80-85% in monsoon.

Four sites were selected from Wadhwana irrigation reservoir for *in situ* water quality assessment and sample collection. These four sites include (1) Open Water near Wadhwana Watch Tower (W1) (2) -Outlet near Wadhwana Watch Tower (W2) (3) Open Water near Manjrol Watch Tower (W3) and (4) Open Water near Simaliya Watch Tower (W4).

MATERIAL AND METHODS

Water sampling methods: The surface water samples were collected from the four sampling sites of the irrigation reservoir from July 2016 to May 2017 for evaluating the seasonal variability (monsoon, winter and summer) of the physic-chemical properties. Certain parameters like pH, water temperature, turbidity, dissolved oxygen (DO), electrical conductivity (EC) were analyzed *in situ*. The surface water samples from these four sites were collected in polyethylene sterilized bottles following grab sampling method. Water samples were transported to the Ecological Research Monitoring Laboratory, GEER Foundation, Gandhinagar and preserved therein for further *ex situ* analyses of other parameters like acidity, alkalinity, chlorides, salinity, total hardness, calcium hardness, magnesium hardness, and nutrients like nitrates, nitrites and phosphates as per Standard Methods [4] (Table 1).

RESULTS AND DISCUSSION

Seasonal variations in water quality parameters of Wadhwana irrigation reservoir

pH: pH of water is important for the biotic communities as most of the species of flora and fauna survive in a narrow range of pH from slightly acidic to slightly alkaline values [5] . The pH values of the surface water of Wadhwana wetland remained above 7 and ranged from 7.02 to 8.85 showing an alkaline trend. The alkaline pH is favourable for aquatic culture [6]. Highest pH value (8.85) was recorded at W1 [Open Water near Wadhwana Watch Tower] during the winter season. On the other hand, the lowest pH value was recorded at W4 [Open Water near Simaliya Watch Tower] during summer season (Table 2). [7] have also reported similar results.

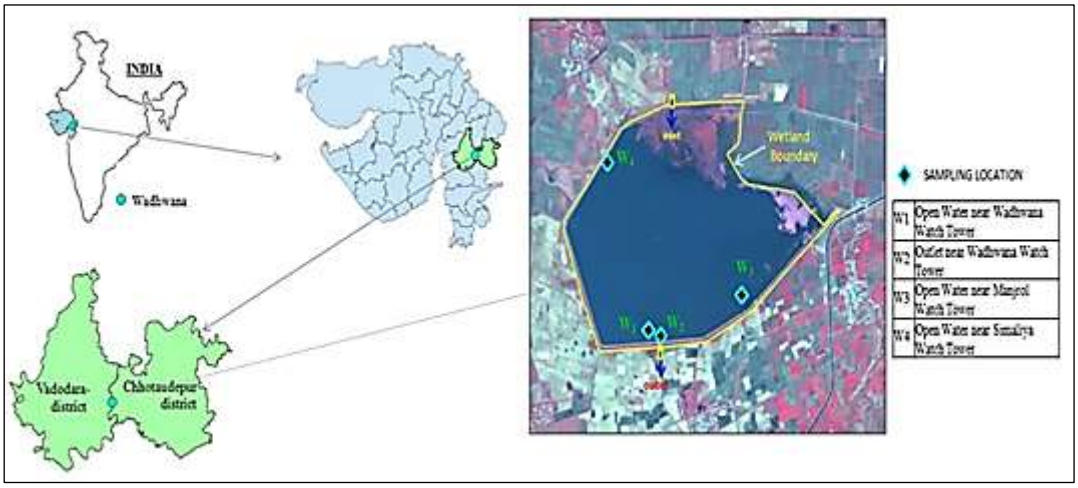

Fig. 1: *Map showing study area*

Table 1: *Physico-chemical water quality parameters monitored for Wadhwana Irrigation Reservoir between July 2016 and May 2017.*

Sr.No	Parameters	Methods/Instruments	References
1	pH	pH meter	APHA, 2012
2	Water Temperature	Digital Environmental Thermometer	
3	Turbidity	Turbidity Meter	APHA, 2012
4	Dissolved Oxygen	Modified Winkler's Method	APHA, 2012
5	Electrical Conductivity	Electrometric	APHA, 2012
6	Acidity	Titrimetric	APHA, 2012
7	Alkalinity	Titrimetric	APHA, 2012
8	Chloride	Argentometric titration	APHA, 2012
9	Salinity	Argentometric titration	APHA, 2012
10	Total Hardness	Titrimetric	APHA, 2012
11	Calcium Hardness	Titrimetric	APHA, 2012
12	Magnesium Hardness	Titrimetric	APHA, 2012
13	Nitrates	Spectrophotometric method	APHA, 2012
14	Nitrites	Spectrophotometric method	APHA, 2012
15	Phosphates	Spectrophotometric method	APHA, 2012

Table 2: *Seasonal variation in Physico-chemical characteristics of surface water of Wadhwana irrigation reservoir.*

Water Quality Parameters	Monsoon		Winter		Summer	
	Range	*Mean ±Std.Dev*	*Range*	*Mean ±Std.Dev*	*Range*	*Mean± Std.Dev*
pH	8.37-8.58	8.50 ± 0.09	8.15-8.85	8.63±0.32	7.02-7.30	7.21±0.13
Temperature (ºC)	28.30-31.70	29.83 ±1.43	12.80-22.40	17.28 ±5.04	31-33	32.50±1
Electrical Conductivity(mS)	0.29-0.43	0.34 ± 0.06	0.37-0.41	0.39 ±0.02	9.66-14.15	12.86±2.14
Turbidity (NTU)	38.20-91.00	61.95 ±22.11	3.70-41.40	18.16 ±16.71	7.10-15	9.48±3.70
Dissolved oxygen(mg/l)	5.45-8.00	6.56 ± 1.18	6.23-8.71	7.66 ±1.04	4.30-6.10	5.35±0.86
Acidity (mg/l as $CaCO_3$)	50 -80	65.00 ± 12.91	20-30	27.50 ±5.00	20-40	30.00±8.16
Alkalinity (mg/l as $CaCO_3$)	260 -280	272.50 ± 9.57	80-200	137.50 ±61.31	120 -150	130.00±14.14
Chlorides(ppt)	1.20-1.50	1.28 ± 0.15	7.50-10.00	8.13 ±1.25	0.02-0.03	0.02±0.01
Salinity (ppt)	1.81-2.71	2.22 ± 0.37	13.54-18.06	14.67±2.26	0.04-0.05	0.04±0.01
Total Hardness (mg/l as $CaCO_3$)	200-600	400±182.57	230-270	242.50 ±18.93	210 -230	222.50±9.57
Ca (mg/l as $CaCO_3$)	31 -105	26.25 ±52.50	94.50-126	115.50 ±14.85	21.00-31.50	26.25±6.06
Mg Hardness (mg/l as $CaCO_3$)	200-600	373.75±170.56	104 -144	127 ±17.29	178.5-209	196.25±12.78
Nitrates(mg/l)	4.50-42.30	22.30±18.46	0.00-1.50	0.58 ±0.72	0.00-17.30	4.48±8.55
Nitrites(mg/l)	0.03-0.18	0.11±0.06	0.01-0.01	0.01 ±0.00	0.01-0.02	0.01±0.01
Phosphates(mg/l)	0.43-1.32	0.75±0.40	0.03-0.59	0.32 ±0.25	1.80-2.90	2.30±0.50

Water Temperature: Water temperature is a significant ecological factor that regulates the physiological behavior, growth and distribution of the aquatic flora and fauna [8-10]. The surface water temperature of the Wadhwana reservoir ranged from 12.8 °C to 33.0 °C. Water temperature of the reservoir was higher during the summer season at most of the sites (W1, W3 and W4) which may be because of heat-raising temperature of surface water [11-14]. Low water temperature (12.8 °C) of the water of the reservoir was recorded during the winter season at W1 [i.e., Open Water near Wadhwana Watch Tower; Table 2].

Electrical Conductivity: Electrical Conductivity (EC) is the capacity of substance or solution to conduct electrical current. Most of the salts in water are present in the ionic forms, capable of conducting electric current. The Electrical conductivity of the reservoir ranged from 0.29 mS to 14.15 mS .EC was recorded higher (14.15 mS) during summer season at W3[i.e., Open Water near Manjrol Watch Tower] and lower (0.29 mS) during monsoon season at W2 [i.e., Outlet near Wadhwana Watch Tower]. High values of EC may be due to the higher rate of evaporation that reduces the water level and increase in nutrients due to run off from irrigation of agricultural lands. Decrease in electrical conductivity values during the monsoon might be due to increase in rainwater that leads to dilution of the dissolved solids in the reservoir (Table-2). Similar observations have been made by [15].

Turbidity: Turbidity is related to the number of suspended solids like clay, silt, organic matter, plankton and other microscopic organisms [16]. The turbidity of the reservoir ranged from 3.70 NTU to 91 NTU. High turbidity (91 NTU) was observed at W4-Open Water (Near Simaliya Watch Tower) during the monsoon season which could be due to the increase in surface run-off, which cause re-suspension of dissolved materials. Low turbidity (3.70 NTU) was observed at W1 [i.e., Open Water (Near Wadhwana Watch Tower) during the winter season which could be as a result of prevailing condition of less-surface run-off (Table-2).

Dissolved Oxygen (DO): Dissolved Oxygen of the reservoir's water is of great limnological significance as it regulates many metabolic processes of aquatic organisms. Even a slight variation in the DO of the water of the freshwater bodies acts as an indicator of trophic status of water bodies. DO is important for direct need of many organisms and affects the solubility of many nutrients and therefore the productivity of aquatic ecosystem [17-18]. The Dissolved Oxygen of Wadhwana reservoir's water varied from 4.30 mg/l to 8.71 mg/l. The results of the present monitoring showed that highest value (8.71 mg/l) of dissolved oxygen was recorded during winter season at W2 [i.e., Outlet near Wadhwana Watch Tower] and lowest (4.30 mg/l) during summer season at W4 [i.e., open water near Simaliya Watch Tower]. The minimum value of DO that had been recorded during summer season might be due to high water temperature which is known to reduce the solubility of oxygen. The higher temperature can also increase the decomposition rate of dead plant and animal matter and in turn lowers the DO. [19] also stated that the DO content in a reservoir would be low at high temperature. Such observations have been made by other workers too [20].

Acidity: Acidity is a net effect of the presence of several constituents, including dissolved carbon dioxide, dissolved multivalent metal ions, strong mineral acids such as sulfuric, nitric, and hydrochloric acids, and weak organic acids such as acetic acid. Dissolved carbon dioxide (CO_2) is the main source of acidity in fresh waters. Acidity from the sources other than dissolved CO_2 is not commonly encountered in fresh natural waters and is often an indicator of pollution. In the present study, Acidity ranged from 20 mg/l as $CaCO_3$ to 80 mg/l as $CaCO_3$. Acidity was found to be highest (80 mg/l as CaCO3) during monsoon season and lowest (20 mg/l as $CaCO_3$) during summer season at W3 [i.e., open water near Manjrol Watch Tower].

Alkalinity: Alkalinity is a function of bicarbonates and carbonates. These salts get hydrolyzed in a solution and produce hydroxyl ions. It is also used as a measure of

productivity of water [19, 21] .Seasonally highest value (280 mg/l as $CaCO_3$) was recorded during monsoon at W1 [i.e., open water near Wadhwana Watch Tower] and W2 [i.e., outlet near Wadhwana Watch Tower] and lowest (80 mg/l as $CaCO_3$) during the winter season at W3 [i.e., open water near Manjrol Watch Tower]. However, the trends observed in all the sites are similar. According to [22] alkalinity is regarded as a measure of productivity of natural waters. Increases in total alkalinity during monsoon season may be due to influx of water and dissolution of calcium carbonate ion in the water column [23]. The degradation of plants and other organism and organic waste might also be one of the reasons for the increase in carbonate and bicarbonate thereby the alkalinity [24, 25].

Chlorides: Chloride is considered as one of the most important inorganic anions in water. Its concentration in freshwater is generally used as an indicator of sewage pollution [26]. Chlorides of Wadhwana reservoir's water ranged from 0.02 ppt to 10 ppt. Chlorides content was recorded to be the highest (10 ppt) during winter season at W2 [i.e., outlet near Wadhwana Watch Tower] and lowest (0.02 ppt) during monsoon season at W1 [i.e., open water near Wadhwana Watch Tower], W2 [i.e., outlet near Wadhwana Watch Tower] and W4 [i.e., open water (Near Simaliya Watch Tower) (Table-2). In fresh waters the manifold increase in chlorides may be largely due to industrial sources, municipal waste waters, including sewage etc[8].

Salinity: In the present study, salinity of the reservoir ranged from 0.04 ppt to 18.06 ppt. Salinity was recorded highest (18.06 ppt) during winter season at W2 [i.e., Outlet near Wadhwana Watch Tower] and lowest during summer season at W1 [i.e., Open Water (Near Wadhwana Watch Tower), W2 (i.e., Outlet near Wadhwana Watch Tower) and W4 [i.e., Open Water near Simaliya Watch Tower].

Total Hardness: Total Hardness of water of a wetland mainly depends on the amount of Calcium and Magnesium salts dissolved in the water. [27,28] examined the loads of inorganic and organic pollutants in stagnant and flowing water and concluded that the Calcium, Magnesium related compounds play an important role in the development and occurrence of aquatic microorganisms. Total Hardness of the reservoir's water ranged from 200 mg/l as $CaCO_3$ to 600 mg/l as $CaCO_3$ (Table 2). Total Hardness was recorded highest (600 mg/l as $CaCO_3$) during monsoon season at W2 [i.e., Outlet near Wadhwana Watch Tower] and lowest (200 mg/l as $CaCO_3$) during monsoon season at W3 [i.e., Open Water near Manjrol Watch Tower]. [29] Classified waters on the basis of hardness into three basic categories i.e., soft waters [0-75 mg/l], moderately hard [75-150 mg/l] and hard [151-300 mg/l]. According to this classification, water samples exceed 200 mg/l which indicates that the water is hard water.

Calcium and Magnesium Hardness: Calcium and Magnesium are major constituents which play an important role in biogeochemical processes in aquatic habitats [30]. Calcium hardness plays a very important role in growth and metabolism of aquatic organisms. The Calcium content of the Wadhwana reservoir's waters varied from 21 mg/l as $CaCO_3$ to 126 mg/l as $CaCO_3$ (Table 2). Calcium Hardness was highest (126 mg/l as $CaCO_3$) during winter season at W1 [i.e., Open Water near Wadhwana Watch Tower] and lowest (21 mg/l as $CaCO_3$) during summer season at W4 [i.e., Open Water near Simaliya Watch Tower]. [31] has classified waterbodies as poor, medium and rich based on whether the calcium content is less than 10 mg/l as poor, 10.0 mg/l to 25.0 mg/ or more than 25.0 mg/l respectively. According to this classification Wadhwana irrigation reservoir falls under the category of medium to rich calcium content in water.

Magnesium content of water of a wetland is also considered as one of the most important criteria in determining quality of water for irrigation. More magnesium in water can affect crop yields as the soils become more alkaline [32]. Variations in magnesium concentration have been attributed to different biogeochemical activities in a wetland ecosystem. The magnesium content of the Wadhwana reservoir varied from 104 mg/l as

$CaCO_3$ to 600 mg/l as $CaCO_3$ (Table-2). Magnesium Hardness was recorded highest (600 mg/l as $CaCO_3$) during monsoon season at W2 [i.e., Outlet near Wadhwana Watch Tower] and lowest (104 mg/l as $CaCO_3$) during winter season at W1 [i.e., Open Water near Wadhwana Watch Tower].

Nitrates: The presence of nitrates in fresh waterbodies depends mostly upon the activity of nitrifying bacteria, domestic and agricultural source. In the present investigation, nitrates content varied from 0.0 mg/l to 42.30 mg/l throughout the monitoring period. Highest values of nitrates were recorded during monsoon season and the lowest value of nitrates were recorded during winter season.

Nitrites: In the present study, nitrites ranged from 0.01 mg/l to 0.18 mg/l (Table-2). There was a slight fluctuation during study period. Nitrites content was found to be the highest during monsoon season, but it was the lowest during winter season. High concentration of nitrites was recorded at W3 [i.e., Open Water (Near Manjrol Watch Tower] during monsoon season while, low concentration was recorded at all the sites during winter season.

Phosphates: During the present seasonal monitoring phosphates ranged from 0.03 mg/l to 2.90 mg/l (Table 2). There was a slight fluctuation during monitoring. The seasonal values of phosphates were found to be high during summer season but low during winter season at W1 [i.e., Open Water near Wadhwana Watch Tower). This may be due to inflow of phosphate content from surrounding areas through runoff. The low content of phosphate in summer season may be due to utilization of phosphate by the phytoplankton. [33] also observed similar results in the water bodies.

CONCLUSION

Evaluation of seasonal variability in physico-chemical characteristics in Wadhwana irrigation reservoir concluded that the aquatic ecology of Wadhwana irrigation reservoir not only has fairly good potential productivity but also supports rich biota. The overall water quality monitored was found within the permissible limit for biological components Fluctuations in various physico chemical parameters were observed during summer, monsoon and winter seasons. This study may be helpful in optimum utilization and sustainable management of the reservoir.

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