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Research Note

ASSESSMENT OF PHYSICO-CHEMICALPARAMETERS AND WATER QUALITY INDEX OF RESERVOIR WATER

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ABSTRACT: The present study was undertaken to know the variation in different seasons in response to physico-chemical properties of Lalpari reservoir situated at Rajkot City in Gujarat. The study was carried out over a period of one year. In India there are enormous number of natural andmanmade water bodies used for various purposes, mainly for drinking and agriculture. One of the most severe problems in arid and semi-arid regions is high concentration of salts in soils and water resources. Thus, water quality and its management have received much attention in developing countries.The present study is aimed at assessing the Water Quality Index of reservoir water and assesses the impact of industries and human activities. Physicochemical parameters were monitored for the calculation of Water Quality Index for the monsoon, winter and summerseasons.The analysis reveals that the surface water of the area needs some treatment before consumption; andit also needs to be protected from the perils of contamination.
Keywords: Physicochemical parameters; Reservoir; Seasonal variations; Water Quality Index

INTRODUCTION

Ground water is a good source of fresh water available on the earth. It is the important renewable resource having several inherent advantages over surface water [23]. Hence it is very important to assess theground water quality not only for its present use but also from the view point of a potential source of water for future consumption [18]. Water sources available for drinking and other domestic purpose must possess high degree of purity, free from chemical contamination and micro-organism [8]. Water is also one of the most important factors for every living organism on this planet. The quality of water is getting vastly deteriorated due to unscientific waste disposal, improper water management and carelessness towards environment, which has also ledto scarcity of potable water affecting the human health [2]. In India there are enormous number of natural and manmade water bodies used for various purposes, mainlyfor drinking and agriculture. However, in recent years due to rapid urbanization industrialization and modernagricultural activities, the quality of water bodies deteriorated causing environmental hazards [7]. Due to thegrowth of population, and man-made activities, the quality of water is deteriorating everywhere [7]. One of the most severe problems in arid and semi-arid regions is high concentration of salts in soils and water resources [13]. Thus, water quality and its management have received much attention in developing countries.

Water quality index provides a single number that express overall water quality at a certain location and time, based on several water quality parameters. The objective of water quality index is to turn complex water quality data into information that is useful for public. However a water quality index based on some very important parameters can provide a simple indicator of water quality. In general, water quality indices incorporate data from multiple water quality parameters into a mathematical equation that rates the health of a water body with number.The mineral impurities in water include principally the Chlorides, Nitrate, Fluoride, and Iron. The water samples were analyzed from major cations, i.e. Total dissolved solids (T.D.S.), electrical conductivity (E.C.), total hardness and pH. Ground water is generally used for drinking, domestic and agricultural purposes. The present study attempts to evaluate the quality of river water of Rajkot, Gujarat. Water is generally used for drinking, fisheries and other domestic purposes in this area.

MATERIAL AND METHODS

Study area

Rajkot is situated in the middle of the peninsular Saurashtra in central plains of Gujarat State of Western India at a height of 138 m above mean sea level. It lies between latitude $22^0$18' N and longitude $70^0$51' E. It has an area of 104.86 sq. kms. The study sites, Lalpari Lake (22^0 18' 11' N 70^0 51' 7' E) at Rajkot City in Gujarat was selected for present investigation. The lake is saturated with fish, many of whom are overgrown due to fishing restrictions. Lalpari Lake, a popular picnic spot is located at a distance of 5kms from Rajkot. It is one of the most exotic natural spots on the outskirts of the city. The lakes are roosting places for different species of birds including rare migratory birds.

Collection of Water

The present study deals with few physical and chemical parameters of the water to check the present status of water quality of sampling site. The study was conducted during February 2011 to January 2012. For water sample collection plastic sample bottles having capacity of one liter were filled without disturbing the substratum to avoid the loose sediments in sample. Samples were collected from surface (1-2 cm). After collection of samples, these bottles were labeled and possible efforts were made to transport them to the laboratory as earlier as possible. The samples for DO and BOD analysis were collected from surface from the sampling site in separate BOD bottles. Two such bottles were used for each sample. One was fixed on the spot immediately after the collection following Winkler method [27], and the second bottle containing water was kept in darkness at 4^0C (in iceboxes) till it reached the laboratory.

Water analysis methods

Physical and chemical analysis of the samples was done according to Standard Methods as per APHA, [3, 4, 27]. The values obtained were compared with standards prescribed by WHO [29] and BIS (1991).Few parameters such as temperature, pH and Electric Conductivity were recorded on the site by their respective probes. Chemical parameters such as Dissolved Oxygen (DO), Biological Oxygen Demand (BOD), Total Solid, Total Dissolved Solids (TDS), Total Suspended Solids (TSS), Hardness, Calcium, Magnesium, Salinity and Free CO_2 were then dealt in the laboratory. The following table reveals the parameters, their units and the methods used for their analysis.

The water quality index has been calculated by using the standard of drinking water quality by the World Health Organization [30], Bureau of Indian Standards [6], and Indian Council for Medical Research [20]. The weighted arithmetic index method has been used for the calculation of water quality index of the lake. Further quality rating or sub index (qn) was calculated using the following formula.

$$qn = 100[(Vn - Vio) / (Sn - Vio)]$$

Where
qn = quality rating for the nth water quality parameter.
Vn = estimated value of the nth parameter at a given sampling station.
Sn = standard permissible value of nth parameter
Vio = ideal value of nth parameter in pure water.

Ideal value in most cases $V_{10} = 0$ except in certain parameters like pH and dissolved oxygen. The calculation of quality rating for pH and DO ($V_{10} \neq 0$) is 7.0 and 14.6 mg/l respectively. Unit weight was calculated by a value inversely proportional to the recommended standard values Sn of the corresponding parameters.

$$Wn = K/Sn$$

Where
Wn = unit weight for nth parameter
Sn = standard value for nth parameters
K = proportionality constant.

The overall water quality index was calculated by aggregating the quality rating with the unit weight linearly.

$$W.Q.I. = \sum^{qnWn} / \sum^{Wn}$$

RESULTS AND DISCUSSION

The physicochemical parameters of water qualitywere analyzed using standard methods given in APHA [4]. The observation and graphical representations of physicochemical characteristics of collected water samples are given in Table 1-4. It should be recognized that, like dissolved oxygen, pH also varies in reservoir naturally throughout the day due tothe photosynthesis and respiration cycles in thepresence of algae in water bodies. The pH is measure of the intensity of acidity or alkalinity andthe concentration of hydrogen ion concentration. pH has no direct adverse effects on health; however, higher values of pH hasten the scale formation in water heating apparatus and also reduce germicidal potential of chloride. High pH induces theformation of tri halo methane which is toxic. pH is one of the most important factors that sever as an index for the pollution. The average pH value of the reservoir water was 8.10 during monsoon, 8.06 during winter and 8.53 during summer season (Table 4). The pH of water relatively high during the summer season and low during monsoon season. However, concern all the seasons are taken into account the reservoir water was found to be slightly seasonal alkaline [24]. In the present study pH values were within the prescribed limit of standards.

The water temperature is one of the most important physical characteristics of aquatic ecosystem, as it affects the organisms. It affects a number of water quality parameters that is one of the concerns for domestic, environmental, industrial and agricultural applications [22]. In the present study temperature was raged between 21.25 to 23.85^{o}C (Table 4), which was within the range of 25 and 30^{o}C needed by fish to grow well [1]. Conductivity is related to the concentration of Total Dissolved Solids (TDS). According to Chapman (1992), TDS may be obtained by multiplying the conductivity by a factor between the ranges of 0.55 to 0.75. The electricalconductivity of the water samples ranged between 785.5 µS/cm and 832.5µS/cm throughout the study period (Table 4). The total dissolved solids were 607 during mg/l during monsoon, 599 mg/l during winter and 516 mg/l during summer season (Table 4). The concentration was high during monsoon season, which may be due to addition of solids from runoff water to the reservoir [17]. Higher values of hardness observed during summer season, which can be attributed to low water level and high rate of evaporation of water and addition of calcium and magnesium salts. The observed maximum value of calcium was 47.46 during summer season. The quantities of calcium in natural water depend upon the type of rocks. While the observed values of magnesium was 44.83 mg/l during summer season and 41.08 during winter season (Table 4). The average dissolved oxygen was 6.63 mg/l during monsoon, 6.96 during winter and 7.10 during summer season (Table 4). This can be attributed to addition of consequent biodegradation and decay of vegetation at higher temperature leading to consumption of oxygen from water. The physical and chemical characteristics of water showed seasonal fluctuations interacting with one another and have a combined effect on animals and plants [21]. Factors controlling the composition of natural waters are extremely varied and include physical, chemical and biological processes [9, 7].

Water Quality Index is established through the measurement ofvarious important physicochemical parameters of the surface water [14]. Season wise water quality index calculations are depicted in the Table 5 to 7. The water quality index obtained for the reservoir water system in different seasons of study period i.e., monsoon season, winter season and summer season are 133.15, 132.64 and 140.99, respectively which indicate the very poor quality of water [12, 10, 26]. The values of Water Quality Index showed the higher percent of poor category of reservoir water was found in the sampling site. It maybe due to the effective ionic leaching, over exploitation and anthropogenic activities such asdischarge of effluents from industrial, agricultural and domestic uses. It is found that the 50 % of reservoir water on the sampling location are of verypoor quality. This clearly indicates that water samples for this region are highly polluted. They are not suitable for drinking purpose and other useful human activities [14].

The above water quality is also supported by the following physicochemical parameters variations observed during the different seasons of the study. Among all the physicochemical parameters selected for the Water Quality Index calculations, pH is an important parameter which determines the suitability of water for various purposes. Dissolved oxygen in water comes from the atmosphere due to the air action. Algae and aquatic plants also release oxygen to water through photosynthesis [19]. The oxygen content of natural water varies with temperature, salinity, turbulence, respiration and photosynthetic activity of algae and higher plants and the atmospheric pressure. DO values were higher in those ponds where there was good aquatic life [26, 7]. The concentration of dissolved oxygen regulates the distribution of flora and fauna. The optimum range of dissolved oxygen in natural waters is 4 to 6 mg/L [16]. The maximum value of dissolve oxygen was recorded during monsoon season, similar observations observed by Vijayan, [28]. Bio-chemical oxygen demand is a parameter to assess the organic load in a water body [19]. The increased levels of BOD indicated the nature of chemical pollution. BOD Variations were observed – maximum being in polluted waters and minimum in pollution free waters [25]. The BOD values obtained in the present study are within the ICMR standards. Seasonally, it was high during summer [7].

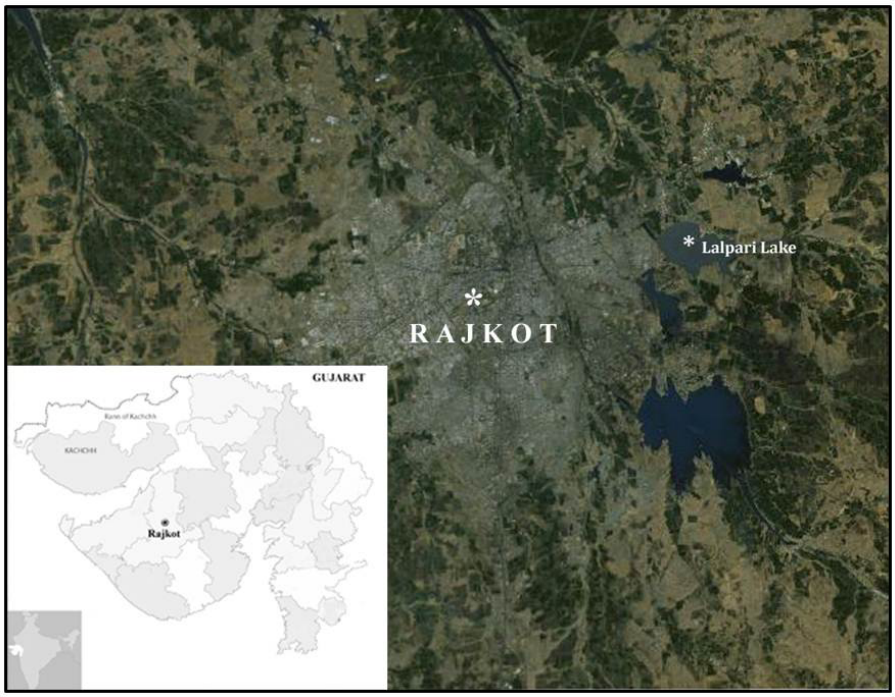

Figure 1. Map showing the study location along Rajkot, Gujarat.

Table 1. Methods used for physical and chemical analysis of water.

Parameter (Unit)	Method
Temperature (^{0}C)	Thermometer probe
Total Solid (g/l)	Gravimetric
Total dissolved solid (g/l)	Gravimetric
Total Suspense Solid (g/l)	Gravimetric
Electric Conductivity (µs)	Potentiometric Probe
pH	pH probe
Salinity (ppm)	Titrimetric
Dissolved oxygen (mg/l)	Titrimetric
Biochemical Oxygen Demand (mg/l)	Titrimetric
Total hardness (g/l)	Titrimetric
Calcium (g/l)	Titrimetric
Magnesium (g/l)	Titrimetric
Free CO_2(mg/l)	Titrimetric

Table 2. Status of water quality based on Water Quality Index (W.Q.I).

Water Quality Index	Water Quality Status
00 -25	Excellent
26-50	Good
51-75	Poor
76-100	Very Poor
< 100	Unsuitable for drinking

Table 3. Standard recommending agencies and unit weight for drinking water.

Parameter	Standards	Recommended Agencies	Unit Weight
pH	6.5 – 8.5	ICMR; BIS	0.2188
TDS	500 mg/l	ICMR; BIS	0.0155
Conductivity	1000 µmho/cm	BIS	0.0018
DO	5.0 mg/l	ICMR; BIS	0.3723
BOD	5.0 mg/l	ICMR; BIS	0.3723
Total hardness	300 mg/l	ICMR; BIS	0.0062
Calcium	75 mg/l	ICMR; BIS	0.025
Magnesium	30 mg/l	ICMR; BIS	0.061

Table 4. Seasonal variation in the physico-chemical parameters of Lalpari Reservoir.

Parameter	Season		
	Monsoon	Winter	Summer
Temperature (^oC)	23.25	21.85	23.8
Total Solid (mg/l)	687	658	607
Total dissolved solid (mg/l)	607	599	516
Total Suspense Solid (mg/l)	80	59	91
Electric Conductivity (µs)	832.5	785.5	816
pH	8.10	8.06	8.52
Salinity (mg/l)	357.5	359.5	399
Dissolved oxygen (mg/l)	6.63	6.96	7.10
BOD (mg/l)	3.95	4.995	5.135
Total hardness (mg/l)	261	243.5	265
Calcium (mg/l)	43.89	43.26	47.46
Magnesium (mg/l)	44.40	41.08	44.83
Free CO_2(mg/l)	16	15.5	15
Water Quality Index	**133.15**	**132.64**	**140.99**

Table 5. Calculation of Water Quality Index during monsoon season of Lalpari Reservoir.

Parameters	Observed Value (Vn)	Standard Values (Sn)	Unit Weight (Wn)	Quality Rating (Qn)	WnQn
TDS (mg/l)	607	500	0.0037	121.40	0.45
TSS (mg/l)	80	500	0.0037	16.00	0.06
Conductivity (µs)	832.5	300	0.371	277.50	102.95
pH	8.1	8.5	0.219	73.33	16.06
Salinity (mg/l)	357.5	250	0.0074	143.00	1.06
DO (mg/l)	6.625	5	0.3723	83.07	30.93
BOD (mg/l)	3.95	5	0.3723	79.00	29.41
Total hardness (mg/l)	261	300	0.0062	87.00	0.54
Calcium (mg/l)	43.885	75	0.025	58.51	1.46
Magnesium (mg/l)	44.4	30	0.061	148.00	9.03
			Σ_{Wn}= 1.4416	**Σ_{Qn} = 1086.82**	**Σ_{WnQn}=191.95**
Water Quality Index **= ΣWnQn/Wn = 133.15**					

Table 6. Calculation of Water Quality Index during winter season of Lalpari Reservoir.

Parameters	Observed Value (Vn)	Standard Values (Sn)	Unit Weight (Wn)	Quality Rating (Qn)	WnQn
TDS (mg/l)	599	500	0.0037	119.80	0.44
TSS (mg/l)	59	500	0.0037	11.80	0.04
Conductivity (µs)	785.5	300	0.371	261.83	97.14
pH	8.055	8.5	0.219	70.33	15.40
Salinity (mg/l)	359.5	250	0.0074	143.80	1.06
DO (mg/l)	6.96	5	0.3723	79.58	29.63
BOD (mg/l)	4.995	5	0.3723	99.90	37.19
Total hardness (mg/l)	243.5	300	0.0062	81.17	0.50
Calcium (mg/l)	43.255	75	0.025	57.67	1.44
Magnesium (mg/l)	41.08	30	0.061	136.93	8.35
			Σ_{Wn}= 1.4416	**Σ_{Qn} = 1062.82**	**Σ_{WnQn}=191.21**
***Water Quality Index* = ΣWnQn/Wn = 132.64**					

Table 7. Calculation of Water Quality Index during summer season of Lalpari Reservoir.

Parameters	Observed Value (Vn)	Standard Values (Sn)	Unit Weight (Wn)	Quality Rating (Qn)	WnQn
TDS (mg/l)	516	500	0.0037	103.20	0.38
TSS (mg/l)	91	500	0.0037	18.20	0.07
Conductivity (µs)	816	300	0.371	272.00	100.91
pH	8.515	8.5	0.219	101.00	22.12
Salinity (mg/l)	399	250	0.0074	159.60	1.18
DO (mg/l)	7.095	5	0.3723	78.18	29.11
BOD (mg/l)	5.135	5	0.3723	102.70	38.24
Total hardness (mg/l)	265	300	0.0062	88.33	0.55
Calcium (mg/l)	47.46	75	0.025	63.28	1.58
Magnesium (mg/l)	44.83	30	0.061	149.43	9.12
			Σ_{Wn}= 1.4416	**Σ_{Qn} = 1135.82**	**Σ_{WnQn}=203.25**
***Water Quality Index* = ΣWnQn/Wn = 140.99**					

CONCLUSION

The observation in this study indicates the higher values of some parameters of the reservoir water. They minimize the suitability of the water for drinking purpose without prior treatment. Higher values of Water Quality Index clearly show thatthe status of water body is entropic and not totally safe for human drinking purpose. It is also observed that the pollution load is relatively higher during summer season when compared to the winter and monsoon season.

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