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Water quality index of Thol Wetland, Mehsana, Gujarat, India

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Abstract

The Water Quality Index (WQI) of the Thol Wetland was calculated based on water quality parameters like pH, Conductivity, Total Dissolved Solids, Phosphate, Alkalinity - as $CaCO_3$, Total Hardness as $CaCO_3$, Sodium, Potassium, Calcium, Magnesium, % Sodium, Sodium Absorption Ratio, Chloride and Sulphate. Physico chemical parameters of water samples were analyzed for summer, monsoon and winter seasons during the year 2015- 2016. The study included sampling and its analysis of water samples, parameter rating and water quality determination. WQI is calculated in context with the basic usage of Thol Wetland water viz. irrigation and propagation of wildlife.

Keywords: Physico-chemical parameters, WQI (water quality index), Thol Wetland.

Introduction

Wetlands provide a spectrum of services such as water purification, water flow regulation, fisheries, habitats for plants, animals and micro-organisms, recreation and tourism opportunities etc. Inland wetlands also replenish groundwater. The abundance and distribution of wildlife in a habitat depends on distribution and extent of water-bodies. A water quality index is a number calculated based on several water quality parameters to denote overall water quality of water at a particular location and time. The index turns complex water quality data into simple, easy to understand and usable information for various stakeholders especially the public and the policy makers[1-4]. The index presented here is specifically in context with its uses for irrigation and for sustenance of wild life. It thus gives an idea whether Thol Wetland water is appropriate for a particular use or about the water related regional problems.

Study area: Thol Bird Sanctuary (TBS) is located in Kadi taluka of Mehsana district, Gujarat. It was declared as a sanctuary in November 1988. It has a total area of 6.99 sq.km and 5.62km periphery[5,6]. There is a continuous earthen bund on its western, southern and eastern periphery, which helps in accumulation of water that runs into it during the monsoon from the catchment area located to its north and North–East. Thol wetland water is also used for irrigation by surrounding villages. The water regime changes through the seasons. It remains covered with water in the rainy season. During winter it begins to dry and by summer it is separated into water bodies of varying in size, the biggest being close to the western side. After a preliminary survey and considering the approachability, anthropogenic pressures and annual water regime in the wetland, following three sampling locations were covered during the study. The general information of the sampling locations is as per Table-1.

Table-1: Sampling locations.

Details	Location 1	Location 2	Location 3
Name	Near culvert no. 1	Front of forest camp site	Near culvert no. 4
Latitude	N23°07'53.9'''	N23°08'01.8'''	N23°08'26.0'''
Longitude	E72°24'46.7'''	E72°24'01.3'''	E72°23'35.0'''
Main Features	Comparatively minimal human intervention, proximity to catchment water influx and Narmada river water influx through canal	Comparatively maximum human intervention, Transit between the other two locations	Comparatively deeper region, water remains almost all through the year

Materials and methods

Surface water samples with a bimonthly frequency were collected covering three seasons[7] viz. summer, winter and monsoon during the year 2015 - 2016 for physical and chemical analysis from three different locations. The collected samples were rushed to the laboratory on the same day and stored in a refrigerator for further analysis following the methods given by APHA AWWA[8]. The values retrieved for physico-chemical parameters like pH, Conductivity (Cond µs/cm), Total Dissolved Solids (TDS mg/l), Nitrate (NO_3-N), Phosphate (PO_4^{-2} mg/l), Alkalinity - as $CaCO_3$ (Alk mg/l), Total Hardness as $CaCO_3$ (TH mg/l), Sodium (Na mg/l), Potassium (K mg/l), Calcium (Ca mg/l), Magnesium (Mg mg/l), % Sodium (%Na), Sodium Absorption Ratio (SAR), Flouride, Chloride as Cl^- (Cl^- mg/l), and Sulphate (SO_4^{-2} mg/l) were utilized[9-12]. The Water Quality Index (WQI) was calculated by taking into consideration the irrigation water standards of BIS, FAO Guide

lines for irrigation water, criteria for designated best use as laid down by CPCB and through expert opinion on relative significance of the parameter[1,12-16] in following manner.

Assigning weight: Weight (w_i) was assigned to each water quality parameter based on its relative significance in the overall quality of water for irrigation and wildlife propagation.

Determination of relative weight (W_i): Relative Weight is determined from the equation $W_i = \frac{w_i}{\sum_{i=1}^{n} w_i}$.

Where: W_i = Relative weight of parameter, w_i = weight of each parameter and n= total number of parameters into consideration.

Determination of Quality Rating Scale: Quality Rating Scale (Q_i) is developed by dividing concentration with its respective standard value laid down by BIS/CPCB and multiplying by 100. Thus, $Q_i = \frac{C_i}{S_i} X\ 100$.

Where: Q_i=Quality rating, C_i = Concentration of each parameter and S_i = Standard value of parameter in mg/l laid down according to BIS / CPCB.

Determination of Sub-index: Sub-index (SI) for each water quality parameter is determined using the formulae $SI_i = W_i X Q_i$.

The Water Quality Index (WQI) is computed using the formula $WQI = \sum SI_i$.

Where: SI_i = Sub-index of i^{th} parameter, Q_i=Quality rating based on concentration of i^{th} parameter, n=the total number of parameters.

The values of WQI thus calculated are classified into four types (Table-2).

Table-2: Classification based on water quality index for irrigation.

WQI value	Classification
< 50	Excellent
50 – 150	Good
150-300	Poor
>300	Very Poor

Table-3: Irrigation Water Guidelines/Criteria values and weight assigned.

Parameter	Unit	FAO Guidelines (1985): Usual range in irrigation water	BIS Standards (2002): Designated Use Class E (Max Values)	Weight (w_i)	Relative Weight (W_i)
pH	-	6.0 – 8.5	6.5 -8.5	1	0.0323
Conductivity	µS/cm	0 – 3000	2250	4	0.1290
Total Dissolved Solids	mg/l	0 – 2000	-	4	0.1290
Nitrate (NO_3-N)	mg/l	0 – 10	-	3	0.0968
Phosphate	mg/l	0 – 2	-	1	0.0323
Alkalinity as $CaCO_3$	mg/l	200	-	1	0.0323
Total Hardness as $CaCO_3$	mg/l	712*	-	1	0.0323
Sodium	mg/l	0 – 920	-	1	0.0323
Potassium	mg/l	0 – 2	-	5	0.1613
Calcium	mg/l	0 – 400	-	1	0.0323
Magnesium	mg/l	0 – 61	-	2	0.0645
% Sodium	-	-	60	2	0.0645
SAR	me/l	0 – 15	26	2	0.0645
Fluoride	mg/l	1.5*	-	1	0.0323
Chloride	mg/l	0 – 1065	600	1	0.0323
Sulphate	mg/l	0 – 960	1000	1	0.0323
			Total	31	

*Values as suggested in Research Bulletin No.71, Directorate of Water Management, ICAR, 2014.

The irrigation water is classified[15] into following four major groups based on hazardous effects of the Total Salt Concentration expressed as the Electrical Conductivity[1,17] and Sodium Absorption Ratio[1,18,19].

Table-4: Irrigation water Classification based hazardous effects of EC and SAR.

Class	Range of Electrical Conductivity (micro mhos/cm)	Sodium Absorption Ratio (SAR)
Low	Below 1500	Below 10
Medium	1500-3000	10-18
High	3000-6000	18-26
Very High	Above 6000	Above 26

Results and discussion

The seasonal average values of different Physico - chemical parameters found for Thol wetland during the study period is as per Table-5. Using the described methodology, prescribed irrigation water guidelines/criteria values and weight assigned, the WQI of Thol Wetland was calculated (Table-6) for all three seasons and all three locations.

Similarly, the WQI was calculated (Table-6) for the winter and summer seasons (Table-5) and also for three different locations by considering the observed yearly average values of Physico-chemical parameters (Table- 7).

The objective of the study is to see the suitability of Thol Wetland water for its one of the intended use (i.e. irrigation), based on Water Quality Index values.

Table-5: Seasonal Variation (average values) of Physico-chemical parameters of Thol Wetland during 2015-2016.

Parameter	Unit	Monsoon	Winter	Summer	Average
pH	-	8.23	8.71	8.03	8.32
Conductivity	µS/cm	269.67	246.05	576.00	363.91
Total Dissolved Solids	mg/l	161.50	164.67	331.17	219.11
Nitrate (NO_3-N)	mg/l	0.115	0.198	0.49	0.27
Phosphate	mg/l	0.015	0.036	0.02	0.02
Alkalinity as $CaCO_3$	mg/l	91.50	102.00	113.00	102.17
Total Hardness as $CaCO_3$	mg/l	67.15	78.53	79.00	74.89
Sodium	mg/l	20.73	23.17	51.88	31.93
Potassium	mg/l	3.37	1.82	3.75	2.98
Calcium	mg/l	14.46	17.01	17.81	16.43
Magnesium	mg/l	6.67	8.68	6.21	7.19
% Sodium	-	40.12	38.82	56.22	45.05
SAR	me/l	1.12	1.15	2.63	1.63
Fluoride	mg/l	0.12	0.27	0.57	0.32
Chloride	mg/l	31.83	26.17	73.67	43.89
Sulphate	mg/l	13.00	17.83	34.00	21.61
	WQI	41.15	29.55	50.97	40.56

Table-6: Estimation of WQI of Thol Wetland during Monsoon season.

Parameter	Average Observed Values (Concentration C_i)	Standard Values (S_i)	Weight (w_i)	Relative Weight (W_i)	Quality Rating Scale (Q_i)	Sub Index (SI_i)
pH	8.23	7.0	1	0.0323	117.55	3.79
Conductivity	269.67	3000	4	0.1290	8.99	1.16
Total Dissolved Solids	161.50	2000	4	0.1290	8.08	1.04
Nitrate (NO_3-N)	0.115	10	3	0.0968	1.15	0.11
Phosphate	0.015	2	1	0.0323	0.75	0.02
Alkalinity as $CaCO_3$	91.50	200	1	0.0323	45.75	1.48
Total Hardness as $CaCO_3$	67.15	712	1	0.0323	9.43	0.30
Sodium	20.73	920	1	0.0323	2.25	0.07
Potassium	3.37	2	5	0.1613	168.33	27.15
Calcium	14.46	400	1	0.0323	3.62	0.12
Magnesium	6.67	61	2	0.0645	10.93	0.71
% Sodium	40.12	60	2	0.0645	66.87	4.31
SAR	1.12	15	2	0.0645	7.47	0.48
Fluoride	0.12	1.5	1	0.0323	8.17	0.26
Chloride	31.83	1065	1	0.0323	2.99	0.10
Sulphate	13.00	960	1	0.0323	1.35	0.04
					WQI	41.15

Table-7: Location wise variation (average values) of Physico–chemical parameters of Thol Wetland during 2015-2016.

Parameter	Unit	Location 1	Location 2	Location 3	Average
pH	-	7.77	8.60	8.61	8.32
Conductivity	µS/cm	334.12	383.98	373.62	363.91
Total Dissolved Solids	mg/l	193.00	237.17	227.17	219.11
Nitrate (NO_3-N)	mg/l	0.53	0.15	0.12	0.27
Phosphate	mg/l	0.03	0.02	0.02	0.02
Alkalinity as $CaCO_3$	mg/l	104.17	99.33	103.00	102.17
Total Hardness as $CaCO_3$	mg/l	89.25	70.48	64.95	74.89
Sodium	mg/l	27.08	36.69	32.01	31.93
Potassium	mg/l	3.02	3.10	2.82	2.98
Calcium	mg/l	18.89	15.48	14.91	16.43
Magnesium	mg/l	9.08	6.22	6.26	7.19
% Sodium	-	37.40	48.44	49.31	45.05
SAR	me/l	1.27	1.91	1.72	1.63
Fluoride	mg/l	0.35	0.37	0.23	0.32
Chloride	mg/l	39.00	49.83	42.83	43.89
Sulphate	mg/l	14.50	25.50	24.83	21.61
	WQI	39.93	42.23	39.52	40.56

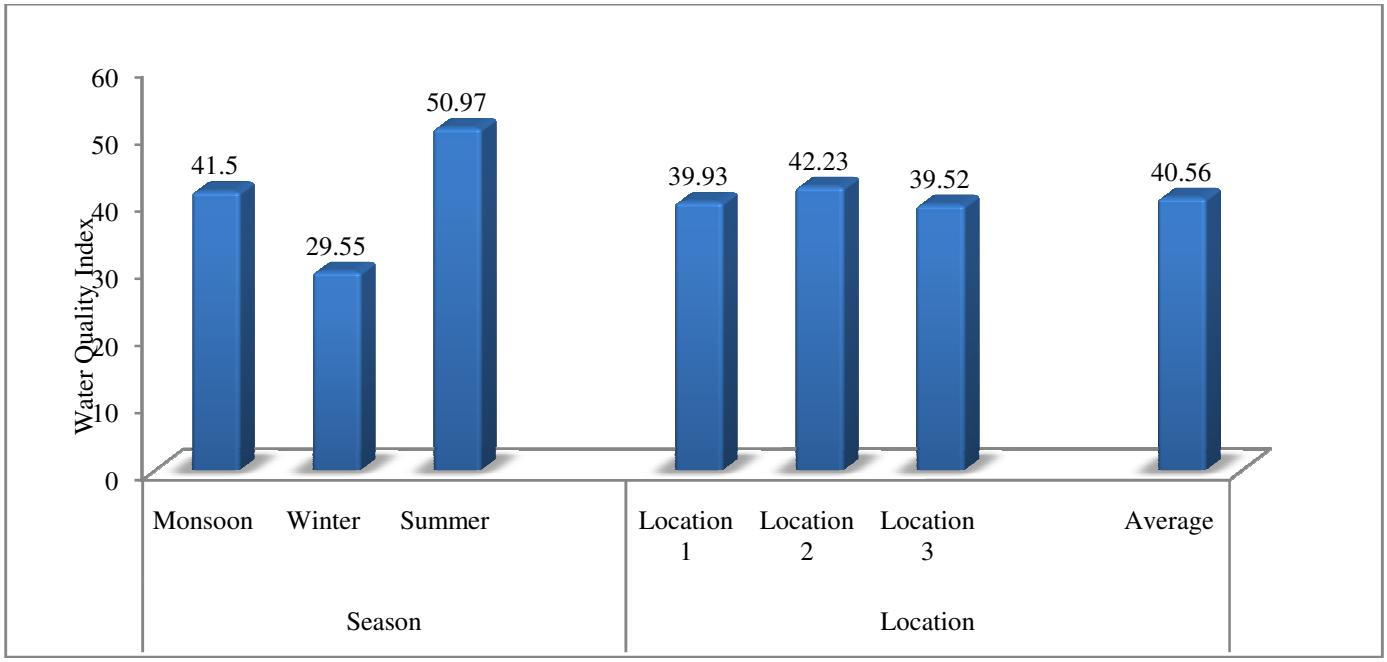

Figure-1: Seasonal and Temporal Pattern of Water Quality Index of Thol Wetland during Year 2015-2016.

Water Quality Index of Thol Wetland is calculated from important physicochemical parameters. The analytical values of different physico chemical parameters for calculation of WQI are presented in Table-5. WQI values for different seasons during the study period are found to be 41.15, 29.55 and 50.97 for monsoon, winter and summer seasons respectively. Whereas the WQI values at different locations of Thol wetland are 39.93, 42.23 and 39.52 for Location 1, Location 2 and Location 3 respectively (Figure-1). The average WQI of Thol Wetland is found to be 40.56 during the study period. Except for the value of summer season, all these values being <50, indicate excellent quality of water for irrigation purpose. During the summer season, the value being 50.97 indicates Good quality of water for irrigation purpose. Moreover, the water quality of Thol wetland shows SAR[1,15,18] value below 10 and Electrical Conductivity[1] value below 1500 µS/cm at all locations and also throughout all seasons of the year. These values thus indicate the hazard class to be low. The average value of different physico chemical parameters of Thol wetland water (Table-5 and Table-7) reveals higher values of Total Dissolved Solids and Total Hardness during summer, which may be due to low water level and high rate of decomposition and evaporation thus concentrating the salts. This is also reflected by a comparative higher seasonal value of WQI in summer season.

Conclusion

The application of WQI is demonstrated for three different locations of Thol Wetland. The WQI values ranged from 29.55 to 50.97 with an annual average of 40.56. The WQI values across the locations and during the monsoon and winter seasons are found to be excellent. The comparative value during the summer is higher than the other period of the year which indicates that organic load gets accumulated during summer. The WQI thus developed is a simple tool yet very useful for the water quality assessment and it can be used by all concerned for maintaining good health of the Thol wetland.

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