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An evaluation of water quality of Pārbati River by using water quality index

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Abstract
The Parbati river in district Sehore, MP India, has a strong economic and traditional attachment to the local people. This study was conducted to assess the Water Quality Index (WQI) of the Parbati River from five different stations. Maximum WQI values were recorded at Station 3 and station 4 throughout all seasons except winter at station 3. The stations 3 and 4 reveal poor quality while Stations 1, 2 and 5 fall under good quality. The present study points out that pH, DO and Phosphate played a central role in affecting the WQI of the river. The condition of water body at present study felt doubtful and needs to adopt proper management policy and conservation efforts along the riparian zones of Parbati river.

Keywords: Parbatiriver, WQI, BIS, ICMR water quality

Introduction
Rivers are an important source of freshwater but are also vulnerable to kinds of pollution to both point and nonpoint sources. Anthropogenic activities related to extensive urbanization, agricultural practices, industrialization and population expansion have led to water quality deterioration in many parts of the world. The adjacent landscapes that act as an interface between the aquatic and terrestrial ecosystem called the 'riparian zones play a significant role in controlling water and chemical exchange between surrounding land and stream systems (Burt and Pinay 2005) [9]. Disturbances in landscape can lead to deterioration of water quality as they influence the flows of energy and material between the terrestrial and aquatic (Fausch*et al*. 2010) [14] interface. Riparian zones form a unique ecosystem and act as 'buffer zones' between upland and streams (Hill 1996; Lowrance 1998) [15, 21] and are vital to the health of the watershed. The riparian forest along the river that receives and processes water, sediments and nutrients transports from upslope areas and effectively functions as sinks for sediment and nutrients, thus regulating the nutrient loading to the aquatic system (Luke *et al*. 2007; Mayer *et al*. 2007) [22, 24]. Water quality of any specific area or source may be assessed using physical, chemical and biological parameters; it is considered harmful and unfit for different human usage and other agricultural activities once they occur more than the well-defined limits (ICMR 1975; BIS 2003) [17, 8]. Accordingly, the suitability of water for its usage may be categorized or described in terms of Water Quality Index (WQI), which is one of the most effective ways to describe the status of water quality. It is calculated from the point of aptness of surface water for human consumption (Atulegwu and Njoku 2004) [3]. WQI is a single number that expresses water quality by aggregating the measurements of water quality parameters (such as dissolved oxygen, pH, nitrate and total hardness). It reduces the bulk of information from the several water quality parameters into a single value and expresses the data in a simplified and logical form (Semiromi*et al*. 2011) [32]. Assessment of water quality provide overall information on the quality of the water bodies and its potential threat to various uses. It helps to understand the overall water quality status of individual sampling stations at a certain time (Yogendra and Puttaiah2008) [38] and its suitability for various beneficial uses. The concept of indices to represent gradation in water quality was first proposed by Horton (1965) [16], since then numerous water quality indices have been formulated that can easily evaluate the overall water quality of an area promptly and efficiently. The general WQI developed by Brown *et al*. (1970) [7] has undergone much improved modification suitable for a different purpose.

Many workers like Debelset al. (2005) [11], Yisa and Jimoh (2010) [37], Akoteyonet al. (2011) [1], Othman *et al*. (2012) [28], Naubiet al. (2016) [26], Ewaid (2017) [13] and Bouslah*et al*. (2017) [5] have worked out the study of WQI of different rivers. Similarly, in India, Yogendra and Puttaiah (2008) [38], Kumar *et al*. (2011), Sharma and Kansal (2011), Singh and Kamal (2014) [33] and Shah and Joshi (2017) have also worked on WQI of rivers in different states of India. In the present study, the application of WQI will give comparative results of the water quality status of Parbati river at different sampling stations in varying seasons. This study would provide us a comprehensive water quality status of the Parbati River. It would ultimately pave ways for future management and action plans so as to protect and facilitate improvement of the water quality.

Study Area

Parbati River originates at a height of 610 m in the Vindhya Range at 76°35’40.75¨E longitude and 22° 50’09.63¨N latitude from Pithapura Lake near village Siddiqueganj in Sehore district, Madhya Pradesh. Being 471 km long it runs through various districts, of Madhya Pradesh and finally joins with Chambal River in Sawai Madhopur District of Rajasthan at District at 76° 33’58.86¨ E longitude and 25° 50’56.86’’ N latitude. It is one of the Chambal River's three main tributaries, along with the Banas River and the Kali Sindh River. Ramgarh crater is located on its eastern bank.

For the study, Samples were collected from 5 selected sites, Selection of the sampling stations was based on the possible pollutant loads and the magnitude of human activities along the rivers. Detailed location information of these sampling sites, and the latitude and longitude of all stations are presented in Table 1.

Table 1: Characteristic features of the sampling station and their coordinates

S. No	Sampling station	Characteristics of sampling stations	Longitude E	Latitude N
1	Station 1	Upstream forested	76⁰36'2.41''E	22⁰50'13.96'' N
2	Station 2	Rural area near the village Siddiqganj	76⁰37'0.41.53''E	22⁰51'41.60''N
3	Station 3	Urban site close tomain town Ashta	76⁰'47'42'' E	23⁰3'35'' N
4	Station 4	Shujalpur road Borkheda around the vicinity klin -brick factory	76⁰49'18.11'' E	23⁰7'0.72'' N
5	Station 5	Downstream close to the dam	76⁰55'49''E	23⁰13'55''N

Materials and methods

Along the stretch of Parbati River, surface water samples were collected from the five sampling stations. Sampling was done from winter 2020 to Post monsoon 2020 for a period of 1 year. Categorized into four different seasons, namely winter, summer, monsoon and post-monsoon for interpretation of data. Water samples were collected from the first 20 cm of the water column using a bottom-weighted polyethylene flask, previously washed in the laboratory with lapoline, 10% HCl and then with a water sample from each spot. In this study, twelve physicochemical parameters of water were selected, namely pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness (TH), chloride (Cl^-), nitrate ($NO3^-$), phosphate and dissolved oxygen (DO) for generating the overall WQI of parbati river (Table12). Parameters like pH and TDS were measured on the spot with the help of pen-type digital pH and TDS meter. Conductivity was analyzed with the help of a digital conductivity meter in the laboratory. Total alkalinity, total hardness, and chloride were analyzed by the titration method. For the measure of dissolved oxygen, fixatives were added on the spot and analyzed thereafter using Winkler’s method. All the parameters were analyzed using standard methods as prescribed by Trivedy and Goel (1986) [35] and APHA (2005) [2]. Finally, the WQI was calculated by employing the Weighted Arithmetic Index method developed by Brown *et al*. (1970) [7] which is given in the following equation.

Water Quality Index

Weighted arithmetic water quality index method classified the water quality according to the degree of purity by using the most commonly measured water quality variables.

$$WQI = \sum WIQI \;/\; \sum WIQI$$

The quality rating scale (Qi) for each parameter is calculated by using this expression:

$$Qi = 100[(\text{VI-VO}SI - VO)]$$

Where,

Viis estimated concentration ofith parameter in the analyzed water

Vo is the ideal value of this parameter in pure water

Vo = 0 (except pH =7.0 and DO = 14.6 mg/l)

Si is recommended standard value of ith parameter the unit weight (Wi) for each water quality parameter is calculated by using the following formula:

The quality rating of the index was calculated by the formula

$$Wi = K/Si$$

Where,

K = proportionality constant and can also be calculated by using the following equation

$$K = \frac{1}{\sum I/Si!}$$

Table 3: Water Quality Rating as per Weight Arithmetic Water Quality Index Method

WQI Value	Rating of Water Quality	Grading
0-25	Excellent water quality	A
26-50	Good water quality	B
51-75	Poor water quality	C
76-100	Very Poor water quality	D
Above 100	Unsuitable for drinking purpose	E

Result and discussion

Water quality parameters The values of water quality parameters obtained from all the sampling stations in for different seasons are presented in Table-12. The pH is a measure of the acidic or alkaline condition of water and serves as an important indicator of water quality and determines the suitability of water for various purposes. The experimental water bodies recorded approximately neutral or slightly alkaline in nature [5]. During the study the (pH) ranged from 7-8.7. The minimum was recorded at station-3 during summer, maximum was recorded at station-2 during post-monsoon. In natural water, the common range of pH falls within 6–8 (Thakre*et al*. 2010) [34]; a similar range of values has also been observed of the current study as well. Electrical conductivity (EC) is an indirect measure of total dissolved salts. The presence of these salts greatly affects the taste and acceptance of the water as potable to the users (Pradeep 1998) [30]. Observed EC of Parbati River was found between 165-569µS/cm. Seasonwise a maximum range 569 µS/cm was observed in summer across station 3 (Yogendra and Puttaiah 2008) [38]. Total dissolved solids (TDS) measure the dissolved particle present in the water sample and indicate the general nature of water quality or salinity. The values recorded were all under the desirable limits of 500 mg/l (BIS) with a range of (117-337 mg/l). Total alkalinity (TA) recorded the highest average value of 139mg/l during the post monsoon. However, there was a significant decrease in TA in the summer and monsoon. This may be attributed to the influx of fresh water into the river system causing dilution (Chatterjee and Raziuddin 2002). In natural water, total hardness (TH) is contributed mainly by dissolved calcium and magnesium ions (Ikomi and Emuh 2000) [18], with all other divalent cations contributing to its concentration. The majority of its source is contributed by the surrounding rocks of the water bodies. The increase in temperature, low level of water and other domestic waste may have contributed toward its higher concentration (Devi *et al*. 2015) [12] during the summer show much variation in their concentration between the stations and seasons. The Total hardness (TH) ranged as 109-238 mg/l maximum during summer season at station3, while minimum during winter at station 1 respectively. Chloride occurs naturally in all types of water; however, its main contributing sources are runoff ofinorganic fertilizers from agricultural fields, sewage discharge, etc. The chloride content of the sample was found to be well within the permissible levels of 250 mg/l. Its highest concentration was recorded during the monsoon at station 3(116 mg/l) and least during winter 15.5 mg/lat station 2. Nitrate is found in surface waters as a result of sewage, fertilizer runoff from agricultural land, etc. Excess of nitrate can cause eutrophication (WHO 1998) resulting in the death of aquatic animals and serious health hazards. The nitrate was found in the range of 0.23-1.96 mg/l maximum 1.96 mg/l during summer at station 4 and least 0.23mg/lduring monsoon at station 1.Dissolved oxygen (DO) is the measurement of the amount of oxygen dissolved in water and is a direct indicator of water quality. In a healthy water body that ensures good water quality, DO must be > 4 mg/l (Prasad and Bose 2001) [31]. Do along Parbati river was recorded significantly high from three stationsthe stations throughout the study period. The highest concentration of DO was observed during the post monsoon season 9.5 mg/l at station 5, while as minimum DO was observed from station 3 and 4 through the seasons these stations are in the high risk of anthropogenic activities. While as other stations showed good concentration of DO this is due to The turbulent nature of the water bodies, photosynthesis and a decrease in temperature might have resulted in the increased concentration of DO (Bouslah *et al*. 2017) [5]. In natural waters phosphate generally occurs low to moderate concentrations. The major source of Phosphate is domestic sewage, detergents, agricultural effluents with fertilizer and industrial waste water. Major sources of phosphate are agricultural runoff containing phosphate fertilizers as well as the waste water containing detergents (Naseema *et al*., 2013) [27]. In present study, the value of phosphate was varied from0.122-0.66 mgl^{-1}. Singh *et al*., 2010, supports the present results observed the value of phosphate between 0.2 mgl^{-1} to 0.5 mgl^{-1} in Manipur river system. (Magadum*et al*., 2017) [25] values of Total phosphate ranged from 0.060 mgl^{-1} to 0.800 mgl^{-1} which supports the findings of the present study. All the nine physicochemical parameters of water analyzed were well within the permissible limits of drinking water given by BIS (2003) [8] and ICMR (1975) [17].

During the present investigation water quality index was applied on all the sampling stations of Parbati river. The overall water quality index values of all sampling stations is given in Table.

Table 4: Relative weights (Wi) of diferent parameters and their standards used for WQI determination

Parameter	ICMR/BIS	Unit weight
pH	6.5-8.5	0.087
Chloride	250	0.003
Total Dissolved Solids	500	0.001
Electrical Conductivity	300	0.002
Dissolved Oxygen	5	0.147
Phosphate	1	0.736
Nitrate	25	0.016
Total hardness	300	0.004
Total alkalinity	120	0.006
$\sum Wi=1$		

Table 5: Showing WQI of different seasons

Sampling Stations	Winter		Summer		Monsoon		Post Monsoon	
	WQI value	Water Type	WQI value	Water Type	WQI value	Water Type	WQI value	Water Type
S1	35	Good	36.4	Good	30.8	Good	41.6	Good
S2	39.5	Good	27.9	Good	28.8	Good	36.6	Good
S3	44.7	Good	58.9	Poor	60.2	Poor	59.4	Poor
S4	55.7	Poor	63.4	Poor	58.9	Poor	52.9	Poor
S5	30.8	Good	33.5	Good	27.7	Good	32.3	Good

The calculation of WQI using Weighted Arithmetic Index involves the estimation of ‘unit weight’ assigned to each physicochemical parameter selected. Different units and dimensions of the selected parameters are transformed into a common scale using the assigning units. Table-4 shows the drinking water quality standards and the unit weights assigned to each parameter used for the calculation of WQI. Tables 6, 7, 8, 9 and 10 depict the values observed for the selected physicochemical parameters from the five sampling stations during each season and their corresponding WQI values. pH, DO and PO_4 were found to be the most significant parameters in the WQI scores worked out. The overall values of WQI of the water samples from all the five sampling stations for each season are presented in Table 5. WQI were observed to have a positive relationship with the seasonal changes. Maximum WQI values were recorded during summer from all the five stations followed by Monsoon, post monsoon and winter. A similar findings has also been reported by researchers like Singh and Kamal (2014) [33], Bora and Goswami (2017) [4] in their studies of assessment of surface water quality status of Kolong river and Nambul River. An average value of WQI for all the stations presented in Table-11. This result indicates that the quality of the water samples from all the stations falls under the class of good and poor. At Station P1 the WQI score ranged from 30.8-41.6. The maximum value was observed during monsoon while as minimum score was recorded in post monsoon (Table 5).Throughout the study period station P1 possessed good water quality. Similar results were observed by (Kaviarasan *et al*. 2015) [19] with WQI ranging from 25 to 50 from Ground Water Quality in Coonoor Taluk, Nilgiri District, Tamilnadu, India. WQI value ranged from 28.8-39.5 at station P2.The maximum value was recorded in winter while as minimum was found in monsoon (Table 5). The study revealed that station P2 observed good water quality. Our results are supported by the findings of (Patela *et al*. 2020) [29] who worked on the Gomti River, during the present study the WQI value varied from 44.7-60.2 at station P3 (Table 5). The maximum was obtained in monsoon while as minimum were recorded in winter. Station 3 recorded poor water quality most of the seasons except winter. Kolekar, 2017 [20] during their study made similar remark for water quality index (WQI) where results ranged from 40.67 – 69.59. At Station P4 WQI varied from 52.9-63.4 with the maximum being recorded during summer season and minimum in post monsoon (Table-5). Station P4 depicts poor water quality. A range of (27.7-33.5) for WQI was observed at Station P5 during the present investigation (Table-5). The maximum WQI score was observed in summer and minimum was recorded in monsoon. Further throughout the study period station P5 recorded good water similar observations were recorded by (Madalina and Gabriela, 2014) [23]. On overall basis it was found that station P1 (35.95), P2 (33.2) and P5 (31.07) (Table-5 and 11) possessed good water quality this is due to the dense riparian vegetation, found on the banks of the river which provide high nutrient sources for macro invertebrates and also play a prominent role in the remediation of contaminated water by pesticides and detergent active ingredients before entering the rivers (Legendre, 1998). The present study depicts poor water quality at stations P3 and P4 (Table-5 and11).The mere possession of bad water quality status at stations is attributed to the anthropogenic activities in the vicinity of the river as several activities are being practiced at station P4 like Klin factory and religious activities, while as station P3 is located near the main town Astha where lot of anthropogenic activities are done. Anthropogenic activities including sewage disposal by the communities residing in the catchment area, agricultural runoff and ongoing construction of national highway across the river and destruction of riparian zone have contributed to the increased concentration of many of the water quality parameters analyzed. And unprotected river sites has been found to deteriorate water quality status (Yasa and Jimoh, 2010; Bouslah *et al*., 2017 & Shah and Joshi, 2017) [37, 5].

Table 6: WQI of Station-1

Parameter	Winter			Summer			Monsoon			Postmonsoon		
	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*
PH	8.1	73.33333	6.347436	7.75	50	4.327797	7.85	56.66667	4.904837	8.1	73.33333	6.347436
CL	17	6.8	0.020012	34.85	13.94	0.041024	39.9	15.96	0.046969	25.88	10.352	0.030465
TDS	116.5	23.3	0.034285	136	27.2	0.040023	125	25	0.036786	167.5	33.5	0.049294
EC	165	55	0.134883	258.5	86.16667	0.211317	210.5	70.16667	0.172078	230.5	76.83333	0.188427
DO	7.95	69.27083	10.19286	7.45	74.47917	10.95924	8.25	66.14583	9.733035	7.3	76.04167	11.18916
PO_4^-	0.2445	24.45	17.98849	0.28	28	20.60031	0.2125	21.25	15.63417	0.318	31.8	23.39607
NO_3^-	0.9	2	0.032699	0.34	0.755556	0.012353	0.229	0.508889	0.00832	0.348	0.773333	0.012644
TH	109	54.5	0.200485	130	65	0.239111	110	55	0.202325	116	58	0.21336
TA	30	25	0.153276	35	29.16667	0.178822	34	28.33333	0.173713	109	90.83333	0.556903
	∑*WiQi*		35.10443			36.61			30.91223			41.98376

Table 7: WQI of Station-2

Parameter	Winter			Summer			Monsoon			Postmonsoon		
	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*
PH	8.55	103.3333	8.944114	8	66.66667	5.770396	8.15	76.66667	6.635955	8.75	116.6667	10.09819
CL	15.5	6.2	0.018246	37.84	15.136	0.044544	29.97	11.988	0.03528	27.865	11.146	0.032802
TDS	135	27	0.039729	150	30	0.044144	120	24	0.035315	167	33.4	0.049146
EC	250	83.33333	0.204368	297	99	0.242789	255	85	0.208456	244	81.33333	0.199463
DO	8.1	67.70833	9.962949	7.35	75.52083	11.11252	7.8	70.83333	10.42278	8.4	64.58333	9.503121
PO_4^-	0.2725	27.25	20.04852	0.14	14	10.30016	0.1525	15.25	11.21981	0.222	22.2	16.33311
NO_3^-	0.91	2.022222	0.033062	0.915	2.033333	0.033244	0.3715	0.825556	0.013497	0.432	0.96	0.015695
TH	119	59.5	0.218878	125.5	62.75	0.230834	114.5	57.25	0.210601	121.5	60.75	0.223477
TA	48.5	40.41667	0.247796	69	57.5	0.352535	38	31.66667	0.19415	122	101.6667	0.623323
	∑*WiQi*		39.71766			28.13116			28.97585			37.07833

Table 8: WQI of Station-3

Parameter	Winter			Summer			Monsoon			Postmonsoon		
	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*
PH	7.8	53.33333	4.616317	7.45	30	2.596678	7.35	23.33333	2.019639	7.95	63.33333	5.481876
CL	77.5	31	0.09123	100.5	40.2	0.118305	79.75	31.9	0.093879	79.5	31.8	0.093584
TDS	209.5	41.9	0.061654	252.5	50.5	0.074308	300	60	0.088287	237	47.4	0.069747
EC	360	120	0.29429	402	134	0.328624	417.5	139.1667	0.341295	349	116.3333	0.285298
DO	7.2	77.08333	11.34243	5.45	95.3125	14.02477	5.35	96.35417	14.17804	6	89.58333	13.18175
PO_4^-	0.3765	37.65	27.70006	0.56	56	41.20063	0.585	58.5	43.03994	0.54	54	39.72918
NO_3^-	1.515	3.366667	0.055043	1.77	3.933333	0.064308	0.387	0.86	0.014061	1.055	2.344444	0.03833
TH	198	99	0.364184	237.5	118.75	0.436837	190	95	0.34947	175	87.5	0.32188
TA	98.5	82.08333	0.503257	84	70	0.429173	80	66.66667	0.408736	130	108.3333	0.664197
	$\sum WiQi$		45.02847			59.27363			60.53335			59.86584

Table 9: WQI of Station-4

Parameter	Winter			Summer			Monsoon			Postmonsoon		
	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*
PH	8.3	86.66667	7.501515	7	0	0	7.55	36.66667	3.173718	8.2	80	6.924475
CL	96.5	38.6	0.113596	106	42.4	0.124779	115.5	46.2	0.135962	92	36.8	0.108299
TDS	245	49	0.072101	337	67.4	0.099176	290.5	58.1	0.085491	252	50.4	0.074161
EC	320	106.6667	0.261591	569	189.6667	0.465142	398.5	132.8333	0.325763	354	118	0.289385
DO	7.35	75.52083	11.11252	5.75	92.1875	13.56494	5.4	95.83333	14.10141	7.7	71.875	10.57605
PO_4^-	0.49	49	36.05055	0.66	66	48.55788	0.55	55	40.4649	0.467	46.7	34.35838
NO_3^-	1.46	3.244444	0.053045	1.955	4.344444	0.071029	0.468	1.04	0.017003	0.842	1.871111	0.030592
TH	226	113	0.415685	226.5	113.25	0.416605	225	112.5	0.413846	193.5	96.75	0.355907
TA	83	69.16667	0.424064	97	80.83333	0.495593	104	86.66667	0.531357	139	115.8333	0.710179
	$\sum WiQi$		56.00467			63.79514			59.24945			53.42743

Table 10: WQI of Station-5

Parameter	Winter			Summer			Monsoon			Postmonsoon		
	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*
PH	8.3	86.66667	7.501515	7.75	50	4.327797	8.35	90	7.790035	8.15	76.66667	6.635955
CL	44	17.6	0.051795	57.2	22.88	0.067334	24.75	9.9	0.029135	47.765	19.106	0.056227
TDS	135	27	0.039729	147.5	29.5	0.043408	130	26	0.038258	148.5	29.7	0.043702
EC	210	70	0.171669	230.5	76.83333	0.188427	204.5	68.16667	0.167173	215.5	71.83333	0.176165
DO	8.4	64.58333	9.503121	7.95	69.27083	10.19286	7.8	70.83333	10.42278	9.05	57.8125	8.506826
PO_4^-	0.18	18	13.24306	0.25	25	18.39314	0.122	12.2	8.975851	0.2235	22.35	16.44346
NO_3^-	1	2.222222	0.036332	0.87	1.933333	0.031609	0.3625	0.805556	0.01317	0.5885	1.307778	0.021381
TH	120	60	0.220718	132	66	0.242789	115	57.5	0.211521	111.5	55.75	0.205083
TA	40	33.33333	0.204368	42	35	0.214587	46	38.33333	0.235023	116	96.66667	0.592668
	$\sum WiQi$		30.97231			33.70195			27.88294			32.68147

Table 11: Overall WQI

Parameter	Average value of Site-1		Average value of Site-2				Average value of Site-3		Average value of Site-4			Average value of Site-5		
	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*	Vi	*Qi*	*Wi*Qi*
PH	7.9	63.33333	5.48187	8.3625	90.833	7.86216	7.6	42.5	3.678627	7.7	50.83333	4.39992	8.1	75.83333	6.56382
CL	29.4075	11.763	0.03461	27.79375	11.1175	0.03271	84.3125	33.725	0.099249	102.5	41	0.12065	43.4288	17.3715	0.05112
TDS	136.25	27.25	0.04009	143	28.6	0.04208	249.75	49.95	0.073499	281.125	56.225	0.08273	140.25	28.05	0.04127
EC	216.125	72.04167	0.17667	261.5	87.1666	0.21376	382.125	127.375	0.312377	410.375	136.7917	0.33547	215.125	71.70833	0.17585
DO	7.7375	71.48438	10.5185	7.9125	69.6614	10.2503	6	89.5833	13.18175	6.55	83.85417	12.3387	8.3	65.625	9.65639
PO_4^-	0.26375	26.375	19.4047	0.19675	19.675	14.4754	0.515375	51.5375	37.91745	0.54175	54.175	39.8579	0.19388	19.3875	14.2638
NO_3^-	0.45425	1.009444	0.01650	0.65712	1.46027	0.02387	1.18175	2.62611	0.042935	1.18125	2.625	0.04291	0.70525	1.567222	0.025623
TH	116.25	58.125	0.21382	120.125	60.0625	0.22094	200.125	100.062	0.368093	217.75	108.875	0.40051	119.625	59.8125	0.22002
TA	52	43.33333	0.265679	69.375	57.8125	0.354451	98.125	81.77083	0.501341	105.75	88.125	0.540298	61	50.83333	0.311661
	$\sum WiQi$		36.1526	$\sum WiQi$		33.47575	$\sum WiQi$		56.17532	$\sum WiQi$		58.11917	$\sum WiQi$		31.30967

Table 12: Seasonal mean value, of water quality of Parbati river

	parametres	PH	CL	TDS	EC	DO	PO_4^-	NO_3^-	TH	TA
station 1	Winter	8.1	17	117	165	7.95	0.245	0.9	109	30
	Summer	7.75	34.9	136	259	7.45	0.28	0.34	130	35
	Monsoon	7.85	39.9	125	211	8.25	0.213	0.23	110	34
	POM	8.1	25.9	168	231	7.3	0.318	0.35	116	109
station 2	Winter	8.55	15.5	135	250	8.1	0.273	0.91	119	48.5
	Summer	8	37.8	150	297	7.35	0.14	0.92	126	69
	Monsoon	8.15	30	120	255	7.8	0.153	0.37	115	38
	POM	8.75	27.9	167	244	8.4	0.222	0.43	122	122

station 3	Winter	7.8	77.5	210	360	7.2	0.377	1.52	198	98.5
	Summer	7.45	101	253	402	5.45	0.56	1.77	238	84
	Monsoon	7.35	79.8	300	418	5.35	0.585	0.39	190	80
	POM	7.95	79.5	237	349	6	0.54	1.06	175	130
station 4	Winter	8.3	96.5	245	320	7.35	0.49	1.46	226	83
	Summer	7	106	337	569	5.75	0.66	1.96	227	97
	Monsoon	7.55	116	291	399	5.4	0.55	0.47	225	104
	POM	8.2	92	252	354	7.7	0.467	0.84	194	139
station 5	Winter	8.3	44	135	210	8.4	0.18	1	120	40
	Summer	7.75	57.2	148	231	7.95	0.25	0.87	132	42
	Monsoon	8.35	24.8	130	205	7.8	0.122	0.36	115	46
	POM	8.15	47.8	149	216	9.05	0.22	0.59	112	116
	Min	7	15.5	117	165	5.35	0.122	0.23	109	30
	Max	8.75	116	337	569	9.05	0.66	1.96	238	139

W=Winter, S=Smmer, M=Monsoon, PM=Post monsoon. All the parameters are in milligrams per liter except for pH and EC (µS/cWm)

Conclusion

On overall basis it was found that station P1, P2 and P5 of Parbati river possessed good water quality due to the dense riparian vegetation, which plays a prominent role in the remediation of contaminated water by pesticides and detergent active ingredients before entering the rivers while as station P3 and P4 possessed poor water quality. The mere possession of bad water quality status at stations P3 and P4 is attributed to the anthropogenic activities in the vicinity of the river as several activities are being practiced at station P4 like Klin factory and Relgious activities, while as at station P3 is area around the Ashta main town where various anthropogenic activities including sewage disposal by the communities residing in the catchment area, agricultural runoff and unprotected river sites are done. The present study revealed that Parbati river possess doubtful quality as some stations showed good and some as poor. Hence, continuous anthropogenic input can lead to heavily pollution of the river. To further improve the water quality, proper management policy must be adopted on disposal of sewage by the communities residing in the catchment areas, agricultural runoff, unmanaged land use practices and unprotected riparian areas. Special focus on community participation in conservation efforts could be helpful. Remedial measures along the riparian zones could play a positive role in future monitoring and improvement of parbati water quality.

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