



Ecological Health Assessment of Chambal River using Water Quality Parameters

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ABSTRACT

The river is a main source to fulfill the basic needs of drinking water & irrigation. Due to multifarious anthropogenic activities has created havoc to the river health. Therefore, it is imperative to assess the river health to make it suitable for various purposes. In this study, various water quality indices (WQI) used for assessing river health are discussed. The literature reveals that water quality parameters are the most significant tool to assess the river health. In this paper an attempt has been made to assess the river health by using different methods viz. EQI, RPI & OPI. It is found that the RPI method is most effective, less time consuming and cost effective. By using different methods, it is found that the river health of Chambal River comes in average category, gives an indication that river is slightly/moderately polluted.

Keywords: Chambal River, parameters, river health, indices

INTRODUCTION

In Indian context, rivers are prime source to sustain the life of huge population of the country. Due to various anthropogenic activities rivers are getting polluted day by day. Therefore, it is the need of an hour to assess the river health in a systematic manner so that appropriate remedial measures could be suggested. To evaluate water quality from a large number of samples, each containing concentrations for many parameters is difficult.¹ To analyze water quality, different approaches like statistical analyses of individual parameter, multi-stressors water quality indices, etc have been developed.²

Numerous water quality indices have been formulated all over the world that can be used to assess overall water quality within a particular area promptly and efficiently. For example, US National Sanitation Foundation Water Quality Index (NSFWQI), Canadian Council of Ministers of the Environment Water Quality Index (CCMEWQI), British

Columbia Water Quality Index (BCWQI), and Oregon Water Quality Index (OWQI) are based on the comparison of the water quality parameters to regulatory standards and give a single value to the water quality of a source.³⁻⁷ The term “river health” is inherently ambiguous as it encompasses the natural variation in form and function existing between all river systems. Healthy rivers are the ability to support and maintain key ecological processes and a community of organisms with a species composition, diversity and functional organization that is as similar as possible to that of an undisturbed ecosystem. To assess the health of rivers in the catchment of Chambal River, an understanding of the attributes of a typical healthy river is needed, so that the impacts anthropogenic activities can be determined. The physio-chemical indicators used to assess water quality in the Chambal River were selected because they are known to have ecological importance in aquatic systems and are commonly included in other river health assessment programme like the ISC and ecosystem health monitoring program (EHMP). Water quality is a valuable indicator being both a direct indicators of health and interpretative tool for explaining other indicators score. Physio-chemical indicators are also relatively quick and cheap to assess river health. In present paper three indices have been calculated to assess river health of Chambal River in Madhya Pradesh.

TECHNIQUES TO ASSESS SURFACE WATER HEALTH

(A) WATER QUALITY INDEX (WQI) METHODS

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Water quality indices (WQI) are the tools to determine the conditions of water quality and, require knowledge about principles and basic concepts of water and related issues.⁷ It is a well-known method of expressing water quality that offers a stable and reproducible unit of measure responding to the changes in the principal characteristics of water.⁸ WQI is a mechanism to derive numerical expression that defines a certain level of water quality.⁹ In other words, WQI consist large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for the management and the public at large.

(B) COMPARISON OF WQI

The first prominent comparisons of water quality indices was, followed by Ott et al., who revised water quality indices used in the USA.¹⁰⁻¹¹ Steinhart reviewed more than 20 water quality indices used till late seventies.¹² Cooper and Richardson, proposed that in South Africa and Australia respectively developed WQI.¹³⁻¹⁴ Almost all water quality indices depends upon normalizing, data parameter by parameter according to expected concentrations and interpretation of 'good' versus 'bad' concentrations. The parameters are then weighted according to their perceived importance to overall water quality and the index is calculated as the weighted average of all observations of interest are summarized in Table 1.

Table 1: Summary of Water Quality Indices developed on a national or global level

Sl. No	Index	Objective	Methods
1.	The Scatter score Index. ¹⁵	Water quality	Assess increase or decrease in parameter over time and space.
2.	Index of River Water Quality. ¹⁶⁻¹⁷	River health	Use multiplicative aggregate function of standardized scores for a number of water quality parameters.
3.	Overall Index of Pollution. ¹⁸	River health	Assess and classify a number of water quality parameters by comparing observations against Indian standards and/or other accepted guidelines
4.	Chemical Water Quality Index. ¹⁹	Lake basin	Assess a number of water quality parameters by standardizing each observation to the maximum concentration for each parameter.
5.	WQI for freshwater life. ²⁰	Inland waters	Assess quality of water against guidelines for freshwater life

DATA COLLECTION

As the water quality data available on Chambal river is very scares. Therefore, the data on water quality have been collected based on several studies reported in the literature.²¹ The mighty Chambal River originates near the Janapao temple located at a distance of 24 km in south-west direction from the town called Mhow near Indore in Madhya Pradesh at an elevation of 854.35 m as shown in Figure 1. The place, where from it originate, there are three Nallah which are having a length of 1.6 to 2.4 km in length around the Janapao temple. These Nallah meets the perennial Chambal River. The Chambal is a perennial river in Madhya Pradesh. Three sampling stations were established almost placed at equidistance on the stretch of Chambal River flowing in the National Chambal sanctuary. The Station-A was established at Palighat in Sheopurkalan district of MP, the Station-B was selected at Rajghat near Morena district and the Station-C was chosen at place called Baraighat of Bhind district.

INDICES TO EVALUATE RIVER HEALTH INDEX

To measure the river health indexes of Chambal river three methods have been adopted on the basis of different water quality parameters used in literature. The details to assess the river health by different methods have been explained as given below.

(A) ECOLOGICAL QUALITY INDEX

Joshi proposed that to calculate the Ecological Quality Index (EQI) of any rivers three indices to be evaluated viz. Water Quality Index (WQI), Carlson's Trophic State Index (C.TSI), and Simpson's Diversity Index (SDI).²² The

methods suggested by Joshi have been modified by Athalye and Salaskar for calculating EQI.²² These methods have been described in Equation 1 and on the basis of equation 1. EQI has been calculated as shown in Table 2.

$$EQI = [\text{Status no. for EQI of C.TSI} + \text{Status no. for EQI of WQI} + 1/SDI]/3 \quad (\text{equation 1})$$

By using NSFQWI method it has been observed that the numerical value at Palighat, Rajghat and Baraighat was found to be 64, 61 & 63 respectively, which falls in average category. Similarly TSI index was calculated at Palighat, Rajghat and Baraighat. The numerical values of TSI index at these stations were found to be 55, 57 & 56 respectively which gives an indication that water quality is in the domain of entropic zone, it means the river possess excessive nutrients, especially nitrogen and phosphorus, that means the Chambal river is able to support an abundance of aquatic plants. The Simpson diversity index at all these three stations as discussed earlier was found to be 0.8. On the basis of all these three parameters as discussed earlier, the EQI has been calculated at Palighat, Rajghat and Baraighat. The calculated values at all these three places were in the range (2-3), which shows that the health of the Chambal River is considered as an average.

(B) The River Pollution Index (RPI)

The RPI proposed by Liou et al., involves four variables: dissolved oxygen (DO), biochemical oxygen demand (BOD5), suspended solids (SS), and ammonia nitrogen (NH3-N), each of which is ultimately converted to a four-state quality sub-index (1, 3, 6, and 10).¹⁶⁻¹⁷ The RPI calculated on the basis of four parameters as shown in Table 3.

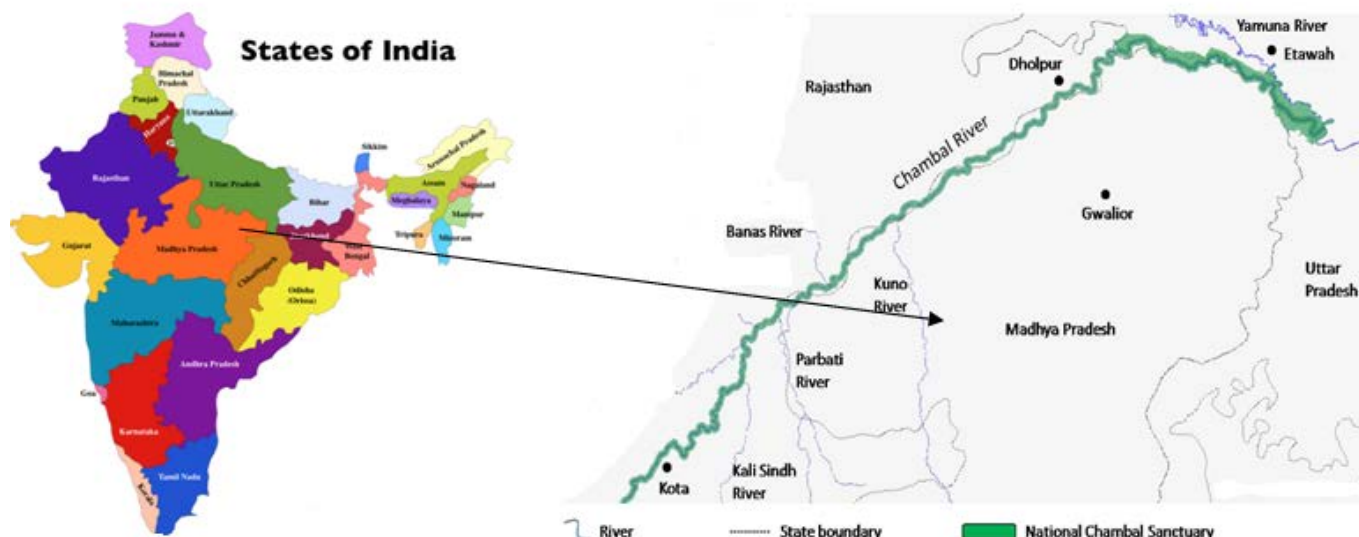


Figure 1: Chambal River of Madhya Pradesh

Table 2: water quality measurement of Chambal River M.P (2008)

Parameter	Palighat			Rajghat			Baraighat		
	Min	Max	Mean	Min	Max	Mean	Min	Max	Mean
Water temp	17.60	31.00	26.47	17.90	33.00	26.75	18.10	32.10	26.69
Transparency	0.15	1	0.67	0.12	1.06	0.78	0.17	1.10	0.82
Turbidity	1.60	86.30	20.15	1.35	178	29.80	1	107.00	19.70
TSS	270	460	325.58	260	450	315.58	260.00	500.00	307.33
pH	7.90	9.33	8.24	8.10	8.92	8.30	7.60	8.98	8.36
DO	4.86	10.33	7.66	5.06	11.75	7.88	5.37	14.59	8.22
Nitrates	0.008	0.024	0.014	0.012	0.025	0.016	0.010	0.021	0.015
Phosphate	0.005	0.030	0.018	0.006	0.050	0.023	0.004	0.045	0.018
BOD	0.81	3.24	1.76	1.01	5.67	2.12	0.60	3.24	1.87
NSFWQI	64		Average	61		Average	63		Average
TSI INDEX	55		Eutrophic	57		Eutrophic	56		Eutrophic
SDI	0.8			0.8			0.8		
EQI	2-3		Average	2-3		Average	2-3		Average

Table 3: River Health Assessment of Chambal River M.P (2008)

Sampling site	DO	BOD	NH3-N	SS	Index score	Sub -index	RPI	Pollution level
Palighat	7.6	1.76	0.014	325	1+1+1+10=13	13/4= 3.25	3.1	Moderate
Rajghat	7.8	2.12	0.016	315	1+1+1+10=13	13/4= 3.25	3.1	Moderate
Baraighat	8.2	1.87	0.015	307	1+1+1+10=13	13/4= 3.25	3.1	Moderate

The above table shows that the water quality Sub-index at Palighat, Rajghat and Baraighat stations comes within the range of 3-6 which indicates moderate level of pollution of the Chambal River.¹⁶⁻¹⁷

(C) Overall index of pollution (OIP)

Sargaonkar and Deshpande have proposed one such scheme for classification of river health on the basis of water quality parameters.¹⁸ The mathematical expressions are calculated for each of the parameter to obtain this numerical value called an index (P_i) indicating the level of pollution for that parameter. The index value up to 1 indicates Excellent

water quality, between 1 and 2 indicates Acceptable, between 2 and 4 indicates Slightly Polluted, between 4 and 8 indicates Polluted and between 8 and 16 indicates Heavily Polluted water. Overall Index of Pollution (OIP) is estimated as the average of all the pollution indices (P_i) for individual water quality parameter considered in this study and is given by the mathematical expression. The OIP at different stations have been calculated by using nine parameters as shown in table 4 given below.

$$OIP = \frac{\sum_i p_i}{n}$$

P_i = pollution index for i th parameter, $i = 1, 2, \dots, n$, n = number of parameters

Where

Table 4: River Health Assessment of Chambal River M.P (2008)

WQP	Palighat			Index	Rajghat			Index	Baraighat			Index
	Min	Max	Mean		Min	Max	Mean		Min	Max	Mean	
Hardness	42	94	74.96	1	52	134	104.3	2	62	140	106.5	2
							1				4	
Turbidity	1.60	86.30	20.15	4	1.35	178	29.80	4	1	107.00	19.70	4
TSS	270	460	325.58	1	260	450	315.5	1	260.0	500.00	307.3	1
							8		0		3	
pH	7.90	9.33	8.24	4	8.10	8.92	8.30	4	7.60	8.98	8.36	4
DO	4.86	10.33	7.66	4	5.06	11.75	7.88	4	5.37	14.59	8.22	4
Nitrates	0.008	0.024	0.014	2	0.012	0.025	0.016	2	0.010	0.021	0.015	1
Cl	15.62	59.64	29.41	1	16.33	39.76	28.87	1	18.46	80.94	42.16	1
Sulphate	8.50	40.40	27.07	1	14	42	31.11	1	3.50	45	26.60	1
BOD	0.81	3.24	1.76	2	1.01	5.67	2.12	4	0.60	3.24	1.87	2
Pollution Status	Slightly polluted			OIP= 20/9= 2.20	Slightly polluted			OIP= 23/9= 2.56	Slightly polluted			OIP= 20/9= 2.23

The above table shows that nine WQP has been used to assess the river health of Chambal River. The index numerical value at Palighat, Rajghat and Baraighat stations has been calculated by using mean values of nine individual WQP. On the basis of numerical value of index, OIP has been evaluated at these stations. The OIP index at Palighat, Rajghat and Baraighat stations are found to be 2.2, 2.56 & 2.23 respectively. The results show that the health of Chambal River comes under the categories of slightly polluted.

RESULTS AND DISCUSSIONS

The table 1 discusses the water quality index developed on national or global level. The literature²³⁻²⁵ reveals that the water quality parameters are important tools to assess the river health. The comparative study of different methods to assess the river health has been shown in the Table 5 as given below.

Table 5: Comparative Study of Different Methods for an Assessment of River Health

Indices	Palighat			Rajghat			Baraighat			No.
EQI	EQI	Calculated	River	EQI	Calculated	River	Range	Calculated	River	9
	Range	EQI	health	Range	EQI	health	EQI	EQI	health	
	2-3	2.43	Average	2-3	2.43	Average	2-3	2.43	Average	
RPI	RPI	Calculated	River	RPI	Calculated	River	Range	Calculated	River	4
	Range	RPI	health	Range	RPI	health	RPI	RPI	health	
	3.1-6.0	3.25	Moderate pollution	3.1-6.0	3.25	Moderate pollution	3.1-6.0	3.25	Moderate pollution	
OIP	OIP	Calculated	River	Range	Calculated	River	Range	Calculated	River	9
	Range	OIP	health	OIP	OIP	health	OIP	OIP	health	
	2-4	2.23	Slightly polluted	2-4	2.56	Slightly polluted	2-4	2.23	Slightly polluted	

The above table shows that different methods have been used to assess the river health at Palighat, Rajghat and Baraighat stations. It is observed that by using EQI method, the river health comes within the average categories at all three stations. It is seen that the RPI method used to assess the river health at three stations falls in the domain of moderately polluted. The calculated value of OIP at all three stations indicates that the river health is slightly polluted.

CONCLUSIONS

The data related to WQP to evaluate river health of Chambal River is very scares. To assess the river health of Chambal, three indices viz. EQI, RPI & OIP have been used. It is noticed that in all the three indices, river health is hovering within an average range. In EQI & OPI methods, nine parameters are considered to assess the river health, whereas merely four parameters have been used in RPI method. The results show that by using all three methods river health comes within the average category. Since only four parameters are considered in RPI method, therefore it is

the most appropriate, less time consuming and cost effective. It is strongly recommended that industrial effluents discharging into Chambal River are need to be duly treated and desilting should be done periodically to counteract the effect of enormous pollution.

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