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ORIGINAL ARTICLE

Water quality assessment of Chenab river and its tributaries in Jammu Kashmir (India) based on WQI

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Abstract An assessment of the water quality has been carried out to explore the water quality index (WQI) of Chenab river and its tributaries in Jammu Kashmir (India). Fourteen water samples from Chenab river and its tributaries at various locations were collected and analyzed for physico-chemical and bacteriological parameters. Nine parameters i.e. BOD, DO, fecal coliforms, nitrate, pH, temperature change, TDS, total phosphate and turbidity were considered for calculating the WQI based on National Sanitation Foundation (NSF) information system. The WQI showed good water quality, except Bichleri stream water indicating that water of Chenab river and its tributaries are least polluted and is suitable for drinking after conventional treatment. The WQI rating of Bichleri stream water is medium as it carries wastewater and may not be useful for domestic use without treatment.

Keywords Water quality index · Physico-chemical parameters · Bacteriological parameters

Introduction

An integral part of any environmental monitoring program is the reporting of results to both managers and the general public. This poses a particular problem in the case of water quality monitoring because of the complexity associated with analyzing a large number of measured variables. Water quality index (WQI) provides a convenient means of summarizing complex water quality data and facilitating its communication to a general audience (Kannan 1991; Sinha and Shrivastava 1994; Pradhan et al. 2001; Neary and Wright 2001). WQI was first formulated by Horton (1965) and later used by several workers for water quality assessment. It is one of the aggregate indices that has been accepted as a rating that reflects the composite influence on the overall quality of numbers of precise water quality characteristics (Tiwari and Mishra 1985). WQI is a dimensionless number with values ranking between 0 and 100, where higher index value represents a good water quality (Cude 2001; Pandey and Sundaram 2002). Much of the work has been done on the water quality indices of several rivers of India and abroad by various workers viz., Bhatt and Pathak (1992), Kumar and Shukla (2002), Patil et al. (2006), Sindhu and Sharma (2007), Santosh and Shrihari (2008), Ramakrishanaiah et al. (2009) and Samantray et al. (2009). In the present study an attempt is made to establish the baseline water quality of the Chenab river and its tributaries based on WQI.

Water, a natural resource which has been used for different purposes, namely for drinking, domestic, irrigation and industrial, mainly depends on its intrinsic quality hence it is of prime importance to have prior information on quality and quality of water resources available in the region, while planning developmental projects. Water quality index (WQI) is regarded as one of the most effective way to communicate water quality (Kannan 1991; Sinha and Shrivastava 1994; Pradhan et al. 2001). The WQI, which was developed in the nearly 1970s, can be used to monitor water quality changes in a particular water supply over time, or it can be used to compare a water supply's quality with other water supplies in the region or from around the world. The present study was aimed to assess rapid and accurate calculation of WQI of river

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Chenab and its tributaries in Jammu and Kashmir state of India.

NSF WQI is an excellent management and general administrative tool in communicating water quality information. This index has been widely field tested and applied to data from a number of different geographical areas all over the world in order to calculate WQI of various water bodies critical pollution parameters were considered.

The mathematical expression for NSF WQI is given by

$$\text{NSF WQI} = \sum_{i=1}^{p} W_i I_i$$

where I_i is the sub-index for ith water quality parameter, W_i is the weight (in terms of importance) associated with ith water quality parameter, p is the number of water quality parameters.

Experimental

The Chenab river is formed by the confluence of Chandra and Bhaga river at Tandi located in the upper Himalayas in the Lahul and Spiti district of Himachal Pradesh (Figs. 1, 2). The Chenab valley is structural trough formed by great Himalayan and Pir Panjal ranges. The river flows through hilly terrain having unstable mountain slopes and weak rock strata. Two tributaries, namely Anji khad and Pai khad meet the Chenab river at the downstream. The water samples were collected from the Chenab river and its tributaries from stretch between Ramban to Riasi. The details of sampling locations are presented in Table 1. The water samples were analyzed for physico-chemical and bacteriological parameters following the standard methods (APHA 2005) and the analytical results are presented in Table 2.

In order to calculate WQI critical pollution parameters were considered. The WQI was calculated using standard Q value of each parameter and weighting factor by using NSF information software and compared with standard water quality rating (Table 3) and depicted in Table 4.

Results and discussion

Water quality

The water quality analysis of Chenab river showed pH 8.2 at all the four locations between Ramban to Riasi. Alkalinity is observed in the range of 40–64 mg/L. Total dissolved solid ranged between 66 and 84 mg/L, total hardness is in the range of 88–104 mg/L, chloride ranged between 6 and 14 mg/L. Sulphate, nitrate and phosphate content were found in the range of 34–36, 6–8 and 0.16–0.29 mg/L respectively. Sodium and potassium in the water ranged between 1.8–4.1 and 1.7–2.2 mg/L, respectively. Turbidity ranged between 27 and 178 NTU. Turbidity is observed to be higher as the river flow is rapid and turbulent due to steep gradient and higher rate of erosion in the catchment area.

The water quality analysis of Anji khad, Pai khad, Jalwa khad and spring water source showed total dissolved solid ranged from 180 to 227 mg/L. Alkalinity is observed in the range of 88–196 mg/L, total hardness is in the range of 180–272 mg/L, chloride ranged between 6 and 8 mg/L.

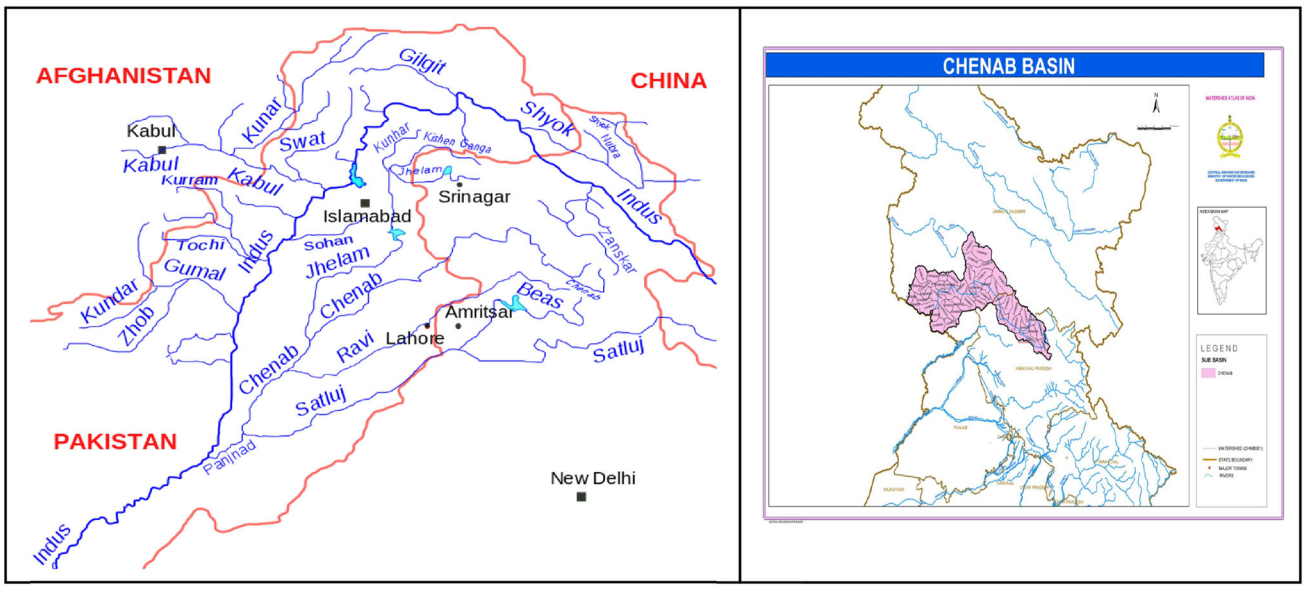

Fig. 1 Study area

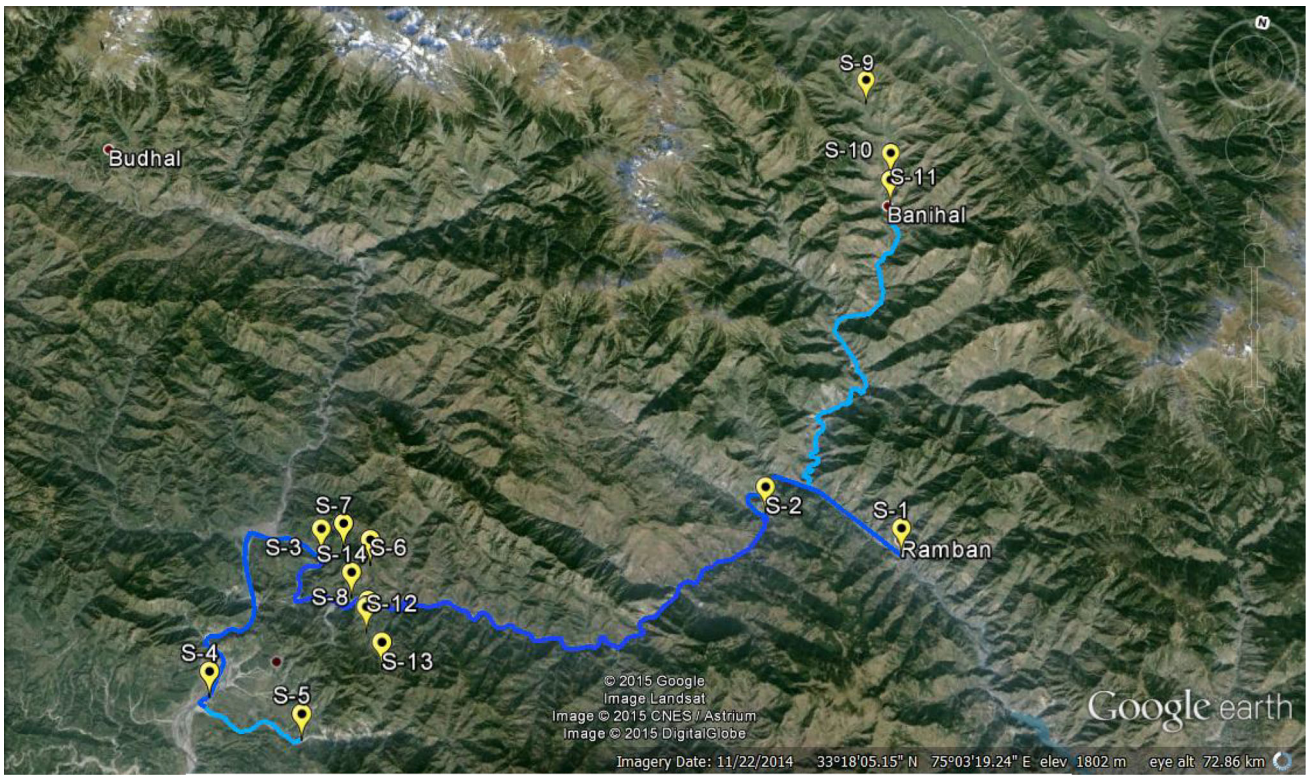

Fig. 2 Google image of study area with sampling locations

Table 1 Water sampling locations of Chenab river and tributaries

S. no.	Sample code	Sampling locations	Longitude (E)	Latitude (N)	Altitude (m)
1	S1	Chenab river near Ramban town	75°14′28″	33°14′11″	700
2	S2	Chenab river near Dhamkund village	75°08′42″	33°14′40″	633
3	S3	Chenab river from Kanthan bridge	74°51′10″	33°10′25″	461
4	S4	Chenab river, 4.5 km from Reasi	74°48′14″	33°05′06″	396
5	S5	Anji khad on Reasi-Katra road, about 1.5 km from Reasi on Katra road	75°36′30″	33°10′21″	444
6	S6	Pai khad, on Reasi-Katra road, near Nandevi Mata Village	74°53′22″	33°10′22″	596
7	S7	Jalwa khad, Surandi village, about 8 km from Kanthal to Kauri road	74°62′04″	33°10′44″	656
8	S8	Spring water near T_5P_2 end of tunnel joining to Chenab bridge	74°53′48″	33°08′23″	854
9	S9	Bitchleri stream near Naugan village	75°09′58″	33°29′58″	1969
10	S10	Bichleri stream near Banihal station	75°11′33″	33°27′24″	1696
11	S11	Bichleri stream flowing by the side of IRCON guest house, Banihal	75°11′43″	33°26′23″	1639
12	S12	Bichleri stream near Sherbibi, Banihal	74°53′48″	33°08′10″	830
13	S13	Mahumannat stream near Nachlana village	74°54′49″	33°07′09″	834
14	S14	Bichleri stream near Nachlana after confluence with Mahumannat stream	74°52′49″	33°09′11″	839

Sulphate, nitrate and phosphate content ranged between 18 and 32, 5–7, and 0.1 and 0.17 mg/L respectively. The total and fecal count ranged between 3 and 32 CFU/100 mL and ND and 10 CFU/100 mL, respectively.

Similarly water quality analysis of Bichleri stream showed pH value in the range of 8.0–8.3. Total dissolved solid of this stream ranged between 40 and 101 mg/L and increasing trend in TDS value is observed as it flows further. It is due to mixing of wastewater and anthropogenic activity in the source vicinity by the residents. Similarly turbidity ranged between 7 and 33 NTU. Alkalinity is observed in the range of 52–90 mg/L, total hardness is in the range of 40–76 mg/L, chloride ranged between 6 and 30 mg/L. Sodium and potassium content ranges are 1.5–4.8

Table 2 Physico-chemical and bacteriological parameters of Chenab river and tributaries

S. no.	Sample code	pH	Temp.	Turb. (NTU)	Cond. (μS/cm)	(mg/L)														CFU/100 mL	
						TDS	TSS	T. alk.	T. hard	Ca hard.	Mg Hard.	Chloride	Sulphate	Nitrate	Phosphate	Sodium	Potassium	DO	BOD	TC	FC
1	S1	8.2	16.8	27	110	66	14	40	104	60	44	6	34	7	0.16	1.8	1.7	7.4	2.0	160	20
2	S2	8.2	13.7	112	126	76	20	56	96	52	44	6	35	6	0.21	2.0	1.7	7.2	<3	120	10
3	S3	8.2	13.3	178	140	84	31	64	96	72	24	8	35	8	0.17	4.1	2.2	7.4	<3	28	6
4	S4	8.2	13.5	147	135	81	24	56	88	56	32	14	36	6	0.29	2.6	1.8	7.1	<3	46	14
5	S5	8.4	14.7	2	300	180	20	188	188	152	36	8	22	6	0.16	4.5	1.1	7.8	<3	20	6
6	S6	8.4	16.4	2	379	227	10	192	192	148	44	8	21	7	0.16	2.8	1.1	7.6	<3	32	10
7	S7	8.5	16.4	15	317	190	30	88	180	120	60	6	18	7	0.10	1.2	1.7	7.8	<3	ND	ND
8	S8	8.5	17.3	15	362	217	14	196	272	180	92	6	32	5	0.17	1.2	1.2	7.5	<3	ND	ND
9	S9	8.2	8.2	7	67	40	14	52	40	24	16	12	3	7	0.14	1.5	0.5	7.9	<3	14	2
10	S10	8.2	8.1	19	101	61	26	84	76	52	24	6	20	5	0.44	4.1	1.1	7.6	<3	40	1
11	S11	8.0	8.0	33	115	69	29	68	52	44	8	16	16	6	0.15	4.8	1.5	7.2	8.2	38	10
12	S12	8.3	13.2	14	140	84	28	90	56	40	16	18	12	7	0.17	3.9	1.0	5.4	10.4	780	240
13	S13	8.2	14.0	24	166	99	31	82	60	42	18	26	16	6	0.14	1.7	0.8	6.8	9.1	530	190
14	S14	8.1	14.3	28	168	101	24	70	48	28	20	30	15	7	0.14	2.0	0.7	6.7	8.9	660	160

Table 3 Water quality index (WQI) legend

Range	Quality
91–100	Excellent
71–90	Good
51–70	Medium
26–50	Bad
0–25	Very bad

and 0.5–1.5 mg/L respectively (Table 2). Sulphate, nitrate and phosphate content ranged between 3 and 20, 5 and 7 and 0.14 and 0.44 mg/L, respectively. The TC and FC count showed increasing trend due to mixing of wastewater in the stream generated by the residents of the area. The TC counts were ranged between 14 and 780 CFU/100 mL FC counts were 1–240 CFU/100 mL.

Water quality index (WQI)

National Sanitation Foundation Water Quality Index (NSF WQI) was developed by selecting parameters rigorously, developing a common scale and assigning weights to the parameters. It has been mentioned in many papers because it's the most comprehensive work. Based on experts opinion rating curves are developed to attribute values for variation in the level of water quality caused by different levels of each of the selected parameters. Computing a water quality index is possible by established rating curves and associated weights. The values of WQI are fed in NSF WQI calculation and obtained the WQI ratings.

A WQI provides a single number (like a grade) that express over all water quality at a certain location and time based on several water quality parameters. Nine parameters i.e. BOD, DO, fecal coliforms, nitrate, pH, temperature change, TDS, total phosphate and turbidity were considered for calculating the WQI for water resources in study area. The water quality data are recorded and transferred to a weighing curve chart, where a numerical value of Wi is obtained. The observed range of WQI is 70–82 for Chenab river and its tributaries whereas WQI ranged between 61 and 67 for Bicheleri stream (Table 4). The WQI rating for Bichleri stream water is medium because of BOD and presence of coliform bacteria in the water as this water is getting polluted by adding sewage from nearby habitations.

On the basis of the present investigation, it was found that the water of none of the sampling station at Chenab river and tributaries is fit for direct human consumption. The upstream of the river was found clean to slightly pollute and may be used as bathing, swimming, laundry, irrigation, pisciculture and industrial purposes but in downstream sampling stations it was polluted and could be used for domestic purposes after treatment and disinfection.

Conclusion

The WQI rating (Table 4) showed good water quality, except Bichleri stream, indicating that water of Chenab river and its tributaries, is suitable for drinking after conventional treatment as per CPCB (1995) standards. The Bichleri stream water rating is medium as this stream carries urban wastewater and may not be useful for domestic use. Therefore, it is concluded that the water quality index is an efficient tool to classify the water of the

Table 4 WQI ratings for water quality parameters

S. no.	Sample code	Water quality index (WQI) ratings									Overall WQI	Water quality grading
		pH	BOD	Temp. change	T. phosphate	Nitrate	Turb.	TS	DO	FC		
1	S1	77	80	93	94	58	55	85	70	63	75	Good
2	S2	77	100	93	91	60	5	84	66	72	73	Good
3	S3	77	100	93	93	56	5	85	68	78	74	Good
4	S4	77	100	93	82	60	5	83	66	67	71	Good
5	S5	70	100	93	94	60	93	73	77	78	82	Good
6	S6	70	100	93	94	58	93	68	73	72	79	Good
7	S7	66	100	93	96	58	67	70	72	91	80	Good
8	S8	66	100	93	93	65	67	68	74	99	81	Good
9	S9	77	100	92	94	58	82	87	67	91	82	Good
10	S10	77	100	92	67	65	62	85	60	99	78	Good
11	S11	84	42	91	94	60	51	84	58	72	70	Good
12	S12	73	34	92	93	58	69	82	46	36	61	Medium
13	S13	77	38	92	94	60	58	81	66	38	65	Medium
14	S14	80	38	92	94	58	55	81	68	40	67	Medium

river for their various advantageous uses and give an rapid and precise idea about the pollution load in the river that may be worthwhile for policy makers.

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