Determination of Water Quality by Water Quality Index Method of Chhoiya River (A Tributary of River Ganga) in Bijnor District (UP, India)

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Abstract : The purpose of present study is to calculate "Water Quality Index" (WQI by Weighted Arthematic method) of a medium sized river "Chhoiya" in Bijnor District of Uttar Pradesh so that it can be ascertained that the quality of water is fit for public consumption, recreation, irrigation and other purposes. It also assesses the impact of various activities e.g. Human activities, agriculture and Industrialisation. Physical and chemical parameters are monitored and used for calculation of WQIfor three seasons namely rainy, winter and summer. The parameters are pH, electrical conductivity, total dissolved solids, total alkalinity, total hardness, total suspended solids, Nitrate, Sulphate, Dissolved oxygen and BOD.Water Quality Index is a number which indicate water quality in terms of index number. In water qulity management programmes WQI is useful tool to represent overall quality of water. A study was done from July 2017 to June 2018 on river Chhoiya to assess the quality of water and its suitability for various purposes.

***Index Terms* - Chhoiya River, Physicochemical Parameters, Water Quality Index WQI and Drinking water Quality.**

I. INTRODUCTION

Water is most basic need of our civilization. It is also one of the most important and basic natural resources. It has a crucial role in economic and social development of any society. Total quantity of water available in the world is said to be adequate to meet all the demands of mankind. However, more than 97 % of the water on earth is contained in oceans and is highly saline which means that it can't be directly used for any productive purposes. Poor quality and uneven distribution of water (both in space and time) has made water scarce in many regions.

The ancient river valley civilizations that prospered in India, Egypt, and Mesopotamia were aware of the importance of the quality of water, although at that time the problems were not of serious nature. In recent years, with the growth of population and industrial activity, the quality of water has deteriorated at many places and has become an important issue all over the world. Clearly, water quality is closely linked to water use and to the state of economic development of the society. Although various countries have developed standards of water quality for different purposes which are being enforced, it has not yet been possible to provide water of desired quality to all the people.

Water Quality Index provides a single number. This number expresses overall water quality at a certain location and time based on several water quality parameters. It provides information that is understandable and usable by general public to get clear cut idea about quality of water. Otherwise it is difficult to understand complex water quality data containing various physico-chemical parametrs and correlate them with quality of water. We can also say that WQI is a mathematical equation used to transform large number of water quality data into single number (Stambuk-Giljanovic,N.,1999). It is simple and easy to undstand for decision makers about quality and possible uses of any water body (Bodalo,A.A., W. Nilsumranchit and K. Chalermwat,2001)

The WQI was first developed by Horton in the early 1970s(Horton, R.K.,1965), is basically a mathematical means of calculating a single value from multiple test results.The index result represents the level of water quality in a given water basin, such as lake, river or stream.After Horton a number of scientists all over the world developed WQI based on rating of different water quality parameters. Basically a WQI attempts to provide a mechanism for presenting a cumulatively derived, numerical expression defining a certainlevel of water quality (Miller *et al.*, 1986). For the evaluation of water quality, WQI was appliedto river water (Ashwani Kumar *et al.*, 2009,Rita.N.Kumar et al., 2009, N. Singkran . et al, 2010).

II. STUDY AREA

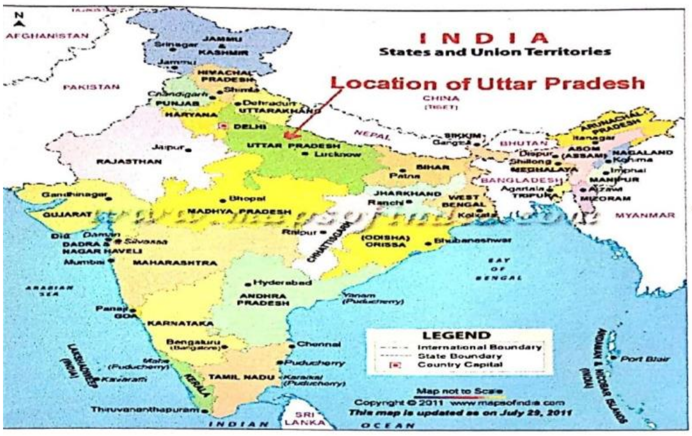
Ganga Plain is one of the most densely populated regions of the world due to its availability of water, fertile soil, and suitable landscape. Rivers are considered as a lifeline but are now adversely affecting the population by fluvial hazards. India is water-stressed and is likely to be water-scarce by 2050 due to the continuous and increasing demand for water (Gupta and Deshpande 2004). Water resources and water quality affect the economic, social, and political development of the society. It has been observed in the field that people of the Bijnor district (UP, India) are suffering from water-borne health problems. However, no attempt has been made to analyze the water quality and water chemistry of rivers. Domestic and industrial wastewater constitutes a constant polluting source, whereas surface runoff is a seasonal phenomena mainly controlled by climate within the basin. Assessment of water quality is important to determine its suitability for consumption in the domestic, agricultural, and industrial sector. To address water-related environmental problems, it is must to have accurate information and to know precisely what the problem is, where it is occurring, how serious it is, and what is causing it.

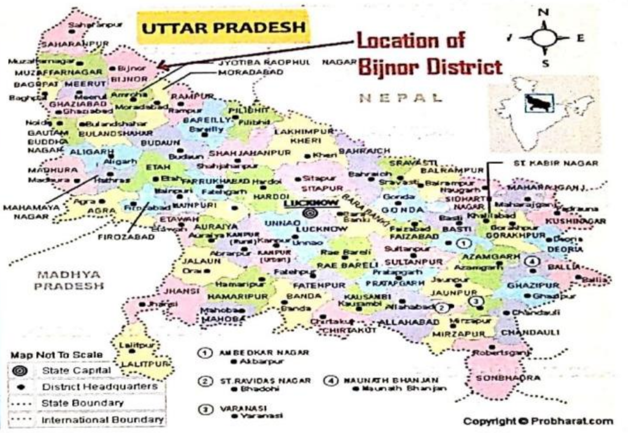
Various rivers flows through Bijnor District of UP. Most of them are tributaries of river Ganga. Prominent among them are Malan, Gangan, Chhoiya and Khoh. Quality of water of these rivers has a definite impact on surrounding environment of the area. Water quality monitoring and management of river Chhoiya, is the main problem of this study as it has been found most polluted among them. The data of Chhoiya River is used to calculate Water Quality Index (WQI) to assess the Quality of water in that area. Chhoiya River(a middle sized river) is a tributary of river Ganga in Bijnor District of Uttar Pradesh(India). It originates 4.5 Km. West of Najibabad Tehsil in Bijnor District. It follows the southern boundary of Najibabad Tehsil and flowing through

Kiratpur and Akbarabad it runs through the middle of Bijnor tehsil. It joins Ganga 3 Km. Downstream of Jahanabad. Throughout it's nearly 54.2km stretch Chhoiya receives the waste loads from several locations including industrial effluents and agricultural wastes. The observations were carried out from Kiratpur –Nehtaur Road (29o25'09"N, 78o13'11"E), village Mozampur Dharman to Bijnor-Noorpur Road (29o20'38"N 78o10'12"E) Village Garhwala, as it is most polluted stretch.

Station No.	Road	Nearby Village	Distance from Bijnor City	Coordinates
Station A	**Kiratpur – Nehtaur Road**	**Mozampur Dharman**	**23 Km**	**29°25'09"N, 78°13'11"E**
Station B	**Bijnor-Noorpur Road**	**Garhwala**	**3.5 Km**	**29°20'38"N 78°10'12"E**

River Chhoiya flows through best agricultural belt of Western UP, its pollution level is a major source for degradation of its surrounding environment. With alarming degradation in its water quality, ground water quality in its surroundings is also deteriorating day by day. There has also been a hue and cry in media about its alarming pollution levels. As no qualitative work has been done on this river till date, water quality monitoring and management of river Chhoiya is the need of the hour.





Location of sampling stations on river Chhoeya (sometimes spelled Choiya)

III. MATERIALS AND METHODS

All samples were collected (from July 2017 to June 2018) at an interval of thirty days within a span of four hours and testing was done within 24 hours as per the standard procedures of APHA(1998). Surface waters were collected from both sampling stations and due care was taken to preserve these samples before testing. Conventional sampling methods based on bottle collection were adopted. Samples were mostly taken in the early hours of the day at an interval of 30 days. **Total collected data was summerised month wise and averaged into three seasonal categories namely Rainyseason, winter season and summerseason to get seasonal variation.**

Observations were taken on **sampling station A and B** for calculation of WQI. As station A is upetream and B is down stream to the industrial belt causing pollution in the river (Chhoiya). In this study we have chosen ten parameters for calculating water quality index WQI. WQI is calculated by using water quality standards recommended by the Bureau of Indian Standards

(BIS) and Indian council for Medical Research (ICMR). T**he weighted arthmetic Index Method(Brown et. al.,) is used for calculation of WQI**.

Quality rating of index (q_n) is calculated using following equation

$$q_n = 100[V_n - V_{io}]/ [S_n - V_{io}]$$

(Assumed that there be **n** water quality parameters and quality rating **q_n** corresponding to **n^{th}** parameter is a number reflecting the relative value of this parameter in the polluted water with respect to its standard permissible value)

q_n= Quality rating for the **n^{th}** water quality parameter

V_n = Estimated value of the **n^{th}**parameter at given sampling station

S_n = Standard value of the **n^{th}** parameter

V_{io} = Ideal value of **n^{th}** parameter in pure water (normally 0 for all parameter except pH = 7 and DO=14.5 mg/l)

CALCULATION OF UNIT WEIGHT

Unit weight is calculated by a value inversely proportional to the recommended standard value **S_n** of corrosponding parameter

$W_n = K/S_n$

W_n= unit weight for the **n^{th} parameter**

K = constant for proportionality

S_n = Standard Value for **n^{th} parameter** $K = \dfrac{1}{\sum_{n=1}^{10} \frac{1}{Sn}}$

The weightage is calculated by using above equation for all the ten factors. Factors having lower permissible limits are more harmful and have high weightage.

The overall WQI is calculated by aggregating the product of quality rating q_n and unit weight W_n linearly.

$WQI = \sum q_n W_n / \sum W_n$

Table1: Water quality parameters (ICMR/BIS standards) and assigned unit weights
(all mg/l except pH and Electrical Coductivity $\mu\ mho/cm$)

SL NO	PARAMETERS	STANDARDS S_n	RECOMMENDED AGENCY	UNIT WEIGHT W_n
1	pH	6.5-8.5	ICMR/BIS	0.208
2	Electrical Conductivity	300	ICMR	0.006
3	Total dissolved Solids	500	ICMR/BIS	0.0035
4	Total alkalinity	120	ICMR	0.015
5	Total Hardness	200	ICMR/BIS	0.009
6	Total Suspended Solids	500	ICMR/BIS	0.004
7	Nitrate	45	ICMR/BIS	0.039
8	Sulphate	150	ICMR/BIS	0.012
9	Dissoved Oxygen	5.0	ICMR/BIS	0.354
10	BOD	5.0	ICMR	0.354

Table 2: SEASONAL VARIATION OF THE PHYSICOCHEMICAL PARAMETERS OF THE WATERBODY AT STATION A&B (all mg/l except pH and Electrical Conductivity)

SL NO	PARAMETERS	Rainy Season		Winter Season		Summer Season	
		Station A	Station B	Station A	Station B	Station A	StationB
1	**pH**	7.33	7.39	7.13	7.11	7.33	7.4
2	**Electrical Conductivity**	262	386.25	222	338.5	207	365
3	**Total dissolved Solids**	144	706.75	127	642.25	133	649
4	**Total alkalinity**	51	124	72	130	73	142

5	**Total Hardness**	203	252	204	301	215	300
6	**Total Suspended Solids**	26	207	33	197.25	26	197.5
7	**Nitrate**	3	23.5	3	21.25	3	19.5
8	**Sulphate**	112	202	108	223	108	265
9	**Dissoved Oxygen**	7.475	5.5	7.75	6.025	7.675	5.6
10	**BOD**	3.75	48.25	4.5	47.25	4.0	65.75

Table 3: CALCULATION OF WATER QUALITY INDEX IN RAINY SEASON AT STATION A

SL NO	PARAMETERS	Obseved Values (V_n)	Standard Values (S_n)	Unit Wt. (W_n)	Quality Rating (q_n)	W_nq_n
1	**pH**	7.33	6.5-8.5	0.208	22.00	4.58
2	**Electrical Conductivity**	262	300	0.006	87.33	0.524
3	**Total dissolved Solids**	144	500	0.0035	28.8	0.1008
4	**Total alkalinity**	51	120	0.015	42.5	0.6375
5	**Total Hardness**	203	200	0.009	101.5	0.9135
6	**Total Suspended Solids**	26	500	0.004	5.2	0.0208
7	**Nitrate**	3	45	0.039	6.67	0.26
8	**Sulphate**	112	150	0.012	74.67	0.896
9	**Dissoved Oxygen**	7.475	5.0	0.354	74.21	26.27
10	**BOD**	3.75	5.0	0.354	75	26.55
			$\sum W_n =$	1.0045	$\sum q_nW_n =$	60.75
	WQI $=\sum q_nW_n/\sum W_n = 61$					

Table 4: CALCULATION OF WATER QUALITY INDEX IN RAINY SEASON AT STATION B

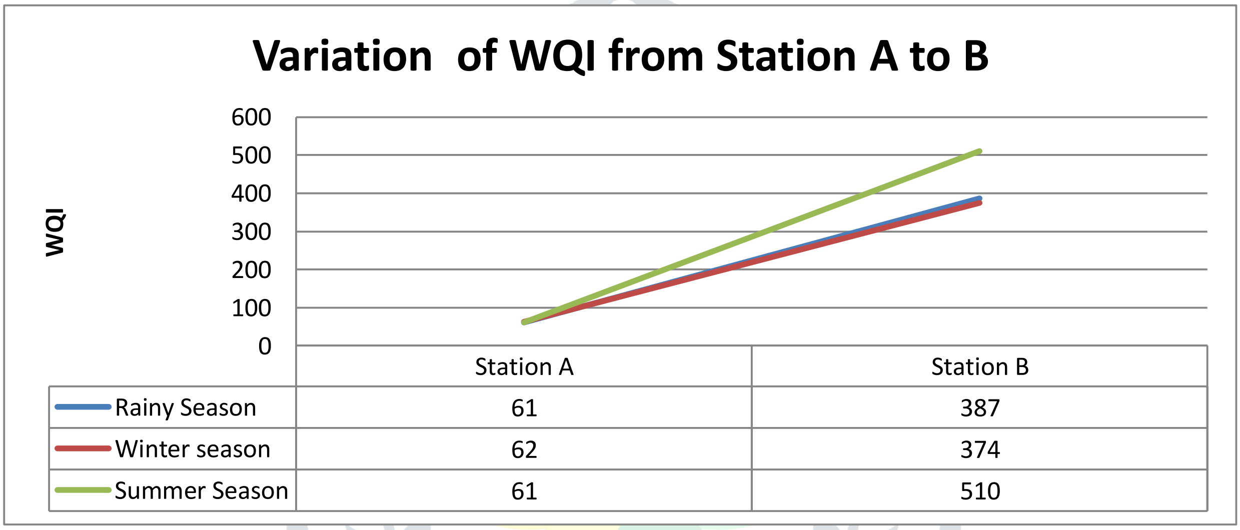
SL NO	PARAMETERS	Obseved Values (V_n)	Standard Values (S_n)	Unit Wt. (W_n)	Quality Rating (q_n)	W_nq_n
1	**pH**	7.39	6.5-8.5	0.208	26	5.408
2	**Electrical Conductivity**	386.25	300	0.006	128.75	0.7725
3	**Total dissolved Solids**	706.75	500	0.0035	141.35	0.495
4	**Total alkalinity**	124	120	0.015	103.333	1.55
5	**Total Hardness**	252	200	0.009	126	1.134
6	**Total Suspended Solids**	207	500	0.004	41.4	0.1656
7	**Nitrate**	23.5	45	0.039	52.222	2.036
8	**Sulphate**	202	150	0.012	134.662	1.616
9	**Dissoved Oxygen**	5.5	5.0	0.354	94.791	33.56

10	**BOD**	48.25	5.0	0.354	965	341.61
			$\sum W_n =$	1.0045	$\sum q_n W_n =$	388.34
	WQI $=\sum q_n W_n / \sum W_n$ = 387					

Similarly water quality index for both the stations are also calculated in winter and summer season. Results are summerised in Table 5

Table 5: Calculated WQI values

Observation Station	WQI in Rainy Season	WQI in Winter Season	WQI in Summer season	Average value for the year
Station A	**61**	**62**	**61**	**61.33**
Station B	**387**	**374**	**510**	**423.67**



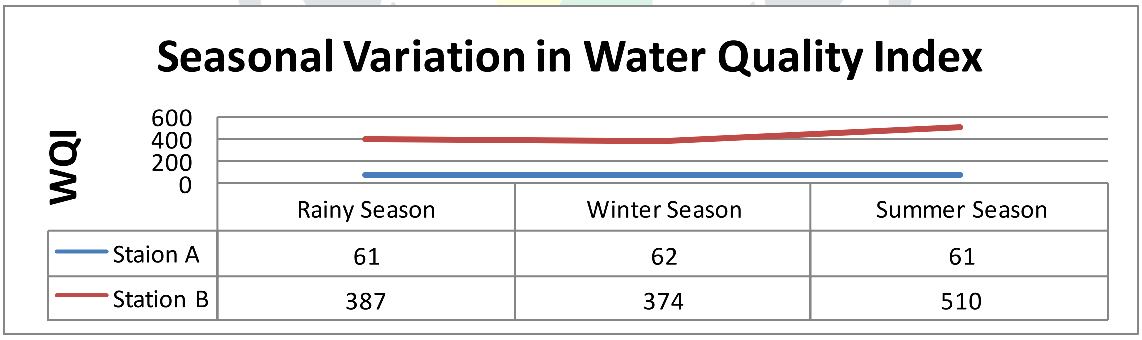


Table 6: Water Quality Index (WQI) and status of water quality
(Chaterjee and Raziuddin, 2002)

Water quality index	Water quality status
0-25	Excellent water quality
26-50	Good water quality
51-75	Poor water quality
76-100	Very poor water quality
>100	Unsuitable for drinking
>300	Unsuitable for all purposes

IV. RESULT AND DISCUSSIONS

Observations were taken at two stations which are nearly 20 Km apart. First station A is upstream to industrial belt and other oneB is down stream to this belt. One Distillary, one paper mill and two chemical plants are situated between station A and B.Level of pollution is very high due to these industries.

As far as WQI index is concerned it depicts poor quality of water even at station A. WQI value remains nearly unchanged (61 to 62) during all three seasons namely rainy, winter and summer at station A. While on station B there is a tremendus change in the value of WQI. WQI value exceeds 100 mark and it lies between 374 and 510,which shows high degree of pollution due to upstream industries. WQI value at station B is higher in summers as there is a sharp increase in value of BOD in summers which has a significant impact on WQI.

The above water quality is also supported by the following variations observed in physio chemical parameters during the all three seasons of study (rainy, winter and summer). Among all parameters pH value ranges (7.11 to 7.43) at both the stations and which quite under limits. But it is slightly higher in summers. If we take average of for three seasons into account the water of river is found to be slightly alkaline. Ambasht(1971), Peter(1975), Shardendu and Ambasht(1988), Swarnalatha and Narasingarao(1993), Sinha(1995), K. Yogendra and E T Puttaiah(2007) and Niktraj and Thakor (2012) have also made similar observations in their study of different water bodies.

Electrical conductivity in all seasons at station A ranges between (207-262 mg/l) which is under limits(300mg/l). But at Station B it ranges between (338-386) which is on higher side and confirms the high value of salinity due to the presence of high degree of chemicals dissolved in water from the industries upstream to station B.

Total dissolved solids are within permissible limit at station A in all three seasons but they have higher values (442 to 706 mg/l) at station B. Concentration at station B is higher due to mixing of industrial effluents downtream to station A. Value in rainy season is high because addition of run off water. Gupta and Singh (2000) in Damodar river and Niktraj and Thakor (2012) in Heranj Lake in Gujrat reported similarly high concentration of TDS in rainy season.

Total alkalinity ranges from 51 to 73 mg/l at station A, which is well under the limits. But when we observe it at station B it comes on higher side(124 to 130 mg/l). Higher values are observed during summers due to the presence of excess of free Co_2 product as a result of decomposition process coupled with pollutants. Rainy season shows low alkalinity because of dilution. Jain et.al(9) also reported same findings in Halali reservoir.

At station A value of hardnessis slightly higher than normal value. But in summers it is highest (215 mg/l) due to low water level and high rate of evaporation and addition of calcium and magnesium salts. Station B recorded higher values of hardness, it is due to the contribution of pollutants. These results are in tune with Niktraj and Thakor (2012) in Heranj Lake in Gujrat. Hardness value above 300 mg/l causes gastrointestinal irritation (12).

Total suspended solids range from 26 to 33 mg/l at station A and 180.6 to207 mg/l at station B which are within permissible limits for all seasons.

Nitrate is supposed to be most important nutrient in our environment. Its higher values give indication of presence of high organic matter. In our study all values of nitrate are within permissible limits. As river uptream to station B does not have any point of disposal of domestic sewage, it is in tune with our observed values.

Sulphate ion concentration ranges from 108 to 112 mg/l at station A, which are well within acceptable limits. At station B it ranges higher as 202,223 and 265 mg/l in rainy,winter and summer seasons respectively. Most of the sulphate in water comes from dissolved minerals and fertilizers. As river upstream to station B passes through agricultural fields, effect of chemical fertilizers is visible in observed values. Sulphate is also present in industrial pollutants.

Average dissolved oxygen at station A is 7.6 mg/l and at station B is 5.7 mg/l . There is a significant decline in its values from station A to station B. This is a clear indication of pollutants being mixed between these two stations. These pollutants attributeoxidizable organic matter and consequent biodegradation and decay of vegetation leading to consumption of oxygen from water (Niktraj and Thakor 2012). DO obseved in our study are within acceptable limits.

Biological Oxygen Demand (BOD) is used to assess the organic load in water body. It is desirable to have BOD less than 5 mg/l in drinking water. BOD more than 30 mg/l makes water unsuitable for all purposes. All observed values at station A are below 5 mg/l. This indicates that there is no loading of organic pollutants, upstream to station A. It is also true in actuality. As we move down stream to station A, we find loading of chemical and organic pollutants, that is clearly visible from observed values of BOD at station B (48.25 to 65.75 mg/l). Similar observations were also reported by Tiwari(18) in the river Ganga. S Kalavathy, T Rakesh, P Suresh Kumar (2011) also reported the same senerio in Cauvery river. Values of BOD are observed high in summer season it is in conformity with the observations of Chaterji(1992) and), K. Yogendra and E T Puttaiah(2007). Higher values of BOD at station B also contributes to the higher values of WQI, indicating unsuitability of water due to alarmingly high degree of pollution in the river.

From the above observations of physicochemical parameters it is clear that qulity of water is very poor at station A and worst at station B. This is also significantly visible in WQI values. Hence application of water quality index technique for assessment of quality of water body is a useful tool.

IV. CONCLUSION

Water Quality Index is more than 50 at Station A which indicates poor quality of water. This water is not suitable for drinking but fit for other purposes like recreation, agriculture and industrial uses. After treatment it can also be used even for drinking. At Station B its value is higher than 300, which makes it unsuitable for any purpose. As Chhoiya is a tributary to river Ganga, its pollution is a threat to the water quality of Holy River Ganga. It is required that some mechanism is to be developed to treat effluents from industries before they are discharged in the river. It will directly improve quality of water of Chhoiya and indirectly contribute to maintain good quality of water of Ganga.

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