

# ASSESSMENT OF WATER QUALITY OF BHAGIRATHI RIVER USING WATER QUALITY INDEX

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**Abstract :** A preliminary study was conducted to know the water quality status of Bhagirathi River from March 2009- February 2010. A total of 4 sampling stations Goumukh, Gangotri, Uttarkashi and Rishikesh were selected. 15 physico-chemical parameters were studied to know the water quality in different seasons (summer, monsoon and winter) in all the selected sampling sites. Water quality index of all 4 sites were shown excellent status of water quality in summer and winter as compared to monsoon. It shows good quality of water for Goumukh, Gangotri and Uttarkashi. In Rishikesh, WQI indicates the water quality in winter (Excellent) and good to poor quality in summer to monsoon season. The degradation of water quality in Rishikesh may be due to the anthropogenic activity like discharge of sewage in Ganga, and tourism activity. The present study shows the water quality of upper Ganga basin by using the water quality index.

**Index Terms -** Physico-chemical Parameters, water quality index, Bhagirathi River.

## I. INTRODUCTION

As far as water is concerned, it plays an important role for sustaining all life forms on earth. Starting from lower class to higher classes of flora and fauna, all are dependent on water for fulfilling their metabolic activities. In fact, the origin of life had taken place in water itself. The availability of water on this earth is vast, but the consumable form is present in a small amount i.e., approximately 1%. There are various sources of water; Bhagirathi River is one of them. It is the sacred river with many tributaries extending towards eastward direction originating from Gangotri glacier up to Bay of Bengal. Due to human interruption, the quality of this river is deteriorating at a greater scale affecting the aquatic flora and fauna and the adjoining entities present there in (Laishram *et al.*, 2007). During the past some decades' river water qualities have emerged as one of the most significant and confronting environmental issues. The quality of water may be described by its physico-chemical and microbiological properties, therefore physico-chemical analysis of Ganga water was done by many workers (Sinha, 1986). Water quality index (WQI) is a marker of water quality, which reveals the intricate influence of a number of water quality parameters and is useful in determining appropriateness of water for different reasons in an easy and explicable way even by a general and non-scientific person.

## 2. Material and Methods

### 2.1 Study area and Collection of water samples

The locations for the sampling and analysis of water samples were selected along the river Ganges, namely: Goumukh, Gangotri, Uttarkashi and Rishikesh. Goumukh is about 19 km (11.8 mi) from the town of Gangotri and the precise source of the Bhagirathi River, an important tributary of the Ganges. Uttarkashi is located at an altitude of 1352 m above sea level. Rishikesh (from Rishikesh, another name for Lord Vishnu) is a Holy city for Hindus located in the foothills of the Himalaya in Northern India. The description of the sampling sites is given in the Table 1.

**Table 1:** Sampling Stations and their geo-coordinates of Bhagirathi River

S.No.	Name of study sites	Geo-coordinates	Altitude (Above Mean sea level )
1.	Goumukh	30° 47' 25.19" N, 79° 04' 6.00" E	3159 m
2.	Gangotri	30° 58' 48.00" N, 78° 55' 48.00" E	3048 m
3.	Uttarkashi	30° 43' 48.00" N, 78° 27' 0.00" E	1256 m
4.	Rishikesh	30° 5' 13.7760" N, 78° 16' 5.2032" E	366m

### 2.2 Collection of water samples

Water samples were collected from all above four sampling stations from March 2009- February 2010. The study is divided into three season viz. March- June (summer), July- October (monsoon) and November- February (winter). During this period keeping in view of the impact of seasonal variations on various Physico-Chemical properties of the river water. In order to perform the Physico-Chemical studies, all the river water samples were collected in sterilized bottle. The samples for determination of Dissolved Oxygen were collected in sterilized 300 ml bottle and preserved immediately in ice-cool pack.

### 2.3 Analysis procedure of water samples

The analyses of water samples for various parameters were studied using standard methods prescribed in Bureau of Indian Standards (BIS): 10500 (2005) method. The pH was recorded on site and remaining parameters Turbidity (NTU), Total Alkalinity (ppm), Total Solid (ppm), Total Dissolved Solid (ppm), Dissolved Oxygen (ppm), BOD (ppm), COD (ppm), Total Hardness (ppm), Calcium, Magnesium, Chloride, Sulphate, Sodium and Potassium were analysed in laboratory and standard methods prescribed (APHA, 1995 and Trivedy and Goel, 1986).

### 2.4 Water Quality Index

WQI was calculated by the measured values of physico-chemical parameters as described elsewhere (Brown *et al.*, 1972). For Calculation of WQI, 9 physico-chemical parameters were selected in different season (summer, monsoon and winter) for all the sampling station.

WQI is calculated by the following equation:

The equation used for the computation of WQI is:

$$WQI = \sum_{n=1}^{\infty} W_n Q_n / W_n$$

Where,

$Q_n$  = sub-index or quality rating for the  $n^{\text{th}}$  parameter

$W_n$  = unit weight for the  $n^{\text{th}}$  parameter

$Q_n$  was calculated by the following equation:

$$Q_n = \frac{(V_n - V_i)}{(V_s - V_i)} \times 100$$

Where,

$Q_n$  = sub-index for the  $n^{\text{th}}$  parameter

$V_n$  = actual value present of the  $n^{\text{th}}$  parameter at a given sampling station.

$V_i$  = ideal value for the  $n^{\text{th}}$  parameter

$V_s$  = standard value for the  $n^{\text{th}}$  parameter

The ideal value of all parameters was zero except (pH= 7 and DO= 14.6). We calculated the unit weight ( $W_i$ ) for the  $n^{\text{th}}$  parameter, which is inversely proportional to the standard value of that particular variable.

$$W_i = k/V_s$$

$k$  = proportionality constant, which can be calculated as:

$$k = 1/\sum 1/V_s$$

We categorized the computed WQI values into five classes for water quality, given as Table-2 and BIS standards (2005) used for WQI shown in (Table 3).

**Table 2:** Status of water quality index (Brown et al., 1972)

S.No.	Water quality index	Water quality status
1	0.00-25.00	Excellent
2	26.00-50.00	Good
3	51.00-75.00	Poor
4	76.00-100.00	Very poor
5	< 100	Unsuitable for drinking

**Table 3:** BIS Standard (2005) of different parameters of water quality

Parameters	Standard value
pH	6.50-8.50
Dissolved Oxygen(ppm)	5.00
Total alkalinity	200.00
Total Dissolved Solid (ppm)	500.00
Total Hardness (ppm)	300.00
Calcium	75.00
Magnesium	30.00
Chloride	250.00
Sulphate	200.00

### 3. Result and Discussion

From the results, it was observed that increasing inhabitants in Ganga river basin has resulted in the immense changes in water quality of the river basin. Seasonal changes in Characteristics of water quality were depicted in Table-4

During the study average pH of surface water samples varied from 6.75-7.31 at all sites. Maximum pH was observed in winter season of Rishikesh region.

Turbidity is the measure of light scattered by suspended particles, the substances not present in the form of solution cause it. Turbidity in river water is generally caused by the presence of clay and silt, Organic matter, Algae *etc.* (Sawyer *et.al.*, 1994). Turbidity of every sample station increases when go to summer season to Monsoon season and then again decreases when go to winter season (Table 4).

The alkalinity of a water sample is its quantitative capacity to neutralize a strong acid to a designated pH. Total alkalinity of every sample station increases when go to summer to Monsoon and then again decreases when go to winter. Total alkalinity of four sample station increases respectively in all three season when we move Goumukh to Rishikesh via Gangotri and Uttarkashi.

Total solids and their analysis have great implications in the control of biological and physical waste water treatment processes (Kumar and Singh, 2002). During the study, the quantity of Total solids present in monsoon is higher and lower in the winter. This is due to the fact that solid particles settled the bottom of the river in the winter seasons.

The D.O. reflects the physical and biological process prevailing in the water, therefore, its measurement is of prime importance. A definite level of D.O. is required to sustain the higher life forms in water (Bhargava 1983). The dissolve oxygen varied from 6.71 to 9.51 during the study period. Minimum dissolve oxygen was found in Uttarkashi during monsoon and maximum was found in Goumukh during winter season. According to Chaturvedi *et al.*, 2003, the dissolve oxygen found minimum in monsoon and maximum in winter.

The B.O.D. is essentially a bioassay procedure involving the measurement of oxygen consumed by living organism (mainly bacteria) while utilizing the organic matter present in Waste, under conditions as similar as possible to those that occur in nature.

The biochemical oxygen demands in all the sampling station were increase summer to monsoon seasons and decrease in the winter seasons. The BOD were maximum found in Rishikesh 1.61 in monsoon and minimum in Goumukh (0.56) in winter. Biochemical oxygen demand recorded less than 3 mg/L in the study of Ganga River (Singh *et al.*, 1999 and Sharma *et al.*, 2000).

Chemical oxygen demand values were found maximum in Rishikesh (12.60 ppm) in monsoon and Minimum found in Goumukh (0.65 ppm) in winter. The observed values of C.O.D. are much higher than the corresponding B.O.D. values. The change pattern for C.O.D. from One study area to another. As the C.O.D. in much higher than BOD but not very high because there is no outfall of domestic or industrial waste in the given stretch. Result of present study draw support from the findings of Chaturvedi *et al.*, 2003.

Total hardness is the mixture of major contribution of calcium and magnesium. In the study period the maximum value of hardness, calcium and magnesium were maximum recorded in monsoon (100.20 ppm; 24.31 ppm and 13.21 ppm respectively) in Rishikesh. The reason for the hardness is the weathering of rocks and other factors like sediments load during monsoon.

Chlorides of every sample station increases when go to summer season to Monsoon season and then again decreases when go to winter. The result agree with those obtained by Trivedi (1979) for Chambal River.

Sulphate was found maximum in monsoon season in all sampling stations and minimum found in the winter throughout the study. The maximum concentration of sulphate was found in Rishikesh and minimum found in Goumukh. The source of sulphate in natural water is weathering of rocks and municipal sewage waste.

Sodium and Potassium were found maximum in monsoon season and minimum in winter season in all the sampling sites. The sodium and potassium were maximum recorded in Rishikesh. The source of sodium and potassium was the discharging of municipal waste in the Ganga River at Rishikesh.



Table 4: Seasonal variation of physico-chemical parameters of Different sites of Upper Ganga Basin

Parameters	Goumukh			Gangotri			Uttarkashi			Rishikesh		
	Sum	Mon	Win	Sum	Mon	Win	Sum	Mon	Win	Sum	Mon	Win
pH	7.19	7.05	7.12	7.21	6.95	7.10	7.16	6.85	7.22	7.25	6.75	7.31
Turbidity (NTU)	5.00	9.90	5.10	5.51	9.92	5.31	6.21	10.81	5.80	7.71	13.81	6.82
Total Alkalinity (ppm)	150.31	162.31	122.51	152.31	166.31	125.51	168.92	190.32	155.31	193.51	213.31	178.01
Total Solid (ppm)	89.31	115.41	64.30	90.24	116.31	65.10	116.23	180.46	98.23	124.12	202.31	100.21
Total Dissolved Solid (ppm)	74.30	92.21	49.11	74.31	88.20	50.30	88.23	143.21	69.11	97.32	156.11	75.21
Dissolved Oxygen (ppm)	8.00	7.60	9.51	7.91	7.71	9.92	7.23	6.71	7.35	6.52	7.00	7.95
BOD (ppm)	1.00	1.32	0.56	1.10	1.42	0.90	0.92	1.13	0.86	0.87	1.61	0.79
COD(ppm)	1.10	2.10	0.65	2.03	4.12	2.56	3.21	4.60	2.87	2.92	12.60	2.76
Total Hardness (ppm)	51.13	70.12	48.31	52.23	72.23	49.91	72.24	90.31	80.21	84.52	100.20	93.00
Calcium	10.80	13.01	11.00	11.21	14.21	11.92	12.30	20.47	11.21	13.21	24.31	12.31
Magnesium	6.03	9.98	7.10	6.21	10.20	7.82	8.02	10.44	7.54	10.31	13.21	9.50
Chloride	4.11	8.11	4.00	4.77	8.63	4.21	5.45	14.18	4.85	7.21	18.31	6.42
Sulphate	10.31	15.00	11.21	10.33	16.11	12.21	14.60	17.60	12.46	16.31	18.91	15.31
Sodium	8.21	16.00	7.31	8.31	16.21	7.41	10.31	17.89	8.51	11.61	19.02	9.92
Potassium	2.51	4.10	2.21	2.53	4.21	2.31	3.62	5.08	3.00	4.21	6.31	3.16

(Sum= summer, Mon=monsoon, Win= winter)

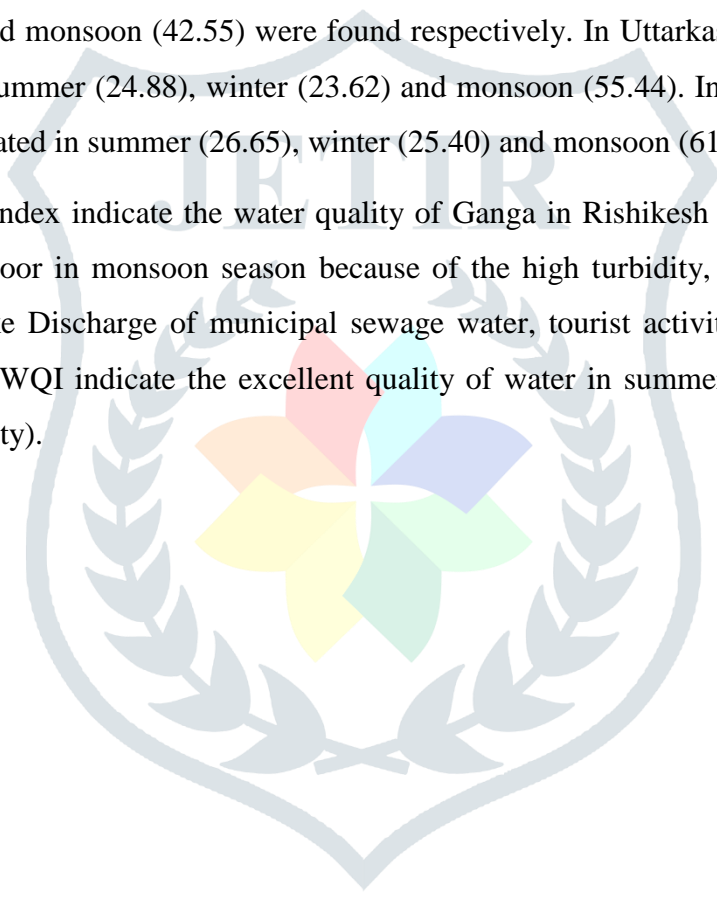


### 3.1 Water quality index

Water quality index is the mathematical measurement, to know the status of any water body. For this study the arithmetic mean water quality index (Brown *et al.*, 1972) was used. The status of water quality was divided into 5 categories (Table 3). If the water quality index show the 0.00-25.00 (Excellent); 25.00-50.00 (Good quality); 50.00-75.00 (Poor); 75.00-100.00 (Very poor) and if the value is more than the 100 than it is not suitable for drinking.

During the study period all sampling stations show the excellent in summer and winter season as comparison to monsoon (good quality). In Sampling station 1 (Goumukh) (Table 5), the value of WQI in summer (22.06); winter (19.08) and monsoon (35.62). In Gangotri (Table 6), the value of WQI in summer (21.12); winter (19.44) and monsoon (42.55) were found respectively. In Uttarkashi (Table 7), the value of WQI were calculated in summer (24.88), winter (23.62) and monsoon (55.44). In Rishikesh ((Table 8), the value of WQI were calculated in summer (26.65), winter (25.40) and monsoon (61.17).

Therefore, water quality index indicate the water quality of Ganga in Rishikesh were excellent to good in winter and summer but poor in monsoon season because of the high turbidity, sediments load and other anthropogenic activity like Discharge of municipal sewage water, tourist activity (rafting). In Goumukh, Gangotri and Uttarkashi, WQI indicate the excellent quality of water in summer and winter as compared with monsoon (good quality).



**Table 5:** Seasonal water quality index at Goumukh (Station -1)

Parameters	Standard value	Wn	Summer			Monsoon			Winter		
			Vn	Qn	WnQn	Vn	Qn	WnQn	Vn	Qn	WnQn
pH	6.50	0.37	7.19	-38.00	-13.92	7.05	-10.00	-3.66	7.12	-24.00	-8.79
Dissolved Oxygen(ppm)	5.00	0.48	8.00	68.75	32.75	7.60	72.92	34.73	9.51	53.02	25.26
Total alkalinity	200.00	0.01	150.31	75.16	0.90	162.31	81.16	0.97	122.51	0.61	0.01
Total Dissolved Solid (ppm)	500.00	0.00	74.30	14.86	0.07	92.21	18.44	0.09	49.11	9.82	0.05
Total Hardness (ppm)	300.00	0.01	51.13	17.04	0.14	70.12	23.37	0.19	48.31	16.10	0.13
Calcium	75.00	0.03	10.80	14.40	0.46	13.01	17.35	0.55	11.21	14.95	0.47
Magnesium	30.00	0.08	6.03	20.10	1.60	9.98	33.27	2.64	7.10	23.67	1.88
Chloride	250.00	0.01	4.11	1.64	0.02	8.11	3.24	0.03	4.00	1.60	0.02
Sulphate	200.00	0.01	10.31	5.16	0.06	15.00	7.50	0.09	11.21	5.61	0.07
Total			$\sum WnQn$		22.06	$\sum WnQn$		35.62	$\sum WnQn$		19.08

**Table 6:** Seasonal water quality index at Gangotri (Station-2)

Parameters	Standard value	Wn	Summer			Monsoon			Winter		
			Vn	Qn	WnQn	Vn	Qn	WnQn	Vn	Qn	WnQn
pH	6.50	0.37	7.21	-42.00	-15.39	6.95	10.00	3.66	7.1	-20.00	-7.33
Dissolved Oxygen(ppm)	5.00	0.48	7.91	69.69	33.20	7.71	71.77	34.19	9.92	48.75	23.22
Total alkalinity	200.00	0.01	152.31	76.16	0.91	166.31	83.16	0.99	125.51	62.76	0.75
Total Dissolved Solid (ppm)	500.00	0.00	74.31	14.86	0.07	88.20	17.64	0.08	50.3	10.06	0.05
Total Hardness (ppm)	300.00	0.01	52.23	17.41	0.14	72.23	24.08	0.19	49.91	16.64	0.13



Calcium	75.00	0.03	11.21	14.95	0.47	14.21	18.95	0.60	11.92	15.89	0.50
Magnesium	30.00	0.08	6.21	20.70	1.64	10.20	34.00	2.70	7.82	26.07	2.07
Chloride	250.00	0.01	4.77	1.91	0.02	8.63	3.45	0.03	4.21	1.68	0.02
Sulphate	200.00	0.01	10.33	5.17	0.06	16.11	8.06	0.10	4.21	2.11	0.03
Total			$\sum W_n Q_n$		21.12	$\sum W_n Q_n$		42.55	$\sum W_n Q_n$		19.44

**Table 7:** Seasonal water quality index at Uttarkashi (Station-3)

Parameters	Standard value	W <sub>n</sub>	Summer			Monsoon			Winter		
			V <sub>n</sub>	Q <sub>n</sub>	W <sub>n</sub> Q <sub>n</sub>	V <sub>n</sub>	Q <sub>n</sub>	W <sub>n</sub> Q <sub>n</sub>	V <sub>n</sub>	Q <sub>n</sub>	W <sub>n</sub> Q <sub>n</sub>
pH	6.50	0.37	7.16	-32.00	-11.73	6.85	30.00	10.99	7.22	-44.00	-16.12
Dissolved Oxygen(ppm)	5.00	0.48	7.23	76.77	36.57	6.71	82.19	39.15	7.35	75.52	35.98
Total alkalinity	200.00	0.01	168.92	84.46	1.01	190.32	95.16	1.13	155.31	77.66	0.92
Total Dissolved Solid (ppm)	500.00	0.00	88.23	17.65	0.08	143.21	28.64	0.14	69.11	13.82	0.07
Total Hardness (ppm)	300.00	0.01	72.24	24.08	0.19	90.31	30.10	0.24	80.21	26.74	0.21
Calcium	75.00	0.03	12.3	16.40	0.52	20.47	27.29	0.87	11.21	14.95	0.47
Magnesium	30.00	0.08	8.02	26.73	2.12	10.44	34.80	2.76	7.54	25.13	2.00
Chloride	250.00	0.01	5.45	2.18	0.02	14.18	5.67	0.05	4.85	1.94	0.02
Sulphate	200.00	0.01	14.6	7.30	0.09	17.60	8.80	0.10	12.46	6.23	0.07
Total			$\sum W_n Q_n$		24.88	$\sum W_n Q_n$		55.44	$\sum W_n Q_n$		23.62

**Table 8:** Seasonal water quality index at Rishikesh (Station-4)

Parameters	Standard value	Wn	Summer			Monsoon			Winter		
			Vn	Qn	WnQn	Vn	Qn	WnQn	Vn	Qn	WnQn
pH	6.50	0.37	7.25	-50.00	-18.32	6.75	50.00	18.32	7.24	-48.00	-17.59
Dissolved Oxygen(ppm)	5.00	0.48	6.52	84.17	40.09	7.00	79.17	37.71	6.85	80.73	38.46
Total alkalinity	200.00	0.01	193.51	96.76	1.15	213.31	1.07	0.01	178.31	89.16	1.06
Total Dissolved Solid (ppm)	500.00	0.00	97.32	19.46	0.09	156.11	31.22	0.15	75.21	15.04	0.07
Total Hardness (ppm)	300.00	0.01	84.52	28.17	0.22	100.20	33.40	0.27	93.00	31.00	0.25
Calcium	75.00	0.03	13.21	17.61	0.56	24.31	32.41	1.03	12.31	16.41	0.52
Magnesium	30.00	0.08	10.31	34.37	2.73	13.21	44.03	3.50	9.50	31.67	2.51
Chloride	250.00	0.01	7.21	2.88	0.03	18.31	7.32	0.07	6.42	2.57	0.02
Sulphate	200.00	0.01	16.31	8.16	0.10	18.91	9.46	0.11	15.31	7.66	0.09
Total			$\sum WnQn$		26.65	$\sum WnQn$		61.17	$\sum WnQn$		25.40

#### 4. Conclusion

The present study was carried out to know the water quality status of upper Ganga basin during 2009-2010. The water quality index indicates the excellent quality of water in Goumukh, Gangotri and Uttarkashi in summer and winter and Rishikesh show the good quality of water in summer and excellent shows in winter. In all the sampling station the WQI indicates the good quality of water in monsoon in Goumukh and Gangotri as compared with Uttarkashi and Rishikesh shows the poor quality of water in monsoon. Overall, the present study shows the status of water quality in Bhagirathi River.

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