Comparative Analysis of Physiochemical Parameter of Major Tributaries of the River Ganga in Uttarakhand

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ABSTRACT: The present paper is an attempt to identify the pollution level at different locations within Uttarakhand along the river Ganga and its major tributaries. Samples have been collected from upstream and downstream of Karnaprayag, Rudraprayag, Shrinagar, Devprayag, Rishikesh and Haridwar cities. These are the largest cities along river Ganga or its major tributaries. The important physiochemical parameters like pH, Temperature, BOD, DO & Turbidity were calculated for these sampling sites. On the basis of these physiochemical parameters Water Quality Index at each site was calculated and results were compared with standards given by different organizations. An overall analysis of river water quality of the Ganga and its tributaries is provided in this paper.

Key words: Water Quality Index, physiochemical parameters, River Ganga.

Introduction:

Rivers are the most important natural resource for human development but it is being polluted by indiscriminate disposal of sewage, industrial waste and plethora of human activities, which affects its physiochemical and microbiological quality. Due to increasing problem of deterioration of river water quality, it is necessary to monitor of water quality of rivers. The river Ganga is subjected to multiple uses like for community water supply, irrigation, bathing and disposal of sewage and industrial effluents. The Ganga river basin is the largest river basin in India, extending over the states of Uttarakhand, Uttar Pradesh, Haryana, Himachal Pradesh, Delhi, Bihar, Jharkhand, Rajasthan, Madhya Pradesh, Chhattisgarh and West Bengal (MoEF 2009). Today, over 29 cities, 70 towns and thousands of villages extend along the Ganga banks. Nearly all of their sewage—over 1.3 billion liters per day—goes directly into the river, along with thousands of animal carcasses, mainly cattle (Bhardwaj et al. 2010). Domestic and industrial wastewater constitute as a constant polluting source, whereas surface runoff is a seasonal phenomena mainly controlled by climate (Singh et al. 2004).According to World Health Organization (WHO), about 80% of all the diseases in human beings are caused by use of polluted water.

Assessment of surface water quality can be a complex process undertaking multiple parameters capable of causing various stresses on overall water quality.

The Water Quality Index is well known method as well as one of the most effective tools to express water quality that offers a simple, stable, reproducible unit of measure and communicate information of

water quality to the concerned citizens and policy makers. It thus becomes an important parameter for the assessment and management of surface water. Water Quality Index is defined as a technique of rating that provides the composite influence of individual water quality parameters on the overall quality of water for human consumption (WHO, 1993). WQI summarizes large amounts of water quality data into simple terms (e.g., excellent, good, bad, etc.) for reporting to management and the public in a consistent manner. Horton (1965) first introduced and defined it as mathematical form of WQI by selecting, rating and integrating the significant physical, chemical and biological parameters of water in a simple, yet scientifically defensible manner. After that it was improved by Brown et al., 1970 and Deininger (Scottish Development Department, 1975) respectively.

Materials and methods: This study is an attempt is to evaluate the water quality of the river Ganga at different sites within Uttarakhand. For this study water quality indices have been used to assess variation in the quality of the River Ganga at 15 different upstream and downstream monitored locations in the Uttarakhand.

General Physicochemical Parameters and Considerations:- The samples were analyzed as per standard methods for five different Physico-Chemical parameters namely pH, Temperature, Dissolved Oxygen, Biological Oxygen Demand, and Turbidity.

Water Quality Index an effort to develop a system to compare water quality .The index is basically a mathematical means of calculating a single value from multiple test results.
The WQI 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.
To determine the WQI, the following water quality parameters are measured by us:

1. Biological Oxygen Demand
2. Dissolved Oxygen
3. pH
4. Temperature change
5. Turbidity

METHODS FOR WQI DETERMINATION:-

The standard formula to calculate water quality index is:

$$WQI = \sum WXQX = W_{BOD}\, Q_{BOD} + W_{DO}Q_{DO} + W_{pH}\, Q_{pH} + W_{PHOSPHATE}Q_{PHOSPHATE} + W_{NITRATE}Q_{NITRATE} + W_{FC}Q_{FC} + W_{TDS}Q_{TDS} + W_{TEMP}Q_{TEMP} + W_{TURBIDITY}Q_{TURBIDITY}$$

In the case when concentrations of some parameters are not available,

- First we can calculate the Q values of those parameters, the concentration of which is available
- Now those Q values are multiplied with their respective weighting factors.
- Now the summation of these values are taken and then divided by the summation of weighting factors of available parameters.

The equation can be given as:

$WQI_{\textbf{MISSING PARAMETERS}} = \sum W_x Q_x / \sum W_x$

Here, x = available parameters

Q_x = q- values of available parameters

W_x = weighting factors of available parameters (Srivastava and Kumar 2013).

Table 1 Weighting factors of five parameters.

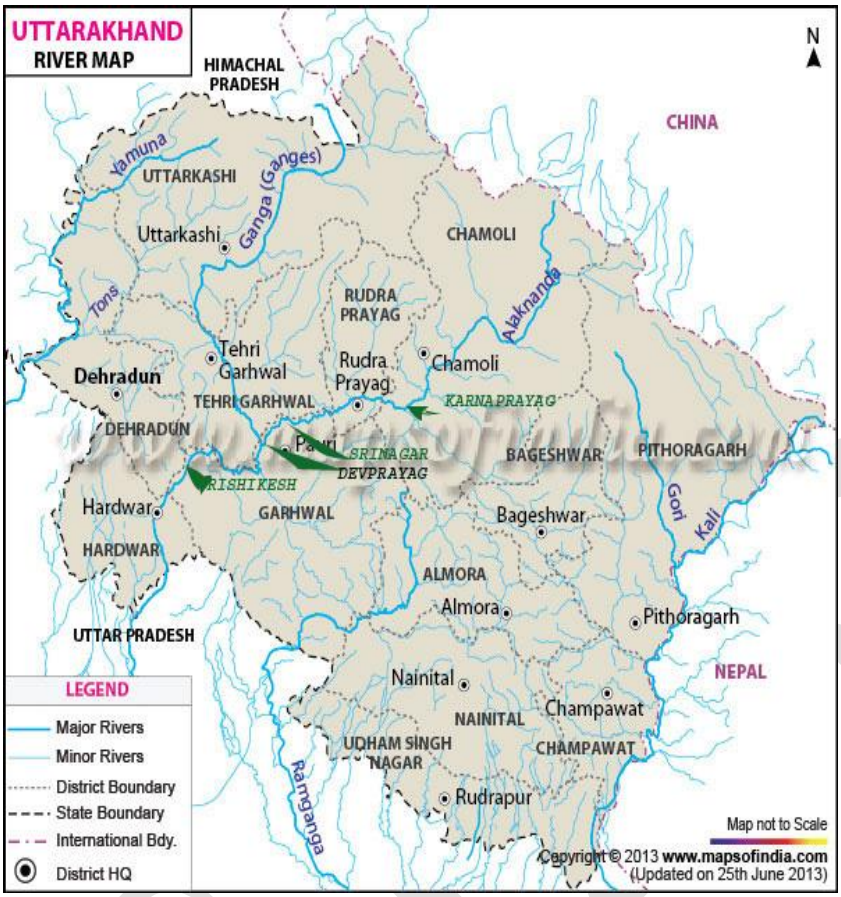
Parameters	**pH**	**Turbidity (NTU)**	**% DO saturation**	**BOD**	**Temperature change (^oC)**
Weight factor of parameters W_i	0.11	0.08	0.17	0.11	0.10

This equation would give result almost close to the result obtained by the standard equation. It means, if all nine parameters are available and we calculate water quality index by using standard equation it will give almost same result as if we calculate water quality index in the absence of some parameters by using the above equation.

Determination of Q value: Q value can be either determined by using some standard website from where it can be directly calculated using the different parameters or it can be determined using the Q value graphs. It is the indication of water quality relative to 100 of one parameter. The Q-Value is an indication of how good (or bad) the water quality is relative to one parameter.

100 = Very Good
1 = Very Bad

STUDY AREA: Samples collected from upstream and downstream of Karnaprayag, Rudraprayag, Srinagar, Devprayag, Rishikesh and Haridwar cities. The sampling sites are showing on the map of Uttarakhand.



Results and Discussion: The research showed that surface water samples were collected at 14 sampling sites, analyzed 5 parameters for degradation of surface water quality in 2 different locations upstream and downstream monitored locations in the Uttarakhand the results are shown in Table 2.

Table2. WQI for all the sampling sites have been calculated in the table below:

Site \ Parameters		pH	Turbidity (NTU)	% DO saturation	BOD (mg/l)	Temperature change (^oC)	$\sum W_i$	WQI = $\sum W_i Q_i / \sum W_i$
Weight factor of parameters W_i		0.11	0.08	0.17	0.11	0.10	**0.57**	-
Haridwar u/s (Ganga)	Observed Value	7.36	14	96	0.0	3	-	-
	Q value	93	69	99	100	81	-	-
	W_iQ_i	10.23	5.52	16.83	11	8.1	51.68	**90.67**
Haridwar d/s (Ganga)	Observed Value	7.44	19	94	0.0	3.2	-	-

	Q value	93	62	98	100	80	-	-
	$W_i Q_i$	10.23	4.96	16.66	11	8	50.85	**89.21**
Rishikesh u/s (Ganga)	Observed Value	7.69	15.2	91	8.0	2.8	-	-
	Q value	91	67	96	42	82	-	-
	W_iQ_i	10.01	5.36	16.32	4.62	8.2	44.51	**78.08**
Rishikesh d/s (Ganga)	Observed Value	7.80	14.8	90	0.0	2.9	-	-
	Q value	90	67	95	100	81	-	-
	W_iQ_i	9.9	5.36	16.15	11	8.1	50.51	**88.61**
Devprayag u/s (Bhagirathi)	Observed Value	7.14	9.7	110	0.0	1.2	-	-
	Q value	91	77	96	100	88	-	-
	W_iQ_i	10.01	6.16	16.32	11	8.8	52.29	**91.74**
Devprayag u/s (Alaknanda)	Observed Value	7.22	8.1	100	0.0	1.0	-	-
	Q value	92	80	99	100	89	-	-
	W_iQ_i	10.12	6.4	16.83	11	8.9	53.25	**93.42**
Devprayag d/s (Bhagirathi)	Observed Value	7.16	8.6	105	0.0	1.2	-	-
	Q value	91	79	98	100	88	-	-
	W_iQ_i	10.01	6.32	16.66	11	8.8	52.79	**92.61**
Rudraprayag u/s (Alaknanda)	Observed Value	7.45	9.1	102	0.0	0.9	-	-
	Q value	93	78	99	100	89	-	-
	W_iQ_i	10.23	6.24	16.83	11	8.9	53.2	**93.33**
Rudraprayag u/s (Mandakini)	Observed Value	7.23	6.5	109	0.0	1.2	-	-
	Q value	92	83	96	100	88	-	-
	W_iQ_i	10.12	6.64	16.32	11	8.8	52.88	**92.77**
Rudraprayag d/s (Alaknanda)	Observed Value	7.18	8.3	105	0.0	0.8	-	-
	Q value	92	79	98	100	90	-	-
	W_iQ_i	10.12	6.32	16.66	11	9	53.10	**93.16**
Srinagar u/s (Alaknanda)	Observed Value	7.40	9.4	109	0.0	1.3	-	-
	Q value	93	77	96	100	88	-	-
	W_iQ_i	10.23	6.16	16.32	11	8.8	52.51	**92.12**
Srinagar d/s	Observe	7.42	9.9	106	0.0	1.2	-	-

(Alaknanda)	d Value							
	Q value	93	76	98	100	88	-	-
	W_iQ_i	10.23	6.08	16.66	11	8.8	52.77	**92.58**
Karnaprayag u/s (Alaknanda)	Observed Value	7.46	8.9	99	0.0	0.8	-	-
	Q value	93	78	99	100	90	-	-
	W_iQ_i	10.23	6.24	16.83	11	9	53.3	**93.51**
Karnaprayag u/s (Pindar)	Observed Value	7.64	12.7	85	0.0	0.9	-	-
	Q value	92	71	91	100	89	-	-
	W_iQ_i	10.12	5.68	15.47	11	8.9	51.17	**89.65**
Karnaprayag d/s (Alaknanda)	Observed Value	7.52	9.6	94	0.0	1.1	-	-
	Q value	92	77	98	100	89	-	-
	W_iQ_i	10.12	6.16	16.66	11	8.9	52.84	**92.7**

Table 3. Permissible values of different water quality parameters for drinking purpose have been **given below:**

Parameters	**USEPA**	**WHO**	**ISI**	**ICMR**	**CPCB**
pH (mg/l)	6.5 - 8.5	6.5 - 8.5	6.5 - 8.5	6.5 – 9.2	6.5 - 8.5
Turbidity NTU	-	-	10	25	10
Conductivity (mg/l)	-	-	-	-	2000
Alkalinity (mg/l)	-	-	-	-	600
Total hardness (mg/l)	-	500	300	600	600
Iron (mg/l)	-	0.1	0.3	1.0	1.0
Chlorides (mg/l)	250	200	250	1000	1000
Nitrate (mg/l)	-	-	45	100	100
Sulfate (mg/l)	-	-	150	400	400
Residual (mg/l) free	-	-	0.2	-	-
Chlorine	-	-			
Calcium (mg/l)	-	75	75	200	200
Magnesium (mg/l)	-	50	30	-	100
Copper(mg/l)	1.3	1.0	0.05	1.5	1.5
Fluoride (mg/l)	4.0	1.5	0.6-1.2	1.5	1.5
Mercury (mg/l)	0.002	0.001	0.001	0.001	No Relaxation
Cadmium (mg/l)	0.005	0.005	0.01	0.01	No Relaxation

Selenium (mg/l)	0.05	0.01	-	-	No Relaxation
Arsenic (mg/l)	0.05	0.05	0.05	0.05	No Relaxation
Lead (mg/l)	-	0.05	0.10	0.05	No Relaxation
Zinc (mg/l)	-	5.0	5.0	0.10	15.0
Chromium (mg/l)	0.1	-	0.05	-	No Relaxation
E. Coli (MPN/100 ml)	-	-	-	-	No Relaxation

Table 4. Permissible values of different physiochemical parameters for river water have been tabulated below:

S.N.	Physiochemical parameter	Permissible value
1.	pH	6.0 – 9.0
2.	Turbidity	< 20 NTU
3.	Dissolved Oxygen	> 6 ppm
4.	Biological Oxygen Demand	< 4 ppm
5.	Temperature	< 30^{o}C

Discussions: The results obtained from analysis of water samples of river Ganga are shown in table 2
The reported values refer to the mean value of water samples collected in winter seasons (duration was **January 2015 to February 2015)** at different areas along the stretch of Ganga river. The results indicate that the quality of water varies considerably from location to location. A summary of the findings is given below: Results and permissible values for all the physiochemical parameters have been tabulated in the above tables and here is a brief discussion about the physiochemical parameters

PH: pH is a measure of the acidic or basic nature of a liquid. The concentration of the hydrogen ion [H^{+}] activity in a solution determines the pH. The permissible value of pH has been decided 6.5 to 8.5 for drinking purpose by WHO and it is between 6 to 9 for river water. The maximum pH was found at

Rishikesh downstream (Ganga) and the value is 7.80 and the minimum pH was found at Devprayag downstream (Bhagirathi) and the value is 7.16.

Turbidity: Turbidity is the measure of light penetration through a liquid or it is the measure of the suspended solids in a liquid. The turbidity in the river Ganga at Haridwar was lowest during winter season. From summer season onwards the water became turbid due to melting of snow and rains. The permissible value of turbidity for drinking water has been determined up to 20 NTU. The maximum turbidity was found at Haridwar downstream (Ganga) and the value is 19 NTU and the minimum turbidity (8.1 NTU) was at Devprayag upstream (Alaknanda).

Dissolved Oxygen: The Dissolved Oxygen analysis measures the amount of gaseous oxygen dissolved in water or any aqueous solution. The minimum value of dissolved oxygen is 6 ppm for river water. The maximum value of dissolved oxygen (13.81 ppm) was found at Devprayag upstream (Bhagirathi) and the minimum value (8.87 ppm) was found at Haridwar downstream (Ganga). The Ganga water contained highest dissolved oxygen during winter season, followed by a gradual decrease to its lowest values during monsoon season. The higher concentrations of dissolved oxygen during winter season was probably due to low water temperature, no turbidity and increased photosynthetic activity of the green algae found on the submerged stones and pebbles.

Biological Oxygen Demand: The amount of oxygen required to carry out biological decomposition of solids in sewage under aerobic condition at standard temperature is known as BOD. BOD value should be zero (0) for drinking water, for river water it is permissible up to 4 ppm. The maximum BOD (8 ppm) was found for Rishikesh upstream (Ganga) and for rest of the sampling sites it was zero ppm.

Temperature Change: Temperature change is very important parameter for river water quality. If temperature change is sudden and excessive it can cause harm to aquatic life. The maximum temperature change (3.2 ^{o}C) was found at Haridwar downstream (Ganga) and minimum temperature change (0.8 ^{o}C) was found at Rudraprayag downstream (Alaknanda) and Karnaprayag upstream (Alaknanda).

Water quality according to water quality index can be determined as per the table below:

S.N.	Water Quality Index Value	Water Quality
1.	91-100:	Excellent water quality
2.	71-90:	Good water quality
3.	51-70:	Medium or average water quality
4.	26-50:	Fair water quality

5.	0-25:	Poor water quality

In the present study tt may be stated that the water quality requirements differ from one place to another and thus any polluted water may be considered suitable for some of the beneficial uses but may remain unsuitable for other purposes. From testing it was clearly indicated that water samples from Haridwar downstream (Ganga), Rishikesh upstream and downstream (Ganga) and Karnaprayag upstream (Pindar) had WQI 71 to 90 and hence water quality at these sites was good. For rest of the sampling sites the WQI value was more than 90 and hence the water quality was Excellent at these sampling sites.

CONCLUSION: In the present study water of river Ganga was found to be in excellent quality in winter season at all the 14 sampling sites as the WQI ranged from 78.08 to 93.74 in Rishikesh u/s (Ganga) and Devprayag u/s (Bhagirathi) respectively for both the months. The WQI of Rishikesh u/s (Ganga) was not excellent as compared to the Rishikesh d/s (Ganga), because of addition of some municipal waste water. On the basis of present study some findings can be summarized as:

- The water quality is excellent for most of the sampling sites; hence it can be directly used for drinking purpose. But it should be considered that we have not tested the water samples for Fecal colliform, Nitrates, Phosphates and Total Dissolved Solids.
- The sampling and testing was done in winter season (January and February 2015). At this time the river water was comparatively clear than rest of the year. Hence the water quality will be poorer for rest of the year.
- The best quality of water in Uttarakhand is available at Karnaprayag upstream (Alaknanda) and the worst was at Rishikesh upstream (Ganga).

References:

- Census India 2011 (www.census2011.co.in): demographic data about all sampling sites .
- www.water-research.net
- www.waterontheweb.org
- Avnish Chauhan and Suman Singh *Deptt. of Applied Sciences and Humanities, College of Engineering , Teerthanker Mahaveer University, Moradabad, UP, India-244001: Evaluation Of Ganga Water for Drinking Purpose by Water Quality Index at Rishikesh, Uttarakhand, India
- BIS Analysis of Water Waste water, Bureau of Indian Standards, New Delhi (1993)
- Bhardwaj V, Singh DS, Singh AK (2010) Water quality of the Chhoti Gandak River using principal component analysis, Ganga Plain, India. J Earth Syst Sci 119:117–127.
- C.S.Rao-environmental pollution control engineering (2006), new age international publication.

- Matta, G. (2013) A study on physico-chemical Characteristics to assess the pollution status of river Ganga in Uttarakhand, ISSN: 0974-2115, Journal of Chemical and Pharmaceutical Sciences,
- MoEF (2009) Status paper on River Ganga, State of Environment and Water Quality, National River Conservation Directorate Ministry of Environment and Forests, Government of India.

- Pandey M., Sundaram S.M., Trend of water quality of river Ganga at Varanasi using WQI approach, International Journal of Ecology and Environmental Science, 28, 139142 **(2002).**

- R .K. Horton, "An index number system for rating water quality", J. Wat. Pollut. Cont. Fed., 37., 300- 306., 1965.
- R. M. Brown, N. I. McClelland, R. A. Deininger, R.G. Tozer, "Water quality index-do we dare", *Water Sewage Works*, 117. (10)., 339-343., 1970.

- Singh KP, Malik A., Mohan, D., and Sinha S (2004) Multivariate statistical techniques for the evaluation of spatial and temporal variations in water quality of Gomti River (India)—a case study. Water Res 38(18):3980–3992.

- Srivastava, G. and Kumar, P. (2013).Water quality index with missing parameters, IJRET, ISSN: 2319 – 1163 Volume: 2 Issue: 4, 609 – 614
- WHO, "Guidelines for drinking water quality",(Recommendations, Genev and World Health Organization, 2ndEd. 1. 188., 1993.