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Effect of Monsoon season on physicochemical characteristics of river Ganga water at Rishikesh,Uttarakhand

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Abstract
River Ganga- the life line for billions of people, provides water for the essential requirements of life. However, over the years, it has been subjected to tremendous pressure due to untreated sewage and industrial waste being dumped in to the river at many places and the residues of pesticides and insecticides used in the agriculture are ultimately washed and released in to it. In this study, water samples from river Ganga were monitored for temperature, pH, DO, BOD, COD, TSS, TDS, conductivity and turbidity at four sampling sites on seasonal basis. All the quality parameters were compared with the standard values of BIS. The study of physico-chemical parameters on river Ganga water have shown a demonstrable decline in its quality. Deteriorated water quality of river is known for mounting potential health hazards to people drinking this water and organisms present in Ganga river basin. Further research work is urgently needed to determine the bioaccumulation of these toxic elements in the food web and the associated risks to the ecosystem and human health.

Keywords
River Ganga pollution, Physico -chemical characteristics, Monsoon, Water quality.

Introduction

Ganga, a religious and divine river of India, originates from Himalayan state of Uttarakhand. It is one of the longest rivers in India and also third largest river in the world in terms of water discharge in the sea. Ganga immensely contributes through its highly fertile Indo-Gangetic basin by creating ideal conditions for cultivation of many crops. It also provides habitat for some of the rarest species on earth. Ganga water is used for rituals, irrigation, transportation, fishing and tourism. Rishikesh is an important place where Ganga river first enters into the plain terrain. From here onwards, the problem of water pollution begins. Intensified human activities including dumping of untreated sewage waste water, washing clothes, bathing of animals, agriculture run away water and

discharge of industrial effluents. In the preceding years, many studies have been carried out on water quality assessment. Lakshminarayana (1965) published a series of papers reporting the results of studies carried out at Varanasi during March, 1957 to 1958. It was observed by him that the values of the most of the parameters decreased during rainy season while no marked variation was observed during winters and summers. Khanna *et al*., (1997) studied physio-chemical and biological parameters of river Ganga at Lalji Wala, Haridwar. Similarly, Chopra *et al*., (1994) studied the impact of local sewage on self-cleansing of Ganga water at Rishikesh with reference to physico-synthetic parameters. Chopra and Rehman (1995) again researched on the self purification of physico-chemical properties of Ganga River at Jwalapur Haridwar. Kumar *et al.,* (2010) conducted studies on physical, chemical and bacteriological properties of water from rivers of Uttarakhand. Matta *et al*., (2018) examined the seasonal variation in hydro-chemical parameters of Ganga river water at Rishikesh using comprehensive pollution index (CPI). The present study is aimed at investigating the water quality of Ganga river in Rishikesh for establishing its suitability to aquatic ecosystem and the human health. We conducted this research study in Monsoon season for generating the basic data on physico–chemical properties of river Ganga at Rishikesh.

Materials and Methods

River Ganga was selected for the assessment of water quality because its spiritual, divine, cultural, emotional and ritual, agricultural, tourism, fishing, rafting and drinking significance. For proper and comparative assessment of anthropogenic interventions to water quality, samples from four sites namely, Site 1- Laxman Jhula (the entry point of river in the city), Site 2- Chandreshwar Nagar, Site 3- Triveni Ghat (heart of the city) and Site 4- Pashulok Barrage (the exit of river Ganga) were collected and transported to the Lab during Monsoon period.

Sampling and analysis

The water samples were collected in clean plastic sample bottles of 2 liter size from four locations of Ganga river at Rishikesh. The physical parameters such as pH, temperature, Color, taste, Odor and were studied. For estimation of DO, water samples were preserved on spot and transported to laboratory. Further, the chemical parameters like DO, TDS, TSS BOD, COD and Conductivity were analyzed in the laboratory using standard methods. (APHA, 2012 and Trivedy and Goel).

Results

S. No.	Parameters with units	Laxaman Jhula	Chandre-shwar Nagar	Triveni Ghat	Barrage	Standards recommended by agencies (ICMR /BIS)
1.	pH	8.1	8.3	8.1	7.8	6.5- 8.5 (ICMR /BIS)
2.	Temperature ^{0}C	22.3	23.8	23.4	22.1	-
3.	Colour	Grayish	Grayish	Grayish	Grayish	-
4.	Taste	sweet	Sweet	sweet	sweet	-
5.	Odor	normal	Normal	normal	normal	-
6.	COD(mg/l)	8.98	45.79	21.05	10.18	-
7.	BOD(mg/l)	3.09	7.83	6.14	4.03	5.00 (ICMR

8	DO(ml)	5.3	2.2	2.5	5.1	5.00 (ICMR / BIS)
9.	TDS(mg/l)	191.3	369	125.4	254	500 (ICMR / BIS)
10.	Conductivity (µmoh/cm)	290.1	278.00	269.0	258.0	300 (ICMR)

Table showing values obtained for several physico-chemical parameters.

The results tabled from the four sampling sites of river Ganga clearly demonstrate alterations in some of the physicochemical characteristics of river Ganga water during Monsoon season. In present study, we have recorded maximum temperature 23.8^{0}C at Chandreshwar Nagar and minimum 22.1^{0}C at Barrage in Rishikesh during rainy season. The temperature is, however, not showing any pronounced change during the study period. For determining the chemical nature and biological suitability of water, pH was studied from all the sites of Ganga. The maximum pH 8.06 was observed at Chandreshwar Nagar and minimum pH 7.9 at Barrage. The other relevant chemical parameters were also studied. Here, we have measured the chemical oxygen demand (COD) and its maximum value 45.79 mg/l was found at Chandreshwar Nagar and minimum 8.98 mg/l at Laxman Jhula in Monsoon period. In this research communication, the biological oxygen demand (BOD) was recorded 7.83mg/l as the maximum value at Chandreshwar Nagar and minimum 4.03mg/l at Barrage in the same season. Similarly, the dissolved oxygen (DO) content in Ganga water at all sampling sites was analyzed and maximum DO 5.3 mg/l and minimum 2.2mg/l were recorded at Laxman Jhula and Chandreshwar Nagar, Rishikesh, respectively in this season. Considering the significance of total dissolved solids (TDS), we determined the values of TDS and maximum TDS value 369 mg/l at Chandreshwar Nagar and minimum191.3 mg/l at Laxman Jhula were recorded respectively. The water conductivity significantly influences its quality and applicability to biotic community including the human beings. Therefore, we studied this feature of Ganga water at Rishikesh and found its maximum value 290.1 µmoh/cm at Laxman Jhula and minimum 259.0 µmoh/cm at Barrage.

Discussion

The physicochemical characteristics of water system are known to impact significantly the biotic communities including the human beings. Due to the problem of water pollution, this component of the ecosystem is getting altercated and thus causing several health related complications. Further, temperature- one of the most important component, affects the vitality of living beings and is the most commonly used parameter for the physical assessment of water quality. It mounts enormous effects on the chemical as well as biological properties of surface water.

Our data in table show no marked difference in temperature recorded from four sampling sites during rainy season. Bisht *et al*., (2018) observed similar range of temperature, 19.8^{0}C from December to 25.5^{0}C in the month of May in Alaknanda and Mandakini rivers and their confluence at Rudraprayag. Earlier studies have found same range of water temperature 17.47 to19.33^{0}C, minimum in winter season and maximum in pre-monsoon season in the rivers of Garhwal and Kumaon regions (Kansal *et al*., 2011). The findings of Raghuvanshi *et al*., (2014) clearly show a range of temperature i.e., 24.2°C to 32.4°C in summer season in Ganga River water at Allahabad. The significance of temperature can be envisaged from the fact that it determines the value of pH and dissolved oxygen (DO) in water (Kumar *et al*., 2010). Thus, based on foregoing interpretations, it becomes clear that temperature in river Ganga in Himalyan region is approximately similar as compare to findings of others.

However, drarratic change in temperature range was noticed in the plains of Utter Pradesh at Allahbad. This big change may be attributed to be detritions in the water quality due to increased water pollution.

The pH is very crucial for the survival and vitality of organisms dwelling in water bodies and elsewhere. It indicates acidity and alkalinity of the material present in the water. We have observed a gradual trend of increase (as shown in table) in the pH of Ganga water at Rishikesh from several sampling sites during rainy season. Our findings show an ascending trend in pH, from Barrage through Laxman Jhula and Triveni Ghat to Chandreshwar Nagar, indicating increase in alkalinity of water. Similar reports were made by Kamboj *et al*., (2016) wherein same range of pH, from 8.07-7.89, at Rishikesh and Haridwar during October respectively. However, pH range from 7.37 to 7.93 at Rudraprayag was noted from December to May (Bisht *et al.*, 2018).

The chemical oxygen demand (COD) is the quantity of oxygen used by the water system. Our data represent the abrupt changes in COD quantity measured with highest level of 45.79 mg/l at Chandreshwar Nagar. Subsequently, a profound down fall in COD at Triveni Ghat, 21.05 mg/l, to10.18 mg/l at Barrage and 8.98 mg/l at Laxman Jhula was recorded. The effect of seasonal variation in COD value from 4.58mg/l in Monsoon to 13.72mg/l in winter was recorded in river Ganga at Haridwar Joshi *et al*., (2009). These workers, further, determined the biological oxygen demand (BOD) and found 3.90 mg/l in Monsoon and 1.35 mg/l in Winter. Our findings are in good consonance with reports of Matta *et al*., (2018) where these workers found high level of COD value maximum 6.49mg/l in Summer and mimimun 8.50mg/l in monsoon season in Ganga at Rishikesh.

The biological oxygen demand (BOD) is understood as the amount of oxygen utilized by aquatic consumers in water. Our observations show the increased value of biological oxygen demand 7.83mg/l as the maximum value at Chandreshwar Nagar and 4.03mg/l as the minimum value at Barrage in rainy season. However, the findings of Bisht *et al*., (2018) are not similar to our reports. They have recorded BOD between 2.0 mg/l to 2.6 mg/l during December to May at Rudraprayag. This range of BOD was due to the presence of large number of microbes in the water. Our data showing higher values for BOD in comparison with other reports from Ganga may be attributed to the lockdown impact of Corona on the environment, natural resources including Ganga.

Dissolved oxygen is a significant parameter for the determination of water quality. It indicates the physical and biological activities running in the water system. Further, dissolved oxygen denotes the level of pollution in water bodies. We have determined dissolved oxygen (DO) content in Ganga water at Rishikesh in all samples and maximum DO 5.3 mg/l and minimum 2.2mg/l were recorded at Laxman Jhula and Chandreshwar Nagar, respectively in this season. The average value of DO in river Ganga was found 10.0 mg/l in December at Rishikesh.
Haritash *et al*., (2016). However, Kansal *et al*., (2011) has determined the average value of DO 4.65mg/l in winter season and 1.49 mg/l in pre monsoon period. These observations are in agreement to our findings. Variations in DO values may be held responsible to seasonal factors and Corona lockdown. Higher values of DO in winter season are due to more dissolution of oxygen at lower temperature.

The high concentration of total dissolved solid (TDS) in drinking water is hazardous to human health including stone formation in kidney, heart diseases and gastro-intestinal irritation. We have found recorded maximum TDS value 369 mg/l at Chandreshwar Nagar and minimum191.3 mg/l at Laxman Jhula respectively. The value of TDS ranging between 255 - 501 mg/l in the water of river Ganga at Kanpur was reported during monsoon period Praveen *et al*., (2013). Similar to our result, Kamboj *et al*., (2016) found the range of TDS value 187.7 mg/l to 172.9 mg/l fom Rishikesh to Sukratal in October month. However, TDS was reported between the range of 78

mg/l to 96.0 mg/l from December to May at Rudraprayag Bisht *et al*., (2018). The differences in the values of TDS may be interpreted on various grounds including season, locality and the intensity of anthropogenic interventions. TDS concentration is increased due to human interferences including discharge of domestic wastes, disposal of untreated sewage and dumping of solid wastes in the water system.

The conductivity of water is affected by the suspended impurities and also depends upon the amount of ions in water salt concentration in the water samples. We measured the conductivity of Ganga water from four sites at Rishikesh and found its maximum value 290.1 µmoh/cm at Laxman Jhula and minimum 259.0 µmoh/cm at Barrage. The increase in conductivity values depicts the load of water pollution due to increased sewage disposal in the river Ganga at Laxman Jhula. The water conductivity significantly influences its quality and applicability to biotic community including the human beings. Our findings on water conductivity values are supported by Kamboj *et al*., (2016) findings where they reported the range of conductivity from 290.1 µmoh /cm to 278 µmoh cm at Rishikesh in the month of October. However, Joshi *et al* (2009) reported water conductivity as 415.66µmho/cm in monsoon season at Haridwar. The variations in water conductivity may be seen due to varying factors affecting the flow of water in river system.

Conclusion

In this research article, we have reported various physicochemical parameters of river Ganga at Rishikesh in Monsoon season. Parameters like pH, temperature, colour, odour, TDS and conductivity are within the standard limits as recommended by ICMR/BIS, whereas, BOD and D O are found more than the prescribed standard limits. The reasons for the increase in BOD and DO may be due to increasing water pollution by dumping of solid wastes and discharge of untreated sewage water in river Ganga. The number of living beings in Ganga gets decreased due to increase in water pollution resulting in down-gradation of suitable water quality and depletion of the aquatic biodiversity. It may be concluded that such research studies on aquatic system require more emphasis so as to normalize the disruptions and alterations in hydroecology

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