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A Review of the Ganga River Water Pollution along Major Urban Centers in the State of Uttar Pradesh, India

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Abstract – *River is a highly dynamic ecosystem which is affected by activities that happen at the river bank including industrial and direct human activities. Ganga river water quality was assessed at 6 urban centers of Uttar Pradesh. The river water quality monitoring data of the UPPCB was used for the analysis. Four water quality parameters, namely Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Coliform (TC) and Fecal Coliform (FC) were used for the analysis. Six urban centers were Anupshahar, Kannauj, Kanpur, Prayagraj, Mirzapur and Varanasi. Anupshahar was the least polluted center and showed minimum accumulation of organic and pathogenic pollutants. Kannauj was another less polluted center with downstream values slightly higher than the upstream values that signified slight accumulation pollutants. Maximum difference in the BOD level and pathogenic concentration between the upstream and downstream side were observed at Kanpur and Varanasi signifying huge interference of human activities in the river ecosystem in Kanpur and Varanasi. Prayagraj showed continuous decline in pollution signifying improving water quality. However maximum TC and FC concentration at the upstream side was seen in Prayagraj which can be attributed to greater downstream values in Kanpur. The difference between the upstream and the downstream values at Prayagraj was comparatively less than that in Kanpur and Varanasi showing lesser accumulation of contaminants in the river stream. While all the centers showed declining trend of pollution owing to valiant government efforts and community participation, Mirzapur showed alarming and continuous increase in the organic and pathogenic pollutants.*

Key words: Ganga river, UPPCB, DO, BOD, Total Coliform, Fecal Coliform, Urban Centers, Pathogenic pollutants.

1. Introduction

Water sources are integral part of our ecosystem. Water sources are present in the form of rivers, glaciers, lakes, rain water, ground water etc. They not only ensure sustenance for animals but also facilitate for economic growth, agricultural development, power generation and industrial development. Human population living on the banks of rivers depend hugely on it for livelihood through fishing and livestock production. But this dependence also plays vital role in the deterioration of water quality of the water sources. Increasing population, industrialization and urbanization are some of the prominent factors responsible for the degradation of water quality [1]. In general trend, the water quality of the rivers is better in the upstream side as compared to the downstream side because of accumulation of waste and toxicants in the stream while flowing from the upstream side to the downstream side [2,3]. River water pollution is one of the major global environmental concerns today. Diminished river water quality upsets the balance of aquatic ecosystem and lead to fatal consequences both for humans and animals. It is not only and environmental concern but also a socio-economic issue that need to be acted upon immediately [4,5].

Anthropogenic activities like direct sewage discharge, washing and bathing, waste disposal and direct industrial discharge have deteriorated the river water quality globally. Ganga river is one of the most sacred rivers of India. But unfortunately it has been taking the jolt of pollution from decades and that has led to serious degradation in its water quality. Ganga river originates from the Himalayas and falls into the Bay of Bengal covering a catchment area of more than 2500 Km [6]. Such vast extent makes it liable to be polluted at different places. Vast population resides along the banks of the river Ganga and thus flow of domestic sewage is a huge factor that adds up to the misery. A lot of industrial activities also flourish along the bank of river Ganga that leads to direct discharge of effluent into the river. Religious activities, bathings and disposal of the remains of the dead are other factors that add up to the woes of the Ganga. Rivers do have the natural ability to remediate themselves however the situation with Ganga is alarming because the rate of inflow of pollutants is way beyond its natural remediation capabilities [7].

A lot of previous studies have focused on increasing deterioration of Ganga River water quality [8-10]. The situation needs immediate action of researchers and policy planners because such contamination and pollution can lead to outbreak of water borne diseases like cholera, dysentery, hepatitis A and typhoid. People living on the bank of river Ganga use its

water for cooking and daily use that increases the health risk. Study by Indian Council of Medical Research (ICMR) says that the pollution in Ganga river has made people of Uttar Pradesh and Bihar highly prone to cancer [8]. Hence it is imperative to undertake more research activities to assess the real time pollution status of the Ganga river thereby facilitating the policy makers to formulate specific and goal oriented task plan.

A comprehensive analysis of the variation of pollution levels in Ganga river water at 6 urban centers of Uttar Pradesh is presented here. Four pollution parameters, i.e. Dissolved Oxygen (DO), Biochemical Oxygen Demand (BOD), Total Coliform (TC) and Fecal Coliform (FC) were used for the analysis. While DO levels represent if the water body is fit for the sustenance of aquatic life, the BOD levels signify the concentration of organic pollutants in the water body. Total coliform is a class of rod shaped bacteria whose presence in the river water body signifies the presence of pathogenic bacteria that may be harmful to the humans. Fecal coliform bacteria are the subset of total coliform bacteria and their presence shows that the water is polluted by the fecal matter of humans and animals (figure 1). Fecal coliform bacteria are the thermoresistant total coliform bacteria and hence are harmfull for the humans. Fecal coliform pathogens can cause health comorbities like diarrhea and stomach infections. Pathogens like *E.Coli* and Salmonella, that are subsets of Fecal Coliform Bacteria, can cause serious health implications like typhoid fever.

The data from the monitoring results of Uttar Pradesh Pollution Control Board (UPPCB) was used for comparative analysis. Six urban centers were selected according to the route that the Ganga river follows in the state of Uttar Pradesh and the availability of data for upstream and downstream locations. The selected centers were Anupshahar, Kannauj, Kanpur, Prayagraj, Mirzapur and Varanasi. Upstream and downstream data for all the four parameters of all the urban centers were taken from UPPCB site and then the descriptive analysis was done using Origin software. The data were represented as Mean ± SEM (Standard Error of Mean) and the graphs were plotted using Origin software.

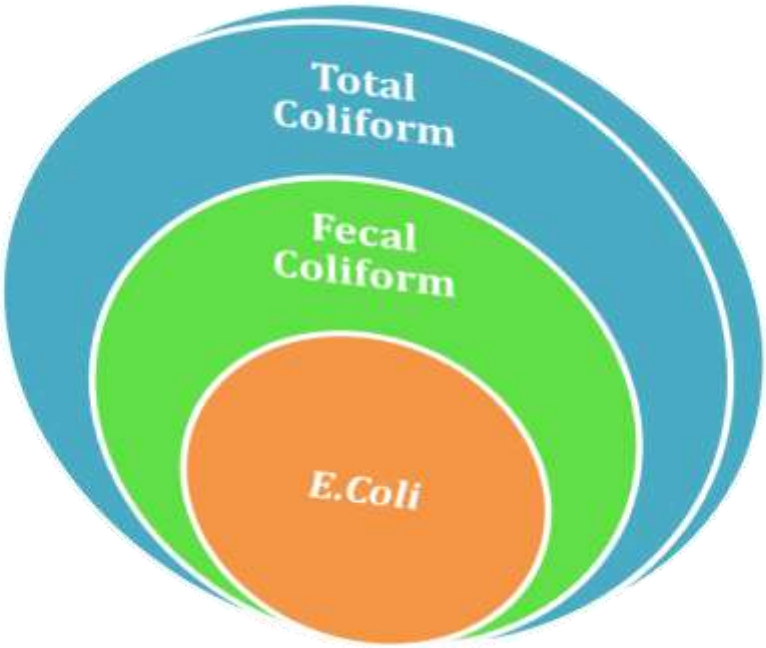


Figure 1: Relationship between Total and Fecal Coliform.

2. Pollution trend at the urban centers

In this section the trend of variation of the four parameters from January 2016 to December 2019 is represented for all the urban centers in the form of graphs. The data is represented as annual Mean ± SEM and is shown with the help of line graph.

2.1. Anupshahar

The DO levels at both upstream and downstream end were well beyond 4 mg/L mark which is essential for the survival of aquatic ecosystem. The trend of DO and BOD showed increasing DO and decreasing BOD at both upstream and downstream ends that signifies healthy aquatic ecosystem (figure 2). The BOD levels were never much beyond 3 mg/L mark which shows significantly low concentration of organic pollutant in Ganga in Anupshahar. Almost similar trends of DO and BOD at upstream and downstream ends highlight substantially low interference of human activities in the riverine system in Anupshahar. The concentration of Total Coliform bacteria and Fecal Coliform bacteria was found to be lower at the downstream side except for the year 2019. TC and FC bacteria signify pathogenic population in the water body and hence must be minimum. Both TC and FC concentration have been declining in the upstream side but have shown increasing trend since 2017 (figure 2). It shows increase in the sewage discharge and fecal matter in Ganga river water. The TC bacteria concentration have however been not much above 500 MPN/100 mL mark and thus the river water in Anupshahar can still be used for outdoor bathing but increasing trend of coliform concentration is a matter of concern and must be taken into consideration immediately before the water becomes too polluted. Community participation and behavioral modifications are of utmost importance in order to curb the flow of sewage and fecal matter into the Ganga.

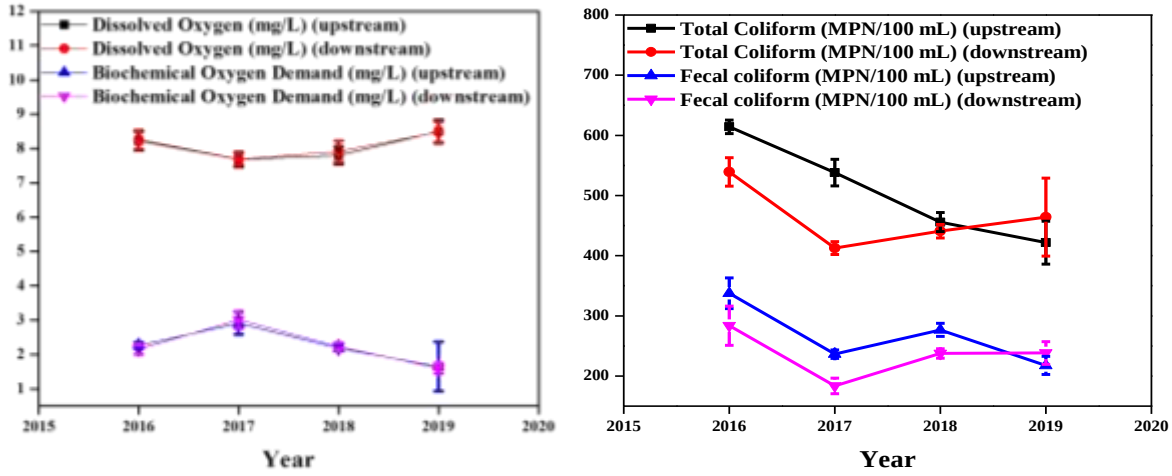


Figure 2: Variation of DO, BOD, TC and FC in Ganga river water at upstream and downstream points of Anupshahar.

2.2. Kannauj

DO levels were found to be higher than the threshold limit of 4 mg/L that signified favorable condition for aquatic ecosystem. DO level slightly decreased in the year 2019 at the downstream side. BOD levels were higher at the downstream side for all the four years which showed the accumulation of organic pollutant. BOD levels were found to be consistently higher than 3 mg/L that meant substantial pollution of the river water. BOD level although decreased in the year 2019 at both the ends however it was still greater than 3 mg/L mark at the downstream side that signified presence of organic pollutants in the Ganga river in significant concentration (figure 3). The TC and FC concentration were substantially higher at both the ends for all the four years. The coliform concentration was found to be higher at the downstream side which highlighted the active interference of human activities in the riverine system (figure 3). The TC and FC concentration have significantly decreased since 2017 but still the absolute values are much higher than the permissible threshold.

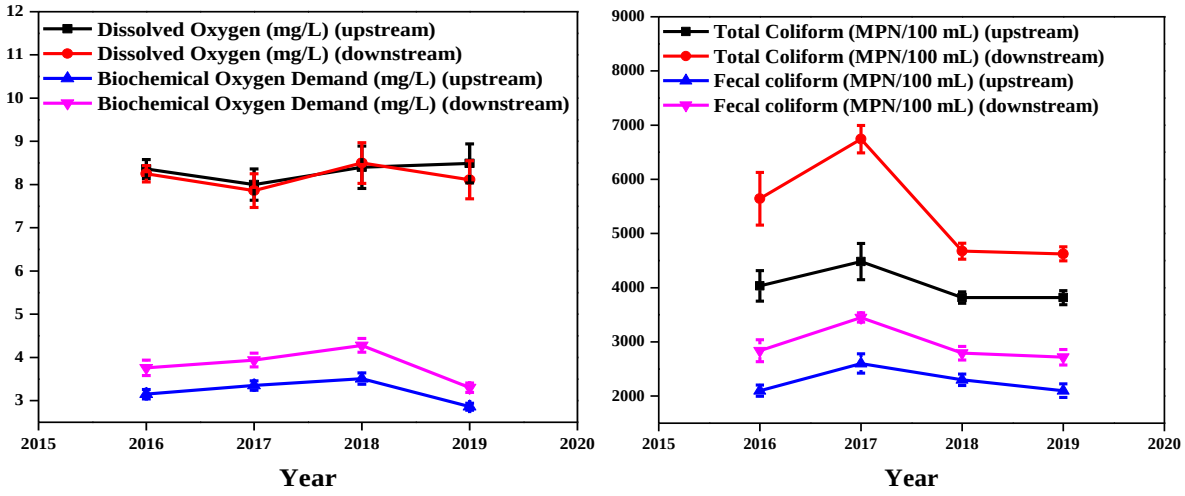


Figure 3: Variation of DO, BOD, TC and FC in Ganga river water at upstream and downstream points of Kannauj.

2.3. Kanpur

Ganga river water was found to be highly polluted in Kanpur which can be attributed to direct industrial effluent discharge besides discharge of sewage and other pollutants. While the DO level at the upstream side was fairly constant and well above threshold limit, the DO level at the downstream side was qute low (figure 4). However it was greater than the threshold of 4 mg/L and showed increasing trend in the year 2019. The BOD level at the downstream side was found to be well above 3 mg/L in all the four years and hence the river water is polluted with organic pollutants coming from industrial as well as residential areas. Vast difference between the BOD level at upstream and downstream sides signify accumulation of pollutants in the riverine system. The BOD level decreased in the year 2019 at the downstream side but was still at the higher side. Huge interference of industrial and human activities in the Ganga river system in Kanpur was evident from the TC and FC concentration (figure 4). Presence of pathogenic bacteria in such high concentration can be detrimental for both animals and humans. The trend of TC and FC bacteria showed decline since 2017 but still a lot of work needs to be done both at administrative and community level. The absolute values of TC and FC are very high in Kanpur and thus the river water is highly unfit for any type of use by the humans.

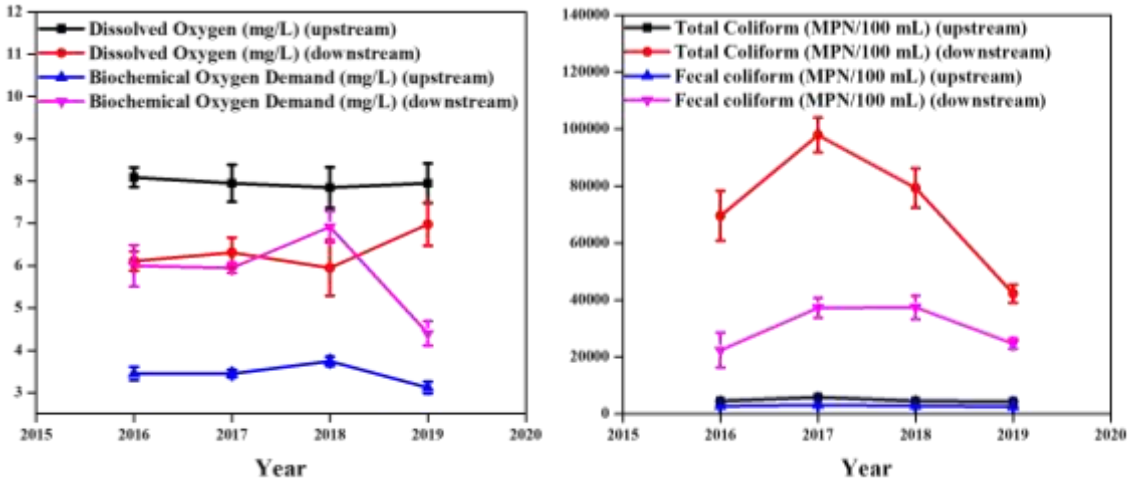


Figure 4: Variation of DO, BOD, TC and FC in Ganga river water at upstream and downstream points of Kanpur.

2.4. Prayagraj

The DO and BOD level showed favourable trend in Prayagraj. While the DO increased since 2017, the BOD level decreased post 2017. Decreasing BOD level signified diminishing pollution level in the river water (figure 5). The BOD level at both the sides reached the mark of 3 mg/L in 2019 from almost 5 mg/L in 2017 which is a commendable decline. Absolute values of TC and FC were found to be on a higher side however the trend showd that the pathogenic bacteria concentration is on a continuous decline in Prayagraj. This can be attributed to vigilant attitude and valiant efforts for Ganga rejuvenation. The absolute values of TC and FC in Prayagraj were less than that in Kanpur. The TC and FC concentration at the upstream and downstream sides were almost same that signified minimum accumulation of the pathogenic contaminats in the Ganga river water (figure 5). This point must be appreciated and more community participation must be encouraged to lower down the absolute values of TC anf FC bateria concentration.

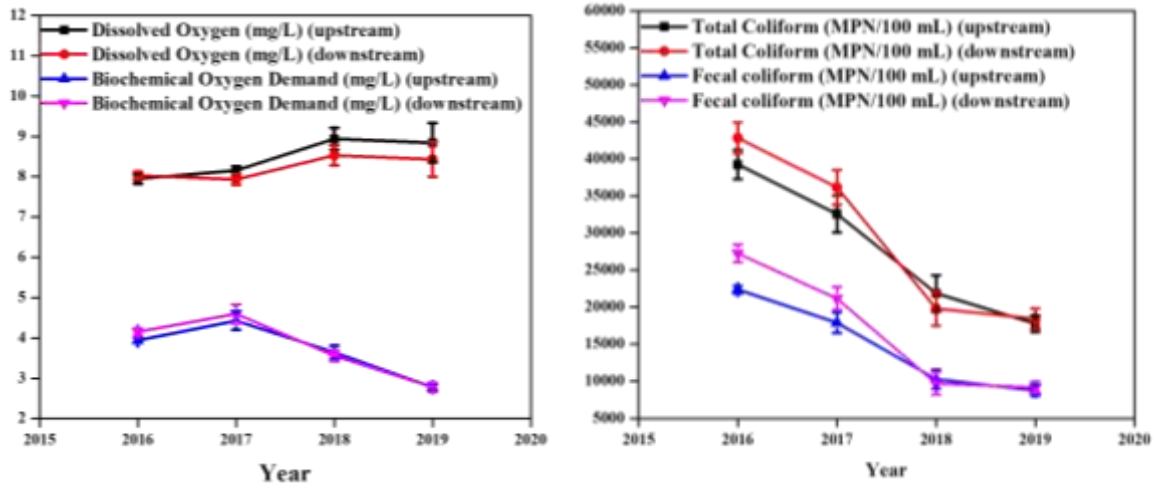


Figure 5: Variation of DO, BOD, TC and FC in Ganga river water at upstream and downstream points of Prayagraj.

2.5. Mirzapur

Data analysis for the Mirzapur district showed alarming trends. The DO level was found to be on a continuos decline while the BOD was found to be increasing continously at the downstream side. DO and BOD at the upstream side was found to be fairly constant. This showed that the Ganga river water quality is getting degraded continously in the Mirzapur district (figure 6). The BOD level crossed the 3 mg/L mark in 2019 that showed significant contamination of the river water with decaying organic matter. Similar trend was seen in the case of TC and FC bacteria concentration. While TC and FC concentration at the upstream side remained failrly constant, the values at the downstream side kept on increasing at an alarming rate post 2017 (figure 6). The result was contrasting to other urban centers where decline in pollution level was evident after 2017. The gap between the TC and FC concentration at the upstream and downstream sides showed increasing trend that signified alrmingly increasing accumulation of pathogenic contaminants in the Ganga river water in Mirzapur. Such high gap can be attributed to lack of awareness among common mass or even to negligence. It is imperative to put in valiant efforts to control Ganga river water degradation in Mirzapur district before the condition becomes fatal.

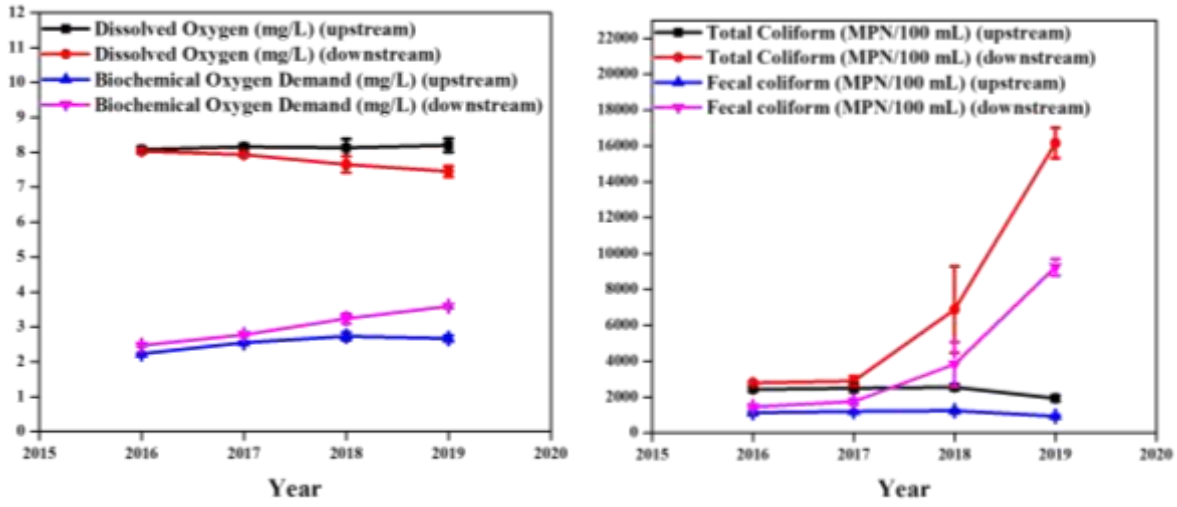


Figure 6: Variation of DO, BOD, TC and FC in Ganga river water at upstream and downstream points of Mirzapur.

2.6. Varanasi

The DO and BOD level at the upstream side in Varanasi were almost constant. DO at the downstream side was constantly lower than that in the upstream side while the BOD in the downstream side was consistently higher than that in the upstream side. Year 2019 witnessed increasing gap between the DO and BOD at the downstream side that indicates improving health of the riverine system (figure 7). The DO at the downstream side showed increasing trend while the BOD at the downstream side showed declining trend signifying diminsihing pollution level in the river water. However, absolute values of BOD at upstream and downstream side were higher than 3 mg/L with downstream values being much higher than the upstream values. This signifies accumulation of organic pollutants in the Ganga river water in Varanasi. The trend of TC and FC concentration was nearly same to that followed in Kanpur. TC and FC concentration in upstream side was fairly constant and comparatively low while the values in the downstream side were much higher and thus showed the presence of pathogenic contaminants in large concentration (figure 7). The TC and FC concentration at the downstream side showed a declining trend post 2017 which is something to cheer about however the absolute values are still very high and need immediate attention of both policy makers and the general public.

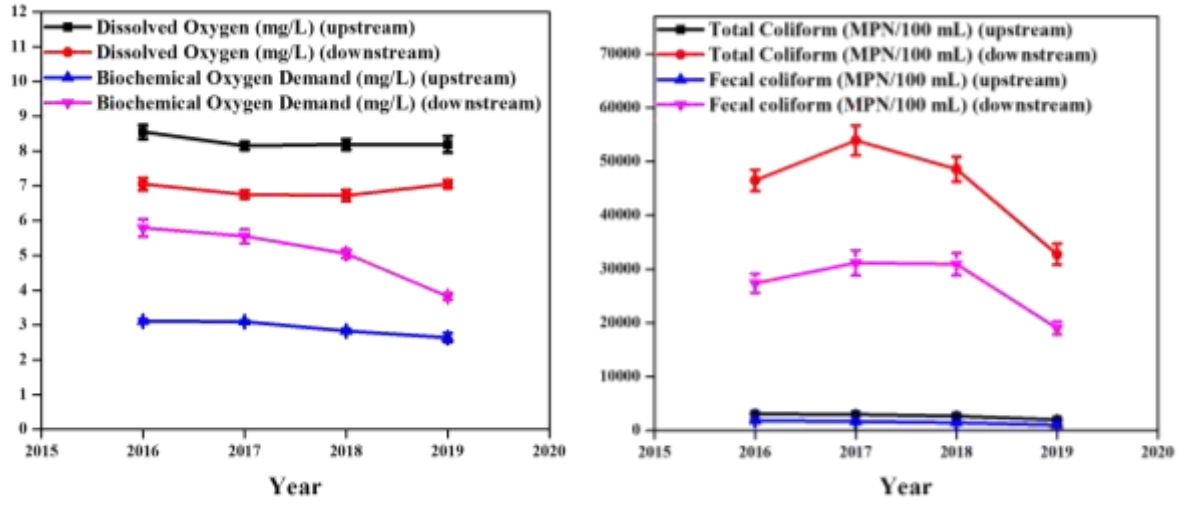
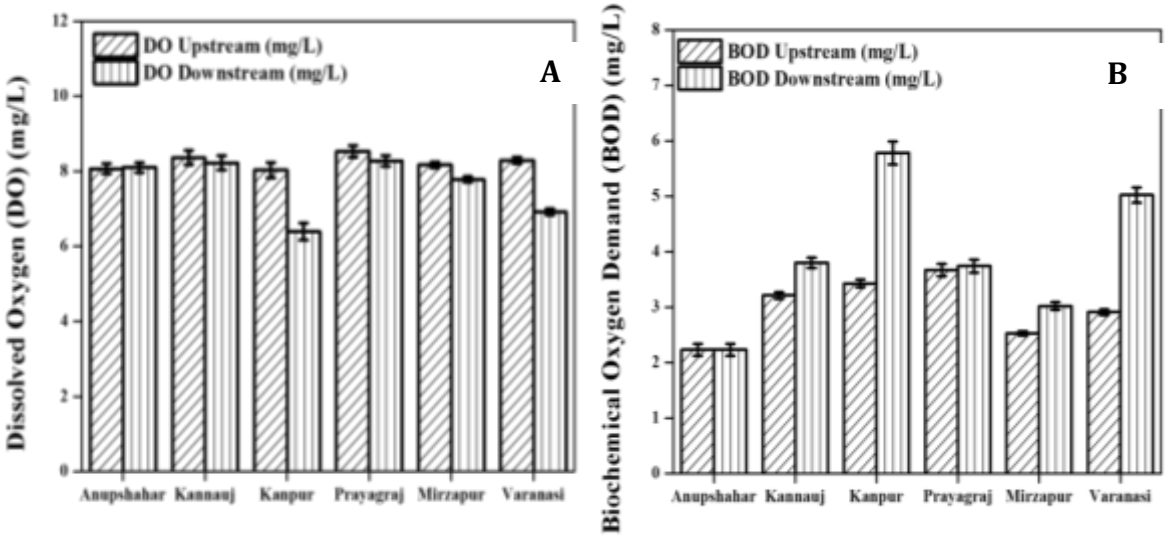


Figure 7: Variation of DO, BOD, TC and FC in Ganga river water at upstream and downstream points of Varanasi.

3. Overall comparison of Ganga river water quality at the six urban centers

The overall comparison of the Ganga river water quality at the six urban centers was done by using the data (UPPCB) from January 2016 to January 2020. While the DO level was nearly constant in Anupshahar, Kannauj and Prayagraj, it was substantially less at the downstream side in Kanpur, Varanasi and Mirzapur. However all the centers had DO level greater than 4 mg/L mark at both the sides which is essential for the survival of aquatic life. BOD level at the upstream and downstream side in Anupshahar and Prayagraj was almost same signifying minimum accumulation of organic pollutant in the Ganga river stream. While Kannauj and Mirzapur showed slightly higher value of BOD at the downstream side, Kanpur and Varanasi showed greater difference (figure 8 A and B). Larger the difference between the BOD level at the upstream and downstream sides greater is the accumulation of organic pollutant in the river stream flowing through that place. Hence greater is the impact of anthropogenic activities on the river stream. This fact was substantiated from the trend shown in figure 8 C and figure 8 D. Anupshahar showed the least values of TC and FC concentration and the values were failry constant at both the sides signifying minimum accumulation of pathogenic contaminants in the flowing stream. Kannauj and Mirzapur showed relatively low values of TC and FC concentration (compared to Kanpur, Prayagraj and Varanasi) however the TC and FC concentration at the downstream side was found to be elevated that shows discharge of pathogenic pollutants in the Ganga river stream. It was evident in the pollution trend analysis (figure 6) of Mirzapur that the downstream side showed alarmingly increasing concentration of TC and FC bacteria. It is to be noted that however the absolute values of TC and FC concentration in Mirzapur are relatively less but the trend shows alarming rate of accumulation of pathogenic contaminants in the river stream and hence must be given immediate attention. Highest absolute values of TC and FC bacteria concentration was found in Prayagraj. However the difference between the TC and FC concentration at the upstream and downstream side was much higher for Kanpur and Varanasi as compared to the difference in the values in Prayagraj. Hence lesser accumulation between upstream and downstream side was observed in Prayagraj as compared to that in Kanpur and Varanasi. Highest values for TC and FC concentration were observed in Kanpur and then in Varanasi at the downstream side. This signifies that a lot of pathogenic matter is getting discharged into the river stream along its course in Kanpur and Varanasi. Highest concentration of TC and FC bacteria in Kanpur can be attributed to the cumulative effect of industries and human activities. Second highest concentration of TC and FC bacteria at the downstream side was found in Varanasi and that can be attributed largely to human activities. Varanasi is a holy city and a large chunk of population use Ganga river water for daily needs including washing and bathing. Direct discharge of domestic sewage is also a prominet factor that leads to elevated levels of pathogenic bacteria in the river water in Kanpur and Varansi. Elevated level in Kanpur is also a result of industrial effluent discharge into the river stream. However a lot if improvement has been done in this regard and more valiant effrots are on the way and persistent attitude is needed to tackle the situation.



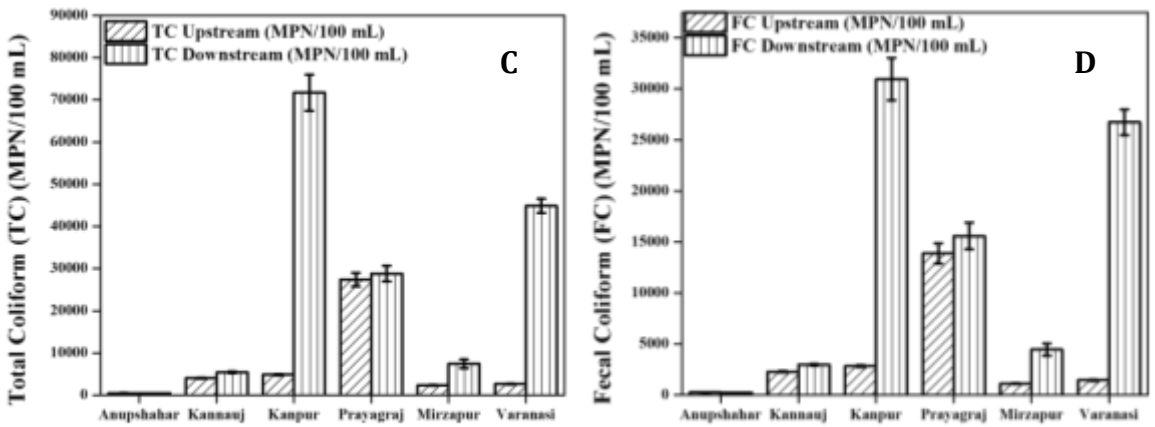


Figure 8: Overall variation of DO (A), BOD (B), TC (C) and FC (D) at the six urban centers from januray 2016 to january 2020.

4. Conclusion

A comparative analysis of the Ganga river water quality at six urban centers of Uttar Pradesh was presented here. Ganga river water quality was found to be fit for outdoor bathing only in Anupshahar. All the urban centers showed declining trend of pollution level post 2017 except Mirzapur which showed alrmingly increasing rate of accumulation of pathogenic and organic pollutant in the Ganga river water stream. Kanpur and Varanasi were found to be the polluted centers in terms of highest absolute values of TC and FC concentration at the downstream side. The DO level was also found to be minimum in Kanpur at the downstream side while the BOD was maximum. The pollution trend in Varanasi was similar to that in Kanpur. While absolute value of TC and FC concentration was found to be maximum in Prayagraj, the difference between the values at the upstream and downstream side were not so pronounced as that in Kanpur and Varanasi signifying lesser accumulation. The pollution trend in Prayagraj showed continous decline in BOD level and TC and FC concentration which signified towards improving water quality. The difference between the BOD level and TC and FC concentration at the upstream and downstream side in Kannauj was found to be relatively less and thus the accumulation of organic and pathogenic pollutants was less in the river stream.

Decreasing trend of pollution level in the Ganga river water stream showed that the efforts from the government sector and participation from the general community is in right direction. However significantly high absolute values of pathogenic contamination and BOD level signify presence of substantial amount of waste and pollutants in the river stream that may prove to be fatal for humans as well as animals. Apart from valiant efforts from the government there is also need for more active participation from the general community in order to control and reduce the pollution level of Ganga river water. Higher pathogenic contamination highlight greater interference of human activities in the river ecosystem which is not desirable. It negatively affects the remediation capability of the river besides having negative impacts on the socio-economic and health aspects of the public.

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