International Journal of Lakes and Rivers.
ISSN 0973-4570 Volume 17, Number 1 (2024), pp. 29-46

https://dx.doi.org/10.37622/IJLR/17.1.2024.29-46

Water Quality Parameters of Major Rivers of Uttar Pradesh in Winter Season

N. Yaduvanshi[1], Divya Ghildiyal[1], Ranu Pandey[2] and Yash[3]

[1] Department of Physics, [2]Department of Maths, [3]Department of Civil Engineering,
JSS Academy of Technical Education,
Noida, India

Abstract

Water is the elixir of life as there is no life without water and the rivers are the life line of our economy and culture. The river water pollution in India and abroad is a gigantic problem as it has affected not only human and animal health but also the economy of the society as a whole. This work reviews the different physico-chemical parameters and finds that the river water and other water bodies in India and abroad are highly polluted physically, chemically and bacteriologically with different hazardous pollutants including both chemical and microbial, coming from various sources such as industries, mines, agriculture, urban and domestic. A total of 113 samples in Uttar Pradesh from various rivers and water bodies were analyzed for Dissolved oxygen (DO), Biochemical oxygen demand (BOD), Total Chloriform (TC) and Fecal Choliform(FC) in winter season (November, December ,January) of 2023. Water samples of river Ganga, Yamuna, Gomti, Hindon, Ghagra, Rapti, Betwa,Kali ,Ramganga ,Rihand dam, Badhganga, Govindsagar lake ,Ramgarh lake ,Samaspur lake, Mahiltalaab, Lakshmi talaab water bodies at Ramsar site were analysed.

In our study DO level vary from(0.6 to 12.6) mg/l in all these water bodies in November and (0.5 to 11.5)mg/l in all the water bodies in December .BOD level for all the water bodies varyfrom (1.3 to 58) mg/l in November and (1.1 to 56) mg/l in December .Mean value of DO was 6.94mg/l and BOD was 8.69mg/l.The mean value of DO and BOD level was above the WHO permissible limit for the protection of fisheries and aquatic life and for domestic water supply.

The total Coliform varied from (460/100ml to 41, 00,000/100ml) in November and (540/100ml to 580,0000/100ml) in December. Fecal Coliform ranged (240/100ml to 340, 0000/100ml) in November and (240/100ml to 400,

0000/100ml) for all the water bodies in December. Mean value of Total Coliform is 101, 7884/100ml and Fecal Coliform is 64104/100ml, which is above permissible limits. The Biological Oxygen Demand (BOD) and Dissolved oxygen (DO) values indicate serious concerns about aquatic ecosystems and human health risks. Several types of heavy metals, some of which are hazardous, are transported into the river body in several ways. Growing industrial development, urbanization, e-waste disposal, effluent discharge, and sewage deteriorate the water quality. This review presents the pollution status of the river higher in the downstream region of the river system due to the tendency of pollutants to accumulate in the lower part of the river. However, it is now essential to take adequate measures to recover water quality in the rivers.

Keywords: DO, BOD, TC (Total coliform), FC (Fecal coliform)

INTRODUCTION

Rivers are surface water flows that flow from upstream to downstream and are used for irrigation, drinking water sources, agriculture, and other activities. Natural factors and human factors strongly influence river water quality. Natural factors can affect river conditions, such as high rainfall intensity resulting in a decrease in water quality and pollution originating from human activities, including waste disposal from industry, agriculture, and domestic[1].The network of sampling stations in the river course was finalized considering the locations of discharge of industrial effluents, sewage, and dumping waste. The entire path of the rivers from upstream to downstream was analysed. Addressing these issues a comparative field study on two rivers has been undertaken in order to (i) quantify the fluctuations of DO concentrations across the monitoring periods. The major sources of these pollutant are Urban, agricultural and industrial activities .An important pollution indicator of water is the total oxygen demand. It represents the organic indicator of water quality. The total oxygen demand includes dissolved oxygen (DO), biological oxygen demand (BOD) [2-5].

Water contaminated with Fecal matter have the capability to pose serious health risks for shell fish consumers and swimmers and major economics losses for shell fish harvesting and business. Bacterial, viral and protozoan pathogens can be introduced into waters in various ways, including leaking septic tanks, sewer malfunction contaminated storm drains, runoff from animal feedlots, human Fecal discharge and other sources[6].

Study Area

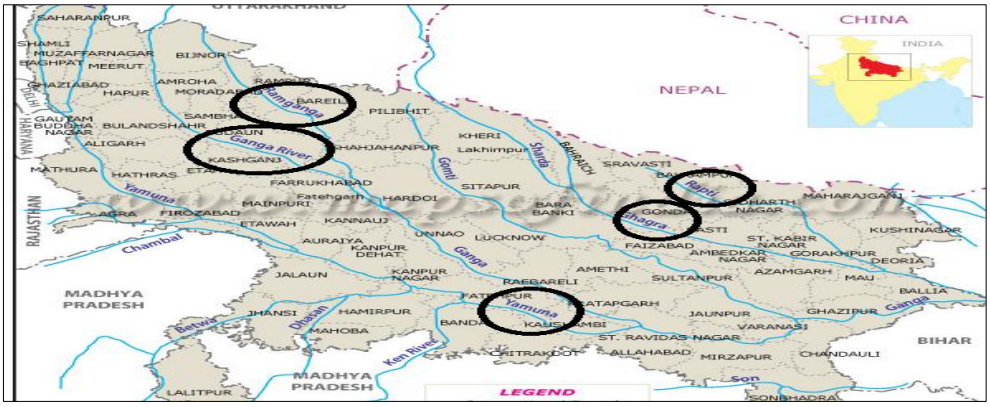

Figure 1(a): Location of river River Ganga, Yamuna, Ghagra, Rapti, ,Ramganga

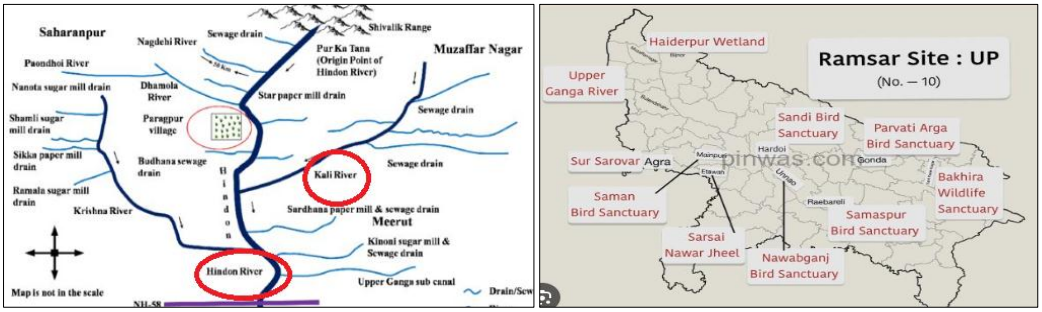

Figure 1(b): Location of river Hindon, Kali River and Ramsar site

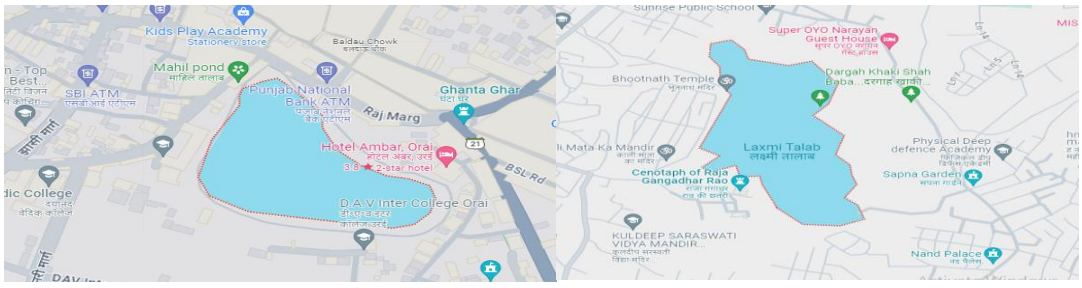

Figure 1(c): Location of Ramgarh Lake, Samaspur Lake, Mahil talaab, Lakshmi talaab

Water bodies used for analysis were River Ganga, Yamuna, Gomti, Hindon, Ghagra, Rapti, Betwa,Kali ,Ramganga ,Rihand dam, Badhganga, Govindsagar lake ,Ramgarh lake ,Samaspur lake, Mahiltalaab, Lakshmi talaab water bodies at Ramsar site.

Ganga basin is the largest river basin in India in terms of catchment area, constituting 26% of the country's land mass (8,61,404 Sq. km) and supporting about 43% of its population (448.3 million as per 2001 census). The basin lies between East longitudes 73°02’ and 89°05’ and North latitudes of 21°06’ and 31°21’, covering an area of 1,086,000 sq km, extending over India, Nepal and Bangladesh.

Hindon River is an important tributary of Yamuna River. In fact, this river is sand-witch between two major rivers: Ganga on the left and Yamuna on the right. Hindon originates from upper Shiwalik (Lower Himalayas). It lies between the latitude 28^0 04' to 35^0 05' N and longitudes 77^0 08' to 77^0 04'E. It is a purely rain fed river with catchment area of about 7,083 sq. km. This river has a total run of about 400 km. The width of Hindon River ranges from 20 m to 160 m.

Yamuna River,major river of northern India primarily in Uttar Pradesh states. It is one of the country's most sacred rivers. It lies between the latitude 280 04' to 350 05' N and longitudes 770 08' to 770 04'E. It is a purely rain fed river with catchment area of about 7,083 sq. km.

Gomati River,tributary of the Ganges (Ganga) River, central Uttar Pradesh state, northern India. It rises in northern Uttar Pradesh about 32 miles (51 km) east of Pilibhit and is intermittent for the first 35 miles (56 km) of its course, becoming perennial after its junction with the Joknai. Below this point it flows generally southeastward for some 500 miles (800 km), receiving its only major tributary, the right-bank Sai River, near Jaunpur and emptying into the Ganges near Saidpur. It drains a basin of about 7,240 square miles (18,750 square km).

The **Kali River**, originates in the Upper Sivaliks and passes through Saharanpur, Muzaffarnagar and Baghpat districts, before merging with Hindon River (at Barnava, Baghpat), which goes on to merge with the Yamuna River (near Delhi), which itself goes to merge with the Ganga River, which finally merges with the Bay of Bengal. The total length of the river from its origin up to its confluence with the Hindonriver is 150 km. The river is named after the Hindu goddess Kali.

The **Ramsar sites** in India nurture the country's enormous ecological wealth, and the recent sites in UP stand to significantly enhance the state's tourism potential over the next fewyears.Then there is Nawabganj bird sanctuary located in Unnao, which is a heaven for birds, giving shelter to some of the most endangered species.The Sur Sarovar Bird Sanctuary, or Keetham Lake, in Agra, got the recognition of a Ramsar site in 2020. It is a man-made reservoir that boasts a rich ecosystem that provides dwelling to residents and migrating birds and over 60 species of fish.

There are Saman Bird Sanctuary in Mainpuriand Sarsai Nawar Jheel in Etawah.Mahiltaalab and Lakmi Talab is a lake located in Jhansi, Uttar Pradesh.

MATERIAL AND METHODS

The sources of data (113 Samples) were collected for two months i.e. November and December from various water bodies in Uttar Pradesh. The data which were collected from sampling stations for two months are tabulated in Table 1 and Table 2 below.

Water samples are collected using a special BOD bottle: a glass bottle with a ground glass stopper. You can fill the bottle directly in the stream if the stream is wadable or boatable, or you can use a sampler that is dropped from a bridge or boat into water

deep enough to submerse the sampler. Samplers can be made or purchased. Dissolved oxygen is measured primarily either by using some variation of the Winkler method or by using a meter and probe [8-9].

The Biochemical Oxygen Demand (BOD) is one of the most widely used criteria for water quality assessment. It provides information about the ready biodegradable fraction of the organic load in water. Samples of water were collected in sterilized borosilicate glass stoppered bottles, the stopper and neck of the bottle should be covered to protect against dust and handling contacts and wrapping paper, pressed over stopper and neck sealed by secure hood.

The Winkler Method [10-12] is a technique used to measure dissolved oxygen in freshwater systems. The Winkler Method uses titration to determine dissolved oxygen in the water sample. The presence of sufficient DO in water is a positive sign of a healthy body of water but the deficiencies of DO is a signal of severe pollution. A DO value of less than 2 mg/ L may pose serious threats to an aquatic ecosystem.

Biochemical Oxygen Demand (BOD) is the amount of oxygen, expressed in mg/L,that bacteria take from water when they oxidize organic matter. BOD is measured by Dilution method [13-16].A survey of the occurrence of Fecal indicator bacteria (Total coliform TC, Fecal coliform FC) in these water bodies was carried out using membrane filter (MF) technique [17-23]. The study was implemented to assess the hygiene of water quality in order to give an indication about the actual magnitude of fecal pollution post the discharge of domestic sewage discharge.

Assessment parameters for River Ganga

41 Sampling stations were chosen for river Ganga to analyse the water quality parameters for two months. Following four parameters were analysed for river Ganga at different site locations of Uttar Pradesh, (DO, BOD,Total Choliform and Fecal Choliorm).

Do: As observed in Table 1 for November DO ranged from (7.2 -12.6),with highest value of DO in Hapur upstream Ganga of 12.6 and lowest value of 7.2 at Upstream, Prayagraj(Rasoolabadghat).In Dececember DO ranged from 7.4 -11.5, with highest value at Garhmukteshwar upstream Brijghat,Hapur Ghaziabad and lowest value at Downstream Tarighat , ghazipur, Varanasi.

The range of standard DO records (7.30-8.15) mg/L. Mean value of DO in both months is 8.57,which is much more than standard value [24-25].This review study concluded that the physicochemical properties of the Ganga River water indicate it is not fit for potable use[26-28]. On the basis of the result water was considered to be unsatisfactory for domestic and agricultural purposes throughout the study period in some water bodies.

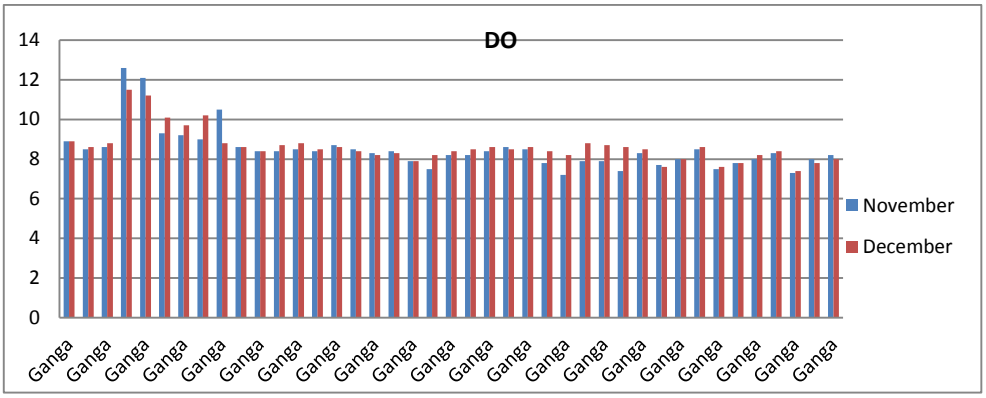

Figure 2 Plot for DO in Ganga River in month of November and December at different sampling stations.

BOD: In our study the BOD of surface water ranges from 1.3 -3.9 mg/l in November and 1.2-4 in December in River ganga .The observations of the present study show that the highest BOD was observed at at Jajmau bridge (bathing ghat), Kanpur of 3.9 in November and lowest value of 1.3 at Mid ganga Barrage ,Bijnor. In December highest value of BOD was 4 at Downstream Ganga at Kanpur (Jana village) and lowest value of 1.2 at Mid ganga barrage, Bijnor.Mean value of BOD in both the months was 2.814[29-30].

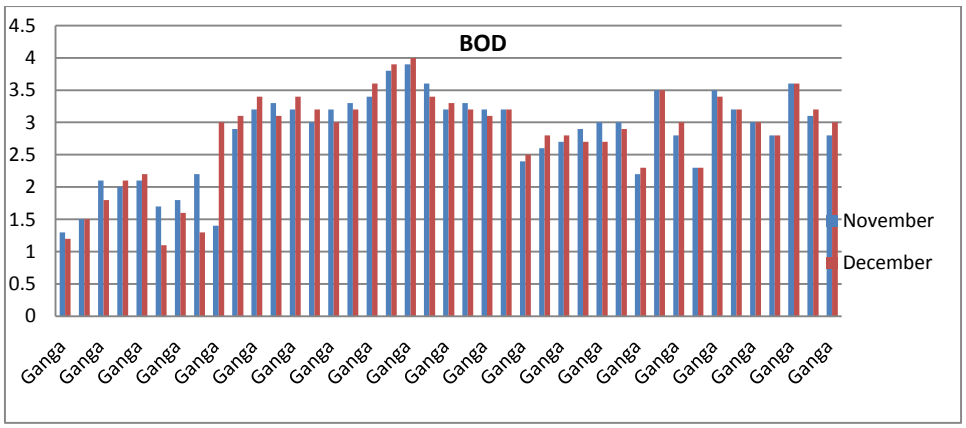

Figure 3: Plot for BOD for Ganga River in month of November and December at different sampling stations

Total Choliform:Total Coliform varies from 460 -11,000 in November and 460-17,000 in December in river Ganga .Highest value of Total Coliform was found at Downstream Kanpur (Jana village) of 11000in November and lowest value was 460 at at Farrukhabad (Ghatiyaghat), Badaun. In December the highest value of Downstream Ganga at Mirzapur, Sonbhadr of 17000 and lowest value of 460 at Rajghat downstream, Narora, Bulandshar. Mean value of Total Coliform was 4274.99 in both the months.

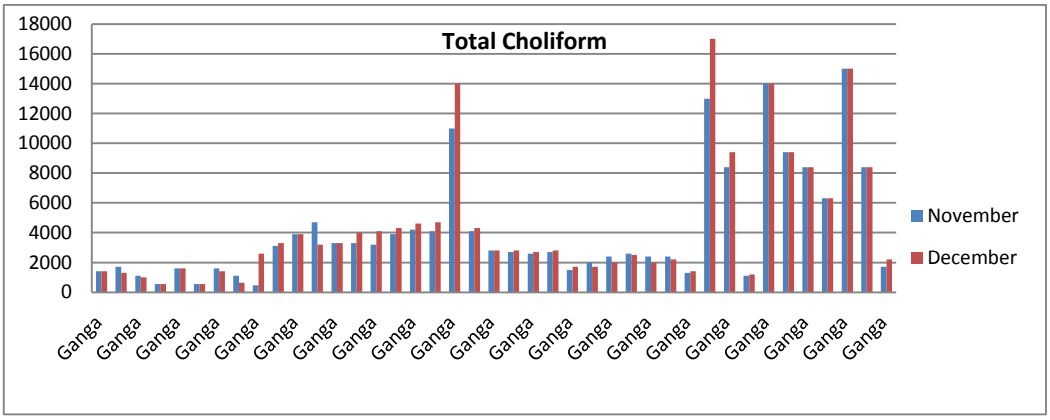

Figure 4: Plot of Total Choliform in month of November and December at different sampling stations of river Ganga

Fecal coliform: Fecal coliform ranges from 240-9400 in November and 240-11000 in December in river Ganga. Highest value Fecal choliform was at Downstream Tarighat, Ghazipur Varanasi of 9400 in November and lowest value was 470 at mid ganga barrage, Bijnor. In December highest value was at Downstream Mirzapur, Sonbhadr of 11000 (above permissible limit) and lowest value of was 240 at Garhmukteshwar upstream Brij ghat and Upstream Anupshahar at Bulandshar.

Average value of Fecal Coliform was 2578.29 in November and 2792.92 in December.

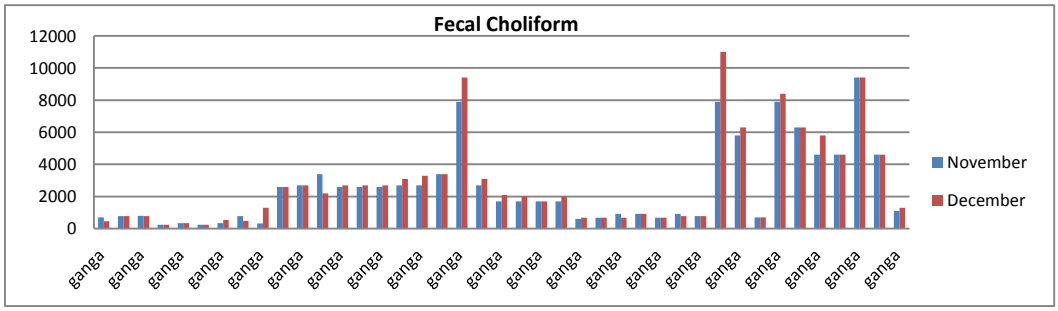

Figure 5: Plots of Fecal Coliform in month of Nov and Dec at different sampling stations

Assessment parameters for River Gomti

River water of Gomti was collected from 20 sampling stations.

DO: for Gomti river ranged from 1.8-8.3 in November and 1.5-8.7 in December.

Highest value of DO for Gomti river was found to be 8.3 in Nov at Jaunpur upstream, Varanasi and lowest value of 1.8 at Gangaganj downstream , Barabanki Lucknow.

Highest value of DO in December was 8.7 at Bhattpur upstream, Sitapur, and lowest value was 1.5 at downstream Lucknow.

Mean value of DO in both months was 5.65.

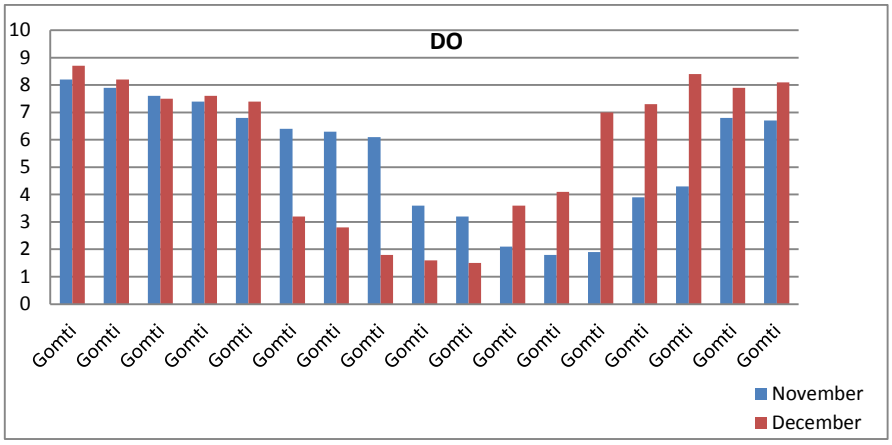

Figure 6: Plot for DO in Gomti River in month of November and December at different sampling stations

BOD: BOD ranged from 2.4-11.6 in November and 2.2-11.5 in December for river Gomti.

Highest value of BOD was found to be 11.6 at Pipraghat downstream Lucknow and lowest value of 2.4 at Upstream Sitapur, Dadhnamau ghat, Lucknow in November .In December Highest value of BOD was found at 11.5 at Pipraghat downstream, Lucknow and lowest value of 2.2 at Upstream, Sitapur, Dadhnamau ghat, Sitapur, Lucknow. Average value of BOD was 5.53 in November and in December was 5.23.

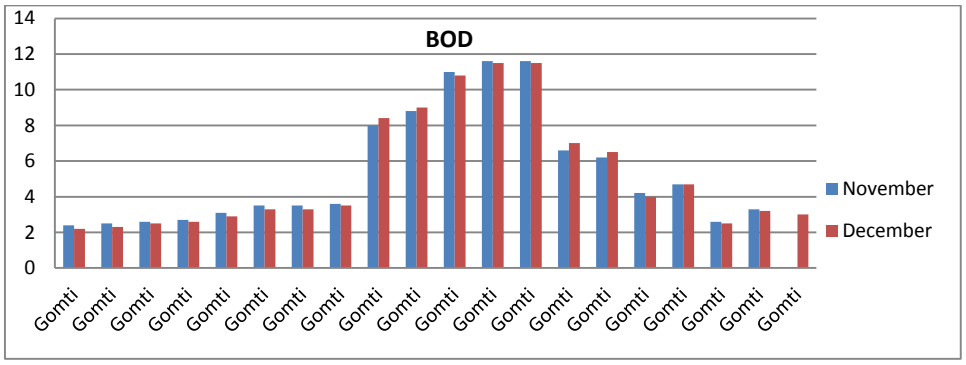

Figure 7: Plot for BOD in Gomti River in month of November and December at different sampling stations

Total Coliform: Total Choliform ranged from 1300-160,000 in November and 1100-140,000 in December for Gomti River. Highest value of Total Choliform was found to be 160,000 at Pipraghat downstream, Lucknow and lowest value of 1300 at Jaunpur stream, Varanasi in November .In December Highest value of Total Choliform was found to be 140,000 at Pipraghat downstream, Lucknow and lowest value of 1100 at Jaunpur stream, Varanasi in November. Average value of Total Choiform was 40,525 in November and in December was 37,630.

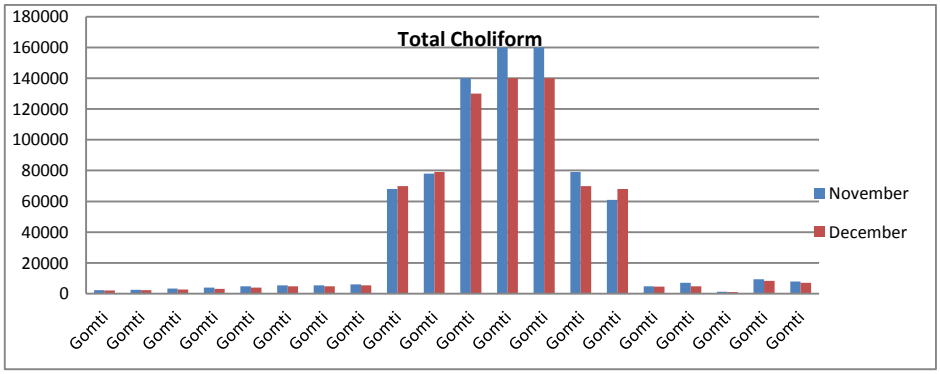

Figure 8: Plot for Total Coliform in Gomti River in month of November and December at different sampling stations

Fecal Coliform :Fecal Coliform ranged from 610-28,000 in November and 700-79,000 in December .Lowest value of Fecal Choliform for Gomti was found to be 610 at Lucknow downstream and highest value of 28,000 at Bhattpur downstream, Sitapur lucknow in November .In December Highest value of fecal choliform was found to be 79,000 at downstream lucknow and 700 Jaunpur upstream. Average value of Fecal Coliform was 39,259.5 in November and in December was 22,195.

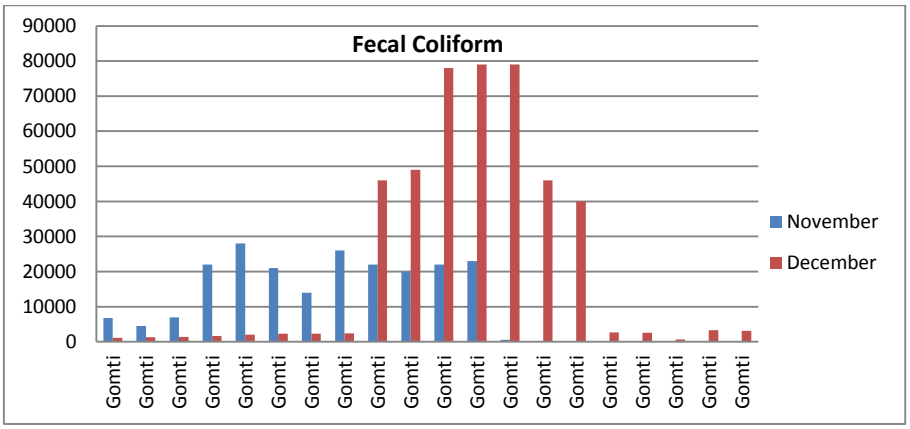

Figure 9: Plot for Fecal Coliform in Gomti River in month of November and December at different sampling stations in Gomti River.

Assessment parameters for River Yamuna: 13 site locations for river Yamuna were chosen at various points of Uttar Pradesh.

Yamuna River ranged from 5.9-7.8 in November and 4-7.6 in December.

Highest value of DO was found at Yamuna Pragagraj of 7.8 and lowest of 5.9 at Etawa downstream, Firozabad in November .In December lowest value at Kesighat Vrindavan of 4 and highest value of 7.6 at Yamuna Prayagraj.

Average value of DO in Yamuna River was 6.73 in both November and December.

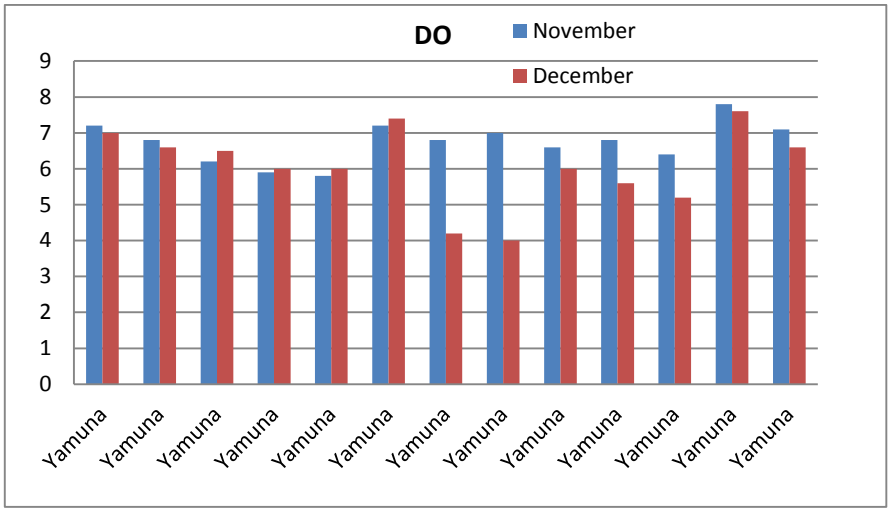

Figure 10: Plot for DO in Yamuna River in month of November and December at different sampling stations

BOD: BOD in Yamuna River ranged from 2.5-18.4 in November and in December from 3.2-19.2.Lowest value of BOD was found at Downstream Yamuna at Mathura and highest of 18.4 at Udi, Etawa Firozabad in November .In December lowest value of BOD at Hamirpur, Banda and highest value at Etawa, Firozabad.

Average value of BOD in November was 9.45 in November and in December of 10.5.

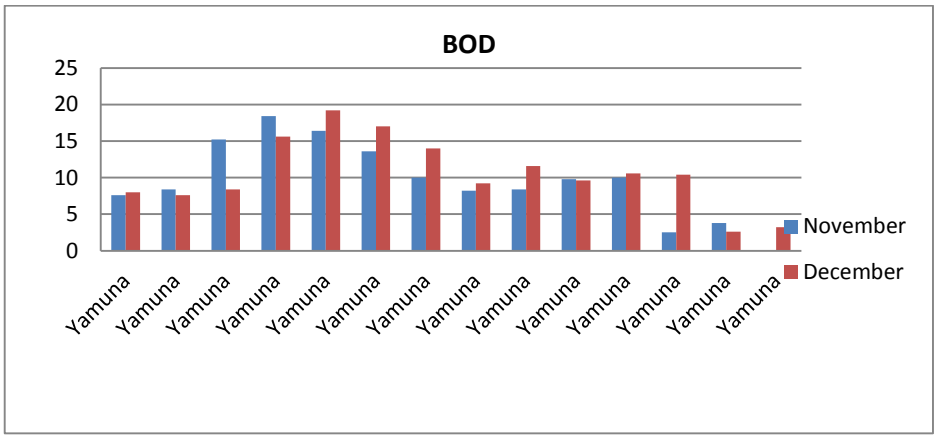

Figure 11: Plot for BOD in Yamuna River in month of November and December at different sampling stations

Total Coliform: Total Coliform ranged from 1400-92,000 in November and in December 1500-160,000.Lowest value of Total Coliform was found at Yamuna prayagraj in November and highest value at Etawa downstream, Firozabad. In December lowest value of Total Coliform at Yamuna Prayagraj and highest value at Shahpur Mathura.

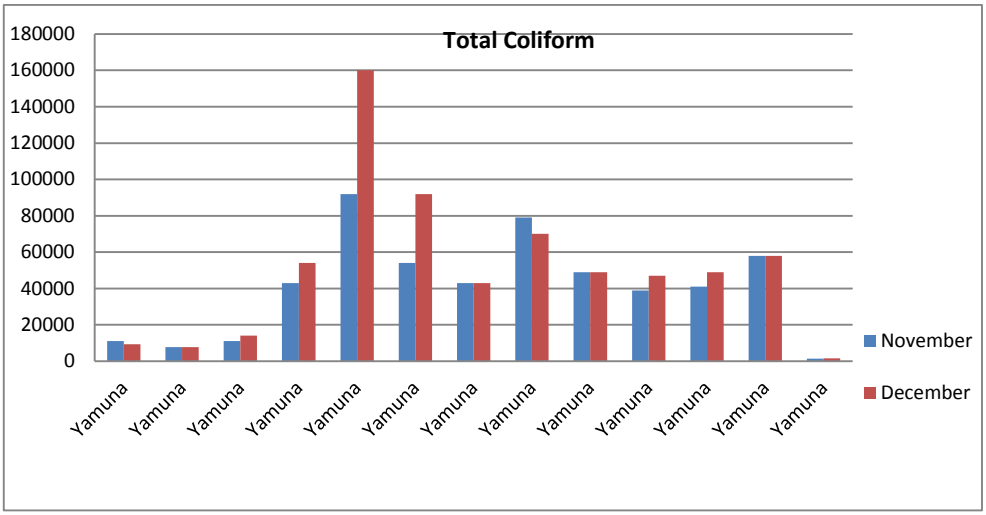

Figure 12: Plot for Total Coliform in Yamuna River in month of November and December at different sampling stations

Fecal Coliform:Fecal Choliform ranged from 450- 27,000 in November and in December 610-26,000.Lowest value of Fecal Choliform was found at Yamuna prayagraj in November and highest value at Shahpur Mathura .In December lowest value of Total Coliform at Yamuna, Prayagraj and highest value at Etawa downstream, Firozabad.

Average value of Fecal Coliform is 12,853 in November and in December 16,685.38.

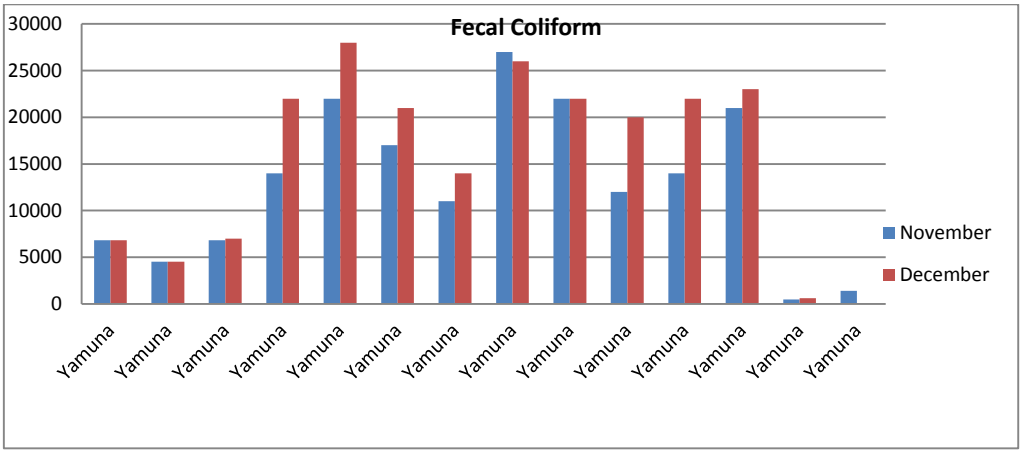

Figure 13: Plot for Fecal Coliform in Yamuna River in month of November and December at different sampling stations

Assessment parameters for rivers Kali , Sainadi, Hindon, Ramganga ,Rihand dam, Ghagra, Rapti, betwa, Ramgarhlake,Govindsagar lake, Badhganga, nawabganj bird sanctuary,sarsainavarjhil,sursarovarpakshivihar (kithamjhil),samanpakshiviharkishni at mainpuri,mahiltaalab, jalaun,lakshmitalab, Jhansi

DO: DO of these rivers ranged from ranged from 0.6-9.2 in November and in December 0.2-9.8. Lowest value of DO was found at Hindon River Downstream, Saharanpur in November and highest value at upstream Rihand dam Renukoot. In December lowest value of DO at Downstream Hindon River at Saharanpur and Maheshpur and highest value at Ram Ganga, Farrukhabad. Average value of DO is 5.37 in November and in December 5.92.

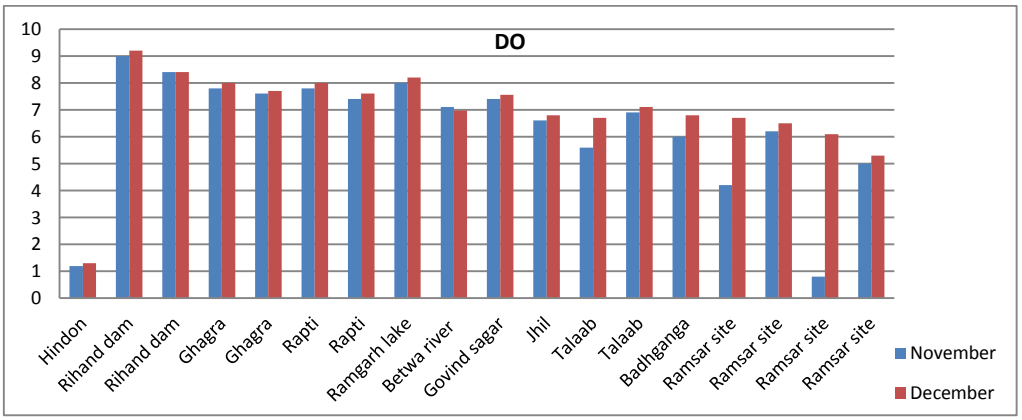

Figure 14: Plot of DO of Kali , Sainadi, Hindon, Ramganga ,Rihand dam, Ghagra, Rapti, betwa,Ramgarhlake, Govindsagar lake, Badhganga, nawabganj bird sanctuary,sarsainavarjhil,sursarovarpakshivihar (kithamjhil),samanpakshiviharkishni at mainpuri,mahiltaalab, jalaun,lakshmitalab, Jhansi

BOD: BOD of these rivers ranged from ranged from 2-52 in November and in December 2-56.Highest value of BOD was found at Hindon nadi, Puramahadevbaleni, Baghpat, in November and lowest value at upstream Rihand dam Renukoot.

In December lowest value of DO at shukrataal ghat, Badhganga, Muzaffarnagar and highest value at Hindon River Sardhana, Budhna road, gram Baparsi, Baghpat.

Average value of BOD is15.98 in November and in December 16.97.

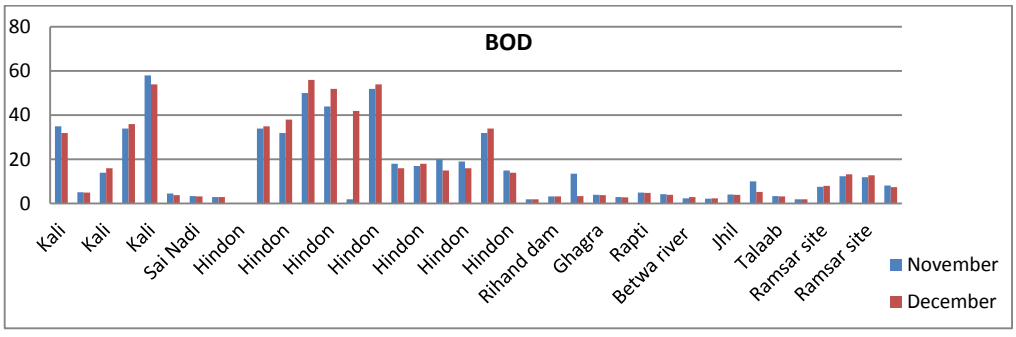

Figure 15: Plot of BOD of Kali , Sainadi, Hindon, Ramganga ,Rihand dam, Ghagra, Rapti, betwa, Ramgarhlake,Govindsagar lake, Badhganga, nawabganj bird sanctuary,sarsainavarjhil,sursarovarpakshivihar (kithamjhil),samanpakshiviharkishni at mainpuri,mahiltaalab, jalaun,lakshmitalab, Jhansi

Total Coliform :Total Coliform of these rivers ranged from ranged from 460-410,00,00 in November and in December 580-117,00,00.Highest value of Total Choliform was found at Kali nadi , Upstream Bulandshahr and lowest value at Rihand dam , upstream Renukoot.

In December lowest value of DO at shukrataalghat, Badhganga, Muzaffarnagar and highest value at Hindon River Sardhana, Budhna road, gram Baparsi, Baghpat.

Average value of BOD is 2,67,353 in November and in December 3,14,176.

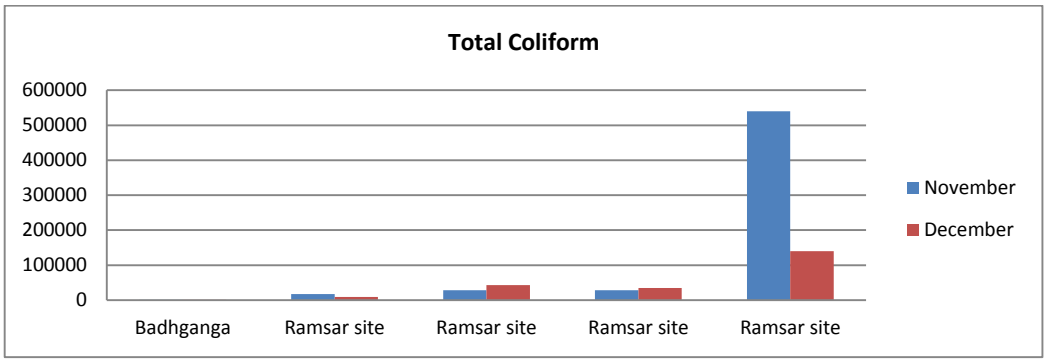

Figure 16 :Plot of Total Coliform Plot of DO of Kali , Sainadi, Hindon, Ramganga ,Rihand dam, Ghagra, Rapti, betwa, Ramgarhlake,Govindsagar lake, Badhganga, nawabganj bird sanctuary,sarsainavarjhil,sursarovarpakshivihar (kithamjhil),samanpakshiviharkishni at mainpuri,mahiltaalab, jalaun,lakshmitalab, Jhansi

Fecal Coliform: Fecal Coliform of these rivers ranged from ranged from 210- 350000 in November and in December 310-270,000.Highest value of Fecal Coliform was found at Ghaziabad Upstream (Karheda), Hindon River and lowest value at Lakshmitalab, Jhansi.

In December lowest value of DO at shukrataalghat, Badhganga, Muzaffarnagar and highest value at Hindon River Sardhana, Budhna road, gram Baparsi, Baghpat.

Average value of BOD is 2,67,353 in November and in December 3,14,176.

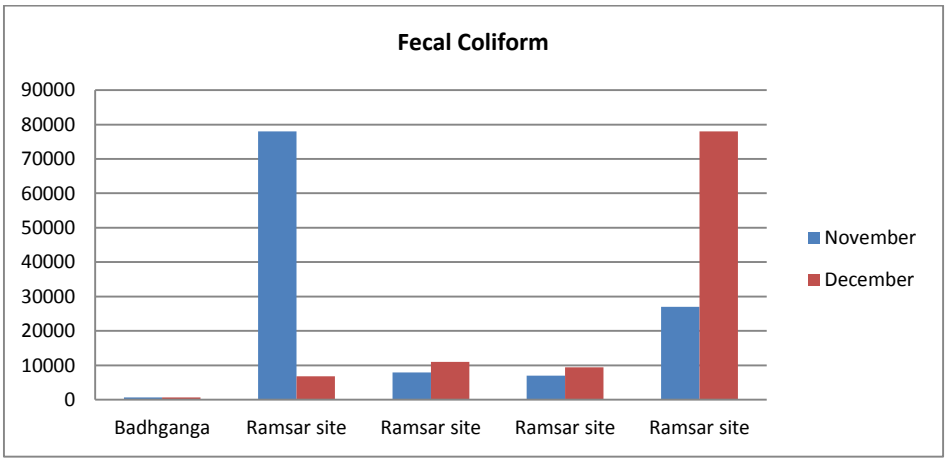

Figure 17 : Plot of Fecal Coliform of Kali , Sainadi, Hindon, Ramganga ,Rihand dam, Ghagra, Rapti, Betwa, Ramgarhlake,Govindsagar lake, Badhganga, nawabganj bird sanctuary,sarsainavarjhil,sursarovarpakshivihar (kithamjhil),samanpakshiviharkishni at mainpuri,mahiltaalab, jalaun,lakshmitalab, Jhansi

Statistical Analysis

Table 1: Coorelation Matrix

	DO	***BOD***	***TC***	***FC***
DO	1			
BOD	-0.98708	1		
TC	-0.49647	0.537906	1	
FC	-0.466	0.507835	0.999378	1

The correlation matrix of the water quality parameters (DO, BOD, TC and FC) showed a very weak correlation with Dissolved Oxygen (DO), the most important parameter for assessing the quality of water. DO showed weak to very weak correlation with Total and faecal Coliforms, which is a matter of grave concern. Also, none of the river water seems suitable even for agricultural purposes.

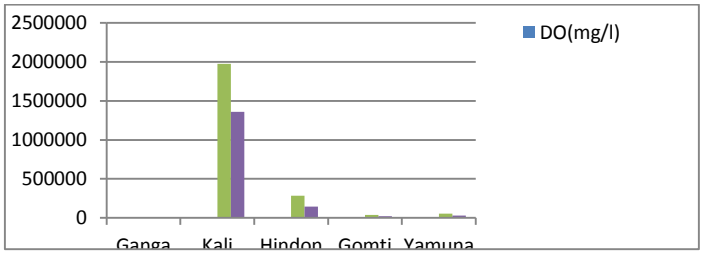

Figure 18: Analysis of DO, BOD, Total Coliform, Fecal Coliform in major rivers

Out of the major four rivers Ganga, Kali, Hendon, Gomtianf Yamuna assessed in winter season, Kali River as per data analysis is not fit even to be called river. Its water should not be used for even agricultural purposes.

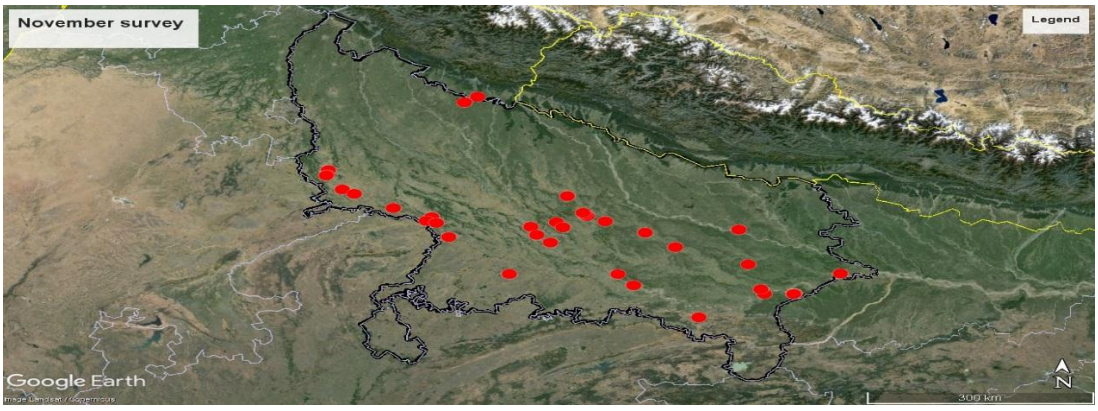

Figure 19: Plots of places in month of November where water quality is in danger zone

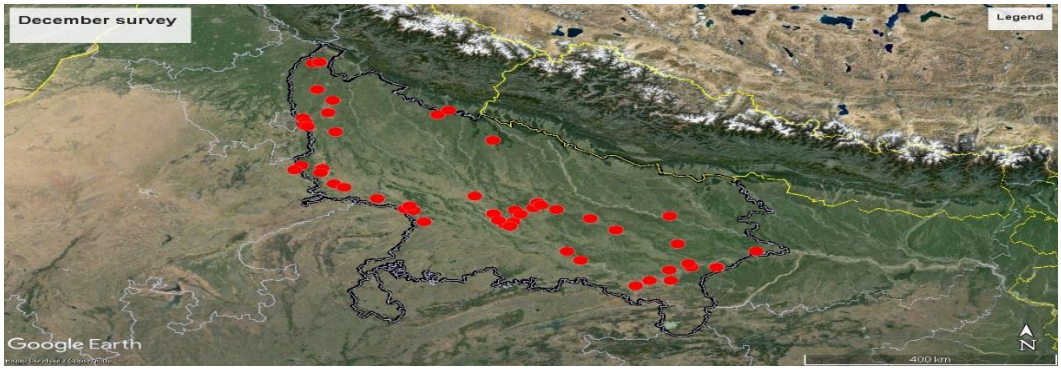

Figure 20: Plots of places in month of December where water quality is in danger zone

From above study in both the months it is clear that water quality in these places is in danger zone and is not even fit for washing clothes, vegetation,et

Conclusion

The category of Ganga water declined from November to December from Category B to C at Farrukhabad (Ghatiyaghat), Badaun in December .The category of Ganga water declined from November to December from Category C to D at Upstream Kannauj, Farukkhabad, Bithoor, Kanpur, Rameshwar, Varanasi and Dalmau,Raebareli. The category of Sai nadi water declined from November to December from Category C to D at Jalalpur, Jaunpur. The category of Ganga water declined from November to December from upstream Renukoot, Rihand dam from B to C. The category of Ganga water declined from November to December from C to D at Sursarovar pakshi vihar (kitham jhil).The quality of river water of Hindon river improved from November to December from category E to D at Mohanpur.The category of Gomti water improved from November to December from Category D to C.The category of Betwa river improved from November to December at Betwa, Hamirpur from C to B.

Highest value of DO was found at Garhmukteshwar upstream Brijghat in Ganga River of 12.6 in November and 11.5 in December at Garhmukteshwar upstream Brijghat.The desirable limit of dissolved oxygen is 5 mg/L as per BIS standards. From the observation, it was concluded that the water quality of downstream Ganga River is much more polluted than the upper portion. This may be due to the tendency of pollutants to accumulate in the downstream region of the river.

The lowest BOD was at Upstream Ganga at Anupshahar of 1.3 mg/l in November and highest value was at Sai Nadi at Unnao of 58 mg/l which is much upper than desireable limit. In December highest value was of Hindon River at Sardhana, Budhna road, gram Baparsi, Baghpat of 56 mg/l and lowest value was at 1.1 mg/l at at Upstream Ganga at Anupshahar.In November lowest value was at Upstream Ganga Garhmukteshwar upstream Brijghat of 1.3 mg/l and Highest value was of Sainadiat Bani, Unnao of 58 mg/l.

In November highest value of Total coliform was of Kali nadi Bulandshahr of 410,00,00 and highest value of Fecal coliform was of 340,00,00 Kali nadi Bulandshahr. Lowest value of Total coliform was of 460 at Badaun, Ganga River and lowest value of Fecal coliform at Lakshmi talab, jhansi of 210.

In December highest value of Total coliform was of Kali nadi Bulandshahr of 580,00,00 and highest value of Fecal coliform was of 400,00,00 Kali Nadi Bulandshahr. Lowest value of Total Coliform was of 540 at Garhmukteshwar Ganga upstream Brijghat, Hapur and lowest value of Fecal coliform at Garhmukteshwar Ganga upstream Brijghat, Hapur of 240.

In the water samples under research Category E was observed in Hindon, Gomti, and Kali Nadi in both the months. Category D was observed mostly in Ganga River and Yamuna River. Category C was observed also in some ghats of Ganga River and Gomti river .Category B was observed in Rihand dam, Govindsagar and Ganga at Badaun.

From plot in Figure 19 and 20, we can conclude that water quality deteriorated more in December as compared in November.

Conflicts of Interest: The author declares that there are no conflicts of interest regarding the publication of this article.

Acknowledgement: The Author is grateful to JSS Academy of Technical education, Noida, India for helping out in research work.

REFERENCES

[1] S.P. Gorde and M.V. Jadhav, Assessment of Water Quality Parameters: A Review, Journal of Engineering Research and Applications, 3(6), 2029-2035 (2013)

[2] Kavitha R. and Elangovan K., Review article on Ground water quality characteristics at Erode district, (India), of I.J.E.S., 1(2), (2010)

[3] Yadav, R. C., and V. C. Srivastava. "Physico-chemical properties of the water of river Ganga at Ghazipur." *Indian Journal of Scientific Research* 2.4 (2011): 41-44.

[4] Das, A., et al. "Assessment of physico-chemical properties of river bank soil of Yamuna in Allahabad city, Uttar Pradesh." *International Journal of chemical studies* 6.3 (2018): 2412-2417.

[5] Shukla, Saurabh, and Smriti Gupta. "Assessment of few impacts of mass bathing on river-water quality at prayag during mahakumbhamela 2013, Allahabad." *International Journal of Engineering Research and Technology* 4 (2015): 313-319.

[6] APHA (1995). Standard methods for examination of water and wastewater, 19th edn. Washington, D.C.

[7] Jha, Ramakar, C. S. Ojha, and K. K. Bhatia. "Development of refined BOD and DO models *for highly polluted Kali River in India." Journal of Environmental Engineering* 133.8 (2007): 839-852.

[8] Sharma, Priyanka, and Sujata Gupta. "Study of amount of Oxygen (BOD, OD, COD) in water and their effect on fishes." *American International Journal of Research in Formal, Applied and Natural Sciences* 7.1 (2014): 53-58.

[9] Sharma, P. and Gupta, S., 2014. Study of amount of Oxygen (BOD, OD, COD) in water and their effect on fishes. *American International Journal of Research in Formal, Applied and Natural Sciences*, *7*(1), pp.53-58.

[10] Okura, Takeshi, Katsumi Goto, and Toshiro Furukawa. "Determination of dissolved oxygen in polluted waters." *Memoirs of the Faculty of Engineering, Hokkaido University* 11.1 (1960): 11-24.

[11] Jha, Ramakar, C. S. P. Ojha, and K. K. S. Bhatia. "Critical appraisal of BOD and DO models applied to a highly polluted river in India." *Hydrological sciences journal* 52.2 (2007): 362-375.

[12] ABDUL MAJEED, et al. "Correlation of COD and BOD of domestic wastewater with the power output of bioreactor." J. Chem. Soc. Pak 33.2 (2011): 269-274.

[13] Sawyer, C. N., and A. E. Williamson. "The Selection of a Dilution Water for the Determination of the BOD of Industrial Wastes." *Sewage Works Journal* (1942): 1000-1020.

[14] Elmore, Harold L. "Determination of BOD by a Reaeration Technique." *Sewage and Industrial Wastes* (1955): 993-1002.

[15] Ryu, Hong-Duck, Ji-Hyoung Park, and Yong Seok Kim. "Novel techniques to determine dilution ratios of raw wastewater and wastewater treatment plant effluent in the 5-day biochemical oxygen demand test." *Chemosphere* 286 (2022): 131923.

[16] Martin, George, and E. P. Miller. "Effects of dilution water on BOD of waste sulfite liquor." *Sewage Works Journal* (1941): 659-668.

[17] Cohen, Judith, and Hillel I. Shuval. "Coliforms, fecal coliforms, and fecal streptococci as indicators of water pollution." *Water, Air, and Soil Pollution* 2 (1973): 85-95.

[18] Geldreich, Edwin E., and Warren Litsky. "Fecal coliform and fecal streptococcus density relationships in waste discharges and receiving waters." *Critical reviews in environmental science and technology* 6.4 (1976): 349-369.

[19] Kabler, Paul W., and Harold F. Clark. "Coliform group and fecal coliform organisms as indicators of pollution in drinking water." *Journal-American Water Works Association* 52.12 (1960): 1577-1579.

[20] ORSANCO Water Users Committee. "Total coliform: fecal coliform ratio for evaluation of raw water bacterial quality." *Journal (Water Pollution Control Federation)* (1971): 630-640.

[21] Geldreich, Edwin E. Sanitary significance of fecal coliforms in the environment. US Department of the Interior, Federal Water Pollution Control Administration, 1966.

[22] Raji, M. I. O., et al. "Faecal Coliforms (FC) and Faecal Streptococci (FS) ratio as tool for assessment of water contamination: A case study of River Sokoto, NorthwesternNigeria." *The Asia Journal of Applied Microbiology* 2.3 (2015): 27-34.

[23] Byamukama, Denis, et al. "Discrimination efficacy of fecal pollution detection in different aquatic habitats of a high-altitude tropical country, using presumptive coliforms, Escherichia coli, and Clostridium perfringens spores." *Applied and Environmental Microbiology* 71.1 (2005): 65-71.

[24] Sargaonkar, Aabha, and VijayaDeshpande. "Development of an overall index of pollution for surface water based on a general classification scheme in Indian context." *Environmental monitoring and assessment* 89 (2003): 43-67.

[25] Nasrabadi, T. "An IndexApproachtoMetallic Pollution in RiverWaters." *International Journal of Environmental Research* 9.1 (2015): 385-394.

[26] Bora, Swati. "Water Quality Analysis of River Ganga: a Case-Study of Rishikesh-Haridwar-Garhmukteshwar Stretch." (2018).

[27] Shukla, Anoop Kumar, et al. "Water Quality Challenges in Ganga River Basin, India." *The Ganga River Basin: A Hydrometeorological Approach* (2021): 1-19.

[28] Ansari, Asif, and Anish Kumar. "Water quality assessment of Ganga River along its course in India." *Innovative Infrastructure Solutions* 7 (2022): 1-9.

[29] *Vidyarthi, ajit kumar, et al. "assessment of water quality of ganga river stretch from kanpur to deori ghat."*

[30] Mariya, Ayesha, et al. "The pristine nature of river Ganges: its qualitative deterioration and suggestive restoration strategies." Environmental monitoring and assessment 191.9 (2019): 542.