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SEASONAL VARIATION IN WATER QUALITY OF RIVER GANGA AND POLLUTION DUE TO DRAINS: A CASE STUDY OF KANPUR (INDIA)

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ABSTRACT

The present study assessed the seasonal (summer, monsoon, and winter) variation in the surface water quality (temperature, pH, color, DO, BOD, COD, and total Cr) of the rivers Ganga and Pandu (a tributary of Ganga) in Kanpur. In river Ganga, pH varied as 6.3-9, color as 5-25 Hazen, DO as 3.5-12.6 mg/L, BOD as 1-19.2 mg/L, COD as 5.1-35.8 mg/L and total Cr as < 0.02 mg/L during one year of the study period (March 2019 to February 2020). In river Pandu, pH varied as 7.1-8.7, color as 10-60 Hazen, DO as 1-8.5 mg/L, BOD as 3 to 31.5 mg/L, COD as 12.5-69.1 mg/L and total Cr as < 0.02 mg/L. The seasonal variation of water quality of river Ganga indicated that high DO was found during the winter season in comparison to summer or monsoon seasons due to high photosynthetic activity because of better illumination and better dissolution of oxygen in water at lower temperatures. Out of drains discharging into the river Ganga, high color, BOD, COD, and total chromium were found in three drains namely Budhiyaghat drain, Wazidpur drain, and Sheetla bazar drain due to the discharge of untreated/partially-treated tannery effluents into these three drains from Jajmau industrial area. This study concluded that improper management of sewage and industrial effluent in Kanpur is polluting the river Ganga. The present study recommends (i) up-gradation of the capacity of tapping arrangement of drains, and (ii) proper treatment of sewage and tannery effluents to mitigate the pollution exerted by the highly industrialized city Kanpur on the river Ganga.

KEYWORDS: Dissolved oxygen, River Ganga, Tannery effluent, Water quality

INTRODUCTION

Ganga river basin is the largest amongst river basins in India, and the fourth-largest in the world. It originates at Gaumukh (30°362 N; 79°042 E) in the snout of the Gangotri Glacier as the Bhagirathi river in the Higher Himalayas at an elevation of 3,800 m above mean sea level and traverses a total distance of 2525 km. In the Himalaya, the river Bhagirathi joins the river Alaknanda and the collective stream is known as the Ganga river (Singh and Singh, 2007). Urban-industrial-drainageis asignificant source of Ganga river pollution. Kanpur has been identified as the most polluted stretch of river Ganga (Tare *et al.,* 2003). Surface water of the river Ganga at Kanpur has been reported to be polluted with inorganic and organic compounds, and heavy metals (Paul, 2017). The major contribution of pollution load in river Ganga is attributed to one of the largest industrial clusters of the Ganga plain i.e., Kanpur-Unnao region in the Uttar Pradesh state of India. This industrial area constitutes cotton and wool textile mills, tanning and leather manufacturing industries, large fertilizer factories and several arms factories. The present study was carried out (i) to assess the seasonal variation of water quality of the river Ganga in Kanpur (India); and (ii) to evaluate the pollution load of domestic and industrial wastewater on the river Ganga in Kanpur region.

MATERIALS AND METHODS

Description of the Study Area

For a comprehensive analysis of river water quality and pollution sources, fifty weekly monitoring surveys (15 in the summer season, 18 in monsoon season and 17 in winter season) in Kanpur (lies between 25°552 and 27° N latitude and 79°302 and 80°352 E longitude) were conducted from March 2019 to February 2020. The study area experiences a humid subtropical climate which is divided into three seasons: summer season (March-June), monsoon season (July-October) and winter season (November-February). The stretch of river Ganga in Kanpur was selected to evaluate the water quality. In this stretch, river Pandu also meets river Ganga at Fatehpur. On river Ganga, six locations were selected and one location was selected on river Pandu (to assess its impact on river Ganga) for assessing river water quality. During each sampling survey, the following were performed (i) collection of water samples from six locations on river Ganga and one location on river Pandu; (ii) collection of wastewater samples from 24 drains; and (iii) assessment of flow and the tapping status of the drains.

Collection and Analysis of Samples

Grab-samples were collected for analyzing physico-chemical (temperature, color, pH, DO, BOD, and COD) and biological (total and fecal coliform) properties of river water. Wastewater samples from drains were collected before the confluence point of the drain with the river (Ganga or Pandu) for analyzing BOD, COD and color. For the analysis of total chromium in water/wastewater samples, grab samples from the river and drains were collected. The samples were analyzed using standard protocols (APHA, 2017). Flow in drains was measured as per standard protocols defined by CPHEEO (2013).

RESULTS AND DISCUSSION

Physico-chemical Properties of River Water

The temperature governs vital chemical and biological processes in rivers such as photosynthesis, biological degradation of organic matter, and oxygenation or deoxygenation rate of the river (Piccolroaz *et al.,* 2016). The temperature of the river Ganga in different seasons varied as 23-35 °C in summers, 25-32 °C in monsoon, and 9-25 °C in winters whereas in river Pandu, it varied as 26.5-33 °C in summers, 25.5-33 °C in monsoon, and 9-25 °C in winters. The temperature in summer and monsoon season did not show any significant difference ($p < 0.05$).

The pH varied as 6.3-9.1 in river Ganga and as 7.1-8.7 in river Pandu. The pH in the river Ganga at all monitoring locations reached levels that do not comply with the primary water quality criteria for bathing. The lowest pH was recorded as 6.3 at d/s Kanpur barrage during winters and the highest was 9.1 a/c with the river Pandu during summers. Sood *et al.* (2008) reported slightly alkaline pH in winter, but almost neutral in summer in the river Ganga in Uttarakhand (India).

The color in the river Ganga was highest after the confluence with river Panduin all the three seasons. The color in the river Ganga varied as 5-25 Hazen however, in river Pandu, the color varied as 10-60 Hazen. The color in the river Pandu was significantly higher ($p < 0.05$) than the river Ganga. In river Pandu, the color was found significantly higher ($p < 0.05$) in the winter season as compared to summer or monsoon seasons. The high color in river Pandu may be attributed to the discharge of industrial effluents from the Panki industrial area in Kanpur. The color of the water in the river Ganga increased after confluence with the river Pandu. The total Cr concentration was found below the detection limit at all the monitoring locations on rivers Ganga and Pandu. This might be due to sufficient dilution of the incoming pollutants into the rivers Ganga and Pandu.

The DO in river water is an important parameter for evaluating the water quality as it controls the diversity of aquatic fauna and acts as an indicator of the effect of waste discharge into the river (Naubi *et al.,* 2016). The DO content also depends upon the temperature and photosynthesis process and is directly proportional to the rate of photosynthesis and inversely proportional to the rates of respiration and organic degradation. The DO content in the river Ganga varied as 3.5-12.6 mg/L and as 1-8.5 mg/L in the river Pandu. The DO in the river Ganga at all locations before the confluence of the river Pandu was greater than 5 mg/L which meets the primary water quality criteria for bathing. However, the DO in the river water declined after the confluence with the river Pandu. In river Ganga, higher DO was found during the winter season in comparison to summer or monsoon seasons which

may be attributed to the high photosynthetic activity due to better illumination and better dissolution of oxygen in water at lower temperatures. However, the low DO content in the river during monsoon may be due to a decrease in photosynthesis activity owing to low turbidity, and low biological decomposition of organic matter (Rani *et al.*, 2011). Tare *et al.* (2003) reported that, in Kannauj-Kanpur stretch, the rate of photosynthesis in the river Ganga was much higher than the rate of oxygen consumption due to respiration. Due to this, the DO content in the river remains high despite the fact that a large amount of organic waste is discharged into the river in this stretch.

The BOD and COD quantify the degree of organic pollution in a river. The BOD takes the biodegradable portion into account while the COD measures both biodegradable and non-biodegradable pollution as well (Khan *et al.*, 2016).

The BOD in river Ganga varied between 1-19.2 mg/L being highest after the confluence with the river Pandu. The BOD in the river Pandu ranged from 3 to 31.5 mg/L. In river Ganga, at d/s Shuklaganj, the BOD was found statistically similar ($p > 0.05$) during all three seasons. The BOD in the river Ganga at all locations was observed to reach levels that do not comply with the primary water quality criteria for bathing. The BOD in the river Ganga may be attributed to the discharge of sewage and industrial effluents. The COD in the river Ganga ranged between 5.1 and 35.8 mg/L and was similar ($p > 0.05$) during all three seasons at d/s Kanpur barrage, u/s Shuklaganj, and d/s Shuklaganj. The COD in the river Pandu ranged as 12.5-69.1 mg/L which increased the COD in the river Ganga after the confluence with river Pandu.

Biological Properties of River Water

The FC count at all the river locations reached levels that do not comply with the primary water quality criteria for bathing. The TC and FC count in the river Ganga at d/s Shuklaganj was higher in monsoon season in comparison to summer or winters. Baghel *et al.* (2005) reported higher TC and FC counts in summer followed by rainy and winter seasons. The total viable counts in the Gangotri glacier area of the river Ganga were found in the range of 2×10^2 to 40×10^2 mL^{-1} in winter, 7×10^2 to 40×10^2 mL^{-1} in summer, and 2×10^2 to $40 \times 10^2 mL^{-1}$ in monsoon. The industry-induced human settlements on the banks of the river Ganga contributed to the FC load. Moreover, mass bathing activities also increase the FC count in the river (Kulshrestha and Sharma, 2006).

Pollution in Rivers Ganga and Pandu due to Drains

The river Ganga received pollution from 18 drains. Out of these 18 drains, City jail drain was found dry at the confluence (downstream of Fatehpur) with the river Ganga during all the sampling surveys. The other 17 drains were either tapped to STPs/CETPs, tapped with overflow or having flow directly reaching to the river Ganga. The drains which are tapped and dry were highest during winters (6-11) followed by summer (6-9) and monsoon (4-6). This can be attributed to two reasons: (i) Increased flow in drains during monsoon season; and (ii) Insufficient tapping capacity at drains which leads to the overflow of drains reaching river Ganga. Four drains namely TEFCO drain, Police line drain, Jail drain, and Air force drain were found tapped and dry throughout the sampling period. In the case of the river Pandu, three out of six drains were tapped since September 2019 however, the tapped drains were observed with an overflow most of the time. Three drains namely Ratanpur drain, Panki drain, and ICICI drain were observed to have flow reaching to the river throughout the sampling period.

BOD, COD and Colour in Drains

In the river Ganga, Permiya drain discharged maximum wastewater with flow observed up to 302.8 MLD. Highest BOD was found in Budhiyaghat drain (369-8833 mg/L) followed by Wazidpur drain (68-1455 mg/L) and Sheetla bazar drain (40.6-586 mg/L). Similarly, the highest COD was observed in Budhiyaghat drain (863-16019 mg/L) followed by Wazidpur drain (169-2771 mg/L) and Sheetla bazar drain (118-1364 mg/L). High BOD and COD in these drains may be due to the discharge of untreated/partially-treated tannery effluents into these three drains from the Jajmau industrial area in Kanpur. Jajmau industrial area consists of many large- and small-scale tannery industries. High color was observed in Budhiyaghat drain (80-400 Hazen), Wazidpur drain (35-1000 Hazen) and Sheetla bazar drain (40-600 Hazen) due to industrial discharge in Jajmau. The high color was also observed in City jail drain (20-300 Hazen) due to illegal discharge of effluent from industries in Magarwara and Banthar industrial areas. In drains discharging into the river Pandu, high color (25-3750 Hazen) was found in the Ratanpur drain

due to the illegal discharge of effluents from near-by textile industries. Textile effluents are characterized with high color and COD which when released untreated may contaminate the receiving river water body (Malik *et al.,* 2018).

Total Chromium in Drains

The high concentration of total chromium was found in Budhiyaghat drain (7.7-647 mg/L), Wazidpur drain (0.5-121 mg/L), and Sheetla bazar drain (1-75.3 mg/L). However, no concentration of total Cr was observed in the water of the river Ganga because of the tapping of drains and proper dilution in the river Ganga in case of overflow from drains. The chromium content in drains can be attributed to the discharge from tanneries in the area (Sharma and Adholeya, 2011).

CONCLUSION

The water quality of river Ganga in Kanpur stretch indicated that pH varied as 6.3-9, color as 5-25 Hazen, DO as 3.5-12.6 mg/L, BOD as 1-19.2 mg/L, COD as 5.1-35.8 mg/L and total Cr as < 0.02 mg/L during one year of the study period (March 2019 to February 2020). In river Pandu, pH varied as 7.1-8.7, color as 10-60 Hazen, DO as 1-8.5 mg/L, BOD as 3 to 31.5 mg/L, COD as 12.5-69.1 mg/L and total Cr as < 0.02 mg/L. The pH, DO, BOD, and FC in the river Ganga reached levels that do not comply with the primary water quality criteria for bathing. The seasonal variation of water quality of river Ganga indicated that high DO was found during the winter season in comparison to summer or monsoon seasons due to high photosynthetic activity because of better illumination and better dissolution of oxygen in water at lower temperatures. It is indicated that the capacity of tapping provision of drains was not sufficient and overflow from drains reaching directly into the river Ganga was observed.

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