Physiochemical Characteristics Analysis of Garrah River Water at Shahjahanpur, Ganga River Basin, Uttar Pradesh, India

Abhinav Sahay[1], *Umesh* Kumar[1], *Kundan* Kumar[2], *Sunil* Prasad Bhatt[3], *Amit* Ranjan Kumar[2], *Rajesh* Mahadeva[4,5], *Vinay* Gupta[4], *Saurav* Dixit[6,7,*]
[1] *Amity School of Engineering & Technology, Amity University, Patna, Bihar, India*
[2] *FRI Deemed University, Dehradun, Uttarakhand, India*
[3] *HNB Garhwal Central University, Srinagar, Uttarakhand, India*
[4] *Khalifa University of Science and Technology, Abu Dhabi, 127788, United Arab Emirates*
[5] *Division of Research and Innovation, Uttaranchal University, Dehradun, 248012, India*
[6] *Peter the Great St Petersburg Polytechnic University, St Petersburg, 195251, Russia*
[7] *Research and Development Cell, Lovely Professional University, Punjab, India-144411*
*Corresponding Author -sauravarambol@gmail.com

Abstract: This study focuses on the physiochemical analysis of the Garrah River in Shahjahanpur, within the Ganga River Basin, Uttar Pradesh, India. The research evaluates the impact of various pollutants, including industrial and municipal sewage, on the river's water quality. Water samples were collected from three locations along the river, representing different pollution levels. The analysis included parameters such as pH, dissolved oxygen (DO), total suspended solids (TSS), color, odor, electrical conductivity, temperature, chemical oxygen demand (COD), salinity, and the concentrations of various elements. The findings showed variations in water quality parameters, with DO, TSS, COD, and heavy metals indicating significant pollution, particularly downstream. Color and odor also suggested pollution from nearby industries. The study revealed that some parameters exceeded WHO standards for drinking water, raising concerns about health risks from exposure to contaminants like chromium. Urgent actions are required to treat municipal sewage and industrial effluents before discharging into the Garrah River. This research highlights the need for ongoing monitoring and sustainable management of water resources in the Ganga River Basin to protect the ecosystem and local communities. It underscores the importance of improving water quality in the region.

Keywords: Garrah River, Shahjahanpur, Ganga River Basin, Physiochemical Characteristics, Environmental Impact, Water Quality Standards

1 Introduction

Rivers are lifelines of human civilianization; we have encountered this phrase several times daily. Rivers provide water for domestic use, industry, agriculture, and power generation. They also serve as a means to dispose of sewage and industrial waste. As a result, rivers face immense pressure. An estimated 580 people in India die of water pollution-related illnesses daily [1]. In recent years, there has been an increasing concern and focus on the degradation of Indian Rivers caused by various developmental activities. The pollution sources in rivers are generally classified into two categories: 1) Point source water pollution, which refers to pollutants that enter a waterway from identifiable single sources such as pipes or ditches, and 2) Nonpoint source pollution, which involves diffuse contamination that does not originate from a specific source. Nonpoint source pollution is often the result of small amounts of contaminants accumulating over large areas. An example is the release of nitrogen compounds from fertilized agricultural lands through leaching processes. Throughout history, rivers have served as vital lifelines for human civilization.

These waterways fulfill many essential roles, such as providing a crucial water source for domestic use, industry, agriculture, and power generation. However, they also face immense challenges due to the added burden of sewage and industrial waste disposal. As a result, rivers are subjected to substantial pressure to meet these various demands. Currently, numerous rivers are being irresponsibly utilized as dumping grounds for domestic and industrial waste, far exceeding their natural ability to absorb and assimilate. As a result, these waterways have become heavily polluted. Despite its immense importance, the management of water resources on a global level is inadequate. The condition of water has significantly declined primarily due to improper waste disposal practices, ineffective water management strategies, and indifference towards environmental preservation. Consequently, there is now a shortage of clean drinking water, which poses risks to human health, according to a study conducted by National Geographic Channel [2].

- In developing countries, 70 percent of industrial waste is dumped untreated into waters, polluting the usable water supply.
- Every day, 2 million tons (1.8 billion kilograms) of human waste are disposed of in waterways worldwide.
- On average, 99 million pounds (45 million kilograms) of fertilizers and chemicals are added to the rivers yearly.

Individuals residing near the river utilize its water for various household needs. Unfortunately, no monitoring and information system is available on water quality assessment and the amount of industrial effluent discharged into the river. Such information is essential for the authorities to take proper action to prevent pollution of the environment for the good health of people and aquatic life. Before water can be described as potable, it must comply with specific physical, chemical, and microbiological standards to ensure it is palatable and safe for drinking and other domestic purposes [3]. In a World Health Organization (WHO) case study on the water quality of River Ganga, Sharma (1997) [4] stated that the river Ganga receives about 1.4 × 106 m3d-1 of Domestic Wastewater and 0.26 × 106m3d-1 of Industrial Sewage. Nonpoint sources of pollution, like agricultural run-off containing residues of harmful pesticides and fertilizers, also contribute to deteriorating water quality.

The Garrah River is one of the prominent tributaries of the Ganga River, located in the Saharanpur district of Uttar Pradesh, India. It flows through a region crucial to the Ganga Basin ecosystem [5]. The Ganga basin, often called the Ganges basin, is one of the largest river basins in the world, encompassing a vast and ecologically diverse area. The Ganga basin is not only historically and culturally significant but also environmentally sensitive, hosting a multitude of flora and fauna. The Garrah River, as a tributary of the Ganga, is an integral part of this vast network of rivers, and its water quality is paramount. Assessing water quality in the Garrah River is critical for several reasons. The Garrah River, like other tributaries, significantly contributes to the overall health of the Ganga River. The Ganga basin is home to many aquatic and terrestrial species, and maintaining the water quality of its tributaries is essential for the survival of these species [6]. The Ganga River and its tributaries are water sources for millions of people and are critical for agriculture, industry, and daily household needs. Ensuring clean and safe water is vital for the well-being of the local communities that depend on these water bodies [6,7].

The Ganga River holds immense cultural and religious importance for the people of India. Millions rely on its waters for various rituals, and maintaining its purity is integral to their beliefs and practices [8]. The Ganga basin is economically significant, supporting multiple sectors, including agriculture, tourism, and fisheries. A decline in water quality can have adverse economic consequences for the region. [9,10,11]. The Garrah River, as part of the Ganga basin, is home to diverse ecosystems. It supports various aquatic life, including fish and other organisms. Changes in water quality can disrupt these ecosystems and lead to ecological imbalances. Given the ecological, social, and economic importance of the Garrah River and connection to the Ganga basin, assessing its physiochemical water quality is a fundamental step in understanding and addressing the environmental challenges and ensuring the sustainable use of this vital resource. This research aims to contribute to the knowledge of the Garrah River's water quality, which can inform effective management and conservation strategies for this critical river and the broader Ganga basin.

2 Material and Methods

2.1 Study Area

Shahjahanpur is a well-known industrial area of Uttar Pradesh, and six big industries are located near the city. Some big industries are Kribhco-Shyam Chemical and Fertilizer Ltd., McDowell's Distillery, Rosa Sugar Factory, Rosa Paper and Pulp Factory, and Vidhya Plywood Factory. The waste from the industries and the municipal sewage from the city might have a deteriorating impact on the water quality of the Garrah River. Therefore, we conducted a study to assess the extent of various pollutants received by the Garrah River and their impacts on its water quality. Shahjahanpur city lies in the Rohilkhand division of the upper Gangetic plain between $27^{0}50'$ N latitude and 79^{0} 55'E longitude and is situated on the eastern side of the Garrah River. It is located at an altitude of 182 m.a.s.l. (Figure. 1).

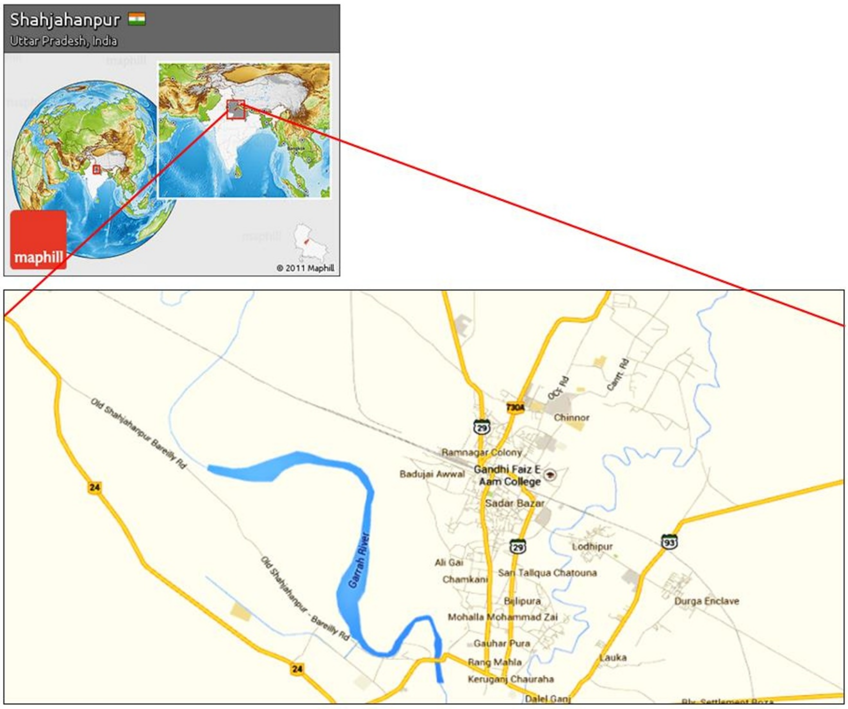

Fig 1 Location Map of Garrah River Near Shahjahanpur, U.P, India.

2.2 Sampling Sites

Water samples were collected from three different selected sites of the Garrah River in the western part of Shahjahanpur City, Uttar Pradesh, India, in April 2014. The three sampling sites with varying pollution regimes have been selected; details of the sites are given below (as shown in Table 1).

Table 1 Water Sampling locations and their details.

S.N.	Sampling Site	Location	Lat./Long.	Remark
1.	Location I	Upstream of the river, before Garrah River enters the city	$27^0$51.765'N & $79^0$53.473'E	Without pollution load from the city
2.	Location II	Near Garrah Bridge, at the center of the city	$27^0$51.672'N & $79^0$54.246'E	With sewage and other solid wastes from the city
3.	Location III	Downstream of the river, at the confluence point with Garai Nala	$27^0$49.288'N & $79^0$49.182'E	With the city's sewage and industrial effluents

2.3 Collection and Storage of Water Samples

Three water samples were taken from each sampling site to reduce the chances of error. The water samples were collected in BOD Bottles of 300ml capacity and high-grade plastic bottles of one-liter capacity. Before collection, the plastic bottles were rinsed once with distilled water and then thrice with respective water samples. During collection, care was taken to avoid the trapping of air within the bottle by completely immersing the bottle within the respective water sample until the bottle was filled in with the water.

3 Methodology Applied for Water Sample Analysis

Water samples were collected separately from the three river sampling stations in April 2014. The parameters measured are Colour, Temperature, Conductivity, Odour, pH, TSS, COD, DO, Salinity, Na, K, Ca, Cu, Cr, Zn, Fe, and Fecal coliform. The water samples were preserved and analyzed for the above parameters per the Standard Methods [12] and [13] in the Forest Ecology and Climate Change Division laboratory and of Forest Research Institute Deemed University Dehradun.

4 Results and Discussion

This study aims to analyze the water characteristics of the Garrah River in Shahjahanpur. Table 2 below shows the average values for the physicochemical analysis of river water.

Table 2 Water Quality Assessment Results.

S.No.	Water Quality Parameter	Location 1	Location 2	Location 3
1.	pH	7.48	7.68	7.74
2.	D.O.	6.6 mg/L	4.4 mg/L	2.2 mg/L
3.	TSS	20 mg/L	60 mg/L	140 mg/L
4.	Colour	Colourless	Colourless	Light brown
5.	Oduor	Non-objectionable	Non-objectionable	Objectionable
6.	Electrical Conductivity	75.98 mho/cm	80.1 mho/cm	92.06 mho/cm
7.	Temperature	25.6 °C	26.2 °C	26.8 °C
8.	C.O.D.	70.6 mg/L	152.4 mg/L	216.8 mg/L
9.	Salinity	4.83 mg/L	4.58 mg/L	4.70 mg/L
10.	Na	18.80 mg/L	19.30 mg/L	20.00 mg/L
11.	K	4.50 mg/L	4.80 mg/L	6.00 mg/L
12.	Ca	11.70 mg/L	11.94 mg/L	13.24 mg/L
13.	Cu	0.06 mg/L	0.07 mg/L	0.08 mg/L
14.	Zn	0.09 mg/L	0.07 mg/L	0.05 mg/L
15.	Fe	0.56 mg/L	0.30 mg/L	0.80 mg/L
16.	Cr	2.33 mg/L	0.11 mg/L	1.59 mg/L
17.	Fecal coliform (Presence/Absence test)	Present	Present	Present

4.1 pH : The pH at three locations falls within the WHO standards for drinking water, i.e., between 6.5 and 8.5 (Figure 2). The maximum pH (7.74) was recorded at location-III and minimum (7.48) at location-I. pH shows an increasing trend when we move downstream from Location I towards Location III. This may be due to the addition of uric acid, nitric acid, and sulphuric acid from sewage, agricultural, and industrial effluent.

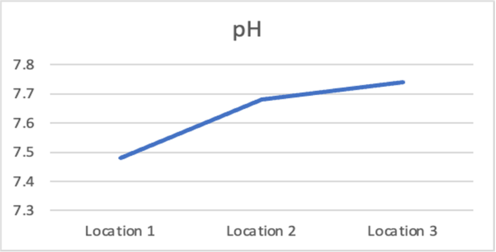

Fig 2 pH variation at three different locations.

4.2 Dissolved Oxygen (DO): Dissolved oxygen measures pollution load, decreasing with increased pollution (Figure 3). DO was found at maximum, i.e., 6.6 mg/L at Location-I and minimum, i.e., 2.2 mg/L at Location-III. The decreasing trend of DO indicates an increased pollution load downstream of the river.

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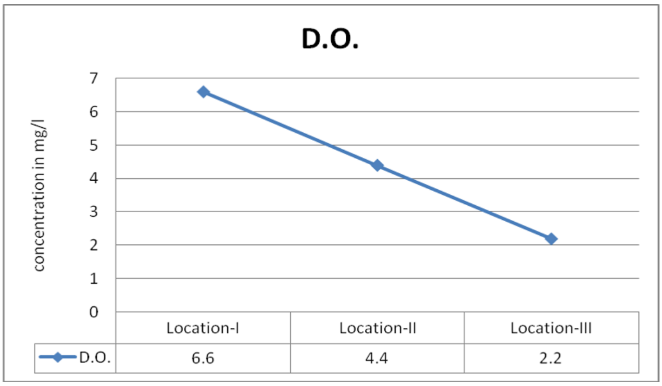

Fig 3 D.O. variation at three different locations.

4.3 Total Suspended Solids: TSS at the three sampling locations conforms with WHO drinking water standards, i.e., 20-150 mg/L (Figure 4). However, the graph shows that the amount of suspended solid increases as we move from location I towards location II. TSS values were recorded at maximum, i.e., mg/L at location-III, and minimum, i.e., 20 mg/L at location-I.

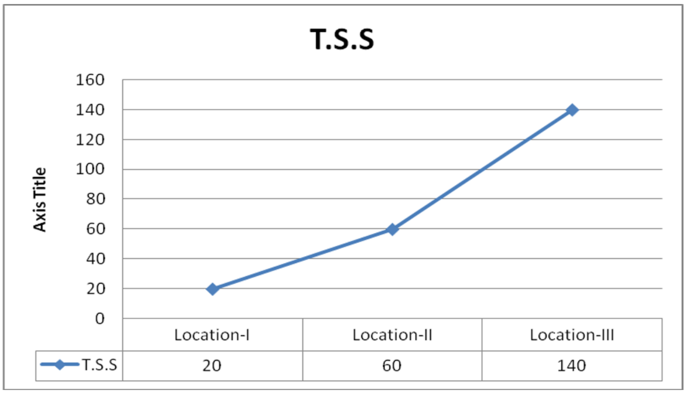

Fig 4 T.S.S. variation at three different locations.

4.4 Colour & Odour: No colour has been recorded at location-I and location-II, while a light brown color of water has been seen at location-III. The objectionable odour was recorded in the water collected from location III (Table.3). Colour and odour of the water sample indicate the presence of pollution load at Location III. (Table 3). This may be due to the industrial effluents from the nearby industries.

Table 3 Color and Odour variation at three different locations.

Parameter	Location-I	Location-II	Location-III
Color	Colourless	Colourless	Light Brown
Odour	Non-Objectionable	Non-Objectionable	Objectionable

4.5 Electrical Conductivity: Electrical conductivity is a key river water quality assessment parameter. It indicates water purity, salinity, and TDS levels. Electrical conductivity increases due to an increase in the ionic species. It is within the WHO Standards between 30 and 1500 mho/cm. The maximum electric conductivity (92.06 mho/cm) was recorded at location III, and the minimum (75.98 mho/cm) was recorded at location-I (Figure 5). Electrical conductivity

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is increasing from location I to location III due to the addition of chemical ions from the city's sewage and industrial effluent.

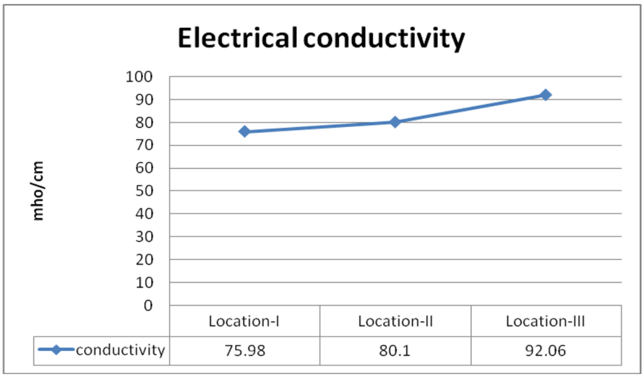

Fig 5 Electrical conductivity variation at three different locations.

4.6 Temperature: The maximum temperature (26.8^{0}C) was recorded at location III, whereas the temperature was found to be minimum (25.6^{0}C) at location I (Figure 6). Temperature is showing an increasing trend downstream; this may be due to the addition of comparatively warm liquid wastes from sewage and hot wastewater used for cooling purposes in the industries.

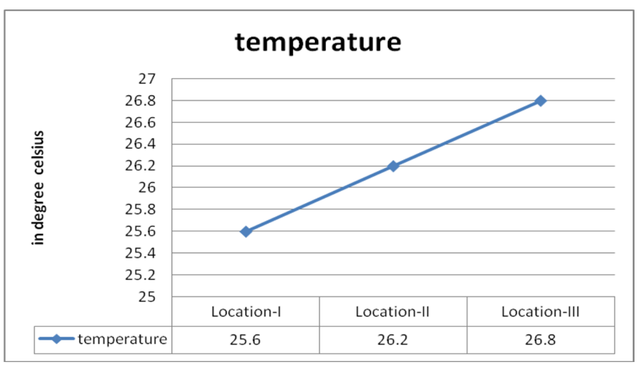

Fig 6 Temperature variation at three different locations.

4.7 Chemical Oxygen Demand (COD): High COD levels in water indicate pollution from different sources, which can carry harmful substances. It can make treating drinking water more difficult, affecting human health, harming aquatic ecosystems, and impacting the environment and communities. The maximum (216.8 mg/L) COD was observed at location III and the minimum (70. mg/L) at location I (Figure 7). COD at all three locations is greater than the prescribed limits of WHO for drinking water, i.e., 10mg/l. The pollution load at all three locations is alarming, rendering water unfit for human consumption. The graph shows C.O.D. concentration increases as we move from Location I to Location III.

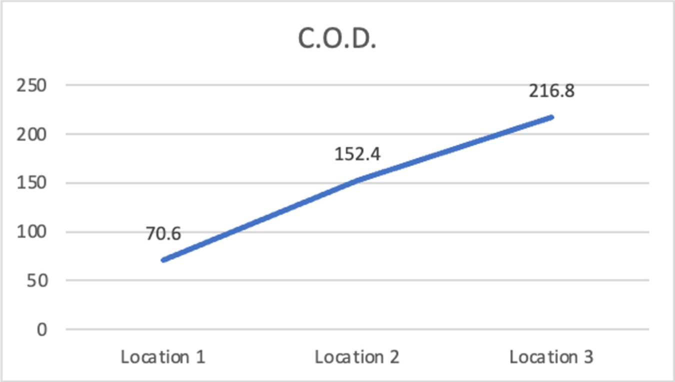

Fig 7 C.O.D. variation at three different locations.

4.8 Salinity: High salt levels in river water harm aquatic life, reduce crop yields when used for irrigation, affect drinking water taste, and harm infrastructure and public health. Salinity values were recorded as 4.83 mg/L, 4.58 mg/L, and 4.70 mg/L at locations I, II, and III, respectively (Figure 8).

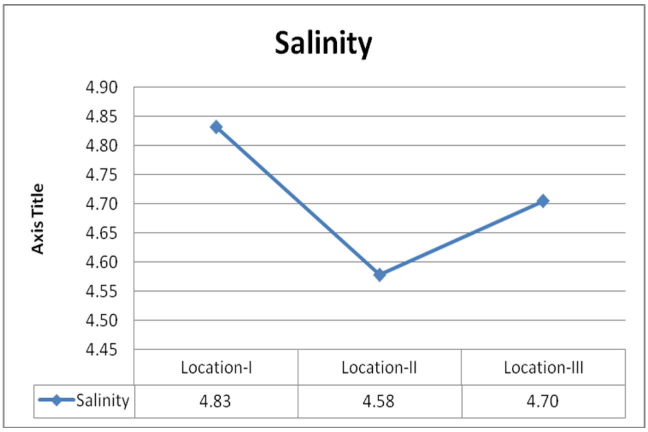

Fig 8 Salinity variation at three different locations.

4.9 Sodium (Na), Potassium (K), and Calcium (Ca): Sodium, potassium, and calcium in river water can impact health. Adequate levels are essential for normal bodily functions, but excessive sodium can lead to high blood pressure. [14]. The maximum Na was recorded as 13.24 mgl^{-1} at location III, and its minimum value was recorded as 11.70 mgl^{-1} at location-I. The highest (6.00 mgl^{-1}) K was also recorded at location III, followed by 4.80 mgl^{-1} at location II and 4.50 mgl^{-1} at location I. Similarly, Calcium was recorded highest (20.00 mgl^{-1}) at location-III and lowest (18.80 mgl^{-1}) at location-I (Figure 9).

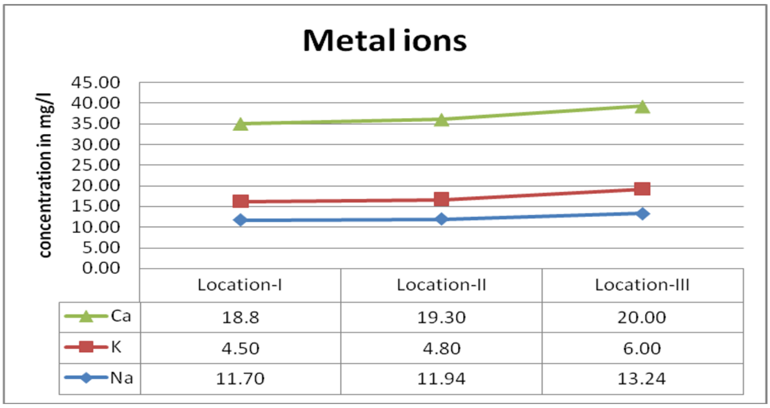

Fig 9 Metal ions variation at three different locations.

4.10 Heavy metals (Copper, Zinc, Iron, and chromium): The health impact of these heavy metals depends on concentration and form. Adequate essential metals (Cu, Zn, Fe) are necessary, but excess can be toxic. Prolonged Exposure to toxic metals, like chromium, can cause serious health effects in humans. Heavy metals like Cu, Zn, and Fe conform with the standards, but the concentration of Cr is greater than the standards at Location I and Location II, which renders river water unsuitable for human consumption as prolonged exposure to Cr causes Renal ailments. [15,16,17]. The WHO Standards of drinking water for Cu (1.5 mg/L), Zn (3 mg/L), Fe (50 mg/L), and Cr(0.05 mg/L) (Figure 10).

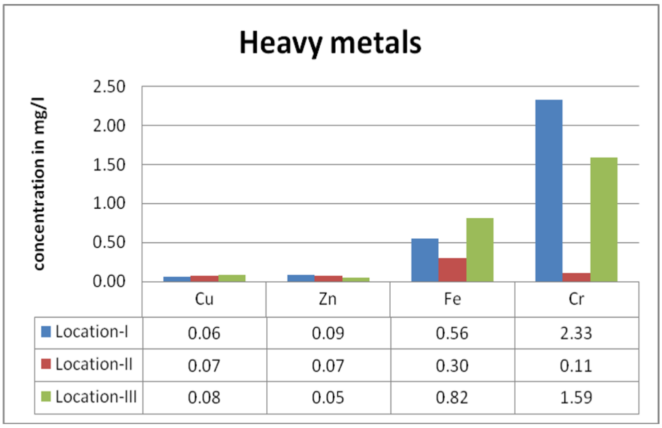

Fig 10 Heavy metal variation at three different locations.

4.11 Fecal Coliforms: The Presence/absence of fecal coliforms in water samples is a critical indicator of water quality, impacting its safety for various uses like drinking, recreation, and ecosystem preservation. These bacteria, originating from warm-blooded animal intestines, signify fecal contamination and the presence of a potential waterborne pathogen. This parameter is vital for evaluating water safety, particularly in areas with water quality regulations [18]. Fecal coliform was present in all three locations of the study area (Table 4), rendering river water unfit for human consumption.

Table 4 Fecal coliform Presence /Absence test at three different locations.

Parameter	Location 1	Location 2	Location 3
Fecal Coliform	Present	Present	Present

5 Conclusion

The comprehensive river water quality assessment at three distinct locations revealed several noteworthy findings. The pH levels remained within the WHO standards for drinking water, with a slight upward trend downstream. Dissolved oxygen (DO) decreased as the pollution load increased downstream, highlighting deteriorating water quality. Total Suspended Solids (TSS) adhered to WHO standards, but TSS concentrations increased in the downstream direction. At Location III, a light brown color and objectionable odour indicated pollution, likely from nearby industries. Electrical conductivity increased downstream, meaning an influx of ionic species from sewage and industrial effluents. Water temperature also increased downstream due to warm liquid wastes and hot industrial wastewater. Chemical Oxygen Demand (COD) exceeded WHO limits at all locations, rendering the water unsuitable for human consumption. Salinity levels remained relatively consistent. The presence of essential and toxic heavy metals within permissible limits emphasized the need for maintaining concentration standards. Fecal coliforms were detected in all locations, highlighting fecal contamination and the unsuitability of the river water for human consumption. These results underscore the importance of continued monitoring and stringent management practices to preserve environmental and public health in the studied river system.

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