



# A Study Of Physico-Chemical Qualities Of Ramganga River At Five Different Locations Of Aonla In District Bareilly

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**Abstract:** The water bodies like rivers, lakes, backwaters and estuaries are continuously subjected to human induced changes affecting them adversely. Addition of undesirable substances from various sources into the river water causes alteration in the physical, chemical and biological characteristics of water and leads to conditions which disturb the ecological balance. The pollution of river water results in deleterious effects causing hazards to human health, hindrance to aquatic life. Cremation of dead bodies at river bank is a usual practice which is further deteriorating the quality of river water. The objective of the present study is to analysis the water pollution status of river Ramganga. In the preliminary analysis, the survey of river revealed that there is a common practice of natives regarding the disposal of waste water and toxic wastes in it. The present study carried out in river Ramganga at Aonla, district Bareilly, India, to assess the extent of pollution by different industrial and domestic activities. The findings showed that pollution caused an extreme change in chemical quality and physical properties of Ramganga River. The pollution level of River Ramganga was evaluated by collecting and analyzing the water sample from different places (stretch of about 70-75 km) with a View to study the physical, chemical and biological characteristics and to investigate the factors responsible for causing pollution. The study can also help in formulating remedial measures.

**Index Terms - Pollution, physico-chemical analysis, water, Ramganga, water quality.**

## I. INTRODUCTION

In any ecosystem, water is a natural resource that is necessary for life. With the modern economy developing so quickly and the population continuing to rise, maintaining its quality is a fundamental problem for society, which must fulfill the increasing demands for water. Actually, a lot of chemical and biological pollutants are introduced to surface water either directly or indirectly by human activities and natural factors such sewage water, industrial processes, and irrigation. Rivers and other surface features' physico-chemical characteristics are impacted as a result. These factors result in an uncomfortable ecosystem and numerous disturbances to the natural environment (Hayek et al., 2020).

In July 2016, the United Nations General Assembly proclaimed access to safe and clean drinking water a human right (UN, 2016). Since the hydrological cycle is being significantly altered by climate change and human activity, water quality degradation has emerged as a critical global concern for humankind's sustainable development. Pollution from human activities and improper agricultural drainage from rivers pose serious risks to water resources (Jin et al., 2020a, 2020b). The main causes of surface water pollution and declining water quality are anthropogenic sources, including untreated industrial effluents, inadequately disposed of household trash, and agricultural runoff (UN, 2016; Uddin and Jeong, 2021; Hasan et al., 2019). River water quality is impacted by seasonal changes in both natural and man-made processes, such as

temperature and precipitation, which result in distinct characteristics for each season (Islam et al., 2018; Barakat et al., 2016; Rahman et al., 2021).

The introduction of pollutants into water bodies is known as pollution. Without sufficient treatment to eliminate dangerous materials, water contaminants are released into bodies of water either directly or indirectly. Animals and plants that live in these bodies of water are impacted by water pollution, as are other aquatic biota. Eutrophication, or the introduction of nutrients (mostly phosphates and nitrates) into water bodies, is the most common issue with water quality worldwide (Kjelstrom et al., 2006).

Excessive pollutants in water that impact the biosphere's ecosystem are now an unavoidable result of rapidly increasing urbanization, changing consumption habits, population increase, and social and economic development—all of which contribute to environmental pollution. As a result of increased urbanization, industrialization, and human population growth, chemical contaminants are commonly found in aquatic habitats. There are numerous studies on how chemical pesticides, steroids, and antibiotics can contaminate water sources (Kumar et al., 2024a).

Due to toxicity, carcinogenicity, and mutagenicity, synthetic dye contamination of water bodies may pose a concern to both human health and the environment. Furthermore, to regulate wastewater emissions, ever-tougher statutory limits are required (Alsukaibi, 2022; Anwar et al., 2024a). Wastewater from textiles industries can be especially hazardous since it contains contaminants like heavy metals (Kumar et al., 2024b). Among the leading causes of death worldwide are cancer and carcinogens (Anwar et al., 2020). The beneficial uses of water are significantly hampered by eutrophication. Several laboratory-based studies have demonstrated that single heavy metals or pure organic pollutants can cause liver damage and various liver diseases (Lin et al., 2023). The liver actively participates in metabolism and carries out a variety of tasks (Anwar et al., 2024b). The liver plays a role in digestion, xenobiotic detoxification, gluconeogenesis, lipid metabolism, storage, iron homeostasis, and the synthesis of vital plasma proteins. The liver also breaks down hemoglobin and converts poisonous ammonia to less toxic urea. Additionally, all blood exiting the stomach and gut passes through the liver, which also controls the amounts of various chemicals in the blood (Yahia and Anwar, 2020).

Ramganga is an important river in Bareilly in Uttar Pradesh, India (Gangwar et al., 2013). Hence, an attempt has been made to study the water quality and potential of pollution in its water which may causes the damage in quality which makes it unfit to drinking and other purposes. The quality of water is classified as excellent, good, moderate and poor or unfit to drinking. The quality of water is analyzed by using physicochemical parameters like temperature, pH, total solid, TSS, TDS, total alkalinity, B.O.D., C.O.D., and total hardness, were prescribed limit of W.H.O. guideline for drinking purposes. While all analyzed water quality parameter fall within the FAO standard limit for irrigation purposes. The water is thus not potable for domestic purposes without some forms of physical and chemical treatment while it is useful for irrigation purpose. The present study is a attempt to study the effect of sewage discharge in to river ganga. The study is conducted in village Shivpuri Kailash Giri Mani, Aonla Distt., Bareilly, U.P. water sample were collected on the period of February to May. There are five samples are collected from five sites near Shivpuri Aonla.

## 2. MATERIAL AND METHODS

Ramganga is an important river in Bareilly district (UP). Hence an attempt has been made to study water quality and pollution of water. Shivpuri Village is located in Aonla Tehsil of Bareilly district in Uttar Pradesh, India. It is situated 25 km away from sub-district headquarter Aonla and 55 km away from district headquarter Bareilly. The sampling was completed at five different places Kailashgiri Mani (site 1), Hazi Pur (site 2), Sisauna (site 3), Kashinath Pur Ehatmali (site 4), and Loknath pur (site 5). After collecting the samples in 1 liter sized plastic bottles, the samples were transported to the laboratory and preserved. Later, the samples were analyzed for physico-chemical parameters as per standard methods (APHA, 1998, APHA, 2005). The digital pH meter (Tecpel Co. Ltd.) and thermometer (Hicks DX 100) were used to test the pH and temperature of each water sample directly. GraphPad Prism software, version 6.0 (San Diego, CA, USA), was used for all statistical analyses. Temperature, pH, total solids, turbidity, total hardness (EDTA titration method), total alkalinity (simple titration method), dissolved oxygen (Winkler method), biochemical oxygen demand (5 days incubation method), and chemical oxygen demand (by dichromate titration method) were among the physico-chemical and biological parameters that were examined in the samples. Within 24 hours of sampling, the entire experiment was completed. In this manuscript, we provide the analysis of samples which were collected in May only.

### 3. RESULTS

A thorough grasp of the differences in water quality is provided by the assessment of the physical and chemical characteristics of the Ramganga River at various sampling sites. Figures show the results and indicate notable variations among the sampled sites.

#### 3.1. PH VALUE

Water's pH is not a physical characteristic that can be quantified or measured as a concentration. Rather, it is a number on a logarithmic scale that ranges from 0 to 14 and indicates how basic or acidic a body of water is. For more acidic water, the pH is lower in value. The more fundamental it is, the higher the number. A pH of 7 is regarded as neutral. The aquatic life in the water will perish if the pH is too high or too low. The toxicity and solubility of chemicals and heavy metals in water can also be impacted by pH. Animal systems may experience stress as pH levels deviate from this range, either upward or downward, which lowers the rates of hatching and survival. The death rates increase with increasing distance from the ideal pH range. A species' sensitivity to pH changes increases with its level of sensitivity. In addition to their biological impacts, high pH levels typically make substances more soluble, increasing the likelihood that aquatic life will absorb harmful substances (Fondriest Environmental, Inc. "pH of Water." Fundamentals of Environmental Measurements. 19 Nov. 2013. Web. < <https://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/> >.<https://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/>).

pH was determined by a Digital pH meter (model 101 E of environmental and Scientific instrument company). Electrode was calibrated according to the instruction manual provided by the company (using different calibration buffers). The pH of water samples were observed to be little higher at site I and II, than other sites. Usually the natural water is alkaline owing to the presence of carbonates (Figure 1). is sample paper format only please use this format and follow this structure as per your requirement

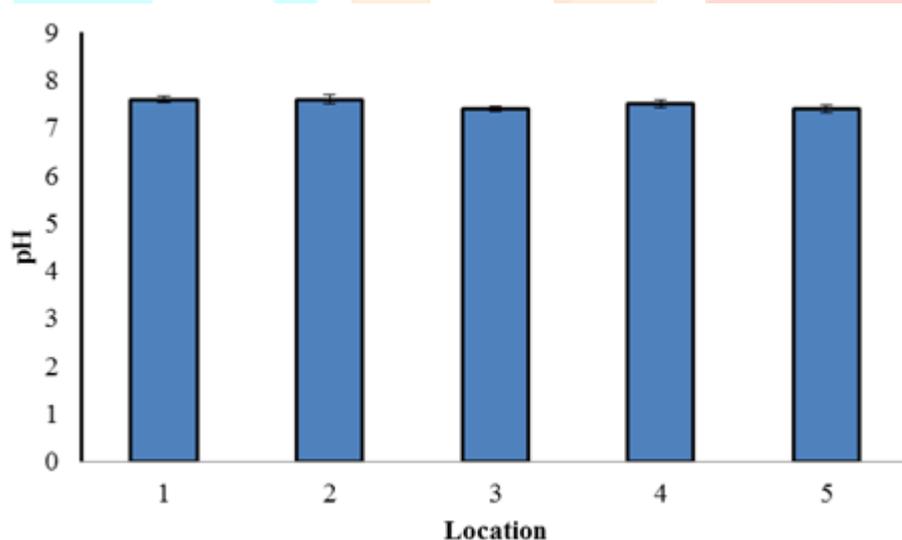


Figure 1- pH of water at different sites.

#### 3.2. COLOR

Different water colors in natural bodies are important because they can reveal information about the environment's safety and health. Variations in water color can indicate the presence of hazardous materials, pollution, or algal blooms. People can make better decisions regarding drinking water sources, recreational activities, and environmental conservation initiatives if they are aware of these changes. Additionally, it gives customers the ability to speak out against possible problems and promote water quality (<https://beforest.co/blogs/colours-of-water-what-they-reflect-about-our-ecosystems/>). Both dissolved and suspended components can contribute to the color of the water you see around you. The majority of the color in the water you see around you is caused by suspended material from a tributary (seen on the right above), which contributes highly turbid water with suspended sediment (fine clay particles) to the river's main stem's clearer but still colored water. The most prevalent particulate matter that gives natural waters their color is algae and suspended silt particles. Although swimming in dirty water would not be pleasant, the water's hue is inferior to that of water with dissolved tannins (<https://www.usgs.gov/special-topics/water-science-school/science/water-color>)

After the collection of the sample, the water samples were centrifuged so as to remove turbidity or suspended matter and in a clean tube and its color was compared with the 22 mixture of forelule color scale. The matching color was observed and recorded as blue, green etc. The water sample was generally colorless at site I and site II. However, it turned light brownish-reddish at site III onwards. The color of above site is due to the sewage disposal and due to the addition of distillery and sugar mill effluent. During downward course, the color of water sample becomes less intense. During rainy season, the color of the water sample was generally yellow or dirty yellow, throughout the stretch.

Table 1: Color of samples collected at different sites.

Location	Kailashgiri Mani (site1)	Hazi Pur (site 2)	Sisauna (site 3)	Kashinath Pur Ehatmali (site 4)	Loknath Pur (site 5)
Color	Colorless	Colorless	Light brownish-reddish	Light brownish-reddish	Light brownish-reddish

### 3.3. TEMPERATURE

River ecosystems are already feeling the effects of rising river water temperatures brought on by climate change. Aquatic life is impacted both directly and indirectly by warming water, which also exacerbates widespread problems like pollution, eutrophication, and disease transmission (Johnson et al., 2024). Rising water temperatures exacerbate eutrophication and other pervasive pressures, and human changes to river channels, land use, and water resource consumption patterns have made rivers susceptible to thermal change (Reid et al., 2019; Woodward et al., 2010).

It was measured by the calibrated mercury thermometer. The temperature was recorded immediately by dipping the thermometer for about one minute directly into the surface water. The temperature is basically important for its kinetic effects on the chemical and biological activities taking place in water-environment. Also with increasing temperature the specific conductivity increases due to increased solubility of salts and other soluble solids. Temperature of water samples were 34.0 (at site I); 34.2 (at site II); 34.5 (at site III); 34.4 (at site IV); 34.6 (at site V) in degree Celsius (Figure 2). The variation is mainly related with the temperature of the atmosphere and weather conditions.

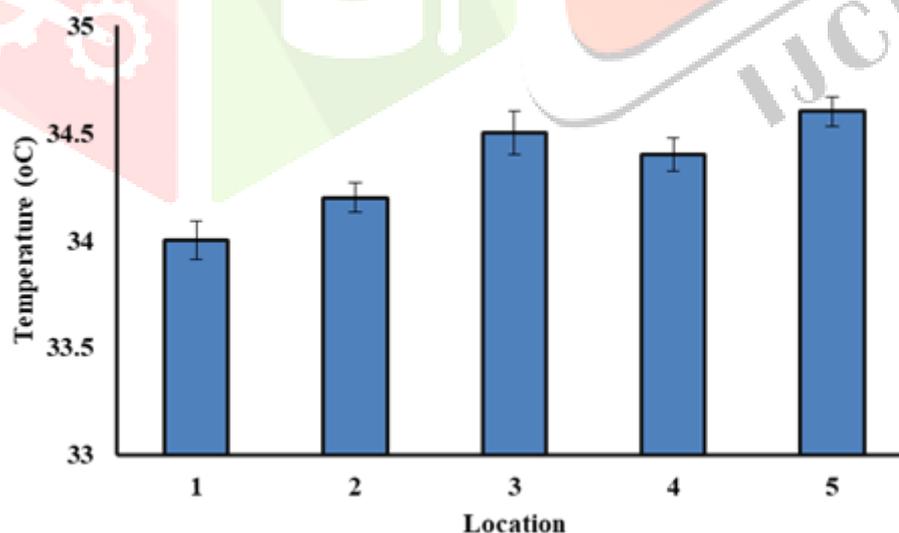


Figure 2- Temperature of surface water at different sites.

### 3.4. Flow Velocity

A float (a piece of wood of known weight and size) was placed on water surface. The time required for it to travel a known distance was observed at all sites. The average velocity was calculated. The velocity of river was varied from 0.54 m/sec. to 0.78 m/sec (Figure 3).

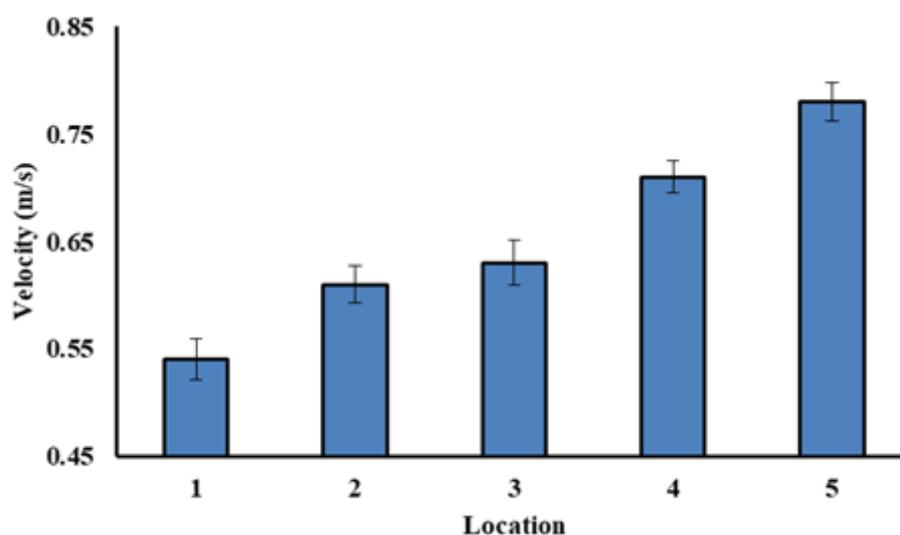


Figure 3- Flow velocity of water at different sites.

### 3.5. Turbidity

When light is passed through sample having suspended particles, some of the light is scattered by the particles. The scattering of the light is generally proportional to the turbidity. The turbidity of the sample is thus measured from the amount of light scattered by the sample taking a reference with standard turbidity suspension. The determination of turbidity is interfered by the debris and the presence of suspended particles in the sample increases the values of turbidity (Matos et al., 2024). Figure 4 compares the turbidity of all five locations in NTU.

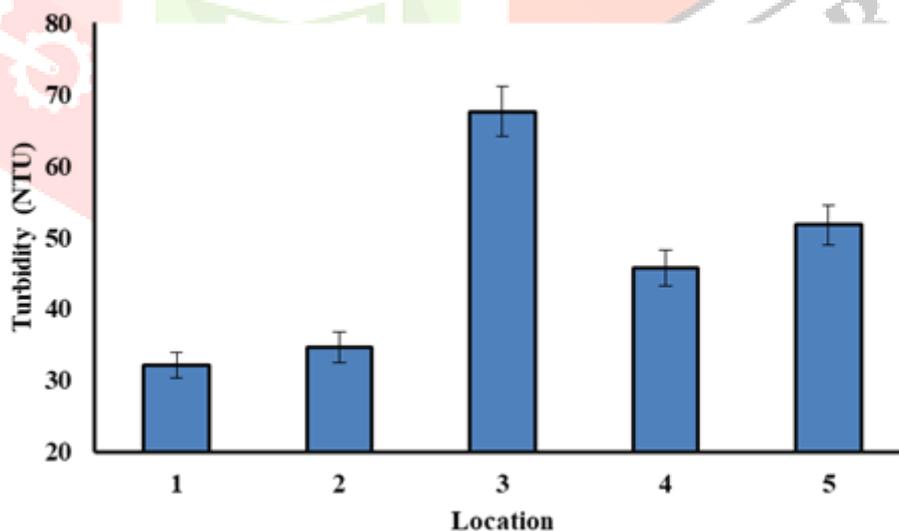


Figure 4- Turbidity of water at different sites.

### 3.6. Electrical conductivity

Electrical conductance is the ability of a substance to conduct the electric current. High conductivity indicates the presence of the larger quantities of dissolved mineral salts, thereby making it sour and unsuitable for the drinking purpose. The conductivity of water is caused by the presence of various ionic species. The conductivity of water is ranged from 405 to 471 ( $\mu\text{mhos/cm}$ ) (Figure 5).

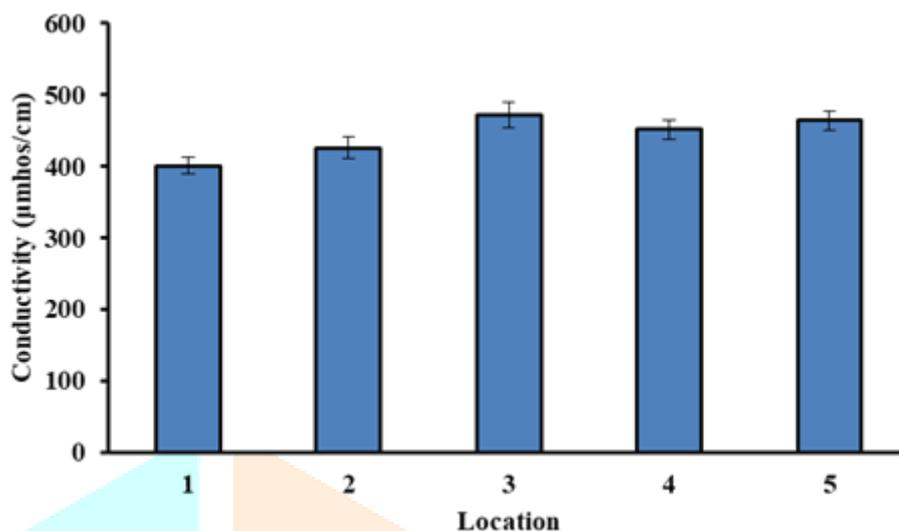


Figure 5- The conductivity of water is ranged from 405 to 471 ( $\mu\text{mhos/cm}$ ).

### 3.7. Total Solids

Residue may affect water quality adversely, and total solids are determined as the residue left after evaporation of the unfiltered sample. Water with high residue generally is of inferior palatability and may induce an unfavorable physiological reaction in the transient consumer ([https://ueppcb.uk.gov.in/files/Identification\\_of\\_Sources\\_of\\_Wastewater\\_Its\\_Characterization\\_and\\_Quantification\\_in\\_Hospitals-July-2017.pdf](https://ueppcb.uk.gov.in/files/Identification_of_Sources_of_Wastewater_Its_Characterization_and_Quantification_in_Hospitals-July-2017.pdf))

Highly mineralized waters also are unsuitable for many industrial applications (<https://ecequip.com/industrial-water-pollution-causes-and-effects-that-you-dont-know/>). The values of total-solids were higher at site III than site V, which is mainly due to the addition of distillery and sugar industries waste water in winter and domestic sewage water in all the seasons (Figure 6).

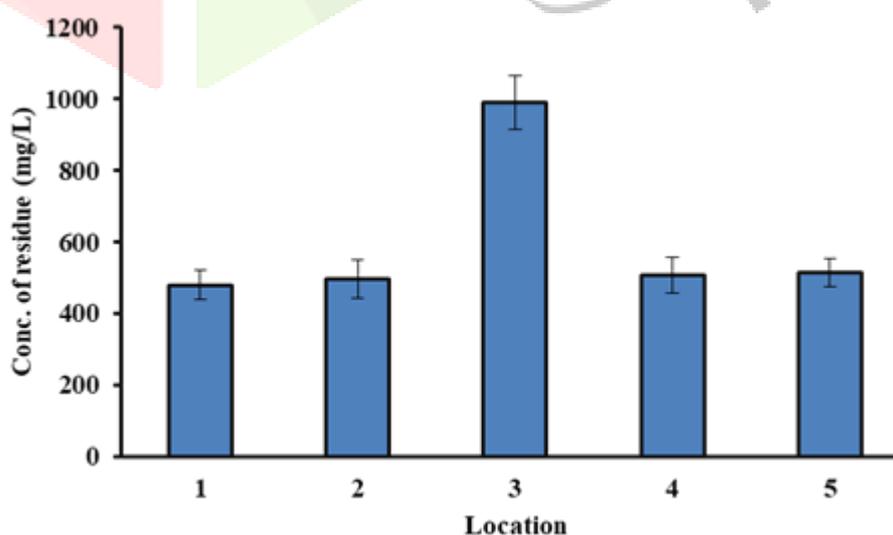


Figure 6- Total solid content in various water samples collected at different locations.

### 3.8. Biological Oxygen Demand (BOD)

Biochemical Oxygen Demand (BOD) is the measure of the degradable organic material present in a water sample, and can be defined as the amount of oxygen required by the micro-organisms for the biochemical degradation of organic matter under aerobic conditions or in stabilizing the biologically degradable organic matter under aerobic condition (Arlyapov et al., 2022). The BOD test is widely used to determine the pollution strength of domestic and Industrial wastes in terms of the oxygen that they will require if discharged into natural water courses in which aerobic conditions exist (<https://archive.epa.gov/water/archive/web/html/vms52.html>). BOD was highest at location 3 (Figure 7).

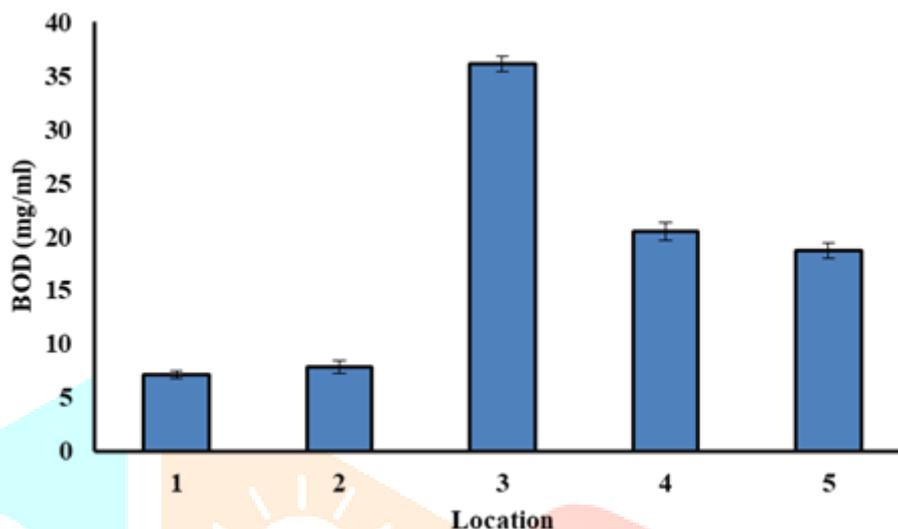


Figure 7- BOD of various water samples collected at different locations.

### 3.9. Chemical Oxygen Demand (COD)

The determination of COD values is of great importance where BOD values cannot be determined accurately due to the presence of toxins and other such unfavorable conditions for growth of micro-organisms (Geerdink et al., 2017). COD determinations has an advantages over BOD determinations, is that the result can be obtained in a about 5 hours as compared to 5 days required for BOD test, further the test is relatively easy, gives reproducible results and is not affected by interferences as the BOD test (<https://law.resource.org/pub/in/bis/S02/is.3025.58.2006.pdf>). Chemical oxygen demand (COD) is the amount of oxygen consumed during the chemical oxidation of the organic matter using a strong oxidizing agent (Lacalamita et al., 2024). COD values was found to be maximum at location 3 (Figure 8).

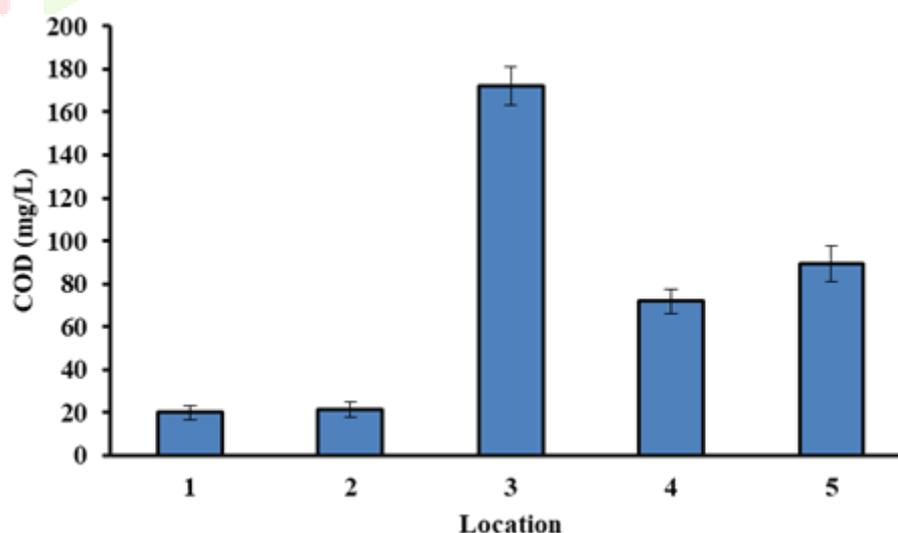


Figure 8- COD of various water samples collected at different locations.

### 3.10. Free carbon dioxide

Most of the free carbon dioxide in water comes from the decomposition of organic matter and from respiration of organisms (Yadav et al., 2021). In polluted water the free carbon dioxide is generally high (Vesper and Edenborn, 2012). Free CO<sub>2</sub> (mg/L) were ranged from Below detection limit to 5.39 (at site I), 6.00 (at site II), 36.52 ( at site III), 20.11 (at site IV), and 20.61 (at site V) (Figure 9).

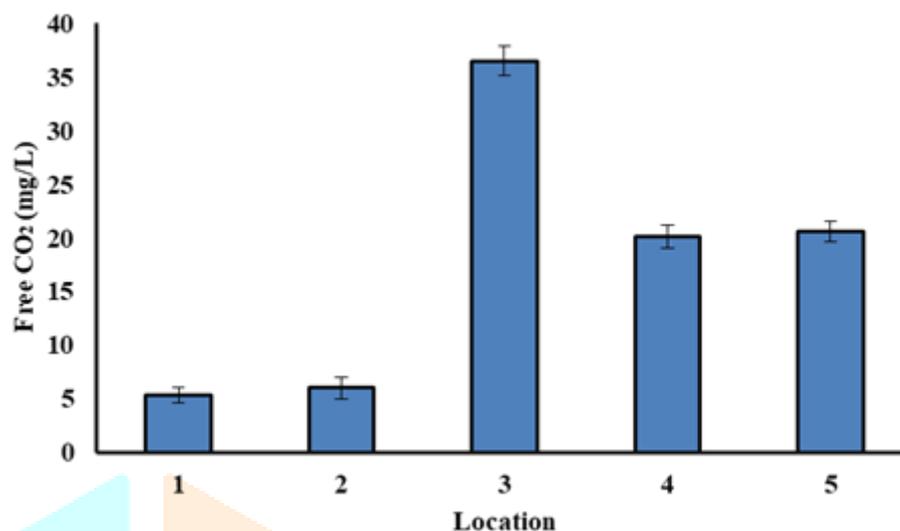


Figure 9- Free CO<sub>2</sub> of various water samples collected at different locations.

### 3.11. Total-alkalinity

It is the quantitative capacity of water samples to neutralize a strong acid to a designated pH (Hassan et al., 2009). The alkalinity of natural waters is due to the salts of carbonates, bicarbonates, borates, silicates and phosphates along with the hydroxyl ions in the free State. However the major portion of the alkalinity in natural water is caused by hydroxide, carbonate and bicarbonates which may be ranked in order of their association with high pH values. Alkalinity of water sample is the capacity to neutralize a strong acid to a given pH. It is also significant in determining the suitability of water for irrigation purpose (Islam and Hoque Majumdar, 2020). The alkalinity of water sample at location 3 was highest (Figure 10).

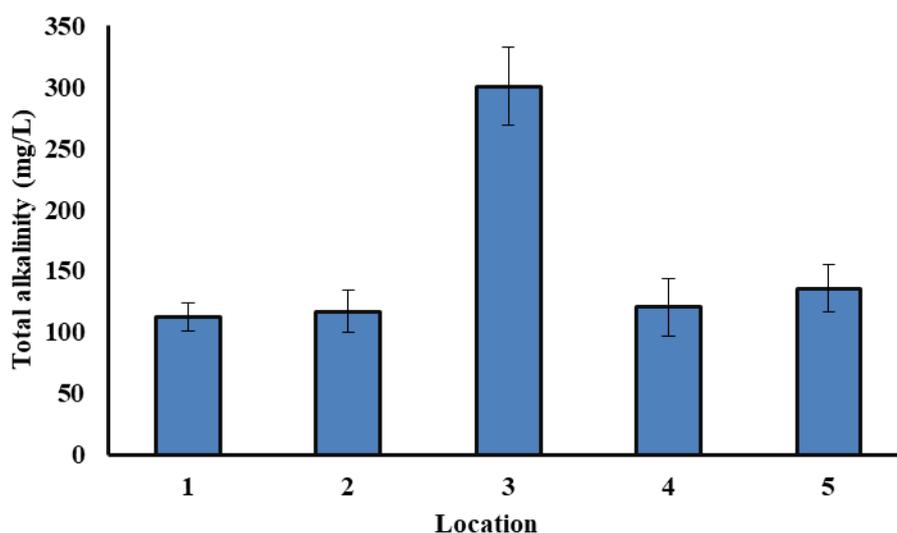


Figure 10. Alkalinity of various water samples collected at different locations.

### 3.12. Hardness

The water hardness is the traditional measure of the capacity of water to react with soap, as hard water requiring considerable more soap to produce lather. The hardness of water varies considerably from place to place. In general surface waters are softer than ground waters. Hard water forms heat insulating scales in the boilers reducing their efficiency (<https://www.usgs.gov/special-topics/water-science-school/science/hardness-water>).

Hardness of water makes it unfit for domestic and industrial purposes. It hinders the lather formation, increases the boiling-point of water and form heat insulating scales in the boilers. The values of hardness (mg/L) were ranged from 125.65 (at site I), 131.65 (at site II), 334.98 (at site III), 134.19 (at site IV), 149.62 (at site V) (Figure 11).

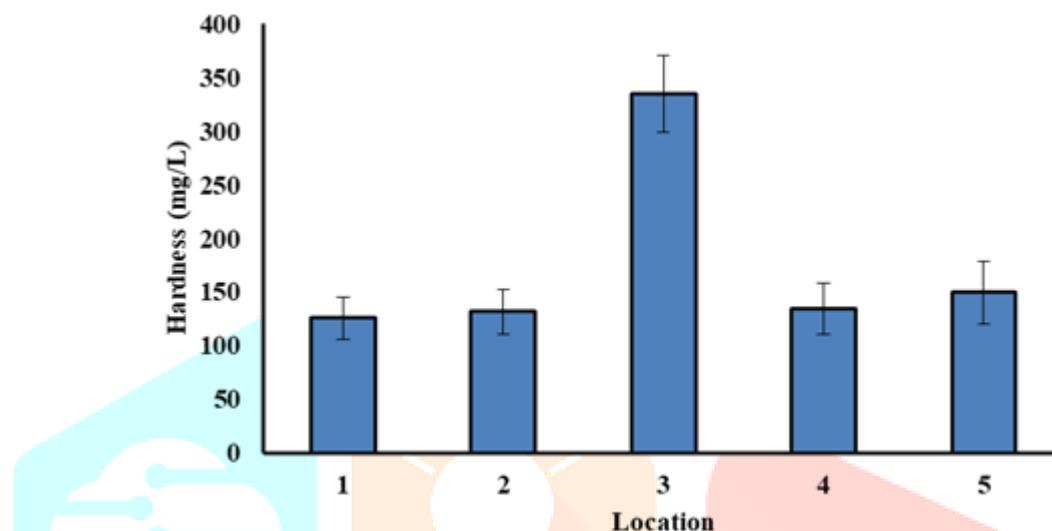


Figure 11- Hardness of various water samples collected at different locations.

### 4. Discussion

India holds a special position in the world for historical, geographical, religious, political, and sociocultural reasons (Agarwal et al., 2016). The Ramganga, the first tributary to reach the Ganga on its left bank, is a significant river in Uttar Pradesh. At 3110 meters above mean sea level, it rises in the lower Himalayas close to the village of Lobha in Utrakhnad's Garhwal region (Chandra et al., 2020). The river is roughly 596 kilometers long; the first 200 km of that length is in the state of Uttar Pradesh, while the remainder length is in Utrakhnad. Inside Jim Corbett National Park, it is confined by the Kalagarh dam before descending into the lowlands. Before joining the Ganga in Uttar Pradesh, the river passes through the cities of Bijnor, Moradabad, Bareilly, Badaun, Shahjehanpur, and Hardoi (Gangwar et al., 2013). Numerous environmental scientists in India have studied the physico-chemical and biological aspects of water quality (Trivedy and Goel, 1986; Kodarkar, 1992; Parveen et al., 2013). The Ramganga River has also been the subject of numerous researches (Rani and Kumar, 2014; Gangwar et al., 2021; Gangwar et al., 2012). These studies noted similar findings. Numerous variables can directly or indirectly affect the Ramganga River's water quality (Gangwar and Bhadauria, 2021).

Over the past few decades, pollution-causing activities have drastically altered aquatic habitats. The safe use of river water for drinking and other uses has recently been the subject of serious concerns. River water pollution is mostly caused by a variety of pollutants. For the majority of urban areas in emerging countries, it is one of the primary problems. Any nation's natural, cultural, and economic features are greatly influenced by its rivers (Rafiq, 2016). The quality of water is determined by its physical, chemical, and biological content (Allee and Johnson, 1999). The chemical composition is made up of materials including petroleum, detergents, insecticides, and heavy metals (Tiwari et al., 2020). Temperature, color, and turbidity make up the physical composition, while pigments and planktons make up the biological arrangement. Sampling from widely dispersed places is necessary for the observation and analysis of various water quality characteristics, which takes time and necessitates significant field and laboratory work to get statistical data (Shi et al., 2018). The higher values of BOD in winter at site III to V was due to the addition of sugar and distillery industry effluent along with sewage-water in to the river. The BOD variations give a quantitative index of the organic substances that are degraded quickly in a short span of time. The very high BOD and very low DO is a serious problem as it may cause mass-death of aquatic organism. Aquatic species may experience oxidative stress due to elevated levels of BOD in a river (Menon et al., 2023).

Severe abiotic stress, including oxidative stress in aquatic species, is brought on by changes in physicochemical parameters like pH, temperature, etc., as well as pollutants like crude oil, pesticides, and other toxins. Many studies have been conducted on oxidative stress in aquatic species, particularly fish. An essential physiological reaction in all animals, oxidative stress affects the amount, quality, growth, and reproduction of animals of water systems. Numerous studies have linked oxidative stress to the pathophysiology of assisted reproduction and infertility (Anetor et al., 2022; Menon et al., 2023). Proteins, lipids, carbohydrates, and DNA may all be affected by oxidative stress (Anwar et al., 2024c;), and oxidative stress is partially shown to be involved in endometriosis, tubal and peritoneal factor infertility, and infertility that cannot be explained (Anwar et al., 2023). Oxidative stress is associated with diabetes complications (Anwar et al., 2024d). The burden of kidney diseases on the world's health is substantial. An incurable condition that is spreading around the world and putting a financial and social burden on health systems is chronic kidney disease (CKD) (Anwar et al., 2024e). Because of its filtering capabilities, the kidney is especially vulnerable to the harmful effects of environmental contaminants, making prolonged exposure a major risk factor for kidney disorders (Meena et al., 2025).

Ramganga River's declining water quality is caused by sewage discharge. At all study sites, transparency is typically higher in the winter and lower during the monsoon season. According to this study, household, industrial, and human wastes are the primary causes of Ramganga river water contamination. Due to changes in human lifestyle, such as extensive industrialization, building projects, and the use of forest and agricultural land for other developmental objectives, the quality of water is fast declining. We found that the rate of water flow varies everywhere when we calculated the water's velocity. Due to the presence of domestic and industrial outfall in the study zone (site III to V), organic pollution was high. The maximum values of COD at sites I to II were recorded in rainy season (in September); and site III to V in winter season (in February). The reason for higher value of COD for site I and II (upstream) in rainy season was due to addition of agricultural runoff and organic debris, along with rainy water. The reason for higher value of COD at site III to V in winter was due to the effluent discharged from the sugar and distillery industries along with sewage water. It gives an idea about all kinds of utilizable organic-matter, both bio and non-bio-degradable. This test gives valuable information's about the pollution potential of industrial effluents and domestic sewage. The higher values of alkalinity (mg/L) were recorded at site III and at site V, in winter, among all sites, were due to discharge of industrial effluent into the river. As river descent from upstream to downstream, it receives contributions of polluted water from Bareilly city and sugar industries due to which, free CO<sub>2</sub> increases. In polluted water it is formed by the biological oxidation of organic matter. The higher values (mg/L) of hardness were recorded at site III and V, in winter, is due to the addition to sugar and distillery industry discharge into the river. Although hard-water has no know ill-effects on health but it is unsuitable for domestic uses. It also forms heat-insulating scales in the boilers and other heat exchange equipment, reducing its efficiency. Since, hardness of Ramganga 's water ranged from 66.12 to 334.32, it is unsuitable for industrial purposes also. Higher temperature indicates the presence of insoluble pollutants. Hence, more insoluble pollutants are present at location 3 and 5. Greater electrical conductivity suggests that higher amount of dissolved mineral salts is present. Therefore, the water of location 3 can be said as least suitable for drinking purpose. Higher alkanity may be caused by a greater amount of industrial effluents.

Current study reports that the water quality of the Ramganga River has been become not acceptable. According to the aforementioned view, the majority of the water characteristics already existed and could withstand certain restrictions. It still has time to reduce the contamination of the river water.

#### 4. Conclusions

Increasing water contamination is a serious issue. The largest health danger is contaminated water, which still poses a threat to public health and quality of life. The current analysis makes it evident that the pollution load in River environments was rising. The high association between many of the variables under investigation confirmed this conclusion. The study and findings unequivocally demonstrate that the primary causes of the decline in Ramganga River water quality, are domestic wastewater, and industrial effluents. Hence, Ramganga river water is not good for drinking purposes without any form of treatment recommended by CPCB. Therefore, waste must be properly collected, treated, and the flow must be controlled. In future, there is need for regular monitoring of water quality in order to detect changes in physiochemical parameters of river water at different sites, implementation of remediation measures and public awareness.

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## Author Contributions

Conceptulization: VK, PK; Writing the manuscript: VK; Review & editing: VK, PK.

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