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Microbial contamination in Ganga River Water: Public health implications and sources of sewage pollution in Haridwar

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Abstract

The Ganga River, a lifeline for millions in India, is facing severe microbial contamination due to untreated sewage discharge, particularly in urban centers like Haridwar. This study investigates the levels of microbial contamination, including fecal coliforms and pathogenic bacteria, in the Ganga River water in Haridwar and evaluates the associated public health risks. Water samples were collected from multiple locations along the river, and microbial analysis was conducted using standard microbiological techniques. The results revealed alarmingly high levels of fecal coliforms and pathogenic bacteria, exceeding permissible limits set by the Central Pollution Control Board (CPCB) and the World Health Organization (WHO). The study identifies sewage discharge as the primary source of microbial contamination and highlights the urgent need for improved sewage treatment infrastructure and public health interventions to mitigate the risks posed by contaminated river water.

Keywords: Microbial, Ganga River Water, CPCB, WHO, pollution

Introduction

The Ganga River, revered as a sacred entity in India, is a vital source of water for drinking, irrigation, and religious practices. However, rapid urbanization, industrialization, and population growth have led to increased pollution levels, particularly from untreated sewage discharge. Haridwar, a major pilgrimage site, attracts millions of devotees annually, exacerbating the pollution load on the river. Microbial contamination, including fecal coliforms and pathogenic bacteria, poses significant public health risks, as the river water is used for drinking, bathing, and other domestic purposes. This study aims to assess the levels of microbial contamination in the Ganga River water in Haridwar, identify the sources of sewage pollution, and evaluate the associated public health implications.

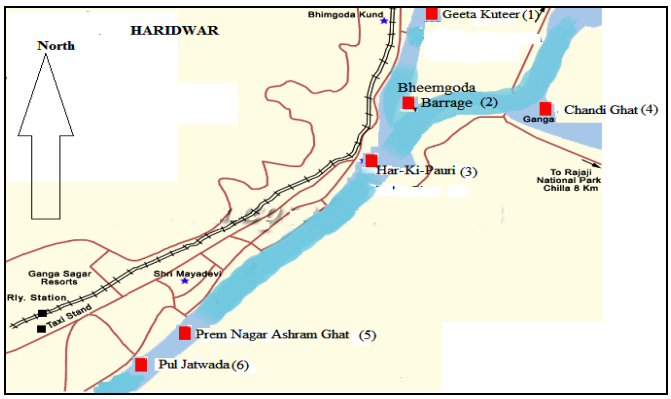

Fig 1: Map of Haridwar city showing location the of study site.

One of the largest cities in the state of Uttarakhand is Hardwar. Its religious significance is well known. Haridwar has a population of roughly 2.5 lakh. Conversely, approximately 75,000 individuals come here each day. Ganga water holds great religious significance, and every Hindu household keeps it in their houses. In addition, pilgrims drink this water (Achman) regardless of its purity. In Haridwar, there are roughly fourteen household drains that run straight into the Ganga River (canal). Thus, the purpose of this study is to ascertain how sewage in Haridwar City affects the Ganga River's biodiversity and water quality. There are roughly fourteen household drains that flow directly into the Ganga River or canal without being properly treated.

Numerous substances found in sewage contribute to pollution. Sewage pollution damages aquatic ecosystems' biological diversity in addition to posing a threat to water quality. Significant population growth also results in higher sewage levels in cities and municipalities. Sewage enters rivers directly because of inadequate treatment and a lack of sewage treatment facilities. As indicated earlier, Ganga water is also utilized for drinking (Achman); consequently, if it contains sewage, it could seriously harm humans. Many pathogenic microorganisms, including Salmonella typhi, Entamoeba histolytica, Ascaris gonorrhoeae, Teania, and other parasites, can be found in sewage.

On the basis of above account, the current study is being conducted to monitor the water quality of the Ganga River using physicochemical and biological parameters. The current study is attempted to find out the impact of sewage on water quality of Ganga River and status of River in terms of water quality and biological diversity at different places.

Aims and Objectives

The primary aim of this study is to assess the levels of microbial contamination in the Ganga River water in Haridwar and evaluate the public health risks associated with sewage discharge. The specific objectives are:

1. To analyze the levels of fecal coliforms and pathogenic bacteria in the Ganga River water at various sampling points in Haridwar.
2. To identify the primary sources of sewage pollution contributing to microbial contamination.
3. To assess the public health risks associated with the use of contaminated river water for drinking, bathing, and other domestic purposes.
4. To provide recommendations for improving sewage treatment infrastructure and public health interventions to mitigate the risks posed by microbial contamination.

Review of Literature

The Ganga River has been the subject of numerous studies focusing on microbial contamination and its public health implications. Previous research has highlighted the significant impact of sewage discharge on the microbial quality of river water. Studies conducted in various stretches of the Ganga River have reported elevated levels of fecal coliforms and pathogenic bacteria, particularly downstream of urban centers and sewage discharge points. The Central Pollution Control Board (CPCB) and other environmental agencies have consistently identified sewage as a major contributor to microbial contamination in the river. Despite various initiatives like the Ganga Action Plan (GAP) and Namami Gange, the river continues to face pollution challenges. This review synthesizes the findings of previous studies up to 2022, providing a comprehensive understanding of the current state of microbial contamination in the Ganga River and the associated public health risks.

The Buyuk Melen river basin's seasonal variations in water quality were assessed by Karagul *et al*. (2005) [11] in Duzce, Turkey. A study by Bhadra *et al*. (2005) [12] examined several fundamental water quality metrics in the Kaljani river, a tributary of the Torsa river in north Bengal Terai. Singh (2004) [13] discussed the environmental effects of pilgrimages and religious tourism in the Himalayan Mountains. In order to control the repercussions, waiting line management was recommended by Ravichandran and Subba Rao (2005) [14] in large pilgrimage centers.

The water quality of Uttarakhand's sacred Himalayan rivers. They found that a significant number of India's sacred rivers and locations are consistently contaminated due to poor municipal management and high pilgrimage rates. Examined a number of issues pertaining to the tourism business as well as the rapid growth of the industry and its impact on World Heritage Sites. A method of classification for municipal solid waste was created by Dixon and Langer (2006) [15] in order to assess how well solid waste management was operating.

Karthick and Ramachandra (2007) [16] examined hydrological and physicochemical parameters. They found that anthropogenic activities and seasonal variations were the causes of the physicochemical parameter fluctuation. According to Karat (2010) [17] research, tourism has a negative influence on both the ecology and the cultural significance of the location in question. Dulo and Otieno (2008) [18] studied a few physico-chemical characteristics of the Nairobi River in Kenya and found that various anthropogenic activities in the river were causing a degradation of all the physico-chemical parameters. Conducted a study on the physical and chemical parameters of the Kaveri River. They discovered significant depletion in all the parameters at the sample station that collected home waste water and municipal sewage.

Studies on the effects of adventure tourism in the Himalayan River Ganga were conducted by Farooquee *et al*. (2008) [19]. They found that visitors generate income, improve the region's infrastructure, raise locals' standards of living, are easily receptive to new experiences, and expose and develop new skills. In addition to their good effects, tourists also have negative effects on the environment, traditional agriculture, animal husbandry, youth mentality, elder respect in the community, increased workload for women, family dissolution, and increased out-migration.

Studied on the effects of human activity on drinking water quality and found that while the pH level was within allowable bounds, other parameters-such as BOD, DO, turbidity, total dissolved solids, phosphates, and ammonia-were not within allowable bounds due to a variety of anthropogenic activities. According to Puri *et al*. (2008) [20] who made an investigation on waste management and its effects on community health, water quality and the local community was experiencing a number of illnesses as a result of the solid waste being dumped in the problematic

regions, including loose motion, malaria, and kala azar.

The effects of human activity on the atmosphere were examined by Sharma and Dhariwal (2008) [21], who also classified the various pollutants that result from both natural and human activity. In a remote location, Leal *et al*. (2009) [22] described the local atmospheric emissions levels and contrasted them with the component resulting from global pollution.

Pollutants in water and the surrounding air rise during holidays due to the large number of pilgrims, cars, and people taking group baths in the Ganga River. Water contaminants, such as soap, detergents, sewage, and heavy metals, are known to cause significant health consequences in humans and to disrupt the aquatic life system. Solid waste management and sanitation issues are made worse during these festive times, which leads to an uncomfortable situation where stray dogs and pigs are drawn to the SW that is dumped.

One of these significant studies, looked at the effects of incorrect solid waste disposal on the physical, chemical, and biological parameters of subterranean water. All year long, Haridwar sees a large stream of pilgrims, but during celebratory days, the number rises by around six times compared to regular days. Varunprasath and Daniel (2010) [23] conducted research on the physico-chemical state of the Bhavani River in Tamilnadu. Studies on the effects of human activity on the environment, such as those conducted by Shirodhkar *et al*. (2010) [24], have shown that human activity has a major negative impact on environmental conditions, including water quality.

Bhardwaj *et al*. (2010) [25] used the Principle Component Analysis Ganga Plan to study the water quality of the Choti Gandak River. They found that anthropogenic activities are the cause of the pollution in the river, which has a negative impact on both plant development and human health. Abowei *et al*. (2010) [26] examined the salinity, DO, pH, and surface water temperature conditions in the Nkoro River. They found that the riverine environment and water quality were severely contaminated by a number of industrial establishments, the operation of slaughterhouses, residential activities, and seasonal variations. Abowei (2010) [26] conducted a study on the physico-chemical parameters of the Nkoro River and discovered that the upstream sampling stations had greater dissolved oxygen levels than the downstream stations.

Research Methodologies

Study Area

Haridwar, located in the state of Uttarakhand, India, was selected as the study area due to its significance as a pilgrimage site and the high volume of sewage discharge into the Ganga River. Sampling points were strategically chosen upstream and downstream of major sewage discharge points to assess the impact on microbial water quality.

Sampling and Analysis

Water samples were collected from multiple locations along the river during different seasons to account for seasonal variations. Microbial analysis included the enumeration of fecal coliforms and the identification of pathogenic bacteria such as Escherichia coli, Salmonella spp., and Vibrio cholerae. Standard microbiological techniques, including membrane filtration and selective media cultivation, were employed for microbial analysis. The Most Probable Number (MPN) method was used to quantify fecal coliforms, while biochemical and molecular techniques were used for the identification of pathogenic bacteria.

Data Analysis

The data collected were subjected to statistical analysis to determine the significance of differences in microbial contamination levels upstream and downstream of sewage discharge points. Correlation analysis was performed to identify relationships between microbial contamination levels and sewage discharge. The results were interpreted in the context of permissible limits prescribed by the CPCB and WHO guidelines for drinking water quality.

Results and Interpretation

The results of the microbial analysis revealed significant variations in microbial contamination levels upstream and downstream of sewage discharge points. Fecal coliform levels were found to be significantly higher downstream, with values ranging from 1.2 x 10^4 to 2.5 x 10^5 MPN/100 mL, compared to upstream values of 1.0 x 10^2 to 5.0 x 10^3 MPN/100 mL. Pathogenic bacteria, including Escherichia coli, Salmonella spp., and Vibrio cholerae, were also detected in higher concentrations downstream. The findings indicate a significant deterioration in microbial water quality downstream of sewage discharge points, with elevated levels of fecal coliforms and pathogenic bacteria.

The elevated levels of fecal coliforms and pathogenic bacteria downstream of sewage discharge points suggest a higher organic load and the presence of untreated sewage. The detection of pathogenic bacteria such as Salmonella spp. and Vibrio cholerae poses significant public health risks, as these pathogens can cause waterborne diseases such as typhoid, cholera, and gastroenteritis.

Discussion

The results of this study are consistent with previous research highlighting the impact of sewage discharge on the microbial quality of Ganga River water. The elevated levels of fecal coliforms and pathogenic bacteria downstream of sewage discharge points underscore the urgent need for effective sewage treatment and management strategies. The detection of pathogenic bacteria such as Salmonella spp. and Vibrio cholerae is particularly concerning, as these pathogens can cause severe waterborne diseases, particularly in populations that rely on the river for drinking and bathing.

The findings also highlight the limitations of existing pollution control measures, such as the Ganga Action Plan and Namami Gange, in addressing the issue of sewage discharge. Despite significant investments in infrastructure and treatment facilities, the river continues to face pollution challenges due to inadequate sewage treatment capacity and enforcement of regulations.

Conclusion

This study provides a comprehensive assessment of microbial contamination in the Ganga River water in Haridwar and evaluates the public health risks associated

with sewage discharge. The results indicate a significant deterioration in microbial water quality downstream of sewage discharge points, with elevated levels of fecal coliforms and pathogenic bacteria. The findings underscore the urgent need for effective sewage treatment and management strategies to mitigate the public health risks posed by microbial contamination. Recommendations include increasing sewage treatment capacity, enforcing stricter regulations, and promoting public awareness and participation in pollution control efforts.

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