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Pollution Dynamics of Kali Nadi and Its Impact on Aquatic Ecosystem and Agricultural Productivity in Aligarh District, Uttar Pradesh: A Review

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Abstract

River ecosystems play a crucial role in sustaining ecological balance, agricultural productivity, and human livelihoods. However, increasing industrialization and urbanization have led to severe degradation of freshwater resources. The Kali Nadi, an important tributary of the Ganga River flowing through western Uttar Pradesh, has experienced significant pollution due to untreated industrial effluents, domestic sewage, and agricultural runoff. The present review analyzes the environmental consequences of pollution in Kali Nadi with a special focus on its effects on aquatic ecosystems and agricultural productivity in the Aligarh region. Observations and water sampling from multiple districts indicate deterioration in water quality characterized by high concentrations of heavy metals, organic pollutants, and pathogenic microorganisms. These contaminants adversely affect fish diversity, soil fertility, groundwater quality, and crop yield in nearby agricultural fields. The study highlights the urgent need for strict environmental regulation, effective wastewater treatment systems, and sustainable agricultural practices to restore the ecological health of Kali Nadi and protect local communities dependent on this river.

Keywords **:** Kali Nadi, Water Pollution, Industrial Effluents, Agricultural Productivity, Aquatic Ecosystem, Aligarh

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Introduction

Freshwater rivers are essential for maintaining ecological balance and supporting human civilization. They provide water for domestic consumption, agriculture, industry, and biodiversity conservation. However, rapid industrialization, population growth, and urban expansion have significantly increased the discharge of pollutants into river systems worldwide (Jain *et al*., 2007). The Kali Nadi, a tributary of the Ganga River, originates in the Upper Shivalik region and flows through several districts of western Uttar Pradesh including Muzaffarnagar, Meerut, Hapur, Bulandshahr, Aligarh, Kasganj, Etah, Farrukhabad, and Kannauj before merging with the Ganga River. The river is culturally significant and serves as a major water source for more than a thousand villages located along its banks. Despite its importance, the Kali Nadi has become one of the most polluted rivers in the region. Industrial activities such as sugar mills, paper mills, distilleries, dairies, and chemical industries discharge untreated effluents directly into the river. These industries are categorized among the major pollution-generating sectors in India (Pathak, 2011). Domestic sewage is another significant contributor to river pollution. Large volumes of untreated wastewater from urban settlements are discharged into the river through drainage systems. Such sewage contains organic waste, detergents, oils, pathogens, and plastics, which deteriorate water quality and affect aquatic organisms. Agricultural runoff also contributes significantly to the contamination of the river. Farmers in western Uttar Pradesh use large quantities of fertilizers and pesticides to increase crop yield. These chemicals are transported into the river through rainfall and soil erosion processes. Due to these multiple pollution sources, the physico-chemical properties of the river water have deteriorated significantly. This pollution has not only affected aquatic biodiversity but has also contaminated groundwater and agricultural soils in nearby areas. The present review evaluates the environmental impact of pollution in Kali Nadi and its implications for aquatic ecosystems and agricultural productivity in the Aligarh region. Water pollution is a major environmental issue affecting river ecosystems worldwide. Industrial effluents and domestic sewage are the primary sources of contamination in most developing countries (Jain *et al*., 2007). Studies have shown that rivers receiving untreated industrial wastewater often contain high levels of heavy metals, organic pollutants, and toxic chemicals (Khan, 1987). The Kali Nadi has been identified as one of the most polluted tributaries of the Ganga basin. Historical studies indicate that the river once supported a healthy aquatic ecosystem and was widely used for irrigation and domestic purposes. However, increasing industrial activities along the riverbanks have drastically altered its ecological condition (Growse, 1884). Sugar mills and distilleries are major contributors to river pollution in western Uttar Pradesh. These industries discharge wastewater containing high concentrations of organic matter, chemicals, and suspended solids. When such effluents enter the river, they increase biochemical oxygen demand (BOD) and reduce dissolved oxygen levels, which

negatively affects aquatic organisms. Paper mills are another significant source of pollution in the Kali Nadi basin. Effluents from paper manufacturing processes contain toxic chemicals, dyes, and bleaching agents that contaminate river water and sediments. Long-term exposure to these pollutants can cause severe ecological damage. Domestic sewage also plays an important role in river contamination. Urban settlements located near the river discharge untreated wastewater directly into the water body. This sewage contains organic waste, pathogens, detergents, and plastics that degrade water quality and increase the risk of waterborne diseases among local communities. Previous studies conducted by environmental agencies have reported the presence of heavy metals such as lead, chromium, iron, and zinc in water samples collected from villages located along the Kali Nadi basin . Such contamination poses serious health risks to rural populations that depend on groundwater for drinking purposes. In addition to affecting human health, river pollution also impacts agricultural productivity. Irrigation with contaminated water can lead to the accumulation of heavy metals in soil, reducing soil fertility and crop yield. Therefore, understanding the extent and sources of pollution in the Kali Nadi is essential for developing effective environmental management strategies.

Materials and Methods

The present review is based on field observations and water sampling conducted along the course of the Kali Nadi from its origin in Muzaffarnagar district to its confluence with the Ganga River in Kannauj district. Water samples were collected from several locations including Khatauli, Meerut, Hapur, Bulandshahr, Aligarh, Kasganj, Farrukhabad, and Kannauj districts. Groundwater samples were also collected from hand pumps located near the river to assess the impact of river pollution on groundwater quality. The collected water samples were analyzed for physico-chemical parameters such as pH, dissolved oxygen, biochemical oxygen demand (BOD), chemical oxygen demand (COD), and heavy metal concentrations. Field surveys were also conducted to identify major pollution sources such as industrial effluent discharge points, sewage drains, and dumping of solid waste along the riverbanks.

Results and Discussion

Table 1-Major sources of pollution in Kali Nadi

Source	Location	Type of Pollutants
Sugar mills	Muzaffarnagar	Organic waste, molasses
Paper mills	Meerut	Dyes, bleaching chemicals
Distilleries	Aligarh	Alcohol waste, organic matter
Domestic sewage	Urban settlements	Pathogens, organic waste
Agricultural runoff	Rural farmland	Fertilizers, pesticides

Table 2-Environmental impacts of Kali Nadi pollution

Parameter	Observed Impact
Dissolved oxygen	Decrease in oxygen levels
Aquatic biodiversity	Decline in fish populations
Soil fertility	Reduced agricultural productivity
Groundwater quality	Contamination with heavy metals
Human health	Increased risk of waterborne diseases

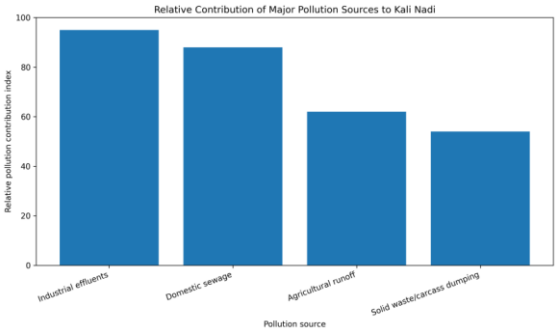

Figure 1. Relative Contribution of Major Pollution Sources to Kali Nadi

Figure 1 shows the relative contribution of major pollution sources affecting the Kali Nadi. Industrial effluents and domestic sewage were identified as the dominant contributors, followed by agricultural runoff and solid waste dumping. The figure highlights the cumulative anthropogenic pressure responsible for the deterioration of river water quality in the study corridor.

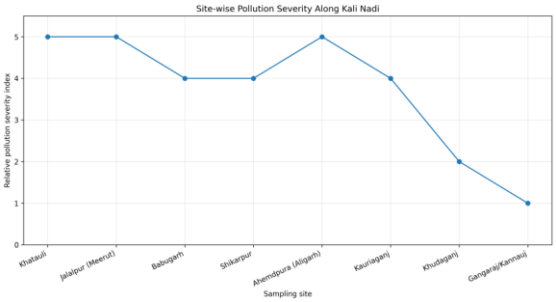

Figure 2. Site-wise Pollution Severity Along Kali Nadi

Figure 2 presents the relative pollution severity at major sampling locations along the Kali Nadi. The highest pollution severity was observed at Khatauli, Jalalpur, and Ahemdpura stretches, whereas downstream locations such as Khudaganj and Kannauj showed comparatively lower pollution intensity. The pattern reflects the influence of industrial discharge and urban sewage inputs in upstream and midstream sections.

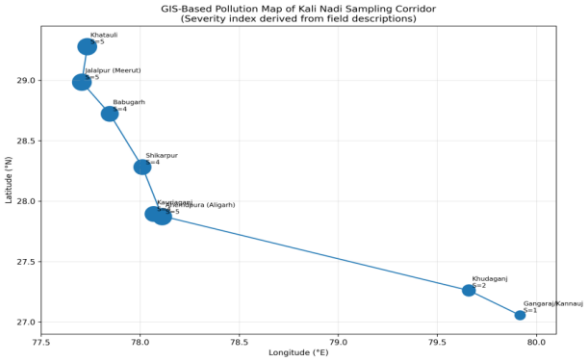

Figure 3. GIS-Based Pollution Map of Kali Nadi Sampling Corridor

Figure 3 illustrates a GIS-based pollution map of the Kali Nadi sampling corridor. The mapped locations represent major study sites from Khatauli to Kannauj, with symbol size indicating relative pollution severity. The map provides a spatial overview of pollution distribution and identifies the Aligarh stretch as one of the critically affected zones.

The results of the present study indicate that the Kali Nadi has experienced severe environmental degradation due to the combined effects of industrial discharge, domestic sewage, and agricultural runoff. Rivers in developing regions are often subjected to intense anthropogenic pressure due to rapid urbanization and industrial expansion, leading to deterioration of water quality and ecological imbalance (Jain, Agarwal, & Singh, 2007). The Kali Nadi basin is a typical example of such environmental stress, where untreated industrial effluents and sewage drains continuously pollute the river system. Industrial activities represent one of the most significant sources of pollution in the Kali Nadi basin. Sugar mills, paper mills, distilleries, and chemical industries located along the river discharge large volumes of wastewater containing organic pollutants, suspended solids, and heavy metals into the river. Industrial effluents from sugar processing units and distilleries contain high biochemical oxygen demand (BOD) and chemical oxygen demand (COD), which drastically reduce the dissolved oxygen concentration in water bodies (Pathak, 2011). Decreased dissolved oxygen levels negatively affect aquatic organisms, particularly fish and benthic invertebrates, which require oxygenated water for survival. Paper mills and chemical industries located in districts such as Meerut and Muzaffarnagar are particularly responsible for releasing toxic chemicals into the river. These effluents may contain dyes, bleaching agents, and heavy metals such as chromium, lead, and zinc. Long-term exposure to heavy metals may cause severe ecological damage, including disruption of aquatic food chains and bioaccumulation in fish tissues (Jain *et al*., 2007). The presence of these heavy metals in river water samples collected from several villages along the Kali Nadi basin has been previously reported, indicating widespread contamination of the river system . Domestic sewage is another major contributor to the pollution of the Kali Nadi. Rapid population growth and urban expansion have resulted in the discharge of large quantities of untreated wastewater from towns and cities located along the river. Sewage drains carry organic matter, pathogens, detergents, plastics, and household chemicals into the river, leading to severe degradation of water quality. According to environmental assessments, untreated domestic sewage contributes significantly to river eutrophication and microbial contamination (Khan, 1987). The presence of pathogenic microorganisms in sewage-contaminated water increases the risk of waterborne diseases among communities that rely on the river for domestic use. In rural areas where access to treated drinking water is limited, people often depend on groundwater sources located near the riverbanks. However, contamination of groundwater has also been observed in several villages located along the Kali Nadi basin. Previous reports have shown that groundwater samples collected from hand pumps in villages near the river contain elevated levels of heavy metals such as lead and chromium . These findings indicate that pollutants from the river may infiltrate underground aquifers through soil and sediment layers. Agricultural runoff also contributes significantly to the pollution of the Kali Nadi. Western Uttar Pradesh is one of the most agriculturally intensive regions of India, where farmers use large quantities of fertilizers, pesticides, and herbicides to enhance crop productivity. During rainfall events, these chemicals are washed from agricultural fields into nearby rivers through surface runoff. Excess nutrients from fertilizers promote eutrophication, resulting in excessive growth of algae and aquatic plants. Such algal blooms reduce oxygen levels in water and disrupt the ecological balance of aquatic ecosystems (Jain *et al*., 2007). The decline in water quality of the Kali Nadi has serious ecological consequences for aquatic biodiversity. Fish populations in polluted river stretches have declined significantly due to reduced oxygen levels and toxic contamination. Aquatic organisms are highly sensitive to changes in water chemistry, and the accumulation of pollutants can cause physiological stress, reproductive failure, and mortality among fish species. Similar observations have been reported in several polluted rivers of India where industrial discharge and sewage contamination have led to loss of aquatic biodiversity (Pathak, 2011). Another important consequence of river pollution is its impact on agricultural productivity. Farmers living along the Kali Nadi frequently use river water for irrigation due to limited availability of alternative water sources. However, irrigation with contaminated water may introduce heavy metals and toxic chemicals into agricultural soils. Over time, these contaminants accumulate in the soil and reduce its fertility. Crops grown in contaminated soils may also accumulate toxic substances, which can enter the food chain and pose health risks to humans and livestock. Soil contamination caused by polluted irrigation water can also affect plant growth and crop yield. Studies have shown that heavy metals such as lead and chromium can inhibit plant metabolic processes, reduce nutrient uptake, and interfere with photosynthesis. As a result, agricultural productivity in areas irrigated with polluted water may decline over time. The pollution of the Kali Nadi also has significant socio-economic implications for local communities. Rural populations living along the river depend heavily on agriculture, fisheries, and groundwater resources for their livelihood. Declining water quality therefore affects both food security and economic stability in these regions. In addition, the contamination of groundwater used for drinking purposes increases the risk of chronic health problems among rural populations.

Despite the alarming environmental condition of the Kali Nadi, there are opportunities for restoration and sustainable management of the river ecosystem. Effective wastewater treatment systems must be installed in industries located along the river to prevent the discharge of untreated effluents. Strict monitoring and enforcement of environmental regulations are also necessary to control industrial pollution. Municipal authorities should implement sewage treatment plants in urban areas to ensure that domestic wastewater is treated before being discharged into the river. Several government initiatives have been launched to restore polluted rivers under national river conservation programs. The Kali Nadi has also been identified as a priority river for restoration under river basin management initiatives aimed at improving water quality and protecting aquatic ecosystems (Jain *et al*., 2007). Community participation is also essential for successful river restoration programs. Public awareness campaigns should be conducted to educate people about the importance of protecting river ecosystems. Local communities, industries, and government agencies must work together to reduce pollution and restore the ecological health of the river. In addition, sustainable agricultural practices should be promoted in the Kali Nadi basin to reduce chemical runoff into the river. Farmers should be encouraged

to adopt integrated pest management techniques and organic farming practices to minimize the use of chemical fertilizers and pesticides. Overall, the evidence presented in this study suggests that pollution in the Kali Nadi has severe ecological, agricultural, and public health consequences. Immediate intervention and long-term environmental management strategies are required to restore the ecological balance of this important river system and ensure sustainable use of its water resources.

Conclusion

The Kali Nadi has undergone significant environmental degradation due to industrial effluents, domestic sewage, and agricultural runoff. Pollution has severely affected aquatic biodiversity, groundwater quality, and agricultural productivity in the Aligarh region. Effective wastewater treatment systems, strict environmental regulations, and sustainable agricultural practices are essential to restore the ecological health of the river.

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