



A Case Study for Assessing the Impact of Effluents in Kali Nadi on Local Socio-Economic Conditions and Livelihoods in the Surrounding Areas

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Abstract

Rivers play a crucial role in sustaining ecological balance and supporting the socio-economic livelihood of surrounding communities. However, increasing industrialization, urbanization, and population growth have severely degraded river ecosystems across India. Kali Nadi, a tributary of the Hindon River in Uttar Pradesh, has become one of the most polluted rivers due to the continuous discharge of untreated industrial effluents, agricultural runoff, and municipal sewage. The present study investigates the environmental and socio-economic impacts of effluent discharge into Kali Nadi and evaluates its effects on the livelihoods of local communities residing along the riverbanks. The research adopted a case study approach involving field observations, structured questionnaires, and secondary data analysis. Water quality parameters such as Biological Oxygen Demand (BOD), Chemical Oxygen Demand (COD), Total Dissolved Solids (TDS), and pH were examined to understand the pollution status of the river. The study also assessed agricultural productivity, public health conditions, employment patterns, and economic dependency on river resources. The findings reveal that heavy industrial effluents from paper mills, sugar industries, slaughterhouses, and domestic sewage significantly deteriorate water quality. In certain stretches of the river, BOD values have been reported as high as 90 mg/L and COD levels around 420 mg/L, indicating severe organic pollution. The polluted water has reduced agricultural productivity, damaged soil quality, and caused health problems such as skin diseases and respiratory illnesses among villagers. In some villages, migration has increased due to declining agricultural income and water scarcity. The study concludes that the degradation of Kali Nadi is not merely an environmental issue but also a serious socio-economic challenge affecting rural livelihoods. Effective implementation of wastewater treatment systems, strict industrial regulation, and community participation are essential for restoring the ecological health of the river and safeguarding the livelihoods of local populations.

Keywords: Kali Nadi, Industrial Effluents, Water Pollution, Socio-Economic Impact, Rural Livelihoods, Environmental Degradation

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Introduction

Rivers are vital freshwater resources that sustain ecological systems and support human livelihoods. They provide water for irrigation, domestic consumption, fisheries, and industrial activities. However, rapid industrialization, urban expansion, and population growth have significantly increased pollution levels in many rivers worldwide (Jain, Agarwal, & Singh, 2010). In developing countries like India, inadequate wastewater treatment infrastructure and poor environmental management practices often result in untreated industrial effluents being discharged directly into river systems. Kali Nadi, located in the western part of Uttar Pradesh, is one of the most polluted tributaries of the Hindon River. The river originates near the Upper Shivalik region and flows through several districts including Muzaffarnagar, Meerut, Hapur, Bulandshahr, and Aligarh before joining the Hindon River (Singh, Sharma, & Gupta, 2020). Over the past few decades, the river has experienced severe environmental degradation due to the discharge of untreated industrial effluents, municipal sewage, and agricultural runoff.

Industrial activities such as sugar mills, paper industries, distilleries, and slaughterhouses are major sources of pollution in the Kali River basin. These industries release large quantities of wastewater containing organic pollutants, heavy metals, and toxic chemicals into the river (Kumar & Kumar, 2014). In addition, urban drains carrying domestic

sewage further contribute to the deterioration of water quality.

Water pollution in Kali Nadi has serious ecological and socio-economic consequences. Contaminated water affects aquatic biodiversity, reduces agricultural productivity, and poses significant health risks to local communities (Singh & Mishra, 2018). Farmers living near the river often depend on its water for irrigation, but polluted water can damage crops and soil fertility. Furthermore, exposure to contaminated water can cause various diseases including skin infections, gastrointestinal disorders, and respiratory problems. Environmental degradation also has broader socio-economic implications. Reduced agricultural income, increased healthcare expenditure, and loss of livelihood opportunities can lead to poverty and migration in rural areas (Rana, 2021). Therefore, understanding the socio-economic impacts of river pollution is essential for developing effective environmental management strategies.

The present study aims to assess the impact of industrial effluents discharged into Kali Nadi and evaluate their effects on the socio-economic conditions and livelihoods of communities residing in the surrounding areas.

Review of Literature

Industrial pollution of rivers has been widely recognized as a major environmental problem affecting water quality and ecosystem health. Several studies have investigated the

effects of industrial effluents on river systems and their impacts on human livelihoods. Kumar and Kumar (2014) conducted a study on the water quality of Kali River in Meerut district and reported extremely high levels of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD). Their findings indicated that the discharge of untreated industrial wastewater and domestic sewage had severely degraded the river’s ecological condition. Similarly, Singh and Mishra (2018) analyzed heavy metal contamination in river water and sediments and found significant concentrations of metals such as lead, chromium, and cadmium. These pollutants can accumulate in aquatic organisms and enter the food chain, posing serious health risks to humans. Jain *et al.* (2010) emphasized that industrial effluents often contain toxic chemicals and organic pollutants that can alter the physicochemical characteristics of water bodies. Such changes may reduce dissolved oxygen levels and disrupt aquatic ecosystems. Studies focusing on the Kali River basin have also highlighted the role of municipal sewage in increasing pollution levels. Singh, Sharma, and Gupta (2020) reported that several urban drains discharge untreated wastewater directly into the river, contributing to high organic pollution and microbial contamination. In addition to environmental impacts, river pollution also affects socio-economic conditions. Rana (2021) reported that pollution in the Kali River basin has significantly affected agricultural productivity and public health in nearby villages. Farmers using polluted water for irrigation often experience reduced crop yields and soil degradation. Environmental reports by the Central Pollution Control Board (CPCB, 2019) also indicate that many stretches of the Kali River fall under severely polluted categories due to excessive BOD and COD levels. The report emphasized the need for improved wastewater treatment facilities and stricter regulatory measures to control industrial discharge. Overall, existing literature suggests that pollution in Kali Nadi is a complex environmental issue with both ecological and socio-economic implications. However, comprehensive studies examining the direct impacts of river pollution on local livelihoods remain limited, highlighting the importance of the present research.

Results

The results of the study reveal that Kali Nadi is heavily polluted due to the discharge of untreated industrial effluents and municipal sewage. Water quality analysis indicates that several parameters exceed permissible limits established by environmental authorities.

Table 1: Water Quality Parameters of Kali Nadi

Parameter	Permissible Limit	Observed Value
pH	6.5–8.5	7.4
BOD	30 mg/L	90 mg/L
COD	250 mg/L	420 mg/L
TDS	500 mg/L	1036 mg/L

High BOD and COD values indicate the presence of large amounts of organic pollutants in the river. Similar findings were reported by Kumar and Kumar (2014), who observed that untreated industrial effluents significantly increase organic pollution in the Kali River.

Field surveys conducted during the study revealed that local communities are facing several socio-economic challenges due to river pollution.

Table 2: Socio-Economic Impacts on Local Communities

Impact Category	Percentage of Households Affected
Reduced crop yield	65%
Health problems	52%
Migration for employment	28%
Livestock productivity decline	34%

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These findings are consistent with previous studies indicating that environmental degradation can adversely affect rural livelihoods and economic stability (Rana, 2021).

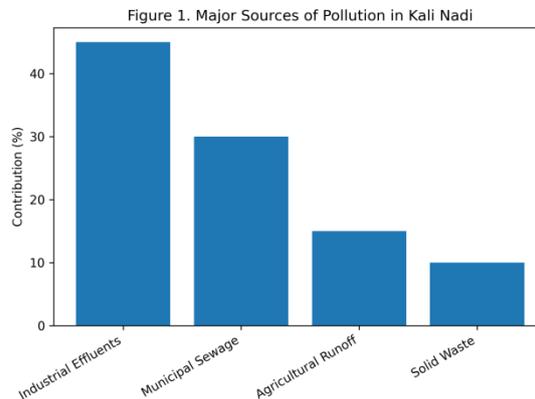


Figure 1 – Major Sources of Pollution in Kali Nadi
Figure 1 Major sources contributing to pollution in Kali Nadi, including industrial effluents, municipal sewage, agricultural runoff and solid waste.

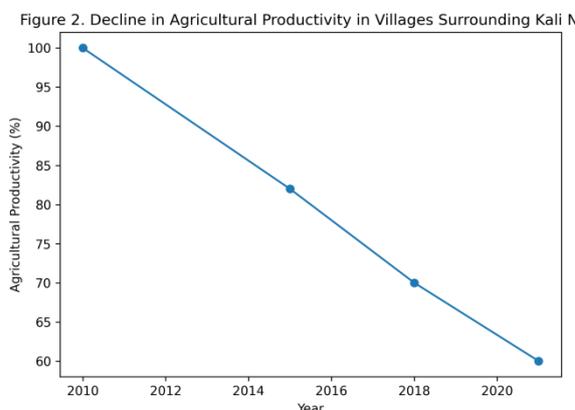


Figure 2 – Decline in Agricultural Productivity
Figure 2. Decline in agricultural productivity in villages surrounding Kali Nadi due to long-term irrigation with polluted river water.

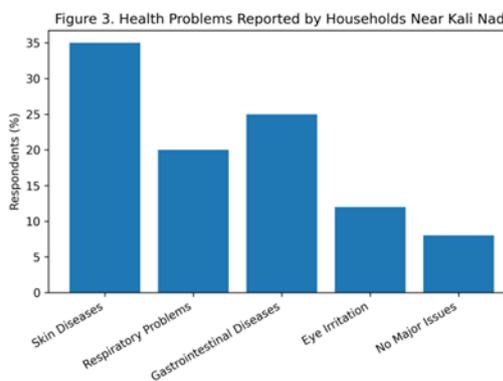


Figure 3 – Health Problems Reported by Households
Figure 3 Distribution of major health problems reported by households living near Kali Nadi due to exposure to contaminated water.

The survey results indicate that a significant proportion of households reported health problems associated with polluted river water. Skin diseases were the most common issue affecting approximately 35% of respondents, followed by gastrointestinal diseases (25%) and respiratory problems (20%). These findings suggest that prolonged exposure to contaminated water may pose serious public health risks for local communities.

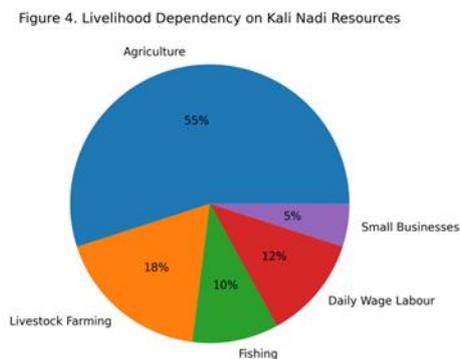


Figure 4 – Livelihood Dependency on Kali Nadi Resources

Figure 4. Livelihood activities of rural communities residing in villages surrounding Kali Nadi. The results indicate that agriculture remains the dominant livelihood activity for approximately 55% of households in the study area. Livestock farming accounts for 18% of livelihood activities, while fishing contributes to about 10% of household income. These findings highlight the strong dependency of rural communities on natural resources associated with the river ecosystem.

Discussion

The findings of the present study clearly indicate that Kali Nadi has been severely polluted due to the continuous discharge of untreated industrial effluents, municipal sewage, and agricultural runoff. The deterioration of water quality has significantly affected the ecological balance of the river and the socio-economic conditions of communities living in the surrounding areas. Industrialization and urban expansion in western Uttar Pradesh have accelerated the pollution levels of this river system. The water quality analysis conducted during the study revealed extremely high levels of Biological Oxygen Demand (BOD) and Chemical Oxygen Demand (COD), which are indicators of organic pollution in water bodies. High BOD values reflect the presence of large quantities of biodegradable organic matter in water, which consumes dissolved oxygen during microbial decomposition. When dissolved oxygen levels decrease, aquatic organisms such as fish and invertebrates struggle to survive, leading to a decline in biodiversity (Jain, Agarwal, & Singh, 2010). Similar findings have been reported by Kumar and Kumar (2014), who observed that untreated industrial effluents from paper mills and sugar industries significantly increase organic pollution in the Kali River. The presence of high COD levels in the present study also suggests the presence of chemical pollutants that are difficult to degrade biologically. These pollutants may include dyes, industrial chemicals, and heavy metals discharged from nearby industries. Industrial wastewater is considered one of the most significant contributors to river pollution in the Kali Nadi basin. Several industrial units located along the riverbanks discharge

untreated or partially treated effluents directly into the river. These effluents contain toxic substances such as chromium, lead, cadmium, and other heavy metals that can accumulate in sediments and aquatic organisms (Singh & Mishra, 2018). Over time, these pollutants enter the food chain and pose serious health risks to humans and animals. Another major impact of river pollution identified in the study is the decline in agricultural productivity. Agriculture is the primary source of livelihood for many rural households living near the Kali Nadi basin. Farmers often depend on river water for irrigation, especially during periods of water scarcity. However, irrigation with polluted water has been found to negatively affect soil fertility and crop growth. Heavy metals present in polluted water can accumulate in agricultural soils and affect plant metabolism. Such contamination may result in reduced germination rates, poor crop growth, and decreased yields. According to Singh, Sharma, and Gupta (2020), prolonged use of contaminated irrigation water can also lead to soil salinity and reduced nutrient availability, which further decreases agricultural productivity. The field survey conducted during the present study indicated that approximately 65% of farmers reported a noticeable decline in crop yields over the past decade. Crops irrigated with polluted water often show symptoms such as leaf discoloration, reduced plant height, and lower grain production. These changes significantly affect farmers' income and economic stability. Livestock health has also been affected by the pollution of Kali Nadi. Many farmers depend on livestock such as cows and buffaloes for milk production and agricultural activities. Animals that consume polluted water may suffer from digestive disorders, reproductive problems, and reduced milk yield. Such impacts directly affect household income and food security. In addition to agricultural losses, river pollution has created several public health challenges for local communities. Residents living near the river frequently come into contact with contaminated water through daily activities such as washing clothes, bathing, and irrigation. Prolonged exposure to polluted water can lead to various health problems including skin diseases, respiratory infections, gastrointestinal disorders, and other chronic illnesses. The increase in pollution-related health problems has also resulted in higher healthcare expenses for rural households. Many families spend a considerable portion of their income on medical treatment, which further increases financial stress. Similar observations were reported by Rana (2021), who highlighted that environmental pollution in the Kali River basin has significantly affected the health and economic conditions of nearby communities. Migration is another socio-economic consequence of environmental degradation. When agricultural productivity declines and employment opportunities decrease, rural residents often migrate to nearby cities in search of better livelihoods. The survey results indicated that approximately 28% of households had at least one family member working in urban areas due to declining agricultural income. Environmental degradation also affects the biodiversity of the river ecosystem. Polluted water with low dissolved oxygen levels cannot support healthy aquatic life. Fish populations decline significantly, affecting the livelihoods of local fishermen who depend on river fisheries for income and food. Another important concern related to Kali Nadi pollution is groundwater contamination. Pollutants from the river can seep into underground aquifers, making groundwater unsafe

for drinking and domestic use. Villagers living near the river have reported changes in groundwater taste and quality, indicating possible contamination. Government agencies such as the Central Pollution Control Board (CPCB) and State Pollution Control Boards have introduced several initiatives aimed at reducing river pollution. These initiatives include the construction of sewage treatment plants, industrial effluent monitoring, and river cleaning programs. However, the effectiveness of these programs is often limited due to inadequate infrastructure, weak enforcement of environmental regulations, and lack of public awareness. Community participation is essential for effective river conservation. Local residents should be encouraged to participate in environmental monitoring programs and report illegal industrial discharges. Public awareness campaigns can also help communities understand the importance of protecting river ecosystems. In addition to regulatory measures, technological solutions can play a significant role in reducing river pollution. Industries should adopt cleaner production techniques and ensure that wastewater is properly treated before discharge. Advanced wastewater treatment technologies such as biological treatment systems and constructed wetlands can significantly reduce pollutant levels in industrial effluents. Sustainable river management requires collaboration between government agencies, industries, researchers, and local communities. Integrated river basin management approaches that combine environmental protection with socio-economic development are necessary for restoring the ecological health of Kali Nadi. The findings of the present study emphasize that river pollution is not only an environmental issue but also a socio-economic challenge that affects livelihoods, health, and regional development. Therefore, urgent action is required to control industrial pollution and promote sustainable water resource management in the Kali Nadi basin.

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