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Analysis of Organic Pollutants in the Kali River of Muzaffarnagar Region: Sources, Environmental Impact and Remediation Strategies

Meenal Maan, Ritika Saharawat, Dr. Rishabh Bhardwaj
Department of Chemistry, Shri Ram College, Muzaffarnagar.

Abstract- The Kali River, originating from Antwada village in Muzaffarnagar district, Uttar Pradesh, is one of the most polluted river systems in northern India. Rapid industrialization, urbanization, and intensive agricultural practices have significantly increased the discharge of organic pollutants into the river. The present study reviews the occurrence, sources, environmental impacts, and remediation strategies associated with organic pollutants in the Kali River of the Muzaffarnagar region. Major pollution sources include untreated industrial effluents from sugar mills, paper mills, distilleries, textile units, domestic sewage, and agricultural runoff. Elevated levels of Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), pesticides, phenolic compounds, surfactants, and other organic contaminants have severely degraded water quality. The study highlights ecological consequences such as dissolved oxygen depletion, biodiversity loss, eutrophication, and contamination of agricultural soils and groundwater. Advanced remediation approaches including wastewater treatment technologies, bioremediation, phytoremediation, constructed wetlands, and integrated river basin management are discussed. Sustainable implementation of these measures is essential for restoring the ecological integrity of the Kali River and safeguarding public health.

Keywords- Kali River, Organic Pollutants, Water Quality, Muzaffarnagar, Industrial Effluents, Bioremediation, River Restoration.

I. INTRODUCTION

Freshwater ecosystems are vital for sustaining biodiversity, agriculture, industry, and human well-being. However, increasing anthropogenic activities have led to significant deterioration of river water quality worldwide. In India, rivers located in densely populated and industrialized regions are particularly vulnerable to pollution.

The Kali River originates from Antwada village in Muzaffarnagar district of Uttar Pradesh and traverses several districts before joining the Ganga River near Kannauj. The river receives substantial loads of untreated industrial wastewater, municipal sewage, and agricultural runoff, making it one of the most polluted rivers in western Uttar Pradesh.

Studies have reported severe deterioration in water quality, oxygen depletion, and accumulation of pollutants due to continuous discharge of untreated wastes. Industrial sectors including sugar processing, paper manufacturing, distilleries, slaughterhouses, and textile units contribute significantly to organic pollution loading.

Organic pollutants are of particular concern because of their persistence, toxicity, bioaccumulation potential, and adverse effects on aquatic ecosystems and human health. Therefore, understanding their sources, environmental impacts, and mitigation strategies is essential for effective river restoration. The present study aims to analyze the occurrence of organic pollutants in the Kali River of Muzaffarnagar and evaluate potential remediation strategies for sustainable water resource management.

II. STUDY AREA

The Kali River originates in Muzaffarnagar district and flows approximately 300 km through western Uttar Pradesh before joining the Ganga River. The river basin supports intensive agriculture and numerous industrial establishments.

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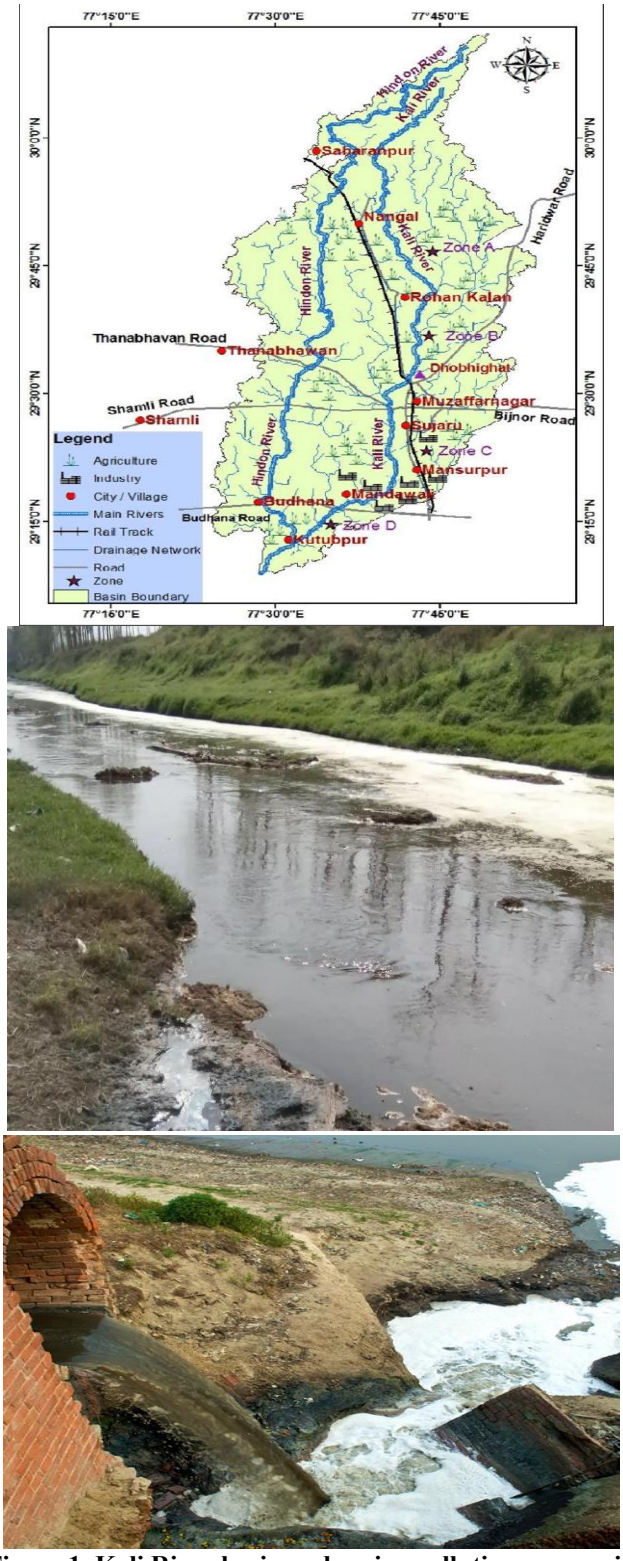

Figure 1. Kali River basin and major pollution sources in western Uttar Pradesh

Geographic Characteristics

Parameter	Description
River Name	Kali River (Kali Nadi)
Origin	Antwada Village, Muzaffarnagar
Length	~300 km
State	Uttar Pradesh
Major Districts	Muzaffarnagar, Meerut, Hapur, Bulandshahr, Aligarh, Etah, Farrukhabad, Kannauj
Confluence	Ganga River

III. SOURCES OF ORGANIC POLLUTANTS

Industrial Effluents

Industrial activities contribute substantially to the organic pollution load of the Kali River.

Major polluting industries include:

- Sugar mills
- Distilleries
- Paper and pulp industries
- Textile processing units
- Food processing industries
- Slaughterhouses

These industries release wastewater rich in:

- Organic matter
- Phenolic compounds
- Dyes
- Detergents
- Hydrocarbons
- Suspended solids

Previous studies indicate that industrial discharges account for a major share of pollution entering the river system.

Municipal Sewage

Rapid population growth in Muzaffarnagar and nearby urban centers has increased sewage generation. A significant portion of untreated or partially treated sewage enters the river through drains.

Sewage contributes:

- Organic carbon
- Nutrients
- Pathogens
- Pharmaceuticals
- Household detergents

Agricultural Runoff

The Kali River basin is characterized by intensive cultivation of:

- Sugarcane
- Wheat
- Rice

Agricultural runoff introduces:

- Pesticides
- Herbicides
- Insecticides
- Fertilizers
- Organic residues

Non-point source pollution from agricultural activities has been recognized as a significant contributor to nutrient and organic loading in the river.

IV. MAJOR ORGANIC POLLUTANTS IDENTIFIED

Pollutant Category	Sources	Environmental Concern
Pesticides	Agriculture	Toxicity to aquatic life
Phenolic Compounds	Distilleries, paper mills	Carcinogenicity
Surfactants	Domestic sewage	Foaming and toxicity
Hydrocarbons	Industrial discharge	Bioaccumulation
Organic Acids	Distilleries	Oxygen depletion
Dyes and Colorants	Textile industries	Reduced light penetration
Detergents	Household wastewater	Eutrophication

V. WATER QUALITY CHARACTERISTICS

Organic pollution significantly alters water quality parameters.

Parameter	Acceptable Limit*	Impact of High Values
BOD	<3 mg/L	Organic pollution
COD	<10 mg/L	Chemical contamination
Dissolved Oxygen	>5 mg/L	Aquatic life survival
Total Organic Carbon	Low	Pollution indicator
Nitrate	<45 mg/L	Eutrophication
Phosphate	<0.1 mg/L	Algal bloom

Table 2. Typical Water Quality Indicators in Polluted River Systems

Indicative standards

Studies on Kali River have reported oxygen depletion and elevated BOD and COD levels due to heavy organic loading.

VI. ENVIRONMENTAL IMPACTS

Impact on Aquatic Ecosystems

Organic pollutants adversely affect aquatic biodiversity by:

- Reducing dissolved oxygen
- Causing fish mortality
- Altering microbial communities
- Destroying breeding habitats

Excessive pollution has resulted in stretches exhibiting critically low oxygen levels and ecological degradation.

Eutrophication

High nutrient concentrations stimulate excessive algal growth. Consequences include:

- Algal blooms
- Reduced sunlight penetration
- Oxygen depletion
- Loss of aquatic biodiversity

Soil and Agricultural Impacts

Use of polluted river water for irrigation may lead to:

- Soil contamination
- Reduced crop productivity
- Altered soil microbial activity
- Accumulation of toxic residues

Human Health Risks

Exposure pathways include:

- Drinking contaminated groundwater
- Consumption of contaminated crops
- Direct contact during bathing and washing

Potential health effects include:

- Gastrointestinal disorders
- Skin diseases
- Neurological effects
- Cancer risks associated with persistent organic contaminants

VII. REMEDIATION STRATEGIES

Advanced Wastewater Treatment

Recommended technologies include:

Technology	Pollutant Removal Efficiency
Activated Sludge Process	High
Membrane Bioreactors	Very High
Advanced Oxidation Processes	Excellent
Anaerobic Digesters	High
Sequencing Batch Reactors	High

Bioremediation

Bioremediation utilizes microorganisms capable of degrading organic pollutants.

Advantages:

- Cost-effective
- Eco-friendly
- Sustainable

Common microorganisms:

- Pseudomonas spp.
- Bacillus spp.
- Aspergillus spp.

Phytoremediation

Aquatic plants can absorb pollutants from contaminated water.

Suitable species:

Plant Species	Function
Water Hyacinth	Organic pollutant uptake
Typha latifolia	Nutrient removal
Phragmites australis	Wetland treatment
Vetiver Grass	Bank stabilization

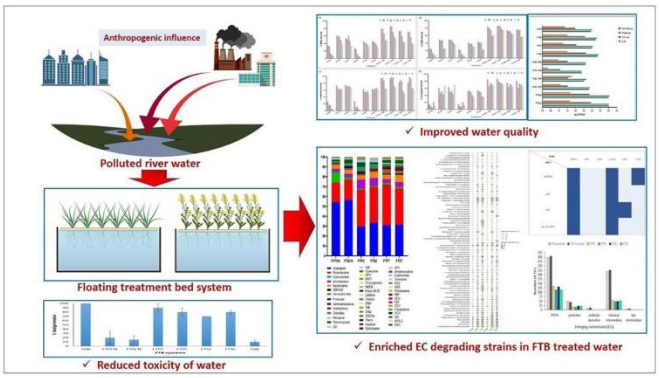

Figure 2. Sustainable remediation approaches for river pollution control

Constructed Wetlands

Constructed wetlands offer:

- Natural filtration
- Nutrient removal
- Reduced maintenance costs
- Habitat restoration

River Basin Management

Integrated management should include:

- Strict industrial discharge regulation
- Expansion of sewage treatment facilities
- Continuous water quality monitoring
- Community participation
- Sustainable agricultural practices

VIII. FUTURE RESEARCH DIRECTIONS

Future studies should focus on:

- Seasonal monitoring of organic pollutants
- Emerging contaminants (pharmaceuticals and microplastics)
- GIS-based pollution mapping
- Remote sensing applications
- Ecological risk assessment
- Development of low-cost treatment technologies

IX. CONCLUSION

The Kali River in the Muzaffarnagar region is under severe environmental stress due to continuous discharge of industrial effluents, domestic sewage, and agricultural runoff. Organic pollutants have significantly degraded water quality, resulting in oxygen depletion, ecological imbalance, and potential health risks. Effective remediation requires a combination of advanced wastewater treatment, bioremediation, phytoremediation, and integrated watershed management.

Sustainable implementation of these strategies, supported by strict environmental regulations and community participation, can substantially improve the ecological health of the Kali River and ensure long-term water security for the region.

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