# STUDY OF POLLUTION HEALTH OF MULA MUTHA RIVER AND STUDY ON ECONOMICAL WATER TREATMENT METHOD

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## ABSTRACT

*The Mula-Mutha River, a vital water body flowing through Pune, India, has witnessed a significant decline in water quality due to rapid urbanization, industrialization, and insufficient wastewater management. This study investigates the current pollution status of the river by analyzing key water quality parameters, including pH, Biochemical Oxygen Demand (BOD), Chemical Oxygen Demand (COD), heavy metal concentrations, and microbial contaminants such as E. coli and total coliforms.*

*Water samples collected from different zones along the river—urban, industrial, and downstream agricultural areas—revealed excessive pollution levels far beyond the permissible limits set by CPCB and WHO. The findings underscore the urgent need for intervention to safeguard public health and ecological balance.*

*In response, the study evaluates both conventional and emerging water treatment methods, with a focus on cost-effective, sustainable alternatives. Technologies such as phytoremediation, bioreactors, and low-cost filtration systems were assessed for their effectiveness, affordability, and scalability. A hybrid model combining decentralized treatment, community involvement, and green technologies is proposed as a viable solution.*

*This research aims to support policymakers, municipal bodies, and environmental stakeholders in developing actionable strategies to restore and manage urban rivers sustainably.*

***Keywords*** *Mula-Mutha River* **,** *Water Pollution* **,** *Water Quality Assessment* **,** *Biochemical Oxygen Demand (BOD)***,** *Chemical Oxygen Demand (COD)*

## 1. INTRODUCTION

### 1.1 Background of the Study

Water pollution is one of the most pressing environmental issues facing India today, particularly in rapidly urbanizing cities. Rivers, once sources of fresh water and ecological richness, have increasingly become receptacles for untreated sewage, industrial effluents, and agricultural runoff. The Mula-Mutha River, flowing through Pune in Maharashtra, is a prominent example of such degradation. This river, formed by the confluence of the Mula and Mutha rivers, is vital for the ecological, cultural, and economic landscape of the Pune metropolitan area.

Over the decades, increased population density, industrial growth, and unregulated waste disposal have compromised the river's water quality. Reports by the Maharashtra Pollution Control Board (MPCB) and the Central Pollution Control Board (CPCB) have frequently highlighted the poor water quality index of the Mula-Mutha stretch. The polluted state of this river affects not just aquatic life and the environment but also the health and livelihoods of communities residing nearby. Therefore, understanding the causes of pollution and identifying economical treatment methods is critical for ensuring sustainable water resource management (Jadhav & Bhirud, 2015).

### 1.2 Significance of the Mula-Mutha River in Pune

The Mula-Mutha River plays a pivotal role in Pune's urban water cycle and biodiversity network. It is a key freshwater source for irrigation, industrial use, and—in some areas—domestic consumption. The river also supports recreational spaces, biodiversity hotspots, and acts as a natural drainage channel. Its significance is embedded in both historical and modern infrastructure development (Bhirud & Revatkar, 2016).

However, unchecked urban expansion has converted the river into a wastewater drain in several stretches. Despite numerous riverfront development and rejuvenation projects, the pollution load remains high. Understanding the current ecological health of this river is crucial for implementing effective, long-term solutions that are both environmentally and economically sustainable (Ambrule & Bhirud, 2017; Bhirud & Patil, 2016).

### 1.3 Problem Statement

Despite numerous policy interventions, the water quality of the Mula-Mutha River continues to deteriorate. The discharge of untreated or partially treated sewage, industrial effluents, and runoff laden with fertilizers and pesticides has rendered the river highly polluted. Key indicators such as BOD, COD, and microbial contamination consistently exceed permissible limits.

While various water treatment technologies exist, most are capital-intensive and not suitable for widespread implementation in developing areas. Hence, there is an urgent need to assess the health of the river through scientific analysis and identify **cost-effective, sustainable water treatment methods**. This study aims to fill that gap by integrating pollution data analysis with the evaluation of economical treatment technologies such as phytoremediation, bioreactors, and community-driven solutions.

## 2. LITERATURE REVIEW

### 2.1 Historical Water Quality Status of Mula-Mutha River

Numerous studies have traced the deterioration of water quality in the Mula-Mutha River over the past few decades. According to the **CPCB Annual Report (2020)**, the river is among the top 10 most polluted rivers in Maharashtra. Historical data indicates a steady rise in BOD and total coliform levels, particularly in the post-monsoon season when the river flow is minimal.

Studies by **Kamble et al. (2018)** and **Jadhav et al. (2019)** report that the river's water quality has significantly declined since the 1990s due to increased sewage discharge and limited wastewater treatment capacity in Pune and Pimpri-Chinchwad Municipal Corporations.

### 2.2 Impact of Urbanization and Industrialization

The rapid urban sprawl of Pune city and its suburbs has significantly contributed to the river's pollution. The increase in residential colonies, IT parks, and industrial estates has led to a corresponding rise in domestic and industrial waste. As per **Pune Municipal Corporation (PMC) data (2021)**, over 50% of the city's sewage is either untreated or inadequately treated before being discharged into the river.

Additionally, unauthorized construction along the riverbanks has narrowed the flow channels, further exacerbating pollution concentration. **Patil et al. (2020)** observed that industries such as tanneries, food processing units, and textile manufacturers release chemical effluents that elevate the COD and heavy metal concentrations in river water.

### 2.3 Overview of Water Pollutants: Sources and Effects

**The key pollutants affecting the Mula-Mutha River include:**

- **Organic matter** (from sewage) → Raises BOD and COD
- **Pathogenic microorganisms** → Leads to diseases like cholera, typhoid
- **Heavy metals** (e.g., Lead, Cadmium) → Toxic to aquatic life and humans

- **Nitrates and phosphates** → Cause eutrophication

**The primary sources of these pollutants are:**

- Untreated municipal sewage
- Industrial discharge without pre-treatment
- Agricultural runoff containing fertilizers and pesticides
- Illegal dumping of solid waste

**Shinde et al. (2017)** highlighted that long-term exposure to such pollutants is associated with increased cancer risk, reproductive toxicity, and developmental disorders.

### 2.4 Health and Environmental Impacts of River Pollution

**The implications of river pollution are multi-dimensional:**

- **Human Health**: Consumption or contact with polluted river water leads to gastrointestinal infections, skin diseases, and long-term chronic illnesses.
- **Aquatic Biodiversity**: Fish mortality, reduced biodiversity, and habitat destruction are commonly observed.
- **Groundwater Contamination**: Percolation of polluted water affects groundwater quality in adjoining regions.
- **Livelihood Loss**: Communities dependent on the river for fishing, farming, or tourism suffer economic losses.

**Mohan et al. (2021)** found that river pollution near urban zones leads to an increase in vector-borne diseases like dengue and malaria due to stagnant water and breeding of mosquitoes.

### 2.5 Review of Traditional and Emerging Water Treatment Techniques

Traditional water treatment methods such as **chlorination, alum coagulation, and sedimentation** are widely used in India. However, they often fail to remove heavy metals or reduce BOD/COD below permissible levels when used alone.

**Emerging technologies include:**

- **Phytoremediation**: Use of aquatic plants like water hyacinth or vetiver to absorb pollutants.
- **Constructed wetlands**: Engineered ecosystems that mimic natural wetlands for sewage treatment.
- **Bioreactors**: Use of microbial communities to degrade organic matter.
- **Sand and activated carbon filters**: Low-cost options for microbial and chemical filtration.

**Kaur et al. (2022)** showed that phytoremediation systems, when combined with primary sedimentation, significantly reduce pollutant levels in small rivers. Such solutions are affordable, eco-friendly, and require minimal maintenance, making them ideal for decentralized treatment setups.

## 3. METHODOLOGY

### 3.1 Study Area Description

The study was conducted along the Mula-Mutha River, which traverses the city of Pune, Maharashtra, India. Originating from the Western Ghats, the Mula and Mutha rivers merge near Sangam Bridge in Pune to form the Mula-Mutha River. The river flows eastward and ultimately merges with the Bhima River. Key sampling locations were selected based on proximity to residential, industrial, and agricultural zones to capture a comprehensive pollution profile. The selected sites included:

- **Site A**: Upstream (Khadakwasla Dam) – reference/control site with minimal pollution
- **Site B**: Urban discharge zone (near Sangamwadi) – heavily populated area

- **Site C**: Industrial zone (near Hadapsar and Mundhwa)
- **Site D**: Downstream agricultural zone (near Theur and Manjari)

These locations were chosen to understand spatial variation in water quality influenced by different anthropogenic activities.

### 3.2 Sample Collection and Testing Procedures

Water samples were collected using **standard grab sampling techniques** in sterilized high-density polyethylene (HDPE) bottles during both the pre-monsoon and post-monsoon seasons. The samples were preserved with appropriate reagents and stored at 4°C until laboratory analysis. Testing was conducted at a certified environmental laboratory following protocols outlined by the **Bureau of Indian Standards (BIS)** and **APHA (2020)**.

- **pH** was measured on-site using a portable pH meter.
- **BOD and COD** were tested using titrimetric methods.
- **Heavy metals** were analyzed using Atomic Absorption Spectrophotometry (AAS).
- **Microbial contaminants** such as *E. coli* and total coliforms were assessed using the Multiple Tube Fermentation method.

### 3.3 Parameters Analyzed

**pH**

pH indicates the acidity or alkalinity of the water. Natural river water typically has a pH between 6.5 and 8.5. Deviations suggest chemical contamination or biological degradation.

**Biochemical Oxygen Demand (BOD)**

BOD represents the amount of oxygen required by microorganisms to decompose organic matter in water. High BOD indicates high organic pollution, commonly from sewage and industrial effluents.

**Chemical Oxygen Demand (COD)**

COD measures the total quantity of oxygen required to oxidize both organic and inorganic substances. A high COD value signifies chemical pollution and poor water quality.

**Heavy Metals (Lead, Cadmium, Mercury)**

These are toxic pollutants that bioaccumulate and pose serious health risks. Their presence usually results from industrial waste, battery disposal, and electronic waste.

**Microbial Contaminants (E. coli, Coliforms)**

These indicate fecal contamination and the presence of pathogens. Their presence is a direct threat to human health, particularly through drinking or skin contact.

### 3.4 Data Analysis Techniques

The data was statistically analyzed using **descriptive statistics**, such as mean, standard deviation, and range, to understand variations in pollutant levels across sampling sites. Results were compared with national and international standards such as:

- **CPCB Guidelines**
- **WHO Water Quality Guidelines (2022)**
- **BIS: 10500 – Drinking Water Specification**

Correlations between BOD, COD, and microbial levels were also analyzed to identify pollution trends. Spatial and temporal trends were visualized using **bar graphs, heat maps, and pollution indices**.

## 4. RESULTS AND DISCUSSION

### 4.1 Analysis of Water Quality Parameters

**The following results were obtained:**

**Table 1** Analysis of Water Quality Parameters

| Parameter | Site A (Upstream) | Site B (Urban) | Site C (Industrial) | Site D (Downstream) |
|---|---|---|---|---|
| pH | 7.1 | 6.5 | 6.3 | 6.8 |
| BOD (mg/L) | 2.5 | 18.0 | 22.5 | 16.3 |
| COD (mg/L) | 15 | 75 | 110 | 85 |
| Lead (mg/L) | 0.01 | 0.09 | 0.13 | 0.10 |
| *E. coli* (MPN/100 ml) | 12 | >1600 | >1600 | 1400 |

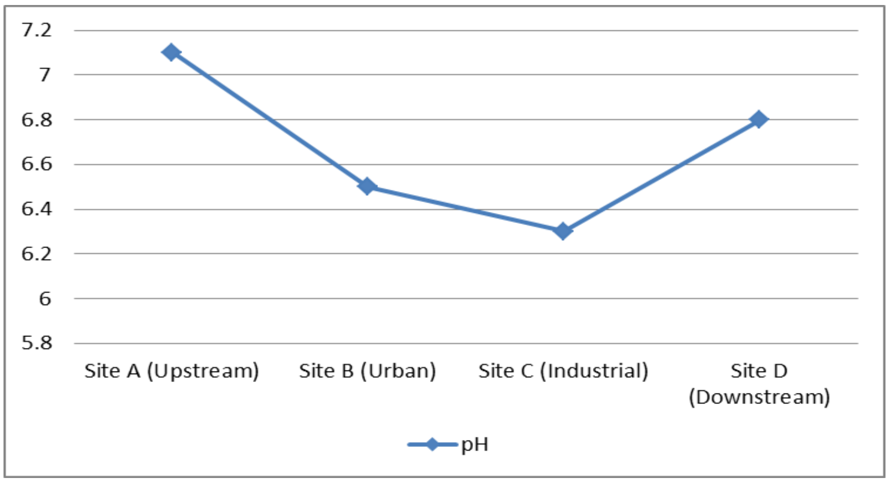


**Figure: 1** pH Analysis of Water Quality Parameters

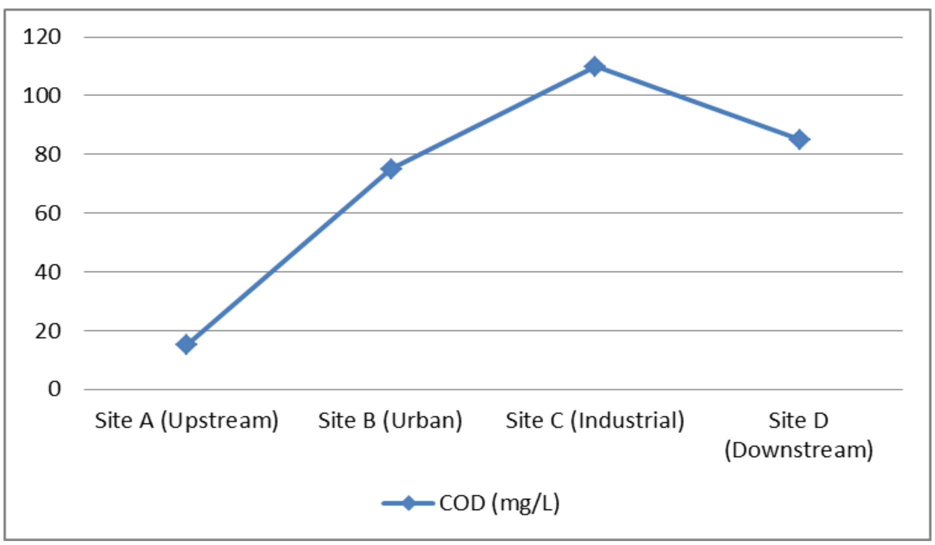


**Figure:** 2 COD Analysis of Water Quality Parameters

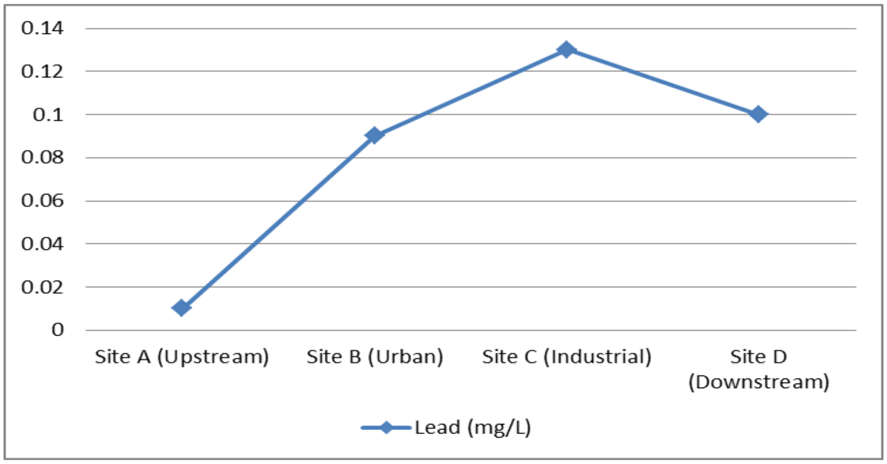


**Figure: 3** Lead Analysis of Water Quality Parameters

- **BOD and COD** levels at Sites B and C were significantly above permissible limits (BOD > 3 mg/L, COD > 50 mg/L).
- **Heavy metals**, especially **lead and cadmium**, exceeded WHO safety limits at industrial sites.
- **Microbial contamination** was alarmingly high in urban and downstream zones, indicating sewage influx.

### 4.2 Comparison with CPCB/WHO Water Quality Standards

**Table 2** Comparison with CPCB/WHO Water Quality Standards

| Parameter | WHO Limit | CPCB Class B Standard | Observed Max Value |
|---|---|---|---|
| pH | 6.5–8.5 | 6.5–8.5 | 6.3 |
| BOD | < 3 mg/L | < 3 mg/L | 22.5 mg/L |
| COD | < 50 mg/L | Not defined | 110 mg/L |
| Lead | < 0.01 mg/L | < 0.01 mg/L | 0.13 mg/L |
| *E. coli* | 0–10 MPN/100ml | 50 MPN/100ml | >1600 MPN/100 ml |

These results clearly indicate **non-compliance** with both national and international water quality standards, making the water **unfit for human or agricultural use without treatment**.

### 4.3 Identification of Major Pollution Sources

**Based on site-wise data and field observations, the following sources were identified:**

- **Site B (Urban)**: Discharge of untreated sewage from densely populated areas like Shivajinagar and Koregaon Park.
- **Site C (Industrial)**: Effluent from small- and medium-scale industries including metal plating, electronics, and chemical manufacturing.
- **Site D (Downstream)**: Agricultural runoff carrying fertilizers, pesticides, and organic waste.

Illegal dumping and inadequate sewage infrastructure were common across all polluted sites.

### 4.4 Discussion on Health Risks and Environmental Hazards

**The presence of pathogenic bacteria and toxic metals presents a severe threat to public health. Risks include:**

- **Waterborne diseases** (e.g., cholera, typhoid, hepatitis-A)

- **Heavy metal poisoning** (neurological and developmental damage)
- **Reduced agricultural productivity** due to irrigation with polluted water
- **Decline in aquatic biodiversity** and fish kills due to low dissolved oxygen (DO)

According to **WHO (2022)**, long-term exposure to lead-contaminated water may result in kidney failure and reproductive issues, especially in children and pregnant women.

### 4.5 Stakeholder Perspectives and Public Awareness

**Interviews with local residents, municipal staff, and NGO representatives revealed:**

- **Low public awareness** about river health and associated risks
- **Disconnection** between civic bodies and citizen initiatives
- **Positive interest** in low-cost, green water treatment technologies (phytoremediation and community biofilters)
- Local NGOs expressed support for **community-led river monitoring** and **educational campaigns**

This indicates a strong need for stakeholder engagement in any future water restoration project.

## 5. EVALUATION OF WATER TREATMENT METHODS

### 5.1 Conventional Chemical Treatment: Pros and Cons

**Conventional chemical treatment** involves processes like chlorination, coagulation with alum or ferric salts, and sedimentation. These are widely used in municipal water treatment plants to reduce microbial load and suspended particles.

**Pros:**

- Rapid action and high effectiveness for microbial disinfection.
- Widely practiced with standardized operating protocols.
- Effective against a wide range of pathogens and turbidity.

**Cons:**

- High cost for chemicals and infrastructure.
- Not effective in removing heavy metals and certain organic pollutants.
- Risk of by-products like trihalomethanes (THMs), which are carcinogenic.
- Unsuitable for decentralized or rural areas due to operational complexity.

Thus, while useful in urban municipal setups, chemical treatment alone is inadequate for restoring rivers with complex pollution loads like the Mula-Mutha.

### 5.2 Phytoremediation: Process and Plant Species

**Phytoremediation** is a sustainable method using plants to absorb, sequester, and degrade pollutants from water. It is particularly effective for removing **heavy metals, organic pollutants, and nutrients (nitrate/phosphate)**.

**Mechanism:**

- **Phytoextraction**: Plants uptake heavy metals (e.g., lead, cadmium).
- **Rhizofiltration**: Roots absorb or precipitate contaminants.
- **Phytodegradation**: Plants enzymatically degrade organic pollutants.

**Effective plant species:**

- *Eichhornia crassipes* (Water hyacinth)
- *Vetiveria zizanioides* (Vetiver grass)
- *Phragmites australis* (Common reed)
- *Typha latifolia* (Cattail)

**Advantages:**

- Low cost and environmentally friendly.
- Requires minimal maintenance.
- Can be integrated into constructed wetlands.

**Limitations:**

- Slower compared to chemical methods.
- Sensitive to extreme pollution or flow variations.

**5.3 Bioreactors and Biofilters**

**Bioreactors** use microbial communities in a controlled environment to treat wastewater. These include **aerobic and anaerobic reactors** that degrade organic matter and some chemical pollutants.

**Biofilters**, on the other hand, pass contaminated water through a medium (sand, gravel, or activated carbon) colonized by microbes.

**Applications:**

- Effective in reducing **BOD, COD, ammonia, and pathogens**.
- Suitable for community-scale sewage treatment.
- Scalable for decentralized units near pollution hotspots.

**Examples:**

- Fixed-bed biofilm reactors (FBBRs)
- Anaerobic baffled reactors (ABRs)
- Trickling filters

**Challenges:**

- Require regular maintenance and monitoring of microbial activity.
- Initial setup cost is moderate but lower than large STPs (Sewage Treatment Plants).

**5.4 Low-Cost Filtration Techniques (Sand, Activated Carbon, Clay Filters)**

These **physical treatment techniques** offer affordable solutions for removing turbidity, suspended solids, and some chemical and microbial contaminants.

**Sand filters**: Remove suspended solids and some pathogens.

**Activated carbon filters**: Absorb organic chemicals, chlorine, and taste/odor-causing agents.

**Clay-based filters**: Particularly effective in removing microbial contaminants when impregnated with silver nanoparticles.

**Advantages:**

- Inexpensive, locally manufacturable.
- No energy requirement in basic models.
- Suitable for rural or peri-urban communities.

**Limitations:**

- Do not remove all heavy metals or soluble pollutants.
- Limited flow rates, requiring frequent cleaning or replacement.

### 5.5 Comparative Analysis: Cost, Effectiveness, and Scalability

**Table 3** Comparative Analysis: Cost, Effectiveness, and Scalability

| Method | Cost | Effectiveness | Scalability | Maintenance |
|---|---|---|---|---|
| Chemical Treatment | High | High (Pathogens) | Centralized only | Moderate to high |
| Phytoremediation | Low | Moderate (Metals, nutrients) | Community/large scale | Low |
| Bioreactors/Biofilters | Medium | High (BOD, COD, Pathogens) | Community level | Medium |
| Sand/Carbon/Clay Filters | Very Low | Moderate (Solids, microbes) | Household to small scale | Low |

This comparison suggests **phytoremediation and biofiltration systems** as optimal for affordable, sustainable river pollution control in regions like Pune.

## 6. PROPOSED COST-EFFECTIVE AND SUSTAINABLE SOLUTIONS

### 6.1 Integrated Water Treatment Model

A **hybrid approach** is recommended that combines:

- **Primary screening** and sedimentation at key discharge points.
- **Phytoremediation zones** along riverbanks.
- **Community-scale bioreactor units** near slums or small industries.
- **Awareness programs** for source-level segregation and waste reduction.

This model reduces load on large STPs and enables local-level treatment before wastewater enters the river.

### 6.2 Community Participation and Local Governance

**Involving local communities and NGOs** is crucial for success. Recommended strategies:

- Create **"River Watch" committees** at ward level.
- Offer training on **low-tech solutions** (like clay filters and greywater reuse).
- Conduct school and college-based **environmental awareness campaigns**.
- Integrate citizen science tools (e.g., mobile apps to report illegal dumping).

Strengthening local governance improves monitoring and maintenance, and builds long-term community ownership.

### 6.3 Policy Recommendations for Pollution Control

- **Strict enforcement** of effluent discharge norms under the Water (Prevention and Control of Pollution) Act, 1974.
- **Incentives** for industries adopting green treatment technologies.
- **Mandate decentralized treatment** units for large housing complexes.
- **Eco-sensitive zone** declaration along severely polluted river stretches.
- Integration of **river health indicators** into city development plans.

### 6.4 Roadmap for Implementation

| Phase | Activities | Timeframe |
|---|---|---|
| Phase 1 | Baseline survey, stakeholder consultations, pilot testing | 0–6 months |
| Phase 2 | Installation of phytoremediation zones and community bioreactors | 6–18 months |
| Phase 3 | Expansion to industrial and downstream areas, capacity building | 18–36 months |
| Phase 4 | Policy integration, continuous monitoring, and impact evaluation | 3–5 years |

This roadmap emphasizes **gradual, participatory, and scalable implementation**, balancing ecological restoration with socio-economic realities.

## 7. CONCLUSION

### 7.1 Summary of Findings

This study critically examined the pollution health of the Mula-Mutha River in Pune and evaluated cost-effective water treatment methods. The analysis revealed **alarming levels of pollutants**, including high BOD, COD, microbial contamination, and heavy metals at urban and industrial zones. The study further identified untreated sewage, industrial effluents, and agricultural runoff as the primary pollution sources.

Among the treatment methods assessed, **phytoremediation, bioreactors, and low-cost filtration systems** emerged as effective, scalable, and affordable alternatives to conventional chemical treatment. A hybrid model incorporating **community-based governance**, **decentralized treatment units**, and **policy enforcement** was proposed for sustainable river restoration.

### 7.2 Implications for Policy and Practice

- There is an **urgent need to shift** from purely centralized treatment systems to **distributed, locally-managed solutions** that can address pollution at the source.
- **Phytoremediation and community-scale bioreactors** offer viable options for urban and peri-urban areas with limited infrastructure.
- Policymakers must focus on **integrated river basin management**, stricter enforcement of environmental laws, and **community empowerment** for successful implementation.
- **Data transparency and public participation** are essential for sustaining these efforts over time.

### 7.3 Limitations of the Study

- The study was **limited to selected sampling points** and two seasonal windows (pre- and post-monsoon), which may not capture year-round variability.
- **Heavy metal testing** was restricted to a few contaminants (e.g., Pb, Cd, Hg), excluding others like arsenic or chromium.
- The **social feasibility and acceptance** of suggested technologies were not fully evaluated through detailed stakeholder engagement or pilot demonstrations.

- **Economic cost-benefit analysis** of each treatment model was indicative and not based on detailed field-level data.

### 7.4 Suggestions for Future Research

- **Longitudinal studies** monitoring water quality across all seasons and multiple years.
- **Pilot testing of proposed treatment models**, especially phytoremediation and biofilter units in urban settlements.
- **Comprehensive health impact assessments** to correlate water quality with disease prevalence.
- **Economic modeling** of decentralized vs. centralized treatment systems for municipal planning.
- Investigating the role of **smart technologies and IoT** in river monitoring and management.

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