"Feasibility Analysis and Strategic Development for Preventing Sewage Ingress into Rivers and Lakes"

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***Abstract*—**

Urban water bodies in India, such as rivers and lakes, are increasingly endangered due to the uncontrolled ingress of untreated sewage. This issue is particularly critical in metropolitan regions like Mumbai, where infrastructure struggles to keep pace with rapid population growth. The Mithi River and Powai Lake, once ecologically vibrant, are now heavily polluted due to illegal sewage connections, stormwater contamination, and inadequate wastewater treatment facilities. This review paper aims to analyze existing literature, case studies, and technical interventions related to sewage ingress prevention in urban water bodies. It explores various engineering strategies such as the construction of interceptor chambers, hydro-brakes, and the redirection of dry weather flows, while also considering socio-political dimensions like policy reforms and community participation. International case studies and national guidelines are reviewed to draw parallels and lessons that can be adapted to the Indian context. The review identifies key research gaps, including a lack of integrated planning, underutilization of decentralized treatment systems, and inadequate enforcement of pollution control norms. By synthesizing technical and administrative insights, this paper proposes a holistic, multi-stakeholder approach to controlling sewage pollution. The findings contribute to the design and planning phases of the author's dissertation project and offer scalable strategies for urban water quality improvement under initiatives such as the Swachh Bharat Abhiyan and Namami Gange.

Keywords: Urban Water Pollution, Interceptor Chambers, Stormwater Drainage, Mithi River, Powai Lake

I. INTRODUCTION

India's urban water bodies are under severe environmental stress due to the persistent and increasing influx of pollutants, particularly untreated domestic and industrial sewage. With a rapidly urbanizing population—expected to reach 600 million in urban areas by 2031—the pressure on municipal infrastructure has grown exponentially. According to reports by the Central Pollution Control Board (CPCB), more than 70% of urban wastewater in India is discharged untreated into rivers, lakes, and groundwater systems. The major causes include poor coverage of sewerage networks, aging infrastructure, illegal connections, unregulated construction, and the absence of decentralized treatment solutions in newly developed areas. In many Indian cities, open stormwater drains double as sewers, especially during the dry season when domestic greywater and blackwater are illegally discharged. This leads to chronic pollution of natural water systems, depleting dissolved oxygen (DO) levels, increasing biochemical oxygen demand (BOD), and fostering eutrophication. Despite investments under national programs like the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Swachh Bharat Abhiyan, and Namami Gange, there remains a significant implementation gap. Issues like poor inter-departmental coordination, lack of real-time monitoring, and insufficient public awareness continue to exacerbate the crisis.

A. Importance of Powai Lake and the Mithi River

Mumbai offers a stark example of how urban growth, when unmanaged, can compromise critical natural resources. Powai Lake and the Mithi River, two historically significant water bodies in the city, have become symbols of this urban environmental crisis. Powai Lake, built in 1891 to supply drinking water, sits amidst a dense mix of residential complexes, academic institutions like IIT-Bombay, and commercial developments. Once a freshwater lake, it now faces serious pollution issues. Stormwater drains feeding into the lake often carry greywater and raw sewage, especially from nearby localities such as Hiranandani Gardens and parts of the IIT campus. The Mithi River, roughly 17.8 kilometers long, begins at the confluence of Powai and Vihar Lakes and empties into the Mahim Creek. It plays a crucial role in draining rainwater from densely populated areas like Bandra, Kurla, and Dharavi. However, over time, it has transformed into an open drain—choked with industrial effluents, domestic waste, and solid debris. Encroachments along its banks and illegal connections to stormwater drains have not only worsened pollution levels but also contributed to catastrophic flooding, most notably during the infamous 2005 deluge. What's especially troubling is that both these water bodies were once teeming with life and served vital functions within the city's ecological and drainage systems. Today, they pose a serious risk to public health and biodiversity.

B. Problem of Sewage Ingress

Sewage ingress refers to the unregulated influx of untreated or partially treated wastewater, encompassing both domestic and industrial sources, into natural water systems. In urban areas like Mumbai, this issue is widespread and deeply rooted in systemic failures. In the cases of Powai Lake and the Mithi River, numerous studies have confirmed that stormwater drains are frequently contaminated with dry weather flows that are essentially raw sewage. These flows stem from illegal household outlets, leaking manholes, malfunctioning septic tanks, and informal settlements with little to no sanitation infrastructure. The problem becomes even more critical during Mumbai's intense monsoon season. Heavy rainfall overwhelms already fragile systems, causing sewage and stormwater to mix, and leading to dangerous backflows into residential zones and large-scale discharge into rivers and lakes. The resulting

nutrient overload—primarily nitrogen and phosphorus—fuels the rapid spread of aquatic weeds like water hyacinth. These not only clog waterways but also suffocate aquatic life by depleting oxygen levels. Beyond the environmental impact, the human toll is significant. Contaminated water bodies become breeding grounds for pathogens, leading to frequent outbreaks of illnesses like gastroenteritis and cholera, especially in nearby low-income communities. At the root of this crisis is a failing infrastructure system: old, undersized sewer lines, overburdened treatment plants, and poorly enforced pollution control laws. Even court orders, public protests, and media attention have yet to trigger the kind of coordinated action that the situation clearly demands.

II. STATE OF DEVELOPMENT

Overview of Urban Sewage Ingress

Urban sewage ingress is a critical environmental challenge in India, degrading water quality, harming aquatic ecosystems, and endangering public health. Rapid urbanization, inadequate infrastructure, and unregulated settlements have overwhelmed existing sewage systems, leading to widespread discharge of untreated wastewater into rivers, lakes, and groundwater. India's urban water bodies often receive high BOD and COD loads due to direct sewage inflow, resulting in oxygen depletion and eutrophication. A notable case is the Mithi River in Mumbai, where untreated domestic sewage enters via storm drains and illegal connections. Jadhav and Joshi (2020) highlight the inability of infrastructure to cope with urban sprawl, resulting in a sharp decline in water quality and elevated health risks. According to CPCB (2020), 70% of urban wastewater in India remains untreated, entering natural water systems through open drains, broken pipelines, or illegal outflows. This affects nearly 80% of the country's water bodies, aggravating public health issues and reducing biodiversity. CPCB and MoEFCC reports indicate that stormwater drains in many cities now act as permanent sewers, especially during dry periods.

Key Statistics:

- **70%** of urban wastewater is untreated (CPCB, 2020)
- **80%** of Indian water bodies are affected by sewage ingress (Kumar et al., 2019)
- **70%** of stormwater drains are misused as sewers (Sharma et al., 2021)
- **60%** of rivers in India are classified as having 'bad' to 'very bad' water quality (MoEFCC, 2020)

City	Water Body	Major Causes	Untreated Sewage Discharged
Mumbai	Mithi River, Powai Lake	Illegal sewage, storm drains used as sewers	75%
Delhi	Yamuna River	Industrial/domestic sewage, STP overflow	80%
Bengaluru	Varthur Lake	Underperforming STPs, mixed drains	60%
Chennai	Cooum River	Poor sewer coverage, untreated effluent	85%

These figures underline the systemic nature of the problem. The presence of untreated sewage leads to nutrient loading (N, P), aquatic weed growth, and unsafe water conditions. Waterborne diseases such as cholera and gastroenteritis become prevalent, particularly in high-density, low- income communities. The issue is compounded by poor enforcement, lack of public awareness, and insufficient investment in infrastructure. National initiatives like **Swachh Bharat Abhiyan** and **Namami Gange** have made progress, but implementation remains weak due to fragmented responsibilities and limited technical capacity at local levels. A mix of centralized and decentralized treatment systems, along with citizen participation, is essential for long-term solutions.

Case Studies on River/Lake Pollution in India.

Urban water pollution in India is best illustrated through specific cases where sewage ingress has significantly impacted environmental quality. This section discusses key examples from Delhi, Bengaluru, and Mumbai.

A. Case Study 1: Yamuna River, Delhi

The **Yamuna River** is one of the most polluted rivers in India, with over **80% of its pollution attributed to untreated domestic sewage** (Mehta & Sharma, 2021). Delhi's STPs are either under-capacity or outdated, unable to handle the growing wastewater load.

Key observations:

- High reliance on centralized STPs with limited decentralization.
- Illegal sewage connections persist, bypassing treatment entirely.
- Recommended interventions include expanding STPs, introducing DEWATS
- In residential and industrial zones, and stricter enforcement of environmental norms

B. Case Study 2: Varthur Lake, Bengaluru

Once a healthy lake ecosystem, **Varthur Lake** now suffers from heavy **eutrophication** due to the inflow of untreated sewage. Stormwater drains in the region often act as sewers, discharging directly into the lake.

As per Rao et al. (2019), the key issues include:

- High nutrient levels from sewage causing water hyacinth overgrowth.
- Declining oxygen levels and biodiversity loss.
- Proposed solutions involve:
- **Installing interceptor** chambers at key inlets.
- **Re-routing stormwater** to separate rainwater and sewage.
- Implementing a **lake rejuvenation plan**, including de-weeding, de-silting, and native species restoration.

C. Case Study 3: Mithi River, Mumbai

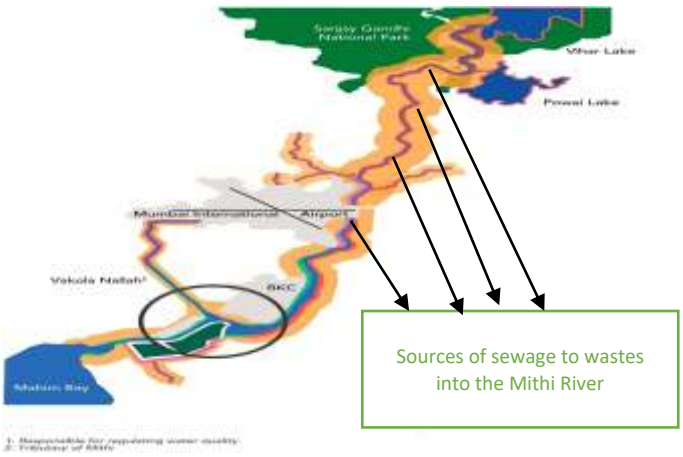
The Mithi River in Mumbai faces severe pollution from untreated sewage and industrial waste. According to Singh et al. (2020), the river's high BOD and COD levels are due to continuous sewage discharge. The overflow of sewage treatment systems during the monsoon, illegal sewage connections, and encroachments further worsen the situation.

Proposed solutions include:

- Enforcing environmental regulations and removing illegal sewage connections.
- Constructing interceptor chambers to capture sewage before it

enters the river.

- Upgrading sewage treatment infrastructure to handle peak loads.
- Running community awareness campaigns to curb illegal dumping.



Google Image: Of Mithi River

III. FINDING OF LITERATURE

This review of literature, case studies, and engineering solutions reveals that tackling sewage ingress into urban water bodies like the Mithi River and Powai Lake requires a multi-dimensional approach. While technical interventions such as interceptor chambers, hydro brakes, and DEWATS have potential, they must be integrated into broader urban sanitation strategies alongside strong governance, policy enforcement, and community engagement. Case studies from cities like Delhi, Bengaluru, and Chennai highlight that untreated sewage is often due to fragmented governance, underperforming sewage treatment plants, and poor infrastructure maintenance. In contrast, international examples such as the Thames River in London and the Han River in Seoul show the power of long-term planning, integrated governance, and public-private partnerships in successfully restoring water bodies. This review identifies critical gaps in India's current approach, including a lack of real-time monitoring, limited use of decentralized systems, and weak community involvement. Future research should focus on benchmarking sewage management systems, urban hydrology modeling, and adaptive policy frameworks tailored to local conditions. For the dissertation, the findings provide a strong foundation for designing a multi-pronged strategy combining engineering tools like Sewer GEMS, community-level feasibility assessments, and policy alignment. The suggested strategy for Powai Lake and the Mithi River focuses on::

- Unified urban water management authority for better inter-agency coordination
- Smart monitoring through flow meters and sensors.
- Policy incentives for the adoption of decentralized systems such as Decentralized Wastewater Treatment Systems (DEWATS).
- Enhanced community engagement through the establishment of local water quality committees and the implementation of awareness campaigns.

IV. THE SCOPE OF WORK

This review paper aims to provide a thorough examination of the issue of sewage ingress into urban water bodies, specifically highlighting Powai Lake and the Mithi River. By synthesizing insights from engineering, ecology, and governance, the paper aims to explore both the technical and administrative measures that can help curb this problem.

The key objectives of this review are:

- To understand the underlying causes and current extent of sewage ingress, through both Indian and international case studies.
- To examine practical solutions such as interceptor chambers, hydro-brakes, dry weather flow redirection, and decentralized wastewater treatment systems (DEWATS)
- To evaluate the role of municipal agencies, policy frameworks, and community engagement in preventing sewage ingress.
- To identify research and implementation gaps that hinder progress in this field.
- To provide a solid foundation for the author's ongoing dissertation work on sewage pollution control in Mumbai's urban water bodies.

The scope of this review extends across multiple domains—ranging from environmental engineering and hydrology to urban governance and behavioral science. It draws from peer-reviewed research, government documents, technical manuals, and global best practices. While the geographic focus remains on Mumbai, the lessons learned can easily apply to other Indian cities grappling with similar challenges of urban water degradation

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