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Feasibility Study And Strategy Development For Stopping The Ingress Of Sewage Into River & Lake

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Abstract: Urban water bodies in India, particularly in rapidly expanding cities such as Mumbai, are confronting a significant challenge: the unregulated discharge of untreated sewage into rivers and lakes. This issue extends beyond mere infrastructural inadequacies in keeping pace with population growth; it also encompasses inadequate urban planning, ineffective enforcement of regulations, and a general lack of public awareness. Once vibrant ecosystems, the Mithi River and Powai Lake have deteriorated into severely polluted water bodies, primarily due to illegal sewage discharges, contaminated stormwater runoff, and insufficient treatment facilities.

This review paper examines strategies to mitigate sewage ingress. It synthesizes a diverse array of literature, real-world case studies, and technical approaches that have been implemented in various contexts. Solutions such as interceptor chambers, hydro-brakes, and the rerouting of dry weather flows are analyzed not only as engineering solutions but also within a broader framework that emphasizes community engagement and policy reform. The paper integrates insights from international best practices alongside Indian guidelines to identify effective strategies, shortcomings, and areas for improvement.

A significant conclusion drawn from this review is that, despite the availability of technological solutions, their incorporation into urban planning and regulatory enforcement remains inadequate. Decentralized treatment systems, while promising, are still underutilized. By merging technical expertise with administrative and social considerations, this paper advocates for a more comprehensive and collaborative approach to addressing urban sewage pollution. The findings not only support the planning phase of the author's dissertation but also aim to contribute to larger initiatives such as Swachh Bharat Abhiyan and Namami Gange, providing actionable insights for the enhancement of urban water quality and public health.

Index Terms – Urban Water Pollution, Interceptor Chambers, Stormwater Drainage, Mithi River, Powai Lake

1.INTRODUCTION

1.1 Overview of Urban Water Pollution in India

Urban water bodies in India are increasingly facing significant environmental challenges, primarily due to the continuous influx of untreated sewage. As the nation's cities undergo rapid expansion—projected to accommodate nearly 600 million residents by 2031—the pressure on urban infrastructure has escalated dramatically. The Central Pollution Control Board (CPCB) reports that over 70% of wastewater generated in urban areas is discharged into rivers, lakes, and even groundwater without undergoing any treatment.

This concerning trend stems from a confluence of interrelated issues: insufficient sewerage coverage, deteriorating pipeline infrastructure, unauthorized sewage connections, and inadequate regulation of new developments that frequently lack essential sanitation planning. In numerous cities, stormwater drains have effectively transformed into open sewers, particularly during the dry season, when illegal discharges of both greywater and blackwater occur unchecked. Consequently, critical water quality parameters—such as dissolved oxygen (DO) and biochemical oxygen demand (BOD)—remain consistently poor, leading to issues like eutrophication and the degradation of aquatic ecosystems.

Despite the implementation of significant national initiatives such as the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), Swachh Bharat Abhiyan, and Namami Gange, a substantial gap persists between policy objectives and actual execution on the ground. Challenges such as weak inter-departmental coordination, a lack of real-time monitoring, and limited public involvement have hindered the achievement of sustainable outcomes.

1.2 Importance of Powai Lake and the Mithi River

Mumbai serves as a poignant illustration of how unmanaged urban growth can jeopardize essential natural resources. Powai Lake and the Mithi River, two historically significant water bodies in the city, have become emblematic of this environmental crisis.

Powai Lake, constructed in 1891 to provide drinking water, is now surrounded by a dense array of residential complexes, educational institutions such as IIT Bombay, and commercial developments. Once a pristine freshwater lake, it now grapples with severe pollution challenges. Stormwater drains that feed into the lake frequently carry greywater and untreated sewage, particularly from adjacent areas like Hiranandani Gardens and sections of the IIT campus.

The Mithi River, which spans approximately 17.8 kilometers, originates at the confluence of Powai and Vihar Lakes and flows into Mahim Creek. It serves a vital function in draining rainwater from densely populated neighborhoods, including Bandra, Kurla, and Dharavi. However, over the years, it has devolved into an open drain, clogged with industrial effluents, domestic waste, and solid debris. Encroachments along its banks and illegal connections to stormwater drains have exacerbated pollution levels and contributed to catastrophic flooding, most notably during the devastating deluge of 2005.

What is particularly concerning is that both of these water bodies were once vibrant ecosystems, playing crucial roles in the city's ecological balance and drainage systems. Today, they represent a significant threat to public health and biodiversity, highlighting the urgent need for effective management and restoration efforts.

1.3 Problem of Sewage Ingress

Sewage ingress refers to the uncontrolled introduction of untreated or partially treated wastewater—both domestic and industrial—into natural water systems. In urban areas like Mumbai, this issue is pervasive and deeply entrenched in systemic failures. Studies concerning Powai Lake and the Mithi River have consistently

shown that stormwater drains are often contaminated with dry weather flows that consist primarily of raw sewage. These flows originate from illegal household discharges, leaking manholes, malfunctioning septic tanks, and informal settlements that lack adequate sanitation infrastructure.

The situation becomes particularly critical during Mumbai's intense monsoon season. Heavy rainfall can overwhelm already fragile systems, resulting in the mixing of sewage and stormwater, which leads to hazardous backflows into residential areas and significant discharges into rivers and lakes. This nutrient overload—primarily composed of nitrogen and phosphorus—promotes the rapid proliferation of aquatic weeds such as water hyacinth. These invasive species not only obstruct waterways but also deplete oxygen levels, suffocating aquatic life.

The human impact of this crisis is equally alarming. Contaminated water bodies serve as breeding grounds for pathogens, resulting in frequent outbreaks of illnesses such as gastroenteritis and cholera, particularly affecting low-income communities in proximity to these water bodies. At the core of this issue lies a failing infrastructure system characterized by aging, undersized sewer lines, overburdened treatment facilities, and poorly enforced pollution control regulations. Despite court orders, public protests, and media scrutiny, there has yet to be a coordinated response that adequately addresses the urgent needs of the situation.

1.4 Objectives and Scope of the Review

This review paper aims to provide a comprehensive examination of the issue of sewage ingress into urban water bodies, with a specific emphasis on Powai Lake and the Mithi River. By integrating insights from engineering, ecology, and governance, the paper seeks to explore both technical and administrative measures that can effectively address this pressing problem.

The key objectives of this review are:

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

The scope of this review encompasses multiple domains, including environmental engineering, hydrology, urban governance, and behavioral science. It draws upon peer-reviewed research, government documents, technical manuals, and global best practices. While the primary geographic focus is on Mumbai, the insights gained from this review are applicable to other Indian cities facing similar challenges related to urban water degradation.

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2. LITERATURE REVIEW

Overview of Urban Sewage Ingress

Urban sewage ingress represents a significant environmental challenge in India, leading to the degradation of water quality, harm to aquatic ecosystems, and threats to public health. The rapid pace of urbanization, coupled with inadequate infrastructure and unregulated settlements, has overwhelmed existing sewage systems, resulting in the widespread discharge of untreated wastewater into rivers, lakes, and groundwater.

India's urban water bodies frequently experience high biochemical oxygen demand (BOD) and chemical oxygen demand (COD) loads due to direct sewage inflow, which contributes to oxygen depletion and eutrophication. A prominent example of this issue is the Mithi River in Mumbai, where untreated domestic sewage enters through storm drains and illegal connections. Jadhav and Joshi (2020) emphasize that the existing infrastructure is ill-equipped to handle urban sprawl, leading to a significant decline in water quality and increased health risks. According to the Central Pollution Control Board (CPCB, 2020), approximately 70% of urban wastewater in India remains untreated, entering natural water systems through open drains, broken pipelines, or unauthorized discharges. This situation affects nearly 80% of the country's water bodies, exacerbating public health concerns and diminishing biodiversity. Reports from the CPCB and the Ministry

of Environment, Forest and Climate Change (MoEFCC) indicate that stormwater drains in many cities have effectively become permanent sewers, particularly 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)

These statistics highlight the systemic nature of the sewage ingress problem. The presence of untreated sewage results in nutrient loading—primarily nitrogen and phosphorus—which fosters the growth of aquatic weeds and creates unsafe water conditions. Consequently, waterborne diseases such as cholera and gastroenteritis become increasingly prevalent, particularly in densely populated, low-income communities.

The situation is further exacerbated by inadequate enforcement of regulations, a lack of public awareness, and insufficient investment in infrastructure. While national initiatives such as Swachh Bharat Abhiyan and Namami Gange have made some strides, their implementation remains weak due to fragmented responsibilities and limited technical capacity at the local level.

To achieve long-term solutions, a combination of centralized and decentralized treatment systems, along with active citizen participation, is essential. This integrated approach can help address the multifaceted challenges of urban sewage ingress and improve the overall health of urban water bodies.

Case Study: Mithi River, Mumbai

The Mithi River in Mumbai is grappling with severe pollution stemming from untreated sewage and industrial waste. According to Singh et al. (2020), the river exhibits alarmingly high levels of biochemical oxygen demand (BOD) and chemical oxygen demand (COD), primarily due to continuous sewage discharge. The situation is exacerbated by the overflow of sewage treatment systems during the monsoon season, illegal sewage connections, and encroachments along the riverbanks.

Proposed Solutions Include

Enforcing Environmental Regulations: Strengthening the enforcement of existing environmental regulations and removing illegal sewage connections to prevent untreated wastewater from entering the river.

Constructing Interceptor Chambers: Implementing interceptor chambers to capture sewage before it can flow into the river, thereby reducing the volume of untreated waste entering the waterway.

Upgrading Sewage Treatment Infrastructure: Enhancing the capacity and efficiency of sewage treatment facilities to manage peak loads, particularly during the monsoon season when inflows increase significantly.

Running Community Awareness Campaigns: Initiating community awareness campaigns aimed at educating residents about the impacts of illegal dumping and the importance of proper waste disposal practices.

Despite these proposed solutions, progress has been slow. There is a pressing need for better coordination among various governmental agencies and stronger enforcement of regulations to facilitate effective clean-up efforts and restore the health of the Mithi River.

3.METHODOLOGY

The methodology adopted for this study integrates both qualitative and quantitative approaches to provide a comprehensive understanding of the sewage ingress problem and to develop realistic solutions. The process follows a structured path, encompassing data collection, modeling, and design recommendations.

I. Review of Existing Data

Data related to existing sewer systems, manhole locations, stormwater drains, outfall points, and water quality parameters were collected from municipal authorities. Pre-monsoon water sampling was conducted to establish baseline pollution levels in Powai Lake and the Mithi River.

II. Site Surveys and Inspections

Comprehensive field surveys were conducted to identify sources of dry weather flow, blocked or damaged sewers, and unauthorized sewage connections. Geographic Information System (GIS) mapping tools were employed to visualize the spatial distribution of pollution sources, facilitating a clearer understanding of the problem.

III. Water Quality Analysis

Water samples were collected from various points along Powai Lake and the Mithi River and analyzed for critical parameters such as BOD, COD, dissolved oxygen (DO), fecal coliform, and nutrient concentrations. These parameters were essential for assessing the extent of pollution and identifying potential health hazards.

IV. Hydraulic Flow Verification

Population-derived flow estimation methods were utilized to verify whether the existing sewer infrastructure could accommodate the additional load from diverted dry weather flows. Modeling tools were employed to simulate flow behavior under different scenarios, providing insights into the system's capacity and performance.

V. Stakeholder Consultations

Meetings were organized with municipal engineers, environmental experts, local community leaders, and non-governmental organizations (NGOs) to understand practical challenges and ensure community cooperation in the implementation of proposed solutions. These consultations were vital for gathering diverse perspectives and fostering collaboration.

VI. Preliminary Design Proposals

Based on the data collected, preliminary designs for interceptor chambers, hydro-brakes, and sewer diversions were developed. These designs took into account factors such as topography, existing utilities, land availability, and construction constraints, ensuring that they are feasible and contextually appropriate.

VII. Feasibility and Cost Estimation

A cost-benefit analysis was conducted to compare different strategies for addressing sewage ingress. Capital and operational costs were estimated, along with the anticipated environmental and public health benefits, providing a comprehensive overview of the economic viability of the proposed solutions.

This structured methodology aims to create a robust framework for addressing the sewage ingress issue in Mumbai, particularly focusing on the Mithi River and Powai Lake, while ensuring that the solutions are practical, sustainable, and community oriented.

4.EXPECTED OUTCOMES

This study aims to achieve a comprehensive understanding of the sewage ingress problem and propose implementable solutions to effectively mitigate it. The following are the primary expected outcomes:

Identification of Direct Sewage Discharge Points- One of the key outcomes will be the identification and mapping of direct sewage discharge points into Powai Lake and the Mithi River. This will include a detailed mapping of all inflows from stormwater drains that carry not only rainwater but also contaminated dry weather flow. This dry weather flow often consists of a mixture of greywater and sewage, which enters storm drains due to illegal connections or leakages in the sewage network.

Mapping of Solid Waste Dumping Hotspots: The study will highlight hotspots for solid waste dumping along the banks of rivers and lakes. These hotspots contribute indirectly to sewage contamination by clogging

drains and causing overflow. Through field surveys and water quality sampling, we expect to produce a detailed mapping of both point and non-point sources of sewage pollution, enabling a deeper understanding of how and where contamination enters the water bodies.

Classification and Quantification of Pollution Sources Another significant outcome will be the classification and quantification of contributions to overall pollution from industrial, domestic, and stormwater sources. By evaluating these individual contributors, the study can recommend targeted interventions tailored to each type of pollution source.

Technical Evaluation of Existing Infrastructure A thorough technical evaluation of the existing sewage and drainage infrastructure is anticipated, which will provide insights into deficiencies within the current system. This evaluation will help identify critical areas for improvement, which can then be addressed through the proposed strategies.

Implementation Roadmap The study will also aim to develop a clear implementation roadmap for the proposed solutions, including timelines, responsible stakeholders, and necessary resources. This roadmap will facilitate coordinated action among various agencies and community stakeholders.

Enhanced Community Awareness and Engagement By involving local communities and stakeholders throughout the study, we expect to foster greater awareness and engagement regarding sewage pollution issues. This increased awareness can lead to more active community participation in monitoring and maintaining water quality.

Overall, the expected outcomes of this study will provide a solid foundation for addressing the sewage ingress problem in Mumbai, particularly in relation to Powai Lake and the Mithi River, ultimately contributing to improved water quality and public health.

5.CRITICAL ANALYSIS & RESEARCH GAPS

Despite significant efforts in research and practice, urban sewage ingress into rivers and lakes remains a persistent issue in India. While there is growing recognition of the problem, several critical gaps continue to hinder sustainable solutions

Technical Gaps

Many Indian cities still depend on outdated or fragmented sewage systems. Key gaps include:

- **Limited use of smart technologies** like IoT sensors and real-time monitoring, which are common in cities like Singapore and Tokyo.
- **Inconsistent design standards** and **cost-benefit evaluations** for decentralized systems like DEWATS, limiting their scalability.
- Most studies focus on **water quality outcomes**, but fail to assess **energy use, maintenance needs**, and **climate resilience** of interventions.

Institutional & Policy Challenges

While programs like the Swachh Bharat Mission and Namami Gange exist, their implementation faces several challenges:

- **Lack of coordination** between municipal bodies, state pollution boards, and urban development authorities.
- **Weak enforcement** of discharge norms, allowing illegal discharges to continue.
- **Inconsistent political support** and project funding, leading to **discontinuity** in initiatives.

- **Absence of a standardized framework** for decentralized systems such as DEWATS, despite their success in certain regions.

Social and Community-Related Gaps

Public participation in sewage management remains underutilized. Key issues include:

- **Short-lived community efforts** due to lack of sustained government support and limited **awareness** of health and environmental risks.
- **Resistance to behavioral change**, such as source segregation and paying for decentralized treatment systems.
- Limited **social research** on fostering long-term community ownership over water bodies and wastewater systems.

Integration into the Present Project

The findings from this review offer insights for the dissertation on "Stopping the Ingress of Sewage into Rivers and Lakes":

- **Technical solutions** from global best practices (e.g., Seoul's stormwater separation and Singapore's advanced STPs) can inform interventions for Powai Lake and the Mithi River.
- Addressing **governance gaps** and enhancing **community engagement** can inform the strategic framework for Mumbai.
- Incorporating **real-time monitoring systems**, **modular DEWATS units**, and **public- private collaborations** could offer a scalable roadmap for water body rejuvenation..

6.CONCLUSION

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 proposed strategy for Powai Lake and the Mithi River emphasizes:

- Unified urban water management authority for better inter-agency coordination
- Smart monitoring through flow meters and sensors.
- Policy incentives for adopting decentralized systems like DEWATS.
- Strengthened community participation through local water quality committees and awareness

campaigns.

This approach aligns with national programs such as Swachh Bharat Abhiyan and Namami Gange, aiming to bridge the knowledge-practice gap and promote sustainable urban water body restoration

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