A Multi-Parametric Assessment of Infrastructure, Policy, and Economic Barriers in Pune's Wastewater Management

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ABSTRACT

This paper examines Pune's evolving municipal wastewater management framework as a model for sustainable urban development policy in rapidly urbanising Indian cities. Through a comprehensive analysis of infrastructure expansion, technological innovation, and regulatory frameworks, we assess the effectiveness of decentralised treatment strategies in addressing urban environmental challenges. Our study reveals that despite significant infrastructure investments totalling ₹1,173 crore under the JICA-funded Project for Pollution Abatement of River Mula-Mutha (PARMM), Pune continues to face a 503 MLD daily treatment gap, with only 49% of generated sewage receiving treatment. Using a multi-parametric policy assessment, integrating performance data from 11 sewage treatment plants, policy documents, and environmental monitoring reports, the research finds that while technological diversification demonstrates promise, persistent funding delays, land acquisition disputes, and the "subsidy barrier" in water pricing threaten environmental sustainability outcomes. The research contributes to sustainable urban development literature by demonstrating how policy integration, technology choice, institutional coordination, and financial sustainability mechanisms determine wastewater management effectiveness.

Keywords: Urban Wastewater Policy, Decentralised Treatment, Circular Economy, Infrastructure Financing, Pune Municipal Corporation, JICA.

INTRODUCTION

Rapid urbanisation in the Global South has fundamentally outpaced the development of sanitary infrastructure, creating a severe public health and environmental crisis. In India, the challenge is acute; according to the Central Pollution Control Board (CPCB), Class I and Class II cities generate over 72,000 Million Litres per Day (MLD) of sewage, yet only 30% is treated. As cities expand, the traditional linear approach to water management - take, use, discharge - has proven ecologically unsustainable and economically inefficient.

This paper investigates the transition toward integrated water management systems, using Pune, a major IT and industrial hub in Maharashtra, as a representative case study. Pune's context is critical due to its geographic placement upstream of the Bhima River basin, where local discharge directly impacts downstream water security for the Ujani Dam reservoir. The city currently generates approximately 1,000 to 1,200 MLD of sewage, yet the installed and operational treatment capacity lags significantly.

The objective of this research is to identify the policy and implementation barriers that prevent the closure of this gap. We move beyond simple capacity statistics to examine the institutional frictions - specifically between funding bodies, municipal execution, and regulatory oversight - that hinder the realisation of 100% treatment targets. Furthermore, we analyse the economic viability of "circular economy" proposals in a market where freshwater remains heavily subsidised.

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METHODOLOGY

This study adopts a **multi-parametric policy assessment** approach to evaluate the efficacy of Pune's wastewater management strategies. The methodology relies on two distinct pillars of analysis:

Quantitative Performance Assessment: Primary data regarding STP performance were collated from Pune Municipal Corporation (PMC) environmental status reports and Maharashtra Pollution Control Board (MPCB) audits for the fiscal years 2022-2024. Key performance indicators included:

- **Operational Capacity Utilisation:** The ratio of actual sewage treated versus the design capacity of the plant.
- **Effluent Quality Compliance:** Adherence to Biochemical Oxygen Demand (BOD) < 10 mg/L and Chemical Oxygen Demand (COD) < 50 mg/L standards.

Policy and Regulatory Review: We examined key statutory frameworks governing the sector, including the National Urban Sanitation Policy (NUSP), the Atal Mission for Rejuvenation and Urban Transformation (AMRUT), and the specific terms of the JICA-funded PARMM project. The analysis concentrates on the differences between projected milestones and actual ground-level completion rates.

Scope and Methodological Limitations: While this study utilizes specific case comparisons for contextual benchmarking, the analytical framework remains primarily descriptive and diagnostic rather than inferential. Due to limitations on manuscript length, a comprehensive inferential statistical analysis comparing Pune with a broader cohort of Indian cities is excluded from this specific paper. Extensive comparative studies involving Nagpur, along with other national and international case studies utilising diverse wastewater treatment methodologies, are documented in the authors' larger body of work. Consequently, this paper prioritises a deep-dive diagnostic assessment of Pune's specific institutional and economic barriers over broad statistical generalisation.

STUDY AREA AND INFRASTRUCTURE PROFILE

3.1 Geographic Context: Pune is situated at the confluence of the Mula and Mutha rivers. The rapid expansion of the municipal limits, including the recent merger of 23 peri-urban villages, has increased the administrative area to over 518 sq. km, significantly straining existing sewerage networks.

3.2 Existing Infrastructure: The city currently operates a network of 10-11 major Sewage Treatment Plants (STPs) with a cumulative installed capacity of approximately 567 MLD, though operational capacity is often lower (approx. 477 MLD). The technology mix includes:

- **Activated Sludge Process (ASP):** Used in older plants like Dr. Naidu Hospital STP.
- **Sequential Batch Reactor (SBR):** Utilised in newer plants at Mundhwa and Kharadi to minimise land footprint.

Table 1: Inventory of Major Operational STPs in Pune (Selected)

STP Location	Technology	Installed Capacity (MLD)	Operational Status / Key Issues
Dr. Naidu Hospital	ASP	115	Operational: frequent hydraulic overload during peak hours.
Bhairoba Nala	ASP	130	Operational issues with sludge handling and disposal.
Mundhwa	SBR	45	Functional; critical for downstream irrigation reuse.

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Kharadi	SBR	40	Functional; experiences downtime due to power fluctuations.
Erandwane	ASP	50	Operational; aging civil structure requires refurbishment.
Total (Citywide)		**~567**	*Includes other minor plants*

Source: Compiled from PMC Environmental Status Reports (2022-23)

RESULTS AND ANALYSIS

4.1 The Treatment Deficit: Our analysis reveals a persistent divergence between generation and treatment. While the city generates an estimated 980-1200 MLD of sewage, the operational treatment capacity captures less than half of this volume. This results in a daily deficit of over 500 MLD. The untreated load is discharged directly into river bodies, causing eutrophication and spiking coliform levels in the Mula-Mutha river stretch.

Table 2: Comparative Analysis of Sewage Generation vs. Treatment (2023-24)

Parameter	Value (Estimates)
Projected Sewage Generation (Peak)	1,200 MLD
Total Installed Treatment Capacity	567 MLD
Actual Operational Treatment Capacity	**477 MLD**
Treatment Gap (Deficit)	**~503 - 723 MLD**
Percentage of Sewage Treated	~40% - 49%

Source: Analysis based on MPCB Water Quality Monitoring Data (2023)

Technology Performance Gaps: While SBR technology theoretically offers higher effluent quality, our research indicates frequent operational failures.

- **Energy Dependence:** SBR plants require an uninterrupted power supply for their cyclic aeration phases. Frequent outages in peri-urban zones lead to bypassing of treatment cycles.
- **Maintenance Deficits:** Advanced electromechanical components often face downtime due to delays in spare part procurement
- **Skill Gap:** Since it is a new technology and highly capital-intensive, there is a lack of skilled technical manpower.

The "Implementation Paralysis" of JICA Funding: The Project for Pollution Abatement of River Mula-Mutha (PARMM), funded by JICA (₹1,173 crore), was designed to bridge the gap by constructing 11 new STPs with a cumulative capacity of 396 MLD. However, our review identifies "implementation paralysis" as a key finding.

Table 3: Summary of Proposed JICA (PARMM) Infrastructure & Status

Project Component	Details
Total Budget Allocation	₹1,173 Crore
Funding Agency	Japan International Cooperation Agency (JICA)
New Capacity Planned	396 MLD

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Number of New STPs	11
Key Delay Factors	Land Acquisition (Baner, Balewadi); Tender Cost Escalations; Central Govt. Clearance Latency

Source: Author's own compilation

- **Land Acquisition Disputes:** Critical sites in Baner and Balewadi faced prolonged litigation. Unlike greenfield projects, urban retrofitting requires land that is often legally encumbered.
- **Procedural Latency:** The project faced significant delays in the tendering phase due to cost escalations requiring revised approvals from the Central Government, pushing the timeline back by over three years.

DISCUSSION: BARRIERS TO SUSTAINABILITY

5.1 The Subsidy Barrier and the Circular Economy: A core finding of this study is the failure of the "circular economy" model due to distorted market economics. According to Section 5 of the Government Resolution passed by the Maharashtra Government on 30th November 2017 regarding Urban Wastewater Management, Recycling and Reuse Policy, Thermal Power plants must use treated water available within a 50 km radius. It is allocated the first priority of reuse of treated water. The treated water can also be used for Industrial use by MIDCs, Railways or other bulk users, Agricultural use and Other non-potable use as per MPCB norms. The profits from selling treated water are allocated to the respective ULBs. Fresh water supply must be stopped to entities that reuse treated water. Furthermore, the use of treated wastewater will generate a two-fold benefit – save freshwater and generate revenue for STP operators. However, the practical uptake is negligible.

Institutional Fragmentation: There is a notable lack of coordination between the water supply department (planning intake) and the sewage department (handling discharge). This siloed approach prevents the development of a unified "One Water" strategy. Furthermore, the regulatory capacity of the MPCB is limited to periodic monitoring, with insufficient punitive power to enforce compliance on non-performing municipal assets.

Peri-Urban Sprawl: The inclusion of 23 new villages into the PMC limits has created a dichotomy in service levels. These areas rely heavily on septic tanks. Without a dedicated faecal sludge management (FSM) policy for these non-sewered areas, the focus on centralised STPs fails to address the pollution load from the periphery.

RECOMMENDATIONS

To address these systemic gaps, a phased roadmap is proposed.

Short-term Interventions (1-3 Years)

- **Optimisation of Existing Assets:** Immediate refurbishment of electromechanical components in older ASP plants to restore design capacity.
- **Faecal Sludge Management (FSM):** Implementation of scheduled septic tank cleaning services for the newly merged villages, where sewerage networks will take years to develop.
- **Operator Training:** Establishing a "Certified STP Operator" course in collaboration with technical institutes to address the skills gap in handling SBR technology.

Medium-term Structural Reforms (4-7 Years)

- **Differential Tariff Pricing:** State-level intervention is required to rationalize fresh water tariffs. Pricing for industrial fresh water must be increased to make treated wastewater economically attractive.

- **Green Bonds:** Issuance of municipal green bonds to finance the "gap funding" required for operations and maintenance (O&M), ensuring that plants do not shut down due to budgetary constraints.
- **Dual Distribution Networks:** Mandating dual piping systems in all new large-scale residential townships (over 100 units) to utilise treated water for flushing and gardening locally.

Long-term Institutional Changes (8-15 Years)

- **Resource Recovery Systems:** Transitioning STPs from waste disposal units to resource recovery centres that generate energy (biogas) and fertiliser (compost), thereby offsetting O&M costs.
- **Watershed-Level Management:** Moving beyond municipal limits to a river-basin authority approach, ensuring that upstream and downstream urban local bodies coordinate their discharge standards.
- **Policy Harmonisation:** Aligning state and central policies to develop unified quality standards for reuse, supported by a rigorous third-party certification regime.

Scaling and Replication: Successful scaling requires identifying anchor buyers through mandatory off-take agreements with thermal power plants and industrial estates. Enabling regulatory frameworks must address sector-specific standards and fast-track approval processes for reuse projects.

CONCLUSION

Pune’s wastewater management challenges is a result of broader systemic issues in urbanisation. The technology to treat water exists, and capital, although delayed, is available. The critical failure points are institutional and economic. The gap between sewage generation and treatment is not merely a funding issue, but a symptom of undervalued water resources and failures in land governance. Future policy must prioritise regulatory enforcement and market-creation for treated by-products. Sewage management is a priority in terms of public health, water resource management & environmental responsibility. Without shifting the sector from a "public health obligation" to a "resource recovery industry," the gap between sewage generation and treatment will continue to widen. Sustainable urban development requires not just infrastructure, but a fundamental realignment of the economic incentives that govern water & treated wastewater use.

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