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A Noble Method for the Enhancement of Water Utility Efficiency: Using Water Meters to Reduce Non-Revenue Water in Jalgaon City Networks Maharashtra

Shashikant Bharat Bhuse

At Post Aundhi Tal. Mohol Dist. Solapur Pin 413248
Dr. Abhijit Kundu, Dept. of civil Engineering, GH Raisoni University, Maharashtra, India

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Abstract - Non-Revenue Water (NRW) represents a significant challenge for urban water utilities, resulting in financial losses, reduced water availability, and inefficiencies in water distribution. This project, titled "Enhancing Water Utility Efficiency: Using Bulk & Domestic Water Meters to Reduce Non-Revenue Water in City Water Supply Networks from Source to Consumer," aims to address these issues by implementing an integrated metering approach. The project explores the use of bulk water meters at key points in the water distribution network, such as treatment plants, reservoirs, and distribution mains, to monitor large-scale water flows and detect system-wide losses. At the consumer level, domestic water meters provide accurate data on individual consumption, enabling utilities to identify unauthorized usage, address billing discrepancies, and promote responsible water use.

Through real-time data collection and analysis, the proposed metering system allows for proactive leak detection, targeted maintenance, and better overall management of the water distribution network. By integrating bulk and domestic metering with GIS and SCADA technologies, the project aims to create a robust data management framework that enhances utility decision-making, minimizes operational losses, and improves revenue collection. This comprehensive approach not only reduces NRW but also strengthens the financial sustainability of water utilities, ensures fair billing, and supports sustainable water resource management. The project's findings contribute to a scalable NRW reduction model that can be adapted across various urban settings, paving the way for more resilient and efficient water supply systems.

***Key Words*: 1.NRW, 2. SCADA, 3. Physical losses, 4. Water supply, 5. Water Meter 6. Urban Water Management 7. Jalgaon**

1.INTRODUCTION

The Jalgaon City Municipal Corporation is the governing body of the city of Jalgaon in the Indian state of Maharashtra. Jalgaon is 'D' class Municipal Corporation. It was founded in 22 Sept. 2003. Jalgaon Municipal Corporation serves an area approximately 68.46Sq. km & provides civil services & facilities around the 4.60 Lacks people

Jalgaon City's water supply network experiences significant inefficiencies, with NRW levels exceeding 35%, well above the global acceptable benchmark of 15%. NRW encompasses water lost due to leaks, theft, meter inaccuracies, and unbilled consumption, resulting in financial losses for the municipal corporation and unsustainable water resource management.

2. OBJECTIVES AND SCOPE

2.1 Objectives:

Identify NRW sources, including leaks and unauthorized connections.

Implement bulk and domestic water meters to monitor and reduce water losses.

Enhance utility efficiency using GIS and SCADA technologies.

Promote financial sustainability and equitable billing practices.

2.2 Scope:

This study integrates advanced technologies and public engagement to reduce NRW, focusing on operational improvements, data-driven decision-making, and scalable frameworks adaptable to other cities.

3. NRW Analysis for Jalgaon City

3.1 Current Water Supply System

The city sources water primarily from the Waghur Dam. Water is treated at Umale Village Having Capacity of 130.00 MLD and distributed through a network of aging pipelines to residential, commercial, and industrial users. Despite sufficient water production, inefficiencies in the network result in high levels of wastage. Additionally, intermittent supply practices lead to pressure fluctuations, further contributing to losses.

3.2 NRW Components

Physical Losses: Resulting from pipeline leaks, storage tank overflows, and infrastructure failures. These losses account for nearly 60% of total NRW in Jalgaon.

Commercial Losses: Arising from unauthorized connections, meter tampering, and billing inaccuracies. Commercial losses lead to significant revenue deficits for the utility.

Unbilled Authorized Consumption: Including water used for firefighting, public fountains, and other municipal purposes. This consumption is often not accurately recorded, further contributing to NRW.

3.3 Key Challenges

Lack of metering and monitoring systems.

Deteriorated pipeline infrastructure prone to frequent breakdowns.

Limited technical capacity for leakage detection and repair.

Insufficient awareness among the public about the impact of NRW.

Inadequate financial resources to implement large-scale upgrades.

3.4 Service Level Benchmarks (SLB) for Water supply

A standardized set of key performance indicators related to urban management and service delivery were defined, measured and being reported on across urban areas by ULBs and other city-level parastatals. The standardization is ensured by setting definitions and units along with data requirements and reliability of measurements (MoHUA, 2009).

The water related Service Level Benchmarks (SLBs) focus on extent and accessibility to quality service while considering effectiveness of the system to manage the water supply network including aspects of financial sustainability. The following are the indicators for water services which includes the extent of NRW.

Table 1: SLBs for water supply services.

S.No.	Indicator	Benchmark
1	Coverage of water supply connections	100%
2	Per capita supply of water	135 LPCD
3	Extent of metering of water connections	100%
4	Extent of non-revenue water (NRW)	20%
5	Continuity of water supply	24 Hours
6	Quality of water supplied	100%
7	Efficiency in redressal of customer complaints	80%
8	Cost recovery in water supply services	100%
9	Efficiency in collection of water supply-related charges	90%

Credits: MoHUA (2009). Handbook for Service Level Benchmarking. *http://cpheeo.gov.in/upload/uploadfiles/files/Handbook.pdf*

As per the SLB Handbook, the rationale for introducing 'Extent of NRW' indicator is to assess the financial sustainability of the water utility by reducing losses which can be utilized to meet excess demand and defer capital-intensive expenditure to enhance supply capacity. The benchmark value for NRW is 20% which has been achieved by most well-performing utilities in developed countries (MoHUA, 2009).

Table 2: Data requirement for measuring extent of NRW.

Data required	Unit	
a. Total water produced and put into the transmission and distribution system	Million litres per month	Daily quantities should be measured through metering, and records on the transmission and distribution system should be maintained. The total supply for the month should be based on the aggregate of the daily quantum.
b. Total water sold	Million litres per month	The actual volume of water supplied to customers who are billed for the water provided. Ideally, this should be the aggregate volume of water consumed as per which consumers have been billed.
NRW		NRW = [((a - b)/a)*100]

Credits: MoHUA (2009). Handbook for Service Level Benchmarking. *http://cpheeo.gov.in/upload/uploadfiles/files/Handbook.pdf*

As per the SLB Handbook, the frequency of measurement of the indicator should be quarterly to be done at the ULB level. The highest and preferred level of reliability is given to those ULBs where quantity of water produced is computed based on bulk flow meter measurements at the bulk production points and metering is undertaken at key distribution nodes and the user-end for all categories of users (MoHUA, 2009). However, other methods of assessment along with their level of reliability are detailed out in the handbook. The benchmark value for NRW is 20% as the cost of reduction below the benchmark outweighs the benefits.

3.5 NRW Reduction Toolkit

In 2005, as part of the Government of India's urban reform agenda Jawaharlal Nehru National Urban Renewal Mission (JNNURM) efforts to strengthen and empower urban local bodies. This toolkit was prepared to assist ULBs in the NRW reduction process for the water supply service system. It details the water auditing process and calculating losses at various points of the water distribution system. The toolkit provides initial guidance to officials and policy makers in the water sector (MoHUA, 2012).

3.6 Impact of NRW on water and power

Most water utilities with high NRW fall into a vicious cycle where high levels of NRW lead to low levels of efficiency. The marketable product of a water utility is treated water, if a majority of this treated water is lost in the distribution cycle, the cost of water collection, treatment and distribution increases and the water sales decrease. This triggers the need for substantial capital expenditure programmers to meet ever-increasing demand which doesn't address the core problem

NRW has a significant impact on water availability, power consumption and cost-recovery in a city. In the following scenario based on a real case example we can see the impacts of NRW on the same.

4. Proposed Interventions

4.1 Advanced Metering Infrastructure (AMI)

Overview: The installation of advanced metering systems is a cornerstone of NRW reduction strategies. Digital water meters with automated reading capabilities provide real-time data on water consumption, enabling better monitoring and billing accuracy.

Implementation Strategy: Installation of AMI at household, commercial, and industrial levels.

Integration with central data systems to allow remote monitoring.

Benefits: Accurate measurement of water usage.

Quick identification of anomalies such as leaks or unauthorized usage.

Enhanced transparency in water usage and billing processes.

4.2 Infrastructure Upgrades

Pipeline Replacement: Replacement of old pipelines with modern, durable materials to reduce physical losses. Priority will be given to areas with the highest reported leakages.

Pressure Regulation: Installation of pressure-regulating valves to maintain optimal pressure and prevent pipe bursts. These valves ensure the longevity of pipelines and improve service reliability.

4.3 Leakage Detection and Repair

Technologies Used: Acoustic leak detection, GIS-based mapping, and advanced sensors.

Action Plan: Conducting a comprehensive network audit to identify vulnerable sections.

Developing a systematic maintenance and repair schedule.

Deploying rapid response teams for timely repairs.

4.3.1 In-line Leak Detection Techniques

With the advent of new technologies, in-line leak detection techniques are used for large diameter pipelines. Probes are placed in the pipe which picks up leak noises/pressure differences as they pass through it. These methods/techniques are highly sophisticated and need skilled supervision. They may be applicable only under specific conditions, like availability of full bore, branchless lengths, absence of air valves/scour valves which may draw the sensor to its stub, etc.

4.3.1.1 Parachute/Tethering device

Parachute / tethering device is a tool which can be used in pipelines larger than 150 mm diameter without the need to put the pipeline out of the service. The tool is connected with the pipes, hence, a leak, air pockets and visual anomalies can be monitored. A tap of 50mm or more may be used to insert the tool into an active pipeline. The flow velocity of the water inflates a small parachute or drogue after the tool is inserted. The parachute pulls the tool through the pipe, with the probe lighting the way with its onboard LED lighting system, highlighting any visual defects in the pipeline as shown in Figure 1.0 If the tool detects any acoustic events, such as a leak, the operator can stop the tool at the precise location of the leak, and an above-ground operator can locate the sensor as shown in Figure 1.0, marking the exact leak location within plus or minus 0.5 metres. This enables users to know in real time where the leaks are, and where repairs are needed.

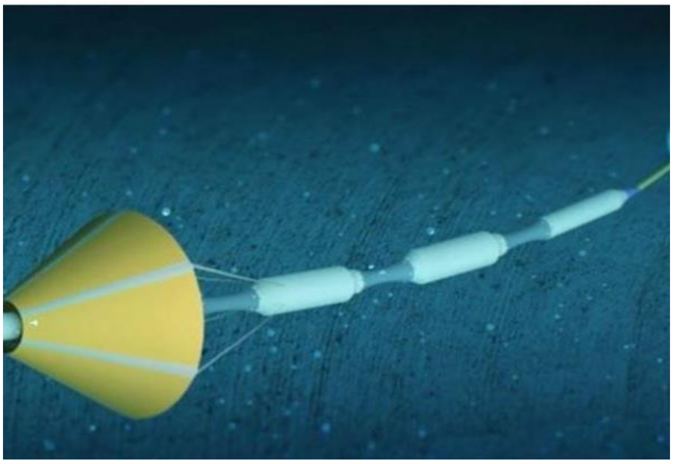

Figure 1.0 Tethering Device for Inline Leak Detection System

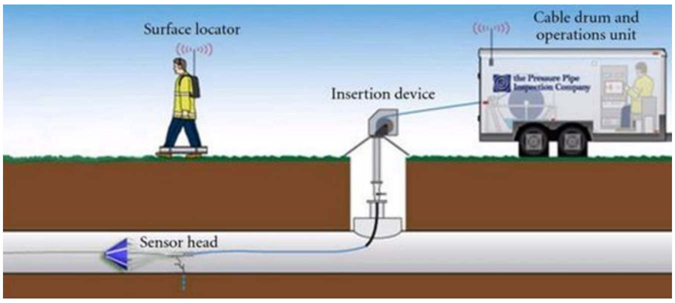

Figure 1.1 Surface Locator

4.3.1.2 Robot for Leak Detection

A robot with a soft rubber skirt/hand (Figure.2.1) attached at the rear end, which fills the diameter of the pipe, is inserted into the system through hydrants, Tee, etc. This robot inspects pipes as it moves/propels with the water through the pipe, and its "hands" touch the pipe to detect the suction forces created by leaks. The gadget is subsequently recovered with a net through another hydrant, and its data is uploaded, revealing the location and size of the leak. No digging is required, and there is no need for any interruption of the water service.

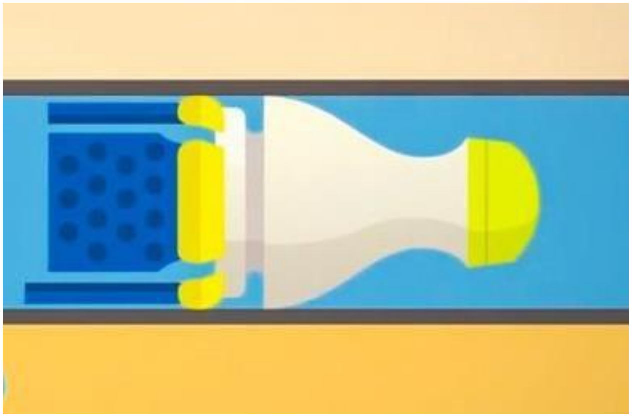

Figure 2.1: Robot for Leak Detection

4.4 Community Engagement

Awareness Campaigns: Educating citizens about the importance of water conservation and their role in reducing NRW. Campaigns will include workshops, social media outreach, and school programs.

Reporting Systems: Establishing a helpline and mobile application for citizens to report leaks and illegal connections.

Incentives: Offering rebates to households that demonstrate water conservation practices.

4.5 Capacity Building

Staff Training: Equipping municipal staff with the skills required for handling modern metering systems, analyzing data, and managing infrastructure.

Task Force: Forming a dedicated NRW reduction task force within the municipal corporation to oversee and coordinate efforts.

4.6 Policy and Regulatory Framework

Establishing clear policies to penalize unauthorized connections and reward efficient water usage.

Creating guidelines for water auditing and reporting, ensuring accountability at all levels of the water utility.

5 Research Methodology

This project utilizes Bentley's Water GEMS software to simulate water network behavior and identify NRW hotspots. GIS data integrates spatial mapping of pipelines, valves, and other network components. Thiessen polygons delineate service areas, enabling precise population demand allocation. Scenario management tools aid in testing various operational strategies

6. Results and Discussion

Preliminary findings suggest that integrating bulk and domestic water meters can significantly reduce NRW by pinpointing leaks and unauthorized usage. The data-driven framework supports targeted maintenance and enhances revenue recovery through accurate billing

7. Conclusion

The proposed metering system offers a scalable model for reducing NRW in urban settings. By leveraging advanced technologies, Jalgaon's water utility can achieve financial sustainability, operational efficiency, and equitable water distribution. This approach is adaptable for other cities facing similar challenges.

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