ESP Journal of Engineering & Technology Advancements (ESP-JETA)
ISSN: 2583-2646
Special Issue: International Conference on Modern Engineering and Future Technologies (ICMEFT-26)

Original Article

Experimental of Urban Water Distribution System for Pressure and Water Loss Reduction

Sujith.R[1], Mr. S. Kesavan[2]
[1] *UG Student / Department of Civil Engineering / P.S.R. Engineering College / Sivaksi, Tamilnadu, India – 626140.*
[2] *Associate Professor / Department of Civil Engineering / P.S.R. Engineering College / Sivaksi, Tamilnadu, India – 626140.*

Abstract: *Urban water distribution systems are essential for supplying water to cities, but they often face problems like uneven pressure, leaks, and water loss. This study analyzes an existing water network using field data and hydraulic modelling to identify these issues. Key factors such as pressure, flow, and leakage points are examined. The study finds that problems are mainly caused by old pipes, poor maintenance, and illegal connections. To improve the system, solutions like pressure control, leak detection, and pipeline repair are suggested. Overall, proper pressure management and regular maintenance can reduce water loss and improve efficiency, helping ensure a sustainable water supply.*

Keywords: *Urban Water System, Pressure Management, Water Loss, Leakage Control, Hydraulic Modeling, Pipe Network, PRVs, NRW, Leak Detection, Water Efficiency, Network Optimization, Infrastructure Management*.

I. INTRODUCTION

Urban water distribution systems play a vital role in supplying safe and adequate water to growing populations. With rapid urbanization and increasing demand, maintaining an efficient water supply network has become a major challenge in modern cities. One of the key issues faced by these systems is the imbalance in pressure distribution, which often leads to excessive water losses, pipeline failures, and inefficient service delivery. Water loss in distribution systems mainly occurs due to leakage, illegal connections, faulty meters, and poor maintenance practices. High pressure in pipelines is one of the primary causes of leakage, as it increases stress on pipe walls and joints, leading to cracks and bursts. Conversely, low pressure results in inadequate water supply, especially in elevated and remote areas. Therefore, maintaining optimal pressure throughout the network is essential for both system efficiency and customer satisfaction.This experimental study focuses on analyzing pressure variations and identifying water losses in an urban water distribution system. By conducting field measurements and using modeling tools like EPANET, the study aims to evaluate system performance under different conditions. The research also explores effective pressure management techniques such as pressure reducing valves (PRVs), district metered areas (DMAs), and pipeline The findings of this study will help in improving water distribution efficiency, reducing non- revenue water, and ensuring sustainable water management practices in urban areas. This project provides practical insights into real-time system behavior and supports the development of cost-effective solutions for better water resource management.

II. LITERATURE REVIEW

Urban water distribution systems (WDS) play a vital role in supplying safe and reliable water, but they often suffer from high water losses and pressure-related issues. Studies show that nearly 25–30% of water is lost globally due to leakage in distribution networks, making water loss reduction a major concern for utilities Pressure management is considered one of the most effective methods to control leakage and improve system efficiency Excess pressure in pipelines increases the rate of leaks and pipe bursts, while controlled pressure helps extend infrastructure life and reduce non- revenue water (NRW). The use of Pressure Reducing Valves (PRVs) is widely adopted to maintain optimal pressure levels within the network Hydraulic modeling tools such as EPANET are commonly used to analyze system behavior, simulate flow and pressure conditions, and identify leakage zones. Research indicates that combining field data with hydraulic models provides accurate results for system assessment and decision-making Techniques like Minimum Night Flow (MNF) and District Metered Areas (DMAs) are also used to quantify and monitor water losses effectively Recent studies highlight that real-time pressure control can significantly reduce water losses. For example, a case study showed that reducing network pressure led to about 19% reduction in water loss, proving the effectiveness of pressure management strategies. Additionally, advanced methods such as predictive modeling and smart monitoring systems are improving leak detection and network optimization Overall, the literature confirms that proper pressure management, hydraulic modeling, and regular maintenance are essential for reducing water losses and improving the performance of urban water distribution systems.

III. METHODOLOGY

- The project follows the CPHEEO guidelines for designing and improving the urban water distribution system. The study is planned with a design period of
30 years (2027–2057), considering future population growth.

  Population is projected using standard methods such as arithmetic, geometric, incremental, and graphical techniques to estimate water demand for future years. Based on this, per capita water demand of 135 lpcd is adopted along with allowances for losses and fire demand.
- Hydraulic analysis of the pipeline network is carried out using the Hazen- Williams formula to determine flow and pressure conditions. Proper limits are maintained for velocity (0.3–3.0 m/s) and minimum pipe diameter (100 mm) as per standards.
- Suitable materials like Ductile Iron (DI) and Mild Steel (MS) pipes are considered for durability. The system is designed to maintain adequate residual pressure (7– 22 m) at consumer points.

IV. RESULTS AND DISCUSSION

A. Pressure Analysis

Significant pressure variations were observed across the network. Low-pressure zones were identified at tail-end areas and elevated regions, leading to inadequate water supply. High-pressure zones were observed near source points, increasing the risk of pipe bursts and leakages. The pressure distribution was found to be uneven and inefficient.

Pressure analysis helps in identifying weak zones and high-stress areas in the water distribution network. By maintaining optimal pressure, municipalities can:

- Improve service reliability
- Reduce water losses
- Extend pipeline lifespan

Table 1: Pressure Analysis Result

Category	Conclusions / Findings
Pressure Analysis	Low-pressure zones at tail-end and elevated areas and High-pressure zones near source points
Water Loss Assessment	High Non-Revenue Water (NRW) detected and Leakages, illegal connections, meter inaccuracies
Network Performance	Poor hydraulic performance in certain areas Head loss and reduced flow efficiency
Critical Areas Identified	Leakage-prone zones identified and Low-pressure and high-loss regions

High Pressure Zones: Located near pumping stations and storage reservoirs (OHT). These areas experience excessive pressure, which increases the chances of pipe bursts and leakage.

Medium Pressure Zones: Found in central parts of the network where supply is relatively stable and satisfactory.

Low Pressure Zones: Observed at tail-end areas and higher elevation regions, resulting in inadequate water supply to consumers.

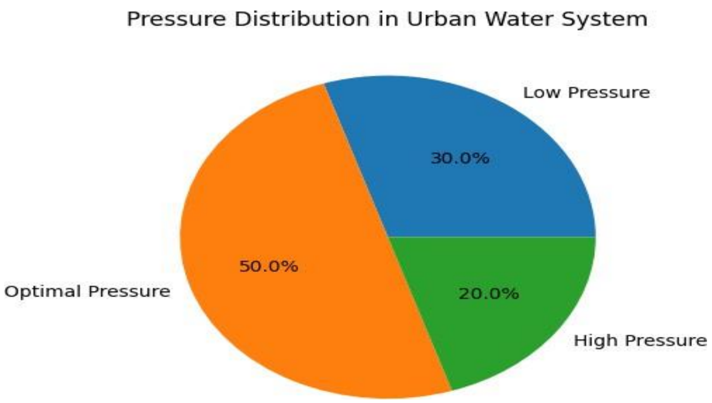

Figure 1: Pressure distribution in urban water system

B. District Metered Areas

A District Metered Area (DMA) is a specific, isolated zone within a water distribution system where the flow and pressure are continuously measured and monitored. The area is hydraulically separated so that water entering and leaving the zone can be accurately controlled.

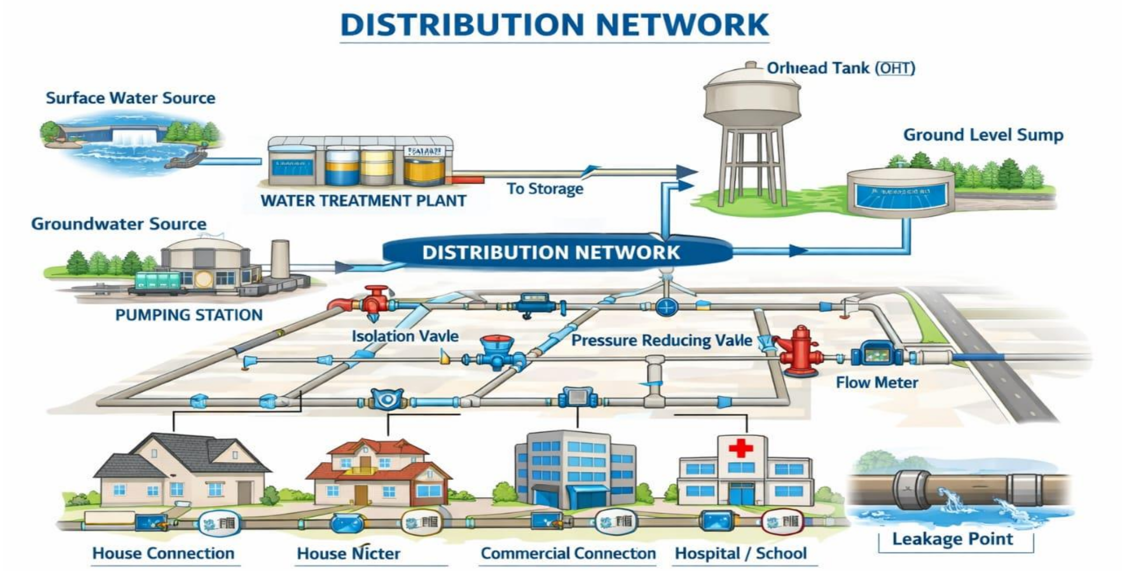

Figure 2: Distribution system

Table 3 shows that The study area is divided into multiple zones, each representing a District Metered Area (DMA), to effectively monitor and manage the urban water distribution system. Each DMA is hydraulically isolated by boundary valves, allowing accurate measurement of water inflow, consumption, and losses within the zone. By analyzing these zones individually, variations in pressure and flow can be identified, helping to detect leakage and reduce non-revenue water.

Central zones with dense networks tend to experience higher pressure and greater leakage risks, while outer zones may face low- pressure issues. This zonal approach improves system efficiency by enabling better pressure control, quick leak detection, and optimized water supply management.

Table 2: System Pressure table

Location	Pressure (m)	Status
Near Source	22	High Pressure
Mid Area 1	15	Medium Pressure
Mid Area 2	12	Medium Pressure
Tail-End Area 1	8	Low Pressure
Tail-End Area 2	6	Very Low Pressure

The system performance analysis indicates several critical issues affecting the efficiency of the urban water distribution network. Pressure distribution is uneven, with low pressure observed at tail-end areas and excessive pressure near the source, leading to leakage problems. Flow rates are inconsistent due to reduced flow in certain areas, and a high level of non-revenue water is observed because of leaks, illegal connections, and meter inaccuracies.

Water Loss Analysis Results

The water loss analysis was carried out to evaluate the efficiency of the distribution system and to identify the major sources of water loss. The results indicate that a considerable amount of water supplied into the system is not effectively utilized, leading to high Non-Revenue Water (NRW).

Non-Revenue Water (NRW) Assessment:
NRW represents the difference between the total water supplied and the water actually billed to consumers.
NRW = Water Supplied – Water Consumed

The analysis shows: A significant percentage of water is lost before reaching consumers
High NRW indicates poor system efficiency and management issues

Table 3: Water Loss Components Table

Component	Percentage (%)	Remarks
Physical Loss	55%	Major leakage in pipes
Commercial Loss	25%	Illegal connections
Operational Loss	20%	Poor management

V. CONCLUSION

The experimental study of the urban water distribution system reveals that improper pressure management is one of the main causes of water loss and inefficiency. Significant variations in pressure were observed across the network, with high-pressure zones leading to increased leakage and low-pressure areas affecting the reliability of water supply. The presence of non-revenue water due to leakage, illegal connections, and aging infrastructure further reduces system performance.

The analysis using field data and modeling tools such as EPANET demonstrates that effective pressure control can significantly reduce water losses and improve overall efficiency. The implementation of District Metered Areas (DMA) helps in accurate monitoring and quick identification of leakage zones, while pressure reducing valves (PRVs) play a key role in maintaining optimal pressure levels. It is also concluded that regular maintenance, replacement of old pipelines, and adoption of modern technologies like SCADA and real-time monitoring systems are essential for sustainable water management. By integrating these strategies, the water distribution system can achieve reduced losses, improved service reliability, and better resource utilization.

Overall, the study highlights that a combination of proper planning, advanced monitoring, and efficient pressure management techniques is necessary to ensure a reliable and sustainable urban water supply system.

VI. REFERENCES

[1] Water LossReduction in Water Distribution Networks. Case Study May 2019 Journal of Applied https://www.researchgate.net/publication/3347030 04
[2] Assessment of Water Losses in Urban Water Supply Systems Mutikanga, H.E.; Sharma, S.K.; Vairavamoorthy, https://link.springer.com/article/10.1007/s11269- 010-9743-9
[3] Lambert 2002 introduced the concept of Non-Revenue Water (NRW) and emphasized the importance of leakage

control in water distribution systems. He developed performance indicators for assessing water losses.https://www.iwawater.org/resources/water- loss-performance-indicators/

[4] Farley & Trow (2003)Their book discusses practical methods for leakage control, including pressure management and DMA implementation.https://www.iwapublishing.com/bo oks/9781900222115/losses-water-distribution- networks

[5] Alegre et al. (2006) Focused on performance indicators for water supply services, helping utilities improve efficiency and reduce losses. https://www.iwapublishing.com/books/978184339 0513/performance-indicators-water-supply-services

[6] Kingdom et al. (2006)Discussed global challenges of water loss management and strategies to reduce NRW in urban systems. https://documents.worldbank.org/en/publication/documentsreports/documentdetail/38576146833032 6484/the-challenge-of-reducing-non-revenue-water- in-developing-countries

[7] Puust et al. (2010)Studied causes and control of leakage in water distribution networks, highlighting pressure as a key factor. https://www.sciencedirect.com/science/article/pii/S 0043135409005485

[8] Thornton (2008)Explained advanced leakage management techniques, including DMA and pressure,optimization. https://www.iwapublishing.com/books/978184339 2555/water-loss-control

[9] Mutikanga et al. (2013)Analyzed water loss management in developing countries and emphasized,DMAimplementation. https://www.sciencedirect.com/science/article/pii/S 2210670713000147

[10] Serafeim et al. (2024)This study provides a comprehensive review of leakage estimation methods and reduction strategies in water distribution systems. It highlights the impact of pressure and network conditions on leakage. https://www.mdpi.com/2073-4441/16/11/1534

[11] Özdemir (2018)Focused on DMA-based leakage management, showing how district metering helps identify water losses and faulty meters effectively. https://pubmed.ncbi.nlm.nih.gov/29497875/

[12] Kakeshpour et al. (2025)This research explains optimization of DMA and pressure zones, showing improved reliability and reduced leakage in water networks. https://link.springer.com/article/10.1007/s13201- 025-02640-w

[13] Rajakumara et al. (2020)Studied pressure management using PRVs inside DMA, showing significant reduction in water losses and improved system control. https://www.tandfonline.com/doi/abs/10.1080/157 3062X.2020.1773508