CEST 2023

18th International Conference on Environmental Science and Technology

Athens, Greece, 30 August to 2 September 2023

A smart integrated platform for leakage detection on water supply network in Aigio town

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Abstract Non-revenue water (NRW) is the volume of water participating in urban water supply processes that does not generate revenues for the water utility company, and it is divided into water losses and unbilled consumption. In the era of sustainable water resources management, the reduction of NRW is among the main objectives of both national and regional management plans; especially to cope with the losses. In this frame, the Municipal Enterprise for Water Management of Aigialeia (DEYA.A) and the Research Laboratory of Smart Technologies, Renewable Energy Sources & Quality (UNIWA) collaborate in the project entitled "Smart system for Leak Detection for water supply Network of Aigio" with the purpose of controlling water leakage, which now reaches around 48% of the total water supply in the study area. This paper describes the main objective of the project, which is the development of a smart system for leakage detection in the internal network of Aigio City. Particularly, the system's components as well as the implementation scheme of the project are presented, and overall analysis serves the municipality's new water saving strageties that may lead to an estimated amount of 600000 m^3 of water saving per year.

Keywords: Non-revenue water, water supply network, water leakage, water supply monitoring, Aigio

1. Introduction

Water loss due to leakage in water distribution networks is a significant global challenge faced by water utility companies, impacting both economic sustainability and environmental conservation efforts. Leakage monitoring plays a crucial role in mitigating this problem by enabling timely detection, localization, and repair of leaks, thereby reducing water losses and improving the overall efficiency of water distribution systems. In recent years, significant advancements have been made in the field of leakage monitoring, driven by innovative technologies, data-driven approaches, and smart water management systems.

There are many innovative approaches for non-revenue water management, such as advanced metering infrastructure, smart water networks, pressure management systems, acoustic leak detection, and asset management technics (Farouk et al., 2023). The best approach is the implementation of a combination of technological and managerial approaches to effectively manage non-revenue water, by providing valuable insights for water utility companies, policymakers, and researchers involved in non-revenue water management, offering guidance on the selection and implementation of innovative technologies and strategies to mitigate water losses and improve the overall efficiency of the water supply system.

Water leakages in the internal water supply networks of cities are the most common and, at the same time, the most important problem water utility companies face (National Research Council, 2006). Indicatively, the cost of leakages is estimated at 39 billion USD per year (Liemberger and Wyatt, 2019), while, apart from this cost, the impact on potable water quality is also important, which monitoring is still not easy (Crocker and Bartram, 2014).

In Aigio (Greece), according to the Municipal Enterprise for Water and Wastewater of Aigialeia (DEYA.A), water leakage is estimated around 48% (Table 1), an amount that cannot be accurately calculated, not even monitored. Trying to deal with this issue, one of the main purposes of the research project entitled "Smart system for Leak Detection for water supply Network of Aigio" is to develop a smart monitoring system that is estimated to contribute to saving up to 600000 m^3 of water per year in the internal water network of the city of Aigio. This work presents the general framework of the project. One of the prominent strategies for leakage reduction is pressure management, which involves optimizing pressure levels to minimize leaks (Kingdom et al., 2006). Active leak control

strategies, such as acoustic leak detection systems and real-time monitoring technologies, offer efficient methods to identify and locate leaks promptly (e.g., Atef et al., 2016; Hunaidi et al., 2000). Additionally, the speed and quality of repairs, along with robust asset management systems, play crucial roles in minimizing water losses and maintaining infrastructure integrity (Kingdom et al., 2006). Finally, the integration of smart systems, including smart water meters and data analytics, presents new opportunities for real-time leakage detection, consumption monitoring, and optimized network management (Shi et al, 2022; Schultz et al., 2018). These technologies enable proactive leak detection, leading to rapid response and timely repairs (Chasiotis et al., 2022).

Table 1. Water Leakages in several municipalities in Greece

City	Percentage of Leakages
Aigio,N. Peloponnese	48%
Argos, E. Peloponnese	54%
Ioannina, Epirus	63%
Souli, Epirus	72%

2. Integrated platform for leakage monitoring

2.1. IoT sensors

As part of the system development, IoT sensors have to be installed in the internal water network of the City of Aigio, in four main areas (Figure 1). The sensors that will be installed are Electromagnetic Flowmeters providing measurement every second, connected to PLC. Furthermore, to have more accurate monitoring of the complete closed District Metered Area (DMA), pressure sensors will be installed in the closed loop, connected to data loggers with internal modem, in order to send every 15 minutes the pressure of the network.

2.2. Monitoring system

A monitoring system will be developed based on an online platform that holds significant potential in addressing the challenges associated with leakage detection and management in water distribution networks. By incorporating real-time data and advanced analytics, an online platform can provide a centralized hub for monitoring the performance of internal city water networks (Hudiono et al., 2021; Perumal et al., 2015). This platform will enable continuous data collection from the deployed sensors in the network. The collected data will be transmitted to the online platform, where information will be processed and analyzed using machine learning algorithms and statistical techniques. This platform will provide visualization, alerts, and reports, which will facilitate efficient decision-making and prompt response to leakages. Additionally, the online platform can interact with other smart systems and technologies, such as smart water meters and other IoT devices, to enhance the overall functionality and effectiveness of leakage monitoring. By providing real-time insights, facilitating remote monitoring, and enabling proactive leak detection, an online platform-based monitoring system may be a valuable tool for water utility companies and authorities to optimize their internal city network management, to reduce water losses, and to ensure the sustainable use of water resources.

2.2. Hydraulic Model

A hydraulic model will be developed for Aigio based on the EPANET (Rossman, 1994) and incorporating the concept of digital twin. By integrating EPANET with a digital twin framework, the hydraulic simulation can be enhanced by incorporating real-time data from the sensors and the monitoring system. Several simulations will be also examined to gain valuable insights into the system's real-time performance. Key hydraulic parameters will be monitored, while any anomalies will be detected, and also potential issues can be predicted before they occur. This proactive approach facilitates timely decision-making and enables efficient management of the water distribution network. Additionally, the digital twin can be utilized for scenario analysis, allowing engineers and operators to evaluate the impact of different operational strategies, infrastructure upgrades, or demand changes on the system's behavior. Through this approach, decision-makers can assess the effectiveness of various interventions, optimize system performance, and plan for future contingencies. The proposed approach adds an extra layer of sophistication to hydraulic simulations, enhances their accuracy and responsiveness. By harnessing the power of real-time data and advanced analytics, this approach empowers water utility companies to make informed decisions, to improve operational efficiency, to reduce water losses, and, finally, to ensure the reliable water supply to the City of Aigio.

3. Results and Discussion

This paper describes the main objectives, the system's components, and the implementation scheme of a research project, which will contribute to the development of a smart system for leakage detection in the internal network of Aigio City, which is estimated to save up to 600000 m^3 of water per year. The system will be operated by the Municipal Enterprise for Water and Wastewater of Aigio, and, amongst the expected results, is that a holistic approach regarding networks operation will be provided, as well as, a case-oriented hydraulic model will be designed for the Municipal Enterprise, to monitor various technical and physical parameters (e.g., pressure and temperature). Several scenarios will be examined based on the integrated platform, with the purpose of detecting any specific areas, pipes and nodes that leakages are possible to occur.

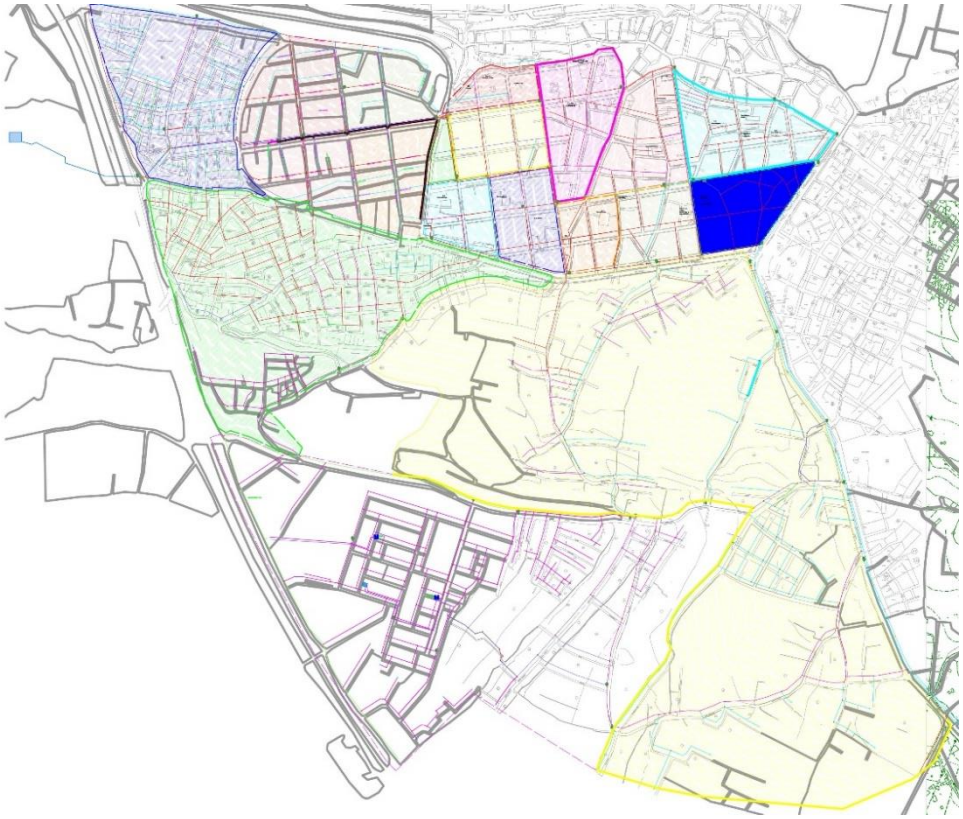

Figure 1. DMA's Zones of Aigio City (Source: DEYA.A)

Acknowledgments: The research project entitled "Smart system for Leak Detection for water supply Network of Aigio" is co-funded by the Program "Water management" of EEA Grants 2014-2021, with the contribution of Iceland, Liechtenstein and Norway, and the Greek Public Investments Program. Authors would like to thank the Municipal Enterprise for Water and Wastewater of Aigio for the provision of available data regarding water consumption.

References

Atef, A., Zayed, T., Hawari, A., Khader, M., and Moselhi, O. (2016), Multi-tier method using infrared photography and GPR to detect and locate water leaks, *Automation in Construction*, **61**, 162-170.

Chasiotis, A., Tsitsifli, S., …, Louta, M. (2023), Building a smart green system to control water leakage and monitor drinking water quality in the water supply system of Paramythia city, Greece: the case of SMASH project, *EGU General Assembly 2023*, EGU23-10057, Vienna, Austria, 24–28 April.

Crocker, J., and Bartram, J. (2014), Comparison and cost analysis of drinking water quality monitoring requirements versus practice in seven developing countries, *International journal of environmental research and public health*, **11**(7), 7333-7346.

Farouk, A. M., Rahman, R. A., and Romali, N. S. (2023), Non-revenue water reduction strategies: a systematic review, *Smart and Sustainable Built Environment*, **12**(1), 181-199.

Hudiono, H., Taufik, M., Perdana, R. H. Y., and Rakhmania, A. E. (2021), Digital centralized water meter using 433 MHz LoRa, *Bulletin of Electrical Engineering and Informatics*, **10**(4), 2062-2071.

Hunaidi, O., Chu, W., Wang, A., and Guan, W. (2000), Detecting leaks in plastic pipes, *Journal-American Water Works Association*, **92**(2), 82-94.

Kingdom, B., Liemberger, R., Marin, P. (2006), The Challenge of Reducing Non-Revenue Water in Developing Countries--How the Private Sector Can Help: A Look at Performance-Based Service Contracting, *Water Supply and Sanitation Sector Board discussion paper series*; no. 8. World Bank, Washington, DC.

Liemberger, R., and Wyatt, A. (2019), Quantifying the global non-revenue water problem, *Water Supply*, **19**(3), 831-837.

National Research Council (2006), Drinking Water Distribution Systems: Assessing and Reducing Risks, Washington, DC: *The National Academies Press*.

Perumal, T., Sulaiman, M. N., & Leong, C. Y. (2015). Internet of Things (IoT) enabled water monitoring system, In *2015 IEEE 4th Global Conference on Consumer Electronics (GCCE)*, 86-87, IEEE, October.

Rossman, L. A. (1994), EPANET users manual : project summary. Cincinnati, OH:U.S. Environmental Protection Agency, Risk Reduction Engineering Laboratory.

Schultz, W., Javey, S., and Sorokina, A. (2018), Smart water meters and data analytics decrease wasted water due to leaks, *Journal-American Water Works Association*, **110**(11), E24-E30.

Shim, K., Berrettini, E., and Park, Y. G. (2022), Smart Water Solutions for the Operation and Management of a Water Supply System in Aracatuba, Brazil, *Water*, **14**(23), 3965.