**Abstract:** Water leakages in urban water supply networks are a major cause of non-revenue water (NRW) and pose significant challenges for water management. To address this issue, the Municipal Enterprise for Water and Wastewater of Aigialeia (DEYA Aigialeias), the Institutionalized Research Laboratory of Smart Technologies, Renewable Energy Sources and Quality of UNIWA (STRESQ), and the Laboratory of Climatology and Atmospheric Environment (LACAE, NKUA) are collaborating on a project titled “Smart system for Leak Detection for water supply Network of Aigio”. By installing sensors and implementing a SCADA system with PLC controllers, critical parameters such as water supply, pressure, and quality will be monitored. This project aims to reduce water leakage, which currently accounts for approximately 48% of the town’s total water supply, ultimately saving around 600,000 m^3^ of water annually.

**Keywords:** non-revenue water; water supply network; water leakage; digital twin

**1. Introduction**

Non-revenue water (NRW) is the volume of water participating in the urban water supply processes without generating revenue for the water utility company [1]. NRW includes both water losses and unbilled consumption [2]. Effective strategies such as pressure management, active leak control, efficient repairs, and asset management are being implemented to minimize these real losses [3]. Water leakages present a common and significant challenge in urban water supply networks [4]. The financial implications of these leakages are substantial, with an estimated annual cost of 39 billion USD [5]. Furthermore, the quality of potable water is adversely affected by these leakages [6].

In Aigio, Greece, water leakage is estimated to be approximately 48% of the total water supply, as reported by the Municipal Enterprise for Water and Wastewater of Aigialeia. To address this, the research project titled “Smart system for Leak Detection for water supply Network of Aigio” aims to develop an advanced monitoring system. Among the purposes of the project is the aim to save around 600,000 m^3^ of water per year within Aigio’s internal water distribution system. The integration of smart systems, including smart water metering devices and data analytics, presents new opportunities for real-time leakage detection, consumption monitoring, and optimized network management [7,8]. These technologies enable proactive leak detection, enhancing rapid response and timely repairs [9]. By implementing innovative technologies and proactive leak detection methods,
the project strives to improve water resource management and enhance the overall efficiency of the water supply system in Aigio.

2. Study Area and Data

The system is designed for the town of Aigio, which is served by DEYA-Aigialeias. Aigio is the largest town in the Aigialeia Prefecture with a total population of 20,249 habitants. The region of Aigio is characterized by a temperate Mediterranean climate, while the air temperature ranges from $-0.7\,^\circ\text{C}$ to $37.7\,^\circ\text{C}$. Regarding water requirements in this area, there is a seasonal fluctuation due to tourism, with an increased demand during summer months, which is difficult to be fully met. Particularly, Table 1 presents the estimated daily water needs per capita, which correspond to an annual water supply from the DEYA-Aigialeias of around 2.5 hm$^3$. Considering this situation and after taking into account the available data from the local system of operation and water supply infrastructures, DEYA-Aigialeias in collaboration with STRESQ and LACAE assessed the value of improving the operation of the water supply system. The first priority is the monitoring of qualitative and quantitative parameters, in combination with the development of a hydraulic model for the simulation of the operation of the local water supply network.

Table 1. Average water requirements per capita per day (data source: [10]).

<table>
<thead>
<tr>
<th>Population Class</th>
<th>Water Needs (L/cap/d)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Permanent Population</td>
<td>250</td>
</tr>
<tr>
<td>Tourists</td>
<td>400</td>
</tr>
<tr>
<td>Residents in B’ residence</td>
<td>250</td>
</tr>
</tbody>
</table>

3. Concept Design

DEYA-Aigialeias will acquire a smart integrated platform for leakage detection in the water supply network, through utilizing modern digital telemetry, remote control and management, and through procuring the sensors required to record and monitor consumption. The main components of the system are described as follows.

3.1. IoT Sensors

As part of the comprehensive system implementation, the DEYA-Aigialeias in collaboration with STRESQ and LACAE will install IoT sensors in its internal water network. The project aims to enhance monitoring and management capabilities within four main areas that are already configured as closed loops. Electromagnetic Flowmeters will be used as the selected sensors, providing measurements every second. These sensors will be connected to programmable logic controllers (PLCs) for efficient data collection. Additionally, pressure sensors will be strategically placed in the closed loops to ensure precise monitoring of the entire closed district metered area (DMA), as illustrated in Figure 1. These pressure sensors will be connected to dataloggers equipped with internal modems, enabling the transmission of pressure data from the network at 15-min intervals. The operation will aim at gathering real-time data and achieving more accurate monitoring of the water distribution network.
3.2. Monitoring System

A monitoring system will be developed based on an online platform that holds significant potential for addressing the challenges associated with leakage detection and management in water distribution networks. By leveraging real-time data and advanced analytics, an online platform can provide a centralized hub for monitoring the performance of internal city water networks [11]. The implementation of an online platform enables seamless and continuous data collection from sensors deployed throughout the water network. These sensors, strategically positioned in key areas, provide valuable information on flow rates, pressure levels, and other critical parameters. The collected data is transmitted in real time to the online platform, ensuring up-to-date and accurate insights into the network’s performance.

The online platform leverages the power of machine learning algorithms and statistical techniques to process and analyze the collected data. These advanced analytical methods enable the identification of patterns, anomalies, and potential leakages within the water distribution network. By analyzing historical data and establishing baseline patterns, the platform can detect deviations and alert authorities to potential issues, allowing for prompt response and intervention. To enhance the overall functionality and effectiveness of leakage monitoring, the online platform can seamlessly integrate with other smart systems and technologies. Integration with smart water meters and IoT devices offers additional data points and insights into water consumption patterns, enabling a comprehensive understanding of the network’s dynamics. This integration fosters a holistic approach to water management, optimizing resource allocation and minimizing wastage.

3.3. Hydraulic Model

A hydraulic model will be developed based on EPANET [12] and incorporating the concept of a 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. Based on the hydraulic model several simulations will run in order for engineers and operators to gain valuable insights into the system's performance in real time. They can monitor key hydraulic parameters, detect anomalies, and predict potential issues 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 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. Integrating EPANET with a digital twin framework adds an extra layer of sophistication to the hydraulic simulations, enhancing their accuracy. By harnessing the power of real-time data and advanced analytics, this approach empowers water utility companies to make informed decisions, improve operational efficiency, reduce water losses, and ensure the reliable delivery of clean water to the town of Aigio.

4. Expected Results

The Municipal Enterprise for Water and Wastewater of Aigialeia supports the development of a smart system for the detection of leakages, in the frame of improving water management within Aigio’s internal network. The project aims to save approximately 600,000 m³ of water annually.

IoT sensors, including electromagnetic flowmeters and pressure sensors, will be deployed throughout the network to collect real-time data on flow rates and pressure levels. This data will be transmitted to an integrated platform for analysis using advanced algorithms and scenario simulations. The system will identify specific pipes and nodes where leakages are likely occurring, providing real-time alerts and suggesting targeted interventions. The project also includes the development of a comprehensive hydraulic model for the Municipal Enterprise, enabling better network management and maintenance planning.

The implementation of this smart system is expected to significantly reduce water losses, improve water balance convergence, and promote sustainable water resource utilization in Aigio.

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