International Journal for Multidisciplinary Research (IJFMR)
E-ISSN: 2582-2160 ● Website: www.ijfmr.com ● Email: editor@ijfmr.com

Design and Development of the Pipeline Leak Detection System Using Sensor Technology with Mobile and Web Applications

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Abstract
This study presents the design and development of a Pipeline Leak Detection System that utilizes sensor technology integrated with both mobile and web applications to support household-level water monitoring. The core of the system is a leak detection device that continuously monitors water pressure in pipelines and identifies potential leaks through pressure drop analysis. Once a leak is detected, the system promptly sends SMS notification and real-time alerts to users through a dedicated mobile application and a web-based dashboard, allowing for timely intervention and improved water management.
The mobile and web interfaces were carefully designed to provide users with intuitive access to leak alerts, and basic system diagnostics. These platforms enhance user interaction by offering responsive notifications, easy-to-read data visualizations, and remote monitoring features. Together, the hardware and software components form an integrated solution that aims to minimize unnoticed water loss and promote proactive leak management at the household level.

Keywords: Leak Detection System, Sensor Technology, Mobile Application,

1. Introduction

Water remains one of the most essential yet vulnerable natural resources, often undervalued in daily use. Among the critical challenges in water management is the issue of undetected pipeline leaks, particularly at the household level. These leaks, though seemingly minor at first, can result in substantial water loss over time, contributing to increased household bills and operational burdens for water districts. Beyond the cost implications, such inefficiencies hinder broader goals of sustainability and water conservation.
While past research has explored leak detection strategies through manual inspection and sensor-based technologies (Al-Washali et al., 2020), the majority of these solutions are designed for large-scale water distribution networks. Consequently, real-time leak detection and notification systems tailored for individual households remain limited. Furthermore, existing systems often suffer from delayed response mechanisms, relying on periodic checks or manual reporting, which allow leaks to persist unnoticed (Kumar et al., 2022).
This study addresses this gap by designing and developing a Pipeline Leak Detection System using Sensor Technology integrated with Mobile and Web Applications. The system features a pressure-based sensor device capable of detecting anomalies in household pipelines. Once a leak is identified, it sends SMS

Notifications and instant alerts through a dedicated mobile application and a web-based platform, enabling timely awareness and action by both the household and the water district. These platforms provide accessible, real-time monitoring and visualization tools that support more proactive water management.
By delivering an integrated solution for leak detection, notification, and remote access, the system offers a user-friendly approach to household-level water conservation, empowering users with timely information and enhancing the responsiveness of water management services.

II. Methodology

Research Design

The research design for developing a pipeline leak detection system using sensor technology and SMS notifications follow the Agile methodology, which focuses on flexibility and continuous improvement. This approach is ideal for ensuring the system meets both technical requirements and user needs throughout the development process.

Figure 1. Agile Methodology Cycle. Adapted from an online source (Unknown author, n.d.).

The Agile methodology in Figure 1 breaks the project into smaller, more manageable parts, making it easier to test and improve along the way. This helps the water district catch problems early and make sure the system works well for real users. Since feedback is gathered often, the final leak detection system ends up being more reliable, efficient, and tailored to what users actually need.

Plan Phase

During this phase, the core functionalities and features were identified. And also, the hardware and software were specified for the development of the system.
Hardware:

1. NodeMCU V3 Type C
2. NodeMCU Base Board
3. 12V/24V to 5V Step down Module
4. 5V Relay Module
5. Power Adapter 12V 2A
6. Analog Water Pressure Sensor
7. 220V Solenoid Valve
8. SIM800L
9. DuPont Wires

Software:

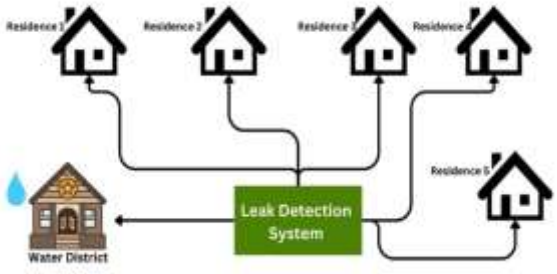
1. Sensor Node (Microcontroller + Sensor)
2. Backend Server (WAMP, MySQL)

3. Mobile Application (Android Studio + Kotlin)
4. Web Dashboard (JavaScript, CSS, PHP)

Design Phase

The design phase outlined how everything works together. From how the system detected a leak, processed it, and notify users through SMS and alerts in mobile and web application. This also map out how the entire system function smoothly, making sure all parts work together as intended before moving on to development and testing.

Figure 2. Leak Detection System Design Flow



The Figure 2 shows how a water district, a leak detection system, and several homes are connected. If a leak occurs, the system promptly identified which specific residence was affected and alerts the water district, helping to ensure that issues are addressed promptly. This setup helps prevent water loss, ensures efficient delivery, and keeps the water supply system running smoothly for all households.

Development Phase

The development phase focused on creating a functional and reliable Pipeline Leak Detection System. This process involves several key steps to ensure the system meets technical and user requirements:

- Sensor Integration
- Software Development
- Notification System
- User Experience Testing

Test Phase

Ongoing testing conducted to identify and resolve technical issues early. This includes testing the sensors accuracy, the algorithm's reliability, and the notification system's responsiveness. Ensuring the system is intuitive and easy for homeowners to use.

Deployment Phase

The system was deployed in selected households in Brgy. San Pedro, Brgy. Magosilom and Brgy. Lininti-an to monitor its performance in actual usage scenarios. During this phase, sensors was tested for accuracy in detecting leaks, the software's responsiveness in analyzing data was evaluated, and the notification system was assessed for timeliness and clarity.

Review Phase

The review mechanism for the Pipeline Leak Detection System was a structured and iterative process designed to continuously refine the system based on real-world performance and user input.

Launch Phase

The launch phase involved strategic steps to ensure successful adoption of the system in the community. This phase emphasizes a comprehensive implementation plan guided by the 6Ps framework: Publication,

Product, Patent, People, Partnership, and Policies.

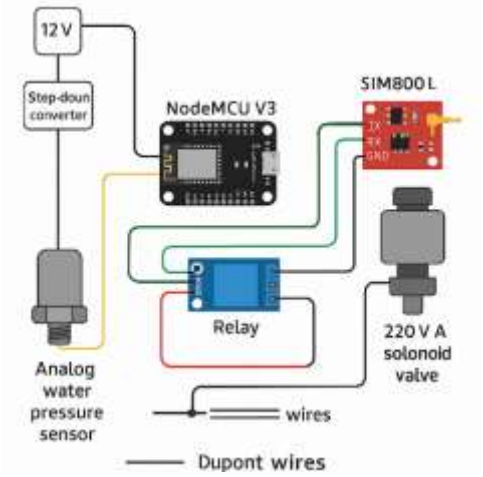
III. Result and Discussion

The Developed Pipeline Leak Detection System is presented, highlighting its core functionalities, performance, and user interaction outcomes. This innovative system includes a leak detection hardware device, along with integrated mobile and web applications for monitoring and alerts.

1. Leak Detection Hardware Device

The leak detection hardware device was developed to monitor household water systems and promptly identify any signs of leakage. It offers a practical solution by using real-time sensor technology to help prevent water waste and reduce damage.

Figure 3. Leak Detection Device Circuitry



The leak detection system is made up of several key components shown above in Figure 3 which work together to monitor water flow, detect leaks, and respond automatically.

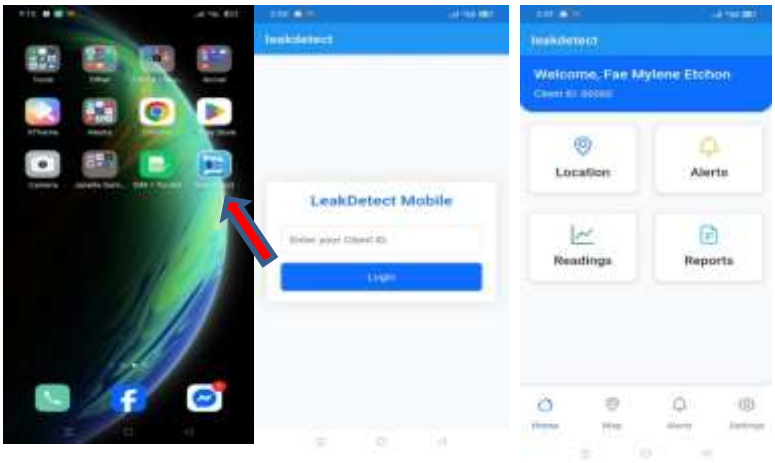
Figure 4. Device attached in the household

As illustrated in Figure 4, Three devices were installed, one in Brgy. Magosilom, Brgy. Lininti-an, and Brgy. San Pedro. Whenever a possible water leak was detected, the system automatically alerts the Water District and the House Owner. All household water usage readings can be viewed through both the mobile and web applications.

2. Mobile Application

Other output of this study was the LeakDetect mobile application. It was developed to address the pressing issue of undetected water leakages in household. This application embodies the integration of research findings into a practical solution, bridging technological innovation with real-world needs.

Figure 5. LeakDetect Mobile Application

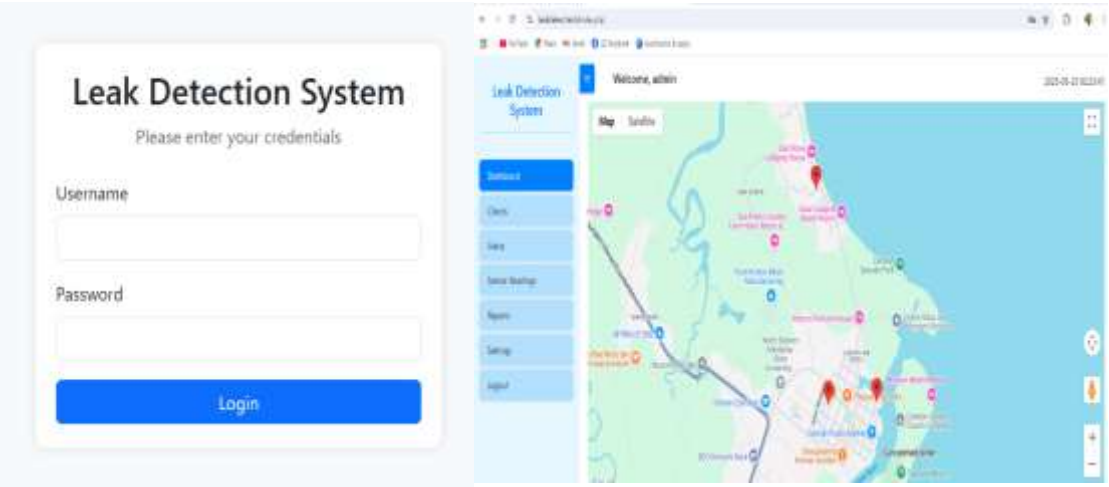


The LeakDetect Mobile App is a user-friendly tool designed to help clients monitor water leaks efficiently. With just a Client ID, users can log in and access real-time data like location, alerts, readings, and reports. Its clean interface makes it easy to navigate, even for first-time users. This app brings convenience by allowing users to keep track of potential leak issues right from their smartphones.

3. Web Application

The web application helps the water district easily monitor all sensor locations through a simple, interactive dashboard. It helps users know the possible leaks before they become serious problems.

Figure 6. Leak Detection Web Application



The Pipeline Leak Detection System features a secure login interface and an intuitive web dashboard designed for water district administrators. Upon logging in, users can view a real-time map displaying the locations of detected leaks across monitored households, with visual markers for quick identification. The sidebar menu provides access to modules such as client records, sensor readings, alerts, reports, and system settings. This integrated interface supports efficient monitoring, incident tracking, and timely response to pipeline leaks.

IV. Conclusions

This study set out to address the often-overlooked but critical issue of household water leaks, particularly from hoses and small pipelines, by developing and designing a Pipeline Leak Detection System that

combines sensor technology with real-time alerts. The design of this proposed system unique by means of integrating advanced sensors, a SMS notification, and easy-to-use tools like a mobile and web application providing homeowners not only with automatic leak detection but also with accessible, real-time information that empowers them to take immediate action.

The results clearly show that this system is user-friendly, dependable, and sustainable, making it a strong candidate for practical use in everyday residential settings. It offers a meaningful solution to water conservation challenges by helping households detect leaks early, prevent potential property damage, and support local water authorities in managing supply more efficiently. Most importantly, the study proves that integrating modern technology into something as simple as a household pipe can lead to smarter and more sustainable living. It's not just about saving water; it's about giving users the tools and information they need to take control, protect their homes, and contribute to community wide conservation efforts.

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