Public Water Supply Grid Monitoring and Leakage Detection in Underground Pipelines Using IOT

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***Abstract*—This project presents an Internet of Things (IoT)-based solution for monitoring and detecting leakage in underground pipelines, aiming to enhance water supply management and reduce water wastage. The system integrates ESP32, a low-cost microcontroller with Wi-Fi capabilities, alongside multiple sensors to monitor water quality, detect leakage, and manage water levels. A flow sensor monitors the water flow rate, detecting anomalies such as a sudden decrease in flow that may indicate leakage. In case of leakage or water quality issues, the system automatically activates a water pump to reroute or stop the water supply, mitigating further loss. The real-time data is transmitted via the ESP32 to the Blynk IoT platform, providing remote monitoring and alerting capabilities. This system allows operators to receive immediate notifications and take corrective action swiftly. The proposed IoT solution offers significant advantages such as real-time monitoring, automated response mechanisms, and efficient use of water resources. The system is ideal for urban water management, helping municipalities and water authorities detect and fix pipeline issues promptly, reducing operational costs and minimizing water wastage. This can also enhance the sustainability of water supply systems in water-scarce regions.**

***Index Terms*—ESP32, Flow Sensor, Water Pump, Turbidity Sensor, Blynk IoT, Arduino IDE [7]**

I. INTRODUCTION

Access to clean water is essential for all living organisms, particularly humans and animals, as it supports both daily life and sustainable economic activities. Malaysia is naturally endowed with abundant water resources. However, the growing demand for water—driven by residential, agricultural, industrial, and medical needs—is putting increased pressure on these resources. Rapid population growth, urban development, and rising living standards are contributing factors to this strain.Although water supply coverage in Malaysia has improved significantly—from 80% in 1990 to 95% in 2000, according to Akademi Sains Malaysia, the National Hydraulics Research Institute of Malaysia, and the Ministry of Science, Technology, and Innovation—the per capita availability of clean water is on the decline. This calls for effective water monitoring systems, especially at the residential level.

One of the critical challenges is the frequent water supply disruptions in the Klang Valley, which have become a near-monthly issue for over a million residents. River pollution is a major concern, as around 90% of Malaysia's raw water comes from rivers or surface sources. With many river basins exposed to contamination, the public has called for the implementation of advanced technologies to address the issue.Another significant issue is water loss during distribution, known as Non-Revenue Water (NRW). NRW results from various causes, such as metering inaccuracies, water theft, accounting errors, and pipeline leaks. Traditional methods to detect these problems often involve labor-intensive and costly surveys that do not allow for continuous monitoring.Undetected leaks pose serious risks—not only do they contribute to water wastage and reduced water pressure for residents, but they also create health hazards, such as the growth of harmful mold and fungi. These can spread rapidly, damaging property and equipment and leading to expensive repairs if not addressed promptly. In residential settings, undetected leaks can significantly impact water availability and compromise building integrity.At present, the management of public water supply pipelines mainly depends on manual inspection methods. Leakages in underground pipelines are usually identified only after a large

volume of water has been lost or when signs of damage become visible above the surface. This causes unnecessary delays in taking action, leading to both water wastage and potential harm to nearby infrastructure. Traditional systems do not offer real-time monitoring capabilities, and identifying the exact location of leaks often requires significant time and labor. Due to the absence of smart technologies and automation, the existing approach is inefficient, slow, and unable to meet the growing demands of modern urban water management.

II. DESIGN PROCEDURE/ METHODOLOGY

The proposed system introduces an IoT-based solution for continuous monitoring and leak detection in underground water pipelines. It uses a flow sensor connected to an ESP32 microcontroller to measure the rate of water flow in real-time. The data is sent to a cloud platform and monitored through the Blynk application, allowing users to remotely track pipeline performance. If the system detects any unusual drop or fluctuation in water flow, it sends an immediate alert to notify the user. This automation improves response time, reduces water wastage, and minimizes the need for manual checks. The system offers a cost-effective, scalable, and smart way to enhance the efficiency and reliability of public water supply networks. [1] [7] [13]

III. IMPLEMENTED DESIGN

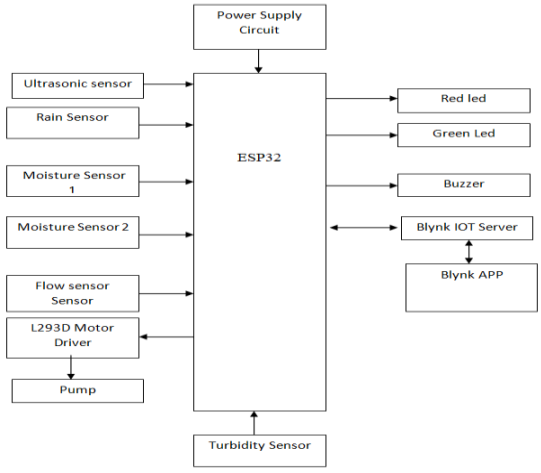

Fig 1 Block Diagram

The system uses IoT technology to monitor water flow in underground pipelines in real time using flow sensors and ESP32. It detects leakage by analyzing abnormal changes in flow rate. Data is sent to the Blynk app for live updates and instant alerts. [7]

Microcontroller

The ESP32 is a powerful microcontroller with built-in Wi-Fi and Bluetooth, making it ideal for IoT applications. [1]

- It collects data from flow sensors and processes it in real time. [7]
- The ESP32 sends the processed data to the Blynk IoT platform via Wi-Fi. [9]
- It supports multiple GPIO pins, allowing integration with various sensors and actuators.
- Its low power consumption and high performance make it suitable for continuous pipeline monitoring. [17]

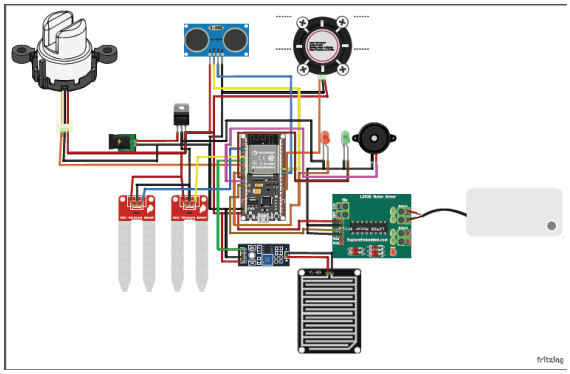

Fig 2 Schematic Diagram

Hardware Components:

ESP32 Microcontroller- Main microcontroller with built-in Wi-Fi; controls all sensors and communicates with Blynk [1]

Water Flow Sensor- Measures the flow rate of water through the pipeline [7]

Ultrasonic Sensor- Measures water tank level or distance

Rain Sensor- Detects presence of rainfall

Turbidity Sensor- Detects water clarity to indicate contamination

Soil Moisture Sensor- Monitors soil water content [3]

Motor Driver Module- Interfaces ESP32 with high-power components like motors or pumps

DC Motor Pump- Controls water flow through pipeline or irrigation system

Buzzer- Provides audio alerts for leakage or abnormal conditions

Software Components:
Arduino IDE- Used for writing, compiling, and uploading code to the ESP32 microcontroller [1]
Blynk IoT- Cloud-based platform used for real-time monitoring, control, and alert notifications via mobile app [13]

IV. RESULT & DISCUSSION

In the practical implementation of the project titled "Public water supply grid monitoring and leakage detection in underground pipelines using IoT", the ESP32 microcontroller was successfully interfaced with a flow sensor to monitor water flow in real-time. The system measured the flow rate and total volume of water passing through the pipeline. This data was transmitted to the Blynk IoT platform using the ESP32's Wi-Fi capabilities, where users could view it on their mobile devices. During testing, the system displayed accurate flow rates under normal conditions and effectively identified abnormal flow behavior that could indicate leakage. When a sudden drop in flow rate was simulated, the system generated an alert on the Blynk dashboard, notifying the user of a potential leak in the pipeline. This confirms that the system can reliably monitor the water supply grid and detect leakages, thereby demonstrating its potential for real-world water management applications. [1] [7] [9] [19]

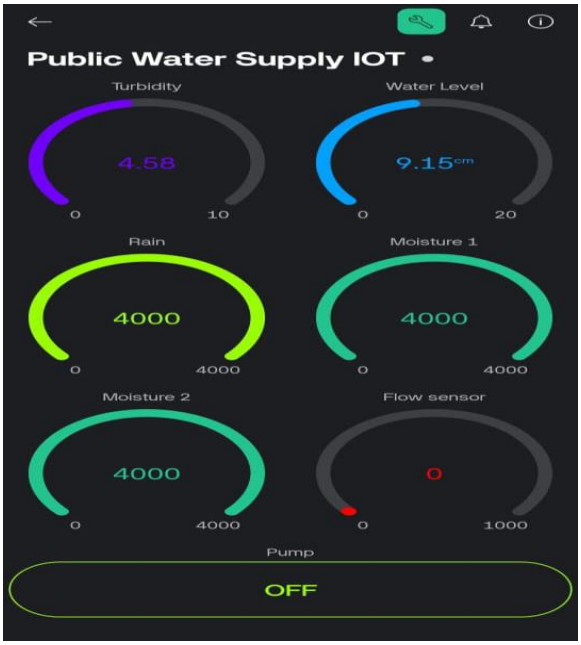

Fig 3 Blynk Iot Server

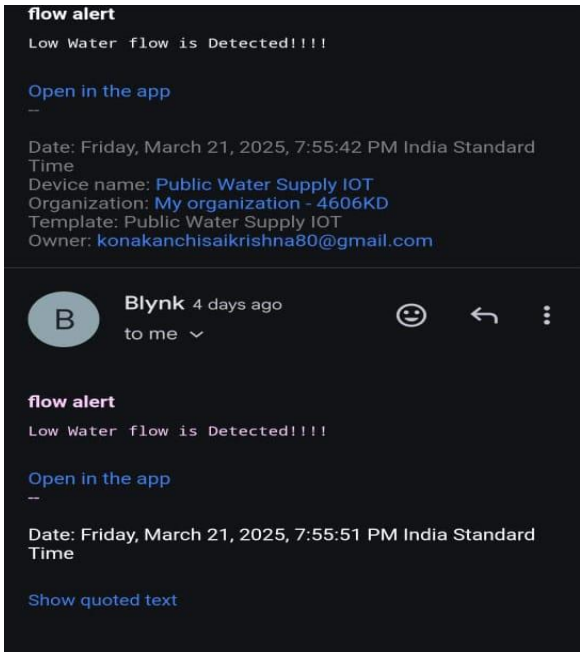

Fig 4 Alerting System

V. CONCLUSION

Water Pipeline Leakage Monitoring System based on Internet of Things (IoT) is designed to monitor the pipeline system in the house. Many sensors that been used in this project which is turbidity, water flow and water sensors. The turbidity sensor is more suitable to be placed at the main pipe as the user can know the water quality before the water entered the water tank in the house. There were two water sensor that been set to detect the water leakages so that the user can easily estimate the pipe's location that leaked while the water sensor is used to detect the water level detection as the pump will be automatically stop when the water is full in the water tank. Lastly, the water flow sensor is used the measure the flow of the water within the pipe from main pipe into the water tank of the house. Based the result the system and prototype is successful monitor all parameters that have been proposed. From the result that has been shown, the overall system has many advantages in many ways. Firstly, the IoT system implemented is a real-time system where all data collected from the sensors which water, water flow and turbidity sensors are sent to cloud system at the same time and the user can see the data online. [1] [7] [13]

The system has shown that there are multiple ways of given notification to the users either through email or through its own mobile Blynk app. The user also can monitor the recent data from mobile application which more fasters than website. The notification also been displayed in these mobile app as the condition of the data sensor been set by the user. This system however requires a strong connection to the internet in order the data to be sent to Blynk website. If data is not being sent to Blynk website, alert notification to Telegram application is impossible. Furthermore, the power of the microprocessor which is Arduino is not able to support the water pump as the water pump is need 12volt to work properly. So, to solve this problem, the power adapter has been added to support the water pump. Next, the turbidity sensor's values sometimes do not very accurate as other water quality sensors. With increase the sensitivity of this sensor, the problem can be avoided.

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