AquaWatch: IoT Community Water Management Platform for Conservation and Efficiency

Dr. Praveen Banasode*[1], Prof. Swati Sangolli[2], Sagar Indi[3], Snehit Hatti[4], Nishchal Daddi[5], Prajwal Ganachari[6]

Department of Master of Computer Applications,
Jain College of Engineering, Belagavi
Affiliated to Visvesvaraya Technological University, Belagavi Karnataka, India.

Abstract: Water wastage due to leakages is a very common and disruptive issue to the ecosystem as it results in considerable infrastructure damage and the economic crisis, given the conservation and environmental losses. This innovative device Smart Water Leakage Detection System would, therefore, be fastened to solve the problem using the most advanced sensors and thus the means of big data processing. The technology, to begin with, includes the use of IoT or Internet of Things coupled with sensors interconnected through networks which are the main issue. More specifically, sensors are the eyes and ears of the system constantly tracking the flow and pressure of the water. This platform makes a water ecosystem a futuristic intelligent data-sharing instrument, profitable both for the urban and the village regions. Using the smart cloud crypto- gram, the device ascertains that data is computed and evaluated in real-time, and thus, the calculated information is correct in the case a leakage is present. The amalgamation of machine learning further ensures that the sensitivity of the system grows. As a result, the forecast ability of the occurrence of leakages also becomes more accurate. Besides, the system tends to bring water management to a higher level by offering a detailed dictionary of water usage patterns. The collected information can hence be used by utility providers and private end-users likewise to identify discrepancies and bring in changes in their water consumption profiles. Additionally, through a convenient and simple unfolding interface, the people not only can track all the leakage spots, at the same time, they are equipped to perform control actions even when they are not there. Beyond that, by integrating with home IoT systems, the technology provides additional support for such functions as automatic water valves and enables integration with home automation systems allowing for better water monitoring and security features.

Keywords: Water Leakage Detection, IoT-enabled Sensors, Real-time Data Analytics, Machine Learning, Predictive Maintenance, Water Management, Smart Home Integration, Sustainable Water Usage, Infrastructure Protection.

1. INTRODUCTION

Water conservation is a crucial goal for countries, as efficient water management is essential for any society given its necessity for humanity. Ensuring that water provided for consumption is used effectively and without wastage is key. In nations like India, where approximately 30 to 40% of water in the sector is lost due to leakage, there are significant risks to public health, financial resources, and the environment. In 1993-1994, India had an irrigation efficiency of 36%.

Implementing water supply systems with acoustic and pressure detection technology can be costly for developing countries. Some leak detection methods use heating coils to detect changes in flow rate, which can be challenging to adjust due to the temperature sensors' responses. Other systems use only flow sensors, which may not effectively address all leakage issues within the system.

Traditional leak detection systems often rely on expensive acoustic and pressure detection devices, making them unaffordable for many regions. This project stands out by designing an affordable system using economical components, making it accessible to a wider audience and more feasible for widespread implementation.One of the key innovations is combining flow sensors with a microcontroller. This integration allows the system to monitor water flow in real-time and quickly detect leaks caused by pipeline breakages. By using both technologies together, the system can identify anomalies much more accurately than methods that rely on a single parameter, such as temperature sensors or basic flow rate measurements. Another standout feature is the system's ability to automatically stop further leakage once a problem is detected. This proactive approach minimizes water wastage and reduces the need for manual intervention, ensuring that the water distribution net- work operates continuously and efficiently. This represents a significant improvement over traditional systems that only detect leaks without addressing them in real- time. The project includes the development and testing of a prototype to validate the system's effectiveness. This practical aspect provides concrete evidence of the system's capabilities and demonstrates its potential for real-world application. It offers a tangible solution that can be immediately evaluated and refined, moving beyond theoretical promises. The system is designed to be scalable and adaptable, catering to various sizes and complexities of water distribution networks. This flexibility ensures that the solution can be customized to meet the specific needs of different regions, making it a versatile tool in the global effort to conserve water.

2. LITERATURE SURVEY

Mukul Kulshrestha's study, "Efficiency Evaluation of Urban Water Supply Utilities in India," likely addresses a critical issue in India's rapidly urbanizing landscape. The research probably employs quantitative methods such as Data Envelopment Analysis or performance indicators to assess the efficiency of water utilities across Indian cities. This work builds on previous studies examining urban water management in India, potentially revealing efficiency variations, influencing factors, and areas for improvement. The findings could have significant implications for resource allocation, water management strategies, and policy formulation in the urban water sector.

"Irrigation Leak Detection: Using Flow Rate Sensors to Detect Breaks in an Irrigation System" by Adam Openshaw and Kalvin Vu, available from Cal Poly Digital Commons. The research likely addresses a crucial issue in agricultural water management and conservation. Openshaw and Vu presumably explore the application of flow rate sensors to identify leaks in irrigation systems, a technology that could significantly reduce water waste and improve irrigation efficiency.

The study "Design and Development of Automatic Water Flow Meter" by Ria Sood, Manjit Kaur, and Hemant Lenka, published in the International Journal of Computer Science, Engineering and Applications in 2013, likely addresses the growing need for efficient water management systems. The research probably focuses on creating an automated solution for measuring water flow, which is crucial for both conservation efforts and accurate billing in urban and rural settings.

A notable advancement in this field is the RideGuard system, as detailed by Dr. Praveen Banasode and Dr. Poorna Chandra S et al. in their 2024 study. The RideGuard system integrates Internet of Things (IoT) technologies to offer a comprehensive suite of safety features, including ride tracking, navigation, accident detection, and alcohol detection (Banasode et al., 2024).

Dr. Praveen Banasode et al. have developed the "Mobility Guard Plus," an innovative IoT-enabled smart wheelchair system, as detailed in their GOYA Journal (2024) publication. This system integrates remote monitoring, fall detection, and real-time data analysis into a user-friendly interface. By leveraging IoT technology, it enhances user safety and caregiver peace of mind. The Mobility Guard Plus has the potential to improve quality of life for wheelchair users and reduce healthcare system burden through continuous monitoring and rapid emergency response. This research marks a significant advancement in assistive technology, potentially transforming care for individuals with mobility challenges.

Dr. Praveen Banasode et al. have developed the "Smart Night Watch" as detailed in their GOYA Journal (2024) publication; system represents a significant advancement in automated security solutions, combining robotics, mobile technology, and AI to create a more efficient and responsive night patrol system. This research contributes to the growing field of intelligent security systems and opens up new possibilities for integrating technology into traditional security practices. and further it addresses, Privacy concerns related to continuous surveillance, the impact of automated security systems on human employment in the security sector, ethical considerations of AI-driven decision making in security contexts

3. METHODOLOGY

The water leakage detection system is designed for easy integration into existing plumbing systems. It employs flow rate sensors positioned along the water flow path. These sensors do not obstruct the flow but continuously collect data on the water rate. If a leak is detected, the system utilizes actuators like solenoid valves to control the water flow, stopping it to prevent further wastage.

At the heart of the system is a microcontroller that constantly monitors the data from multiple flow rate sensors. It calculates the differences in flow rates between these sensors and compares them to a predefined threshold. When a discrepancy that exceeds this threshold is identified, the microcontroller signals the solenoid valve to shut off the water flow and alerts the user about the leak, thus minimizing water loss.

In cases where the flow rate differences are within acceptable limits, the microcontroller sends the sensor data to the cloud for logging. This online data logging feature allows users to track their water usage over time, providing valuable insights for better water conservation and management. By offering real-time leak detection and detailed usage data, the sys- tem helps users manage their water resources more effectively.

This section delves into the hardware components of the smart water leakage detection system, with a particular focus on the flow sensor. Serving as a vital input for the microcontroller, the flow sensor is instrumental in measuring how quickly liquid moves through the pipes. It operates using the Hall Effect principle, where the movement of liquid spins a small turbine attached to the sensor. This spinning action generates pulses, which the Hall Effect sensor detects and converts into an analog signal. The microcontroller then processes this signal to determine the flow rate, and this data is transmitted to the cloud via a GPRS module for logging and analysis. The sensor is designed to handle flow rates of up to 30 liters per minute and pressures of up to 2.0 MPa, ensuring it is well-suited for various water flow conditions. Its robust performance and accuracy make it a crucial component in monitoring and managing water flow, ultimately contributing to the effectiveness of the leakage detection system.

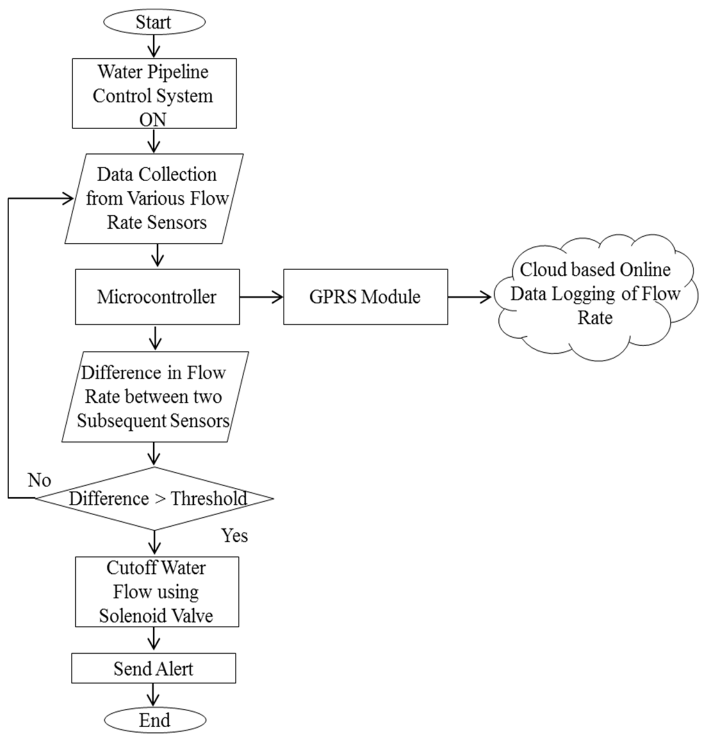

Fig.1: Flow Chart describing the Control Action to minimize Water Wastage

Fig. 2: Water Flow Rate Sensor

The solenoid valve plays a crucial role in controlling water flow during a leak event by stop- ping it altogether. As depicted in Fig. 3, this electromechanical device helps regulate liquid flow through the system. It features a ferromagnetic rod inside that blocks the flow when deactivated. When the valve's coil is energized with 12V DC power, the rod is attracted, opening up the path for the fluid to pass through. Essentially, when energized, the valve functions like a closed switch, halting the water flow to prevent further leakage. It can manage up to 3 liters per minute and handle pressures up to 3 psi. Connected to the microcontroller via a relay circuit, the solenoid valve is activated by a trigger pulse from the microcontroller whenever a leak is detected by the sensors. This automatic action ensures that water wastage.

GPRS Module

The GPRS Module (SIM900A) is a key component of the system, designed to wirelessly transmit flow rate sensor data from the microcontroller to a cloud-based server. This module is particularly useful in areas where traditional internet access points are unavailable or out of range. By leveraging mobile network radio waves, the GPRS module connects to the internet through a SIM card and an external power supply. To establish this connection, the module uses a series of AT commands and operates with an inbuilt TCP/IP protocol. It maintains a baud rate of 9600 for communication with the micro- controller, ensuring smooth data transfer. The Arduino IDE's serial monitor is used to keep track of the communication between the microcontroller and the GPRS module, providing real-time updates on connection status and data transfer activity. This setup allows for reliable and efficient data transmission, even in areas with limited internet connectivity.

4. RESULTS AND DISCUSSION

4.1 Construction and Working

This section explains how the smart water leakage detection system is built and how it functions. The system kicks into action when water is distributed by the authorities for both industrial and domestic use. To ensure accurate leak detection, flow sensors are installed at regular intervals along the main pipeline and its branches, as illustrated in Fig. 4 & 5. These sensors are strategically placed to monitor the flow of water throughout the entire network. As water moves through the pipelines, it flows past these sensors, which measure the flow rate. By having sensors in the main pipeline and various branches, the system can identify exactly where a leak might be occurring. This setup allows for detailed tracking of water flow and helps quickly locate and address any leaks, ensuring that the water distribution remains efficient and reliable.

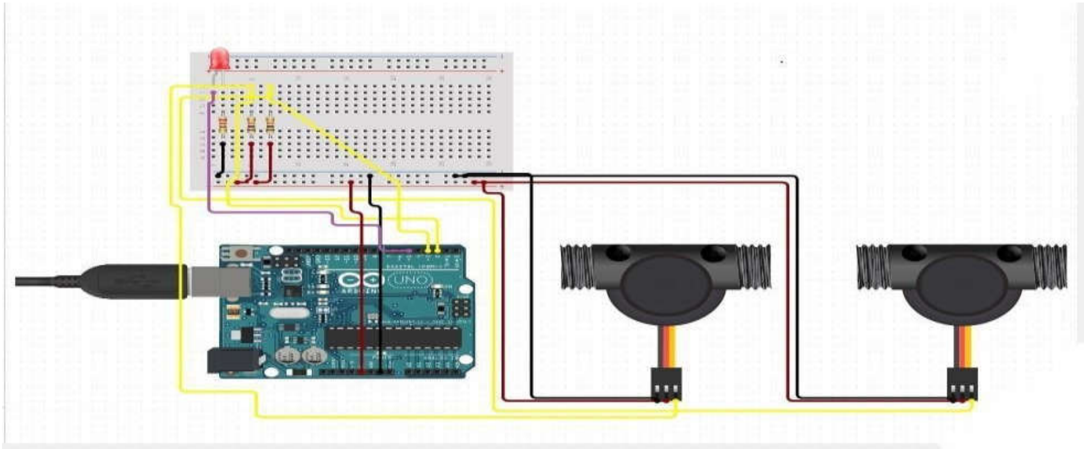

Fig. 3: Circuit Diagram

Fig.4: Water flow sensor placement

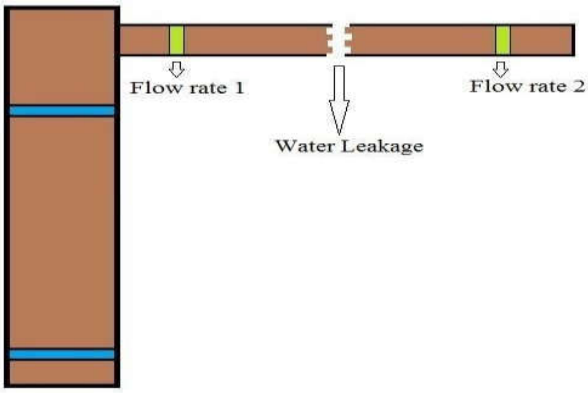

Fig. 5: Leakage Scenario

Hardware Setup, Sensor-Actuator Placement in the pipeline, Flow sensor Placed in the path ofwater flow.

In our system, flow rate measurement sensors installed across a specific area are connected to a central microcontroller, as depicted. To efficiently manage and monitor water distribution over a larger region, multiple microcontrollers are networked together. Each sensor continuously measures and reports the volume of water passing through it to its respective microcontroller, which then aggregates this data. The microcontroller sends the collected data to the cloud using a GPRS module connected to the internet. This process logs and stores the flow rate measurements in a cloud-based system, enabling future analysis and monitoring. By keeping the data in the cloud, we gain valuable insights into water usage and system performance, ensuring effective water management.

The leak detection algorithm operates continuously within the Arduino whenever the system is active. It monitors the flow rate from the sensors and looks for discrepancies. Specifically, if the difference in flow rate between two consecutive sensors exceeds a pre-set threshold, the Arduino identifies this as a potential leak. As illustrated in this difference is logged in the cloud via the GPRS module.

When a leak is detected, the system triggers an alert or notification and sends a message to the relevant authorities, ensuring prompt attention and action. The automatic water cut- off system is crucial for halting water leakage at various points when a leak is detected. The monitoring system identifies leaks and sends an alert signal. To address the leakage, the system employs a solenoid valve integrated with the water pipelines. The solenoid valve is connected in series with a transistor, which acts as a switch, as illustrated in this solenoid valve is of the normally closed type, meaning it blocks water flow by default. When a base signal is applied to the transistor, it opens the solenoid valve, allowing water to flow. In the event of a leak, however, the base signal is removed, causing the solenoid valve to close and stop the water flow. This mechanism effectively prevents water wastage by promptly cutting off the supply at the initial sign of a problem.

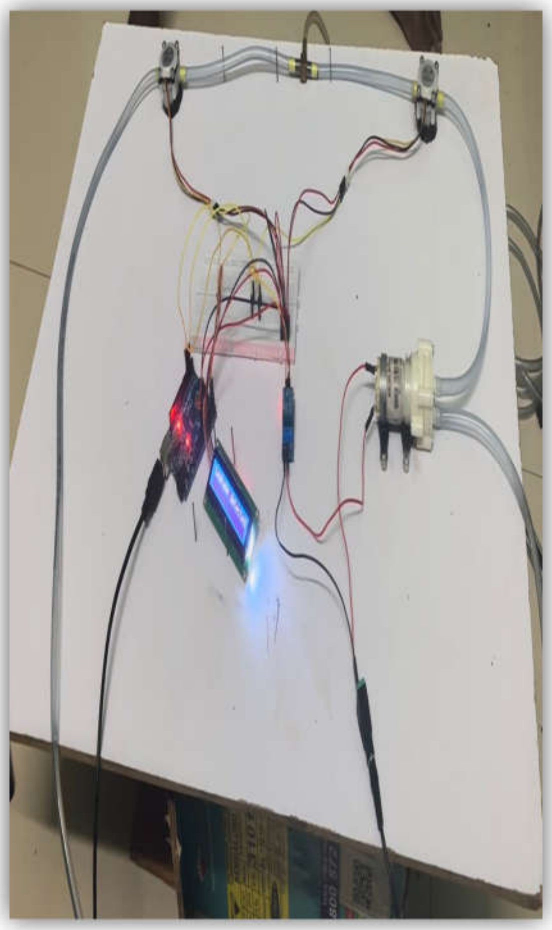

Fig. 6: Prototype Design

5. CONCLUSION

Water is crucial for daily life, and preventing its wastage due to pipeline leaks is essential. The designed prototype offers an effective solution for monitoring water flow and detecting leaks in pipelines. By enabling remote activation of solenoid valves, the smart water leakage detection system enhances water distribution efficiency. Cloud logging techniques facilitate data acquisition and analysis from any point along the pipeline, making the system cost -effective and straightforward.

While the system excels at detecting leaks between sensor nodes rather than pinpointing the exact location, it does require extensive wiring for power and data transmission, which can limit the monitoring area. However, powering the sensors and actuators with batteries or solar panels and using wireless transceivers for data acquisition and command transmission can extend the system's reach. Though this sensor network approach might increase overall costs, it offers the advantage of monitoring a large area with minimal human intervenes.

REFERENCES

1. Mukul Kulshrestha, "Efficiency Evaluation of Urban Water Supply Utilities in India," Environmental Engineering Division, Department of Civil Engineering, National Institute of Technology, MANIT-Bhopal, India.
2. "Water Sector in India: Overview and Focus Areas for the Future," PanIIT Conclave 2010. Available from: KPMG Water Sector Report
3. "Guidelines for Improving Water Use Efficiency in Irrigation, Domestic & Industrial Sectors," Central Water Commission, Ministry of Water Resources, Government of India, November 2014. Available from: [Guidelines for Improving Water Use Efficiency](http://wrmin.nic.in/writereaddata/Guidelines_for_improving_water_use_effi-ciency.pdf)
4. Adam Openshaw and Kalvin Vu, "Irrigation Leak Detection: Using Flow Rate Sensors to Detect Breaks in an Irrigation System," Available from: Cal Poly Digital Commons
5. Teddy Ariyatham, "Water Leak Detection," California State University, Northridge. Available from: CSU ScholarWorks
6. Ria Sood, Manjit Kaur, and Hemant Lenka, "Design and Development of Automatic Water Flow Meter," International Journal of Computer Science, Engineering and Applications (IJCSEA), Vol. 3, No. 3, June 2013.
7. T. Deepiga and A. Sivasankari, "Smart Water Monitoring System Using Wireless Sensor Network at Home/Office," International Research Journal of Engineering and Technology, Vol. 2, No. 4, pp. 1305-1314, July 2015.
8. N. Suresh, E. Balaji, K. Jeffry Anto, and J. Jenith, "Raspberry Pi Based Liquid Flow Monitoring and Control," International Journal of Research in Engineering and Technology, Vol. 3, pp. 122-125, July 2014.

9. Ali M. Sadeghioon, Nicole Metje, David N. Chapman, and Carl J. Anthony, "Smart Pipes:

10. Dr. Praveen Banasode, Dr. Poorna Chandra S et., al "RideGuard: IoT-Enabled Smart Helmet with Ride Tracking, Navigation, Accident, and Alcohol Detection Features" GIS Science Journal, Volume 11 Issue 7 2024, Page No: 882 - 890, DOI:20.18001.GSJ.2024.V11I7.24.41185673.

11. Dr. Praveen Banasode et., al "Aquawatch: Iot Liquid Level Monitoring System For Industrial Applications" GIS Science Journal, Volume 11 Issue 7 2024, Page No: 813-819, DOI:20.18001.GSJ.2024.V11I7.24.41185667.

12. Dr. Praveen Banasode, Milind Rao Pawar et., al "Smart Night Watch: Intelligent Night Patrol Robot with Real-time Mobile Alerts and Streaming Surveillance" GOYA Journal, Volume 17 Issue 07 2024, Page no : 405 – 415, DOI:12.163022.Gj.2024.v17.07.034.

13. Dr. Praveen Banasode, Dr. Poorna Chandra S et., al "Mobility Guard Plus: Advanced IOT Smart Wheelchair with Remote Monitoring and Fall Detection" GOYA Journal,Volume 17 Issue 07 2024, Page no : 339 – 344,DOI:12.163022.Gj.2024.v17.07.028.

14. Smart Wireless Sensor Networks for Leak Detection in Water Pipelines," Journal of Sensor and Actuator Networks, Vol. 3, pp. 64-78, 2014.

15. Dr. Praveen Banasode, Sonal Patange et al.,"Aqua Sense: Real-Time Water Quality Monitoring System with Alert Notifications", Gis Science Journal, VOLUME 11 ISSUE 8 2024, Page No: 93-99, DOI:20.18001.GSJ.2024.V11I8.24.41185691.

16. Dr. Praveen Banasode, Sonal Patange et al.,"Smart Farming", Gis Science Journal, VOLUME 11 ISSUE 8 2024, Page No: 100-107, DOI:20.18001.GSJ.2024.V11I8.24.41185692.