iJRASET
International Journal For Research in
Applied Science and Engineering Technology

INTERNATIONAL JOURNAL FOR RESEARCH

IN APPLIED SCIENCE & ENGINEERING TECHNOLOGY

Volume: 13 **Issue:** III **Month of publication:** March 2025

DOI: https://doi.org/10.22214/ijraset.2025.67463

International Journal for Research in Applied Science & Engineering Technology (IJRASET)
ISSN: 2321-9653; IC Value: 45.98; SJ Impact Factor: 7.538
Volume 13 Issue III Mar 2025- Available at www.ijraset.com

Pipe Guard: Real-Time Leak Detection and Management

P. Sravani[1], K. Aditya[2], M. Devaki Charisma[3], M. Yellagi[4], T. Vamsi Krishna[5]
[1]Assistant Professor, Department of Computer Science & Engineering, Raghu Engineering College, Visakhapatnam, A.P, India
[2, 3, 4, 5]Department of Computer Science & Engineering with Specialisation in Internet of Things, Raghu Engineering College, Visakhapatnam, A.P , India

Abstract: This project introduces an integrated IoT-based water monitoring system utilizing NodeMCU and Blynk for real-time alerts and efficient water resource management. The system employs flow sensors, water level sensors, and turbidity sensors to monitor water usage, detect leaks or unauthorized usage, and assess water quality. Flow sensors establish baseline water consumption patterns, enabling instant anomaly detection, while an LCD display provides real-time visual feedback on critical parameters. The system also includes a buzzer for immediate auditory alerts in case of irregularities such as low water levels or high turbidity. By leveraging IoT technology, this solution ensures prompt notifications through the Blynk app, reducing water loss and enhancing sustainability through real-time interventions.

Keywords: IoT, NodeMCU, Blynk, Water Monitoring, Flow Sensor, Leakage Detection, Water Theft Detection, Turbidity Monitoring, Real-Time Alerts, Sustainable Water Management.

I. INTRODUCTION

Water is a critical resource, and its efficient management is essential to prevent wastage, unauthorized usage, and contamination. Traditional water monitoring systems rely heavily on manual inspections and periodic assessments, which are time-consuming and prone to inaccuracies. These conventional methods fail to provide real-time insights, resulting in delayed detection of water leaks, theft, and deteriorating water quality. Additionally, the absence of instant alerts in these systems limits the ability to take prompt action, leading to excessive water loss and increased operational costs. To address these challenges, an integrated IoT-based water monitoring system is proposed, leveraging NodeMCU and Blynk for real-time notifications and remote management. The system employs flow sensors to detect anomalies in water usage, water level sensors to prevent overflows or shortages, and turbidity sensors to assess water quality. The collected data is processed and displayed on an LCD screen while also being transmitted to the Blynk app for remote monitoring. In case of irregularities such as leaks, theft, or contamination, a buzzer provides an immediate auditory alert, enabling quick intervention. By integrating these technologies, the system enhances water conservation efforts and ensures efficient utilization of water resources.

II. EXISTING SYSTEM

The current water management systems primarily rely on manual monitoring and periodic inspections, which are inefficient and prone to errors. Water leaks and unauthorized usage often go undetected for extended periods, leading to significant water wastage and increased operational costs. Without real-time monitoring, authorities and users struggle to identify and address issues promptly, resulting in inefficient resource allocation and potential infrastructure damage. Additionally, traditional systems often employ separate monitoring mechanisms for leakage detection, water level measurement, and water quality assessment. This fragmented approach limits overall efficiency and makes it difficult to integrate data for comprehensive decision-making. The absence of instant alerts further exacerbates the problem, as users remain unaware of critical changes in water consumption patterns or quality levels until it is too late. These limitations highlight the urgent need for an automated, real-time monitoring solution to improve water resource management and reduce losses.

III. PROPOSED SYSTEM

The proposed system is an integrated IoT-based water monitoring solution that leverages NodeMCU and Blynk to provide real-time notifications and enhance water management. This system incorporates flow sensors, water level sensors, and turbidity sensors to continuously track water usage, detect anomalies, and assess water quality. Flow sensors monitor water consumption patterns and identify deviations that may indicate leakage or unauthorized usage, ensuring timely intervention. The system's ability to process real-time data significantly improves efficiency compared to traditional methods.

To enhance user awareness, an LCD display provides real-time visual feedback on flow rates, water levels, and turbidity measurements. Additionally, a buzzer delivers immediate auditory alerts when abnormal conditions, such as excessive water loss or poor water quality, are detected. The collected sensor data is transmitted to the Blynk app, allowing users to remotely monitor and control the system. By integrating multiple functionalities into a single platform, this approach optimizes water conservation efforts, minimizes wastage, and ensures sustainable resource management through automated and data-driven decision-making.

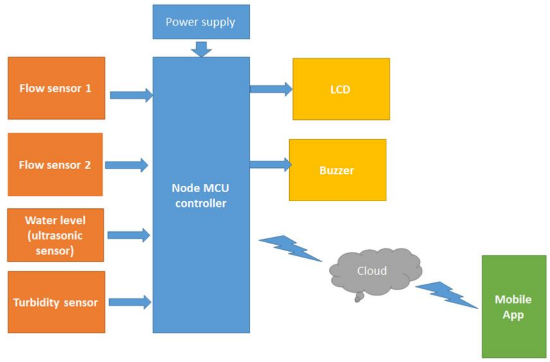

Fig.1. General Block diagram

IV. COMPONENTS USED AND DESCRIPTION

A. *Arduino UNO*

The ESP-12E module, which houses the ESP8266 chip with Tensilica Xtensa 32-bit LX106 RISC CPU, is included with the NodeMCU ESP8266 development board. This microprocessor runs at a configurable clock frequency of 80MHz to 160MHz and supports RTOS. To store information and applications, the NodeMCU features 4MB of Flash memory and 128 KB of RAM. It is perfect for Internet of Things applications because of its powerful processing capacity, built-in Wi-Fi and Bluetooth, and Deep Sleep Operating capabilities.

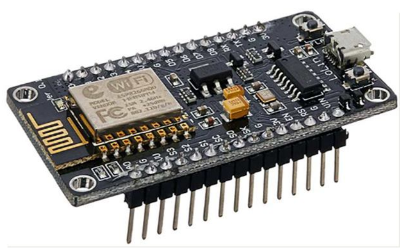

Fig.2. Arduino UNO

B. *Power Supply*

Either an external power source or a USB cable can be used to power the Arduino Uno. An AC to DC converter is the most common external power source; batteries are sometimes used. The adapter can be connected to the Arduino Uno by plugging into the power jack of the Arduino board. The Vin and GND pins of the POWER connector can also be used to connect the battery leads. Seven to twelve volts is the recommended voltage range.

C. *Ultrasonic Senso*

An apparatus that uses sound waves to determine an object's distance is called an ultrasonic sensor. By emitting a sound wave at a certain frequency and watching for its return, it calculates distance. It is feasible to determine the distance between the sonar sensor and the item by timing the interval between the sound wave's generation and returning.

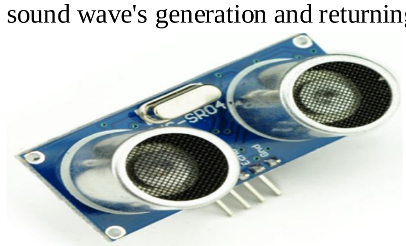

Fig.3. Ultrasonic Senso

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D. Water Flow Sensor

A plastic valve body, a water rotor, and a hall-effect sensor make up a water flow sensor. The rotor rolls when water passes through it. Its speed varies according to the flow rate. The matching pulse signal is produced by the hall-effect sensor.

Fig.4. Water flow sensor

E. Buzzer

A buzzer is used to provide audio feedback for system notifications. It sounds an alert when an order is placed, a payment is completed, or when a customer presses the waiter call button. This feature ensures staff members are immediately notified, reducing response time and enhancing service quality.

Fig.5. Buzzer

F. LCD Display

In pipeline monitoring systems, LCDs (Liquid Crystal Displays) are frequently used to give visual feedback on system status. By showing data including sensor readings, alarms, and diagnostic messages, operators may quickly evaluate the pipeline network's condition.

Fig.6. LCD Display

G. Blynk APP

Blynk is an IoT platform designed to make it easier to create web and mobile apps for the Internet of Things. In only five minutes, link more than 400 hardware models, including Arduino, ESP8266, ESP32, Raspberry Pi, and other comparable MCUs, and create drag-and-drop IOT mobile apps for iOS and Android.

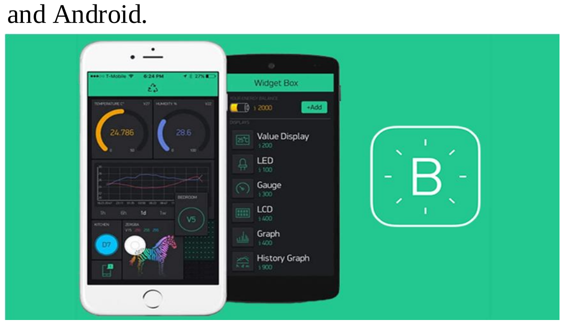

Fig.7. Blynk App

V. WORKING

The proposed system operates based on the following step-by-step process:

1) *Data Collection from Sensors:*The system consists of flow sensors, water level sensors, and turbidity sensors that continuously monitor various parameters. The flow sensors measure the water usage rate, the water level sensors track reservoir or tank levels, and the turbidity sensors assess water quality by detecting suspended particles.
2) *Data Processing by NodeMCU:* The collected sensor data is sent to the NodeMCU microcontroller, which processes and analyzes it. NodeMCU uses predefined thresholds to determine whether water leakage, theft, or quality issues are present.
3) *Real-Time Monitoring and Display:* The processed data is displayed on an LCD screen, providing real-time feedback to users. Key parameters such as flow rate, water levels, and turbidity are shown, allowing users to monitor water conditions instantly.
4) *Detection of Abnormalities:* If any sensor data deviates from normal conditions (e.g., unexpected water flow indicating leakage, low water levels, or high turbidity), the system triggers alerts. The flow sensor identifies unauthorized usage or leaks by comparing current usage with baseline consumption patterns.
5) *Alert Notification via Blynk App:* When abnormalities are detected, the NodeMCU sends alerts to users through the Blynk app. These real-time notifications help users take immediate action to prevent further water wastage or contamination.
6) *Buzzer Activation for Immediate Response:* In case of critical issues such as excessive leakage, very low water levels, or dangerous turbidity levels, the buzzer sounds an alarm. This auditory alert ensures prompt action even if users are not actively monitoring the system via the app.
7) *Continuous Monitoring and System Optimization:* The system continuously monitors water usage and quality, updating data in real time. Over time, it helps establish trends and optimize resource utilization, reducing wastage and improving sustainability.

VI. RESULTS

The implementation of the IoT-based water leakage, theft detection, and water quality monitoring system has demonstrated significant improvements in water management. The system effectively detects abnormalities such as unauthorized water usage, leaks, and contamination in real-time. By integrating flow sensors, water level sensors, and turbidity sensors, it ensures continuous monitoring and immediate alerts, helping users take timely action to prevent water loss.

Real-time notifications through the Blynk app have enhanced user awareness and response times. Whenever unexpected flow variations or critical water quality issues arise, users receive instant alerts, allowing them to intervene promptly. Additionally, the LCD display provides continuous visual feedback, making the system easy to monitor even without a mobile device.

The activation of the buzzer for critical alerts has further improved responsiveness, ensuring that urgent issues such as extreme water leakage or dangerously high turbidity levels are addressed immediately. By automating water monitoring and integrating multiple sensors into a single system, the proposed solution enhances efficiency, minimizes wastage, and promotes sustainable water resource management.

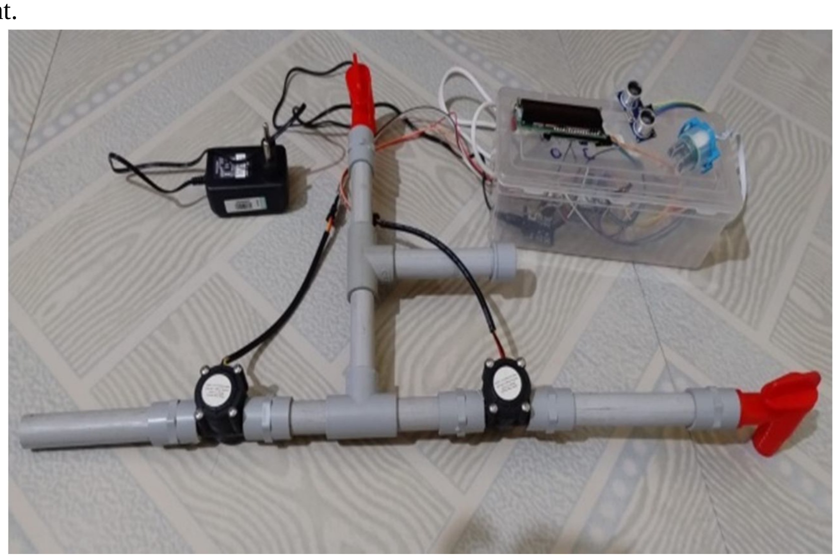

Fig.12. architecture

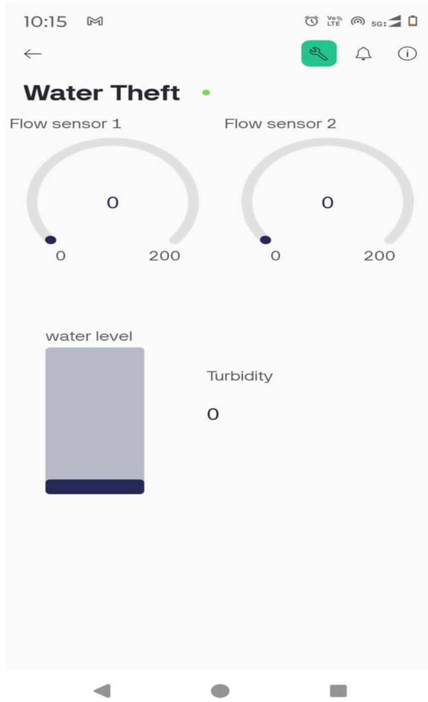

Fig.13. results

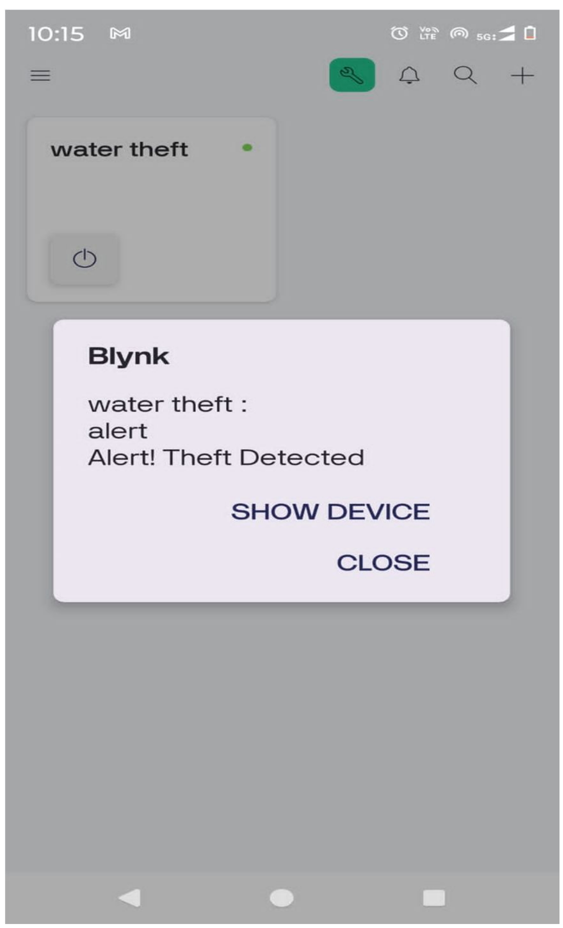

Fig.14. results

VII. CONCLUSION

The IoT-based water leakage, theft detection, and water quality monitoring system offers a smart and automated approach to managing water resources efficiently. By integrating flow sensors, water level sensors, and turbidity sensors with NodeMCU, the system enables real-time tracking of water usage, reservoir levels, and contamination levels. This ensures immediate detection of leaks, unauthorized water extraction, and changes in water quality, helping to prevent resource wastage.

The use of the Blynk app for real-time notifications enhances user awareness, allowing for prompt corrective actions whenever abnormalities are detected. Additionally, the LCD display provides continuous visual feedback, while the buzzer ensures immediate alerts in case of critical conditions. These features contribute to better monitoring and control of water resources.

Overall, the proposed system improves water conservation, minimizes wastage, and supports sustainable resource utilization. By leveraging IoT technology, it provides a cost-effective and scalable solution to modern water management challenges, making it suitable for residential, industrial, and municipal applications.

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