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SMART WATER FLOW AND PIPELINE LEAKAGE DETECTION USING IOT AND ARDUINO UNO

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ABSTRACT: This paper introduces a smart water pipeline monitoring system designed to address water leakage issues. With the increasing demand for water, its wastage is also rising, making effective monitoring crucial. The proposed system leverages the Internet of Things (IoT) to enhance water management. Utilizing readily available sensors, the system incorporates a water flow sensor to measure the flow rate and a turbidity sensor to assess water quality. The water flow sensor operates based on the Hall effect principle. A NodeMCU microcontroller, popular in IoT applications due to its interrupt capabilities, is employed to manage sensor data. This data is transmitted to a cloud server for storage and analysis. The ThingSpeak cloud server is chosen for its open and free accessibility. Through this system, real-time monitoring of water flow and quality in pipelines is facilitated, enabling effective management and conservation.

Keywords: Water Flow Sensor, IoT, Smart Monitoring System, Cloud Serve

1. INTRODUCTION

Only 3% of the world's water is freshwater, and one-third of this is not readily accessible. The demand for water has surged due to rising populations, rapid industrialization, and increasing living standards. To address this, various water collection methods have been employed, including dams, reservoirs, and groundwater structures such as wells. However, projections suggest that in thirty years, one-third of the global population may face water scarcity. In major cities like Delhi, Kolkata, Mumbai, Hyderabad, Kanpur, and Madurai, approximately 5 million households lack access to clean water. The World Health Organization (WHO) recommends a daily water requirement of 100-200 liters, exceeding the average urban consumption of 90 liters. One effective measure to mitigate water loss is the installation of underground water pipeline monitoring systems to reduce leakage. Key factors contributing to pipeline leakage include the material of the pipes and their age. As pipes age, water loss in the network can approach 50%. Additionally, pipeline networks are often located beneath city streets, where excavation by other utilities, such as gas, electricity, and communication services, can damage the pipes. Inadequate materials and poor pipe foundations can also lead to imbalanced strain and damage.

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Identifying and locating leaks in pipelines can be challenging and time-consuming, leading to significant water loss before repairs are made. Traditional methods of leak detection are inefficient, necessitating a shift towards automated, sensor-based technologies. By employing water flow sensors and Internet of Things (IoT) technologies, pipeline monitoring can be greatly improved. Water flow sensors measure both the flow rate and volume of water, and IoT enables this data to be transmitted to the cloud for processing.

The Internet of Things (IoT) enhances data communication by connecting multiple devices to the internet, facilitating interactions between machines and between humans and machines. Sensors collect environmental data, ranging from simple temperature measurements to complex video streams, and send it to cloud services for processing. Data communication is supported through various networking methods, including cellular, satellite, Wi-Fi, and low-power wide-area networks. With the plethora of wireless network options available, selecting the most suitable communication method for IoT devices is crucial.

Once data is transferred to the cloud and processed, it is made accessible to end-users through various means, such as mobile alarms, email notifications, or dedicated apps, allowing for real-time monitoring and management of IoT devices from anywhere.

2. EXISTING SYSTEM

Currently, water pipeline monitoring is performed by workers from water distribution companies. In urban areas, it is impractical for these workers to monitor every street individually. Typically, each worker is responsible for overseeing 5 to 10 streets, leading to a high demand for manpower in monitoring operations.

3. PROPOSED SYSTEM

The proposed system employs non-acoustic leak detection through flow sensors. The YF-S201 water flow sensor is utilized to measure the flow rate and monitor the volume of water passing through the pipeline. Additionally, a turbidity sensor is employed to assess water contamination and ensure water purity. This sensor is crucial for detecting any impurities, such as soil mixing with the water due to leaks. To provide real-time updates, IoT technology is implemented, with the microcontroller transmitting data to a cloud server for further processing.

4. BLOCK DIAGRAM

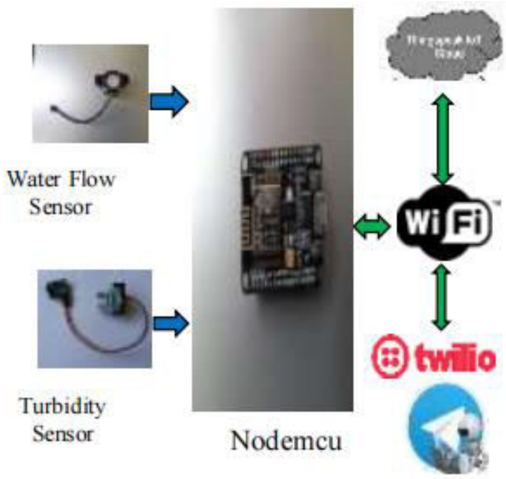

Figure 1 illustrates the block diagram of the water pipeline leakage detection system. The NodeMCU is a cost-effective Wi-Fi microcontroller featuring 8 digital pins and one analog input pin, with all pins supporting interrupts except for D0. The

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YF-S201 water flow sensors are connected to digital I/O pins D8 and D7 on the NodeMCU. These sensors include a rotor and are installed inline with the water pipe, incorporating a pinwheel sensor that measures the amount of liquid passing through. An integrated magnetic Hall effect sensor generates an electrical pulse with each rotor revolution. This Hall effect sensor is sealed from the water to ensure it remains dry and protected. Unlike motors, the Hall effect sensor produces pulses as the rotor turns, with the speed of rotation correlating to the pulse frequency. The microcontroller reads these pulses as interrupt signals, and by counting the pulses, the water flow rate can be determined, with each pulse corresponding to approximately 2.25 milliliters of water. The turbidity sensor monitors water contamination or purity by using a light transmitter and receiver. The amount of light received varies with the particles present in the water. The turbidity sensor provides both analog and digital outputs, but the analog output is used for greater accuracy. This output is connected to the analog input pin on the NodeMCU. Data from both the flow and turbidity sensors is sent to ThingSpeak, a cloud server used for IoT, for analysis and monitoring.

5. WORKING PROCEDURE

In the turbidity sensor, light is continuously transmitted and scatters through the water to reach the receiver. The analog output voltage of the turbidity sensor reflects the amount of light reaching the receiver. For clean water with no contamination, the output voltage will be below 2 volts (NTU = 0-20). Conversely, if the water is highly contaminated, the output voltage will be around 4.8 volts (NTU = 2500-3000). This data is sent to ThingSpeak's cloud server and displayed on its web interface. The turbidity sensor's primary function is to detect water contamination. If a pipeline has a defect causing soil to mix with the water, making it undrinkable, the turbidity sensor can help identify this contamination even if flow sensors fail to detect a leak.

The flow sensor operates based on the Hall effect. When water flow is high, the rotor's rotation speed increases, and when water flow is low, the rotor's rotation speed decreases. The TTL pulse output varies with the rotor's rotation speed. The sensor's operating flow range is from 1 to 30 liters per minute, with 450 pulses per liter. The NodeMCU reads these digital pulses by measuring the time interval between them.

The calculations are as follows:

- **Flow Rate** = Pulse Frequency / 7.5
- **Flow of Water per Minute** = Flow Rate / 60
- **Total Volume of Water Flowed Through Pipe** = Volume + Flow Rate

Flow sensors are installed at both the receiving line and the water source transmission area. The amount of water passing through the flow sensor is transmitted to ThingSpeak's cloud server. This allows for easy monitoring of water flow at both the transmission and receiving ends (streets). If there is a discrepancy in the amount of water between these areas, it indicates a potential leak in the pipeline.

The connections are configured according to the circuit schematic shown in Figure 2. The main source water line flow sensor is

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connected to the D8 pin (GPIO 15). The flow sensor for Street A is attached to the D7 pin (GPIO 13), and the flow sensor for Street B is connected to the D6 pin (GPIO 12). The circuit is powered by a 9V external battery. Once powered on, the NodeMCU connects to Wi-Fi and begins updating data to Thing Speak.

As depicted in Figure 3, when water flows through the primary source flow sensor, it is distributed between Streets A and B. The flow sensor can detect up to 30 liters per minute, so the water flow rate should be moderate to ensure accurate measurements.

7. RESULTS AND DISCUSSION

The ThingSpeak web server allows for easy monitoring of the water volume flowing through the pipe. With MATLAB analysis integrated into ThingSpeak, data can be further analyzed by sending it to MATLAB. Additionally, the data received by ThingSpeak can be exported as an Excel spreadsheet, providing a comprehensive record of water flow over time. Table 1 displays the Excel datasheet output from the water flow sensors. For instance, when water flows at a rate of 1 liter per second from the transmission pipeline and is distributed between two streets, the total distributed water should equal the total received water if there are no leaks or damage.

However, Figure 7 illustrates that due to a pipeline leak, not all the water distributed from the transmission line is received at the endpoints. Specifically, a leak in Street B results in water loss, causing a discrepancy where 16 liters of water are wasted. This numerical difference between the water transmitted and received highlights the presence of a leak.

If leakage occurs, water wastage will be evident as a discrepancy between the water transmission and receiving areas. MATLAB analysis can help identify pipeline leaks and assess the extent of water loss. Moreover, ThingSpeak, along with ThingHTTP and IFTTT, can be used to send notifications to users about water wastage. Notifications can be configured through various methods, such as calls with Twilio or push updates using Prowl, whenever a discrepancy in water flow is detected.

8. CONCLUSION

The primary goal of this system is to detect leaks in water pipelines. This system is particularly valuable for smart cities, where numerous water pipelines and associated leakages exist. By employing this system, leak detection becomes more straightforward, and issues can be addressed efficiently. Additionally, this system is suitable for water distribution systems in remote locations.

Experimental results confirm that water flow sensors are effective for tracking and detecting leaks in pipeline control systems. Given the extensive network of water pipelines and the frequency of leaks, this system proves highly beneficial. Currently, water distribution staff are responsible for leak monitoring, but this system offers a quicker resolution by automating the process.

The IoT-powered water monitoring system offers several significant advantages:

- Automated identification of pipeline leaks and bursts
- Cost-effective manufacturing, installation, and maintenance
- Rapid data collection
- Automatic detection of leakage areas without manual intervention
- Real-time water leak detection
- Enhanced management of water premises
- Affordable installation within a budget-friendly range

This method is adaptable and highly beneficial in urban environments, where water distribution contracts are often managed by private companies. They can effectively utilize this system to monitor water flow to urban households.

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