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Water Pipeline Leakage Detection and Monitoring System Using Smart Sensor with IoT

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Water Pipeline Leakage Detection and Monitoring System Using Smart Sensor with IoT

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ABSTRACT - This paper presents a smart water pipeline monitoring system to control the water leakages occurring in it. In day by day life, usage of water is increasing with proportional to increase in wastage of water. So, to overcome from this, a smart monitoring system with the help of Internet of Things (IoT) is designed and proposed. In this modern era, usages and advantages of IoT are immeasurable. There are a lot of sensors are available in the market to measure the water flow [2]. In this system, to monitor the flow of water, the water flow sensor is used in the pipeline and also to measure the contamination of water a turbidity sensor has been used. Flow sensor works on the principle of a hall effect [5]. Nodemcu microcontroller, is one of the most common microcontrollers used for IoT purposes has been used in this system [8]. Main purpose of this microcontroller used is because of its interrupt pins. The values measured by the water flow sensor and turbidity sensor are uploaded to the cloud server. For storing the data in the cloud, the ThingSpeak cloud server has been used for this system, because ThingSpeak cloud server is open and free to use. With the values measured by the water flow sensor the data is displayed in the ThingSpeak cloud webserver. So, monitoring of the water flow in the pipeline will be done very easily.
Keywords – *Water Flow Sensor, IoT, Smart Monitoring System, Cloud Server*

1. INTRODUCTION

Only 3% of the world's water is fresh and one-third of fresh water is inaccessible. The demand for water has increased over time as a result of rising population, rapid industrialization and rising living standards. Dams and reservoirs have been built, as well as ground water structures such as wells, in an attempt to collect water. Thirty years from now, it is estimated that one-third of our population will be affected by water scarcity. According to a survey, 50 lakh households in Delhi, Kolkata, Mumbai, Hyderabad, Kanpur, and Madurai lack access to clean water. According to the World Health Organization (WHO), the minimum daily water requirement should be 100-200 litres, which is higher than the average urban figure of 90 litres [2]. One such measure is the installation of an underground water pipeline monitoring system to reduce pipeline leakage.

The effective factors causing leakage in the water pipeline are the material of the pipes is one of the most important factors and another critical consideration is the age of the pipes used for it. With the ageing of pipes, the loss of water entering the networks will approach 50% approximately. The majority of the water supply system network runs under city streets. Digging by other organizations, such as gas, electricity and communication can cause damage to the pipes. Unsuitable materials for the pipes foundation and coverage result in unbalanced strain, which causes harm.

If there is a water leakage in the pipes, it will be difficult to track down the source of the leakage occurred. It may take days for the concerned authorities to track down the source of the leakage and repair the pipe [7]. As a result of the delay, a significant amount of water is lost. The traditional approach needs to be automated by using sensors-based technology to identify leaks occurred and track where they are occurring so that leaks can be repaired or prevented in a short period of time, resulting in minimal water loss [10]. With the help of water flow sensors and IoT, monitoring the underground pipelines can be done easily. Here to monitor the flow rate the water flow sensor has been used and also the volume of water flowed through the pipeline is also measured [1]. By using IoT, the water flow rate consumed in the pipeline and also the volume of water consumed data is sent to the cloud for further data processing. By using this methodology monitoring the pipeline flowrate can be done easily [9].

The concept of Internet of Things (IoT) is used for the data communication to the next level by linking several devices to the internet at the same time, enabling man-machine and machine-machine interactions [8]. To begin, sensors or devices collect data from the external environment and send it to the cloud. For example, from a basic temperature control sensor to a complex video stream, all of this data collected may have varying degrees of complexities [2]. These collected data are then sent to a cloud service for further data processing. Sensors will communicate with the cloud through the device using a various methodology of networking like cellular networks, satellite networks, Wi-Fi, low-power wide-area networks, and others [8].

As a result, nowadays, selection of the best communication choice for the IoT device is found to be more critical because of the more wireless networks available [8]. After the data is obtained from the device and transferred to the cloud for data processing and analysing [12]. After that the data information is then made available to the end-user in some way for their application. This can be accomplished by using many methods like setting off alarms on their phones or receiving notifications to their emails. Additionally, a user will have access to an app from which they can actively monitor their IoT device from anywhere else [2].

2. EXISTING SYSTEM

Currently, water pipeline monitoring is carried out by the workers of the water distributors. It is impossible for water distributor in urban city to have workers in each street for monitoring the pipes. Each worker is assigned with at least 5 to 10 streets for monitoring. Man, power requirement for monitoring is high [7] [9] [10].

3. PROPOSED SYSTEM

In this system, non-acoustic leak detection systems by using flow sensors can be carried out. Using YF-S201 water flow sensor, the flow rate can be calculated and the volume of water flowed through pipe also monitored. Additionally, turbidity sensor is used to check the contamination of the water flowing through the pipe. Purpose of using this sensor is mainly to check the purity of water. If there is any leakage in the pipe and due to that any soil mixed with water, purity of water will be changed. So, it is also important to monitor the purity of water. For the real time updates, IoT technology is implemented in which the microcontroller sends the data to the cloud server for further data processing.

4. BLOCK DIAGRAM

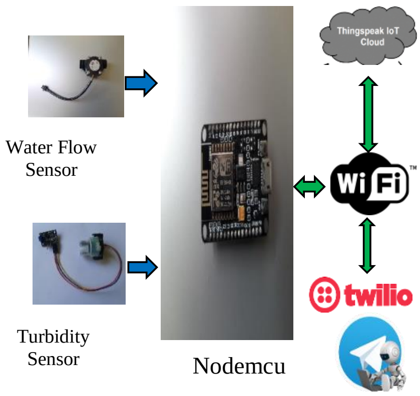


Figure 1 Block Diagram of the System

Figure 1 shows the block diagram of the water pipeline leakage detection system. NodeMCU is a low-cost in-built Wi-Fi microcontroller. It has 8 digital pins and one analog read pin. Except D0, all other pins are support with interrupts. YF-S201 water flow sensors are connected to digital I/O pins D8 and D7 of NodeMCU. This water flow sensor consists of a rotor in it and also this sensor sits in line with your water line and contains a pinwheel sensor to measure how much liquid has moved through it [7]. There's an integrated magnetic hall effect sensor that outputs an electrical pulse with every revolution. The hall effect sensor is sealed from the water pipe and allows the sensor to stay safe and dry. Unlike motor, hall effect sensor produces pulse as an output when rotor rotates. So, when water flows through the flow sensor, with speed of rotation, pulses will be produced at the output. In microcontroller, this pulse signal is read as an interrupt signal. By counting the pulses from the output of the sensor, the water flow can be calculated. Each pulse is approximately 2.25 millilitres. Turbidity sensor is used to monitor the contamination (purity) of water. Turbidity sensor has light transmitter and receiver. With the respect to the particles present in the water, light received in the receiver will be vary. Turbidity sensor has both dual outputs, analog and digital signal. In this, we are using analog signal output because for accuracy. Turbidity sensor output is connected to analog read pin. ThingSpeak is a cloud server used for IoT. The data received from flow sensor and turbidity sensor is send to this cloud server for analysing the outputs.

5. WORKING PROCEDURE

Light is continuously transmitted in a turbidity sensor, scattering through the water to reach the receiver. The analogue output voltage of the turbidity sensor corresponds to the amount of light that reaches the receiver. If there is no contamination in the water (clean water), the output voltage will be less than 2 volts (ntu = 0~20). The output voltage will be 4.8v (2500-3000) if the water contamination is high, i.e. unclean water. This information will be transferred to the cloud server of ThingSpeak. The output is shown in the ThingSpeak webserver. The primary aim of employing a turbidity sensor in this system is to detect water contamination. If the pipeline has a flaw and soil has entered the pipe and mixed with the water, the water cannot be used for drinking. Even if flow sensors fail to detect a leak, we can monitor pipeline leaks using a turbidity sensor and water pollution [12].

The hall effect is used in the flow sensor's operation. When the flow of water is high, the rotor's rotation speed is high, and when the flow of water is low, the rotor's rotation speed is low. The output TTL pulse will vary with constant voltage according on the rotor's rotation speed. The working flow will range from 1 to 30 litres per minute. There will be 450 pulses per litre. Since output of the flow sensor is digital pulses, in NodeMCU, data is reading digitally (digitalRead) by time interval between pulses.

The formula for calculating:

- Flow rate = pulse frequency / 7.5
- Flow of water per minute = Flow rate / 60
- Total Volume of water flows through pipe = Volume + flow rate

Flow sensors are being installed in the receiving line and the water source transmission area [10] [13]. The amount of water flowing through the flow sensor is communicated to a cloud server through ThingSpeak. The amount of water that flows through the flow sensor in the transmission area and the amount of water that arrives at the receiving end may both be easily monitored (streets). If the difference in the amount of water between transmission area and receiving area, then there will been a leakage in the water pipeline.

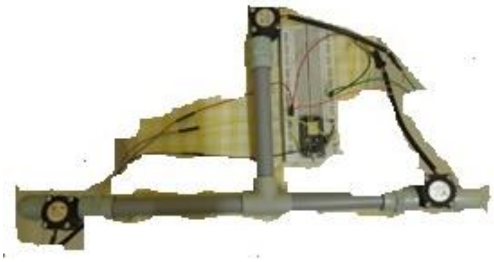


Figure 2 General View of Pipe Connection

The connections are made according to the circuit schematic in figure 2. The output of the main source water line flow sensor is attached to the D8 pin (gpio 15). D7 (gpio 13) is connected to Street A flow sensor, while D6 (gpio 13) is connected to Street B flow sensor (gpio 12). The circuit is powered by a 9V external battery. NodeMCU will switch on and connect to WiFi after being connected and powered. Once the water flows through the flow sensor, the data is updated to the ThingSpeak.

When water flows via the primary source flow sensor, water is apportioned between streets A and B, as shown in figure 3. Since the flow sensor can detect upto 30 litres per minute, the water flow speed should be moderate.

Figure 3 Water Pipeline Connection System

6. FLOWCHART

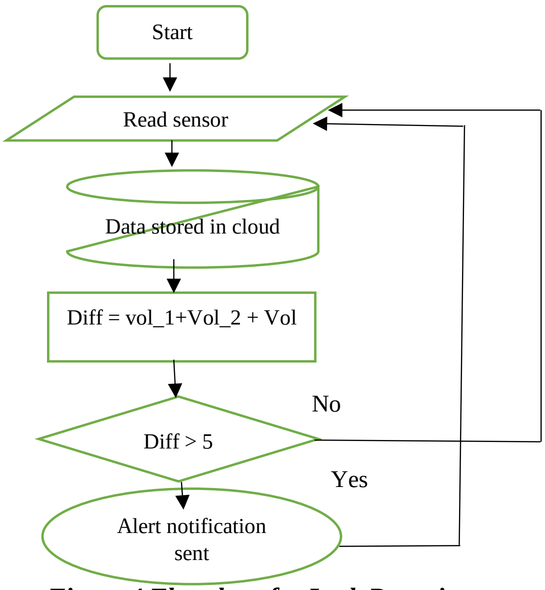


Figure 4 Flowchart for Leak Detection

The above figure 4 shows the working procedure or flow to monitor and detect the leakage occurring in the water pipeline. In that first read the data from the flow sensor and send the data to the cloud server for analysing purpose through the wireless network. Next calculate and compare the received data volume of the water with the transmitted data volume of the water. If the difference is available when compared with the reference or threshold value send an alert notification to the user through any app.

7. RESULTS AND DISCUSSION

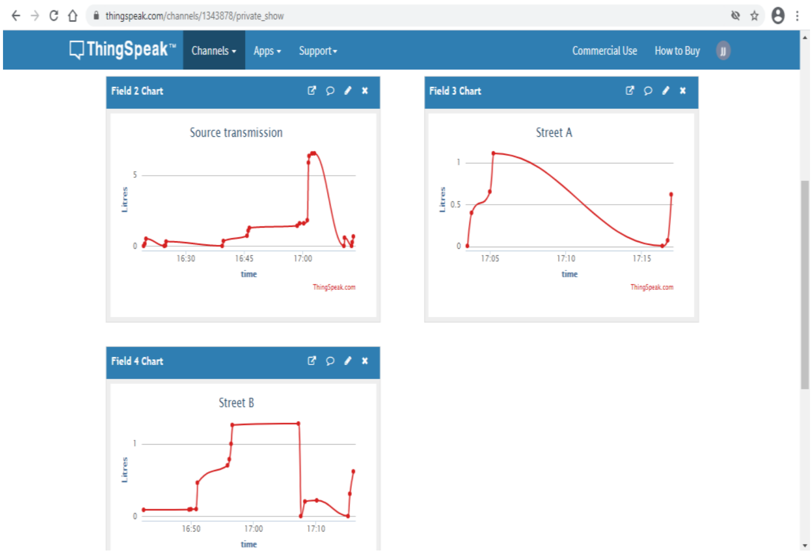
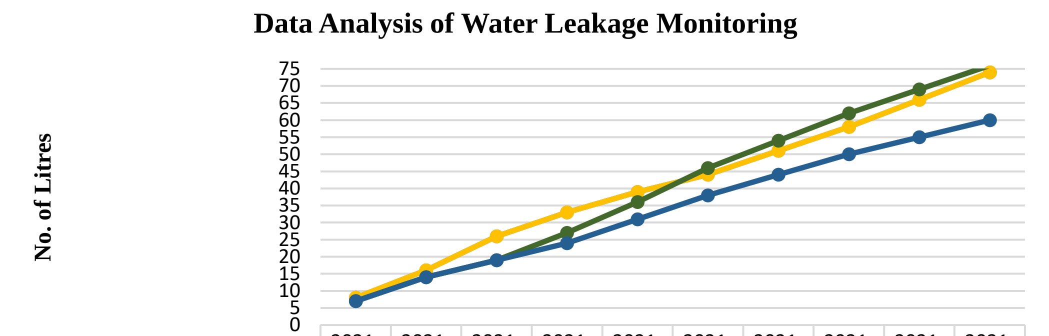


Figure 5 ThingSpeak Cloud Data Output

created_at	entry_id	Water out(L) without leakage	Street A without leakage	Street A with leakage	Street B without leakage	Street B with leakage
2021-04-22 16:19:15 IST	1	15	8	8	7	7
2021-04-22 16:19:35 IST	2	30	16	16	14	14
2021-04-22 16:19:51 IST	3	45	26	26	19	19
2021-04-22 16:24:32 IST	4	60	33	33	27	24
2021-04-22 16:24:48 IST	5	75	39	39	36	31
2021-04-22 16:25:03 IST	6	90	44	44	46	38
2021-04-22 16:39:26 IST	7	105	51	51	54	44
2021-04-22 16:39:41 IST	8	120	58	58	62	50
2021-04-22 16:42:26 IST	9	135	66	66	69	55
2021-04-22 16:45:48 IST	10	150	74	74	76	60
Total amount of water transmitted			**150**			
Total amount of water received			**134**			
Loss			**16**			

Table 1 Excel Datasheet of Water Consumption and Leakage Detection

The figure 5 shows the output of the flow sensors in the ThingSpeak web server. From the ThingSpeak webserver we can easily monitor the volume of water flows through the pipe. Since MATLAB analysis is available in the ThingSpeak, further the data can be sent to it for analysis purposes. If there is any leakage in the pipeline, there will be a wastage of water. Due to this, there will be a numerical difference between the water transmission area and the receiving area. So, by using MATLAB analysis, easily the leakage of the water pipeline can be identified and the difference amount of the water utilised can also be analysed. With the help of ThingSpeak, ThingHTTP the different notifications can be sent to the various user by using IFTTT, make calls with Twilio, Send push updates using Prowl when there is a difference (water wastage).



	2021-04-22 16:19:15 IST	2021-04-22 16:19:35 IST	2021-04-22 16:19:51 IST	2021-04-22 16:24:32 IST	2021-04-22 16:24:48 IST	2021-04-22 16:25:03 IST	2021-04-22 16:39:26 IST	2021-04-22 16:39:41 IST	2021-04-22 16:42:26 IST	2021-04-22 16:45:48 IST
Street A without leakage	8	16	26	33	39	44	51	58	66	74
Street A with leakage	8	16	26	33	39	44	51	58	66	74
Street B without leakage	7	14	19	27	36	46	54	62	69	76
Street B with leakage	7	14	19	24	31	38	44	50	55	60

Figure 6 Data Analysis of Water Flow with Water Supplied and Leakage

Data received by the ThingSpeak webserver can be exported as excel datasheet. By using this, we can get the full data of water flow in a particular time. Table 1 shows the excel datasheet output of water flow sensors. Water is flowing at a speed of 1 L/s from the water transmission pipeline. Distributed water is received by 2 streets. When there is no damage and no leakage in the pipeline, total amount of distributed and received are equal.

Figure 6 shows that due to a leakage in the pipeline, water distributed from the transmission line is not fully received in the receiving ends. Due to a leak in the Street B, there is a loss of water. Due to this total amount of water distributed and total amount of water received is not equal i.e., 16 litres of water got wasted.

8. CONCLUSION

Main aim of this system is to find the leakage occurring in the water pipeline. This system is really helpful in smart cities because there are lot of water pipelines as well as leakages. So, with the help of this system, the leakage detection in the water pipeline can be easily identified and the problems related to it can be rectified easily. This system can also be used in the remote location water distribution system.

Water flow sensors are ideally suited to track and detect leakage in water pipeline control systems, according to experimental findings. Since there are several water pipelines will available in the city and leaks also will be more, this system is extremely beneficial for it. At present, in our cities and all only water distribution staffs are monitoring the leaks. As a result, with the assistance of this type of system, the problem can be resolved quickly. This system can also be used in a water delivery system for remote locations.

With wide applicability of successful integration with multiple industries, IoT-powered water monitoring system has many advantages. Here are the most essential advantages that can be obtained while using this system.

- Automated identification of water delivery pipeline leaks and bursts
- Low-cost to manufacture, mount, and maintain
- Data collection at a high pace
- Easy way to find out leakage area automatically without man power.
- Real-time Water Leak Detection
- Improved Premise Management
- Easily installable in a pocket-friendly budget

This method is really adaptive and useful in urban cities, since the distribution of water in the urban cities contract are giving to private companies, they can easily use this method to monitor the flow of water to the urban households.

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