Water Pipeline Leakage Monitoring System based on Internet of Things

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Abstract. Water leakage detection of pipeline in the resident household is important to ensure that water supply networks can operate effectively. This paper presents an experimental investigation and prototype of a water pipeline leakage monitoring system based on a low-cost microcontroller, Arduino, with three types of sensors. The system will monitor the turbidity of the water before pump the water into water tank of household. Then, later if there any leakages, a notification will be given to the user either through SMS or Telegram notification. These leakages are being detected using water flow and water sensors. A simple mobile application has been designed to monitor the condition of water pipeline remotely and allowed user to remotely call the repairing services if the leakage happened when there are no one at home. Simulation analysis and experimental results indicate that the proposed leakage identification method can effectively identify water pipeline leakage and has lower consumption than other methods.

1. Introduction
Sufficient clean water is a necessary element for every organism and needs, especially to human and animals to provide sustainable economic activities and daily lives activities. Malaysia is enriched with water resources with the demand of water increasing either from residential, agricultural, industrial, or medical. The rise in population and urbanization as well as improved living standards is imposing additional pressure on the water resources in the country. As a result, the per capital availability of water is decreasing, where evidence has shown that national coverage of water supply has increased from 80% of the total population in 1990 to 95% in 2000 stated by Akademi Sains Malaysia, National Hydraulics Research Institute of Malaysia, Ministry of Science, Technology, and Innovation. Thus, providing a good water monitoring system is required, especially in the residential household. Additionally, the report also stated that the frequency of water supply disruptions in the Klang Valley has been like a “monthly event” to more than one million consumers in the area. The frequent river pollution is like a nightmare to the affected residents who have been seeking for more concrete action to be taken as 90 percent of the country’s source of raw water is river water or surface water. With the river basin exposed and frequency of water supply disruptions, many have suggested for the government to use high technology to overcome these problems.

Yet, a large portion of water is lost during lost during transportation and distribution, commonly known as nonrevenue water (NRW) which required labour-intensive detection surveys which are usually expensive and not be able to give a continuous monitoring system. NRW is attributed to a various...
of sources, including metering errors, accounting errors, water theft and pipeline leakage. Undetected water problems also pose a health risk to occupants, which can lead to the growth of hazardous mold and fungus that can spread quickly to the surrounding areas. These causes lead to property damage, faulty equipment, and expensive clean-up costs if the undetected water leak problems are not resolved or improved. Undetected water leakage will cause a low pressure of water and the flow of water will be small among the residential. The undetected water leaks problems in residential can lead to large water loss and damage to building structures. The cost of repairing these damages can increase into thousands of ringgit if the water leaks are not detected as soon as possible.

Several works have been proposed for detecting water leakage in the pipeline, focusing on detecting leakage using microcontrollers, [1]–[3], wireless sensor networks [4], [5], SVM classification [6] others on fluid mechanics and kinematic physics based on water flow rate obtained from liquid meter sensor [7]. Meanwhile, [8] proposed an approach to household leakage detection by using sound signal recordings. Their work records the sound signals produced by water fixtures and appliances, then used recordings to detect any abnormalities which indicate the leak. To addition, [9], [10] detected the leak by acoustic sensors based on Internet of Things (IoT). Although there are many studies, research in water leakage remains limited in applying the approach using the Internet of Things (IoT) and to expand this technology in measuring the quality of household water to be drinkable. More advanced work can been seen from [11], which present a novel leak detection based on relative pressure sensor attached to the outside of pipe combined with temperature difference measurement between the pip wall and the soil. Work from [12] proposed an intelligent monitoring approach to supervise efficiently the Water Pipeline System which focused on sensing the continuous water parameters in this case, pressure and flow rate. Interesting work have been shown by [13], where the cloud-based NB-IOT system is designed to realize cloud traffic data management and online remote water leakage diagnosis, by comparing the flow data at both ends of the pipeline. On the other hand, [14] proposed Cognitive Water Distribution System that integrates IoT, smart sensors, actuators and connected objects and used a big data analysis to give a real time processing of large amount of collected data on pipeline damages and hydraulic failures. Another work used an IoT approach is shown by [15] which implemented neural networks for monitoring water leakages in real time by connecting IoT enabled to monitor tank level, water quality and pipe leakage.

Therefore, the work shown in this paper is to propose a water pipeline leakage monitoring system based on Internet of Things (IoT) where allows the resident to monitor their house pipeline leakage. Additionally, this system also allows users to monitor the quality water by sending notification or alarm to the resident if there were leaking problems appear. The design of the work involved three sensors, which are flow, water, and turbidity sensors. The GSM module is used to send the message to the user’s mobile phone and through the notification of Telegram. A simple mobile app also been used to monitor the reading data of the sensors remotely.

2. Methodology

The work shown in this paper proposed a system that monitors the water leakage inside the residential household which contained water turbidity, water flow and water sensors which have been focused on by the researchers. The design of the work focuses in measuring the turbidity of the water, water flow, the location of water leakage, message to users using GSM module and display of the information to the mobile apps to provide easy and low cost of system that give a real time monitoring to the residential residence. Figure 1. shows the flowchart of the proposed work.
Figure 1. Flowchart of the proposed work.
Initially, the work proposed in here is to pump the water into the household water tank only if the turbidity of water can be considered clean to drink which be less than or equal to 0.3 NTU and maximum limit is not exceeding 5 NTUs based on the national drinking water quality standard. Once the water was tested for its quality, the water will pump into the pipe by using the water pump. The water pump is connected with Arduino through relay where the water pump will stops pumping the water automatically when the water tank is full. The water sensor is used to detect the water level in the water tank, as shown in Figure 2.

![Figure 2. The flow of water to the water tank.](image)

When the water went through the pipe, the water flow sensor is used to measure the flow of water. For this prototype, the working flow rate is set at 200 milliters/minute. The purpose of water flow sensor is to monitor the flow of the water, if the water is slow, there is the possibility of a water leakage is higher. Additionally, the function of water is also used to detect any leakage at the pipeline, and it will notify an alarm to the user. As shown in Figure 3, three units of water sensor has been located at two location with each sensor is to cover 10cm of pipe.

![Figure 3. Location of water sensor.](image)

The flow and turbidity sensor are connected to the Arduino and integrate with the GSM module to send the message to the user’s phone. The notification will be given to the users when the value turbidity sensor is bigger than 5 NTU. The data collected from the sensors will be collected and stored into the cloud for controlling and monitoring purposes. By using ThingSpeak, all data are stored in here using an application program interface (API) and retrieve data using Hypertext Transfer Protocol (HTTP) over the Internet or Local Area Network (LAN). If there is a leak either at Location 1 or at Location 2 or if
the water tank is full, a push notification is given to the Telegram by using If This Then That (IFTTT). The data that been stored in the cloud will be updated every 15 minutes.

Alarm will be given to the user into two forms, which are from blinking LEDs and the buzzer. There will be four types of data will upload and store into the cloud, which are the turbidity, water flow, leakage and water level detection which all were connected to Arduino Mega 2560 as the main microcontroller and communicated via NodeMCU. Figure 4 shows a complete schematic diagram of the prototype.

![Figure 4. Schematic Diagram of the proposed work](image)

3. Result and Discussion

Figure 5 shows the prototype of the work. The output of the work is to display data in serial monitor, turning on light-emitting diode, SMS, and notification in the Telegram.

![Figure 5. Prototype setting of the Water Pipeline Leakage Monitoring System.](image)

The prototype setting shows a process of transferring water from main pipe into a water tank. Turbidity sensor is set at the main pipe as it will monitor the water quality before transfer to the water tank meanwhile water flow and water sensor is implemented at the pipe to check the level of the water in the water tank. When microcontroller is power up, all sensors are starting to sense respective surrounding and check the condition of the pipeline. Water sensors as previously been explained will be located at two different location as to make it easier to detect the water leakage. If there are leakage
being detect, the buzzer will alarm the user. Figure 6, 7, and 8, shows the result from the serial monitor of water sensor, water flow sensor and turbidity sensor, respectively.

![Serial monitor of water sensor.](image)

**Figure 6.** Serials monitor of water sensor.

![Serial monitor of water flow sensor.](image)

**Figure 7.** Serials monitor of water flow sensor.

![Serial monitor of turbidity sensor.](image)

**Figure 8.** Serial monitor of turbidity sensor.

Then, the water tank shows the fullness of the water based on the water sensor to detect the level of water. The water pump will be automatically stop pumping the water into the water tank when the level of water exceeds the required level. Figure 9 shows sample of output when water tank is full.
Figure 9. Result of water sensor in the water tank.

Four light-emitting diodes (LED) is used to light on when the alarm is triggered to shows which faulty is happen. Each of this LED represent the water level in the water tank, cleanliness of water, and the location the water leakage is happened either at location No 1 or location No 2. When, the alarm is trigger, a notification will be given to user through Telegram. This was achieved by using IFTTT as shown in the communication setting between sensors and NodeMCU in Figure 10 while Figure 11 shows example of notifications given to the users through Telegram applications.

Figure 10. IFTTT setting through Telegram.

Figure 11. Telegram notification of water pipeline monitoring.

Meanwhile, a simple mobile app has been develop using MITT App Inventor which has two main functions which are data sensor and contact. Data sensor allows user to monitor the system remotely by display data from turbidity, water flow and water sensors. The app will be displaying the recent data upload into the cloud as well as allowed user to contact the water repairing services as shown in Figure 12.
Figure 12. A mobile app to monitor the water pipeline monitoring system remotely.

A complete circuit and prototype of the work as shown series of data from the sensors that been collected and upload into ThingSpeak as shown in Figure 13. The figure represents data collected by turbidity, water, and water flow sensors. When range of data has exceeded the normal threshold of condition, it will be triggered alarm features in the ThingSpeak website.

Figure 13. Thingspeak’s channels
4. 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. The system has shown that there are multiple ways of given notification to the users either through SMS, Telegram or through its own mobile app. When the internet is unavailable, the user still can get the warning message by using the GSM module. 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. Moreover, the user also can call and SMS directly the plumber without needed to search the phone number in the contact list.

This system however requires a strong connection to the internet in order the data to be sent to ThingSpeak website. If data is not being sent to ThingSpeak 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 does not very accurate as other water quality sensors. With increase the sensitivity of this sensor, the problem can be avoided.

References

[1] M. A. Uddin, M. Mohibul hossain, A. Ahmed, H. H. Sabuj, and S. Yasar Seaum, “Leakage Detection in Water Pipeline Using Micro-controller,” in 2019 1st International Conference on Advances in Science, Engineering and Robotics Technology (ICASERT), May 2019, pp. 1–4, doi: 10.1109/ICASERT.2019.8934648.
[2] N. Rosli, I. A. Aziz, and N. S. Mohd Ja afar, “Home Underground Pipeline Leakage Alert System Based on Water Pressure,” in 2018 IEEE Conference on Wireless Sensors (ICWiSe), Nov. 2018, pp. 12–16, doi: 10.1109/ICWISE.2018.8633278.
[3] M. Elleuchi, R. Khelif, M. Kharrat, M. Aseeri, A. Obeid, and M. Abid, “Water Pipeline Monitoring and Leak Detection using soil moisture Sensors: IoT based solution,” in 2019 16th International Multi-Conference on Systems, Signals Devices (SSD), Mar. 2019, pp. 772–775, doi: 10.1109/SSD.2019.8893200.
[4] M. Daadoo, A. Eleyan, and D. Eleyan, “Optimization Water Leakage Detection Using Wireless Sensor Networks (OWLd),” 2017, doi: 10.1145/3102304.3102309.
[5] K. Saraswati Vasantrao and S. M. Rajbhoj, “WSN Based Water Pipeline Leakage Detection,” in 2017 International Conference on Computing, Communication, Control and Automation (ICCUBEA), Aug. 2017, pp. 1–5, doi: 10.1109/ICCUBEA.2017.8463752.
[6] S. Porwal, S. A. Akbar, and S. C. Jain, “Leakage detection and prediction of location in a smart water grid using SVM classification,” in 2017 International Conference on Energy, Communication, Data Analytics and Soft Computing (ICECDS), Aug. 2017, pp. 3288–3292, doi: 10.1109/ICECDS.2017.8390067.
[7] R. F. Rahmat, I. S. Satria, B. Siregar, and R. Budiarto, “Water Pipeline Monitoring and Leak Detection using Flow Liquid Meter Sensor,” (IOP) Conf. Ser. Mater. Sci. Eng., vol. 190, p. 12036, Apr. 2017, doi: 10.1088/1757-899x/190/1/012036.
[8] S. Seyoumi, L. Alfonso, S. J. van Andel, W. Koole, A. Groenewegen, and N. van de Giesen, “A
Shazam-like Household Water Leakage Detection Method,” *Procedia Eng.*, vol. 186, pp. 452–459, 2017, doi: https://doi.org/10.1016/j.proeng.2017.03.253.

[9] S. M. Rabeek, H. Beibei, and K. T. C. Chai, “Design of Wireless IoT Sensor Node Platform for Water Pipeline Leak Detection,” in *2019 IEEE Asia-Pacific Microwave Conference (APMC)*, Dec. 2019, pp. 1328–1330, doi: 10.1109/APMC46564.2019.9038809.

[10] L. K. Narayanan and S. Sankaranarayanan, “IoT Enabled Smart Water Distribution and Underground Pipe Health Monitoring Architecture for Smart Cities,” in *2019 IEEE 5th International Conference for Convergence in Technology (I2CT)*, Mar. 2019, pp. 1–7, doi: 10.1109/I2CT45611.2019.9033593.

[11] A. M. Sadeghioon, N. Metje, D. Chapman, and C. Anthony, “Water pipeline failure detection using distributed relative pressure and temperature measurements and anomaly detection algorithms,” *Urban Water J.*, vol. 15, no. 4, pp. 287–295, Apr. 2018, doi: 10.1080/1573062X.2018.1424213.

[12] M. Abdelhafidh, M. Fourati, L. C. Fourati, and A. Abidi, “Remote Water Pipeline Monitoring System IoT-Based Architecture for New Industrial Era 4.0,” in *2017 IEEE/ACS 14th International Conference on Computer Systems and Applications (AICCSA)*, Oct. 2017, pp. 1184–1191, doi: 10.1109/AICCSA.2017.158.

[13] Z. Shi, M. Wang, H. Lin, H. Lin, Z. Gao, and L. Huang, “NB-IOT Pipeline Water Leakage Automatic Monitoring System Based on Cloud Platform,” in *2019 IEEE 13th International Conference on Anti-counterfeiting, Security, and Identification (ASID)*, Oct. 2019, pp. 272–276, doi: 10.1109/ICASID.2019.8925228.

[14] M. Abdelhafidh, M. Fourati, L. C. Fourati, A. Ben Mnaouer, and Z. Mokhtar, “Cognitive Internet of Things for Smart Water Pipeline Monitoring System,” in *2018 IEEE/ACM 22nd International Symposium on Distributed Simulation and Real Time Applications (DS-RT)*, Oct. 2018, pp. 1–8, doi: 10.1109/DISTRA.2018.8600999.

[15] Aramane, Pradyot and Bhattad, Akshay and .M, Madhwesh and Aithal, Nishant and .P, Akshay and S.B, Prof.Prapulla and .G, Dr.Shoba, Iot and Neural Network Based Multi Region and Simultaneous Leakage Detection in Pipelines (2019). International Journal of Advanced Research in Engineering and Technology, 10(6), 2019, pp 61-68.