Research Article

Monitoring leakage in water pipe installation using a water flow sensor

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Abstract: The need for water for humans is the main thing and cannot be replaced with anything else. Water will always be needed every time for consumption and daily activities. Therefore, the need for water is always considered in the distribution process so that every community can meet its water needs. Especially residential areas where water needs are important. However, there are obstacles to pipe leaks that cause this water distribution to be hampered. The development of the Internet of Things is the main solution in terms of monitoring water flow and water pressure in pipes. This makes it easier for pipe repair parties to increase the effectiveness of their supervision of the condition of their housing pipes. Based on the results of trials and evaluations that have been carried out, it gives the conclusion that the existence of this system can help pipe repair parties in knowing the state of water flow in pipe installations in their residential areas. This system is also supported by using the calculation of physical formulas such as the Bernoulli equation and the principle of continuity where the formula $P = 1/2\varrho V^2$ has been used in the calculation of calibration on the water flow sensor and to test the validation of the results issued by the water flow sensor, the Absolute Relative Error calculation is also used where the formula used is Absolute Relative Error = ∣ (estimated - actual) / actual ∣ * 100. Through the calculation processes carried out, it can increase the chances of reading data that is more accurate than usual and the results will be maximized in detecting any anomalies that occur during monitoring. Therefore, the opportunity to implement a residential pipe monitoring system is a convincing thing to do in improving services that are more responsive to residents in the housing complex.

Keywords: Water pipe, monitoring system, residential, Internet of Things, Bernoulli equation.

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1. Introduction

The Internet of Things (IoT) has become an important technological development with the potential to improve efficiency and performance. IoT refers to a network of objects equipped with AI technology, which enables interaction between devices and humans through internet connectivity. This technology enables data sharing and requires strong security systems. One of the benefits of IoT is its ability to monitor the environment and collect data.

A significant issue that requires monitoring is water pipe leaks, which require quick action. Managing pipeline leaks involves managing water pressure, monitoring leaks, repairing pipes efficiently, ensuring the quality of the installation, and actively maintaining and updating the pipeline system. Detecting and addressing leaks can provide economic benefits by improving water distribution management and reducing the intensity of pipeline leaks. Proper pipeline management is essential for distributing clean, high-quality water.

Pipeline leakage is a common problem in many parts of Indonesia, especially in densely populated areas such as Surabaya. In March 2021, a pipe leakage incident affected 30 areas in *the Jagir* sub-district of Surabaya. Pipeline leaks are a regular problem in Surabaya, as seen from a leak in the Lakarsantri area that took two weeks to repair in February 2021. The many instances of pipe leaks highlight the need for adequate handling and prevention to avoid severe damage and disruption to the water distribution system.

Water pipe damage can occur at any time due to factors such as blockages, high water pressure, and pipe corrosion in residential installations. Finding leaks manually can delay prompt repairs. Monitoring the water distribution system using data from sensors and cloud databases can facilitate faster and more efficient pipeline repairs. A web application can display real-time data on water discharge anomalies, making it easier to identify leak locations and prioritize repairs.

By implementing the monitoring prototype and web application, pipeline monitoring can be done by observing changes in the data stored in the cloud database. This eliminates the need to conduct on-site inspections of pipeline installations. A responsive system that can quickly address leaks can improve the efficiency of pipeline repair work, saving time and resources. The objective of this project is to develop a web application that monitors pipeline leaks and assists in quick repairs.

2. Methodology

2.1 Flowchart System

The research method that will be carried out in making the prototype is as follows:

2.1.1 Preparation stage

In this stage, what is done is to collect information about the pipe installation circuit that will be used for the example of the prototype model to be made.

2.1.2 Analysis

In this analysis stage, get what information needs to be entered into the system using Raspberry Pi so that the prototype can send data that will be displayed on the web application to be created.

2.1.3 Design

After analyzing the problems and analyzing the needs, the design stage is carried out. The design stage starts by designing a prototype design that will be made, a FlowChart design, an Entity Relationship Database design, and a web application display design.

2.1.4 Implementation

After the design stage, the implementation stage is carried out and manufacturing will also run. The implementation stage will be divided into several parts, namely: the Prototype Implementation Stage, System Process Implementation Stage, and Web Application Display Implementation Stage.

2.1.5 Trial and Evaluation

The trial and evaluation stage will be carried out together with the implementation stage so that the results obtained are as expected. If there are still problems, an evaluation will be carried out to fix the problems that occur.

2.1.6 Report Preparation

The report preparation stage is carried out following the preparation of reports starting from the analysis stage to the trial and evaluation stage.

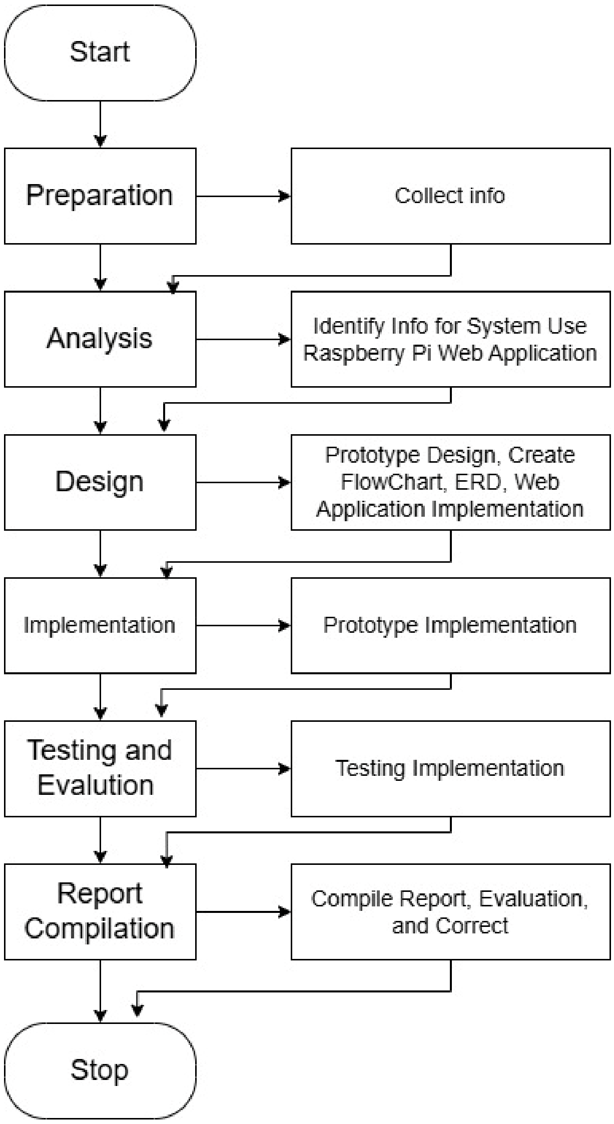

Figure 1. Flowchart System

3. Result and Discussion

3.1 Live Monitoring System

Based on the results of the system created, testing is carried out to check whether the system can run properly. The first test carried out is testing whether the system can show how things are leaking or not. The second test is carried out in the form of testing leak notifications that have been successfully sent or not to the user.

The first test is done by logging into the web application first, if the user does not have an account, the user will register first. Then after that, the user will be taken to the main page, namely the live monitoring page which contains data packaged in the form of line charts and tables. And also a monitoring report page that displays monitoring data that has been stored and displayed again based on the time range specified by the user.

Figure 2. System Implementation Test Results

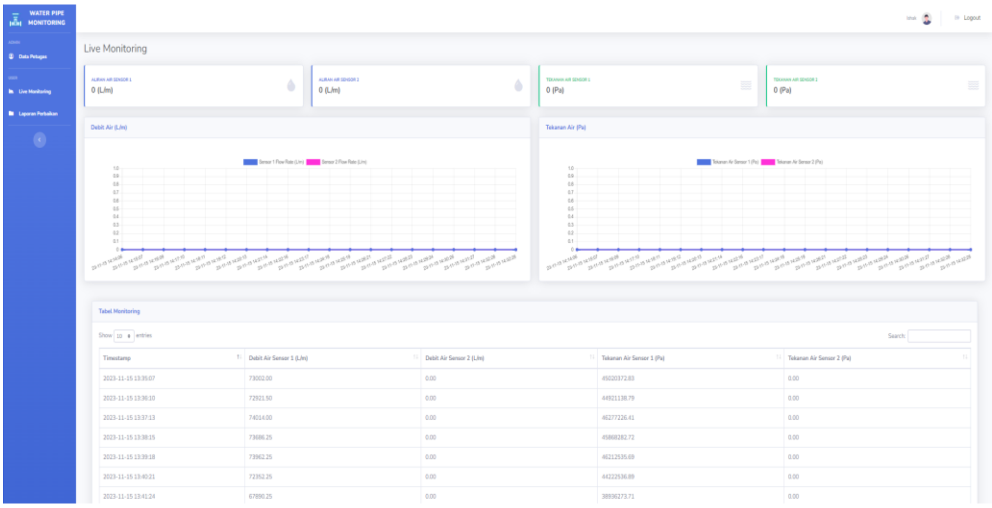

Figure 3. Test Results of Live Monitoring Page Display

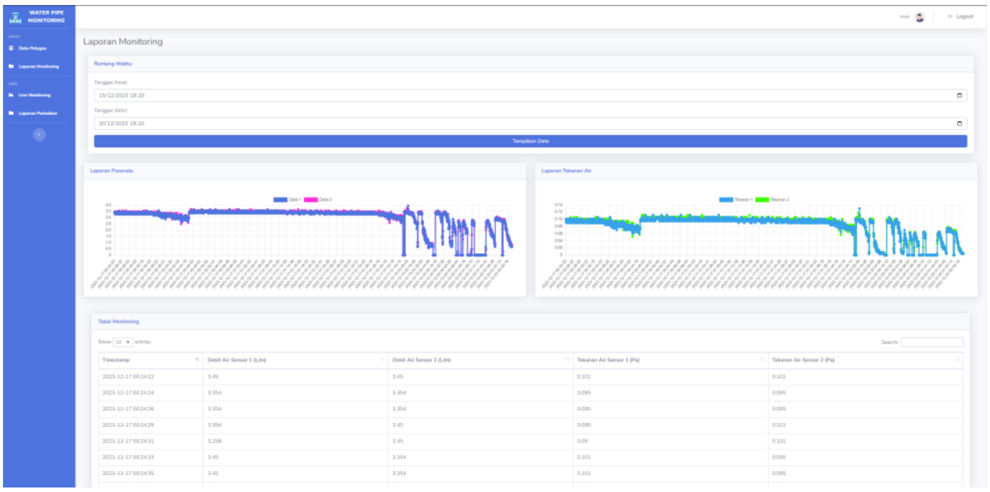

Figure 4. Monitoring Report Page Display Test Results

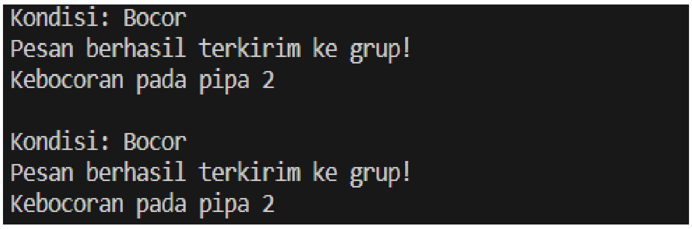

Figure 5. Notification Delivery Test Results

The second test was carried out by checking whether the leak notification could be sent to the user via telegram. After the test was carried out, it was continued with the validation of the test results where the first validation was carried out on the value issued by the water flow sensor using the absolute relative error. The second validation is done to ensure the leak notification can be sent to the user's telegram. The first validation is done by showing a table containing the output of the waterflow sensor which is compared with the results of manual calculations to get the absolute relative error results.

3.2 Analysis system

From the prototype experiment, several states of the system are obtained with calculations as in the following equations, in the Normal state when all holes are closed. By manual calculation, the water discharge is obtained as in Equation 1 and Equation 2.

$$Q = V / t = 220 / 60 = 3.66 \text{ L/s} \tag{1}$$

$$v = 3.66 / (\pi * (8.8)^2) = 0{,}01504 \text{ m/s} \tag{2}$$

Moreover, the water pressure can be seen in Equation 3 and Absolute Relative Error Sensor can be seen in equation 4 and 5.

$$P = 0.5 * 1000 * (0.01504)^2 = 0{,}1131008 \text{ Pa} \approx 0.113 \text{ Pa} \tag{3}$$

Table 1. Sensor Calculation Result

Trial To	Debit Sensor 1 (L/s)	Debit Sensor 2 (L/s)
1	3.450	3.546
2	3.450	3.546
3	3.450	3.546
4	3.450	3.450
5	3.450	3.450
6	3.450	3.546
7	3.450	3.450
8	3.450	3.546
9	3.450	3.546
10	3.450	3.450
Total	34.500	35.076

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{(34.5 - 36.6)}{36.6}\right| \times 100\% = 0.06\% \quad (4)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{(35.1 - 36.6)}{36.6}\right| \times 100\% = 0.04\% \quad (5)$$

Table 2. Water Pressure Sensor Test

Trial To-	Water Pressure Sensor 1 (Pa)	Water Pressure Sensor 1 (Pa)
1	0.101	0.106
2	0.101	0.106
3	0.101	0.106
4	0.101	0.101
5	0.101	0.101
6	0.101	0.106
7	0.101	0.101
8	0.101	0.106
9	0.101	0.106
10	0.101	0.101
Total	1.01	1.04

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{1.01 - 1.13}{1.13}\right| \times 100\% = 0.11\% \quad (6)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{1.04 - 1.13}{1.13}\right| \times 100\% = 0.08\% \quad (7)$$

3.2 *Analysis system 2*

The next analysis is a calculation of the condition of the hole at the sensor placement location 1. By manual calculation, the value of water discharge and water pressure is obtained as in equations 8 and 9, while the water pressure is shown in equation 10.

$$Q = V / t = 140 / 60 = 2.33 \text{ L/s} \quad (8)$$

$$v = 2.33 / (\pi * (8.8)^2) = 0{,}00958 \text{ m/s} \quad (9)$$

$$P = 0.5 * 1000 * (0.00958)^2 = 0{,}0458882 \text{ Pa} \approx 0.0467 \text{ Pa} \quad (10)$$

Furthermore, the discharge of sensors 1 and 2 can be seen in Table 3.

Table 3. Discharge Sensor Testing Results

Trial To-	Discharge Sensor 1 (L/m)	Discharge Sensor 2 (L/m)
1	2.396	2.300
2	2.396	2.300
3	2.204	2.108
4	2.204	2.108
5	2.396	2.300

Trial To-	Discharge Sensor 1 (L/m)	Discharge Sensor 2 (L/m)
6	2.396	2.300
7	2.396	2.300
8	2.396	2.300
9	2.396	2.300
10	2.396	2.300
TOTAL	23.576	22.616

3.3 Analysis system 3

The next analysis is the Absolute Relative Error on sensors 1 and 2, shown in equations 11 and 12.

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{23.5 - 23.3}{23.3}\right| \times 100\% = 0.008\% \quad (11)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{22.6 - 23.3}{23.3}\right| \times 100\% = 0.03\% \quad (12)$$

Table 4. Water Pressure Sensor Testing

Trial To-	Water Pressure Sensor 1 (Pa)	Water Pressure Sensor 2 (Pa)
1	0.048	0.045
2	0.048	0.045
3	0.041	0.038
4	0.041	0.038
5	0.048	0.045
6	0.048	0.045
7	0.048	0.045
8	0.048	0.045
9	0.048	0.045
10	0.048	0.045
Total	0.466	0.436

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{0.466 - 0.467}{0.467}\right| \times 100\% = 0.002\% \quad (13)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{0.436 - 0.467}{0.467}\right| \times 100\% = 0.07\% \quad (14)$$

3.4 Analysis system 4 (Large Leak Condition)

In the Large Leak Condition, the manual calculation of water discharge can be seen in equations 15 and 16.

$$Q = V / t = 120 / 60 = 2 \text{ L/s} \quad (15)$$

$$v = 2 / (\pi * (8.8)^2) = 0{,}00822 \text{ m/s} \quad (16)$$

Moreover, the water pressure (P) formula as in equation 17, and Table 5 is the result of the Discharge Sensor test conditions.

$$P = 0.5 * 1000 * (0.00822)^2 = 0{,}0337842 \text{ Pa} \approx 0.034 \text{ Pa} \quad (17)$$

Table 5. Discharge Sensor test

Trial To-	Discharge Sensor 1 (L/m)	Discharge Sensor 2 (L/m)
1	1.917	1.917
2	1.917	1.917
3	1.917	1.917
4	1.917	1.725
5	1.917	1.725
6	1.917	1.917
7	1.917	1.917
8	1.917	1.917
9	1.917	1.725
10	1.917	1.917
Total	19.17	18.59

Furthermore, In the next calculation, the Absolute Relative Error of Sensors 1 and 2 can be seen in equations 18 and 19. Table 6 is the calculation of water pressure sensors 1 and 2.

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{19.17 - 20}{20}\right| \times 100\% = 0.04\% \quad (18)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{18.59 - 20}{20}\right| \times 100\% = 0.07\% \quad (19)$$

Table 6. Water Pressure Sensor test

Trial To-	Sensor Pressure 1 (Pa)	Sensor Pressure 2 (Pa)
1	0.031	0.031
2	0.031	0.031
3	0.031	0.031
4	0.031	0.025
5	0.031	0.025
6	0.031	0.031
7	0.031	0.031
8	0.031	0.031
9	0.031	0.025
10	0.031	0.031
Total	**0.31**	**0.29**

Moreover, The Absolute Relative Error of Sensors 1 and 2 can be seen in equations 21 and 22.

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{0.31 - 0.34}{0.34}\right| \times 100\% = 0.09\% \quad (20)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{0.29 - 0.34}{0.34}\right| \times 100\% = 0.15\% \quad (21)$$

3.5 Analysis system 5 (Medium Leaking Condition)

Moreover, in the hole between sensors 1 and 2, if there is a medium leak condition, the water discharge formula can be calculated as in formulas 22 and 23, while the water pressure can be seen in equation 24.

$$Q = V / t = 140 / 60 = 2.33 \text{ L/s} \quad (22)$$

$$v = 2.33 / (\pi * (8.8)^2) = 0{,}00958 \text{ m/s} \quad (23)$$

$$P = 0.5 * 1000 * (0.00958)^2 = 0{,}0458882 \text{ Pa} \approx 0.0467 \text{ Pa} \quad (24)$$

Meanwhile, the results of the Debit Sensor test can be seen in Table 7. Table 8 is the measurement result of the Pressure sensor, with the absolute relative error formula for sensors 1 and 2 in equations 25 and 26.

Table 7. Discharge Sensor Test

Trial To-	**Discharge Sensor 1 (L/m)**	**Discharge Sensor 2 (L/m)**
1	2.396	2.108
2	2.396	2.300
3	2.204	2.108
4	2.204	2.108
5	2.396	2.300
6	2.396	2.108
7	2.396	2.108
8	2.396	2.108
9	2.396	2.300
10	2.396	2.300
Total	23.576	21.848

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{23.5 - 23.3}{23.3}\right| \times 100\% = 0.008\% \quad (25)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{21.8 - 23.3}{23.3}\right| \times 100\% = 0.06\% \quad (26)$$

Table 8. Pressure Sensor Test

Trial To-	**Sensor Pressure 1 (Pa)**	**Sensor Pressure 2 (Pa)**
1	0.048	0.038
2	0.048	0.045
3	0.041	0.038
4	0.041	0.038

Trial To-	**Sensor Pressure 1 (Pa)**	**Sensor Pressure 2 (Pa)**
5	0.048	0.045
6	0.048	0.038
7	0.048	0.038
8	0.048	0.038
9	0.048	0.045
10	0.048	0.045
Total	0.466	0.408

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{0.466 - 0.467}{0.467}\right| \times 100\% = 0.002\% \quad (27)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{0.408 - 0.467}{0.467}\right| \times 100\% = 0.13\% \quad (28)$$

Furthermore, in large leak conditions, it can be calculated by manually calculating the water discharge as in Formulas 29 and 30. While the water pressure is shown in formula 31. The complete test results of water discharges 1 and 2 can be shown in Table 9.

$$Q = V / t = 120 / 60 = 2 \text{ L/s} \quad (29)$$

$$v = 2 / (\pi * (8.8)^2) = 0{,}00822 \text{ m/s} \quad (30)$$

$$P = 0.5 * 1000 * (0.00822)^2 = 0{,}0337842 \text{ Pa} \approx 0.034 \text{ Pa} \quad (31)$$

Table 9. Discharge Sensor test

Trial To-	**Discharge Sensor 1 (L/m)**	**Discharge Sensor 2 (L/m)**
1	1.917	1.725
2	1.917	1.725
3	1.917	1.725
4	1.917	1.725
5	1.917	1.725
6	1.917	1.725
7	1.917	1.725
8	1.917	1.725
9	1.917	1.725
10	1.917	1.725
Total	19.17	17.25

Moreover, the calculation of pressure sensors 1 and 2 can be seen in Table 10, and the calculation of Absolute Relative Error Sensors 1 and 2 can be seen in Equations 32 and 33.

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{19.17 - 20}{20}\right| \times 100\% = 0.04\% \quad (32)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{17.25 - 20}{20}\right| \times 100\% = 0.14\% \quad (33)$$

Table 10. Sensor Pressure test

Trial To-	Sensor Pressure 1 (Pa)	Sensor Pressure 2 (Pa)
1	0.031	0.025
2	0.031	0.025
3	0.031	0.025
4	0.031	0.025
5	0.031	0.025
6	0.031	0.025
7	0.031	0.025
8	0.031	0.025
9	0.031	0.025
10	0.031	0.025
Total	0.31	0.25

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{0.31 - 0.34}{0.34}\right| \times 100\% = 0.09\% \quad (34)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{0.25 - 0.34}{0.34}\right| \times 100\% = 0.27\% \quad (35)$$

3.6 Analysis system 6 (Medium Leaking Condition)

Moreover, is the condition of the hole after sensor 2, a medium leakage condition, with manual calculation of water discharge and water pressure as shown in equations 36, 37, and 38.

$$Q = V / t = 140 / 60 = 2.33 \text{ L/s} \quad (36)$$

$$v = 2.33 / (\ \pi * (8.8)^2) = 0{,}00958 \text{ m/s} \quad (37)$$

$$P = 0.5 * 1000 * (\ 0.00958)^2 = 0{,}0458882 \text{ Pa} \approx 0.0467 \text{ Pa} \quad (38)$$

Table 11. Discharge Sensor Test

Trial To-	Discharge Sensor 1 (L/m)	Discharge Sensor 2 (L/m)
1	2.300	2.108
2	2.300	2.300
3	2.300	2.300
4	2.300	2.300
5	2.300	2.300
6	2.300	2.108
7	2.300	2.300
8	2.300	2.300
9	2.300	2.300
10	2.300	2.300
Total	**23**	**22.6**

Moreover, the formula for the absolute relative error of sensors 1 and 2 and the complete pressure test sensor can be seen in Table 12. And then, formulas 41 and 42 for pre-calculating sensor errors 1 and 2 on the pressure test sensor.

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{23 - 23.3}{23.3}\right| \times 100\% = 0.01\% \quad (39)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{22.6 - 23.3}{23.3}\right| \times 100\% = 0.02\% \quad (40)$$

Table 12. Sensor Pressure test

Trial To-	Sensor Pressure 1 (Pa)	Sensor Pressure 2 (Pa)
1	0.045	0.038
2	0.045	0.045
3	0.045	0.045
4	0.045	0.045
5	0.045	0.045
6	0.045	0.038
7	0.045	0.045
8	0.045	0.045
9	0.045	0.045
10	0.045	0.045
Total	**0.45**	**0.44**

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{0.45 - 0.467}{0.467}\right| \times 100\% = 0.04\% \quad (41)$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{0.44 - 0.467}{0.467}\right| \times 100\% = 0.06\% \quad (42)$$

3.7 Analysis system 7 (Large Leak Condition)

Moreover, with a large leak condition, manual calculations for water discharge and water pressure as shown in equations 42, and 43, and water pressure (P) in equation 44 can be seen. As for the Debit formula for sensors 1 and 2, it can be shown in detail in Table 13.

$$Q = V / t = 120 / 60 = 2 \text{ L/s} \quad (43)$$

$$v = 2 / (\pi * (8.8)^2) = 0{,}00822 \text{ m/s} \quad (44)$$

$$P = 0.5 * 1000 * (0.00822)^2 = 0{,}0337842 \text{ Pa} \approx 0.034 \text{ Pa} \quad (45)$$

Table 13. Discharge Sensor 1 dan 2 test

Trial To-	Discharge Sensor 1 (L/m)	Discharge Sensor 2 (L/m)
1	1.917	1.917
2	1.917	1.917
3	1.917	1.917
4	1.917	1.917
5	1.917	1.917

Trial To-	**Discharge Sensor 1 (L/m)**	**Discharge Sensor 2 (L/m)**
6	1.917	1.917
7	1.917	1.917
8	1.917	1.917
9	1.917	1.917
10	1.917	1.917
TOTAL	19.17	19.17

Moreover, for the Pressure Sensor 1 and 2 section, you can see the Absolute Relative Error values of Sensors 1 and 2 in equations 46 and 47, and also table 14 fully states the results of pressure sensors 1 and 2.

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{19.17-20}{20}\right| \times 100\% = 0.04\% \tag{46}$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{19.17-20}{20}\right| \times 100\% = 0.04\% \tag{47}$$

Table 14. Pressure Sensor 1 and 2 test

Trial To-	**Pressure Sensor 1 (Pa)**	**Pressure Sensor 2 (Pa)**
1	0.031	0.031
2	0.031	0.031
3	0.031	0.031
4	0.031	0.031
5	0.031	0.031
6	0.031	0.031
7	0.031	0.031
8	0.031	0.031
9	0.031	0.031
10	0.031	0.031
Total	0.31	0.031

$$\text{Absolute Relative Error Sensor 1} = \left|\frac{0.31-0.34}{0.34}\right| \times 100\% = 0.09\% \tag{48}$$

$$\text{Absolute Relative Error Sensor 2} = \left|\frac{0.31-0.34}{0.34}\right| \times 100\% = 0.09\% \tag{49}$$

The second validation is done by showing proof of sending notifications in the user's telegram. The following is evidence of notifications that appear on the user's device. Moreover, Validate Notifications Sent to Telegram Groups, can be seen in Figure 12.

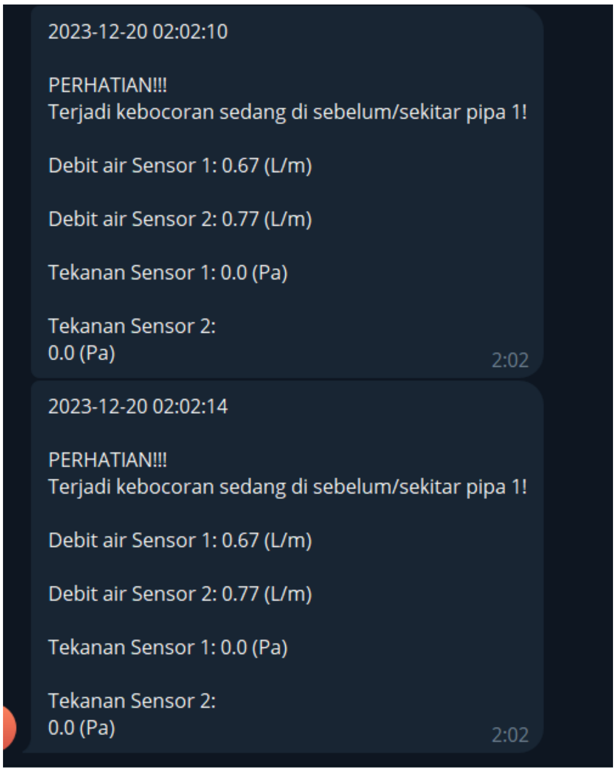

Figure 12. Validate Notifications Sent to Telegram Groups

4. Conclusion

The conclusions obtained from the results of trials and validations that have been carried out on the prototype monitoring system will be described into several important points, namely:

- The prototype makes it easy for housing pipe maintenance parties to monitor the condition of the pipes.
- The prototype can present water discharge and water pressure data.
- The prototype can provide leakage notifications via telegram.
- The prototype can show data in the monitoring report based on the time range specified by the user.

In the measurement of water discharge when normal, the absolute relative error of sensor 1 obtained is 0.06% and 0.04% in sensor 2. As for the measurement of water pressure, the absolute relative error of sensor 1 obtained is 0.11% and 0.08% in sensor 2.

In the measurement of water discharge when there is a hole before sensor 1 and in moderate leakage conditions, the absolute relative error of sensor 1 obtained is 0.008% and 0.03% in sensor 2. As for the measurement of water pressure, the absolute relative error of sensor 1 obtained is 0.002% and 0.07% in sensor 2.

In the measurement of water discharge when there is a hole before sensor 1 and in a large leak condition, the absolute relative error of sensor 1 obtained is 0.04% and 0.07% in sensor 2. As for the measurement of water pressure, the absolute relative error of sensor 1 obtained is 0.09% and 0.15% in sensor 2.

In the measurement of water discharge when there is a hole between sensor 1 and sensor 2 in a medium leak condition, the absolute relative error of sensor 1 obtained is 0.008% and 0.06% in sensor 2. As for the measurement of water pressure, the absolute relative error of sensor 1 obtained is 0.002% and 0.13% in sensor 2.

In the measurement of water discharge when there is a hole between sensor 1 and sensor 2 in a large leak condition, the absolute relative error of sensor 1 obtained is 0.04% and 0.14% in sensor 2. As for the measurement of water pressure, the absolute relative error of sensor 1 obtained is 0.09% and 0.27% in sensor 2.

In the measurement of water discharge when there is a hole after sensor 2 and in moderate leakage conditions, the absolute relative error of sensor 1 obtained is 0.01% and 0.02% in sensor 2. As for the measurement of water pressure, the absolute relative error of sensor 1 obtained is 0.04% and 0.06% in sensor 2.

In the measurement of water discharge when there is a hole after sensor 2 and in a large leak condition, the absolute relative error of sensor 1 obtained is 0.04% and 0.04% in sensor 2. As for the measurement of water pressure, the absolute relative error of sensor 1 obtained is 0.09% and 0.09% in sensor 2.

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References

1. Afiatun, E., Wahyuni, S., & Hamdan, F. (2018). Perbandingan komposisi koagulan biji kelor (Moringan oleifera), biji asam jawa (Tamarindus indica L) dan aluminium sulfat ($Al_2(SO_4)_3$) untuk menurunkan kekeruhan air sungai Citarum Atas, Ciparay, Kabupaten Bandung. Journal of Community Based Environmental Engineering and Management, 2(1), 21-30. https://doi.org/10.23969/jcbeem.v2i1.1453
2. Arsyad, S. (2010). Konservasi tanah & air (2nd ed.). IPB PRESS.
3. Christodoulou, S., Agathokleous, A., Kounoudes, A., & Milis, M. (2010). Wireless sensor networks for water loss detection. In European Water (Vol. 30).
4. Clark, D. (2011). Developing web applications. In Beginning C# Object-Oriented Programming (pp. 243-263). Apress. https://doi.org/10.1007/978-1-4302-3531-6_12
5. Firebase. (2023). Introducing Firebase Realtime Database. Firebase. Retrieved October 26, 2023, from https://firebase.google.com/docs/database
6. Hadi, L. (2021). Dua pekan pipa PDAM bocor, warga Lakarsantri Surabaya kesulitan air. Suara Indonesia.
7. Hanggara, I., Montarich, L. L., & Sisinggih, D. (2015). Analisa peramalan debit sungai menggunakan metode ARIMA (Auto Regressive Integrated Moving Average) di Sungai Brantas Hulu.
8. Indosteger. (2023, Oktober 23). 4 cara menghitung diameter pipa yang presisi! Indosteger. Retrieved November 7, 2023, from https://www.indosteger.co.id/berita/detail/cara-menghitung-diameter-pipa
9. Irwanto, K. (2020, August 22). Pengertian cloud server. Datacomm. https://datacommcloud.co.id/pengertian-cloud-server/
10. Kurniati, A., & Sri, W. (2013, April). Studi analisis perbandingan kecepatan aliran air melalui pipa venturi dengan perbedaan diameter pipa. Jurnal Dinamika, 4(1), 62-78.
11. Lahlou, Z. M. (n.d.). A national drinking water clearinghouse fact sheet one leak detection and water loss control.
12. Muslim, T. (2018). Penentuan faktor kekasaran pipa PVC berdasarkan persamaan Darcy Weisbach (analisis aliran dalam pipa). Program Studi Teknik Kimia Fakultas Teknik Universitas Bosowa Makassar.
13. Nitschke, P., & Williams, S. P. (2021). Conceptualizing the Internet of Things data supply. Procedia Computer Science, 181, 642-649. https://doi.org/10.1016/j.procs.2021.01.213
14. Riupassa, Raflis, R. D., & Hendro, H. (2017). Optimasi nilai konstanta kalibrasi pada water flow sensor YF-S201. Jurnal Teknik

Informatika. https://ejournal.sttbandung.ac.id/assets/file/RobiDany.pdf
15. Schaefer, L. (2023). What is NoSQL? NoSQL databases explained. MongoDB. Retrieved October 26, 2023, from https://www.mongodb.com/nosql-explained
16. Suharjono, A., Rahayu, L. N., & Afwah, R. (2015). Aplikasi sensor flow water untuk mengukur penggunaan air pelanggan secara digital serta pengiriman data secara otomatis pada PDAM Kota Semarang. In Jurnal TELE (Vol. 13).
17. Tejada, Z. (2023). Non-relational data and NoSQL - Azure Architecture Center. Microsoft Learn. Retrieved October 26, 2023, from https://learn.microsoft.com/en-us/azure/architecture/data-guide/big-data/non-relational-data
18. Wasista, S., Setiawardhana, Saraswati, D., & Susanto, E. (2019). Aplikasi internet of things (IOT) dengan Arduino dan Android "Membangun smart home dan smart robot berbasis Arduino dan Android" (H. Susanto, Ed.; 1st ed., Vol. 1). Deepublish. https://www.google.co.id/books/edition/Aplikasi_Internet_Of_Things_IOT_Dengan_A/r824DwAAQBAJ?hl=id&gbpv=1
19. Winarni, W. (2009). Infrastructure Leakage Index (ILI) as water losses indicator note from the editor. Civil Engineering Dimension, 11(2), 126-134.
20. Xia, F., Yang, L. T., Wang, L., & Vinel, A. (2012). Internet of Things. In International Journal of Communication Systems, 25(9), 1101-1102. https://doi.org/10.1002/dac.2417