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# Intelligent Water Systems: Strategies for Reducing Leakage and Ensuring Water Quality

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***Abstract***—An advanced smart water pipeline monitoring sys- tem aimed at managing water leaks and preventing contamina- tion, which is a vital role for sustainable water management and public health in urban areas. Undetected leaks and Contaminated water can lead to significant resource waste and health risks. This system utilizes a water flow sensor to measure flow rate, a turbidity sensor to monitor water clarity, and a pH sensor to evaluate water quality. The cloud-based ThingView app provides a clear visualization of the data, including the time of leakage and the level of contamination. Through this system, real-time monitoring of water flow and quality in pipelines is facilitated, enabling effective management and conservation.
***Index Terms***—**Leakage Detection, contamination found, IoT, Water Flow Sensors, Turbidity sensor, pH sensor, Arduino uno, Wi-Fi module, LCD,Thing view .**

## I. INTRODUCTION

Water is essential for maintaining efficient urban water systems and public health. Leakage detection involves using techniques like acoustic sensors, smart water meters, and pressure monitoring to identify and locate leaks in water distribution networks caused by aging infrastructure or ex- ternal factors. On the other hand, contamination prevention ensures water safety by employing regular monitoring with sensors, maintaining infrastructure to prevent pollutants from entering the system, raising public awareness about proper waste disposal, and using innovative technologies like au- tonomous robots and advanced filtration systems. Together, these measures help conserve water and protect communities and the environment[1].

Detecting leaks in water distribution networks is crucial for conserving water, a finite and precious resource that is increasingly under pressure due to growing populations and climate change. By identifying and fixing leaks, cities can reduce water wastage, ensure equitable distribution, and save significant costs for both water utilities and consumers. Moreover, it helps in maintaining adequate water pressure throughout the network, preventing disruptions in supply and minimizing damage to infrastructure caused by prolonged leaks, which can weaken pipes and lead to costly repairs.

Polluted water can carry harmful pathogens or toxic chem- icals, leading to waterborne diseases and other health risks. Through regular monitoring, timely maintenance of pipelines, and advanced filtration methods, contamination can be min- imized or even eliminated. Educating communities about re- sponsible waste disposal also reduces pollutants entering the water supply from external sources, such as industrial runoff or household waste[2].

By addressing both leakage and contamination, urban water systems become more efficient and resilient. These measures help protect the environment by reducing water loss and pre- venting pollutants from damaging ecosystems. Additionally, they build healthier communities by ensuring access to clean, safe water. Together, they form a comprehensive approach to urban water management that is essential for sustainable development and the well-being of future generations.

Globally, various innovative technologies and methods are employed to address these challenges.

Advanced sensor net- works monitor water distribution systems to detect leaks and contamination by analyzing flow, pressure, and quality data. Embedded technology, including water flow sensors and GSM communication, sends alerts when irregularities are identified. These solutions ensure efficient water conservation and safe- guard urban water quality[3].
In the United States, approximately 26 % of the total water supply is lost due to leaks, with some cities reporting even higher losses of up to 35%. Similarly, in Europe, the average water loss exceeds 25%, with some regions experiencing inefficiencies that result in losses of nearly 50%. These leaks not only lead to massive water wastage but also pave the way for contamination, as damaged pipelines allow external pollutants to infiltrate the water supply. Factors like seepage from the surrounding environment, corrosion of aging pipes, and operational errors exacerbate the problem, putting urban populations at risk of consuming unsafe water.
These advancements highlight the importance of adopting cutting-edge technologies to tackle water leakage and con- tamination effectively. As urban areas continue to grow and demand for clean water rises, ensuring the sustainability and safety of water systems remains a top priority. Global efforts in implementing smart water management solutions are paving the way for a more secure and sustainable future[4].

## II. LITERATURE SURVEY

In the past, numerous studies of water leakage detection methods have been carried out, frequently as a component of technical reports and research publications that covered different geographic areas.
Ruturaj Marathe[5] introduced a smart IoT technology to detect water leaks in pipelines, helping reduce wastage. It includes water flow sensors, NodeMCU, and platforms like ThingSpeak and Pushbullet for real-time monitoring and alerts. When a leak is found, the system sends location-based notifi- cations to water management teams via mobile and Google Maps. It's cost-effective, accurate, and scalable, making it useful for homes, large facilities, and industries. It also has potential applications in smart cities and beyond.
Gopalakrishnan P[6] discussed that Water is essential, but pipeline leaks cause major losses, especially in developing countries. This paper suggests a low-cost system with flow sensors to detect leaks and solenoid valves to stop the water flow. It uses a GPRS module to store data online and send alerts to authorities. A prototype showed it effectively reduces water waste, aiding conservation efforts.
HaeKeum Park [7] discussed that Water distribution net- works are crucial for clean tap water but face issues like leaks and performance decline. In Korea, IoT smart sensors help monitor leaks, and this study uses the XGBoost algorithm, fine-tuned for accuracy. Data from field leak detection showed excellent results, with AUC-ROC scores of 0.9955 for indoor leaks, 0.9956 for outdoor leaks, and 0.9985 for normal condi- tions. A 120 Hz frequency was key in detecting leak vibrations. The model shows promise for integration into GIS systems for real-time leak detection and better water management.
Manel Elleuchi[8] discussed the development of an IoT- based approach for water pipeline monitoring and leak de- tection, utilizing soil moisture sensors and Arduino MEGA as a microcontroller. Through various experimental setups involving different leakage scenarios, the system was tested for its ability to detect leaks accurately. The results demonstrated that the proposed solution effectively detected changes in soil moisture caused by leaks and pinpointed their locations. This work highlights the potential of IoT-driven solutions to mini- mize water wastage and ensure efficient pipeline management. Arya Vijayan[9]developed a Real-Time Water Leakage Monitoring System Using IoT-Based Architecture, which ad- dresses water scarcity by introducing an IoT-based solution that uses flow sensors with an Arduino Uno microcontroller to detect pipeline leaks. The system measures water inflow and outflow, identifying leaks through discrepancies and send- ing alerts via GSM to a mobile device and cloud storage. This approach

enables quick action, reduces water loss, and prevents damage. It also highlights IoT benefits like easy installation, cost efficiency, and minimal human involvement, demonstrating the prototype's accuracy through experiments. Elias Farah [10] study conducted at the University of Lille highlights the use of Automated Meter Reading (AMR) technology for efficient water management and leak detection. Smart water meters, using RF and mobile communication, provided real-time consumption data and identified anomalies. Across 150 buildings, 93 AMR-equipped meters detected significant water losses due to infrastructure issues and unau- thorized usage. By analyzing minimum night flow and water balance methods, the system reduced non revenue water by 36% after addressing leaks. This demonstrates the transformative impact of AMR in water distribution monitoring.

Y. Pavan kumar [11]created a smart solution combining IoT and Machine Learning (ML) technologies to detect and localize leaks efficiently. IoT-enabled sensors monitor water flow in real-time, transmitting data to a central system where ML algorithms analyze it for abnormal patterns. Stakeholders receive alerts with details on the leak's location and severity via SMS, email, or mobile app. Experiments validate the system's effectiveness in reducing water wastage, property damage, and associated costs, showcasing its reliability and cost-efficiency.

Hossein Pourmehrani [12] introduced a simple and cost- effective mechanism for detecting water leaks in pipes using sound data analysis and machine learning. It involves amplify- ing water flow signals with a mechanical sound amplifier and converting these sounds into digital signals for analysis. After extracting and selecting key features, deep neural networks are applied to identify leaks in the pipes. The system has proven capable of detecting water flow as minimal as 100 milliliters per minute, making it a promising component for water leakage detection systems.

## III. PROPOSED SYSTEM

In our proposed system, we implement a smart water leakage detection approach using Arduino Uno and advanced sensors to enhance monitoring and leakage identification. The YF-S201 water flow sensor is employed to accurately calculate the flow rate and monitor the volume of water passing through the pipeline, enabling real-time tracking and leak detection. To ensure efficient management, data is transmitted to an open-source cloud platform such as ThingSpeak, where it is processed and analyzed. Additionally, to improve detection accuracy, a turbidity sensor is integrated into the system to detect any contamination caused by pipeline breaches. If soil or other impurities mix with the water due to a leakage, the system triggers an alert. A pH sensor is also incorporated to continuously monitor the pH levels, ensuring water quality re- mains within safe limits. If significant deviations are detected, an automatic alert is sent to the concerned water management team via Pushbullet or PushingBox, facilitating immediate corrective actions. The integration of IoT technology using the ESP8266 Wi-Fi module ensures real-time alerts and ef- ficient water management, preventing wastage and enhancing municipal water supply monitoring.

### *A. Block diagram*

The water pipeline leak detecting system's block diagram. One type of microcontroller is the Arduino UNO. It processes and carries out instructions using the ATmega328P processor. It has six analog read pins and fourteen digital pins. The Arduino UNO's digital I/O pins D2 and D3 are linked to YF- S201 water flow sensors. A rotor is part of this water flow sensor, which also sits in line with your water line and includes a pinwheel sensor to gauge the amount of liquid that has passed through it. An integrated magnetic hall effect sensor is present, with each movement, produces an electrical pulse. The water line is shut off from the hall effect sensor, keeping it dry

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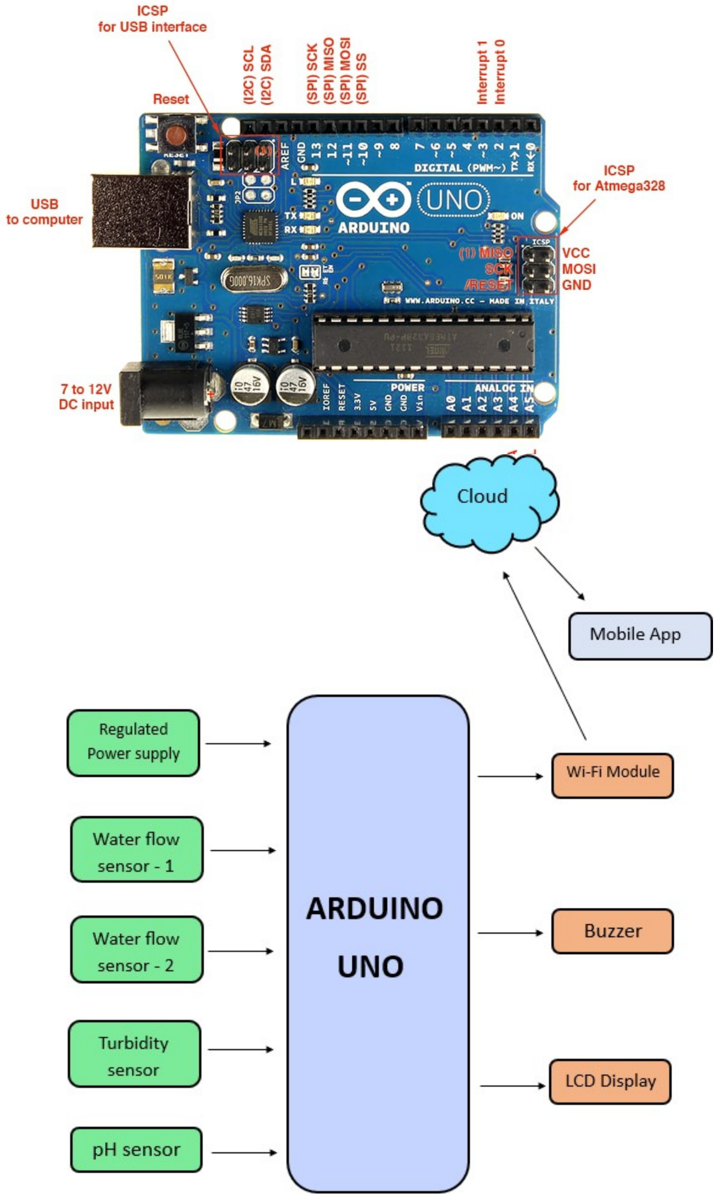


Fig. 1. Block Diagram

and secure. In contrast to the motor, when the rotor rotates, the Hall effect sensor generates a pulse as an output. Thus, pulses will be generated at the output when water passes past the flow sensor at the rotational speed. This pulse signal is read as an interrupt signal by the microcontroller. The water flow can be computed by counting the pulses from the sensor's output. The approximate volume of each pulse is 2.25 milliliters. Water pollution (purity) is tracked with a turbidity sensor. A light transmitter and receiver are part of the turbidity sensor. The light received in the receiver will change depending on the particles in the water. The turbidity sensor may produce both digital and analog signals. For accuracy, we are using analog signal output in this. The analog read pin is linked to the output of the turbidity sensor.Additionally, a pH sensor connected to analog pin A1 monitors the water's acidity or alkalinity, identifying potential chemical contamination from industrial waste or pipe corrosion. Thing View is an Internet of Things cloud server. For output analysis, the data from the pH, turbidity, and flow sensors is transmitted to this cloud server. It has an ESP8266 Wi-Fi module for short-range city communication.

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*B. Components*

- **Arduino uno**: Arduino Uno is an open-source micro- controller board based on the Microchip ATmega328P microcontroller, developed by Arduino.cc. It features 14 digital I/O pins and 6 analog I/O pins and can be powered via USB or an external 9-volt battery. The board is similar Fig. 2. Arduino uno to the Arduino Nano and Leonardo and is the first in a series of USB-based Arduino boards. The ATmega328p microcontroller on the board comes preprogrammed with a bootloader, allowing for easy code upload without the need for an external hardware programmer.

**Water Flow Sensors**: Water flow sensors measure water's flow rate using a rotor, Hall-effect sensor, and plastic valve body. They have three wires: output (yellow), GND (black), and +5V (red). The rotor spins as water flows, with speed varying according to the flow rate.

Fig. 3. water Flow sensor

The hall-effect sensor produces the matching pulse. Any microcontroller, including the Arduino UNO, can connect with this sensor, which operates on +5V. A marking in the shape of an arrow is found on the bottom of the water flow sensor, which is placed between the water pipelines. This indicates the necessary direction for the flow of water through the sensor, which then transmits the flow rate values to the program.

- **Turbidity sensor**:

Fig. 4. Turbidity sensor

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A device used for determining a liquid's turbidity or cloudiness is called a turbidity sensor. When sediments, bacteria, or other substances are suspended in a liquid, it is referred to as turbidity. Low turbidity indicates a clear and clean liquid, but high turbidity frequently indicates contamination.
**pH sensor**:pH sensors detect acidity/alkalinity changes to identify contaminants and ensure safe water quality. The pH scale has a range of 0-6: Acidic
7: Neutral 8–14:Alkaline
-
- **Lcd Display**: A liquid crystal display, or LCD, can be used as a user interface to show system status, turbidity, pH levels, and flow rate. It shows alerts such as "water contaminated" and "leak detected".
- **Wi-Fi module** : The ESP8266 Wi-Fi module is an afford- able Wi-Fi chip that comes with a built-in TCP/IP stack, allowing microcontrollers like Arduino to connect to the internet wirelessly. It works by sending and receiving data over a wireless network using the Wi-Fi protocol. This module can be programmed to link to a local Wi-Fi network, enabling it to send data to external servers or receive commands from the internet.
In the smart water leak detection system, the ESP8266 module connects the system to the internet. After the Arduino gathers water flow data from the sensor, the ESP8266 transmits this information to a remote server using HTTP requests or other protocols. The server can then store and analyze the data, providing users with real-time monitoring and alerts. This setup allows the system to continuously upload water flow data or do so at specified intervals, enabling users to monitor water flow remotely through a web interface or app, even when they are away from the monitoring site. By incorporating the ESP8266, the system gains enhanced functionality with remote access and ongoing data logging.

*C. Methodology*

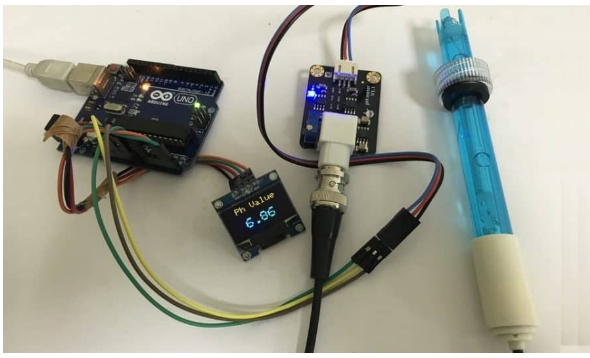
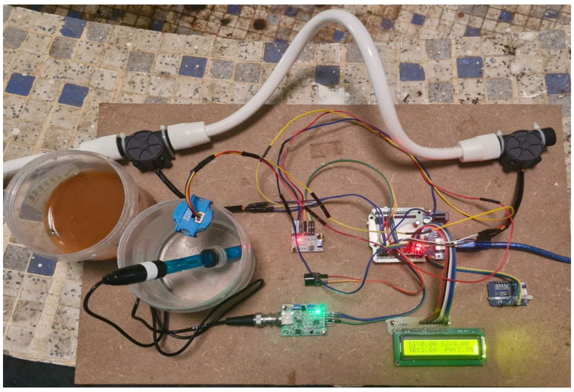



Fig. 5. pH sensor
Fig. 6. Prototype for leakage detection and contamination preventio



To implement water leakage detection and contamination prevention in urban water systems using IoT technology, the process begins with the installation of water flow, turbidity, and pH sensors at critical points in the water pipeline network, such as reservoirs, entry points, and distribution nodes. The YF-S201 water flow sensor mon- itors water movement and detects potential leaks using the Hall effect, where a rotating rotor generates pulses.

These pulses are counted to determine the flow rate using the formula:

$$\text{Flow rate} = \frac{\text{Pulse Frequency}}{7.5}$$

$$\text{Flow of water per Second} = \frac{\text{Flow rate}}{60}$$

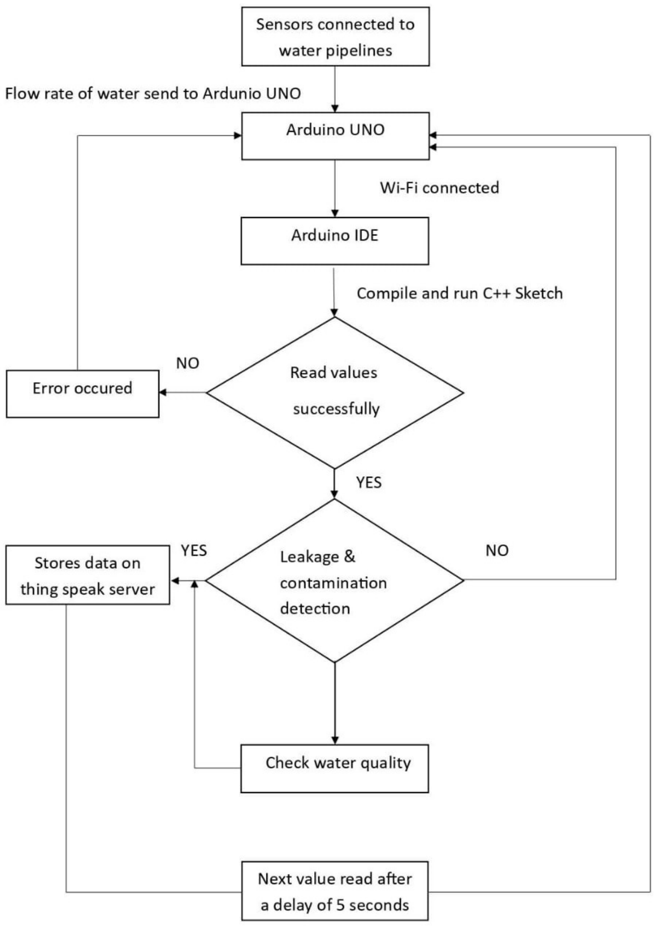


Fig. 7. Flow chart

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Total Volume of water = Previous Volume + Flow rate

By comparing water volume at the transmission source and receiving end, significant discrepancies indicate leak- age. The ESP8266 Wi-Fi module transmits real-time data to ThingSpeak, where the values are stored and analyzed. The system continuously reads flow sensor values and checks for differences beyond a predefined threshold. If the detected difference exceeds the threshold, an alert is sent to the in-charge personnel via the ThingView app, helping them respond quickly and fix the issue.
For contamination detection, a turbidity sensor transmits light through water, detecting changes in suspended par- ticles. If turbidity exceeds 2500–3000 NTU, the water is considered highly contaminated. A pH sensor continu- ously monitors the water's acidity or alkalinity, ensuring that the pH level remains within the safe range
$6.5 \leq pH \leq 8.5$
Any deviation outside this range indicates possible con- tamination due to industrial discharge or pipe corrosion.

| **Parameter** | **Normal** | **Leakage** | **Contamination** |
| --- | --- | --- | --- |
| **Flow Rate (L/min)** | 1 - 30 | Irregular / Decreased | Unstable Flow Rate |
| **Total Water Volume** | Balanced | Lossof Water | No Major Im- pact |
| **Turbidity (NTU)** | 0 - 20 ($V < 2V$) | Slight Increase | High (2500 - 3000 NTU, $V \approx 4.8V$) |
| **pH Value** | $6.5 \leq pH \leq 8.5$ | Slight De- viation | $pH < 6.5$ **or** $pH > 8.5$ |
| **ThingSpeak Data** | Stable | Drop in Flow | High Turbidity |
| **Alert** | No Alerts | Leak Alert | Contamination Alert |

TABLE I
WATER LEAKAGE AND CONTAMINATION DETECTION

All sensors are connected to an Arduino Uno micro- controller, which processes real-time data and transmits it to ThingSpeak via the ESP8266 Wi-Fi module. The ThingView app allows authorities to monitor real-time graphs and receive alerts when abnormalities are detected.
The system operates on a 5-second cycle, ensuring con- tinuous monitoring and immediate response to leaks and contamination, making urban water management more efficient and sustainable.

## IV. RESULTS

The output of the flow sensors, Turbidity sensor, and pH sensor can be displayed on the ThingSpeak web server and on LCD Display.


Fig. 8. Message on LCD before the leakage and contamination was not found

fig.8 shows the content displayed on the LCD screen immediately after switching on the proposed system.

The message indicates that the system is operational and ready to begin monitoring the water supply network. This ensures that the user is informed about the system's status at startup.


Fig. 9. message on LCD after the leakage and contamination found

Fig.9 shows the message displayed on the LCD when a water leak or contamination is detected in the pipeline. The LCD updates to show a warning message such as "Leak Detected" or "Water Contaminated," along with additional details, enabling quick identification of the issue. This immediate feedback ensures that nearby per- sonnel are alerted to the presence of anomalies.

This feature ensures precise localization of the problem, allowing municipal authorities to quickly locate and ad- dress it.

Fig.10 shows the information on the ThingView app. Three graphs are displayed in the ThingView app.The first graph shows values 0 and 1, where value 1 indicates a de- tected leak or contamination, and 0 indi- cates normal op- eration.ThingSpeak ensures timely identification of leaks, contamination, and irregularities in urban water systems. By integrat- ing ThingSpeak into the system, the proposed solution eliminates the need for complex wireless sensor networks (WSNs) or edge computing setups, reducing both cost and operational complexity. Additionally, the platform's scalability and affordability make it ideal for large-scale deployment across cities, enhancing overall water safety and reliability.Through its RESTful API, the system transmits data from

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various sensors, including water flow sensors, turbidity sensors, and pH sensors, directly to ThingSpeak's cloud database, where it is organized into channels for easy access and analysis. This integration not only improves decision-making but also supports predictive maintenance strategies, ensuring proactive responses to potential leaks, contamination, and water quality issues.

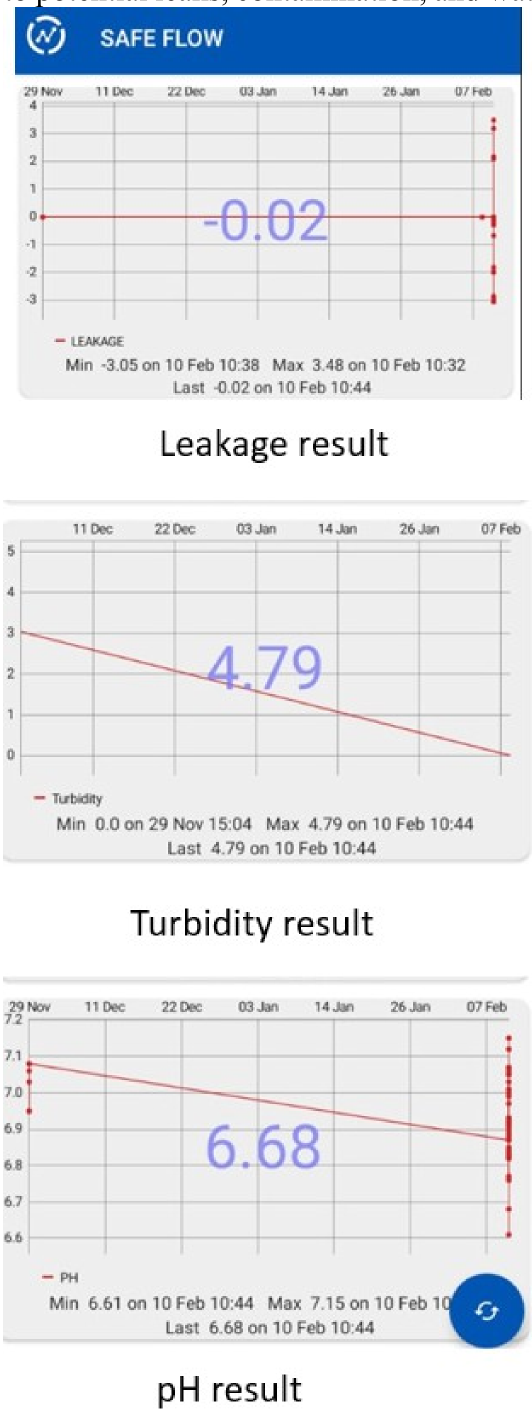


Fig. 10. visualization of the graph in Thingview app on mobile

## V. Conclusion

To make effective use of water resources, water monitor- ing is very important. this system is particularly beneficial for smart cities, where numerous water pipelines are

present, and leakages are frequent. The integration of water flow sensors allows for automated identification of leaks, reducing reliance on manual monitoring and enabling faster resolution of issues. Further combining the water quality monitoring system with the water leakage detection could turn out to be very effective. The water flow sensors are easy to install and don't require special tools. Being manufactured as a robust device, the sensors are less susceptible to damage and hence can be applied in domestic pipelines as well. This feature is especially valuable for urban and rural water supply networks, where water quality can fluctuate due to environmental factors or pipeline conditions.
This idea can be extended to detect leakages in un- derground gas pipelines have now been widely used in smart city developments, can be effectively used in industries and factories and bigger malls/stores/residential apartments where large number of pipelines are required.

**REFERENCES**

[1] Amitangshu Pal and Krishna Kant, "Water Flow Driven Sensor Networks for Leakage and Contamination Monitoring," 2015.
[2] Vengatesan M., & Prabakar T. N. "Leak and Theft Identification with Contamination Detection in Urban Water Supply System Us- ing Embedded Technology." International Journal of Engineering Research & Technology (IJERT), Special Issue - 2015, ISSN: 2278- 0181.
[3] Xi, F., Liu, L., Shan, L., Liu, B., & Qi, Y. (2024). Pipeline Leak Identification and Prediction of Urban Water Supply Network System with Deep Learning Artificial Neural Network. Water, 16(20), 2903. https://doi.org/10.3390/w16202903
[4] Arya Vijayan, Raju Narwade, Karthik Nagarajan, "Real Time Water Leakage Monitoring System Using IoT Based Architec- ture," IJREAM, Vol-05, Issue-08, Nov 2019, DOI: 10.35291/2454-9150.2019.0480.
[5] Marathe, Ruturaj, Tapale, Manisha, Jadhav, Vidya, Hulbatte, Vrushab, & Pawar, Aishwarya. (2021). IoT-based Water Leak- age Detection using Smart Objects for Smart City. 2021 Third International Conference on Intelligent Communication Tech- nologies and Virtual Mobile Networks (ICICV), IEEE. DOI: 10.1109/ICICV50876.2021.9388562.
[6] Gopalakrishnan, P., Abhishek, S., Ranjith, R., Venkatesh, R., & Jai Suriya, V. (2017). Smart Pipeline Water Leakage Detection System. International Journal of Applied Engineering Research, 12(16), 5559–5564.
[7] Park, H., Oh, Y., Kim, K., Kim, T., & Hyung, J. (2024). Opti- mal leakage detection and classification of the water distribution network based on the machine learning approach. Water Supply, 24(6), 2158. doi: 10.2166/ws.2024.122
[8] Elleuchi, M., Aseeri, M., Khelif, R., Obeid, A., Kharrat, M., & Abid, M. (n.d.)(2019). Water pipeline monitoring and leak detection using soil moisture sensors: IoT-based solution. Digital Research Center of Sfax, Tunisia.
[9] Vijayan, A., Narwade, R., & Nagarajan, K. (2019). Real Time Water Leakage Monitoring System Using IoT Based Architecture. International Journal for Research in Engineering Application & Management (IJREAM), 5(8), 24-30. DOI: 10.35291/2454- 9150.2019.0480.
[10] Farah, E., & Shahrour, I. (2017). Smart Water for Leakage Detection: Feedback about the Use of Automated Meter Reading Technology. IEEE. DOI: 10.1109/ICESE.2017.8300507.
[11] Y. Pavan Kumar, R. Jhansi Pravachana, SK. Dilshad, and M. Jhansi, "IoT-Based Water Leakage Detection Using Machine Learning Approach," International Journal of Novel Research and Development, vol. 9, issue 5, pp. e467–e475, May 2024. ISSN: 2456-4184. Available online at IJNRD.
[12] Pourmehrani, Hossein, Reshad Hosseini, and Hadi Moradi. "Wa- ter Flow Detection Device Based on Sound Data Analysis and Machine Learning to Detect Water Leakage." arXiv preprint arXiv:2501.11151 (2025). DOI: 10.48550/arXiv.2501.11151.
[13] Vijay, S., & Abishek, S. (2022). Advances in IoT-Based Urban Water Management Systems.

DOI:10.46647/ijetms.2025.v09i02.024 ISSN: 2581-4621

Environmental and Water Resources Engineering Review.

[14] Xiang, S., & Wang, T. (2017). IoT-Integrated Smart Water Sys- tems: Applications and Future Scope. IEEE Systems Journal.

[15] Kumar, R., & Subramani, P. (2021). Role of Flow Sensors in Detecting Urban Pipeline Leaks. Journal of Sensor Applications.

[16] Ahmed, N., & Khan, Y. (2019). Application of Turbidity and pH Sensors in Monitoring Water Quality. Hydrology and Water Treatment Journal.

[17] Rajesh, P., & Mehra, A. (2021). A Review on pH Sensor Appli- cations in Urban Water Systems. Sensors and Smart Networks.

[18] Das, R., & Singh, K. (2022). Challenges in Urban Water Distri- bution Networks: Leakage and Contamination Issues. Urban Water Journal.

[19] Lam, K., & Zhang, H. (2024). IoT for Sustainable Urban Water Management: Case Studies. Sustainable Development in Cities Journal.

[20] Pal, A., & Kant, K. (2015). Water Flow-Driven Sensor Networks for Leakage and Contamination Monitoring. IEEE Transactions on Smart Systems.