International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

A REVIEW PAPER ON DEVELOPMENT OF UNIVERSAL SMART WATER LEAKAGE DETECTION SYSTEM

Prof. Ritesh J. Raut[1], Shravani R. Kale[2], Pooja D. Jadhav[2], Rohit R. Chavhan[2], Tanmay V. Rathod[2], Sweety R. Ghode[2], Samprati M. Nakhale[2], Bhakti S. Jadhav[2]

[1]Assistant Professor, Department of Civil Engineering, Jagadambha College of Engineering & Technology, Yavatmal, Maharashtra, India

[2]Students of Second Year, Department of Civil Engineering, Jagadambha College of Engineering & Technology, Yavatmal, Maharashtra, India

ABSTRACT

Water is one of the most important natural resources on Earth. It is essential for human life, agriculture, industries, construction, and other daily activities. Water is supplied to homes and buildings through pipelines. However, water leakage in pipelines leads to the wastage of clean water and increases maintenance costs. Therefore, proper water management and leakage detection are necessary to conserve water and ensure its efficient use. Water leakage is a major problem in residential buildings, commercial buildings, and water distribution pipelines. Traditional methods of detecting leakage require manual inspection and may not identify leakage at an early stage.

This project aims to develop a universal smart water leakage detection system using a water flow sensor and a microcontroller. The system monitors the flow of water through the pipeline and detects abnormal changes in flow that may indicate leakage. When leakage is detected, the system provides an alert and can activate an automatic valve to stop the water supply, if included in the design. The project also focuses on low power consumption, cost-effectiveness, and easy installation.

The proposed system can be used in houses, buildings, and small water distribution systems. It helps reduce water wastage, improve water management, and minimize maintenance efforts. Thus, the system provides a simple and efficient solution for smart water leakage detection.

Keywords: Water leakage, Internet of Things, Flow sensor, Pressure sensor, Smart water management, Notification system, Low-power system

I. INTRODUCTION

Water is the foundation of life and plays a vital role in maintaining the balance of nature and supporting all living organisms. It is essential for the survival of humans, animals, and plants. Water is used for drinking, cooking, bathing, washing, agriculture, industries, and construction. Approximately 71% of the Earth's surface is covered with water, but only a small portion is readily available as freshwater for human use. Globally, agriculture accounts for about 70% of freshwater withdrawals, while industries and domestic activities use the remaining share in

International Journal for Innovative Engineering and Management Research
PEER REVIEWED OPEN ACCESS INTERNATIONAL JOURNAL
www.ijiemr.org

varying proportions. Water is necessary for daily life, so preventing its wastage is very important. Water leakage in pipelines can waste large amounts of water and increase maintenance costs. Therefore, an efficient water leakage detection system is needed to conserve water and manage it properly.

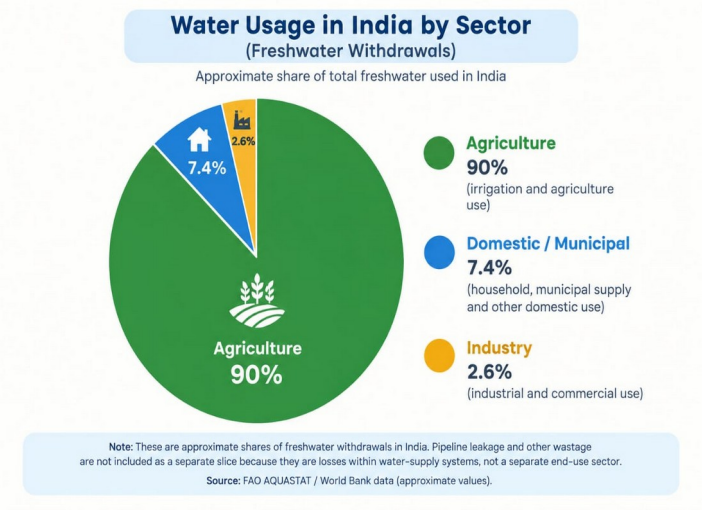




Fig. 1: Pie chart of water used for agricultural, domestic and industrial purposes

The development of a universal smart water leakage detection system aims to identify water leakage in pipelines and reduce water wastage. Traditional leakage detection methods often require manual inspection, which can be time-consuming and may not detect leakage at an early stage. This project uses a water flow sensor and a microcontroller to monitor water flow through a pipeline. When abnormal flow conditions indicate possible leakage, the system generates an alert. An automatic valve can also be used to stop the water supply when leakage is detected. The proposed system focuses on low energy consumption, low cost, easy installation, and efficient water conservation. It can be adapted for residential buildings, commercial buildings, and other water pipeline systems.

II. OBJECTIVES

1. To study existing research and various techniques used for smart water leakage detection in pipeline systems.
2. To review different sensors and monitoring methods used for detecting abnormal water flow and identifying leakage at an early stage.
3. To analyze automatic alert systems and water supply control mechanisms used to minimize water loss during leakage.
4. To compare existing leakage detection systems based on accuracy, cost-effectiveness, energy consumption, reliability, and maintenance requirements.
5. To identify research gaps and explore the development of a universal, efficient, low-power, and cost-effective water leakage detection system suitable for residential, commercial, industrial, and public applications.

III. LITERATURE REVIEW

1. **Ayuba, A., Gambo, F. L., Musa, A., Yakubu, H. A., Malama, B. I., and Ishaq, A. (2026):** Ayuba, A., Gambo, F. L., Musa, A., Yakubu, H. A., Malama, B. I., and Ishaq, A. developed a lightweight IoT-based pipeline leak detection model using thermal imaging and deep learning techniques. The model combines CNN, Autoencoder, and Knowledge Distillation to improve leak detection while reducing computational cost. It achieved 98% accuracy, making it suitable for fast and energy-efficient pipeline monitoring.
2. **Anozie et al. (2026):** Anozie, in "The Designing of a Transparent Hybrid Machine Learning Framework for Water Leak Detection: A Systematic Review," reviewed hybrid machine-learning techniques for water leakage detection. The study focused on combining different machine-learning methods to improve detection accuracy, transparency and reliability. It also discussed the challenges of applying intelligent detection systems in water distribution networks.
3. **Al-Rashed (2026):** Al-Rashed, in "Water Distribution Leakage as a Systems Failure: A Framework for Improved Management Protocols," examined the causes and management of leakage in water distribution networks. The paper discussed technical and operational challenges and emphasized the importance of systematic leakage management to reduce water losses.
4. **Narvaez et al. (2026):** Narvaez, in "AI-Based Leak Detection in Water Distribution Networks: A Decadal Review Across Sensing and Monitoring Scales," reviewed artificial intelligence techniques used for detecting water leakage from 2015 to 2026. The study examined network-level monitoring, district metered areas and sensor-based leak localization. It discussed the benefits and limitations of AI techniques in practical water distribution systems.

5. **Farah and Shahrour (2026):** Farah and Shahrour, in "Standardization and Benchmarking of Datasets and Evaluation Protocols for Machine Learning-Based Water Leak Detection: A Systematic Review," studied different machine-learning methods, sensor technologies and evaluation techniques for water leakage detection. The paper identified the need for standard datasets and reliable testing methods to improve the accuracy and comparison of leakage detection systems.
6. **Zuniga-Uribe et al. (2026):** Zuniga-Uribe, in their paper "Artificial Intelligence in Water Distribution Networks: A Systematic Review of Models, Input Variables, Databases, and Output Strategies for Leak Detection," reviewed machine-learning and deep-learning techniques used for detecting water leakage. The study compared different models, sensor data and detection strategies. It highlighted the importance of reliable data and accurate monitoring for improving leakage detection in water distribution networks.
7. **Kushang Vinodbhai Shah (2025):** Kushang Vinodbhai Shah focused on developing leakage detection strategies and identifying contamination sources in water distribution systems. The research addresses two major challenges: water loss caused by pipeline leakage and water quality deterioration due to contamination. It emphasizes the importance of monitoring pipeline conditions and identifying the sources of abnormal changes in the distribution network. Effective detection and identification techniques can help improve water safety and reduce maintenance problems. The proposed research contributes to reliable water distribution and better water quality management.
8. **Gopika Rajan and Songnian Li (2025):** Gopika Rajan and Songnian Li presented a systematic literature review of flow data-based techniques used for automated leakage management in water distribution systems. The research focuses on analyzing water flow measurements to identify abnormal patterns associated with pipeline leakage. It discusses different data analysis and automated detection methods for identifying water losses. The study highlights the importance of accurate flow monitoring and reliable data analysis techniques. These approaches can improve leakage detection efficiency and support better water distribution management.
9. **Balamurugan, G., Harish, V. M., Giridharan, G. and Staliniose, C. V. (2025):** Balamurugan and co-authors proposed an IoT-based smart water distribution and leakage detection network for monitoring water supply systems. The research focuses on using connected sensors to measure water flow and identify abnormal pipeline conditions. The collected information is transmitted through an IoT network, allowing users to monitor the water distribution process remotely. The system helps identify possible leakage and improves the monitoring of water supply networks. It aims to reduce water wastage and provide more efficient water distribution management.
10. **Beenish Bakhtawar, Ali Fares, and Tarek Zayed (2025):** Beenish Bakhtawar, Ali Fares, and Tarek Zayed proposed an A IoT-driven leak detection system for real water networks using hydrophones. The study uses acoustic sensing technology and

hydroacoustic data to detect pipeline leaks with high accuracy. It aims to reduce false alarms, improve leak localization, and provide efficient water leakage monitoring.

11. **Rajan and Li (2025**): Rajan and Li, in their paper "A Systematic Literature Review on Flow Data-Based Techniques for Automated Leak Management in Water Distribution Systems," reviewed flow-based techniques used for identifying and managing water leakage. The study discussed smart meters, IoT, artificial intelligence and automated monitoring methods. It highlighted the importance of continuous flow measurement and reliable data collection for improving leakage management.
12. **Uma Rajasekaran (2024):** Uma Rajasekaran focused on detecting and locating water pipeline leakage using Machine Learning (ML) and Deep Learning (DL) techniques. The research aims to analyze sensor data and identify abnormal patterns associated with pipeline leakage. Machine learning algorithms help classify different pipeline conditions, while deep learning techniques can extract important features from the collected data. These techniques improve the accuracy of leakage detection and help identify the location of leakage. The approach reduces water wastage and supports intelligent pipeline monitoring and maintenance.
13. **Pooja Chaudhary (2024):** Pooja Chaudhary focused on detecting water leakage in smart water distribution networks using machine learning techniques. The research analyzes water distribution data to identify unusual flow patterns and abnormal conditions that indicate possible leakage. Machine learning algorithms are used to distinguish between normal water flow and leakage situations. This approach helps improve the speed and accuracy of leakage detection compared with traditional monitoring methods. The proposed technique supports smart water management by reducing water loss and improving the reliability of distribution networks.
14. **Megha Mudholkar and P. Mudholkar (2024):** Megha Mudholkar and P. Mudholkar presented a Smart IoT-Enabled Tap Water Leakage Monitoring System to reduce domestic water wastage. The proposed system uses sensors to monitor the water flow rate from taps in real time and provides notifications when water leakage is detected. The system focuses on improving household water conservation through mobile integration and continuous monitoring. This research highlights the importance of smart technology in detecting water leakage and promoting sustainable water management.
15. **Kumar, Y. P., Pravachana R. J., Dilshad, S. and Jhansi, M. (2024):** Kumar, Y. P. and co-authors proposed an IoT-based water leakage detection system using machine learning techniques. The research focuses on collecting pipeline data through sensors and analyzing it to identify abnormal water flow patterns. Machine learning algorithms help classify the collected data into normal and leakage conditions. IoT technology enables real-time transmission and monitoring of sensor information. The proposed approach improves automated leakage detection and helps reduce water wastage through timely identification of pipeline problems.

16. **Udhayavani, M., Venkatesh, T. U., Tharunraj, V. and Sanjay, M. (2024):** Udhayavani and co-authors proposed an IoT-based system for detecting and controlling water leakage in metro pipeline networks. The system focuses on continuously monitoring water flow and identifying abnormal variations that may indicate leakage. Sensors collect pipeline information and transmit it through IoT communication for monitoring and analysis. The proposed approach helps detect leakage conditions and supports automatic control of water supply. It aims to minimize water loss and improve the reliability of large-scale pipeline distribution systems.
17. **Asare, K. O., Twum, F. and Asante, G. (2024):** Asare, K. O., Twum, F. and Asante, G. proposed an IoT-based water leakage detection and localization model using YF-S201 flow rate sensors. The system uses flow sensors to measure the amount of water passing through pipelines and identify differences between normal and abnormal flow conditions. The collected readings are processed to determine possible leakage and estimate its location. IoT communication supports remote monitoring and provides information about pipeline conditions. This approach helps detect leakage efficiently and reduces water losses in distribution systems.
18. **Atharva Bele, Setu Fulawade, Rushikesh Chaudhari, and Kapil Dere (2024):** Atharva Bele, Setu Fulawade, Rushikesh Chaudhari, and Kapil Dere proposed an IoT-based smart water flow and pipeline leakage detection system using Arduino UNO. The system uses flow and pressure sensors for real-time monitoring, early leakage detection, and instant alerts to reduce water wastage and improve water management.
19. **Rozan Boudville and co-authors (2023):** Rozan Boudville and co-authors developed an IoT-based system for monitoring and detecting leakage in domestic water pipelines. The system uses an ESP32 microcontroller, YF-S201 water flow sensor and solenoid valve to monitor and control water flow. The collected water flow data is stored using Google Sheets, while the Blynk mobile application provides notifications to homeowners when leakage is detected. The system identifies abnormal water flow conditions and helps prevent unnoticed leakage. This approach reduces household water wastage and provides an effective solution for domestic water pipeline monitoring.
20. **Benny Zuse Rousso, Martin Lambert and Jinzhe Gong (2023):** Benny Zuse Rousso, Martin Lambert and Jinzhe Gong presented a systematic review of smart water network applications using high-frequency pressure and acoustic sensors. The research examines how these sensors are used in real water distribution systems for monitoring pipeline conditions and identifying leakage. Pressure sensors help detect abnormal pressure variations, while acoustic sensors identify sound patterns generated by water escaping from damaged pipelines. The study discusses the applications, advantages and challenges of these sensing technologies. It highlights the importance of smart sensor-based monitoring for improving leakage detection, pipeline maintenance and water distribution management.

21. **Serra et al. (2023):** Serra, in their paper "Leak Detection and Localization in Water Distribution Networks: Review and Perspective," reviewed model-based and data-driven approaches for detecting and locating water leakage. The study compared different leakage management techniques and discussed their practical applications, advantages and limitations in water distribution networks.

22. **Dipesh Dalal and Rupesh Vasani (2022):** Dipesh Dalal and Rupesh Vasani proposed an intelligent water leakage detection technique for future smart cities. The research focuses on identifying water leakage in pipelines at an early stage using smart monitoring technologies. The system aims to monitor water flow and detect abnormal variations that may indicate leakage. By implementing intelligent detection techniques, the proposed approach helps reduce water wastage and improve the efficiency of water distribution networks. It also supports the development of sustainable water management systems in smart cities.

23. **Ali Abdelmoez, Heshmat and Ibrahim (2022):** Ali Abdelmoez, Heshmat and Ibrahim proposed an IoT-based approach for solving water management and leakage detection problems. The system uses sensors to monitor important water parameters such as pH, turbidity and flow rate. The collected information is transmitted to a cloud platform for storage, monitoring and analysis. The proposed system helps identify abnormal water conditions and possible leakage while providing alerts to users and administrators. This approach improves water management, supports real-time monitoring and helps reduce unnecessary water wastage.

24. **Tina, Kateule, and Luwemba (2022):** Tina, Kateule, and Luwemba developed an experimental IoT-based water leakage detection system using Arduino Uno and two water flow sensors installed at the source and destination of a pipeline. The system compares the water flow readings at both points to identify leakage, no-flow, and overflow conditions. NodeMCU ESP8266 is used to transfer data to a cloud server, while an LCD displays the readings. The study demonstrated that comparing water flow measurements can help detect pipeline leakage and reduce water wastage.

25. **Neeraj Aswal (2021):** Neeraj Aswal and co-authors proposed a Wireless Sensor Network (WSN) architecture for detecting and monitoring leakage in water supply distribution networks. The research focuses on using wireless sensors to continuously monitor pipeline conditions and identify abnormal water flow. The collected information is transmitted through a wireless communication network, reducing the need for manual inspection. The proposed architecture helps improve leakage detection, water supply monitoring and distribution management. It also provides an efficient approach for reducing water losses in distribution networks.

26. **Sunilkumar Hattaraki and Achyut Yaragal (2021):** Sunilkumar Hattaraki and Achyut Yaragal developed an IoT-based system for detecting water leakage and unauthorized water usage in pipelines. The proposed system uses water flow sensors and a NodeMCU microcontroller to continuously monitor water flow and identify

abnormal variations. The collected sensor data is transmitted wirelessly, allowing users to monitor the water distribution system through a mobile application. The system helps detect possible leakage and water theft in real time. This approach reduces water wastage and improves the efficiency of water supply monitoring.

27. **Harshit Shukla and Kalyan Piratla (2020):** Harshit Shukla and Kalyan Piratla proposed a supervised machine learning approach for detecting water pipeline leakage using acceleration signals. In this method, sensors capture vibration signals generated by water flowing through pipelines and identify abnormal patterns caused by leakage. A Convolutional Neural Network (CNN) is used to classify the collected signals and distinguish between normal and leakage conditions. The proposed approach achieved approximately 95% classification accuracy in the reported experiments. This research demonstrates the effectiveness of vibration-based monitoring for accurate and continuous pipeline leakage detection.
28. **Rejeesh Rayaroth (2019):** Rejeesh Rayaroth presented an empirical analysis of classification and optimization techniques for sensor placement in water distribution systems. The research focuses on identifying the most suitable locations for installing sensors to detect pipeline leakage effectively. Optimization techniques help determine the appropriate number and positions of sensors, while classification methods assist in identifying leakage conditions. Proper sensor placement improves detection accuracy and reduces unnecessary installation costs. This approach contributes to reliable and cost-effective water distribution network monitoring.
29. **Samer El-Zahab and Tarek Zayed (2019):** Samer El-Zahab and Tarek Zayed presented an introductory overview of different techniques used for detecting leakage in water distribution networks. The research reviews conventional and modern leakage detection methods, including acoustic monitoring, pressure measurement and flow-based techniques. It explains the advantages and limitations of different approaches used to identify pipeline leakage. The study also discusses the importance of selecting suitable detection techniques according to network conditions. It provides a foundation for understanding existing leakage detection technologies and their development.
30. **Haikal Hafiz Kadar, Sera Syamila Sameon and Mohd. Ezanee Rusli (2018):** Haikal Hafiz Kadar, Sera Syamila Sameon and Mohd. Ezanee Rusli proposed a low-cost wireless system called SMART2L for monitoring water levels and detecting pipeline leakage. The system uses sensors to measure water levels and identify possible leakage conditions. Wi-Fi communication is used to transmit the collected information, while mobile notifications provide alerts to users. The proposed system helps monitor water supply efficiently, detect leakage at an early stage and reduce unnecessary water wastage.

IV. CONCLUSION

After studying the above reviews, we concluded that various techniques such as IoT, machine learning, flow sensors, pressure sensors and acoustic monitoring are useful for detecting water leakage. However, limitations such as high cost, power consumption and complex implementation still exist. Therefore, our proposed Development of a Universal Smart Water Leakage Detection System aims to provide a reliable, cost-effective and low-power solution through continuous flow and pressure monitoring, early leakage detection, immediate alerts and automatic water supply control. This system will help reduce water wastage and improve efficient water management in residential, commercial and industrial areas.

V. REFERENCES

1. A., Gambo, F. L., Musa, A., Yakubu, H. A., Maijamaa, B. I., and Ishaq, A. (2026). "An Enhanced Lightweight IoT-Based Pipeline Leak Detection Model." Engineering Proceedings, 124(1), Article 108. Ayuba https://doi.org/10.3390/engproc2026124108
2. Anozie, C. M., Tuyikeze, T., Obagbuwa, I. C., & Matsebula, F. (2026). The Designing of a Transparent Hybrid Machine Learning Framework for Water Leak Detection: A Systematic Review. Frontiers in Big Data, 9, Article 1761377. https://doi.org/10.3389/fdata.2026.1761377
3. Al-Rashed, W. S. (2026). Water Distribution Leakage as a Systems Failure: A Framework for Improved Management Protocols. Water, 18(17), Article 2099. https://doi.org/10.3390/w18172099
4. Narvaez, A., Navarro, C., Lopez, J., Martinez, F., & Gonzalez, L. C. (2026). AI-Based Leak Detection in Water Distribution Networks: A Decadal Review Across Sensing and Monitoring Scales. Journal of Hydroinformatics, 28(9), 1143–1170. https://doi.org/10.2166/hydro.2026.069
5. Farah, E., & Shahrour, I. (2026). Standardization and Benchmarking of Datasets and Evaluation Protocols for Machine . Learning-Based Water Leak Detection: A Systematic Review. Water, 18(18), Article 2267. https://doi.org/10.3390/w18182267
6. Zuniga-Uribe, M., Rojas-Galvan, R., Alvarez-Alvarado, J. M., Aviles, M., Perez-Soto, G. I., & Perez-Moreno, V. (2026). Artificial Intelligence in Water Distribution Networks: A Systematic Review of Models, Input Variables, Databases, and Output Strategies for Leak Detection. Smart Cities, 9(3), Article 45. https://doi.org/10.3390/smartcities9030045
7. Kushang Vinodbhai Shah (2025) "studied the development of leakage detection strategies and identification of contamination sources in water distribution systems. The study focuses on improving the detection of water leakage and identifying possible contamination sources." http://hdl.handle.net/10603/711214

8. Gopika Rajan and Songnian Li (2025) “reviewed flow-data techniques for automated leakage detection and water management.” Smart Cities, Volume 8, Issue 3, Article No. 78. https://doi.org/10.3390/smartcities8030078

9. G. Balamurugan, V. M. Harish, G. Giridharan, C. Vibin Stalin and D. R. P. Rajarathnam (2025) “developed a sensor-based IoT system for real-time water distribution and leakage monitoring.” International Research Journal on Advanced Engineering Hub, Volume 3, Issue 10, pages 3992–3995. https://doi.org/10.47392/IRJAEH.2025.0583

10. Bakhtawar, B., Fares, A., and Zayed, T. (2025). “A IoT-Driven Leak Detection in Real Water Networks Using Hydrophones.” Water Resources Management, Volume 39, pp. 2551–2566. Springer Link Publication Page

11. Rajan, G., & Li, S. (2025). A Systematic Literature Review on Flow Data-Based Techniques for Automated Leak Management in Water Distribution Systems. Smart Cities, 8(3), Article 78. https://doi.org/10.3390/smartcities8030078

12. Uma Rajasekaran (2024) “Associated with research on water pipeline leakage detection and localization using machine learning and deep learning techniques.” A related paper by Uma Rajasekaran, Mohanaprasad Kothandaraman and Chang Hong Pua was published in IEEE Access, Volume 13, pages 2736–2745. http://hdl.handle.net/10603/698136

13. Pooja Chaudhary (2024) “studied the application of machine learning techniques for detecting leakage in smart water distribution networks. These techniques aim to improve leakage identification and monitoring in water distribution systems.” http://hdl.handle.net/10603/568500

14. Mudholkar, M., and Mudholkar, P. (2024). “Smart IoT-Enabled Tap Water Leakage Monitoring System with Mobile Integration for Sustainable Water Management.” Proceedings of the 7th International Conference on Contemporary Computing and Informatics (IC3I 2024), Greater Noida, India, pp. 330–337. Published by IEEE. 10.1109/IC3I61595.2024.10829157

15. Kumar, Y. P., Pravachana, R. J., Dilshad, S. K., and Jhansi, M. (2024). “IOT Based Water Leakage Detection Using Machine Learning Approach.” International Journal of Novel Research and Development, Volume 9, Issue 5, pp. e467–e475. IJNRD Paper Abstract Page

16. Dr. M. Udhayavani, Venkatesh T. U., Tharunraj V., Sanjay M. and Vetriselvan A. (2024) “developed an IoT-based system using flow sensors and a controller for detecting and controlling pipeline leakage.” International Journal of Engineering Research & Technology (IJERT), Volume 15, Issue 4. Article ID: IJERTV15IS040173. https://www.ijert.org/iot-based-smart-water-leakage-detection-and-control-system-for-metro-pipelines

17. Asare, K. O., Twum, F., & Asante, G (2024). "An IoT-Based Water Leakage Detection and Localization System." Asian Journal of Research in Computer Science, Volume 17, Issue 3, pp. 1–14. 10.9734/ajrcos/2024/v17i3421

18. Atharva Bele , Setu Fulawade , Rushikesh Chaudhari , Kapil Dere (2024). "Smart Water Flow and Pipeline Leakage Detection Using IoT and Arduino UNO." International Journal of Creative Research Thoughts (IJCRT), Volume 12, Issue 11, pp. c323–c327. https://ijcrt.org/viewpaperforall.php?paper=IJCRT2411259

19. Boudville and co-authors (2023) "presented a domestic water piping leakage monitoring and detection system. The system uses an ESP32 microcontroller, YF-S201 water flow sensor and solenoid valve to identify abnormal water flow and control leakage automatically."IEEE ICCSCE 2023, pages 348-352. 10.1109/ICCSCE58721.2023.10237150

20. Benny Zuse Rousso, Martin Lambert and Jinzhe Gong (2023) "reviewed pressure and acoustic sensors for detecting and locating water pipeline leakage." Journal of Cleaner Production, Volume 410, Article No. 137193. 10.1016/j.jclepro.2023.137193

21. Serra et al. (2023). Leak Detection and Localization in Water Distribution Networks: Review and Perspective. Annual Reviews in Control, 55 (2023), 392–419. 10.1016/j.arcontrol.2023.03.012

22. Dipesh Dalal and Rupesh Vasani (2022) "presented a study on the implementation of an intelligent water leakage detection technique for future smart cities". http://hdl.handle.net/10603/658286

23. Ahmed S. Ali, Mahmoud N. Abdelmoez, Mahmoud Heshmat and Khalil Ibrahim (2022) "developed an IoT-based system using sensors and Firebase for water monitoring and leakage detection." Internet of Things, Volume 18, Article No. 100504. .https://doi.org/10.1016/j.iot.2022.100504

24. Tina, J. S., Kateule, B. B., and Luwemba, G. W. (2022). "Water Leakage Detection System Using Arduino." European Journal of Information Technologies and Computer Science, Volume 2, Issue 1, pp. 1–4. Water Leakage Detection System Using Arduino | European Journal of Information Technologies and Computer Science

25. Neeraj, P. K. Suri and V. Yadav (2021) "studied the design and implementation of a wireless sensor network architecture for detecting and monitoring water leakage in water supply distribution networks." pages 559–564. http://hdl.handle.net/10603/357218

26. Sunilkumar Hattaraki and Achyut Yaragal (2021) "developed an IoT-based system to detect water leakage and theft in pipelines. The system uses water flow sensors and a NodeMCU microcontroller to monitor water flow and identify leakage. It supports real-time monitoring through a mobile application, helping to reduce water wastage." Volume 9, Issue 4, pages 26–29. https://ijsrset.com/IJSRSET21946

27. Harshit Shukla and Kalyan Piratla (2020) “studied leakage detection in water pipelines using supervised classification of acceleration signals. The research focuses on identifying pipeline leakage through acceleration signals and classification techniques.” The paper was published in Automation in Construction, Volume 117, Article 103256. https://doi.org/10.1016/j.autcon.2020.103256

28. Rejeesh Rayaroth (2019) “studied classification and optimization techniques for sensor placement in water distribution systems to improve leakage detection”. A related publication by Rejeesh Rayaroth and G. Sivaradje appeared in Water Resources Management, Volume 33, Issue 9, pages 3111–3125. http://hdl.handle.net/10603/436692

29. Samer El-Zahab and Tarek Zayed (2019) “reviewed different leakage detection techniques and their development in water distribution networks.” Smart Water, Volume 4, Article No. 5. Springer Open's Smart Water Journal

30. Haikal Hafiz Kadar, Sera Syarmila Sameon and Mohd. Ezanee Rusli (2018) “developed a wireless IoT-based system for monitoring water levels and detecting pipeline leakage.” International Journal of Engineering & Technology, Volume 7, Issue 4.36, Pages 448–452. https://doi.org/10.14419/ijet.v7i4.36.23914