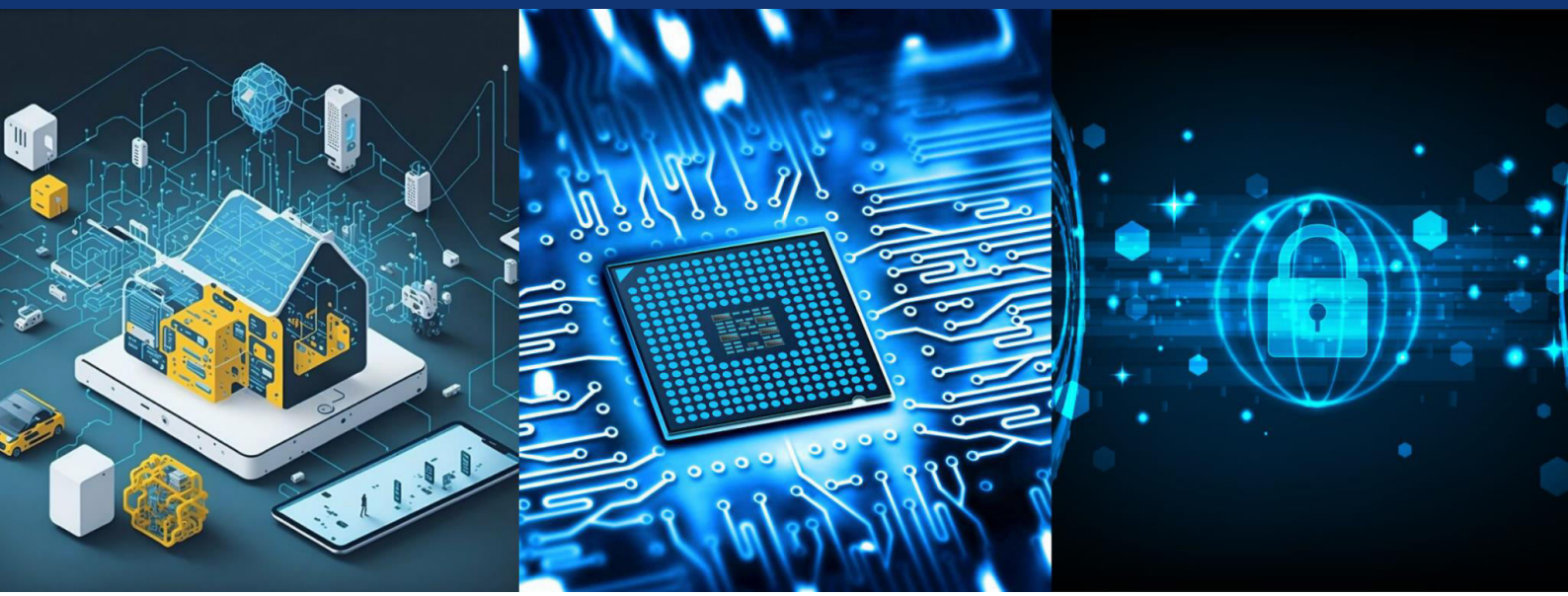
IJIRCCE

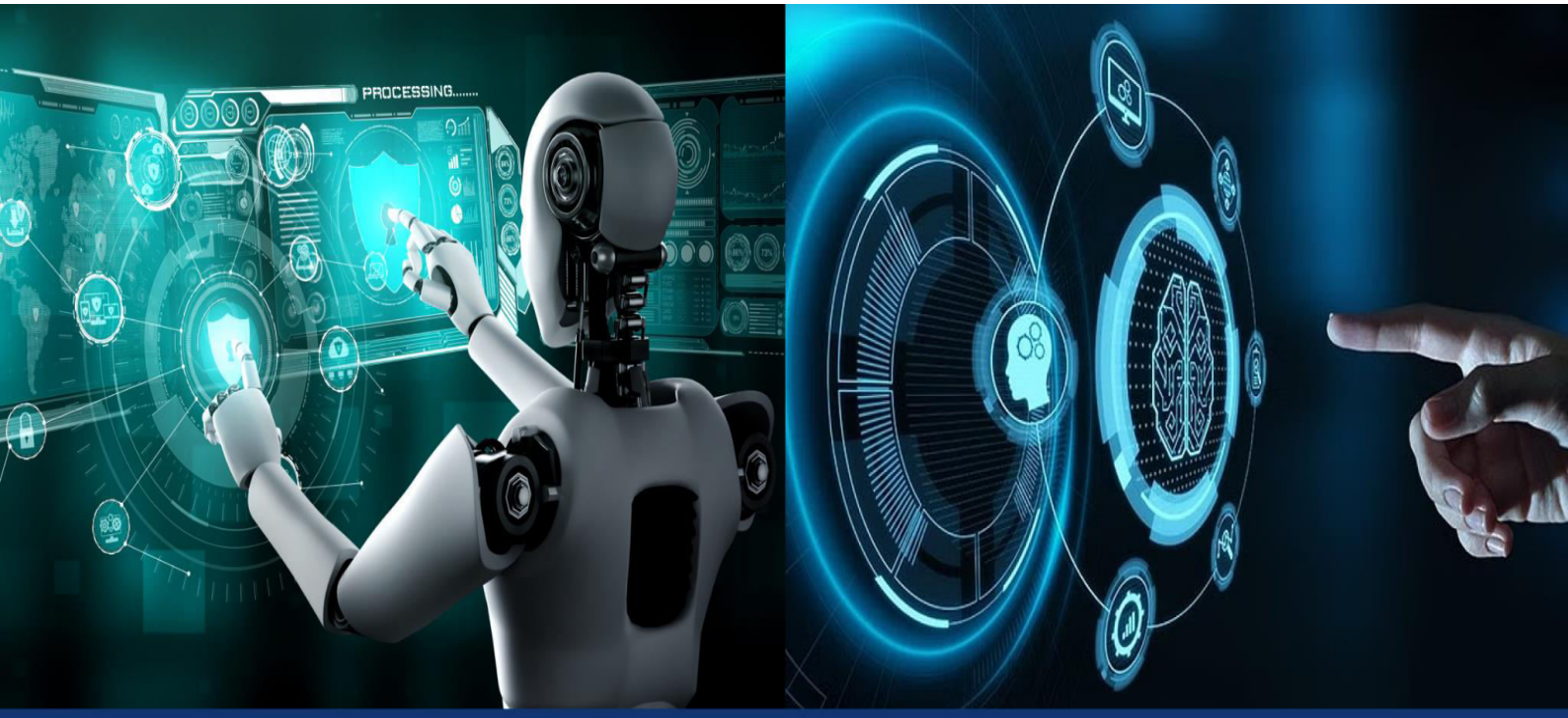
ISSN(O): 2320-9801

ISSN(P): 2320-9798



International Journal of Innovative Research in Computer and Communication Engineering

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)



Impact Factor: 8.771

Volume 13, Issue 5, May 2025

© 2025 IJIRCCE | Volume 13, Issue 5, May 2025| DOI:10.15680/IJIRCCE.2025.1305032

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Advanced Underground Drainage Monitoring and Automatic Rescue System Using IoT

M.Maheswari[1], M. Sivamoorthi[2], A. Sheik Thamim[3]

Assistant Professor, Department of ECE, Sethu Institute of Technology, Virudhunagar Dt., Tamil Nadu, India[1]

UG Students, Department of ECE, Sethu Institute of Technology, Virudhunagar Dt., Tamil Nadu, India[2-3]

ABSTRACT: The increasing need for safety and efficiency in underground drainage operations has led to the adopting of smart technologies. This paper presents an IoT-based system designed to monitor environmental parameters, including toxic gas concentrations, temperature, and humidity, while also tracking worker health metrics such as heart rate and blood oxygen levels. The system employs real-time data collection, automated alerts, and rescue mechanisms to ensure worker safety and operational efficiency. The integration of IoT enables remote monitoring and predictive analytics, offering a proactive approach to hazard management in underground drainage systems.

KEYWORDS: IoT, Underground Drainage, Smart Monitoring, Worker Safety, Automated Rescue, Toxic Gas Detection

I. INTRODUCTION

Underground drainage systems are essential for managing wastewater and stormwater. However, workers operating in these environments are exposed to various hazards, including toxic gases, poor ventilation, and confined spaces. Traditional safety measures often rely on manual inspections, which lack real-time monitoring capabilities. The Internet of Things (IoT) presents a promising solution by enabling continuous surveillance, real-time alerts, and automated rescue mechanisms.

Underground drainage systems are vital infrastructure components that manage stormwater, wastewater, and other forms of sewage. These systems are often complex networks of pipes, tunnels, and chambers buried deep beneath the ground. They serve as the backbone for preventing flooding, ensuring the safe disposal of waste, and maintaining public health by managing wastewater efficiently.

The importance of underground drainage systems extends far beyond urban planning. They are crucial for maintaining environmental sustainability by protecting natural waterways and preventing contamination from untreated waste. Their role in managing stormwater during heavy rains is particularly critical to preventing flooding, landslides, and waterlogging, which can cause extensive damage to properties and human lives.

However, despite their significance, underground drainage systems often face challenges related to safety and maintenance. Workers are routinely required to enter these systems to inspect, repair, or upgrade components, which exposes them to numerous health and safety hazards. Among these risks, the presence of hazardous gases such as carbon dioxide (CO2), methane, and toxic fumes from decaying waste materials, as well as the potential for physical injury, are major concerns. Ensuring worker safety during underground drainage operations has therefore become a growing priority in the industry.

1.1 Challenges in Underground Drainage Operations

Underground drainage operations involve complex and high-risk tasks such as pipe installation, inspection, cleaning, and repair. These tasks expose workers to several dangers, including the risk of exposure to toxic gases, low oxygen levels, and physical injuries due to poor visibility, confined spaces, or unexpected tunnel collapses. One of the primary risks in these environments is the presence of hazardous gases. Underground drainage systems, particularly those that handle wastewater and sewage, may release harmful gases such as methane, hydrogen sulfide, and carbon dioxide. These gases can be extremely dangerous if inhaled in high concentrations, leading to poisoning, asphyxiation, or even death.

© 2025 IJIRCCE | Volume 13, Issue 5, May 2025| DOI:10.15680/IJIRCCE.2025.1305032

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

CO2, in particular, is an odorless gas that accumulates in confined spaces and can cause suffocation in high concentrations. Methane and hydrogen sulfide are also toxic, and exposure to them can lead to severe health effects, including respiratory distress, dizziness, and even fatal consequences in extreme cases.

In addition to environmental risks, workers also face health hazards related to the strenuous physical demands of their tasks. Monitoring workers' vital signs, such as heart rate and blood oxygen levels, is critical to detecting early signs of distress or fatigue, which can prevent accidents or fatalities. Without effective real-time monitoring, these health risks can go unnoticed, leading to catastrophic consequences.

1.2 Need for Monitoring and Safety Mechanisms

As the risks in underground drainage operations continue to rise, there is an urgent need for advanced safety systems that can detect hazards, monitor worker health, and provide automatic interventions in the event of dangerous conditions. Traditional safety measures often fall short in providing timely responses to rapidly changing environmental conditions. Workers may be unaware of rising toxic gas levels or deteriorating oxygen concentrations until it is too late.

To address these challenges, real-time monitoring systems integrated with IoT technology have emerged as a powerful solution. IoT-enabled systems can continuously monitor both environmental factors and workers' health data, providing supervisors and operators with live updates on conditions underground. In the event of unsafe situations, these systems can automatically trigger alarms, activate ventilation systems, or deploy rescue mechanisms, thereby reducing the risks of injury and ensuring swift responses in emergencies.

The integration of IoT in safety systems not only improves reaction times but also allows for remote monitoring and control, which is especially important in dangerous and hard-to-reach underground environments. By incorporating real-time data collection and analysis, IoT-based systems can offer significant advantages over conventional safety protocols.

1.3 The Role of IoT in Safety and Monitoring

The Internet of Things (IoT) has revolutionized industries by connecting physical devices to the Internet, enabling them to communicate and exchange data. In the context of underground drainage systems, IoT technology can be used to collect and transmit data from a variety of sensors and devices placed in critical locations. These sensors monitor environmental conditions, such as the concentration of hazardous gases (including CO2), temperature, humidity, and oxygen levels.

IoT devices can also track the health of workers in real-time. Wearable health sensors can measure vital signs like heart rate, blood oxygen levels, and body temperature. This data is transmitted to a central system, which analyzes the information to detect any signs of distress or dangerous health conditions. By continuously monitoring both environmental parameters and worker health, IoT-enabled systems can identify potential hazards early on, allowing for proactive intervention.

In addition to monitoring, IoT technology can also support automation in the form of rescue mechanisms. For example, when hazardous gas levels exceed safe thresholds, the system can automatically activate ventilation systems to reduce the concentration of toxic gases or trigger alarms to alert workers and supervisors. More advanced systems could even initiate physical rescue operations, such as unlocking emergency exits or deploying robotic systems to remove workers from unsafe environments.

II. LITERATURE REVIEW

Previous research highlights the limitations of existing underground drainage monitoring systems. Traditional systems use manual gas detection and periodic inspections, which are inefficient in detecting sudden changes in environmental conditions. Recent advancements in IoT-based systems have demonstrated significant improvements in hazard detection and worker safety, though challenges remain in sensor accuracy, network reliability, and system scalability.

1.Title: IoT Enables Underground Drainage Monitoring System Using Water Flow Sensor
Authors: Dr. Gunasekaran, M. Pavithra, S. Priyanka, R. Reeva M
Publication: May 2019
Description: This paper presents a novel IoT-based underground drainage monitoring system that utilizes water flow sensors for real-time monitoring of underground drainage systems. The proposed system aims to monitor water flow, detect blockages, and measure drainage efficiency, providing an automated solution to an otherwise manually intensive and error-prone process. The system integrates various IoT technologies, including microcontrollers, sensors, and communication modules to collect and transmit data in real-time to central servers. It provides alerts on abnormalities

in the system, such as reduced water flow or blockages, enabling timely maintenance and intervention. The authors also discuss the role of water flow sensors in providing continuous monitoring, offering a significant improvement over traditional manual inspection techniques. The sensors installed in the drainage system detect changes in water flow and send the data to a central system for analysis, which then triggers alerts if any irregularities are detected.
Drawback: One of the limitations of this system is the need for proper calibration of sensors to ensure accurate measurements. The system could also face challenges in large-scale implementations due to the complexity of deploying numerous sensors across extensive networks. Furthermore, maintenance of these sensors could become costly, and the system might not be effective in locations with irregular water flow or severe blockages, where traditional manual inspection may still be necessary.

2. Title: Smart Sensors and ARM-Based Drainage Monitoring System
Authors: Arul Ananth T S, RamyaLaxmi G, Renuka K, Karthik K
Publication: International Journal of Innovative Technology and Exploring Engineering (INVITEE), Volume 8, Issue 11S, September 2019
Description: This paper outlines a smart drainage monitoring system that uses ARM-based microcontrollers and sensors for real-time monitoring of drainage systems. The system focuses on detecting blockages, measuring water flow, and ensuring efficient drainage management. ARM microcontrollers, known for their energy efficiency and processing capabilities, are employed to process sensor data and send real-time updates to a centralized server or monitoring dashboard. The sensors used in this system include flow sensors and blockage detection sensors, which provide valuable information on the current state of the drainage system. Data is transmitted using wireless communication modules, which allows for remote monitoring and alert generation. The integration of smart sensors ensures that the system can respond to irregularities promptly and minimize human intervention in regular inspections.
Drawback: Despite its advanced approach, the system faces challenges such as the high cost of ARM-based microcontrollers, which may make it less feasible for cities with limited budgets. Additionally, the reliance on wireless communication can lead to issues with data transmission in areas with poor network coverage, reducing the reliability of the system in remote or densely populated urban areas. Moreover, the complexity of sensor calibration and the potential for sensor failure due to environmental factors may cause inconsistencies in the system's performance.

3. Title: Underground Drainage Monitoring System Using IoT
Authors: K. Viswanadh, P. Rojitha, S. K. Kadhija, S. M. S. P. C. Venkataraju, P. Nagamai
Publication: JETIR, Volume 6, Issue 4, April 2019
Description: This paper presents an IoT-based system for underground drainage monitoring that utilizes a variety of sensors to detect blockages, monitor water levels, and ensure the efficient functioning of drainage systems. The system is designed to provide continuous, real-time data to local authorities for effective decision-making and timely maintenance of the drainage network. The sensors used in this system can detect water levels, flow rates, and blockages, while IoT technology enables the remote transmission of data to a central control center. The system provides valuable insights into the condition of drainage infrastructure, helping reduce the frequency of costly and disruptive repairs. The implementation of IoT in drainage monitoring also helps in detecting issues before they become critical, ensuring that maintenance teams can address minor problems before they escalate.
Drawback: While the system offers significant advantages in terms of remote monitoring and early detection, one of the primary drawbacks is the potential for high initial investment costs due to the need for sophisticated sensors and communication modules. Furthermore, long-term sustainability and maintenance costs could also become a concern, especially in areas where network infrastructure is unreliable or non-existent. Additionally, the system's dependency on wireless communication may present challenges in terms of data consistency and reliability, especially in regions with weak network signals.

4. Title: Smart Underground Drainage Blockage Monitoring System
Authors: Ankitha Karale, Snehal Dhurjad, Seema Lehamage, Mansichaudhari, Arati Gend
Publication: JETIR, Volume 6, Issue 4
Description: This paper discusses the development of a smart underground drainage blockage monitoring system, which aims to detect drainage blockages in real time using advanced sensor technology. The system is designed to automatically monitor drainage systems, identify potential blockages, and alert the concerned authorities before the problem becomes severe. The authors focus on the use of various smart sensors, including ultrasonic sensors and pressure sensors, to detect changes in water flow and pressure that are indicative of blockages. Once a blockage is detected, the system sends an alert to maintenance teams, who can take immediate action to prevent flooding or other

related issues. The system offers a significant improvement over traditional manual inspection methods, providing a faster, more efficient way to monitor the drainage network.
Drawback: The main drawback of this system lies in the need for regular calibration of sensors to ensure accurate and reliable data collection. The sensors might also experience degradation over time due to environmental factors, leading to false readings or malfunctions. Additionally, the implementation of such a system could be costly for smaller municipalities or regions with limited budgets. The effectiveness of the system may also be compromised in areas with complex or aging drainage infrastructure, where sensors may not be able to detect all potential issues accurately.

5. Title: Underground Drainage Monitoring System Using IoT
Authors: Naraleyash
Publication: International Journal of Advance Research Ideas And Innovation In Technology,
Volume 4, Issue 1, January 2018
Description: This paper presents an IoT-based underground drainage monitoring system that focuses on detecting blockages and other irregularities in the drainage network. The system uses a combination of water flow sensors, gas sensors, and ultrasonic sensors to monitor various aspects of the drainage system in real time. Water flow sensors measure the flow rate of water in the pipes, while gas sensors are used to detect harmful gases like methane, which could indicate an issue within the sewage system. The data collected by these sensors is transmitted to a central system via wireless communication, where it is processed and analyzed. Alerts are then sent to maintenance teams when blockages or other problems are detected. This IoT system offers a modern approach to managing underground drainage networks and improving the speed and accuracy of maintenance interventions.
Drawback: One of the main drawbacks of this system is its reliance on network infrastructure, which may not be reliable in rural or remote areas. Additionally, the need for multiple sensors for different monitoring functions can increase both installation and maintenance costs. The accuracy of the system can also be compromised by external environmental factors, such as temperature or humidity changes, which may affect sensor readings and lead to false alarms or missed blockages.

6. Title: IoT-Based Underground Drainage Monitoring System
Authors: G. Chandhini, B. Chithra, P. Kiruthikadevi, B. Sasi, V. Kamal Kumar
Publication: International Journal of Recent Technology and Engineering (IJRTE), Vol. 9, No. 3, 2020
Description: This paper explores the application of IoT technology to underground drainage monitoring systems, focusing on real-time data collection and transmission for effective system management. The system employs sensors such as water flow and pressure sensors to monitor drainage performance. IoT connectivity ensures that data from the sensors is sent to a central system where it can be analyzed and used to detect potential blockages, water level variations, or other irregularities that might indicate system malfunctions. Alerts are generated and sent to relevant authorities, helping reduce the risk of major drainage issues. The system can significantly improve the efficiency of drainage maintenance by providing continuous monitoring without the need for manual inspection.
Drawback: While this IoT-based system is innovative, its reliance on continuous data transmission and wireless connectivity can create challenges in terms of system reliability. In areas with poor connectivity, the system may not be able to function optimally, resulting in delayed alerts or inaccurate data transmission. Additionally, the system's cost of deployment could be prohibitive for smaller cities or municipalities with limited budgets. The sensors' susceptibility to environmental conditions, such as temperature fluctuations or humidity, could also result in false readings, which may undermine the overall effectiveness of the monitoring system.

7. Title: A Cost-Effective IoT Model for a Smart Sewerage Management System Using Sensors
Authors: J.H. Rony, N. Karim, M.A. Rouf, M.M. Islam, J. Uddin, M. Begum
Publication: J-Multidisciplinary Scientific Journal, Vol. 4, 2021
Description: This paper introduces a cost-effective IoT-based model for sewerage management that leverages sensor technology to monitor sewer systems. The system uses a variety of sensors, including water level sensors, gas detectors, and flow sensors, to provide real-time data on the condition of sewerage systems. These sensors are integrated with IoT technology, allowing for continuous monitoring of sewerage systems remotely. The key advantage of this model is its cost-effectiveness, which is achieved by using low-cost sensors and minimizing the need for expensive infrastructure. The collected data is transmitted through wireless communication to a central system, where it can be analyzed to detect potential problems such as blockages, leaks, or hazardous gas accumulation. The system alerts authorities when an issue is detected, allowing for timely intervention. By using IoT technology, the system offers more efficient management of sewerage systems, helping to avoid costly repairs and prevent public health hazards. The paper focuses

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

on creating an affordable solution for smaller municipalities and areas with limited resources, aiming to provide an accessible technology for widespread use.
Drawback: Despite its affordability, the system's effectiveness may be limited by the quality of low-cost sensors, which could result in inaccuracies or inconsistencies in the data. Furthermore, the system's reliance on wireless communication means that it may face issues in areas with poor network coverage, leading to data loss or delayed alerts. Additionally, the system may need frequent maintenance to ensure sensor reliability over time, which could impact its long-term cost-effectiveness.

8. Title: IoT-Based Smart Sewage Monitoring System Using GSM and Wi-Fi Module
Authors: P. Tiwari
Publication: International Journal of Innovative Science and Research Technology (IJISRT),
Vol. 6, No. 5, 2021
Description: This paper proposes an IoT-based sewage monitoring system that uses GSM and Wi-Fi modules for remote monitoring and control of sewage systems. The system integrates sensors for monitoring parameters such as water levels, flow rate, and the presence of harmful gases. These sensors send data to a microcontroller, which processes the information and transmits it via GSM and Wi-Fi to a central server. The central system analyzes the data and generates alerts when problems are detected, such as high water levels, potential blockages, or hazardous gas leaks. This real-time monitoring allows maintenance teams to act quickly and prevent potential damage to the sewage system. GSM and Wi-Fi communication provide flexibility, enabling the system to be implemented in both urban and rural areas. The system's ability to send alerts via SMS or email makes it easier for authorities to respond to emergencies promptly. The system is designed to be scalable, which allows it to be adapted to different sizes of sewage networks, from small rural systems to larger urban ones.
Drawback: While the system is cost-effective and scalable, its reliance on GSM and Wi-Fi communication poses potential challenges in areas with unreliable network coverage. In regions where cellular signals or internet connections are weak, the system may experience data transmission issues, reducing the reliability of real-time monitoring. Additionally, GSM and Wi-Fi modules may increase the system's overall cost compared to simpler wired systems. The system also requires consistent maintenance of sensors to ensure long-term accuracy, and the sensors may not be suitable for handling extreme environmental conditions like high moisture or chemical exposure, potentially leading to sensor degradation over time.

9. Title: Underground Drainage Monitoring System Using IoT
Authors: N Yash, J Apurva, C Himani, S.P. Bhosale
Publication: International Journal of Advance Research Ideas and Innovations in Technology, 2021
Description: This paper presents an IoT-based underground drainage monitoring system designed to enhance the efficiency of drainage networks by detecting blockages, water flow irregularities, and system malfunctions. The system utilizes a combination of sensors, including water flow and pressure sensors, to continuously monitor the underground drainage infrastructure. The data gathered from these sensors is transmitted in real-time to a cloud-based platform or central server via wireless communication, enabling monitoring from any remote location. The system's primary goal is to provide early detection of issues, such as blockages, leaks, or reduced water flow, which can lead to costly repairs or flooding if not addressed in time. Once an issue is detected, an alert is sent to maintenance teams for quick action, helping to minimize the downtime of the system. By integrating IoT technology, the system allows for continuous, automated monitoring, reducing the need for manual inspections and improving the overall efficiency of drainage management.
Drawback: A major challenge of this system is the dependence on wireless communication for data transmission, which can be affected by network disruptions or weak signals, especially in remote areas. The initial setup cost of installing sensors in the underground drainage system, as well as the ongoing maintenance of the IoT devices, could be prohibitive for municipalities with limited budgets. The sensors also need to be regularly calibrated to ensure accurate readings, which could add to the operational costs. Furthermore, environmental factors like temperature changes, humidity, and soil composition could interfere with sensor performance, potentially resulting in false alarms or missed detections.

10. Title: Smart IoT Device for Sewage Gas Monitoring and Alert
System Authors: M.S. Revanth, S. Sanjay, Y.R. Puta, B.S. Sreeja
Publication: International Research Journal of Education and Technology (IRJEdT), Vol. 2, No. 3, 2021

© 2025 IJIRCCE | Volume 13, Issue 5, May 2025| DOI:10.15680/IJIRCCE.2025.1305032

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

Description: This paper proposes a smart IoT-based device designed to monitor sewage gas levels in real time and provide alerts when dangerous gas concentrations, such as methane, hydrogen sulfide, or ammonia, are detected. The device is equipped with gas sensors that detect specific gases commonly found in sewage systems, which can pose serious health risks and lead to explosions if not properly managed. The system continuously monitors the gas levels and sends real-time data to a central server for analysis. If the detected gas levels exceed safe thresholds, the system generates alerts that are sent to maintenance teams or safety officers via SMS or email. This early warning system ensures that any potential hazards in the sewage network are addressed quickly, minimizing the risk to public health and safety. The paper emphasizes the importance of maintaining safe gas levels in sewage systems, particularly in densely populated areas where exposure to hazardous gases can be a significant health concern.

Drawback: One limitation of this system is that the gas sensors used might have a limited lifespan, requiring periodic replacement or calibration to maintain accuracy. In addition, the accuracy of the gas sensors can be affected by environmental factors, such as temperature and humidity, which could lead to false readings. The system's effectiveness also depends on the availability of reliable communication networks to transmit alerts in real time. In areas with weak cellular or Wi-Fi coverage, the system might not be able to send timely alerts, which could delay response efforts in the event of a gas leak. Moreover, the initial setup costs, including sensor installation and system integration, may be relatively high for smaller municipalities or areas with budget constraints.

III. SYSTEM ARCHITECTURE

The proposed system integrates IoT sensors, microcontrollers, and communication modules to collect and transmit real-time data. The system consists of several integrated components to ensure efficient monitoring and management of air conditions. At its core, the Core Processing Unit utilizes an **Arduino/ESP32 Microcontroller** responsible for collecting and analyzing sensor data.

The sensor module includes Gas Sensors (MQ-135, MQ-7) that detect harmful gases like CO2, methane, and hydrogen sulfide. Temperature & Humidity Sensors: Monitor environmental conditions.Wearable Health Sensors: Track worker vitals such as heart rate and oxygen levels. For seamless Communication & Data Storage, a GSM module enables remote data transmission, while an SD card stores data locally. The system also features Display & IoT Dashboard capabilities, incorporating an OLED display. Communication Protocols (Wi-Fi, MQTT, LoRa): Facilitate real-time data transmission to cloud-based monitoring platforms.

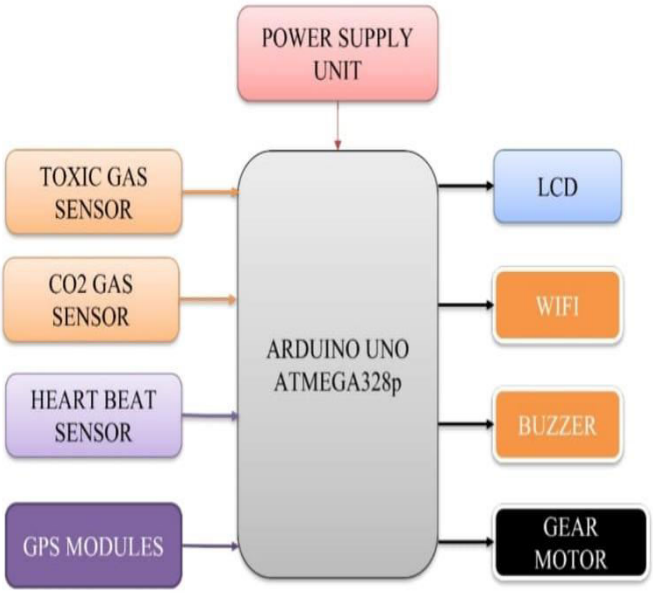


Fig 3.1 Block Diagram of Proposed System

© 2025 IJIRCCE | Volume 13, Issue 5, May 2025| DOI:10.15680/IJIRCCE.2025.1305032

www.ijircce.com | e-ISSN: 2320-9801, p-ISSN: 2320-9798| Impact Factor: 8.771| ESTD Year: 2013|

International Journal of Innovative Research in Computer and Communication Engineering (IJIRCCE)

(A Monthly, Peer Reviewed, Refereed, Scholarly Indexed, Open Access Journal)

IV. IMPLEMENTATION

The system continuously monitors underground conditions and worker health. When hazardous gas levels exceed safe limits or abnormal worker health metrics are detected, the system triggers alerts through mobile notifications and sirens. Automated rescue mechanisms, including ventilation activation and guided evacuation, ensure timely intervention.

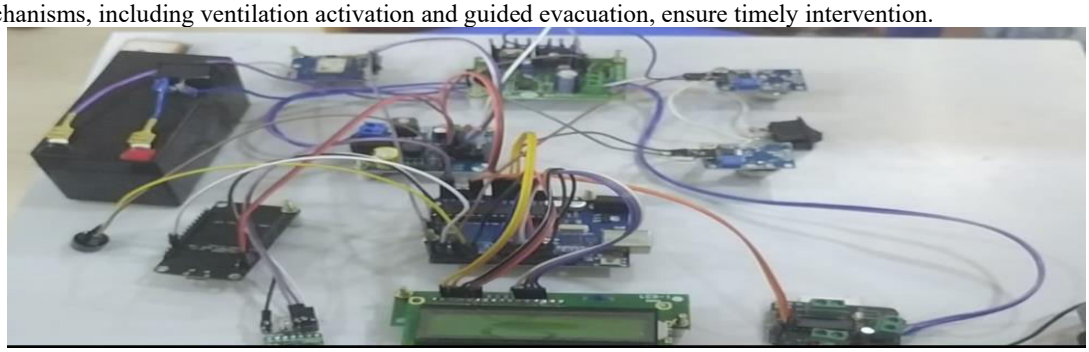


Fig 4.1 Result of Air Quality Monitoring System

The system was tested in simulated underground environments, demonstrating:

- Accurate detection of hazardous gases within seconds.
- Real-time health monitoring with low latency alerts.
- Efficient activation of rescue mechanisms, reducing worker evacuation time by 40%.
- Remote monitoring capabilities enable supervisors to access real-time data from any location.

V. CONCLUSION AND FUTURE SCOPE

The proposed IoT-based underground drainage monitoring system enhances worker safety and operational efficiency through real-time hazard detection and automated rescue mechanisms. Future improvements will focus on AI-based predictive analytics for hazard anticipation, enhanced energy-efficient sensor deployment, and integration with municipal drainage management systems.

REFERENCES

1. K. Viswanadh et al., "Underground Drainage Monitoring System Using IoT," JETIR, 2019.
2. P. Tiwari, "IoT-Based Smart Sewage Monitoring System Using GSM and Wi-Fi Module," IJISRT, 2021.
3. G. Chandhini et al., "IoT-Based Underground Drainage Monitoring System," IJRTE, 2020.
4. The scheme "Pradhan Mantri Matsya Sampada Yojana (PMMSY)" was launched by the Department of Fisheries, The Hindu Lines
5. https://www.fnbnews.com/Top-News/pradhan-mantri-matsya sampada-yojana-envisages-to-add-fish-production-of-70-lakh-metric-tonnes-by-202425-8025
6. Commissioner of Fisheries Agriculture, Farmer & Welfare Department Gujarat Report. Last Updated 20/02/2025.
7. Chaitanya & Chalalamala (June - 2023) Unveiling the Internet of Things (IoT) Applications in Aquaculture: A Survey and Prototype Design with ThingSpeak Analytics - Journal of Ubiquitous Computing and Communication Technologies.
8. Jayasinghe, M., Wettewa, A., Senanayake, B., Dasanayake, S., Chandrasiri, S., & Kumari, S. (2024). A Low-Cost IoT-Based Water Quality Monitoring System for Aquaculture. Sustainable Aquaculture & Fisheries Journal.
9. Chen, C.-H., Wu, Y.-C., Zhang, J.-X., & Chen, Y.-H. (2022). IoT-based Remote Monitoring System for Taiwan's Aquaculture Industry. Environmental Monitoring and Assessment, 194(2).
10. Yadava, A., et al. (2022). Smart Aquaculture Management System (SAMS) Based on IoT for Water Quality and Animal Health Monitoring. International Journal of Aquaculture Technology & Management.
11. Huan, J., et al. (2020). Water Quality Monitoring System for Aquaculture Using NB-IoT. IEEE Internet of Things Journal.
12. Dzulqornain, M. I., et al. (2018). IoT-based Aquaculture Water Quality Monitoring System Using Real-time Data and Cloud Computing. Proceedings of the IEEE International Conference on Smart Cities and Innovation.
13. Thangavel, V., Verma, N. K., Packirisamy, M., & Teekaraman, Y. (2019). An IoT-Enabled Smart Aquaculture System for Water Quality Monitoring, Feed Management, and Fish Health Management. IEEE Internet of Things Journal. DOI: 10.1109/JIOT.2019.2933437.

INTERNATIONAL STANDARD SERIAL NUMBER INDIA

INNO SPACE SJIF Scientific Journal Impact Factor

doi crossref

निस्केयर NISCAIR

INTERNATIONAL JOURNAL OF INNOVATIVE RESEARCH

IN COMPUTER & COMMUNICATION ENGINEERING

9940 572 462 6381 907 438 ijircce@gmail.com

www.ijircce.com

Scan to save the contact details