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Hybrid Sensor Based Drainage Monitoring Systemwith automated alert mechanism for local community networks

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Abstract— The drainage system has been facing issues like accumulated garbage, water logging, foul smell, and flooding in heavy rains resulting in environmental hazards and unusable roads. In this way, toxic gases like nitrogen (N_2), hydrogen sulphide (H_2S), and methane (CH_4) can escape, endangering not only sanitation workers but also general public. Traditional manual monitoring processes are not efficient, laborious and dangerous. In order to mitigate these problems, an IoT-based smart drainage monitoring system is suggested. This system uses water level and gas sensors that constantly monitors the drainage conditions. Real time web or mobile dashboards provide access to the data collected which is transferred to a cloud platform. When abnormal conditions such as hazardous water or toxic gas presence are detected, alerts can be automatically generated. And an alarm system gives real time local alerts. It adds cleanliness, prevents overflow, and is the most economical approach known for both municipal and household drainage systems.

Keywords—IoT, smart drainage monitoring, water level detection, optical sensor, electrical resistivity sensor, methane (CH_4), nitrogen (N_2), hydrogen sulphide (H_2S), gas leak detection, cloud communication, real-time warnings, worker safety, and local drainage networks.

I. INTRODUCTION

Urban drainage and sewerage systems are crucial for environmental safety and community sanitation. Recent studies highlight the application of Internet of Things (IoT) technologies for drainage network monitoring, blockage detection, and water overflow prevention. They provide real-time alerts for maintenance personnel, which reduces health risks and allows for less manual inspection [1]. Common sensors for the water level is ultrasonic and float sensors, depending on your preference to which method would suit your project [2].

Also, sophisticated IoT-based methods surveil sewage quality and the status of manholes, award in comparison with soft sensor models. The integration of cloud notifications with real-time clog detection facilitates quick response by municipalities, mitigating sanitation and flooding problems [5]. Continuous monitoring of drainage flow and issuing alerts under abnormal conditions are also supported by cloud-based frameworks [6–7].

Additionally, integrated IoT systems use multiple sensors and automated alerts to monitor increasing levels of water and detection of drain blockage accurately [8–9]. Others more recently are adding on capabilities to be able to monitor flood-prone areas, detect dust particles in the air for better urban hygiene and use data analytics for actual smart city management. These systems also allow for real-time monitoring of underground drainage pipelines, assisting in flow disturbance detection and sewage management continuity [10–15]

To overcome these challenges, the project titled *"IoT-Based Smart Drainage Monitoring System Using Pressure and Optical Sensors"* presents an intelligent solution for continuous drainage monitoring. It employs pressure and optical sensors to track key parameters and detect irregularities in real time. The sensed data is transmitted to a cloud platform, enabling remote monitoring and instant alert generation. This system facilitates early fault detection, minimizes the risk of system failure, and reduces dependence on manual inspection. Consequently, it improves safety, enhances operational efficiency, and ensures effective and reliable drainage management.

A. Overview

Traditional drainage monitoring systems rely on reactive maintenance approaches and manual inspections which are inefficient and can be time-consuming. More advanced IoT-

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integrated systems allow for constant monitoring of drainage networks and detection of problems in their early stages. These systems do not only mitigate the risk of urban flood but also, helps to provide early notification which increases public safety [16]. IoT sensors are employed to monitor water levels and detect anomalies in occurrence time [17]. Moreover, these types of systems provide data-driven analysis, improved operational efficiency and early warning in flood-affected regions [18–24].

Whenever abnormal conditions are detected, the data is collected and meaningful analysis made directly to the cloud platform. Alerts are automatically deduced and send to the relevant authorities for further unequivocal actions. This reduces human involved, enables quicker reaction, and increases the efficiency and safety of drainage operation and management.

B. *Background and Development of Drainage Monitoring Systems*

Previously, drainage surveillance was solely based on manual inspections that put workers in dangerous locations and exposed them to toxic gases. Then came the basic electronic systems full of level sensors, but they could only crudely tell if you had a blockage or not. Modern systems offer real-time monitoring with better accuracy and reliability thanks to the advancements of IoT, cloud computing, and sensor technologies.

This proposed system using Gas Sensors, Pressure Sensors, Optical Level Sensor and Cloud based availability of Alert Mechanism will enable safe discharge of waste from drainage systems microbial growth in drain channels.

II. LITERATURE REVIEW

In a related study, Ananthu N. K. discusses an IoT Based Manhole Detection and Monitoring System that measures temperature, gas mass and water level in traditional manholes using a set of sensors with cloud-based monitoring [1].

Another work titled Drainage Blockage Monitoring and Detection System based on IoT by P. V. Kashid utilises vibration and ultrasonic sensors for cloud notification as well as blockage detection, but such devices accompanied by vibrations can give false alarms [2].

By leveraging gas and ultrasonic sensors to detect dangerous gasses and high-water levels, E. Kiruthika has developed an IoT-Enabled Smart Drainage Monitoring System that protects sanitation workers from staying in the sewer for long hours. But, the calibration of the sensors and other environmental factors can affect their performance [3].

In another study, Ruo Zhou Lin, in their paper A Low-Cost Soft Sensor for sewage Flow Monitoring — Learning from Water Level Measurements in Manholes proposed a machine learning based soft-sensor model to predict the sewage flow using water level observations. Although it reduces the hardware cost, accuracy relies on high quality training data [4].

Several researchers have proposed IoT-enabled technologies for monitoring drainage and sewer networks. Nour Faris and Tarek Zayed's IoT-based Real-Time Detection System for Sanitary Sewage Blockages is a monitoring system that uses 4G telemetry along with waterlevel sensors, to detect obstructions in sewage, and notify the maintenance workers. However, it consumes additional electricity and focuses solely on measuring the level of water [14].

A. *Literature Overview*

A wide range of IoT-based solutions to monitor sewer and drainage networks have been developed by different researchers In research such as IoT based Real time Sanitary Sewer Blockage Detection System with a Sensor,26 and Monitoring of drainage using IoT sensors,27 the devices record water levels and harmful gasses being released in sewage systems providing live alerts to workers. A different approach, A Low-Cost Soft Sensor for sewage Flow Monitoring — Learning from Water Level Measurements in Manholes, uses machine-learning models trained on water-level measurements to predict sewage flow. The Drainage Blockage Inspection and Detection System and the IoT-Based Manhole Screening and Monitoring system are two such technologies that use various kinds of sensors to track drainage states and identify obstacles. While these systems help to foster monitoring and eliminate manual inspection, issues with sensor accuracy, power consumption as well as an ecological impact, and system complexity still persist.

III. EXISTING SYSTEM

The Journal of Remote Sensing and GIS published a paper on 2025, titled " IoT-Based Manhole Detection and Monitoring System", presenting a smart system for monitoring drainage and manholes. The temperature, gas and water level sensors in the system used are designed to locate overflows and dangerous gases within manholes. In the case of location driven monitoring, sensor data is collected by a microcontroller and sent to a cloud server using IoT connectivity for visualization in a GIS-based dashboard [1]. It sends alerts in real-time, enhances worker safety, and cuts down on manual checks. However, its reliance on threshold-based sensing is to formulate more robust features for monitoring and complex analytic algorithm.

A. *For Existing System Used Components*

The sewage level in a manhole is measured by the water level sensor. It assists recognizing overflow or blockage problems by continuously sending the level data to controller. It is easy to install and good for real-time spotting, but debris can damage its accuracy, and it can't identify exactly where the hindrance is [1]. Gas sensors (CH_4, H_2S, CO_2) are used to make systematic gas sensing current aware of harmful gases from the regular drainage system. These devices improve safety by detecting hazardous gases in real time. However, they are sensitive to changes in temperature and humidity and require periodic calibration [2]. Microcontroller (Arduino or ESP) collects and processes sensor data, makes warnings and communication."""" It is inexpensive, simple to program, but its processing capacity is limited and can require extra communication modules. For remote monitoring IoT Communication Modules (GSM, Wi-Fi, and LoRa) transfer

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sensor data wirelessly to cloud server. They enable long-distance communication, an aspect that is dependent on network coverage and may encounter signal problems in basement zones. The cloud server stores and decodes sensor data, displaying the position and status of the drainage on a web dashboard. While it does require continuous internet connectivity, this allows to monitor and decide better.

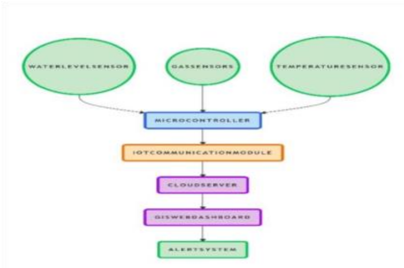

Fig. 1. Block diagram of Existing System [1]

B. *Why Improvement is Needed*

Despite the existing method being capable of real-time monitoring and imaging, the current system lacks appropriate blockage detection and cannot be reasonably afforded for small drainage networks. Because of this deficit, there is a need for an improved system with pressure-based detection and more safety features that can help address scalability issues while being reasonably placed.

IV. Proposed System

The Hybrid Sensor-Based Smart Drainage Monitoring System with Automated Alert Mechanism is intended to keep an eye on drainage conditions and identify harmful gas build up, overflow, and blockages. Conventional drainage inspection is labour-intensive, manual, and dangerous for workers since it exposes them to dangerous gasses. The system uses cloud monitoring and sensors linked to an ESP32 microcontroller to address this issue. While a flow meter measures water flow to identify obstructions, water level sensors identify overflow. Methane and hydrogen gasses are monitored for safety using gas sensors like the MQ4 Gas Sensor and MQ8 Gas Sensor. When anomalous conditions arise, the controller analyses the sensor data and sends out alarms via an LED, buzzer, and cloud notifications.

A. *Overall System Architecture*

This term refers to the system configuration.

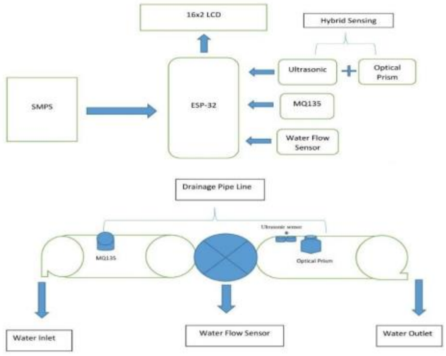

Fig. 2. System Architecture

B. *Working Notion of Proposed System*

This term describes the operation of the proposed system. The proposed system's layout is continually keeping track of the drainage conditions by sensing the water level, flow, and the gas concentration using the sensors that are linked to the ESP32 microcontroller. The gathered data from the sensors are utilized by the controller to evaluate the conditions periodically. While the levels remain normal, the system will continue to monitor them. However, if the water level increases, the flow indicator diminishes or the gas concentration rises above the provided threshold, the controller activates an LED with the help of the buzzer as a warning. Also, it sends data to the cloud using Wi-Fi, on LCD is displayed. This automatic tracking and warning systems allow the pertinent authority to identify the overflow, the road blockages, or the gas threat and to respond on the spot.

C. *Sensor Caluculations*

1. Ultrasonic Sensor (Water Level Calculation)

Distance Measurement

d=v×t2d Where:

- d = distance (cm)
- v= speed of sound (≈ 0.034 cm/μs)
- t= time duration (μs) In code:

distance = duration * 0.034 / 2

Water Level Calculation

Level = H−d

Where:

- H = total height of tank (cm)
- d = measured distance

Percentage Calculation

%Level = H−d/H×100

2. Water Flow Sensor (Flow Rate)

Flow Rate Formula

Flow Rate=Pulse Count/K

Where:

- Pulse Count = number of pulses per second
- K=7.5 (calibration factor for YF-S201)

In code:

flow Rate = pulse Count / 7.5;

Volume Calculation

Volume=Flow Rate× Time

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3. MQ2 Gas Sensor

Analog Voltage Conversion

$$V = ADC/4095 \times 3.3V$$

Where:

- ADC = analog value (0–4095 for ESP32)
- 3.3V = reference voltage

Gas Detection Logic

- If:

Gas Value > Threshold

→ Gas detected

Example:

if (gas Value > 2000)

4. Optical Sensor (Digital Detection)

Logic Equation

Output = 1, Water Present; Output = 0, No water

- 1 (HIGH) → Water reached sensor
- 0 (LOW) → No water

Schematic Diagram:

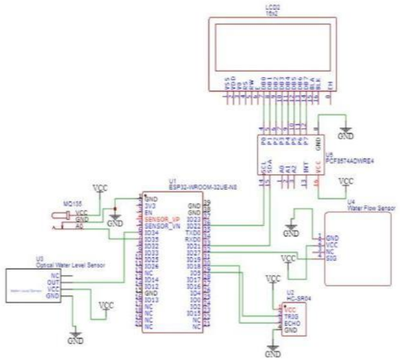

Fig. 3. Schematic Diagram

D. Flow chart

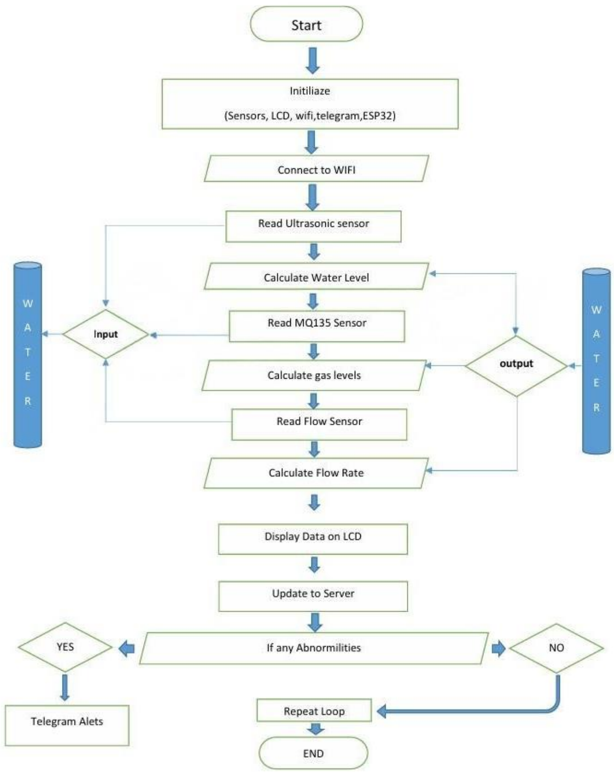

Fig. 4. Flow chart of Proposed System

V. Results And Discussion

Comparision Table

a) Previous data Comparisons: The below table describes about the inventions which are done before consists of which sensors employed and what are the limitations they consists about.

Table I. comparision table

Paper	Sensor Data		
	Sensor Used	Main Idea	Limitation
[14]	Water level sensor,4G communication	Detects sewer blockage and sends real-time alerts	High power consumpt ion and limited sensing parameters
[4]	Water level data machine learning model	Estimates sewer flow using a low-cost soft sensor	Depends on good training data
[3]	Ultrasonic sensor, gas sensor,GPS	Monitors drainage level and hazardous gases	Affected by environmental condition

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[1]	Water level gas, temperature sensor	Monitors manhole condition using IoT and cloud dashboard	Complex deployment and sensor durability issues
Proposed System	Multiple hybrid sensor	Smart drainage monitoring	Maintenance needed

TABLE II. HYBRID SENSOR (ULTRASONIC + OPTICAL)

Distance (cm)	Water Level (cm)	Level (%)	Optical Sensor	Condition	System Interpretation
9.0	0.0	0%	LOW	No Water	Drain empty
7.5	1.5	16%	LOW	Low Level	Normal condition
6.0	3.0	33%	LOW	Medium Level	Normal condition
4.5	4.5	50%	LOW	Half Level	Stable flow
3.0	6.0	66%	LOW	High Level	Monitorin g required
2.0	7.0	77%	LOW	Very High	Near critical
1.5	7.5	83%	LOW	Near Max	Warning stage
1.0	8.0	88%	HIGH	Max Level	Alert triggered
0.8	8.2	91%	HIGH	Critical	Overflow risk
0.5	8.5	94%	HIGH	Overflow	Emergenc y alert

Fig. 4. Water level in LCD (Level)

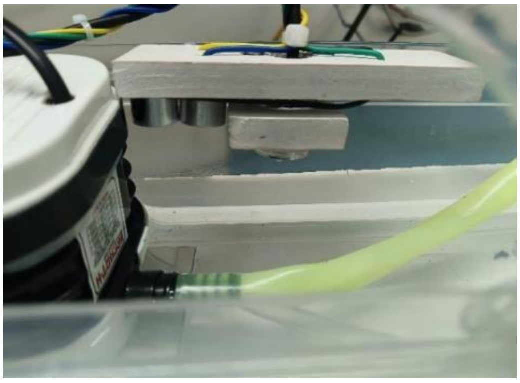

Fig. 5. Physical view of water level

TABLE III. GAS SENSOR (MQ2) READINGS

Gas Value (ADC)	Condition	Alert
500 – 1000	Normal	No Alert
1000 – 1800	Moderate	Warning
> 2000	High Gas	Alert Triggered

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Fig. 6. Gas sensor Readings(G)

TABLE IV. WATER FLOW SENSOR RESULTS

Pulse Count/sec	Flow Rate (L/min)	Condition
0 – 5	< 1.0	No Flow / Blockage
10 – 20	1.5 – 2.5	Low Flow
30 – 50	4.0 – 6.5	Normal Flow

Fig. 6. Water Flow readings (F)

TABLE V. SYSTEM ALERT CONDITIONS

Condition	Sensor Input	System Response
No Water	Level < 5%	Display "NO WATER"
Max Level	Optical = HIGH	Water Level above 90%
Overflow	Optical HIGH + Level > 95%	Overflow detected
Gas Detection	Gas > 2000	Toxic Gas detected
Blockage	Flow < 1 L/min & Water Present	Drainage blockage!

Fig. 7. Telegram Alerts

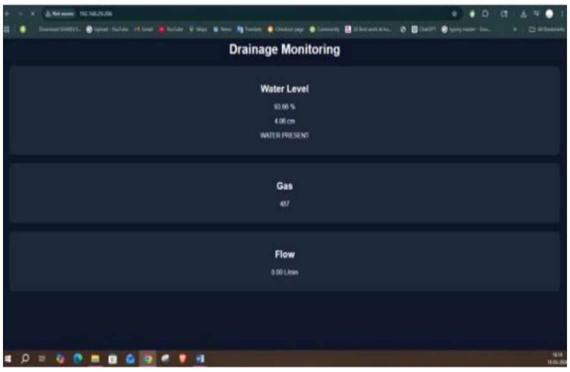

Fig. 8. Web Monitoring

Graph (Hybrid Sensor):

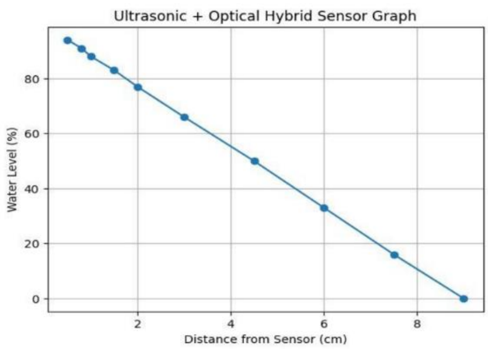

Fig. 9. Graph representing Hybrid Sensor

Graph (MQ135):

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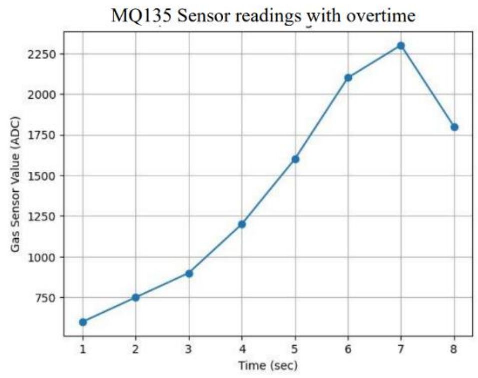

Fig. 10. Graph representing MQ135 sensor

Graph (Water Flow sensor):

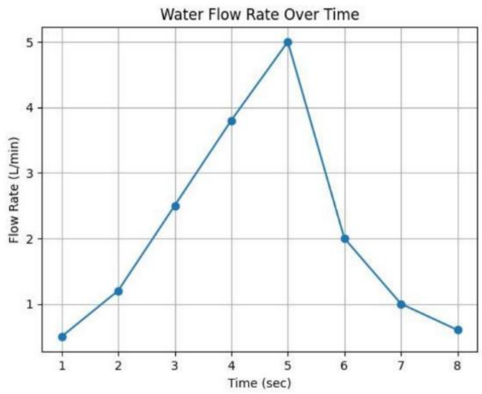

Fig. 11. Graph showing performance of Water flow sensor

VI. CONCLUSION

The developed ESP32-based Drainage Monitoring System had been successfully designed and implemented to provide online real-time monitoring of different drainage conditions. The system successfully coordinates with numerous sensors, including an ultrasonic sensor for continuous calculation of the water level in addition to an optical liquid level detector for maximum level detection, a MQ135 gas sensor for hazardous gas identification, and a water flow meter for measurement of flow rate and obstruction detection. The combination of threshold-based detection and continuous measure in a hybrid sensing method enhances system reliability. While it also hosts a web server for access over the air, the ESP32 handles all sensor data and displays it on a 16x2 LCD locally. To redirect, Telegram alerts are integrated for rapid contact in key situations like narrow flow, overflow, and gas detection.

The results demonstrate the system's capacity for accurate monitoring of drainage indicators and real-time response to anomalous conditions. In conclusion, the proposed approach offers a scalable, affordable, and efficient smart sewer management solution that alleviated manual labour and improved safety.

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