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WIRELESS SENSOR NETWORK BASED HARAZADOUS GAS DETECTION IN SEWAGE LINE USING SMART IOT

***A Surya Shashank*[1], *Yogesh Kumar*[2], *Aashish Kumar Yadav*[3], *Sarvamangala A.N.*[4], *Bobby Sharma*[5]**

[1,2,3]*UG Student, Department of Electronics & Telecommunication Engineering, CEC Bilaspur, Chhattisgarh, India*
[4,5]*Assistant Professor, Department of Electronics & Telecommunication Engineering, CEC Bilaspur, Chhattisgarh, India*

Abstract: Living in an environment that is clean and healthy is a right for everyone. Industrialization and development have made life easier for men, but it has also created many dangers and pollutants. Most cities have adopted an underground sewage system, and it is essential that this system functions properly to maintain the cleanliness, safety and health of the city. Underground sanitation workers face various risks, such as toxic gas explosions and sudden changes in health due to changes in the underground environment. Many underground sanitation workers die annually because of the release of toxic gases and the lack of available facilities. Leaks and bursts are inevitable and can lead to the death of sanitation workers if they are not noticed for a long time.

The goal of the proposed system is to improve the safety and effectiveness of sewage treatment by early detection and warning of hazardous gases like methane, hydrogen sulphide, etc. which are a major threat to human health and environment. The system uses WSNs and strategically deploys sensor nodes along the sewage line for continuous monitoring of gas concentrations. The sensor nodes have gas sensors that detect specific gases, microcontrollers to process the data, and wireless communication module to send real-time information to the central control unit (CCU). The CCU, using smart Internet of Things (IoT) technologies and algorithms, collects and analyzes incoming data to detect potential gas leaks or anomalies.

In addition, the system includes intelligent decision-making capabilities that trigger timely notifications and alerts to relevant stakeholders, allowing for immediate response actions to reduce risks and avoid potential hazards. The integration of IoT allows for remote monitoring and control functions, allowing for proactive maintenance and optimization of the sewage infrastructure.

***Index Terms* – Central Control Unit, Node MCU, IoT, Sensor, Smart City, Alert System, Sanitation Worker, toxics gases, Human Safety.**

I. INTRODUCTION

The concept of Internet of things (IOT) is on the urge in today's world. The IoT applications are enabling Smart City initiatives worldwide. It provides the ability to remotely monitor, manage and control devices, and to create new insights and actionable information from massive streams of real-time data. Sensors are making already smart cities even smarter.

The sewage system is an underground system used to transport waste water and solid waste from homes and businesses to treatment facilities or natural water bodies. Manual scavenging is a common form of sanitation work in India. Sewer manholes are crucial for accessing underground waste water and solid waste. Workers in these manholes face health hazards like gas poisoning and sudden health problems due to temperature and air quality. Lack of proper monitoring and early detection of hazardous conditions can lead to deaths and diseases.

The municipal corporation or other relevant authority is unaware of what is occurring within the drainage system or sewage and what kind of harmful gases have developed there. Because of this, the sewage cleaner's life will also be in jeopardy due to incomplete information. Although they have detrimental effects on health, toxic gases are also widely used in industry. These gases need to be observed so that any rise above their typical levels can be identified and appropriate safety measures can be implemented. It will interfere with the safety precautions. Therefore, a suitable system that is affordable, offers adequate monitoring and alerting, and ensures safety is still required.

The existing systems available are not so portable and are costly and difficult to implement. Our suggested system uses a node MCU controller, several gas sensors, and an efficient IOT platform to notify the relevant authority via a cloud server. The system will guarantee both sewage cleaner and public safety.

II. PROBLEM STATEMENT:

In response to inquiries from MPs Abdul Wahab, Kirodi Lal Meena, and Raghav Chadha, the MINISTER OF STATE FOR SOCIAL JUSTICE AND EMPOWERMENT "Ramdas Athawale" informed the parliament that 308 people had perished in India during the last five years (2018 to 2022).

Activists contend that the real cost is far higher. The Safai Karma Chari Andolan (SKA), a human rights organization advocating for the elimination of manual sewage cleaning, reports that thousands of people suffer crippling injuries, including broken limbs, and that over 2,000 people pass away every year.

According to Athawale, throughout the previous five years, the government gave the families of 240 victims full compensation. Additionally, at least 225 FIRs were filed under the SC/ST (prevention of atrocities) act and the manual scavenging act of the 308 deaths, analysis of the data presented before parliament showed that more over 65% of the cases were reported in Uttar Pradesh, Delhi, Haryana, Tennessee, and Maharashtra.

However, on April 30, 2023, 11 individuals, including three youngsters, passed away in Ludhiana's Giaspura. "High levels of hydrogen sulphide (H2S) were detected, according to reports from the NDRF."

Therefore, the purpose of this project is to create a central control Unit that is linked to a small device that can monitor the presence of hazardous gases while a worker is on the job site or not. This will allow the supervisor or other people present outside the septic tank or sewer to receive an alert or notification when the atmosphere inside the tank becomes unsuitable for entry or work. It has the potential to save many workers' lives and enable them to have happy, healthy lives free from health complication.

III. CHALLENGES OF TOXICS GASES IN HUMAN HEALTH

Health challenges faced by sewage workers are multifaceted and pose significant risks to their well-being. Respiratory problems are pervasive in this occupational group, primarily stemming from exposure to endotoxins and airborne bacteria carried by bio-aerosols present in sewage. The continuous contact with various occupational agents can lead to chronic changes in lung function, making respiratory issues a prevalent concern among sewage workers. Additionally, dermatitis has been identified as a prevalent issue among those engaged in incineration work within sewage treatment facilities.

Infections represent another substantial risk, with sewage workers being vulnerable to diseases such as leptospirosis, hepatitis, and Helicobacter pylori. Leptospirosis, often transmitted through contact with contaminated water, poses a significant threat due to the nature of sewage work. Furthermore, the risk of intestinal parasitic infections is heightened, as workers come into contact with raw sewage that may harbour various pathogens.

Gastrointestinal issues are also a common health challenge, with workers susceptible to gastroenteritis and Pontiac Fever. The exposure to harmful microorganisms in sewage can lead to acute gastrointestinal distress, further emphasizing the need for comprehensive health and safety measures within this profession. As sewage workers play a vital role in maintaining sanitation and public health, addressing these health challenges becomes crucial not only for their well-being but also for the overall effectiveness and sustainability of sewage management systems. Implementing robust safety protocols, providing appropriate protective gear, and offering regular health screenings are essential steps in safeguarding the health of these frontline workers who contribute significantly to public health infrastructure.

Fig. Harmful effect of toxic gases in human health

IV. LITERATURE SURVEY:

In their work "Smart Real Time Drainage Monitoring System Using Iot" (April 2022), Hemamalini M. and Puvaneshwari S. suggested designing an intelligent drainage system with sensors to identify obstructions, floods, and gasses. It senses dangerous gases like methane (CH4), sulfur dioxide (SO2), and carbon monoxide (CO) and produces alarms when gas levels surpass threshold values. It also attempts to identify blockages and provide location data for action. The system ensures a healthy environment and prevents waterborne infections by using Wireless Sensor Networking (WSN) technology to send sensor data to a cloud for real-time monitoring.

In his 2021 paper "Smart Drainage Monitoring and Controlling System Using IoT," Tushar Pathak suggests automating the maintenance of urban subsurface drainage systems through the use of IoT in a smart drainage monitoring and controlling system. Its objective is to continuously monitor air temperature, hazardous gas concentrations, water flow rates, obstructions, and water levels. The drainage system's clogs can be automatically cleared by the system, which is designed to detect blockages and overflow. Cleaner cities, smarter drainage management, real-time environmental condition updates, and an affordable infrastructure management solution are among the goals.

"Smart Real-Time Sewage Monitoring System Using Iot," Rakesh varshan S. (2022). The study suggests an Internet of Things-based Smart Real-Time Sewage Monitoring System with the goal of tracking and resolving issues with sewage outlet systems, especially blockages that may cause overflows. The system makes use of a number of sensors, such as door magnetic sensors for automatic lid closure, ultrasonic sensors to locate obstructions, and gas sensors to monitor gas levels and leaks. These sensors wirelessly transmit data to a server or client for prompt action via an Arduino Uno ATmega328P chip. The system's low cost, ease of maintenance, and ability to send emails or messages when thresholds are exceeded make it ideal for improving sewage management and lowering the risk to manual scavengers.

"Case Study Of Smart Real-Time Drainage Monitoring System," by Rohit Shende (2020). The study suggests a clever, real-time drainage monitoring system for large cities that makes use of Wireless Sensor Networks (WSN). It looks for rising water levels, dangerous gasses, and obstructions between manholes. The system consists of modules with NRF for communication, flow sensors, gas sensors, and Arduino microcontrollers. This configuration enhances worker safety and system maintenance by giving authorities access to real-time information so they can respond promptly.

Aditya Patel, "IoT-Based Drainage Monitoring System" (2020). The study uses an interconnected web of several sensors to provide a realtime alerting system for monitoring manholes and subsurface drainage in metropolitan areas. This system monitors water levels, temperature, and hazardous sewage gasses in an effort to offer safe working conditions and safety measures for cleaners. To help with smarter city management, it also has a notification system to notify government authorities about obstructions, leaks, or high-water levels.

"Smart Drainage System," by Vaibhav Thate (2021). The "Smart Drainage System" that is suggested in this paper monitors the subsurface drainage system with the goal of enhancing city cleanliness and safety. It monitors the drainage system's status in real time using a variety of sensors, such as temperature sensors, gas sensors for hazardous gas detection, and ultrasonic sensors for blockage detection. The technology notifies local officials in advance of obstructions and other problems, enabling prompt intervention. This idea, which aims to improve drainage system management's dependability and efficiency, is especially suited to urban areas and smart cities.

"An IoT Based Smart Drain Monitoring System with Alert Messages," by Samiha Sultana (2021). An Internet of Things-based smart drain monitoring system with an alert system is proposed in this study. It makes use of sensors like the MQ135 to detect sewer gas, an ultrasonic sensor to measure the distance between sewage and water, and a water level sensor to track water flow. When thresholds are crossed, it uses GPS to pinpoint the location and sends a text message to authorities via GSM indicating which areas require attention. In addition, a Node MCU-implemented online website provides real-time data access, enabling public and official monitoring of circumstances. In order to promote community health, the system attempts to promptly alert authorities and give real-time data.

"IoT Based Underground Drainage Monitoring System," G. Chandhini (2020).In order to monitor harmful gases in sewage and notify manual scavengers when gas levels above predetermined thresholds, the article suggests an Internet of Things-based subterranean drainage monitoring system. It uses six sensors to identify gasses, and the Node MCU serves as the system's central controller and internet link. By enabling pollution monitoring on mobile devices and displaying the system's outputs via a smartphone app, pollution worker deaths can be avoided.

"IoT Based Underground Drainage Monitoring System," Pavithra M. (2022). To maintain the city clean, the report suggests a clever Internet of Things-based system for tracking drainage water levels and obstructions. Sensors are used to gather data, which is then transmitted to a Raspberry Pi3 controller. The drainage water level, gas, and humidity levels are graphically shown on an LCD screen and a web page, respectively, based on the controller's output. When the water level surpasses a predetermined threshold, the device additionally sounds an alarm. Real-time services and amenities are offered by this technology to enhance city growth and management.

"Smart Real-Time Drainage Monitoring System Using Internet of Things," by Gaurang Sonawane (2020). The study suggests a clever real time drainage monitoring system that makes use of a variety of sensors, including gas, obstruction, and water level sensors. The system's objectives are to improve flood detection in the early stages, monitor dangerous gas concentrations for worker safety, and identify obstructions in sewer lines to generate early cleaning alerts. With the aim of maintaining the city safe, clean, and healthy as well as minimizing manual drainage monitoring for the protection of sewer workers, it makes use of Wireless Sensor Networking (WSN) technology to gather and send data to a cloud for real-time monitoring.

"Cloud-based smart system for managing and monitoring drainage using IoT," Bhanu Jyothi (2020). The Internet of Things (IoT) is used in this paper's proposed cloud-based smart drainage monitoring framework to autonomously monitor drainage systems. It uses sensors to monitor water flow rates and identify potentially dangerous gasses. Sensors record and analyze data in the cloud when they identify values that are higher than the threshold. The Blynk server sends alerts to the municipal office via SMS, and a buzzer is set off to signal for quick action. The system intends to enhance urban drainage system management and alleviate problems encountered by locals who live close to drainage systems.

IoT-Based Smart Sewage Monitoring System with GSM and Wi-Fi Module, Priya Tiwari (2021). In order to identify clogs, stink gas, and temperature in sewage systems, the article suggests an Internet of Things (IoT)-based smart sewage monitoring system that makes use of sensors and communication modules. An LM35 temperature sensor checks the temperature inside manholes, ultrasonic sensors track water levels, and a MQ-2 gas sensor identifies dangerous gasses. The system uses GSM to send warnings to a registered cellphone number and transfers data to the cloud for graphical representation. Its goals are to increase the safety of sewage workers, operate subterranean systems more effectively, and offer a time- and money-efficient solution that requires no human involvement.

"Intelligent Human Free Sewage Alerting and Monitoring System," Paramesh Chari Bd (2021). The study suggests an automated Internet of Things (IoT) system for developing nations' Underground Drainage Monitoring System (UDMS). It automatically senses and updates physical characteristics, such as temperature, water level, humidity, flow rate, and blockage, using sensor networks. The system can be expanded to agricultural areas or other environmental applications, and it can be customized for environmental monitoring, including the detection of floods and volcanic activity. The platform structure, compliance, renewability, enhancements to sensor nodes and interactions, errors in interactions and functions, service availability for diverse needs, and user server dependability in connection with IoT applications are some of the characteristics of the sensor network.

"IoT-Enabled Underground Drainage Monitoring System Using Water Flow Sensor," by Dr. Gunasekaran M (2021). The study suggests employing a water flow sensor to create an Internet of Things-enabled subsurface drainage monitoring system. This system uses an Arduino, water flow sensors, and GSM technology to update the Internet of Things (IoT) in order to administer and monitor subterranean systems in real-time. It is intended to assist in identifying drainage obstructions, cutting down on water waste, and averting illnesses brought on by tainted water. Real-time updates over the web are made possible by the technology, which helps to keep the drainage system in good condition and free of risks.

V. EXISTING SYSTEM:

In the existing system, sensors are not yet employed in monitoring the sewage system, monitoring garbage full and also, if an overhead line falls down in rain water, only if some person notice it and inform to others in the nearby area orally. Furthermore, the lack of continuous monitoring and centralized data collection hinders the ability to obtain a comprehensive understanding of gas emission patterns and trends over time. This limitation impedes proactive decision-making and preventive maintenance strategies, as there is a lack of timely insights into potential risks or areas of concern within the sewage infrastructure.

Overall, the existing system for hazardous gas detection in sewage lines falls short in terms of effectiveness, efficiency, and safety. There is a pressing need for innovative solutions that leverage advanced technologies such as wireless sensor networks and smart IoT to enable real-time monitoring, early detection, and proactive management of hazardous gases in sewage systems.

VI. PROPOSED SYSTEM:

In our proposed system is to enhance safety, improve monitoring efficiency, and mitigate risks associated with hazardous gases in sewage lines. By leveraging **Wireless Sensor Networks (WSNs)** and **IoT**, we aim to create a robust solution that addresses the following key aspects:

i. **Gas Detection Sensors**:
- Deploy low-cost gas sensors strategically along sewage pipelines.
- These sensors continuously monitor the presence of toxic gases in real time.

ii. **Wireless Communication**:
- To create smooth communication between a central monitoring unit and the gas sensors, use WSNs.
- Wireless transmission of sensor data to the central hub occurs.

iii. **Central Monitoring Unit**:
- All sensor data is combined by the central unit.
- After processing the data, it looks for unusual gas levels and sounds an alert.

iv. **Alert Mechanism:**
- The system notifies the appropriate personnel when hazardous gas levels rise above predetermined levels.
- Notifications for alerts can be sent by email, SMS, or mobile apps.

v. **Remote Monitoring:**
- With IoT-enabled devices (such as smartphones and tablets), authorized personnel can keep an eye on gas levels remotely.
- Timely intervention is ensured by real-time updates.

vi. **Safety precautions:**
- Include safety features that can be heard, like a buzzer for alerts.
- Include a GPS tracker as an optional feature to help locate employees in an emergency.

VII. REQUIREMENT:

7.1 HARDWARE REQUIREMENTS:

- Node MCU.
- DHT11 Humidity and Temperature Sensor.
- Battery 9V.
- Buzzer Mini.
- Node MCU.
- LCD (Liquid Crystal Display).
- MQ 135 Sensor.
- MQ 7 Sensor.
- MQ 2 Sensor.

7.2 SOFTTWARE REQUIREMENTS:
- Thing Speak.
- Arduino IDE.

VIII. ADVANTAGE & DISADVANTAGE:

8.2 ADVANTAGE

- **Worker Safety**: Prevent exposure of sanitation workers to harmful gases.
- **Timely Intervention**: Early detection allows prompt action to prevent accidents.
- **Cost-Effective**: Low-cost sensors and wireless communication reduce infrastructure expenses.
- **Environmental Protection**: Minimize gas leaks and their impact on the environment.

8.2 DISADVANTAGE

- It may face network issues or reliability problems due to the Wi-Fi or GSM module.
- It may be affected by environmental factors such as humidity, pressure, or interference.

IX. BLOCK DIAGRAM

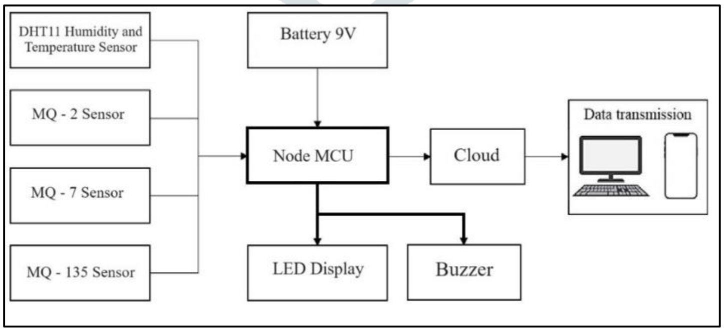

Fig. - Block diagram for wireless sensor network based hazardous gas detection in sewage line using smart IoT.

Step-By-Step Breakdown of Working the Process:

i. **MQ Sensor's:**
The MQ sensor detects various gases and outputs analog and digital signals. Analog values represent gas concentration.

ii. **DHT 11 Humidity and Temperature Sensor:**
This sensor is used in measuring humidity and temperature values in heating, ventilation and air conditioning systems.

iii. **Node MCU:**
Reads analog and digital values from the MQ sensor's and DHT 11 sensor. Connects to Wi-Fi for data transmission through cloud to centralized control system and person standing outside the sewage/septic tank.

iv. **Monitoring:**
Monitors the analog value to detect changes in gas concentration. If the analog value exceeds the threshold, it triggers an alert to centralized control system so that necessary action can be take.

v. **Alert Mechanism:**
Implement a mechanism to send alerts, such as email, SMS, or push notifications, buzzer when hazardous gas levels are detected.

X. CIRCUIT DIAGRAM:

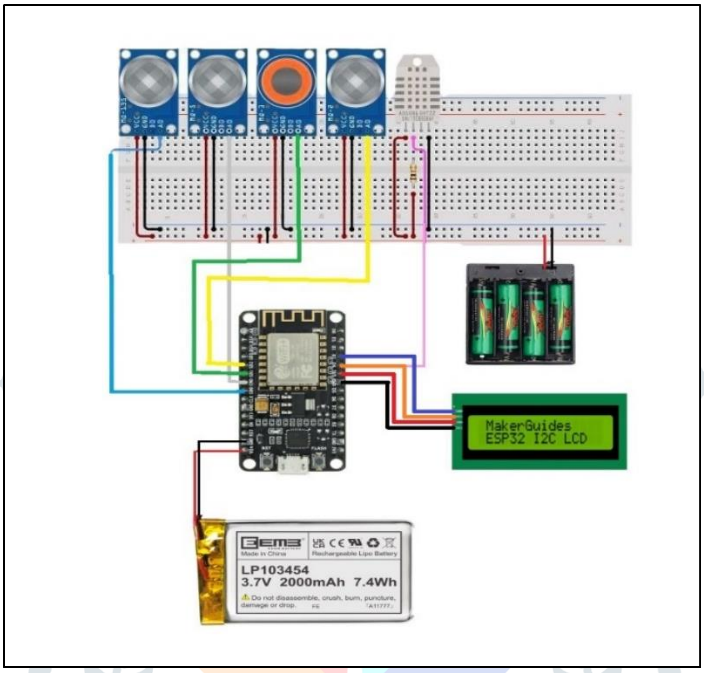

Fig. Circuit Diagram

Explanation of Circuit Diagram:

i. **Node MCU (ESP8266)**: The Node MCU serves as the central microcontroller and communication hub. It integrates Wi-Fi capabilities, allowing it to connect to the internet and communicate with cloud platforms and essential for real-time data transmission and remote monitoring.

ii. **MQ-7 Gas Sensor (Carbon Monoxide)**: The MQ-7 sensor detects carbon monoxide (CO) gas. It has four pins: VCC (power supply), GND (ground), AOUT (analog output), and DOUT (digital output).

iii. **MQ-2 Gas Sensor (Combustible Gases)**: The MQ-2 sensor detects various combustible gases, including methane (CH_4) and propane (C_3H_8). Similar to the MQ-7, it has VCC, GND, AOUT, and DOUT pins.

iv. **MQ-135 Gas Sensor (Harmful Gases)**: The MQ-135 sensor detects gases like ammonia (NH_3) and nitrogen dioxide (NO_2). It also has VCC, GND, AOUT, and DOUT pins.

v. **DHT11 Sensor (Temperature and Humidity)**: The DHT11 measures both temperature and humidity. It has three pins: VCC, GND, and DATA.

vi. **Power Supply**: The system is powered by a battery pack (three AA batteries) or an external power source. The positive terminal of the battery pack connects to the VCC pins of the sensors and Node MCU and the negative terminal connects to the GND pins.

vii. **Wiring Connections**: Jumper wires connect the sensors (MQ-7, MQ-2, MQ-135, DHT11) to the Node MCU.

viii. **Battery**: The battery provides power to the entire system, ensuring continuous operation. Connect the positive terminal of the battery pack to the VCC pins of the sensors and the Node MCU. Connect the negative terminal of the battery pack to the GND pins.

ix. **Display (LCD)**: The parameters and fault state are shown using dot matrix LCD modules. 16 characters are shown on 2 lines.

XI. RESULT:

Future work in the field of Wireless Sensor Network (WSN) based hazardous gas detection in sewage lines using Smart IoT presents several exciting avenues for research and development. Here are some potential areas for future exploration are Enhanced Sensor Technologies, Integration of AI & Machine Learning, Optimization of Network Architecture, Integration with Smart Infrastructure, Field Testing & Validation, Scalability & Cost-Effective, User Interface and Stakeholder Engagement.

XII. CONCLUSION:

In conclusion, the development of a Wireless Sensor Network (WSN) based system for hazardous gas detection in sewage lines using Smart IoT presents a significant advancement in sewage management technology. By integrating WSNs with smart IoT capabilities, this innovative solution offers real-time monitoring, early detection, and proactive management of hazardous gases within sewage infrastructure.

The proposed system addresses the limitations of existing methods, which often rely on manual inspections and periodic sampling, by enabling continuous monitoring and centralized data collection. Through strategically deployed sensor nodes equipped with gas sensors and wireless communication modules, the system can detect specific gases such as methane, hydrogen sulphide, and ammonia, thereby mitigating the risks associated with gas leakages and environmental pollution.

Furthermore, the integration of smart IoT protocols and algorithms enables intelligent decision-making mechanisms for timely alerts and notifications to relevant stakeholders, facilitating prompt response actions to prevent potential hazards. Additionally, the remote monitoring and control functionalities provided by IoT technologies enable proactive maintenance and optimization of sewage infrastructure, contributing to improved safety, operational efficiency, and environmental protection.

Overall, the Wireless Sensor Network based hazardous gas detection system utilizing Smart IoT represents a transformative approach to sewage management, enhancing safety, reliability, and sustainability. As we continue to advance in technology, further research and development in this field hold the promise of even more sophisticated solutions, ultimately leading to safer and more efficient sewage systems for communities worldwide.

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