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Smart Drainage Monitoring System and Clog Detection with IoT

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***Abstract*— The fundamental right to inhabit a clean and salubrious environment is universally acknowledged. Many developing nations, including Bangladesh, grapple with the recurrent issue of flooding caused by obstructed drainage systems, which in turn gives rise to unsanitary conditions. This dire situation can lead to health complications as the atmosphere becomes contaminated by sewage gases. Stagnant water on roadways serves as a breeding ground for the proliferation of Aedes mosquitoes, a major contributor to the escalating health crisis. Detecting these drainage issues manually is arduous, and often, the mess only becomes apparent once the drains are already blocked, flooding entire areas. To address this critical problem, we propose the development of an advanced warning system that employs GSM (Global System for Mobile Communications) and IoT (Internet of Things) technologies. Our system is designed to preemptively avert such incidents, protecting public health. Key components of our system include MQ135 and MQ2 gas sensors to detect sewage gas, an ultrasonic sensor for gauging sewage water levels, and a flow sensor to monitor the rate of water flow. When the water level in the drains surpasses a predetermined threshold, our system will trigger an alert mechanism, sending real-time notifications via GSM to the relevant authorities. These alerts will specify the areas in need of immediate attention and provide precise geographic coordinates using GPS data. Additionally, both government agencies and the general public will have access to real-time data through an online platform, such as Thingspeak. Importantly, our system allows users to fine-tune the threshold values according to their preferences. By ensuring that authorities are promptly notified and by offering real-time data accessibility, our system aims to enhance the overall well-being of the community, enabling residents to lead healthier lives.**

***Index Terms*— Drain Water, GSM SIM808, IoT, Alert system, MQ135, MQ2, Ultrasonic Sensor, DHT 11 Temperature Sensor, Flow Sensor, ESP32, GPS Module.**

I. INTRODUCTION

Inadequate drainage systems pose a significant health risk, giving rise to a multitude of diseases such as campylobacteriosis, typhoid, hepatitis-A, and gastroenteritis. These diseases have the potential to transmit through both direct and indirect means. Indirect transmission occurs when individuals come into contact with contaminated surfaces or materials, creating a pathway for disease transmission. Moreover, stepping on polluted sewage or drain water can inadvertently carry pathogens from one location to another, facilitating the spreading of infectious

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agents, further exacerbating the public health risk associated with subpar drainage systems [1]. The prolonged accumulation of solid waste and stagnant water is a pivotal factor contributing to the alarming surge in dengue fever cases [2]. In 2018, Bangladesh documented a cumulative of 7,450 individuals diagnosed with dengue fever [3]. The third Sustainable Development Goal (SDG) focuses on promoting good health and well-being, while the sixth SDG targets the provision of clean water and sanitation [4]. Prolonged neglect of drainage water maintenance can have detrimental effects on the environment, resulting in foul odors and an inhospitable living environment. Blockages in drainage systems can lead to street flood with even minor rainfall events. The primary cause of these blockages stems from improper disposal practices, with some individuals discarding plastic bags, plastic bottles, and similar waste items into the drains [5]. Consequently, there is an imperative need for a monitoring system that can promptly detect drain blockages leading to widespread contamination and the presence of noxious sewage gas, which can be detrimental to respiratory health, potentially triggering conditions like asthma. Scientific studies have identified a critical threshold, where sewage gas concentrations exceeding 0.0005 parts per million manifests as a highly unpleasant and pervasive odor reminiscent of rotten eggs, significantly disrupting daily life [6]. In 1972, a staggering 90% of the population was living below the extreme poverty threshold, and this figure gradually dwindled to 9% by 2018. As a result, people now have greater financial means and a desire to invest in improving their quality of life. However, tragic incidents like the one involving a teenage girl falling into an uncovered manhole in Bogra, Bangladesh, underscore the critical need for a low-cost solution to address the issue of open manholes, which has tragically claimed many lives. Such a solution is essential and non-negotiable [7, 8]. Hence, we have devised a comprehensive solution with a primary focus on public safety, one that encompasses real-time data monitoring through a web-based platform. This system is designed to display the current status of drainage systems, ensuring that authorities are promptly alerted when conditions reach hazardous levels, facilitating immediate intervention to enhance overall drainage system efficiency. To achieve this, we employ an ultrasonic sensor to gauge sewage distance. When the distance exceeds a threshold of 20cm, an automated alert is generated, signaling "Level Reached," accompanied by the precise location information. In the case of water levels surpassing 500, an alert indicating "Water Level High" is triggered. Additionally, temperature readings are acquired using a DHT11 sensor, and if the predetermined threshold is met, an alert reading "High Temperature Detected" is transmitted along with the location. Furthermore, flow rate monitoring is employed, and if the threshold is exceeded, an alert with the reason "Clog Detected" and the location details is communicated. The primary objective of this research is to introduce an affordable and effective solution that promotes a healthier environment for all, significantly contributing to the well-being of the community.

II. Literature Survey

A. Previous Works And Their Limitations

Within this section, we explore a range of prior systems that have attempted to address the issues associated with inadequate drainage systems. In a study conducted by Dr.Gunasekaran M et al. (2019), the authors employed an innovative combination of IoT technology, GSM communication, and water flow sensors to monitor water levels. However, it's notable that their system did not incorporate gas sensors or any mechanism for monitoring sewage gas levels [9]. In a separate research paper authored by Rjeily et al. (2017), the focus was on establishing a method for continuous real-time data monitoring. However, their system lacked a mechanism for issuing alarms when data levels suddenly surpass predefined thresholds. As a result, individuals relying on this solution would be required to maintain constant vigilance and manually monitor the data, which is not ideal for an effective and proactive response to potential issues [10]. The paper authored by B. M. et al. (2016) provided a solution incorporating GPS and GSM technologies, but it notably lacked the implementation of the Internet of Things (IoT) for the real-time data monitoring that we are currently employing in our research. Furthermore, this particular study did not address the crucial aspect of tracking sewage gas levels, which is an integral component of our proposed system to ensure a comprehensive solution to the drainage-related issues [11]. The study conducted by C. R. et al. (2019) proposed the utilization of Raspberry Pi, Arduino boards, ultrasonic sensors, gas sensors, and temperature sensors [12]. While their system offered similar functionalities to our research, it is worth noting that the inclusion of these components makes the system complex and potentially cost-prohibitive for the average individual. Our research aims to provide a more cost-effective and accessible solution, ensuring that the benefits of such a system are attainable for a broader segment of the population. In the study conducted by N. Nataraja et al. (2018), the research featured a combination of sensors, including the BMP 280 Ultrasonic Sensor, Ultrasonic Sensor HC-SR04, SW-420 Vibration Sensor, an Arduino microcontroller, and the GSM 300 module. These sensors were strategically positioned within the manholes and directly interfaced with the Arduino Uno microcontroller. This system was designed to trigger an alarm in the event of the manhole cover being tampered with, simultaneously notifying local residents and relevant authorities by sending alert messages [13]. In a paper authored by M. SK and S. Rao (2014), a model for an IoT-based underground drainage and manhole monitoring system was presented. Their system featured the utilization of an LCD display to convey warning messages. To detect the unauthorized opening of a manhole lid, a buzzer warning sensor was incorporated. Additionally, temperature detection sensors were employed to assess the status of the manhole lid. However, it's important to note that their system did not offer real-time data display, nor did it provide a solution for situations in which individuals were not in proximity to the LCD during an emergency event [14]. In contrast, the research conducted by G. Gowthaman et al. (2018) introduced a system that harnessed IoT technology, Magnetic Float Sensors, and Arduino for the purpose of sewage level detection and alert notifications via messages and emails. However, it's important to note that this system did not address the critical issue of monitoring and mitigating dangerous gases like CO_2 and methane, which can emanate from sewage and pose significant environmental and health hazards to the community [15]. In the study by K. Viswanadh et al. (2019), their system incorporated NodeMCU, a Flow Sensor, and the Blynk Application, comprising the Blynk app, Blynk server, and Blynk libraries. However, it's essential to note that their system did not offer real-time data monitoring, which is a key aspect of our proposed solution [16].

B. Proposed Model To Overcome The Limitations

Upon a comprehensive review of prior research, it has come to our attention that there is a pressing need for a system that not only offers real-time data monitoring but also enables remote alerts in the absence of direct supervision. While real-time data is essential for continuous tracking, it also plays a critical role in proactively assessing the levels of various elements within the drainage system, including gases, water, sewage, and more. This proactive monitoring allows for the anticipation of elements approaching critical thresholds, thereby enabling preventive measures. Our proposed system in this paper is characterized by its cost-effectiveness and user-friendliness, leveraging affordable components that are readily accessible. This solution effectively addresses the limitations observed in existing models by furnishing real-time data concerning the levels of critical elements, such as gases, water, sewage, and others. Furthermore, in the event of any of these elements surpassing predefined threshold values, the system ensures prompt alerts, delivering messages accompanied by precise location information.

III. PROPOSED SYSTEM

A. Methodology

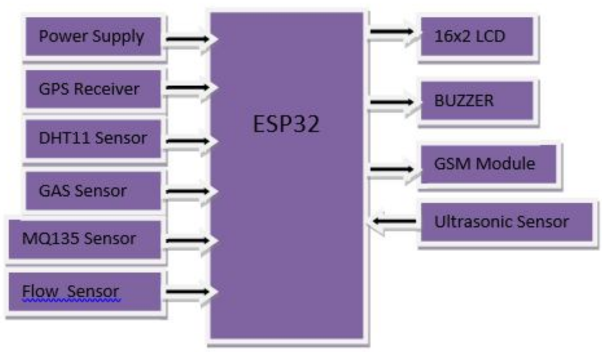


Figure 1. Block Diagram of the proposed model

"Fig. 1" illustrates the block diagram of our proposed model. In order to provide real-time visibility into critical parameters like water level, sewage gas levels, and sewage levels, our proposed model is engineered around the ESP32 platform, enabling the presentation of live data on a monitor via ThingSpeak. Furthermore, for enhanced user-friendliness and the betterment of the environment and human well-being, we have integrated the GSM SIM808 and GPS components. The ESP32 serves as the central processing unit, facilitating the connection of various sensors, GSM, and GPS to relay the current status. This setup ensures that we can promptly ascertain whether sewage levels have exceeded predefined thresholds. Our system allows for both public and private access to the website, affording flexibility to accommodate security concerns or maintenance requirements. Additionally, data sharing with other ThingSpeak account holders can be effortlessly facilitated, streamlining maintenance activities. In the event of a connection loss, the graphical representation on the website will not be displayed. In the event that the graphical representation is not visible, it should serve as an indicator that an issue may be present, signaling the need for authorities to take corrective actions.

B. Hardware And Software

The hardware design is visually represented in "Fig. 2". The hardware components in this system are carefully selected to monitor and assess crucial parameters within the drainage system. These include a Drain Water Sensor for water level measurements, a GSM SIM808 Module for communication, gas sensors such as the MQ135 and MQ2 for the detection of hazardous gases, ultrasonic sensors to gauge distances, a DHT11 Temperature Sensor, and a Flow Sensor to track water flow rates. Additionally, the system is equipped with an ESP32 microcontroller responsible for data processing and decision-making, a GPS Module to enable precise location tracking, an alert system comprising a Buzzer, and a 16x2 LCD screen for user notifications display. Various supporting components contribute to the overall functionality of the system. In parallel, the software components play a pivotal role in ensuring the system's seamless operation. The firmware and programming logic are intricately designed to facilitate data collection, decision-making processes, and the processing of sensor data. Information collected by the sensors is efficiently transmitted and securely stored in the cloud-based platform, Thingspeak, utilizing various protocols, enabling comprehensive data analysis. The system also integrates a clog detection algorithm, which harnesses sensor data to identify obstructions or irregularities within the drainage system. Additionally, an alerting logic is incorporated to trigger notifications through the buzzer and display pertinent information on the LCD screen as the need arises.

Figure 2. The Circuit creation of the Drainage Monitoring System

a) ESP32 Dev-KIT V1: The ESP32 microcontroller, as depicted in "Fig. 3" plays a central and pivotal role within the system, serving as the IoT device's cognitive hub. Distinguished by its dual-core processor and robust connectivity features, including Wi-Fi and Bluetooth capabilities, the ESP32 stands as an indispensable component for handling data processing, communication tasks, and control operations.

Figure 3. ESP32 Dev-KIT V1

Figure 4. GPS Module

b) GPS (Global Positioning System)*:* As illustrated in "Fig. 4" the GPS is a satellite-linked navigation system renowned for its ability to furnish precise time and location-based data to a GPS receiver situated anywhere on or in proximity to the Earth's surface.

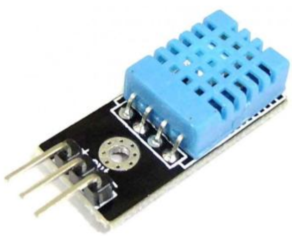


Figure 5. DHT11 Sensor

Figure 6. MQ135

c) DHT11 Sensor: The DHT11 sensor, depicted in "Fig. 5" comprises a capacitive humidity sensing component and a thermistor designated for temperature measurement. Within this sensor, a moisture-sensitive dielectric material is sandwiched between two electrodes, forming a humidity-sensing capacitor. Variations in humidity levels prompt changes in the capacitance value of this component.
d) MQ135: The MQ135 sensor, featured in "Fig. 6" is engineered to detect and quantify various noxious gases, including ammonia, carbon dioxide, and methane. This sensor relies on the fundamental principle of resistance modification in reaction to the presence of specific gases. It assumes a pivotal role in safeguarding the environment and ensuring the timely identification of gas-related concerns within drainage systems.
e) Gas Sensor: As depicted in "Fig. 7" the MQ-2 gas sensor stands out as a versatile and economical component, adept at detecting a range of gases including methane, propane, carbon monoxide, and hydrogen. Its operation hinges on the phenomenon of resistance alterations when it encounters specific gases. This sensor enjoys extensive utility in scenarios such as gas leakage detection, air quality surveillance, and safety systems.

Figure 7. Gas Sensor

Figure 8. GSM Module

f) GSM Module: The SIM900 GSM Module, featured in "Fig. 8" is designed to facilitate communication within the 900MHz frequency band. It's important to note that network providers often use specific frequency bands, and these bands may vary by region and country. In our context, as we are in India, a significant portion of mobile network providers in our country operate within the 900 MHz band.
g) Ultrasonic Sensor: The ultrasonic detector, as illustrated in "Fig. 9" is an apparatus designed to gauge the distance to an object by utilizing sound waves. This detection mechanism operates by transmitting a sound wave at a known frequency, and subsequently, measuring the time it takes for the sound wave to return.

Figure 9. Ultrasonic Sensor

Figure 10. Liquid Crystal Display LCD

h) Liquid Crystal Display LCD: The Liquid Crystal Display (LCD), depicted in "Fig. 10" represents a unique combination of solid and liquid states of matter. It serves as an electronic display module featuring a 16x2 LCD screen, denoting its capacity to display 16 characters across 2 rows.
i) Buzzer: The buzzer, as portrayed in "Fig. 11" functions as an auditory alert system, emitting sound alerts upon activation. Its role is to amplify user awareness and promote swift responses to significant events identified by the IoT drainage monitoring system.

Figure 11. Buzzer

Figure 12. ThingSpeak

j) ThingSpeak

ThingSpeak shown in “Fig. 12” is a cloud-based Internet of Things (IoT) platform developed by MathWorks. It enables users to collect, store, analyze, and visualize data from IoT devices and sensors. With ThingSpeak, users can create IoT applications and dashboards, making it a valuable tool for monitoring and managing sensor data. The platform supports various data acquisition methods, including MQTT, HTTP, and TCP/IP, and provides built-in tools for real-time data analysis and visualization, making it a popular choice for IoT projects and research.

C. Proposed System Design Flow

The flowchart diagram in "Fig. 13", depicts the entire process of the suggested system design.

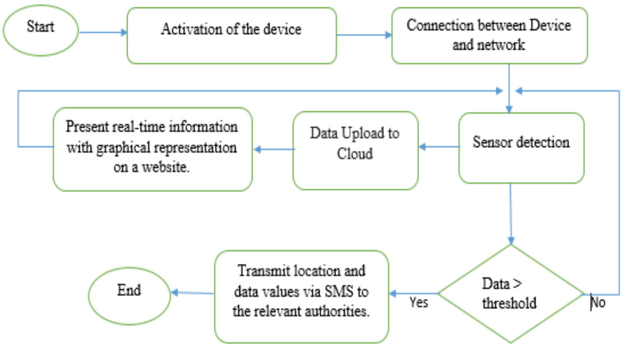


Figure 13. Flow chart of the proposed system

Following are some quick discussions of the process flow's steps:

- Step 1: Sensor Inputs: Collect data from various sensors, including: Sonar sensor for sewage distance detection (with trigger and echo pins). MQ135 sensor for hazardous gas detection (e.g., CH_4, CO_2, CO). Water sensor for water level detection.
- Step 2: Sensor Data Processing: Process the data obtained from the sensors.
- Step 3: Threshold Check: Compare the sensor values with predefined threshold values.
- Step 4: Threshold Exceeded Check: If any sensor value exceeds its respective threshold, proceed to the next step.
- Step 5: Alert Generation: Initiate an alert action, which includes: Sending an SMS to the relevant authority. Providing the exact location (latitude and longitude) in the SMS.
- Step 6: Data Upload to Cloud: Continuously upload real-time sensor data to the cloud.
- Step 7: Data Visualization: The cloud platform presents the data in a user-friendly manner, including: Graphs for the sonar sensor values (sewage distance). Graphs for gas sensor values (e.g., CH_4, CO_2, CO). An alert button for water level: The alert button turns red if the water level exceeds the threshold. The alert button remains green if the water level is within the acceptable range.

IV. Experimental Results

A. Prototype And Graphs

The testing of the application starts by turning on the power source and activating the GSM module linked to the microcontroller. Once the GSM module is activated, the circuit looks as shown in "Fig. 14".

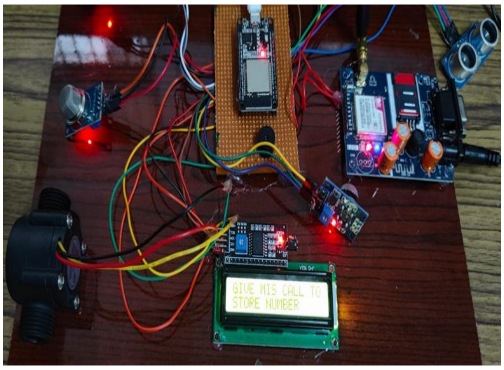
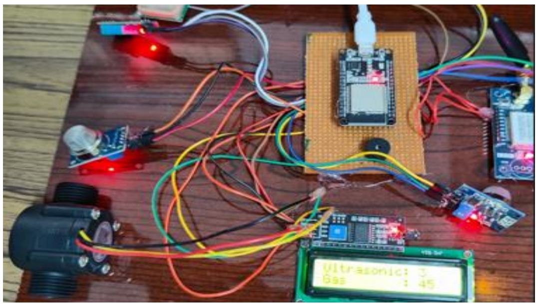


Figure 14. Initial Display of the LCD



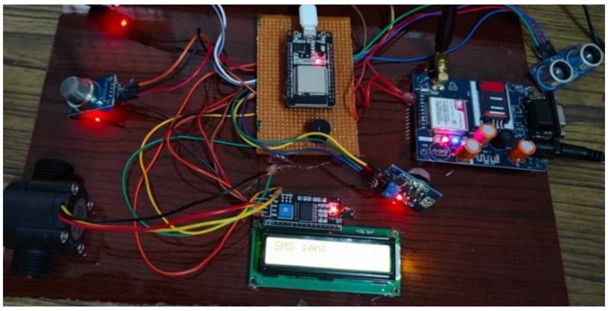


Figure 15. Display after establishing mobile connection to GSM module

Figure 16. Sensor readings on LCD

Once the connection is established message will be sent to the registered mobile number as "Your Mobile Number Registered". If any parameter reaches the set point, then message will be sent to registered mobile number for example "Level Reached" and also buzzer sounds if not it does not send any message to registered mobile number but displays the values on LCD display which can be observed in the "Fig. 15" and "Fig. 16".

Figure 17. Graph of Water Level

Figure 18. Graph of MQ135

Here, the graph in "Fig. 17" shows the Water level distance of the drainage system on LIVE after every 30seconds. We tested 7 or 8 times and got real-time data update on our server. And the graph in "Fig. 18" is showing the Gas level of the drainage system on LIVE after every 30seconds. We tested 7 or 8 times and got some real-time data update on our server. The increase in readings in the graph indicates the increase in Gas level in the environment (drainage system).

B. Data Table

TABLE I. DATASET FOR WATER LEVEL

Distance	Notification	SMS
0 < value <=100	Water Empty	No
100 < value <=300	Water Low	No
300 < value <=500	Water Medium	No
Value > 500	Water High	Yes

TABLE II. DATASET FOR GAS

Level	Notification	SMS
0 < value <=100	Gas level low	No
100 < value <=200	Gas level low	No
200 < value <=400	Gas level medium	No
Value > 400	Gas level high	Yes

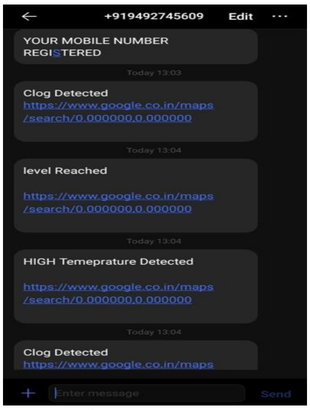


Figure 19. Sample SMSs sent to registered mobile number

In this system, a water sensor is utilized to monitor water levels. If the distance to the water level is below 500 meters, the GSM module remains inactive, refraining from sending any SMS or updates. However, upon detecting a change in water level, the system transmits a notification to the server, indicating the status as either "Water Empty," "Water Low," "Water Medium," or "Water High." In instances where the water level exceeds 500 meters, an alert is generated to notify the server about the elevated water level. Simultaneously, an SMS is dispatched to the relevant authority, signaling that the established threshold has been surpassed, as detailed in "Table. 1".

If the level of Gas changes, then GSM will notify the local server about the state of Gas, i.e. if low, medium, or high. If the value is less than or equal to 400 then the CO2 level is normal, GSM will not send any SMS. But if the level is more than 400, then GSM will send SMS to the authority as shown in "Table. 2". Moreover, in the case of water levels surpassing 500, an alert indicating "Water Level High" is triggered. Additionally, temperature readings are acquired using a DHT11 sensor, and if the predetermined threshold is met, an alert reading "High Temperature Detected" is transmitted along with the location. Furthermore, flow rate monitoring is employed, and if the threshold is exceeded, an alert with the message "Clog Detected" and the location details are relayed as shown in "Fig. 19". Using the latitude and longitude, the exact location can be found by using Google Maps.

V. Conclusions

The prevailing issue of an inadequate drainage system poses a considerable threat to public hygiene and environmental well-being. It is exacerbated by the accumulation of harmful gases, including CO_2, CO, CH_4, NH_3 and others. Our device has been meticulously crafted to address the challenge of controlling drain water overflow, particularly in densely populated regions where plastic blockages in drains are common place. Our solution incorporates GPS technology to precisely determine the location of the drainage system, while a Wi-Fi-based setup ensures that the nearest authority receives daily updates regarding water levels, sewage gas concentrations, and sewage distances within the drainage system. This proactive approach empowers authorities to take timely action in preventing drain overflows. In a bid to foster transparency and accountability, local residents are granted read-only access to the website. For security reasons, we have exclusively reserved full control access to the system for the authorities only, as we believe this approach is essential to maintain system integrity and effectiveness. Local residents, on the other hand, have limited access, restricted to viewing the information on the website as per our design.

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