

# Smart Manhole Detection and Monitoring System

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Publication Date: 2026/05/04

**Abstract:** With the swift expansion of urban infrastructure, a smart strategy is essential for the assessment and upkeep of subterranean utilities like manholes and drainage systems. Relying on manual inspection for evaluation has its limitations, such as the potential for human error and hazardous working conditions. This project report presents the creation and implementation of a Smart Manhole Detection and Monitoring System that incorporates the Internet of Things (IoT). A wireless sensor network is set up at the site. It uses different sensors like gas, temperature, water level, tilt, and worker safety sensors. These sensors connect to an Arduino microcontroller and an ESP8266 Wi-Fi module. They monitor and report important conditions, dangers, and efficiencies inside the manhole in real-time. The sensor data are checked for any unusual readings or dangers, like toxic gas leaks or strange manhole lid movements. If such issues are found, real-time alerts are sent to the municipality using a Global System for Mobile Communication (GSM). The system aims to keep people safe from accidents and help the city work better while focusing on safety. It also helps build healthier and more sustainable communities. By watching in real-time and sending alerts, it protects city workers and reduces the risk of health problems and environmental dangers from broken underground systems.

**Keywords:** Man-Hole Cover, IoT, Drainage System

**How to Cite:** Vishal Aadhithiya S.; Dr. M. Kanthimathi M.; Dr. G.Valarmathy; Thillai Harish S.; Sri Aravind K. (2026) Smart Manhole Detection and Monitoring System. *International Journal of Innovative Science and Research Technology*, 11(4), 3047-3053. <https://doi.org/10.38124/ijisrt/26apr1725>

## I. INTRODUCTION

Public services and utilities have clearly benefited from urbanization and the expansion of urban infrastructure, but managing and maintaining subterranean services like sewage and drainage now presents new difficulties. Manholes provide practical access sites for construction and upkeep, but underutilization or inappropriate monitoring puts public safety and municipal service personnel at clear risk. In recent years, dangerous manhole conditions and open pits have claimed thousands of lives in India, and it appears that India alone. There is a greater need than ever for a solution. Conventional inspection techniques are labor-intensive, slow, and expose human workers to hazardous situations such as poison inhalation, unintentional slips and falls, and unhygienic surroundings. Furthermore, there is a risk of pollution, flooding in the city, and health risks to the populace due to the delayed inspection of anomalies, such as water spills, gaseous leaks, or unauthorized access. Adopting smart technologies is crucial to addressing these significant problems. As an example of a smart technology, the Internet of Things (IoT) has emerged, offering a chance to set up real-time monitoring systems that continuously monitor numerous parameters using a variety of sensors within interconnected networks. Municipal governments may greatly enhance the efficiency, dependability, and

safety of subterranean utility administration by taking IoT into account. The goal of this project is to design and implement a Smart Manhole Detection and Monitoring System that uses a network of sensors, including gas, temperature, water level, and tilt sensors. The system will be implemented using multiple Arduino microcontrollers, ESP8266 Wi-Fi modules, and GSM as a communication option. This kind of adaption makes it possible to continuously check the worker's health while performing maintenance duties in addition to the manhole environment. In an occurrence where a worker may be handicapped, the training solution will alert employees if it finds an anomaly, allowing for quicker action to identify a potentially hazardous tiredness situation. By avoiding service disruptions and optimizing resource use, this clever solution not only keeps workers safe and contributes to a decrease in deaths, but it also encourages sustainable urbanization. The project's ultimate goal is to create safer, cleaner, and more intelligent cities by updating the monitoring and management of vital subterranean infrastructure.

## II. LITERATURE SURVEY

Infrastructure in smart cities may include various sensors, connectivity, intelligent traffic signals, and more. According to the report [9], integrating smart devices into a city's infrastructure through appropriate IoT implementation will improve city living. In poor countries, IoT is also helpful in the design and construction of ecologically friendly monitoring and detecting systems. Using a variety of sensors, including overflow detectors, temperature wetness detectors, ultrasonic detectors, gas detectors, and tilt detectors, the paper [4]

Overflow sensors improve early flood detection by classifying flood levels as low, medium, or high. The sensor measures the amount of various hazardous gasses, and drainage personnel will take precautions when entering manholes. The purpose of this article is to use IoT technologies to create a manhole detection and monitoring system. There are other layers in these papers [2], such as the gripping, application, and perception layers, among others. It also has detecting layers of its own. The Raspberry Pi microprocessor was employed in the sensing layer together with the detector measurements from the man-hole, and IoT technology was used to send data. This research [11] demonstrates that technology has improved QOS security and scalability.(13)

## III. SYSTEM DESCRIPTION

Ultrasonic, tilt, gas, temperature and humidity, and water level sensors are used in its construction. In a certain specific area, it is used to measure the temperature, humidity, water body, gasses, and manhole cover. IoT-based technology was employed in the project [10] to improve performance, facilitate communication, and provide a low-cost drainage water management system. The suggested solution will give users accurate sensor data information and real-time data updates for IoT devices. The temperature and humidity inside the manhole drainage system, excessive toxic gas emissions, drainage water level, and manhole lid position were all monitored, according to the paper [6]. In these study papers [1], understanding how the Raspberry Pi operates and how sensors interact with one another aids in the use of IoT-enabled smart devices to solve problems. The research paper [3] describes how the Manhole Detection System is implemented and developed using sensors. A Raspberry Pi reads data from sensor modules, sends an alert message to the user via a GSM module, and monitors system data in the app. The Manhole Detection and Monitoring system is determined by the block diagram in Figure 1. The corresponding sensor detects variations in temperature and humidity, emissions of hazardous gases, the presence or absence of a manhole cover, and the amount of wastewater. This system is composed of:

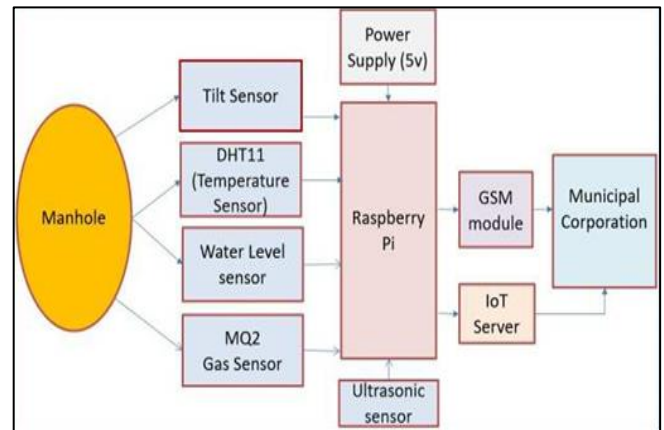


Fig 1 Block Diagram

### ➤ Ultrasonic Sensor- HC-SR04

The particular kind of HC-SR04 (Ultra-sonic sensor) is utilized in the suggested design. It has the ability to translate sound waves into electrical signals. The sensor in Figure 12 emits ultrasonic waves, which are reflected back to the sensor and converted into electrical impulses if they come into contact with an item. As a result, it can recognize the presence of an object in front of the sensor. With a 3 mm precision, this sensor can detect non-contact distances between 2 and 400 cm.

The device won't recognize the attentiveness if there is a manhole cover within the range of 2 to 400 cm. However, if the manhole cover is more over 400 cm, the system will identify attentiveness, and the company will take the appropriate safety measures. The role of the sensor in research work is to verify whether the lid of the manhole is present to the basement of drainage. The ultrasonic sensor used as many industries applications possible to track the object Infront is present or not.



Fig 2 Ultrasonic sensor- HC-SR04

### ➤ Tilt Sensor

The mercury type tilt sensor shown in Fig. 3 will determine whether the manhole cover's leaning angle to the cellar is changing in any way other than zero degrees. Additionally, it can identify the manhole cover's angle of inclination in the basement and update real-time data on the app.



Fig 3 Tilt Sensor

➤ *Water Level Sensor*

The amount of water in the drainage system is detected by the overflow sensor of the magnetic reed liquid level type. Due to the possibility of an increase and overflow of drainage water outside or above the road, there is no doubt that a person will almost certainly be at danger of having drainage water on the roadway during a heavy downpour in urban areas. Unfortunately, accidents will occur as a result of drainage water overflowing all over the road. People are unable to even detect the presence of a manhole cover in a particular area when they are driving on the road. In sensor Fig. 4, the float switch will utilize the magnetic reed switch in the same way, to open or close the circuit. The float switch should be specified with a thermally sealed magnetic reed switch enclosed within the stem, which is typically made of plastic. The float switch will automatically move up and down the stem's length in response to any specified conditions that raise or fall the drainage water level. As a result, under any specified circumstances, the drainage water level inside the manhole cover will be checked for changes.



Fig 4 Water Level Sensor

➤ *Temperature and Humidity sensor - DTH11*

We used a humidity sensor and DTH11 model data to measure the temperature and humidity in the suspension system. The DTH11 is a straightforward, inexpensive digital humidity sensor that can simultaneously detect temperature and humidity. Temperature and humidity have a significant impact on the drainage system beneath the manhole cover. An alarm message will be generated and sent to the municipal corporation if there is a possibility of temperature and humidity rises in the drainage depth.

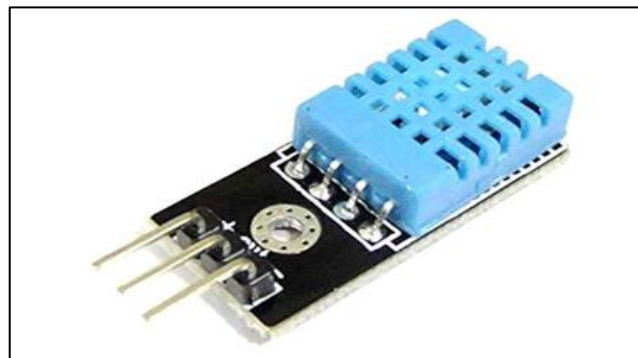


Fig 5 Temperature and Humidity Sensor - DTH11

➤ *MQ2 Gas Sensor*

The MQ2 Gas sensor is the suggested design. Another name for it is chemiresistor. As resistance, it has a sensing material. Different gases are in touch with the resistance that the sensor detects; any variations in the resistance value will be detected based on the type of gases that are released; also, the concentration of the different types of gases will be perceived in Fig. 6 as a voltage divider. The voltage value of the gas concentration will be delivered. When the voltage divider network has voltage values that are too high, the concentration of gases created is output. Fumes, CO gas, CH4 gas, liquid petroleum gas, alcohol, and H2 gas are among the many collected concentrations of gases. Gas concentrations can be detected between 200 and 1000 parts per million. These kinds of gas sensors are utilized in research projects to monitor the emissions of hazardous gases within drainage system manholes. If harmful gasses are released in excess within the drainage depth. Municipal corporations receive an alert message from the microprocessor via the GSM module. output data and the concentration of emitted gasses.



Fig 6 MQ2 Gas Sensor

➤ *SIM900 GSM Module*

A municipal corporation would utilize a SIM900 GSM module to send and receive messages in order to submit the data of all sensor values in the study project. These GSM modules used 900MHz capacity, and mobile networks in India use the same 900MHz bandwidth for services in every district or area.

The SIM card would be inserted into the designated slot to activate the module. With the exception of the Jio network, the GSM module can access all mobile networks at

4G network speeds. A Raspberry Pi board must be attached to the module in order for it to read all of the sensors and produce data from the sensor units. The municipal corporation can get the alarm message from the GSM module shown in Fig. 7.



Fig 7 SIM900 GSM Module

#### ➤ Adaptor

Research studies have mostly used 5-volt and 12-volt adapter power supplies. These adapters function as the system's power supply. The GSM Module uses a 12-volt converter, and the Raspberry Pi board uses another 5-volt adaptor to operate the manhole detection and monitoring system.

#### ➤ Raspberry Pi 3 Model B+

The microprocessor is the primary component used in this suggested architecture, processing and operating all other system components. The Raspberry Pi 3 model B+ is the model used in this study. Figure 8 shows the model that will be utilized in this system, which has more features than its predecessors.

The microprocessor features Blue Tooth 4.2, 1 GB of RAM, and built-in dual-band WiFi. Internet connectivity will be obtained by using a personal hotspot with the Raspberry Pi's WI-FI turned on. The microprocessor's function in the earlier paper [8] was to retrieve data from the sensor and transmit the signal to the GSM Module. Additionally, IoT technology is used in the app to refresh the data.



Fig 8 Raspberry Pi 3 Model B+

A manhole detection and monitoring system helps maintain human safety, keeps the city cleaner, and reduces the amount of work that the municipal corporation must do. Water level, ultrasonic (HC-SR04), temperature and humidity (DHT11), tilt, and MQ2 gas sensors are among the various sensor types that interface with the Raspberry Pi microcontroller to operate the system accurately and correctly. The sensors will deliver the appropriate data value to the CPU right away if they notice that the live data has reached the threshold level. In addition, the municipal corporation received information about the drainage system's status from Raspberry Pi. The municipal corporation officials will act and undoubtedly take precautions based on this information. Additionally, the microprocessor will use IoT to update the live data and display the system's output data while also updating the app. The municipal corporation will receive a GSM alert text message. The detailed flowchart is shown in Fig. 9.

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#### ➤ Algorithm

- Start
- Power supply is given to the hardware system.
- Initialize and run the hardware module.
- Raspberry Pi board senses the data values from the sensors.
- Tilt sensor checks the lid of the manhole for the zero-degree angle of inclination to the basement. If the angle of inclination is greater than zero:
- DHT11 (Temperature and Humidity) sensor measures temperature and humidity levels in the underdrainage system.
- MQ2 Gas sensor checks the harmful gas concentration under respective conditions.
- Water level sensor measures the drainage water level under the manhole cover.
- Ultrasonic sensor detects whether the manhole cover is present or not.
- If any sensor exceeds the threshold or set value:
- An alert message is sent to the municipal corporation through the GSM module.
- Using IoT technology, the output data is updated in the App.
- The information is displayed and monitored in the App.
- Stop

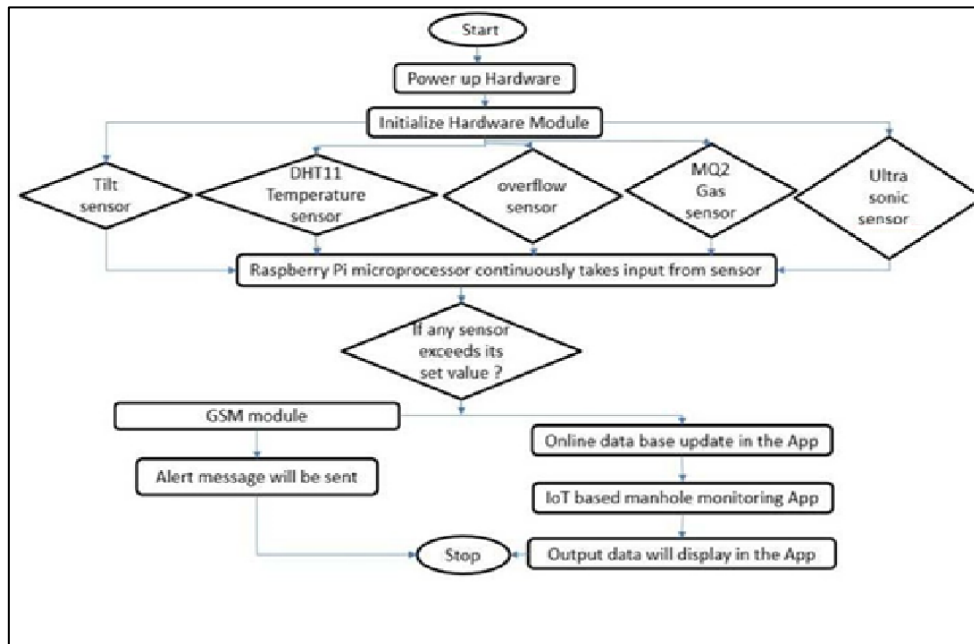


Fig 9 Flow Chart

Different kinds of sensors were used in the research study, and as a result, the sensor data were taken into consideration for continuous manhole detection and monitoring. The following actions will be performed after the Raspberry Pi has gathered all of this information from the different sensors:

• *Ultrasonic Sensor:*

The presence of the manhole cover in the basement is detected by the ultrasonic sensor. The system moves on to the second stage if it is present.

• *Tilt Sensor:*

The tilt sensor detects whether the manhole cover's angle of inclination to the basement is zero degrees or greater. The following step, step 3, is carried out if it is zero degrees.

• *Temperature and Humidity Sensor:*

The values within the drainage system are measured by the temperature and humidity sensor. The system advances to the fourth stage if these values are greater than the threshold.

• *Gas Sensor:*

The different kinds of gases emitted inside the drainage system are detected by the gas sensor. The mechanism moves on to the last stage if too many harmful gasses are released.

• *Water Level Sensor:*

The drainage water level beneath the manhole cover is determined by the water level sensor. The GSM module sends an alarm signal to the municipal corporation whenever the water level rises. The IoT network also provides the app with real-time data updates.

**IV. SOFTWARE IMPLEMENTATION**

There are three primary steps in the software implementation of the suggested design:

- Operating System
- Programming Code
- App Development

➤ *Operating System*

You will require the Raspbian operating system, which is based on the Linux operating system, before you can apply the software. Raspbian OS is essential for running the Manhole Detection and Monitoring System's software because it is needed for:

- Operating the Raspberry Pi board in a Linux environment.
- Installing and configuring the system for smooth functioning.
- Reading and writing the programmed code for the detection and monitoring processes.

The Raspbian OS ensures the integration and proper functionality of all software components within the system.

➤ *Programming Code*

For the system to function and be managed, the proper software code is needed. Python IDLE is used to write the programming code. The code is developed and run on the Raspberry Pi board once it is complete. The desired outcomes are shown.

To work on Python IDLE:

- Open the Python shell.
- Write the code in a new file.
- Save the file with a Python IDLE extension (.py).



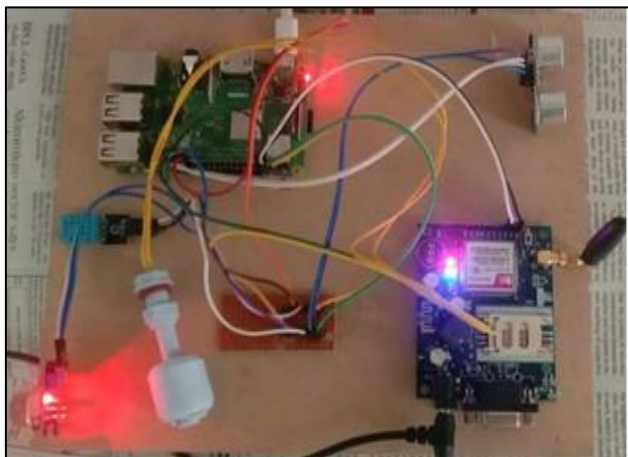


Fig 12 Hardware Setup

The desired results are shown in the IoT based manhole monitoring app in Fig. 12 by using IoT technology.

## VI. CONCLUSIONS

In the end, victims of the drainage system may be saved by the suggested development. The study's main goals were to lessen the risks associated with urban municipal drainage systems and the quantity of labor that municipal corporations had to do.

The study also examined the manhole cover and the conditions within the drainage systems, including gas release, humidity, temperature, and gas. We used a variety of sensors, including the Mercury tilt sensor, the temperature and humidity sensor (DTH11), the ultrasonic distance sensor (HC-SR04), the MQ2 gas sensor, and the water level sensor, because when these systems overflow, people traveling along roads cannot see whether the muck or manhole is there or not. The ultrasonic sensor detects if the manhole cover is present or not, even though the tilt sensor tells whether the manhole cover is correctly connected to its base with a zero-degree slant. Gas sensors identify the many harmful gases released in the drainage system, while temperature and humidity sensors read the data beneath the drainage system. The drainage water level beneath the manhole cover is finally detected by a water level sensor. This data is constantly updated in the app thanks to IoT technology. To transmit messages to municipal corporations, there is a GSM module. Sensors are used in the Raspberry Pi to process all of these units.

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