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# IOT - Based Manhole Monitoring System

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**Abstract**

The effective management and disposal of sewage are essential for urban civilization. As cities grow, the complexity of their sewage systems also increases, making manual monitoring methods obsolete. To address this, a system based on the Internet of Things (IoT) has been developed. This system uses sensors to monitor conditions in manholes in real-time and send data to a central receiver. Any issues are automatically alerted for quick intervention. By using IoT technology, this system represents a significant advancement in waste management practices and will contribute to the development of Smart Cities.

**Keywords:** Sewage, Monitoring, Internet of Things (IoT), Real-Time, Alerts.

## 1. Introduction

In many cities, the management of sewage is a critical issue that is often exacerbated by factors such as unregulated construction and heavy rainfall. The resulting problems with the underground drainage system can lead to disruptions in people's daily commutes. To address these challenges, it is essential to implement a monitoring and alert system that can provide real-time information to municipal authorities. This system will enable officials to take prompt action to restore the drainage system, which is a vital component of effective sewage management in large urban areas. The proposed solution involves the use of sensors to track the status of the drainage system. These sensors will be able to detect issues such as blockages, water overflows, and unauthorized access to drainage lids. The data collected by the sensors will be transmitted to the municipal corporation via integrated Wi-Fi, allowing officials to monitor the situation remotely. Additionally, the Blynk Server will provide the exact GPS location of the drainage system, further enhancing the monitoring capabilities. By installing sensors at key points in the drainage network, this project aims to detect blockages and other issues in real-time. When a blockage is detected, the system will trigger an alert at the monitoring station, prompting officials to take immediate action. Furthermore, temperature sensors inside the manholes will help identify potential problems before they escalate, ensuring a proactive approach to maintenance.

The ultimate goal of this project is to provide continuous monitoring of the drainage system, enabling the civic body to respond swiftly to any issues that arise. By creating a cleaner and safer environment for city residents, we can help reduce the risk of potential mishaps and improve overall quality of life.

## 2. Problem Statement

The sewer system faces various challenges such as population growth in specific areas, construction discharge, heavy rainfall, and more. To address these challenges, we have developed a monitoring system that focuses on four key parameters within a manhole:

1. *Waste water level*: Utilizing a waterproof Ultrasonic sensor, the system will identify sudden increases in water level.
2. *Emitted gases*: Employing a Gas Sensor to detect the toxicity of gases emitted by the wastewater.
3. *Temperature*: Utilizing a Temperature Sensor to identify spikes in internal temperature resulting from sudden chemical reactions between emitted gases.
4. *Alignment*: Utilizing a Tilt Sensor to ascertain whether the manhole lid is properly positioned.

Furthermore, the system includes a SIM module for communication and a microcontroller to integrate all sensors and establish a functional system. Each parameter has been assigned a specific threshold, and if the system detects an elevation in one or more of these parameters, it will promptly send an alert via SMS or email to the designated contact, which in this instance will be the municipal department of the city.

## 3. Objectives

A. Ensure the proper functioning of the sewage system through regular monitoring of manholes.
B. Enhance the safety of the surrounding area by monitoring all manholes within the locality.
C. Prevent costly expenses and accidents through consistent maintenance practices.
D. Improve resource management by conducting quantitative analysis of manholes, allowing for efficient allocation of resources to areas in need of immediate attention.

## 4. Existing Method

The monitoring of manholes is a critical aspect of municipal infrastructure management that has been largely overlooked by authorities. As a result, the existing methods for detecting various parameters are rudimentary at best, and in many cases, non-existent. For example, the increase in sewage water levels within a manhole often goes unnoticed until it overflows, or requires manual inspection by lifting the heavy lid. Gas sensing is sporadically conducted by professionals using imprecise semi-digital handheld devices, necessitating individual visits to each manhole for observation. Tilt and temperature sensing are frequently neglected altogether.

Given these limitations, it is evident that a more sophisticated and dedicated monitoring system is essential for effective manhole management.

## 5. Literature Survey

In Reference [1], researchers explore using the Internet of Things to create a smart and real-time drainage and manhole monitoring system. This study showcases how the system is applied and designed. Reference [2] introduces an accident-avoidance system specifically for large cities, which detects and alerts about open manholes. The system uses an ultrasonic sensor to monitor the manhole lid, with command and control established through IoT for maintenance purposes. Reference [3] presents a cost-effective, low-maintenance, real-time system based on IoT that notifies the management station if manholes exceed certain values. This technology not only reduces the risk for manual scavengers cleaning underground sewage but also benefits the general public. In Reference [4], a

system is described that checks for blockages between manholes, detects dangerous gases' volume and depth, and provides alerts accordingly. Reference [5] proposes a system to monitor manholes using various sensors to detect garbage overflow and harmful gas emissions, sending alerts to relevant authorities. Reference [6] introduces a low-cost, low-maintenance, and robust IoT-based manhole monitoring system as part of an initiative to create a safe and clean environment in Smart Cities. In Reference [7], different methods to reduce power consumption in the analog-to-digital converter of a manhole cover based on IoT monitoring system is explored to extend its lifetime. Additionally, two analog chaotic oscillators of low power capacity are proposed as an alternative to the already existing but inefficient technology used in Compressive Sensing based Analog to Digital converters. The systems are checked and verified through multiple measurement parameters, showing expected results. The model in Reference [8] includes a sensor driver circuit, a regulator circuit, various devices for communication, a microcontroller, and an IoT module. The Manhole Monitoring issue is addressed with an IoT system that sends notification alerts to sewage department officials about overflowing drains and also communicates the same with the residents through a mobile app.

## 6. Methodology

The system utilizes four sensors: a Gas Sensor, an Ultrasonic Sensor, a Tilt Sensor, and a Temperature Sensor. Initially, the battery is connected to the circuit board through a booster module to power up the circuit, which includes sensors, NodeMCU, and other components. Once the hardware module is initialized, the sensors begin collecting data on temperature, gases, water level in the sewage system, and the tilt of the manhole cover. The Gas Sensor detects levels of common gases in the manhole, as well as any presence of toxic gases. The Ultrasonic Sensor measures the sewage water level in the manhole. The Tilt Sensor continuously monitors whether the manhole cover is properly closed. The GPS module acquires the location data of the manhole cover and shares it with the microcontroller. Additionally, the Temperature Sensor monitors the internal temperature of the manhole and the surrounding sewage system. The microcontroller records this data continuously and processes it for transmission if necessary. The data is then transmitted via wifi to a cloud-based platform or server, such as the Blynk platform. Each sensor has a predetermined threshold value, and the system monitors the internal conditions of the manhole in real-time. If any sensor detects changes above or below the threshold limit, the system generates corresponding alerts. Through the GSM Module, alerts are sent to a designated contact number, typically a municipal authority. The system also tracks all data in real-time and updates it using IoT technology, which can be accessed on a saved device.

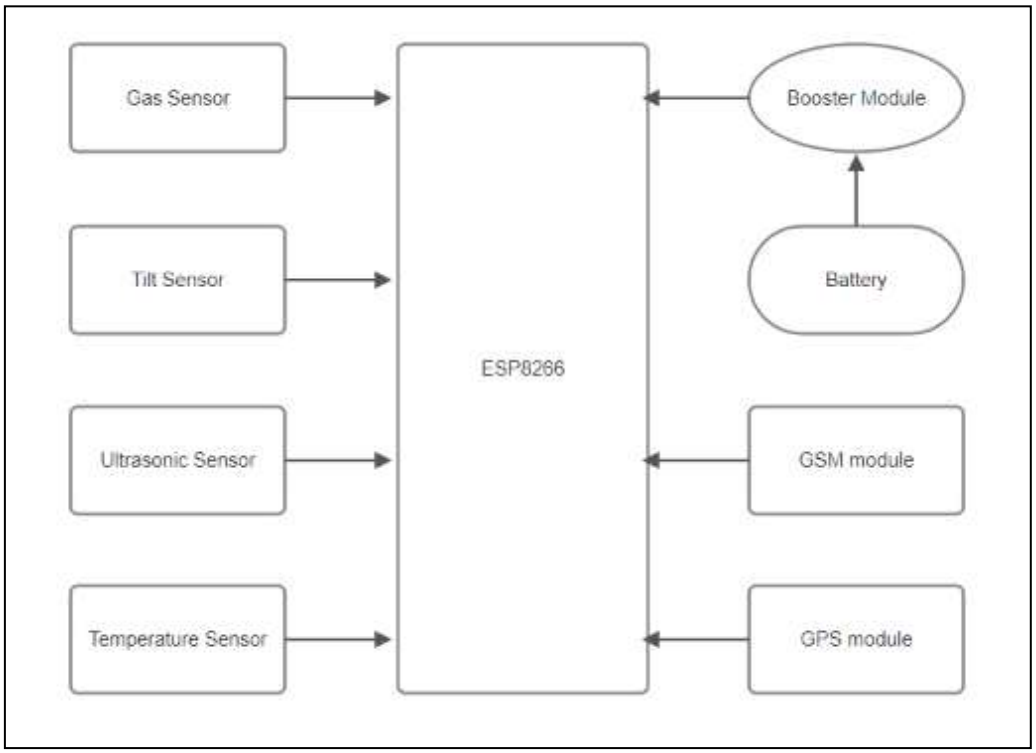
## 7. Components Used

1. **NodeMCU:** The NodeMCU, also known as the Node MicroController Unit, is a flexible platform for software and hardware development. It is based on the affordable ESP8266 System-on-a-Chip (SoC) created by Espressif Systems. The ESP8266 combines key computer components like WiFi connectivity, RAM, a CPU, and one of the latest operating systems and SDK. This makes it perfect for various Internet of Things (IoT) projects.
2. **SIM800L GSM Module:** The SIM900 GSM Module operates in the 900MHz band, which is widely used by mobile network providers in India. For users in other countries, it is important to verify the mobile network band in their region. In the United States, for example, mobile networks

typically operate in the 850 or 1900 MHz bands, while Canada focuses its operation solely in 1900 MHz band.

3. **XL6009 Booster Module:** The XL6009 module is a step-up boost voltage converter that is not isolated. It has an adjustable output voltage and is highly efficient. This module can convert input voltages between 5-32V DC to output voltages between 4-38V DC. The input current is of 4A maximum while 18mA is the no-load current (when the input is 5V and the output is 8V).
4. **MQ Gas Sensor:** The MQ Gas Sensor is an easy-to-use Carbon Monoxide (CO) sensor that is made to detect CO levels in the air. The MQ-2 sensor is capable of detecting CO gas levels between 20 to 2000 ppm, with quick response time and high sensitivity. It provides analog resistance output and has benefits like a long lifespan, affordability, and a straightforward drive circuit.
5. **KY-017 Tilt Switch Module:** Level sensors are important for measuring the levels of different liquids and solid materials that can flow, such as granular materials, slurries and powders with a free surface. When substances flow, they typically settle horizontally in their containers because of gravity, while most bulk solids form a pile at a specific angle called the angle of repose.
6. *Waterproof Ultrasonic Sensor:* The JSN-SR04T Waterproof Ultrasonic Range Finder utilizes ultrasonic waves to detect the presence of objects and measure the distance to them. This sensor is similar to standard ultrasonic modules like the HC-SR04, but it differs in that it utilizes a single waterproof transducer instead of two. Additionally, it offers more options for interfacing with a microcontroller. The waterproof nature of the transducer allows for versatile indoor and outdoor applications, such as car parking sensors, security alarms, obstacle avoidance systems, and monitoring water levels in storage tanks. Like other ultrasonic sensors that rely on sound waves bouncing off objects for detection, the JSN-SR04T can effectively detect all types of objects, including the surface of water.
7. **GPS Module:** The NEO-6M GPS module, developed by U-blox, is a cutting-edge device equipped with a UART interface for seamless communication. This module is designed to provide precise location coordinates, utilizing the NMEA protocol and offering cold/warm/hot start options. With customizable parameters, the NEO-6M is commonly utilized in projects involving GPS tracking and navigation systems.
8. **18650 Cell & Cell Holder:** The 18650 Cell & Cell Holder is a rechargeable lithium battery with a voltage of 3.7 volts. These batteries, similar in size to AA batteries but slightly larger, are also known as Li-ion batteries. The key advantage of these lightweight batteries lies in their rechargeable nature, making them a popular choice for various applications.
9. **IDE Software:** The Arduino IDE Compiler is an open-source platform used for writing and uploading code to Arduino boards. Compatible with Microsoft Windows, Apple Ma, and Linux OS (operating systems), this IDE supports programming languages such as C and C++. Its versatility and user-friendly interface make it a valuable tool for developers and hobbyists alike.

## 8. Flow Chart




## 9. Conclusion

The proposed IoT-based manhole detection and monitoring system presents a valuable opportunity to enhance the safety and security of urban infrastructure. By offering real-time updates on the status of manhole covers, this system empowers city authorities to promptly address any issues and mitigate potential accidents. Moving forward, further research and development efforts should prioritize enhancing the accuracy and reliability of the system, integrating it with other smart city technologies, and addressing cybersecurity concerns associated with IoT-based infrastructure monitoring systems. The subsequent section will delve into the future scope of this project in greater detail.

## 10. Future Scope

There are numerous opportunities for enhancing and integrating the current system to operate in a more rapid, sensitive, and efficient manner. Upgrades could include the addition of sensors with enhanced detection capabilities or sensors with diverse applications to enable the detection of a wider range of parameters. Furthermore, the system could be further optimized for power consumption to prolong the battery life of sensors and microcontrollers. Integration with machine learning algorithms could also enhance anomaly detection accuracy and reduce false alarms. Rather than individual units, multiple units could be deployed in all manholes, creating a connected network or hub within a specific area or locality. This network could then be integrated into a unified system capable of monitoring an entire city in real-time. While implementing such a comprehensive infrastructure will necessitate significant resources and maintenance, the benefits of efficient sewage system monitoring and perfectly planned cleaning schedules align with the vision of a true Smart City.

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