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IoT Enabled Manhole Surveillance System

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Abstract: ***A sewage system is a system of pipes, pumping stations, and other equipment used to transport sewage from its sources to a location for treatment and disposal. Today, the same method is used to transfer many types of data, including power, biogas, and communication networks like fibre. Because of this, the sewage system is important for creating a healthier and cleaner community, and our initiative aims to support an intelligent drainage system. People are dealing with a lot of problems as a result of the system's poor maintenance, including toxic gas exposure, rising water levels inside the sewage system, and accidents brought on by the incorrect placement or absence of manhole lids. As a result, we have created a system to address these issues. The created system seeks to continuously monitor the sewage system. The system can track changes in harmful gas levels (methane, ammonia, CO2, CO, etc.), the level of water in sewage tunnels, and the displacement or tilting of manhole lids. All of this information is communicated with the appropriate authorities via a secure web application and telegram application. Additionally, a system for alerting people to the sewage system's critical problems is included. A solenoid valve system has been added to the hazardous gas pressure control system inside the manhole, and with the system's assistance, the gas levels inside the manhole can be regulated by releasing a tiny amount of gas in response to commands sent by telegram bot or website.***

Keywords: Internet of Things (IoT), Manhole, Arduino, Surveillance,

1. Introduction

A nation's sewage and stormwater systems are crucial components. This system's principal objective is to transport sewage from its sources to a location for treatment and disposal. The same method is being used to transmit other things as well, including power, methane, and communication networks like fibre. Therefore, by enabling an intelligent drainage system, the sewage system contributes significantly to the development of a cleaner and healthier community. The manholes make it easier to do maintenance tasks like cleaning or removing obstacles from the sewage or stormwater line as well as inspections of the sewer or stormwater system. The area around manholes is currently experiencing a number of problems, including accidents caused by cracked or missing manhole lids, blocks caused by the dumping of waste, exposure to toxic gases produced by the drainage system, water overflowing through manholes, accidents caused by tilted manhole lids, and more. The fundamental cause of all these problems is the drainage system's poor upkeep. The majority of the time, this problem arises because the authorities are ignorant of what is going on in the sewage system. It is physically or manually impossible to check the state of the sewage system through each and every manhole on a daily basis. So, traditionally, only when someone is cleaning them are the manholes taken out for inspection. The Sewage will most likely be inundated by this point with water, hazardous vapours, and other things.

This takes us to the drainage system's next major issue, which is cleaning the drains. A lot of hazardous vapours will be released when manholes are opened for cleaning, which is dangerous for everyone nearby and extremely dangerous for the person cleaning the manhole. During the cleaning process, the rising water level and the disposal of waste inside the manhole will both be major problems. Therefore, improved sewage system monitoring is crucial. Here, the suggested system can monitor and regulate both the internal and external circumstances of the manholes, such as rising levels of poisonous gases, rising water levels, obstructions inside the manholes, shifting or tilting of the manhole lid, removal of the manhole lid, and more. The monitored data is analysed and sent in regular intervals to the respected authorities. The observed data are shown in a web application that the authorities can use to examine the situation. Each sensor has a threshold limit determined by its intended usage.

So, whenever the measured values inside the manhole exceed a predetermined limit, an alert signal is issued to the authorities. By releasing a limited amount of manhole gases into the atmosphere in response to a command from the authorities, a second valve system is provided to maintain the hazardous gas levels inside the manhole. In any case, when the manhole opens for cleaning, gases must be released into the air. Huge quantities of hazardous gases are currently entering the atmosphere. Authorities can maintain the harmful gas levels inside the manhole by inserting a control valve system that releases a little amount of gas whenever it receives a command from the authorities. The notifications provided to the authorities are also delivered to a telegram bot that the employees and regular people can access so that they can stay informed about what's going on without having to wait for the authorities to provide them with information.

2. Literature Review

Manhole lid management has historically been plagued by issues such as manhole lid inspection and maintenance; when manhole lids malfunction, maintenance staff cannot pinpoint the exact location of the manhole lids; manhole lids belong to various departments and are managed using

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various techniques, leading to ineffective management and low work efficiency. There are various methods for keeping an eye on manholes and implementing safety precautions. The development of an intelligent manhole lid monitoring system is the basis of the study by Yunhong Xie et al [1], which provides a concept of how the fundamental system might be implemented.

The study provides a thorough overview of the present manhole surveillance system, which makes use of a physical analysis method in which workers physically visit manholes to obtain readings. In order to address the aforementioned issues, a smart manhole lid monitoring system based on narrowband Internet of Things (NB - IoT) was developed, with a focus on whether city manhole lids had been stolen, whether there was combustible gas below ground, and whether the water level and temperature were out of bounds. The main controller of the acquisition terminal for the system is the low - power chip STM32F103, and the sensor module is used to collect data such as pressure, water level, combustible gas concentration, and temperature. Through the NB - IoT module, the data is uploaded to the server, where it is analysed. When the manhole lids malfunction, the client will automatically raise an alarm. By dialling the third party map software, maintenance staff can promptly arrive at the maintenance site and properly find the fault spot.

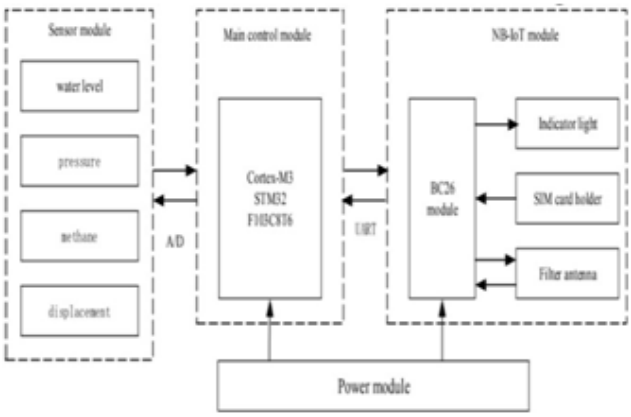

Figure 2.1: Design diagram of NB - IoT - based surveillance system

More research on NB - IoT has revealed that the system's efficiency can be increased in a variety of ways. Low power wide area networks, or LPWANs, are a group of network technologies created to connect wirelessly over relatively large distances while using less power than other networks like WiFi, satellite communications, or cellular networks. Existing smart gadgets and automation systems use dispersed energy resources, but they don't have the centralised generation and transmission network requirements of DSM (Demand Side Management). LPWAN represents a new stage in the development of IoT technology, helping to overcome this barrier and advance the objective of sustainable development. Large wireless connections are included, which has a number of benefits including reduced power requirements, expanded coverage (often up to 15 kilometres), and no maintenance needs. A number of LPWAN technologies have developed in the licenced (NB - IoT) and unlicensed frequency bands (Sigfox and LoRa). The comparison of these frequencies is the major topic of the work by Guo Xiucai et al [1].

According to the study, Sigfox and LoRa technologies are advantageous in terms of cost, capacity, and battery life. However, NB - IoT beats other wireless technologies in terms of latency and service quality. Therefore, LPWAN technology can be used in a system in many different ways, but there are more benefits than drawbacks.

To understand what gases are created within a manhole and what the limit for those is in order to put in place a system that can monitor those gases. The creation of numerous hazardous and explosive vapours is natural given that a manhole includes a variety of chemical and biological waste items. Workers must enter the manhole to perform maintenance on it, which makes it dangerous because gas can build up there and kill. If the gas concentrations are too high, it will be fatal. A sensor array made up of five separate sensors can be utilised to solve the issues and create an electronic device that can identify various gas concentrations. The Data Acquisition System (DAS) with a microcontroller evaluates the ambient conditions using the sensor's output.

The Chirasree IEEE article [4] According to Roy Chaudhuri, an electronic testing unit with a gas sensor array for detecting CH4, CO, CO2, H2S, and NH3 gases in a manhole and an LED display with a buzzer alarm is a straightforward method for estimating the gases in a manhole and can help prevent accidents caused by highly concentrated hazardous gases. [2]

Table 2.1: Detection range of gas sensors

Sensor Name	Detection Range
Methane Sensor	300- 10000ppm
Carbon monoxide Sensor	10- 10000ppm
Carbon dioxide Sensor	0- 100% (volume)
Ammonia Sensor	5- 500ppm
Hydrogen Sulfide Sensor	1-200ppm

A removable plate known as a manhole cover serves as a covering over a manhole's opening to prevent objects from falling in and to keep unwanted people and materials outside. Unwanted manhole openings have recently posed a serious threat to society, resulting in health problems, pedestrian accidents, and even fatalities. Manhole covers opening results in unintentional falls of persons, which results in fatalities. The condition of open manholes results from the breaking of the manhole cover, manhole explosions brought on by dangerous gases found inside the manhole, or sewage overflow, all of which cause pollution and disorder in the surrounding area, spread infectious diseases, and contaminate drinking water, creating a serious health concern. [4]

Other features of the device include detecting movement of the manhole lid. A three - axis accelerometer can be used for this. The usage of a 3 - axis accelerometer for patient fall detection is described in the publication by Liu Xuan at el [2]. Falls are one of the main health issues affecting the aged population, and even if there are no physical injuries, a fall can be psychologically damaging. For fall detection, tri - axial accelerometers or bi - axial gyroscopes are frequently

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utilised. The highly accurate measuring methods of the accelerometer can also be utilised to detect falls. The entire system is made up of a set of sensors that the patient wears on himself, nearby local data collection devices, and systems for gathering, analysing, and storing data on individual patients. The patient's position in relation to the three axes can be determined by the accelerometers, and the patient's movement can be examined. [3] According to studies, the triaxial accelerometer is a useful tool for identifying patient falls. Together with wireless connectivity options like ZigBee, they enable affordable solutions that are effective for both patients and medical staff. The movement and tilting of a manhole cover can be efficiently detected using the same technique that uses a 2 - axis measurement.

The construction of underground manholes is difficult while also being necessary to protect the safety of the roads. Once the manhole is buried beneath the road surface, it can be challenging to find in the event of an emergency. The three main methods for finding manholes are the metal detector method, GPS positioning method, and RFID positioning method. In real life, metal detectors are frequently utilised. However, because to their limited coverage area, they are unable to determine whether the detected object is a manhole cover or not. Positioning is frequently done using the global positioning system (GPS). Even while the GPS positioning method can be used to find where manholes are, it cannot identify a particular manhole by name.

However, the identification of subterranean manholes cannot be done effectively using the metal detector method or the GPS methodology. This is where RFID technology comes into play. Since the RFID operates at a higher frequency than other technologies, it can read data from a greater distance. Therefore, the 2.45GHz band microwave RFID system is the top option from the perspective of long - distance reading, and it is regarded as a dependable system [5].

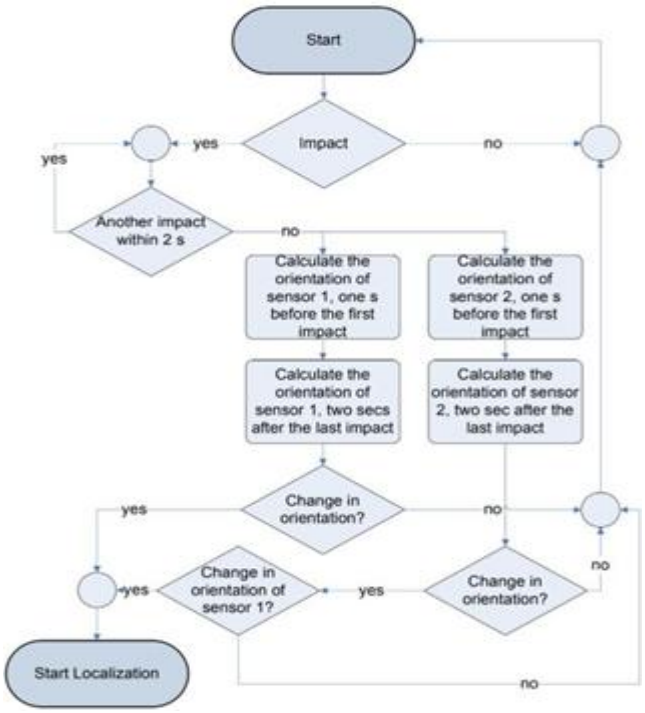

Figure 2.2: Algorithm for fall detection with two accelerometers. [9]

The system's ability to detect an increase in water level inside the manhole is another feature. By measuring the distance between the system and the water bed, this can be discovered. Distance measurement with ultrasonic sensors is one of the simple, practical, and affordable approaches. A high - frequency sound pulse is emitted by the ultrasonic sensor, and when it hits an item, the wave reflects back to the sensor. The front of the sensor contains two holes. In the manner of a tiny speaker, one opening broadcasts and the other receives ultrasonic waves (like a tiny microphone). In air, sound travels at a speed of around 341 metres (1100 feet) per second. The distance to an item is calculated by the ultrasonic sensor using this data combined with the delay between delivering and receiving the sound pulse. It applies the following formula: D = TV/2. Where V is the speed of the ultrasonic sound wave in the air and T is the amount of time it takes for the wave to reflect back to the ultrasonic sensor.

The processing unit is the most crucial component of the system. When looking for the most efficient processor, raspberry pi modules come into play. A keyboard is needed for a procedure on the credit card - sized Raspberry computer, which may be connected to any HDMI input device. When that one is ready, the HDMI and control panel are also not need to be designed for that specific operation because you can then run it using other methods. The following characteristics are included in the primary technical specifications of the most recent Raspberry Pi model, sometimes referred to as Model B.

- The SD Card Slot is utilised for long - term storage, booting, and OS installation. The SD card's entire memory is roughly 8GB
- The 700mA at 5A Micro USB Power Port can deliver.
- The HDMI output display is connected to RCA Video Out. Signals for audio and video are mostly sent via it. They are also known as A/V jacks.
- Sound out If stereo audio is achieved through HDMI, digital audio is produced.
- To connect to the Internet, utilise an Ethernet port. It also significantly contributes to making updating and obtaining new software simpler.
- HDTVs and monitors with HDMI input both use the HDMI OUT (High Definition Multimedia Interface).
- Using the GPIO 40 pin interface, one can direct and communicate with the outside world.

The Raspbian master version of the Linux - based kernel, which can run almost all Linux compatible apps, is used by the Raspberry Pi to run Linux from operating systems. Based on Debian, Raspbian is a free operating system designed specifically for Raspberry Pi hardware. An operating system is a collection of fundamental applications and tools that enable a Raspberry Pi to function. Although the Raspberry Pi is substantially more powerful than an Arduino device, this power comes with some obligations that are not necessary.

The most efficient way or technology that may be used with the raspberry pi module to increase connectivity is LoRa. This is because there will likely be many surveillance systems in a given region. Low power wide area network, or LPWAN, is a technique used by the technology known as

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Lora. A type of intelligent manhole lid monitoring system is proposed in the paper by Nataraja N [10] and is based on electronic sensor technology, wireless communication technology, and computer processing technology. Short - range wireless technology and long - range wireless technology are the two types of wireless communication technologies utilised for manhole lid monitoring in applications. For instance, ZigBee is a wireless technology with low complexity, low power requirements, and low data rates in the context of short - range wireless systems. However, the distance for communication is insufficient. When used over a wide region, a lot of repeaters and routing equipment are required, which raises the price and reduces reliability. The use of LoRa in manhole lid monitoring was proposed in the work by Liu Xuan, Zhang Hesheng, and Li [2] Lei in order to accomplish low power consumption and long - distance communication between the monitoring terminal and the sink node. It can decrease the need for repeaters and concentrators when building large - scale coverage, reduce power usage, save money, and offer a practical solution for managing the safety of urban road covers.

As was already said, a low - power wide area network (LPWAN) is a type of wireless telecommunication that enables long - distance communications at a low bit rate among things (connected items), including sensors that are powered by batteries. This sort of network differs from a wireless WAN in that it is intended to connect people or organisations and carry more data while using less power due to its low power, low bit rate, and intended application. The LPWAN data rate per channel ranges from 0.3 kbit/s to 50 kbit/s. A low - power wide - area network (LPWAN) solution called LoRa was created especially for Internet of Things (IoT) devices that can send and receive small amounts of data over long distances with little power usage. Lora is regarded as a physical layer technology based on the OSI model at the system architecture level, primarily based on Chirp spread - spectrum (CSS) technology. The investigation of utilising a LoRa module with a Raspberry pi model 3b board is contained in the work by Changqing Sun, Fuquan Zhang, Guangxu Zhou, and Kun Guo [5]. The introduction of the LoRa module enhanced the data transmission range and resulted in a 40% reduction in power consumption, according to the performance analysis.

The Raspberry Pi is the most successful method, but we also had to take other options into account because of their affordability and availability. A microcontroller called Arduino Uno uses an ATmega 328 chip. It is an 8 - bit microcontroller with 28 pins. The processor can perform 20 million instructions per second (MIPS) when running at 20 MHz because to the architecture's RISC - based foundation. The board has a USB - to - serial converter built in to make the serial communications protocols on the Microchip ATmega328 processor compatible with the host PC. Several tiny surface - mount light - emitting diodes (LEDs) are also included on the UNO R3 to signal serial transmission (TX) and reception (RX), as well as an additional LED for project use.

The Arduino II Systems book provides a comprehensive analysis of the ATmega328 processor as well as an introduction to C programming and the creation of microcontroller - based systems. The majority of microcontrollers are programmed using a C programming language variation. The C programming language strikes a good compromise between the programmer's ability to manage the hardware of the microcontroller and the speed at which programmes may be written. In contrast, the Arduino Development Environment (ADE) offers a user - friendly interface to quickly create a programme, convert the programme into machine code, and then load the machine code into the Arduino processor in a few easy steps.

3. System Model

3.1 Block Diagram

The operation of the IoT - enabled manhole monitoring system is described in Figure 3.1. A Li - ion battery system that consists of three 2500mAh batteries with a voltage rating of 3.7 that are joined together to create a total of 7500mAh capacity with an output of roughly 12 V powers the entire system. This system can also be supplied by a 230V, 50Hz AC supply due to the availability of power inside manholes in most cities. The battery's remaining energy may be found thanks to an integrated battery level indicator.

The primary goal, according to the purpose, is to gauge the manhole's internal and external conditions. An assortment of sensors are provided to accomplish this purpose. According to the block diagram, a variety of sensors, including MQ - 3, MQ - 6, and MQ135, are employed for the detection of harmful gases. The results from these sensors are sent to the Arduino board and can detect the presence of methane, ammonia, carbon dioxide, carbon monoxide, and more. The introduction of an ultrasonic sensor allows for the measurement of the water level based on the distance between the sensor and the waterbed. Additionally, a continuous transfer of the distance to the water is made to the Arduino board. Based on a 3 - axis measuring mechanism, the movement sensor or accelerometer system will assist in identifying any movement or tilting in the manhole lid; the position information is also sent to the Arduino module.

The Arduino module receives the measurements from the analogue sensors. After data analysis in the Arduino module, instructions based on sensor outputs are transmitted through serial communication to the node MCU. With the aid of built - in wifi networking, this data is sent from the node MCU to a SQL database and a telegram server. The web application can be used at any time to assess the state of the manhole. Additionally, the same web application and a telegram bot receive alarm notifications anytime the threshold set for the sensors is exceeded.

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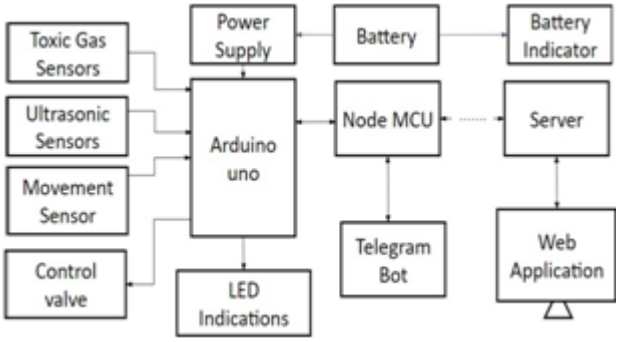

Figure 3.1: Block Diagram of IoT Enabled Manhole Surveillance system

Given the way manholes are now operated, when the lid is opened, poisonous gases are released into the air. Any gas that is currently being produced requires a minimum of 5 years to become naturalised. As a result, a Control valve is included in the system to enable the controlled release of poisonous vapours from the manhole into the atmosphere. Therefore, when it receives a command from reputable authorities, this system releases a very small amount of gas into the environment rather than the entire amount of gas. Both the website and the Telegram bot allow users to customise how the valve operates. By doing this, the conditions inside the manhole can be managed without interfering with society's day - to - day operations.

3.2 Hardware

1) ATMEGA328P

The innovative RISC design of the ATmega328P, a high - performance yet energy - efficient 8 - bit AVR microcontroller, allows it to execute 131 strong instructions in a single clock cycle. It is frequently used as a processor in Arduino boards like the Fio and Uno. The ATmega328P is the system's brain in this project. All sensor data is supplied into the processor, which, with the aid of the right algorithms, enables the system to evaluate the data and conduct the necessary actions. Using the Arduino Uno board and ATmega328P together made it much simpler to communicate with sensors and other components. This ATmega328P is installed on this microcontroller board.

Figure 3.2: ATMEGA328P

2) ESP - 8266 Wifi Module

A self - contained SOC with an integrated TCP/IP protocol stack, the ESP8266 WiFi Module allows any microcontroller to connect to a WiFi network. The ESP8266 is capable of offloading all WiFi networking tasks from another application processor or hosting an application. An AT command set firmware is pre - programmed onto each ESP8266 module, such. You can connect to the Arduino gadget and receive nearly the same amount of WiFi functionality as a WiFi Shield. The module in this project makes it possible for the Arduino module to connect to the server via a wifi network. The Arduino module will send data serially to the ESP - 8266, which will post it to a SQL database.

Figure 3.3: ESP - 8266 Module

3) MQ135 Gas Sensor

The MQ135 gas sensor's sensitive component is SnO2, which has a reduced conductivity in clean air. The conductivity of the sensor increases as the concentration of the target pollutant gas increases. The sensor can detect ammonia, hydrogen sulphide, and steam from the benzene series. This sensor is being used in this instance to find ammonia. Both digital and analogue output can be produced by the sensor. The Arduino Uno board is linked to the analogue output in this instance. Gases beyond 500 ppm can be detected by the sensor thanks to its calibration.

Figure 3.4: MQ135 gas sensor

4) MQ3 Gas Sensor

One of the MQ sensor series' most widely used sensors is the MQ3. It is a sensor of the Metal Oxide Semiconductor (MOS) variety. Because sensing is based on the change in resistance of the sensing material when exposed to alcohol, metal oxide sensors are also known as chemiresistors. Alcohol concentrations can therefore be determined by integrating it into a straightforward voltage divider network. Gases beyond 500 ppm can be detected by the sensor thanks to its calibration.

Figure 3.5: MQ3 gas sensor

5) MQ6 Gas Sensor

The MQ - 6 gas sensor's sensitive component is SnO2, which has a reduced conductivity in clean air. The conductivity of the sensor increases along with the concentration of the target flammable gas when it is present. The MQ - 6 gas sensor responds to natural gas as well as propane, butane, and LPG with great sensitivity. Different flammable gases, particularly Methane, could be found with the sensor. Gases beyond 500 ppm can be detected by the sensor thanks to its calibration.

Figure 3.6: MQ6 gas sensor

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6) HC - SR04 Ultrasonic Sensor

An ultrasonic sensor is a piece of technology that uses ultrasonic sound waves to measure the separation between a target object and the sensor. The transmitter (which generates sound using piezoelectric crystals) and the receiver are the two major parts of an ultrasonic sensor (which encounters the sound after it has travelled to and from the target). The sensor measures the amount of time that passes between the transmitter's sound emission and its contact with the receiver in order to determine the distance between the object and the sensor. D = 12 T x C (where D is the distance, T is the time, and C is the sound speed of 343 metres per second) is the formula for this computation. Here, a sound wave is directed toward the water, making it easier to track the rise in water level. There are four pins in all. One Ground, one VCC, one trigger pin to start the sound wave transmission, and one echo pin that goes high in response to the received signal

Figure 3.7: HC - SR04 Ultrasonic Sensor

7) ADXL 335

A full 3 - axis acceleration measurement system is the ADXL335. The minimum measurement range for the ADXL335 is 3g. Analog voltages that are proportional to acceleration are the output signals. In tilt - sensing applications, the accelerometer can measure both static and dynamic acceleration brought on by motion, shock, or vibration. When doing the data acquisition in conditions that are close to static, one can use software timing. The manhole lid movement in this project is detected using the ADXL 335. The movement of the sensor is initially monitored in two axes, x and y, when it is in an idle posture. The sensor will take the proper action once it notices a tilting of at least 30 degrees.

Figure 3.8: ADXL335 Accelerometer

8) Solenoid Valve

An apparatus that transforms electrical energy into mechanical energy is a solenoid. This arrangement, which comprises a coil looped over conductive material, functions as an electromagnet. An electromagnet's benefit over a natural magnet is that it can be activated or deactivated as needed by energising the coil. As a result, when the coil is electrified, Faraday's law states that the conductor carrying the current has a magnetic field surrounding it. Because the conductor is a coil, the magnetic field is powerful enough to magnetise the substance and produce a linear motion. Figure 3.8 ADXL335 Accelerometer In this project, the solenoid valve aids in the on - demand removal of extra gas from the manhole.

Figure 3.9: Solenoid Valve

9) Li - Ion 18650

Li - Ion 18650 cylindrical rechargeable batteries with a 3.7V 2600mAh high capacity internal voltage protection PCB. smaller weight and higher energy density than conventional rechargeable batteries produced in accordance with ISO 9001 - 2000 to ensure quality International Electrotechnical Commission (IEC) standards were used for battery testing. Here, three Li - Ion 18650 batteries are linked together to provide a power backup of around 7500mAh at 12 V and 1.2 A.

Figure 3.10: Li - ion Batteries

10) Battery Level Indicator

The system's primary energy source is a set of Li - ion rechargeable batteries, and this battery level indicator will determine how much power is left in the battery and show it on an LED display with indicators for 25%, 50%, 75%, and 100% of capacity.

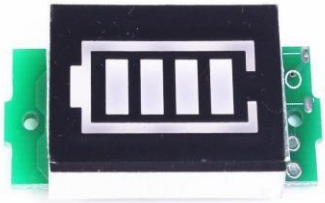

Figure 3.11 Battery level indicator

3.3 Software

1) DipTrace

DipTrace is a software package for electrical design automation (EDA), which produces printed circuit board layouts and schematic diagrams. Four components make up DipTrace: the schematic capture editor, the PCB layout editor with built - in shape - based autoroute and 3D preview, the component editor, and the pattern editor. Advanced circuit design software that offers a variety of tools for logical and visual pin connections and supports multi - sheet, multi - level hierarchical schematics. Principal circuits may be readily turned into a PCB, back - annotated, or imported and exported from and to other EDA applications, CAD formats, and net lists thanks to cross - module management. For external stimulation, DipTrace Schematic offers Spice export and ERC verification.

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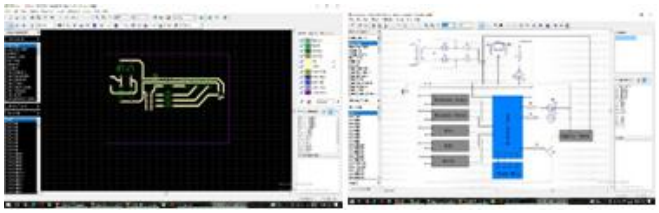

Figure 3.12: Interface of Diptrace

2) Arduino IDE

It is simple to write code and upload it to the board using the free and open - source Arduino Software (IDE). Any Arduino board can be used with this software. It functions on Linux, Mac OS X, and Windows. Embedded C is used to write the environment. Both the ESP - 8266 and ATmega 328 wifi modules are programmed using the Arduino IDE in this project.

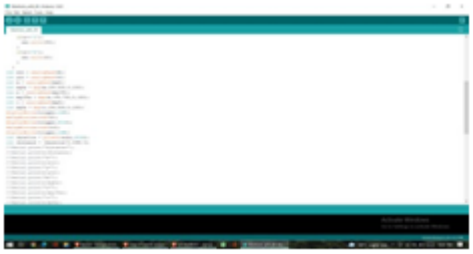

Figure 3.13: Interface of Arduino IDE

3) MySQL

The relational database management system MySQL is built on the SQL (Structured Query Language) language. Data warehousing, e - commerce, and logging applications are just a few of the many uses for the application. The most typical application of MySQL is as a web database, though. Here, node MCU is used to upload the analysis data that the Arduino module collected to this database.

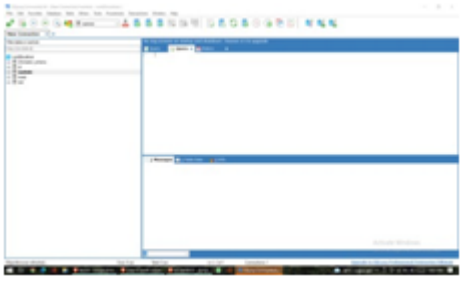

Figure 3.14: Interface of MySQL

4) Pycharm

A Python - specific Integrated Development Environment (IDE), PyCharm offers a wide range of crucial tools for Python developers. These tools are tightly integrated to produce a practical environment for effective Python, web, and data science development. Pycharm enables the configuration of web servers. A backend must be running in order for a web application to be published. A machine will be assisted in running as the backend server by Pycharm.

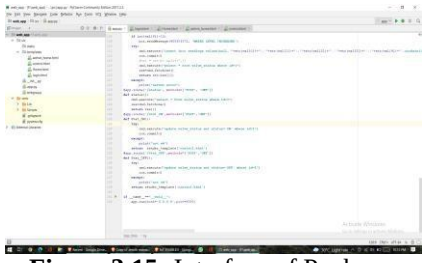

Figure 3.15: Interface of Pycharm

5) Adobe Dreamweaver

With the help of software that supports HTML, CSS, JavaScript, and other languages, you may create websites with Adobe Dreamweaver nearly everywhere. From amateurs to seasoned experts, Dreamweaver is helpful for a range of site designers. Adobe Dreamweaver is used to design the webpage.

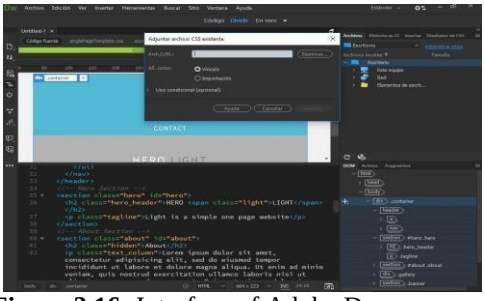

Figure 3.16: Interface of Adobe Dreamweaver

3.4 Circuit Diagram

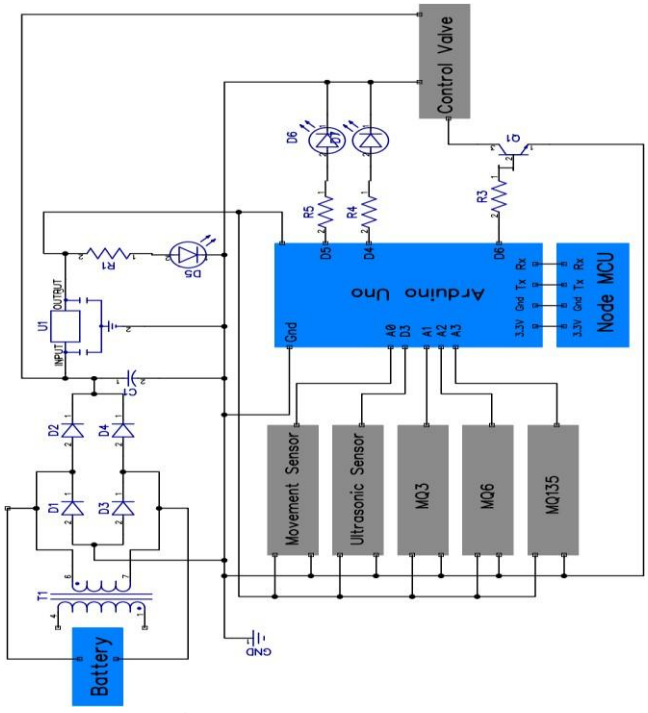

Figure 3.17: Circuit Diagram

Table 3.1: Components used

D1, D2, D3, D4	1N4007
U1	L7805
C1	470µF
D5, D6, D7	5V LED
R1, R3, R4, R5	470 Ω
Q1	BC547B

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1) Power Supply

The power supply's diagram is displayed in Figure 3.18 shown below. This power supply is multifunctional; it can accept a 12 to 20 volt DC supply from a battery and convert it to 5 volts DC using an LM7805 voltage regulator, or it can accept a 230 volt 50 Hz AC supply and convert that to 12 volts DC using a step - down transformer, a bridge rectifier, and a filter capacitor. The supply is then converted to 5 volts DC using an LM7805 voltage regulator. An LED is available to show whether the power source is functioning properly.

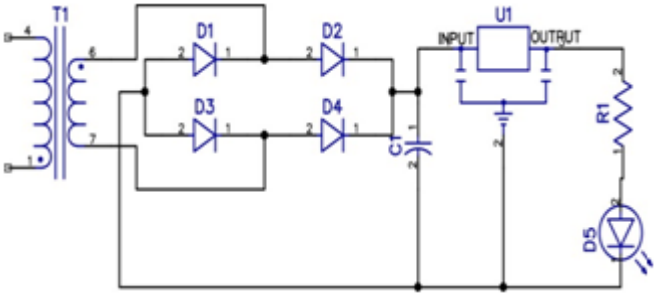

Figure 3.18: Circuit diagram of power supply

2) Controller Section

The schematic for the Atmega328P - based controller portion is shown in Figure 3.19. The analogue input ports of the Arduino module are connected to the gas sensors MQ - 3, MQ - 135, MQ - 6, and the accelerometer ADXL335. The digital input port is coupled to solenoid valve and ultrasonic sensors. The solenoid valve is supplied by a 12V DC source, whereas all of the sensors are powered by a 5V DC supply from the power supply. The output from the analogue ports of the three gas sensors is provided to the analogue input ports of the Arduino module. When using an accelerometer, the Arduino module's analogue port receives the output from the Y - axis terminal. The echo and trigger terminals are connected to the digital I/O port of the Arduino module in the case of the ultrasonic sensor. Echo and trigger are used to create ultrasonic waves from the sensor, and the output echo varies depending on the ultrasonic wave received by the ultrasonic sensor. Through a transistor, the solenoid valve is linked to the Arduino module's digital I/O port. If the transistor is forward biassed by the Arduino module, it will function as a switch to link the valve to the ground terminal when it is turned on. The Atmega338P microcontroller processes all the data that is received by the Arduino module before sending it through serial communication to the ESP - 8266 node MCU. With the aid of the built - in wifi connectivity, the node MCU will upload all of this data into the SQL database.

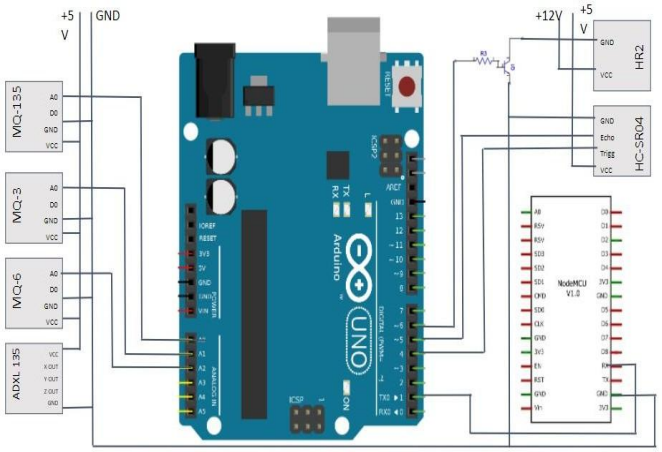

Figure 3.19: Circuit diagram of the controller section

3.5 Flow Chart

Figure 3.21 illustrates how data is transferred from the circuit's various sensors to the Arduino Uno module for processing, and then from there to the Node MCU (ESP 8266).

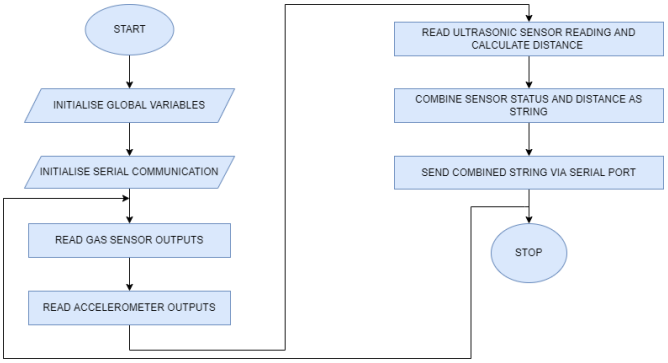

Figure 3.21: Flow chart of Arduino section

The data flow between the ESP 8266 node MCU and the server portion, which includes the web application, is illustrated in Figure 3.22.

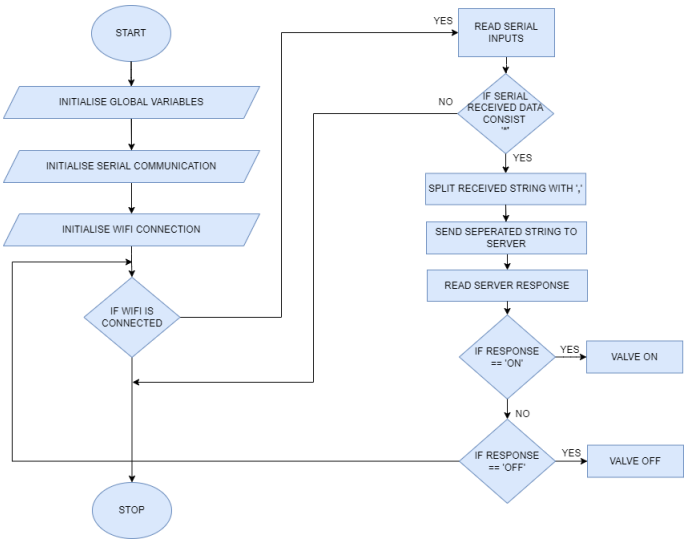

Figure 3.22: Flow chart of node MCU section

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4. Experimental Results

Multiple safety elements around a manhole are ensured via a surveillance system that is IoT - enabled. The prototype has undergone testing in a variety of scenarios resembling a manhole, including the presence of poisonous gases, water rising, and lid movement.

- The ultrasonic sensor successfully activated when the water level came within 30 cm of the sensor, and it has also been continuously sharing the distance to the water with the Arduino module.
- The sensor array successfully measured the variation in the gas levels and responded to the presence of gases such as ammonia, methane, CO2, and CO.
- When the tilting of the demo lid is greater than 30 degrees, the accelerometer can detect it.
- All data is successfully transmitted to the SQL database and from there to the web application.
- The data in the SQL database is updated every 6 seconds.
- Every time the sensor values exceed the threshold, a special alarm notification is sent to the telegram bot within 5 seconds.
- By controlling the solenoid valve from the web application and the telegram bot, we were able to regulate the level of gas inside the manhole.

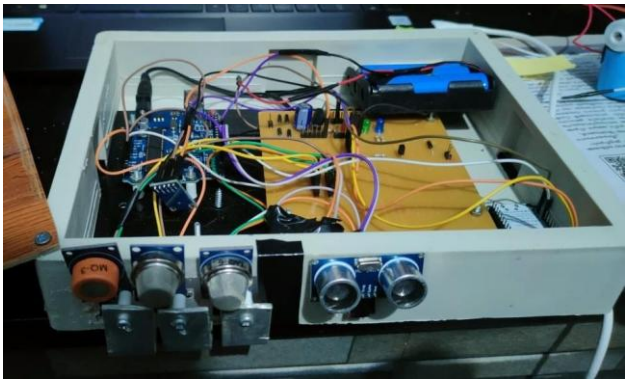

Figure 4.1: Image of project hardware

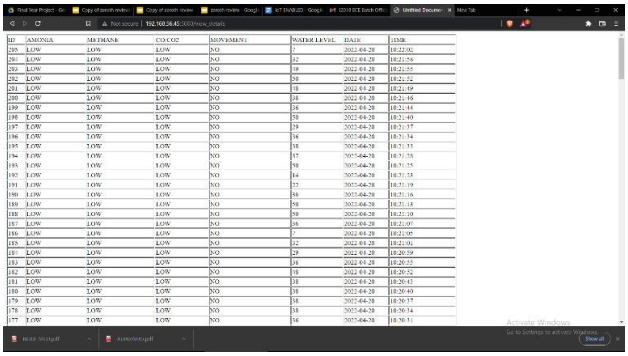

Figure 4.2: Screenshot of data in server

Figure 4.3: Screenshot of alerts in telegram

5. Conclusion and Future Scope

The Internet of Things (IoT) - enabled manhole surveillance system will assist in monitoring and controlling both the internal and external conditions of the manhole while also notifying the respective authorities about the manhole's current status on a regular basis. This assures both the cleaner's safety and the safety of the neighbourhood. It has been discovered that with the aid of this project, we are able to effectively monitor the manhole and, on occasion, even manage the gas concentration inside the manhole thanks to the established system. With the assistance of a web application and a Telegram bot, the condition is also communicated to respected authorities, employees, and members of the general public.

Currently, we have created a system that relies on wifi to connect to the network. The system can be used in locations without wifi access if we include extra GSM capabilities in the following stage of development. Additionally, a circuit that can display the battery level inside a webpage can be added to a gadget that solely relies on a battery for electricity. We can make this system more effective and smaller by swapping out the sensors for smaller ones and the board for another one that is more powerful.

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