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Locating and Detecting Toxic Gases in Manholes

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ABSTRACT: We are learning about more life-threatening casualties as industrialization progresses. Physical labor is used to clean sewage systems. Critical situations have increased dramatically in recent years, finally leading to the fatalities and quick deaths of workers in sewers and manholes. These reports of deaths and environmental issues are spreading at an alarming rate. Toxic and hazardous gases form a combination in the mixture of sewage gases in manholes. It mostly contains a wide range of carbon, nitrogen and sulphur oxides, ammonia, and methane emitted by industrial wastes and domestic residues. Because gases are confined in manholes for extended periods of time, they grow toxic and can be lethal if proper precautions are not taken. Most of the time, we don't bring these difficulties to light, but if they aren't addressed, they can lead to disastrous occurrences. Workers put their lives in danger by going inside manholes to help everyone. It is found that many human lives have been spared due to these toxic and poisonous gases in manhole pits. Pits connecting to subterranean supply systems are critical to their maintenance because they affect many living networks such as communication, water supply, gas supply, power and many other things. A hole while necessary for municipal operations may be one of the safest and most dangerous assets. A research analysis is exhibited on this disaster and a suggestion is made to build this IOT–based application. It is proposed to check the adverse change in temperatures, water levels and pollutant gases. This application will address public safety by preventing from any mishappening caused by manhole adversities.

KEYWORDS: Industrialization, Subterranean, communication, living networks.

I. INTRODUCTION

To access various underground infrastructures such as pipes, power lines, water connections manholes are dug. These places can be dangerous due to pollution. Carbon dioxide in manholes can be produced from many sources, including sewage, chemicals and decomposed radioactive materials in natural gas. Some of the common gases found in manholes are methane, carbon monoxide, hydrogen sulphide, and ammonia. Methane is a flammable gas formed by the decomposition of organic materials in sewage. It is also a by-product of oil drilling and can enter manholes from nearby pipelines. Carbon monoxide is a colourless, odourless gas produced by the breakdown of fuels such as gasoline, natural gas and propane. Hydrogen sulphide is a rotten egg-like gas formed as a result of the decay of organic materials. Ammonia is a common gas in manufacturing facilities and can be found in manholes near manufacturing facilities. Exposure to toxic gases in manholes can cause various health problems such as difficulty breathing, unconsciousness and even death. Methane and other flammable gases can also cause fire or explosion. Since pollutants in manholes are generally colourless, odourless, and tasteless, personnel entering these areas should be appropriately trained in gas recognition and management. Workers should be equipped with appropriate personal protective equipment such as respirators and gas detectors[1].

To prevent contaminants from being released into test wells, it is important to manage the ground well and prevent poisons and other sources of contamination. Employers should have clear procedures for accessing manholes and responding to emergencies. They must also provide their employees with regular safety training and ensure they have access to the necessary equipment and resources. As a result, toxic gases in manholes pose a serious safety hazard to workers and the public. To minimize the risks, it is important that steps are taken to prevent the release of harmful gases and that workers are properly trained and equipped to be safe in these locations[2].

II. LITERATURE REVIEW

U Andrijašević, J Kocić and V Nešić, "Lid Opening Detection in Manholes using RNN", 2020, discussed machine learning algorithms for lid opening detection in manholes. The manhole network is connected to smart IOT devices which detect the various states of manholes like opening or closing of the lid, detection of light, or object etc. **P Bhosale, "**IoT Based System for Detection of Sewage Blockages", 2021, focuses mainly on monitoring of sewage infrastructure, to predict blockages, preventing them from turning into Sanitary Sewer Overflows (SSO). This paper proposes an IoT-based full-fledged system to tackle this issue. **R. Timofte and L. Van Gool,** "Multi-view manhole detection recognition and 3D localization", addresses the problem of accurately 3D localizing specific types of road fixtures, such as manhole covers. The surveying task for manholes has to be done for millions of kilometers of road. An efficient pipeline that starts from images captured by vans, which are then used to detect, recognize, and localize the manholes is accomplished using this work. **SK Muragesh and Santhosha Rao,** "Automated Internet of Things For Underground Drainage and Manhole Monitoring Systems For Metropolitan Cities", exemplifies the design and implementation of a manhole monitoring system for IOT applications. The proposed model benefits the public by monitoring the water level, and blockage in the manhole and in addition to determining the level of harmful gases. **G Dhanalakshmi, S Akhil, M Francisca Little Flower and R Haribalambika,** "Explosion detection and drainage monitoring system by Automation System", exemplifies the design and implementation of a manhole monitoring system for IOT applications. The proposed model benefits the public by monitoring the water level, and blockage in the manhole and in addition to determining the level of harmful gases. **M Aarthi and A Bhuvaneshwaran,** "IoT Based Drainage and Waste Management Monitoring and Alert System for Smart City", there are microcontrollers, gas sensors, liquid level indicators, and temperature sensors. the garbage can and sewer system. The device checks for blockages between the two manholes, detects the amount and depth of different gases that are toxic to the human body and provides information through alarms. **R Pushpakumar and S Rajiv,** "IOT-based smart drainage worker safety system", helps to identify the gas level inside the drainage manholes so that the worker can get some idea of entering into the manholes. It helps workers and their safety before getting down into the manholes and it will sense the level of the gas inside. The savvy framework will check if the blockage has happened in the middle of two sewer vents and furthermore, it will detect different gas level which is hurtful to individuals, furthermore, a framework observing the water level then it will trigger an alert and it will offer data to the crisis division and wellbeing offices which will make a specific move at a time. **Prof S. A. Shaikh and Suvarna A. Sonawane,** "Monitoring Smart City Application Using Raspberry PI based on IoT", represents the implementation and design functions for monitoring and managing underground/road-sided drainage system with different approaches. It also gives a detail regarding the safety issues like gases which adversely affects to the workers, temperature details weather it is suitable for the workers or not and also blocking parts are present or not.**K. H. Lau and C. W. de Silva,** "Detection of Toxic Gases in Sewers Using an Automated Robot" 2016): This study suggested using an autonomous robot fitted with gas sensors to find poisonous substances in sewage systems. The robot was made to navigate the sewage on its own while detecting the presence of chemicals including carbon monoxide, methane, and hydrogen sulphide. The outcomes demonstrated that the robot was capable of rapidly and precisely detecting harmful gases.**T. Ren and Q. Zhou's** "A Review of Gas Sensors for Monitoring Underground Mine Atmospheres" (2020): This review article explored the use of gas sensors for keeping an eye on the manhole-like conditions seen in deep mining atmospheres. The electrochemical, infrared, and catalytic sensors are analyzed for their merits, and demerits for detecting harmful gases were covered in the study. **S. M. Agah and C. J. Hennigan's study,** "Detection and Tracking of Hydrogen Sulfide Plumes in Urban Environments," was published in 2017: The detection and monitoring of hydrogen sulphide plumes in urban settings, including manholes, was the main goal of this work. A mixture of gas sensors and meteorological sensors were employed in the study to find and follow the path of hydrogen sulphide plumes. The outcomes demonstrated that the method was successful in locating and monitoring hydrogen sulphide plumes. **S Sultana, A Rahaman, AM Jhara and AC Paul,** "An IOT Based Smart Drain Monitoring System with Alert Messages", uses MQ135 for sewage gas, an ultrasonic sensor for sewage distance, and a water level sensor is used to keep track of water flow. If the level reaches a certain threshold, it will send a text message using GSM to the authority to report the issues mentioning which areas should be fixed with a location using GPS, and the authority and general people will also be able to keep track of real-time data via an online website which is implemented using Node MCU. It is possible to adjust the threshold values according to the user's choice. **A Pendharkar, J Chillapalli and K Dhakate, "IoT Based Sewage Monitoring System", 2020,** aims to measure and analyze the real-time levels of sewage. In order to ensure the safety of the workers working under severe conditions. This project attempts to devise an IOT technology that shall detect the level of sewage in the tunnel while keeping track of its flow rate of it. If the level exceeds beyond threshold, it shall send an alert through the Blynk web

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app. **V. K. Nallamothu, S. Medidi and S. P. Jannu, "IoT based Manhole Detection and Monitoring System," 2022,** here proposed systems are validated through temperature measurements, showing promising results. This research addresses circuit design challenges and improves system performance for the long-term and efficient operation of IoT-based MC monitoring systems.

III. METHODOLOGY

Our work will satisfy the functional requirements to locate and detect harmful gases in human dug-pits for social purposes. It will include modules for application user interface, simple conversion mechanisms and third-party software products to architect, design, test, train and develop the proposed work. This work also includes workflow, disaster, rules, and claim, risk and customer relationship management. This is going to be an Internet of Things (IoT) gadget that provides real-time statistics on the concentration of different gases in manholes. In addition to detecting harmful gases, this gadget will also send information about the contaminated manhole to the appropriate authorities for follow-up action. This information would be transmitted via the internet and stored in a real-time database, which in turn will inform workers of the various gas concentrations in the mine shaft and assist in lowering potential risks. It is a very efficient monitoring system that successfully and safely completes its task.

3.1System Architecture and Components

To build up the basic, fundamental framework of the system, System Architecture provides the template. The architecture helps to build the framework and the interface between the segments is also provided to build and form subsystems and systems. Construction Modeling is the evolving configuration procedure of recognizing the subsystems and building up a structure for subsystem control and correspondence. The proposed architecture for this system is given below. It shows the way the system is designed and the brief working of it.

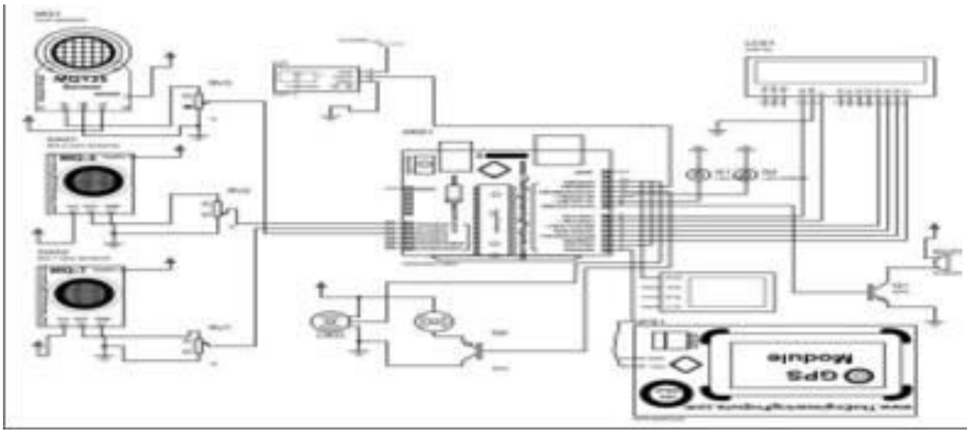

Figure3.1: The System Architecture Framework

3.2 Introduction to Specification

The Framework of System Requirement Specification (SRS) is a documented report that specifies the progress of the product advancement. The necessities of a structure, together with the delineation of its noteworthy highlights are recorded. Customer, end user, or client requirements and conditions at any instant of time are specified and documented before any design or process change work. It is a very beneficial two-way process that favors both the end user and developer in all aspects and at any point in time. This approach reduces the overheads, and headway efforts and helps in revealing the oversights, mixed-up presumptions, and inconsistencies a long way before the design. The SRS can be reworked many times to attain an optimal output and helps in continuing with the creation appraisal. A general SRS will include functional, non-functional, user interface requirements, system constraints, and assumption dependencies together with all additional requirements.

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The prototype was designed in two stages:
1. Gas Detector Prototype Model
2. Data Observation Application (UI Application)

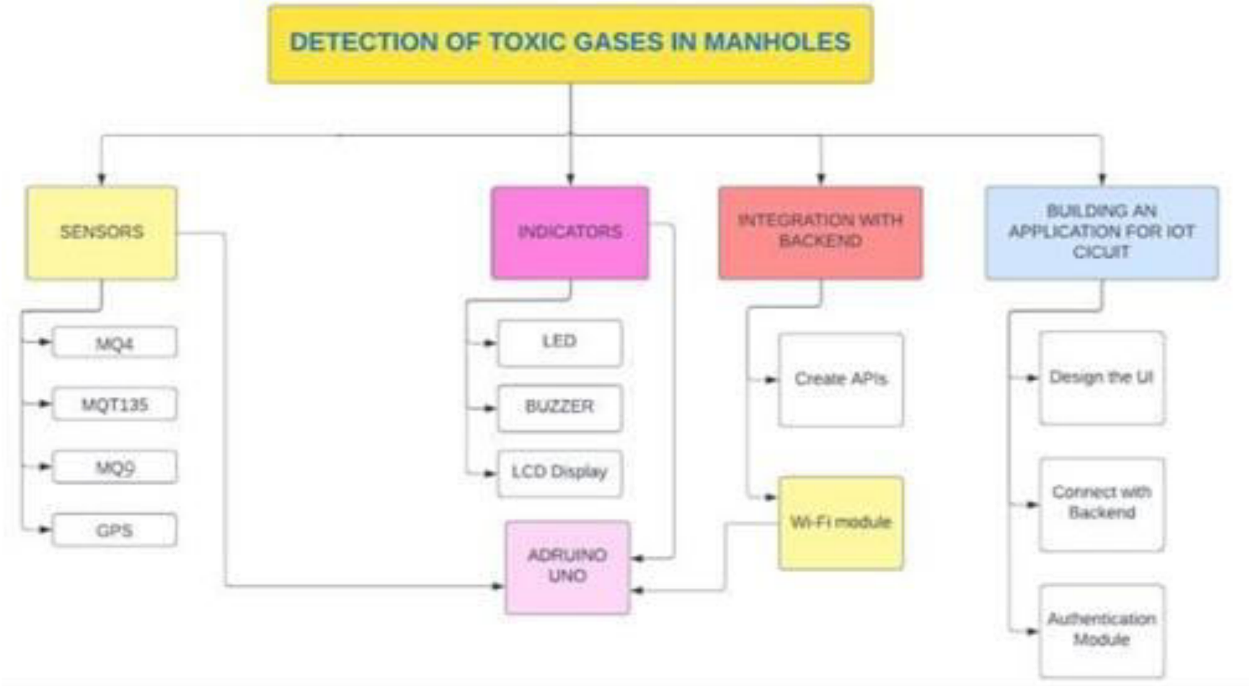

Figure3.2.1: Flowchart diagram

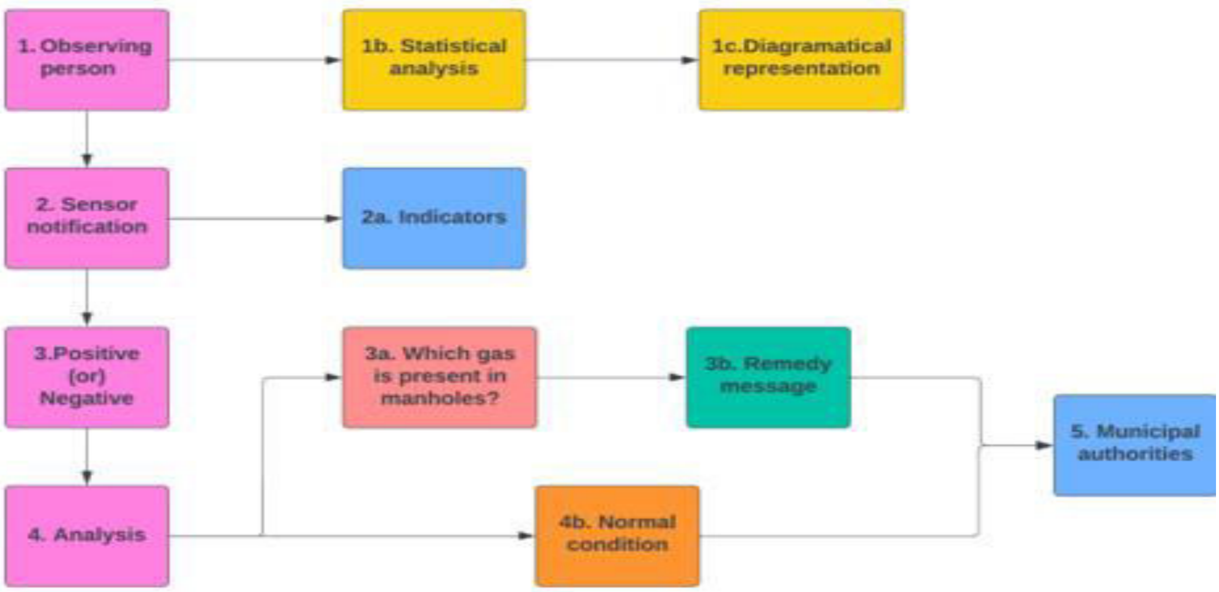

Figure3.2.2: Collaboration diagram

3.2.1Sensor Selection and Functioning Hardware

After a hefty amount of research in the field of sensors and power supply units, we were able to conclude upon which sensors would be best suited for our project. Finding the appropriate sensor was a challenge due to the diversity in the availability of each sensor. From having different resistance issues to providing lesser accuracy and being too delicate. All in all, we were able to finally settle on a particular model for our hardware components.

Based on our research we acquired the following components:

1. Sensors:

- MQ135
- MQ4
- MQ9

2. Microcontroller:

- Arduino Uno
- Power supply
- Connecting wires

1.MQ135

MQ-135 Gas Sensor is used for the detection of pollutant gases such as Ammonia (NH3), sulphur (S), benzene (C6H6), CO2, and other gases. The increase in the amount of gases that exceeds the limit will be notified with the increase in digital pins. In general, a voltmeter or a potentiometer is used to mark the threshold limit on board. Like any other MQSeries gas sensor, it shows both analog and digital outputs. Any change or vulnerability in the concentration of environmental gases is notified using the analog output being generated.

2. MQ4

To detect the emission of methane gas (CNG), MQ-4, a Metal Oxide Semiconductor (MOS) type sensor is widely used to detect in the atmosphere or either in the home or in industry. The conduction increases with the increase in methane concentration and is notified and sensed using MQ4. The amount of methane in the air is notified through an analog PIN by producing an analog signal.

3. MQ9

To detect pollutants and hazardous gases such as carbon monoxide, methane, propane, hexane and other gases, an MQ9 Gas Sensor which is a low-cost Metal Oxide Semiconductor (MOS) type Gas Sensor is used. A sensing element, mainly aluminum-oxide-based ceramic, coated with Tin dioxide (SnO2), enclosed in a stainless-steel mesh is contained in the MQ9 Smoke Sensor. The resistivity of the element changes whenever gas comes into contact with the sensing element. The change or increase in the concentration of the gases present is detected.

4. Arduino Uno

To integrate a variety of electronic project microcontrollers, having a variety of inputs and output for controlling different electronic parts including LEDs, motors, sensors, and displays Arduino UNO which is a low-cost, flexible, and easy-to-use programmable open-source microcontroller board. The programming on board is designed to so easy to use and work with for all kinds of programmers. The Arduino UNO uses an IDE, Arduino Integrated Development Environment, and also can be linked using a USB connection to a computer. This Arduino IDE provides a user-friendly interface so that users are provided with ease-of-use features to build, code, and develop on board.

5. WIFI ESP8266

The WIFI ESP8266 Module is used to provide a WiFi connection to any microcontroller device through its TCP/IP protocol stack. This module is built on board. (System on chip). The module is capable of hosting applications on its own else also sheds off the capabilities to another processor for more functionalities.

6. Liquid Crystal Display (16*2):

This panel Liquid Crystal Display (16*2), is used to create images using liquid crystals. The panel Liquid Crystal Display (LCD) uses liquid crystal to produce images. To control backlight, liquid crystal, and electronics, vary electricity to control the orientation through various layers.

Working of LCD:

On application of electric current onto the liquid crystal molecule, it tends to untwist. As a consequence, the angle of light that is passing through the molecule of the polarized glass changes and also causes a change in the angle of the top polarizing filter.

Figure3.2.3:LCD

7. Buzzer

To the Arduino, is directly connected to a buzzer which is a small speaker. To vary their form, when you apply electricity to some crystals, they alter form. This is known as piezoelectricity. The crystal may generate a sound by applying an electric signal at the proper frequency.

8. LED

LED emits light when current travels through it. When current travels through a light-emitting diode, it emits light. Photons and packets of light energy are produced when electrons fuse with the positive holes in the semiconductors.

Connecting wires

To form varied circuitry, jumper wires or connecting wires are used. It also allows to connection of two endpoints with any soldering with its connector pins. These wires are used in breadboards and in other prototyping tools.

GPS Module

This component GPS module receives signals from a network of satellites orbiting the earth to determine its position. This module contains a GPS receiver that receives signals from at least four satellites to calculate the user's position, speed and altitude. It usually communicates with a host (such as a computer or mobile phone) via a serial or USB interface. GPS modules are often used in many applications such as navigation systems, geolocation services and tracking devices.

IV. IMPLEMENTATION

Implementation is the step where the theoretical information is transformed into the practical working model and also where the hypothetical configuration is transformed into a working framework. Careful planning, investigation of the current system and the constraints on implementation, and training of the team in the newly developed system are the

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criteria very much involved in this stage. The design changes are inculcated in this phase of Implementation. Choosing of the right software together with the selection of platform and language used are all to be finalized here. The real environment in which the system works, the speed that is required, the security concerns, and other implementation-specific details are the right decisions to be, made during the working phase They are the analysis of the hardware components, fabricating the prototype, selection of the programming language for the development of the application, and coding guidelines which are to be followed.

This phase involves installing software and enabling functional aspects of the prototype. Previously implemented codes for detecting gases were studied and analyzed to make necessary modifications that would help us achieve our objectives.

The implementation phase was broken down into the following steps:

1) Step1-Installing Arduino Uno:

The major feature of the Arduino IDE (Integrated Development Environment) is that it is open-source software, which makes it easy to write and upload software on board.

2) Step2-Setting up the module**:**

This step involved in setting up the required modules necessary for the working of the gas sensors.

3) Step3-Sketching(code):

Arduino IDE Supports C and C++. The following Libraries/Headers were included in our code:

- Adafruit Gas Sensors Library: This library provides support for a variety of gas sensors such as MQ, SGX, and Winsen manufacturers.
- Grove Gas Sensors Library: This library was created especially for use with Grove gas sensors, and it provides support for a variety of gas sensors, including, CO2, NO2, and NH3.
- MQ Gas Sensor Library: Designed to operate with MQ gas sensors, this library supports sensorsfor a range of gases, including, LPG, and CH4.
- The Grove-Gas Sensor (MQ2) the Seed Studio Gas Sensors Library. These libraries include tools for reading data from gas sensors, calibrating the sensors, and carrying out a number of additional tasks. To create gas sensor applications, they are simply integrated into programs for Arduino boards.

Algorithm for Locating and Detecting Toxic Gases in Manholes:
Step 1: Initialize the System:
Set up the hardware components (Arduino Uno, MQ-7 gas sensor, etc.).
Calibrate the sensor if necessary, according to the sensor datasheet.
Connect the sensor to the Arduino Uno and provide the necessary power supply and ground connections.
Step 2: Read Sensor Data:
Use the Arduino analogRead() function to read the sensor values.
Convert the analog sensor value to a meaningful gas concentration using the calibration data provided in the sensor datasheet**.**

Step 3: Set Threshold for Toxic Gas Concentration:

- Define a threshold value for gas concentration above which the gas is considered toxic.
- Compare the measured gas concentration with this threshold value.

Step 4: Detect Toxic Gas:

- Compare the measured gas concentration with the toxic gas threshold.
- If the gas concentration exceeds the threshold, trigger an alert (e.g., turn on a buzzer, LED, or send a

notification).

Step 5: Implement Location Tracking:

- To implement location tracking, use additional sensors like GPS modules to obtain the current location of the manhole. Combine this information with gas concentration data for better analysis.

4) Step 4-Connecting the device app**:**

- It handles connectivity, and device authentication in the cloud, and catch all the data from the sensor modules and transfers it to the application database.
- The application fetches all the sensed data from the module and presents it to the user through the interface.

5) Step 5-Final Fabrication and Testing:
The last phase of our project is the process of testing the prototype's efficiency and accuracy

6) Stage1-Final Fabrication:

- Post experimentation with the band model, the components were then installed into an enclosed container made of plastic which was demonstrated as a manhole.

- The prototype is demonstrated in the imaginary manhole which has already been set up differently per the project objective.

7) Stage2-Testing:

- To test the accuracy and reliability of the model, the test was conducted by comparing the readings of the prototype against the real-world gas toxicity levels already fetched from the manhole database.

- The model was tested and the readings were observed

V. EXPERIMENTATION AND RESULTS

A thorough experimentation of the prototype is necessary so as to check the accuracy, calibration, and efficiency of the sensors. The experimentation would also shed light on other factors such as the proper working of UI, accurate data transfer to the system, data storage in the cloud, and soon.

Figure 5.1:Gas Readings

The readings of all the acquired sensors were taken and examined for testing and assurance purposes. These readings were taken under real-life conditions and in natural environment imitating the toxic gases of manholes. The readings were found to be accurate; the readings were also found to reflect during change of environment and change in toxicity level of gases accordingly. A table has been listed depicting the respective readings.

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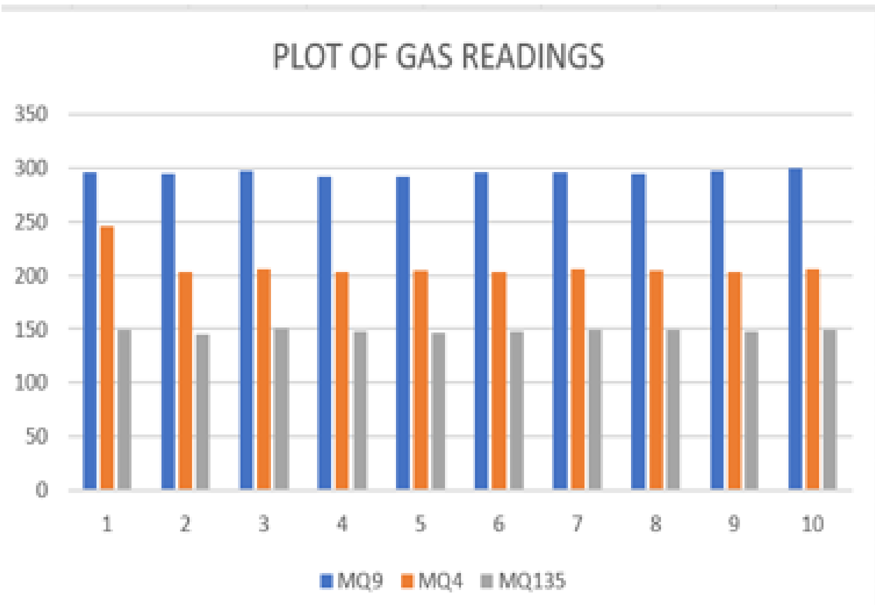
5.1 Sensor Calibration

MQ9	MQ4	MQ135
296	245	149
294	204	146
297	206	150
292	204	148
291	205	147
295	204	148
295	206	149
294	205	149
297	204	148
299	206	149

Table 5.1: Readings of various gases



Graph 5.1:Readings

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5.2 Gas Sensor Prototype Model

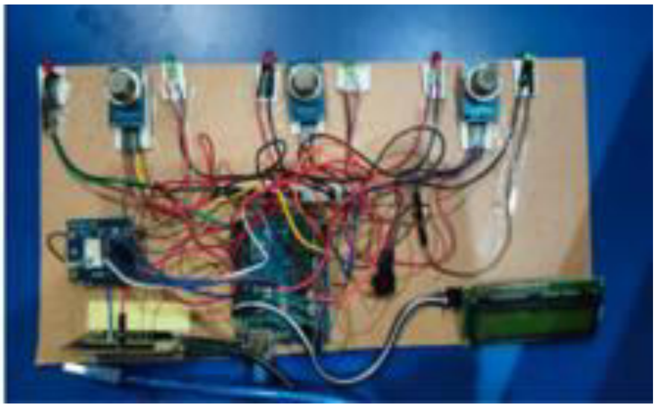

Figure5.2:GasSensor Prototype Model

Gas sensors are used to detect the presence of gases in the air and are important in many applications, including industrial, medical, and environmental monitoring. A prototype helps to identify an error or any further need for optimizations. Therefore, a gas sensor prototype model is necessary for testing, optimization, and validation.

4.3 Application Interface Image

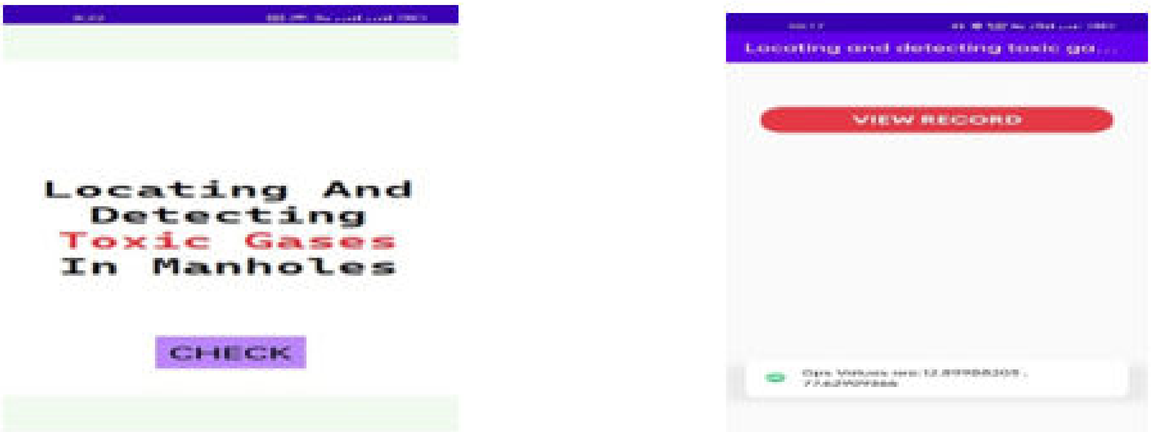

Figure5.3:Application Interface

VI.CONCLUSION AND FUTURE WORK

Manholes are amongst the most unprotected areas in the world. To combat this, we developed an affordable device that can help social workers detect the gas levels and send the details of infected manholes to the government. Our device successfully warns employees about varied gas levels in the manhole and aids in the prevention of future mishaps. It is a high-performance monitoring system that does its work efficiently and safely. Moreover, it will help reduce the tragedies due to gas poisoning from manholes and to be alert for any hazardous gas outburst. In the future, we can try and add various other harmful gas detectors, sprinkler systems to go off during a fire, continuous live data feed to a designated system, escape path lighting system to light up the nearest escape path in case of an emergency, increase ventilation to remove harmful gases quicker, add email service to notify agencies via electronic mail. The mobile application can also be more sophisticated with features such as FAQ, emergency plans and contact, and chatbot. It could also have an SOS service to send locations and all the current stats to emergency help services and notify them in case of any disaster.

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