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IoT Based Monitoring and Alert System for Sewage Worker's Safety

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Abstract

Sewage system maintenance is a cumbersome task that has to be carried out properly since it is inevitable. Fatality occurs every year due to improper and inadequate facilities available as well as dangerous gases emitted during sewage disposal. Sewage workers are unaware of the dangers posed by a sudden attack of poisonous gases since these gases are odourless and if exposed for a prolonged period of time might lead to respiratory issues. To deal with this issue, an effective sewage monitoring and alert system is required. The proposed project continuously monitors the poisonous gases and oxygen present in sewage as well as the sanitation workers' health. This effectively reduces the impact of the poisonous gases on the sewage worker.

Keywords: Sewage monitoring system, Human health, Sewage worker, IoT, Arduino UNO, Node MCU, MQ4 Sensor, MQ7 Sensor, Heart beat sensor

1. Introduction

Sewage is a type of wastewater that is produced by a community of people. Typically, it is dumped in the sewage system. Wastewater from surrounding houses, businesses, educational institutions, and public buildings is considered as sewage. The sewage system is the most crucial part of big cities. Manual scavenging is the most difficult of all sanitation work. According to government data, 58,098 manual scavengers are working on average [5]. Manholes are the critical part of the sewer system through which the sewage worker can gain access to the underground sewage waste. The sewage workers enter the manhole, to remove the blockage which is not safe for them due to sewage gas which is a result of the natural

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decomposition of human waste. It's made up of many gases, including hydrogen sulphide, ammonia, and others. Due to the odorlessness of these deadly gases, they are unaware of the possibility of an unexpected attack. When cleaning septic tanks and sewers, 347 employees died between 2017 and 2022 [6]. In the underground sewage system, the intensity of toxic gas levels is not monitored continuously. If exposed for a prolonged period of time, it may cause respiratory issues such as pneumonitis, bronchiolitis obliterans, infections, leptospirosis, skin infection, and respiratory problems. Due to the inadequacy of proper gas leakage monitoring systems, numerous deadly accidents occurred during the last few decades. Effective monitoring with an alert system is required in the sewage system to overcome this problem.

1.1 Objective

This research is to offer a flexible method for detecting the toxic gas level in the sewage system and updating it in real-time using the IoT Blynk application and to alert the workers to leave their working area, whenever the level of harmful gases is about to reach the threshold value. The protection of sewage workers lives is the main goal of this study, along with the development of efficient, affordable systems.

2. Related Work

Priya Tiwari suggested a solution for the detection of the clog and stink gas in the underground sewage system. The proposed system has MQ-2 sensor, Ultrasonic sensor, and LM35 sensors. The data from the sensors are sent to Arduino UNO and to the cloud through Wi-Fi. Thing Speak interacts with Wi-Fi data. The data can be transmitted to the registered mobile number via the GSM module [1]. Nitin Asthana and Ridhima Bahl proposed a device to monitor hazardous sewage gas and an alert system. This study consists of MQ- 4 sensor, MQ-7 sensor, Arduino UNO, GSM Module. The sensor data are updated in the Thing Speak, IoT cloud platform. The proposed system warns the sewage worker via SMS and calls alerts using the GSM module by examining the concentrations of several harmful gases, when the acceptable level is smaller compared to the observed levels [2]. M. Lizzy Nesa Bagyam Et al identified the lack of proper monitoring in the existing sewage system leads to the death of sewage workers. So the authors proposed a method to measure the water level, and toxicity of methane and carbon monoxide in the drainage system the gas sensors are connected to WEMOS D1 to protect sanitation cleaners from harmful gas exposure. When the toxicity of methane and carbon monoxide increases beyond the threshold value, an alert message using the GSM module will be sent to the base station by which drainage workers can take

precautions while entering manholes [3]. Anushka Pendharkar Et al has proposed a system for measuring and analyzing toxic gas levels. This proposed system has MQ-4 and MQ-7 sensors to measure the methane and carbon monoxide gas level within the waste. The data from the system is transmitted to the cloud via GSM Module. Thing Speak, an IoT platform is used to represent the data graphically which can be used for analyzing changes in the level of sewer gases [4]. Hebziba Jeba Rani S, Yamini C L, Sakthivel M, Surendar S proposes a smart safety monitoring system that uses IoT technology to improve the safety of underground sanitation workers. The proposed system comprises of different sensors that are MQ 2, MQ 135, Fire and DHT 11 sensor. The data are processed in the Arduino Pro Mini and monitored data are displayed in the LCD Display. LED and Buzzer are used to alert the worker when the working environment is not safe. Through Wi-Fi module, alert message is delivered to the concerned monitoring unit and authorities [7]. Sasireka P, Abzari A, Ajay M, Pavithra N presents a system for monitoring the safety of sewage workers using Internet of Things. The proposed system has transmitter and receiver section. The transmitter section has MQ 2, MQ 135, Heart beat and temperature sensor to monitor the working environment and IoT and GSM module. The receiver section receives the data from the transmitter section using Zigbee transmitter. In the receiver section, the data are processed using Arduino UNO and displayed in the LCD display [8]. G Chandhini, B Chithra, P Kiruthikadevi, Bhagya Sasi, V. Kamal Kumar describes a system for monitoring underground drainage systems using IoT technology. The proposed system uses a MQ4, MQ136, SO2, MQ7, N02, MQ135 sensor. The data are transmitted to the server and ionic mobile application through NodeMCU. The data are monitored continuously, when the level cross the threshold the danger alert is displayed in the smart phone. The buzzer and LED are used to alert the worker about the danger [9]. Raakeshvarshan S, Dr. R Rajalakshmi presents a system for monitoring sewage in real-time using IoT. The proposed system uses MQ 4, Door magnetic and ultrasonic sensor for detecting gas leakage, lid closure and distance between object and sensor respectively. The collected data from the sensors, are processed using the Arduino UNO, and transmitted it to the cloud server via GSM modules. The cloud-based server, Thing Speak analyses the data in real-time and provides insights on the performance of the sewage system through a web-based dashboard or mobile application. The alert message is sent to the nearby municipal corporation office when the water level and gas level is increased beyond the limit [10].

3. Proposed Work

The proposed system of IoT-based monitoring and alert system for sewage worker's safety has MQ – 7 and MQ – 4 sensors are used to measure the presence of Carbon monoxide and Methane gas levels respectively. Temperature is measured using DHT 11 sensor. Max30100 Pulse Oximeter sensor is used to monitor the oxygen saturation of the worker. The Heartbeat sensor is used to measure the heartbeat. All these sensor data are given as input to the Arduino UNO. These values are displayed on the LCD. The sensor values are compared with the safety threshold values according to the medical terms. If any of the sensor values breach the safety limit, an alert will be given using the buzzer. If the oxygen level is decreased below the safety limit, oxygen is supplied through an air solenoid valve from the oxygen tank. Live data is streamed using ESP 8266 Wi-Fi module and the data are displayed using the Blynk – IoT platform. The worker will be forced to exit the system if the sensing parameters are not within the safety limit.

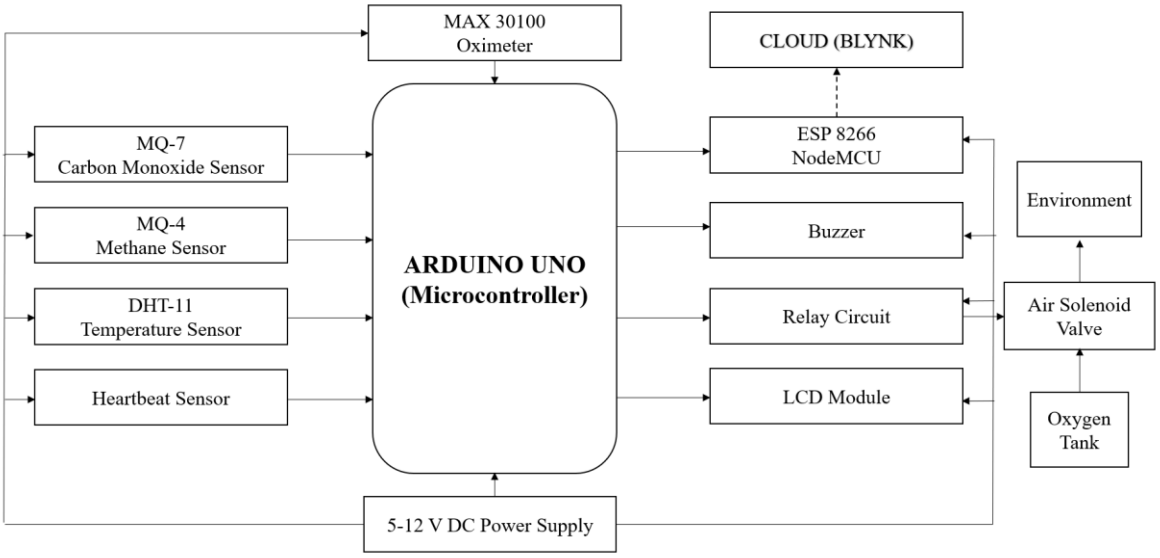

Figure 1. Block Diagram

The block diagram in fig.1 demonstrates the detection of methane and carbon monoxide gas level in the manhole and human body temperature, heartbeat, and oxygen saturation measurement, LCD, monitoring of gas level in the Blynk application using NodeMCU and Arduino, relay circuit, Oxygen tank, and buzzer to alert the sewage workers.

3.1 Hardware and Instrumentation

A. Arduino Uno:

Arduino Uno is built on the ATmega328P microprocessor from Microchip. There are 14 digital I/O pins and 6 analogue I/O pins on the board. It may be programmed using a type B USB port and the Arduino IDE.

B. ESP8266 NodeMCU:

With the help of the ESP8266 Wi-Fi Module, a SoC with an integrated TCP/IP protocol stack, microcontroller of any type may establish a connection to the Wi-Fi network. With the ESP8266, it is possible to act as host an application as well as offload all Wi-Fi networking duties to another application processor.

C. MQ-4 Sensor:

The MQ4 (Methane Sensor) detects methane gas in the air. Leak detection can be monitored within a concentration measurement range of 300 ppm to 10,000 ppm.

D. MQ-7 Sensor:

The MQ-7 (Carbon Monoxide Sensor), often known as a CO detector, detects carbon monoxide (CO) gas presence to prevent CO poisoning.

E. MAX30100 Pulse Oximeter:

The MAX30100 Pulse Oximeter includes heart rate monitoring as well as pulse oximetry. It detects the data using two light-emitting diodes (LED), a photodetector, enhanced optics, and low-noise analogue signal processing.

F. LCD WITH I2C:

The LCD is used along with the integrated circuit to reduce the number of pins connected to the Arduino. The LCD here used is a 16x2 display, the backlight is green and the character color is black. The integrated circuit has the interfacing address of 0x20 to 0x27. The integrated circuit is interfaced at the posterior of the LCD. The information is displayed using the LCD.

G. DHT11 Sensor:

The DHT11 sensor measure both the humidity. Four pins make up the DHT11 sensor: VCC, GND, Data Pin, and a Not Connected Pin. For reliable communication

between the sensor and microprocessor, a pull-up resistor of between 5k and 10k ohms is provided. All the sensors' data are continuously displayed on LCD.

H. Heartbeat Sensor:

This device detects the heartbeat and measures the user's biometric pulse rate. Its diameter of it is 0.625. It has a 0.125 thickness. It is a plug-and-play sensor. The current usage limit is 4 mA. It includes circuitry for noise cancellation and amplification. Once it is attached to the Arduino board, the GND and VCC pins provide the power. This sensor requires either +5V or 3.3V to operate.

I. Buzzer:

An electronic device called a buzzer produces sound in response to incoming electrical signals. It primarily serves as an alarm to signal a dangerous scenario.

J. Relay Circuit:

Relays circuits are electrically driven switches which are used to make and break the circuits by receiving electrical signals from other sources. When the specific gas level is about to hit the threshold value, it trips and alerts the user to the impending danger.

K. Oxygen tank:

An oxygen tank is a storage unit that holds oxygen, that may be kept in gas cylinders under pressure or as liquid oxygen in cryogenic storage tanks. The oxygen tank will provide oxygen to the surrounding environment whenever the oxygen level in the sewage system is low by tripping a relay circuit.

L. Solenoid valve:

To regulate the direction or flow of air or liquid, solenoid valves, which are electrically powered, are frequently utilized. The oxygen from the oxygen tank is delivered to the sewage system using a solenoid valve.

4. Results and Discussion

The gas monitoring sensors such as MQ-4 and MQ-7 sensor and health monitoring sensors such as MAX30100 Pulse Oximeter and Heartbeat sensor are interfaced with the Arduino UNO and ESP8266 NodeMCU module. The data from the system is transferred into the Blynk Application (cloud) using the Wi-Fi module ESP 8266. In the Blynk application, the live data from the underground sewage system can be monitored. When the hazardous gas level is about to reach the threshold value, the relay circuit opens the solenoid valve to release the oxygen into the environment.

4.1 Hardware Setup

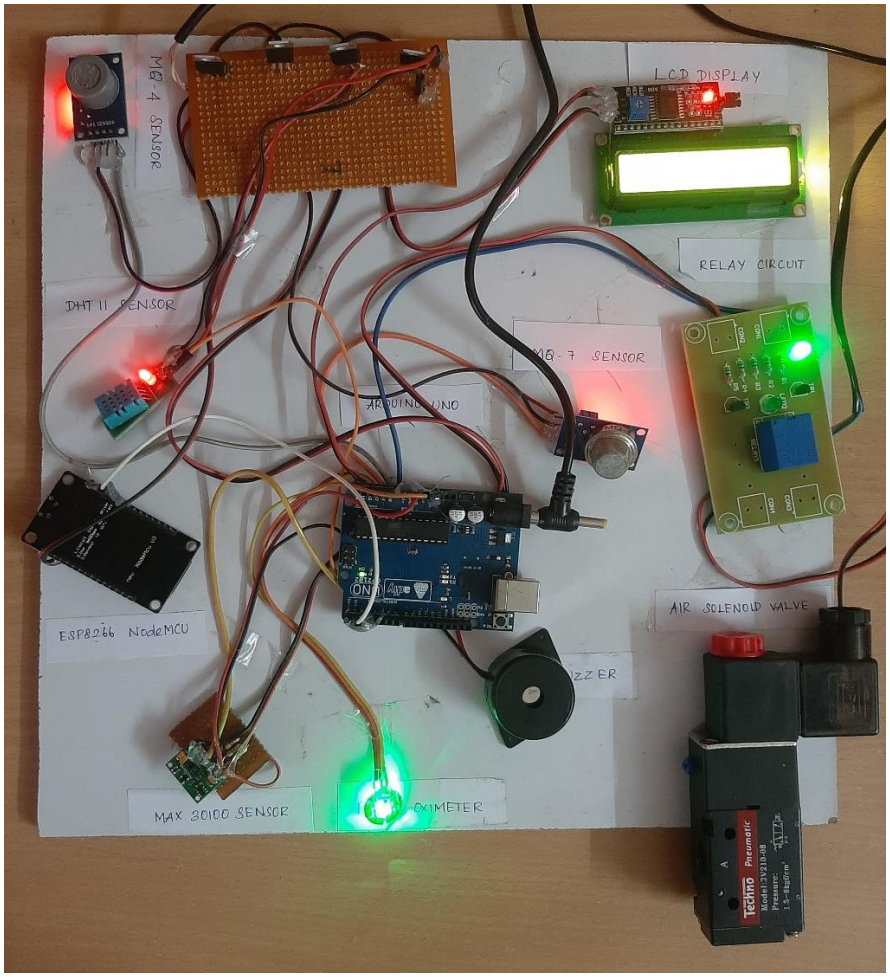

Figure 2. Hardware Setup

Fig 2 shows the hardware setup of the proposed system in which the MQ-4, MQ-7, DHT 11, Heartbeat, MAX 30100 Pulse Oximeter sensors are connected to the Arduino UNO. ESP8266 NodeMCU are connected to Arduino UNO. The Arduino UNO, ESP8266 NodeMCU, Relay Circuits are powered separately. LCD in Fig 3 shows the Methane gas level

as 3 ppm and Carbon monoxide gas level as 4 ppm in the manhole and the temperature as 34°C, humidity as 43%, heartbeat as 73 bpm and oxygen level as 92% of the worker.

Figure 3. LCD Display

4.2 Blynk Application

Figs 4, 5, 6, 7, 8 and 9 shows the screenshots of the DHT11 sensor, the MQ-7 sensor, the MQ-4 sensor, the MAX 30100 Pulse oximeter, the Heartbeat sensor, and all sensor's data in Blynk application respectively. Fig 4 shows temperature as 34°C and humidity as 43% from the DHT11 sensor. Fig 5 shows carbon monoxide gas level as 19 ppm from the MQ-7 (Carbon monoxide) sensor. Fig 6 shows methane gas level as 18 ppm from the MQ-4 (Methane) sensor. Fig 7 shows the oxygen saturation as 90% from the MAX 30100 pulse oximeter. Fig 8 shows the pulse as 70 bpm from the Heartbeat sensor. Fig 9 shows the pulse as 40 bpm, temperature as 35°C, humidity as 41%, carbon monoxide level as 3 ppm, methane gas level as 3 ppm, oxygen saturation as 91% from the heartbeat sensor, DHT 11 sensor, MQ-7 sensor, MQ-4 sensor, MAX 30100 pulse oximeter respectively.

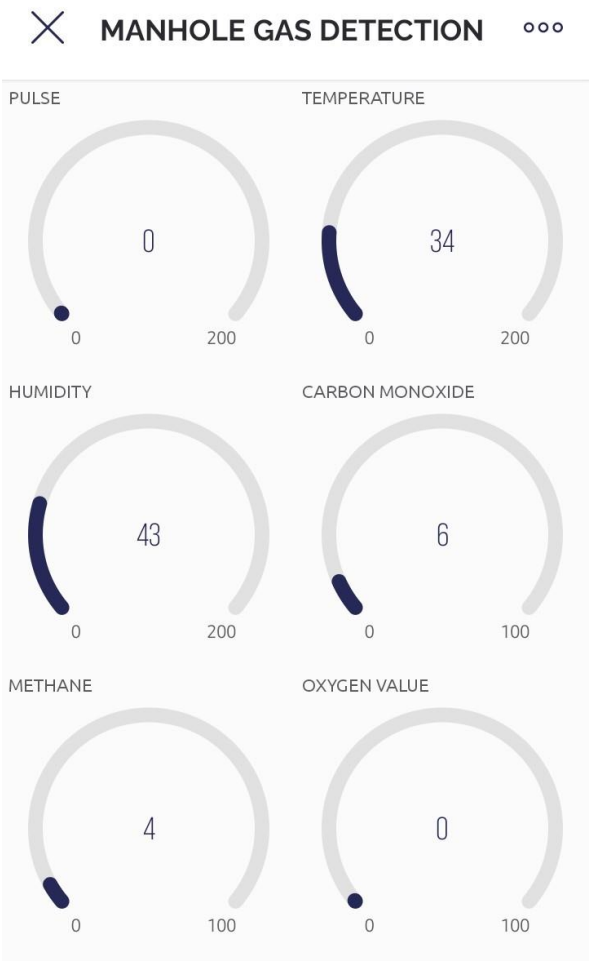

Figure 4. DHT11 sensor data displayed in Blynk Application

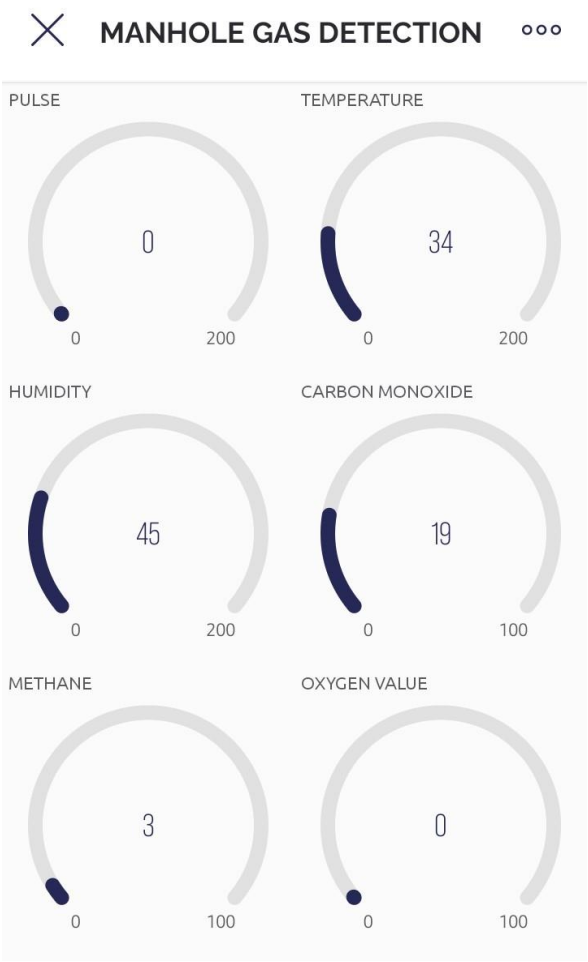

Figure 5. MQ-7 (Carbon Monoxide) sensor data displayed in Blynk Application

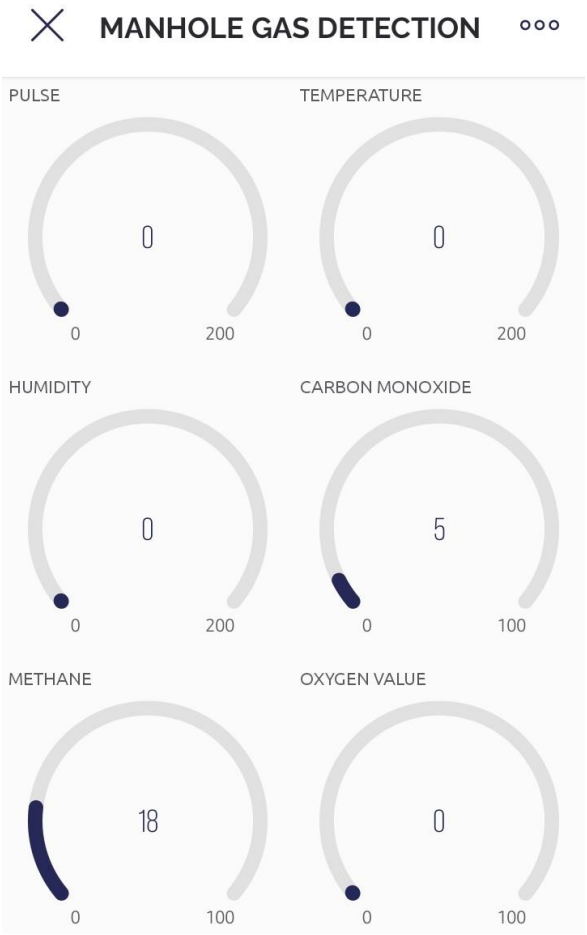

Fig 6. MQ-4 (Methane) sensor data displayed in Blynk Application

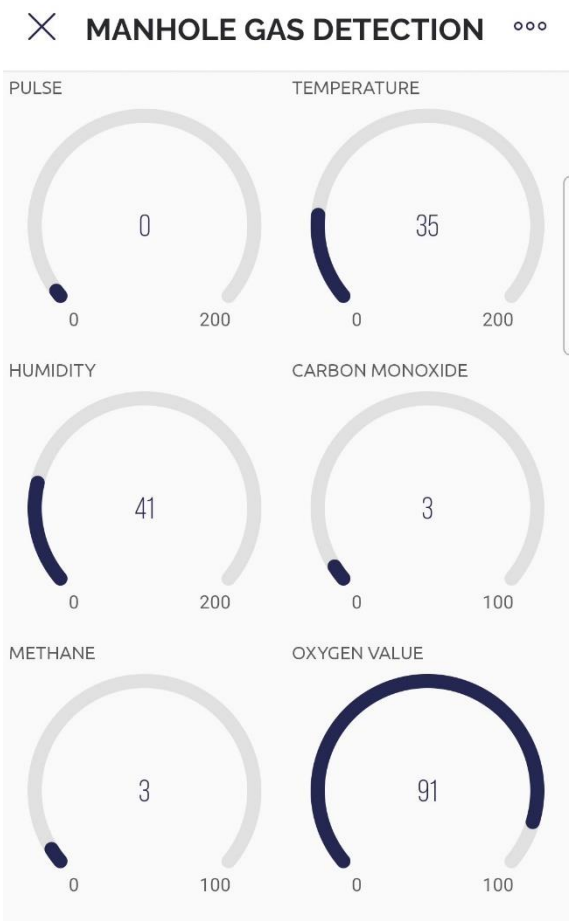

Fig 7. MAX 30100 sensor data displayed in Blynk Application

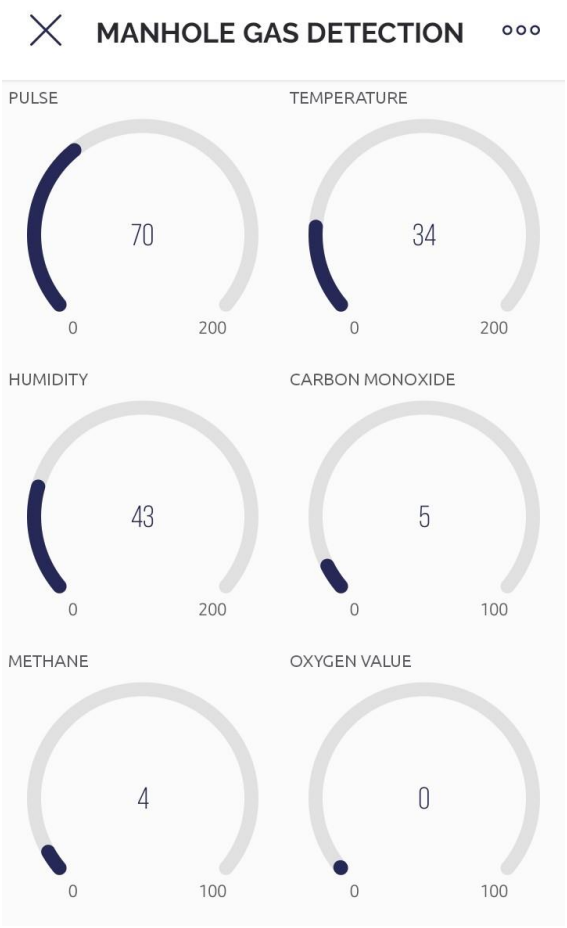

Fig 8. Heartbeat sensor data displayed in Blynk Application

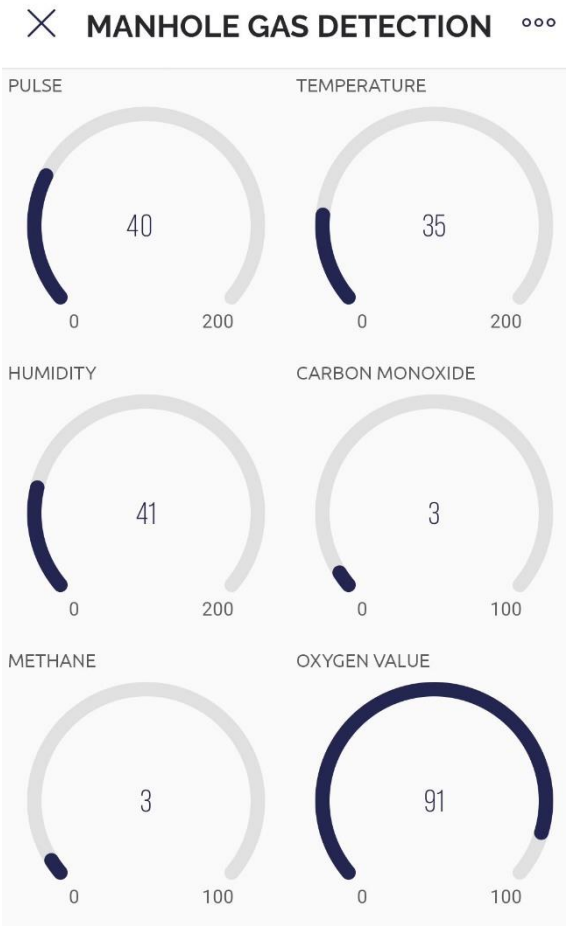

Fig 9. All sensor's data displayed in Blynk Application

5. Advantages

The advantages of IoT based monitoring and alert system for sewage worker's safety are given below

i. It avoids fatalities caused by exposure to gases that are hazardous including carbon monoxide, methane, hydrogen sulphide, etc.,

ii. It alerts the sewage worker about the impending danger.

iii. The proposed system can prevent serious medical problem which is caused by the long-term gas exposure.

iv. In order to avoid suffocation due to lack of oxygen supply, the proposed system provides external oxygen supply through oxygen tank.

v. It provides safety working environment for the workers.

vi. It continuously monitors the heart beat rate of a person and provides a real time update.

vii. Through the Blynk application, real-time data can be continually monitored and analysed.

6. Conclusion

The "IoT-based sewage monitoring and alert system for sewage worker's safety" is successfully created and tested . The study utilized all of the hardware's integrating features. The connection and testing of the DHT 11 sensor, heartbeat sensor, methane sensor (MQ4), carbon monoxide sensor (MQ7), and MAX 30100 oximeter were successful. The suggested approach will work well for both detecting worker health issues and harmful gas levels. An alert is delivered to the control unit and the workers if any one of the gas levels exceeds the threshold value. The employees will then be told to leave the area. So, this guarantees the security of the workforce**.** The Blynk platform also allows users to view real-time worker health and gas level updates. The oxygen tank valve is controlled by the solenoid valve to release the necessary amount of oxygen whenever the oxygen concentration in the body and sewage falls

below the threshold level. Until the worker is removed from the sewage, oxygen is administered.

Shortly, wearables for continuous health monitoring of sewage workers as well as other features like tracing of workers inside the manhole and oxygen-supplying sniffy masks can be developed.

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