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IoT Based Sewage Gas Monitoring System with Overflow Detection

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Abstract: *The sewage system is an important component of urban infrastructure. Most of the cities adopted efficient sewage systems to maintain the cleanliness of the cities. If the sewage maintenance is not proper, infectious disease may spread. Current sewage monitoring system is not efficient, as it is difficult to find out the poisonous gas level of sewage water. In the existing system, water level and temperature sensors are used to detect the overflow and the inside temperature of the sewage plant. An “IoT BASED SEWAGE GAS MONITORING SYSTEM WITH OVERFLOW DETECTION” is proposed to overcome the above mentioned limitations of existing systems. Internet of Things (IoT) is a network of physical objects that use sensors to capture data and exchange information over the internet which can be adopted to detect and monitor the exaction location of sewage system and the amount of poisonous gases present in the sewage plant. One of the advantage of this project is to prevent of sewage water get mixed with drinking water ,so that the environmental health issues can be solved. The advanced MQ5 sensor is used instead of MQ4 sensor as it detects only methane gas. MQ5 sensor helps to detect the poisonous and flammable gases such as carbon monoxide, methane & LPG. Electrochemical oxygen sensor is provided to detect oxygen level. Then the final measurement will be sent through the WiFi module to the database . The GSM and GPS module is used to send the emergency message and current location to a specific smartphone . In future the project can be upgraded with the aid of modern technology like artificial intelligence.*

Keywords: *IoT, Arduino, MQ5 Sensor, Electrochemical Oxygen Sensor, WiFi module.*

I. INTRODUCTION

Sewage treatment is the process of removal of contaminants from wastewater, containing mainly household wastewater and some industrial wastewater. Physical, chemical, and biological processes are used to remove poisonous substances and produce treated wastewater that is safe enough for release into the environment. Sewage gas is a complex mixture of toxic and nontoxic gases. It is collected in sewage systems by the decomposition of organic industrial wastes, typical components of sewage. Sewage gases include ammonia, methane, carbon monoxide, sulfur dioxide, hydrogen sulfide, and nitrogen oxides.

A large number of sanitation workers die every year, from the past 10 years around 631 people died during the cleavage of sewers and septic tanks. To overcome these issues we are implementing this project “IoT BASED SEWAGE GAS MONITORING SYSTEM WITH OVERFLOW DETECTION”. This project describes a system which is able to monitor the wastewater level, different types of gas level with the help of a sensor system. The MQ5 and O2 sensors will detect the carbon monoxide, methane, LPG, O2 gases. Microcontroller board sends information to a database through the WiFi module. GSM module and GPS module will send emergency messages and current location to the corresponding sanitation workers. So the main objective of this project is to obtain an effective low-cost for monitoring and infrastructure management in the city.

Sewage system is an important component of urban infrastructure. Most of the cities adopted the sewage system and it is the duty of managing stations to maintain cleanliness of the cities. If the sewage maintenance is not proper, infectious disease may spread. So the main objective of this project is to obtain an effective, low-cost monitoring system to save the life of sanitary workers.

A system of sewers collects sewage and takes it for disposal. The system of sewers is called a sewage system, where a main sewage system has not been provided, sewage may be collected from homes by pipes into septic tanks, where it may be collected in vehicles and taken for treatment or disposal.

Sewage treatment is the process of removing the contaminants from sewage to produce liquid and solid suitable for discharge to the environment. It is a form of waste management. A septic tank or constructed wetlands can be used to treat sewage systems. Sewage treatment results in sewage sludge which requires sewage sludge treatment before disposal. Monitoring and control systems play a role in the daily operation and maintenance of water supply and sewerage facilities.

Protecting the environment from industrial wastes has become one of the most difficult challenges of the twenty-first century. Sewage water is formed by waste water or other liquids that are drained from a place. In order to maintain the proper function of the sewage system, it should be monitored regularly. It is also difficult to monitor all the areas of sewage because of the physical limitations of human beings. The irregular monitoring results in so many issues such as overflow of sewage water, spreading of toxic gases, etc. Sometimes due to poor maintenance of the water in the sewage system it gets mixed up with the purewater and infectious diseases may spread to the environment. Due to variations in the climate during different seasons the drainage gets blocked and makes the environment unhealthy and makes the people upset and disrupts routine life.

Sewage workers provide an essential public service but they often have the cost of their dignity, health, safety, and living conditions. They are some of the most vulnerable workers. Sanitation workers continue to lose their lives due to the inhalation of toxic gases inside the sewage. Also, leaks and bursts are unavoidable aspects that account for significant loss if left undetected for a long period. This proves the inadequacy of a proper sewage monitoring system. The main objective of this system is to obtain a low-cost and flexible solution for checking water level and sensing the toxicity of gas and updating it in real time through IoT.

II. PROPOSED SYSTEM & DEVELOPMENT

The proposed system “IoT BASED SEWAGE GAS MONITORING SYSTEM WITH OVERFLOW DETECTION ” is based on the IoT. Proposed system presents an effective IoT approach to the sewage system using a small set of evaluative sensors connected to Arduino microcontroller boards communicating using Wi-Fi networking technology. Sensors are used to monitor and to measure different variables such as temperature, water level, gases (LPG, CH₄, CO, O₂). This project helps to save the life of workers.

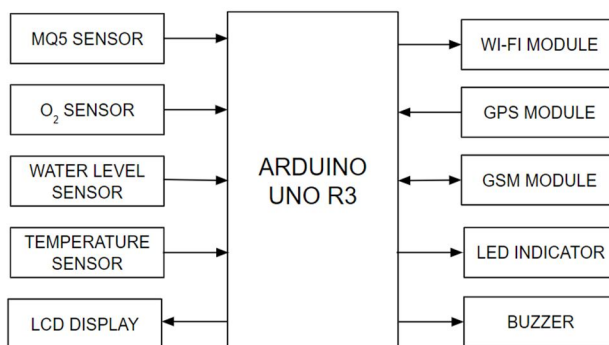


Fig 1. Proposed System Block Diagram

The Grove-Gas sensor (MQ5) sensor is used to detect the gas level of poisonous gases present in sewage , such as Methane (CH₄), Carbon monoxide (CO) and also detect flammable gas Liquefied petroleum gas (LPG). A Grove - Gas O₂ sensor is used for noticing the oxygen gas level. Sewage water levels can be detected by using a water level sensor. Temperature of sewage water detected by using a temperature sensor. The measurement of each gases will be displayed on the LCD display mounted on the device, simultaneously the measurements will be sent through WiFi to the monitor which is placed in the head office. With the help of gas level detection, the workers will get an idea about the current situation inside the manholes.

If the gas level, water level and temperature level is at normal level, green light will glow. When it is in an abnormal condition, the red light will glow. That indicates the dangerous level of poisonous gas, water and temperature inside the sewage. So that the worker will get some knowledge about risk identification. If the analog voltage reaches a certain threshold it will send the digital output high to the arduino and we can monitor the whole sensor's value and live locations to the “IoT webserver”. The arduino will detect this and will send the alert message with the corresponding location to the authorized person by using a GSM and GPS Module.

A. Introduction to IoT

The Internet of Things (IoT) describes the network of physical objects—“things”—that are embedded with sensors, software, and other technologies for the purpose of connecting and exchanging data with other devices and systems over the internet. IoT has become one of the most important technologies of the 21st century. Now that we can connect everyday objects like kitchen appliances, agriculture uses, commercial uses etc to the internet , communication is possible between people, processes, and things. This makes it essential to provide an infrastructure that can connect the monitoring and control systems to an Internet of Things platform.

Due to this rapid growth, there is a huge demand for infrastructure maintenance and advancement in technology. IoT allows objects to be sensed and controlled remotely across existing network infrastructure, creating opportunities for more direct integration between the physical world and computer based systems and resulting in improved efficiency and economic benefits. “Things” in the IoT sense can refer to a wide variety of devices which are mainly used for monitoring. These devices collect useful data with the help of various existing technologies and then autonomously flow the data between other devices.

On the other hand, the IoT system could also be responsible for performing action, not just sensing things. The data collected from devices is quite large and complex and becomes difficult to analyse using traditional data processing techniques called “big Data”. An IoT system consists of sensors/devices which talk to the cloud through some kind of connectivity. Once the data gets to the cloud, software processes it and then might decide to perform an action the need for the user. The functions of the IoT services Platform include the ability to deploy, configure, troubleshoot, secure, manage, and monitor IoT devices.

III. SYSTEM COMPONENTS

A. Arduino Uno R3

The Arduino Uno is a microcontroller board based on the ATmega328. Arduino is an open-source, prototyping platform and its simplicity makes it ideal for hobbyists to use as well as professionals. The Arduino Uno has 14 digital input/output pins (of which 6 can be used as PWM outputs), 6 analog inputs, a 16 MHz crystal oscillator, a USB connection, a power jack, an ICSP header, and a reset button. It contains everything needed to support the microcontroller; simply connect it to a computer with a USB cable or power it with an AC-to-DC adapter or battery to get started.

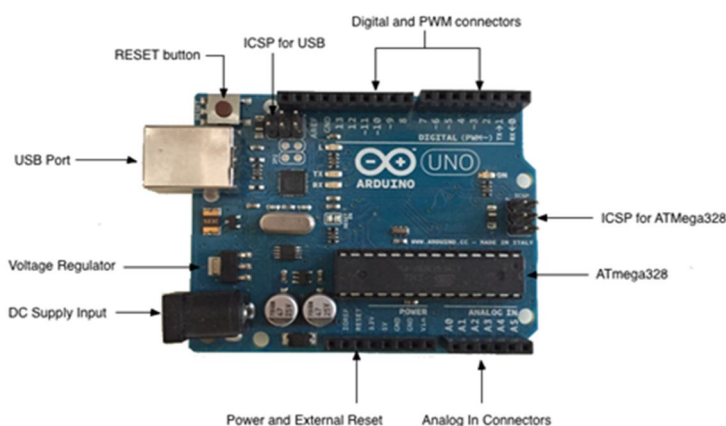


Fig 2. Arduino UNO R3

B. Gas Sensor (MQ5)

A gas sensor is a device which detects the presence of gas in an area. This sensor interacts with a gas to measure its concentration. Each gas has a unique breakdown voltage i.e. the electric field at which it is ionized. Sensors identify gases by measuring these voltages. The sensor value only reflects the approximated trend of gas concentration in a permissible error range, it does not represent the exact gas concentration. The detection of certain components in the air usually requires a more precise and costly instrument, which cannot be done with a single gas sensor.

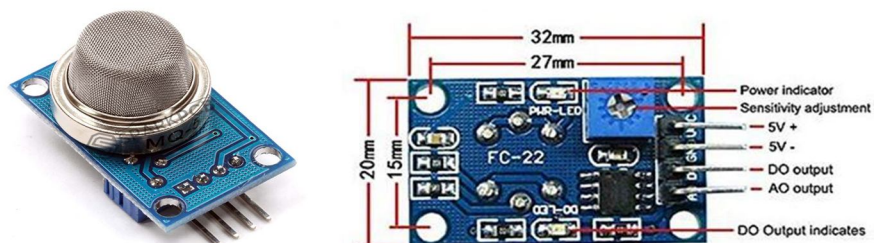


Fig 3. Gas Sensor (MQ 5)

C. Grove - Gas O₂ Sensor(MIX8410)

Grove - Oxygen Sensor(MIX8410) is a kind of sensor to test the oxygen concentration in air, which is based on the principle of the electrochemical cell to the original work. Clearly know the current oxygen concentration when you output voltage values proportional to the concentration of oxygen and refer to the oxygen concentration linear characteristic graph. It's very suitable for detecting oxygen concentration in the environment. Grove - Oxygen Sensor(MIX8410) is an organic reaction module, it can provide a little current while putting it in the air, we don't need to provide an external power to it, and output voltage will change as time current changes.

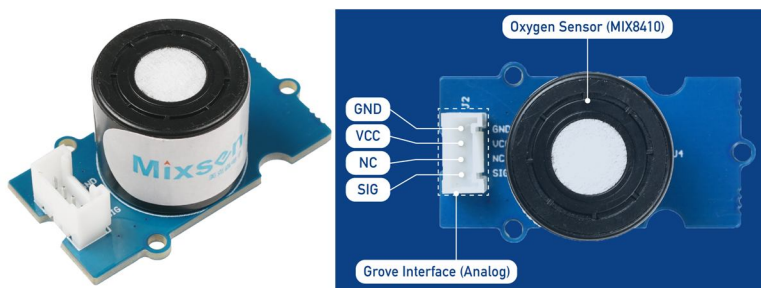


Fig 4.Grove - Gas O₂ Sensor (MIX8410)

D. Water Level Sensor

This sensor can be used to measure the water level, monitor a sump pit, detect rainfall or detect leakage. The sensor has a series of ten exposed copper traces, five of which are power traces and five are sense traces. These traces are interlaced so that there is one sense trace between every two power traces. Usually these traces are not connected but are bridged by water when submerged.

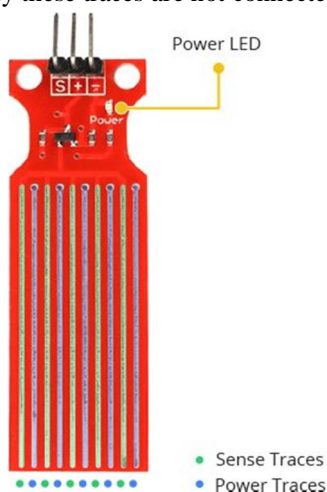


Fig 5.Water Level Sensor

E. Temperature Sensor

LM35 is an Integrated circuit Temperature sensor, whose output voltage varies, based on the temperature around it. It is a small and cheap IC which can be used to measure temperature anywhere between -55°C to 150°C.Measuring temperature of a particular environment Providing thermal shutdown for a circuit/component,Monitoring Battery Temperature,Measuring Temperatures for HVAC applications are of LM35.

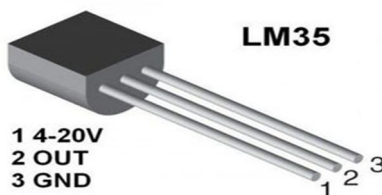


Fig 6.Temperature Sensor

F. Wi-Fi Module (NodeMCU ESP8266)

NodeMCU is an open-source Lua based firmware and development board specially targeted for IoT based Applications. It includes firmware that runs on the ESP8266 Wi-Fi SoC from Espressif Systems, and hardware which is based on the ESP-12 module. The NodeMCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chips having Tensilica Xtensa 32-bit LX106 RISC microprocessor. This microprocessor supports RTOS and operates at 80MHz to 160 MHz adjustable clock frequency. NodeMCU has 128 KB RAM and 4MB of Flash memory to store data and programs. Its high processing power with in-built Wi-Fi / Bluetooth and Deep Sleep Operating features make it ideal for IoT projects. NodeMCU can be powered using a Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface. There are two available versions of NodeMCU as version 0.9 & 1.0 where the version 0.9 contains ESP-12 and version 1.0 contains ESP-12E where E stands for "Enhanced". The name "NodeMCU" combines "node" and "MCU" (micro-controller unit). NodeMCU provides access to the GPIO (General Purpose Input/Output) and a pin mapping table is part of the API documentation.

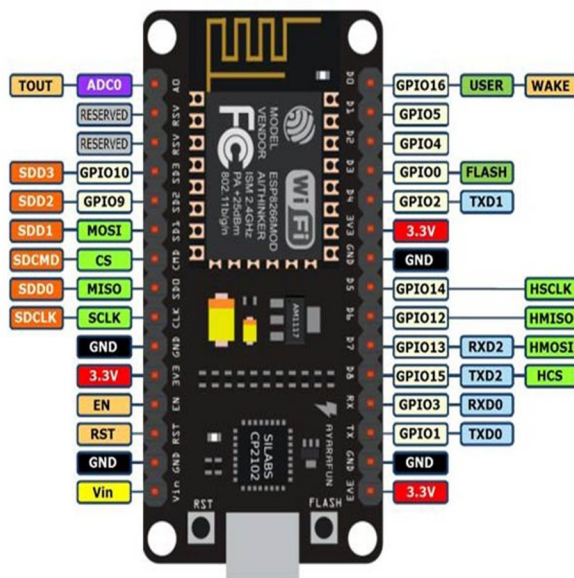


Fig 7. WiFi Module

G. GPS Module

The SKG13BL is a complete GPS module that features super sensitivity, ultra low power and small form factor. The GPS signal is applied to the antenna input of the module, the serial interface outputs NMEA protocol data or customer protocol data with position, velocity and time information. It is based on the high performance features of the MediaTek MT3337 single-chip architecture, Its – 165dBm tracking sensitivity extends positioning coverage into places like urban canyons and dense foliage environments where the GPS cannot fix before. The small form factor and low power consumption make the module easy to integrate into portable devices like PNDs, mobile phones, cameras and vehicle navigation systems.



Fig 8. GPS Module

H. GSM Module

SIM900A Modem is built with a Dual Band GSM based SIM900A modem from SIMCOM. It works on frequencies 900MHz. SIM900A can search these two bands automatically. The frequency bands can also be set by AT Commands. The baud rate is configurable from 1200-115200 through the AT command. SIM900A is an ultra compact and wireless module. The Modem is the coming interface, which allows you to connect a PC as well as a microcontroller with RS232 Chip(MAX232). It is suitable for SMS, Voice as well as DATA transfer applications in the M2M interface. The onboard Regulated Power supply allows you to connect a wide range unregulated power supply. Using this modem, you can make audio calls, SMS, Read SMS, attend the incoming calls and ect. through simple AT commands. This is a complete GSM module in a SMT type and made with a very powerful single-chip, allowing you to benefit from small dimensions. SIM900A GSM Modem with serial and TTL outputs.

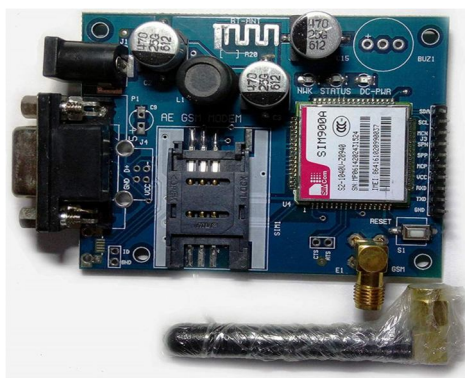


Fig 9.GSM Module

IV. SYSTEM IMPLEMENTATION

A. Flow chart

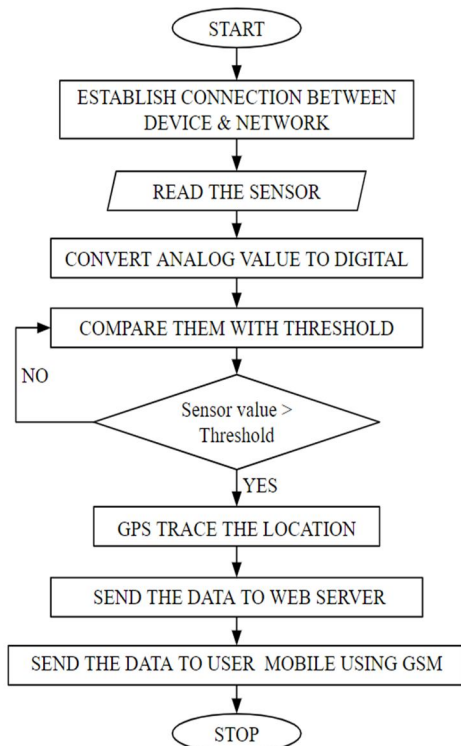


Fig.10. Flow Chart

B. Circuit Diagram

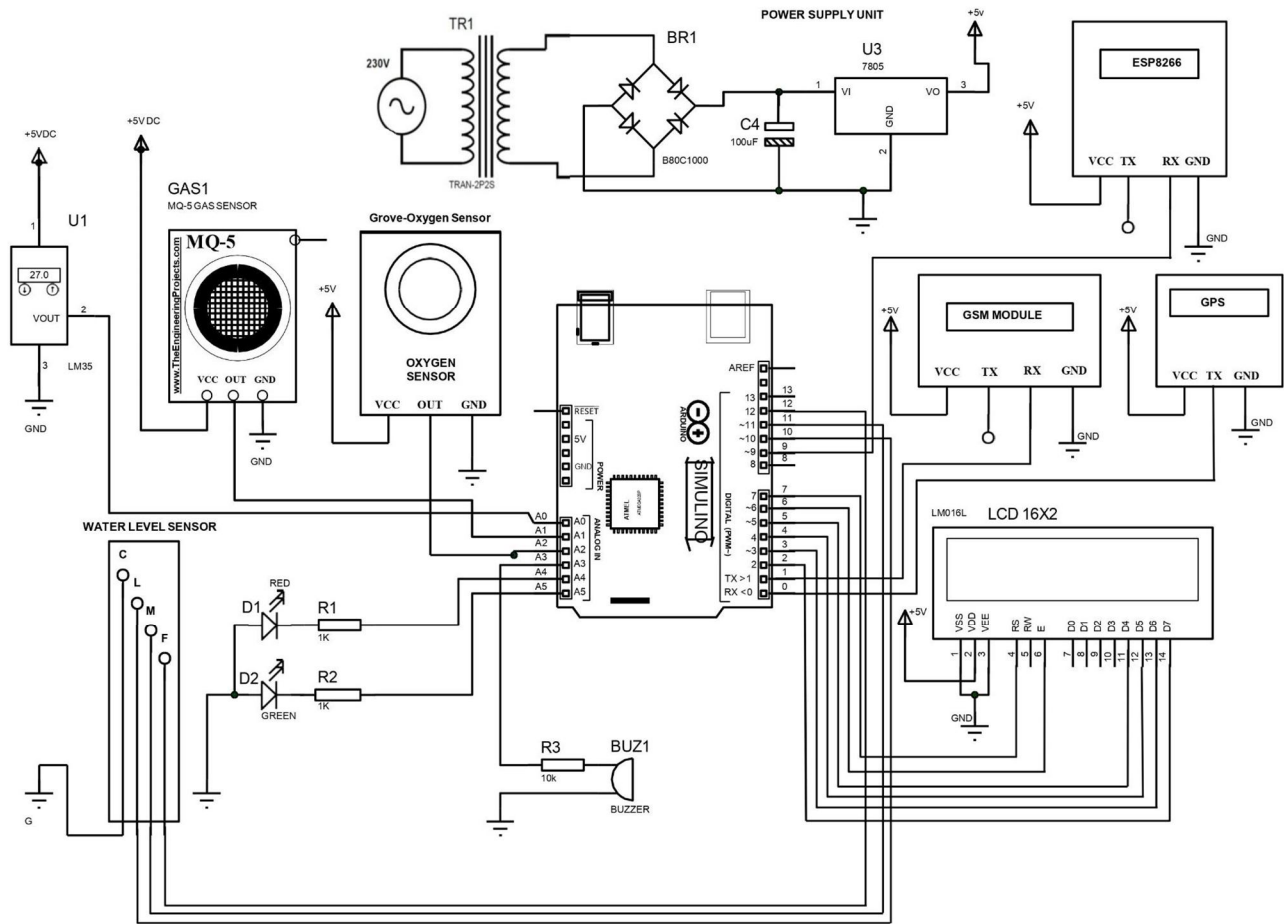


Fig.11.Circuit diagram

V. ADVANTAGES

- A. This device is very easy to integrate, cost effective and can be implemented quickly. And also it is very effective, low-cost, easy to access and reliable. This device helps to maintain the hygiene of the city through emergency alerts.
- B. It will display the result with accurate clarity in the respective web server and also provide clear visibility in emergency situations for the authorities
- C. When sewage water overflows, this device will send an emergency message to the sewage worker's phone, so they can take corrective actions immediately.
- D. By using the emergency alert system in the device, it is very helpful to the sanitation workers before entering into the manholes. Thus workers get an idea of their current status inside the sewage. Hence can reduce the labour calamities.
- E. This device provides safety indications, so that the sewage workers can take remedial precautions, hence can reduce the death rate to a limit.
- F. This device is user-friendly hence it provide rapid and smart response

VI. DISADVANTAGES

- A. If the sewage water level rises, getting only an emergency message.
- B. In today's tech-driven world, each and every device that an individual uses is connected via the internet. This increases the risk of any leakage of data that might be important. This is a major drawback of sharing information, as confidential information might not be safe & could be hacked by third parties easily

VII. APPLICATION

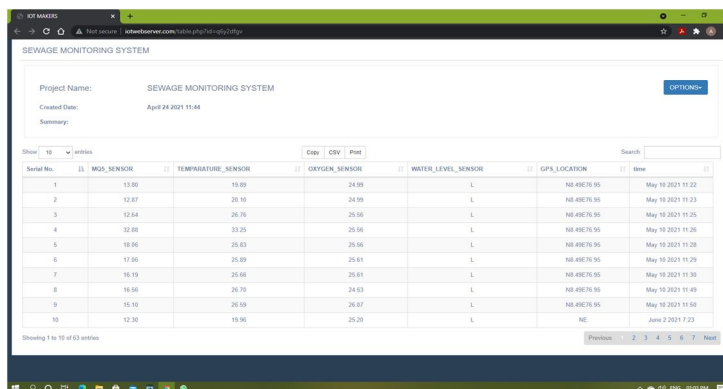
- 1) *Municipal Manhole Sewage System:* This device can apply to urban areas, hence easily to detect the overflow of sewage water and poisonous gas.
- 2) *Deep Well:* This device can be put in a deep well, hence can easily measure the oxygen level inside the well.
- 3) *This Sewage Treatment Plants:* Sewage treatment plants use this device to measure the levels of toxic gases like carbon monoxide and methane.
- 4) *Air Pollution Monitoring System:* Using this device, the MQ5 sensor will detect the presence of poisonous gas such as carbon monoxide, methane and also detect the flammable gas LPG in the atmosphere.
- 5) *Chemical Factory:* Chemical composed gases like carbon monoxide, methane can be detected by using MQ5 sensor.

VIII. FUTURE SCOPE

- A. Work may be implemented in the form of an android application. In future enhancement, the whole operations that take place in our device can be converted into an android application.
- B. The sewage water plants use anaerobic digestion to generate heat and electricity on site. During anaerobic digestion, microorganisms break down organic materials from wastewater. The methane gas produced from this process is then used to generate heat and electricity.
- C. Voice assistants will be provided by the Municipal manhole sewage system:- be provided on the sewage system for understanding the current situation inside the manholes without getting inside.

IX. RESULT ANALYSIS

A. IoT Web Server



Serial No.	MQ5_SENSOR	TEMPERATURE_SENSOR	OXYGEN_SENSOR	WATER_LEVEL_SENSOR	GPS_LOCATION	Time
1	13.80	19.89	24.99	L	NO.49C76.95	May 10 2021 11:22
2	12.87	20.10	24.99	L	NO.49C76.95	May 10 2021 11:23
3	12.64	20.76	25.56	L	NO.49C76.95	May 10 2021 11:25
4	32.80	33.25	25.56	L	NO.49C76.95	May 10 2021 11:26
5	18.56	25.83	25.56	L	NO.49C76.95	May 10 2021 11:28
6	17.56	25.89	25.61	L	NO.49C76.95	May 10 2021 11:29
7	16.19	25.66	25.61	L	NO.49C76.95	May 10 2021 11:30
8	16.56	26.70	24.53	L	NO.49C76.95	May 10 2021 11:49
9	15.10	26.59	20.07	L	NO.49C76.95	May 10 2021 11:50
10	12.30	19.96	25.20	L	NO	June 2 2021 7:23

Fig 12. IoT Web Server

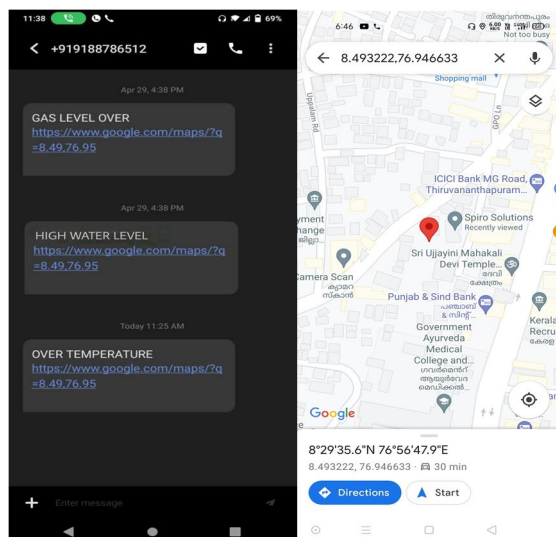


Fig.13. Message and GPS Location

X. CONCLUSIONS

The proposed project helps to prevent the sudden accident of workers and also helps to keep the society clean. The smart device can be implemented and used across the world and also helps to monitor the overflow of the sewage water. In the future the project can be upgraded with the aid of modern technology like artificial intelligence. By small modification in the algorithm, this project can be used in agriculture/crop/environment monitoring and controlling systems. This system directly impacts the health issues of citizens and workers who cleans the underground drainage. It also avoids spreading of infection due to mosquitoes and gives a clean and healthy environment as well as controls the diseases such as malaria, dengue, diarrhea, etc. The system reduces the accident caused by an exposed manhole. The purpose of this project is to satisfy the objective to fulfill the requirement of the sewage monitoring system. It is a user-friendly sewage monitoring system. Based on the experiment verification, correct sensor values detected and recorded. The goal of this project is to provide a methodology to check harmful release of gaseous materials in areas included in the sewage system, When inhaled for a significant period of time, these gases can be harmful, and if high doses are absorbed in the bloodstream, it may lead to serious illnesses in the workforce. Hence this device will be a complete solution for sewage accidents.

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