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Safety Monitoring System for Sewage Workers

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***Abstract*—Sewage system plays an important role in keeping the city clean. But the very task of keeping the sewers clean is done by the sewage workers, who risk their lives every time they attempt to clean the blockage. This serious problem is caused by the sudden release of toxic gases such as Methane, Hydrogen sulphide, Ammonia etc. that leads to long-term health damages such as Anemia, vision loss, lung infection, asphyxiation, heart problems, nausea and traumatic after effects. These gases can even lead to death of the worker. Majority of these deaths were caused due to the unmonitored gas levels. Analyzing the gas levels as a precautionary step reduces the rate of mortality. For this purpose, various types of gas sensors like MQ-8, MQ-135, MQ - 2 are used in the proposed system. Also, in order to make sure that the worker's health condition is well, pulse rate monitoring sensors are intervened by interfacing with ESP8266 processor and transmitted. These sensors are fitted in a water proof jacker and is worn by the worker to provide the real-time data on the conditions. If drainage system gets blocked and water overflows this blockage will be instinctively recognized by the sensor. If the sensor output exceeds the threshold level, the problem will be indicated and displayed on the Mobile or PC of the officer or the co-worker. This smart drainage system will help to maintain the health of the workers at a low cost and easier implementation in the interior cities and rural areas. Mechanical systems to lift the workers and other remedial actions under emergency situations are also scoped in the project.**

***Index Terms*— Toxic gases, Gas sensors, heart rate sensor, ESP8266 processor.**

I. Introduction

Sewages that contain toxic gases, which when inhaled for a long duration can lead to various chronic diseases and lethal damages. High concentrations of gases like Hydrogen Sulfide, Ammonia, Carbon Dioxide, Methane often explodes suddenly causing death and permanent health damages. Sewage workers are often exposed to such danger while cleaning the sewers. The lack of treatment and protection leads to the deaths of many such sewage cleaners. On the other hand, manual system installation and data generation is both difficult and automated cleaning methods are not cost efficient. So, there is a growing need for automated data generation and monitoring. It can be used for monitoring the sewage conditions at different locations.The IoT (Internet of Things) analytics platform sends warnings whenever the gas levels sensed by the sensors go beyond the standard limits. A sensor node containing two gas sensors and a level sensor that transfers the appropriate sensed information about the harmful gases and This is to obtain an effective low-cost and flexible solution for checking water level and sensing the toxicity of gas and updating it in real time through IoT.

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II. Existing Methodology

Daniel Hoonwerg et al (2012) launched “WHAT A WASTE” gloabal review of Solid Waste Management , Urban Development and Local Government Unit World Bank, Washington. His findings are as follows. This paper shows the introduction of a system combined with an integrated combination of Radio Frequency Identification, Global Position System, General Packet Radio Service, Geographic Information System and web camera that will solve the problem of solid waste They also analyzed the actual performance of the system. Narayan Sharma, “Smart Bin Implemented for Smart City”, International Journal of Scientific & Engineering Research, September 2015, Vol.6, No.9.This paper describes the application of a model known as “Smart Bin” in managing the waste collection system of an entire city. The network of sensors enabled smart bins connected through the cellular network generates a large amount of data, which is further analyzed and visualized at real time to gain insights about the status of waste around the city. This paper also aims at encouraging further research in the topic of waste management.pulse and pressure levels. But this method fails in monitoringthe gas levels inside the sewer and the healthconditions of the sewage workers on a real – timebasis.Any abnormalities in the pulse rate of the worker would not be known if not monitored from time to time regularly. Other methods include using ZigBee and GSM for communication. These methods do not offer full functionality when common requirements for the wireless platforms such as optimization of the sensor nodes, optimization of the communication, error recovery from communications and node operation, high availability of service at all levels, application server reliability is taken into consideration.

Sewers Automated cleaning methods of sewage wastes is a widely spoken technique nowadays but the cost of implementing these for all the sewers across the state or country is too high and not affordable. Also, these automated machines are often designed for metropolitan citieswhich is just 23% of the total number of. Most rural areas and non-metropolitan cities cannot be offered this solution as a replacement for the current methods. The cost efficiency is again athreat for the municipalities to bring these intoeffect. The maintenance cost of these machinesalso adds up to the annual cost and thereby hindering its pragmatic implementation in places.

III. Proposed Methodology

The proposed methodology is based on a real-time monitoring system using IoT. The system consists of Air Quality and Gas sensors to detect the levels of Methane (MQ4), Hydrogen (MQ-2) and Ammonia (MQ-135) etc. and a heart rate / pulse level sensor that is fitted on the worker’s body inside the waterproof suit. The ultrasonic sensor is fixed on the lid of the sewage opening to enable the measurement of sewage water levels and to ensure a safe entry for the worker into the sewer. The ESP8266 and the ATmega328P processors are used for their high performance and compatibility with the sensors used.

The ESP8266 processor is responsible to control and process the data generated by the sensor. The data collected is later stored in a cloud database and is accessed through the Cayenne IoT platform. This platform is widely used in several IoT-based systems for its easy user interface and accurate data displaying features. The mobile application of this platform enables monitoring the data not just in PCs and Laptops but also in mobile phones whenever and wherever we go.

In the Node MCU controller, the output value of the sensors is compared with the calculated threshold values and when the level goes above the specified limit, it is intimated through the smart phone. This is very essential for the Health department to take immediate action on it. Also, the co-worker who accompanies the worker working inside the sewage can initiate the rescue action immediately without any delay. The sensors are powered by a battery fitted along with the module fitted in the worker’s waterproof jacket. Eye goggles and oxygen masks are also mentioned to be used by the worker in this system for ensuring the physical safety of the worker and also in order to prevent any skin ailments and infections due to the direct contact with the toxic gases inside the sewage tanks.

The Block diagram represents the proposed system as three separate parts: gas-level and health condition checking, the IoT-based monitoring of data and taking manual and actuated steps under emergency situations. The Gas sensors on the left side of the diagram are used to monitor the levels of toxic gases.

The Pulse rate sensor collects the heart rate-related data from the worker for monitoring health condition from time to time. These sensors are interfaced to NodeMCU controller which is used as a communication module for transmitting the collected data on a real-time basis. The data is received and monitoring using a mobile application or a PC and alerts pop-up in it if there occurs any abnormality in the sensed values and the rescue of the worker is initiated.

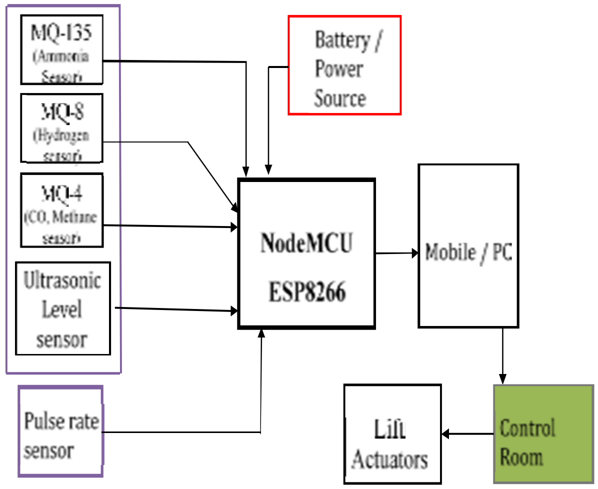

Figure.1. Block Diagram of safety monitoringsystem for sewage workers

IV. HARDWARE REQURIMENTS AIR QUALITY SENSOR (MQ – 135)

The MQ-135 Gas sensors are used in air quality control equipment and are suitable for detecting or measuring of NH3, NOx, Alcohol, Benzene, Smoke, CO2. It converts the charge of conductivity to correspond output signal of gas concentration. The analog pin is TTL driven and works on 5V and so can be used with most common microcontrollers.

Operating Voltage is +5V and is used to detect or measure gases like NH3, NOx, alcohol, Benzene, smoke, CO2, etc. Analog output voltage is 0V to 5V and Digital output voltage is 0V or 5V (TTL Logic). Preheat duration is 20 seconds and can be used as a Digital or analog sensor. The Sensitivity of Digital pin can be varied using the potentiometer. The MQ-135 gas sensor is shown below in Fig 2.

Figure.2. Air Quality Sensor (MQ-135)

A. Methane Gas Sensor (Mq – 4)

The methane gas sensor detects the concentration of methane gas in the air and output is an analog voltage. The concentration of sensing range is about 300 ppm to 10,000 ppm. Sensitivity of the detector is set by a resistive load between the output pins and ground. Resistance value of MQ-4 is different for various kinds of gases. So, sensitivity adjustment is very necessary for this sensor. It is recommended to calibrate the sensor for 5000ppm of CH4 concentration in air and use value of load resistance (RL) about 20KΩ (10KΩ to 47KΩ).

While measuring, the proper alarm point for the gas detector should be determined after considering the temperature and humidity influence. The sensor has a high sensitivity to CH4, Natural gas. Small sensitivity to alcohol, smoke. The MQ – 4 Methane gas sensor is shown below in Fig. 3.

B. Hydrogen Gas Sensor (Mq – 2)

A hydrogen sensor is a gas detector that detects the presence of hydrogen. MQ2 gas sensor is also known as chemi-resistor. It contains a sensing material whose resistance changes when it comes in contact with the gas. This change in the value of resistance is used for the detection of gas. They contain micro-fabricated, point-contact hydrogen sensing material in it and are used to locate hydrogen leaks. The detection level of 10 pg (50

Figure. 3 Methane Gas Sensor(MQ – 4)

ppb) has been obtained. The dependence of the detector response on the mass of hydrogen was found linear in the range of five orders of magnitude. Three gases make up 99.96% of dry air (Nitrogen, Oxygen, Argon MQ2 is a metal oxide semiconductor type gas sensor. Concentrations of gas in the gas is measured using a voltage divider network present in the sensor. This sensor works on 5V DC voltage. It can detect gases in the concentration of range 200 to 10000ppm. This sensor has a high sensitivity and fast response time. The sensor's output is in terms of analog resistance. The MQ- 2 gas sensor is shown below Fig. 4.

Figure.4. Hydrogen Gas Sensor (MQ – 2)

C. Ultrasonic Sensor

Ultrasonic level sensors measure distance by using the ultrasonic waves. The sensor head emits an ultrasonic wave and receives the wave reflected back from the target. Ultrasonic level sensors measure the distance to the target by measuring the time between the emission and reception. The sensor emits a high-frequency pulse, generally in the 20 kHz to 200 kHz range, and then listens for the echo.
The pulse is transmitted in a cone, usually about 6° at the apex. They can reflect a portion of the sound and produce a false echo that interferes with the ability of the sensor to properly detect the echo from the surface of the water. To provide accurate water level measurements ultrasonic sensors are integrated with an Analog- to Digital converter (ADC). This implies that initially the non-electronic (acoustic) Trigger pin is an Input pin. Echo pin is an Output pin. This pin goes high for a period of time which will be equal to the time taken for the US wave to return back to the sensor. The Ultrasonic Sensor is shown below Fig. 5.

Figure.5. Ultrasonic Sensor

D. Heart Rate / Pulse Rate Sensor

The heart rate sensor measures your heart rate in Beats per Minute using an optical LED light source and an LED light sensor. The light shines through your skin, and the sensor measures the amount of light that reflects back. The light reflections will vary as blood pulses under your skin past the light. A pulse wave is the change in the volume of a blood vessel that occurs when the heart pumps blood, and a detector that monitors this volume change is called a pulse sensor and it is entirely harmless.

It uses a technology called vibrometry to detect the subtle vibrations of a person's body caused by the movement of blood throughout their circulatory system. The range of output from the Pulse Sensor running at 3.3V is only 0 to 675. However, when blood flows through a vein/artery in the finger, there is a small change in the composition of light absorbed by the finger. As long as the heart is pumping, there will be a flow of blood within the veins. So, if we check the rate of blood flow, then we can check the heart rate or pulse rate of the person also. The output of the photo-diode will show this change and the presence of a pulse can be determined from the changes observed. A normal resting heart rate for adults range from 60 to 100 beats per minute. The Heart rate sensor is shown below in Fig. 6.

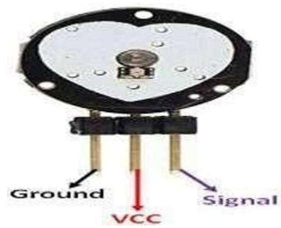

Figure.6. Heart Rate Sensor

This sensor can be used by connecting it to the Arduino or a NodeMCU controller. Once it is connected, then give the power supply with the help of VCC pin and GND pins. The operating voltage of this sensor is +5V or 3.3V.

V. NODEMCU (ESP8266-12E)

NodeMCU isa development board with ESP8266 processor and a firmware with the same name. The 3.3 V power for the ESP8266 is converted from the 5 V of USB. The NodeMCU firmware is a Lua language interpreter, but the NodeMCU development board can be used as any other esp8266 development board. 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. IoT devices are useful in low power battery operated application. It is also used in projects requiring multiple I/O interfaces with the Wi-Fi and Bluetooth functionalities.

The prototyping hardware typically used is a circuit board functioning as a dual in-line package (DIP) which integrates a USB controllerwith a smaller surface-mounted board containing the MCU and antenna. The choice of the DIP format allows for easy prototyping on breadboards. The design was initially based onthe ESP-12 module of the ESP8266, which is a Wi-Fi SoC integrated with Xtensa LX106 core, widely used in IoT applications. 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. The NodeMCU is shown below Fig. 7.

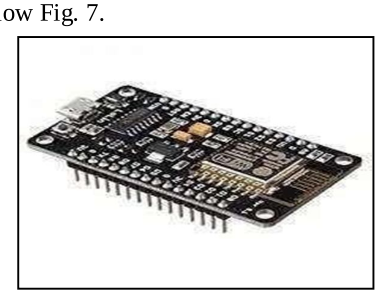

Figure.7. NodeMCU (ESP8266-12E)

VI. LIQUID CRYSTAL DISPLAY

It is a flat-panel display or other electronicvisual display that uses the light modulating properties of liquid crystals. Liquid crystals do not emit light directly. LCDs are available to display arbitrary or fixed images with low information content, which can be displayed or hidden, such as preset words, digits and 7 segment displays as in a digital clock.
LCDs are used in a wide range of applications including computer monitors, televisions, instrument panels, aircraft cockpit displays, and signage. They are common in consumer devices such as DVD players, gaming devices, clocks, watches, calculators, and telephones, and have replaced cathode ray tube (CRT) displays in nearly all applications.

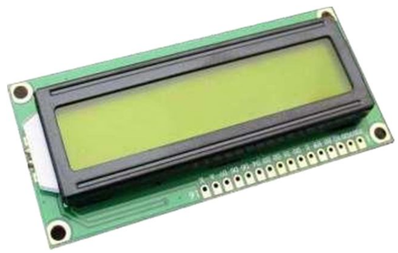

Figure.7. 16x2 Liquid Crystal Display

VII. BATTERY

Lithium remains the preferred choice for remote wireless applications due its intrinsic negative potential, which exceeds that of all other metals. Lithium is the lightest non-gaseous metal, and offers the highest specific energy (energy per unit weight) and energy density (energy per unit volume) of all available battery chemistries. Lithium cells, all of which use a non-aqueous electrolyte, have a normal operating current voltage (OCV) ranging between 2.7 and 3.6 V. The absence of water allows lithium batteries to endure more extreme temperatures.

VIII. SOFTWARE REQURIMENTS

A. Software Description

Cayenne is one of the popular IoT platform which makes it easy to build your own IoT setup. A drag and drop IoT project builder, Cayenne allows developers to quickly create and host their connected device on the internet, without spending a lot of time on programming side. Initially it was only available for Raspberry Pi, but now it has support for Arduino, NodeMCU and other controllers. This development ecosystem fits together seamlessly with a user-friendly interface for our project. This software is used along with the programming done from Arduino IDE using NodeMCU board and interfaced to view real-time values.

Figure.8 Cayenne Icon

B. Arduino Ide

The Arduino Integrated Development Environment - or Arduino Software (IDE) - contains a text editor for writing code, a message area, a text console, a toolbar with buttons for common functions and a series of menus, as shown in Figure 5.2. It connects to the Arduino and Mega 2560 hardware to upload programs and communicate with them. Programs written using Arduino Software (IDE) are called sketches. These sketches are written in the text editor and are saved with the file extension. The editor has features for cutting/pasting and for searching/replacing text.

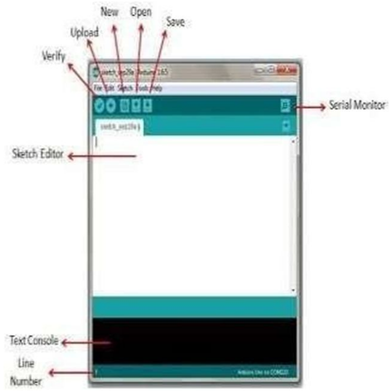

Figure.9.Arduino IDE Components

IX. RESULTS AND DISCUSSION

A. Project Setup

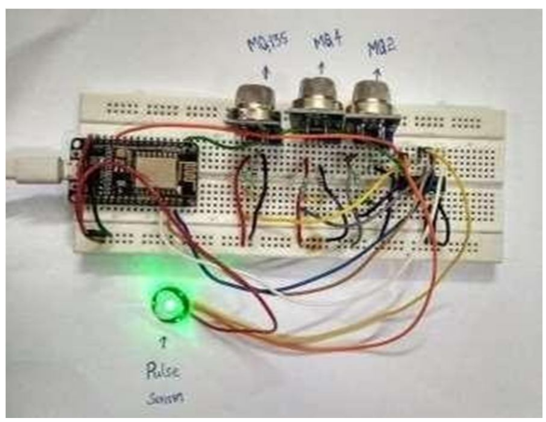

Figure.10. Project Setup for Sewage Workers

Figure.11. Ultrasonic Measurement Sensor

X. CONCLUSION

This project provides a smart solution to monitor the toxic gases present in sewage and alert the manual scavengers when the level goes above the specified limit. Here three gas sensors are used to detect the levels of Methane, Ammonia and Hydrogen gas levels. Node MCU is the heart of the system which controls the entire system. Node MCU consists of an inbuilt Wi-Fi module which connects the whole process to internet and the output is displayed in the smart phone through the app. The smart drainage monitoring system helps the people to move to safer areas when the gas level is above the specified limit. This system helps to reduce the death of sewage workers and it also has an advantage to monitor the real-time conditions of the worker inside the sewage.

FUTURE SCOPE

In order to monitor water quality in different sites, future works can be focused on establishing a system with more sensor nodes and more base stations. Connections between nodes and base station are via WSN, while connections among different base stations are via Ethernet. The Ethernet can also be connected to Internet so that users can loginto the system and getreal-time water quality data far away. The system can be made more innovative by adding more efficient sensors.

Using more sensors, we can measure other parameter of water like dissolved oxygen, conductivity and ions etc. To monitor the qualityof water over larger regions, several sensor nodes and the base stations can be used for better and more frequent readings and accurate data.

REFERENCES

[1] M. Lizzy Nesa Bagyam, B. Raja Nithya,D. Rubikumar, S. Sangeetha, J. Santhosh, "Smart Sewage Alert System For Workers In Real-time Applications Using Iot", International Journal of Innovations in Scientific and Technology (IJIST), Vol.9, Issue 2, February 2020.

[2] Arulananth T S, Ramya Laxmi G, Renuka K, Karthik K, "Smart Sensors and Arm Based Drainage Monitoring System" International Journal of Innovative Technology and Exploring Engineering (IJIET), Vol.8, September 2019.

[3] Pushpakumar R, Rajiv, "IOT based smart drainage worker safety system", International Journal of Innovative Technology and Exploring Engineering (IJITEE), Vol.8, Issue 8, June 2019.

[4] Dr. Gunasekaran M, Pavithra S, Priyanka R, Reeva M, "IoT enabled Underground Drainage Monitoring System", Vol. 09, No. 02, pp. 6411- 6434, May 2019.

[5] K. Viswanadh, P. Rojitha, SK. Khadija,P. Nagamani, "Underground drainage monitoring system using IoT", Journal of Emerging Technologies and Innovative Research (JETIR), Vol.6, Issue 4, pp. 21-26, April 2019.

[6] Gaurang Sonawane, Chetan Mahajan, Anuja Nikalei, "Smart Real-Time Drainage Monitoring using Internet of Things", Iconic Research and Engineering Journals (IRE Journals), Vol.1,Issue 11, May 2018.

[7] G. Gowthaman, K. Hari Haran, G. Keerthee Rajan, "Sewage level maintanence using IoT", (IJMET), Vol.9, Issue 2, pp.389- 397,February2018.

[8] Vikas Mane, Pranav Medsinge, Akash Chavan, Sudhakar Patil (2017), "Water Quality Measuring System Using Wireless Sensor Network", International Research Journal of Engineering and Technology (IRJET), Vol. 04, No. 02, pp. 1926- 1930, June 2017.

[9] Wang T, Mamun A, "Cloud things: A common architecture for integrating the internet of things with cloud computing", Vol. 02, No. 04, pp. 1305-1314, 2015.

[10] Huyong Yan, Ji Xu, Xuerui Zhang, "Smart sewage monitoring system", Environmental Science and Pollution Research, Vol. 22, No. 07, pp. 48–52, 2015.

[11] G. Gowthaman, K. Hari Haran, "Automated Internet of Things for Underground Drainage and Manhole Monitoring System for Metropolitan Cities", ISSN 0974- 2239 Volume 4, No 12, pp. 1211-1220, 2014.

[12] Lazarescu, M.T., "Design of a WSN Platform for Long-Term Environmental Monitoring for IoT Applications," Emerging and Selected Topics in Circuits and Systems, IEEE Journal on , vol.3, no.1, pp.45,54, March 2013.

[13] Kumar, S., Kumar, S., Tiwari, P.M. and Viral, R., 2019, March. Smart Safety Monitoring System for Sewage Workers with Two Way Communication. In2019 6th International Conference on Signal Processing and Integrated Networks (SPIN), pp. 617-622, June 2012.

[14] Retno Tri Wahyuni, Yusmar Palapa, Wijaya Dini Nurmalasari, "Design of Wireless Sensor Network for Drainage Monitoring System", International Research Journal of Engineering and Technology (IRJET), Vol.5, No.5, pp. 3975-3990, August 2012.

[15] Yuwat C. and Kilaso S., "A Wireless Sensor Network for Weather and Disaster Alarm System", Proceedings of International Conference on Information and Electronics Engineering, Vol. 6, Singapore. Pp 1 – 5, 2011.

[16] X. Li, R. Lu, X. Liang, X. Shen, J. Chen, X. Lin, "Smart Community: An Internet of Things Application", IEEE Communications Magazine, vol. 49, pp. 68- 75, 2011.

[17] https://www.arduino.cc/

[18] https://community.mydevices.com/

[19] https://www.ccohs.ca/oshanswers/prev ention/ toxic_safe.html

[20] https://en.wikipedia.org/wiki/Internet_ of_things