Toxic Environment Monitoring Using Sensors Based on IoT

R.Rajalakshmi, J.Vidhya

Abstract— The system planned in this paper is an excellent result for observing the toxic gases in hazardous environment for safety applications and generate the information visible anyplace within the world. The technology behind this Web of Things is advanced and is efficient solution for connecting the devices to the web and to attach the complete world of things in a network. The system deals with monitoring and controlling the environmental conditions like carbon monoxide, methane, hydrogen, LPG and flammable gases with sensors and send this data to the cloud server and draw the sensor data as pictorial statistics. The data upgraded from the enforced system is accessible within the web from anyplace within the world.

Index terms: Internet of Things (IoT), Cloud server, Arduino, Thing speak, Sensors, Toxic gas.

I. INTRODUCTION

Web of Things (IoT) is a modern mechanization and investigation framework that is responsible for organizing, detecting, huge information and registering innovation to convey total framework for profit or resources. These systems permit bigger transparency, control, and performance once applied to any construction or system. IoT systems have applications across industries through their distinctive flexibility and capacity to be appropriate in any atmosphere. They supplement information assortment, automation, operations and far a lot of through good devices and powerful authorized technology. The most important hardware in IoT might be its sensors. These devices incorporate vitality modules, power management modules, RF modules, and apprehending sections. RF modules manage communications through their signal processing, Wi-Fi, Zigbee, Bluetooth, radio transceiver, duplexer. The sensing module manages sensing through assorted active and passive measurement devices. Internet of Things has become an enabling technology eco-system with several application areas such as Smart Home, Smart Farming, Smart Grid, Industrial Internet, Connected Health, Smart Supply Chain etc.

Present developments in innovation for the most part centre on controlling and checking of various enterprises. These are increasingly emerging to reach the human needs. The majority of this innovation is centered around productive observing and controlling diverse exercises. An efficient environmental monitoring system is needed to observe and estimate the conditions in case of exceeding the prescribed level of parameters (e.g. carbon monoxide, hydrogen, methane, LPG). Thing Speak is an IoT analytics platform service that is used to collect and store the data using communication protocols. Collected sensors data will send to ThingSpeak server from devices for creating instant visualizations of live data and sends alert using web services. Arduino, Raspberry Pi are the embedded IoT devices that are connect to the internet. These boards are fetch information or transfer information to ThingSpeak storage employing APIs.

This paper expanded an embedded system utilizing wireless technologies that supplies a scheme for gathering the sensor data at anyplace using Web of Things.

This paper has organized as follows. In section II, presents the related work of toxic environment monitoring system. In section III describes proposed system model. The design and hardware implementation of proposed system are detailed in section IV. Section V discusses experimental results of poisonous environment monitoring. Finally, the conclusion is given in section VI.

II. RELATED WORK

The work described in reference [1] presents wireless sensor network based precarious environment monitoring using data mining algorithm and ID3 algorithm through Bluetooth technology. Sensor values are detected by the sensor grid from different sensors. Analog values will converted to digital values using microcontroller. Data mining is used to calculate the pollutants from chemical industries. ID3 algorithm is used to calculate the values based on probability. Reference [2] declares a master-slave wireless network based on Zigbee and GSM technology for monitoring hazardous gases. This system contains of remote detection terminal, control master station and mobile monitoring terminal. Gas concentration level is detected by the remote monitoring terminal. Remote sense terminal is used to evaluate environmental conditions and gas concentration level. Reference [3] describes the dangerous environment monitoring design using Zigbee technology. This system incorporated multi-hop and multi-sink capabilities. The parameters of the environment to be monitored are chosen as temperature and humidity. The work reported in reference [4] pronounces on monitoring harmful gases in fire places and petrochemical plant areas using recurrent neural network model and understanding the vital early alert of toxicant and dangerous gases. Reference [5]

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describes a environment monitoring implementation for people safety applications using GSM. The parameters of the environment to be monitored are chosen as H2S, CO, CH4. In the event that this gas surpasses the ordinary dimension, at that point a caution is produced right away. Automated detection, quick response time, accurate detection of emergency conditions these are the advantages of this design. Reference [6] illustrates the development of Wireless Sensor Network based vehicular pollution monitoring system using RFID. This design is a cheap price and yields sensible ends up in dominant the air contamination particularly within the metropolitan areas. Reference [7] presents ambient air quality monitoring system using GSM technology. Reference [8] describes the hardware implementation for detecting vehicles causing environmental pollution using RFID technology. Vehicles causing environment pollution data are gathered from gas sensors which are deployed at roadside.

These literature surveys provide different technologies used to monitoring toxic gases. These existing technologies are not efficient for people accessing the sensor's data from anytime and anywhere and provide short distance communications. The proposed system is modern and well organized results for linking things to the server and focus on controlling and monitoring of different toxic places.

III. PROPOSED MODEL SYSTEM ARCHITECTURE

The framework of the advanced technique utilizes IoT to monitoring hazardous environment in real-time applications. Four gas sensors (CO, CH4, H, flammable gas) are used to monitor the pollutants in toxic places. The block diagram of the modern poisonous environment monitoring design is explicated in "Fig. 1"

Collected sensors data are to be given to the Arduino analog inputs. The Arduino converts the analog values into digital values. The Arduino board functions are controlled by the set of instructions through the Arduino IDE software.

Electronic devices and modules are connected using Wi-Fi technology and to provide smart world through Internet of Things (IoT). The collected information are transfer to anywhere in the world using HTTP protocol and HTML language over the internet. The sensors data are transmit to cloud server (ThingSpeak) using ESP8266 Wi-Fi module through the internet.

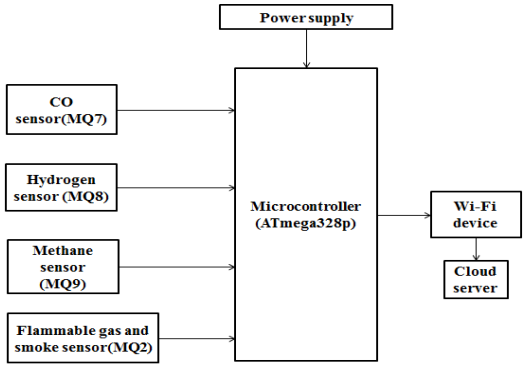

Fig 1. Block diagram of toxic environment monitoring system

The flow chart of "Fig. 2," demonstrates the various operations performed in the proposed design. The operation begins to link the required sensors, Wi-Fi module to the Arduino. Controlled board functions operated by set of instructions via Arduino IDE software. Sensor values are transmitted to ThingSpeak server through the internet and show the sensors data in graphical form on the ThingSpeak platform.

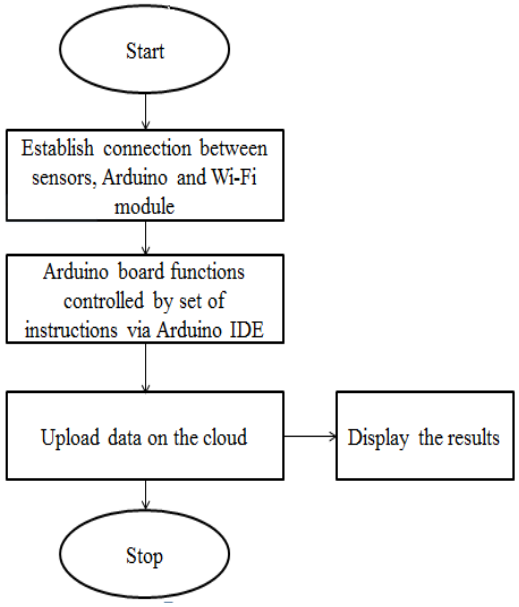

Fig 2. Flow chart of proposed method

The circuit diagram of "Fig.3," displays the various operations in the embedded system.

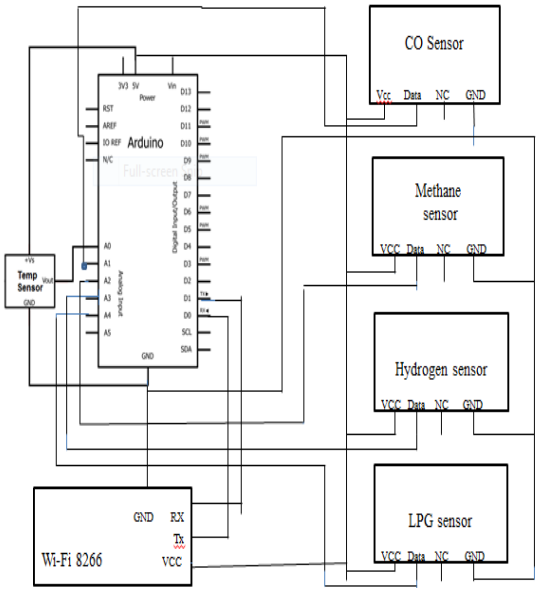

Fig 3. Circuit diagram of toxic environment monitoring framework

The sensors data pins are connected to the analog input pins of Arduino. ESP8266s transmitter pin join to the receiver pin of Arduino and the Rx pin of ESP8266 link to the Tx pin of Arduino. All sensors voltage and GND pins are directly linked to 3.3V and GND of Arduino.

IV. DESIGN & HARDWARE IMPLEMENTATION

The hardware design of toxic environment monitoring system based on IoT is shown in "Fig. 4,"

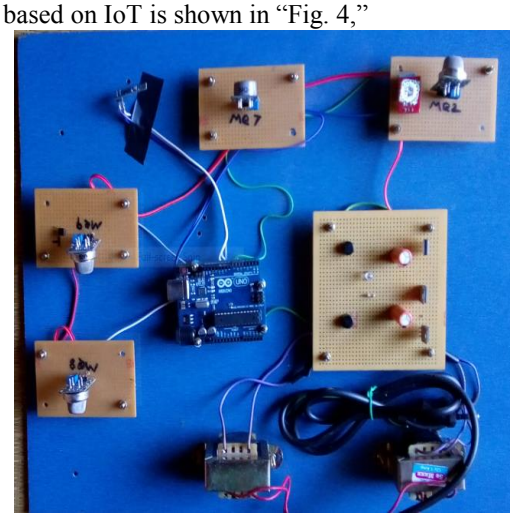

Fig 4. Hardware Design of proposed method

The toxic environment monitoring of hardware implementation have several components and those are listed below:

Hardware materials

1. Arduino UNO Board

The Arduino UNO is a controller board that depends on the ATmega328. It is the combination of hardware and software components used to write and upload computer instructions to the prototype model. The Arduino languages are C, C++. It is used for real-time applications. Analog values are converted to digital values by Arduino.

The Uno varies from boards in that it doesn't utilize the FTDI USB-to-sequential driver chip. Instead, it features an ATmega16U2 programmed as a USB-to-serial converter. This auxiliary microcontroller has its own USB boot loader, which allows advanced users to reprogram it. The Arduino has an expansive help network and a broad arrangement of help libraries and equipment add-on "shields" making it an extraordinary platform for embedded systems. "Fig. 5," demonstrates the Arduino UNO board.

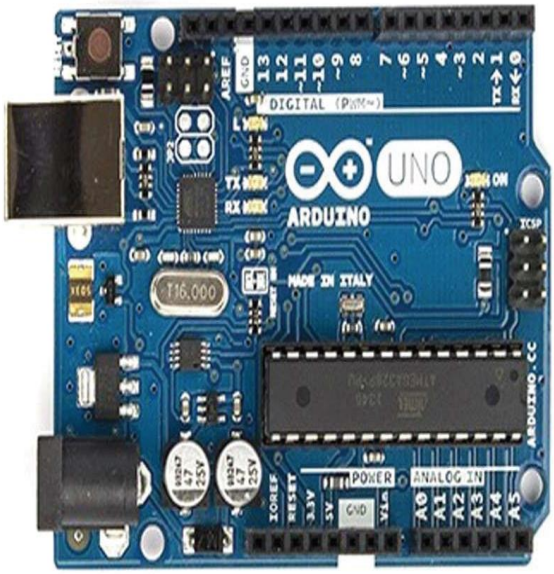

Fig 5. Arduino UNO Board

2. Sensors

a) Carbon Monoxide (CO2) Sensor:

Carbon Monoxide Sensor (MQ7) is a sensor that is sensitive to effects of CO. CO is a very dangerous gas which is odourless, colourless. CO is measured in parts per million (ppm). The average level is 0.5-5ppm.

b) Hydrogen (H) sensor:

Hydrogen sensor is a gas indicator that recognizes the nearness of hydrogen.

c) Methane (CH4) Gas Sensor:

Methane gas sensor is used to discover the methane gas in the toxic places and its output is in analog voltage. The normal value of methane gas is 300ppm to 10,000ppm.

d) Flammable gas and smoke sensor (MQ2):

This combustible gas and smoke sensor is used to discover the flammable gases in hazardous places. The threshold level of sensor is 300ppm to 10,000ppm. The sensor using the temperature level is -20 to 50deg C.

3. ThingSpeak server:

ThingSpeak is a open source platform and it is incorporates API for Web of Things. It is used to collect, analyse, visualize and store information from things. Numerical computing software (MATLAB) is integrated in ThingSpeak server used to analyse and visualize data. It is used for web enabled applications. The sensor information is uploaded to cloud for people can easily visible sensor data from anyplace.

4. Wi-Fi Module:

The ESP8266 Wi-Fi Module is a small chip and incorporates TCP/IP protocols accessed through the internet. It contains input/output pins, transmitter/receiver pins, power supply, GND pins. It is used for transmits and receives data from one to another devices over the net. It is more efficient for embedded processing and larger memory capacity. The chip is integrated with sensors and other electronic devices through the GPIOs. This module uses 3V power supply. It contains I2C software implementation for interfacing electronic devices for transmit data to cloud server through the internet.

Software materials

Arduino IDE software:

The Arduino incorporated advancement condition is a cross-stage application (for windows, macOS, Linux). Java programming language was used to write the program. Arduino board functions are controlled by Arduino IDE software using codes. C and C++ languages are supported in Arduino IDE software for special rules of code structuring. It makes easy to write a code and upload it to the board. Arduino board is able to read analog or digital input signals from various sensors. The control board functions by sending a set of instructions to the microcontroller on the board via Arduino IDE.

It is easy to run the programming and simple for checking the results.

V.EXPERIMENTAL RESULTS

Web of Things based toxic environment observing system is established and different toxic places were monitored. The parameters of the environment to be monitored are chosen as carbon monoxide, methane, hydrogen and flammable gas. This system to obtain the results from following steps given below:

1. Create an account on ThingSpeak platform from www.thingspeak.com.
2. The hardware design is connect to pc through the USB cable.
3. Choose the Arduino board and COM port in Arduino IDE software.

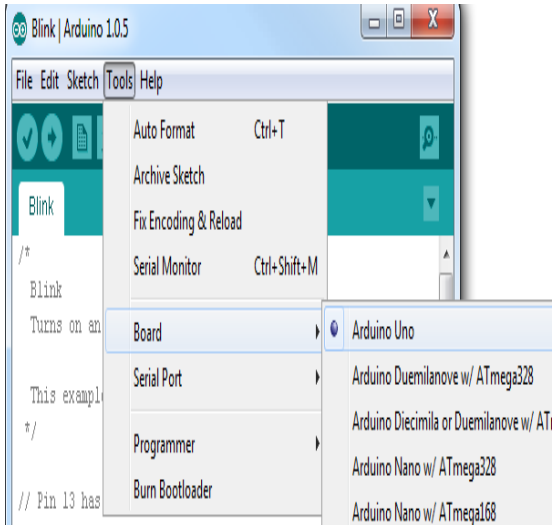

Fig 6.a) Board selection in Arduino IDE software

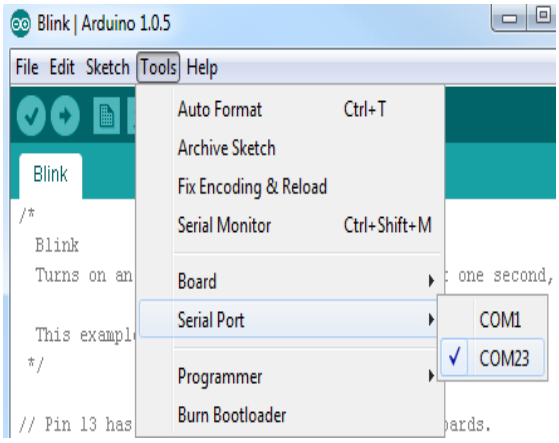

Fig 6.b) Port selection in Arduino IDE software

4. To run the program for sensors data transmit to cloud server by Arduino IDE software.

The sensors data are collected by various poisonous places and this will be automatically transmit to the Thing speak platform (Cloud) through the net, when a proper connection is established with cloud. The results are analyses and shown by the web server.

"Fig. 6.a)," displays Arduino IDE window for board selection, "Fig. 6.b)," shows Arduino IDE window for port selection.

Different toxic places were monitored for the purpose of people safety applications. The sensors data are shown in graphical form and these graphs are plotted between dates versus gas values in ppm. "Fig. 7," displays the fire place. "Fig 8.a)-d)" demonstrates the results of these following gases i.e., H, CH4 and flammable gas in fire places.

Fig 7. Fire place

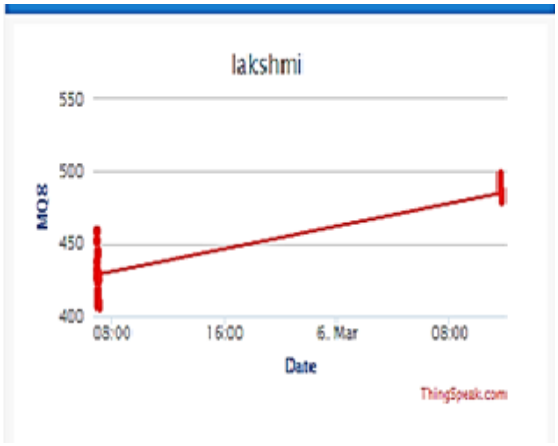

Fig 8.a) Result of H gas in fire place

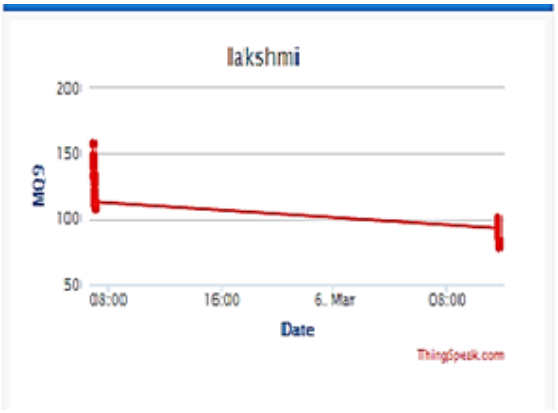

Fig 8.b) Result of CH4 gas in fire place

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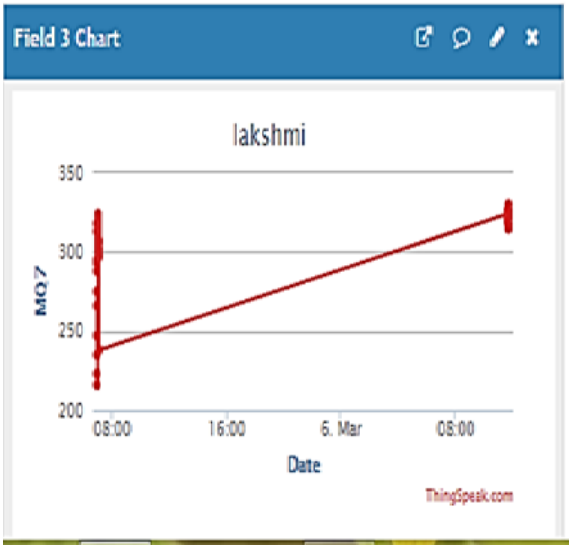

Fig 8.c) Result of CO gas in fire place

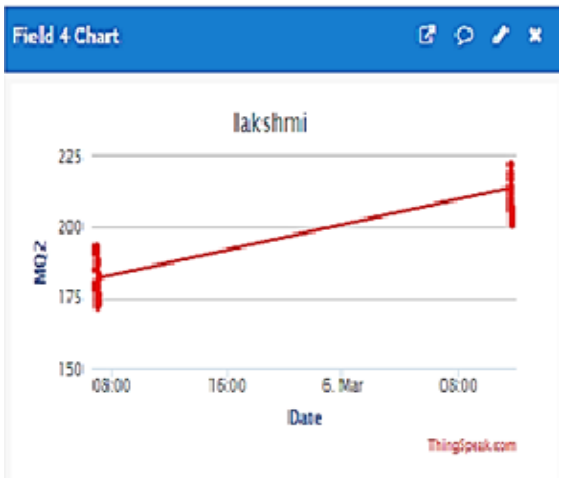

Fig 8.d) Result of flammable gas in fire place

"Fig 9," shows chemical industries. "Fig 10.a)-d)" displays the result of H, CH4, CO and flammable gas in chemical industries.

Fig 9. Chemical industries

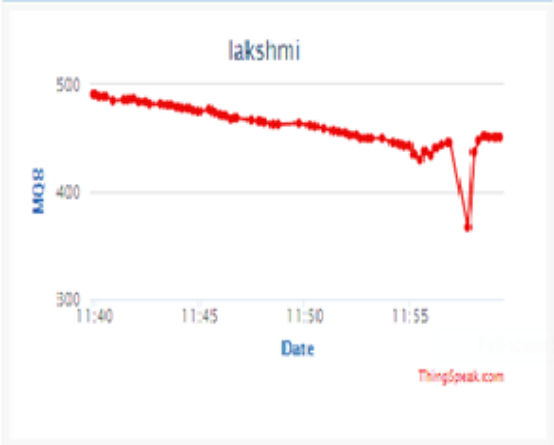

Fig 10.a) Result of H gas in chemical place

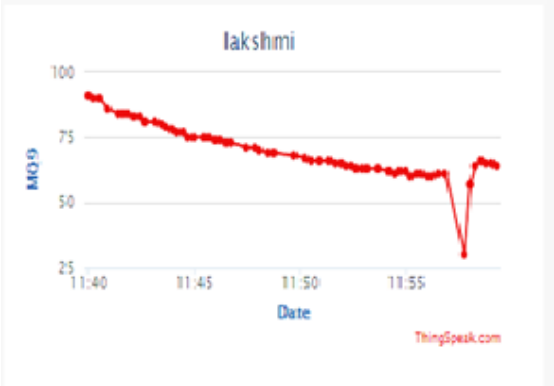

Fig 10.b) Result of CH4 gas in chemical place

Fig 10.c) Result of CO gas in chemical place

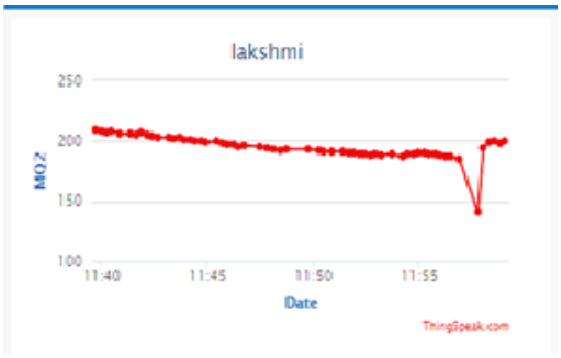

Fig 10.d) Result of flammable gas in chemical place

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"Fig. 11," shows the garbage place. "Fig 12.a) demonstrates the result of H, CH4, CO and flammable gas in garbage place.

Fig 11. Garbage place

Fig 12.a) Result of H gas in garbage place

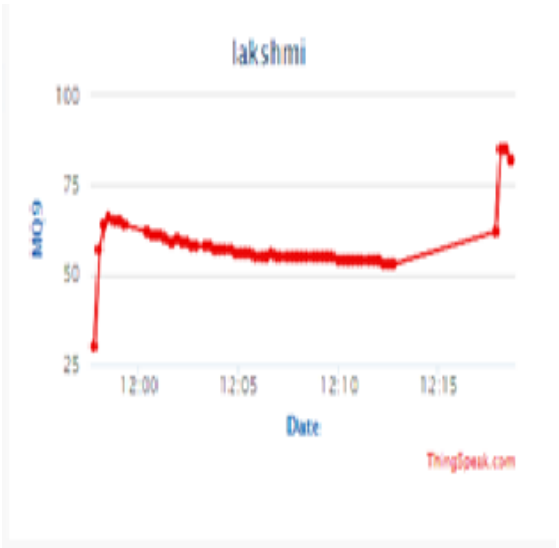

Fig 12.b) Result of CH4 gas in garbage place

Fig 12.c) Result of CO gas in garbage place

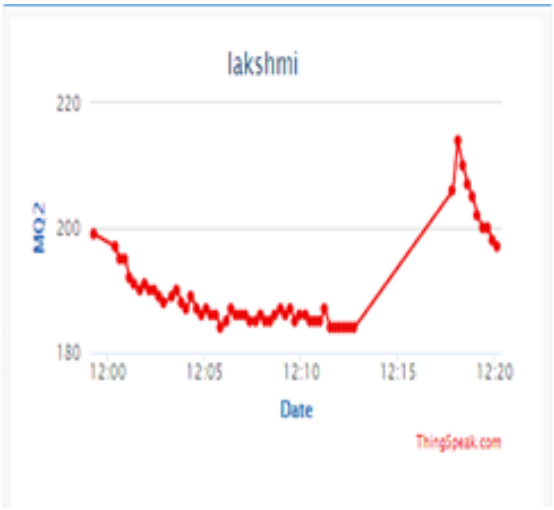

Fig 12.d) Result of flammable gas in garbage place

"Fig. 13," shows the result of IoT based toxic gases monitoring system in Microsoft excel. The sensors information displays with date and time.

	A	B	C	D	E	F
1	created_at	entry_id	Hydrogen	Methane	Carbon monoxide	Flammable gas
2	2019-03-02 07:24:57 UTC	1	482	184	356	186
3	2019-03-02 07:25:12 UTC	2	484	185	377	188
4	2019-03-02 07:25:27 UTC	3	484	184	368	188
5	2019-03-02 07:25:43 UTC	4	482	183	380	186
6	2019-03-02 07:25:58 UTC	5	480	182	366	184
7	2019-03-02 07:26:14 UTC	6	478	179	369	183
8	2019-03-02 07:26:29 UTC	7	477	178	383	182
9	2019-03-02 07:26:44 UTC	8	477	178	348	182
10	2019-03-02 07:27:00 UTC	9	476	177	385	181
11	2019-03-02 07:27:15 UTC	10	474	175	376	180
12	2019-03-02 07:31:37 UTC	11	448	116	359	179
13	2019-03-02 07:31:53 UTC	12	475	178	378	186
14	2019-03-02 07:32:08 UTC	13	473	190	374	179
15	2019-03-02 07:32:23 UTC	14	470	187	370	176
16	2019-03-02 07:34:10 UTC	15	453	165	354	168
17	2019-03-02 07:34:31 UTC	16	460	167	353	172
18	2019-03-02 07:44:22 UTC	17	480			
19	2019-03-02 07:44:57 UTC	18		200		
20	2019-03-05 01:12:28 UTC	19	520	233	396	408
21	2019-03-05 01:12:44 UTC	20	581	389	443	463
22	2019-03-05 01:12:59 UTC	21	587	406	448	427
23	2019-03-05 01:13:14 UTC	22	584	396	446	396

Fig 13. Result of IoT based toxic environment monitoring design in Microsoft Excel

VI. CONCLUSION

This paper propounded the prototype and growth of IoT based poisonous environment supervising framework. The proposed system is efficient to monitoring toxic gases for people safety applications in hazardous places. The various parameters like hydrogen, carbon monoxide, methane and flammable gases were monitored using IoT. The poisonous gases were monitored in fire places, chemical industries and garbage places. Each and every gas values were monitored using sensors and these values are transmitted to cloud server through internet. The results of sensors and system effectiveness indicated that Arduino-based sensors can effectively be used to monitor perilous gases. This IoT system provides real-time applications and makes the statistics observable anyplace in the world. In future work, the proposed system can be extended to a mine safety artificial intelligence-based platform for people safety applications.

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