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IOT BASED TOXIC GAS MONITORING AND CONTROLLING IN SEPTIC TANK

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ABSTRACT: In septic tank system, density of toxic gases such as hydrogen sulphide, Methane, carbon monoxide etc. are continuously monitored by the gas sensors and analysed in graphical format in Thingspeak. If the toxic gases go beyond permissible exposure limit (PEL) then, the controller will send notification to user/concerned officials of public work department to clean the septic tank system.Moreover our system will automatically pump out the gases and desulphurise the toxic gas and store it in storage unit once the values of toxic gases are nearer topermissible exposure limit and thereby it will try to decrease the density of the toxic gases. Therefore, by using IoT based septic tank system, it is possible to avoid abnormality in septic tank and more importantly death of manual scavengers due to toxic gas exposure (asphyxiation).

1. INTRODUCTION

Septic tanks are very dangerous installations. Hundreds of people are killed every year due to septic tank lids collapsing underneath them, or by being overcome by septic tank gases and falling in. Since January 1, 2017, one person have died for every five days, on an average, while cleaning sewers and septic tanks across India, according to numbers collated byNational Commission for SafaiKaramCharis (NCSK), the statutory body that is set up by the Act of Parliament welfare of sanitation workers. A properly maintained and located septic tank does not pose any environmental problems than centralized municipal sewage treatment, certain problems can be raised with septic tanks in unsuitable locations. Since septic tanks systems require large drain fields, they are unsuitable for densely built areas. Some constituents of wastewater, especially sulphates, under the anaerobic conditions of septic tanks, is reduced to hydrogen sulphide, a pungent and toxic gas. Methane is also released. Nitrates and organic nitrogen compounds can be reduced to ammonia. Because of the anaerobic conditions, fermentations processes take place, which may generate carbon dioxide and methane. To reduce the level of the gases in the septic tank gases are pumped out and stored in a separate storage unit and given to industries as combustible fuel after removing the sulphur using Desulphurisation process.Since there is no existing system implemented to reduce the toxic level of the gases due to which many labours died during the cleaning process.Our project deals with reduction of toxic level in the gases and continuous monitoring of gas levels. This is implemented by using internet of things.

2. EXISTING SYSTEM

Septic tanks are self-contained wastewater disposal systems. This means that your septic system is not connected to the city

water supply and that you are responsible for keeping your system operational. When a septic tank is neglected, it can clog with sludge and scum that cannot be broken down by bacteria, leading to a costly systemic collapse. For this reason you must keep your tank clean, inspected and pumped regularly. The existing system used Arduino as the microcontroller and Bluetooth for the transfer of data.

PROCESS:

The gas detectors are used to find the combustible, toxic and flammable gases. Earlier the gases were detected by using semiconductors, oxidation, catalytic, infrared etc.the various sensors used include infrared point sensors, ultrasonic sensors, semiconductorsensors and electrochemical sensors.These sensors are basically mounted near the operation around the plant or control room. The gases are detected by the calibration of the sensors. Pure natural gas is colourless and odourless and it is primarily composed of methane. Sewer gas is a complex mixture of toxic and non-toxic gases that are produced in sewage systems by the decomposition of organic matter. The gases that are present in the sewer gases may include gases like methane, carbon monoxide, hydrogen sulphide. This system connected through IoT is developed to monitor the levels of these gases continually when the people enter the sewer. We take two values into consideration – parts per million (ppm) and beats per minute (bpm). Each value is uploaded to the database which is compared with reference data. The reference data contains the normal data of the hazardous gas and the normal rate of the bpm when the user is in action. The sample data are given below, which are dependent on the age of each person. In the database, the reference data are segregated based on the different age of the person. The basic idea is to determine a safe limit point ‘x’, when the system detects a value ‘y’ (near to or less than x) which then leads to alerting the people. If the value exceeds ‘x’ then a quick high alert is given for all to evacuate the premises. For calculation of bpm, a heartbeat sensor is worn on the wrist by each individual which continuously monitors the pulse rate with each and every value of the reference data. There are various levels of bpm that can be classified as dangerous or normal. These two main calculated values integrate with each other and if the monitoring data show major deviation, then the system finally comes to a conclusion on the level of danger in the environment.

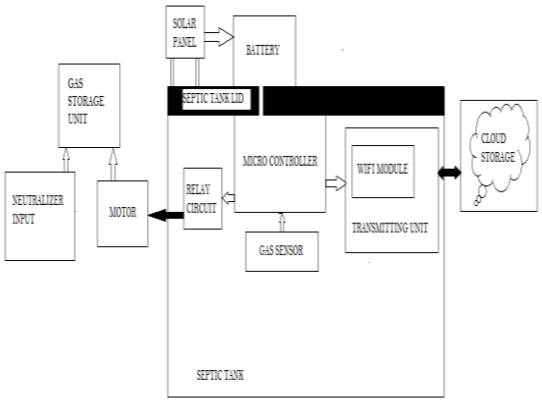
3. PROPOSED SYSTEM

We proposed a system which uses AVR microcontroller atmega 32 and the controller is supplied with power using a solar panel with a back up battery and the values of the toxic gases is sensed using the gas sensors MQ5, MQ7, MQ135 and the values is uploaded to the cloud storage for every 15 seconds using a Wi Fi module. The data can be viewed and when the toxic level of the gas goes off the limit a message is sent to the devices connected to the cloud and the automatic controlling system that we introduced acts in the moment and therefore the toxic level is reduced. The automatic controlling technique includes a pump which is connected to the controller through a relay circuit and a ferrous oxide chamber for desulpurisation process to remove sulphur and the remaining gas is stored in storage unit for industrial purpose.

$FeO + H_2S \quad \xrightarrow{} \quad FeS + H_2O$

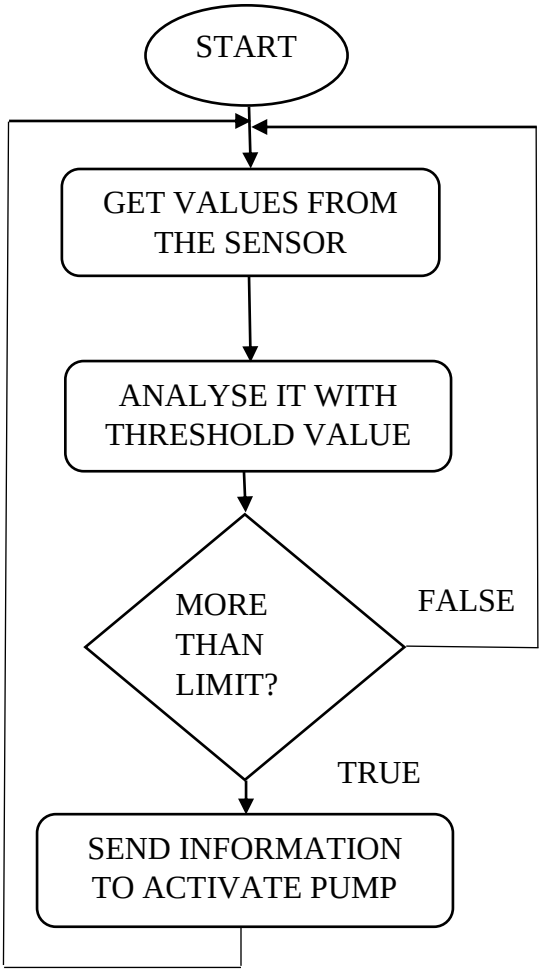
The gas level is maintained less than 100 ppm when it goes beyond 100 ppm the automatic controlling system acts and reduces the toxic level.

4. BLOCK DIAGRAM



The gas sensor senses the gas inside the septic tank and sends the electrical signal continuously to the AVR microcontroller and the microcontroller will convert the voltage value into corresponding gas ppm. The ppm value is then checked with the reference value or threshold value and the controller trips the relay circuit when the ppm value goes beyond the reference value then the pump is turned on and the gases is pumped out and desulphurised and stored in the storage unit. The gas value is continuously uploaded in the cloud using a Wi-Fi module and a message is sent to the mobile using IFTTT server.

5. FLOW DIAGRAM OF WHOLE PROCESS



AVR

AVR microcontroller executes most of the instructions in single execution cycle. It is about 4 times faster than PICs. It consumes less power and can also be operated in different power saving modes. It belongs to RISC family. AVR controllers have register based architecture which means that both the operands for an operation are stored in a register and the result of the operation is also stored in a register. In the AVR microcontroller family we preferATmega-32 is basically an Advanced Virtual RISC (AVR) micro-controller. It supports the data up to eight (8) bits. ATmega-32 has 32KB internal built in memory. ATmega 32 has 1KB Electrically Erasable Programmable Read Only Memory (EEPROM). This property shows if the electric supply supplied to the micro-controller is removed, even then it can store the data and can provide results after providing it with the electric supply. Moreover, ATmega-32 has 2KB Static Random Access Memory (SRAM).ATmega32 is an 8-bit and 28 Pins AVR Microcontroller, manufactured by Microchip, follows RISC Architecture and has a flash type program memory of 32KB. It has an EEPROM memory of 1KB and its SRAM memory is of 2KB. It has 8 Pin for ADC operations, which all combines to form Port A(PA0 – PA7).It also has 3 built in Timers, two of them are 8 Bit timers while the third one is 16-Bit Timer. You must have heard of Arduino UNO, UNO is based on atmega328 Microcontroller. It's UNO's heart. It operates ranging from 3.3V to 5.5V but normally we use 5V as a standard.The ATMEGA16 is a high-performance, low-power CMOS 8-bit microcomputer which has 16K bytes of Flash programmable and erasable read only memory (EPROM).The Atmel's high-density nonvolatile memory technology is used to manufacture this device. It is also compatible with the industry-standard MCS-51 instruction set and the pin out. The on-chip flash also allows reprogramming in-system or it can also be done by a conventional nonvolatile memory programmer. The Atmel ATMEGA16 is a powerful microcomputer which provides a cost-effective and a highly-flexible solution to many embeddeLd control applications by combining a versatile 8-bit CPU with the Flash on a monolithic chip

BATTERY

Lead acid battery is used to store the electrical energy which is generated from the solar panel that is used as the power supply for the circuit. Battery ON for the whole day since the circuit is working for the whole day.

Specifications:
Voltage: 6V
Current: 4.5A
Power rating: 27W

SOLAR PANEL

Conversion of light energy in electrical energy is based on a phenomenon called photovoltaic effect. When semiconductor materials are exposed to light, some of the photons of light ray are absorbed by the semiconductor crystal which causes a significant number of free electrons in the crystal. This is the basic reason for producing electricity due to photovoltaic effect.

Specifications:
Voltage: 12V
Current: 0.18A
Power generated: 5W

RELAY CIRCUIT

A relay is an electromagnetic switch that is used to turn on and off a circuit by a low power signal, or where several circuits must be controlled by one signal. The main operation of a relay comes in places where only a low-power signal can be used to control a circuit. It is also used in places where only one signal can be used to control a lot of circuits. The application of relays started during the invention of telephones. They played an important role in switching calls in telephone exchanges. They were also used in long distance telegraphy. They were used to switch the signal coming from one source to another destination. After the invention of computers they were also used to perform Boolean and other logical operations. The high end applications of relays require high power to be driven by electric motors and so on. Such relays are called contactors. There are only four main parts in a relay. They are

a) Electromagnet
b) Movable Armature
c) Switch point contacts
d) Spring

MQ5 GAS SENSOR

Features:

- High sensitivity to LPG, natural gas and town gassmall sensitivity to alcohol, smoke
- Fast response
- Stable and long life
- Simple driver circuit

Application:

They are used in gas leakage detecting equipments in family and industry are suitable for detecting of LPG,natural gas and town gas avoid the noise of alcohol and cooking fumes and cigarette smoke.

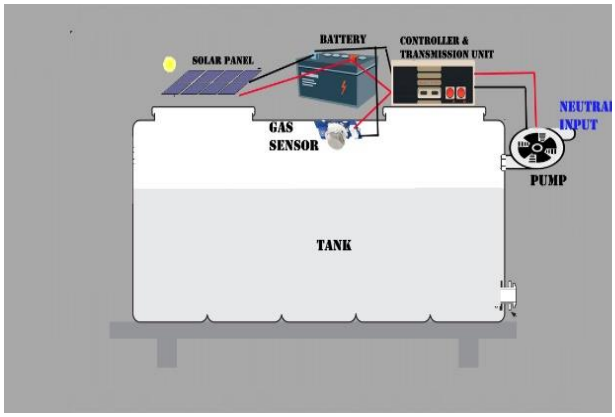
Wi-Fi MODULE- ESP8266

This module has the capability of :
2.4 GHz Wi-fi (802.11 b/g/n, supporting WPA/ WPA2)
General- purpose input/ output (16 GPIO)
Inter – integrated circuit (I^2C)serial communication protocal
Analog – to – digital conversation (10 bit ADC)
Serial Pheripheral Interface (SPI) serial communication protocol
Pulse width modulation (PWM)
ESP8266 can work both as access point and as a station, hence it can easily fetch data and upload it to the internet making Internet of Things as easy as possible. It can be programmed using Arduino IDE which is user friendly.

Specification

Type	32 bit microcontroller
CPU	80 MHz or 160 MHz
Memory	32 KB instruction, 80 KB
Input	16 GPIO pins
Successor	ESP32

6. SEPTIC TANK MODEL SETUP:



CONSTRUCTION

The AVR controller, battery, solar panel and Wi-fi module are kept outside the septic tank and the MQ5 sensor is placed on the inside lid of the septic tank. The pump is placed at the outlet of the septic tank and a filter is placed at the outlet of the pump to filter the toxic gases. The dimension of the solar panel depends on the voltage rating of the panel. The AVR ATMEGA32 controller has an input voltage of 4.5-5.5 V and an input current of 1.1 Ma. The gas sensor MQ5 which is used to sense some of the harmful gases like LPG (Liquefied Petroleum Gas), town gas, methane. This sensor also detects some of alcohol and smoke. The approximate heat consumption value of the sensor is 800 Mw. Concentration of the toxic gas which can be detected at 200-10000 ppm. The usage of Wi-Fi module which has an input voltage of 2.6-3.5 V with average input current 80mA. Based on this voltage value the battery and solar panel is selected.

7. DESIGN

AVR MICROCONTROLLER-ATMEGA32

Per hour power consumption of the controller:
Power= voltage * current
= 5.5 * 1.1
= 6.05 mW = 0.00605 W
Per day power consumption of the controller:
Power= voltage * current * hour/day
= 5.5 * 1.1 *24 = 0,1452 Wh

Wi-Fi MODULE ESP8266

Power consumption per hour:
Power = 3.5 * 80
= 280 mW
Power consumption per day:
Power = 3.5 * 80 * 24= 6.720 Wh

MQ5 GAS SENSOR

Input voltage = 4.9-5.1 V
Heat consumption = 800 mW
Heat consumption of the sensor per day:
Power = 800 * 24
= 0.192 Wh

LEAD ACID BATTERY

Specifications:
Voltage = 6 V
Current = 4.5 A
Power rating = 27 W

SOLAR PANEL

Dimension = 270 * 200 * 18 mm
Maximum Voltage = 12 V
Maximum Current = 0.18 A
Power generated = 12 * 0.18= 2.16 W
Maximum Power = 5 W

SOFTWARE USED THING SPEAK

ThingSpeakis an IoT analytics platform service that allows you to aggregate, visualize and analyze live data streams in the cloud. ThingSpeak provides instant visualizations of data posted by your devices to ThingSpeak. With the ability to execute MATLAB® code in ThingSpeak you can perform online analysis and processing of the data as it comes in. ThingSpeak is often used for prototyping and proof of concept IoT systems that require analytics.

THING SPEAK FEATURES

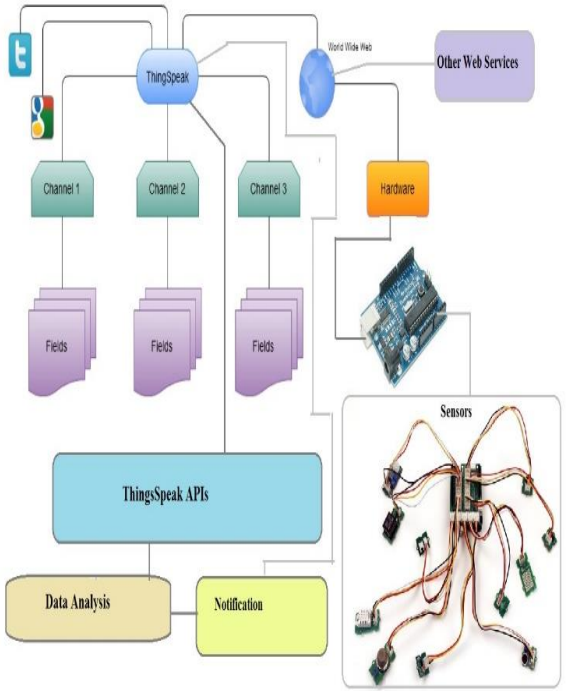
Easily configure devices to send data to ThingSpeak using popular IoT protocols.
Visualize your sensor data in real-time.
Aggregate data on-demand from third-party sources.
Use the power of MATLAB to make sense of your IoT data.
Run your IoT analytics automatically based on schedules or events.

Prototype and build IoT systems without setting up servers or developing web software.

Automatically act on your data and communicate using third-party services like SMS or Twitter.

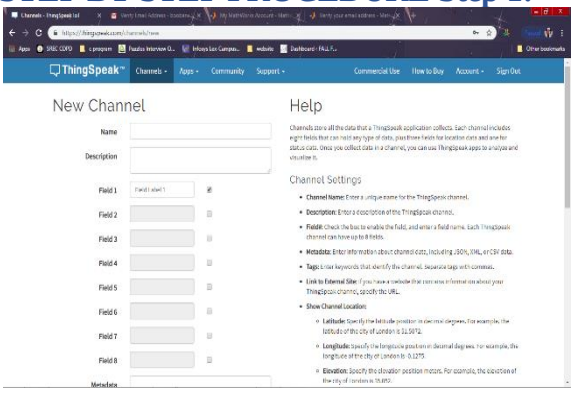
FLOW DIAGRAM

In the thingspeak.com we have to create a new channel. After creating a channel define a name of the channel, channel description and field, we can define multiple number of fields. Then save your channel.

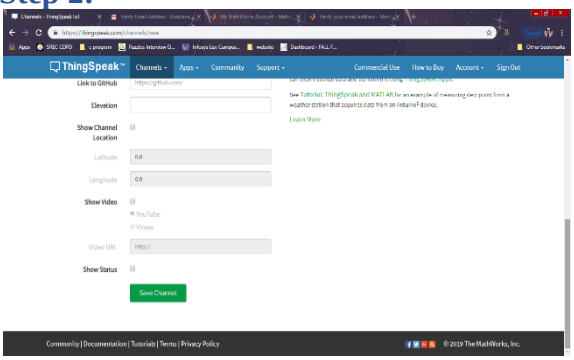


Now your private cloud space is created along the channel ID and accessing author name. Click on the API keys function in that window. Here you can find the read API key and write API key. By using this API key in the code we can connect the cloud storage to the microcontroller

STEP BY STEP PROCEDURE Step 1:



Step 2:



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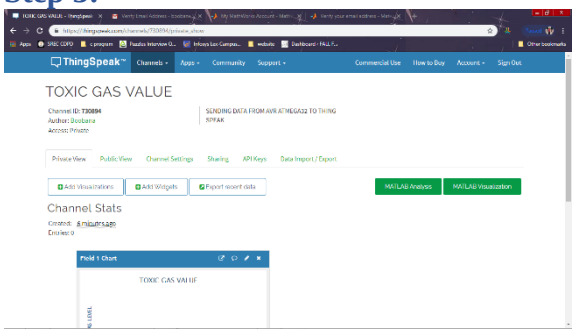

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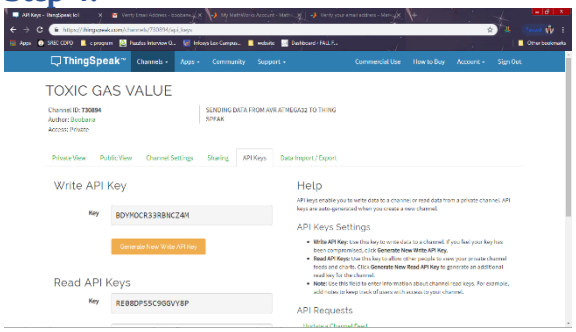

IFTTT SERVER

IFTTT (acronym for “If This Then That”) is an automation platform that communicates between different apps, web services, and devices to trigger user-specific actions through Applets. This free service allows you to connect your favourite services that you use everyday together such as Amazon Alexa for searching the web or Dropbox for sharing files with colleagues. It is also an easy way to introduce automation into your life so that you can skip the tedious daily tasks and get more important things done. tecla-e is compatible with IFTTT, which means that certain tasks that once required a caregiver to perform can now be easily customized by the user to provide quadriplegics with independence and control over their environment.The first thing you

need to know about using IFTTT after downloading the app and creating an account is what an Applet is. Applets are a trigger to action relationship that perform a task or create a personalized notification when certain conditions are met. Once you create and activate the Applet, IFTTT does all the behind the scenes work without you having to remember it again. You can also turn Applets on and off and edit and share them with the IFTTT community.If you want to make a custom Applet, think of the phrase "if this exists, then do that." For example, IFTTT makes automating the lighting of your home simple through Applets. So, one Applet could be if it is 7:00am, then turn on the Philips Hue bedroom light". Applets can serve to be functional or fun, but most importantly, make tasks possible with hands-free technology.

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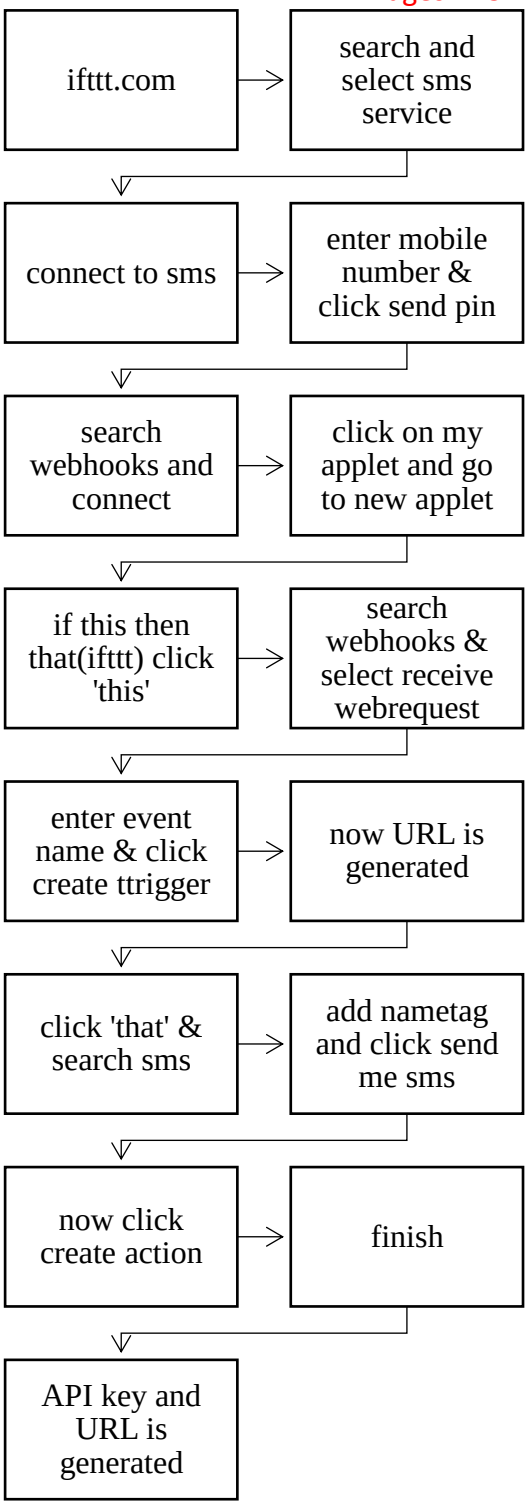

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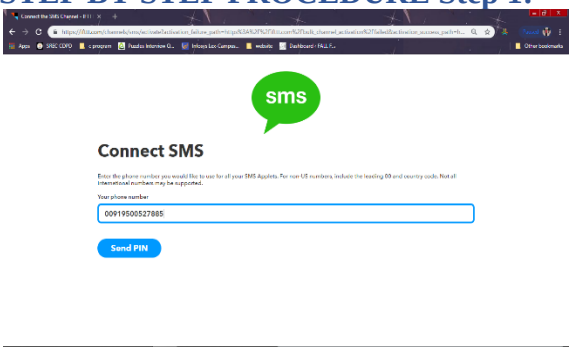

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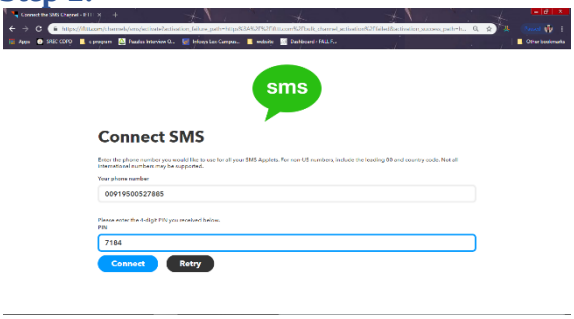

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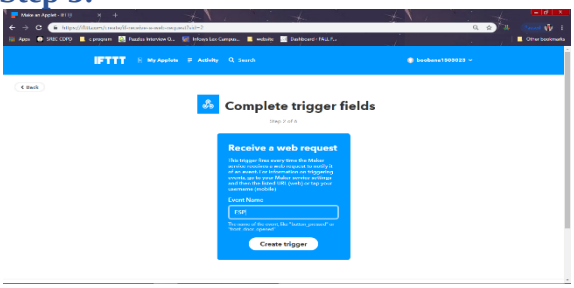

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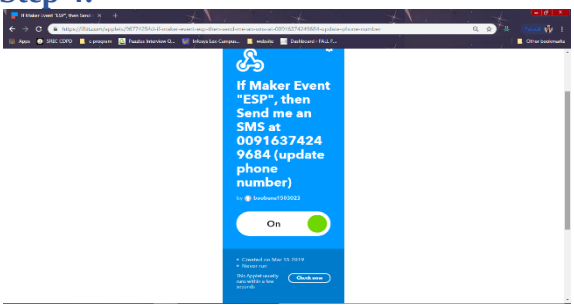

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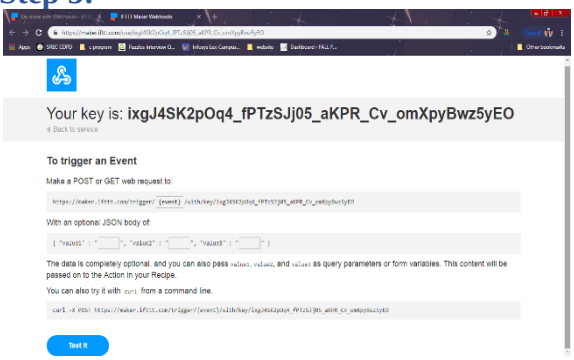
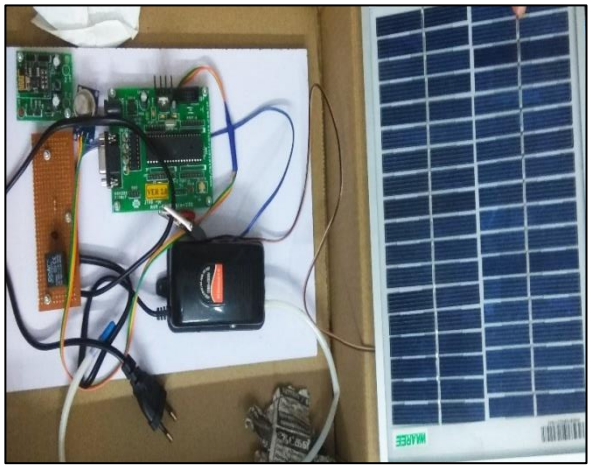


HARDWARE SETUP CONTROLLER SETUP:



TANK SETUP:

HARDWARE DESCRIPTION

The toxic gas monitoring and controlling system consist of Solar panel, Battery, AVR atmega 32 microcontroller, Gas sensor, Wi-Fi module, Air pump, Neutralising input and a storage unit.

Solar panel is used to charge the battery. The battery gives constant power supply to the controller and the Wi-Fi module. The gas sensor senses the gas inside the septic tank. The controller checks the signal from sensor and controls the pump and the Wi-Fi module. The air pump pumps out the toxic gases from the septic tank. The Wi-Fi module sends the data to the cloud (thingspeak) and the message is send to mobile from thingspeak to mobile using IFTTT. The neutralising input consists of FeO which desulphurises the toxic gas. The storage unit will store the gas except H_2S.

AVR microcontroller is powered by battery. The gas sensor senses the gas and the voltage between the plates inside the sensor is decreased due to the concentration of gas. The voltage is converted to ppm using the formula

Gas value= R_S gas/R_0

$R_S$gas= (5.0-sensor_val)/sensor_val

$R_0$is the reference value which is pure air value.

The controller checks if the gas value is less than the Permissible Exposure Limit(PEL). If the value is less than PEL there will be no change in the circuit and if the value exceeds, the relay circuit works and it trips the air pump and the pump starts to operate. And, the Wi-Fi module uploads the data to the cloud and after ten seconds the thingspeak will send a message to the mobile. The gas inside the septic tank in this prototype model is produced by using cow dung which contains $CH_4$and H_2S. The air pump will pump out the gases and send through a glass tube which contains FeO which reacts with H_2S and gives water and FeS.

FeO + H_2S ~~FeS +~~►H_2O

The output from the glass tube contains only methane in this prototype model but in the septic tank it is the combination of methane, carbon dioxide, hydrogen sulphide and sulphur dioxide. The methane from the neutralising unit is stored in the storage unit and it is used as combustible fuel. The toxic gas in the septic tank is continuously monitored and the data is uploaded for every 15s. And, the gas from septic tank is efficiently used.

CONCLUSION

Io T is the growing technology which helps in monitoring the remote area septic tank problems and also the controlling technique is implemented so that the workers who clean the septic is safe inside the septic tank while working. They get notified when the toxic level exceeds the limit and therefore they are evacuated safely from the place.

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