IOT BASED BIOGAS MONITORING SYSTEM USING NODE MCU ESP32S

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Abstract

The production of biogas (CH4) happens when all the necessary conditions like temperature, pressure, humidity and the moisture content are maintained. If required conditions are correctly maintained, then there will be maximum anaerobic digestion which will add up to maximizing the output. The monitoring of the biogas using IOT will help in monitoring and maintaining right condition for the gas production. In this paper, it is discussed about "monitoring biogas reactor using Node MCU ESP32S". The different hardware components and software framework are used to develop the system. The hardware components used are temperature sensor (DS18b20), soil moisture sensor (Yl-69), temperature, pressure and humidity sensor (BME280), methane sensor (MQ4), piezo buzzer (PBUZZ5), and Node MCU ESP32s. And the software platform used are Android studio, proteus, ruby language, and PostgreSQL. The sensor data will be displayed in the mobile application where if a certain value for the sensor is not in optimum range then the user will be notified through app notification and even with the piezo buzzer. The user can intervene at the right time to maintain the right condition for biogas production. Through such a system it will drastically reduce the hectic manual work and helps users to know when to intervene as users will be notified through app notification if parameters like temperature, moisture, and methane content are not in optimal range. Whereby such a system will help in optimum production of biogas.

***Keywords*:** *bio gas, anaerobic, sensors, thermophilic, mesophilic.*

INTRODUCTION

Bhutan was recognized as one of the countries with high amounts of electricity production. About 37.3 percent of total population uses firewood for their cooking purposes, and the 36.3 percent of population uses electricity and the remaining 25.6 was found to be using Liquid petroleum gas imported from India for the cooking purpose (Bajgain, 2008). Using Bio-gas would help to reduce the usage of firewood and the number of people depending on the Liquid Petroleum gas for their cooking purpose. Bhutan started working on the Bio gas project in the early 1980s.The decomposition of waste produces a harmful methane gas which is a main cause of global warming. Every year the amount of methane released into the atmosphere is estimated to be around 500 to 800 million tonnes (Anderson, 2019). Yearly every individual produces 100 kg of waste (Nikolous, 2018). The production of organic waste is a global concern as it produces the methane which is greenhouse gas. This gas can be used as the source of energy for cooking (Meller, 2019)

THE NEED OF THE SYSTEM

The monitoring of biogas reactors will help to improve the process efficiency and increase the performance level of the biogas plants. The anaerobic digestion comprises various stages. Some of them grow gradually and are sensitive to the change in the environment. It is therefore important to maintain the optimum conditions that are required by the bacteria. Monitoring the process in the digester is important to make the process successful.

The biogas process comprises four different stages which are, hydrolysis, acidogenesis, acetogenesis, and methanogenesis. And if one of the processes is unstable it will affect the other process as well thus making the system to fail. With the help of this system the user can get to know about the overall process of the biogas and then set up the required environment accordingly. This system will benefit those people owning biogas to have maximum production of gas at the faster rate.

RELATED WORK

The production of biogas is directly affected by being able to maintain the following factor as per optimum conditions. The factors are retention time, pressure inside the reactor and the temperature. The methane content of the reactor ranges between 55% and 80% depending on the organic matter fermented and subject to conditions (Dobre, Nicolae & Matei, 2014). According to McCarty (1964), a major portion of municipal waste are treated with anaerobic digestion. The benefits of anaerobic digestion include high levels of waste stabilization, low organic sludge production, low nutrient requirements, no oxygen requirements.

Monitoring the parameters of the biogas will help us to get the maximum production of the gas at the faster rate. Globally around 144 million of people do not have clean fuel for their cooking purpose. Biogas provides a better solution to those communities who do not get enough liquid petroleum gas (Acharya, et al., 2017)

The paper and sludge are considered as most polluted products. This product if kept not attended properly will add up to the mass pollution of the river and surroundings. But there is a way to address this issue, this issue can be addressed if subjected to anaerobic digestion where it will stabilize the sludge and produce biogas (Priadi, et al., 2014)

SMALL SCALE PROTOTYPE DEVELOPMENT

Hardware Components

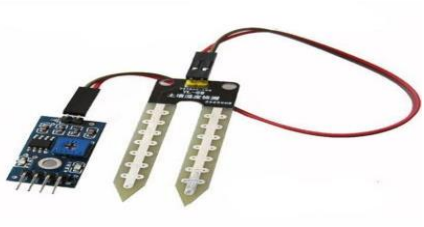
Node MCU ESP32S

It is a microcontroller board having 39 digital pins. The 34 pins are used as GPIO pins and the remaining pins are input only pins. Compared to ESP8266 it has a built-in Wi-Fi module, Bluetooth and high processing power. The microcontroller is connected to the computer using Universal Serial Bus(BUS).

a) Node MCU ESP32S

Soil Moisture Sensors

The sensor detects the presence of water in the soil. It provides us the moisture level as the output and it can be used in both analog and digital mode. It will also let us know whether there is enough water in the soil or not The output will be either HIGH or LOW depending upon the threshold set



b) Yl-69 soil moisture sensor

Temperature sensor Ds18b20

The sensor has a built in 12bit Analog to digital converter. It displays 9 to 12 bits of data reading. No external power supply is needed as it gets the power supply directly from the data line. It is used in industrial systems and in the consumer products. When we have to measure the temperature at the multiple points we can use this sensor.

C)Ds18b20 temperature sensor

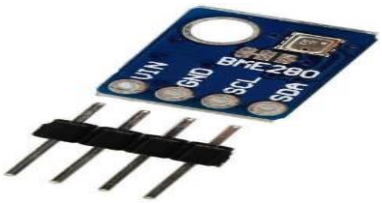
Methane gas sensor

MQ$ is a sensor that measures the volume of methane gas released during the biogas process. It can give the reading at the faster rate as it is very responsive and also has a good sensitivity to flammable gas. It is helpful in detecting the leakage of the gas as it has the sensing range from 300 ppm to 10,000 ppm. It has low sensitivity to the alcohols and the smoke.

d)MQ4 methane gas sensor

BME 280

This sensor was used to measure the humidity of the air inside the biogas reactor. It can also measure the pressure and temperature



e*) BME280*

Biogas Reactor

The reactor was made from jerry can which has a capacity of 12.5 liter. The reactor is fed with kitchen waste which mostly comprises vegetables and food waste. To introduce the microorganism sludge is used as a seed. The ratio of organic waste to water used in reactors is 2.5:1. Where for 8.5L of waste 3.5L of water is used. The seed was added in the reactor so that it can develop a new microorganism which will help in the bio degradation process of the organic waste.

f) Biogas reactor

Software Requirements

Android Studio

Android Studio is a software replacement for android eclipse development. In December 2014 The first version of android was released. The minimum RAM required for android to work is 4 GB. It is a framework for developing android applications.

Ruby Language

Yukihiro developed this language in the year 1990.Ruby an open source programming language is most commonly used for developing web applications. It can also be used for analyzing data and for prototyping. Ruby is the object-oriented one. The syntax of Ruby is similar to that of Python and Perl. However, some of the distinction between the two is that Ruby holds all of its instance variables fully private to the class and only exposes them through accessory methods.

PostgreSQL

PostgreSQL being one of the open source software with high performance is one of the most used databases by the developers. It was released in 1996 and the latest version of PostgreSQL is 11. Most of the mobile applications and the web use PostgreSQL for their data storage. Java, pythons, Ruby, and JavaScript are some of the languages supported by this object relational database. PostgreSQL being an object relational database offers a greater advantage compared to the MySQL database and other databases. It is capable of supporting many users as it is highly scalable.

METHODOLOGY

The following methodology was used to achieve the aims and objectives within the given time schedule.

In the first phase the project has started by gathering the information of the required items. To perform this task, a lot of similar international and the national papers and projects were read to identify all the hardware components and the software required for the project. Along with the requirement gathering, specification of each gathered components was also done. The literature review will be continuous throughout the project.

In the second phase it started with designing a system. The system design was divided under two categories i.e. software and the hardware design. Some of the members worked on the software design and others on the hardware design.

In the software designing part it was of graphical user interface and the designing of the database. The graphical user interface design for the application was designed using the mock plus software. For the database design the entity relationship diagram and the

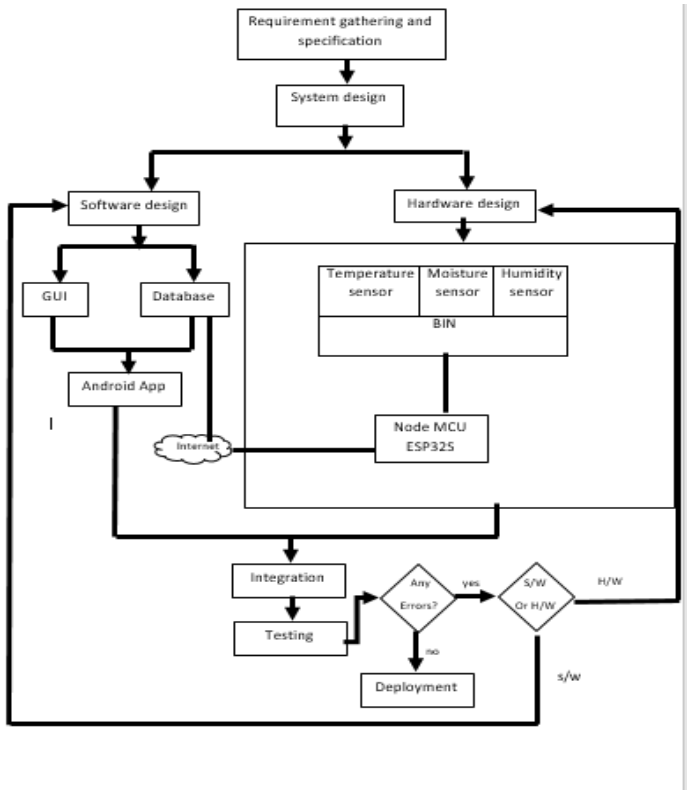
use case of the system was designed. The PostgreSQL was used to develop the database.

After the completion of the GUI and the database design then the it started with the mobile application development using the latest android studio framework which is 4.0 it was developed in the module wise. The login page was developed first and followed by the development of other components.

In the hardware designing part each of the components required for the project underwent unit testing to ensure that each individual component is working well. After the successful completion of the unit testing, integration testing was performed on the circuit. Then the integrated circuit which has a temperature sensor, methane sensor and the humidity sensor was placed inside the biogas reactor. The readings from the sensors are sent to the database using the Wi-Fi module integrated with the Node MCU.

In the third phase the mobile app and the biogas reactor were then integrated together. After the integration, the system was then checked to see if it was functioning accordingly or not. If the system happens to show an error, then recheck whether it is from the hardware or from the software. If the error is from the hardware part, then need to go back to the hardware design and if it was of software design accordingly go back to the software parts.

In the Final phase after the successful completion of the integration of hardware and software then the system becomes ready for the deployment.

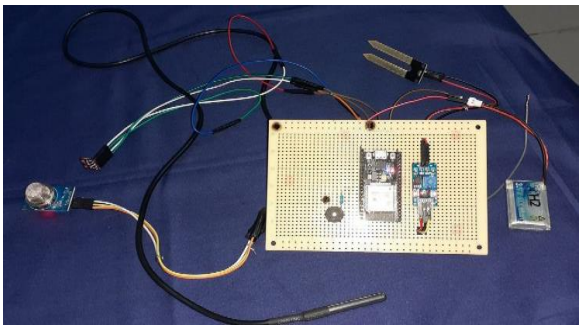


g) Methodology

PROPOSED SYSTEM

The sensors to measure the important parameter in the biogas process will be placed inside the biogas reactor. The reactor is made of the jerry can. Ds18b20 water proof digital temperature sensor will be used to measure the temperature, BME280 to measure the humidity and temperature. To measure the humidity of the mixture inside the reactor, the soil moisture sensor is used. To know the amount of methane production inside the reactor MQ4 is used, Node MCU ESP32S will be used as a microcontroller connecting all the

required sensors together. The data from the sensor will be sent to the database using the Wi-Fi module that is embedded with the microcontroller. Then the data from the database will be displayed in the mobile application. The user will get the notification if the value of any parameter gets higher or lower than the threshold value set. Accordingly, the user can intervene. The value from the sensor will be sent in the form of the json format. The volley library is used to parse the json data and to display in the app.



PROTOTYPE IMPLEMENTATION

The microcontroller used is Node MCU ESP32S as it has high processing power. The Node MCU was identified as an appropriate microcontroller for the real time project.

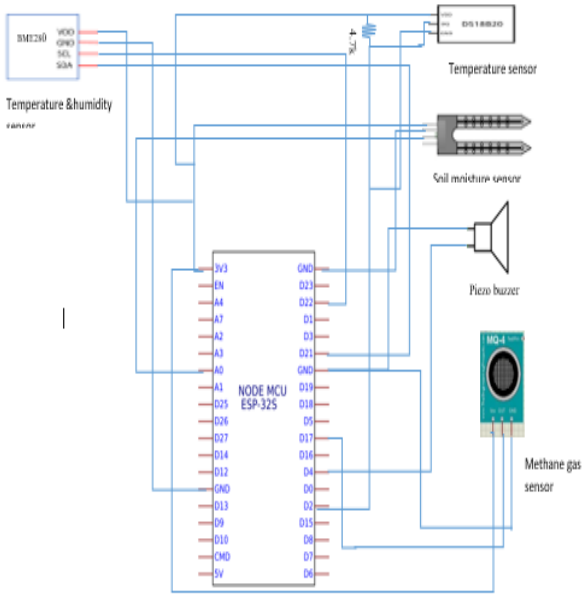
It has 48 pins with some of the pins not usable. The pins from GPIO 34 to GPIO39 are only input pins. There are 18*12 Analog to Digital converter. Some of the pins which are ADC being GPIO 36, GPIO 4, GPIO 15, etc. GPIO 25 and GPIO 26 are the only digital to analog converter. The EN button is used to reset the microcontroller.

The 4.7K Ohm resistor was used between the temperature sensors and the micro controller so that the current flowing through it will be minimized and voltage can be divided. The different types of jumper wires were used to connect the sensors and the microcontroller.

The temperature sensor, humidity sensors and the methane sensors are all connected to the Node MCU ESP32S microcontroller. The data from the sensors will be collected in the micro controller. The micro controller will then send the data to the database. The data from sensors will be updated after every 30 second and the data sent will be in the form of json format. The mobile app will fetch the data from the

database using the GET APIS.The data will get updated after every 30 seconds. The volley library was used for parsing the json data and then displaying it in the mobile application.

When the value of any parameters gets higher than the threshold the app will send notification to the users so that the user can intervene accordingly.

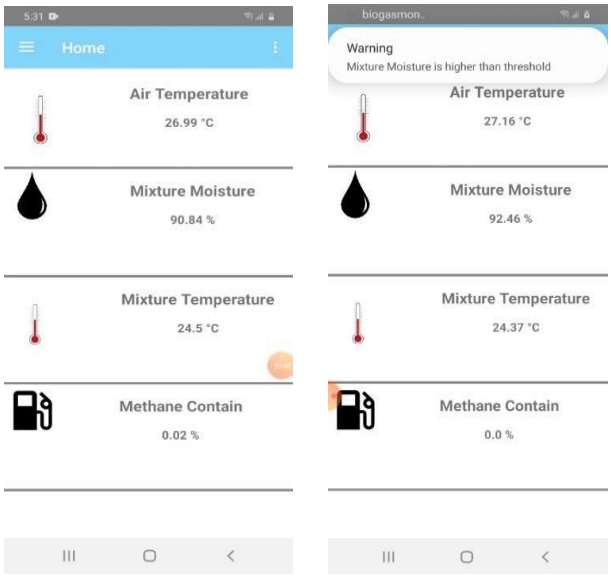


h) Circuit Diagram and implementation

RESULT AND DISCUSSION

The production of methane is maximum when the temperature is around 30- 40 degree Celsius. The moisture content must be around 40-60% and the mixture temperature around 20-30 degree Celsius. The numbers of days taken by the food waste to generate the biogas is almost a week to 10 days. The methane required for the cooking purpose is 5% to 20% which is around 50,000ppm to 150,000ppm. The monitoring of biogas using the mobile will help to reduce the workload and helps in optimizing the gas production. It also addresses some of the issues that come across while monitoring manually. The production of biogas could be much easier at a place with high air temperature. The user will be notified if the value of the parameter gets higher than the threshold set. While comparing the results with the literature, the two were

mostly inclined and supported each other while there were some differences too.



I. The sensor value displaying in the android app

CONCLUSIONS

The "monitoring of biogas reactor using Node MCU ESP32S" is finally completed through combined effort and support from every individual who have contributed in successfully completion of the project. It is a moment to be cherished as team have achieved its aim and fulfilled all the objectives of the project besides completing the project fruitfully.

The monitoring of the biogas reactor using Node MCU ESP32S helps the user in monitoring the biogas reactor properly and fruitfully. The sensor data from the biogas reactor will be displayed on the mobile app whereby users will know the exact reading of the respective sensors. If the certain parameter in biogas reactor is not correctly maintained, then the mobile app will get notification whereby the user will be notified on what parameter is not correctly maintained. Then instantly the user can intervene at a rightful time to have optimum output.

If such a system is in place, then the intensive manual work and the human error will be drastically minimized. Hence the user can easily monitor the biogas reactor with the help of a mobile app.

FUTURE WORK

The system would be more efficient and effective if it is made automatic in the future. Including the pH detector sensor in the reactor would be best as it is also considered as one of the important parameters in the biogas process. The system can be scaled up and be used by the municipality to combat the waste management issues and to produce the valuable things from the waste. Collecting data everyday will help to do the data analysis.

The system would help not only help the individual but also will help to reduce the global issues of waste. Many of the people will be benefited from the biogas thus reducing the need for liquid petroleum gas in the country.

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