SMART HYDROPONIC SYSTEM

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Abstract-- This study describes the design of a smart Hydroponic system in which plants, most crops are grown in aqueous solvents using a water-based-mineral nutrition solution. There are several techniques in hydroponic culturing: Wick, Ebb and Flow, Nutrient Film Technique, and Water culture. The growing population is witnessing an increasing demand for food and water and this system would pave way for great productivity in food. The design is being implemented using a Microcontroller, sensors for real-time data, Esp-01 module, and MQTT that were picked based on needed criteria during component selection. The data which are being derived from the sensors are Temperature, PH value, Electricity conductivity, Gas, and Humidity Which are being monitored with the help of a web application and are controlled based on the required, an email will also be received to notify the disturbance in the threshold value. The system aims to improvise Hydroponics farming with greater and faster production of food. Future projects may also include Artificial Intelligence and Machine learning algorithms which can enhance the credibility of this system.

Keywords— Hydroponic farming, MQTT, Sensors, Microcontroller.

INTRODUCTION

The provision of food is one of the most pressing issues confronting human civilization. The world population will reach 9.1 billion people in 2050, according to the United Nations Food and Agriculture Organization (FAO). To feed the world's 9.1 billion people, food production must increase by 70% between 2005 and 2050. The UN also predicts that by 2030, cities will house 60% of the world's population. This will result in an increase in the city's urban area and a decrease in agricultural land. Hydroponic farming has emerged as a solution to this problem. This approach to urban agriculture allows people to use their property or buildings for agricultural purposes even if they don't have a lot of space.

Agriculture is the art or practice of cultivating crops and breeding animals to create goods for humans. As a result of the fast population increase and the development of varied businesses, people began to migrate from rural regions where agriculture was practiced to places where these companies were located. As a result, cities were established where other equivalent companies could be found, and this phenomenon known as urbanization resulted in many people working in vocations other than agriculture. As an outcome, subsistence farming was no longer able to feed the population, and the farming sector needed to expand.

Soil is an essential component of agriculture since it nourishes plants, supplies nutrients to plants, and serves as a home for certain microscopic animals that create symbiotic relationships with the plants. On the contrary, hydroponics has the capacity to deliver all of these ingredients. Hydroponics is a method of growing plants without the need for soil. The Egyptian wall paintings showed traces of hydroponics. Hydroponics has a number of advantages: 1) It does not require soil, 2) it is more rapid than conventional farming, 3) it takes up less room and can be cultivated anywhere, 4) it is not impacted by seasonal swings, and 5) it requires very little pesticides and herbicides 6) Plants receive a comprehensive spectrum of nutrients in the quantities required, and 7) Plants are protected from diseases and pests. Hydroponic farming gives the exact amount and type of nutrients that plants require at a certain moment and may be grown within to maximize available space. Hydroponics solved soil-related concerns by producing plants that required less upkeep and were easier to harvest in difficult-to-maintain soil conditions. The combination of aquaponics with IoT can result in a productive crop harvest and perhaps increased growth quality.

PROPOSED DESIGN

I. Client side

For the system to function properly and for crops and plants to yield more, the client side must be carefully configured. The microcontrollers are programmed and fed data from the sensors here, which serves as an initialization step for the system. Temperature, PH value, electrical conductivity, TDS, Gas, and humidity are all measured in real-time by the sensors. These statistics assist users in identifying crop requirements. After configuring the sensors and microcontrollers, all of the cabling and power supply are combined as a single 5-volt component.

II. Server side

The second step of the system consists of an MQQT, which wirelessly transfers data from and to the microcontroller. An MQQT is a standard-based messaging protocol or collection of rules that aid in machine-to-machine communication by securing data flow between two devices: the transmitting device and the receiving device. Smart sensors, wearables, and IoT devices must transmit and receive data within a resource-restricted bandwidth, which MQQT assists with for improved system performance.

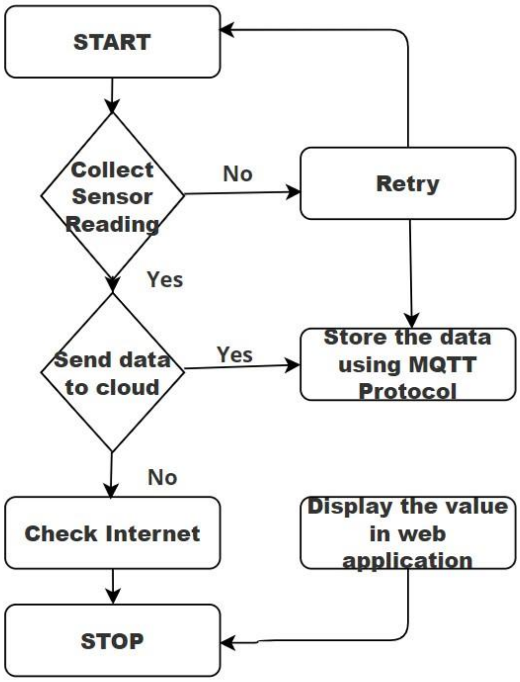


FIGURE 1. Data Flow

Figure 1 represents the flow of data from the cloud to the web application which is built for the analysis of real-time data for the user in pictorial representation. The data from the sensors is delivered to the cloud via a microcontroller and transferred to the cloud with the assistance of an ESP module; if the data is not sent, the internet is confirmed. The data is exchanged and stored via the MQTT Protocol before it is transmitted to the web application.

III. Web Application

The system's last stage is the development of a web application that will allow us to monitor all of the real-time data from the sensors and make modifications as needed. Maintaining all of the nutrient contents in the aqueous solution is critical in the hydroponics framework for plant development and production. The web app built using HTML, CSS, and JavaScript is required to deliver the necessary nutrients to the plants on a constant basis. The existing Hydroponic framing techniques is considered time-consuming, Require expertise and involves high risk of failure. The Novelty of the proposed system lies in introducing an enhanced way of monitoring all the parameters required for plant growth which pays wave for higher profits as well as ensures a healthy growth phase for plants and the monitoring and controlling facilities in the proposed design degrades the risk of failure.

WORKING PRINCIPLE

The operating principle of the system created is explained with the aid of the structure displayed in Figure 2. The intelligent hydroponics system is made up of three primary components: input data, cloud server (monitoring and managing), and GUI. To begin with, the input data, because IOT refers to the internet of things, a group of devices, mostly sensors, link with one another over a network, an IOT system requires a group of sensors. Several sensors in the smart hydroponics system capture data such as temperature, humidity, PH level, Gas, electrical conductivity, and TDS value in the aqueous solution. The ability to monitor and see data in real-time while also delivering data and managing settings across a network is known as the internet of things. MQTT, an acronym for MQ Telemetry Transport, is a lightweight messaging protocol developed for low bandwidth, high latency networks. The data collected in the cloud is compared to a threshold value. If the PH value goes less than 5 then motor 1 connected to pin D5 gets activated and if the value becomes more than 10 then motor 2 gets activated which is connected to pin D6 for achieving its limits for healthy plant growth.

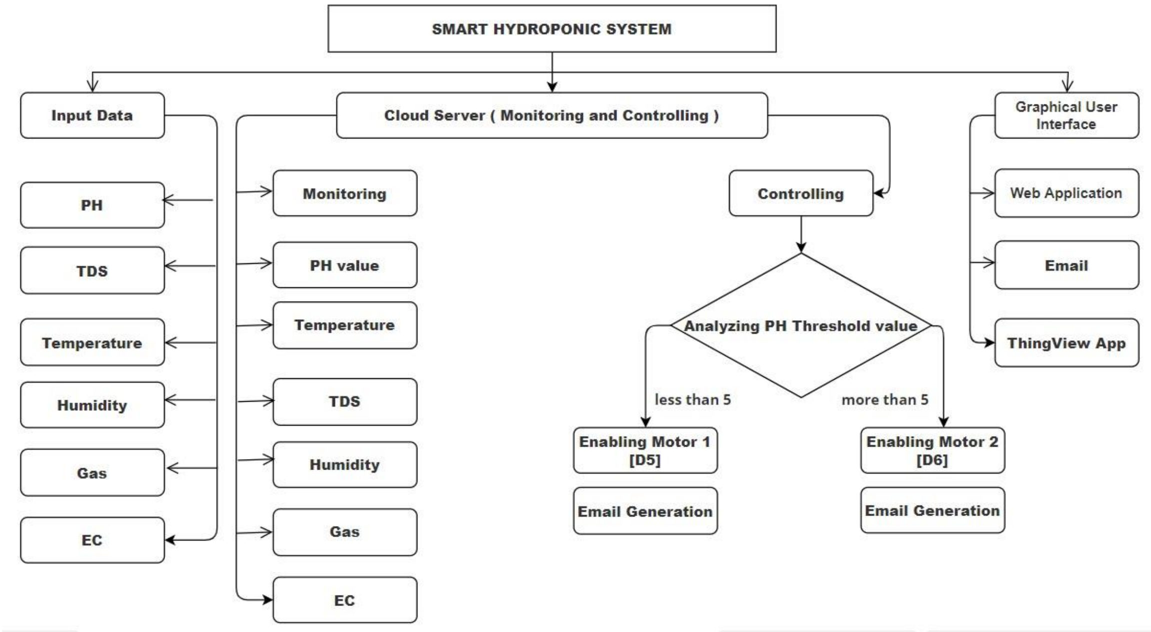


FIGURE 2. Smart Hydroponic System Structure

The sensors' output data is seen via the web application that has been created for the end user. The obtained output data is utilized to analyze the proper demands of the plants and crops that are being cultivated. The web application pays way for the end user to acknowledge the level of essential as well as the system alerts the end user when there is an imbalance in the level of the nutrients in the aqueous solution or if any disturbances occur due to the environmental factors through an Email. With this email facility, the end user could easily track which element has an imbalance in its threshold value.

RESULT

1) HARDWARE:

The outcomes of hardware will be reviewed in this part. All the sensors have been connected in the Arduino Uno and have been programmed in order to monitor whether there are no changes in the reference values which have been already set for the effective growth of the plants. If there occur any changes in the data from the sensor which is either lower or higher than the reference point then an email will be generated to the owner regarding the change in value and also the imbalance in the value will also be rectified if possible, automatically.

Table 1 shows the pin connections of all the sensors with two motors which in this project act as an element for balancing the PH value which is essential for the growth of the plant. At first, the real-time value from all the sensors are being sent to the cloud with the help of an ESP module and is transferred to the web application where the owner can view live data meanwhile the values are verified whether it lies between their threshold values and if not then the system acts accordingly to balance the values, here this hydroponic system has been built in such a way that when the PH value gets below 5 the motor which is connected to the pin D5 gets activated and if the PH value gets higher than 10 then the motor connected to pin D6 gets activated. Since we use a 12 V adapter there is also a need for a buck converter that converts the 12 V to 5 V for the working of the sensors. There are both analog and digital values that are being generated from sensors which are connected accordingly, such as the DHT sensor which gives Humidity and Temperature values of 16-bit data where the first 8 bits consist of Temperature value and the upcoming 8 bits consist of humidity values are connected to digital pins along with motors whereas the remaining sensors produces analog values which are connected to analog pins.

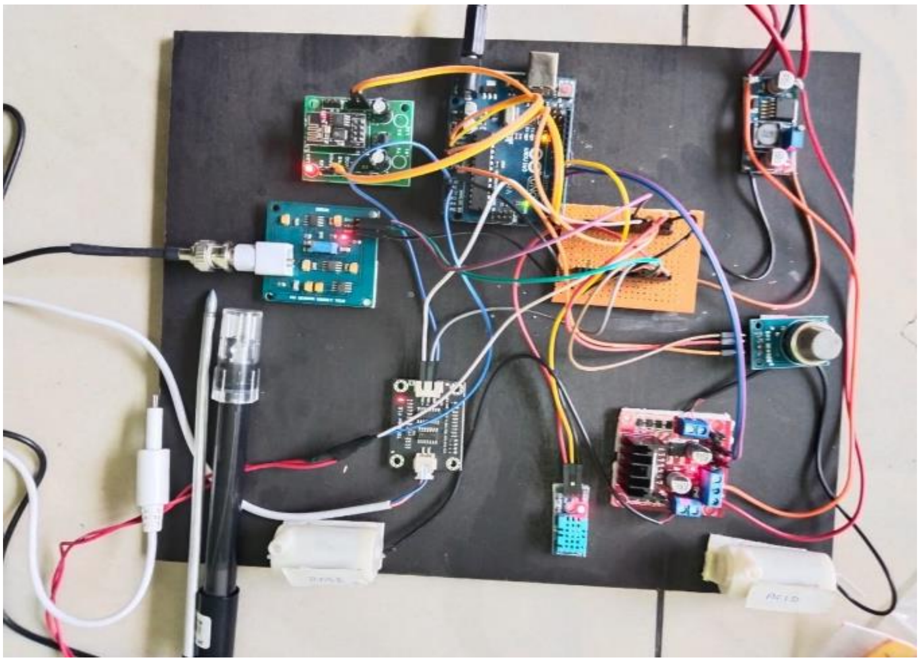


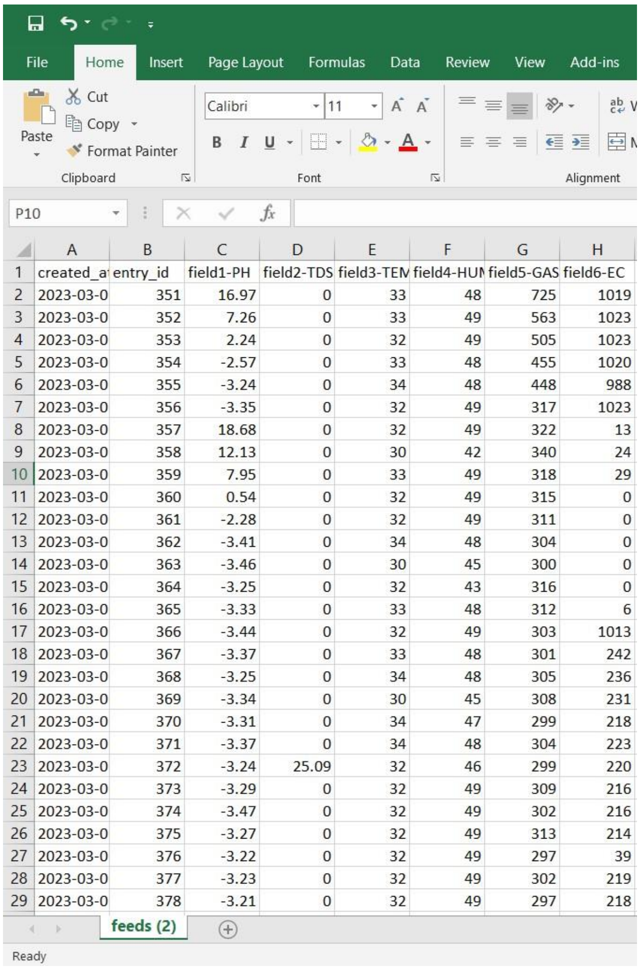
FIGURE 3. Smart Hydroponic System Structure

Table 1: Pin description

S.NO	Pin	Sensor
1	A0	PH Sensor
2	A1	TDS Sensor
3	A2	EC Sensor
4	D7	Temperature Sensor
5	A3	Gas Sensor
6	D7	Humidity Sensor
7	D5	Motor 1
8	D6	Motor 2

2) SOFTWARE:

This section will go over the results of the software. Testing was used to evaluate the performance of the established automated smart hydroponics system. The result of comparing numerous parameters such as temperature, humidity, gas, TDS, electrical conductivity, and PH, which are measured using sensors and compared to data collected from think speak. MQTT is an ingenious solution for wireless connections that suffer from different degrees of latency owing to periodic bandwidth limitations or unreliable connections. It is appropriate for connecting devices that have a tiny code footprint. The standard is used in many industries, including automobiles, power generation, and communications. Additionally, MQTT is chosen for its reliability, QOS (Quality of Service), and server accessibility encryption. Hence, MQTT is used throughout this project to transmit and receive information from the microcontroller to the cloud and vice versa via a secure MQTT server that has been developed. Some Applications of MQTT Protocol includes Remote sensing, Smart cities, Social media platform, Home automation, smart farming.



	A	B	C	D	E	F	G	H
1	created_at	entry_id	field1-PH	field2-TDS	field3-TEM	field4-HUM	field5-GAS	field6-EC
2	2023-03-0	351	16.97	0	33	48	725	1019
3	2023-03-0	352	7.26	0	33	49	563	1023
4	2023-03-0	353	2.24	0	32	49	505	1023
5	2023-03-0	354	-2.57	0	33	48	455	1020
6	2023-03-0	355	-3.24	0	34	48	448	988
7	2023-03-0	356	-3.35	0	32	49	317	1023
8	2023-03-0	357	18.68	0	32	49	322	13
9	2023-03-0	358	12.13	0	30	42	340	24
10	2023-03-0	359	7.95	0	33	49	318	29
11	2023-03-0	360	0.54	0	32	49	315	0
12	2023-03-0	361	-2.28	0	32	49	311	0
13	2023-03-0	362	-3.41	0	34	48	304	0
14	2023-03-0	363	-3.46	0	30	45	300	0
15	2023-03-0	364	-3.25	0	32	43	316	0
16	2023-03-0	365	-3.33	0	33	48	312	6
17	2023-03-0	366	-3.44	0	32	49	303	1013
18	2023-03-0	367	-3.37	0	33	48	301	242
19	2023-03-0	368	-3.25	0	34	48	305	236
20	2023-03-0	369	-3.34	0	30	45	308	231
21	2023-03-0	370	-3.31	0	34	47	299	218
22	2023-03-0	371	-3.37	0	34	48	304	223
23	2023-03-0	372	-3.24	25.09	32	46	299	220
24	2023-03-0	373	-3.29	0	32	49	309	216
25	2023-03-0	374	-3.47	0	32	49	302	216
26	2023-03-0	375	-3.27	0	32	49	313	214
27	2023-03-0	376	-3.22	0	32	49	297	39
28	2023-03-0	377	-3.23	0	32	49	302	219
29	2023-03-0	378	-3.21	0	32	49	297	218

FIGURE 4. Real-time Data from all sensors for analysis purposes (CSV file)

The above figure 4 represents the data's for analyzing the fluctuation in the values from the sensors which help in understanding the level of changes over the period of time due to environmental changes. This helps the owner to calculate their essential precaution for the well-being of plant's growth. The file is emanated in csv format from thing speak application in channel 2055181. There occur 6 fields which represent six sensor data as PH, TDS, Temperature, Humidity, Gas, and EC accordingly.

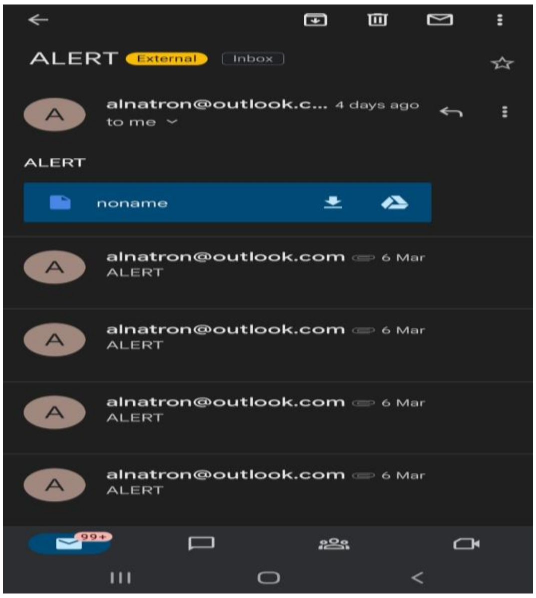


FIGURE 5. Smart hydroponic system Alert Notification to the owner

Above Figure 5 shows the alert mail which has been received by the owner due to the imbalance in the PH level [below 5 or above 10] which is caused due to environmental factors. The mail received by the owner will have an attachment that consists of all the values being measured, which is shown in figure 6.

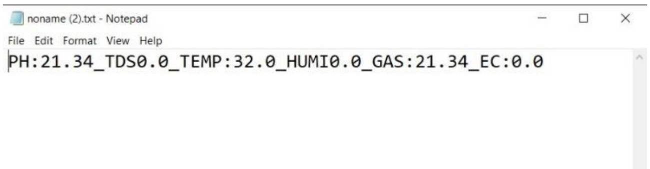


FIGURE .6. Attachment along with the email

There is a total of six parameters that are measured in this smart hydroponic system where their real-time values are viewed in a web application for easy understanding which also pays the way for tracking the changes in the values of the data from sensors. The below graphs represent all such values from the sensor along with the day, date, and time of readings. These graphs are generated with the help of values derived from the cloud which is sent by the microcontroller.

FIGURE 7. PH value

The above graph represents the PH level, wherein the level of PH is noted to be 11 on Saturday, April 1st of 2023.

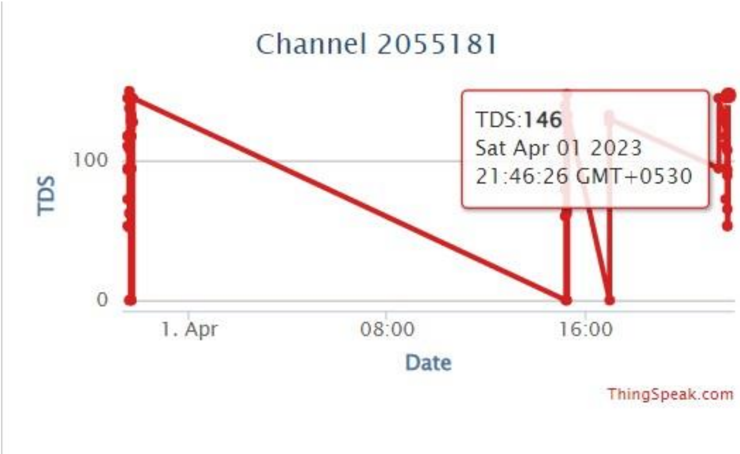


FIGURE 8. TDS (ppm)

The above graph represents the TDS value, wherein it is noted to be 146 on Saturday, April 1st of 2023.

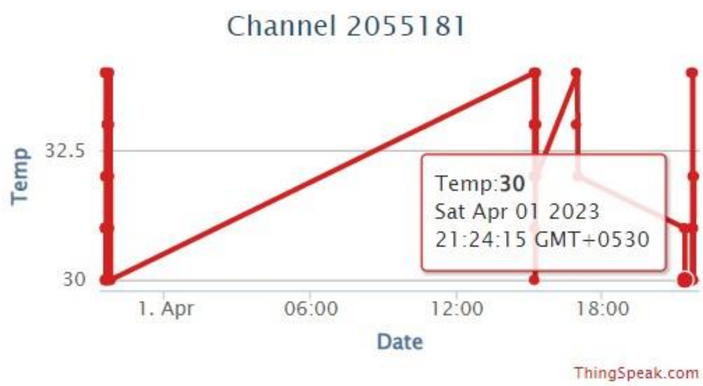


FIGURE 9. Temperature (degree Celsius)

The above graph represents the Temperature, wherein the Temperature is noted to be 30 on Saturday, April 1st of 2023.

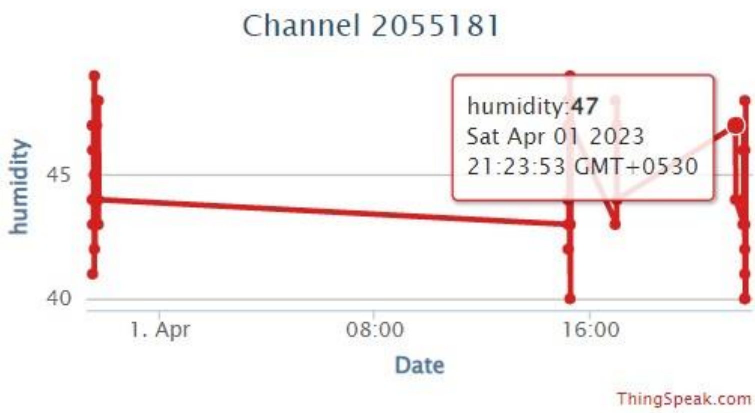


FIGURE 10. Humidity (percentage %)

The above graph represents the Humidity, wherein it is noted to be 47 on Saturday, April 1st of 2023.

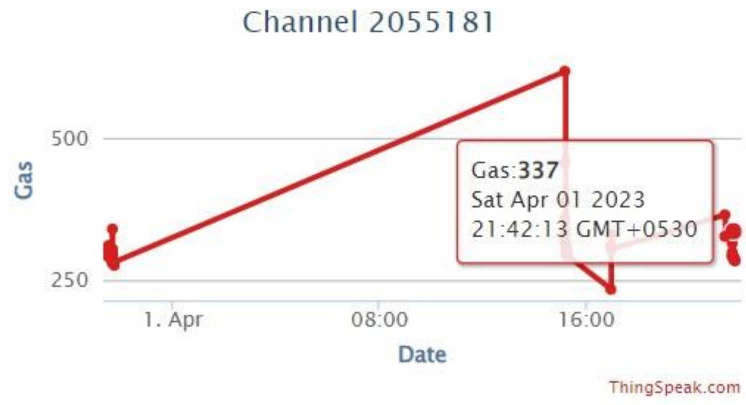


FIGURE 11. Gas (ppm)

The above graph represents the Gas in ppm, wherein the level of Gas is noted to be 337 on Saturday, April 1st of 2023.

FIGURE 12. Electrical conductivity (ppm)

The above graph represents the Electrical conductivity, wherein the EC is noted to be 1022 on Saturday, April 1st of 2023.

CONCLUSION

The suggested system has ameliorated the existing system by adding to the concept of the internet of things. This technique aids in the production of food in a short amount of time while also conserving water. A solacing effect on bringing the internet of things was it prohibits the most concerning problem: Maintenance, by providing a platform to monitor data from the cloud. The Email Alert facility further improvises the system to the next level enabling the user to identify the problem as soon as possible and the attachment along the email helps in making note of values of the data from the sensor at that moment of time to make arrangements accordingly and to check whether the problems are rectified. The Integration of Data analysis and machine learning algorithms would be a greater suggestion for the future upliftment of this system, increasing the number of sensors for improvising the data accuracy Which would help the Artificial intelligence technology to aid better outcomes, and by including C1000 microcontroller with image processing to improvise the plant health.

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