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Design and Implementation of Greenhouse Monitoring and Controlling System using IoT

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Abstract -In traditional farming, farmer has to visit the farming land regularly to measure the various environmental parameters such as temperature, humidity, light intensity, Air Quality and soil moisture to cultivate the right crops at right time in right soil. Even though this traditional farming system have been used for years, the system is hectic and fail to prove high productivity rate as farmer usually unable to measure all the parameter accurately. In contrast, greenhouse farming is a system where farmer cultivate crops in ecosystem environments where all environmental parameters are adjusted based on crop types. Automation in greenhouse is a method where farmer is able to monitor and control the greenhouse environment automatically from anywhere in the world any time.The greenhouse environment parameters such as temperature, humidity, moisture, light is monitored and controlled as per requirement. It has three sensors at output side, and it has four devices at the input side to control the environment parameters.

Key Words:Automation, Ecosystem, Greenhouse Farming, Soil Moisture Sensor, Temperature Sensor

1. INTRODUCTION

A greenhouse is where plants such as flowers and vegetables are grown. Greenhouses warm-up during the day when sunrays penetrates through it, which heats the plant, soil and structure. Greenhouses help to protect crops from many diseases, particularly those that are soil borne and splash onto plants in the rain. Greenhouse effect is a natural phenomenon and beneficial to human being. Numerous farmers fail to get good profits from the greenhouse crops for the reason that they can't manage two essential factors, which determines plant growth as well as productivity. Greenhouse temperature should not go below a certain degree, High humidity can result to crop transpiration, condensation of water vapour on various greenhouse surfaces, and water evaporation from the humid soil. To overcome such challenges, this greenhouse monitoring and control system comes to rescue. This project demonstrates the design and implementation of a various sensors for greenhouse environment monitoring and controlling. This greenhouse control system is powered by NodeMcu microcontroller it consists of temperature sensor, light sensor, soil moisture sensor, Air Quality Monitoring system, LCD display module, DC fan, Bulb and pump. Temperature sensor senses the level of temperature if it goes high DC fans gets on and when the temperature goes low the fan gets off. Soil moisture sensor senses the water level as the level decreases the pumps gets on. In the absence of light, the LDR sensor senses and the bulb start glowing. By this way it will become easy to monitor and control the system.

Planning in greenhouse environment is a process where an ideal environment is provided for crops to grow strong that in turns improves the quality of the crops and enhances the performance of the farmers. Automation in greenhouse is a method where farmer is able to monitor and control the greenhouse environment automatically Plants that grow in a greenhouse are not provided with the same temperature variation as the outside cultivation rather than retaining the heat inside the enclosure that is not possible before the emergence of greenhouse. The microclimate which is in the greenhouse actually extends the growing season of the plants who could not survive outside the enclosure. Automation of a greenhouse provides efficient data acquisition and control of the microclimatic parameters. It also significantly reduces the labour involved in its maintenance thus making the system useful for small-scale agriculturists, gardeners, and agricultural researchers.

1.1 Related Work

Automated greenhouse system helps the farmers by controlling the environment parameters through the environmental parameters through the internet of things (IOT) including crop health inspection using image analysis the greenhouse is generally affected by two factors: plant diseases &weather condition, which leads to the fall in production. The weather condition can be controlled through Microcontroller Unit (MCU) & the plant diseases can be monitored using image inspection system. The research recommends cheaper image evaluation framework for the plant disease can be monitored using image inspection system [1].

The research recommends Cheaper image evaluation framework for the plant diseases analysis& fully automated greenhouse data security. The prototype of the proposed system consists of Temperature/Humidity Sensor, Moisture Sensor, &Light Sensor. The Motor, Fan Light, are controlled by Arduino UNO through Relays upon reaching predetermined threshold values. The proposed architecture is equipped with embedded data security by implementing Extended Tiny Encryption Algorithms (XTEA) lastly, the agriculturists can familiarize with the recommended

framework through the cloud-centred application. The autonomous frameworks permit the agriculturists to evaluate &control their greenhouse ecology remotely [2].

1.2 Problem Statement

Several challenging difficulties related with the existing systems are the complexities in monitoring climatic parameters like humidity, Air quality, water level, light, and temperature directly or indirectly manage the plant growth and the system cannot be controlled remotely. It involves high maintenance and needs for skilled labour for controlling the greenhouse. If there is any variation in the system, then the changes or maintenance should be completed according to farmer directions.

2. DESIGN OF GREENHOUSE MONITORING AND CONTROLLING SYSTEM

In order to develop a successful greenhouse system, the following parameters such as temperature, light intensity, humidity, and moisture of the soil should be adjusted in such a way that different plants can grow perfectly. Therefore, continuous monitoring of temperature, light intensity, humidity, and moisture of the soil is utmost important in greenhouse system. In this paper, four different sensors such as temperature sensor & humidity sensor, light sensor, Air Quality Monitoring Systemand soil moisture sensor have been used for collecting data of such four essential parameters continuously. The primary device of the greenhouse monitoring and controlling system is Arduino Uno R3 which is used to store the data collected by different sensors mentioned above as well as process the data. An android app has been developed in order to monitor and control the greenhouse information through Smartphone from anywhere in the world any time. Besides, if there are any changes inside the greenhouse system then users of greenhouse system will be notified by SMS which is done by GSM module. Moreover, the whole greenhouse system is powered by solar power system incorporating solar panel and a rechargeable battery. Here, rechargeable battery is used to store the power and deliver the continuous power supply to the different devices of greenhouse system. The following Fig. 1 depicts the block diagram of greenhouse monitoring and controlling system.

- The system's temperature monitor and control system work according to the temperature value set by the user. First it gets the value from the user and maintains the temperature on the LED screen for user reference. The temperature of the greenhouse is reduced by the fan that is placed inside the greenhouse. The temperature of greenhouse is increased by using heater which is placed at the floor of the greenhouse to ensure that the whole greenhouse is warmed equally.
- The light control system controls the light falling on the greenhouse. When there is not enough light the LDR detects this, and the light bulbs are switched ON When there is lighter the light bulbs are turned OFF but at night the system will automatically get turned ON and this has harmful effects on the plants therefore a switch is placed to OFF the lights at times when we feel the lights are unnecessary.

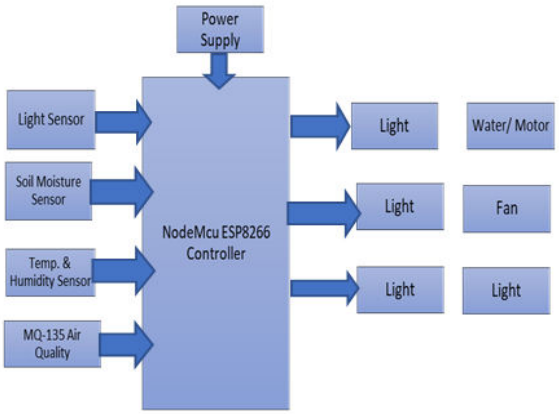


Fig. 1 Block Diagram of Set-up

- The humidity level monitoring system monitors, and it maintains around a predefined value. When the system detects the drop in humidity level the pipelines installed inside the greenhouse allows water to floor. The pipes contain small hoes and hence allow water Reach the soil quickly. When the humidity level reaches the correct value the system OFF the motor and flow of water stop.
- One LDR is fixed inside the system since light is falling onto the greenhouse evenly. If the light intensity is high the bulbs are switched off if they are once switched ON when the light intensity is low to save power.A switch is place to cut OFF the power supply to the bulbs manually this is because having lights ON at night will make plants weak and consumes more power.
- The MQ-135 Gas sensors are used in air quality control equipments and are suitable for detecting or measuring of NH_3, NOx, Alcohol, Benzene, Smoke, CO_2.

3. HARDWARE DESCRIPTION

In order to monitor the complete greenhouse system environment different type sensors such as temperature sensor, humidity sensor, light sensor, gas sensor and soil moisture sensor are employed for designing hardware system for greenhouse. An NodeMcu ESP8266 Controller has been used as a central device to store and process data. An LCD (Liquid Crystal Display) Module has been used to display the parameters to the user. Besides, a GSM (Global System for Mobile Communication) Module has been used to update user through SMS. Moreover, some Relays, converters (analog to digital and digital to analog), Rechargeable Battery have been used in this novel greenhouse monitoring and controlling system.

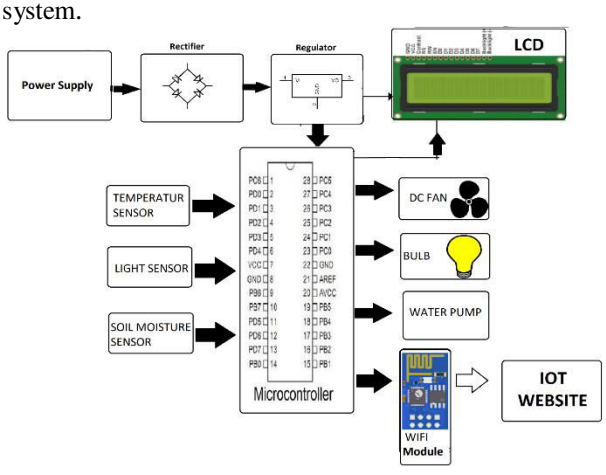


Fig. 2 System Architecture

In this paper, following hardware units have been used.

- **Light Dependent Resistor (LDR)**

The Light Dependent Resistor (LDR) is just another special type of Resistor and hence has no polarity. Meaning they can be connected in any direction. The arrows indicate the light signals. Light intensity also plays an important role in greenhouse system. Proper light intensity is essential for growth of the plants. Varying light intensity may result severe affect in plant growing and hence loss of productivity. There is a LDR in light sensor module which can help to detect light intensity. In this paper, artificial lights are used to resolve the problem of low light intensity inside the greenhouse system. When light intensity is compared lower level with a defined level, the artificial lights automatically turn on. In case of normal range of light intensity can lead the artificial lights automatically turns off.

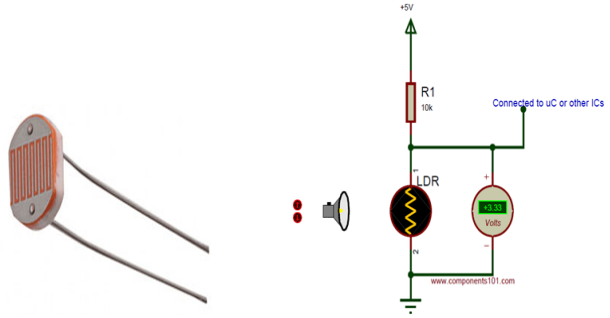


Fig. 3 LDR and its circuit connection

- **Gas Sensor**

When it comes to measuring or detecting a particular Gas the MQ series Gas sensors are the most inexpensive and commonly used ones. **MQ135** is available as a module or as just the sensor alone. If you are trying to only detect (not measuring PPM) the presence of a gas, then you can say it as a module since it comes with an op-amp comparator and a digital output pin. But if you planning to measure the PPM of a gas it is recommend buying the sensor alone without module.

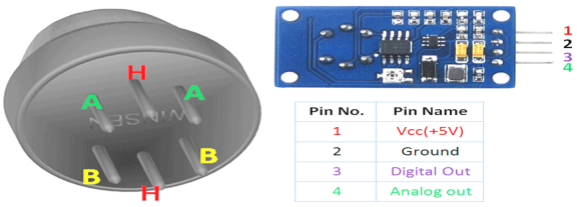


Fig. 4 MQ-135 Gas Sensor

- **NodeMCU ESP8266**

The NodeMCU ESP8266 development board comes with the ESP-12E module containing ESP8266 chip having TensilicaXtensa 32-bit LX106 RISC microprocessor. 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. NodeMCU can be powered using Micro USB jack and VIN pin (External Supply Pin). It supports UART, SPI, and I2C interface.

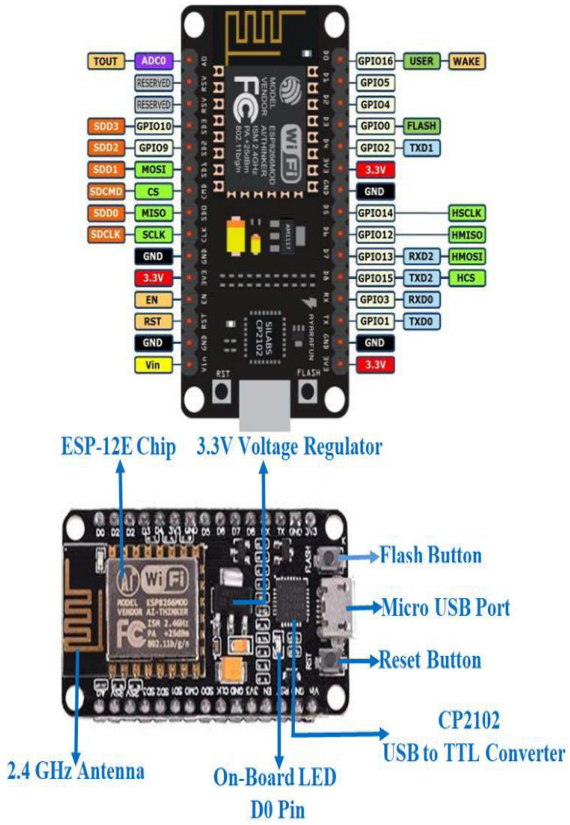


Fig. 5 NodeMCU ESP8266

- **Soil Moisture Sensor**

This soil moisture sensor module is used to detect the moisture of the soil. It measures the volumetric content of water inside the soil and gives us the moisture level as output. The module has both digital and analog outputs and a potentiometer to adjust the threshold level. Soil moisture plays an important role for growing good plants. A soil moisture sensor has been used to determine the moisture of the soil. By placing two probes of soil moisture sensors inside the soil, value of moisture in the soil can be measured and the outcome is sent to the owner of the greenhouse system using GSM via SMS.

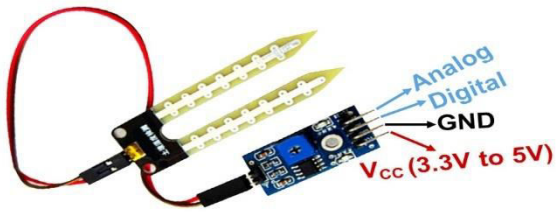


Fig. 6 Soil Moisture Sensor

- **Temperature and Humidity Sensor**

The **DHT11 sensor** can either be purchased as a sensor or as a module. Either way, the performance of the sensor is same. The sensor will come as a 4-pin package out of which only three pins will be used whereas the module will come with three pins as shown above.The only difference between the sensor and module is that the module will have a filtering capacitor and pull-up resistor inbuilt, and for the sensor, you have to use them externally if required. The DHT11 Sensor is factory calibrated and outputs serial data and hence it is highly easy to set it up.

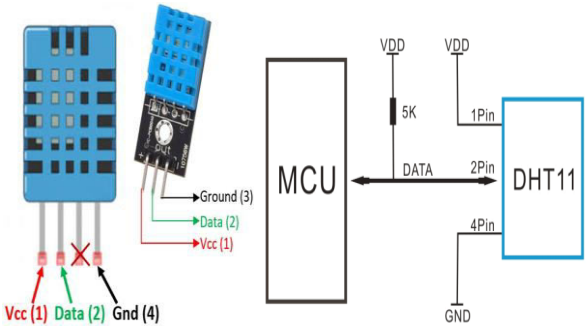


Fig. 7 Temperature and Humidity Sensor

4. IMPLEMENTATION OF GREENHOUSE MONITORING SYSTEM

4.1 Software Specification

To show the parameters that are collected through different sensors and to monitor the complete greenhouse system a program has been developed in this paper. Different sensors will provide various measurements which comprise the reading of data, converting analog to digital values, showing in the LCD module and updating the user by sending short message. The program is written in Arduino IDE (1.8.3). The program will be loaded in the Arduino, once the program is successfully built in the IDE by using serial communication. It is easy to write code and upload it to the board. C and C++ language are used for programming.For software implementation, Fig. 9 demonstrates the flow chart of the program for the proposed greenhouse monitoring and controlling system. The program has been written in Arduino IDE for measuring the intensity of light, inside temperature, humidity, and moisture of the soil. The measured value of different parameters is sent to the owner's mobile phone as SMS via GSM module.

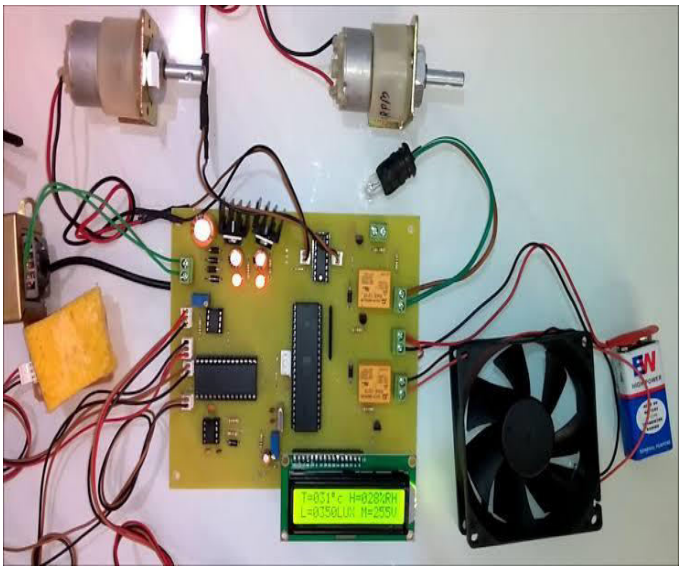


Fig. 8 Actual Experimental Set-up

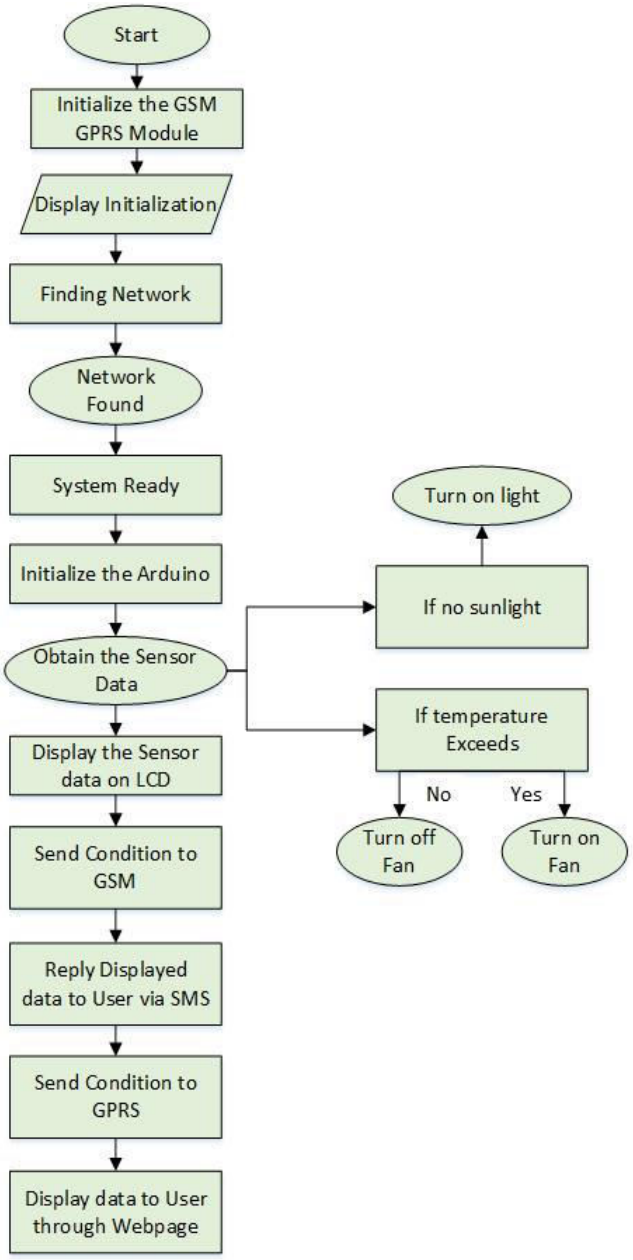
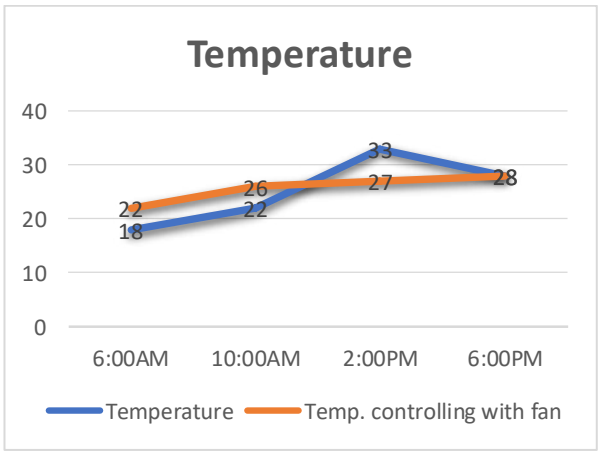


Fig. 9 Flowchart of System

5. RESULT ANALYSIS

Development of automatic greenhouse monitoring and controlling system using sensors and solar power is completed effectively. The system has been tested under simulated environment successfully and depicted the capability of monitoring and controlling the intensity of the light, humidity of the air and inside temperature and moisture level of the soil. The values of various parameters like temperature, humidity, soil moisture, and light intensity are measured successfully, and the measured values are displayed on LCD that is attached with the system. Thecommunication between NodeMCU ESP8266 board and various sensors is done accurately with no interference observed. It can be seen that the device is capable to send SMS that incorporate updated temperature, humidity, light intensity and moisture of soil using GSM module. The user has to send a code like *total# to the GSM. Then, the measured values are sent to the owner's mobile phone as SMS via GSM module. In terms of light intensity, If the value exceeds, the light and fan are

automatically switched on and when the value is in normal condition the fan and light remain off. Fig. 10, 11, 12 and 13 provide graphical representation of temperature, humidity, light Intensity and water content respectively in different times of the day. The graph has been created using the data from the database. The complete greenhouse system is powered by solar power system incorporating a rechargeable battery. The solar power ensures uninterrupted and continuous power supply to the greenhouse system.



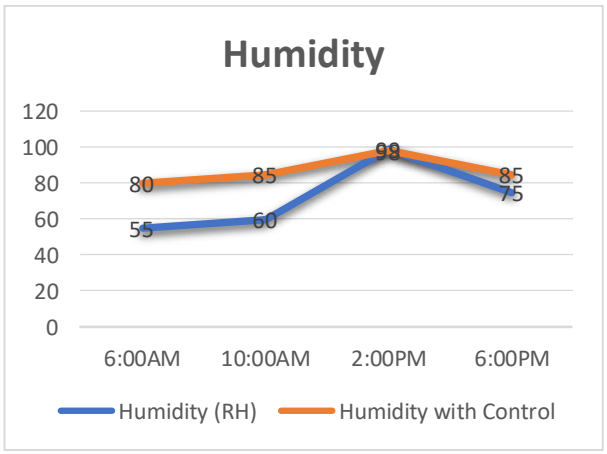


Fig. 10 Graphs shows results of Temperature and Humidity w.r.t. time

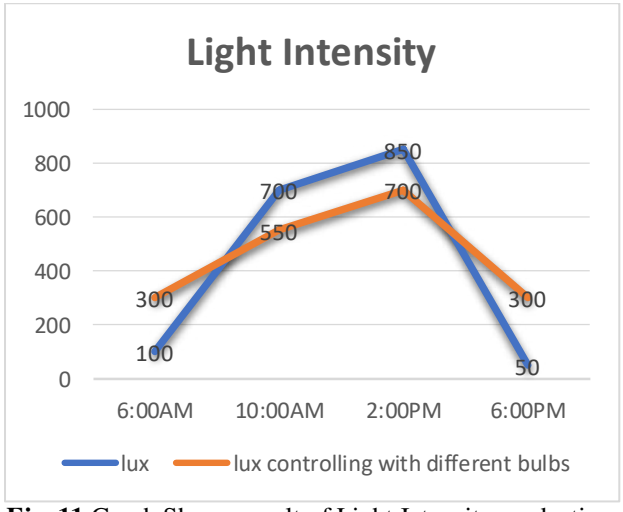


Fig. 11 Graph Shows result of Light Intensity on daytime

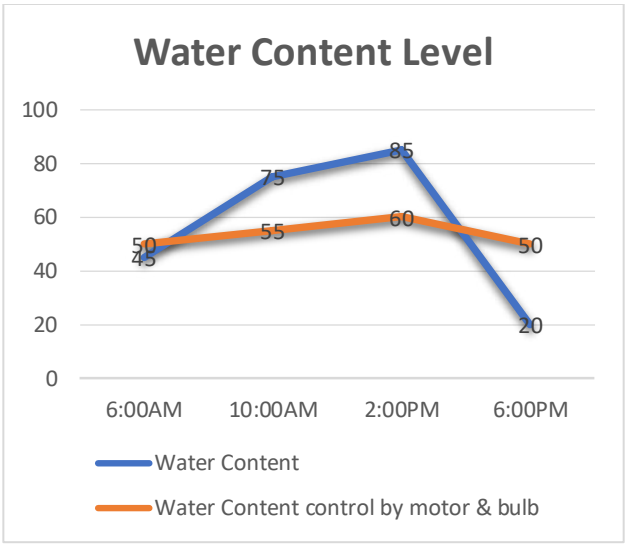


Fig. 12 Graph shows result of Water Content in soil w.r.t. time

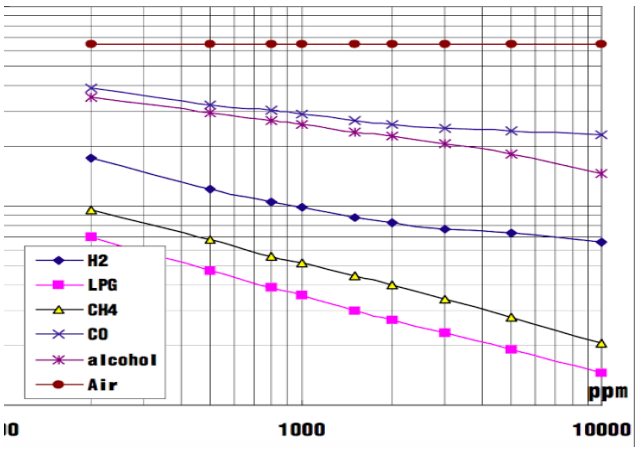


Fig. 13 Scatter line shows result of type of Air present in ppm

6. CONCLUSION

Greenhouse prevents the plants from the effects of climate; inspect and so on, which makes great sense for agricultural production. The automation and high efficiency on greenhouse environment monitoring and control are crucial. Applying new technologies to greenhouse is a revolution for protected agriculture which overcomes the limits of wire connection systems. Such a system can be easily installed and maintained. The developed cost-effective greenhouse model can be used to monitor and control temperature, light intensity, humidity and soil moisture of a greenhouse in order to increase productivity in farming especially in countries like Bangladesh where there is ample risk of insect infestation, harsh climate and increasing demand of food with the decrease of fertile land. The model is fully automatic and so, does not require human interaction to smooth monitoring the plant as it is operated by solar power system with rechargeable battery. In order toanalyse the data, an Internet of Things based databases has included in this model. Besides, the authors presented a comparison table that clearly described the developed greenhouse model as state-of-the-art greenhouse system. Moreover, a cost analysis table has added in this paper to depict affordable and cost-effective greenhouse model for farmers. However, there are some

future work needs to be done such as exact determination of soil texture and use of fertilizer aptly.

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