# IoT APPLICATION FOR MUSHROOM CULTIVATION TO INCREASE PRODUCTIVITY

**J COMPONENT PROJECT REPORT**

**SLOT - B1**

*Submitted by*

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# Table of Content

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## 1. Abstract

This is an IoT based application project made using ThingSpeak and NodeMCU ESP-8266 microcontroller, that focuses on the increasing the production of mushrooms especially Oyster mushrooms and White Button mushrooms grown indoors on a small scale for which parameters like temperature, humidity and light intensity are be monitored and even controlled by using actuators like fan and air pump .There is mode selection option to choose between white button mushrooms and oyster mushrooms and buzzer indicators to help ease the job of knowing the mode and light intensity of the system. The NodeMCU ESP -8266 is programmed using Arduino IDE and then connected to ThingSpeak tha is an IoT based cloud platform by MathWorks which helps to store the data and visualize it in the form of graphs and digits.As we are using ESP-8266 we are using Wi-Fi as our wireless technology and HTTP as our messaging protocol. For the project we have worked only with oyster mushrooms as they are easy to grow in a PP bag and require low maintenance . Also the weather where the cultivation is taking place is quite cold so oyster mushrooms are best for this season. We have grown two bags of oyster mushrooms : one for the IoT system and the other is put outside the IoT system in a cool and dark place . Both are grown on the same day . At the end of harvesting we compare the results of the mushroom cultivation for both the bags and see which has resulted in a higher yield.

*Keyword: ThingSpeak, NodeMCU , ESP-8266,Arduino IDE,Wi-Fi, HTTP, IoT, Oyster mushroom,White Button Mushroom.*

## 2. Introduction

Agriculture sensors have started to play a very important role in modern agriculture. The employment of sensors in various agriculture sectors minimizes the environmental impact on crops and helps in increasing yield and also saving the value of the operation. Internet of Things (IoT) is blending with modern agriculture enabling farmers to keep a track of their farms in real-time and access all of the knowledge they require from anywhere at any time. Mushroom cultivation has also experienced the same spike in IoT based monitoring for improved production and quality of crops obtained by controlling the climate for mushroom cultivation because the perfect environmental conditions like temperature, carbon dioxide level, humidity level, sunlight, nutrient, and pH are monitored and controlled using modern IoT enabled techniques. On a broader level, this can be one step towards curbing the food crisis globally. The idea in this project is limited to mushrooms but by changing the environmental conditions with respect to needs of various other fruits and vegetables, we can see a major increase in food production with better quality too.

The project hopes to bring a huge difference in the plantation industry by enhancing the existing conventional farming methods. Talking specifically about India which has extreme weather conditions, this can be a great way to give the agricultural sector the much needed boost by increasing the variety of plantations.

This project focuses mainly on the major environmental conditions that are necessary for increasing the production of mushrooms i.e. temperature, light intensity and humidity and using actuators to automatically control these parameters when required. The main category of mushrooms used will depend upon the season in which this project is being carried out thus we have added a mode selection option to choose between white button mushrooms and oyster mushrooms.

To make this process easier, we aim to make this project as user friendly as possible. Our project includes thingspeak which aims to keep the user aware about the progress in their farm and keeps them updated about its growth rate. We also aim to include actuators which act in case the parameters change from the threshold value. The objective is to keep the system intact in a way the system maintains a state that was preferred with respect to the crop of choice ( in our case mushrooms). The data can be retrieved by the users of our project via the browser application (smartphone, computer etc).

Here, in this project, we are choosing an indoor environment to make a small scale setup for studying and analysing, but this project has a lot of scope and can be easily implemented on bigger terrain by adding the sensors accordingly. The aim for both the setups will be the same.

There are a lot of plants with high nutritional values like mushrooms that are seasonal in nature. One huge objective of our project has been to remove the barrier between healthy plant growth and weather. In India, due to restricted weather conditions in different parts of the country, the variety of crops that can be grown in one particular state is pretty much restricted. To curb this, our project makes all seasons favourable for the growth of any plant that one wants by changing the preferred threshold values.

## 3.1 Literature Review/Related Work

This paper explains the use of the Blynk Platform to store and analyze data obtained from humidity sensors used to keep a track of the humidity level of paddy stored in paddy bags in the warehouse. They have used four orange capsules to put the hardware component consisting of Node MCU ESP 8266, battery, SHT1 temperature and humidity sensor and wires, inside four paddy bags and using WiFi-connected them to Blynk application that keeps checking on the working of hardware and the collection of data. Although the research is quite successful in monitoring paddy bags, some future works were proposed to improve the capsule size and use more IoT compatible communication technologies like LoRa, NB-IoT. [1]

This paper talks about mushroom cultivation in Malaysia and how to improve the production of mushrooms using an environmental monitoring and controlling system. The research uses temperature and humidity sensor DHT22, gas sensor MQ135, LDR, WiFi module ESP8266-01, solid-state relay G3MB, and AC (alternating current) control device, push-button switch, Arduino UNO microcontroller, switch, LEDs (light-emitting diode) and various resistors to make a controlling system connected to ThingSpeak that captures and stores data from the sensors. Also, an application is made using Virtuino that displays ThingSpeak data for ease of monitoring. Although successful implementation was achieved, the only limitation in this research is the error percentages obtained in the data due to the atmosphere inside and outside the cultivation area. The measured percentage error of temperature, humidity, carbon dioxide and the light intensity using the circuit was as low as 0.4%, 1.5%, 2.2% and 1.34% respectively.[2]

This paper tells about the Easy- Mushroom mobile application that collects only humidity and light intensity data from the sensors and analyzes the data using MATLAB. The research uses this analyzed data to predict the type of mushroom that could be used to yield the best mushroom but the paper fails to elaborate the conditions and the hardware necessary to do the research also the high computation of machine learning required a higher-end microprocessor and data training which will increase resource requirements and cost especially for large-scale farming.[3]

This research uses a fully automated system that is put in an oyster mushroom house in NASOM Bandar Puteri Centre with a temperature and humidity sensor, Node MCU ESP8266 and actuators like a water pump to spray water on the ground and nets and exhaust to regulate the temperature and humidity. Although the system is completely successful, the research utilizes a large area for the use of actuators.[4]

This paper elaborates on the use of IoT for white button mushrooms in India using Raspberry Pi 3 ESP 8266, DHT11 temperature and humidity sensor, MG811 carbon dioxide sensor and soil moisture sensor all connected to actuators like solenoid valve, conveyor belt and water pump. The data is collected on ThingSpeak and sent to Raspberry Pi that analyzes the data and sends it to actuators. The overall control is set up on a website made using JavaScript, CSS, HTML for frontend and SQL for backend and connected through python framework Django. The system and implementation are very complex, especially the use of a conveyor belt to lay down the manures containing mushroom spawns to maintain hygiene and less human interaction but requires more space and power.[5]

This paper aims to discuss temperature and humidity control and monitor the mushroom cultivation process using the Internet of Things technology by utilizing the MQTT protocol and comparing the data transfer rates of MQTT and HTTP(TCP/IP). For the QTT protocol, Raspberry Pi acts as a broker and collects data from a DHT11 temperature and humidity sensor while allowing the actuators like fan and sprinkler to work based on the requirements. For HTTP protocol the data is stored in Google Firebase and from there it is used in an android based application made using Android Studio. The paper successfully testifies that MQTT takes lesser time than HTTP for data transfer and also automates the process of mushroom cultivation.[6]

This research aims to prototype a smart Lingzhi mushroom farm by applying the use of IoT with a sensor to measure and monitor the humidity of the farm. The humidity data was processed through NETPIE, stored into a NET FEED and displayed on mobile devices and computers through NET FREEBOARD. There are actuators like sprinkler and fog pumps that automatically start or shut down and their functional state is pushed through notifications using LINE API on the LINE application. The hardware used in this research were NodeMCU ESP8266, humidity sensor DHT22, RTC (real-time clock), relay module, LCD, sprinkler and fog pumps. C++ and Node.JS were used as programming. The services and protocol used were NETPIE (Network Platform for the internet of everything) with sub-services such as NETPIE FEED, NETPIE FREEBOARD, and NETPIE REST API.[7]

This paper uses IoT to automate the process of mushroom cultivation using sensors like MQ2 for carbon dioxide, DHT11 temperature and humidity sensor and soil moisture sensor FC 28 soil moisture sensor and actuators like a sprinkler, lamp, fogger and fan.C++ is used to write program which is flashed to particleboard using Particle Dev to monitor and automate the system. MQTT with Mosquitto as broker and Raspberry pi help analyse data and trigger messages. The future works include making smaller farms and connecting to weather data from the meteorological department for better use and future predictions.[8]

This paper focuses on reviewing other research papers from 2011 to 2019 based on smart farming using IoT. It classified these techniques into three types: IoT-based agricultural monitoring and controlling system, automatic irrigation system, and plant disease monitoring system. In farm monitoring, different devices were used to monitor various environmental conditions and the observed details were accessed even from remote places. In an automatic irrigation system based on the environmental condition, the system automatically irrigates the field, which saves farmers time and effort and also saves water usage. In disease monitoring the sensors used are usually light-based as it helps to capture the movement of insects near plants whenever there is some disturbance between the light sensors or image sensor.[9]

This research paper focuses on the use of Machine Learning with Prediction Analysis(MLPA) for mushroom cultivation and disease prevention for mushrooms. In this proposed MLPA technique, a PIC microcontroller with sensors like soil moisture sensor, temperature and humidity sensor, light intensity sensor, carbon dioxide sensor is used to collect data from soil and air, which is then used to predict disease for mushrooms from previous data. Actuators like LED, sprinkler and humidifier are also used which are automatically triggered when needed. There are three types of components associated with IoT devices together with monitoring sensors and controllers, IoT service platform (Mobius will create a virtual illustration of every device according to the resource type) and IoT gateway (cube). Kalman filter (PKF) and decision tree algorithm are used for the prediction process. Based on the sensor value and prediction by ML algorithm, the farmer can predict weekly irrigation plans.[10]

This paper focuses on the Nepal based agriculture of white button mushrooms.
White Button Mushroom is known to have special requirements. It requires an optimum temperature ranging from 22 to 25 °C and humidity from 70% to 90%. This project uses the Hardware and software to automate IoT based cultivation.Blynk: Platform with IOS and Android apps to control Arduino, Raspberry Pi, and the likes over the Internet. ThingSpeak: uses the power of MATLAB to make sense of IoT dataNode MCU (micro-controller unit) is an open-source IoT platform and is a low-cost Wi-Fi module with a full TCP/IP (Transfer Control Protocol/ Internet Protocol) stack and a microcontroller. They have used ESP8266 as their MCU for this paper. Light sensor is a passive device that converts light energyArduino is an open-source platform used for building electronics projects. A temperature sensor, A humidity sensor, A soil moisture sensor[11]

This Malaysian based university has done a research paper on how watering the mushroom production of the house lowers down the temperature and increases the humidity. Keeping this in mind, the project has made changes to the existing method of mushroom cultivation and avoids over-watering.This project uses DHT11 and MQ135 to read internal production house temperature/humidity and $CO_2$ concentration respectively.NODEMCU Firmware Programmer is also used in updating the firmware of the module.[12]

To implement IoT based mushroom cultivation, the sensor system and controllers used in this paper include the Arduino Nano microcontroller as the control centre. i.)This project uses the SHT11 which is a single-chip temperature and relative humidity sensor with multi-sensor modules whose output has been digitally calibrated.ii.)The data collected by the SHT11 will be sent to ThingSpeak (thingspeak.com) which acts as a cloud using the POST method. iii.)For the control system, Peltier modules are used as a component of temperature control. This module will be activated by Arduino Nano using a relay when the temperature value is above 28 oC so that the temperature can be lowered again.[13]

This paper is presenting an implementation of Internet of Things (IoT) monitoring and environment control for indoor cultivation of oyster mushrooms and how to implement the same. Important parameters for oyster mushroom growth: Temperature 26-29 oC controlled by Fan as the equipment,Light 50-300 lux controlled by Lamp ,Humidity 80-90 % RH controlled by a humidifier ,Main equipment used in this research paper:,Controller Board: Arduino Mega ,Humidity & temperature sensor: DHT22,Light sensor: BH1750 ,Relay circuit: 10 A, 250 Vac and 5V dc, active low module ,Wifi module: ESP8266-01 ,Display: Nokia 5110 graphic LCD[14]

This article, explains the design of control and monitoring systems for many mushrooms cultivation fields (kumbung) in real-time based on Wireless Sensor Network (WSN) and the Internet of Things (IoT). The system consists of several node boards in each kumbung and master board. The main components of the node board consist of Arduino Uno is connected to XBee, DHT22 sensor, an actuator in the form of a sprayer pump, a blower and lamp. The main components of the Master board are Raspberry Pi and Xbee. Data is sent from each node to the Master using the WSN network with data packages that contain temperature and humidity data with the ID of each kumbung. The master board sends all kumbung data through a WiFi network to the Firebase real-time database that can be monitored via a smartphone. Kumbung control is performed by an actuator at each board node. The actuator keeps the temperature between 26-290C and the humidity between 70-90%RH for mushrooms in the phase of body formation. [15]

This paper has focused on collecting data with respect to the difference between the success and growth of mushrooms in conventional environments vs in a smart environment. It shows how the actuators have enhanced the growth of the cultivation. The thickness is 0.3 cm more than conventional growth and the weight is 5 gm more than usual.[16]

This paper aims towards improving watering techniques by farmers. Oyster mushroom sprinklers are automatically made based on the Internet of Things that takes into account temperature and humidity factors that can be monitored and controlled through the ABUJAT android application

using Android Studio software. This system is made using a DC PG45 motor to drive the sprinkler section which is controlled by DOIT ESP32 DevKit V1 as a microcontroller and combined with a DHT22 sensor as a temperature and humidity sensor, DS1307 RTC module, water sensor, buzzer module
for watering the alarm notification, 12VDC pump for pumping water, 16x2 LCD to display sensor values, limit switches, and BTS7960 motor drivers.[17]

This paper, using the C# programming language and the database technology, data bank technology has realized the data collection, early warning, control in the process of the growth and management of vegetables in the traceability system and, using the RFID technology, has realized the effective input of data from vegetables' packing, the processing and transportation to avoid the disturbance from an artificial operation, to safeguard the data authenticity and to form the traceable vegetables file information.
This method can be implemented in Mushroom cultivation too to get better produce by the cultivators.[18]

In this paper, the authors describe the utilization of IoT in controlling the temperature and humidity of oyster mushrooms by being integrated with the fuzzy logic controller.
The inputs of time, temperature and humidity from the sensors are further processed by Arduino Uno as a microcontroller using fuzzy logic calculation. The output of Arduino Uno produces a time delay of the spray system that is connected to the relay.
Sensors include DHT 11: serves as a Temperature and humidity sensor whose data will be processed as inputs and RTC is time input to know about time conditions.
The LCD with I2C interface is used for showing output. Relay and spray system, which is used for spraying systems that use special dynamo sprinklers Ethernet shield is an electronic module for connecting to the internet.[19]

In this paper, the IoT based mushroom cultivation system has been designed with an Arduino Mega microcontroller and an ESP12E Devkit being at the core of its components. For temperature and humidity sensing, a low-cost digital sensor DHT 22 has been used. For CO2 gas sensing, MQ – 135 has been used. These two sensors along with light-dependent resistors (LDR) have been connected to ESP12E Devkit. To control the room environment, there is a provision to connect four external devices to the microcontroller board. An air conditioner, an exhaust fan, a water pump motor and a light bulb can be used to control temperature, CO2 level, humidity and the light intensity of the nursing room respectively. The interfacing of these devices has been carried out on a separate board. The control board has been designed for controlling different external devices (AC, water pump motor, exhaust fan, light bulbs). The devices have been connected with the Devkit using a standard 220V to 5V relay circuit.[20]

This particular research paper talks about IoT based design implementation of mushroom farm monitoring. It uses Arduino microcontrollers and sensors. In this model, user can monitor temperature, humidity, carbon dioxide concentration and light intensity in a mushroom farm on an android device by using thing Speak online platform. The current status is transmitted to the monitoring station via ESP8266 as Wi-Fi modem. The codes for the controller are written in the Arduino programming language as the IDE. The project includes various technologies such as, with PLC Naxgene 1000,ARM7, ATmega and latest Arduino.It is an efficient and cost effective setup. The classification algorithm provides results with accuracy of about 77.45%.[21]

This paper focuses on environmental factors like  temperature, humidity and carbon dioxide. For this, they have used DHT11 as temperature humidity sensor and MQ135 as CO2 sensor connected to the ESP8266 Wi- Fi module. Based on data analysis, the system will automatically turn on and off the irrigation system to put the temperature at the required level for mushrooms. The control system inside the device is automatically triggered if the environmental conditions are not in optimum condition. The system requires a stable internet connection for sending the data over the internet. The system, combined with a water dripper and mist device gives a better effect to the environmental condition inside the cultivation farm.[22]

This project uses IoT for mushroom growth and monitoring. The Paper aims to minimize the amount of care that has to be provided for the mushrooms in places where environmental conditions for mushroom farming are not available. The project runs using temperature, humidity, MQ6 (Gas Sensors), MQ135 (Air quality), BMP180 (Air pressure and attitude) and water level square measure obtained by Arduino Nano by coding in Arduino IDE. In keeping with the water level, the pump can ON/OFF. Additional data analysis packets can transfer to ESP8266 as Wi-Fi electronic equipment to create it in the cloud. Using the assistance of cloud server and mobile APP, information can be stored and analysed. This automatic mushroom cultivation system can be installed in any type of farm. This project tends to reduce the time and efforts of farmers. [23]

This survey talks about mushroom monitoring systems using IoT. The control unit is set up with some basic parameters such as temperature, humidity and gas content that is required for the cultivation. When the values vary from their threshold values the control unit triggers the actuators. The values are obtained from the farm using sensors that are placed conveniently in the farm. An app is designed to check the status of the farm which can be connected with the control unit through a server. The app will be used by the cultivator to check the status of the farm. Once the actuators are triggered the farmer will be notified with the help of SMS. RFID and WSNs are used in this project. The hardware includes 220V to 12V DC adapter connected to an IC LM7805 which is a 12V to 5V regulator. The particle board and the sensor MQ2 is powered with the 5V. The other sensors are powered by the 3v pin. [24]

This project aims to develop an IoT based smart system for white button mushroom farming. This work aims to develop a monitoring and controlling system for the environmental conditions such as temperature, humidity, moisture and lighting conditions of the white button mushroom farm. Sensors are placed on a fixed location and spots of the farm. The sensors provide the status of the parameters which are then transmitted to the remote monitoring station via Node MCU. The conditions of the mushroom farm are then monitored through Node-RED, ThingSpeak, Blynk. The codes for the controller are written in the Arduino programming language. Along with this Node-RED is used for wiring the hardware devices. The project uses a 10HS Decagon moisture sensor to measure volumetric moisture content of soils. The value is given by the DHT-22 sensor for temperature and humidity. The value of the light intensities is then measured using LDR.[25]

## 3.2 Survey Table

*Table 1 Comparison of the IoT platforms*

| IoT Platforms | Type | Open Source | Build Mobile Application directly | Data Collection | Cloud based | Supported messaging protocols |
|---|---|---|---|---|---|---|
| Blynk [1][11][25] | Full - integrated IoT platform | Yes | Yes | Yes | SaaS | HTTP |
| ThingSpeak [2][5][11][13][25] | IoT analalytics platform | Yes | No | Yes | SaaS | HTTP,MQTT |
| Arduino [11][21][22][23][25] | IDE and Iot Cloud service | Yes | No | Yes | Paas | UART,SPI,I2C,MQTT,CoAP |

| | | | | | | |
|---|---|---|---|---|---|---|
| NETPIE[7] | Iot Cloud Platform | Yes | Yes | Yes | PaaS | HTTP,CoAP,MQTT, WebSocket,WIFI |
| Particle[8][24] | Fully-integrated IoT platform | Yes | Yes | Yes | SaaS | HTTP,CoAP,MQTT ,WebSocket |
| Mobius[10] | Iot server platform | Yes | Yes | Yes | oneM2M | HTTP,CoAP,MQTT, WebSocket |

*Table 2 Comparison of the Microcontollers*

| CATEGORY FOR COMPARISON | RASPBERRY PI<br>(1 &2)<br>[5][6][8][11][15][30] | ARDUINO NANO<br>[13][23] | NODE MCU<br>(ESP8266)<br>[4][7][10][22] |
|---|---|---|---|
| PHYSICAL SIZE | 65mm x 30mm | 43.18 mm x 18.54 mm | 49 mm x 24.5 mm |
| Max Current Per I/O Pin | 50 mA | 40mA | 12 mA |

| | | | |
|---|---|---|---|
| Pinout | 40 pins ( 28 of which are GPIO, 12 for power) | 22 pins (14 digital with 6 PWM and 8 Analog) | 16 pins (11 usable digital, 1 Analog) |
| WiFi embedded? | Yes | No | Yes |
| Clock Speed | 1.2 GHz | 16-20MHz | 24–52MHZ |
| Operating Voltage | 5V | 5V | 3.3V |
| SRAM | Uses DRAM | 2KB | 50KB |
| STORAGE | Micro SDHC Slot | 1KB | 4 MB |
| POWER | USB,Power Supply | USB,Battery,Power Supply | USB |
| OS | LINUX | None | XTOS |
| CPU | ARM Cortex | Atmel, ARM, Intel | LXT106 |
| COST COMPARISON | EXPENSIVE<br>($35) | AVERAGE<br>($3-$30) | CHEAP<br>($3) |
| APPLICATION | TALKING TO WEB | REAL TIME APPLICATION | REAL TIME APPLICATION |

*Table 3 Comparison of Mushroom types*

| CATEGORY FOR COMPARISON | WHITE BUTTON MUSHROOM [5][11][25] | OYSTER MUSHROOM<br><br>[4][14][17][19] |
|---|---|---|
| TEMPERATURE(in degree Celsius) | 20-28$^0$ C for vegetative growth | 20 to 30$^0$ C |
| COST COMPARISON | CHEAPER | EXPENSIVEWI-FI |
| HUMIDITY REQUIREMENT | 80-90% | 55-70% |
| GROWTH RATE | 3-4 Crops per year | 5-6 Crops per year |
| Protein Content | Lower | Higher |
| LIGHT INTENSITY REQUIREMENT | 50-300 lux | 50-300 lux |

*Table 4 Comparison on Wireless Technologies*

| CATEGORY FOR COMPARISON | WI-FI<br><br>[1][2][4][5][7][11][17][20][21][22][23][26][27][29] | ZIGBEE<br><br>[22] | BLUETOOTH[27] |
|---|---|---|---|
| FREQUENCY | 2.4 GHz - 5 GHz | 2.4GHz | 2.4GHz |
| DATA RATE | 54 Mbps | 250 Kbps | 3Mbps |

| | | | |
|---|---|---|---|
| RANGE | 150 feet | 32-65 feet | 300 feet |
| POWER | HIGH | LOW | LOW |
| COST | LOW | LOW | LOW |
| FULLY BI-DIRECTIONAL | NO | YES | YES |

### 3.3 Problem Definition:

We need to make an IoT based system that helps in environment monitoring for the mushrooms and use actuators to automate the process. The system should also be capable to be used for two types of mushrooms: oyster mushrooms and white button mushrooms.

## 4. Proposed Model

Our project aim is to control and monitor the mushroom cultivation for oyster mushrooms.
We will monitor the following:

- Light intensity
- Temperature
- Humidity

We will also control the following functions:

- ❖ Auto control environment temperature and humidity
- ❖ Sound alert on high light intensity and on mode change
- ❖ Mushroom selection types oyster mushrooms, white button mushrooms

## 4.1 Flow Diagram

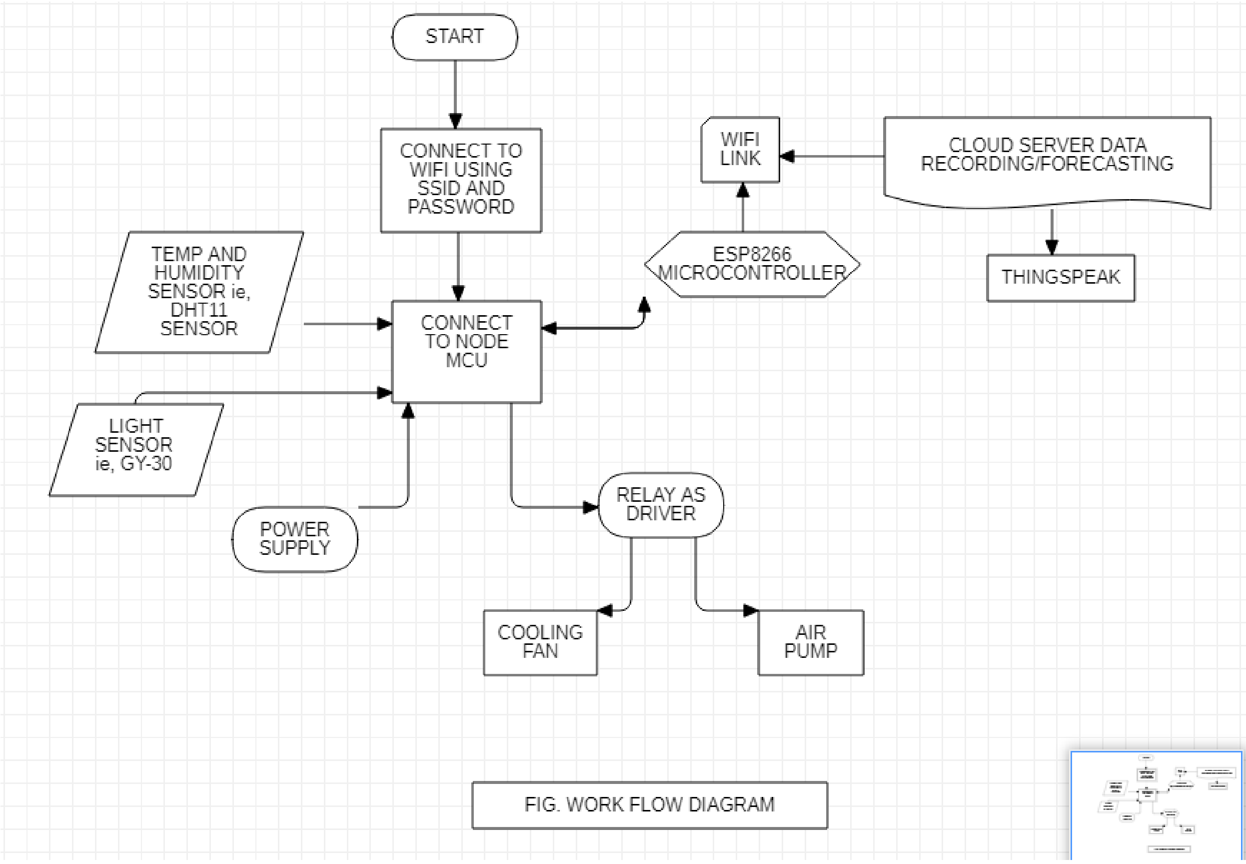
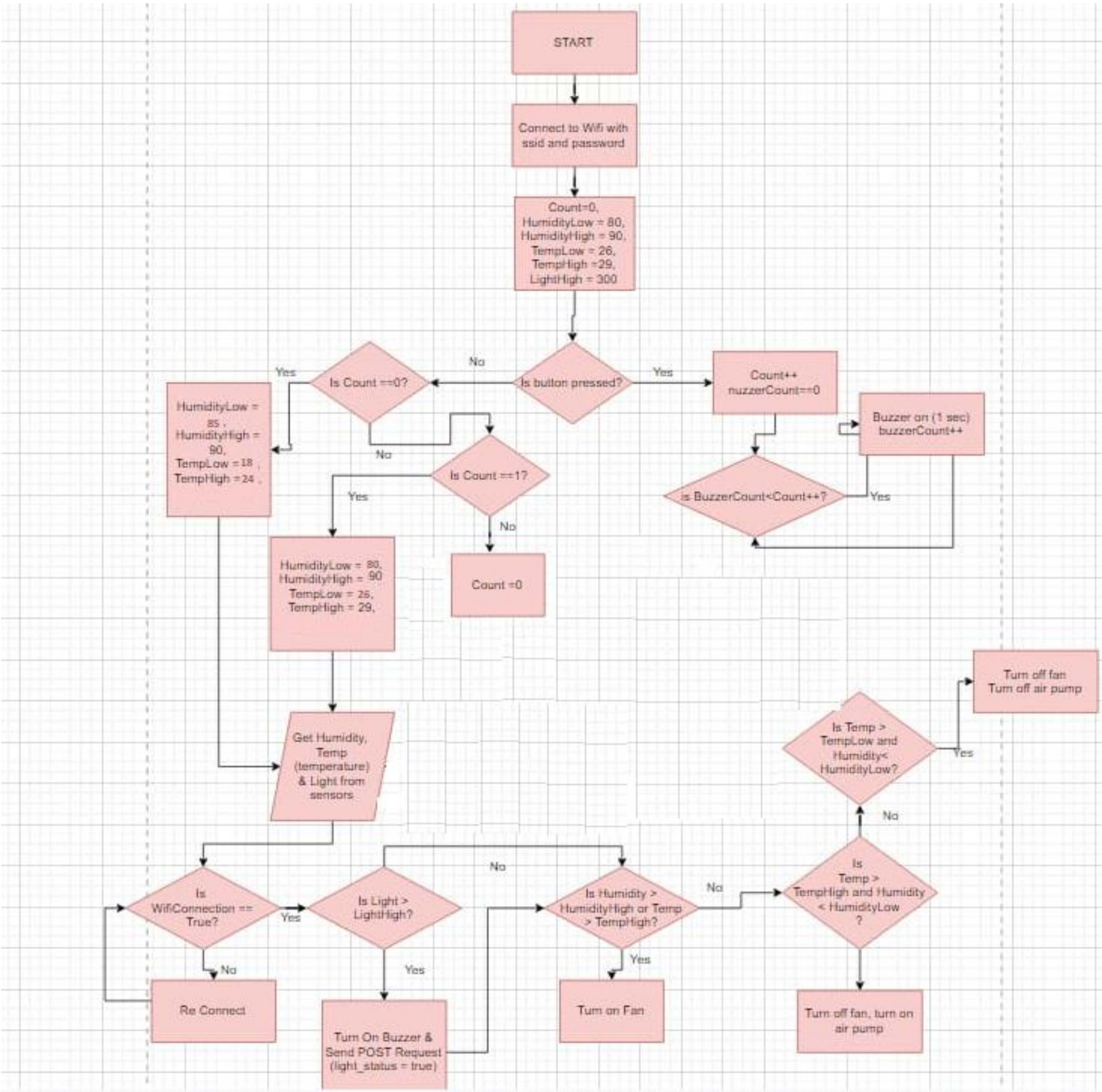



Fig 1: The **workflow diagram** for the proposed model

## 4.2 Proposed Algorithm



## 4.3 Circuit Diagram

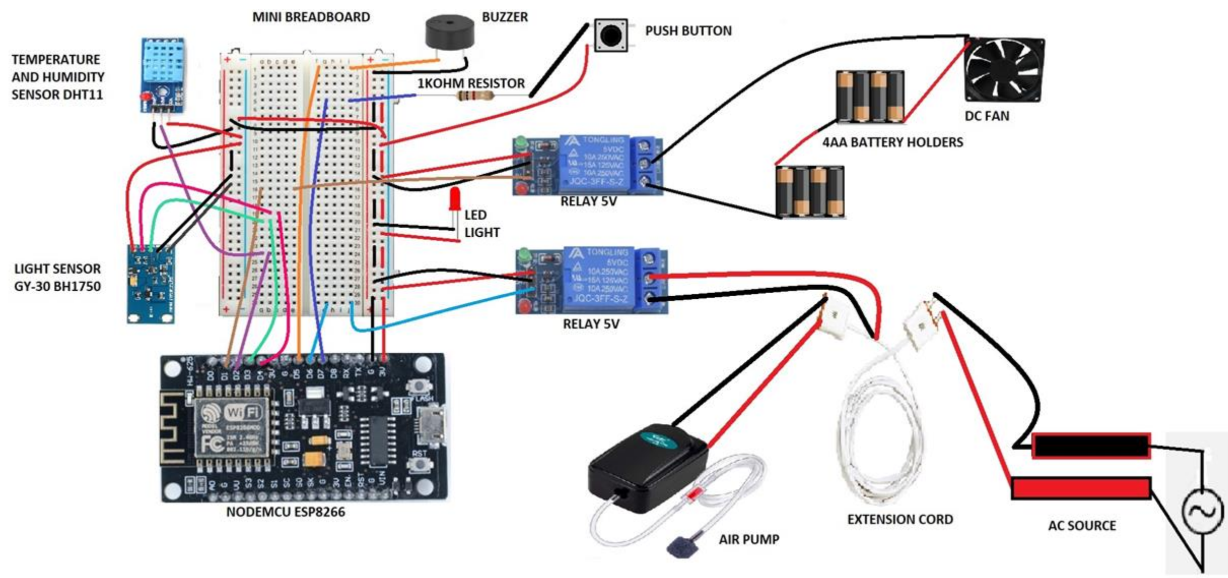



**Fig 2:**Pin diagram for IoT based mushroom cultivation

The hardware to be used:

- NodeMCU ESP 8266 WiFi Module
- Light Sensor GY-30 BH1750
- Humidity and Temperature sensor DHT11
- Breadboard Mini
- Fan
- Extension cord
- Air Pump
- Buzzer
- Relay(5V DC)
- Jumper cables
- Button
- Led Light
- Battery Holder
- Resistor 1Kohm
- Plastic Box

The software to be used is *Arduino Programming language* for configuring and connecting sensors to the application and using *ThingSpeak* to collect data, monitor the environment and control the actuators.

# 5. Implementation:

## 5.1 Process For Mushroom Cultivation:

The material received for setup for cultivation bag included 2 PP bags, a bag full with Straw, some rubber bands and the spawn of Oyster Mushroom. Initial process was to sterilize the straw for which hand picking was done to remove insects and then boiling of the handpicked straw for at least 10-15 minutes so that all the remaining pest and bacteria are removed and the cellulose is broken down which helps the mushroom to feed on it easily. Then the straw was squeezed out of moisture and dried until it just wet enough to touch. The bags where then tightly packed with this straw and spawn layer by layer and then closed with a rubber band. Around 8 holes are made and stuffed with cotton and kept in a dark humid area for 15 days without any water. After 15 days when the bag has turned all white remove the cotton and make more holes and water daily twice with a little water. It takes around 10 -15 days for the mushroom bulb to come out from the holes.

## 5.2 Process For Hardware and Software Setup:

The hardware required for the environment monitoring of the mushroom cultivation system is : NodeMCU ESP8266 WiFi Module that helps to control the entire system, mini breadboard to connect all the sensors and relay to the microcontroller ,Humidity and Temperature sensor DHT11 to monitor humidity and temperature of the system, Light Sensor GY-30 BH1750 to measure the light intensity of the system, 2 relay module to automize the actuators i.e. air pump to increase humidity and decrease temperature and DC fan to decrease temperature and humidity when required, led light to indicate that system is working or not, a 4 pin push button to help change modes of mushroom being used like oyster and white button mushroom, battery holder for help connect DC fan to battery power, 1 k ohm Resistor for the push button and jumper cable (male to male and male to female types). All this were connected in a circuit to help monitor the temperature, humidity and the light intensity of the system and switch on the air pump and fan when required. The software used id Arduino IDE for uploading the sketch to the NodeMCU, Thing Speak to visualize the data collected from the sensors .

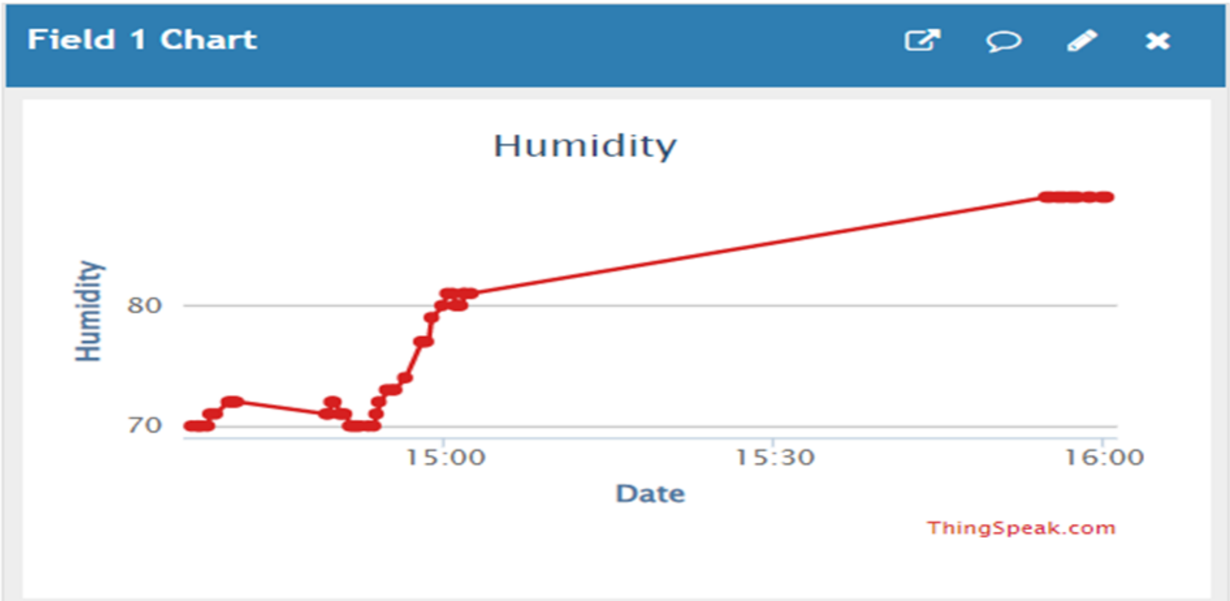



**Fig3:ThingSpeak channel graph for humidity where x axis is the date and y axis is the humidity in percentage.**

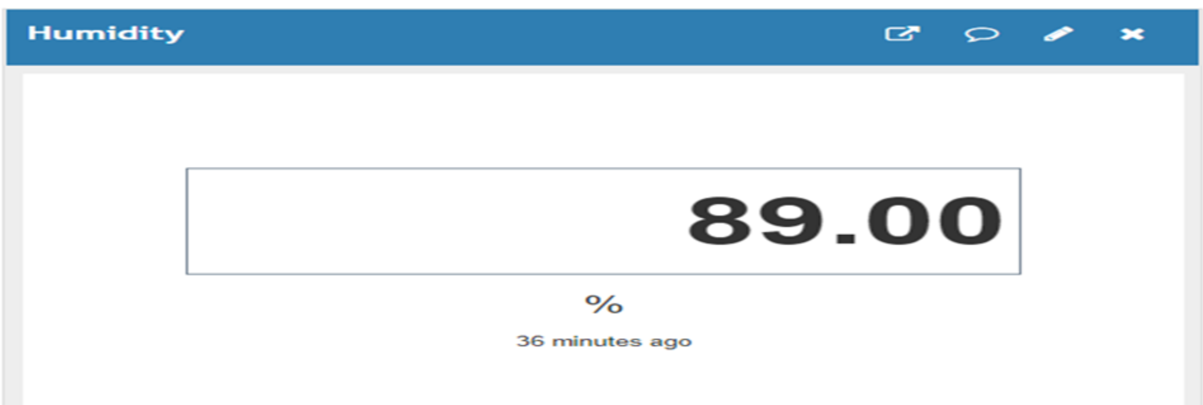



**Fig4: ThingSpeak channel label indicating humidity in percentage numerically.**

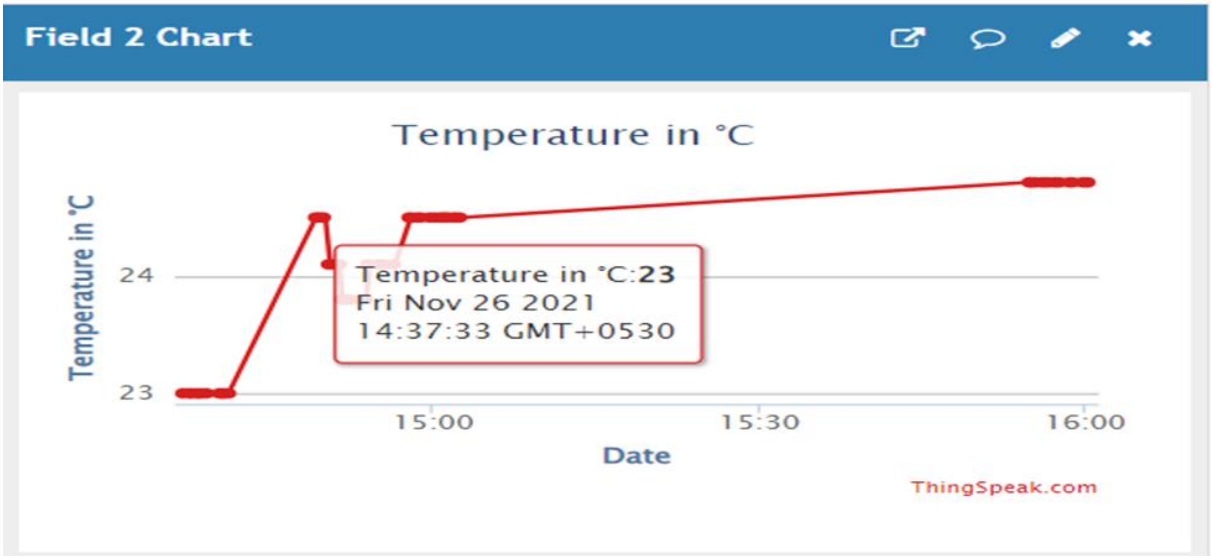



**Fig5:ThingSpeak channel graph for temperature in celsius where x axis is the date and y axis is the temperature in ⁰C.**

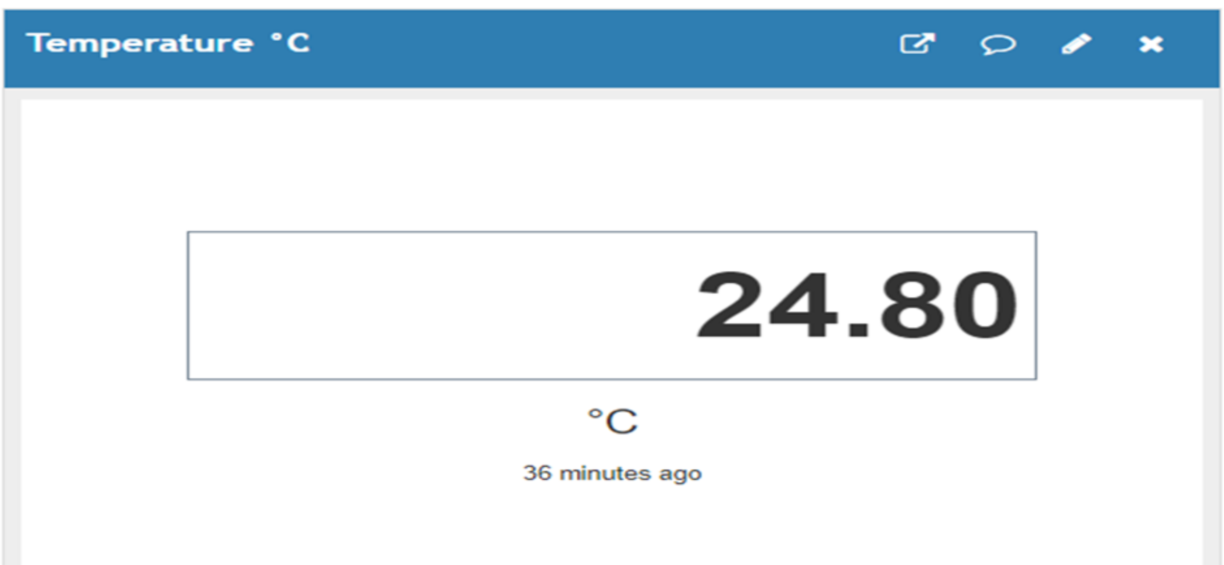



**Fig6: ThingSpeak channel label indicating temperature in ⁰C numerically.**

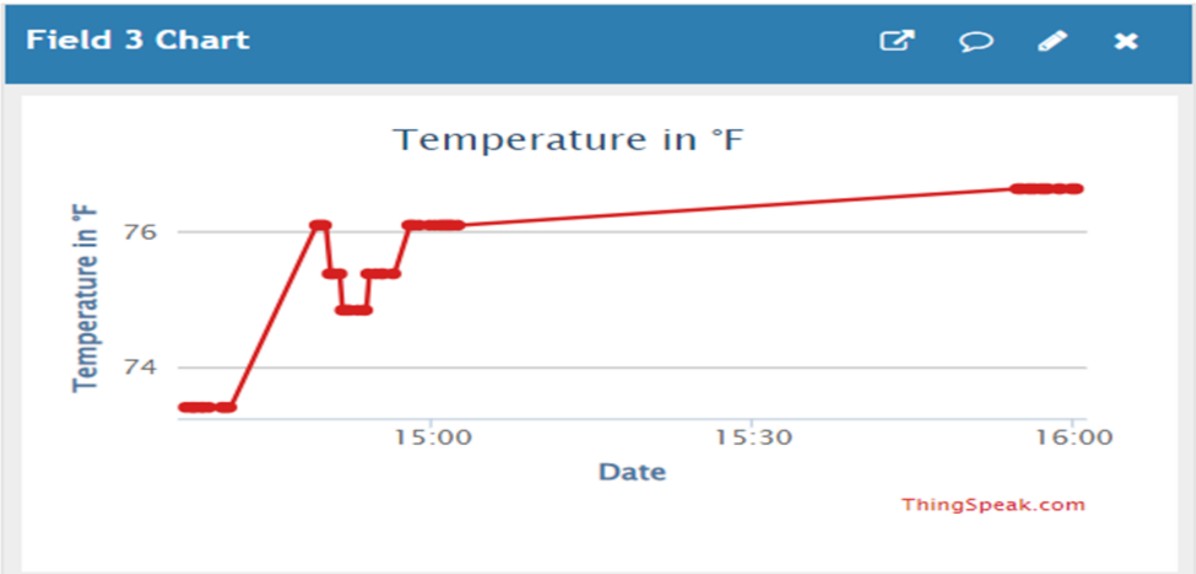



**Fig7:ThingSpeak channel graph for temperature in Fahrenheit where x axis is the date and y axis is the temperature in ºF.**

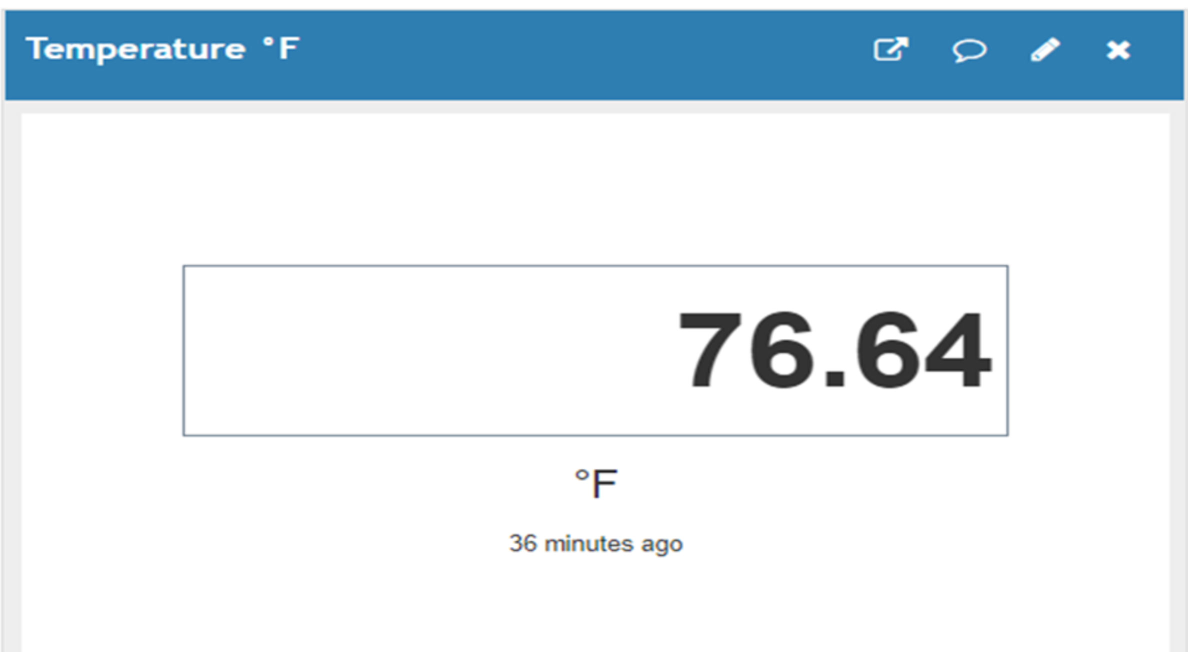



**Fig8: ThingSpeak channel label indicating temperature in ºF numerically.**

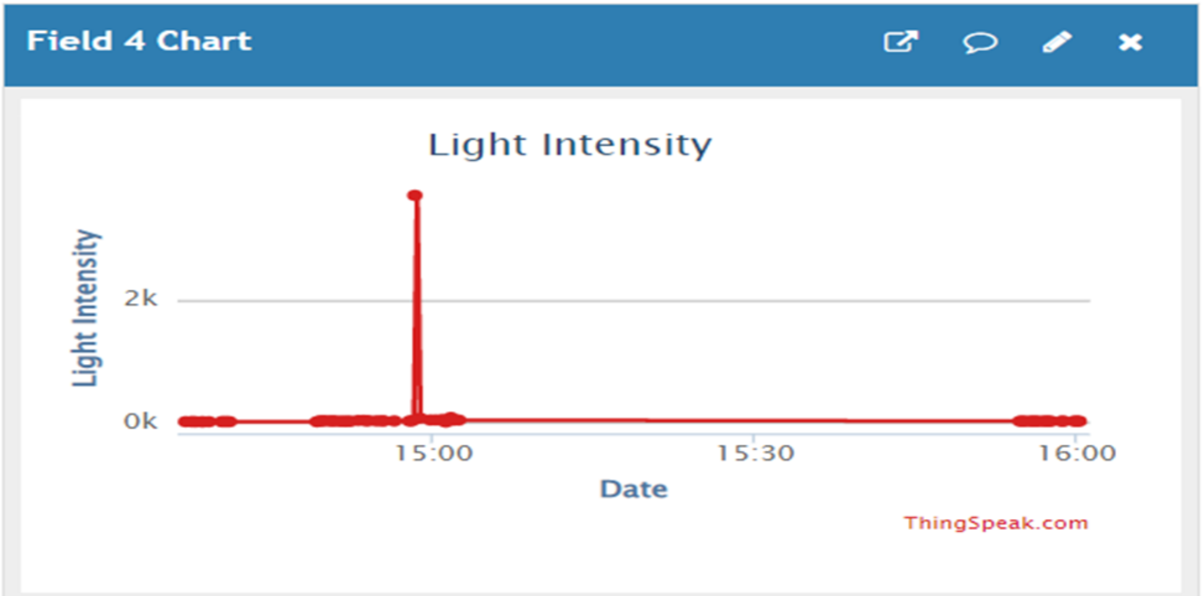



**Fig9:ThingSpeak channel graph for light intensity where x axis is the date and y axis is thelight intensity in lux.**


**Fig10 : ThingSpeak channel label indicating intensity in lux numerically.**

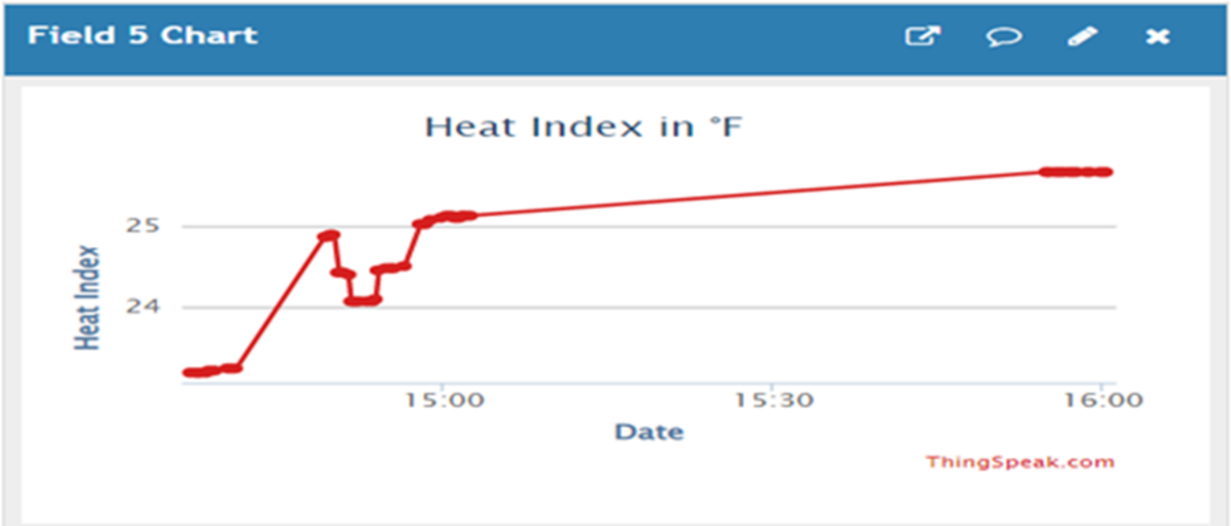



**Fig11 :ThingSpeak channel graph for heat index in ºF where x axis is the date and y axis is the heat index in ºF.**

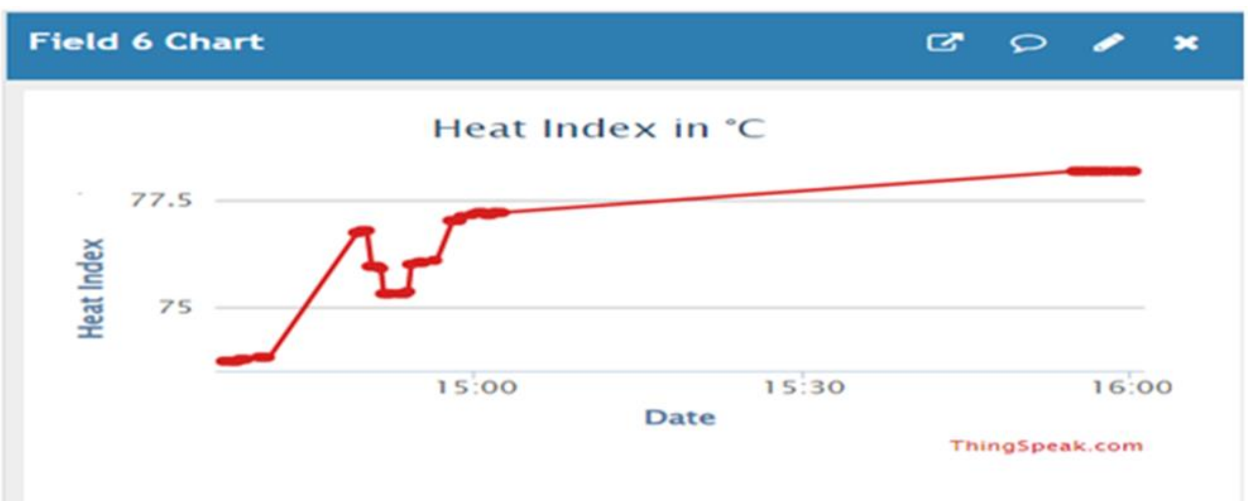



**Fig12:ThingSpeak channel graph for heat index in ºC where x axis is the date and y axis is the heat index in ºC.**

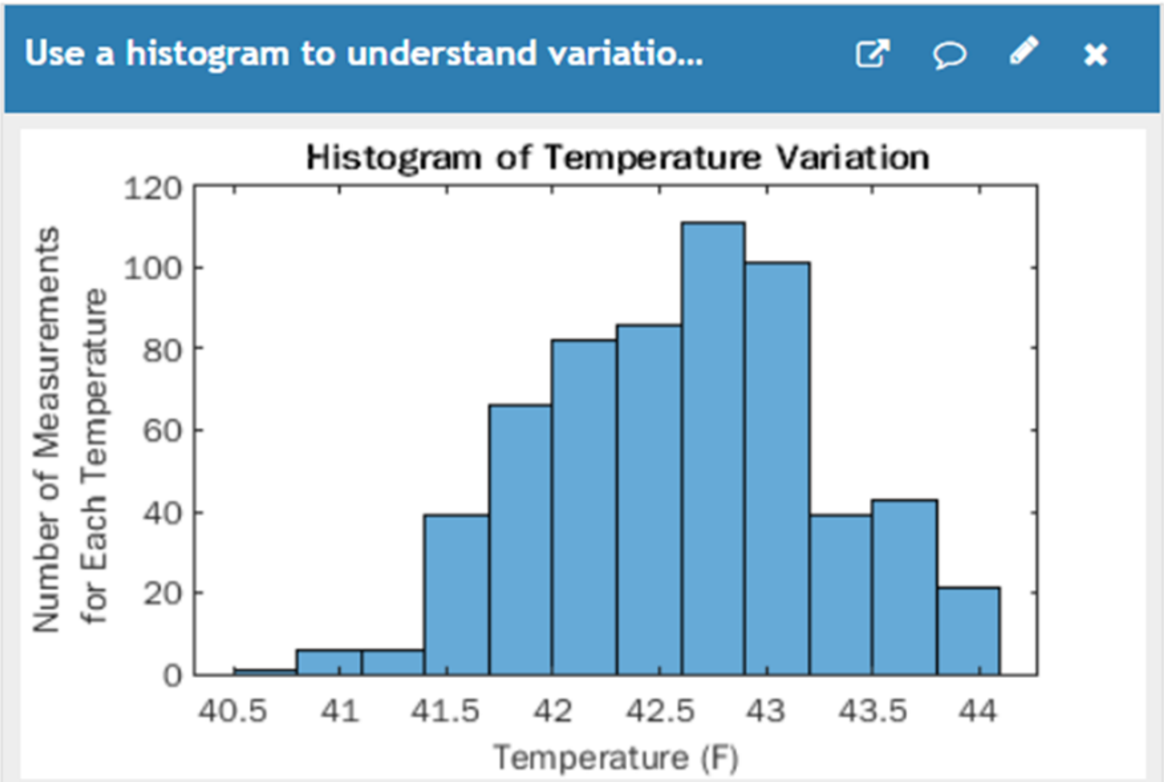



**Fig 13: Histogram of temperature variation where x axis is the temperature in ºF and y axis is the number of measurements for each temperature.**

**Explanation for Fig 3 to Fig 13:** This is the visualization of the sensor data collected using ThingSpeak . The graph show the variation of humidity in percentage, temperature in °C and °F ,light intensity in lux and heat indexes in °F and °C . The channel also has widgets that show the numerical values of these fields and a histogram showing temperature variation .It can be seen that the channel gets successfully updated after few seconds and displays this change both numerically and graphically . The high peak in Fig9 for light intensity indicates the that the light is too high which results in a long beep from buzzer and the fan turns off while the air pump starts to work as the light effects humidity inside.

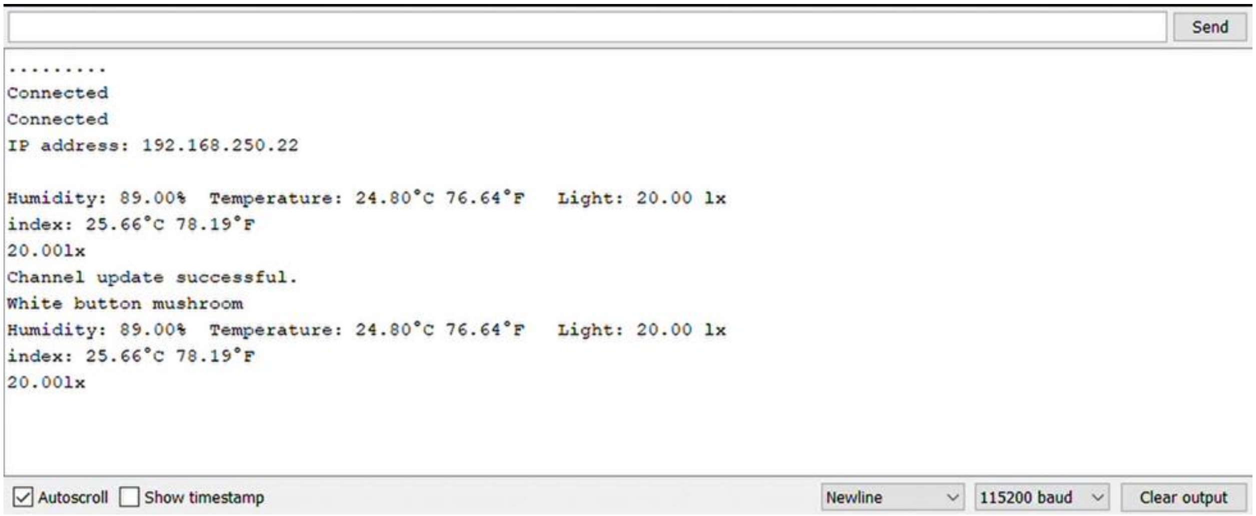



**Fig 14: Mode Switching using push button**

**Explanation for Fig14:** On clicking the push button the mode changes to White Button Mushroom from Oyster Mushroom and the buzzer beeps twice for white button mushroom mode again on clicking the push button mode changes back to oyster mushrooms and the buzzer beeps once indicating it.

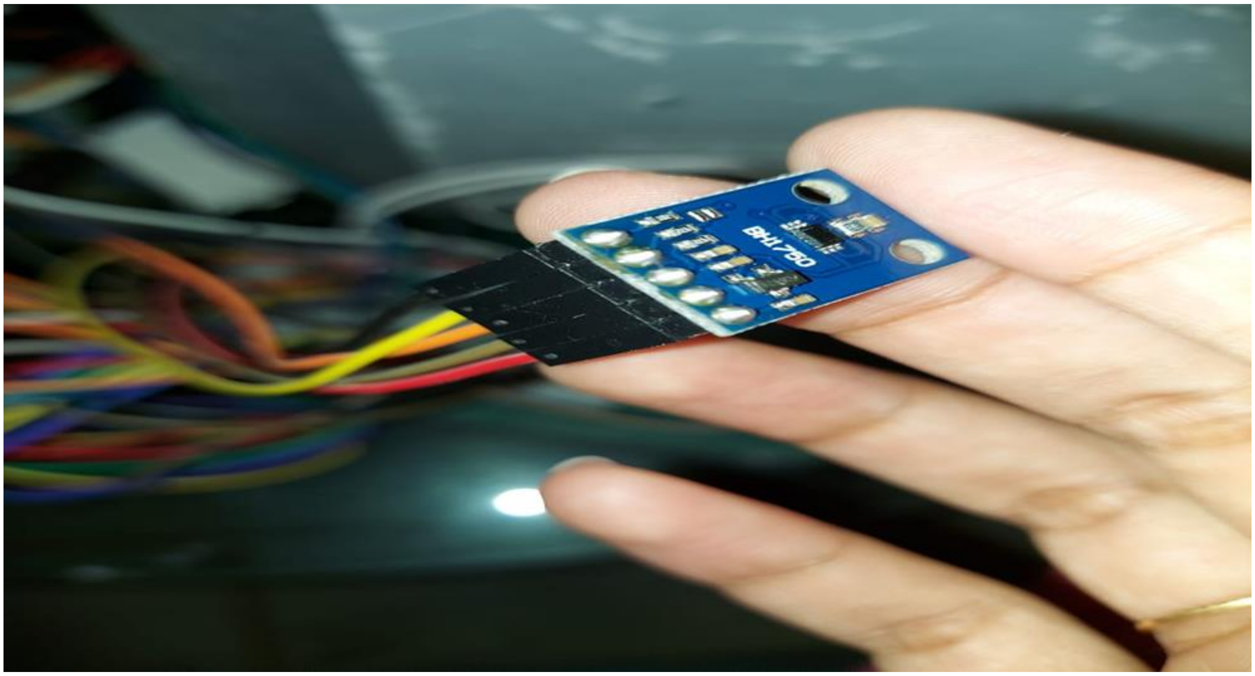



**Fig15:Light sensor BH1750**

**Fig16: DHT11 temperature and humidity sensor**

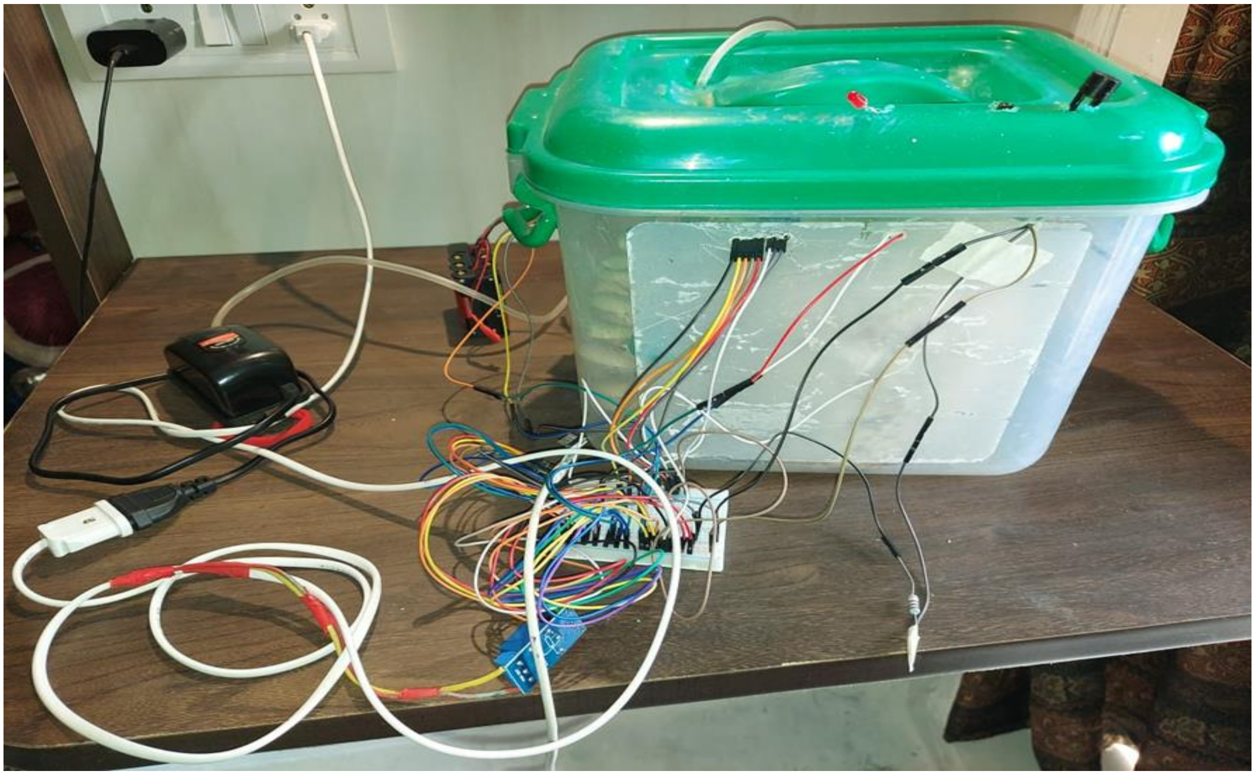


**Fig 17: The front side and hardware of the box setup**

**Fig18: The back side of the box setup**

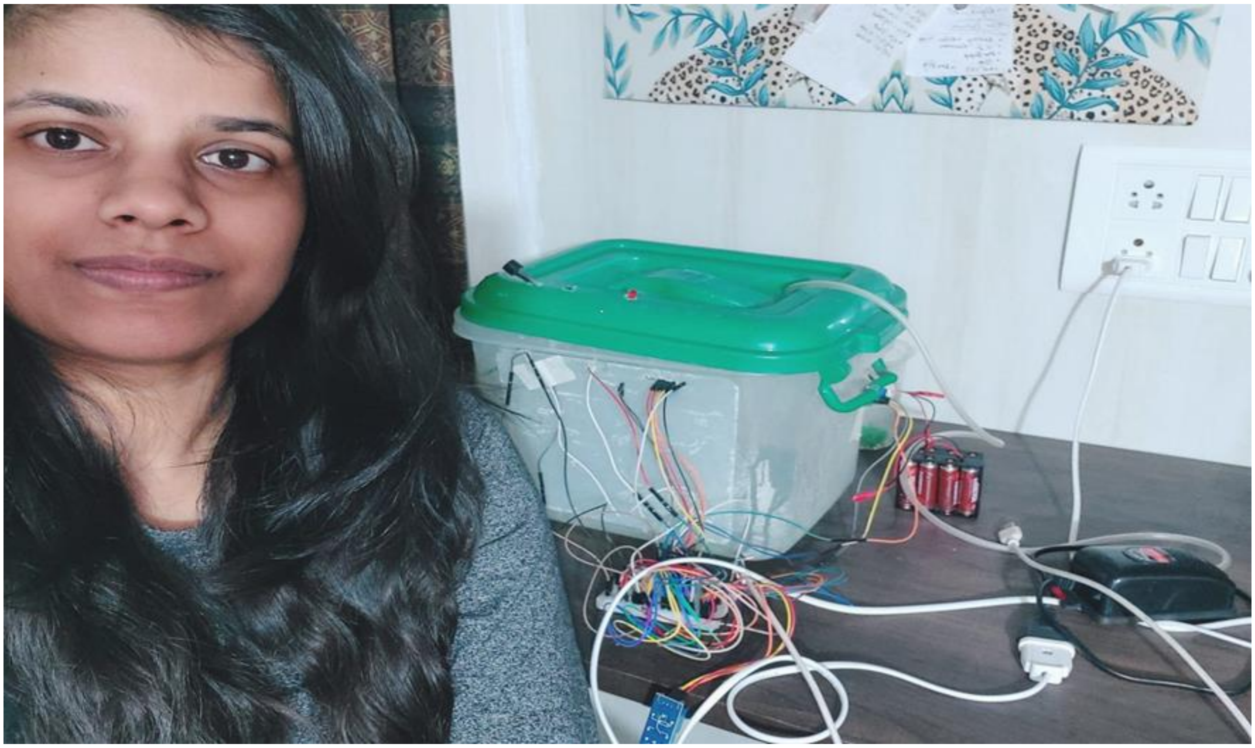


**Fig19: The front side and hardware of the box setup**

**Fig20: The front side and hardware of the box setup**

**Fig:21: The back side of the box setup**

**Explanation for Fig 17 to Fig 21 :**All the hardware components are connected and Oyster mushrooms are present in the box. As we are doing this cultivation in a small scale thus we chose to use a box to hold the mushrooms and this also helps maintain the favorable environment for them. All the harware parts except the DC fan are present in the front side while the DC Fan is at the back side as it acts as an exhaust to cool the environment and the front side has the sensors.

## 6. Result

**Fig 22: Inside view of the system with ready to harvest oyster mushrooms**

**Fig 23:Mushrooms in the IoT system near to harvest and grow healthy**

**Fig 24: Mushrooms grown outside the IoT System still in pinning stage**

**Fig 25: Mushrooms in IoT system taken out to harvest**

**Fig 26: Harvested Oyster mushroom from the IoT system.**


**Fig 26: Weighing the harvested mushrooms collected after 2$^{nd}$ cycle weighs around 0.5kg**

**Explanation for Fig 22 to Fig 26:** Mushrooms inside the IoT system grew faster and yield is also high while those outside are growing slow but were cultivated on the same day and time as the ones in IoT system. Also, after first harvesting more mushroom pinheads came out from the

IoT system mushrooms as compared the time before first cultivation. There were only two clusters. The weight of the second cultivation is around 0.5 kg.

## 7. Conclusion and Future Work

Mushroom cultivation is a tedious work specially the beginning process .Even maintaining perfect environment to get the most from your cultivation is important for which we have made a system that helps automate this part of the cultivation process. The system monitors the temperature, humidity and light intensity so we can get the best quality mushrooms that have big tops and medium thick stalk. On comparing the two mushroom bags it is clearly evident that the bag in IoT system is definitely giving higher yield while the one outside is not. The proposed model is efficient only for a small-scale mushroom cultivation done indoors and on Oyster mushrooms only till now. For a large-scale production, we need to add more sensors like CO2 sensor MG811 and soil moisture sensor. In a small-scale system, the CO2 level is almost at equilibrium with the outside surrounding thus no need to measure it but it is not true for a large-scale system. Even the moisture levels remain at equilibrium with the surrounding thus no need for soil moisture measurement in a small-scale system. Even a cultivation setup for white button mushroom is also not done currently but is included in future work. We also plan to optimize the software and hardware implementation of the system so that the system has high accuracy that results in high yields of mushroom and even connect it to Blynk application to control the fan and air pump when required.

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