Evolution in Electrical and Electronic Engineering Vol. 3 No. 1 (2022) 199-207
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Homepage: http://publisher.uthm.edu.my/periodicals/index.php/eeee
e-ISSN : 2756-8458

Monitoring System for Mushroom Cultivation in Indoor Farming using ESP32 Arduino

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DOI: https://doi.org/10.30880/eeee.2022.03.01.023
Received 20 January 2022; Accepted 29 March 2022; Available online 30 June 2022

Abstract: This Monitoring System is to observe mushroom cultivation in indoor farming using ESP32 Arduino. Also can monitor mushroom cultivation on the shed that apply in the hardware been developed with MQ-135, DHT11 and soil moisture sensor to notify the gases and temperature on the environment indoor, also the condition of the soil for the mushroom. The LED and buzzer are applied to the shed as indicators to the user can compare the gases, temperature and soil moisture conditions for mushroom cultivation. Hence, the hardware was installed with DC Fan and pump water to control the condition of the hardware if the above the range that has been set on the ESP32 using Arduino IDE. The user can notify the user using Blynk application that has been linked to ESP32 Arduino. It can ease the farmer to monitor mushroom cultivation indoors. Reading also been taken by 2 parameters for 70 days for the hardware and analyze with 2 mushroom bags within 2 conditions indoor and indoor with a monitoring system for 5 days. Mushrooms grow quicker indoors with a monitoring system than indoors without a monitoring system. This is due to the fact that the mushrooms are exposed more to the environment and controlled by parameters been developed.

Keywords: Monitoring System, Mushroom Cultivation, Indoor Farming,

1. Introduction

Mushroom production employing agricultural waste as a growth medium, followed by the utilisation of wasted substrate, has a high value for horticultural activity, organic fertiliser, and animal feed potential. One of the advantages of mushroom production is that it has the ability to contribute to a more sustainable and ecologically friendly agricultural method [1]. Due to inconsistencies in climatic

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circumstances, mushroom farmers in the tropical and subtropical regions are encountering increased hurdles and problems in growing mushrooms in response to rising demand [2].

Malaysia is having significant weather which is having both hot weather and rainfall every year. Crop yields are poor due to inefficient procedures and unpredictable weather, situations vary depending on factors such as location and resources [3]. Also, the gases like carbon monoxide that are released in the environment from industries, open burning and burning fuel affect agriculture. A massive drop in plant primary metabolism (photosynthesis) related to stomatal closure resulted in a drop in protein, carbohydrate, and sucrose content due to the generation of reactive oxygen species (ROS) during extended gas stress exposure [4].

The environment is an important factor to consider while growing mushrooms. Mushrooms will not grow if the temperature is higher than 33°C or lower than 25°C. This allows individuals to keep an eye on the state of the environment from anywhere they have internet connection. Based on the data analysis, the technology will automatically turn on and off the watering system to maintain an appropriate temperature [5]. The purpose of the project is to investigate mushroom cultivation in a controlled indoor and compare the results to without the monitoring system cultivation. The cultivation of the mushroom needs intensive care by the farmer. Also, the gases like carbon monoxide that are released in the environment from industries, open burning and burning fuel also affect agriculture.

2. Methodology

2.1 System Design

This project use Node MCU as a controller which is it contains the WIFI module (ESP32). A soil moisture sensor has been equipped to let the user detect the condition of the soil is it dry or moist. The second sensor that has been equipped is Temperature & Humidity Sensor (DHT11) to detect temperature on the farm above the range, the Oscillating fans ON around the mushroom to cool down the temperature. The project contains some main hardware component which is Node MCU, soil moisture sensor, Temperature & Humidity Sensor (DHT11), Air Quality Detector Sensor (MQ-135), pump water, oscillating fan, and smartphone. Figure 1 shows the system design for this project. The hardware design can be separated into two parts which are the detection part and the monitoring part.

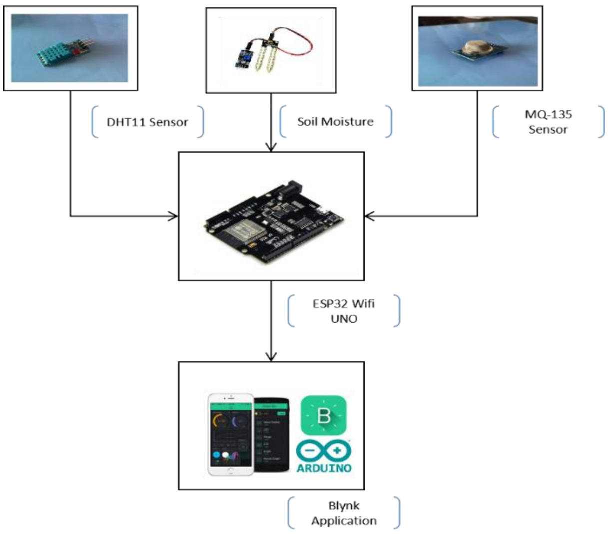


Figure 1 : System Design Diagram

The coding develops using the Arduino IDE for the project. The coding below Blynk Application linked to the microcontroller that is Node MCU ESP32 to get notified to user. The each of the project on the Blynk Application has own token that sent by email. The ESP32 will connected to WIFI server that used for the project.

For MQ-135, the coding will set if the range above 600 ppm the red LED will ON and the DC fan also ON to suck the gases around the hardware that been develop on the close chamber (shed). The green LED will ON if the gases(CO) below 600 ppm.

DHT11 is to sense the temperature around the hardware. If the temperature is above 33 ^{o}C the red LED will ON and the DC fan also ON to cool down the temperature around the hardware. The green LED will ON if the temperature below 33 ^{o}C.

Soil moisture is to detect the condition for the soil mushroom cultivation. The soil moisture detect the soil is dry, the water pump will ON to water the soil on the mushroom cultivation and the red LED will ON. All the description given as given on the Figure 2 for operation of the system.

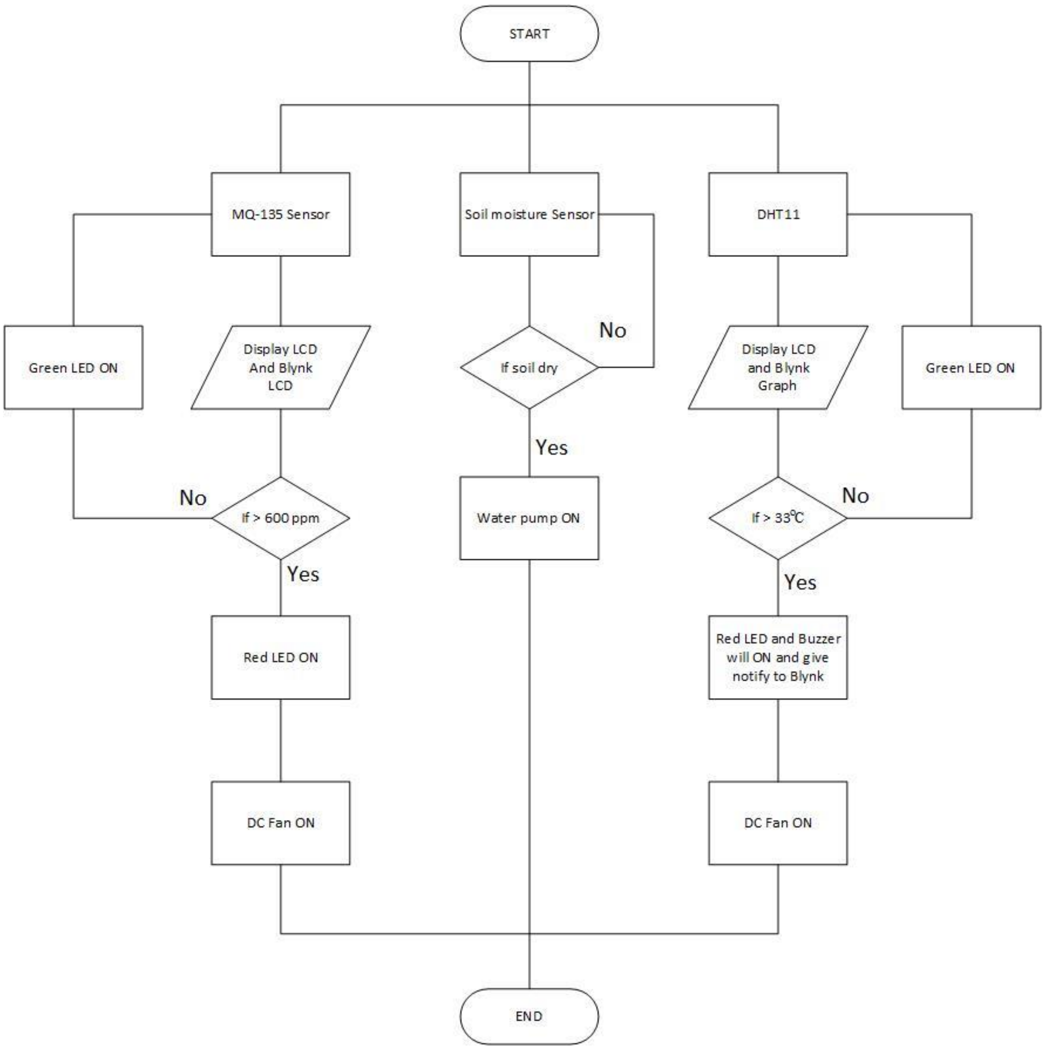


Figure 2 : Flowchart of the system

2.2 Circuit Design and Connection

The project is to investigate mushroom cultivation in indoor farming in weather, air, and soil conditions. The system use Node MCU ESP32, MQ-135 sensor, DHT11 sensor, and soil moisture sensor. Figure 3 shows the design for the hardware using fritzing before developing hardware. DC Fan and water pump is response from the sensor to monitor the mushroom cultivation.

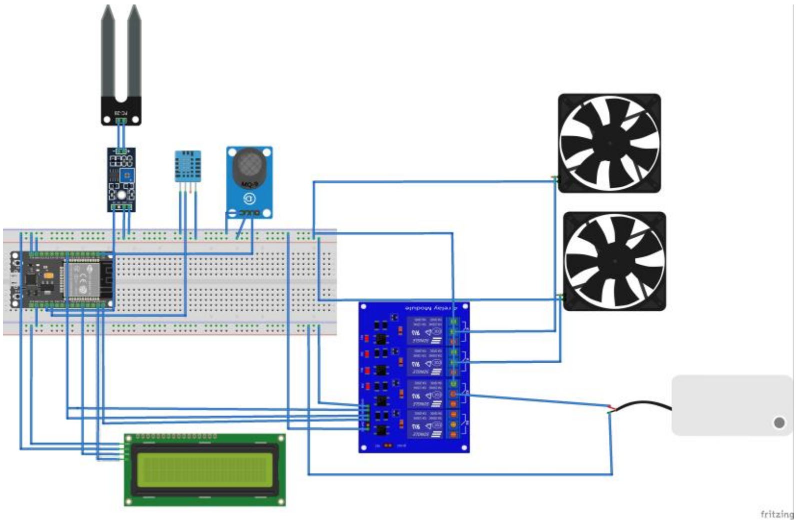


Figure 3 : Design of Fritzing

3. Results and Discussion

3.1 Hardware Design for the System

Figure 4 shows the hardware setup for the project. The project can investigate and monitor mushroom cultivation in indoor environment. Figure 5 shows the hardware were apply on the mushroom to investigate and monitor the mushroom cultivation. If temperature is higher than 33 °C, the DC fan will be ON to cool the environment on the hardware. The MQ-135 is to detect gases (CO, CO2 or NH4) on surrounding and DC fan will ON to suck the gases surrounding on the hardware, if the gases is higher than 600 ppm. The soil moisture sensor is to detect the condition of the soil whether dry or wet, if the soil is dry the pump will ON to wet the soil.

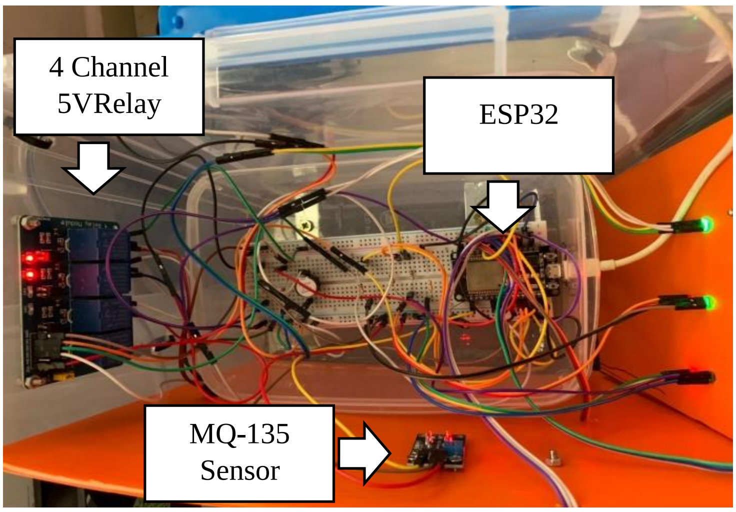


Figure 4 : Hardware Setup

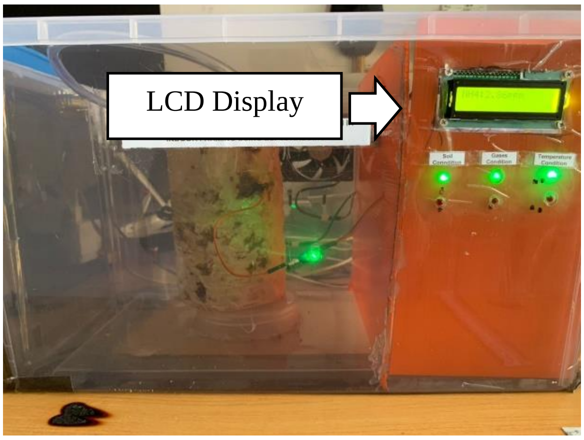


Figure 5 : Prototype of Monitoring System For Mushroom Cultivation

Arduino IDE is used to program the hardware on the Node MCU ESP32 in order to control the variable sensor and the output. The software and hardware that has been developed using the Blynk application are used to notify the output for the user. Figure 6 and Figure 7 show the LCD and interface for the system to notify the user using Blynk. The interface of the system shows the measurement of the temperature, humidity, and gases (CO, CO2 & NH4) from the sensor that has been applied on the hardware.

Figure 6 : LCD Display

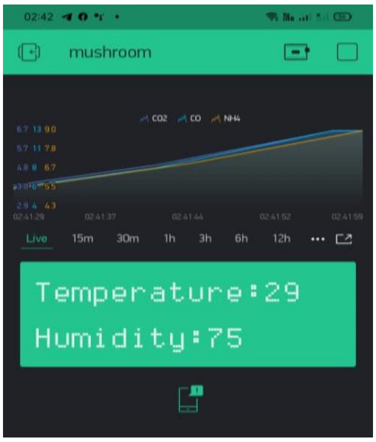


Figure 7 : Display Output on Blynk

3.2 Results

The measurement will be taken for 70 days using the MQ-135 and DHT11sensors. The first cycle is from 1 July 2021 to 8 September 2021 and the second cycle is 1 October 2021 until 9 December 2021. It shows the reading for CO, CO_2, and NH_4 using MQ-135 and for the DHT11; the temperature, humidity, and heat index on the environment. The reading are shown in Table 1.

Table 1 : 2 cycle period for 70 day

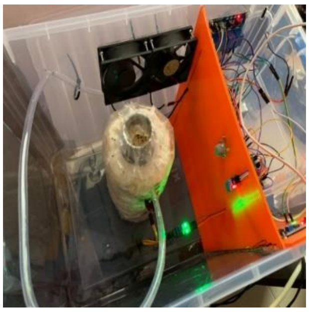
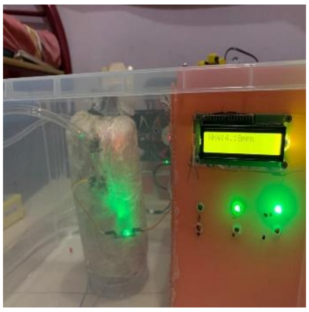
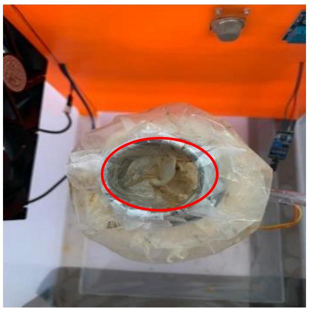
Serial No.	Time	Sensor	Parameter	Result	
				First Cycle of 70 day (01/07/2021 to 08/09/2021)	Second Cycle of 70 day (01/10/2021 to 09/12/2021)
1	Morning (0500am to 10am)	MQ-135	CO	(3.39 ± 4.87) ppm	(4.01 ± 4.57) ppm
			CO_2	(2.55 ± 3.54) ppm	(2.88 ± 3.21) ppm
			NH_4	(3.93 ± 4.57) ppm	(4.35 ± 4.58) ppm
		DHT11	Temperature	(29.7 ± 30) °C	(29° ± 30) °C
			Humidity	(73 ± 75) %	(75 ± 76) %
			Heat Index	(35.1 ± 35.6) °C	(33.69 ± 35.2) °C
2	Afternoon (1200pm to 0200pm)	MQ-135	CO	(3.91 ± 7.87) ppm	(2.61 ± 8.87) ppm
			CO_2	(2.83 ± 4.77) ppm	(2.67 ± 6.87) ppm
			NH_4	(4.31 ± 6.87) ppm	(4.09 ± 9.87) ppm
		DHT11	Temperature	(32.1± 32.6) °C	(32.9 ± 33) °C
			Humidity	(74 ± 75) %	(68 ± 69) %
			Heat Index	(42.24 ± 42.5) °C	(42.32 ± 45) °C
3	Evening (0300pm to 0600pm)	MQ-135	CO	(3.93 ± 8.74) ppm	(3.47 ± 6.98) ppm
			CO_2	(2.84 ± 4.97) ppm	(2.59 ± 4.29) ppm
			NH_4	(4.32 ± 9.27) ppm	(3.99 ± 6.45) ppm
		DHT11	Temperature	(31.1 ± 32.4) °C	(31.2 ± 32.7) °C
			Humidity	(71 ± 76) %	(75 ± 77) %
			Heat Index	(38.18 ± 40) °C	(39.78 ± 42.1) °C
4	Night (0800pm to 1100pm)	MQ-135	CO	(3.02 ± 5.19) ppm	(3.45 ± 6.97) ppm
			CO_2	(2.34 ± 3.07) ppm	(2.58 ± 3.7) ppm
			NH_4	(3.66 ± 6.01) ppm	(3.98 ± 5.77) ppm
		DHT11	Temperature	(30 ± 31) °C	(30.3 ± 31.1)°C
			Humidity	(72 ± 74) %	(74 ± 75) %
			Heat Index	(35.53 ± 36.9) °C	(36.85 ± 37) °C

* °C - Degree Celsius

* ppm - Particle Per Million

The analysis is taken for 5 days to observe changes in mushroom cultivation between in the indoor and indoor with monitoring system environment. The mushroom starts to grow on day 3 in indoor with monitoring system based on Table 2. On day 5, the mushroom in indoor with monitoring system keep grow and the outdoor start to grow on the mushroom cultivation. The mushroom grows faster in indoor with monitoring system than indoor environments because the indoor is more exposed to environment that may contain carbon dioxide and carbon monoxide that can harm the mushroom cultivation. The project can control any event that affects mushroom cultivation by applying a DC fan to cool down the temperature and pull out the gases surrounding the mushroom cultivation.

Table 2 : Observation between Indoor And Outdoor Cultivation

Day	Indoor with Monitoring System	Indoor
1	 On the first day, the mushroom was placed in the hardware that had been developed. The mushroom has been applying with a hose to supply water if the soil moisture detects the condition of the soil.	 Mushroom will place on room and expose to air and temperature room. The mushroom will be sprayed with water to make sure the mushroom is wet 3 times a day.
2	 The mushroom on the hardware has no change.	 At outdoor also no change onto the mushroom.
3	 On the circle show, the mushroom starts to grow.	 But at outdoor remain no change after 3 days.

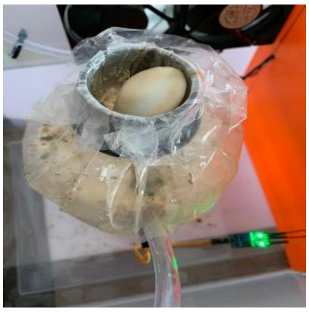
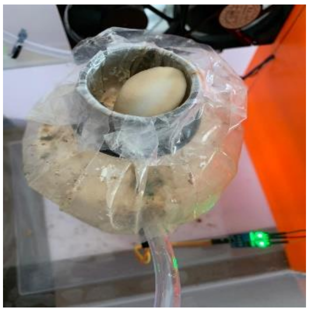
4	 The mushroom start to grows bigger.	 But at outdoor remain no change after 4 day
5	 The mushroom grows bigger	 On day 5 the mushroom grows but in minimal growth.

Figure 8 shows the mushroom after 8 days on the shed. The mushroom grows healthy and bigger than estimated day taken on 5-day analysis. Since it rainy season, the mushroom shows the response quicker because the weather is cold and breezy.

Figure 8: The mushroom after 8 day

4. Conclusion

This project has achieved the objective to identify the suitable hardware for monitoring the mushroom cultivation. Then, the installation process of the ESP32 with the appropriate code using Arduino IDE has been successfully applied. The installation process of the temperature/humidity(DHT11) sensor, gas sensor (MQ135) and soil moisture sensor with the motherboard to monitor the temperature, gases and soil for the mushroom cultivation have been done.

The trial process of the hardware function and fabricate a closed chamber (Shed) for the cultivation of mushrooms has been implemented. The hardware function in the cultivation of mushrooms is to monitor and control the variable parameters inside the chamber (shed) in different weather conditions. The mushroom had been analysed with monitoring system and without the monitoring system. Thus, Monitoring System for Mushroom Cultivation In Indoor Farming Using ESP32 Arduino was built successfully.

Acknowledgement

The authors would like to thank the Faculty of Electrical and Electronic Engineering, Universiti Tun Hussein Onn Malaysia and Kongu Engineering College, India for their support.

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