EcoGold Monitor: An IoT-Based System for Real-Time Vermicompost Monitoring

Nor Azimah Mohd Zain[1] and Mohd Suardi Suhaimi[2]

[1]Department of Biosciences, Faculty of Science, Universiti Teknologi Malaysia, 81310 Skudai, Johor, Malaysia

[2]VerdantIQ Sdn Bhd, Jalan Pulai Perdana 3/11, Taman Sri Pulai Perdana, 81110 Johor Bahru. Johor, Malaysia

norazimah@utm.my, mka2global@gmail.com

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*Corresponding author
norazimah@utm.my

Abstract

EcoGold Monitor, an Internet of Things (IoT)-based system designed for real-time compost and soil condition monitoring. The prototype employs an ESP32 microcontroller integrated with a DS18B20 digital temperature sensor and a capacitive soil moisture sensor to collect composting data, environmental data pertinent to plant health and precision agriculture. Sensor data are acquired periodically and transmitted over Wi-Fi to the Blynk IoT platform, which provides cloud-based visualization, logging, and remote access through a web or mobile interface. To enhance user accessibility, the system incorporates WiFiManager, enabling dynamic network configuration without hardcoded credentials. This feature allows non-technical users to connect the device to any available Wi-Fi network through a temporary access point interface. Data are visualized in real-time via graphs and historical logs, allowing users to make informed decisions regarding irrigation scheduling and microclimate management.

Keywords *Internet of Thing (IoT), Microcontroller, Soil moisture sensor, Temperature sensor, Agriculture.*

1. Introduction

Agriculture faces growing challenges in maintaining productivity while conserving resources. Smart farming technologies, particularly those leveraging on the Internet of Things (IoT), offer significant potential to address these challenges by allowing real-time monitoring on environmental and soil conditions. The deployment of automated monitoring and advanced control systems in agriculture was significantly constrained by limited cellular network coverage and technological limitations related to device size, energy consumption, and processing capabilities—particularly in highly productive yet sparsely populated rural regions [1].

* *Corresponding author. norazimah@utm.my*
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2. Literature Review

Recent advancements in wireless networking, sensor miniaturization, and microcontroller technology have made it feasible to remotely monitor and manage a wide range of critical agricultural parameters. These include soil temperature and moisture, air quality, rainfall, water quality, crop health, local weather conditions, and the operation of machinery such as harvesters and irrigation systems. Additionally, systems can now track livestock movement, detect threats such as fire, theft, or flooding, and monitor animal health and feeding levels. As such, the IoT is exceptionally well-suited to precision agriculture due to its interoperable, scalable, and pervasive nature, enabling seamless data collection and real-time decision-making [2].

The vermicomposting technique using the earthworms can be used to reduce the impact of intense agriculture and industrial activity. It has several advantages such as enhancement of soil fertility, enhanced crop productivity, increase in the water retainment capability of the soil, promote the growth of plants, reduction of disease-causing pathogens [3]. The vermicomposting process use African Night Crawler (Eudrilus eugeniae), require about 90 days for conversion of waste into fertilizer. During the entire time, parameters like temperature and moisture have to maintained at a level that promotes the survival and growth of these worms and thereby maintains the microbial activity of the worms at the optimum [3].

The vermicompost unit needs to be adequately aerated to release methane gas that is produced during the process. Vital parameters such as temperature and moisture have to be monitored and maintained at specified range by employing IoT to continuously monitor these parameters in real time and maintain them as desired [3].

Thus, EcoGold was developed to improve the success rate of the vermicomposting process by monitoring the temperature and moisture in real time to assist in any manual intervention when required. The proposed automated monitoring system is built with the help of sensors and wireless network to transmit live data of the compost from compost bin to the monitoring system on the cloud server. This allows for off-site remote monitoring of the compost thereby reducing manual work.

2. System Architecture

2.1 Hardware Components

For the system, it used ESP32 microcontroller [4], DS18B20 sensor [5] and capacitive soil moisture sensor. The microcontroller provides Wi-Fi connectivity and sufficient GPIO for sensor integration. As for the DS18B20 sensor, it is a digital temperature sensor known for accuracy and one-wire communication. Capacitive soil moisture sensor is use to measures volumetric water content in soil with improved longevity over resistive types. Figure 1 represents the block diagram of the system, meanwhile Table 1 shows the parts, parameters and range of the reading of EcoGold Monitor.

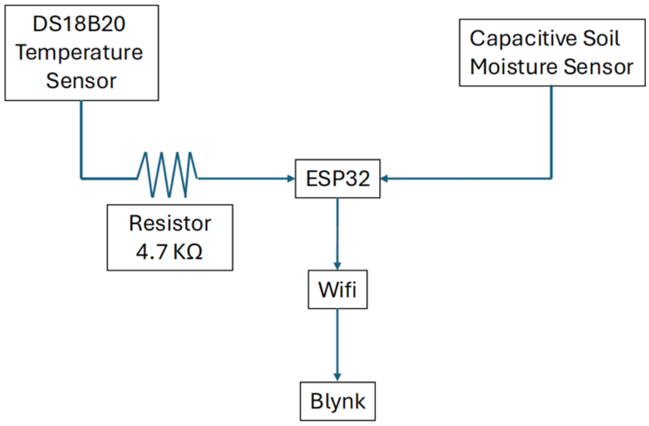

Figure 1: Block diagram of the system

Table 1: The parts, parameters and range of reading in the EcoGold Monitor

Parts	Parameter	Range
ESP32 Microcontroller		
Resistor 4.7 KΩ		
Soil capacitive moisture sensor	Moisture	1% – 100%
DS18B20 Temperature sensor	Temperature	0 °C – 100 °C

2.2 Connectivity and Cloud Integration

The ESP32 transmits data to the Blynk IoT platform [6] via Wi-Fi. Blynk IoT enables real-time dashboards, historical data storage, and mobile or web access. Users interact with the system through virtual pins and cloud APIs.

2.3 Wi-Fi Configuration

The WiFiManager library [7] allows the system to open a local access point when no credentials are stored. Users connect to this access point to configure the device without editing source code.

3. Methodology

3.1 The firmware

The firmware was developed using the Arduino IDE 2.0 and leverages several libraries such as DallasTemperature, OneWire, WiFiManager, and BlynkSimpleEsp32. The sensors are read every five seconds, and the data are mapped and sent to Blynk virtual pins for visualization. Figure 2 shows the flowchart of the process.

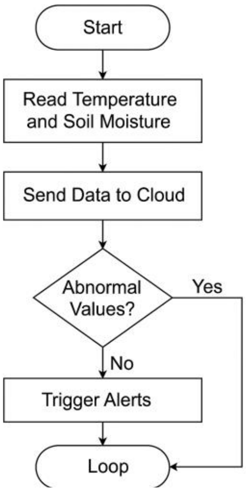

Figure 2: Flowchart of the process

3.2 Experiment to test the effectiveness of EcoGold Monitor

An experiment was designed to study the effectiveness of the EcoGold Monitor in monitoring vermicomposting process. Three EcoGold Monitor was assembled, and these devices were used to monitor the parameters (soil moisture and temperature) in three different vermicompost conditions (wet, moist and dry). The experiment was conducted in triplicate. Table 2 shows the condition of the experiment.

Table 2: Parameter, range and repetition conducted in the experiment

Parameter	Range	Repetition
Soil Moisture (%)	Wet, Moist and Dry	Triplicate
Temperature (°C)	Wet, Moist and Dry	Triplicate

4. Results and Discussion

4.1 The hardware setup and blynk app

In preliminary field tests, the system maintained stable Wi-Fi connections and consistent data transmission. The DS18B20 returned temperature readings within an accuracy margin of ±0.5°C, while the soil moisture sensor provided repeatable results under different soil conditions. The setup process was completed by non-technical users in under three minutes using a smartphone.

The EcoGold Monitor successfully addresses key requirements for a practical smart agriculture solution: low cost, wireless connectivity, and ease of use. However, limitations include the lack of redundancy and limited sensor types. Future improvements could include integration with solar power, additional environmental sensors (e.g., light, pH), and machine learning-based decision support. Figure 3 shows the hardware setup of the prototype. Meanwhile, Figure 4 and 5 show the Blynk console and Blynk app snapshots, respectively.

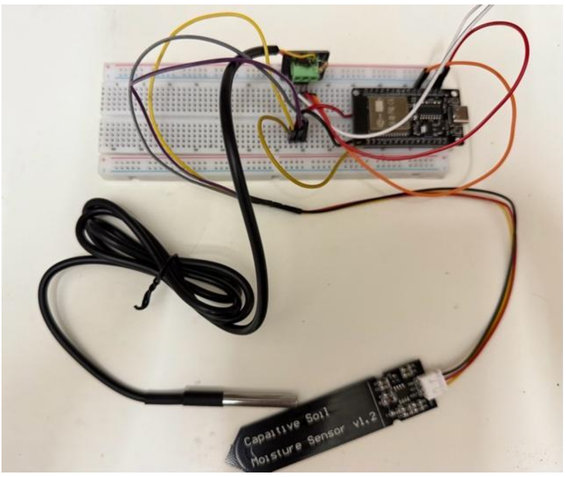

Figure 3: Hardware setup

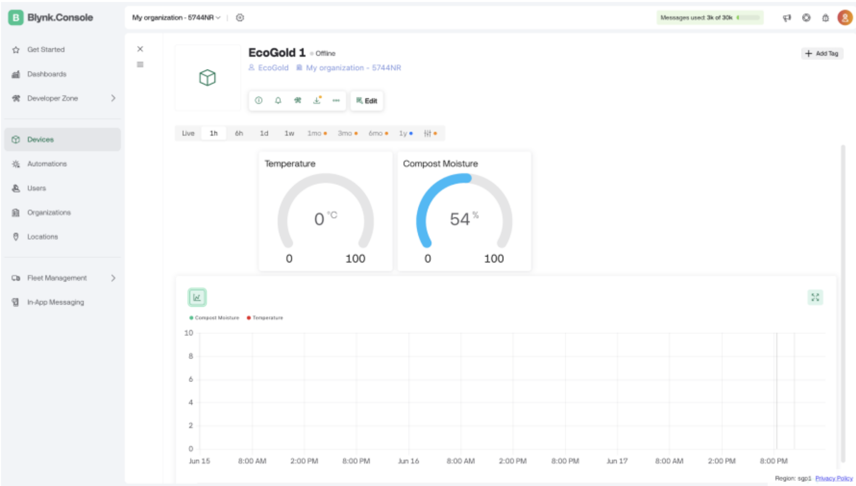

Figure 4: Blynk console snapshot

Figure 5: Blynk app snapshot

4.2 Effectiveness of EcoGold Momitor

Figure 6 and 7 show the soil moisture and temperature sensors' reading of vermicompost in wet, moist and dry condition. Based on Figure 6, during the wet condition, the devices able to give reading about 86.7% of soil moisture. As for moist and dry condition, the reading was 72% and 54% respectively. For Figure 7, the temperature recorded were 29.56 °C, 29.56 °C and 30.48 °C, respectively.

Based on the conducted experiments, the device can provide readings in real time with negligible delay time of around 2 seconds. This is crucial should any emergency manual interventions are needed. Vermicompost should have moisture level of 60% – 80% [8] and temperature range of 25 °C – 30 °C [9] to prevent the worm from escaping. Therefore, EcoGold Monitor would be an ideal device to give the operator an insight of the vermicomposting and the worm condition since it could provide readings in the range of interest in real time.

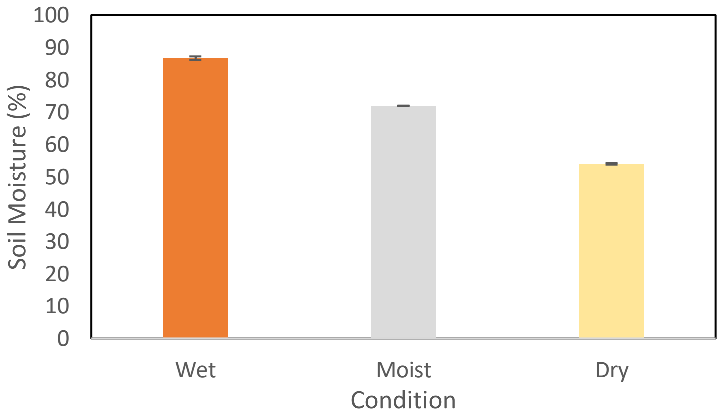

Figure 6: Soil moisture of vermicompost in wet, moist and dry condition

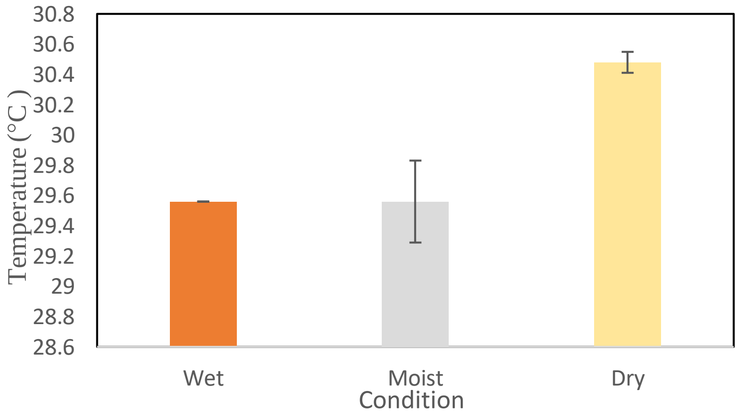

Figure 7: Temperature of vermicompost in wet, moist and dry condition

5. Conclusion

The EcoGold Monitor demonstrates the feasibility of low-cost, Wi-Fi-enabled compost monitoring system using off-the-shelf components and open-source platforms. Experiment conducted revealed the EcoGold Monitor is capable in monitoring the moisture and temperature within the typical temperature and moisture range for optimum vermicomposting. Its capability to acquire data in real time combined with modular design and cloud integration make it suitable for small-scale composting and agricultural operations as well as educational use. Further studies on upscale commercial use would be beneficial to improve the device operability in real world applications.

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Conflict of Interest Statement
The author declares that there is no conflict of interest regarding the publication of this paper.

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