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Smart Composting IOT Solution For Waste Reduction

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ABSTRACT

By analyzing the environmental protection agency's study, the amount of waste material thrown on the landfills is increases annually on a large scale. Thus, in developing countries, the organic waste becomes a global issue which becomes a big problem. As these waste materials emit methane gas and other toxic pollutants, the pollution rises as a result. These gasses cause global warming as it continues to heat the earth. Practices in waste management are not consistent between countries, regions and residential. Therefore, a new technique for smart compost system is proposed here whereby we can crush the organic waste for the composting process and can also achieve required compost by maintaining and controlling its parameters. Composting means keeping a waste in a close unit and let the micro-organism to grow to breakdown to make product ready for fertilizer. This Fertilizers or ready product can be used for agriculture or farming purpose. In this proposed system, the temperature, humidity, gas availability of the compost and the water level, requirement of the soil/waste is monitored with the help of Arduino, Node MCU, relays and various sensors. Thus, by utilizing the system process, the garbage or organic waste Pollution can be controlled.

***Keywords*: IOT, Waste reduction, micro controller.**

I.INTRODUCTION

Composting is the delicate process of controlled organic Waste decomposition, which slowly transforms waste into a Manure rich in nutrients. It takes profound knowledge and relentless professional attention to arrive at a timely result Outcome. However, because of the particular nature of the Material and overall operation, along with the area required and odors emitted, it is compulsory to build composting Machinery away from the residential areas, thus monitoring is a challenging task. Smart composting system is much more advance and easier to use still it cannot replace the Human supervision insightfulness. We incorporate Composting as a Service in this article. It is cloud service With embedded advanced composting machinery based on Internet of Things (IOT), which allows unsupervised composting. This smart composting system which has Multiple sensors and pump system, perform specific task and send values to cloud service that perform real time data analysis and give instruction to the system to perform various tasks depend on the analysis result. This smart composting is conducted in a totally unattended manner and test have shown up to 30 percent faster result compared to traditional supervised composting. Making use of this smart technology, it become more convenient to use and the waste can used for various useful purposes. The Internet of Things (IoT) Deals with the creation of a network of physical objects such as smartphones, sensors and actuators for data sharing over the Internet. The Inter net of Things is generally referred to as Web-connected objects. In order to provide advanced smart services to end-users, organizations communicate and exchange information provides opportunities for more efficient incorporation of the physical world into computer based systems, resulting in Improved economic benefits, performance, precision and decreased human intervention. The communication between the objects and the Internet is through a wired or wireless link, without user intervention. The advanced waste management system is necessary to avoid the spread of some Deadly diseases. It includes constant composter control, Which helps to decompose the waste. But manual control Of composters is difficult because of a lack of human Resources. In this we propose the system in which the waste is manage d intelligently by monitoring and controlling the Composter, with the help of IoT. The smart composter is connected to the internet to get the real-time information and its status to take the necessary phase of compositing. With the aid of IoT the number of these composters can be monitored.

II. LITERATURE REVIEW

The concept of integrating IoT technology into composting systems has garnered attention over the past decade, given the growing urgency to manage organic waste efficiently. This chapter presents a comprehensive review of related work and research efforts in the areas of smart composting, automation, sensor networks, and IoT-based waste management systems. The literature survey highlights the evolution of composting technology, identifies limitations in existing solutions, and justifies the need for the proposed system using an ESP32 microcontroller and KME Smart App.

2.1 Traditional Composting Techniques

Traditional composting is a natural decomposition process requiring a balance of carbon-rich (browns) and nitrogen-rich (greens) materials. Studies such as Barker et al. (1998) emphasize the importance of maintaining a 30:1 C/N ratio, turning the compost heap for aeration, and monitoring temperature and moisture manually. While simple and cost-effective, traditional methods have several drawbacks:

Require continuous manual intervention.

Unreliable outcomes due to inconsistent environmental conditions.

Long decomposition periods (3–6 months).

2.2 Introduction of Sensors in Composting

In early studies (e.g., Risse and Faucette, 2001), researchers introduced electronic temperature and humidity sensors into compost heaps for research monitoring purposes. However, these systems lacked real-time feedback and control capabilities.

Pansari et al. (2018) designed a system using Arduino to monitor compost parameters. Although this represented a shift toward smart composting, it required local supervision and had limited wireless data capabilities. The sensors were basic and not integrated with IoT platforms for remote data access or automation.

2.3 IoT in Waste Management Systems

IoT applications in smart cities have revolutionized solid waste management. Bharadwaj et al. (2016) developed an IoT-based waste collection and tracking system using RFID and GSM. Although effective for collection logistics, the system did not address composting

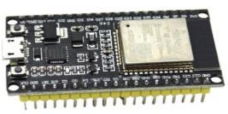
III. IMPLEMENTATION AND METHODOLOGY

Implementation

The implementation of the IoT-Based Smart Composting System begins with the collection of organic waste in a designated bin, which is then transferred to a grinding vessel operated by a DC motor to break the waste into smaller particles for efficient decomposition. This processed waste is moved into a compost chamber where various environmental parameters are monitored using sensors:

1.Microcontroller

ESP32 (38-pin): Dual-core microcontroller with built-in Wi-Fi and Bluetooth, used for reading sensor data, controlling actuators, and connecting to the KME Smart App.

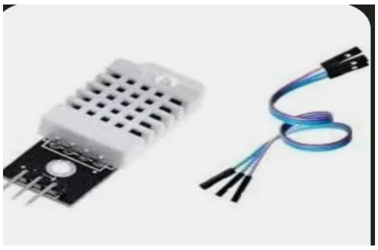


2.Sensors

DHT22 or DHT11: For monitoring temperature and humidity of the compost environment.

Soil Moisture Sensor: To check moisture content inside the compost bin.

MQ135 Gas Sensor: To detect harmful gases like methane, ammonia, and carbon dioxide.



3. Actuators DC Motor with Blade Assembly: For grinding the organic waste.

Water Pump: Automatically activated when moisture drops below a threshold.

Relay Modules (2-channel): To control motor and pump.

Exhaust Fan (optional): To release excess gases.

4.Power Supply

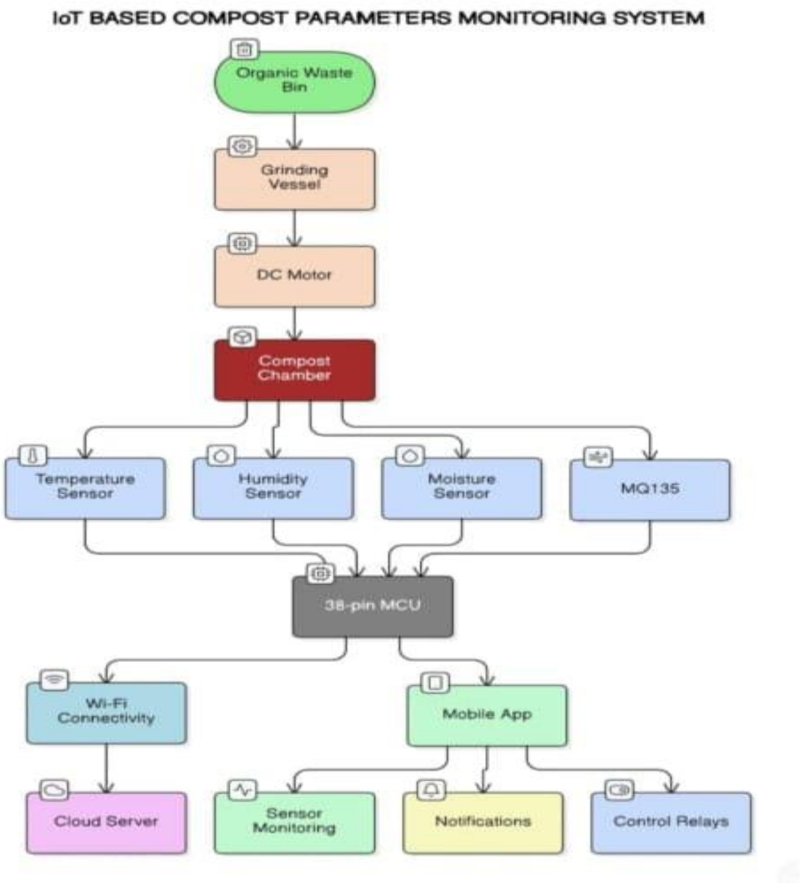
12V/5V regulated power supply for ESP32 and peripherals.Power bank or adapter.

. Connectivity

Wi-Fi Router or mobile hotspot to connect ESP32 to KME Smart App.

IV. METHODOLOGY

This chapter provides an in-depth explanation of the methods used to design, develop, and implement the Smart Compost System. It includes the system architecture, hardware components, process flow, and working principle, detailing how the ESP32 microcontroller and KME .Smart App interact to monitor and control the composting process in real time.



4.1 Hardware Requirements
Below are the hardware components used in the smart compost system:

1.Microcontroller

ESP32 (38-pin): Dual-core microcontroller with built-in Wi-Fi and Bluetooth, used for reading sensor data, controlling actuators, and connecting to the KME Smart App.

2.Sensors

DHT22 or DHT11: For monitoring temperature and humidity of the compost environment.
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4.Power Supply
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5. Connectivity
Wi-Fi Router or mobile hotspot to connect ESP32 to KME Smart App.

Advantages:
1.Real-Time Monitoring: Sensors monitor temperature, humidity, moisture, and gas levels, enabling precise compost control.
2. Waste Reduction: Efficiently processes organic waste into compost, reducing landfill use.
3. Automation: DC motor and relays automate grinding and composting, reducing manual effort.
4. Remote Access: Data sent to the cloud and mobile app allows remote monitoring and control.
5. Data Logging: Cloud storage supports historical data analysis for optimizing composting cycles.
6. Environmentally Friendly: Promotes sustainable practices and reduces harmful emissions.

Disadvantages:

1. Initial Cost: Setup may require investment in sensors, MCU, motor, and connectivity modules.
2. Power Dependency: System operation relies on continuous power supply or battery backup.
3. Sensor Maintenance: Sensors may degrade over time and need calibration or replacement.
4. Connectivity Issues: Internet or Wi-Fi failure can affect cloud syncing and remote access.
5. Limited to Organic Waste: Only suitable for compostable organic materials.

Applications:

1. Home Composting Units: For individuals managing kitchen waste smartly and sustainably.
2. Urban Farming: Provides high-quality compost for rooftop or balcony gardens.
3. Educational Institutions: Teaches students about sustainability and IoT integration.
4. Restaurants & Cafeterias: Converts food waste into usable compost on-site.
5. Smart Cities: Integrated into municipal waste systems for decentralized waste processing.

V. CONCLUSION

The "Smart Compost System Using IoT with ESP32 and KME Smart App" represents a modern, sustainable approach to organic waste management. By integrating embedded systems with cloud connectivity and real-time monitoring, this project successfully addresses the limitations of traditional composting methods. Through automated regulation of moisture, temperature, and gas emissions, it ensures optimal conditions for efficient decomposition with minimal human intervention.

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