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Smart Composting System

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Abstract -A smart composting system integrates sensor-driven monitoring, automated control mechanisms, microcontroller based and data analytics to optimize the composting process and improve organic waste management. By utilizing sensors to track key parameters—including temperature, humidity, oxygen levels, and pH-the system can dynamically regulate environmental conditions through automated aeration, moisture control, and real-time alerts. Wireless data transmission and an intuitive user interface enable remote monitoring, performance visualization, and predictive insights that enhance compost quality and reduce manual intervention. Leveraging machine-learning algorithms, the smart composting system improves decomposition efficiency, shortens processing time, and supports sustainable waste-to-resource practices for households, farms, and industrial applications. This approach promotes environmental sustainability while offering a scalable solution for modern waste management challenges. This focuses on automating the decomposition process of organic waste by monitoring environmental parameters.

Keywords: automated, microcontroller

1.INTRODUCTION

Organic waste is increasing, and traditional composting requires constant manual monitoring to maintain proper conditions. A smart composting system uses sensors, automation, and IoT technology to monitor temperature, humidity, and other factors in real time. This helps maintain ideal conditions for faster and more efficient composting while reducing human effort. The project aims to create an easy-to-use, technology-based solution that improves compost quality and supports sustainable waste management.

Organic waste generated from households, hotels, farms, and industries creates serious environmental problems if not managed properly. Biodegradable waste such as vegetable peels, food waste, leaves, and agricultural residues can be converted into nutrient-rich compost through the process of decomposition. Composting is a biological process in which microorganisms break down organic matter into simpler substances under controlled conditions. Traditional composting methods require regular turning and monitoring to maintain oxygen supply and moisture balance. Manual composting is time-consuming, labour intensive, and less efficient. To improve the composting process, automation technology can be used. The Smart Composting System based on the PIC16F877A

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microcontroller automates the compost mixing process using a DC gear motor controlled through a relay module. The system periodically rotates the compost material to provide proper aeration and improve decomposition speed. The 16x2 LCD provides a simple human-machine interface for displaying system status.

This project provides: Automated compost mixing, Reduced human effort, Faster decomposition process, better compost quality, Eco-friendly waste management solution.

2.LITERATURE REVIEW

Composting is one of the most effective and eco-friendly methods for managing biodegradable waste. Traditional composting methods require continuous manual monitoring and regular mixing to maintain proper aeration and decomposition. Recent advancements in embedded systems, microcontrollers, IoT, and automation technologies have improved the efficiency of composting systems. Several researchers have developed automated composting systems using sensors, microcontrollers, and intelligent control techniques to reduce manual effort and improve compost quality.

Composting is an eco-friendly method used to convert biodegradable waste into useful organic fertilizer. Traditional composting methods require regular manual mixing and monitoring, which makes the process time-consuming and less efficient. Many researchers have developed automated composting systems using microcontrollers, sensors, and motorized mechanisms to improve compost quality and reduce human effort. Studies show that automatic mixing improves aeration, speeds up decomposition, and reduces foul odour generation Several. smart composting systems use embedded controllers and automated motor control for efficient waste management. Researchers have also implemented LCD displays, relay modules, and intelligent monitoring systems for better process control. Advanced systems use IoT and sensors for monitoring temperature and moisture, but such systems are expensive and complex for small-scale applications.

Based on the reviewed literature, the proposed SMART COMPOSTING SYSTEM using the PIC16F877A Microcontroller provides a simple, low-cost, and efficient solution for automated compost mixing. The system uses a relay-controlled DC gear motor and LCD display to improve composting efficiency and reduce manual labour. Several researchers have worked on automated composting systems to improve the efficiency of organic waste management. Traditional composting methods require manual mixing and monitoring, which increases labour and decomposition time. To overcome these limitations, automation and embedded systems are increasingly used in composting applications.

A study by P. K. Yadav et al. developed an automated compost monitoring system using microcontroller technology for controlling the composting process. The researchers explained that regular aeration and mixing improve microbial activity and reduce decomposition time. The system also reduced foul odour and improved compost quality.

Another research work by M. S. Islam et al. focused on smart waste management systems using embedded systems and automation techniques. The study concluded that automated waste handling systems help in reducing human effort and improving environmental sustainability.

Research conducted by K. Saravanan et al. proposed a microcontroller-based composting control system for automatic compost mixing and monitoring. The study highlighted that motorized mixing mechanisms increase oxygen circulation inside the compost material and accelerate the decomposition process.

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Recent studies on intelligent composting systems also introduced IoT-based monitoring techniques using temperature and moisture sensors. Although these systems provide advanced monitoring features, they increase system complexity and cost. Therefore, simple microcontroller-based systems remain suitable for small-scale and low-cost composting applications. Based on the reviewed literature, the proposed Smart Composting System using the PIC16F877A Microcontroller is designed as a simple, economical, and efficient solution for automated compost mixing using a relay-controlled DC gear motor and LCD display.

3.METHODOLOGY

3.1HARDWARE REQUIREMENT:

- DHT11 Sensor
- DS18B20 Waterproof Temperature Sensor
- PIC 16F877A Microcontroller
- 16x2 LCD Display
- RCC Relay
- Crystal Oscillator
- Push Button
- LEDs
- LM7805 Voltage Regulator
- Capacitors
- Diodes
- Resistors
- Digital Temperature Controller Module
- PCB Board
- Connecting Wires
- Terminal Blocks
- DC Power Supply Connections

Fig1: PIC 16F877A MICROCONTROLLER

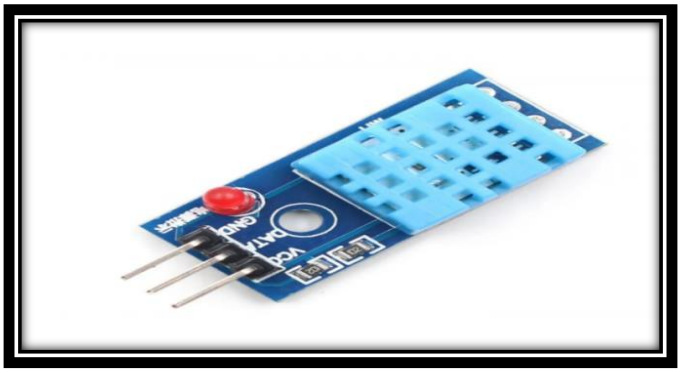

FIG2:DHT11 TEMPERATURE AND HUMIDITY SENSOR

FIG3: RCC RELAY

FIG4:LM35 TEMPERATURE SENSOR

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FIG5: CRYSTAL OSCILLATOR

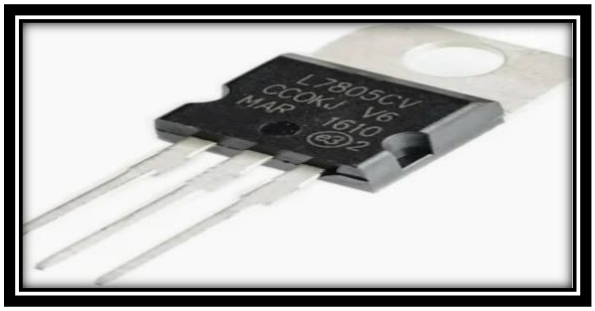

FIG6: L7805 VOLTAGE REGULATOR

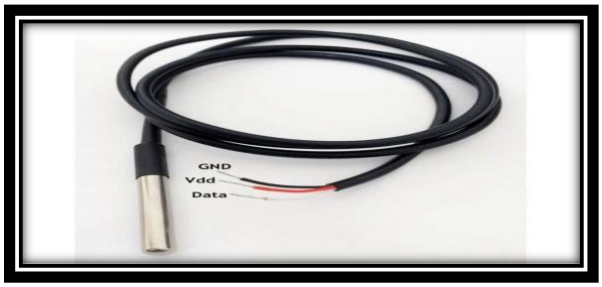

FIG7:DS18B20 WATERPROOF TEMPERATURE SENSOR

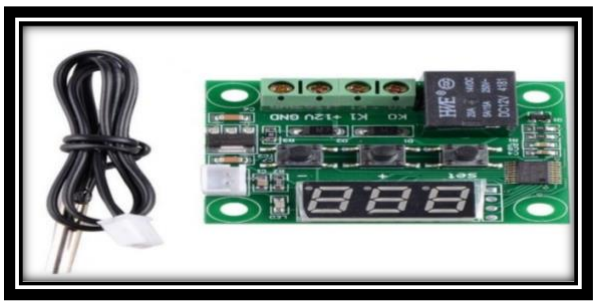

FIG8:W1209 DIGITAL TEMPERATURE CONTROLLER MODULE

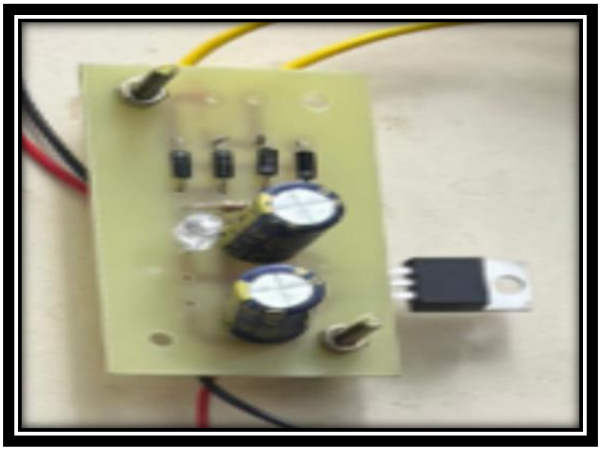

FIG9: RECTIFIER CIRCUIT

3.2 BLOCK DIAGRAM:

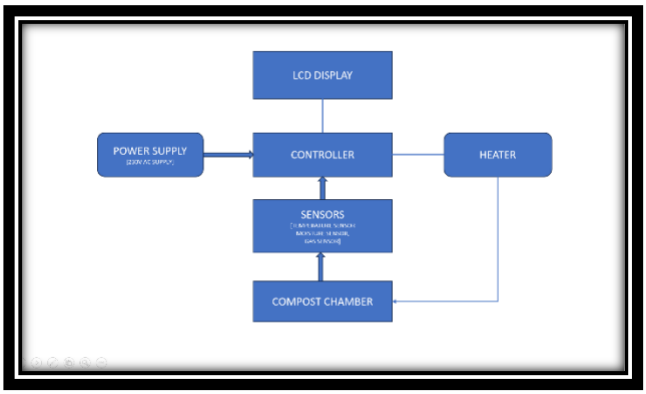

Fig10: Block Diagram of smart composting system

- **POWER SUPPLY:** The power supply converts 230V AC into regulated DC voltage required for the system.
- **CONTROLLER:** The controller (PIC16F877A microcontroller) acts as the main processing unit and controls the entire composting operation.
- **SENSOR:** Temperature, moisture, and gas sensors monitor the conditions inside the compost chamber and send data to the controller.
- **LCD DISPLAY:** The LCD displays temperature, moisture level, gas information, and system status.
- **HEATER:** The heater maintains the required temperature inside the compost chamber for proper decomposition.

International Journal of Engineering Research & Technology (IJERT)
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- **COMPOST CHAMBER:** Organic waste is stored inside the compost chamber where decomposition takes place.
- **WORKING:** Sensors continuously monitor compost conditions. The controller processes the sensor data and controls the heater accordingly. The LCD shows the system information, helping maintain proper composting conditions.

3.3 FLOWCHART:

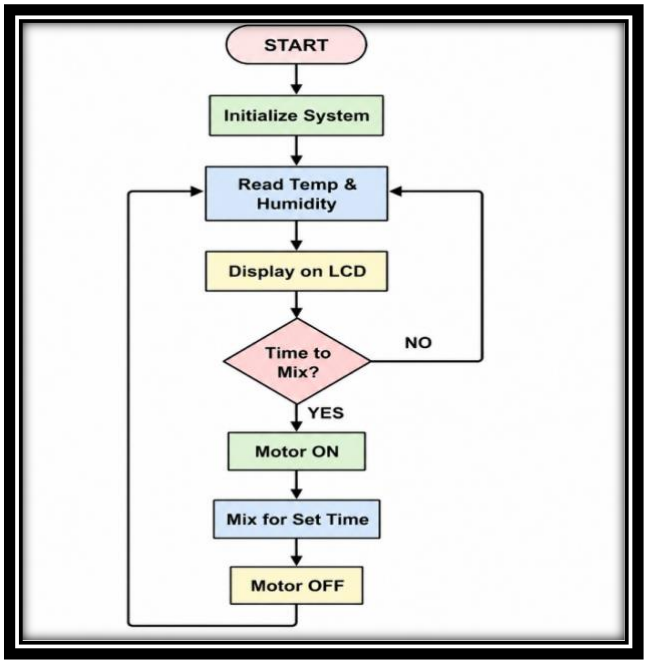

Fig11: FLOWCHART

Explaination:

Start: The system starts when power is supplied.

Intialize Process: The PIC16F877A Microcontroller intialises all components like LCD, Sensor and Relay.

Read Temperature and Humidity: The DHT11 sensor measures temperature and humidity inside the compost chamber.

Display On LCD: The measured values and system status are displayed on the 16x2 LCD.

Time to mix: The microcontroller checks whether it is time to mix the compost material.

Motor ON: If mixing is required, the relay turns ON the DC gear motor.

Mix for set time: The motor rotates the mixing mechanism for a fixed duration to improve aeration.

Motor OFF: After mixing is completed, the motor turns OFF automatically.

Repeat process: The system continuously repeats the monitoring and mixing process automatically.

3.4 CIRCUIT CONNECTION AND DESCRIPTION:

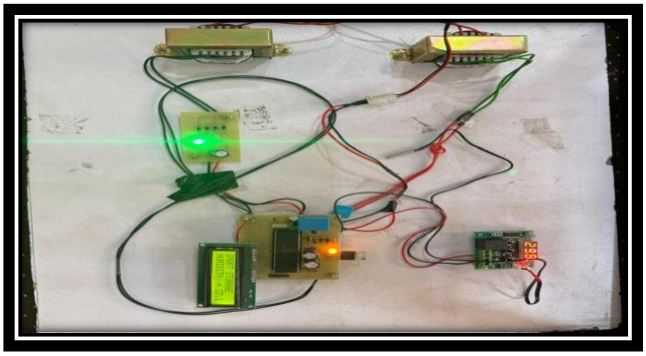

FIG12: CIRCUIT

- **Power Supply:** Transformer converts 230V AC to 12V AC. Rectifier and 7805 provide 5V DC supply. 5V is given to PIC16F877A, LCD, DHT11, and relay.
- **PIC16F877A Connections:** VDD pins → +5V VSS pins → Ground, Crystal oscillator connected to OSC pins, Controls LCD, relay, and sensor.
- **LCD Connections:** VCC → +5V GND → Ground Data and control pins connected to PIC microcontroller. Displays temperature, humidity, and motor status.

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- **DHT11 Sensor connection:** VCC → +5V DATA → PIC input pin GND → Ground, Measures temperature and humidity.
- **Relay Connection**: Relay input connected to PIC output pin. Relay controls DC gear motor ON/OFF.
- **DC Gear Motor Connection**: Connected through relay circuit. Motor rotates compost mixing blades.
- **Working**: Sensor sends data to PIC. LCD displays values.PIC activates relay. Relay turns motor ON for mixing compost. Motor turns OFF after fixed time.

4. RESULTS AND DISCUSSION

4.1 DISSCUSSION:

- This project is an automated smart composting system designed to accelerate the decomposition of organic waste by maintaining optimum environmental conditions inside the compost chamber [i.e; for Temperature ideal range- 50°C to 60°C For Humidity ideal range-50% to 60% For ph level-6.5 to 7.5].
- Initially, biodegradable waste is loaded into the compost container. Temperature and humidity sensors continuously monitor the internal conditions and transmit the data to the controller. The controller compares the sensed values with predefined set points and accordingly operates the actuators through relay circuits.
- If the temperature exceeds the desired range, the exhaust fan is activated for cooling and ventilation. Similarly, if the temperature falls below the required level, the heating system is turned ON to maintain suitable microbial activity. Moisture levels are also regulated to ensure efficient compost formation.
- The LCD display provides real-time monitoring of temperature, humidity, and device status. By maintaining controlled environmental parameters, the system enhances decomposition efficiency, minimizes manual intervention, and produces high-quality compost in reduced time.

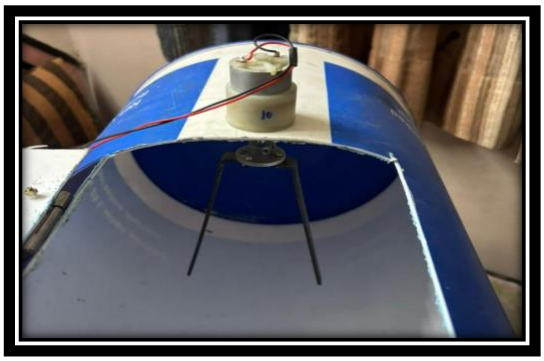

Fig13: compost chamber

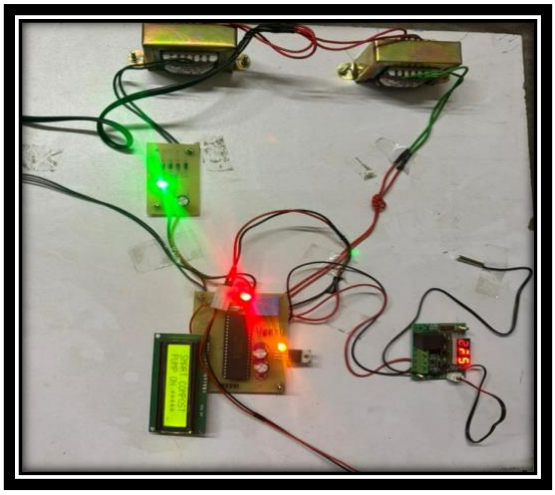

Fig14: circuit for smart composting system

4.2 RESULTS:

- The system successfully monitored and controlled the temperature and humidity inside the compost chamber automatically.
- Proper environmental conditions increased the rate of organic waste decomposition.
- The automated fan and control system maintained effective aeration and thermal regulation.
- Real-time parameters were displayed continuously on the LCD for easy monitoring.

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- The project reduced manual effort and improved composting efficiency.
- Stable operating conditions helped in producing better-quality compost within less time.

Fig15: smart composting system

5. CONCLUSION

The Smart Composting System using the PIC16F877A Microcontroller successfully automates the composting process by monitoring temperature and humidity and controlling the mixing mechanism. The system reduces manual effort, improves compost quality, and supports eco-friendly waste management. It is a low-cost and efficient solution suitable for homes, farms, and small-scale composting applications.

6. FUTURE ENHANCEMENT

The Smart Composting System can be further improved by adding advanced technologies such as IoT and wireless communication for remote monitoring and control through mobile applications. Automatic water spraying and advanced temperature and humidity control systems can be included to maintain ideal composting conditions. Solar power can be used to reduce electricity consumption and make the system more ecofriendly. Additional gas sensors can also be added for odour monitoring and safety. In future, AI-based monitoring and fully automatic compost management systems can be implemented to improve efficiency, reduce human intervention, and make the composting process smarter and more reliable.

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