Design Of Cow Dung Fermentation Equipment For Organic Fertilizer Based On Esp32

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Abstract
The excessive use of chemical fertilizers in the Indonesian agricultural sector leads to soil damage, water pollution, and a decline in the quality of farm products. To overcome this, it is necessary to process cow dung into organic fertilizer that is more efficient and sustainable. The traditional fermentation process, which is time-consuming and requires precise control, encourages the development of ESP32-based fermentation tools. This fermentation tool is designed to automatically control temperature, humidity, and fermentation time parameters. This tool is equipped with scheduled stirring at 07:00, 12:00, and 21:00 for 2 minutes, ventilation, and a fan, as well as real-time monitoring via the Telegram application with notification of completed fermentation. The fermentation process was carried out for 14 days, during which time the humidity changed from 71% to 43%, exhibiting a decreasing pattern. The high initial moisture (71%) gradually decreased due to microbial activity and evaporation, which was also affected by temperature and ventilation. Towards the end, the humidity stabilized at 55%-48%, indicating fermentation was almost complete. Test results indicate that the temperature sensor readings are accurate, with a difference of 0.365 and a percentage error of 1.3%. In contrast, the humidity sensor has a difference of 2.7 and a percentage error of 9%. This tool has been proven to efficiently speed up the fermentation process compared to the manual method, which requires human labor for stirring, filling liquids, and data collection.
Keywords: Organic fertilizer, cow dung, ESP32, real-time monitoring, Telegram

1. INTRODUCTION

Indonesia, being an agrarian country, relies heavily on the agricultural sector, with fertilizer being one of its essential components. However, the overuse of chemical fertilizers leads to environmental degradation and health issues [15]. Cattle manure is one of the abundant sources of organic matter in Indonesia. However, the use of cow dung as organic fertilizer has not been optimized. The traditional fermentation process of cow dung requires a long time and precise control to ensure the quality of the resulting fertilizer. In this context, technology can play a crucial role in enhancing the efficiency and effectiveness of the fermentation process. Fermentation production from cow dung waste employs different methods; some utilize anaerobic fermentation [3], [6]. Additionally, some use aerobic fermentation [1], [2].

The use of ESP32 in automation has been proven to improve performance and consistency in various production processes. ESP32 offers flexibility, reliability, and the ability to control multiple parameters in real-time [4]. By applying ESP32 to the cow dung fermentation process, it is hoped that a tool can be created that optimizes the fermentation process with better control, shorter time, and more consistent fertilizer quality.

2. METHODS

2.1. Block Diagram

The following is a block diagram used to complete the final project:

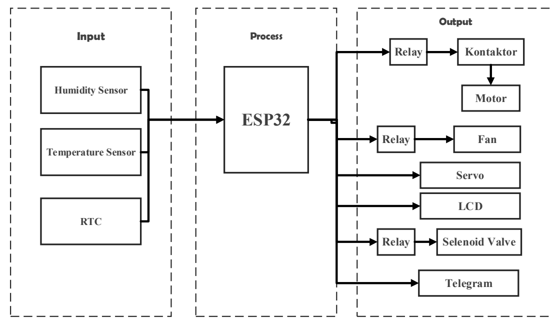

Figure1. Block diagram

Fermentation is the process by which anaerobic microorganisms decompose organic matter, producing acids, gases, and heat [3], [6]. The purpose is to remove odor, lower temperature, kill pathogens, and improve fertilizer quality. The optimal temperature is 40°-60°C with a minimum duration of 7 days. The fertilizer is considered successful if, after 2 weeks, it is odorless and has a solid, black appearance [1], [2].

The process begins by placing cow dung, bran, and husk charcoal into the device's bucket. Once all the ingredients are added, the cow dung is mixed with a liquid bioactivator consisting of EM4 (Effective Microorganisms 4) and molasses. The stirring motor is then activated to ensure that the mixture is well mixed. The motor will automatically switch off once the ingredients are well mixed.

Once the mixing is complete, the mixed ingredients will undergo fermentation. During fermentation, the temperature and humidity sensors work together to maintain a temperature inside the tank between 45 ° and 60 °C. If the temperature rises above 60° C, the fan will turn on, and the servo will activate ventilation or open the window on the bucket to stabilize the temperature. Meanwhile, the RTC will monitor the time in real time during the fermentation process. Information about the temperature, humidity, and process time will be displayed on the LCD. If the temperature drops below 30°C and the humidity falls below 50%, the system will send a notification via Telegram, informing you that the fermentation process has been completed.

2.2. Circuit Schematic
The following is a schematic of the circuit used in this research:

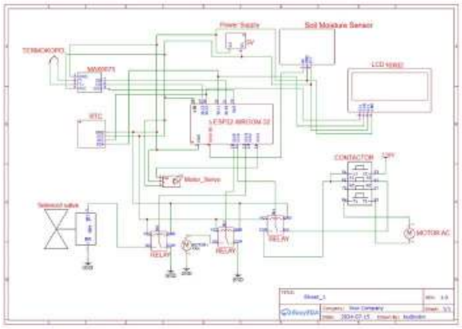

Figure 2 . System Wiring Design

2.3. Flowchart
The following flowchart explains each stage in detail:

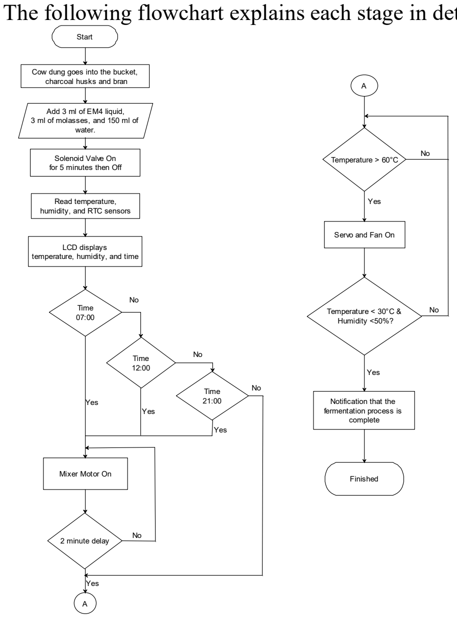

Figure 3 . Flowchart

2.4. Tool Design
The following is a tool design that will be made, as follows:

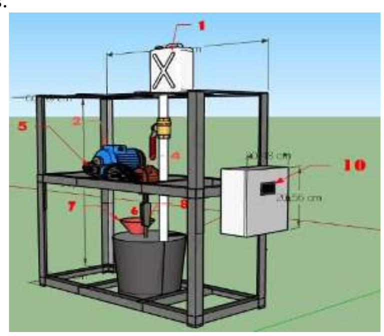

Figure 4 . Hardware Design

2.5. Hardware design
2.5.1. LCD with ESP32
LCD (Liquid Crystal Display) is a display medium that uses liquid crystals to form images. Each pixel contains liquid crystals that do not emit light on their own but are assisted by a backlight [13]. Meanwhile, the ESP32 microcontroller is equipped with built-in WiFi and Bluetooth, supporting the development of low-cost, energy-efficient, and exible IoT [17]. The LCD circuit and ESP32 enable efficient real-time data display via I2C or SPI interface.

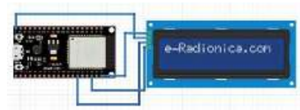

Figure 5 . LCD circuit with ESP32

2.5.2. RTC with ESP32
The RTC module is an in-chip electronic clock that keeps accurate time even when the computer is turned off, powered by a CMOS battery. RTC is also called CMOS because it stores system settings, including the time [14]. The RTC circuitry on the ESP32 provides accurate time data independently, even when the device is turned off or reset, thanks to its internal battery. This module is essential for applications that require precise time recording or scheduling, such as monitoring and IoT.

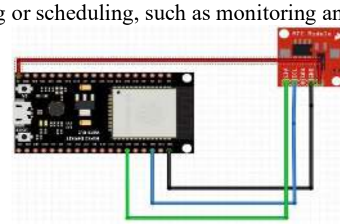

Figure 6 . RTC Module Circuit with ESP32

2.5.3. Servo with ESP32
Servo motors are motion control components that operate on command through a closed-loop control system. With the help of sensors and controllers, these motors adjust the position of the shaft to a specific angle through control signals, thereby allowing remote control of the mechanism [19]. The servo circuit with ESP32 enables precise motion control using PWM signals, suitable for applications such as robotics. This integration supports responsive and scalable automated systems. By utilizing PWM (Pulse Width Modulation) on the ESP32, the angle of servo movement can be accurately controlled.

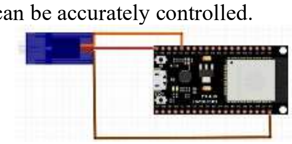

Figure 7 . Servo circuit with ESP32

2.5.4. Type K thermocouple with MX6675 Amplifier connected to ESP32
A thermocouple is a temperature sensor that utilizes two dissimilar metals to generate an electrical voltage due to the temperature difference, a phenomenon known as the Seebeck effect. Invented by Thomas Seebeck in 1821, thermocouples are popular due to their fast response, wide temperature range (-200°C to 2000°C), shock resistance, and ease of use [10]. The thermocouple family, combined with the ESP32, enables accurate temperature measurement over a wide range, making it ideal for environmental monitoring and temperature control. With modules such as the MAX6675 or MAX31855, temperature data can be read and transmitted in real-time over WiFi for remote monitoring, such as via Telegram.

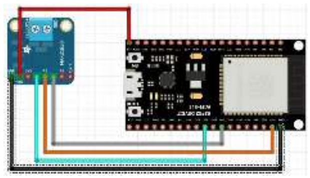

Figure 8 . K-type Thermocouple circuit with MX6675 Amplifier connected to ESP32

2.5.5. Soil Moisture Sensor with ESP32

The YL-69 sensor is a capacitive soil moisture sensor that measures the resistance between two conductors. The wetter the soil, the lower the resistance. This sensor operates at 5V with a voltage output of 0-4.2V [12]. The soil moisture sensor suite with ESP32 enables real-time monitoring, making it ideal for tracking the moisture content of cow manure in barrels. Data can be sent via WiFi or Bluetooth, and the ESP32 can automate watering when the soil is dry, thus improving fermentation efficiency

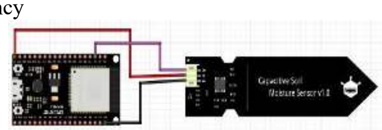

Figure 9 . Soil Moisture Sensor Circuit with ESP32

3. RESULTS AND DISCUSSION

3.1. Calibration of K-type thermocouple sensor

Calibration of K-type thermocouple sensors is an essential step in ensuring the accuracy and reliability of temperature measurements. By verifying and aligning the sensor response with a de ned standard measuring device, this calibration helps to reduce measurement errors and maintain the consistency of the resulting temperature data.

Table1 . Thermocouple sensor calibration

Value From Sensor Measurement (°C)	Value of Standard Measuring Instrument Measurement (°C)	Error Difference	Error (%)
28,45	28	0,45	1,6%
28,7	28	0,7	2,5%
28,2	28	0,2	0,7%
27,95	28	0,05	0,2%
27,7	28	0,3	1,1%
27,45	28	0,55	2,0%
28,2	28	0,2	0,7%
28,45	28	0,45	1,6%
28,7	28	0,7	2,5%
27,95	28	0,05	0,2%
Total Error		0,365	1,3%

3.2. Calibration of Soil Moisture Sensor

The Soil Moisture Sensor calibration stage ensures that the sensor functions properly in detecting soil moisture levels within the expected specifications. The Soil Moisture Sensor must first be calibrated with standard measuring instruments. This sensor calibration is performed to minimize measurement errors and ensure the sensor's value is as close as possible to that of the standard measuring instrument.

Table2 . Soil Moisture Sensor Calibration

Value of Sensor Measurement (%)	Measurement Value of Measuring Instrument (%)	Error Difference	% Error
33	30	3	10,0%
33	30	3	10,0%
32	30	2	6,7%
33	30	3	10,0%
33	30	3	10,0%
33	30	3	10,0%
33	30	3	10,0%
33	30	3	10,0%
32	30	2	6,7%
32	30	2	6,7%
Total Error		2,7	9%

3.3. Automatic Tool Testing

After testing the device, data were obtained on the fermentation process of cow dung for 14 days. The optimal temperature is expected to range from 40°C to 60°C, with humidity between 50% and 60%, to produce high-quality organic fertilizer. However, the highest temperature only reached 36.20°C and then continued to decrease, eventually reaching its lowest point of 26.95°C. Humidity levels were quite optimal, although some values exceeded the target, with the highest reading at 71% and the lowest at 43%. Fermentation began on the second day, characterized by an initial increase in temperature, followed by a gradual decrease every day.

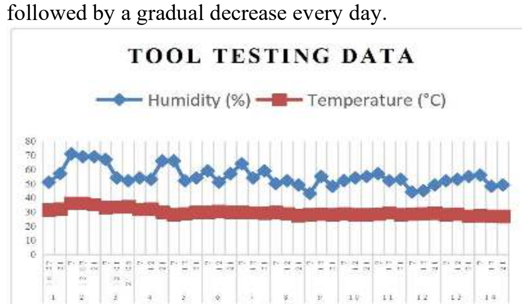

Figure 10 . Tool Testing Curve

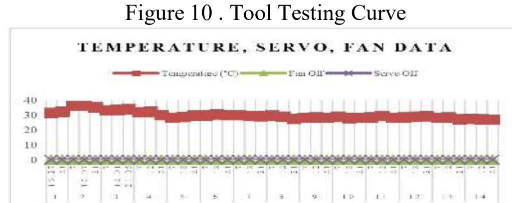

Figure 11 . Servo and Fan Response Curves

The curve above shows the response of the fan and servo, indicating that they are inactive during the fermentation process. This is because the temperature does not reach above 60°C during the fermentation process.

3.4. Manual Testing

The manual fermentation process is similar to fermentation using tools, but it is performed manually with human labor, including tasks such as stirring, liquid filling, and monitoring. The temperature and humidity ranges used were the same, namely 40°C-60°C and 50%-60% humidity. However, the highest temperature achieved was 39.70°C, close to the target, with the lowest temperature of 27.70°C. The humidity was also in line with the target, although some values were below the optimal level.

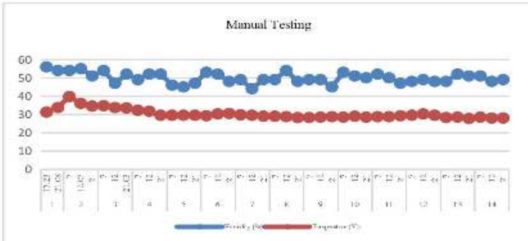

Figure 12 . Manual Testing Curve

3.5. Message Display on Telegram

The following notification is displayed on Telegram when fermentation is complete. Telegram also enables remote monitoring of fermentation conditions. Users can type the command '/status' to retrieve information on the condition of the cow dung, as speci ed in the settings.

Telegram Display	
Display of cattle fermentation conditions	The fermentation display is complete.

Figure 13 . Telegram display

3.6. Fermentation Results

The following are the results of the fermentation process for cow dung processed into organic fertilizer using two methods: manual and automated. The fermentation process is conducted over 14 days to achieve optimal results.

Automatic Tools	Manual
	

Figure 14 . Fermentation results

4. CONCLUSION AND SUGGESTIONS

Conclusion

The fermentation process lasted 14 days, with a maximum temperature of 36.20°C and a minimum temperature of 26.95°C, and a humidity range of 43% to 71%. Fermentation began on the second day, characterized by a rise in temperature. The use of automated equipment has proven to be more efficient than manual methods, as it produces a darker-colored, ner-textured, and more consistently high-quality fertilizer thanks to regular mixing. The efficiency of automated equipment includes time and labor savings, as well as complete control over processes such as mixing and fermentation duration. Monitoring is done through the Telegram app using the "/status" command and automatic notifications when fermentation is complete. The equipment is also equipped with vents and fans to maintain temperature.

4.2. Suggestion

In this study, the temperature obtained has not reached the ideal range of 40°C to 60°C, so it is necessary to add a heater or insulator. The gearbox experiences heat and wear due to improper positioning, so it needs to be repositioned and lubricated with the appropriate oil. Additionally, physical observation of the fertilizer is still performed manually by opening the fermentation container, which disrupts the anaerobic process. Therefore, the use of a monitoring camera is highly recommended for observation without the need to open the container directly.

5. REFERENCE

Farid, M. (2020). Assistance in Processing Cow Manure into Organic Fertilizer for Cattle Farmers in Pendanarum Village, Tempeh District, Lumajang. Syarifuddin Islamic Institute, Lumajang, Indonesia. Khidmatuna: Journal of Community Service; Volume 1, Number 1.

Astuti, F., Fatimah, I., Silvia, L., Purwaningsih, S.Y., Cahyono, Y., (2024), Processing Cow Manure Waste into Environmentally Friendly Organic Fertilizer in Slumbung Village, Gandusari District, Blitar Regency. Journal of Community Service, 8(1), 2024 (e-ISSN: 2613-9960).

Purnamsari, I., Ristiyana, S., Wijayanto, Y., & Saputra, T. W. (2022). Processing Cattle Manure into Organic Fertilizer to Improve Environmental Quality in Seputih Village, Mayang District, Jember Regency. Journal of Master of Science Education, 5(1). https://doi.org/10.29303/jpmpi.v3i2.1357.

Ida, DKK. (2020). Implementation of Internet of Things (IoT) in Processing Organic Fertilizer from Nodemcu-Based Cow Manure Waste. Computer Systems & Information Systems, STMIK Triguna Dharma.

Wibowo, Ariefcha Anugrah Adi (2018). Electronic Device Control and Monitoring System Based on Nodemcu ESP8266 and Blynk Application. Final Project, STMIK Akakom Yogyakarta.

Hobby, Around (2023). How to Ferment Manure from Cow Manure. Accessed on January 8, 2025, from https://kumparan.com/seputar-hobi/cara-fermentasi-pupuk-kandang-dari-kotoran-sapi-21NmLMuFrUR

Utomo, Kukuh Prasetyo (2018). Design of Humidity and Water Level Control System with Monitoring Using Human Machine Interface (HMI) on Schneider PLC Based Automatic Egg Hatching Machine. Bachelor Thesis, Undip.

Wibowo, Ariefcha Anugrah Adi - 143310013 (2018). Electronic Equipment Control and Monitoring System Based on Nodemcu Esp8266 and Blynk Application. Diploma thesis, STMIK AKAKOM YOGYAKARTA.

Suprianto (2015). AC Motor Theory and Types of AC Motors. Accessed on January 8, 2025, from https://blog.unnes.ac.id/antosupri/motor-ac-teori-motor-ac-dan-jenis-motor-ac/

Tempsens (2022). Definition of Thermocouple, Types and How it Works. Accessed on January 8, 2025, from https://tempsens.co.id/apa-itu-termokopel/

Umam, Faikul, Budiarto, Hairil, & Dafid, Ach. (2016). Electric Motor Publisher Deepublish (Cv Budi Utama Publishing Group). ISBN number 978-ISBN.

PUSPITASARI, SINTA DEVI - 193310020 (2022) IoT-based Tomato Plant Monitoring and Irrigation Using ESP

32. Diploma thesis, Digital Indonesia University of Technology.
Furqoni, Ramadhan - 173310020 (2020) RFID System Design for Easy Payment Login. Diploma thesis, STMIK AKAKOM Yogyakarta.
Hexahost (2023). Definition of RTC (Real-Time Clock), Types, and How it Works. Accessed on January 8, 2025, from https://hexahost.id/pengertian-rtc/
Widowati, Retno, Ladiyani, Hartatik, Wiwik, Setyorini, Diah, & Trisnawati, Yani (2022). Organic Fertilizer Made Easy, Harvests Abundant. Published by: Ministry of Agriculture of the Republic of Indonesia. ISBN 978 979 582 203 5. UDC 631.86:661.152.4
Bojonegoro District Government (2015). Production of Bokashi Fertilizer from Cow Manure and CharcoalUsingEM4Decomposer. Accessed on January 8, 2025, from https://bojonegoro.bojonegorokab.go.id/berita/baca/3
Rifky, Ihsan (2021). ESP32 microcontroller. Accessed on January 8, 2025, from https://raharja.ac.id/2021/11/16/mikrokontroler-esp32-2/
Nugroho, Septian Adi (2019) Implementation of Telegram Bot for Monitoring Mikrotik Router. Bachelor Thesis, University of Muhammadiyah Purwokerto.
Syahrul (2011) Servomotor Characteristics and Control. UNIKOM Scientific Journal, Volume. X, NO. 1, PP. 1-10. ISSN 1411-9374.