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Fertilization of Food Waste Management in UTHM's Cafeteria Using Arduino

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Abstract: Everyday food is consumed by humans for survival and basic needs for daily consumption. When humans eat food, there will be waste such as unfinished food or bones. With increasing food waste on earth, it can cause many kinds of diseases if the waste is not managed properly. Tons of food waste are created yearly on earth. To overcome the food waste problem, composting was introduced so we can recycle the food waste into compost fertilizer that can help improve soil nutrition. This research paper presents an overview of Fertilization of Food Waste Management in UTHM's Cafeteria. This project aims to produce compost fertilizer within a shorter time. The machine will preserve the food waste and let it decompose by letting good bacteria eat the waste. The machine will create an optimum temperature so that the microorganism can live and decompose food waste into fertilizer. Temperature and moisture are monitored during the decomposition of food waste. With the help of this machine, food wastage produces daily can be reduced. Different kinds of pollution and sickness can also be reduced so that humans can live in a healthy world.

Keywords: Compost, Fertilizer, Food

1. Introduction

Billion tons of food is being produced yearly for human consumption. Each country will have its local food manufacturer and local farmer that will work in making foods. Meals are essential for human consumption as healthy food will provide many benefits such as strong physical and mental, reduce the risk of chronic disease, and promote overall health. The nutrients in food allow the cells in our bodies to do the necessary functions. It is essential for the growth, development, and maintenance of body function. So, it will be a waste to thrown food away. Instead, we can consume it wisely with a considerable portion. By doing that, less food will be produced and can reduce the addition of garbage.

Roughly one third of the edible parts gets lost or wasted globally, which estimated around 1.3 billion ton per year [1]. Food waste has a significant impact on the economy of a country. Food waste represents

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big money wasted and management costs, given a large amount of edible food thrown away every year. The waste management will cost the maintenance of landfills (where food waste is disposed) as well as transport cost, separation costs in some cases, and operation costs for treatment plants. According to [1] "Producing food that will not be consumed leads to unnecessary CO_2 emissions in addition to the loss of economic value of food produced". Many kinds of current technology have been made to reduce the production of food waste. One of them is the technology in our refrigerator. The refrigerator will create an optimum temperature below 5 °C and -18 °C for frozen so that it can significantly increase the length of time foods can be stored [2]. There is also a technology where raw fruits and vegetables will be sprayed with an electrically charged solution that will kill bacteria responsible for spoilage. Thus, with many kinds of technology nowadays, less food waste is produced. Composting is a biological treatment process for organic constituents involving the placing of organic material in a pile with sufficient water and air to stimulate microbial activity [3]. The efficient method to dispose of organic waste is by composting it to use in the agriculture field [4].

Table 1 illustrates the literature research in which several methods of previous research being taken and become a guideline for this project.

Table 1: Comparison of related projects

NO	Title of the project	Implementation	Comments
1	Design of Organic Compost machine [5]	▪ Controller: - N/A ▪ Input Devices: - Temperature humidity sensor ▪ Output Devices: - Agitation Motor - Heating element - Exhaust fan ▪ Operation: - Agitation motor to move the blade which is used to slice the waste into small pieces - Exhaust fan to provide air for aerobic processes. ▪ Programming software: - N/A	▪ The controller was not stated in this project. Probably used Arduino since not many components needed to control. ▪ The design was simple and easy to make. Moreover, easy to retrieve the compost when done.
2	Design of Food Waste Recycling Machine [6]	▪ Controller: - Arduino microcontroller ▪ Process Decomposition: - Aerobic process ▪ Input Devices: - Temperature sensor - Moisture sensor - On/off button (power supply) ▪ Output Devices: - Mixing motor (Shear Mixing mechanism) - cutting motor (two-shaft shredder) - heating gun ▪ Operation: - Shredder will crush the food when entered for the top lid manually. - Then the motor will rotate to mixed the food waste and undergoes an aerobic process. ▪ Programming Software: - Arduino IDE	▪ Using a two-shaft shredder so it was able to cut hard material, including bones.

3	Design of Food Waste Recycling Machine [6]	▪ Controller: - Arduino microcontroller ▪ Process Decomposition: - Aerobic process ▪ Input Devices: - Temperature sensor - Moisture sensor - Proximity sensor (opening of the lid) - Advanced touch screen technology ▪ Output Devices: - Mixing motor (Diffusion mixing mechanism) - Cutting motor (sharp convex blades) - Heating coil - Advanced touch screen technology ▪ Operation: - It is a fully automatic system. - Food enters from the top where the lid is automatically opened. When entered, it gets shredded with sharp convex blades. - Then the motor will rotate to mix the food waste and undergoes an aerobic process. ▪ Programming Software: - Arduino IDE	▪ Fully automatic, which makes it more convenient and reduce human errors. ▪ Having a touchscreen panel that will make it easier to control and monitor.
4	Design of Food Waste Recycling Machine [6]	▪ Controller: - Arduino microcontroller ▪ Process Decomposition: - Aerobic process ▪ Input Devices: - Temperature sensor - Moisture sensor ▪ Output Devices: - Mixing motor (convection mixing mechanism) - Cutting motor (continuous spiral blades) - Heating element not stated - LCD screen and buttons ▪ Operation: - Food entered from the top which is manually opened the lid - Then spiral blades will slice the waste into small pieces. - After that, it continues to mix the chamber to be mixed and undergoes an aerobic process. ▪ Programming Software: - Arduino IDE	▪ The use of LCD is beneficial as we can monitor the process, although it is not very convenient as a touch screen panel.
5	Design of Kitchen Waste Composting Machine: A Smart Approach [7]	▪ Controller: - Arduino Uno ▪ Input Devices: - Heating sensor - Moisture sensor ▪ Output Devices: - Cutting motor - Mixing motor - Heating element (Nicker and Chromium) ▪ Operation: - Food waste will enter the cutting chamber to get crushed into a semi-powdered form.	▪ Use Arduino coding, which is easy to code and understand the process. ▪ The capacity of food waste is small, which is convenient to be stored and indoor use.

		- After some time, the material will go into a homogeneous mixing process at a low speed. - Now Heating will turn ON. Is it a biological process, it must go through heating at 60 Degree Celsius for a particular time. Continuous moisture sensing and heating sensing is going on. Once all parameters reached to set point, the heater and motor will turn OFF. ▪ Programming Software: - Arduino IDE	
6	Design and Development of Compost Bin for Indian Kitchen [8]	▪ Controller: - Switch ON/OFF ▪ Process Decomposition: - Aerobic process ▪ Output Devices: - DC motor ▪ Operation: - Vegetable waste is chopped with the help of a cutting blade setup on the top lid. - Accelerator and calcium oxide is put into composting bin parts to help with the aerobic processes. - Then the switch is switched on, and the mixing blade starts rotating which is connected to a DC motor and rechargeable batteries	▪ Despite fully manual and without monitoring systems, it could produce compost fertilizer. It is only in small quantities, and limited types of waste can be used.
7	Smart Chopper and Monitoring System for Composting Garbage [9]	▪ Controller: - Arduino Mega 2560 ▪ Process Decomposition: - Aerobic process ▪ Input devices: - Light-dependent resistor (LDR) - Ultrasonic Sensor - Room temperature sensor - Humidity sensor - Relay time clock ▪ Output Devices: - Light Indicator (LED) - Buzzer - Chopper motor - Chopper knife - Liquid Crystal Display (LCD) ▪ Operation: - The push-button acts as an emergency button if the trash can have an error when processing organic waste. - Arduino acts as a controller for the performance of household organic waste crushing trash boxes. - The relay disconnects or connects voltage to the motor so that the motor is controlled for on or off. - The ultrasonic sensor is used to determine whether the waste container resulting from the destruction of garbage is full or not. ▪ Programming Software: - Arduino IDE	▪ An ultrasonic sensor is useful to detect the level of waste full or not. ▪ Arduino programming software is easy and flexible for beginners. ▪ The Arduino component is cheap and easy to get.
8	Design and Development of	▪ Controller: - PIC 16F886 microcontroller	▪ The use of a microcontroller is

	Automatic Rabbit Droppings Compost Grinder [10]	▪ Input Devices: - 4x4 keypad. ▪ Output Devices: - water pump motor. - Grinder motor. - LCD 16X2. ▪ Operation: - The rabbit waste is filled into the container of manure that acts as the container that will keep the waste until it becomes the manure. - After setting the timer, the grinder blades will mix the waste into the parts. - Simultaneously, the water was also pumped into the manure container with a mixture of yogurt and brown sugar. ▪ Programming Software: - MP Lab software (C language)	cheaper and easier instruction for the system ▪ The use of a water pump is useful in transferring liquid substances. ▪ Implementation of relay made it easier to turn on and off of the motor.
9	Design and Test of the Smart Composter Controlled by Sensors [11]	▪ Controller: - Programmable Logic Controller (PLC) ▪ Process Decomposition: - Aerobic process ▪ Input Devices: - Temperature sensor - Humidity sensor - PH level sensor ▪ Output Devices: - Rotating drum motor - Heating element - Water sprinkler ▪ Operation: - The rotating drum will spin to mix the waste and activate the aeration process. - Temperature, humidity, NH3 content, PH level, and oxygen level are checked through sensors installed regularly. - After receiving the data, the server-based cloud platform will store the data in the database. - Then the client (including the machine control console, the mobile phone device, and the remote web browser) will get data from the database promptly. ▪ Programming Software: - CX-programmer	▪ Checking the production of compost wirelessly is very efficient as it can be checked anywhere and anytime. ▪ The use of PLC is important because PLC supports multiple inputs and outputs. ▪ Support with a hard material such as branches, hay, and even manure.
10	A microcontroller-based household anaerobic food digester[12]	▪ Controller: - Arduino Mega 2560 ▪ Process Decomposition: - Anaerobic process ▪ Input Devices: - Heating sensor (LM35) - DFRobot PH meter kit ▪ Output Devices: - Macerator pump - LCD - DC motor (Mixing and cutting) - Heating element ▪ Operation: - Food chopped into small pieces. - Macerator pump is used to pump food waste between containers.	▪ Do not support with a hard material such as bone or wood. ▪ Arduino programming software is easy and flexible for beginners.

		- DC motor is turned on when food waste is pumped into the second container, which is turned on 3 minutes per hour. - Temperature sensors and PH sensor read every 10 minutes and the water pump and heater switched on or off accordingly ▪ Programming Software: - Arduino IDE	
11	Design of Compost Machine [13]	▪ Controller: - N/A ▪ Process Decomposition: - Aerobic process ▪ Input Devices: - Heating sensor - Humidity sensor - Digital centriolar ▪ Output Devices: - Agitation motor - Exhaust fan - Heater ▪ Operation: - Waste entering from the top lid and goes straight into the U-shaped tank. - Then agitation motor will start to mix the food waste mixed with particular bacteria called "Acidulo." - The temperature sensor will be running to maintain the temperature inside the tank. The same goes for the humidity sensor. ▪ Programming Software: - N/A	▪ The addition of food waste with bacteria helps to improve the decomposition of food.
12	In-Vessel Composting System to Manage Pre and Post-Consumer Cafeteria and Ground Landscape Waste [14]	▪ Controller: - Programmable Logic Controller (PLC) ▪ Input Devices: - Touch screen panel - Temperature sensor - Variable frequency drives ▪ Output Devices: - Conveyor - Trommel - Drum motor - In-feed Auger - Exhaust fan - Mixer motor ▪ Operation: - Food will be poured into the mixer, where it will be sliced and aerate the waste. - Then In-feed Auger will move the compost into the compost drum. - The compost drum will rotate where air and heat will mix with the compost to speed up the composting process. - After finish, the conveyor will move the compost to other places. ▪ Programming Software: - N/A	▪ This project utilizes large space as the machinery was made on a large scale. ▪ Using a rotating drum is hard to design because of the stationary part, and rotating parts need to be separated.

2. Materials and Methods

A block diagram is used to represent the layout and function of the device that is involved. Within this sub-chapter, the project's design will be briefly explained and illustrated. This project consists of 3 main sections where the first part will be retrieving plates from the conveyor, grinding food is second, and the third is mixing. Figure 1 illustrates the overall process of making compost fertilizer. It will show the process of what will occur to the system.

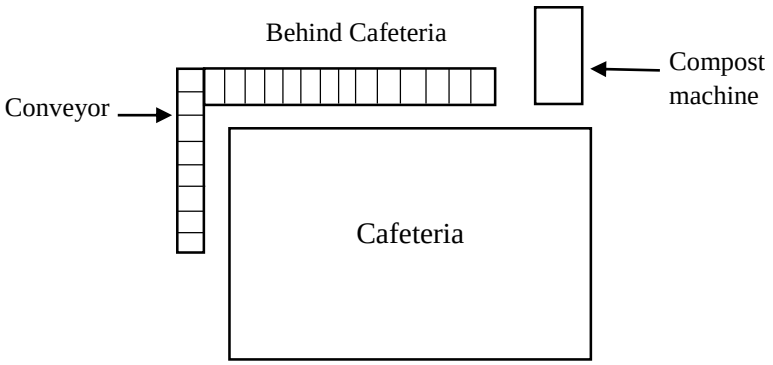

Figure 1: Overall layout design

Figure 2 shows the block diagram for the Fertilization of Food Waste Management, which will be using Arduino MEGA2560 as a controller to control all the inputs and outputs. All of the sensors will be installed near the mixing tank to get accurate readings.

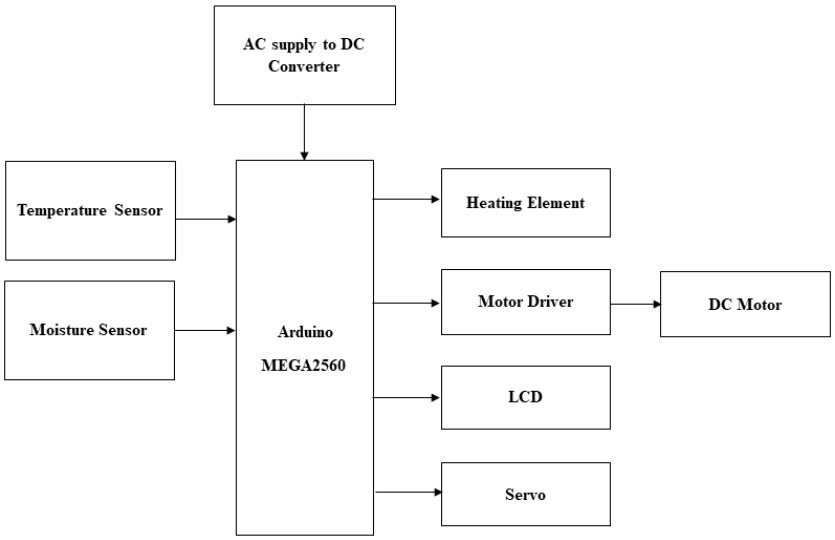

Figure 2: Fertilization of Food Waste Management block diagram

2.1 Materials

Table 2 shows the list of components for electrical parts and mechanical parts.

Table 2: List of components

Component	Item	Description
1. Electrical Components	- Arduino MEGA2560	54 digital I/O pins, 16 analog input
	- Heat sensor	LM35 heat sensor
	- Moisture sensor	Detect moisture of the compost

	- AC to DC converter	240 AC to 12V DC output
	- Push-button	ON and OFF operation
	- Liquid Crystal Display	16x2 display
	- DC motor	6-12 V DC motor
	- PTC aluminum heater	Increase the temperature
	- L298N Driver	Control the motor
	- Relay 2 channel	Control ON/OFF of heater
	- Relay 1 channel	Control ON/OFF of fan
2. Mechanical Components	- Mild steel sheet	Internal structure
	- Mild Steel rectangular hollow	External structure

2.2 Methods

The programming begins with the flowchart, which is essential to the step-by-step procedure to solve the solution. By using these programming techniques, the process flow and instruction for the programmed code could be shown to resolve the issue.

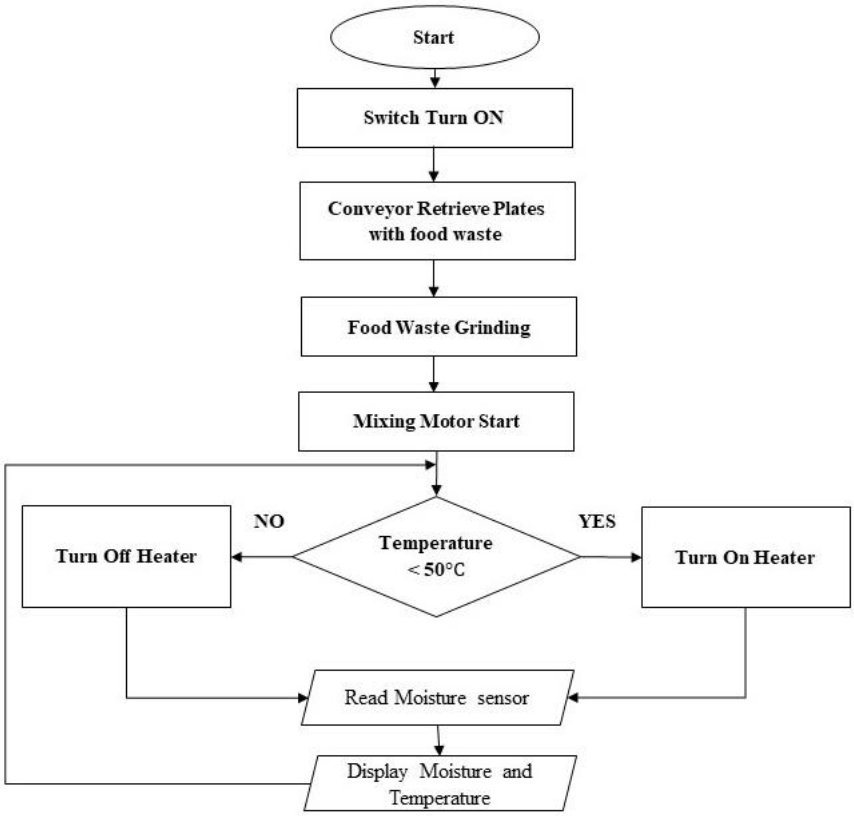

Figure 3: Flow Chart for Controlling Fertilization of Food Waste Management

3. Results and Discussion

An experiment is conducted to determine with a temperature set to 50 °C, can food waste be decomposed when an effective microorganism is added. 0.5 liters of food waste is used to be filled into the compost machine prototype. Moisture and temperature will be controlled and monitored during the

decomposition of food waste. From Figure 4, banana peel, rice, pineapple peel, anchovies, bread, and mango peel are used to experiment.

Figure 4: Excess Food Waste Used

Table 3 shows the performance of each of the systems.

Table 3: Performance of each system

No	System	Performance	Condition
1	Compost machine	- Mixing motor = 100 PWM (3.0 kg torque) - Grinder motor = 255 PWM (0.5 kg torque) - PTC aluminum heater = Turn on when the temperature below 50 - Moisture sensor = Measure the moisture of the compost	• Arduino Controller = Working • LM35 = Working • Moisture sensor = Working • LCD = Working • Relay = Working • DC motor = Working • Motor driver = Working • PTC aluminum = Working
2	Conveyor	- Servo motor = 80 PWM	• Servo motor = Working

3.1 Results

Table 4 shows the moisture and temperature recorded for 48 hours in the tank.

Table 4: Moisture and temperature for 48 hours

Time (Hours)	Temperature (^{o}C)	Moisture (%)
3	25	80
6	30	76
9	36	76
12	40	74
15	48	70
18	53	68
21	60	68
24	59	68
27	55	65
30	50	65
33	50	65
36	49	65
39	49	65

42	50	65
45	50	65
48	49	65

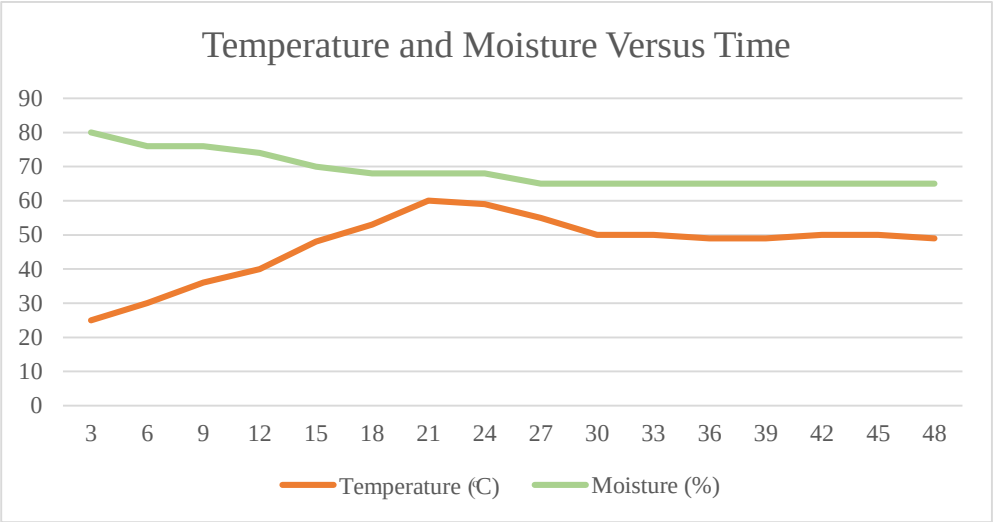

Figure 5: Graph of Temperature and Moisture versus Time for 48 hours

Table 5: Comparison of PH for compost fertilizer with normal soil

Organic Material	PH
Compost fertilizer	5.1
Soil for chili tree	5.0
Soil for flower	6.0
Soil for grass	6.6

From table 5, we can see that the compost fertilizer PH value is close to the other three soil tested. This means that compost fertilizer produced is safe to be used. The addition of lime or dolomite can be used to reduce the acidity of the compost fertilizer.

Figure 6: Compost Fertilizer

Figure 5 shows the result after two days of decomposing. It is still wet due to the low power heater used to heat the tank.

3.2 Discussions

From figure 4, we can see the trend of temperature and moisture. The moisture gradually decreases as the temperature keeps rising to make all the water evaporate. Due to the low temperature emit from the PTC aluminum heater, not all water in the tank evaporates. For the temperature during the first twelve hours, it is in the mesophilic temperature range. The temperature ranges from 25 °C- 40 °C. This is the initial state where the bacteria start to grow. For the next eighteen hours, it is in thermophilic temperature where the microorganism starts actively decomposing the food waste. Temperature ranges from 48 °C to 50 °C where the highest temperature recorded is 60 °C. After that it enters the mature process where there is no more food to decompose, because of that the temperature gradually decreases. Temperature sensors have been set to 50 °C as the minimum temperature in the tank, that is why the graph shows constant temperature in the tank during the mature process.

4. Conclusion

It was a great experience to make the Fertilization of Food Waste Management in UTHM's Cafeteria as The Final Year Project. The project has achieved all the listed project objectives. The software used to investigate and characterized the compost machine and conveyor system is implemented by using the Arduino IDE platform. The result shows that compost fertilizer can be produced. With controlled temperature for the growth of effective microorganisms in the tank, the microorganism can decompose the food waste. With this, garbage created daily can be reduced as the excess food can be recycled into compost fertilizer. The performance of the Arduino controller with the fabricated prototypes works as expected which can demonstrate the system application. In a conclusion, the Fertilization of Food Waste Management in UTHM's Cafeteria is accomplished with the contribution both of software and hardware development.

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