Eco-Friendly Waste Management: A Segregation and Composting System for Domestic Use

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Abstract. The proper disposal of home garbage has recently emerged as a pressing issue on a global scale. Also, the city government has been trying to get people to separate their dry and moist trash. But there is still a problem with trash management and a big domestic population that isn't helping out. This paper details the process of creating a waste management system that separates organic kitchen trash into dry and moist categories. Both models are part of the proposed system: The first step is to design a bin that can separate dry and moist trash. Additionally, a composting facility is showcased for the purpose of transforming organic waste into compost. Twenty homes' worth of garbage was fed into the suggested model, and the results show promise for trash segregation and composting.

Keywords. Wet Waste, Dry Waste, Compost, Sorter Bin, Trash Management.

1 Introduction

Recycling and waste disposals are one of the world's most pressing problems right now. About half of the world's trash consists of organic materials. The second most populous nation in the world (India) produces almost 143,449 MT of solid waste daily. Garbage that is both organic and inorganic is mixed together. Approximately three-quarters (about 78%) of the trash is recyclable, with food scraps making up the majority. The improper segregation of rubbish leads to its improper disposal on the ground, where it mixes with inorganic waste, creating a horrible stench and degrading the soil [1]. Effective management of solid waste requires proper sorting at the point of generation (houses). Garbage must be separated into organic and inorganic components; the former can be composted [2]. Soil conditioner compost is made when organic waste is broken down by microbes in an oxygen-rich environment; the resulting soil is rich in nutrients [3]. City compost, which is made from biodegradable solid waste can be used in place of kitchen garbage.

The quantity of solid garbage produced by municipalities and businesses has grown due to rising urbanisation and industrialization. In poor nations in particular, landfilling the practise of disposing of solid waste in open dumpsites is by far the most prevalent waste management

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strategy [4]. The landfilling process has major environmental implications, despite its apparent economic viability as a waste disposal option. The effects of landfilling on ecosystems have been the subject of investigations by researchers from across the world. Toxic effects on different kinds of animals, pollutants in the air and water, and pollutants in the soil and vegetation are all things to consider [5]. To make garbage management easier, this endeavour primarily aims to segregate waste streams, such as organic waste and metallic waste. Reusability is possible due to the waste's great recovery potential [6]. The requirement for pesticides can be reduced or eliminated when the wet waste is converted into manure [7]. However, the metal scraps can be reused and recycled. Disposal of waste has lately sparked debates all over the globe. The production and disposal of a substantial amount of waste have negative impacts on the ecosystem [8]. To reduce pollution and find new uses for trash, composting and biogas production are viable remedial methods. The farmers stand to gain in the long run from this approach [9]. The environment is affected by inefficient and disorganised garbage handling. Cities may be kept cleaner, greener, and more habitable for healthy living through the trash creation and recycling cycle [10]. An affordable equipment that might be used for small-scale composting of food scraps. This system achieved a practical efficiency of 64.09% compared to an ideal efficiency of 80% [11]. A method for making a compost container for an Indian kitchen that is aesthetically pleasing, ergonomic, and odour-free. Composting blades, air filters, and a collection pan make up composting chamber of the compost bins [12]. The usage of rechargeable batteries makes the product portable. The air filter uses Azadirachta Indica and Gomaya pellets, which are antimicrobial and prevent unpleasant smells. A direct process allows the user to keep things clean. Authors [13] explains how to compost food scraps more quickly using a simple and inexpensive system. Composting typical vegetable scraps in a bacterial composter took roughly sixty days in a controlled laboratory setting. Size of particles, amount of water, temperature, and air circulation were some of the factors that controlled the amount of time it took for compost to break down [14]. To monitor the disposal of solid waste, a system was suggested. A proximity sensor detects metal trash, and the input component regulates the flow of trash onto the conveyors [15]. The use of a blower mechanism allows for the separation of dry and moist waste. The timing and motion of the conveyor belt are managed by the Arduino Uno. This method of trash sorting is time-consuming, and the trash size needs to be very close to the dimensions of the funnel [16]. An automated clustered mixed waste maintenance system model was created to lay the groundwork for fully automated waste management systems. The mobility and sweeping mechanism of the machine were controlled using a wireless link [17]. A model for solid waste management was created with an emphasis on the collection and separation stages. There are three main parts to the framework: hardware, software, and the trash collection schedule monitoring and control subsystem. The extra data visualisation and management subsystem is introduced for analysis and management purposes [18]. Intelligent systems and radio frequency identification (RFID) were suggested by the authors [19] as a means to track and control solid waste. The system for tracking the location of garbage trucks incorporates radio frequency identification technology, a geographic information system, and mobile communication networks like GSM. The use of sensors in trash cans to autonomously sort rubbish and generate reports for garbage trucks was discussed by researchers [20]. Here, rubbish classification makes use of image recognition and ML methods. An urban household waste segregation system that is compact, inexpensive, and easy to use is the target of this effort Incorporating an automatic sorter bin (ASB) to segregate organic garbage from dry trash, the project model incorporates a wet and dry waste separator to assist the recycling and utilisation of metal trash. After that, the right process is used to transform organic waste into compost.
2 Software and Hardware Description

An autonomous sorter bin and composting unit was conceptualised, designed, and built using a set of input/output devices shown in Table 1.

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Components</th>
<th>Range/Type</th>
<th>Purpose</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Inductive sensors</td>
<td>LJ30A3-15</td>
<td>To Sense the inorganic as well as organic waste</td>
</tr>
<tr>
<td>2</td>
<td>DC Motor (Stepper)</td>
<td>5V</td>
<td>To Switch the wheel of BO motor</td>
</tr>
<tr>
<td>3</td>
<td>Adapter</td>
<td>12V</td>
<td>For supply</td>
</tr>
<tr>
<td>4</td>
<td>Board</td>
<td>Arduino UNO</td>
<td>To regulate the whole procedure</td>
</tr>
<tr>
<td>5</td>
<td>Ultrasonic sensor</td>
<td>HC-SR04</td>
<td>To Spot the garbage</td>
</tr>
<tr>
<td>6</td>
<td>LEDs: Red Green</td>
<td></td>
<td>Program awaiting the arrival of an item When using the machine, not allowed to toss anything.</td>
</tr>
<tr>
<td>7</td>
<td>Motor Driver</td>
<td>ULN2003</td>
<td>To regulate the speed of the stepper motor</td>
</tr>
</tbody>
</table>

2.1 Arduino UNO

The LJ30A3-15 Inductive Proximity sensor, ATmega328 Arduino Uno microcontroller, and HC-SR04 ultrasonic sensor are shown in Fig. 1(a) to Fig. a(c). As its central processing unit, this project makes use of the Arduino UNO microcontroller. The microcontroller's internal clock frequency is 16 MHz, and it features a crystal oscillator, 6 analogue I/P pins, and 14 digital I/O pins. Using a printer USB link, the Arduino IDE can be used to transfer...
programmes to the Arduino board. Processors employ random access memory (RAM) to carry out software instructions read from flash memory. With this board comes a 1KB EEPROM, or Electrostatic Read Only Memory. Data remains accessible after powering off or restarting the device due to this form of long-term storage. The C++ based Arduino Programming Language is an internal framework that is fully supported by Arduino. The Arduino IDE is software that includes an editor with pre-built libraries and a way to rapidly construct and upload our programmes onto a computer-connected board [21].

2.2 Inductive Proximity Sensor

For this model, the manufacturer opted for the LJ30A3-15 inductive proximity sensor, which allows it to detect metallic objects in close proximity without actually touching them [22]. It can distinguish between organic waste and metal-containing trash. The inductance principle, upon which an inductive proximity sensor is built, states that a target item's electromotive force (EMF) is produced by a changing current. The proximity sensors are designed to detect ferrous objects of varying thicknesses, ideally with a thickness of less than one millimetre, like mild steel [23].

2.3 Ultrasonic Sensor (HC-SR04)

The suggested automatic sorter bin has an HC-SR04 ultrasonic sensor attached to its intake for the purpose of detecting trash dropping into the bin. The HC-SR04 has two transducers that generate ultrasonic waves. A single transducer acts as a transmitter, translating electrical signals into ultrasonic pulses with a frequency of 40 kilohertz. To detect the broadcast pulses, the receiver tunes in. An ultrasonic sensor measures the distance a pulse has travelled by generating and outputting pulses of varying widths in response to pulses received at the receiver. Ultrasonic sensors provide superior non-contact range sensing in the 2-400 cm range, with a resolution of 3 mm.

3 Experimental Process of the System

3.1 Strategy of Automatic Sorter Bin

Using an Arduino UNO microcontroller as its central component, the suggested automatic sorter bin separates organic garbage from metallic rubbish. Fig. 2 and Fig. 3 display the automatic sorter bin's block diagram and connection diagram, respectively.
Fig. 2. An Experimental Layout of Automatic Sorter Bin

Fig. 3. An Experimental Wiring Illustration of Proposed System
The introduction of an ultrasonic sensor allows for the detection of falling garbage. The waste is detected using ultrasound by means of the trigger pulses. After receiving the garbage echo, the microcontroller uses it to calculate the latency. The ultrasonic sensors are installed to make sure the organic and metallic disposal containers do not overflow. An inductive proximity sensor can detect metal objects without touching them physically. It determines if the trash is made of biological materials or metal. Fig. 2 shows the two trash cans attached to a stepper motor at a right angle to one another. According on the proximity sensor's predicted readings, the right trash can is selected. Fig. 4 is a flow diagram of the algorithm that is suggested for trash management.

### 3.2 Composting Unit

The composting device is used to turn the segregated organic waste into compost. Fig. 5 shows the composting unit's block diagram. The primary goal in developing this composting unit was to address the organic waste that is generated in the kitchen. Instead of spending too much time chopping or thrashing the leftovers by hand, a kitchen waste shredder is used to prebreak, rough size, or fine size the waste.
3.3 Calculations of Load

The 1HP induction motor was used to operating at full load from 230 V [24].

1 HP = 745.7 Watts

Power (P) = V×I (Watts) \hspace{1cm} (1)

I = Power/V = 745.7/230 = 3.242 A

Force (F) = m×a (N) \hspace{1cm} (2)

Where,

a = acceleration due to gravitation (9.81 m/s²)

m = Waste in mass (kg)

F = Force required (N)

F = 10×9.81 = 98.10 N

P = \left[\frac{2×3.14×N×T}{60×746}\right] \hspace{1cm} (3)

By assuming N = 100 rpm,

T = \left[\frac{(60×746×1)}{2×3.14×100}\right] = 71.23 Nm

Heating coil Calculations

(P) = \frac{V^2}{R} \hspace{1cm} (4)

Whereas

R = Heating coil Resistance Ω

V = Voltage (V)

P = Power (kW)

R = \frac{V^2}{P} = \left[\frac{230^2}{(1.2×1000)}\right] = 44 Ω

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![Diagram](image-url)

**Fig. 5.** An experimental layout of Composting Unit

Calculation of Composting Tank Area

Area of the composting tank = L×W \hspace{1cm} (5)

Whereas,

L= Length (m)

W= Width (m)

Area = 0.92×0.611 = 0.562 m²

Volume of the composting tank = L×H×W (m³) \hspace{1cm} (6)

= 0.92×0.763×0.611 = 0.428897 m³

Capacity of the composting tank = \left[\frac{L×H×W}{1000}\right] \hspace{1cm} (7)

= \left[\frac{(0.92×0.763×0.611/1000)}{1000}\right] = 428.897 m³
The composting tank was constructed using the aforementioned equations.

4 Results and Discussions

The outcomes of the comprehensive project model are detailed in this section. The food scraps were gathered from 20 different homes. The proposed automated sorter bin successfully separated dry and wet waste. Table 2 shows the various types of wastes that were grouped. About four or five seconds elapsed during segregation on average. Since only organic waste can be utilised to generate compost, Table 3 indicates the length of the peels after shredding. Shredder blades were placed close to the composting tank's entrance to further shred the organic waste that had been divided into small particles. The shredded waste is then sent into the composting tank, where it is assisted by a rotary motor with a shaft that has blades. The graph in Fig. 6 demonstrates the decrease in organic waste volume over various time intervals. The volume of the organic waste decreases as a result of the moisture content evaporating. Ten kilogrammes of wet trash, after shredding and composting for ten days, was used for the aim of this test. As can be seen in Fig. 7, we also took note of the composting unit's temperature. A heating coil and 1kW engine were used in the composting unit's construction. Multiplying 746 W by 0.5 hours yielded 0.373 kWh, assuming a continuous runtime of 30 minutes every day.

Table 2. Sorting Organic and Dry (Metal) Waste into Different Categories

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Wastes types</th>
<th>Dry (Metallic)</th>
<th>Organic</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Onion peel</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>2</td>
<td>Pepsi Tin</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>Brinjal</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>4</td>
<td>Watermelon peel</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>Broken Spoon</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>Carrot peel</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>7</td>
<td>Capsicum</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>8</td>
<td>Egg shell</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>9</td>
<td>Coriander leaves</td>
<td>*</td>
<td></td>
</tr>
<tr>
<td>10</td>
<td>Pumpkin Peel</td>
<td></td>
<td>*</td>
</tr>
<tr>
<td>11</td>
<td>Badam Milk Tin</td>
<td></td>
<td>*</td>
</tr>
</tbody>
</table>

Table 3. Residual Waste Size after Descreening

<table>
<thead>
<tr>
<th>Sl. No.</th>
<th>Kitchen Waste</th>
<th>Initial Dimension of a specimen (cm)</th>
<th>Final Dimension of a specimen after cut (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>Brinjal</td>
<td>4.2</td>
<td>2.0</td>
</tr>
<tr>
<td>2</td>
<td>Carrot peel</td>
<td>3.9</td>
<td>1.6</td>
</tr>
<tr>
<td>3</td>
<td>Watermelon Peel</td>
<td>4.7</td>
<td>2.3</td>
</tr>
<tr>
<td>4</td>
<td>Pumpkin Peel</td>
<td>5.2</td>
<td>2.5</td>
</tr>
<tr>
<td>5</td>
<td>Capsicum</td>
<td>3.3</td>
<td>1.7</td>
</tr>
<tr>
<td>6</td>
<td>Onion peel</td>
<td>4.3</td>
<td>1.5</td>
</tr>
<tr>
<td>7</td>
<td>Banana Peel</td>
<td>5.4</td>
<td>2.7</td>
</tr>
</tbody>
</table>
Coriander leaves 4.5 1.9

During the given time period, the total running cost of the composting unit is 1.492 units, calculated as 0.373 × 4.

**Fig. 6.** Comparison of Organic Waste Drop Weightage in Different Days

**Fig. 7.** Comparison of Recorded Temperature During the Composting Process

## 5 Conclusions

The outcomes of the comprehensive project model are detailed in this section. The food scraps were gathered from 20 different homes. The proposed automated sorter bin successfully separated dry and wet waste. This research work detailed the process of creating
a waste management system that separates organic kitchen trash into dry and moist categories. Additionally, a composting facility is showcased for the purpose of transforming organic waste into compost. Twenty homes' worth of garbage was fed into the suggested model, and the results show promise for trash segregation and composting. The volume of the organic waste decreases as a result of the moisture content evaporating. An automated sorter bin is used to separate dry and wet trash in the proposed system, and the composting model is employed to progress the organic trash that has been separated. For better and cheaper waste management, it offers a compact, inexpensive, and easy-to-use separation system. In urban areas, this system streamlines garbage collection and disposal for homes, schools, and businesses.

References


