Development and evaluation of a mini trommel for small-scale vermicompost screening

Mark Angelo Ilagan, Marjun Caguay*

(Institute of Agricultural and Biosystems Engineering, Mindoro State University, Alcate, Victoria, Oriental Mindoro, 5205, Philippines)

Abstract: The increasing demand for high-quality compost has highlighted the need to improve post-composting processes, particularly sifting, which remains labor-intensive and time-consuming in many small- and medium-scale operations. This study aimed to develop a mini compost trommel machine using locally available materials and technologies to enhance screening efficiency, reduce manual labor, and promote sustainable compost production. The machine was designed, fabricated, and evaluated based on input capacity, screening efficiency, electrical energy consumption, noise level, and economic viability. Testing was conducted using 150 kg of vermicompost across five trommel screen speeds (10, 20, 30, 40, and 50 rpm) with three replications per treatment, following a Completely Randomized Design. Results showed a maximum screening efficiency of 97.65% at 10 rpm and an input capacity of 473.46. kg hr^{-1} at 30 rpm. Noise levels remained within safe occupational limits (66 –75 dB), and no significant variation in energy consumption was observed across treatments. Economic analysis indicated a favorable payback period of 1.04 years and a 51.35% rate of return. The findings demonstrate that the mini compost trommel machine is a cost-effective, energy-efficient, and high-performance solution suited for small-scale compost producers.

Keywords: mini compost trommel machine, vermicompost screening, compost mechanization, screening efficiency, input capacity, energy consumption, cost analysis

Citation: Ilagan, M. A., and M. Caguay. 2026. Development and Evaluation of a Mini Trommel for Small-Scale Vermicompost Screening. Agricultural Engineering International: CIGR Journal, 28(2):275-291.

1 Introduction

Composting is an essential agricultural practice that supports sustainable farming by converting organic waste into nutrient-rich material. This organic amendment enhances soil fertility, improves structure, increases microbial activity, and contributes to better water retention and drainage—ultimately leading to increased crop yields. Composting also plays a vital role in reducing the volume of agricultural and household waste, thereby mitigating environmental pollution. However, one of the most laborious stages in the composting process is the sieving or sifting of compost to remove non-biodegradable materials, stones, clods, and undecomposed plant residues. These contaminants, if not removed, may harm plant roots and inhibit healthy growth. Screening compost is vital to ensure its suitability for agricultural use, as unwanted materials like twigs and stones can impede root development and soil integration (Churchill, 2021; Miller, 2005; Pleasant, 2024; US Composting Council, 2023; United States Environmental Protection Agency [EPA], 2025).

Received date: 2025-06-15 **Accepted date:** 2026-03-30

***Corresponding author: Marjun Caguay.** Institute of Agricultural and Biosystems Engineering, Mindoro State University, Oriental Mindoro, 5205, Philippines. Email: jupitermercurio@gmail.com.

The mechanized compost trommel requirement has become increasingly apparent, especially in light of the growing demand for compost and vermicompost products. A study by Acabal (2022) revealed a steady rise in vermicompost fertilizer production and sales, increasing from PHP 1,370,469 in 2015 to PHP 1,631,700 in 2019, with projected revenues reaching PHP 2,253,686 by 2024. These figures underscore the need for improved compost processing technologies to meet market demands.

Despite this need, several technical challenges hinder the development of suitable mechanized sifters. One major issue is the lack of standardized drum speeds in existing trommel designs. Literature reports a wide range of operating speeds, including 12-15 rpm 18–20 rpm (Deya Machinery, 2023), 20–25 rpm (Wilson, 2014), 40 rpm (Kabudake et al., 2020), and 50 rpm (Manyuchi and Phiri, 2013). Another challenge lies in the choice of screen material: while galvanized iron mesh is common, it is prone to rust when exposed to moist compost, and alternative materials such as chicken mesh often lack the structural strength to withstand operational loads.

This study aims to develop a mini compost trommel machine using locally available materials and fabrication technologies. The objectives include the design, construction, and evaluation of the machine in terms of sifting capacity, efficiency, electrical energy consumption, and operational cost. The purpose is to create an accessible and cost-effective mechanized solution that can reduce labor requirements, increase productivity, and support the economic viability of small- and medium-scale compost producers.

Through this innovation, the study contributes to the mechanization of compost processing and the broader goal of promoting sustainable and efficient agricultural practices in the local setting.

2 Materials and methods

2.1 Conceptualization of the study

Organic farmers in the Philippines commonly use compost as a growing medium, soil amendment, and potting mix during crop production. Due to the increasing demand for compost and the abundant availability of biodegradable waste, municipal composting facilities have been established across the country, including in Oriental Mindoro. In addition to these public initiatives, several private organic farmers and community organizations also produce their own compost.

The conceptual framework of this study outlines the key activities required to achieve its objectives. As part of the input stage, benchmarking was conducted through field visits and interviews with vermicompost producers. Insights into the challenges and suggestions of target users regarding the mechanization of the compost sifting process were collected and considered during the machine design phase. Existing designs, relevant literature, and Philippine national standards for agricultural machinery were also reviewed to analyze each component of the machine, identify appropriate materials, and understand its working principles.

The expected output of the study is a mini compost trommel machine designed to assist laborers by reducing the physical effort involved in the compost sifting process. This machine aims to enable workers to complete sifting tasks more efficiently within a single day without requiring additional labor, ultimately improving productivity and operational efficiency. Figure 1 presents the conceptual framework of the study, following the Input-Process-Output (IPO) model.

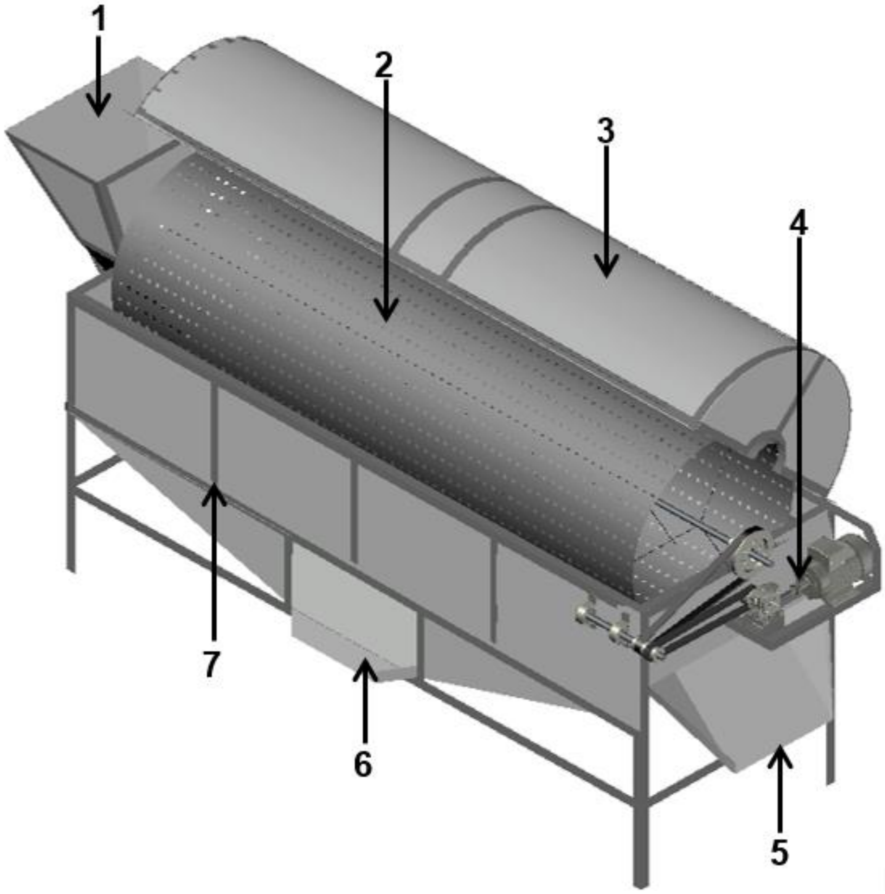
2.2 Design and description of major components

The mini compost trommel machine is specifically designed to facilitate the sifting process of compost. It is intended for operation by a single user, with the goal of reducing the labor intensity associated with manual sifting while improving productivity and screening efficiency. These considerations were integrated into the design conceptualization, which was developed using AutoCAD software.

The major components of the machine include the trommel screen, power transmission system, and frame assembly. All parts and materials are intended to be locally sourced and fabricated using equipment commonly available within the locality. The design emphasizes user-friendly features to ensure ease of operation, comfort, and safety for the operator. Figure 2 illustrates the detailed design of the machine.

INPUT	**PROCESS**	**OUTPUT**
1. Literatures, IP search, design considerations, Autodesk AutoCAD	1. Design conceptualization, design analysis, design calculations	1. 2D and 3D Design plan of the Mini compost trommel machine
2. Design plan of the machine, licensed manufacturer, locally available materials	2. Fabrication of the machine using local manufacturing technology	2. Mini compost trommel machine
3. Mini compost trommel machine and other test materials	3. Preliminary Testing, Adjustments, Final Testing and Performance Evaluation	3. Machine operating performance, energy demand and other assumptions
4. Machine operating performance, energy demand and other assumptions	4. Cost analysis	4. Cost of operation and other financial indicators: Break-Even Point (BEP), Payback Period (PBP), and Rate of Return (ROR)

Figure 1 Conceptual framework of the study



Legend	
1	Hopper
2	Trommel Screen
3	Screen Cover
4	Transmission Assembly
5	Foreign Matter Discharge Chute
6	Compost Discharge Chute
7	Frame Assembly

Figure 2 design of the mini compost trommel machine

2.2.1 Trommel cylinder assembly

The trommel is a cylindrical unit equipped with a perforated screen that rotates to separate fine compost particles from larger clods, non-biodegradable materials, and undecomposed waste. The screening drum was fabricated using two perforated stainless-steel sheets, each measuring 4 ft × 8 ft with 3 mm-diameter holes. These sheet dimensions were selected based on local commercial availability and fabrication practicality, allowing the formation of a cylindrical screen with adequate length and diameter for continuous compost flow.

The perforation size of 3 mm was chosen based on preliminary benchmarking of locally produced vermicompost and on reported ranges in the literature, where hole sizes between 2 and 5 mm are commonly used for fine compost screening. The selected diameter was found to effectively separate market-ready compost while retaining oversized particles such as clods, stones, and undecomposed organic matter. Although compost characteristics vary depending on feedstock and production location, the 3 mm perforation provided a balanced compromise between screening efficiency and throughput for the vermicompost used in this study.

To form the cylindrical structure, a supporting frame was constructed using 3/16 in × 1½ in flat bar, ½ in diameter steel round bar, and ⅜ in diameter rebar to ensure structural rigidity during rotation. Since compost is typically moist, stainless steel was selected for the screen to prevent corrosion and ensure durability under prolonged exposure to wet organic materials.

According to Sullivan and Miller (2001), a bulk density of 700 kg m^{-3} is at the higher end of the typical range for compost, which generally falls between 500 and 700 kg m^{-3}. Therefore, a value of 700 kg m^{-3} was used as the basis for calculating the weight or load of compost being screened by the trommel cylinder during operation. Assuming that one-fifth of the cylinder's volume is occupied by compost, the estimated load is approximately 142.06 kg.

The diameter of the trommel shaft was determined using Equation 1, yielding a computed shaft size of 18.53 mm. However, considering the availability of standard shaft sizes in the local market, a 25 mm (1 inch) diameter shaft was selected. Although this results in a slight increase in material cost, the larger diameter improves the factor of safety (Equation 2) to 3.15. This enhancement implies greater durability, improved safety, and an extended service life of the shaft. AISI 1065 carbon steel was selected as the material for the trommel shaft due to its high strength and wear resistance.

$$d = \left(\frac{16T}{\pi\tau}\right)^{1/3} \tag{1}$$

Where,

d is the shaft diameter (mm);

T is the torque applied to the shaft (N·mm);

τ = allowable shear stress of the material (N mm^{-2}).

$$\sigma_{Allow} = \frac{YS}{FOS} \tag{2}$$

Where,

σ_{Allow} is the allowable stress (MPa);

YS is the Yield Strength (MPa);

FOS is the Factor of Safety.

2.2.2 Power transmission assembly

A 0.746kW electric motor, calculated using Equation 3, was selected as the prime mover of the trommel machine. A 4-inch diameter flange coupling was used to ensure a strong and direct connection between the motor and the speed reducer, with its dimensions verified using Equation 4 (Varma, 2020).

As illustrated in Figure 2, power from the electric motor is transmitted to the trommel through a combination of a speed reducer, belt-and-pulley system, and chain-and-sprocket assembly. The motor operates at a rated speed of 1740 rpm, which is reduced using a worm-type gearbox with a reduction ratio of 1:30. This reduction lowers the rotational speed to approximately 58 rpm while increasing the available torque required to rotate the loaded trommel.

A belt-and-pulley arrangement and chain-and-sprocket system were employed to transmit power, change the direction of motion, and further adjust the rotational speed of the trommel. By selecting appropriate pulley and sprocket sizes, the trommel was operated at five different shaft speeds (10, 20, 30, 40, and 50 rpm) during performance evaluation.

The required torque for the transmission shaft was calculated using the standard power–torque relationship, considering the motor power and reduced shaft speed. The resulting torque values served as the basis for selecting the shaft diameter and ensuring safe operation under load, with an adequate factor of safety applied to account for dynamic effects and material variability.

The required torque was determined by rearranging the power–torque relationship (Equation 3) to solve for torque. Substituting the motor power (0.746 kW) and rated speed (1740 rpm) yielded a motor shaft torque of 4.10 N·m. Considering the 1:30 speed reduction, the torque at the gearbox output increased to 123 N·m. Accounting for transmission efficiency, the effective torque available at the trommel shaft was approximately 92 N·m. This value was used as the basis for the design of the shaft and coupling components.

$$P = \frac{2\pi NT}{60x1000} \tag{3}$$

Where,

P is the power required (kW);

N is the shaft speed (rpm);

T is the torque (N·m).

$$D_o = (4d + t_1) \tag{4}$$

Where,

D_o is the outside diameter of flange (mm);

d is the diameter of shaft (mm);

t_l is the thickness of protecting rim (mm).

The design calculations for the belt and pulley system were based on PAES 301 (2000), using Equations 5, 6, and 7 while the chain and sprocket system was designed in accordance with PAES 303 (2000), as shown in Equation 8.

$$N_1 D_1 = N_2 D_2 \tag{5}$$

Where,

N_1 is the speed of motor (rpm);

D_1 is the pulley diameter of motor (inches);

N_2 is the speed of shaft (rpm);

D_2 is the pulley diameter of the driven machine (inches).

$$C = \frac{b + \sqrt[2]{b^2 - 32(D_2 - D_1)^2}}{16} \tag{6}$$

Where,

D_1 is the pulley diameter of motor (inches);

D_2 is the pulley diameter of the driven machine, (inches);

L_s is the Standard belt length;

C is the center distance, and $b = 4L_s - 6.28\ (D_2 + D_1)$.

$$L = 2C + \frac{\pi}{2}(D_L + D_S) + \frac{(D_L - D_S)^2}{4C} \tag{7}$$

Where,

L is the length of the belt (mm);

C is the distance between centers of pulleys (mm);

D_L is the pitch diameter of the large pulley (mm);

D_S is the pitch diameter of the small pulley (mm).

$$N_1 T_1 = N_2 T_2 \tag{8}$$

Where,

N_1 is the speed of speed reducer (rpm);

T_1 is the pulley diameter of speed reducer (inches);

N_2 is the speed of transmission shaft (rpm);

T_2 is the pulley diameter of the transmission shaft (inches).

2.2.3 Frame assembly

The frame serves as the structural backbone of the machine, providing the main support that holds all components together. Mounted on the frame are the hopper, screen cover, compost discharge chute, and foreign matter discharge chute. The frame was designed to withstand operational loads and vibrations during machine use. Materials used for fabrication include 3/16 in × 2 in angle bar, 3/16 in × 1½ in flat bar, and a 1.2 mm thick galvanized iron (GI) plain sheet.

To ensure structural integrity, the frame assembly was evaluated using analytical methods based on the basic bending stress equation (Equation 9). This approach was used to assess the strength of the frame components and verify their ability to safely support the imposed loads during machine operation without yielding or excessive deformation. A factor of safety of 2.0 was incorporated in the design to account for uncertainties in loading conditions, material properties, and fabrication tolerances.

$$\sigma = \frac{Mc}{I} \tag{9}$$

Where,

σ is the bending stress (N mm^{-2});

M is the bending moment (N·mm);

c is the distance from the neutral axis to the outermost fiber (mm);

I is the moment of inertia of the cross-section (mm^4).

To determine the maximum load that the frame will carry use the equation:

$$W_{Total} = W_{Trommel} + W_{Compost} + W_{Motor} + W_{Dynamic} \tag{10}$$

Where,

W_{Total} is the total load carried by the frame (N);

$W_{Trommel}$ is the weight of the trommel and rotating parts (N);

$W_{Compost}$ is the weight of the compost during operation (N);

W_{Motor} is the weight of the motor and gearbox assembly (N);

$W_{Dynamic}$ is the dynamic load due to vibration and motion (N).

The maximum bending moment is calculated using the Formula:

$$M = \frac{WL}{4} \tag{11}$$

Where,

M is the maximum bending moment (N·mm);

W is the total load the frame member supports at its midpoint (N);

L is the span length between supports (mm).

The moment of inertia of the angle bar was calculated using Equation 12, while for the L-shaped (angle) section, the approximate distance from the neutral axis to the outermost fiber was determined using Equation 13.

$$I = \frac{bh^3}{12} \tag{12}$$

$$c = \frac{h}{2} \tag{13}$$

Where,

I is the moment of inertia of the frame section (mm^4);

b is the base width of the rectangular section or leg of the angle bar (mm);

h is the height of the rectangular section or leg of the angle bar (mm);

c is the distance from the neutral axis to the outermost fiber (mm).

The hopper serves as the inlet where the unscreened compost is placed. It is positioned at the elevated end of the trommel cylinder and is constructed from GI plain sheet. The hopper was designed with a fixed inclination angle to ensure continuous gravity-assisted flow of compost materials while maintaining structural simplicity and ease of fabrication. The volume of the hopper was calculated using Equations 14 and 15 (Caguay et al., 2023). A variable slope mechanism was not incorporated in order to minimize design complexity, fabrication cost, and maintenance requirements, as the selected fixed angle was found to be sufficient for the material used in this study.

$$V = \frac{1}{3}\left(A_1 + A_2 + \sqrt{A_1 + A_2}\right) x\, h \tag{14}$$

$$Tan\theta = \frac{h}{\frac{S_1 - S_2}{2}} \tag{15}$$

Where,

V is the volume of the truncated pyramid (mm^3);

A_1 is the area of the upper base (mm^2);

A_2 is the area of the lower base (mm^2);

h is the height of the truncated pyramid (mm);

S_1 is width of the upper base (mm);

S_2 is the width of the lower base (mm);

θ is the angle of inclination of the hopper side.

2.3 Research design

A total of 150 kg of vermicompost, ready for harvesting and screening, was used as the test material for the performance evaluation of the mini compost trommel machine. The vermicompost used in the study was characterized by its typical physical properties, including moisture content, bulk density, and heterogeneous particle size distribution, which are known to influence screening performance.

The evaluation was conducted at five different trommel screen speeds: 10, 20, 30, 40, and 50 rpm, with three replications for each treatment. The experimental design followed a Completely Randomized Design (CRD) to ensure the reliability and validity of the data. The study focused on isolating the effect of rotational speed on machine performance; thus, other factors such as material type, screen perforation size, and feeding rate were kept constant throughout the experiments.

Randomization of treatment order was performed using a draw-lot method to minimize bias and eliminate systematic errors due to sequencing or operator influence. Statistical analysis was carried out using one-way Analysis of Variance (ANOVA) to determine the significance of treatment effects on performance parameters, including operating time, noise level, input capacity, power consumption, and screening efficiency.

Additionally, the Least Significant Difference (LSD) test was employed as a post hoc analysis to identify significant differences among treatment means. The results were used to determine the optimal trommel screen speed under the specified test conditions.

It is acknowledged that further evaluation under varying material properties, perforation sizes, and feeding rates is recommended for future studies to enhance the general applicability of the results.

2.3 Performance parameters

The following equations was utilized for the purpose of this study. It was adopted from the Philippine Agricultural Engineering Standards (PAES).

The input capacity of the device was determined using Equation 16, following the method specified in PAES 235 (2008). The input capacity was calculated by measuring the total mass of vermicompost fed into the machine and dividing it by the time required to process the material during each trial.

$$Ci = \frac{Wi}{T} \tag{16}$$

Where,

Ci is the input capacity (Kg hr^{-1});

Wi is weight of input materials (Kg);

T is the operating time (hr).

The efficiency of the machine was computed using equation (David, 2024):

$$Es = \frac{Ws}{Wi} \times 100 \tag{17}$$

Where,

Es is the machine efficiency (%);

Ws is the weight of sifted materials (Kg);

Wi is the weight of input materials (Kg).

For the electrical energy consumption of the device, Equation 18 was used from PAES 235 (2008).

$$E_c = \frac{P_c T_o}{W_i} \tag{18}$$

Where,

E_c is the electrical energy consumption (kW-h kg^{-1});

P_c is the power consumed (kW);

T_o is the total operating time (h);

W_i is the weight of input material, kg.

The noise level was measured using a calibrated sound level meter and expressed in decibels (dB). Measurements were taken at a position approximately 50 mm from the operator's ear level to represent typical working conditions. During each experimental run, noise readings were recorded while the machine was operating under steady-state conditions. Three measurements were taken for each treatment, and the average value was used for analysis. The measurement procedure followed standard practices for evaluating occupational noise exposure.

2.4 Cost analysis

The economic analysis involved tracing the flow of resources generated by the investment in the compost trommel machine from fabrication to operational use in compost sifting. This assessment accounted for all essential financial expenditures, encompassing both construction and operational phases. Specifically, the analysis included estimates of fixed costs, variable costs, annual operating expenses, net income, payback period, and rate of return (ROR). These indicators were used to evaluate the financial viability and profitability of the compost trommel machine as a mechanized solution for compost processing. Standard economic evaluation methods were applied to perform a simple cost analysis, following the equations outlined by Hunt (2001), Al Issa (2001), and Caguay (2023).

2.4.1 Annual Fixed Cost (AFC)

$$AFC = D + I + TIS \tag{19}$$

Where,

D is the depreciation cost (PHP yr^{-1});

I is the interest on investment (PHP yr^{-1});

TIS is the taxes, insurance and shelter (PHP yr^{-1}).

2.4.2 Annual Variable Cost (AVC), PHP yr^{-1}

$$AVC = FC + R\&M + LC + LaC \tag{20}$$

Where, FC is the electrical cost (PHP yr^{-1});

$R\&M$ is the repair and maintenance cost (PHP yr^{-1});

LC is the lubrication cost (PHP yr^{-1});

LaC is the labor cost (PHP yr^{-1}).

2.4.3 Break-even Point (BEP), Kg yr^{-1}

$$BEP = AFC/(CR - VC/C) \tag{21}$$

Where,

AFC is the annual fixed cost (PHP yr^{-1});

CR is the custom rate (PHP kg^{-1});

VC is the variable cost (PHP hr^{-1});

C is the extracting capacity (kg hr^{-1}).

2.4.4 Payback period (Pp), yr

$$Pp = (IC - SV)/AANi \tag{22}$$

Where,

Pp is the payback period (yr);

IC is the initial cost (PHP);

SV is the salvage value (PHP);

$AANi$ is the added annual net income (PHP).

2.4.5 Rate of return (ROR), %

$$ROR = AANi/AOC \times 100 \tag{23}$$

Where,

$AANi$ is the added annual net income (PHP),

AOC is the annual operating cost (PHP).

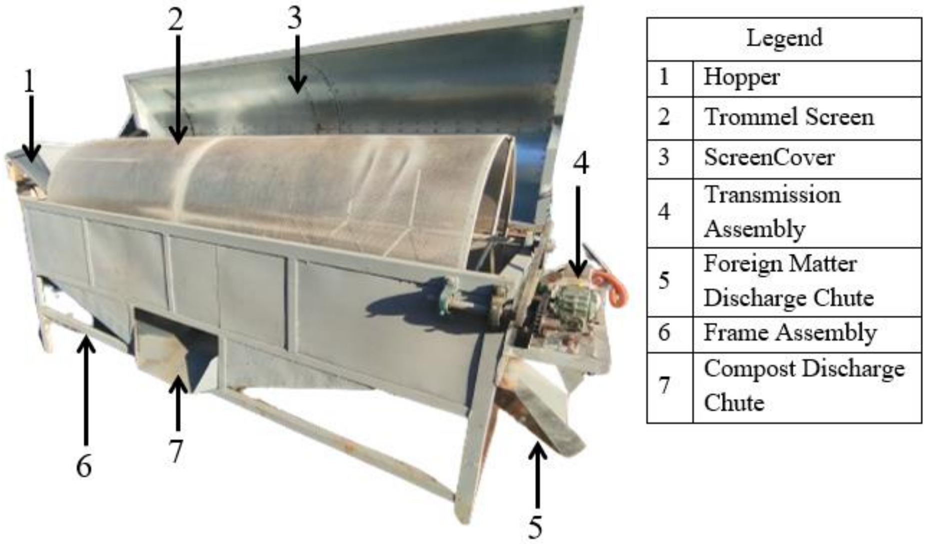


Figure 3 Fabricated mini compost trommel machine

3 Results and discussion

3.1 Description of the Mini Compost Trommel Machine

The machine was designed for the production of compost that is ready for plant use. Several design criteria were considered to guide its development. Specifically, the machine was required to: (1) efficiently sift small compost particles from larger clods, non-biodegradable waste, and undecomposed materials; (2) operate as a self-propelled unit; (3) significantly reduce the need for manual labor; and (4) be constructed using locally available materials. The machine is motor-driven, and the separation process begins by activating the switch to rotate the trommel. Once raw compost is loaded into the hopper, it is fed into the rotating trommel screen, where the separation of fine and coarse materials occurs. Fine compost particles pass through the perforated screen and fall onto the compost discharge chute located beneath the trommel, eventually being directed to the outlet for collection. In contrast, coarse, undecomposed, and non-compostable materials are retained inside the trommel and gradually move toward the foreign material discharge chute due to the cylinder's inclination. After the machine is switched off, the fine compost is collected and prepared for use, while the coarse and undecomposed materials are manually returned to the composting site to continue the decomposition process. Figure 3 shows the fabricated compost trommel machine, while Table 1 presents its technical specifications.

Table 1 Specifications of the mini compost trommel machine

Components	Specifications
Machine overall dimensions	
Length, mm	2734
Width, mm	925
Height, mm	1420
Prime pover	
Type	Single Phase Induction Motor
Rated Speed, rpm	1740
Frequency, Hz	60
Transmission assembly	
Gearbox WPS speed reducer	1:30 speed ratio
Pulleys diameter, in	2 & 7
Sprocket, teeth	13
V-belt	B-54
Cylinder assembly	
Screen material	SAE 304 stainless steels
Diameter, mm	775
Length, mm	2438
Thickness, mm	1
Perforation size, mm	3
Frame assembly	
Material	ASTM A36/A36M
Angle bar size, in	1 ½ x 1 ½ x 3/16
Flat bar size, in	1 ½ x 3/16
Cover	
Material	Galvanized Iron sheets
Thickness, mm	1.2
Machine performance parameters	
Input Capacity, kg hr^{-1}	441.21
Screening Efficiency, %	97.65

3.2 Performance parameters of the mini compost trommel machine

3.2.1 Noise level

Noise level referred to the amount of sound emitted by the machine during operation. It was measured using a noise level meter and expressed in decibels (dB). During testing, the device was positioned near the operator to obtain a more accurate measurement of the noise that could potentially affect the operator’s working environment. Figure 4 presents the line graph of all recorded noise levels during machine testing. Based on the data, the lowest noise level recorded was 66 dB at treatment T4, while the highest was 75 dB at treatment T3. Despite these variations, the overall trend indicated that the noise levels across different treatments were closely similar, even as the trommel screen speed ranged from 10 to 50 rpm.

The computed F-value of 0.53 did not exceed the tabular F-values at the 5% and 1% significance levels, which were 3.48 and 5.99, respectively. This indicated that there was no statistically significant difference between the treatment effects on the noise level emitted by the machine. In other words, changes in the rotational speed of the trommel screen within the tested range had no significant impact on noise emissions. Furthermore, the recorded noise levels were found to comply with the permissible noise exposure limits set by the Occupational Safety and Health (OSH)

Standards of the Department of Labor and Employment (DOLE) (2016). According to these standards, the maximum allowable noise exposure for an 8-hour work duration is 90 decibels.

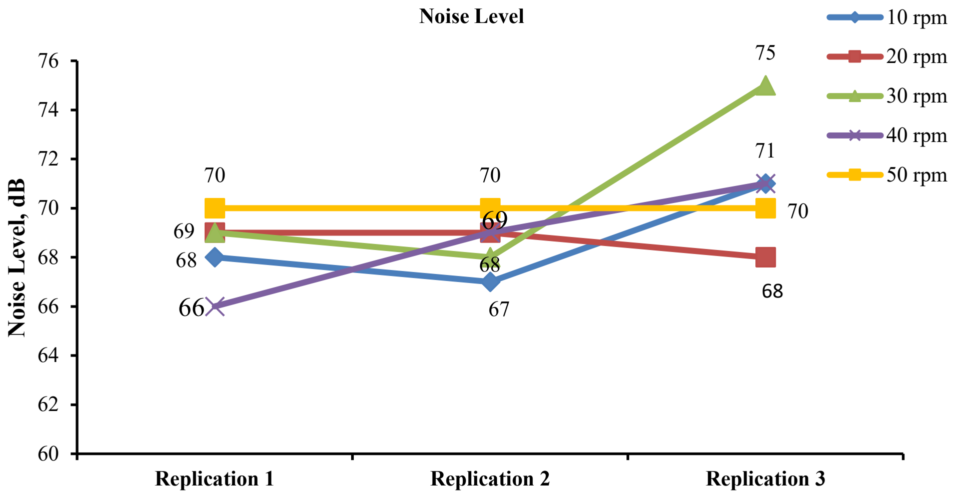


Figure 4 Line graph of noise level

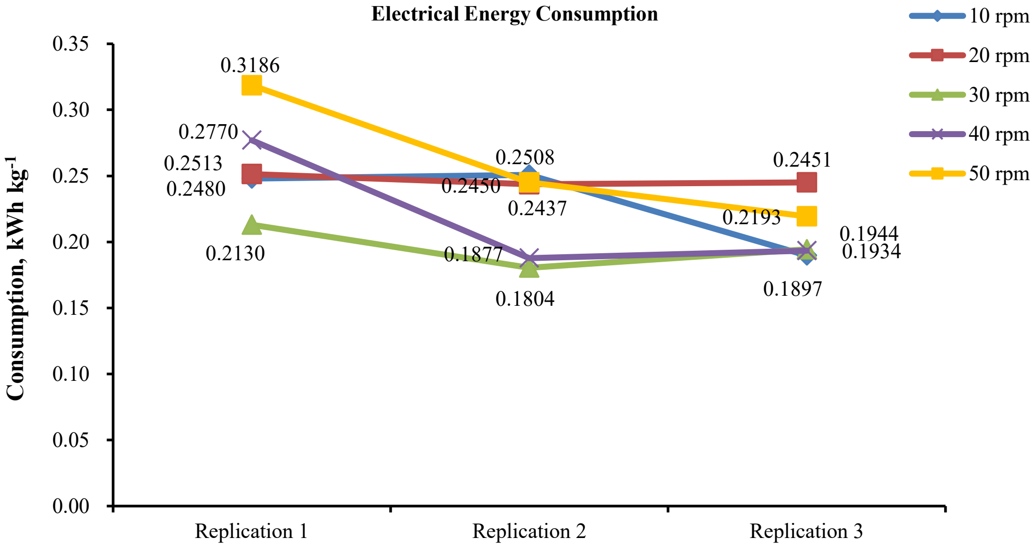


Figure 5 Line graph of power consumption

3.2.2 Electrical energy consumption

Electrical energy consumption referred to the amount of electrical energy used by the electric motor during machine operation. Data collected during the performance trials were utilized to calculate the machine's power consumption. The parameters required for this computation included voltage, current (amperes), power factor, screening time, and the weight of the input material. Figure 5 presents the computed power consumption of the machine, expressed in kilowatt-hours per kilogram (kWh kg^{-1}), over 15 trials.

Among the fifteen trials, treatment T3 exhibited the lowest power consumption at 0.18 kWh kg^{-1}, while treatment T5 showed the highest at 0.3186 kWh kg^{-1}. The comparison of mean power consumption across treatments also indicated that T3 remained the lowest, with an average of 0.196 kWh kg^{-1}. The computed F-value was 1.42, which was lower than the critical F-values at the 5% and 1% significance levels, which were 3.48 and 5.99, respectively. This result suggested that there was no statistically significant difference in power consumption among the treatments. In other words, changes in belt and pulley sizes did not significantly affect the machine's energy consumption.

Furthermore, in the study conducted by Hoque et al. (2011), power consumption was reported at 0.37 kW, while the Mini Compost Trommel machine in this study recorded a similar value of 0.381 kW, with both machines powered by a 1-hp electric motor. This comparison indicates that the power consumption performance of the two machines was consistent, thereby validating the efficiency of the designed compost trommel in terms of energy use.

The relatively higher variation observed at 50 rpm may be attributed to increased material agitation and non-uniform distribution of compost within the trommel at higher rotational speeds. This condition can lead to fluctuating motor load and corresponding variations in power consumption during operation. Such variability is expected in handling heterogeneous and moist materials like vermicompost.

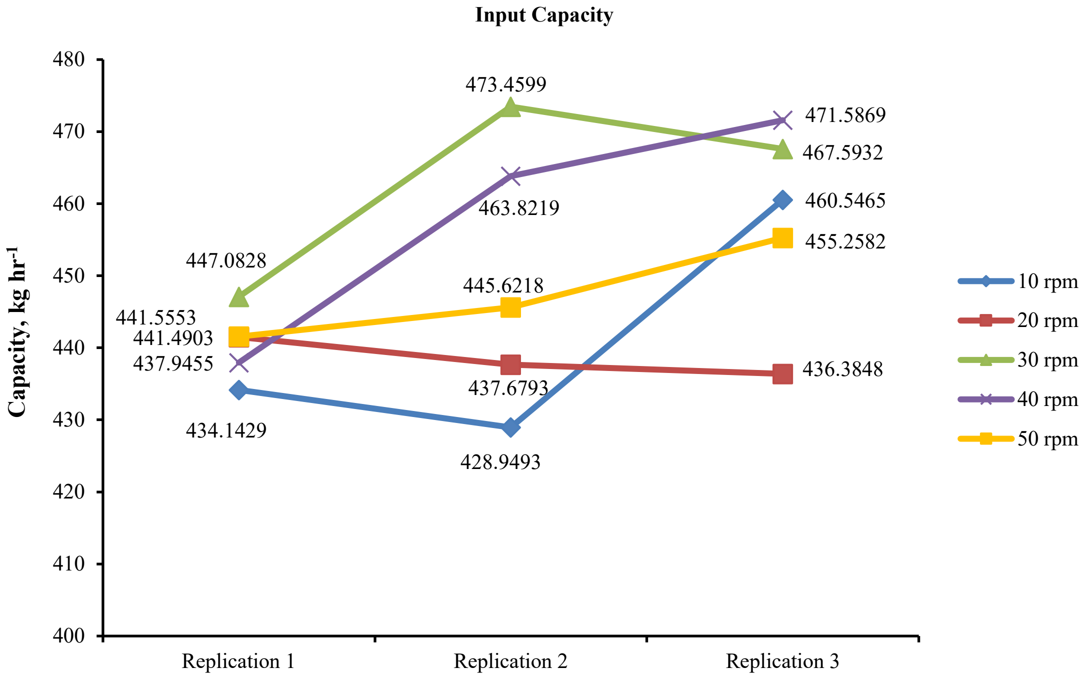


Figure 6 Line graph of the input capacity

Figure 7 samples of the screened compost materials

3.2.3 Input capacity

Input capacity refers to the amount of material the machine can process over a specific period, expressed in kilograms per hour (kg hr^{-1}). In this study, it was calculated by dividing the recorded weight of the screened vermicompost by the time taken to process 150 kilograms of raw material. All measurements were standardized in kg hr^{-1}.

Figure 6 presents the line graph depicting the input capacity of the Mini Compost Trommel machine, while Figure 7 shows samples of the screened materials. Based on the results, the highest input capacity was recorded under treatment T3, which achieved a rate of 473.46 kg hr^{-1}. Among the treatments, T3 also had the highest mean input capacity at 462.71 kg hr^{-1}, followed by T4 (457.78 kg hr^{-1}), T5 (447.48 kg hr^{-1}), T1 (441.21 kg hr^{-1}), and T2 (438.52 kg hr^{-1}). The computed F-value of 1.97 did not exceed the tabular F-values at the 5% (3.48) and 1% (5.99) significance levels, indicating that there was no statistically significant difference in input capacity among the treatments. This suggests that variations in trommel screen speed within the tested range did not significantly affect the machine's input capacity. Similarly, changes in pulley and belt sizes had no substantial impact on throughput.

Amin et al. (2022) developed and evaluated a vermicompost sifting machine with a specified capacity of 600 kg hr^{-1}. Meanwhile, Morad et al. (2014) emphasized that machine capacity is influenced by the feed rate of the material. In this study, the feed rate was manually controlled by the operator, resulting in variability due to inconsistent input. The operator’s shoveling capacity also contributed to this inconsistency, as physical strain and fatigue may have reduced efficiency over time. According to the Canadian Centre for Occupational Health and Safety [CCOHS] (2024), the most efficient shoveling rate ranges from 18 to 21 scoops per minute, with each scoop weighing approximately 1.5 to 3 kg. Furthermore, the CCOHS specifies a maximum workload of 750 kg for continuous shoveling over a 15-minute period. These ergonomic limitations likely contributed to the fluctuations observed in the input capacity during testing.

3.2.4 Screening efficiency

Screening efficiency refers to the machine's effectiveness in separating oversized from undersized materials. It was calculated by dividing the weight of the sifted (undersized) materials by the weight of the input materials, expressed as a percentage. Figures 8 and 9 present the line and bar graphs, respectively, of the computed screening efficiencies across 15 replications, with Treatment 1 (T1) demonstrating the highest performance. Table 2 summarizes the mean screening efficiencies and Least Significant Difference (LSD) comparisons across treatments. In the N Group column, treatments sharing the same letter are not significantly different from each other.

T1 (10 rpm) achieved the highest mean screening efficiency at 97.65%, closely followed by T2 (20 rpm) with 95.97%. In contrast, T5 (50 rpm) recorded the lowest efficiency at 86.44%. The mean difference observed in T1 was the highest, and the LSD test identified T1 as significantly more efficient than the other treatments.

These findings are consistent with the results of Manyuchi and Phiri (2013), who reported that increasing the trommel screen speed leads to a decline in separation efficiency. This trend was also evident in the current study, where increased screen speeds resulted in greater material loss, thereby reducing overall screening performance.

Moreover, the Mini Compost Trommel Machine demonstrated a screening efficiency of 97.65%, exceeding both the study’s target efficiency of 90% and those reported in related research. For instance, Manyuchi and Phiri’s Cylindrical Rotary Trommel Separator achieved 95% efficiency; Amin et al. (2022) reported 84.56% for an Earthworm-cum-Compost Separator; and Kabudake et al. (2020) recorded 90% for a Vermicompost Cleaning Machine. The superior performance of the Mini Compost Trommel Machine highlights its effectiveness and potential applicability for efficient compost processing.

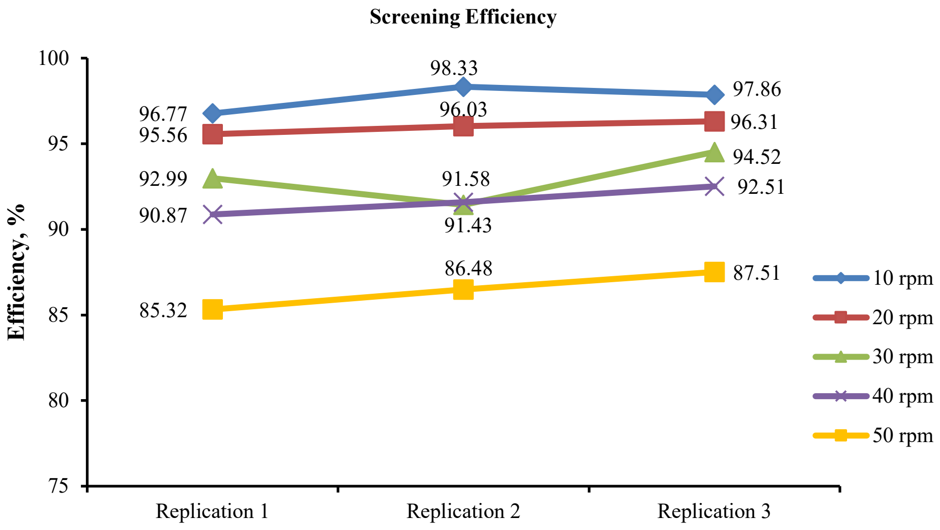


Figure 8 Line graph of screening efficiency

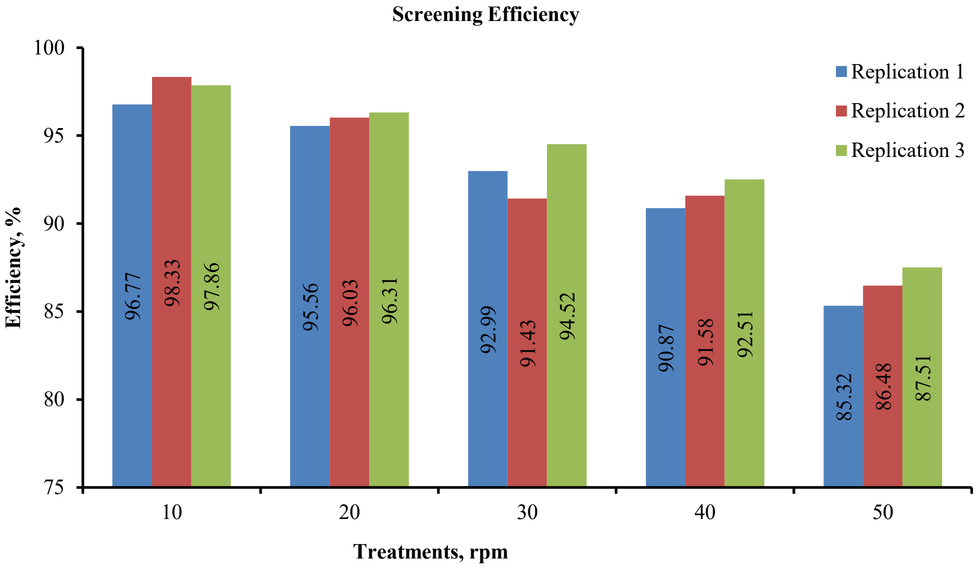


Figure 9 Bar Graph of Screening Efficiency

Table 2 Mean comparison for screening efficiency as affected by shaft speed

Treatment	Mean	N Group
1 (10 RPM)	97.65	3 a
2 (20 RPM)	95.97	3 a
3 (30 RPM)	92.98	3 b
4 (40 RPM)	91.65	3 b
5 (50 RPM)	86.44	3 c

Note: * Means with the same letter are not significantly different.

3.3 Cost analysis

Table 3 presents the assumed values used in the simple financial analysis, while Table 4 summarizes the computed results. The financial analysis aimed to evaluate the economic viability of the compost trommel machine by calculating key financial indicators based on the assumed values. These indicators include the Annual Fixed Cost (AFC), Annual Variable Cost (AVC), Annual Operating Cost (AOC), Added Annual Revenue, Added Annual Net Income, Break-even Point (BEP), Payback Period (PBP), and Rate of Return (ROR).

The Annual Fixed Cost refers to the yearly expenses that remain constant regardless of machine usage. It was computed by summing the depreciation cost, interest on investment, and estimated tax and insurance. The resulting AFC was PHP17,030.90 per year. In contrast, the Annual Variable Cost—expenses that fluctuate with machine usage—was calculated by totaling the annual costs for electricity, repair and maintenance, and labor, yielding PHP 115,604.70 per year. Adding AFC and AVC gave the total Annual Operating Cost of PHP 132,635.60.

The Break-even Point (BEP) represents the production level at which total costs and total revenues are equal, indicating no profit or loss. BEP was calculated by dividing the AFC by the difference between the custom screening rate and the variable cost per kilogram, adjusted by machine capacity. The computed BEP was 160,616.76 kg of vermicompost per year.

To determine revenue, the custom rate per kilogram of vermicompost was multiplied by the annual machine capacity, resulting in a projected Annual Revenue of PHP 200,750.55. Subtracting the operating cost from this amount yielded an Annual Net Income of PHP 68,114.95. Consequently, the Rate of Return (ROR), calculated as the ratio of net income to operating cost, was 51.35%.

The Payback Period (PBP) was determined by dividing the difference between the initial machine cost and its salvage value by the annual net income. The resulting PBP was 1.04 years, indicating that the investment could be recovered just over a year of operation.

Figure 10 illustrates the cost curve associated with machine operation. As shown, the breakeven point occurs at 160,616.76 kg of screened vermicompost, assuming a screening cost of Php 0.25 per kilogram.

Table 3 Assumptions

Particulars	Value	Unit
Initial Cost	78,303.00	PHP
Salvage Value	7,830.30	PHP
Life span	5	Yrs.
Electric consumption	0.746	kW
Daily operating time	8	hrs.
Total annual operating time	2,080	hrs.
Electric rate	11.6	PHP kWh^{-1}
Custom rate	0.25	PHP kg^{-1}
Number of operators	1	Person
Daily operator’s wage	369.00	PHP day^{-1}
Machine capacity	441.21	Kg hr^{-1}

Table 4 Summary of the Financial Analysis

Particulars	Value	Unit
Annual Fixed Cost (AFC)	17,030.90	PHP yr^{-1}
Depreciation Cost	14,094.54	PHP yr^{-1}
Interest on Investment	2,153.33	PHP yr^{-1}
Tax and Insurance	783.03	PHP yr^{-1}
Annual Variable Cost (AVC)	115,604.70	PHP yr^{-1}
Electrical Cost	15,749.55	PHP yr^{-1}
Annual Repair and Maintenance	3,915.15	PHP yr^{-1}
Labor Cost	95,940.00	PHP yr^{-1}
Annual Operating Cost (AOC)	132,635.60	PHP yr^{-1}
Break-even Point (BEP)	160,616.76	kg yr^{-1}
Annual Revenue	200,750.55	PHP yr^{-1}
Annual Net Income	68,114.95	PHP yr^{-1}
Rate of return	51.35	%
Payback period	1.04	Yrs.

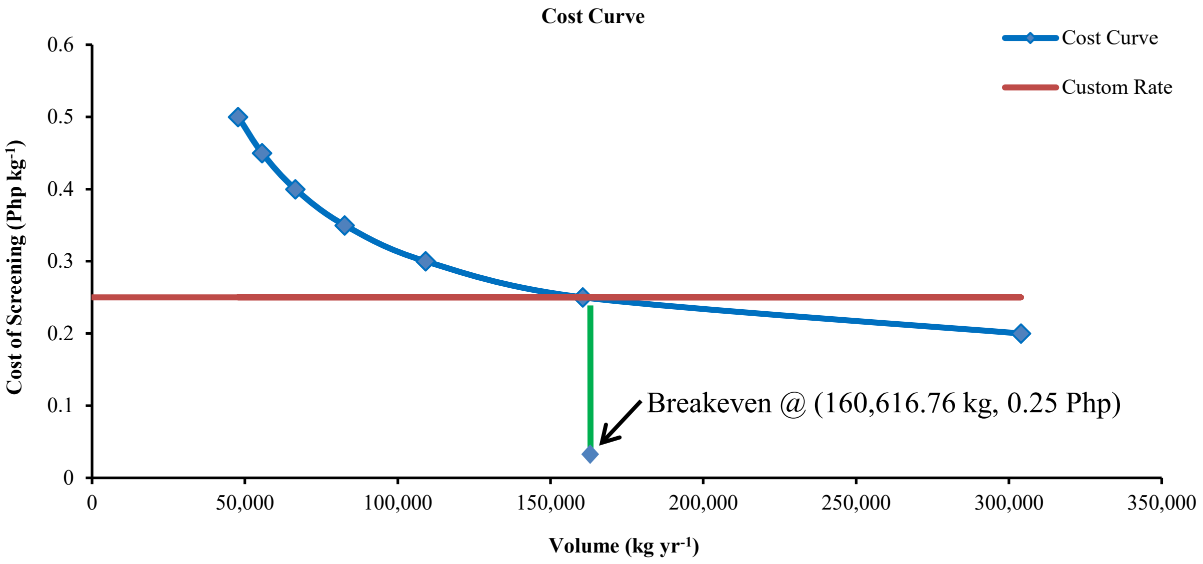


Figure 10 Cost curve of using the Mini Compost Trommel Machine

4 Conclusions

The study successfully developed and evaluated a Mini Compost Trommel Machine designed to enhance compost sifting operations for small- to medium-scale applications. The machine, constructed using locally available materials, demonstrated strong performance in terms of functionality and economic viability.

The fabricated unit efficiently separated fine compost from non-compostable materials with a screening efficiency of up to 97.65%, surpassing the targeted benchmark and outperforming similar machines reported in related studies. The machine exhibited an input capacity of 441.21 kg hr^{-1}, confirming its suitability for continuous operation in farm or community composting environments.

The noise levels generated during operation ranged from 66 to 75 dB, falling well within the DOLE-OSH permissible limits for an 8-hour workday, thus ensuring a safe working environment. Additionally, the machine showed no significant variation in energy consumption or throughput across different treatments, indicating stable performance regardless of changes in screen speed or pulley configuration.

From a financial standpoint, the machine required a modest initial investment of PHP 78,303.00 and demonstrated strong profitability. The payback period was calculated at 1.04 years, while the rate of return stood at 51.35%, indicating that the investment could be recovered in just over a year of operation. The break-even point was determined to be 160,616.76 kg year^{-1} of vermicompost at a screening rate of PHP 0.25 kg^{-1}.

Based on the combined evaluation of screening efficiency, input capacity, and energy consumption, the optimal operating condition of the machine was observed at a trommel speed of 30 rpm (Treatment T3). At this condition, the machine demonstrated the lowest average energy consumption while maintaining high screening efficiency and stable throughput. This indicates that 30 rpm provides the most efficient balance between performance and operating cost, making it the recommended operating condition for practical applications.

The Mini Compost Trommel Machine offers a cost-effective, energy-efficient, and highly productive solution for compost processing. Its application is ideal for labor-saving, sustainable waste management, and enhanced productivity in rural agricultural settings. The study confirms that locally-fabricated machines can match or exceed the performance of imported counterparts, supporting wider adoption and localization of agricultural mechanization technologies.

References

Acabal, C. 2022. Profitability and Sustainability of Vermi

Composting Business toward Social Entrepreneurship in Negros Oriental, Philippines. *Asia Pacific Journal of Management and Sustainable Development*, 10(1): 17-26.

Al Issa, T. A. 2001. Farm machinery management and the impact of conservation tillage systems on soil erosion and the sustainability of wheat production in rainfed areas of Northern Jordan (Order No. 3021602). Available at: http://edgewood.idm.oclc.org/login?url=https://www.proquest.com/dissertations-theses/farm-machinery-management-impact-conservation/docview/304755746/se-2. Accessed June 3, 2024.

Amin, S., S. Kawoosa, S. Mushtaq, S. Hamid, and J. Dixit. 2022. Development and Evaluation of Earthworm-cum-compost Separator. *Journal of Agricultural Engineering*, 59(1): 31-46.

Caguay, M. E., R. B. Gavino, H. F. Gavino, and T. B. Sayco. 2023. Development and performance analysis of a mini Twin-Shaft shredder for efficient polyethylene terephthalate (PET) bottle recycling. *Journal of Engineering Research and Reports*, 25(8): 217–229.

Caguay, M. 2023. Enhancing value and efficiency in calamansi and banana processing: A study on waste utilization and chopping machine development. *American Journal of Multidisciplinary Research and Innovation*, 2(4): 48–57. Accessed December 05, 2024.

Canadian Centre for Occupational Health and Safety [CCOHS]. 2024. Shoveling. Available at: https://www.ccohs.ca/oshanswers/ergonomics/shovel.pdf. Accessed June 03, 2024.

Churchill, S. 2021. Vermicomposting: the ultimate guide for the beginner and beyond. Urban Worm Company. Available at: https://urbanwormcompany.com/vermicomposting-ultimate-guide-beginner-expert/. Accessed June 16, 2024.

David. 2024. Calculate a Classifier and Screen's Efficiency - 911Metallurgist. 911Metallurgist. Available at: https://www.911metallurgist.com/blog/formula-to-calculate-a-classifier-and-screen-efficiency/. Accessed October 23, 2024.

Department of Labor and Employment [DOLE]. 2016. Occupational Safety and Health Standards. Available at: https://www.dole.gov.ph/php_assets/uploads/2019/04/OSH-Standards-2017-2.pdf. Accessed June 03, 2024.

Deya Machinery. 2023. Trommel Screen. Available at: https://www.deyamachinery.com/screens/trommel-screen.html. AccessedJune 08, 2024.

Hoque, M. A., M. A. Wohab, M. A. Hossain, M. N. Amin, and M. S. Hassan. 2011. Design and development of a compost separator. *Bangladesh Journal of Agriculture* (BARC), 36: 53–60.

Hunt, D. 2001. *Farm Power and Machinery Management*. 10th ed. Iowa City, IA, USA: Iowa State Press.

Kabudake, P. D., G. Pradumnya, J Adit, G. Sanket, and K. Madhuri. 2020. Design and manufacturing of Vermicompost cleaning machine. *International Journal of Engineering Research & Technology (IJERT)*, 9(5): 1033-1036.

Manyuchi, M., and A. Phiri. 2013. Effective Separation of Vermicast from Earthworms Using Cylindrical Rotary Trommel Separator. *International Journal of Innovative Research in Science, Research and Technology*, 2(8): 4069-4072.

Miller, R. A. 2005. A COMPOST SCREENING PRIMER. Available at: https://www.biocycle.net/a-compost-screening-primer/. Accessed June 03, 2024.

Morad, M. M., H. A. El-Maghawry, and K. I. Wasfy. 2014. Optimizing Some Different Operating Parameters Affecting the Performance of Compost Trommel Screen. *Misr Journal of Agricultural Engineering*, 31(1): 111–132.

Philippine Agricultural Engineering Standard [PAES]. 2000. Engineering Materials – V-belts and pulleys for agricultural machines – Specifications and Applications PAES 301:2000. Available at: https://amtec.uplb.edu.ph/wp-content/uploads/2020/06/PNS-PAES-301-2000-Engineering-Materials-V-belts-and-Pulleys-Specifications-and-Applications.pdf. Accessed September 08, 2024.

Philippine Agricultural Engineering Standard [PAES]. 2000. Engineering Materials –Roller chains and sprockets for Agricultural machines – Specifications and Applications PAES 303:2000. Available at: https://amtec.uplb.edu.ph/wp-content/uploads/2020/06/PNS-PAES-303-2000-Engineering-Materials-Roller-Chain-and-Sprochets-Specifications-and-Appli.pdf. Accessed Accessed September 08, 2024.

Philippine Agricultural Engineering Standard [PAES]. 2008. Agricultural Machinery–Multicrop Juice Extractor–Methods of Test PAES 235: 2008. Available at: https://amtec.uplb.edu.ph/wp-content/uploads/2019/07/paes-235.pdf. Accessed September 08, 2024.

Pleasant, B. 2024. Sifting compost - is it necessary? Available at: https://www.growveg.com/guides/sifting-compost-is-it-necessary/. Accessed June 03, 2024.

Sullivan, D. M., and R. O. Miller. 2001. Compost quality attributes, measurements and variability. In *Compost*

Utilization in Horticultural Cropping Systems, eds. P. J. Stofella, and B. A. Kahn, ch. II, 95-120. Boca Raton, FL: CRC Press.

United States Environmental Protection Agency [EPA]. 2025. Composting at home. US EPA. Available at: https://www.epa.gov/recycle/composting-home#:~:text=Most%2C%20if%20not%20all%2C%20of,of%20%C2%BC%20inch%20hardware%20cloth. Accessed February 18, 2025.

US Composting Council. 2023. Plant Growth Benefits. Available at: https://www.compostingcouncil.org/page/PlantGrowthBenefits. Accessed June 04, 2024.

Varma, N. 2020. Shaft couplings 3 rigid flange coupling. Available at: https://www.slideshare.net/narendravarma11/shaft-couplings-3-rigid-flange-coupling. Accessed September 08, 2024.

Wilson, J. 2014. How to build a motorized Trommel—And why on earth you would want to. Popular Mechanics. Available at: https://www.popularmechanics.com/home/how-to-plans/how-to/a11370/how-to-build-a-motorized-trommel-and-why-on-earth-you-would-want-to-17246926/. Accessed September 08, 2024.