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A Smart Rubbish Bin Innovation (E.M.P.A.T.H.Y) for Household Organic Waste Management to Enhance Community Physical and Mental Well-being

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ABSTRACT

Indonesia faces a critical environmental challenge in managing household waste, particularly organic food waste, which constitutes 41.60% of the total 69.9 million tons of garbage generated in 2023. Improper waste management has historically led to tragic incidents, such as the 2005 garbage explosion that resulted in 143 fatalities, highlighting the urgent need for innovative solutions. This study aims to present the design of a smart rubbish bin, E.M.P.A.T.H.Y. – Eco-friendly Machine Processing All Trash Holistically for You**,** as a sustainable solution for processing organic food waste. Using a descriptive research method, data were collected from literature studies, case analyses, and internet-based searches on relevant topics. The study is non-experimental and focuses on conceptual innovation. The E.M.P.A.T.H.Y. smart bin is designed with integrated features that convert organic waste into environmentally friendly fertilizer while providing interactive screens to engage users responsibly. The innovation is adaptable for multiple scales, including households, restaurants, schools, and public spaces. Results from the conceptual planning indicate that the implementation of E.M.P.A.T.H.Y. can enhance public awareness of proper waste disposal and motivate community participation in environmental conservation. By integrating technological solutions with behavioral engagement, this smart bin has the potential to reduce food waste, promote sustainable waste management practices, and foster long-term environmental responsibility among citizens.

Introduction

One of Indonesia's biggest environmental problems is the garbage treatment system, which has not provided an effective solution to the increasing amount of waste at the landfill (*TPA*). According to the national garbage management information system (*SIPSN*) of 2023, Indonesia produces 69.9 million tons of waste annually, 41.60% of which comes from leftover food, making it the largest type of waste in the country. Moreover, according to the same 2023 *SIPSN* data, households constitute the largest contributor to waste, with a total contribution of 44.37% of the total waste generated. This suggests that the problem of food waste not only occurs in major industries or restaurants but also on a domestic scale, where organic waste is simply discarded without a well-managed system.

As a result of this less effective waste management at *TPA*, unhealthy food waste becomes a major source of methane gas (CH_4), which has a global warming potential 25 times greater than carbon dioxide (CO_2). This not only contributes to climate change but also increases the risk of explosions at *TPA* due to the accumulation of methane gas. The tragedy of the garbage explosion at *TPA* Leuwigajah, West Java, in 2005 is living proof of the adverse effects of improper waste management. The incident destroyed two villages and killed 143 people, making it one of the biggest environmental disasters in Indonesia.

Accumulated food waste not only causes air pollution from methane gas but also damages soil and water ecosystems. The process of putrefaction produces leachate, a toxic liquid that can seep into the soil and contaminate public groundwater sources. In addition, the high volume of organic waste at *TPA* reduces landfill capacity, forcing the government to search for new *TPA* locations—often leading to deforestation and a reduction in green land. As waste production continues to rise each year, it is predicted that many *TPA* in Indonesia will reach capacity limits within the next 10 years. A better solution is urgently needed to reduce reliance on *TPA*.

From an economic perspective, unutilized food waste causes enormous losses. According to *Bappenas*, Indonesia loses between IDR 213 trillion and IDR 551 trillion per year due to food waste. This figure is equivalent to 4–5% of the total national gross domestic product (*PDB*), which could have been used to improve people's welfare (Nisaputra, 2023). On the other hand, the high production of food waste in Indonesia contrasts sharply with the number of people who are still undernourished and hungry. According to the Food and Agriculture Organization (FAO), 8.3 million people in Indonesia are still undernourished, while millions of tons of food are wasted every year (Yonatan, 2024).

From a social and psychological perspective, many people are still unaware of the adverse effects of food waste. Many individuals believe it is normal to throw food away, without realizing that every discarded portion has a chain effect on the environment and economy. Furthermore, unmanaged organic waste can also impact mental health. Studies have shown that exposure to unpleasant odors, dirty surroundings, and visual pollution caused by unmanaged waste can increase stress, anxiety, and feelings of helplessness among community members, particularly in densely populated urban areas (Nguyen et al., 2021). The presence of unmanaged waste is linked with perceptions of environmental neglect, which can reduce overall life satisfaction and increase psychological distress—especially among vulnerable groups such as children and the elderly (Evans, 2003).

From these various problems, it is clear that food waste management must be addressed directly at its source—namely households and public places. If people can process their own organic waste, the volume of waste going to *TPA* can be significantly reduced, environmental impacts can be minimized, and a circular economy can be established through the reuse of food waste as organic fertilizer or alternative energy. However, traditional composting methods are often considered impractical because: (1) they take a long time—weeks to months—to produce compost; (2) they often cause unpleasant odors, especially when not managed properly; (3) they require a large amount of land, which is difficult to allocate in urban areas; and (4) there is a lack of public understanding on how to process food waste independently.

From these challenges, it can be concluded that technological innovations are needed to help people manage food waste more quickly, cleanly, and practically, so that it can be easily applied in daily life. Several studies have addressed the challenges of food waste management in urban environments. Nguyen et al. (2021) examined the

psychological impact of unmanaged waste on urban populations, finding that exposure to unprocessed organic waste increases stress, anxiety, and reduces overall life satisfaction. Similarly, Yonatan (2024) highlighted the economic and nutritional consequences of food waste in Indonesia, emphasizing that millions of tons of edible food are discarded while millions of citizens remain undernourished. While these studies provide critical insights into the social, psychological, and economic dimensions of food waste, they primarily focus on the consequences rather than practical technological solutions for households and public spaces.

This research fills that gap by proposing a smart waste management system—E.M.P.A.T.H.Y. (*Eco-friendly Machine Processing All Trash Holistically for You*)—which is designed to process organic food waste quickly, hygienically, and efficiently at the source. The study aims to reduce the volume of waste sent to landfills, mitigate environmental pollution, and promote the circular economy by converting food waste into organic fertilizer or alternative energy. The expected benefit is a dual impact: it enhances public awareness and participation in sustainable waste management while providing a practical tool that can be applied at home, in restaurants, and in schools—thereby addressing environmental, economic, and social issues simultaneously.

Research methods

This article employs library research as the primary method of data collection, which involves understanding and analyzing relevant theories, concepts, and frameworks from various literature sources related to the research topic. The data collection process includes systematically searching for, identifying, and compiling information from books, journals, scientific articles, and prior research studies. This approach ensures that the study is grounded in existing knowledge, allowing for comprehensive coverage of both theoretical and practical perspectives on the topic of interest. All sources are critically evaluated for relevance, credibility, and accuracy before being incorporated into the research analysis.

Following data collection, a qualitative data analysis approach is applied to interpret and synthesize the information gathered from the literature. The analysis involves categorizing findings based on key themes, identifying patterns and relationships, and critically comparing the results of previous studies. Through this method, gaps in existing research can be identified, and insights are drawn to support the development of new concepts or innovations. This analytical process enables the study to produce well-informed conclusions and recommendations, ensuring that the findings are coherent, reliable, and relevant in addressing the research problem.

Results and Discussion

Description Innovation

Organic waste accounts for more than 50% of the total household waste production, which if this waste is not managed properly will cause environmental pollution and can even have a negative impact on health. Not only from the physical side, the presence of piling organic waste also has an impact on mental health. A dirty and smelly environment can lead to stress, sleep disorders, anxiety, and even depression.

In addition, organic waste has considerable potential to be processed into compost which is rich in nutrients and can be used as a natural fertilizer. But to turn organic waste into compost itself has stages that are quite time consuming if done traditionally. And

because the time required is quite long, most people are reluctant to process organic waste and choose to dispose of it directly and in the end many end up in the landfill.

To reduce environmental pollution caused by organic waste, researchers are trying to provide innovations that can help encourage public awareness to care for the environment, namely designing technology-based smart rubbish bin *E.M.P.A.T.H.Y. – Eco-friendly Machine Processing All Trash Holistically for You* Can innovations. Which is where this smart rubbish bin facilitates the processing of organic waste into compost that is beneficial to the environment.

This smart rubbish bin is designed with an automation system that allows users to directly put organic waste into the chimney without the need to sort it first. The chimney is equipped with a one-way cover that makes it easy for waste to enter and helps minimize the release of unpleasant odors. The uniqueness of this product lies in the interactive screen mounted on the front of the bin. This screen is designed to display an emotional visual response such as a smiling emoticon or an appreciative message such as "Thank you for taking care of the earth!" every time the user takes out the trash. The design is inspired by the concept of emotional interaction, as if the user is feeding a grateful living being. The aim is to build positive habits through a pleasant emotional experience and encourage active community involvement in environmentally friendly organic waste management.

A. Composting System

In addition to making it easier for users to process with the innovation of smart bin technology, it can speed up the process of making compost from 2 to 4 weeks to approximately 24 - 48 hours depending on the condition and type of organic waste.

1. Shredding Stage

The organic waste fed into the chimney will be directed to the shredding tube in the second layer, which is equipped with sharp, rust-resistant stainless steel shredders. These knives are driven by electric motors to shred the waste into small pieces. This shredding process is very important as it expands the surface of the material, thus speeding up the decomposition process by microorganisms.

Examples of materials that can be crushed:

a. Food scraps such as vegetables, fruit, rice, and bread
b. Kitchen waste such as potato peels and coffee grounds
c. Egg shells and other organic materials

2. Drying Stage

After shredding, the waste enters the drying section in the same tube. In this stage, the heating element will reduce the water content in the

organic material to optimize the fermentation process and prevent it from getting too wet, which can slow down decomposition.

3. Mixing Stage
   The dry waste is then flowed into the stirring tube in the third layer.
   Here, an automatic stirring system mixes the waste evenly while being controlled by temperature and humidity sensors. Stirring helps to spread the decomposing microorganisms consistently, maintain the ideal temperature (50- 70°C), and ensure an efficient composting process.

4. Final Layer - Water Storage and Distribution
   The fourth layer or the bottom consists of two compartments:
   a. The first compartment serves as a container for the final product in the form of ready-to-use compost fertilizer.
   b. The second compartment is the water tank, which is connected to the automatic spray system in the agitator tube. The function of this water is to maintain the ideal humidity level throughout the process.

B. Encouraging user awareness to care for the environment

The smart rubbish bin is equipped with an interactive virtual screen designed to build an emotional connection between the user and the device. The system is inspired by pet owners' interactions with their animals-where every act of feeding is met with a positive response from the animal. In this innovation, the same approach is applied: when the user removes organic waste, the screen will display smiling emoticons, cute character animations, as well as positive messages such as “Thank you for taking care of the earth!” or “Go on, keep up your good habits!”.

This feature is intended not just as entertainment, but as a form of positive reinforcement that stimulates good habits without coercion. The visual and emotional response provided by the smart rubbish bin will slowly create an affective connection between the user and the activity of disposing of organic waste. By doing so, a simple act like throwing away food waste becomes a fun and psychologically meaningful activity. This can encourage the formation of new sustainable habits, especially for the younger generation who are familiar with visual and digital interactions.

In addition to helping overcome laziness in managing organic waste, this interactive feature also fosters a sense of personal ownership and environmental

responsibility. When the result of this process in the form of composted fertilizer can be directly utilized at home, users feel the direct benefit of the habit they have built. This sense of ownership of the composted fertilizer encourages them to start planting and caring for plants, as they now have easy access to resources that may have previously been out of reach. This not only raises awareness of the importance of waste management, but also reinforces sustainable living practices emotionally and practically.

Design Planning

Mind mapping

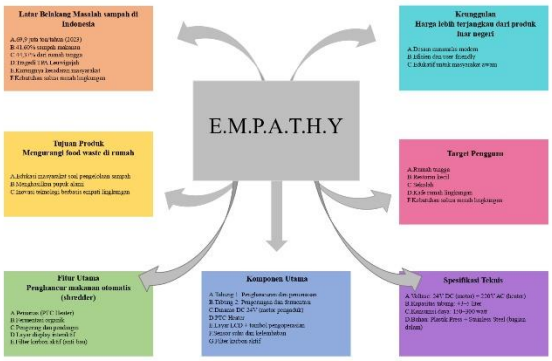

Figure 1. mind mapping

Mood board

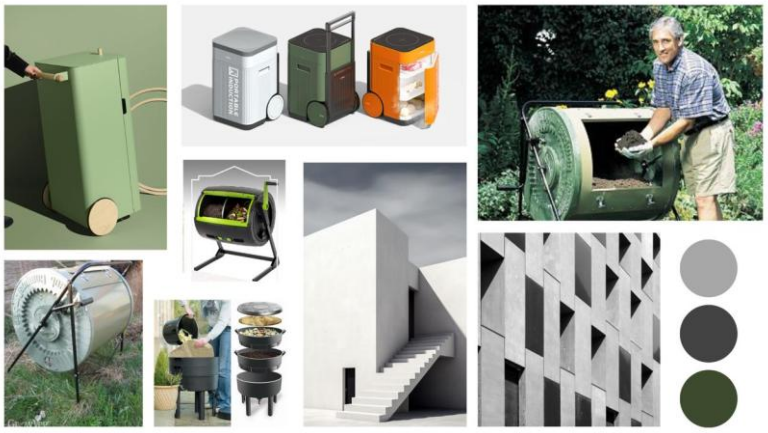

Figure 2. Mood board

5W+1H

1. What

What is E.M.P.A.T.H.Y.?

E.M.P.A.T.H.Y. is an innovative smart rubbish bin designed to process household organic waste into compost within 48 hours. It

combines user-friendly technology, dual-tank separation, and an eco-heating system to accelerate decomposition.

1. Why

   Why should E.M.P.A.T.H.Y. be made?

   Indonesia generates approximately 69.9 million tons of waste annually, with 41.60% being food waste. However, the infrastructure and awareness to manage organic waste are still lacking. E.M.P.A.T.H.Y. aims to empower households to process food waste at the source, reduce landfill loads, and support sustainable living.

2. Who

   Who will use E.M.P.A.T.H.Y.?

   This product targets households, restaurants, and public spaces such as schools or dormitories. It is especially useful for communities striving to adopt zero-waste lifestyles.

3. Where

   Where will E.M.P.A.T.H.Y. be used?

   E.M.P.A.T.H.Y. is designed for indoor placement in kitchens, service areas, or any area with regular food waste production. Its compact and modern design makes it adaptable to urban homes.

4. When

   When is E.M.P.A.T.H.Y. needed?

   The urgency is now. As food waste continues to rise and landfills reach maximum capacity, smart waste solutions like E.M.P.A.T.H.Y. are essential to improve waste management at the household level.

5. How

   How does E.M.P.A.T.H.Y.work?

   The system utilizes a dual-tank design. In the first tank, food waste is shredded and warmed using PTC heaters to initiate breakdown. After partial processing, the material moves to the second tank for further decomposition aided by controlled heating

and filtration. The final product is ready-to-use compost in just 48 hours.

SWOT

Strengths:

6. Brief process time: transformation in only a day or two greatly increases efficiency and productivity.
7. Garbage volume reduction: helps waste management quickly, suitable for densely populated areas or the food industry.
8. Environmentally friendly: producing natural fertilizer without chemicals, supporting organic farming.
9. Additional economic value: garbage becomes a valuable product (fertilizer), may be sold or reused.

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Weaknesses:

1. High initial costs: machines and installations can be expensive for umkm or individuals.
2. Energy consumption: acceleration processes likely require

more energy than conventional methods
3. Maintenance and technology: it requires technicians and technical understanding for care and troubleshoot.
4. Limited capacity: the scale of the machine can restrict the amount of waste that can be processed daily

Opportunities:

1. Applications in various sectors: schools, restaurants, traditional markets, until industrial areas can become user targets.
2. Eco-education: could be used as an educational tool in waste management campaigns.

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Threats:

1. A similar technological rivalry: many innovations in waste management, including cheaper or more efficient ones.

2. Social ignorance: a lack of understanding of how organic waste management can hinder adoption.

Alternative sketch

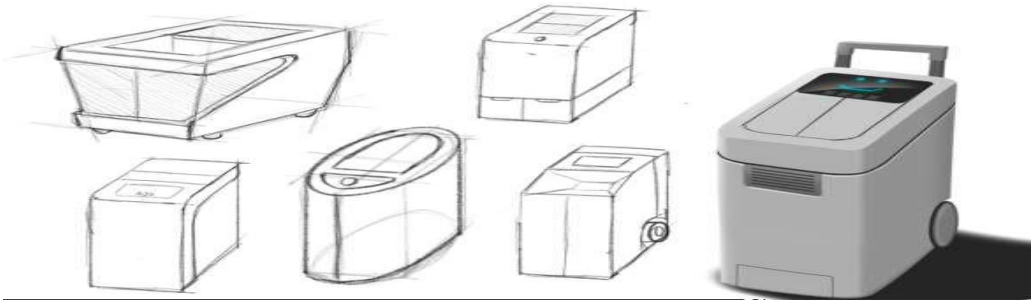

Figure 3. Alternative sketch

Final Design

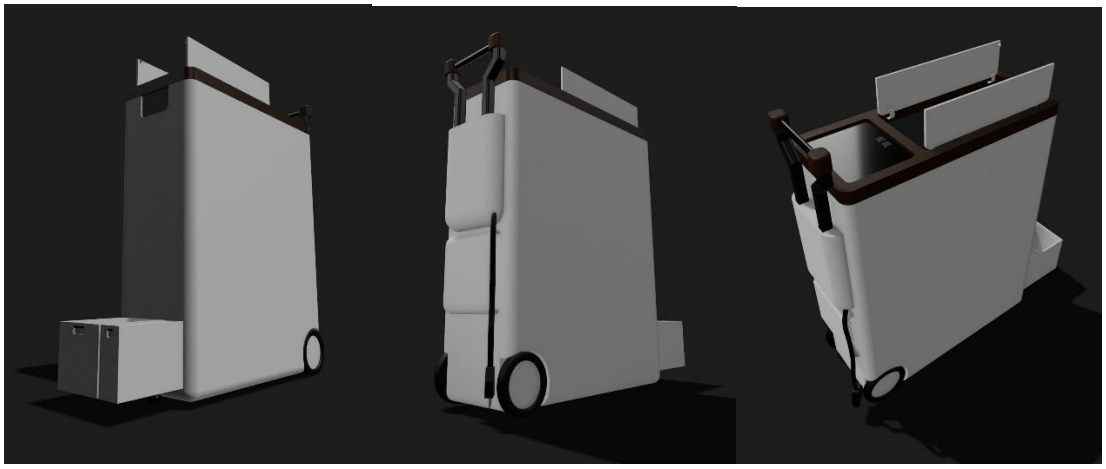

Figure 4. Final Design

Still Cut

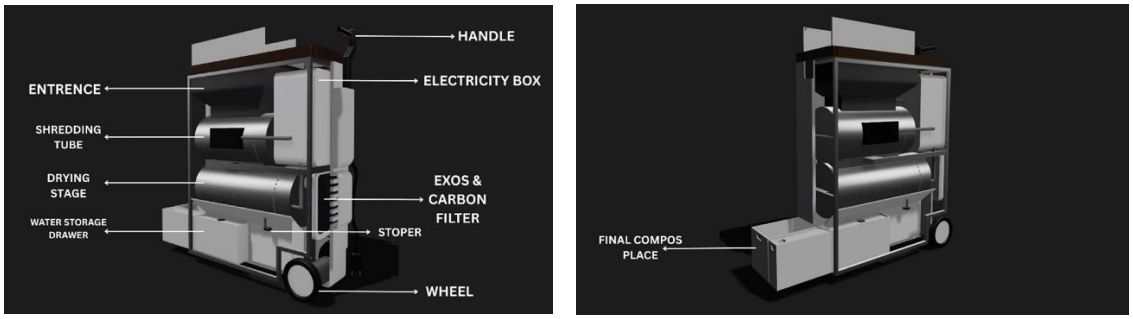

Figure 5. Still Cut

Exploded

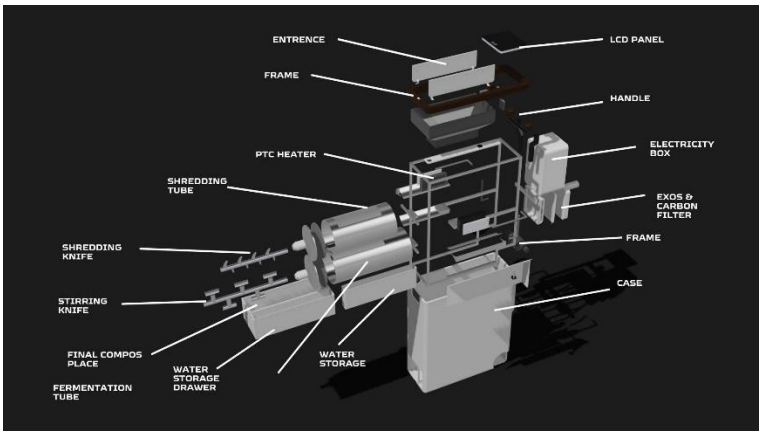

Figure 6. Exploded

Size

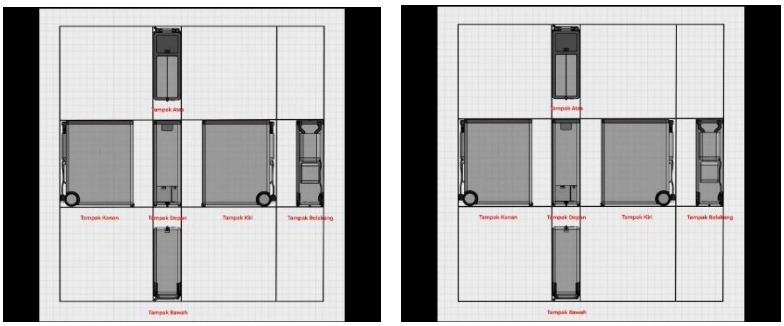

Figure 7. Size

Product working mechanism

Figure 8. Product working mechanism

1. The lid will open after pressing the "open" button.
2. Once closed, a smiley face will appear as a sign of appreciation. Afterward, the waste will enter the first processing tube.

3. The waste will enter the first processing tube.
4. The first tube undergoes the shredding process (1 hour): Stainless steel blades cut the waste, increasing the surface area of the organic material and allowing microbes to work more quickly and evenly.
5. Drying (5 hours): A PTC heater reduces humidity from 70-80% to 40-60%. This prevents anaerobic decay and creates an ideal environment for aerobic microbes.
6. Transfer 1 (10 minutes): The dry material is transferred to the fermentation chamber through an automatic valve.
7. Active Fermentation (24 hours): Thermophilic bacteria decompose complex compounds. Slow stirring and aeration maintain the temperature (50-70°C) and oxygen supply. A carbon filter removes odors from the air.
8. Stabilization & Light Maturation (2 hours): Microbes complete the decomposition process. The compost begins to solidify and smells earthy. 6. Transfer 2 (10m): The mature compost is transferred to an automatic storage container.
9. Ready-to-Use Compost (1 hour): The compost can be used immediately to fertilize potted plants or the garden.

Conclusion

E.M.P.A.T.H.Y. is designed to address the growing issue of organic waste management in Indonesia, where food waste is a major contributor to household waste and, if not managed properly, can cause environmental pollution—particularly through the release of methane gas, which has the potential to significantly damage the global climate. Ineffective waste management also impacts both the physical and mental health of the community. E.M.P.A.T.H.Y. offers a solution in the form of a smart rubbish bin capable of processing organic waste into compost within approximately 48 hours. Equipped with automation technology to facilitate shredding, drying, mixing, and fermentation, as well as an interactive screen to encourage positive habits and raise public awareness of environmentally friendly waste management, this innovation is expected to reduce the volume of waste entering landfills (*TPA*) while fostering community responsibility in processing organic waste independently. Furthermore, it supports the development of a circular economy by transforming organic waste into environmentally friendly natural fertilizer, thereby contributing to sustainable environmental and economic practices.

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