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Design and Development of a Compost bin with Integrated Odor control and Compost Utilization.

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Abstract: *The improper disposal of biodegradable kitchen waste in urban Indian homes has emerged as a major environmental concern, contributing to the overloading of landfills and the emission of harmful greenhouse gases like methane. Despite growing awareness, the adoption of domestic composting remains low due to persistent issues such as unpleasant odor, lack of user-friendly systems, space constraints, and minimal understanding of compost utilization. This paper presents a design-led solution aimed at bridging these gaps through the development of a modular, non-electric compost bin that integrates natural odor control mechanisms and compost transformation features. The research and design process began with an extensive review of existing composting products, materials, and techniques, followed by ethnographic studies, surveys, and user interviews to identify user pain points and expectations. The final design comprises features like manual mixing blades, natural filters using activated carbon and neem, a gravity-based compost tea collector, and a mold press system to produce solid fertilizer capsules. A prototype was developed using sunboard, and user feedback validated the bin's odor-free operation, ease of use, and suitability for Indian homes. The outcomes indicate that this low-cost, user-centered design can significantly enhance the adoption of composting practices at the household level and contribute to sustainable urban waste management.*

IndexTerms – Compost bin, odor control, organic waste management, user-centered design, compost tea, fertilizer capsule, sustainable design, non-electric composting

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I. INTRODUCTION

The rapid growth of urban areas in India has led to an unprecedented increase in household waste, with organic kitchen waste forming a significant portion of the total. This organic waste, when disposed of improperly, contributes to several environmental problems such as land pollution, methane emissions, and water contamination. Composting offers a practical solution to this challenge by converting biodegradable waste into nutrient-rich material. However, in Indian homes, composting is not a widespread practice due to several deterrents. The predominant issues identified include the foul smell associated with composting, insects, lack of proper understanding of composting methods, and the absence of a clear value proposition in terms of compost usability. Existing solutions either lack proper odor control or require high maintenance, while premium smart composters are priced beyond the reach of most households. The purpose of this project is to design and develop a user-friendly, compact, and cost-effective composting solution that not only mitigates odor but also provides users with usable outputs in the form of compost tea and solid fertilizer capsules. The design aims to promote sustainable waste disposal practices by making composting accessible and desirable for Indian homes.

Figure 1 Compost (pexels,2020)

II. LITERATURE REVIEW

A thorough review of both domestic and international composting solutions revealed considerable gaps in terms of odor management, compost usability, and cost-effectiveness. Traditional composting systems in India such as Daily Dump, Orbin, and EcoBin use either aerobic or anaerobic techniques, but lack user-centered features such as compost transformation and aesthetic appeal for indoor use. Internationally, products like Lomi and

Whirlpool Zera offer high-speed composting through electric mechanisms, but they are expensive, energy-intensive, and less suited for average Indian households. Academic studies underline the importance of managing the carbon-to-nitrogen (C:N) ratio, aeration, and moisture content to achieve effective composting. The inclusion of additives like biochar, microbial inoculants, and compost starters can enhance microbial activity and improve compost quality. Ergonomic studies further stress the need for intuitive interfaces, safe operation, and design adaptability for kitchen environments. Despite these technological and scientific advancements, few designs offer an integrated solution that transforms compost into user-friendly forms like compost tea or solid capsules while also addressing the problems of odor and insects. This project seeks to merge these diverse insights into a holistic design that is functional, affordable, and environmentally responsible.

III. MARKET ANALYSIS

To better understand the landscape of composting products in India and abroad, a benchmarking analysis was conducted. Products like Daily Dump Kambha, Smart Bin Air, Trustbin, Eco Bin, and Orbin represent popular Indian models that rely on passive aerobic composting. While some of them feature basic aeration and stacking techniques, none offer integrated compost tea collection or shaped fertilizer output. Daily Dump's Kambha, for example, is effective when maintained regularly but lacks any built-in mechanism for turning or odor control. Orbin includes a drainage outlet but does not support compost shaping or filtering.

In contrast, smart composters such as Lomi and Whirlpool Zera boast automation, odor sealing, and fast composting cycles. However, their cost, electricity dependence, and bulky design limit their appeal to Indian users. Additionally, many of these smart systems do not yield compost that is immediately ready for soil application without drying or separation. These observations reveal a critical market opportunity: an affordable, odor-free, non-electric composting solution designed for tight spaces and optimized for end-use compost utility.

Figure 2 Orbin, Smartbin, Daily dump, Ecobin, trustbin, Whirlpool Zera, Lomi

IV. METHODOOGY

The project followed a five-phase design methodology that began with an in-depth literature review and market benchmarking to understand the state of composting solutions. Secondary research included an analysis of composting parameters, material behavior, and existing product mechanisms. The next phase involved primary research through a Google Forms survey conducted among 54 respondents, as well as face-to-face ethnographic interviews with households across different age groups and professions. These methods helped reveal behavioral insights and pain points associated with composting. Based on these findings, personas and use-case scenarios were developed to guide the ideation phase. Multiple sketches and concepts were generated, followed by the use of QFD (Quality Function Deployment) and Pugh Matrix analysis to evaluate each design concept. Concept 5, which featured modular construction, natural filters, a compost tea outlet, and a manual mold press, was selected for further development. A 1:1 physical prototype was constructed using sunboard and supplemented by a digital 3D model. The final stage involved validation through usability testing, ergonomic evaluation, and direct user feedback, leading to refinements in form, handle design, and compost output mechanisms.

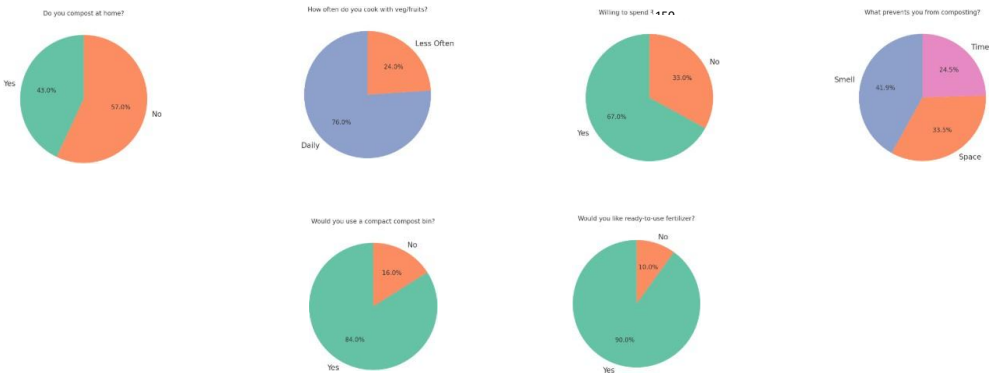

Figure 3 Google survey charts

V. RESULTS

The findings from both primary and secondary research strongly indicated that foul odor and lack of awareness were the primary reasons preventing users from composting at home. The user survey revealed that while only 43% currently composted, 84% of participants expressed interest in a compact, indoor composting system. More significantly, 90% indicated a desire for ready-to-use compost outputs like liquid fertilizer, while 67% were willing to invest ₹2,000–₹4,000 in such a system. Interviews with users emphasized frustration with insects, lack of space, and expensive composters. These insights directly influenced key design features such as integrating a manual stirring system for aeration, creating a chamber to collect compost tea, and developing a pressing mechanism for forming compost into capsules. Ethnographic observations of composting practices also revealed the role of cultural habits, such as the use of neem powder and cow dung, which were adopted into the design for odor control. These collective findings shaped a solution that prioritized simplicity, cleanliness, and functional compost reuse.

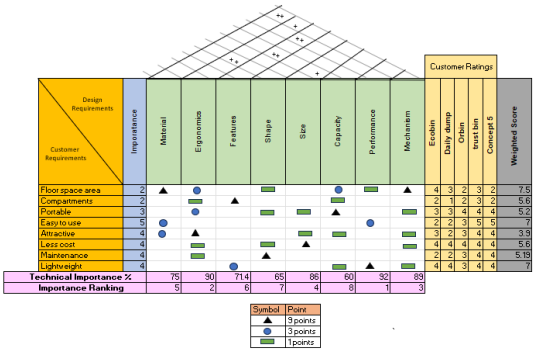

Figure 4 QFD

Criteria	Daily Dump	Concept 1	Concept 2	Concept 3	Concept 4	Concept 5
Ease of use	0	+	+	+	+	+
features	0	+	+	+	+	+
Mechanism placement	0	-	-	+	-	+
Aesthetics	0	+	+	-	+	+
Ease of manufacturing	0	-	-	+	+	+
maintenance	0	-	-	+	+	+
odor	0	+	+	+	+	+
Bio degradable	0	-	-	-	-	-
Toal +	0	4	4	6	6	7
Total -	0	4	4	2	2	1
Total score		0	0	4	4	6

Table 1: Pugh Matrix

VI. FINAL PRODUCT

The final compost bin design is a vertically aligned, modular system with a form factor suitable for indoor use. It includes a manually operated mixing system consisting of vertical blades rotated via an ergonomic handle, allowing proper aeration and microbial activity. The base of the composting chamber is sloped to direct excess liquid into a dedicated compartment, from which compost tea can be collected through an integrated tap. For solid compost transformation, the system includes a mold cavity equipped with a pressing mechanism that compresses decomposed compost into solid fertilizer capsules. Odor control is achieved through a chamber near the venilaion containing activated carbon pads and natural pellets made from neem and cow dung. The outer structure of the prototype was made using sun board, while production versions would employ HDPE or PP plastic for durability. The bin measures approximately 300×300×600 mm and weighs around 8–10 kg, ensuring portability without sacrificing capacity. The aesthetic design includes a modern matte finish in camel brown, allowing it to blend into household environments. The user interface comprises manual knobs and handles with clearly marked zones for input and output, ensuring intuitive interaction. CAD models, exploded views, and environmental renders illustrate the design process and final product presentation.

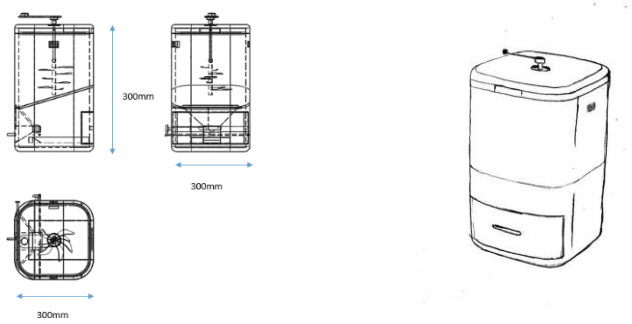

Figure 5 concepts generated

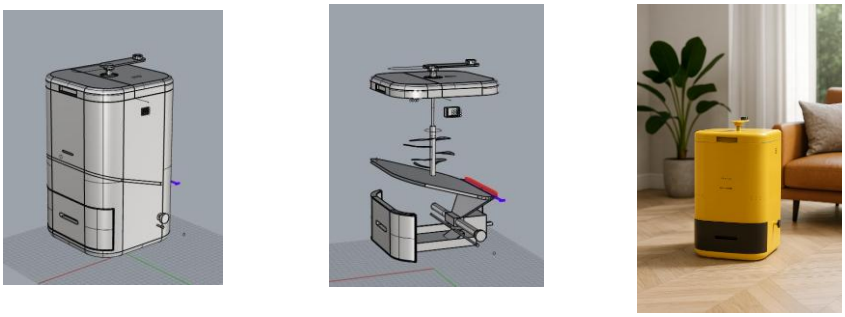

Figure 6 3D model

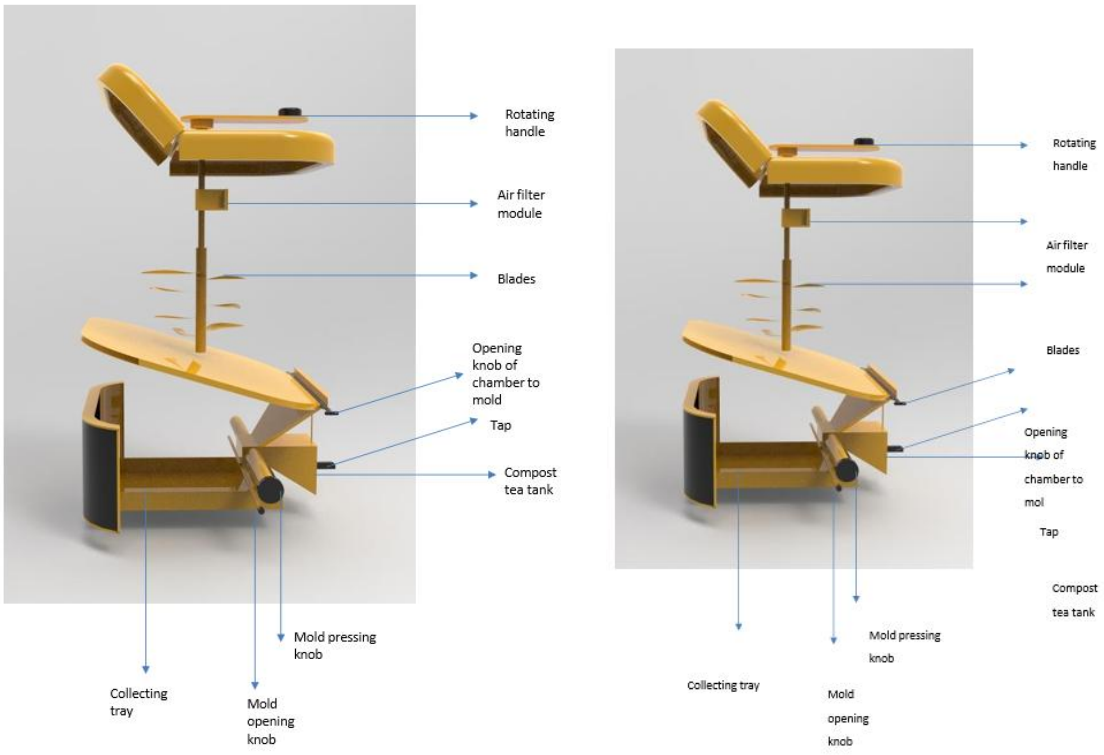

Figure 7 Exploded view

6.1 Compost bin workflow

The compost bin model is designed with three primary compartments, each serving a distinct function within the composting cycle. The top unit has the lid which has a compartment to put coir which helps In maintaining moisture. This unit also integrates a simple manual mixing mechanism that allows the starter to be dispensed into the composting chamber below. A rotating handle on the lid drives vertical blades positioned strategically to assist in light churning of the waste materials, improving aeration and initiating the decomposition process. sloped base for drainage and a mesh layer that filters excess liquid into the bottom tank. This compartment can accommodate up to 8 kilograms of vegetable and food waste. At the center is a manually operated mixing blade that is connected from the lid. The vertical blades are designed to reach the base of the chamber and stir the waste from the bottom upward, ensuring uniform aeration and microbial activity throughout the decomposition process. Additionally, this unit contains an odor control module with replaceable filters composed of neem powder and activated carbon, effectively suppressing foul smells and discouraging pest intrusion during the active composting phase.

The bottom unit of the system is a compost collection tray and tea tank. Decomposed liquid, also known as compost tea, drains through the mesh layer into this tank, which includes a small tap for easy dispensing. Beside it is a compression mold, which users can fill with matured compost to form dry fertilizer capsules. Depending on environmental conditions and frequency of mixing, the composting process typically completes within 7–14 days. The modular design allows for easy disassembly, cleaning, and maintenance, making it suitable for regular indoor use in Indian kitchens or balconies.

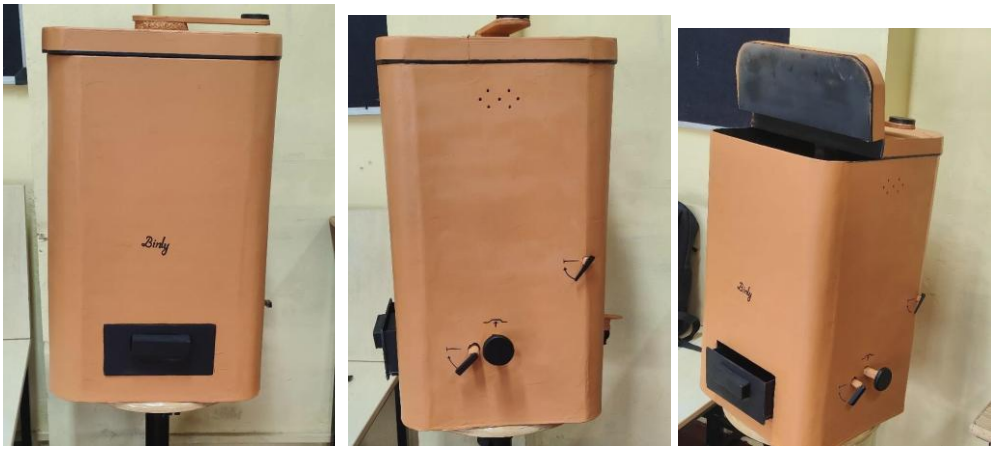

Figure 8 Final Prototype

6.2 Steps in working of compost bin

The steps involved in composting of the working prototype are as follows: Composting process
Cutting into small pieces of organic waste and mixture of compost starter, accelerator and calcium oxide is added to the storage unit along with the greens and browns.
Activated carbon pads along with need capsule is put in the air filter module.
Close the lid
Rotate the mixing blade handle (periodically mix in order to speed up the compost)
Because of the slanting base of compost storage, the excess water is transferred and segregated to the compost tea tank
After compost is done, open the valve to the mould
Press the mould knob and make the compost into a cube
Now open the mould gate and the compost cube will be transferred to the collecting tray.
Take the cubes and use it as per your wish.

Figure 9 Task analysis & Testing of prototype

VI. Validation and Testing

User validation was carried out through hands-on testing by individuals from diverse demographic backgrounds. Participants tested the prototype for usability, odor levels, and clarity of interaction. The feedback was positive, particularly regarding the ease of mixing, accessibility of compost tea, and the absence of unpleasant smells. Users reported that the product felt intuitive, manageable, and aesthetically acceptable for indoor spaces. Ergonomic assessments confirmed that the handle, knobs, and levers were suitable for a wide range of user hand sizes. Performance testing showed effective moisture separation, minimal odor, and visible compost transformation over time. However, areas of improvement were also noted, including the need for sturdier materials for long-term use and refinement in the pressing mechanism to handle denser compost. Despite these limitations, the prototype successfully validated the design intent and demonstrated potential for real-world application.

Figure 10Testing the working of prototype

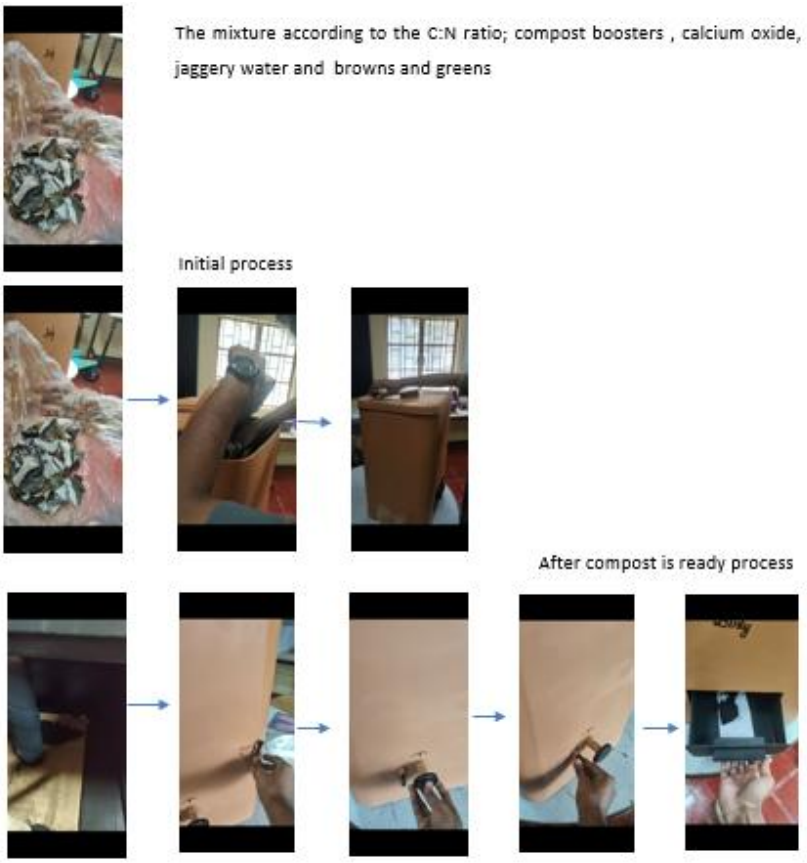

Figure 11 Testing the working of prototype

VII. Conclusion

The project began with the recognition that household composting in urban India is hindered by odor, effort, and lack of clear value. Through an iterative and research-driven process, a compost bin was developed that is compact, ergonomic, and equipped with features that convert waste into usable forms. The integration of natural deodorization, compost tea collection, and a fertilizer mold transforms the composting experience from

passive disposal to active value creation. User testing confirmed the viability of the design and highlighted its ease of use, affordability, and functional relevance. This project not only proposes a viable solution for sustainable waste management but also contributes to the discourse on user-centered design, environmental engineering, and behavioral change in domestic settings.

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