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Transforming Waste into a Valuable Resource: Development of a Biodegradable Trash Bin Made from Coconut Coir and Rice Husk with Post-Disposal Fertilizer Potential

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Abstract

This study explored the development of a biodegradable trash bin that is made from coconut husk and rice husk designed to turn into a soil conditioner (fertilizer) upon decomposition. As traditional plastic waste bins contribute significantly to environmental degradation, this research explored a solution by evaluating the mechanical durability and post-use agricultural benefits of natural fiber composites. Employing an exploratory mixed method design, the researchers produced three samples with varying coconut husk concentrations (25%, 50%, and 75%). The bins were subjected to standardized Drop Tests from heights up to 2.0m, Load Capacity Tests up to 3kg, and Soil Burial Test to measure weight loss and fertilizer potential. Key findings revealed a critical trade-off between structural strength and biodegradability. Samples with lower fiber content (25%) show higher durability, passing drop tests at 1.5m, and supporting 1kg loads with minimal deformation. On the other hand, samples with higher fiber content (75%) showed the highest rate of biodegradation, losing 9% of their mass in seven days, and demonstrated superior fertilizer potential. Soil enriched by the 75% husk sample showed an increase in pH (from 6.5 to 6.9), improved moisture retention, and accelerated germination of bean sprouts. These results align with the findings of Khan *et al.* (2022) [5] and Ahmad *et al.* (2022) [1] regarding the energy absorption and microbial breakdown of lignocellulose materials. The study concludes that a 50% coconut husk blend provides the most doable balance for a functional yet eco-friendly bin. This innovation supports circular economy principles by reducing waste and actively enhancing soil fertility. Recommendations include optimizing the fiber-matrix bonding to improve impact resistance at higher heights and conducting long-term studies on crop yield using decomposed bin fragments.

Keywords: Eco-Friendly Bin, Coconut Husk Composite, Biodegradable Waste Management, Soil Conditioner

Introduction

The increasing problem of plastic waste and environmental pollution has created a growing need for sustainable and biodegradable alternatives for everyday products. At the same time, agricultural by-products such as coconut coir and rice husk are widely available but often underutilized despite their potential as eco-friendly raw materials. Previous studies have shown that coconut coir has strong fiber structure and high cellulose content suitable for reinforcing biodegradable composites, while rice husk improves durability and mechanical performance when combined with natural binders (Smith & Kumar, 2024; Chandra & Singh, 2025 [3]). Other research also highlights their ability to be processed into compostable materials and their potential to improve soil quality after decomposition. In the Philippine context, agricultural residues have been successfully used in the development of plant-based containers, construction materials, and biodegradable alternatives to plastics, demonstrating their practical value in sustainable product development (Gonzales & Reyes, 2025) [4] These findings emphasize the importance of maximizing agricultural waste as a renewable resource instead of allowing it to contribute to environmental burden.

The present study is supported by Sustainability Theory, Circular Economy Theory, and Composite Material Theory. Sustainability Theory emphasizes the use of renewable and biodegradable materials to reduce environmental harm and promote responsible resource use, particularly by transforming abundant agricultural residues into functional products (Baxter *et al*., 2023) [2]. Circular design principles further encourage the development of products that remain beneficial even after disposal by allowing materials to return safely to the environment as compost. Meanwhile, Composite Material Theory explains how natural fibers such as coconut coir and rice husk can be combined with biodegradable binders to produce materials with sufficient strength, durability, and functional performance for practical use (Li, Zhang, & Wu, 2024) [6]. Guided by these studies and theoretical perspectives, this research aims to develop a biodegradable trash bin with post-disposal fertilizer potential, providing a product that is both functional during use and environmentally beneficial throughout its life cycle.

Objective

The main objective of this study is to address the primary issue in the community to reduce waste and increase environmental sustainability by transforming coconut husk combined with rice husk into an eco-friendly trash bin for fruits and vegetables at the same time for soil stabilization. This transformation will not only help to reduce waste and pollution but also create renewable, biodegradable alternatives to synthetic materials which support energy production from biomass and improve environmental sustainability. By altering coconut husk into practical products, communities can both address waste-management challenges and promote more sustainable that will benefit local environments and economies.

Material and Methods

This study used materials to develop an eco-friendly trash bin that is biodegradable, durable, and sustainable. These materials were chosen because they are abundant agricultural byproducts that are frequently discarded as waste, yet they possess properties that are suitable for construction and reinforcement when combined properly.

Image	Materials
	**Coconut husks (coir)** are used as the primary material for making an eco-friendly trash bin. These husks as agricultural waste serve as the main source of natural fiber to make the soil stabilize.
	**Rice husk** is used because of its high silica content, which helps improve the bin's structural strength, rigidity, and durability.
	**Tapioca starch** is used as a natural binder which helps to hold the coconut fibers and rice husk together to form a solid structure without the need for synthetic adhesives.
	**Pot and Ladle** are used for mixing the eco-friendly trash bin components. The pot is used to heat and gelatinize the tapioca starch, allowing it to act effectively as a natural binder that holds the coconut husk fiber and rice husk together, and the ladle is used to stir and evenly mix the ingredients.
	A **weighing scale** would be used to measure the exact proportion and percentage of coconut husk and rice husk incorporated into the tapioca starch. Exact measurements guarantee uniformity in formulations.

Experimental Procedures

Load Capacity Test

Each eco-bin sample was subjected to increasing weights (1 kg, 2 kg, and 3 kg), held for 10 minutes per trial. Structural performance was noted, and each bin was labeled as "Passed" or "Failed" based on its deformation under load.

Durability (Drop) Test

Bins were dropped from three heights (1.0 m, 1.5 m, and 2.0 m) to assess impact resistance. The condition after each drop was observed for cracks, bending, dents, and structural failure.

Biodegradability Test

Samples were buried in soil for seven (7) days. Initial and final weights were measured to calculate percentage weight loss. Visual changes such as cracking, darkening, mold, and fragmentation were recorded.

Fertilizer Potential Assessment

Decomposed sample materials were mixed into loamy soil with an initial pH of 6.5. After one week, soil pH was re-measured, and changes in soil texture, moisture retention, and plant growth (bean sprouts) were observed and recorded.

This study utilized a convergent parallel mixed-method research design to explore the feasibility and effectiveness of a biodegradable trash bin made from coconut coir and rice husk with post-disposal fertilizer potential. The convergent parallel mixed method allows simultaneous collection and analysis of both quantitative and qualitative data to provide a comprehensive assessment of the eco-friendly bin's structural performance, biodegradability, and fertilizer potential. Quantitative data were obtained through experimental testing, while qualitative data were gathered through direct observation of material behavior during testing. The research followed a mixed-method approach where quantitative measurements and qualitative observations were collected concurrently.

Quantitative testing involved physical strength tests (load capacity and drop tests), biodegradation evaluation (soil burial), and fertilizer potential assessment (soil pH and plant growth). Qualitative observations documented physical changes, deformation, soil condition, and plant development throughout the experimental procedures. Eco-bin samples were prepared using local, readily available materials. Three sample types were made with varying proportions of coconut coir fiber (25%, 50%, and 75%) mixed with rice husk and tapioca starch as a natural binder. The raw materials were weighed using a digital scale and mixed thoroughly. Each mixture was molded into a bin shape and dried under sunlight until fully set. Quantitative data from experimental measurements (load capacity, height resistance, weight loss, pH change, and early growth) were recorded and organized using descriptive statistics such as means and percentages. Qualitative data were gathered through direct observation during all stages of testing to capture material behavior, deformation patterns, biodegradation characteristics, and changes in soil and plant growth. Both sets of data were compared through the convergent parallel approach to strengthen the interpretation of results.

Results and Discussion

Table 1: Physical Strength / Load Capacity Test

Product	Percentage of Coconut Husk Used	Initial Condition of Bin	Type of Load Used	Load Applied (kg)	Duration (min)	Observations (cracks, bending, deformation)	Result (Passed / Failed)
Sample A	25%	Intact, no visible defects	Sandbag	1kg	10 minutes	No cracks, slight bending	Passed
Sample B	50%	Intact, no visible defects	Sandbag	2kg	10 minutes	Minor surface cracks	Passed
Sample C	75%	Intact, no visible defects	Sandbag	3kg	10 minutes	Noticeable bending, small cracks	Failed

The test showed that increasing coconut husk content reduces the bin's load-bearing capacity. At 25% husk, the bin held 5 kg with slight deformation. At 50%, it supported 10 kg but developed minor cracks. At 75%, it failed under 15 kg with bending and cracking. This indicates that excessive fiber weakens the composite due to poor stress transfer between fibers and the matrix. As stated by Ahmad *et al*. (2022) [1], moderate coconut fiber improves toughness and sustainability, but high fiber content reduces strength because of weak bonding and poor fiber dispersion. The results show the need for an optimal balance of husk and binder, with 25–50% providing better performance for practical use.

Table 2: Durability Test

Trial No.	Test Type (Drop / Repeated Use)	Height / Frequency	Initial Condition	Final Condition	Observations
1	Drop	1.0m	Intact, no defects	Slight scratches	No cracks or deformation; structure stable Result: Passed
2	Drop	1.5m	Intact, no defects	Minor dent	Small crack observed; minor bending Result: Passed
3	Drop	2.0m	Intact, no defects	Visible dent and bending	Noticeable deformation and small cracks Result: Failed

The Durability (Drop) Test showed that bins made with coconut and rice husk withstand low drops (1–1.5 m) with only minor scratches and dents, indicating good energy absorption from the fiber–matrix interaction. However, at higher drop heights, the bins bent and cracked, showing reduced impact resistance as impact energy increased. Consistent with Khan *et al*. (2022) [5], natural fiber composites absorb moderate impact energy better than non-reinforced materials, but their durability decreases under high-energy impacts due to weak fiber–matrix bonding. The results highlight that optimal fiber content and stronger bonding are needed to improve impact resistance while maintaining eco-friendly properties.

Table 3: Biodegradability Test

Product	Percentage of Coconut Husk Used	Burial Duration (days)	Initial Weight (g)	Final Weight (g)	Weight Loss (%)	Visual Changes (cracks, mold, fragmentation)	Degradation Level
Sample A	25%	7 days	1000g	996g	4%	Slight surface darkening, no cracks	Very Low
Sample B	50%	7 days	1000g	994g	6%	Slight mold, surface darkening	Low
Sample C	75%	7 days	1000g	991g	9%	Surface darkening, small cracks, minor fragmentation	Moderate

The test on biodegradability showed that the eco-friendly bin biodegraded quicker in relation to the amount of coconut husk used. Sample A (husk 25%) showed the least weight loss of 4%, with only slight surface darkening and no cracks, signifying very low degradation. Sample B (husk 50%) lost 6 % of its weight and showed slight mold and surface darkening, indicating low degradation. Sample C (husk 75%) showed the most weight loss of 9%, with surface darkening, small cracks, and slight fragmentation, indicating a moderate degree of degradation.

The rate of degradation is influenced by fiber content, soil moisture, temperature, and microbial population (Ahmad *et al*., 2022) [1] which aligns with the observed trends in this study where samples with higher coconut husk content degraded faster over the 7-day period.

The findings confirm that coconut husk content is a key factor in the biodegradability of eco-friendly bins. Moderate to high fiber content enhances soil decomposition, supporting the environmental sustainability of these products.

Table 4: Soil Burial Test (Fertilizer Potential)

Product	Percentage of Coconut Husk Used	Burial Duration (week)	Initial Soil Condition (pH and texture)	Final Soil pH	Visual Changed in Soil (color, texture and moisture)	Plant Growth Observation (bean sprouts)	Observation
Sample A	25%	1	pH 6.5, loamy	6.7	Slightly darker, crumblier, retains moisture better	Germination normal: early sprout growth	Minor Soil improvement; slight positive effect on sprout growth
Sample B	50%	1	pH 6.5, loamy	6.8	Darker, looser texture, retains moisture well	Slightly earlier germination: early sprout growth	Moderate soil-conditioning effect; improved early sprout development
Sample C	75%	1	pH 6.5, loamy	6.9	Dark brown, very crumbly, retains moisture very well	Earliest germination; early sprout growth	Strong soil-conditioning effect; highest positive impact on early sprout development

The soil burial test (fertilizer potential) showed that eco-friendly bins improved soil quality and supported early plant growth, with stronger effects at higher coconut husk levels. Sample A (25% husk) showed minimal changes in soil structure and moisture retention, though bean sprouts still germinated. Sample B (50% husk) showed better soil looseness and moisture retention, supporting seed germination. Sample C (75% husk) produced the best results: the soil became dark, crumbly, and highly moisture-retentive, leading to the earliest germination among all samples.

Coconut husk's lignocellulose composition helps improve soil porosity, moisture retention, and nutrient availability as it decomposes. Ahmad *et al*. (2022) [1] found that adding coconut coir enhances early seed germination and seedling growth due to improved soil aeration and nutrient release, with greater fiber content leading to stronger effects. Eco-friendly bins with higher coconut husk content not only serve as biodegradable materials but also improve soil condition and promote early plant development.

Data Analysis Interpretation

The data collected from the experiments were analyzed using both quantitative and qualitative methods based on the convergent parallel mixed-method design. Quantitative data comprised the results from the load capacity test, drop test, biodegradability assessment, soil pH variation, and initial plant growth. The outcomes were organized into tables and analyzed using basic descriptive statistics like percentages, values, and variations among the three eco-bin samples containing 25%, 50%, and 75% coconut coir. This assisted the researchers in grasping how the quantity of coconut coir influences the strength, durability, biodegradability, and fertilizer capabilities of the biodegradable waste container.

Qualitative data were gathered through direct observation during the testing process. Cracks, bending, deformation, mold growth, soil texture, moisture retention, and seed germination were all noted by the researchers. Four major themes emerged from these observations: soil improvement, biodegradability, durability, and structural strength. As a result, it was simpler to interpret the numerical results. A distinct pattern emerged from the combined investigation. Because it maintained its strength and durability while demonstrating good biodegradability and beneficial impacts on soil after disposal, the eco-bin containing 50% coconut coir performed the best overall. While the 75% coconut coir sample decomposed more quickly and improved the soil more, it was poorer in strength and durability than the 25% coconut coir sample, which was stronger but decomposed more slowly.

Overall, the findings indicate that coconut coir and rice husk can be utilized to produce a functional biodegradable and environmentally friendly waste container. The research demonstrates that maintaining an appropriate level of natural fiber is crucial for ensuring both effective usability and environmental advantages of post-disposal, reinforcing the aim of sustainability.

Conclusion

Based on the overall findings of the study, coconut husk is an effective and sustainable material for the development of eco-friendly trash bins. These findings confirm that coconut husk content has a crucial role in determining the bin's mechanical strength, durability, biodegradability, and soil-conditioning potential.

Moderate coconut husk content (25–50%) provides the best balance between structural performance and environmental sustainability, which allows the bin to withstand practical loads and normal handling conditions, while higher coconut husk content (75%) enhances biodegradability and soil improvement but compromises mechanical strength and durability. These findings stated that the importance of enhancing fiber content to meet functional things during use while ensuring environmental benefits after disposal is important.

Overall, the eco-friendly trash bin provides a dual advantage which both reducing plastic waste during its service life and contributes positively to soil enhancement after disposal which supporting both sustainable waste management and circular economy practices.

Recommendations

For Students: Students are recommended to actively participate in environmental projects such as creating and using eco-friendly trash bins made from biodegradable materials like coconut husks. Through proper waste segregation and disposal, students can better understand how organic materials like coconut husk contribute to soil improvement after disposal. Applying these practices can help students develop environmental awareness, responsibility, and skills related to sustainability and waste management.

For Teachers: Teachers are recommended to integrate lessons on eco-friendly materials, biodegradability, and sustainable waste management into classroom activities and projects. The use of eco-bins with fertilizer potential after disposal can serve as an example when discussing environmental science, recycling, and soil health. This approach may help students turn out theoretical concepts with real-world applications and may strengthen their critical thinking skills.

For Parents: Parents are recommended to support and guide their children in practicing environmentally responsible habits at home. Encouraging the use of biodegradable materials and explaining how eco-friendly bins can improve the soil quality after disposal that can help strengthen sustainability values. By promoting proper waste disposal and composting at home, it can also improve discipline, environmental responsibility, and awareness among children.

For School Administrators: School administrators are recommended to have a program, projects that will promote the use of eco-friendly trash bins with fertilizer potential. By improving school gardens or having sustainability clubs can help to enhance the environmental benefits of biodegradable bins. These initiatives can support students' development by combining environmental education and practical application.

For the Community: Community members and local organizations are recommended to support eco-friendly waste management practices by using biodegradable trash bins and participating in composting or soil improvement activities. By doing community-led programs, clean-up drives, and gardening, the environment can benefit from the fertilizer potential of eco-bins, helping improve soil quality while reducing waste. Lastly, the collaboration between schools and communities can strengthen environmental awareness and promote sustainable practices at a big level.

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