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Transforming Organic Waste into an Environmentally Efficient and Value-Added Solution through the EnzymPoz Innovation Program

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ABSTRACT: The increasing amount of organic waste in industrial and domestic settings demands innovative solutions that are efficient, low-cost, and environmentally sustainable. This study evaluates the EnzymPoz program as an integrated model for managing non-hazardous organic waste (non-B3) through ecoenzyme fermentation and composting. The program was implemented at PT Paiton Energy using fruit peels and dry leaves as primary materials. Ecoenzyme was produced through anaerobic fermentation, then used to enrich compost and transform fermentation residue into value-added products, including organic fertilizer and ecoenzyme-based pillows (EcoPillow). The method involved documenting process parameters, calculating material recovery, and estimating economic savings. Results indicated that the program successfully utilized 12.60 tons of organic waste within one year. Energy efficiency analysis yielded a normalized material conversion rate of 6.32×10^{-7} ton/GJ. The program also generated direct operational cost savings of IDR 50,336,000,00 per year through product substitution. Beyond technical outcomes, EnzymPoz fostered community involvement through CSR collaboration, making it a model for inclusive circular economy practices. The findings support EnzymPoz as a replicable solution for industries aiming to adopt zero-waste principles and valorize organic waste streams into functional and marketable products.

KEYWORDS: Organic Waste; Ecoenzyme; Composting; Circular Economy; Waste Valorization

I. INTRODUCTION

The generation of organic waste remains a significant environmental challenge in both industrial and residential areas. Left unmanaged, this waste contributes to increased greenhouse gas emissions, environmental pollution, and inefficient resource use. Data from the Ministry of Environment and Forestry of Indonesia in 2023 showed that organic waste still constitutes more than 50% of total municipal solid waste, emphasizing the urgent need for effective management strategies. In response, integrated waste treatment initiatives that support zero-waste and circular economy principles have become increasingly relevant.

PT Paiton Energy, as an energy company committed to sustainability, initiated an innovation program called EnzymPoz. The program aims to manage non-hazardous organic waste generated from industrial facilities and employee residential areas by utilizing fermentation-based ecoenzyme production and composting processes. This approach is designed not only to reduce the volume of waste sent to landfills but also to transform waste into valuable resources.

EnzymPoz integrates two main processes: anaerobic fermentation of organic matter primarily fruit and vegetable waste to produce ecoenzyme, and composting of dry leaves and other biodegradable waste. The resulting products include enzyme-enriched compost and ecoenzyme residue that can be repurposed into practical goods such as EcoPillow, a health-supportive pillow product. This reflects a shift from conventional waste treatment to waste valorization, aligning with sustainable development goals and corporate environmental responsibility.

This study evaluates the performance of EnzymPoz in terms of material recovery, cost efficiency, and added value creation. It also explores how the program strengthens community engagement through Corporate Social Responsibility (CSR) mechanisms. The research outcomes are expected to offer insights and models that can be replicated in similar industrial environments striving for zero-waste targets and sustainable waste management innovation.

II. METHOD

This study employs a descriptive quantitative approach aimed at evaluating the technical and operational effectiveness of the EnzymPoz program in managing non-hazardous organic waste within an industrial setting. The main focus of this method lies in documenting the processing stages, formula formulation, selection of tools and materials, as well as the program's implementation system to support the principles of zero waste and resource efficiency.

2.1. Research Location and Period

The research was conducted within the premises of PT Paiton Energy, Probolinggo Regency, East Java, covering both the employee residential area and supporting operational facilities. Observations and data collection were carried out throughout the year 2024, in line with the full-scale implementation of the EnzymPoz program. Information was obtained through activity log records, daily documentation, and operational monitoring instruments.

2.2. Materials and Equipment

The primary raw materials used in this program include fruit peel waste (banana, apple, orange) and dry leaves obtained from vegetation trimming around the premises. Additional materials such as molasses are used as a carbon source for the fermentation process, while clean water serves as the solvent. Equipment utilized includes fermentation buckets, compost sacks, digital scales, blenders, sieves, cloth, and pillowcase fabric. All materials are sourced from internal domestic waste, without the addition of external chemical substances.

2.3. EnzymPoz Process Stages

The EnzymPoz program integrates two main approaches: ecoenzyme fermentation and composting. The general stages of the process can be described as follows:

a. Ecoenzyme Fermentation

Fruit peels are mixed with molasses and water in a ratio of 3:1:10. The mixture undergoes fermentation for approximately 90 days under anaerobic conditions to produce liquid ecoenzyme and solid fermentation residue.

b. Enzyme Fertilizer Production

The liquid ecoenzyme is used as a compost bioactivator, while the solid residue is mixed with dry leaves and subjected to aerobic fermentation in compost sacks for a duration of 21 to 30 days with periodic stirring.

c. EcoPillow Production (Health-Support Pillow)

The soft residue obtained from the fermentation separation process is further processed through refining and drying, then packaged using pillowcase fabric to become an organic-based pillow product.

Figure 1. EcoPillow (EcoEnzyme-based Pillow)

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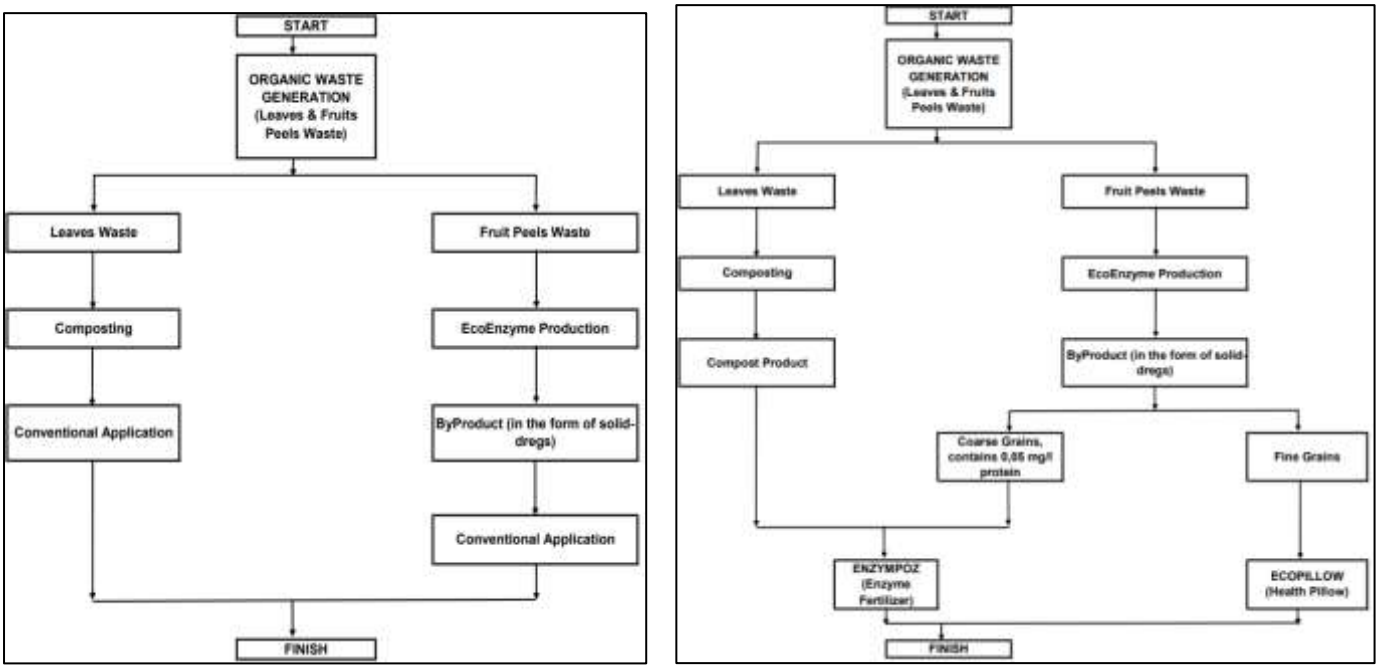
The integrated process flow has been illustrated in a schematic visualization, which serves as an additional technical reference.



(a) (b)

Figure 2. Process Diagram of the EnzymPoz Innovation for the Production of Enzyme Fertilizer and EcoPillow (a) before improvement, (b) after improvement

2.4. Documentation and Data Collection Techniques

Data were collected through daily logbook records, weight measurements of materials and products at each process stage, as well as visual and administrative documentation. The observed variables included the type and volume of waste, material ratios in the formulation, process duration, types of end products, and input resource consumption.

2.5. Analysis and Procedure Validation

The procedure was evaluated narratively and systematically to ensure replicability. No inferential statistical analysis was performed, as the focus of the evaluation was operational and descriptive in nature. Validation was conducted through comparison with previously applied organic waste treatment protocols implemented internally within the company.

The soft fermentation residue that could not be utilized in composting was repurposed as a raw material for derivative products in the form of health-supportive pillows (EcoPillow). This process involved partial drying, textural refinement, and packaging using environmentally friendly pillowcase fabric. The additional utilization of fermentation residue as pillow filling is in line with the principle of reusing soft-textured organic waste, which has potential as a filler material based on natural fiber content (Deng et al., 2023).

III. RESULTS

This study generated several key findings related to the effectiveness of the EnzymPoz program in managing non-hazardous organic waste and converting it into functional products that can be reused. The results presented in this section are provided in the form of data quantification, efficiency calculations, product economic value assessments, and visual documentation of the treatment process and innovation outcomes.

3.1. Quantification of Organic Waste Utilization

Throughout the year 2024, the EnzymPoz program successfully utilized 12.60 tons of organic waste. This total included 1,569 kg of fruit peels and 11,030 kg of dry leaves collected from household activities of employees and vegetation maintenance around company facilities. The waste treatment process was carried out entirely without leaving any residue to be sent to landfill. The total amount was calculated based on the conversion of each type of organic waste from kilograms to tons.

Table 1. Quantification of EnzymPoz Organic Waste Utilization

Type of Waste	Weight (Kg)
Fruit peels	1.569
Dry leaves	11.030
Total Waste	12.600

This data provides a concrete illustration of the material potential that can be converted through an integrated fermentation and composting system. The total volume also reflects the amount of waste that can be diverted from conventional disposal pathways.

3.2. Efficiency of Material Utilization (Normalized Value)

To measure material efficiency from an energy-equivalent perspective, a normalization calculation was performed based on the total amount of waste processed using the standardized energy unit (GJ). The results of the calculation showed the following normalized values:

- 7.87×10^{-8} tons/GJ for fruit peels,
- 5.53×10^{-7} tons/GJ for dry leaves, and
- 6.32×10^{-7} tons/GJ for the total combined waste

Table 2. Normalized Utilization Value of Fruit Peel Waste

Fruit Peel	
Absolute Utilization Value (Ton)	**Normalized Value (Ton/GJ)**
1,57	$7,87 \times 10^{-08}$

Table 3. Normalized Utilization Value of Dry Leaf Waste

Dry Leaves	
Absolute Utilization Value (Ton)	**Normalized Value (Ton/GJ)**
11,03	$5,53 \times 10^{-07}$

The calculation provides a foundation to evaluate the efficiency of waste utilization from an energy-based perspective and enables comparison with other treatment approaches that may have different energy profiles. These values demonstrate that the EnzymPoz process yields material conversion performance that can be consistently achieved.

The normalized value resulting from this process was 6.32×10^{-7} tons/GJ, reflecting the level of energy efficiency in converting organic waste into functional products. This finding shows that the system applied in the EnzymPoz program has a competitive material conversion efficiency when compared to small-scale industry and community-based systems. This approach aligns with strategies for organic waste management based on energetic recovery efficiency, which are also applied in urban composting systems in South Asia (Zhao et al., 2023).

3.3. Economic Value and Cost Savings

The EnzymPoz program produced two types of products, namely 10,984 kg of enzyme fertilizer and 160 units of ecoenzyme-based pillows (EcoPillow). Based on the local market price, organic fertilizer is valued at IDR 4,000.00 per kilogram and organic pillows are valued at IDR 40,000.00 per unit. The estimated economic value of the products is as follows:

- Enzyme fertilizer: IDR 43,936,000.00
- EcoPillow: IDR 6,400,000.00

Total operational cost savings: IDR 50,336,000.00

a. Absolute Value Calculation

- Fruit peel (Ton) = $\frac{\text{Fruit peel utilization (kg)}}{1{,}000}$
- Dry leaves (Ton) = $\frac{\text{Dry leaves utilization (kg)}}{1{,}000}$

- Total (Ton) = Fruit peel + Dry leaves

b. Normalized Value Calculation

- Normalized = $\frac{\text{Utilized waste (ton)}}{\text{Total energy input (GJ)}}$

c. Cost Savings Calculation

- Cost savings = Product quantity × Product unit price

This calculation demonstrates the potential for direct substitution of equivalent products that would otherwise be purchased from external vendors, while also generating added value from residual organic waste that previously remained unutilized.

Table 4. Normalized Value of Dry Leaf Waste Utilization

Cost Savings			
Year	**Compost**	**Ecoenzyme Pillow**	**Total**
2024	Rp 43.936.000,00	Rp 6.400.000,00	Rp 50.336.000,00

3.4. Documentation of Production and Innovative Products

Visual documentation was used to showcase the implementation process of the program, beginning from the fermentation stage, material mixing, and product packaging of both the fertilizer and EcoPillow, while highlighting community involvement in the continued production phase.

(a) b)

Figure 3. (a) Fermentation residue of EcoEnzyme ready for compost production; (b) The process of enzyme-based fertilizer preparation.

Figure 4. Community empowerment activities by PT Paiton Energy through the EnzymPoz program.

This visualization highlights both the technical success and social acceptance of the program at the operational level. In this CSR initiative, employees and community members were directly involved in training and production activities, supporting the transition from company-based waste management to community-based product development

IV. DISCUSSION

The implementation of the EnzymPoz program has made a significant contribution to the management of non-hazardous organic waste in industrial environments, covering technical, economic, social, and environmental aspects. The program integrates fermentation and composting processes to generate two valuable products: enzyme-based fertilizer and health-supportive pillows (EcoPillow) made from ecoenzyme residue. In this section, the findings are interpreted in depth, connected to relevant literature, and linked to potential future development.

4.1. Waste Conversion Effectiveness and Material Efficiency

The total utilization of 12.60 tons of organic waste per year demonstrates the success of zero-waste practices at the operational level. This figure is particularly significant as it indicates that the program can prevent all organic waste from entering final disposal. Compared to conventional waste schemes that mostly focus on plastic and paper, this approach is more holistic as it addresses the broader issue of organic waste, which dominates national waste generation (Manea et al., 2024).

The normalized value of 6.32×10^{-7} tons/GJ further indicates competitive energy conversion efficiency suitable for micro-industry scale operations. This means that each unit of available energy can be utilized to convert a substantial volume of waste into useful final products. (Xu et al., 2023) reported similar normalized values in a community-based composting system in China, although with greater community involvement. In the context of EnzymPoz, a similar level of efficiency was achieved through a company-based operational approach.

4.2. Economic Value of Derived Products and Cost Efficiency

This program also provides tangible evidence that organic waste can become a new economic resource. With total annual savings of IDR 50,336,000.00, the program makes a clear contribution to operational cost reduction. When analyzed further, this amount is equivalent to the cost of procuring external products for land maintenance and CSR-based promotional materials.

The enzyme fertilizer produced has enhanced quality due to its enrichment with liquid ecoenzyme. This aligns with findings from (Galintin et al., 2021), which indicate that ecoenzyme improves nutrient availability and accelerates decomposition. Furthermore, the EcoPillow production offers a rare innovation in conventional waste management systems. It addresses the issue of solid fermentation residue while opening opportunities for circular economy practices through high-value products.

4.3. Integration with Social Aspects and Community Empowerment

One of the key strengths of EnzymPoz is its ability to combine technical operations with social components through Corporate Social Responsibility (CSR). The production of EcoPillows involves direct participation from community members, empowering them as operational actors. This model supports an inclusive circular economy approach, where the community is not merely a recipient of benefits but also an active agent in the transformation of waste into economic products (Muliarta, 2024).

This practice also fosters a collaborative ecosystem among the company, business partners, and local communities. Such collaboration enhances the company's social legitimacy and supports sustainability reputation, particularly in the context of external assessments such as Public Disclosure Program for Environmental Compliance (PROPER) - Program of the Ministry of Environment and Forestry of the Republic of Indonesia or ESG reporting.

4.4. Academic Implications and Future Research Directions

Academically, the EnzymPoz approach enriches the literature on innovations in organic waste management through bioactivator-based and closed-loop resource utilization strategies. Integrated models like this are still rarely found in industrial practice in Indonesia, especially those combining waste with the production of derivative functional goods with monetization potential. Therefore, this study makes an important contribution to the development of transdisciplinary waste management theory and practice, connecting environmental engineering, resource economics, and social empowerment.

Further research can explore the following topics:

- Life Cycle Assessment (LCA) of EnzymPoz production processes,
- Market feasibility and consumer perception of EcoPillow,
- Replication potential for other organic waste types such as kitchen scraps, food waste, or restaurant residues,

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The value chain modeling system is proposed to integrate organic waste production with logistics and the distribution of processed end-products. This integration aligns with the circular economy approach and supports the efficient flow of materials from production to end-use.

Academically, the EnzymPoz approach enriches the literature on innovations in organic waste management based on bioactivators and closed-loop resource utilization. Such an integrated model is still rarely encountered in industrial practices in Indonesia, particularly one that combines organic waste management with the production of high-value functional products. Furthermore, this type of model becomes increasingly relevant in the current transdisciplinary framework that links environmental engineering, social engagement, and sustainable production systems (Davis & Aid, 2022).

V. CONCLUSION

The EnzymPoz program demonstrates the effectiveness of an integrated approach in managing non-hazardous organic waste through the combination of ecoenzyme fermentation and composting. The program successfully converted 12.60 tons of waste into valuable products: enzyme-based fertilizer and ecoenzyme-based pillows. This utilization not only supports waste reduction and zero-waste implementation, but also shows strong energy efficiency, with a normalized value reaching 6.32×10^{-7} ton/GJ.

From an economic perspective, the program generated total savings of IDR 50,336,000.00 per year by substituting external products and optimizing internal company resources. One of EnzymPoz's key strengths lies in its ability to integrate social aspects, where products are developed through CSR partnerships with local communities. This creates an inclusive circular economy model that is not only environmentally beneficial but also socially valuable.

With this achievement, EnzymPoz has strong potential to be replicated in other industrial sectors that generate similar organic waste streams and can contribute meaningfully to sustainable waste management at both local and national levels.

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