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Implementation Of Household Organic Waste Composter Using Aerobic And Anaerobic Fermentation Methods

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Abstract

The problem of household organic waste management has become a serious challenge in many regions of Indonesia, including RT 10 of Sungai Duren Village, Muaro Jambi Regency. Most residents still rely on traditional methods such as burning or disposing of waste in vacant land, which leads to environmental pollution, foul odors, and serves as a breeding ground for disease vectors such as flies and rats. In fact, more than 57% of the total 67.8 million tons of national waste per year consists of organic waste that can actually be processed into useful products. The main obstacles faced by the community are the lack of appropriate wasteprocessing equipment designs and low literacy in waste management. This community service program aims to design and implement a householdscale organic waste processing device that integrates aerobic and anaerobic fermentation in a single, unified system. The implementation method uses Focus Group Discussion (FGD) with a participatory approach so that the community can be actively involved in all stages of the activity, which include: preparation and initial survey, design and fabrication process, socialization, as well as monitoring and evaluation. Monitoring is carried out using an online survey via Google Forms to assess the effectiveness, ease of use, and sustainability of the device. The results show that the device functions effectively in reducing the volume of household organic waste and produces compost and biogas that can be reused. In addition, there is an increase in community knowledge, awareness, and participation in independent, sustainable, and environmentally friendly waste management.

Keywords: Organic waste; Composter; Aerobic anaerobic_fermentation

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INTRODUCTION

Waste management is a crucial issue faced by many developing countries, including Indonesia. Based on data from Sistem Informasi Pengelolaan Sampah Nasional (SIPSN) released by the Ministry of Environment and Forestry (KLHK), in 2021 Indonesia generated approximately 67.8 million tons of waste per year, and more than 57% of it consisted of household organic waste such as food scraps, leaves, and kitchen waste [1]. Poorly managed organic waste can lead to various environmental problems, including groundwater pollution, increased greenhouse gas emissions, and the potential growth of disease vectors. Waste management that still relies on the collect–transport–dispose system to Final Disposal Sites (TPA) is becoming increasingly inefficient due to the limited capacity of disposal sites in many urban areas of Indonesia.

Sungai Duren Village is one of the villages located in Jambi Luar Kota District, Muaro Jambi Regency, Jambi Province. According to data from the Sungai Duren Village in 2023, the village has a population of more than 4,000 people, with most residents working as farmers, daily laborers, and micro, small, and medium enterprise. Specifically in RT 10, there are more than 80 households, most of which reside in densely populated areas with a high volume of household waste, particularly organic waste such as food scraps and kitchen waste.

Field observations show that the waste management system in RT 10 is still traditional, in which waste is collected and then burned or dumped in vacant land around the settlement. There is no Integrated Waste Processing Facility, community composter, or organized waste collection system. These issues lead to waste accumulation, air pollution from waste burning, and potential health risks due to the presence of flies and rats.

In this context, one strategic solution is sourcebased waste management or processing at the household level. This approach can not only reduce the burden on final disposal sites but also create valuable products such as compost and biogas. One applicable method is fermentation. Aerobic fermentation is a process of decomposing organic matter with the help of microorganisms in oxygenrich conditions, producing compost as the final product. Meanwhile, anaerobic fermentation occurs in oxygenfree conditions, where microorganisms break down organic waste into biogas (mainly methane) and solid residue (digestate), which can also be used as fertilizer [2].

Each fermentation approach has its own advantages. Aerobic fermentation is generally faster in producing compost and is suitable for waste with low lignin content, while anaerobic fermentation is highly efficient for wet waste such as food scraps with high water content. Therefore, integrating aerobic and anaerobic fermentation into a single processing system has strong potential for householdscale application. Combining both methods not only reduces waste volume but also enables renewable energy utilization (biogas) and supports household agriculture through compost production.

However, implementing fermentationbased waste processing technologies at the household level still faces several challenges. One of the main issues is the lack of equipment design that meets community needs in terms of technical feasibility, cost, and ease of use. Household waste processors available on the market typically accommodate only one processeither composting (aerobic fermentation) or biodigestion (anaerobic fermentation) and often come in sizes unsuitable for limited spaces in densely populated settlements [3]. Additionally, community literacy on independent waste management remains low, so innovations in equipment must be accompanied by educational approaches to ensure sustainable use.

Several studies show that smallscale organic waste processing using appropriate technology can significantly reduce household waste generation. According to Arsyad et al. [4] simple multitier bucket aerobic composters have been successfully used by communities in several major cities in Indonesia and can reduce kitchen waste by up to 60%75%. Meanwhile, plasticdrumbased anaerobic biodigesters have also been proven to produce up to 0.5 m^3 of

biogas per day from family food waste [5]. These findings indicate that simple technological innovations can generate real impact when designed appropriately for local conditions.

Based on these considerations, this community service program aims to design and implement a householdscale organic waste processing device that integrates both aerobic and anaerobic fermentation systems in a unified structure. The device will be designed to be efficient, ergonomic, affordable, and easy for community members to operate. In addition, a participatory approach will be applied in the design and implementation process by involving the local community to foster a sense of ownership and ensure sustainability. The expected outcomes of this activity include not only a functional device but also improved community capacity in independently managing organic waste.

METHODS

The implementation method uses Focus Group Discussion (FGD) with a participatory approach to ensure active community involvement in all stages of the activity [6–8]. The community service program consists of several systematic stages, namely: the preparation stage, tool design and production, socialization, implementation and assistance, as well as monitoring and evaluation. All activities are designed to involve the community partners actively and sustainably, and also serve as a platform for student engagement within the Merdeka Belajar Kampus Merdeka (MBKM) framework.

Stage 1. Preparation and Preliminary Survey

At this stage, the community service team conducts field surveys and collects primary data regarding community habits in disposing of waste, environmental physical conditions, and the potential use of wastederived products (compost and liquid fertilizer). This activity also includes interviews with community leaders, the head of the neighborhood unit (RT), and representatives of residents in RT 10 to obtain a comprehensive understanding of the problems and the community's readiness to participate in the program. The community partner plays an active role in providing initial information, identifying potential locations for pilot testing, and selecting representative households. The survey results will serve as a basis for adjusting the equipment design to suit local needs and environmental carrying capacity.

Stage 2. Equipment Design and Fabrication

The organic waste processing device to be developed combines two fermentation technologies: Aerobic fermentation: uses an open system that allows natural oxygen supply into the waste, accelerating organic decomposition and producing compost (Bacillus spp., Pseudomonas spp., Trichoderma spp.). Anaerobic fermentation: uses an airtight closed reactor to produce liquid fertilizer and small amounts of methane gas (Lactobacillus spp., Clostridium spp., Methanosaeta concilii). To improve efficiency and accelerate fermentation, microbial cultures or effective microorganisms (EM) are often used. These microbes contain bacterial strains. The starter may come from commercial products such as EM4 or be produced from Local Microorganisms (MOL) such as fermented stale rice or fermented rinsed rice water [9–11]. These microbes accelerate the breakdown of organic materials and produce solid compost, liquid fertilizer, and methane gas. The equipment is designed with considerations for modularity, ease of use, and the availability of local materials (plastic drums, PVC pipes, gas valves, and liquids). Fabrication will be carried out in the partner's workshop or the university workshop. Students are actively involved in the technical design process using simple simulations as well as in the fabrication process.

Stage 3. Socialization, Implementation, and Assistance

The socialization activities are conducted through facetoface meetings with RT 10 residents, including: education on types and impacts of household waste, introduction to waste processing principles based on fermentation, and explanation of the benefits of compost and liquid fertilizer for the environment and household economy. Handson training is provided to the residents of RT 10, Sungai Duren Village, Jambi Luar Kota District, designed

collaboratively and supported with simple modules and tutorial videos. Lecturers and students serve as facilitators and activity documenters.

Stage 4. Monitoring, Evaluation, and Sustainability

Program monitoring is carried out systematically and participatively to ensure active community involvement and the effectiveness of the wasteprocessing equipment. The community service team uses log sheets distributed to participating households to record usage frequency, volume of waste processed, and fermentation outputs such as the amount of compost and liquid fertilizer produced. In addition, regular onsite observations are conducted to evaluate the technical condition of the equipment and provide support if operational issues arise. Qualitative interviews are also conducted with selected households to assess satisfaction levels, ease of use, and potential behavioral changes in organic waste management. The detailed sequence of activities in the community service program (PPM) is illustrated in Figure 1.

Figure 1. Community Service Implementation Flowchart (adhitya et al., 2024)

RESULTS AND DISCUSSION

The implementation of the Community Service Program (PPM) with the theme Design and Implementation of a HouseholdScale Organic Waste Processing Device Based on Aerobic and Anaerobic Fermentation in RT 10, Sungai Duren Village, Muaro Jambi Regency, was carried out through four main stages conducted continuously.

Stage 1. Preparation and Preliminary Survey

The implementing team coordinated with the neighborhood administrators and community representatives to map out the needs and existing conditions. A field survey was conducted to inventory the types and volumes of household organic waste as well as residents' waste management practices. The findings indicated that most organic waste was still disposed of directly or burned, with very limited community involvement in waste separation. This aligns with studies showing that community participation is a key factor in reducing household waste and encouraging composting activities [12].

Figure 2. Preliminary survey conducted by the community service team to identify residents' waste disposal habits and the physical environmental conditions in RT 10, Sungai Duren Village, Muaro Jambi Regency.

Stage 2. Design and Production/Fabrication of the Aerobic and Anaerobic Organic Waste Processing Tool (Composter)

Based on the results of the survey and discussions with residents, the community service team designed a dualsystem composter (aerobic and anaerobic), combining ventilation features and a sealed container for fermentation. The materials used included used plastic paint drums, ventilation pipes, faucet systems for liquid and gas discharge, and modular components to allow easy assembly. The design components refer to composting principles that integrate aeration and anaerobic conditions to accelerate organic decomposition (Li et al., 2022). Initial trials showed that the tool was able to produce solid compost and liquid fertilizer within a relatively short period of time, supporting efficient processing of household organic waste volumes. The design and fabrication process of the organic waste processing tool can be seen in Figures 3 and 4.

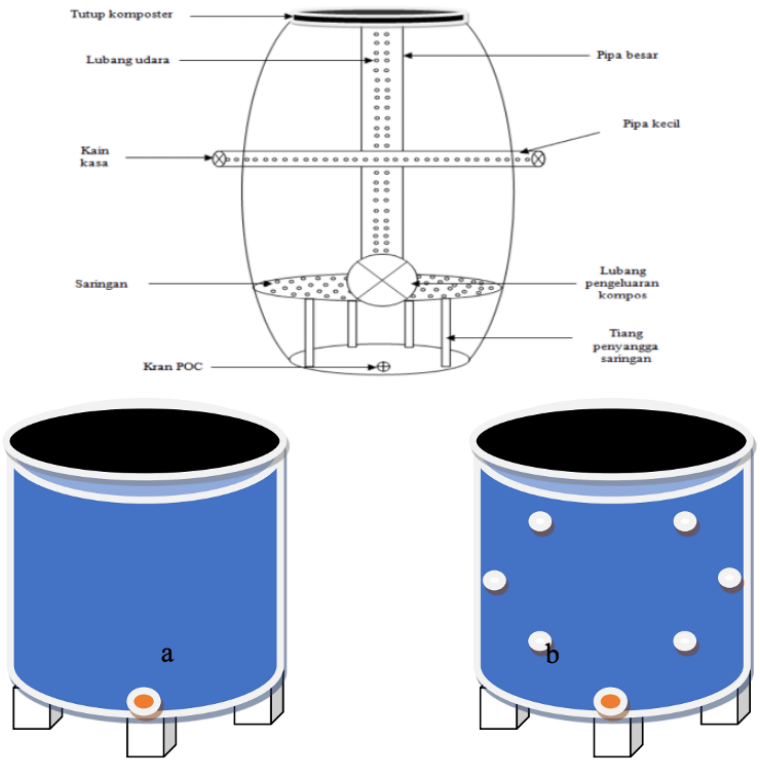

Figure 3. Design of the organic waste processing tool (composter): a. anaerobic composter; b. aerobic composter [13]

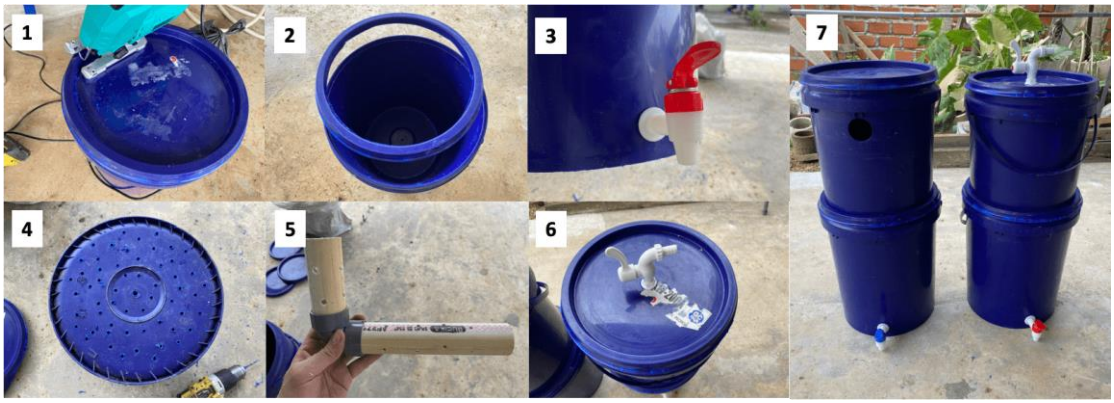

Figure 4. Fabrication process of the organic waste processing tool

Stage 3. Socialization and Implementation of the Organic Waste Processing Tool

After the tool was completed, the team conducted socialization activities for residents through counseling sessions and direct demonstrations. The explanation covered the tool's working mechanism, the principles of aerobic and anaerobic fermentation, as well as the environmental and economic benefits. Residents were involved in trial use of the tool after the socialization activities. This active community involvement in the demonstration aligns with the communitybased waste management approach, which shows that the success of waste management strongly depends on community participation (Mulasari et al., 2024). The community's response was quite positive; the tool was considered easy to operate and began to help reduce organic waste accumulation in households.

Figure 5. Socialization and implementation activities of the aerobic and anaerobic organic waste processing tool (composter) conducted in the front yard of the RT 10 head's house in Sungai Duren Village, Muaro Jambi Regency

Stage 4. Monitoring and Evaluation

Monitoring was carried out periodically to assess the effectiveness of tool usage and community perceptions. The monitoring process showed an increase in residents' awareness of separating organic and nonorganic waste. The fermentation process successfully produced solid fertilizer (compost) and liquid fertilizer within 3–4 weeks. Some residents began using the organic fertilizer from the aerobic and anaerobic composters for plants in their home gardens. Based on the evaluation, a wastemanagement group was formed at the RT level to provide assistance and expand tool usage to other households as a sustainability strategy. This strategy is important because communitybased waste management models have been proven to be more effective in the long term.

Evaluation of the community's understanding of organic waste management was conducted using pretests and posttests administered before and after the socialization activities. The results of the posttest indicated an improvement in residents' understanding of aerobic and anaerobic organic waste processing. Based on the pretest results conducted prior to the socialization activity, 40% of participants obtained moderate scores, 50% obtained high scores, and 10% obtained very high scores. Meanwhile, the posttest results conducted after the socialization showed that 20% of participants obtained high scores and 80% obtained very high scores. The pretest and posttest results are presented in Figure 6.

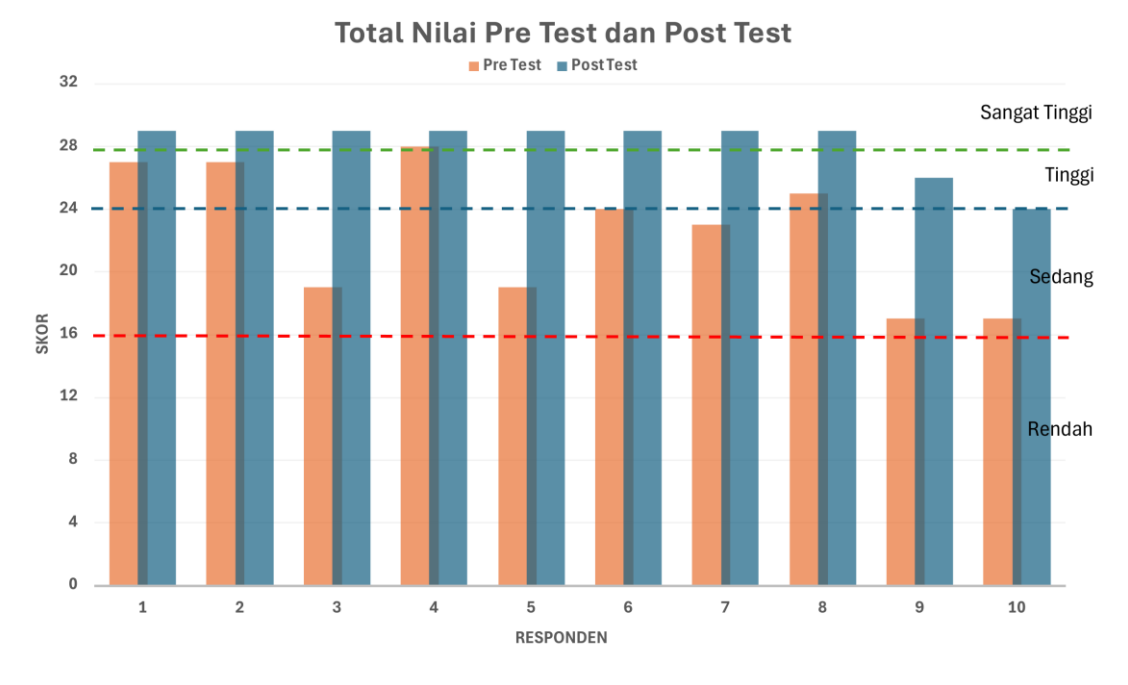

Figure 6. Total PreTest and PostTest scores obtained by the participants

(PreTest in orange and PostTest in blue)

Table 1. Examples of questions given in the PreTest and PostTest and the improvement in understanding of aerobic and anaerobic composters, environmental cleanliness, confidence, and interest in applying aerobic and anaerobicbased organic waste processing

Questions	Pre Test (%)		Post Test (%)	
	True	False	True	False
Knowledge about Aerobic and Anaerobic Composters	73,8%	26,3%	96,3%	3,8%
Community awareness level regarding environmental cleanliness	73,8%	26,3%	95%	5%
Level of confidence in using aerobic and anaerobic composters to address waste problems	67,5%	32,5%	75%	25%
Interest in applying aerobic and anaerobic-based waste processing	67,5%	32,5%	86,3%	13,8%

Overall, the implementation of this program successfully achieved its main objectives: reducing household organic waste volume through appropriate technology, improving community capacity in environmentally friendly waste management, and fostering collective awareness in maintaining cleanliness and environmental quality sustainably.

CONCLUSIONS

The Community Service Program (PPM) titled Design and Implementation of a HouseholdScale Organic Waste Processing Tool Based on Aerobic and Anaerobic Fermentation for the Community of RT 10, Sungai Duren Village, Muaro Jambi Regency has been carried out up to the monitoring stage. Field observations show that most organic waste in the partner area is either disposed of directly or burned together with other waste, with very limited sorting by residents. Therefore, the PPM team designed, socialized, and demonstrated

the organic waste processing tool to the community, followed by direct implementation by the residents. A monitoring process was then conducted to evaluate the effectiveness of the socialization in changing community perceptions and to assess the performance of the organic waste processing tool. Overall, it can be concluded that the implementation of this PPM activity has effectively increased the awareness and capability of residents in the partner area to manage organic waste using appropriate technology, thereby supporting sustainable environmental quality management.

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AUTHOR CONTRIBUTIONS

In the implementation of this program, each team member contributed according to their specific expertise and assigned role. Bagus Adhitya was responsible for Conceptualization, formulating the core ideas of the program and ensuring that its objectives and direction were properly achieved. Muhammad Ikrar Lagowa contributed to the Methodology, designing the technical approach and field procedures for the community service activities. The Validation process was carried out by Yosa Megasukma, who ensured that each stage of the activities and the resulting outputs aligned with the program standards and objectives. To ensure data accuracy and organization, Data Curation was handled by Maulina Tanjung. The Writing – Original Draft Preparation was carried out by Bagus Adhitya, while the Writing – Review & Editing was completed by Muhammad Ikrar Lagowa, who reviewed the manuscript for structure, academic clarity, and content consistency. The Visualization aspects, including illustrations, process diagrams, and image arrangements, were prepared by Yosa Megasukma. Overall program Supervision was provided by Bagus Adhitya, ensuring effective coordination among team members. Project Administration responsibilities were carried out by Jarot Wiratama, particularly in managing the implementation workflow at the community level. Meanwhile, Funding Acquisition was coordinated by Bagus Adhitya as the principal investigator.

CONFLICT OF INTEREST

There is no conflict of interest.

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