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Towards a Fertilizer-Independent Village: Zero-Waste Management in Tik Kuto Village, Rimbo Pengadang-Lebong, Bengkulu Province

Mimi Sutrawati[1*], Sura Menda Ginting[2], Dewi Jumiarni[3], Apri Andani[4], Sukisno[5], Ulfasari Rafflesia[6], Elva Nadiya[7], Hengki Windra[8], Maylan Ratu Dewi[9], Fadhillah Akbar Pratama[10]

[1,2,3,4,5,6,7,8,9,10]Universitas Bengkulu
Indonesia
✉ mimi_sutrawati@unib.ac.id*

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Abstract

Background: In Tik Kuto Village, organic household and agricultural waste remains largely underutilized, contributing to environmental pollution and potentially reducing community health status and productivity. The lack of practical, low-cost, and easily applied waste management technologies at the household and farm levels highlights the need for community-based interventions that support sustainable and environmentally friendly practices.
Aims: The specific objective is to enhance community capacity to process organic waste into Local Microorganisms (MOL), Liquid Organic Fertilizer (POC), and ecoenzymes within a Zero-Waste Management framework.
Methods: The program was implemented through participatory outreach and counseling, demonstrations, technical training, and mentoring activities involving farmer groups and housewives. Educational support materials included posters and booklets. The resulting MOL served as an activator for POC, which was fermented for four weeks. Ecoenzymes were produced from fruit peels, brown sugar, and water in a 3:1:10 ratio and fermented for a minimum of three months. Program effectiveness was evaluated using pre-tests, post-tests, and direct observation of participant engagement.
Results: A total of 18 farmers participated in the program. Although most participants were middle-aged and experienced farmers, their baseline knowledge of organic waste processing was low. Post-training evaluation showed substantial improvements, with understanding of waste sorting and processing reaching 94–100%. Knowledge related to materials, production steps, application dosage, and benefits of MOL, POC, and ecoenzymes increased from 6–28% to 83–94%.
Conclusion: The program successfully improved participants' knowledge and behavioral intentions regarding organic waste management at the household and community levels.

A. Introduction

Organic waste from households and agricultural activities constitutes the largest fraction of waste generated in many regions of Indonesia and has the potential to degrade soil, water, and public health if not managed properly (Dinas Lingkungan Hidup, 2022). Various studies have shown that long-term dependence on chemical fertilizers alone can degrade soil quality, reduce fertilizer efficiency, accelerate the loss of soil

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organic carbon, and increase the risk of environmental pollution (Bai et al., 2020; Ge et al., 2018; Wang et al., 2016). At the same time, at the household and farming level, the use of organic waste as a source of raw materials for organic fertilizer is still relatively limited.

Waste can originate from both household and industrial activities. Population growth is directly proportional to increased activity and consequently leads to a rise in waste volume. Indonesia is the second-largest contributor to municipal solid waste, producing 187.2 million tons per year, following China in first place with 262.9 million tons per year, and followed by the Philippines, Vietnam, and Sri Lanka. Based on these figures, it can be estimated that Indonesia generates approximately 175 thousand tons of waste per day, or about 0.7 kg per person per day (Juniarti, 2020).

Tik Kuto Village, Rimbo Pengadang District, Lebong Regency, was selected as the intervention site because of its abundant household and agricultural organic waste and emerging environmental challenges in waste management and agriculture. Daily activities generate large quantities of organic waste, such as vegetable and fruit scraps, rice washing water, straw, banana stems, coffee peels, and other kitchen residues, which are mostly unmanaged and often disposed of through open dumping or burning. These practices cause unpleasant odors, potential water contamination, and greenhouse gas emissions. Local agricultural systems remain dependent on chemical fertilizers, which over time can degrade soil fertility, disrupt soil microbial balance, and increase production costs for farmers. The lack of effective organic waste processing alternatives worsens these issues and leads to underutilization of local biomass. Given these conditions, Tik Kuto Village represents a strategic and urgent location for the development of Liquid Organic Fertilizer (POC), Local Microorganisms (MOL), and ecoenzymes. Transforming organic waste into value-added bio-inputs offers an integrated solution that addresses waste accumulation, reduces reliance on chemical fertilizers, improves soil health, and promotes environmentally sustainable agricultural practices. Some of the advantages of organic fertilizers over synthetic fertilizers include their gradual release of nutrients (Shaji et al., 2021). Although the use of synthetic fertilizers cannot be completely eliminated, the use of organic fertilizers in conjunction with synthetic fertilizers can improve soil quality physically, chemically, and biologically (Muktamar et al., 2016).

MOL and biofertilizers based on local wisdom are reported to be able to increase plant growth and can be an environmentally friendly alternative to reduce dependence on inorganic fertilizers (Firdaus et al., 2022; Irwandhi et al., 2024; Mukarramah & Nahar, 2024; Yuliana, 2021). On the other hand, ecoenzymes and similar organic waste processing technologies have been proven to reduce the volume of household organic waste while producing multifunctional products that are beneficial for households and agriculture (Aji et al., 2025; Aristya et al., 2025; Maharani et al., 2024; Prarikeslan et al., 2022). In 2024, community mentoring activities were carried out in Tik Kuto Village, which aimed to improve farmers' knowledge and skills regarding soil and plant health diagnostic techniques, as well as to improve skills in making compost (Sutrawati et al., 2025). Processing of organic coffee fruit skin compost waste has also been carried out in Kepahiang Regency and has shown good results (Ginting et al., 2022).

Ecoenzymes can be utilized in various household activities. Some applications of ecoenzymes include serving as a plant growth factor, a mixture for floor-cleaning detergents, a cleaner for pesticide residues, a descaling agent, and a coolant temperature-reducing agent in car radiators (Supriyani et al., 2020). Utilization of organic waste into useful products is in line with the zero-waste management paradigm and circular economy, namely reducing waste production, maximizing reuse, and minimizing emissions to the environment (Ghisellini et al., 2016; Muliana et al., 2025). Various community-based waste management programs show that a participatory approach through outreach, training, and mentoring can increase knowledge and encourage the adoption of new behaviors in organic waste management (Putra et al., 2023; Sasmita et al., 2025). Based on these conditions, the community service program "Towards a Fertilizer-Independent Village: Zero Waste Management in Tik Kuto Village" is designed to empower the community to process household and agricultural organic waste into MOL, POC, and ecoenzymes using simple and inexpensive technology. This article presents the implementation method, activity implementation, and results related to changes in knowledge, initial behavior, and behavioral intentions of the community in organic waste management.

B. Methods

The community service activity was conducted in Tik Kuto Village, involving 18 farmers as the primary respondents. The approach used was a participatory approach through a combination of outreach, technical

training, demonstrations, and ongoing mentoring, as is commonly applied in community capacity building programs in the areas of waste management and organic fertilizer production (Sasmita et al., 2025).

The implementation stages included: (1) preparation and socialization with the village government and farmer groups to discuss the targets, schedules, and activity locations; (2) participatory outreach regarding the zero waste concept, the impact of unmanaged organic waste, and its potential utilization into MOL, POC, and ecoenzymes; (3) training and technical demonstrations for making MOL, POC, and ecoenzymes using local materials (rice washing water, coconut water, rice waste, banana stems, snail pests, fresh fruit peels, and brown sugar) with controlled fermentation; (4) assistance in the practice of making and utilizing MOL, POC, and ecoenzymes in households and village compost houses; and (5) evaluation of participants' knowledge, initial behavior, and behavioral intentions through pre-test and post-test questionnaires, supplemented by active participant observation and reflective discussions.

The evaluation instrument included three main components: (1) level of knowledge regarding waste sorting, processing, and ecoenzyme/MOL/POC production; (2) initial behaviors related to waste sorting, processing, and the production of organic waste-based products; and (3) behavioral intentions after participating in the activity. Data were analyzed descriptively and presented as percentages to illustrate changes before and after the intervention. This assessment approach is in line with various studies of organic waste and ecoenzyme management training at the community level (Maharani et al., 2024; Prarikeslan et al., 2022; Putra et al., 2023).

The program began with coordination and outreach to the village government, farmer group administrators, farmers, and representatives of women's farmer and housewife groups in Tik Kuto Village. At this stage, the participants were selected, locations for the outreach (village hall) and demonstration of ecoenzyme/MOL/POC production (village compost house and village hall) were agreed upon, and the activities were scheduled. The outreach also explored the existing situation of household waste management and the community's need for organic fertilizer.

The outreach activities were carried out in the form of interactive lectures and group discussions regarding the sorting and classification of organic and inorganic waste, the risks of open dumping and burning, and opportunities for utilizing organic waste into value-added products in line with the zero waste management concept and circular economy (Ghisellini et al., 2016; Muliana et al., 2025). Before the outreach session, participants filled out a pre-test questionnaire to measure basic knowledge related to waste sorting and the production of MOL, POC, and ecoenzymes.

The next training and technical demonstration session involved practical training on making MOL, POC, and ecoenzymes using local ingredients readily available in Tik Kuto Village. Participants were invited to directly practice the process of chopping ingredients, mixing them with brown sugar, adjusting the ratio of ingredients to water, and fermentation techniques in a closed container (stacked bucket or used gallon containers) with monitoring of fermentation time. MOL is used as a POC activator and decomposer, while ecoenzymes are made from fresh fruit peels with a minimum fermentation of three months as reported in other ecoenzyme training programs in Indonesia (Maharani et al., 2024; Prarikeslan et al., 2022).

To ensure the sustainability of the practice, the team provided field assistance through visits to participants' homes and composting facilities to monitor the fermentation process and product application on the land. At this stage, participants were given the opportunity to report technical challenges, such as odor issues, fermentation failures, or raw material difficulties, which were then addressed with suggestions for improvement. At the end of the series of activities, a post-test questionnaire was completed to assess knowledge gains and behavioral intentions, accompanied by reflective discussions regarding follow-up plans at the household and group levels.

Activity Evaluation and Data Analysis

Evaluation of the implementation of the community partnership service program was carried out through several approaches, namely:

1. Changes in the level of farmers' knowledge of the technology and innovations introduced before and after training, and
2. Changes in farmers' skill levels regarding technology and innovation before and after participating in training.

The stages carried out in the evaluation process are:

1. Initial ability test (pre-test) of farmers before implementing training activities

2. Question-and-answer sessions and participant engagement during training
3. Final test (post-test) to determine the success of training participants in understanding the training material
4. Practice testing skills in the application of technology and innovation.

C. Results and Discussion

1. Results

A total of 18 farmers participated in this activity. The majority of respondents were male (72%), with an average age of 48 years and approximately 21.7 years of farming experience. Educational attainment was dominated by high school graduates (39%) and elementary school graduates (33%), with the remainder having junior high school (17%), diploma (6%), and bachelor's degree (6%). This profile indicates that participants were experienced farmers with lower to middle levels of formal education, making extension and practical training relevant as a capacity-building strategy.

Prior to the intervention, all respondents had never received specific training on waste management, and only 6% had received training on ecoenzyme/MOL/POC production. Household organic waste sorting and management practices were also low: only 11% sorted waste and 28% collected organic waste in dedicated bins. Meanwhile, 83–100% of respondents stated they had never sorted, processed, or produced ecoenzyme/MOL/POC before the program. This situation aligns with findings that household waste management in many villages in Indonesia remains rudimentary and unstructured (Dinas Lingkungan Hidup, 2022).

Figure 1. Organic Waste Sorting Outreach Activities and Activity Evaluation

MOL, POC, and Ecoenzyme Production Demonstration

The practice of making MOL, POC and ecoenzyme was carried out at the Tik Kuto village hall with members of the farmer group. MOL was made from household waste, brown sugar, and water, then fermented for 7 days. POC was made from household waste in the form of vegetable waste and fruit peels and rotting fruit, all ingredients were chopped and put into a stacked bucket and fermented for approximately one month. Meanwhile, ecoenzyme was made from fresh fruit peels cut into small pieces, added with sugar and water in a ratio of 3:1:10 then put into a closed container and fermented for 90 days. Every morning the container lid was opened to release the fermentation gas. During the practice, one participant had already brought the results of independent practice in the form of a stacked bucket system POC which was made starting 1 month earlier and had produced POC liquid in the form of leachate. The community service team also brought a sample of the finished fruit-scented ecoenzyme to share with the participants. Ecoenzymes tend to be light brown and cloudy in appearance, depending on the organic materials used as the fermentation substrates (Rochyani et al., 2016).

The pre-test and post-test results demonstrate a substantial improvement in participants' knowledge across all assessed indicators following the outreach and training activities. Similar training-based interventions have been shown to significantly enhance participants' understanding of organic waste processing and bio-input production, particularly when hands-on demonstrations are emphasized. The pre-test and post-test scores for each assessed indicator are summarized in Table 1.

Table 1. Pre-Test and Post-Test Scores for Each Assessed Indicator

No	Assessed Indicator	Pre-test Score (%)	Post-test Score (%)	Improvement (%)
1	Knowledge of waste sorting techniques	17–39	100	61–83
2	Knowledge of waste processing techniques	17–39	100	61–83
3	Knowledge of ecoenzyme production (materials)	<30	100	>70
4	Knowledge of ecoenzyme production (production steps)	<30	100	>70
5	Knowledge of MOL production (materials)	<30	100	>70
6	Knowledge of MOL production (production steps)	<30	100	>70
7	Knowledge of POC production (materials)	<30	100	>70
8	Knowledge of POC production (production steps)	<30	100	>70

Notably, indicators that initially exhibited very limited understanding such as manufacturing procedures, dosage, and application methods experienced the largest relative gains, rising from only 6–11% at baseline to 83% after the intervention. This finding aligns with previous studies reporting that participatory, practice-oriented training is more effective in transferring applied knowledge than lecture-based approaches alone. Overall, the consistently high post-test scores (83–100%) indicate that the intervention successfully enhanced both conceptual understanding and practical readiness, thereby supporting the effectiveness of community-based training in improving sustainable waste management and organic input utilization practices.

Figure 2. Practice of Making MOL, POC, and Ecoenzyme and Evaluation of Activities

In terms of behavior and behavioral intentions, before the program, most respondents had never separated/sorted or processed waste or made ecoenzymes/MOL/POC. After the intervention, 100% of respondents stated their intention to sort and process waste at home, invite family members to get involved, and try making ecoenzymes/MOL/POC independently. All respondents (100%) also considered this activity beneficial. This pattern of increased knowledge accompanied by strengthened behavioral intentions is consistent with the findings of ecoenzyme training programs and other organic waste management programs that reported increased technical capacity as well as changes in attitudes toward waste management (Aristya et al., 2025; Maharani et al., 2024; Prarikeslan et al., 2022).

Figure 3. Handover of training Tools and Materials from the Bengkulu University Community Service Team Funded by the 2025 Kemdiktisaintek DPPM Grant to the Tik Kuto Village community

Overall, these results indicate that the community service program based on simple MOL, POC, and ecoenzyme technologies with a participatory approach in Tik Kuto Village is effective in increasing knowledge, improving perceptions, and strengthening community behavioral intentions regarding organic waste management toward the implementation of zero-waste management and a Fertilizer-Independent Village. Community training in Lawang Agung Village likewise demonstrated that fruit and vegetable waste can be effectively converted into ecoenzymes using simple, low-cost fermentation techniques, with post-training assessments showing substantial improvements in participants' understanding of ecoenzyme concepts, production steps, and applications (Sutrawati et al., 2024). Together, these findings highlight that household-scale production of ecoenzymes not only reduces organic waste but also provides environmentally friendly products that support sustainable daily practices in rural communities. Ecoenzymes can also be used as fertilizers and soil nutrients because they contain nitrites and organic residues produced during the fermentation process. Ecoenzymes contain lipase, amylase, and trypsin enzymes, which act as biocatalysts capable of reducing the concentration of pollutants in wastewater (Wang et al., 2016). The detergent concentration in domestic wastewater without the addition of ecoenzymes is 1.9385 mg/L, which decreases to 0.8477 mg/L on the seventh day. In samples treated with 5% ecoenzymes, the concentration drops to 0.6796 mg/L, and with 10% ecoenzymes, it further decreases to 0.3019 mg/L on the seventh day (Pratamadina & Wikaningrum, 2022).

2. Discussion

The results of this study indicate that the community-based outreach and hands-on training program in Tik Kuto Village was effective in improving farmers' knowledge, perceptions, and behavioral intentions related to organic waste management and the production of MOL, POC, and ecoenzymes. The participant profile, dominated by middle-aged, experienced farmers with lower-to-middle educational backgrounds, highlights the relevance of extension approaches that emphasize practical demonstrations rather than purely theoretical instruction. Similar farmer characteristics have been reported in rural agricultural communities across Indonesia, where experiential learning has been shown to be more effective than lecture-based approaches (Dinas Lingkungan Hidup, 2022).

Prior to the intervention, baseline conditions reflected limited exposure to waste management training and very low adoption of household waste sorting and processing practices. More than 80% of participants had never sorted or processed organic waste or produced ecoenzyme/MOL/POC, confirming that organic waste management at the household level remains underdeveloped and largely informal. This finding is consistent with national assessments indicating that rural waste management systems are still rudimentary, with minimal segregation at source and limited utilization of organic waste for productive purposes (Dinas Lingkungan Hidup, 2022).

Following the intervention, pre-test and post-test comparisons revealed substantial knowledge gains across all indicators, particularly in practical competencies such as waste sorting, waste processing, and the production steps of MOL, POC, and ecoenzymes. The most notable improvements occurred in indicators with very low baseline understanding (6–11%), which increased to 83% after training. This pattern suggests that participatory, practice-oriented training is especially effective in transferring applied knowledge and skills, rather than merely increasing general awareness. Similar outcomes have been reported by Prarikeslan et al. (2022), Maharani et al. (2024), and Aristya et al. (2025), who found that hands-on ecoenzyme and organic waste management training significantly enhanced both technical understanding and confidence among participants.

The demonstration activities further reinforced learning by allowing participants to directly observe and practice simple fermentation technologies using locally available materials. The presence of a participant who had already initiated independent POC production prior to the training also indicates emerging local innovation and readiness for adoption. The physical characteristics of the ecoenzymes produced, which were light brown and cloudy, were consistent with previous descriptions of ecoenzyme products derived from fruit-based substrates (Rochyani et al., 2016), thereby validating the appropriateness of the methods used.

Beyond knowledge gains, the intervention led to a marked shift in behavioral intentions. After the program, all participants expressed willingness to sort and process household waste, involve family members, and independently produce ecoenzyme/MOL/POC. This alignment between increased knowledge and strengthened behavioral intentions supports behavioral change theories suggesting that improved understanding and perceived benefits are critical precursors to pro-environmental action. Comparable findings have been reported in community training programs in Lawang Agung Village, where ecoenzyme production from household organic waste resulted in improved knowledge, attitudes, and intended practices (Sutrawati et al., 2024).

From a broader perspective, the results also align with studies highlighting the multifunctional benefits of ecoenzymes and organic liquid fertilizers. Ecoenzymes have been shown to contain enzymatic compounds such as lipase, amylase, and trypsin, which can act as biocatalysts in reducing organic pollutants in wastewater (Wang et al., 2016). Empirical evidence demonstrates significant reductions in detergent concentrations in domestic wastewater following ecoenzyme application, particularly at higher concentrations (Pratamadina & Wikaningrum, 2022). These findings support the potential of ecoenzymes not only as agricultural inputs but also as environmentally friendly agents for household and environmental sanitation.

Overall, the consistency between the present findings and previous studies reinforces the conclusion that simple, low-cost, community-based technologies for organic waste processing can effectively enhance knowledge, foster positive attitudes, and stimulate behavioral intentions toward sustainable waste management in rural settings.

2.1. Implications

This community service program, based on the application of MOL, POC, and ecoenzyme production technologies in Tik Kuto Village, had implications for strengthening organic waste management at the household and farmer group levels. Significant improvements in participants' knowledge and behavioral intentions demonstrate the effectiveness of the participatory extension approach and hands-on training in driving behavioral change.

2.2. Research Contribution

Community service activities based on empowerment in organic waste management using local resources can make a significant contribution to the community. This program can increase community knowledge by 80–100% across various indicators. Evaluation of these activities provides empirical data on community behavior and readiness to implement simple, independent waste management technologies.

2.3. Limitations

This activity still has several limitations, including: (1) the evaluation only focused on changes in knowledge and practice; (2) there were not many participants and only from one village, so these findings need to be further examined in other villages with different social and economic backgrounds; (3) the assessment did not include technical measures regarding the quality of MOL, POC, and ecoenzymes in the laboratory, meaning that the quality of the production results was only assessed from what was visible and

usable by the participants. In addition, matters regarding long-term sustainability, for example the availability of tools, raw materials, and routine assistance, could not be fully measured in this study.

2.4. Suggestions

Based on the findings and the challenges encountered, several suggestions are proposed. Continued support is crucial to enable residents to continue separating and processing organic waste themselves. Further training on how to improve the quality of MOL, POC, and ecoenzymes, including simple lab tests, is needed to help standardize the quality of these products. This initiative should be expanded to other villages so that this empowerment approach can serve as a model and have a broader impact. The village government should incorporate the zero-waste and Fertilizer Self-Sufficient Village (*Desa Mandiri Pupuk*) initiatives into the Village Medium-Term Development Plan, while also providing supporting facilities such as composting facilities, decomposition areas, and easy-to-use production tools. Further studies are needed to assess the long-term effects of this program on community behavior, soil quality, crop yields, and reduced agricultural costs.

D. Conclusion

A community service program based on the utilization of organic waste into Local Microorganisms (MOL), Liquid Organic Fertilizer (POC), and ecoenzymes with a zero-waste management approach in Tik Kuto Village has been shown to increase knowledge levels and behavioral intentions within the community in managing organic waste. The extension activities, training, and technical demonstrations carried out in a participatory manner succeeded in changing the knowledge profile of participants from initially very limited to high in almost all indicators. Knowledge of waste sorting, processing, and ecoenzymes/MOL/POC production increased from 6–50% to 83–100%. All respondents stated their intention to implement waste sorting and processing at the household level, try to produce ecoenzymes/MOL/POC independently, and considered the activity beneficial. These findings indicate that simple technology combined with mentoring and practical learning media has the potential to become a replication model for the development of Fertilizer-Independent Villages and strengthening the implementation of zero-waste management in rural areas.

Based on the activity results, it is recommended that the zero-waste management program in Tik Kuto Village be continued with regular mentoring to ensure that waste sorting and processing practices are truly integrated into household and farming routines. The village government needs to integrate the “Desa Mandiri Pupuk” (fertilizer-independent village) and zero waste management initiatives into village policies and planning, while strengthening the role of farmer groups and women's farmer groups as key drivers. Furthermore, infrastructure and facilities, such as compost houses, fermentation containers, and organic product storage and distribution facilities, need to be improved so that the program's benefits can be sustained and potentially replicated in other villages with similar characteristics.

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F. Author Contribution Statement

MS is responsible for the proposals, and the reports (including publications) of the community service activity, as well as the content, material, and technical part of ecoenzyme/MOL/POC production. SMG is responsible for communications and relationships with the local partner as well as the chemistry part of the content material of ecoenzymes/MOL/POC. DJ is responsible especially for ecoenzyme/MOL/POC production as part of DJ’s expertise. AA is responsible for collecting quantitative data (assessment of the activity). S is responsible for the demonstration activities of ecoenzymes/MOL/POC as well as the application of ecoenzymes/MOL/POC to soil and plants.

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