

Empowering Junior High School Students through Eco-Enzyme Production Training from Fruit Peel Waste: A Community Engagement Program at SMPIT Al-Qudwah, Tugumulyo District

Solina Balqis^{1*}, Elva Febriyanti², Nurkayah³, Muhammad Arif Fadillah⁴, Lia Aseptin Murdini⁵, Aldi Fahlefi⁶, Hosiaroba⁷, Viar Refri Zadin⁸

^{1,2,3,4,5,6,7,8}Institut Teknologi Muhammadiyah Sumatera, Jl. Pesantren, Tegal Rejo, Kec. Lubuk Linggau Sel. II, Kabupaten Musi Rawas, Sumatera Selatan

*E-mail: solinamareta@gmail.com

* Corresponding Author

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ABSTRACT

Pengelolaan sampah organik, khususnya sampah kulit buah, masih menjadi tantangan di lingkungan sekolah. Produksi enzim ramah lingkungan menawarkan solusi sederhana dan ramah lingkungan yang juga mendukung pendidikan lingkungan. Program pengabdian masyarakat ini bertujuan untuk meningkatkan pengetahuan dan keterampilan siswa dalam mengelola sampah kulit buah melalui pelatihan produksi enzim ramah lingkungan di SMPIT Al-Qudwah. Program ini dilaksanakan menggunakan pendekatan pelatihan praktik langsung, termasuk penyampaian materi, praktik langsung, dan evaluasi menggunakan desain pretest-posttest yang melibatkan 15 siswa. Hasil menunjukkan peningkatan yang jelas pada skor posttest dibandingkan dengan skor pretest, yang mengindikasikan peningkatan pemahaman tentang pengelolaan sampah organik dan produksi enzim ramah lingkungan. Pelatihan ini secara efektif meningkatkan kesadaran lingkungan dan keterampilan praktis siswa, menunjukkan potensi pembelajaran berbasis pengalaman sebagai model yang dapat direplikasi untuk pendidikan lingkungan berbasis sekolah.

Organic waste management, particularly fruit peel waste, remains a challenge in school environments. Eco-enzyme production offers a simple and environmentally friendly solution that also supports environmental education. This community service program aimed to improve students' knowledge and skills in managing fruit peel waste through eco-enzyme production training at SMPIT Al-Qudwah. The program was implemented using a hands-on training approach, including material delivery, direct practice, and evaluation using a pretest-posttest design involving 15 students. The results showed a clear increase in posttest scores compared to pretest scores, indicating improved understanding of organic waste management and eco-enzyme production. The training effectively enhanced students' environmental awareness and practical skills, demonstrating the potential of experiential learning as a replicable model for school-based environmental education.



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INTRODUCTION

The management of organic waste, particularly fruit peel waste, remains a significant environmental challenge in Indonesia (AL-Huqail et al., 2022; Karjoko et al., 2022). Organic waste generated from households and educational institutions is often inadequately managed and commonly disposed of in landfills without sustainable treatment (Jalalipour et al., 2024; Zaki et al., 2024). This condition not only contributes to environmental pollution but also increases greenhouse gas emissions

and degrades overall environmental quality. Therefore, educational and practical approaches are urgently needed to enhance awareness and skills related to environmentally friendly organic waste management (Blanchard et al., 2023; Sayara & Sánchez, 2021).

Eco-enzyme represents a simple and innovative alternative solution for processing fruit peel waste. Eco-enzyme is produced through the fermentation of organic materials, such as fruit and vegetable residues, combined with sugar and water over a specific period (Mavani et al., 2020). This product offers multiple benefits, including its use as a natural cleaning agent, liquid fertilizer, deodorizer, and eco-friendly substitute for chemical-based products (Varshini & Gayathri, 2023). In addition to its environmental advantages, eco-enzyme production provides strong educational value due to its simplicity, low cost, and ease of application in daily life (Safrida et al., 2023).

Environmental education at the school level plays a crucial role in shaping sustainable pro-environmental behavior from an early age. Junior high schools serve as strategic institutions for instilling environmental awareness, waste management skills, and the principles of reduce, reuse, and recycle (3R) (Hoffmann & Muttarak, 2020; Prabawani et al., 2020). However, in practice, environmental learning activities in schools are often limited to theoretical instruction and lack hands-on, experiential components (Salinas-Navarro et al., 2024). As a result, students' understanding and practical competencies in organic waste management remain underdeveloped (Mkhonto & Mnguni, 2021).

SMPIT Al-Qudwah, located in Tugumulyo District, possesses considerable potential to be developed as an environmentally oriented educational institution. Preliminary observations indicated that fruit peel waste generated from daily student consumption and school canteen activities has not been optimally utilized and is primarily discarded as waste. This situation highlights a clear opportunity to implement a practical organic waste management program that can simultaneously enhance students' environmental awareness and practical skills (Salinas-Navarro et al., 2024).

As part of the implementation of the Tri Dharma of Higher Education, particularly in the area of community service, lecturers from the Institut Teknologi Muhammadiyah Sumatera (ITMS) are responsible for disseminating knowledge and appropriate technology to the broader community, including school-based communities. The eco-enzyme production training program from fruit peel waste was designed as an empowerment initiative employing participatory and educational approaches. This program aims to bridge the gap between theoretical environmental knowledge and its practical application in real-world contexts.

Based on the aforementioned background, this community service activity aims to improve students' knowledge, attitudes, and skills in managing fruit peel waste through eco-enzyme production training at SMPIT Al-Qudwah. Furthermore, the program is expected to foster environmentally responsible behavior, promote a school culture of sustainable waste management, and serve as a replicable model for environmental education initiatives in other schools within Tugumulyo District and surrounding areas.

METHOD

Program Design and Implementation Site

This community service program was designed using a practical training (hands-on learning) approach focusing on the production of eco-enzyme from fruit peel waste. The activity was conducted at SMPIT Al-Qudwah, Tugumulyo District, and implemented by lecturers from the Bioengineering Study Program, Institut Teknologi Muhammadiyah Sumatera (ITMS). The program targeted junior high school students as primary participants, with the objective of enhancing their environmental awareness and practical skills in managing organic waste through simple biotechnology applications.

Training Stages

The community service training was implemented in several systematic stages. The first stage was a preliminary assessment and introduction, during which participants completed a pretest to evaluate their initial knowledge regarding organic waste management and eco-enzyme concepts (Rusdi et al., 2022). This stage was followed by an introductory session that explained environmental issues related to organic waste, the benefits of eco-enzyme, and its potential applications in daily life.

The second stage consisted of direct practical training, where participants actively practiced eco-enzyme production under the supervision of ITMS lecturers. This hands-on approach enabled students to directly engage in each step of the process, ensuring better understanding and skill acquisition. The

final stage involved evaluation and reflection, including posttest administration, discussion sessions, and feedback related to the training outcomes and future application of eco-enzyme production.

Tools and Materials

The tools used in this training included fermentation containers or plastic barrels with lids, knives, cutting boards, measuring cups, funnels, plastic bottles, labels, and a pH meter (optional) for monitoring acidity changes during fermentation. These tools were selected based on safety, availability, and ease of replication in school and household settings (Balqis et al., 2023).

The materials consisted of fruit peel waste (such as citrus, dragonfruit, banana, mango, orange and apple peels), brown sugar or molasses as a carbon source, and clean water. All materials were environmentally friendly, low-cost, and easily accessible, making the eco-enzyme production process suitable for educational purposes.

Eco-Enzyme Production Procedure

The eco-enzyme production procedure implemented in this community service program employed a simple and environmentally friendly fermentation method that was directly practiced by the participants. Fruit peel waste was first sorted to remove non-organic materials, thoroughly washed to reduce surface contaminants, and then cut into small pieces to increase surface area and enhance microbial activity during fermentation. This preparation step was emphasized during the training to ensure product quality and process efficiency.

The prepared fruit peels were then mixed with a carbon source using a standard formulation ratio of 3 parts fruit peel waste, 1 part sugar, and 10 parts clean water (3:1:10) (Varshini & Gayathri, 2023). Brown sugar or molasses was used to support microbial growth and fermentation. The mixture was transferred into airtight fermentation containers, with approximately 20–30% empty space left at the top of the container to accommodate gas production. The containers were tightly sealed, labeled with the date of preparation, and stored at room temperature in a shaded and well-ventilated area.

The fermentation process was conducted for a period of approximately three months. During the first two to four weeks, gas formed as a result of microbial activity; therefore, the containers were periodically opened to release excess gas and prevent pressure buildup. Changes in color, aroma, and acidity were explained to participants as indicators of successful fermentation. A pH meter (optional) was introduced to demonstrate the gradual decrease in pH as organic acids formed during fermentation.

Figure 1 presents a schematic illustration of the tools, materials, and composition ratio used in the eco-enzyme production process practiced during the training. The figure depicts a fermentation container containing a mixture of 3 parts fruit peel waste, 1 part sugar, and 10 parts water, representing the standard eco-enzyme formulation applied in this program. Supporting equipment shown includes a pH meter (optional) for acidity monitoring, a funnel, measuring containers, plastic bottles, clean water, and sweeteners in the form of brown sugar or molasses. This visual representation was used as an instructional aid during the training to help participants clearly understand the required materials, equipment setup, and sequential steps involved in eco-enzyme preparation (Tallei et al., 2023).



Figure 1. Tools, Materials, and Composition Ratio for Eco-Enzyme Production from Fruit Peel Waste

Data Collection and Analysis

Data collection was conducted using a pretest–posttest design to assess the effectiveness of the training program. The pretest was administered before the training to measure participants’ baseline knowledge and understanding of organic waste management and eco-enzyme production. The posttest was administered after the completion of the training to evaluate improvements in knowledge, attitudes, and practical understanding.

The collected data were analyzed using descriptive quantitative analysis by comparing pretest and posttest scores. The effectiveness of the training was determined by calculating the percentage increase in posttest scores relative to pretest results. This analysis provided empirical evidence of the impact of hands-on eco-enzyme production training as a community service activity conducted by ITMS lecturers.

RESULTS AND DISCUSSION

Delivery of Eco-Enzyme Training Materials

The first stage of the community service activity focused on the delivery of training materials related to eco-enzyme production and organic waste management. This session was designed to establish a strong conceptual foundation before participants engaged in hands-on practice. The material covered key topics, including the definition of eco-enzyme, the environmental impact of unmanaged organic waste, the basic principles of fermentation, and the potential applications of eco-enzyme in daily life, such as natural cleaning agents, liquid fertilizers, and odor neutralizers (Balqis et al., 2023).

As illustrated in Figure 2, the material was delivered by lecturers from the Bioengineering Study Program of Institut Teknologi Muhammadiyah Sumatera (ITMS) using an interactive learning approach. Visual aids, real-life examples, and open-ended questions were employed to stimulate students’ critical thinking and participation. During the session, students showed a high level of engagement, as evidenced by active questioning and discussion related to waste separation practices and eco-enzyme utilization within the school environment. This indicates that the delivery of material successfully raised students’ awareness and interest in environmentally friendly waste management solutions.

Furthermore, the material delivery session emphasized the relevance of eco-enzyme production to students’ daily experiences, particularly in relation to fruit peel waste generated from school canteen activities. By contextualizing the topic within their immediate environment, students were able to better understand the practical value of eco-enzyme production. This stage was crucial in shaping positive learning attitudes and preparing participants cognitively for the subsequent practical training.



Figure 2. Material Delivery Session on Eco-Enzyme Production

Practical Implementation of Eco-Enzyme Production by Students

The second stage of the program involved direct practical implementation of eco-enzyme production, which served as the core component of the training. This hands-on activity aimed to translate theoretical understanding into practical skills through experiential learning. Students were guided to perform each step of the eco-enzyme production process, including sorting and cleaning fruit peel waste, cutting the materials into smaller pieces, measuring ingredients according to the standard ratio, and properly sealing fermentation containers.

Figure 3 depicts students of SMPIT Al-Qudwah actively participating in the eco-enzyme production process under the supervision of ITMS lecturers. During this activity, students worked

collaboratively in small groups, which fostered teamwork and peer learning. They demonstrated increasing confidence in applying the 3:1:10 ratio of fruit peels, sugar, and water, as well as proper container handling techniques to ensure a successful fermentation process.

In addition to technical skills, this practical session also emphasized hygiene, safety, and environmental responsibility. Students were introduced to basic fermentation indicators, such as changes in aroma, color, and acidity, and were informed about the importance of periodic gas release during the early stages of fermentation. This comprehensive approach enabled students not only to follow procedural steps but also to understand the underlying biological processes involved. The practical activity thus contributed significantly to the development of students' procedural knowledge, environmental awareness, and problem-solving skills.



Figure 3. Hands-on Eco-Enzyme Production Practice by SMPIT Al-Qudwah Students

Analysis of Pretest and Posttest Results

The effectiveness of the eco-enzyme training program was evaluated through a pretest and posttest administered to 15 students of SMPIT Al-Qudwah. The pretest results indicated that students' initial understanding of eco-enzyme concepts and organic waste management was relatively limited, with scores ranging from 50 to 75. This suggests that prior to the training, students had minimal exposure to practical environmental biotechnology concepts.

Following the completion of the training program, the posttest results showed a marked improvement, with scores ranging from 85 to 100. As shown in Figure 4, all participants experienced an increase in their scores, indicating a consistent improvement in knowledge and comprehension across the group. The comparison between pretest and posttest results demonstrates a clear positive impact of the training on students' cognitive learning outcomes.

The substantial increase in posttest scores can be attributed to the integration of interactive material delivery, visual demonstrations, and direct hands-on practice. This combination aligns with experiential learning theory, which emphasizes that active participation enhances understanding and knowledge retention. Moreover, the structured evaluation approach provided measurable evidence of learning effectiveness, reinforcing the value of practice-based training models in environmental education.

Overall, the results indicate that the eco-enzyme production training conducted by ITMS lecturers effectively improved students' knowledge, skills, and environmental awareness. The program not only enhanced students' understanding of organic waste management but also encouraged sustainable behavior by demonstrating practical and replicable solutions. These findings highlight the potential of school-based community service programs to serve as effective platforms for promoting environmental education and sustainable practices at the grassroots level.

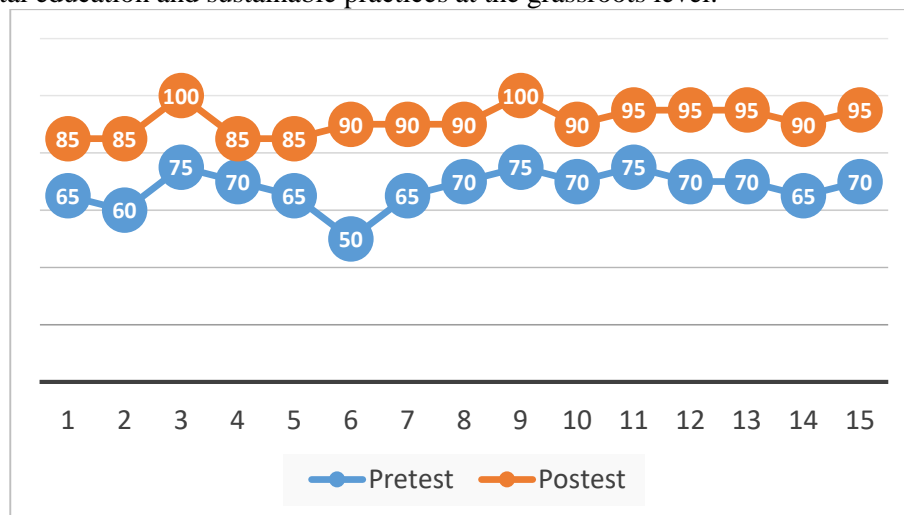


Figure 4. Pretest and Posttest Score Comparison of SMPIT Al-Qudwah Students

CONCLUSION

The findings of this community service activity indicate that practice-based eco-enzyme production training significantly improves students' understanding and practical skills in organic waste management. The combination of theoretical instruction and direct hands-on practice allowed students to actively engage in the learning process and apply fermentation concepts in a real-world context.

The observed increase in posttest scores compared to pretest results provides empirical evidence that experiential learning is highly effective in enhancing environmental literacy at the junior high school level. Moreover, the use of fruit peel waste and simple fermentation techniques supports the feasibility and sustainability of eco-enzyme production as an educational tool.

Therefore, this program demonstrates that eco-enzyme training can serve as a strategic intervention for promoting environmentally responsible behavior among students. The approach adopted by lecturers of the Biological Engineering Study Program, Institut Teknologi Muhammadiyah Sumatera (ITMS), may be replicated and scaled up to strengthen environmental education initiatives in other schools and community settings.

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