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Development and Application of Eco Enzyme for Household Organic Waste Management in Kampung Lio Area, Depok

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Abstract

Organic food waste accounts for the largest category of waste, comprising 40.8% according to data from the National Waste Management Information System (SIPSN). The high volume of this waste encourages alternatives for utilizing and processing household waste. One alternative method is producing an eco-enzyme, a liquid resulting from the fermentation of leftover fruits and vegetables. Its numerous uses and benefits have led to eco-enzyme development as an alternative method for processing household organic waste. To introduce this method, a Community Service (PKM) activity themed 'Development and Application of Eco Enzyme for Household Organic Waste Management' was conducted in the Kampung Lio area, Depok. This activity aims to enable the residents of Kampung Lio, Depok, to process their organic waste into eco enzyme and utilize it for various daily needs, such as floor cleaner, vegetable and fruit wash, insect repellent, plant fertilizer, disinfectant, laundry soap, bath soap, shampoo, toilet cleaner, and many other uses. After this activity, all participants started to implement their knowledge by processing their household organic waste into an eco enzyme because it has many benefits and simultaneously processed household waste.

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INTRODUCTION

Waste is any material discarded or thrown away from sources resulting from human activities or nature that has no economic value. Based on its composition, the National Waste Management Information System (SIPSN) categorizes waste into categories such as food scraps, wood/branches, paper/cardboard, plastic, metal, fabric, rubber/leather, glass, and others. According to these categories, in 2023, organic food waste accounted for the largest proportion, with 40.8%. This type of waste primarily comes from households, particularly household waste. The high volume of waste, especially from household sources, necessitates alternative waste processing methods. An alternative that needs to be instilled in the community is the process of recycling waste. Waste processing can be utilized for energy, compost, fertilizers, briquettes, industrial raw materials, and eco-enzyme.

Eco enzyme was first introduced by Dr. Rosukon Poompanvong (Pranata *et al.*, 2021; Novianti & Muliarta, 2021), and it is a liquid resulting from the fermentation of organic waste (Sari *et al.*, 2021). Eco enzyme has many uses, including as a floor cleaner, vegetable and fruit wash, insect repellent, plant fertilizer, disinfectant (Sari *et al.*, 2021), laundry soap, bath soap, shampoo, toilet cleaner, and for cleaning dirty or rusty tools, as well as pet soap and hand sanitizer (Hariani *et al.*, 2022). Given the numerous benefits of processing waste into eco-enzymes, conducting training activities on eco enzyme production for the community is crucial. Training on waste processing can be part of community service programs carried out by the academic community.

Community service is a part of the Three Pillars (Three Dharmas) of Higher Education, which higher education institutions must perform. Politeknik Negeri Jakarta is one of the vocational higher education institutions that implements community service activities to practice the Tri Dharma of higher education. To fulfil the obligation of implementing Tri Dharma activities and to address the urgent issues of

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waste management, faculty members from the Mechanical Engineering Department of Politeknik Negeri Jakarta conducted community service activities by providing training on food waste processing into eco enzyme to the residents of the Kampung Lio area, Depok city.

The term 'Lio' is associated with brick burning or pottery making, as well as clay artisans. The Kampung Lio area has become a densely populated settlement inhabited by thousands of residents. It consists of narrow alleys with a high population density. The high population density correlates with the amount of household waste produced. This condition is illustrated in Fig. 1(a). Furthermore, the high level of waste produced in Kampung Lio area only ends up piling up, not being sorted, and requiring further handling (Fig. 1(b)). Given the large volume of waste produced, training on waste processing in eco-enzyme is highly beneficial for this area.

Fig. 1. (a) Dense housing (b) Scattered waste

The research and training activities for processing waste into eco-enzymes are not new initiatives within community service programs conducted by the academic community. In 2023, similar activities were previously carried out in Kampung Sawah area, Bogor District, led by Tatun Hayatun Nufus (Saidatuningtyas *et al.*, 2024), and in areas such as Deli Serdang (Jati *et al.*, 2021), Medan (Harahap *et al.*, 2023), Riau (Sari *et al.*, 2021), Samarinda in East Kalimantan (Hariani *et al.*, 2022), Semarang (Rifandi *et al.*, 2022), South Kalimantan (Dewi, 2021), Surabaya (Iswati *et al.*, 2021), Kuningan Regency (Nasihin *et al.*, 2022), East Rumbai District (Yanti *et al.*, 2021), South Bekasi (Rustanta *et al.*, 2022), Mataram City (Wahyuni *et al.*, 2023), Bengkulu (Nurhamidah *et al.*, 2021; Mahali *et al.*, 2022), Banyuwangi (Istanti & Utami, 2022), Permata Tembalang (Samadikun *et al.*, 2023), and Surakarta City (Budiyanto *et al.*, 2022).

The difference between this community service and others is that the fermentation reactor (Fig. 2) facilitates the release of excess gas and makes it easier to harvest the enzyme after approximately six months. Given the numerous similar community service activities conducted in various regions, this community service aims to reduce the daily volume of organic waste in the Kampung Lio area, Depok City, by providing training on waste processing there. This community service program is also expected to provide benefits that contribute to environmental preservation by recycling household waste, specifically fruit and vegetable scraps, while creating business opportunities for housewives by producing eco-enzyme products.

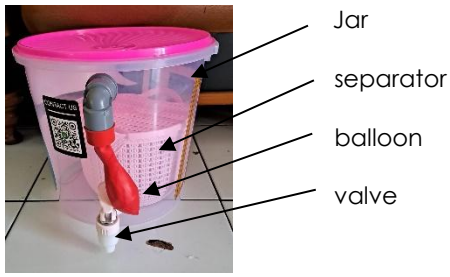

Fig. 2. Fermentation reactor for organic materials

MATERIALS AND METHODS

The Community Service Activity entitled "Development and Application of Eco Enzyme for Household Organic Waste Management in Kampung Lio, Depok" aimed to improve organic waste management and enhance the self-sufficiency of the Kampung Lio area, Depok city. This activity was led by Dr. Tatun Hayatun Nufus and was conducted on July 31 2024. This community service aimed to train the residents of Kampung Lio in Depok city to process their organic waste and utilize it for various daily needs. The processed eco enzyme could be used for floor cleaning, plant fertilizers, disinfectants, and other purposes (Sari *et al.*, 2021).

Materials

The materials and equipment needed for the practice of making eco enzyme consisted of the following: sugar varieties (brown sugar, molasses, palm sugar, coconut sugar, lontar sugar, or granulated sugar); fresh fruit and vegetable peels; water (tap water, rainwater, wastewater from air conditioning, etc.); cutting board; knife; container (the container should have a wide mouth, either large or small, made of plastic, and must be able to be sealed tightly and securely).

Methods

The method used in this community service activity refers to the Dignan Theory framework related to community empowerment, where we must determine the target community to develop a program to run according to expectations (Diyanah *et al.*, 2019). The stages of community service activities using the Dignan Theory framework consist of problem analysis (community analysis), target assessment, program plan development, implementation, and evaluation (Diyanah *et al.*, 2019). The Development and Application of Eco Enzyme for

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Household Organic Waste Management in Kampung Lio area program was developed using Dignan Theory based on community analysis and target determination.

At the implementation stage, workshops and training activities were conducted to make eco-enzymes using organic waste. Before the workshop, participants will be given a questionnaire about their initial knowledge about eco enzymes (Table 1). At this stage, participants were taught new skills and knowledge interactively through theory and practice to make eco-enzymes. Below were the general steps in making eco-enzymes within the training:

1. The container was cleaned from any soap or chemical residues, the volume of the container was measured, and water in a ratio of 10 parts was added (Fig. 3(a)).
2. A part of sliced brown sugar was weighed and added to the water. Then, it was stirred until the sugar was fully dissolved (Fig. 3 (b)).

Fig. 3. Process of making eco-enzyme

3. Preparation of raw materials: The organic materials used as a carbon and energy source for microbes included vegetable and fruit waste. These materials were washed and cut into small pieces to accelerate fermentation.
4. Addition of organic materials: Three pieces of organic materials were added to the container containing water and brown sugar. Then, they were stirred until well mixed (Fig. 3 (c)).
5. Fermentation process: The fermentation process was carried out under anaerobic conditions for 3-6 months at a temperature of 25-35°C. During fermentation, the microbes produced beneficial enzymes for cleaning the environment, such as protease, amylase, lipase, and cellulase (Fig. 3 (d)).
6. Separation and filtration: After the fermentation process, the resulting eco enzyme was separated from the organic materials by filtering or centrifugation. The eco enzyme was packaged in bottles or sealed containers to maintain quality.
7. Quality testing: Before being marketed, the eco enzyme went through quality testing to ensure safe use and meet the established quality standards. In this community service activity, the produced eco enzyme had not yet reached the market stage but was still being used by itself. Therefore, the eco enzyme that was made needed to be left for approximately 3-6 months before being used.

At the evaluation stage of the activity, a discussion and question-and-answer session were conducted regarding the participants' responses to their interest in practicing making eco-enzymes. The questionnaire was distributed to the participants to assess their level of understanding of the participants regarding the eco-enzyme (Table 2). The results of the discussion showed that most participants were very interested in practicing making eco-enzymes because they saw that this activitity had many benefits and could simultaneously process household waste.

RESULTS AND DISCUSSION

The community service activity was divided into two parts at the implementation stage. 40 participants attended the community service activity. The first activity is the workshop. Workshop activities in the form of presentations on the topic of eco-enzymes (Fig. 4).

Fig. 4. Presentation on eco enzyme by the eco enzyme speaker

Before the workshop activity, questionnaires were given to participants. Based on the questionnaires distributed to the participants, it could be known that 27.5% had previously attended socialization sessions related to waste sorting and processing, while 82.5% had never participated in similar activities before (Table 1). In addition to this question, several other questions were provided to gather more in-depth information regarding the waste processing behaviors of the residents of Kampung Lio area, Depok city.

Fig. 5. The participants conducted a practical session on making an eco-enzyme

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Table 1. Results of the initial questionnaire administered to the participants of the community service

No.	Question components	Yes	No
1	I have provided trash bins at home.	95%	5%
2	I sort waste into two categories: organic and inorganic.	40%	60%
3	Do you know what organic waste is?	90%	10%
4	I manage waste by burning it.	22.5%	77.5%
5	Have you ever processed organic waste for a specific purpose?	37.5%	62.5%
6	I process organic waste into compost.	35%	65%
7	I am aware that I have an important role in waste management.	95%	5%
8	Are you familiar with eco enzyme?	32.5%	67.5%
9	Are you interested in processing organic waste into valuable products?	100%	0

Table 2. Results of the final questionnaire administered to the participants of the community service

No	Question components	Yes	No
1	I am aware that I have an important role in waste processing	100%	0
2	Do you know what organic waste is?	95%	5%
3	Have you ever processed organic waste?	75%	25%
4	Are you familiar with eco enzyme?	92.5%	7.5%
5	Are you interested in processing organic waste into valuable products?	100%	0
6	Do you intend to process organic waste into eco enzyme after the activity?	100%	0

The second activity is training activities in the form of practical sessions where participants were directly engaged in making eco enzymes (Fig. 5). After the training activities in the form of practical sessions, the evaluation stage was carried out in the form of discussion and question-and-answer sessions. The questionnaire (post-test) was distributed to determine the participants' understanding. The results of the final questionnaire administered to the participants can be seen in Table 2.

Based on the results of the questionnaire (Table 1 and Table 2) and implementation of activities, the evaluation results of the community service activity encompass two main aspects, which are knowledge level and skill level. First, the knowledge level was measured through pre-tests and post-tests, which were comparing scores before the training (an average of 32%) and after the training (an average of 92.5%). This significant increase indicates that participants are able to absorb the information and apply it in practice.

Second, the skill level refers to the participants' ability to practice the techniques that were taught. While the knowledge evaluation results show progress, monitoring how well participants can apply this knowledge in their daily lives is essential. It requires ongoing observation to ensure that they do not only understand the theory but can also implement it effectively. The participants' skills were assessed through direct observation, yielding a success rate of approximately 90%.

When comparing this activity to previous community service events, there is an important distinction. In this event, the use of a fermentation reactor was specifically designed to facilitate the release of excess gas and ease the harvesting of eco-friendly enzymes after a fermentation period of about six months. It indicates a more systematic and sustainable approach compared to previous activities that may not have utilized such tools. Thus, this innovation has the potential to enhance efficiency and yield better results in waste management, providing greater benefits to the community.

The Impact of Community Service is evident from the results of the questionnaires distributed to participants, both before and after the activities, including:

1. Increased Community Awareness: The socialization activities regarding the benefits of eco enzyme have enhanced the community's knowledge about organic waste management. Before the program, 32.5% of the community was unaware of how to process organic waste, while after the program, this understanding increased to 92.5%.
2. Reduction of Organic Waste: With the implementation of eco enzyme, a reduction in the volume of organic waste disposed of is expected. Questionnaire data show that participants are interested in processing organic waste into valuable products, which indirectly serves as an indicator for reducing waste volume and improving environmental quality.
3. Local Economic Development: Eco enzymes can be used as commercial products for personal use,

reducing the purchase of other cleaning products. It is reflected in the questionnaire, where participants expressed their intention to process organic waste into eco enzyme after the activities.

4. Community Participation: The level of community participation in this program is evident from the invitations sent to nine neighbourhood units (RT), each sending five participants, totalling around 45 people if all attended. However, 85% attendance shows that the community is quite active in this community service training.
5. Program Sustainability: To measure the sustainability of eco enzyme use after the community service ends, the questionnaire indicates that participants express their intention to continue processing organic waste into eco enzyme after the activities.

Implementations in the community are:

1. Socialization and Education: The activities begin with socialization to raise community awareness about the importance of managing organic waste. Training on how to make and use eco-enzyme is conducted, involving local residents.
2. Collection of Organic Waste: The community is taught to collect organic waste from households, such as vegetable scraps, fruit, and other organic materials. Workgroups are organized to facilitate the collection and processing of waste.
3. Eco Enzyme Production: Residents are trained to produce eco-enzymes using fermentation with the collected raw materials. Practical sessions are held to ensure the community can effectively carry out this process.
4. Application in Daily Life: The produced eco enzyme is used in various activities, such as home cleaning, agriculture, and as a natural fertilizer. Demonstrations of ecoenzyme usage are conducted to showcase its benefits.
5. Monitoring and Evaluation: The service team conducts periodic monitoring to evaluate the use of eco enzymes and their impact on the environment and public health.

Expected outcomes from this community service are:

1. Increased Environmental Awareness: The community becomes more aware of the importance of waste management and its impact on the environment. There has been a shift in mindset toward the value of organic waste as a resource. This is reflected in the questionnaire results, showing that 100% of the community acknowledges this.
2. Waste Reduction: A significant reduction in the amount of organic waste disposed of in landfills occurs, contributing to decreased pollution.
3. Improved Public Health: With reduced waste and improved environmental quality, a decrease in health issues related to poor sanitation is expected.
4. Replication Model: If this program is successful, it can serve as a model that other communities can adopt, expanding the positive impact of using eco enzyme as a renewable energy solution.
5. Community Empowerment: The community becomes more self-reliant and skilled in waste processing, creating new income opportunities by selling eco-enzyme or waste-based products.

With effective implementation and measurable results, this program not only provides direct benefits to the residents of Kampung Lio but can also serve as inspiration for similar initiatives in other regions.

CONCLUSION

The community service activity in the form of training on making ecoenzymes shows a measurable level of success through several indicators. Out of 40 invited participants, 37 attended and actively participated, resulting in a participation rate of 92.5%. The level of participant satisfaction is also quite high, with all 40 participants providing positive feedback, leading to a satisfaction rate of 100%. Furthermore, the increase in participants' knowledge can be seen from the results of the pre-test and post-test, where 35 participants demonstrated improved understanding of how to make ecoenzymes, reflecting an increase of approximately 87.5%. The contributions of this activity are highly significant, as participants learned the techniques for producing eco enzymes for cleaning and fertilizing, which supports waste reduction and environmental preservation efforts. However, there are several limitations, such as the lack of follow-up to ensure the application of the knowledge gained, limited resources for independent production, and challenges in changing community behavior. To address these limitations, follow-up activities can include advanced training sessions, the formation of support groups, regular monitoring and evaluation, and providing access to raw materials. With these steps, it is hoped that the positive impact of the training can continue and provide greater benefits to the community.

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