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Community Empowerment Through the Utilization of Microorganism Enzymes (EMO) to Enhance Food Security

Jumriah[1], Nico Ferianzo[1], Ulfah Sarach Sheftiana[1], Ratna Setiani Nico[1], Ifhan Dwinhoven[2], and Andi N Renita Relatami[3].*

[1] *PT Pertamina Patra Niaga Integrated Terminal Balikpapan, Balikpapan, East Kalimantan. Indonesia*
[2] *Fish Hatchery Technology Study Program, Department of Aquaculture, Pangkep State Polytechnic of Agriculture. Indonesia*
[3] *Veterinary Medicine Study Program, Faculty of Medicine, Hasanuddin University, Jl Perintis Kemerdekaan Km 10, Makassar, 90245, South Sulawesi. Indonesia*

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CORRESPONDING AUTHOR

*E-mail: ifhan.dwinhoven@polipangkep.ac.id

A B S T R A C T

This community service program aimed to empower local communities by utilising Microorganism Enzymes (EMO) to support food security. EMO was applied to process organic waste into organic fertilizer as a substitute for chemical fertilizers, while also enabling the use of rainwater as a clean water source. The implementation methods included socialisation, training on EMO production, its application in agriculture, and an impact evaluation. The results indicated an increase in community knowledge and skills in producing and utilising EMO, as well as cost savings in fertilisers, pesticides, and water storage, along with improvements in the quality of urban vegetable production. This program contributes to achieving sustainable food security and aligns with the United Nations' Sustainable Development Goals (SDGs).

Contribution to Sustainable Development Goals (SDGs):
SDG 1: No Poverty
SDG 2: Zero Hunger
SDG 3: Good Health and Well-Being
SDG 9: Industry, Innovation and Infrastructure

1. INTRODUCTION

1.1. Research Background

Population growth and urbanization in major cities across Indonesia have posed serious challenges in food provision, clean water availability, and waste management. Balikpapan City, with a population growth rate of approximately 5.84% during the 2021–2023 period [1], is a concrete example where the increase in population directly correlates with the rising volume of household waste. Data from the National Waste Management Information System (SIPSN) indicate that over the past three years, the average annual increase in waste generation in Balikpapan has been 4.94%, with food waste accounting for the largest composition at 42.3% [2]. This condition has led to waste accumulation at the landfill site (TPA), which not only affects environmental quality but also threatens public health and creates an economic burden for the city.

As part of its social responsibility and commitment to sustainable development, PT Pertamina Patra Niaga Integrated Terminal Balikpapan initiated the Kampung Pangan Berseri: Waste to Value program. This program was designed to address the multidimensional challenges faced by the community, ranging from limited access to organic fertilisers and clean water to low productivity in urban agriculture. The innovation offered through the utilisation of Microorganism Enzymes (EMO) holds high urgency, as it can transform organic waste into an environmentally friendly fertiliser, replacing chemical fertilisers that have long posed financial burdens and negative impacts on

ecosystems. In addition, EMO also functions in purifying rainwater, making it a potential alternative source of clean water in urban areas.

The urgency of this program lies not only in its technical aspects of waste processing and food production but also in its contribution to achieving the Sustainable Development Goals (SDGs). Community empowerment, particularly of women household groups as the main implementer, supports efforts to reduce poverty and increase household income (SDG 1: No Poverty), while ensuring the availability of safe and pesticide-free food for local communities (SDG 2: Zero Hunger). The improved food quality has a positive impact on public health and well-being (SDG 3: Good Health and Well-being), while the socialisation and training of EMO serve as a form of non-formal education that enhances community knowledge and skills (SDG 4: Quality Education).

The application of EMO, based on simple yet environmentally friendly biotechnology, represents an innovation relevant to the development of sustainable industry, innovation, and infrastructure (SDG 9: Industry, Innovation and Infrastructure). This program also promotes responsible consumption and production, as organic waste no longer ends up in landfills but is instead processed into valuable products (SDG 12: Responsible Consumption and Production). Furthermore, the economic impact of reduced fertilizer and pesticide expenses contributes to inclusive local economic growth (SDG 8: Decent Work and Economic Growth). On a broader scale, this initiative strengthens efforts toward sustainable cities and communities (SDG 11: Sustainable Cities and Communities) by establishing a resilient, efficient, and environmentally friendly urban food system.

In conclusion, this program is not only responsive to the local needs of Balikpapan communities but also strategic in supporting the global development agenda through tangible contributions to achieving the SDGs.

1.2. Literature Review

Microorganisms are highly diverse biological agents that are widely distributed across ecosystems due to their unique metabolic capabilities. This metabolic diversity enables microorganisms to play crucial roles in the biodegradation of pollutants, the utilization of organic waste, and the improvement of environmental quality [3]. These abilities position microorganisms as an essential resource in environmental biotechnology, particularly in the production of enzymes that accelerate the decomposition of complex organic matter into simpler compounds that can be more readily reused.

In the context of urban environmental management, the use of enzymatic microorganisms (EMO) offers an environmentally friendly and sustainable alternative solution. EMO not only reduces the burden of organic waste, which constitutes the majority of urban waste generation, but also produces both liquid and solid organic fertilisers that can serve as substitutes for chemical fertilisers. This is critical because the long-term use of chemical fertilisers has been shown to degrade soil quality, contaminate groundwater, and leave harmful residues that can impact human health and ecosystems [4, 5]. Thus, the application of EMO aligns with efforts to promote safe, sustainable, and environmentally conscious food production.

Several studies have demonstrated that microorganisms are widely utilised in agriculture, aquaculture, and the healthcare sector. For instance, [6] reported that microorganisms are the most efficient source of enzymes compared to plants and animals, with utilisation rates increasing by 10–15% annually. The advantages of microorganisms in enzyme production include high efficiency, good selectivity, and environmental friendliness, as their reactions are predictable and do not generate hazardous by-products. Similarly, [3] emphasized the role of microorganisms in the bio-remediation of various pollutants as a key step in maintaining urban environmental quality.

Furthermore, research by [7] identified several enzyme-producing microorganisms with significant potential for application across multiple industrial sectors, including agriculture, showing promising results in enhancing nutrient availability and improving soil quality. The community-scale application of EMO is particularly relevant because this approach not only addresses environmental issues but also provides economic value through savings on fertilizer and pesticide costs as well as increased crop productivity. In fisheries industry, these were significant findings that influenced others, including body weight and specific growth rate (8) *B. amyloliquefaciens* was able to inhibit the growth of *V. alginolyticus* bacteria with an inhibition zone of 3.5 cm and *V. harveyi* with an inhibition zone value of 4 cm and was also positive for catalase (9) These bacteria have characteristics that have the potential to be used as probiotics in the aquaculture industry and another agro-complex industry, especially vibrio biocontrol agents (10).

From a sustainable development perspective, the literature on enzymatic microorganisms highlights that simple biotechnology-based interventions can contribute to several Sustainable Development Goals (SDGs), particularly SDG 2 (*Zero Hunger*), SDG 3 (*Good Health and Well-Being*), SDG 6 (*Clean Water and Sanitation*), and SDG 12 (*Responsible Consumption and Production*). Therefore, the integration of EMO into community empowerment programs in urban settings holds strategic urgency, not only as a technical solution to waste management and the scarcity of organic fertilizers but also as a socioeconomic empowerment instrument that contributes to achieving global development goals.

1.3. Research Objective

This community service program aims to provide innovative solutions to the challenges of organic waste management, limited access to nutrient-rich fertilisers, and the availability of clean water in urban areas, particularly in Balikpapan City. The primary objective of this activity is to demonstrate that organic waste can be recycled through the use of enzyme-producing microorganisms (Enzymatic Microorganisms/EMO), resulting in valuable products such as organic fertilizer and usable water.

More specifically, the objectives of this program are to:

1. Enhance community capacity through awareness campaigns and training on the production and application of EMO, enabling households, especially women's groups and urban farming communities, to acquire skills in processing organic waste into useful products.

2. Develop EMO-based organic fertilisers as alternatives to chemical fertilisers, thereby promoting environmentally friendly, sustainable, and cost-effective urban agriculture practices.
3. Reduce the urban environmental burden by utilizing food waste, which dominates household waste composition, into value-added products, while simultaneously decreasing the volume of waste sent to landfills.
4. Strengthen food security and public health by promoting the production of pesticide-free organic food and providing an alternative source of clean water through rainwater purification using EMO.
5. Support the achievement of SDGs 1–12 through socio-economic empowerment, improved quality of life, sustainable environmental management, and the advancement of local innovations based on simple biotechnology.

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With the achievement of these goals, this program is expected to serve as an integrative model of community empowerment, where environmental, social, and economic aspects can work in tandem to build a sustainable urban food security system.

2. MATERIALS AND METHODS

2.1. Location and Time of Activities

This community service program was implemented in 2024 at the Semarak 49 Group, Muara Rapak Subdistrict, Balikpapan City, East Kalimantan, Indonesia. The location was purposively selected because the community in this area is actively engaged in urban farming activities facilitated by PT Pertamina Patra Niaga Integrated Terminal Balikpapan, yet still faces challenges in meeting the demand for organic fertilizer and clean water.

2.2. Target Participants

The target participants were 10 housewives from the Semarak 49 Group involved in urban farming management, along with the Joint Business Group (Kelompok Usaha Bersama/KUB) Kampung Pangan Berseri. Women's groups were selected as the primary beneficiaries due to their strategic role in household and food management, as well as their potential contribution to strengthening family economies.

2.3. Implementation Stages

The program was carried out through several integrated stages:

1. Socialization of Enzymatic Microorganism (EMO) Application

Conducted at the RT 49 Community Hall in Muara Rapak Subdistrict, involving community leaders, local government, farmer groups, and posyandu (community health post) cadres. A biotechnology expert presented the basic concepts of EMO, the mechanisms of microorganisms in decomposing organic waste, and the potential applications in agriculture, livestock, and water purification.

2. EMO Production Training

Practical training was provided to members of KUB Kampung Pangan Berseri to enable them to produce EMO independently. The training followed Standard Operating Procedures (SOPs) based on Intellectual Property Rights (IPRs) of PT Pertamina Patra Niaga Integrated Terminal Balikpapan No. 000781804 (2024) as outlined in the EMO Production Brochure. Participants were trained in the preparation of raw materials, fermentation processes, and quality control of EMO products.

3. Application of EMO

The EMO produced was applied for two main purposes: (1) as liquid organic fertilizer for horticultural crops in urban farming plots, and (2) as a bioremediation agent in the utilization of rainwater. Application procedures included adding EMO solution to planting media and rainwater reservoirs, followed by monitoring the quality outcomes over a designated incubation period.

4. Impact Evaluation

Evaluation was conducted to assess the effectiveness of EMO use in terms of:

- Technical aspects: plant quality (vegetable growth) and rainwater quality (reduction of Fe, chromium, and hardness).
- Economic aspects: savings on fertilizer, pesticide, and water storage costs.
- Social aspects: increased community capacity and group independence in EMO production.

2.4. Methodological Approach

The methodological approach used was Participatory Action Research (PAR), where the community acted not only as beneficiaries but also as key actors in the learning, production, and application processes of EMO. This participatory approach is expected to foster a stronger sense of ownership among the community, thereby ensuring the sustainability of the program.

3. RESULT AND DISCUSSION

3.1. Socialization of EMO Application

The socialization stage served as the initial step to provide the community with a basic understanding of the concept and benefits of Enzymatic Microorganisms (EMO). The session was held at the RT 49 Community Hall in Muara Rapak Subdistrict, involving the Patra Janaka Group, Posyandu Semarak 10 Sehati (PARAS), Fish Cultivation Group, Joint Business Group (KUB) Kampung Pangan Berseri, and local government representatives. A biotechnology expert presented material on the mechanisms of enzymatic microorganisms in decomposing organic compounds into simpler forms that can be applied in agriculture, livestock, and household waste management. The results showed that the community gained an understanding of EMO's potential as a solution to everyday problems, such as dependence on chemical fertilizers, limited access to organic fertilizers, and difficulties in obtaining clean water. This activity also raised community awareness about the importance of simple, environmentally friendly, technology-based waste management.

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Figure 1. Socialization of Enzymatic Microorganism (EMO) Application

3.2. EMO Production Training

The EMO production training aimed to enable community groups to produce EMO using inexpensive and locally available materials independently. The training followed the Standard Operating Procedures (SOP) outlined in the Intellectual Property Rights (HAKI) of Pertamina Patra Niaga Integrated Terminal Balikpapan No. 000781804 (2024). The main ingredients included settled water, refined sugar, beef broth protein, fermipan yeast, and oil-degrading bacterial starters. Fermentation was carried out with the assistance of an aerator, and an incubation period of 10 days was used. This training enhanced community skills, particularly among members of KUB Kampung Pangan Berseri, in transforming organic waste into value-added products. Participants not only understood the theory but also directly practised EMO production, thereby fostering independence and program sustainability.

Figure 2. Enzymatic Microorganism (EMO) Production Training

3.3. EMO Application

The application of EMO was carried out in two main areas: urban agriculture and rainwater purification. In urban agriculture, EMO was applied as a liquid organic fertiliser to horticultural crops, such as spinach and lettuce. Observations revealed improved plant growth quality in terms of colour, size, and freshness compared to control crops that relied solely on chemical fertilisers.

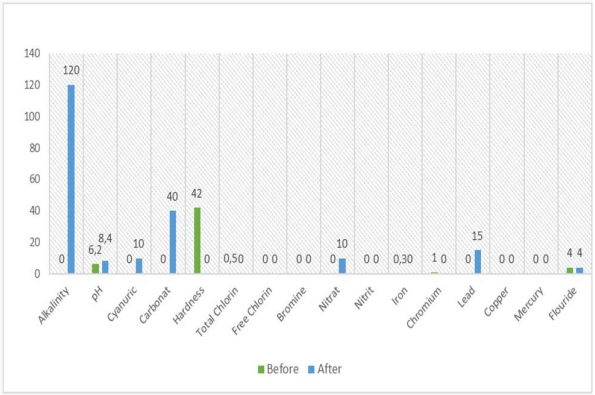

Figure 3. Test Results of EMO Application on Rainwater

In water purification, 3 ml of EMO was inoculated into a rainwater reservoir. After 7 days, test kit results indicated that EMO improved nitrate, carbonate, and alkalinity levels, while reducing heavy metals such as chromium and iron, and lowering water hardness. This demonstrated that EMO can function as a simple bioremediation agent, enhancing rainwater quality to make it suitable for daily use.

3.4. Impact Evaluation

An impact evaluation was conducted by assessing the technical, economic, and social aspects. Technically, EMO proved effective in improving both plant and water quality. Economically, the program generated substantial cost savings: IDR 1,380,000/year on fertilizers, IDR 660,000/year on pesticides, and IDR 268,800,000/year on water storage facilities. Socially, partner communities experienced increased knowledge and skills, especially among housewives who are now capable of independently producing EMO. Overall, the program demonstrated that EMO application successfully addressed pressing urban community challenges, namely organic waste management, fertilizer shortages, and the need for clean water. The program aligns with previous studies that emphasise the role of enzymatic microorganisms in biodegradation and bioremediation [3,7], while making tangible contributions toward achieving SDGs 1–12, particularly in poverty alleviation, food security, health, gender equality, access to clean water, innovation, and sustainable consumption and production.

4. CONCLUSION

The socialisation and training activities on the production and utilisation of enzymatic microorganisms, organised by PT Pertamina Patra Niaga Integrated Terminal Balikpapan, had a positive impact on the beneficiary communities, specifically the Joint Business Group (KUB) Kampung Pangan Berseri and the residents of Muara Rapak Subdistrict, Balikpapan City. Through these activities, the community gained enhanced knowledge and skills in producing and applying Enzymatic Microorganisms (EMO) for various daily needs, particularly as an alternative to chemical fertilizers and as an agent for rainwater purification. The application of EMO not only reduced dependence on synthetic chemicals but also supported the development of more environmentally friendly agricultural and livestock systems.Furthermore, the program has the potential to increase household income by reducing production costs, enhancing productivity, and improving the quality of agricultural products, such as pesticide-free lettuce and spinach. Additionally, this innovation promotes community self-reliance in managing local resources, enhances food security, and contributes to sustainable development programs at the regional level. Thus, the initiative not only delivers direct benefits to community welfare but also opens opportunities to develop a model of community empowerment based on simple bioremediation technology that can be replicated in other areas.

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