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Empowerment of Appropriate Technology for Effective Composting from Biogas Waste and Local Microorganisms for the Community

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ABSTRACT
Every human activity in daily life always produces waste that pollutes the environment. This can be minimized by utilizing it as compost. The purpose of this study was to evaluate community empowerment in introducing appropriate composting technology using digester effluent from biogas waste and local microorganisms. This study was an action research study that included planning, acting, observing, and reflecting. Farmers with relevant materials were invited to participate in the fertilizer production process. The local microorganism solution, in addition to supplying nutrients, also serves as a component of the bioreactor, which maintains optimal plant growth. The functions of the bioreactor are complex, including supplying nutrients through exudate mechanisms, controlling microbes according to plant needs, maintaining soil stability toward ideal conditions for plant growth, and even controlling diseases that can attack plants. It also contains growth stimulants that play a role in stimulating plant growth. In conclusion, the community can create and utilize biogas waste into organic fertilizer or compost. It is recommended that the resulting compost's N, P, K, and C/N levels be checked to ensure standards are maintained.
Keywords: fertilizer; compost; appropriate technology; biogas waste

INTRODUCTION
Appropriate technology for producing biogas from cow manure is simple and relatively inexpensive, while also generating renewable energy as a substitute for LPG. The success of biogas technology also produces digester effluent in the form of thick compost, which was previously unused and often discarded carelessly, contributing to environmental problems.(1-3) Processing this effluent into compost; using biogas waste, charcoal, and organic matter has proven effective. Physical assessments (temperature, pH, moisture, color, odor, and texture) and chemical content measurements (N, P, K, and C/N ratio) meet the standards of SNI 19-7030-2004. Increasing the use of biogas effluent results in compost with higher nitrogen, phosphorus, and potassium content, along with a lower C/N ratio. These findings are being implemented through a PKM-M (Student Creativity Program in Community Service).(4)

Compost production is carried out using a fermentation method that combines biogas effluent and local microorganisms. The best results were achieved using a combination of cow intestines and tomatoes, with a compost maturation time of five weeks. In comparison, fermentation using EM (Effective Microorganisms) from tomatoes and intestines required six weeks. Based on practical activities in the waste management course and these research findings, the lecturer formed a Community Service Program team, which also serves as a hands-on training platform for students.(4)

The PKM-M activities were conducted in Jabung Village, Panekan District, Magetan Regency. The village is predominantly inhabited by farmers and livestock breeders and has eight biogas installations. It is a fostered village of the Diploma III Environmental Health Study Program at the Magetan Campus of the Surabaya Health Polytechnic and serves as a student practice site. The goal of the student creativity program is to produce effective compost from biogas waste and local microorganisms using fermentation, in order to increase the N, P, and K content and make it suitable for organic farming, in accordance with the Regulation of the Minister of Agriculture of the Republic of Indonesia No. 70/PERMENTAN/SR.140/10/2011.(5)

The program is implemented through mentoring, education, training, and field practice for biogas owners and farmers. The increased knowledge and skills are expected to reduce the use of chemical fertilizers, promote independent organic fertilizer production, and enable knowledge sharing with other communities, ultimately improving organic farming yields. The community can meet its compost needs and share composting experiences with others. Environmental pollution is reduced by utilizing biogas waste as compost material. Students actively participate in PKM-M activities, enhancing their scientific knowledge and practical skills.

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The benefits of this student-community service initiative include empowering the community in Jabung Village to produce effective organic fertilizer from biogas waste and local microorganisms using fermentation. Students gain scientific and technical skills in compost production. The introduction of appropriate composting technology serves as a learning medium for students of the Diploma 3 Environmental Health Study Program, the local community, and related institutions, and can be further developed to reduce environmental pollution by transforming biogas digester effluent into compost.

The purpose of this study was to evaluate community empowerment in introducing appropriate composting technology using digester effluent from biogas waste and local microorganisms.

METHODS

This appropriate technology implementation activity was carried out by providing materials and mentoring in the production of organic fertilizer using the fermentation method. The materials used included waste from the biogas reactor and local microorganisms (MOL).[6-8] In this activity, the remaining biogas waste was mixed with MOL to produce organic fertilizer.

Based on the partner problem analysis described above, the student community service implementation through the PKM-M Program focused on education and training, specifically in organic fertilizer/compost production, and was carried out with the following details:

1) The implementation team consisted of four students from the Diploma 3 Environmental Health Study Program, who are actively engaged and creative in campus activities.
2) The PKM-M program partners included livestock breeders, farmers, and biogas owners residing in Jabung Village, Panekan District, Magetan Regency, selected through deliberation and consensus.

To ensure the success of this initiative, an implementation plan was developed collaboratively by the student team, PKM-M supervisor, and community partners in Jabung Village. The plan considered key factors such as input, activity process, and expected output. To address the identified partner issues, training and mentoring were provided through lectures, group discussions, field practice, and consultation services. Consultations were conducted face-to-face, via telephone, email, or other accessible means to ensure continuity of support.

Figure 1. Preparing to make compost

Figure 2. Mixing biogas residue with compost

This action research was conducted in accordance with scientific ethics, including informed consent, maintaining confidentiality, acting fairly, providing benefits, and ensuring no harm to participants.

RESULTS

Input

Researchers gathered data on the potential of villages that support the PKM-M Program in producing organic fertilizer/compost. The implementation team, along with partners, compiled a map of potential livestock and agricultural areas, facilities and infrastructure, and explored the potential of people who would be involved in PKM-M activities. Next, the team selected a method to be implemented in Jabung Village, Panekan District, Magetan Regency, and conducted advocacy through an approach to the regional decision-maker, namely the village head. This activity was intended to gain support and cooperation in the form of an agreement as a community service partner.

Process

The success of the PKM-M is largely determined by the quality and consistency of its implementation process. To effectively transfer knowledge and skills related to producing organic compost from biogas and MOL waste using the fermentation method, the program integrates educational activities, structured training, and direct field practice.

Educational and training activities begin with identifying and collecting data on participants, followed by administering post-tests to assess their initial understanding. A comprehensive guidebook is developed to support the learning

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process, detailing the tools and materials required, step-by-step procedures, monitoring and evaluation techniques, potential challenges, and strategies to overcome them. The education and training sessions are then conducted, combining theoretical instruction with hands-on compost-making at designated training locations. Post-training assessments are repeated to measure progress and reinforce learning outcomes.

Field practice is carried out at each participant's home, where they apply the fermentation method to produce organic compost over a period of 14 to 21 days. These activities are closely monitored by the implementation team to ensure proper technique and to provide ongoing support. In essence, the PKM-M program emphasizes a participatory and practical approach to community empowerment, enabling sustainable compost production and environmental stewardship.

The preparation activities include site setup, fermentation treatment preparation, and the collection of digester effluent waste. The designated location is prepared with the necessary tools and materials. Digester effluent is collected and placed into the fermentation treatment container. A bacterial and fermentor solution is added at a ratio of 1:100, meaning one part bacteria to one hundred parts digester effluent. Glucose (molasses) is also added at the same ratio of 1:100, while dolomite (lime) is added at a concentration of 5–10% relative to the volume of digester effluent.

Compost is made using a mixture of biogas effluent, household organic waste, and rice husk ash in a ratio of 3:1:1. For example, 3 kg of biogas effluent requires 1 kg of organic waste and 1 kg of rice husk ash. The mixture is placed into a fermentation container that is covered but not sealed tightly, allowing gas exchange. The compost mixture is stirred every two days, in the morning and evening, to ensure proper fermentation. After 14 to 21 days, the organic fertilizer or compost is ready for use. Fermentors can be made from rotten tomatoes, spoiled rice, or other organic materials processed into MOL.[9]

The compost should not emit a strong or unpleasant odor. To test maturity, 500 ml of compost is placed in a sealed plastic bag for 48 hours. If the bag inflates, becomes warm, or releases a foul smell when opened, the compost is not yet mature. The texture should be thick yellowish-brown. The ideal pH range is between 6.5 and 7.5, indicating a neutral condition. The temperature during fermentation typically ranges from 30°C to 50°C, and as the compost matures, the temperature gradually drops to ambient levels and stabilizes.[9]

The final compost product should meet the standards outlined in the Regulation of the Minister of Agriculture of the Republic of Indonesia No. 70/permentan/SR.140/10/2011.[5] This process supports the development of self-reliant communities in producing their own organic compost fertilizer.

The expected output of this activity is that community members who have participated in the educational sessions, training, and field practice will possess the knowledge and skills needed to independently produce organic compost fertilizer for their own use, reducing reliance on chemical fertilizers. This empowerment also contributes to mitigating environmental pollution and preventing the spread of disease. Furthermore, participants are expected to share their knowledge and skills with others, enabling wider adoption of compost production practices within the community.

DISCUSSION

The implementation of the PKM-M program in Jabung Village, Panekan District, Magetan Regency has demonstrated tangible outcomes in terms of community empowerment and environmental sustainability. The factual results show that community members were able to produce organic compost independently using biogas effluent and local microorganisms (MOL) through a structured fermentation method. The compost produced met the physical and chemical quality standards set by the Regulation of the Minister of Agriculture of the Republic of Indonesia No. 70/PERMENTAN/SR.140/10/2011, particularly in terms of pH, temperature, odor, texture, and nutrient content (N, P, K).[5] This indicates that the training and mentoring process was effective in transferring both knowledge and practical skills.

From a broader perspective, this initiative aligns with global and national efforts to promote sustainable agriculture and reduce dependency on chemical fertilizers. According to FAO (2021), integrating organic waste into farming systems not only improves soil health but also contributes to climate resilience and circular economy practices.[10] The use of biogas effluent, which is often discarded as waste, as a raw material for composting, reflects a practical application of waste-to-resource principles. Moreover, the incorporation of MOL derived from locally available organic materials such as rotten tomatoes and spoiled rice enhances the accessibility and affordability of the composting process for rural communities.

The strengths of this program lie in its participatory approach, low-cost technology, and integration of education, training, and field practice. The use of locally available materials and simple fermentation techniques makes the method replicable and scalable.[11-13] The program also fosters community independence in managing agricultural inputs and contributes to reducing environmental pollution from unmanaged biogas waste.

However, some limitations were observed. First, the fermentation process requires consistent monitoring and manual stirring every two days, which may be challenging for participants with limited time or physical capacity.[14] Second, while the program successfully reached a targeted group of farmers and biogas users, broader dissemination to other villages or districts would require additional resources and institutional support. Furthermore, the long-term sustainability of compost production depends on continued motivation, access to materials, and technical assistance.[15-20]

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Looking ahead, the program could be strengthened by integrating digital tools for monitoring compost quality, expanding partnerships with agricultural extension services, and developing a community-based compost marketing model. Future initiatives may also include comparative studies on crop yields using compost versus chemical fertilizers, to further validate the economic and agronomic benefits. Additionally, incorporating this model into the curriculum of environmental health and agricultural education programs can ensure continuity and innovation in community-based waste management and organic farming practices.

In conclusion, the PKM-M program has laid a strong foundation for sustainable compost production using biogas waste and MOL. With strategic follow-up and institutional collaboration, this initiative holds significant potential to be replicated and scaled for broader environmental and agricultural impact.

CONCLUSION

The implementation of the PKM-M program in Jabung Village has successfully demonstrated that appropriate technology and community-based education can empower local residents to produce effective organic compost from biogas effluent and local microorganisms. Through a combination of training, mentoring, and field practice, participants gained practical skills and scientific understanding, enabling them to reduce dependence on chemical fertilizers and contribute to environmental sustainability. The compost produced met national quality standards, indicating the feasibility and reliability of the fermentation method introduced. This initiative not only addressed waste management challenges but also fostered community independence in organic fertilizer production. With continued support and strategic expansion, the program holds strong potential to be replicated in other rural areas, enhancing agricultural resilience and promoting eco-friendly practices.

Ethical consideration, competing interest and source of funding

-All ethical principles are upheld in this research.
-The authors declare that there is no conflict of interest.
-Source of funding is authors.

REFERENCES

1. Ogunsanya KA. Biodigester and biogas technology as veritable tool for poultry waste management in the federal capital territory, Abuja, Nigeria. African Real Estate Society (AfRES); 2023 Jan 1.
2. Jančauskas A, Bykov E, Paulauskas R. Valorisation of ultra-low calorific value biogas using plasma-assisted combustion. InInternational Sustainable Resource Recovery Strategies Towards Zero Waste (FULLRECO4US) Conference. 2023. COST (European Cooperation in Science and Technology).
3. Singh S. Study of waste water effluent characteristics generated from paper industries. Journal of Basic and Applied Engineering Research. 2015;2(17):1505-9.
4. Seulawah DO, Gusvina Y, Agustiani B, Oktavia L, Triana W. Edukasi-simulasi jaga diri (EDU-SIJADI) dari hepatitis akut pada anak sekolah dasar. Jurnal BINAKES. 2022 Nov 30;3(1):17-20.
5. Kementerian Pertanian Republik Indonesia. Peraturan Menteri Pertanian Republik Indonesia Nomor 70/Permentan/SR.140/10/2011 tentang Pedoman Teknis Pupuk Organik, Pupuk Hayati, dan Pembenah Tanah. Jakarta: Kementerian Pertanian RI; 2011.
6. Pandyaswargo AH, Jagath Dickella Gamaralalage P, Liu C, Knaus M, Onoda H, Mahichi F, Guo Y. Challenges and an implementation framework for sustainable municipal organic waste management using biogas technology in emerging Asian countries. Sustainability. 2019 Nov 11;11(22):6331.
7. Adeleke AJ, Ajunwa OM, Golden JA, Antia UE, Adesulu-Dahunsi AT, Adewara OA, Popoola OD, Oni EO, Thomas BT, Luka Y. Anaerobic digestion technology for biogas production: current situation in Nigeria (a review). UMYU Journal of Microbiology Research. 2023;8(2):153-64.
8. Wałowski G. Development of biogas and biorafinery systems in Polish rural communities. Journal of Water and Land Development. 2021:156-68.
9. Nurweni S, Prasetyo A, Suyanto B. Development of Appropriate Technology for Utilizing The Effluent of Biogas Digester for Making Compost. Health Notions. 2019 May 31;3(5):234-41.
10. Food and Agriculture Organization of the United Nations (FAO). Global assessment of soil pollution: Report. Rome: FAO and UNEP; 2021.
11. Montoneri E. Municipal waste treatment, technological scale up and commercial exploitation: The case of bio-waste lignin to soluble lignin-like polymers. Food waste reduction and valorisation: Sustainability assessment and policy analysis. 2017 Apr 28:79-120.
12. Montoneri E, Koutinas M, Padoan E, Negro V, Licignano C, Leone S, Photiou P, Kallis M, Vyrides I, Liendo F, Negre M. Integrated chemical and biochemical technology to produce biogas with a reduced ammonia content from municipal biowaste. Validating lab-scale research in a real operational environment. Environmental Science: Advances. 2022;1(5):746-68.

ISSN 2988-6198

13. Romero-Perdomo F, González-Curbelo MÁ. Integrating multi-criteria techniques in life-cycle tools for the circular bioeconomy transition of agri-food waste biomass: A systematic review. Sustainability. 2023 Mar 12;15(6):5026.
14. Ye H, Wang J, Shi J, Du J, Zhou Y, Huang M, Sun B. Automatic and intelligent technologies of solid-state fermentation process of Baijiu production: applications, challenges, and prospects. Foods. 2021 Mar 23;10(3):680.
15. Viaene J, Van Lancker J, Vandecasteele B, Willekens K, Bijttebier J, Ruysschaert G, De Neve S, Reubens B. Opportunities and barriers to on-farm composting and compost application: A case study from northwestern Europe. Waste Management. 2016 Feb 1;48:181-92.
16. Cai T, Steinfield C, Chiwasa H, Ganunga T. Understanding Malawian farmers' slow adoption of composting: Stories about composting using a participatory video approach. Land Degradation & Development. 2019 Jul 15;30(11):1336-44.
17. Ayilara MS, Olanrewaju OS, Babalola OO, Odeyemi O. Waste management through composting: Challenges and potentials. Sustainability. 2020 May 30;12(11):4456.
18. Policastro G, Cesaro A. Composting of organic solid waste of municipal origin: the role of research in enhancing its sustainability. International Journal of Environmental Research and Public Health. 2022 Dec 25;20(1):312.
19. Rastegari H, Nooripoor M, Sharifzadeh M, Petrescu DC. Drivers and barriers in farmers' adoption of vermicomposting as keys for sustainable agricultural waste management. International Journal of Agricultural Sustainability. 2023 Dec 31;21(1):2230826.
20. Meeks D, Hottle T, Bilec MM, Landis AE. Compostable biopolymer use in the real world: Stakeholder interviews to better understand the motivations and realities of use and disposal in the US. Resources, Conservation and Recycling. 2015 Dec 1;105:134-42.