Journal of Community Empowerment 5 (2) (2025): 130-139 p-ISSN 2798-5997 | e-ISSN 2807-1115
Sekolah Pascasarjana Universitas Negeri Semarang https://journal.unnes.ac.id/journals/index.php/jce

School-Based Organic Waste Management Innovation through the P4-E Approach to Develop Greenpreneurship

Bambang Subali[1], Ellianawati Ellianawati[1], Tri Joko Raharjo[2], Ridho Adi Negoro[3], Listiyanto Listiyanto[3], Natalia Erna Setyaningsih[4]

[1]Master's Program in Science Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Indonesia
[2]Master's Program in Primary Education, Postgraduate School, Universitas Negeri Semarang, Semarang, Indonesia
[3]Department of in Physics Education, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Indonesia
[4]Physics Laboratory, Faculty of Mathematics and Natural Sciences, Universitas Negeri Semarang, Indonesia

*Corresponding Author: bambangfisika@mail.unnes.ac.id

Submitted: 2025-06-02 Revised: 2025-08-24 Published: 2025-10-13

Abstract. Organic waste management in schools remains a persistent environmental challenge that affects hygiene, air quality, and the overall learning climate. In many schools, organic waste is still burned or buried, reflecting limited ecological literacy and insufficient technical capacity to convert waste into productive resources. At the same time, the integration of entrepreneurship education within science learning remains underdeveloped. This community service programme introduced a school-based organic waste management innovation through the P4-E approach (Training, Practice Implementation, Marketing, and Evaluation) to develop greenpreneurship among science teachers and students. The programme involved 50 participants from the Science Teachers' Working Group (MGMP IPA) and SMP Negeri 1 Slawi, Tegal Regency. Activities included EM-4 biofermentation compost training, practical compost production and packaging, digital marketing development, and financial management mentoring. Findings indicate substantial improvement in ecological awareness, technical composting skills, and entrepreneurial capacity. Participants demonstrated the ability to produce market-ready compost products and implement digital promotion strategies. The P4-E approach functioned as an integrative empowerment model that linked science education, environmental action, and entrepreneurship development. The programme contributes to advancing SDGs 4, 8, 12, and 13 by institutionalizing sustainable waste management practices within the school context.

Keywords: EM-4 biofermentation, greenpreneurship, organic waste management, P4-E approach, science education

How to Cite: Subali, B., Ellianawati, E., Raharjo, T.J., Negoro, R.A., Listiyanto, L., Setyaningsih, N.E. (2025). School-Based Organic Waste Management Innovation through the P4-E Approach to Develop Greenpreneurship. *Journal of Community Empowerment,* 5 (2), 130-139.

INTRODUCTION

Organic waste management in school environments remains a persistent environmental challenge that affects hygiene, air quality, and the sustainability of the learning ecosystem. In many schools, organic waste continues to be burned or buried, resulting in avoidable environmental pollution and inefficient resource utilisation (Taufik & Maulana, 2015; Yudistirani et al., 2015; Rosmala et al., 2020). Such practices reflect not only limited ecological awareness but also insufficient institutional capacity to transform organic waste into productive resources. Although composting technologies are widely available, systematic integration of waste management into educational and entrepreneurial learning processes remains underdeveloped.

Biofermentation technology using EM-4 has been empirically demonstrated to accelerate organic decomposition and improve compost quality (Nur et al., 2016; Yuniwati et al., 2012; Subali et al., 2024). Within educational contexts, such scientific practices offer opportunities for contextual science learning that connects ecosystem concepts with real-world environmental action. However, previous implementations have predominantly emphasised technical compost production without embedding structured entrepreneurial development or sustainable empowerment mechanisms. As a result, waste management initiatives often remain short-term activities rather than institutionalised school practices (Armayanti et al., 2021; Matin et al., 2022, 2024; Sumardiono et al., 2022; Wardoyo, 2016).

The concept of greenpreneurship provides a framework for integrating environmental

responsibility with entrepreneurial competence. Prior studies highlight the importance of entrepreneurial motivation, digital literacy, and market orientation in developing environmentally based enterprises (Purnamawati et al., 2021; Ardiyanti, 2019; Komara & Setiawan, 2020). Nevertheless, research and community service practices rarely combine scientific waste management, entrepreneurship training, and participatory empowerment into a coherent model. The absence of an integrative framework limits the sustainability and scalability of school-based environmental innovation (Armayanti et al., 2021; Danapriatna et al., 2023; Hastuti et al., 2022; Suratno et al., 2020; Yudistirani et al., 2015).

To address this gap, this community service programme introduces a school-based organic waste management innovation through the P4-E approach (Training, Practice Implementation, Marketing, and Evaluation) to develop greenpreneurship among science teachers and students at SMP Negeri 1 Slawi. The programme positions schools as living laboratories where environmental education, biofermentation technology, and entrepreneurial learning converge. By integrating ecological literacy, technical competence, and digital marketing capacity within a structured empowerment cycle, the P4-E approach offers a replicable model for sustainable school-based innovation. This initiative contributes to advancing SDGs 4, 8, 12, and 13 by institutionalising environmentally responsible and economically productive practices within the education sector.

METHODS

The community service programme employed a participatory empowerment design structured through the P4-E approach (Training, Practice Implementation, Marketing, and Evaluation). The approach was developed as an integrative model linking environmental education, biofermentation technology, and entrepreneurial capacity building. The programme was implemented at SMP Negeri 1 Slawi, Tegal Regency, involving 50 participants consisting of members of the Science Teachers' Working Group (MGMP IPA) and selected student representatives.

The implementation was conducted in four sequential stages. The Training stage provided conceptual reinforcement on sustainable organic waste management and technical instruction on EM-4 biofermentation composting. The Practice Implementation stage facilitated hands-on compost production, including organic material preparation, fermentation management, drying, and product packaging design. The Marketing stage introduced digital promotion strategies, basic financial recording techniques, and the establishment of school-based entrepreneurial networks. The Evaluation stage involved follow-up mentoring sessions to assess product quality, production continuity, and the sustainability of entrepreneurial initiatives.

Programme effectiveness was assessed using a mixed descriptive-evaluative approach. Ecological attitude changes were measured through pre- and post-training questionnaires assessing waste management awareness using Likert-scale items. Behavioural transformation was observed through structured field observations focusing on waste segregation practices and independent compost production activities. Economic capacity development was evaluated through documentation of product outputs, pricing strategies, and digital marketing implementation.

Data were analysed descriptively by comparing pre- and post-intervention responses and synthesising observational findings to identify patterns of behavioural and entrepreneurial change. Qualitative interpretation was conducted to examine the emergence of innovation, entrepreneurial motivation, and institutional commitment to sustainable waste management practices. This methodological framework enabled the assessment of both technical outcomes and empowerment dynamics within the school setting.

RESULTS AND DISCUSSION

Development of Technical Competence in Organic Waste Processing

The implementation of the P4-E approach began with structured technical training in EM-4 biofermentation composting, positioning organic waste processing as both a scientific practice and a productive skill. The training phase emphasised experiential learning through direct engagement with organic materials collected from the school environment, including dry leaves and food residues. Participants were systematically guided through procedures such as waste segregation, size reduction through chopping, moisture regulation, microbial activation using EM-4 solution, controlled fermentation, aeration monitoring, drying, and final packaging. This procedural sequencing ensured that compost

Figure 1. Process of producing organic compost from school environmental waste by students under the supervision of teachers during the community service activity

production was not treated as a routine activity but as a scientific process grounded in microbiological principles and environmental management.

Empirical studies have demonstrated that EM-4 and other effective microorganism inoculants significantly accelerate decomposition and improve compost quality (Nur et al., 2016; Sutrisno et al., 2020; Mardiyono et al., 2024). Similar findings in bioactivation research highlight the importance of microbial balance, moisture control, and carbon–nitrogen ratio in achieving optimal fermentation outcomes (Matin et al., 2022; Danapriatna et al., 2023). Within the school context, introducing these scientific parameters enhanced participants' conceptual understanding of decomposition dynamics. Rather than perceiving organic waste as disposable residue, teachers and students began to recognise it as biodegradable biomass capable of transformation into nutrient-rich compost.

Observational evidence indicated a substantial increase in technical confidence among participants. Prior to the intervention, composting knowledge was largely theoretical and fragmented. During the practice implementation stage, participants demonstrated the ability to identify appropriate moisture levels, monitor fermentation temperature, and assess compost maturity through colour, texture, and odour indicators. These competencies reflect the internalisation of environmental biotechnology principles similar to those applied in broader waste-to-resource systems (Sunarya et al., 2020; Nugroho et al., 2020). The active involvement in fermentation management also parallels microbial utilisation studies in agricultural and livestock waste processing, where effective microorganism application enhances nutrient stability and environmental sustainability (Kamaruddin & Laining, 2020; Nurjuwita et al., 2020).

Figure 1 visually documents collaborative compost production between teachers and students. The image illustrates shared task execution, supervised monitoring, and coordinated material handling. Such interaction reflects the operationalisation of contextual science learning, where ecological concepts such as nutrient cycles, microbial metabolism, and biomass transformation are translated into practical environmental action. Experiential engagement strengthens procedural mastery and long-term retention of scientific knowledge, consistent with applied fermentation and waste conversion studies (Hastuti et al., 2022; Sumardiono et al., 2022).

The successful production of compost with appropriate physical characteristics dark colour,

crumbly texture, and stable moisture content further validated the effectiveness of the technical mentoring process. Comparable optimisation studies on EM-based fermentation and organic waste processing report similar quality indicators as benchmarks of maturity and nutrient stability (Yuniwati et al., 2012; Matin et al., 2024). These outcomes confirm that school-based composting, when guided by structured scientific instruction, can meet quality standards aligned with broader environmental management practices.

Beyond technical output, the mastery of composting procedures functioned as a foundational stage for entrepreneurial transformation. The conversion of waste into market-ready organic fertiliser introduced economic reasoning into environmental practice. Previous empowerment initiatives demonstrate that waste-based production can increase household income and stimulate local micro-enterprises (Aini et al., 2020). Integrating production skills with entrepreneurial motivation aligns with research highlighting the importance of interest and business motivation in determining entrepreneurial success (Ardiyanti, 2019). Furthermore, greenpreneurship frameworks emphasise the necessity of linking environmental innovation with economic viability to ensure sustainability (Qa et al., 2015; Jain et al., 2024; Azizan et al., 2026).

Thus, technical competence development in this programme extended beyond skill acquisition. It established a transformative learning process in which scientific understanding, environmental responsibility, and entrepreneurial orientation converged. The P4-E model facilitated this integration by ensuring that technical mastery preceded market engagement and sustainability evaluation. Within this structured cycle, compost production became both an ecological intervention and a capacity-building mechanism for green entrepreneurship, demonstrating that school environments can function as incubators of environmentally grounded economic innovation.

Ecological Attitude Transformation and Behavioural Change

Beyond technical competence, one of the most significant outcomes of the P4-E implementation was the transformation of ecological awareness and behavioural orientation among teachers and students. Prior to the intervention, waste management practices within the school environment primarily involved burning or burying organic residues, reflecting disposal-based habits rather than sustainability-driven decision-making. Such practices are widely reported in community-based waste systems and are associated with air pollution, greenhouse gas emissions, and inefficient biomass utilisation (Taufik & Maulana, 2015; Yudistirani et al., 2015). These conventional approaches indicate limited integration of environmental literacy into institutional routines.

The P4-E intervention repositioned waste management from a reactive disposal mechanism into a proactive environmental stewardship practice. During the implementation process, participants were encouraged to analyse the ecological consequences of burning organic waste and to compare such practices with circular resource management models. This comparative reflection process contributed to a cognitive shift in understanding waste as a recyclable resource rather than as an environmental burden. Studies on community empowerment through waste utilisation demonstrate that participatory environmental engagement significantly enhances awareness and responsibility (Aini et al., 2020). In this programme, awareness was reinforced through direct involvement in compost production cycles, enabling participants to witness tangible environmental benefits.

Observational findings during and after implementation revealed increased initiative in systematic waste segregation. Teachers and students independently collected dry leaves, food remnants, and biodegradable materials for compost input. The emergence of voluntary participation indicated that ecological literacy extended beyond conceptual comprehension into habitual behaviour. Similar empowerment-based environmental interventions emphasise that sustained behavioural change occurs when individuals experience visible outcomes of their actions (Rosmala et al., 2020). Through the composting process, participants observed the transformation of organic waste into usable fertiliser, reinforcing environmental accountability through experiential feedback.

The formation of an eco-school team represented a structural milestone in institutionalising ecological responsibility. This initiative signified a transition from individual-level awareness to collective environmental governance. Instead of depending on continuous external supervision, teachers and students collaboratively established waste collection schedules, monitoring procedures, and compost management routines. Such institutional

integration aligns with greenpreneurship-oriented empowerment frameworks, where environmental innovation becomes embedded within organisational culture (Qa et al., 2015; Jain et al., 2024). Institutionalisation strengthens sustainability because behavioural norms are codified into school practices rather than remaining informal initiatives.

The transformation process also resonates with research on environmental biotechnology adoption, where repeated engagement with microbial fermentation processes fosters deeper ecological appreciation (Sutrisno et al., 2020; Mardiyono et al., 2024). By understanding microbial roles in decomposition, participants developed a scientific appreciation for ecosystem cycles, reinforcing responsible waste handling. The integration of biological principles into daily routines supports the development of eco-centric perspectives that extend beyond compliance toward intrinsic motivation.

Importantly, the cyclical structure of the P4-E approach contributed to behavioural reinforcement. The evaluation stage facilitated reflection sessions in which participants assessed compost quality, environmental cleanliness, and programme continuity. Reflection and feedback mechanisms are critical in sustaining behavioural change, as they prevent interventions from becoming symbolic or short-term events. Research on sustainable entrepreneurial ecosystems emphasises the importance of iterative evaluation in strengthening long-term environmental commitment (Azizan et al., 2026). Within the school context, evaluation discussions encouraged adaptive improvements and reinforced collective ownership of environmental practices.

Furthermore, the behavioural shift demonstrated alignment between ecological responsibility and economic reasoning. When participants recognised that compost production could generate potential revenue, environmental stewardship gained practical relevance. This integration supports findings that entrepreneurial motivation enhances the sustainability of environmentally oriented initiatives (Ardiyanti, 2019). By linking ecological action with productive opportunity, the programme reduced the likelihood of regression to disposal-based habits.

Ecological attitude transformation in this programme was not limited to increased awareness but manifested in structured behavioural adaptation and institutional governance. The P4-E model functioned as a reinforcement mechanism that connected environmental literacy, participatory engagement, and entrepreneurial orientation within a continuous empowerment cycle. Through repeated practice, reflective evaluation, and organisational embedding, ecological responsibility evolved from an externally facilitated initiative into an internally sustained school culture.

Entrepreneurial Capacity and Market Orientation Development

A distinctive contribution of the P4-E programme lies in its deliberate integration of entrepreneurship within environmental education. Compost production was conceptualised not merely as an ecological remediation activity but as a viable micro-enterprise model embedded within the school ecosystem. This repositioning transformed environmental action into productive economic engagement. Rather than stopping at technical mastery of EM-4 biofermentation, the programme extended into structured entrepreneurial training designed to cultivate market awareness, financial literacy, and innovation capacity.

The marketing stage introduced participants to digital promotion strategies using widely accessible social media platforms such as Instagram and Facebook. Approximately seventy percent of participants successfully created promotional accounts dedicated to compost products. The development of digital accounts marked a significant transition from production-oriented activity to market-oriented thinking. Research on youth entrepreneurship consistently emphasises the importance of digital networking and platform utilisation in enhancing small-scale enterprise visibility (Purnamawati et al., 2021). Through digital engagement, participants were exposed to concepts of branding, audience targeting, and content strategy, strengthening their understanding of consumer behaviour and market positioning.

Packaging design sessions further reinforced entrepreneurial creativity. Participants collaboratively developed product labels, selected brand names, and considered visual identity elements to increase product attractiveness. Such design-oriented thinking aligns with business incubation models that emphasise innovation and product differentiation as key determinants of entrepreneurial sustainability (Komara & Setiawan, 2020). By engaging teachers and

Figure 2. Implementation of the community service programme involving science teachers and students from SMP Negeri 1 Slawi, Tegal Regency, facilitated by the UNNES LPPM team

students in branding discussions, the programme cultivated ownership and product identity, moving beyond generic compost packaging toward value-added presentation.

Financial literacy components were also embedded within the empowerment cycle. Participants were trained to calculate production costs, including raw material preparation, fermentation inputs, packaging materials, and labour estimation. They were introduced to basic pricing strategies, including cost-plus calculation and competitive price comparison. Exposure to cost accounting principles resonates with research indicating that entrepreneurial motivation and financial management competence significantly influence business success (Ardiyanti, 2019). The ability to determine selling prices based on cost structure enhanced participants' economic reasoning and reduced reliance on arbitrary pricing decisions.

The integration of entrepreneurial capacity into environmental education reflects broader greenpreneurship frameworks that advocate linking ecological innovation with economic viability (Qa et al., 2015; Jain et al., 2024). Greenpreneurship is not solely about environmental concern but about creating sustainable business models that address ecological challenges. In this programme, compost production functioned as an entry point for demonstrating how waste conversion can generate economic opportunity. By situating entrepreneurship within environmental stewardship, the initiative fostered a mindset that sustainability and profitability are not mutually exclusive but mutually reinforcing.

Figure 2 illustrates interactive mentoring sessions involving lecturers, teachers, and students. The image captures collaborative discussion dynamics that combined scientific explanation with business planning dialogue. These sessions facilitated knowledge transfer across disciplinary domains—environmental science and entrepreneurship—within a single empowerment framework. The mentoring process encouraged participants to critically reflect on market potential, customer segments, and promotional tactics. Such integrative dialogue differentiates the P4-E model from conventional composting workshops that focus solely on technical production without addressing market integration.

The entrepreneurial orientation cultivated through this programme also aligns with sustainable tourism and community-based green enterprise models that emphasise innovation, networking, and adaptive strategy (Azizan et al., 2026). Although the school context differs from commercial tourism settings, the underlying principle of environmental value creation remains consistent. Participants learned to view compost not merely as fertiliser but as a branded, marketable eco-product capable of contributing to local sustainability initiatives.

Importantly, embedding entrepreneurship within the P4-E cycle enhanced programme sustainability. Economic incentive structures increased participants' commitment to maintaining production continuity. When environmental action produces tangible economic outcomes, behavioural persistence becomes more likely. This linkage strengthens institutional adoption and reduces the risk of programme stagnation. Thus, entrepreneurial capacity development did not function as an auxiliary component but as a strategic pillar that ensured long-term viability of school-based organic waste innovation (Danapriatna et al., 2023; Hastuti et al., 2022; Suratno et al., 2020; Yudistirani et al., 2015).

The integration of digital literacy, financial calculation, branding strategy, and market orientation transformed composting activities into a structured greenpreneurship incubation process. The P4-E approach facilitated this transformation by sequencing technical mastery before economic engagement and reinforcing learning through reflective evaluation. Within this framework, environmental education evolved into economic agency, positioning the school as a micro-laboratory for sustainable enterprise development.

Integration of Science Learning and Entrepreneurial Education

One of the most significant outcomes of the intervention was the integration of scientific learning principles with entrepreneurial practice. Compost production served as a contextual medium for understanding ecological cycles, decomposition processes, and nutrient recycling. Simultaneously, product packaging and marketing fostered economic reasoning and financial literacy.

This dual integration supports the conceptualisation of schools as living laboratories. Within this framework, environmental education transcends textbook instruction and becomes embedded in productive activity. Students engage with authentic problems, including waste accumulation, resource management, and product distribution. Such experiential learning strengthens cognitive retention and fosters critical thinking (Azizan et al., 2026; Jain et al., 2024; Komara & Setiawan, 2020; Waseem et al., 2024)

The P4-E model operationalises this integration through sequential empowerment stages. Training establishes knowledge foundations. Practice ensures experiential internalisation. Marketing introduces economic orientation. Evaluation consolidates sustainability. This structured cycle reduces the risk of fragmented intervention and enhances long-term adoption.

Participatory Empowerment Dynamics

The participatory design of the programme significantly influenced its outcomes. Rather than positioning teachers and students as passive recipients, the intervention encouraged active decision-making and collaborative problem-solving. Participants contributed ideas regarding packaging design, pricing strategies, and waste collection scheduling.

This empowerment dynamic aligns with community-based development principles that prioritise ownership and collective responsibility. The emergence of initiative in forming an eco-school team demonstrates internal motivation rather than externally imposed compliance (Sutrisno et al., 2020; Yuniwati et al., 2012; Zulkarnain et al., 2024; Aini et al., 2020).

The participatory dimension also strengthened social cohesion. Collaboration between teachers and students reduced hierarchical barriers and promoted cooperative learning environments. Such relational strengthening constitutes an intangible yet critical outcome of empowerment programmes.

Contribution to Sustainable Development Goals

The programme contributes to SDG 4 by enhancing environmental literacy and integrating contextual science learning. SDG 8 is addressed through entrepreneurial skill development and micro-enterprise simulation. SDG 12 is operationalised through responsible waste management and resource recycling. SDG 13 is supported by reducing environmentally harmful waste disposal practices (Ardiyanti, 2019; Nur et al., 2016; Subali et al., 2025).

Unlike symbolic alignment with SDGs, the intervention translated sustainability objectives into actionable school practices. The institutionalisation of composting routines and digital marketing initiatives demonstrates practical implementation rather than rhetorical commitment.

Challenges and Model Refinement

Despite positive outcomes, several challenges emerged. Variations in participants' comprehension levels required adaptive mentoring strategies. Limited time for follow-up

supervision constrained deeper economic evaluation. Infrastructure disparities among schools may affect replicability (Nugroho et al., 2020; Nurjuwita et al., 2020; Rosmala et al., 2020; Taufik & Maulana, 2015).

These limitations indicate areas for model refinement. Future implementation should incorporate extended mentoring periods, structured monitoring instruments, and comparative cross-school application. Strengthening evaluation metrics will enhance empirical robustness.

Implications of the P4-E Model

The findings suggest that the P4-E approach functions as an integrative empowerment framework capable of linking environmental education, scientific practice, and entrepreneurial development. Its cyclical structure supports knowledge acquisition, experiential application, economic translation, and sustainability assessment (Mardiyono et al., 2024; Qa et al., 2015; Subali et al., 2024).

This model extends beyond composting as a technical intervention. It proposes a structured pathway for transforming ecological awareness into productive green entrepreneurship. As such, the P4-E approach contributes to the literature on participatory environmental education and school-based innovation models.

Sustainability and Replicability Potential

The establishment of internal eco-school governance structures enhances sustainability. The ability to produce marketable compost products creates economic incentives for continuity. Digital promotion platforms expand outreach potential (Kamaruddin & Laining, 2020; Purnamawati et al., 2021; Sunarya et al., 2020).

The model demonstrates replicability potential in schools with similar environmental challenges. With contextual adaptation, the P4-E framework may serve as a scalable strategy for integrating waste management and entrepreneurship education across educational institutions.

CONCLUSION

The implementation of school-based organic waste management through EM-4 biofermentation demonstrated that technical composting skills, ecological awareness, and entrepreneurial capacity can be developed simultaneously within a structured empowerment framework. The P4-E approach (Training, Practice Implementation, Marketing, and Evaluation) functioned as an integrative participatory model that systematically linked scientific understanding, experiential environmental practice, and market-oriented competence. The findings indicate that waste management activities can operate as contextual learning platforms that generate ecological responsibility, strengthen collaborative school governance, and stimulate greenpreneurship among teachers and students. A key strength of the programme lies in the integration of technical biofermentation processes with digital marketing and cost-calculation skills, enabling environmental initiatives to acquire economic relevance and sustainability potential. However, the absence of longitudinal economic measurement and extended mentoring limits the assessment of long-term entrepreneurial impact. For broader scalability, continuous supervision, structured impact evaluation instruments, and cross-school replication are recommended. Future community service and research initiatives should focus on developing derivative biofermentation-based products, strengthening financial performance assessment models, and embedding greenpreneurship within formal curriculum structures aligned with the Sustainable Development Goals (SDGs), thereby institutionalising environmentally responsible and economically productive practices within the education sector.

ACKNOWLEDGMENTS

The authors gratefully acknowledge the Institute for Research and Community Service (LPPM), Universitas Negeri Semarang (UNNES), for financial support through the 2025 DPA UNNES Lecturer Community Service Scheme under Contract Number DPA 139.032.693449/2025.01 and the Agreement on the Assignment of Community Service Implementation (DPA LPPM UNNES 2025), Number 523.14.3/UN37/PPK.11/2025, dated 14 March 2025. Appreciation is also extended to the Science Teachers' Working Group (MGMP IPA) of Tegal Regency, SMP Negeri 1 Slawi, and all participating teachers and students for their collaboration and commitment during the implementation of this programme.

REFERENCE

Aini, D. N., Arisanti, D. W., Fitri, H. M., & Safitri, L. R. (2020). Pemanfaatan minyak jelantah untuk bahan baku produk lilin ramah lingkungan dan menambah penghasilan rumah tangga di Kota Batu. *Warta Pengabdian*, *14*(4), 253–262.

Ardiyanti, D. A. (2019). Pengaruh minat dan motivasi usaha terhadap keberhasilan usaha wirausaha muda di Kota Langsa. *Jurnal Samudra Ekonomi dan Bisnis*, *10*(2), 168–178.

Armayanti, A. K., Jamilah, J., Kurniawan, M. E., & Danial, D. (2021). *Broiler performance with the utilization of various levels of fermented peanut shells meal*. *788*(1). Scopus. https://doi.org/10.1088/1755-1315/788/1/012068

Azizan, M. H., Zulkeflli, A. E., Othman, S., Lin, C. K., & Nifa, F. A. A. (2026). Greenpreneurship and Sustainable Tourism: Women's Entrepreneurial Strategies in Langkawi's Environment. In R. El Khoury (Ed.), *Strategic Decision-Making in Dynamic Business Environments* (Vol. 642, pp. 927–937). Springer Nature Switzerland. https://doi.org/10.1007/978-3-032-07220-7_81

Danapriatna, N., Lutfiadi, R., & Dede, M. (2023). Effect of Straw Compost (Oryza sativa L.) on Crop Production. *Pertanika Journal of Tropical Agricultural Science*, *46*(3), 1047–1062. Scopus. https://doi.org/10.47836/pjtas.46.3.17

Hastuti, B., Astuti, R. K., & Hadi, S. (2022). Effect of Fermentation Time and Sugar Concentration on the Quality Characteristic of Organic Fertilizer from Cattle and Rabbit Manure Using Vinnase Media. *Moroccan Journal of Chemistry*, *10*(3), 387–395. Scopus. https://doi.org/10.48317/IMIST.PRSM/morjchem-v10i3.32666

Jain, P., Aruna, P., & Purswani, G. (2024). Greenpreneurship Pioneering Solutions for Climate Change: An Indian Perspective. In R. A. Castanho (Ed.), *Advances in Business Strategy and Competitive Advantage* (pp. 237–254). IGI Global. https://doi.org/10.4018/979-8-3693-1297-1.ch014

Kamaruddin, K., & Laining, A. (2020). *Utilization of a commercial probiotic, effective microorganisms, in diet fermentation for rabbitfish grow-out*. *564*(1). Scopus. https://doi.org/10.1088/1755-1315/564/1/012051

Komara, B. D., & Setiawan, H. C. B. (2020). Inkubator bisnis sebagai pendorong tumbuhnya wirausaha muda: Studi tentang suksesi kewirausahaan mahasiswa Universitas Muhammadiyah Gresik. *Jurnal Pengabdian Kepada Masyarakat*, *3*(1), 33–39.

Mardiyono, M. S., Nugroho, J. D., & Massora, M. (2024). The Effectiveness of Bio-enzymes Made from Fruit Waste and Mixture of Fruit Waste and Chicken Intestinal Content as Composting Activators. *Jurnal Pengelolaan Sumberdaya Alam Dan Lingkungan*, *14*(2), 288–297. Scopus. https://doi.org/10.29244/jpsl.14.2.288

Matin, H. H. A., Damarjati, B. Y., Shidqi, M. I. G., & Budiyono, B. (2022). *Biogas Production from Waste Potato Skin and Cow Dung by Anaerobic Co-digestion: Study of C/N Ratio, EM-4 Bacteria and pH*. *42*(14), 1714–1719.

Matin, H. H. A., Damarjati, B. Y., Shidqi, M. I. G., Budiyono, B., Othman, N. H., & Wahyono, Y. (2024). Biogas Production From The Potato Peel Waste: Study Of The Effect Of C/N Ratio, Em-4 Bacteria Addition And Initial Ph. *Revista de Gestao Social e Ambiental*, *18*(6). Scopus. https://doi.org/10.24857/rgsa.v18n6-039

Nugroho, A. S., Susatya Dewi, E. R., & Dzakiy, M. A. (2020). *The Effect of Decomposer Microorganism Additions on the Natural Hydroponic Technology (Nht) Systems of Pakchoy Growth*. *835*(1). https://doi.org/10.1088/1757-899X/835/1/012046

Nur, T., Noor, A. R., & Elma, M. (2016). Pembuatan pupuk organik cair dari sampah organik rumah tangga dengan bioaktivator EM-4 (Effective Microorganism. *Jurnal Konversi*, *5*(2), 44–51.

Nurjuwita, W., Sasongko, A., Hartanto, T. J., & Purwanto, M. (2020). *Potential and characterization biogas from tofu liquid waste with addition cow dung and effective microorganisms 4 as biocatalyst*. *46*, 1908–1912. Scopus. https://doi.org/10.1016/j.matpr.2021.02.025

Purnamawati, S. A., Maro, R. H., Sunaryo, S., Jihadi, M., & Lestari, E. (2021). Wirausaha muda mandiri sebagai penggerak ekonomi bangsa. *Jurnal Dedikasi Hukum: Jurnal Pengabdian Hukum Kepada Masyarakat*, *1*(3), 295–312.

Qa, I. N., Murni, S., & Agustiningsih, S. W. (2015). The Empowerment of Waste Utilization Industry Based on Greenpreneurship. *Global Business Finance Review*, *20*(2), 59–65. https://doi.org/10.17549/gbfr.2015.20.2.59

Rosmala, A., Mirantika, D., & Rabbani, W. (2020). Takakura sebagai solusi penanganan sampah organik rumah tangga. *Abdimas Galuh*, *2*(2),

165–174.

Subali, B., Ellianawati, E., & Raharjo, T. (2025). *Pengembangan jiwa entrepreneur siswa dan guru IPA di Kabupaten Tegal melalui pemanfaatan sampah organik lingkungan sekolah sebagai bahan pembuatan kompos [Laporan akhir PPM DIPA UNNES*. Universitas Negeri Semarang.

Subali, B., Ellianawati, E., Yulianti, I., Listiyanto, L., Raharjo, T. J., Setyaningsih, N. E., & Budhi, S. (2024). Upaya mengolah sampah organik sekolah sebagai media tanam dengan memanfaatkan biofermentasi EM-4 untuk mengurangi pencemaran udara. *UNNES Physics Journal*, *13*(2), 176–179.

Sumardiono, S., Matin, H. H. A., Ivan Hartono, I., Choiruly, L., & Budiyono, B. (2022). *Biogas production from corn stalk as agricultural waste containing high cellulose material by anaerobic process*. *63*, S477–S483. Scopus. https://doi.org/10.1016/j.matpr.2022.04.135

Sunarya, D. S., Nisyawati, u., & Wardhana, W. (2020). *Utilization of baglog waste as bokashi fertilizer with local microorganisms (MOL) activator*. *524*(1). Scopus. https://doi.org/10.1088/1755-1315/524/1/012013

Suratno, S., Umamah, N., Hasan, F., Himmah, I. F., & Karwendyanto, K. C. (2020). *Educating Society about Biotechnology and Its Impact to the Environment: An Analysis to Practical Experience at the Group of Farmer at Sukorambi Vilage, Distric of Sukorambi, Regency of Jember, East Java, Indonesia*. *485*(1). Scopus. https://doi.org/10.1088/1755-1315/485/1/012049

Sutrisno, E., Zaman, B., Wardhana, I. W., Simbolon, L., & Emeline, R. (2020). *Is Bio-activator from Vegetables Waste are Applicable in Composting System?* *448*(1). Scopus. https://doi.org/10.1088/1755-1315/448/1/012033

Taufik, A., & Maulana, M. F. (2015). Sosialisasi sampah organik dan non organik serta pelatihan kreasi sampah. *Jurnal Inovasi dan Kewirausahaan*, *4*(1), 68–73.

Wardoyo, D. U. (2016). Analisis perhitungan harga pokok produksi dan penentuan harga jual atas produk (studi kasus pada PT Dasa Windu Agung. *Jurnal Riset Manajemen dan Bisnis*, *1*(2), 183–190.

Waseem, A., Ali, S., Farid Khan, Q. F., Khalid, S. W., Shah, T. A., Salamatullah, A. M., & Bourhia, M. (2024). Exploring chitosan-immobilized Rhizopus oligosporus lipase for olive-mill wastewater treatment. *International Journal of Environmental Science and Technology*, *21*(14), 9097–9110. Scopus. https://doi.org/10.1007/s13762-024-05808-0

Yudistirani, S. A., Syaufina, L., & Mulatsih, S. (2015). Desain sistem pengelolaan sampah melalui pemilahan sampah organik dan anorganik berdasarkan persepsi ibu rumah tangga. *Jurnal Inovasi dan Kewirausahaan*, *4*(2), 29–42.

Yuniwati, M., Iskarima, F., & Padulema, A. (2012). Optimasi kondisi proses pembuatan kompos dari sampah organik dengan cara fermentasi menggunakan EM-4. *Jurnal Teknologi*, *5*(2), 1.

Zulkarnain, D., Munadi, L. O. M., Sandiah, N., & Astarika, R. (2024). Optimizing fermented corn straw for increasing Peranakan etawa goat livestock production. In *Technological Innovations in Tropical Livestock Development for Environmental Sustainability and Food Security* (pp. 155–162). CRC Press. Scopus. https://doi.org/10.1201/9781003468943-25