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Interfaith Collaboration in Waste Management through Black Soldier Fly Cultivation in Tulungagung

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Abstract

This study explores a community-based approach to organic waste management using Black Soldier Fly (BSF) cultivation in Tulungagung. Conducted within a Community Engagement Program, the project involved interfaith communities using a participatory method that combined training, practice, and sustainability assessment. Participants engaged in hands-on BSF cultivation and waste sorting activities, which improved their understanding and practices in organic waste management. Quantitative and qualitative evaluations revealed enhanced awareness, skills, and behavioral change among participants. The initiative also fostered stronger interreligious social networks, contributing to a more inclusive and sustainable local environment. This study highlights the potential of integrating technology, religion, and community participation in a replicable waste management model. Future initiatives are encouraged to explore economic incentives and technological improvements to further enhance BSF effectiveness.

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Introduction

The issue of waste management has become a global concern in line with population growth, urbanization, and high consumerism. Ineffective waste management systems have led to waste accumulation that negatively impacts both the environment and public health. According to the United Nations Environment Programme (UNEP), the world generates more than 2 billion tons of waste annually, most of which is not properly managed. In Indonesia, approximately 70% of total waste ends up in landfills, causing soil, water, and air pollution. This

situation highlights the need for more innovative and participatory approaches to waste management to mitigate environmental harm and improve sustainability.

One increasingly recognized approach is community-based waste management, which emphasizes active public participation in sorting, recycling, and processing waste. Studies have shown that community-based models enhance environmental awareness and reduce the volume of waste ending up in landfills(Kurniawan et al., 2021). For instance, in Sukunan, Yogyakarta, the community has adopted a circular economy model by separating waste at its source and composting organic matter, contributing to a zero-waste initiative. In Jatiluwih, Bali, waste management involves local community engagement in short-, medium-, and long-term planning, demonstrating the critical role of community participation in achieving sustainable waste management (Winaya, 2020).

Despite various efforts to improve waste management, the primary challenge remains low public participation in existing programs. In many areas, littering remains a common practice, and current programs often fail to operate optimally due to limited resources and lack of coordination among stakeholders. This issue is further complicated by social and cultural factors that influence environmental awareness (Susilowati et al., 2023). Therefore, a more holistic approach is needed—one that incorporates not only technical waste management strategies but also social and cultural dimensions to effectively transform public behavior.

One innovative solution is the cultivation of Black Soldier Flies (BSF). These larvae are highly efficient in decomposing organic waste and converting it into high-quality protein sources and organic fertilizers beneficial for agriculture (Filho et al., 2023). Studies show that BSF can reduce organic waste volume by up to 70%, making it a sustainable alternative for waste processing (Kurniawan et al., 2021). However, implementing BSF cultivation at the community level faces challenges such as limited infrastructure, insufficient education, and low public acceptance of this innovation (Leslie et al., 2021). The success of BSF-based waste management therefore relies heavily on active community participation and support from both government and academic institutions (Susilowati et al., 2023).

In addition to technical approaches, the integration of religious values into environmental programs is gaining attention. Interfaith approaches in social

action have proven effective in increasing public involvement in environmental initiatives (Gutberlet, 2021). Religious teachings often emphasize ecological stewardship as a human responsibility. For example, Islam advocates the concept of *khalifah*, or stewardship of the Earth, while Christianity and Hinduism also promote conservation values and moral responsibility for the environment (Duan et al., 2018; Vannucchi et al., 2023). Community engagement programs have indicated that applying religious values to environmental initiatives can enhance public awareness and participation in pro-environmental actions (Schmidt et al., 2022).

Although previous studies have demonstrated the effectiveness of community-based waste management and interfaith collaboration, there is still a gap in integrating both approaches with innovative technologies such as BSF cultivation. Prior community service studies have mostly focused either on community-based waste management or on BSF independently, without considering broader social synergies (Lohman et al., 2020). Therefore, further engagement is needed to combine community-based approaches, sustainable technology, and religious values to create a more effective and widely adoptable waste management model.

This study aims to analyze the synergy among interfaith communities, academic institutions, and BSF cultivation practices in managing organic waste in Tulungagung. The Community Engagement Program evaluates the effectiveness of community-based training in improving public awareness and skills in waste management. Additionally, it seeks to identify the factors influencing the program's success and the challenges encountered during implementation. The outcomes are expected to provide new insights into how community-based and religiously driven approaches can contribute to environmental sustainability through innovative waste management technologies. The findings of this study may also serve as a reference for policymakers and environmental practitioners in designing more sustainable and impactful community-based waste management programs.

Methods

Community-based approaches to waste management have been shown to be effective in enhancing public awareness and influencing behavioral change. This study adopted a participatory method involving interfaith communities in

training sessions focused on waste management through Black Soldier Fly (BSF) cultivation. The approach was designed to build community understanding and technical skills, while also strengthening collaboration among diverse societal groups to establish sustainable solutions for organic waste management.

The methodology employed experiential learning, where participants were directly involved in waste sorting, recycling, and BSF cultivation. Community engagement literature has shown that interactive methods are more effective in promoting awareness and behavioral change than conventional ones (Kurniawan et al., 2021). To reinforce learning outcomes, visual aids and interactive educational materials were utilized to deepen participants' understanding of proper waste management practices (Davids et al., 2022).

A participatory approach was used to foster a sense of ownership and responsibility within the community. Active community involvement in planning, implementation, and program evaluation allowed for the identification of local needs and challenges in waste management (Browne et al., 2023). Research has demonstrated that participatory decision-making processes enhance the success of environmental management programs, as evidenced by a study conducted in Durban, South Africa (Davids et al., 2022).

A mixed-methods approach was applied to evaluate the program's impact, combining both quantitative and qualitative data. Quantitative data were collected through pre- and post-program surveys to assess changes in participants' waste management behaviors. Meanwhile, qualitative data were gathered through in-depth interviews and focus group discussions to explore participants' perceptions and experiences throughout the training (Kim & Kim, 2022). This comprehensive evaluation allowed for a deeper analysis of the social, environmental, and economic impacts of the program (Al-Musawi, 2023).

The program was conducted at the Indonesian Christian Church (GKI) in Tulungagung, a central hub for interfaith activities in the region. The location was selected due to the active participation of diverse religious communities in social and environmental initiatives. A total of 76 participants from different religious backgrounds—including Islam, Christianity, Hinduism, and Buddhism—took part in the program. Participants were selected on a voluntary basis, considering their commitment to improving waste management in their respective communities. Previous studies indicate that interfaith approaches to social action

enhance community engagement and foster stronger social cohesion in addressing environmental issues (Gutberlet, 2021).

The implementation of the program consisted of three main phases: preparation, execution, and evaluation. During the preparation phase, the team conducted needs assessments through community surveys and interviews with religious leaders to understand the local challenges and opportunities in waste management. A team was formed comprising academics, environmental activists, and religious leaders to manage the technical and non-technical aspects of the program. Training materials were developed based on local case studies, theories of waste management, recycling techniques, and BSF cultivation methods. Facilities and equipment were prepared, including BSF containers, organic waste, and educational media. Public engagement was encouraged through the dissemination of information via social media, places of worship, and community discussions.

The implementation phase involved a two-day training that combined theoretical and practical elements. On the first day, participants were introduced to the environmental impacts of waste and the advantages of community-based waste management. They also participated in waste sorting and recycling demonstrations, including how to create valuable products from inorganic waste. An interfaith dialogue was held to explore the role of religious values in environmental conservation. On the second day, participants learned about BSF cultivation as a solution for organic waste. They engaged in hands-on activities involving container preparation, feeding, and harvesting. The day concluded with a preliminary evaluation of participants' understanding and their plans for implementing the method within their communities.

In the evaluation phase, the effectiveness of the training and its impact on behavioral change were assessed through direct observation of participant engagement and enthusiasm. Pre- and post-training questionnaires were used to measure comprehension levels, while focus group discussions provided insight into the participants' experiences, challenges, and opportunities for applying their new knowledge. Follow-up mentoring was provided to those committed to independently continuing the program.

The collected data were analyzed using both qualitative and quantitative descriptive methods. Quantitative survey data were examined through

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descriptive statistics to identify changes in participants' knowledge and behavior. Qualitative data from interviews and FGDs were analyzed using thematic analysis to identify patterns in participants' perceptions and the challenges they encountered (Al-Musawi, 2023).

With its structured and community-driven methodology, this program is expected to enhance public awareness and skills in waste management and promote interfaith collaboration in environmental conservation.

Results and Discussion

Participation and Engagement of Participants

Active community participation is a key indicator of success in community-based waste management programs. In this study, the involvement of participants from various religious backgrounds in training programs demonstrated the effectiveness of interfaith approaches in enhancing environmental awareness and social concern. A total of 76 participants from different faith communities engaged in the program with high levels of enthusiasm for implementing sustainable waste management practices. Previous research suggests that interfaith approaches in social action increase community participation by creating inclusive spaces for dialogue and facilitating interreligious collaboration (Davids et al., 2022; Gutberlet, 2021).

Several factors influence the level of public participation in community-based programs. One primary factor is the individual's level of education and environmental awareness. Studies show that individuals with greater understanding of environmental issues are more likely to actively engage in waste management programs (Filho et al., 2023; Susilowati et al., 2023). In addition, support from community leaders and local organizations plays a significant role. When community leaders exhibit commitment to a program, it tends to motivate broader public involvement (Al-Musawi, 2023; Leslie et al., 2021). This program incorporated such a strategy by involving religious leaders from multiple communities to encourage participation.

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Figure 1. Introduction to the Environmental Impacts of Waste and the Benefits of Community-Based Waste Management

Besides leadership support, program accessibility also contributes to public engagement. Research has shown that programs offering incentives—such as awards for active participants—can significantly boost involvement (Lohman et al., 2020; Thakur & Sharma, 2020). In this initiative, symbolic rewards were given to participants who effectively implemented waste management practices in their communities, helping to sustain long-term engagement.

Participant involvement in the training extended beyond theoretical sessions to include practical waste management activities. The community-based training emphasized experiential learning, allowing participants to directly engage in waste sorting, recycling, and BSF cultivation (Kurniawan et al., 2021). Studies indicate that experiential learning is more effective in enhancing skills and understanding compared to theory-only methods (Davids et al., 2022). Accordingly, this training was designed with an interactive approach, enabling participants to acquire applicable skills for daily life.

To further strengthen engagement, the program considered the local context and community-specific needs. Trainings that address issues directly relevant to participants, such as local waste problems, tend to be more impactful and beneficial (Filho et al., 2023). Involving community leaders in the training process also enhanced the program's credibility and attracted more participants (Hosseinian et al., 2021). Hence, this approach was implemented by involving religious leaders and environmental activists as facilitators.

Program evaluations revealed that participant engagement led to positive behavioral changes in waste management. A mixed-methods approach was used

to assess program effectiveness, integrating both quantitative and qualitative data. Quantitative surveys measured behavioral changes before and after participation, while qualitative data from in-depth interviews and focus group discussions captured participants' experiences during training (Al-Musawi, 2023; Kim & Kim, 2022). Previous community engagement studies have found that combining quantitative and qualitative evaluations offers deep insights into program outcomes and behavioral transformation (Senekane et al., 2022).

Findings from this program align with results from a community engagement initiative in Durban, South Africa, which showed that active public involvement in community-based waste management led to environmentally positive behaviors such as increased recycling and reduced waste (Davids et al., 2022). By employing a comprehensive evaluation approach, this community engagement program successfully provided broader insight into the effectiveness of interfaith strategies in promoting community participation in waste management initiatives.

Improvement in Understanding and Skills

The effectiveness of the training in enhancing participants' understanding and skills in waste management was evaluated through changes in knowledge, attitudes, and practical capabilities in applying the concepts taught. Evaluation results showed a significant increase in participants' comprehension of sustainable waste management principles, including waste segregation, recycling, and composting. Previous research indicates that systematically designed training can significantly boost environmental literacy in communities (Kurniawan et al., 2021).

The evaluation method combined quantitative and qualitative approaches to assess the observed changes. Quantitative data were collected via pre- and post-training surveys to measure participants' understanding of waste management. Findings indicated marked improvement in participants' grasp of fundamental waste management concepts and their ability to identify waste types and suitable handling methods. A comparable study in Durban, South Africa, also demonstrated that participation in community-based waste management programs resulted in positive shifts in environmental attitudes and behaviors (Davids et al., 2022).

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In addition to the surveys, qualitative data were gathered through in-depth interviews and focus group discussions with participants. This approach provided deeper insight into how the training shaped participants' perceptions of waste management and environmental responsibility. Many participants noted that the training not only delivered information but also inspired them to adopt new waste management practices at home and within their communities. These findings are consistent with prior research suggesting that experiential learning has a stronger impact than purely theoretical instruction (Filho et al., 2023).

The training emphasized a practice-based learning approach, where participants not only received theoretical instruction but also engaged in hands-on waste management activities, including composting organic waste and simple recycling techniques. Educational models that integrate theory with practice have proven more effective in enhancing understanding and skills (Kurniawan et al., 2021). Other studies affirm that participants involved in practical activities are more likely to apply the knowledge gained in their daily lives compared to those receiving only theoretical input (Senekane et al., 2022).

Figure 2. *Black Soldier Fly*, BSF

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Beyond theoretical comprehension, the training also equipped participants with technical skills for effective waste management. Participants who previously lacked experience in waste sorting and processing were able to apply these techniques in their daily routines. One of the program's success factors was the live demonstrations by facilitators, which presented concrete examples of how to implement waste management techniques in diverse situations. Practice-based approaches have been shown to be more effective in fostering environmental behavior change (Filho et al., 2023).

The learning strategy was developed with sensitivity to local conditions and participants' specific needs. Involving the community in curriculum development ensured relevance to the issues and challenges they face. Prior community engagement programs found that trainings incorporating local figures are more effective in promoting participation and adherence to sustainable waste management practices (Lohman et al., 2020). Accordingly, this method was adopted to ensure training materials were acceptable and applicable within local contexts.

Evaluation results also indicated that changes in participants' attitudes toward waste management occurred following the training. Prior to training, most participants had limited awareness of the importance of proper waste management and its environmental impact. However, after participating, they showed increased awareness and a stronger commitment to adopting sustainability principles in their daily lives. Studies support that behavior and attitude changes related to environmental responsibility can be significantly influenced through experiential education programs (Al-Musawi, 2023).

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Figure 3. The training participants demonstrated a commitment to implementing community-based waste management

Effectiveness of Black Soldier Fly Cultivation

Black Soldier Fly (BSF) cultivation is increasingly gaining attention as an innovative solution for organic waste management. BSF larvae can rapidly and efficiently break down organic waste, generating nutrient-rich biomass that can be used as animal feed and organic fertilizer (Filho et al., 2023). Studies have demonstrated that BSF cultivation can reduce organic waste volume by more than 50%, positioning it as an effective method for addressing waste problems at the community level (Kurniawan et al., 2021).

Findings from this community engagement initiative indicate that BSF cultivation implemented by interfaith communities in Tulungagung had a significant impact on reducing organic waste. Measurements taken during the training and implementation phases showed that communities actively practicing BSF cultivation managed to reduce their organic waste by up to 65% within the first three months. These results are consistent with previous studies showing that BSF cultivation can be integrated into sustainable community waste management strategies (Kurniawan et al., 2021).

Beyond environmental benefits, BSF cultivation offers economic potential for local communities. The larvae produced can be sold as alternative feed for poultry and fish, reducing reliance on expensive conventional feed. In this program, several active participants successfully marketed dried BSF larvae and organic fertilizer, earning promising income. This demonstrates that BSF cultivation not only addresses waste management but also opens up economic opportunities, particularly in rural areas with limited access to economic resources (Senekane et al., 2022).

However, there were challenges in the community-based implementation of BSF cultivation. A major issue was the lack of technical understanding and skills needed to manage the BSF life cycle efficiently. Some participants struggled to regulate humidity and temperature in BSF containers, affecting the conversion rate

of waste into biomass. Research shows that successful BSF cultivation depends heavily on optimal environmental conditions and adequate technical knowledge (Das et al., 2020). Continued support and follow-up training are essential to ensure the long-term sustainability of BSF practices.

The adoption rate of BSF cultivation technology varied between rural and urban communities. Rural areas showed greater receptiveness due to easier access to organic household and agricultural waste. In contrast, urban participants initially showed reluctance, primarily due to space constraints and limited awareness of BSF's potential (Lohman et al., 2020). Nevertheless, interest among urban participants gradually increased following further education and engagement efforts.

Program evaluation revealed that active community participation in BSF cultivation is influenced by several factors, including community leader support, economic incentives, and access to ongoing training. Previous studies suggest that areas receiving training and equipment support from local governments or non-governmental organizations have higher success rates in BSF adoption (Susilowati et al., 2023). In this context, the Tulungagung program highlighted the critical role of stakeholder involvement in ensuring the sustainability of community-based BSF cultivation.

Challenges in Program Implementation

The implementation of community-based waste management and Black Soldier Fly (BSF) cultivation programs faces a variety of challenges across social, economic, and policy dimensions. Identifying and analyzing these barriers is essential to formulating effective solutions that can enhance program outcomes. Previous research has highlighted that obstacles in community waste management often include low environmental awareness, inadequate infrastructure, and insufficient policy support (Thakur & Sharma, 2020).

One major challenge encountered in this program was the low level of public awareness regarding the importance of sustainable waste management. Limited environmental consciousness often leads to minimal participation in recycling and organic waste processing programs. Community engagement studies suggest that education and outreach rooted in the community context are critical for overcoming such barriers (Kurniawan et al., 2021). Therefore, more

effective communication strategies are needed to increase public understanding of the benefits of community-based waste management.

Infrastructure limitations also posed significant hurdles to the program's success. These included a lack of waste processing facilities, insufficient waste sorting stations, and limited access to BSF cultivation tools. Research shows that inadequate infrastructure can hinder the effectiveness of community-based waste management systems and reduce public participation in recycling programs (Filho et al., 2023).

Policy support for such initiatives remains limited. In many developing countries, policies that promote circular economy models and recycling programs are still underdeveloped, resulting in a lack of governmental support for community-based initiatives (Lohman et al., 2020). Progressive policies—such as economic incentives for households participating in waste segregation and subsidies for communities engaging in BSF cultivation—could help address these barriers (Susilowati et al., 2023).

Some countries have implemented policy solutions to improve community waste management. Multi-stakeholder approaches involving local governments, non-governmental organizations, and communities have proven effective in strengthening waste management initiatives (Filho et al., 2023). For instance, offering financial incentives to households actively involved in recycling can significantly increase participation rates (Kurniawan et al., 2021).

Other challenges specific to BSF cultivation include social and economic acceptance. As a relatively new practice, BSF cultivation is not yet widely accepted, and cultural norms and habits can affect its community adoption (Thakur & Sharma, 2020). Additionally, access to markets for BSF-derived products such as animal feed and organic fertilizer remains limited, posing a barrier to the economic sustainability of the initiative (Filho et al., 2023).

Policy support in the form of subsidies for BSF cultivation tools and materials can ease the initial cost burden for communities adopting this technology (Kurniawan et al., 2021). Furthermore, training and education involving community and religious leaders can accelerate the acceptance and adoption of BSF cultivation (Susilowati et al., 2023).

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Technological and innovative applications in community-based waste management also offer potential solutions to existing challenges. Internet of Things (IoT) technologies can be used to monitor and manage waste collection and processing more efficiently (Hosseinian et al., 2021). Real-time data systems provide accurate information on waste generation and handling, thus improving operational efficiency and public participation (Senekane et al., 2022).

Innovations in facility design can also enhance community involvement. Research shows that user-friendly waste collection sites and improved waste sorting systems increase the effectiveness of recycling and community waste management programs (Lohman et al., 2020). Additionally, mobile applications that provide education and information on waste management can help raise public awareness and boost participation in community-based waste initiatives (Davids et al., 2022).

Innovative Strategies in Community-Based Waste Management: Education, Practice, and Sustainability

Community-based waste management approaches have proven more effective than individual approaches by involving the active participation of residents at every stage of the waste handling process. By engaging the public in waste separation, recycling, and composting activities, this approach fosters a sense of ownership and collective responsibility for the environment (Kurniawan et al., 2021). A case in Sukunan, Yogyakarta, shows that communities involved in waste management are more likely to comply with agreed-upon practices, thereby reducing the amount of waste ending up in landfills (Kurniawan et al., 2021). Moreover, this model enables the exchange of information and experiences among community members, enhancing their skills and understanding of more effective waste management methods.

The impact of community-based waste management on public behavior and consumption patterns is also significant. Programs involving community members in waste initiatives have been shown to raise awareness of sustainable practices, leading to changes in consumption habits. Community engagement efforts reveal that participants in waste programs tend to reduce single-use plastics and opt for recyclable products (Senekane et al., 2022). Furthermore, such individuals become more aware of the environmental consequences of their

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consumption choices and are more motivated to adopt sustainable lifestyles (Senekane et al., 2022).

The sustainability of community-based waste management programs can be evaluated using various indicators, including reductions in waste volume, increases in recycling rates, and heightened public awareness of environmental issues. Studies indicate that these programs can significantly reduce the volume of waste sent to landfills (Kurniawan et al., 2021). Other indicators include the quantity of recycled waste and the decline in the use of disposable materials within the community (Winaya, 2020). These indicators can be tracked through surveys and waste management data collected before and after program implementation.

A key element of sustainable waste management is collaboration among government, academia, and community stakeholders. Such collaboration enables synergistic benefits, wherein government bodies provide policy and infrastructure support, academics contribute through research and community service, and communities act as agents of change by adopting best practices in daily life (Susilowati et al., 2023). For example, Kurniawan et al.'s community engagement study showed that community-based approaches supported by government policy increased public participation and program effectiveness (Davids et al., 2022). Strong governmental support in the form of regulations and funding helps ensure the sustainability of these programs.

Moreover, collaboration between academics and communities creates platforms for knowledge sharing that empower residents with access to information on best waste management practices. Through training and outreach by academics, communities gain a deeper understanding of sustainability and effective waste handling methods (Davids et al., 2021). Evidence from community engagement projects shows that training programs led by academics and grounded in local contexts improve public awareness and skills in waste management, ultimately encouraging environmentally responsible behavior.

In addition to participation and policy support challenges, the sustainability of community-based waste programs also depends on innovation and technological adoption. Technology enhances waste management efficiency—for instance, the use of Internet of Things (IoT) sensors to monitor real-time waste volumes and optimize waste collection systems (Hosseinian et al., 2021). Digital

applications providing education and waste management information also increase public awareness and engagement (Senekane et al., 2022).

Besides technology, economic incentive policies can play a vital role in improving the effectiveness of community-based waste programs. Some countries have implemented incentive schemes for households participating in recycling, such as reduced waste service fees or direct financial rewards for proper waste sorting (Susilowati et al., 2023). Circular economy models adopted in various countries demonstrate that when communities see economic value in waste management, they are more likely to participate in sustainability initiatives (Filho et al., 2023).

Conclusion

This community engagement program successfully enhanced public awareness and skills in community-based waste management through the implementation of Black Soldier Fly (BSF) cultivation as a core solution. The findings demonstrate that active community involvement in training and hands-on practices positively influenced participants' understanding and behavioral change related to organic waste management. Through this approach, communities became more self-reliant in reducing organic waste and converting it into valuable resources such as animal feed and organic fertilizer.

Beyond environmental benefits, the program also had significant social impacts, particularly in fostering solidarity and interfaith collaboration. The involvement of diverse religious groups in achieving shared environmental goals illustrated that waste management initiatives can serve as effective platforms for strengthening social interaction and building inclusive, environmentally conscious communities. These findings also emphasize the role of religious values in motivating environmental stewardship.

From an academic perspective, this community engagement initiative contributes to the discourse on community-based waste management by integrating social ecology approaches with sustainable technology. The study offers a reference point for academics, policymakers, and communities to develop more effective and inclusive waste management strategies. Additionally, the program's success underscores that experiential environmental education is more impactful than purely theoretical methods.

Nevertheless, several challenges remain in the program's implementation, including limited resources, lack of waste processing facilities, and persistent behavioral resistance within some segments of the community. To address these issues, continuous efforts are needed through follow-up training, policy reinforcement, and further exploration of economic incentives that can enhance public participation in waste management.

Future community engagement initiatives should focus on optimizing BSF systems with technological support, developing circular economy models for community-based waste management, and conducting policy analyses to strengthen the long-term sustainability of such programs in various regions. Ultimately, community-based waste management programs like this can serve as scalable models for broader adoption at national and international levels to achieve cleaner and more sustainable environments.

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