

Community Empowerment through Incinerator Technology for Sustainable Waste Management in Kedunglurah Village, Indonesia

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Abstract

Waste management remains a challenge in rural communities, particularly in handling dry, non-recyclable residual waste. This community engagement program aimed to support waste management through education and the use of appropriate incinerator technology in Kedunglurah Village, Trenggalek, East Java, Indonesia. A participatory community empowerment approach based on Asset-Based Community Development (ABCD) involved 50 households, the village government, and the community engagement team. Activities comprised four stages: community consultation and asset identification, waste-management education, incinerator fabrication and assembly, and demonstration and application. Discussions, question-and-answer sessions, waste classification and segregation practices, and training addressed residual-waste selection, incinerator operation, and ash handling. The program produced a 10-kg-per-batch incinerator constructed from lightweight concrete blocks, mortar, cement, and sand, equipped with an 8-mm iron grate, a ventilation opening, a loading door, and a chimney. The technology was intended for selected dry, non-recyclable residual waste and required proper segregation, safe operation, responsible ash handling, and regular maintenance. Participants demonstrated active engagement, and the incinerator was successfully produced and introduced. However, no quantitative measurements of knowledge change, waste-volume reduction, long-term behavioral change, or continuous performance were conducted. Monitoring is required to assess long-term effectiveness and sustainability.

Keywords

appropriate technology; asset-based community development; incinerator; residual waste; rural waste management.



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1. INTRODUCTION

Waste management is a major environmental challenge requiring systematic, participatory, and sustainable solutions, particularly at the community and village levels. Population growth, increasing household activities, and changing consumption patterns continue to increase solid waste generation (Voukkali et al., 2024), while local management capacity and treatment facilities are not always sufficient to accommodate the growing volume of waste (Alshaikh & Abdelfatah, 2024; Awino & Apitz, 2024; Budiyarto et al., 2025). Inadequate management can result in indiscriminate disposal and open burning, which may adversely affect environmental quality and public health (Prawisudawati et al., 2024). Therefore, effective waste management requires an integrated approach combining waste reduction, source segregation, recycling, appropriate treatment technologies, and active community participation. Community empowerment, education, and continuous assistance are essential for strengthening local capacity, fostering collective responsibility, and sustaining waste-management practices (Hidayati et al., 2025; Kartini et al., 2023; Muhibbah et al., 2025; Santoso et al., 2022). Community-based initiatives, including waste banks and other locally driven programs, can further support waste reduction, environmental awareness, and the development of cleaner and more sustainable villages (Alang et al., 2025; Kusumodestoni et al., 2024; Rachman et al., 2021). In Trenggalek Regency, waste generation reached 111,498.74 tons per year, or approximately 305.48 tons per day, with 76,045.02 tons (68.20%) managed and 35,453.72 tons (31.80%) remaining unmanaged (Pemerintah Kabupaten Trenggalek, 2024). This condition highlights the need to strengthen waste reduction and management at the source. Although Trenggalek has promoted participatory upstream waste management through initiatives such as *Satu Desa Satu Bank Sampah*, which has established 31 waste banks across the regency, these mechanisms primarily focus on economically valuable recyclable materials. Consequently, non-recyclable residual waste remains a management challenge requiring complementary, locally appropriate treatment strategies (Mukharohmah et al., 2026).

A localized intervention was therefore conducted in Kedunglurah Village, Pogalan District, Trenggalek Regency, East Java, based on a preliminary assessment of 50 households (50 KK). The assessment examined household waste-management practices, segregation behavior, disposal methods, waste characteristics, and available facilities. The results showed that 60% of households still burned their waste, while 70% did not routinely separate it by type. These findings indicate that household waste management remains predominantly disposal-oriented and that source segregation

has not yet become a consistent practice (Wulandari et al., 2026). The condition is particularly relevant because the Trenggalek environmental performance document identifies indiscriminate disposal and open burning as indicators of low environmental awareness, with open burning potentially producing harmful air pollution and inappropriate disposal contributing to environmental degradation (Islamiyati et al., 2026). Thus, the challenge in Kedunglurah is not only waste generation but also the absence of systematic management before waste reaches further treatment processes.

To address this condition, waste must first be classified according to its potential for recovery. Compostable organic waste, recyclable materials, and reusable materials should be separated before treatment, while the incinerator introduced in this program is limited to selected non-recyclable and combustible residual waste (Johannes, 2018; Rachman et al., 2021). Hazardous, medical, electronic, battery, pressurized, and other inappropriate materials are excluded from incineration. Safe operation also requires attention to combustion control, ventilation, occupational safety, emissions, equipment maintenance, and appropriate handling of combustion residues (Lahl & Zeschmar-Lahl, 2018). Technology implementation is therefore combined with community empowerment rather than treating the incinerator as a substitute for waste reduction and recycling. A participatory Asset-Based Community Development (ABCD) approach was adopted to identify local assets, formulate solutions, build community capacity, and support sustainability (Susanti et al., 2025; Taufiq & Fazza, 2025). Previous community-based programs have demonstrated that participation, education, appropriate technology, and mentoring can strengthen community ownership and environmental management capacity (Adawiyah et al., 2025; Kusumodestoni et al., 2024; Santoso et al., 2022).

Nevertheless, a practical gap remains in integrating household-level baseline assessment, source segregation, residual waste identification, appropriate incinerator operation, safety training, and community mentoring into a single participatory village-level intervention. Previous community-based programs have often focused on participation, waste education, recycling, or the provision of technology. In contrast, the present program connects these components through a sequential process beginning with a 50-KK baseline assessment, followed by community asset mapping, participatory planning, segregation education, identification of appropriate residual waste, technical training, and hands-on incinerator operation. The distinctive contribution, therefore, lies not in introducing incinerator technology alone but in positioning it as a complementary technology within an ABCD-based waste-

management system (Mukharohmah et al., 2026; Sawiji & Yulianti, 2024). This approach addresses the gap between managing recyclable waste through community mechanisms and treating residual waste left after source-level recovery.

Accordingly, this program aims to strengthen the capacity of the Kedunglurah Village community to manage household and residual waste through source segregation and the safe, appropriate application of incinerator technology. The expected outputs are an improved understanding of waste classification and segregation, increased practical competence in residual waste management and safe incinerator operation, and strengthened community capacity to maintain the waste management system. By integrating empirical baseline assessment, local community assets, participatory planning, source segregation, appropriate technology, safety training, and mentoring, the program contributes a locally grounded and systematic model for managing residual waste at the village level.

2. METHODS

This community engagement program employed a participatory community empowerment approach based on the principles of Asset-Based Community Development (ABCD), emphasizing active community participation, collaborative planning, capacity building, and the utilization of local assets and appropriate technology to address community problems (Najamudin & Fajar, 2024; Sari et al., 2022). Participatory approaches have also been applied in community-based waste management to encourage community involvement in waste segregation, environmental management, and locally appropriate waste-treatment practices (Fadillah et al., 2025; Muhibbah et al., 2025). The program was conducted in Kedunglurah Village, Pogalan District, Trenggalek Regency, East Java, Indonesia, in Juli 2026, involving 50 KK as the primary community participants, together with the village government and the community engagement team. The households were selected based on their residence in Kedunglurah Village and their direct involvement in household waste generation and management, making them relevant participants for identifying local waste management practices and implementing household-level interventions. The community was positioned not merely as the recipient of the program but as an active partner throughout the implementation process. The initial consultation was conducted through group discussions, interviews with community members and village representatives, and direct observation of household waste-management practices and available facilities. These activities were used to identify local waste management problems, assess community needs, examine existing waste

disposal and segregation practices, and determine the suitability of appropriate technologies for managing residual waste. The consultation involved the community engagement team, village government representatives, and participating households, allowing different stakeholders to contribute their experiences, expectations, and proposed solutions (Fig. 1). The discussion also addressed the potential application of incinerator technology for selected residual waste and the community's readiness to participate in its operation and maintenance. This participatory process enabled the intervention to align with the community's actual conditions and needs while strengthening local ownership and collective responsibility for waste management (Kusumodestoni et al., 2024; Santoso et al., 2022).



Figure 1. Community consultation and participatory discussion

The second stage consisted of community education on sustainable waste management, conducted over two days in two sessions. The first session focused on the delivery of educational materials covering waste classification, source segregation, the environmental impacts of improper waste disposal, and sustainable waste management principles. The materials were delivered through interactive presentations supported by presentation slides and practical examples of household waste, followed by group discussions and question-and-answer sessions involving the community engagement team and residents. Community-based education and practical demonstrations have been applied to improve understanding of waste classification, segregation, and responsible waste management practices (Antarja et al., 2024; Pujiana et al., 2024). Particular attention was given to the importance of separating recyclable and reusable materials from residual waste before further treatment, consistent with community-based waste management approaches that emphasize source segregation and reducing the amount of waste requiring further disposal (Hamsiah & Nuradji, 2023; Kusumodestoni et al., 2024). Participants were also

introduced to the role of incinerator technology as a complementary component of an integrated waste management system rather than as a substitute for waste reduction, segregation, reuse, and recycling practices. Previous community engagement programs have similarly combined waste-management education with incinerator technology, while emphasizing community participation and appropriate waste-treatment practices (Adawiyah et al., 2025; Fadillah et al., 2025).

The second session focused on the application and demonstration of the incinerator for managing selected residual waste. Participants were introduced to the basic operating procedures, appropriate types of residual waste for treatment, safety considerations, and proper handling of combustion residues. The community engagement team demonstrated the incinerator's operation and provided opportunities for participants to observe and participate in the application process. Because the program did not employ formal pre-tests or post-tests, changes in participants' understanding were evaluated qualitatively through their responses during discussions and question-and-answer sessions, their participation during the training, and direct observation of their ability to identify and classify waste and follow the demonstrated incinerator application procedures. This evaluation assessed participants' immediate understanding and practical engagement with the waste management practices introduced during the program. The two-session educational and practical activities were intended to establish a basic understanding of responsible waste management and prepare community members to apply appropriate technology safely and appropriately for residual waste management. Community education and continuous assistance are important for strengthening local capacity and encouraging active participation in sustainable waste management practices (Kusumodestoni et al., 2024; Muhibbah et al., 2025).

The third stage focused on manufacturing and assembling a simple incinerator as an appropriate technology intervention to manage selected residual waste that could not be reused or recycled. Simple incinerator technology has been used in community-based waste-management programs as an alternative treatment for residual waste, when combined with appropriate operating procedures and community participation (Prasetyaningsih et al., 2024). The incinerator had a treatment capacity of approximately 10 kg of waste per batch, with a total height of 2 m and a width of 60 cm. The main wall structure was constructed from lightweight concrete blocks (Hebel) bonded with mortar made from cement and sand. The main components consisted of a level foundation, an insulated combustion chamber, an iron grate, a lower access and ventilation opening, a waste-loading door, and a smoke

chimney. The 8-mm iron grate was positioned approximately 20 cm above the base of the combustion chamber to support the waste while maintaining airflow beneath the combustion zone. The lower opening served to introduce the initial ignition material, supply combustion air, and facilitate ash removal. At the same time, the upper loading door was used to introduce dry residual waste into the combustion chamber. The chimney at the top of the incinerator functioned as an outlet for hot gases and smoke and supported the upward movement of combustion gases. The operating principle involved controlled combustion of selected dry residual waste within the combustion chamber, with airflow maintained through the lower ventilation opening and the chimney providing an outlet for combustion gases. The technical design, including the dimensions, main components, combustion chamber, ventilation openings, grate, and chimney, served as the reference for the fabrication and assembly process, as shown in Figure 2.

The manufacturing process involved preparation of the construction materials, fabrication of the foundation and main structure, installation of the Hebel walls, construction of the combustion chamber, installation of the iron grate and ventilation opening, installation of the waste-loading door and chimney, and final inspection of the assembled unit. After completion, the incinerator was inspected by the community engagement team before being demonstrated and introduced for community use. The inspection covered structural integrity, including the stability and condition of the foundation, walls, joints, and main components; safety, including the condition of the combustion chamber, access openings, ventilation system, and structural stability; combustion functionality, including the ability of the chamber and airflow system to support the combustion of selected dry residual waste; and operational viability, including the ease of waste loading, ignition, airflow management, and ash removal. Technical testing and practical trials are important components of community-based incinerator implementation because they help ensure that the technology can be operated according to its intended function before broader community use (Gunawan et al., 2025; Prasetyaningsih et al., 2024). Any deficiencies identified during the inspection were addressed before the incinerator was used in the practical training session. This inspection was intended to ensure that the incinerator was structurally stable, operationally functional, and suitable for community-level residual waste management.

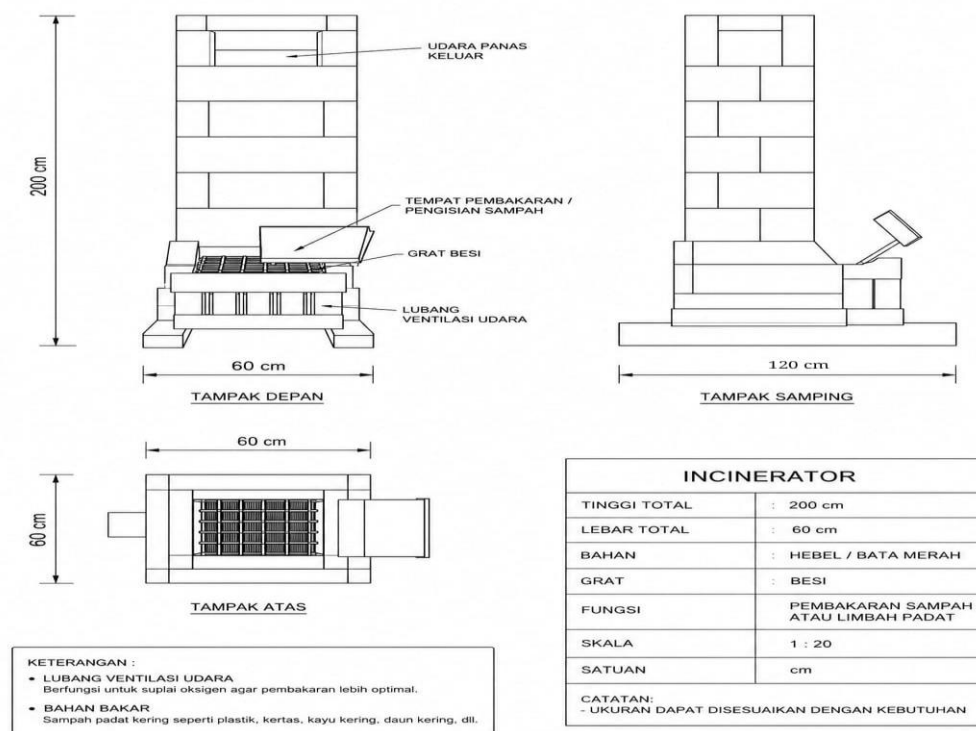


Figure 2. Technical design, dimensions, and main components of the incinerator

The community engagement team conducted the manufacturing and assembly of the incinerator. In contrast, community members actively participated through observation, technical explanations, discussions, and demonstrations of the main components and their functions. Following fabrication, participants directly engaged in the practical application of the incinerator by identifying suitable residual waste, loading the combustion chamber, maintaining airflow, and handling combustion ash under the team's guidance. This approach combined technical demonstration with practical participation to strengthen community capacity for appropriate operation and maintenance, while the incinerator functioned as a complementary component of a waste management system in which waste reduction, source segregation, reuse, and recycling remained essential practices (Adawiyah et al., 2025; Fadillah et al., 2025; Lesmana et al., 2024).

The final stage involved evaluating the implementation and outcomes of the community empowerment program using the ABCD approach. The four activity stages consisted of (1) community consultation and identification of local assets and waste-management problems, evaluated through community participation and stakeholder involvement; (2) community education, evaluated through participants' responses, discussions, and observed understanding of waste classification and segregation; (3) incinerator fabrication and assembly, evaluated based on the successful completion, structural condition, operational functionality, and safety of the

equipment; and (4) demonstration and practical application, evaluated through participants' ability to identify suitable residual waste, operate the incinerator under guidance, and handle combustion residues appropriately. Photographic documentation and direct observation were used to document the implementation process, community involvement, knowledge transfer, and technological output. These indicators were used descriptively to assess the achievement of the program objectives and the integration of community participation, local capacity, and appropriate technology. However, the evaluation had limitations because it did not employ quantitative pre- and post-tests and did not measure long-term behavioral changes or reductions in household waste volume. Therefore, the findings primarily reflect participants' immediate understanding, practical engagement, and successful production and application of the incinerator rather than measurable long-term environmental impacts. Consistent with the ABCD approach, the program positioned community members as active partners in identifying local problems and assets, acquiring knowledge and skills, and applying the resulting technology, while the incinerator served as a complementary component of an integrated waste management system in which waste reduction, source segregation, reuse, and recycling remained essential practices (Adawiyah et al., 2025; Fadillah et al., 2025; Lesmana et al., 2024).

3. FINDINGS AND DISCUSSION

3.1. Community Education on Sustainable Waste Management

The community education activity involved 50 households (50 KK) from Kedunglurah Village, representing community members directly involved in household waste generation and management. The activity aimed to strengthen participants' understanding of waste classification, source segregation, the environmental impacts of improper waste disposal, and sustainable waste management principles. Through interactive presentations, practical examples, group discussions, and question-and-answer sessions, participants were encouraged to distinguish recyclable and reusable materials from residual waste and to recognize that waste management should begin with source reduction and segregation. The evaluation was conducted qualitatively because no formal pre-test or post-test was administered. Based on participants' responses during discussions and Q&A sessions, and observations during the activities, participants demonstrated an understanding of the importance of waste segregation and the distinction between recyclable materials and residual waste that requires further treatment. Participants also showed active engagement by discussing household waste management practices and identifying the

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challenges they encountered in managing residual waste. These findings indicate that the educational activity provided an initial basis for strengthening community understanding and participation in responsible waste management. The subsequent introduction and practical demonstration of the incinerator further connected the knowledge gained during education with the application of appropriate technology for selected residual waste. Community education combined with practical assistance can strengthen local capacity and encourage active participation in sustainable waste management (Hanafi et al., 2025; Kusumodestoni et al., 2024; Muhibbah et al., 2025; Santoso et al., 2022).



Figure 3. Community education and awareness activities

Figure 3 shows the implementation of the educational activity as the program's initial stage. The activity generated active participation from community members, particularly during discussions and question-and-answer sessions concerning household waste segregation, the distinction between recyclable and residual waste, and the environmental consequences of improper disposal. Participants shared their experiences of household waste management and raised questions about how residual waste should be handled when it can no longer be reused or recycled. These responses indicated that the participants were able to relate the educational materials to waste management practices in their daily lives and recognize the importance of segregation before further treatment. The discussion also revealed participants' initial understanding of the need for an appropriate treatment option for residual waste, which provided a basis for introducing the incinerator in the subsequent activity. Thus, the education stage served not only as knowledge transfer but also as a participatory process to assess community understanding and prepare participants for the practical application of appropriate waste-management technology.

3.2. Incinerator Manufacturing Process as an Appropriate Technology Intervention

Following the educational activity, the program proceeded to fabricate an incinerator as the main appropriate-technology output for managing selected residual waste. The incinerator had a capacity of approximately 10 kg per batch, with a total height of 2 m (200 cm) and a width of 60 cm. The main structure was constructed from lightweight concrete blocks (Hebel) bonded with mortar made from cement and sand, on a level foundation designed to support the furnace. The main components consisted of an insulated combustion chamber, an 8-mm iron grate positioned approximately 20 cm above the furnace base, a lower access and ventilation opening, a waste-loading door, and a chimney. The grate supported the waste while maintaining airflow beneath the combustion chamber, whereas the lower opening functioned to introduce ignition material, supply combustion air, and facilitate ash removal. The loading door was used to introduce dry residual waste into the combustion chamber, while the chimney provided an outlet for hot combustion gases and smoke. The incinerator operated through controlled combustion of selected dry, non-recyclable residual waste, with airflow supplied through the lower opening and combustion gases discharged through the chimney. The completed unit was subsequently inspected for structural integrity, safety, combustion functionality, and operational feasibility before being introduced to community members during the practical application.

The incinerator was developed as a complementary treatment technology for residual waste that could not be reused or recycled and was therefore not intended to replace waste reduction, source segregation, reuse, or recycling. The technical design was adapted to the community context to provide a relatively simple technology that could be operated and maintained at the local level. The fabrication and introduction of this technology also provided an opportunity to strengthen community understanding of appropriate waste treatment and the role of technology within an integrated waste management system. This approach is consistent with previous community engagement programs emphasizing the integration of appropriate technology, community participation, and responsible waste management practices (Adawiyah et al., 2025; Fadillah et al., 2025; Lesmana et al., 2024).



Figure 4. The process of manufacturing and assembling the incinerator

Figure 4 documents the development and assembly stages of the incinerator. The community engagement team carried out the manufacturing and assembly, while community members participated through direct observation, technical explanations, discussions, and demonstrations of the main components and their functions. Participants were introduced to the combustion chamber, grate, ventilation opening, waste-loading door, and chimney, followed by practical training in selecting suitable dry residual waste, loading waste, managing airflow, operating the equipment, and handling ash under the team's guidance. Thus, community involvement extended beyond observation to practical training in basic incinerator operation and handling. However, because no quantitative evaluation of technical skills, behavioral change, or long-term technology ownership was conducted, the program does not demonstrate increases in community capacity or local ownership. Instead, the manufacturing demonstration and practical training provided an opportunity to familiarize participants with the technology and potentially support its appropriate future operation and maintenance (Kusumodestoni et al., 2024; Lesmana et al., 2024).

The manufacturing process, therefore, served as both a technical activity and an introduction to appropriate technology for managing residual waste. The incinerator was positioned as a complementary treatment option for selected dry residual waste that could not be reused or recycled, rather than as a substitute for waste reduction, source segregation, reuse, and recycling. The combination of technical demonstration and practical training was intended to facilitate community familiarity with the

equipment and provide a basis for its appropriate use within the local waste management system.

3.3. Incinerator Product and Its Potential Contribution to Community-Based Waste Management

The program's final output was an incinerator designed to support community-level management of residual waste. The completed product is presented in Figure 5. The availability of the incinerator provides the community with an appropriate technology option for managing residual waste that cannot be further utilized through reuse or recycling. The introduction of this technology is expected to help reduce the volume of residual waste requiring transportation and final disposal, while strengthening the community's capacity to manage waste in its local environment.



Figure 5. The completed incinerator product

The completed incinerator represents a tangible technological output of the community engagement program. The unit has a capacity of approximately 10 kg of waste per batch, with a height of 2 m and a width of 60 cm, and was constructed from lightweight concrete blocks (Hebel), mortar, cement, and sand, with an 8-mm iron grate, ventilation opening, waste-loading door, and chimney. The equipment was designed to treat selected dry, non-recyclable residual waste that could not be reused or recycled. However, because no operational performance testing, waste-volume measurements, or before-and-after assessments were conducted, the incinerator is considered a technological output of the program rather than a technology with demonstrated treatment effectiveness. Its potential contribution to reducing residual waste volume should therefore be interpreted cautiously. The technology may

potentially reduce the amount of residual waste requiring further disposal, provided that it is operated appropriately and supported by proper waste segregation, safe operating procedures, responsible ash handling, and continued technical assistance.

The findings are broadly consistent with previous community engagement programs that have applied incinerator technology to address village-level waste management challenges. Lesmana et al. (2024) introduced the Rocket Eco Stove Incinerator (REST-I) technology as part of a community-based waste management intervention (Lesmana et al., 2024), while Fadillah et al. (2025) emphasized the application of appropriate incinerator technology at the village level (Fadillah et al., 2025). Adawiyah et al. (2025) similarly integrated environmentally friendly incinerator technology with community-based waste management practices (Adawiyah et al., 2025). The present program differs in its explicit application of the ABCD approach, which emphasizes identifying local problems and assets, community consultation, technical education, and practical participation in technology applications. Community members did not directly fabricate and assemble the incinerator. Still, they participated by observing, engaging in technical discussions, attending demonstrations, and receiving practical training in waste selection, loading, operation, and ash handling. In addition, the technology developed in this program was a relatively simple 10-kg-per-batch incinerator adapted to the local context and intended specifically as a complementary treatment option for selected residual waste. These characteristics distinguish the present intervention from previous programs while supporting the broader principle that appropriate waste-treatment technology can be applied more effectively when combined with community participation, education, and ongoing assistance.

Overall, the program comprised four stages: (1) community consultation and identification of local waste-management problems and assets, (2) community education, (3) incinerator manufacturing and assembly, and (4) demonstration and practical application of the completed incinerator. These stages integrated the ABCD approach with appropriate technology intervention. The consultation stage identified local conditions and community needs; the education stage provided knowledge on waste classification and source segregation; the manufacturing stage produced a 10-kg-per-batch incinerator; and the final stage introduced participants to its practical operation and basic ash handling. The program, therefore, produced a tangible technological output and provided participants with opportunities to become familiar with its operation; however, no quantitative evidence was collected to demonstrate changes in community capacity, long-term behavioral change, or local ownership.

The program contributed to Kedunglurah Village by combining community consultation, knowledge transfer, practical training, and the provision of an appropriate technology output for selected dry residual waste. Nevertheless, the evaluation was limited by the absence of quantitative measurements of waste volume reduction, long-term monitoring of household waste management behavior, and continuous performance testing of the incinerator. Therefore, the program does not claim demonstrated effectiveness in reducing residual waste or achieving long-term behavioral change. Instead, the incinerator should be regarded as a complementary technological intervention that can support residual waste management when accompanied by proper segregation, safe operation, ash handling, regular maintenance, and institutional support. Future activities should monitor incinerator utilization and operational performance, measure changes in residual waste volume before and after treatment, and evaluate longer-term changes in community waste management practices. Continued collaboration among the community, the village government, and relevant stakeholders will be important for assessing the intervention's sustainability and practical contribution.

4. CONCLUSION

The community engagement program in Kedunglurah Village, Pogalan District, Trenggalek Regency, integrated community consultation, education, appropriate technology, and practical training to support community-based waste management. The activities provided participants with an understanding of waste classification, source segregation, sustainable waste management, and responsible management of residual waste. At the same time, the incinerator was introduced as a complementary treatment option for selected residual waste that cannot be reused or recycled. The fabrication and implementation produced a tangible technological output with a capacity of approximately 10 kg per batch, accompanied by practical training on its basic structure, operation, and ash handling. However, the absence of quantitative measurements of changes in community capacity, long-term behavior, waste volume reduction, and continuous incinerator performance limits the conclusions about the intervention's long-term effectiveness and sustainability. Therefore, the program provides an initial basis for supporting residual waste management through appropriate technology. At the same time, future activities should incorporate quantitative monitoring of waste reduction, household waste management practices, and incinerator performance to assess their longer-term contribution to sustainable waste management in Kedunglurah Village.

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