



Community Service Report

Community-Based Plastic Waste Pyrolysis in Mattiro Ade Village: Converting Waste Into Alternative Fuel

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ARTICLE INFO

Keywords:

alternative fuel; waste; circular economy; plastic; pyrolysis

History:

Submitted : 21 May 2026

Reviewed : 3 June 2026

Accepted : 5 February 2026

Competing Interests:

The authors declare no conflicts of interest related to this work.

ABSTRACT

Growing interest in plastic waste valorization has highlighted the potential of pyrolysis technology; however, its community-level application remains limited, particularly in rural waste management systems. This community engagement program aimed to strengthen local capacity by implementing pyrolysis technology to convert plastic waste into alternative fuel in Mattiro Ade Village, Pinrang Regency, Indonesia. The program adopted a participatory approach integrating Community-Based Research and Participatory Action Research. Activities included preparation, pyrolysis unit fabrication, operational testing, community outreach, practical training, and transfer of the unit to the local Reduce, Reuse, Recycle Waste Processing Facility. Qualitative evaluation was conducted through participatory observation of community understanding, involvement, and operational readiness. The results showed improved awareness of plastic waste management, active community participation, and adequate readiness among local operators to use the pyrolysis unit. The initiative also demonstrated the feasibility of introducing small-scale pyrolysis within a community-based waste management framework. By linking plastic waste reduction with alternative fuel production, this program offers a practical pathway for strengthening local environmental governance and promoting circular resource use. Further implementation should prioritize technical assistance, routine monitoring, and fuel quality assessment to support operational sustainability and replication in comparable rural communities.

1. Introduction

Plastic waste has become a major environmental management challenge at both global and national levels (Nasution & Hadiansah, 2020). Global plastic production continues to increase, reaching millions of tons annually, while a substantial proportion is discarded without adequate

treatment (Kubota et al., 2020). In Indonesia, plastic waste generation has also shown a significant upward trend and has become one of the principal contributors to environmental pollution. The widespread use of plastic across various sectors is driven by its lightweight, durable, and cost-effective characteristics (Nasution & Hadiansah, 2020; Iacovidou et al., 2025; Corsita et al., 2024; Saleh et al., 2024). However, its non-biodegradable nature allows plastic waste to persist in the environment for extended periods, potentially lasting for hundreds of years. This persistence leads to the accumulation of plastic residues in soil, water bodies, and ecosystems, with subsequent implications for environmental quality and public health.

From an environmental health perspective, plastic waste is not merely an aesthetic problem but also a source of chemical and biological contamination. The fragmentation of plastic materials into microplastics increases the likelihood of their entry into food chains and potential accumulation in the human body. In addition, the open burning of plastic waste, which remains common in many communities, can release hazardous compounds, including dioxins, with adverse effects on human health. Addressing this issue is therefore relevant to the achievement of the Sustainable Development Goals, particularly SDG 3 on good health and well-being, SDG 7 on affordable and clean energy, SDG 11 on sustainable cities and communities, SDG 12 on responsible consumption and production, and SDG 13 on climate action.

Several strategies have been introduced to improve plastic waste management, including source reduction, recycling, and technology-based treatment. Among the emerging technologies, pyrolysis offers considerable potential because it involves the thermal decomposition of plastic waste under oxygen-limited conditions and can convert selected plastic materials into liquid fuels with characteristics comparable to kerosene, diesel, or gasoline fractions (Al-Salem et al., 2017; Fresh et al., 2023). This technology is consistent with the waste-to-energy concept, which seeks to transform waste materials into economically valuable energy resources (Amalin & Rahman, 2019; Ellen MacArthur Foundation, 2019). Previous studies have indicated that pyrolysis can achieve promising conversion efficiency and may be adapted for community-level application when supported by simple, affordable, and context-responsive equipment.

Despite its potential, the implementation of technology-based plastic waste treatment at the community level remains constrained by limited knowledge, restricted access to appropriate technologies, and insufficient technical assistance. Many waste management initiatives continue to prioritize technical performance without adequately integrating community empowerment and institutional strengthening. Consequently, the continuity of such programs often declines after the initial implementation stage. A sustainable intervention must therefore combine technological innovation with participatory capacity-building so that local communities are able to operate, maintain, and manage the system independently.

This community engagement program was implemented in Mattiro Ade Village, Patampanua District, Pinrang Regency, Indonesia. It involved multiple stakeholders, including the Pinrang Regency Environmental Agency, the Patampanua District Government, the Mattiro Ade Village Government, the Pinrang Regency Family Welfare Empowerment Team, health office personnel, staff from the Mattiro Ade Community Health Center, community leaders, and managers of the local

Reduce, Reuse, Recycle Waste Processing Facility. This cross-sectoral involvement reflects a collaborative approach to strengthening community-based environmental management.

The program was conducted through a systematic sequence of activities, including preparation, fabrication of the pyrolysis unit, operational testing, community outreach, and transfer of the technology to local managers. The program aimed to improve community capacity and independence in plastic waste management through the application of pyrolysis technology. It also sought to promote a community-based environmental management model that integrates technological innovation, stakeholder collaboration, and local empowerment. Through this approach, the intervention is expected to contribute not only to plastic waste reduction but also to the development of a more sustainable and locally managed waste treatment system.

2. Method

2.1 Study Design and Approach

This community engagement program employed a participatory approach by integrating Community-Based Research (CBR) and Participatory Action Research (PAR). These approaches positioned community members as active participants throughout the planning, implementation, and evaluation processes. Accordingly, the program focused not only on the introduction of pyrolysis technology but also on strengthening community capacity to manage plastic waste independently and sustainably (Coughlin, 2017; Bischoff & Jany, 2018).

2.2 Study Location and Participants

The program was conducted in Mattiro Ade Village, Patampanua District, Pinrang Regency, Indonesia. Approximately 30 participants were involved, consisting of housewives, youth representatives, and managers of the local Reduce, Reuse, Recycle Waste Processing Facility (TPS 3R). Participants were selected purposively based on their involvement in household waste management, community activities, or the operation of the TPS 3R facility.

The program also involved multiple stakeholders, including the village government, the Pinrang Regency Environmental Agency, the Health Office, the Mattiro Ade Community Health Center, the Family Welfare Empowerment Team, and community leaders. This multi-stakeholder involvement was intended to strengthen institutional support, improve program effectiveness, and promote the sustainability of community-based plastic waste management.

2.3 Program Implementation

The program was implemented through five main stages: preparation, fabrication of the pyrolysis unit, operational testing, community outreach, and technology transfer with initial technical assistance.

The preparation stage included a literature review, consultations with technical experts, and the design of a pyrolysis unit adapted to local conditions. This stage aimed to ensure that the selected technology was evidence-based, feasible, and suitable for community-level application. Consideration was given to operational simplicity, affordability, safety, and the availability of components.

The pyrolysis unit was assembled using several principal components, including a reactor drum, condenser, liquid fuel collection container, and heating system. The equipment was designed according to the principles of appropriate technology, emphasizing simplicity, cost-effectiveness, and ease of operation. The design was intended to allow local operators to understand the basic functions of each component and perform routine operation with minimal technical complexity.

Operational testing was conducted to assess the ability of the unit to convert plastic waste into liquid fuel. This stage also examined the stability of the conversion process, the functionality of the main components, and basic operational safety. The testing process served as an initial verification step before the technology was introduced to the broader community and transferred to the TPS 3R managers.

Community outreach was conducted through educational sessions and a direct demonstration of the pyrolysis process. The educational materials covered the environmental and health impacts of plastic waste, the basic principles of pyrolysis, the functions of the equipment components, and the operational procedures required to process plastic waste. Participants were also given opportunities to engage in discussions, ask questions, and observe the practical use of the unit.

Following the outreach and demonstration activities, the pyrolysis unit was transferred to the TPS 3R managers. Technical explanations were provided regarding basic operation, maintenance, and safety considerations. A person responsible for the equipment was appointed to support accountability and continuity of operation. Initial technical assistance was also provided to strengthen the readiness of local operators to manage the unit independently.

2.4 Indicators and Measurement of Program Success

Program outcomes were evaluated using a qualitative descriptive approach based on participatory observation. Three principal indicators were assessed.

The first indicator was increased community understanding. This was assessed through participants' ability to identify the functions of the main components of the pyrolysis unit and explain the basic process of converting plastic waste into liquid fuel.

The second indicator was community participation. This was evaluated based on participants' active involvement in discussions, question-and-answer sessions, and the direct demonstration of the equipment.

The third indicator was operational readiness. This was assessed through the availability of a designated person responsible for the unit, the ability of local operators to perform basic operational procedures, and the readiness of the TPS 3R facility to support the implementation of the technology.

2.5 Data Collection and Analysis

Data were collected through direct observation during program implementation, activity documentation, and written records of participants' responses and interactions. The collected data were analyzed descriptively to determine the extent to which the program objectives were achieved. The analysis focused on changes in participant understanding, the level of engagement during program activities, and the readiness of the local management team to operate the pyrolysis unit.

2.6 Ethical Considerations

Participation in the program was voluntary. Before the activities were conducted, participants received information regarding the objectives, procedures, and expected benefits of the program. Verbal consent was obtained for participation in the educational sessions, demonstrations, observations, and documentation activities. Personal information was not disclosed in the reporting of program outcomes.

3. Results & Discussion

3.1 Program Implementation and Technology Application

The implementation of this community engagement program demonstrated that integrating appropriate technology with a community empowerment approach can support plastic waste management at the local level. The pyrolysis technology introduced during the program addressed the challenge of non-biodegradable plastic waste while providing added value through the production of alternative liquid fuel.

The program was conducted through five main stages: preparation, fabrication of the pyrolysis unit, operational testing, community outreach, and transfer of the equipment to local managers. Overall, all stages were completed successfully. The principal output was a functional pyrolysis unit that could be operated at the community level.

During the fabrication and operational testing stages, the pyrolysis unit successfully converted plastic waste into liquid fuel. This result confirms the practical potential of pyrolysis as a waste-to-energy technology. Its application may simultaneously reduce the volume of unmanaged plastic waste and generate a useful energy product. Although the present program did not quantify fuel yield, conversion efficiency, or physicochemical characteristics, the successful production of liquid fuel indicates that the unit was technically feasible for initial community-level implementation.

The success of the program was not determined solely by the technical performance of the equipment. The participatory approach also contributed to community acceptance and involvement. Participants were engaged in discussions, demonstrations, and the initial operational process, allowing them to develop a basic understanding of the technology. This finding is consistent with the principle of community empowerment in environmental health, which emphasizes active participation as an essential factor in the success and sustainability of community-based interventions (Kolb, 2015).

Nevertheless, further development is required to strengthen the effectiveness of the program. Future implementation should include routine monitoring, quantitative performance assessment, and continued technical assistance. These measures are necessary to evaluate the operational stability of the unit and improve the capacity of local managers to use the technology safely and consistently.

3.2 Community Outreach and Capacity Building

Community outreach activities were conducted to improve participants' understanding of technology-based plastic waste management. The sessions involved stakeholders from multiple sectors, including local government institutions, health services, community organizations, and TPS

3R managers. This cross-sectoral participation strengthened the collaborative basis of the program and increased the likelihood of institutional support for future implementation.

Participatory observation indicated a high level of enthusiasm among the participants. This was reflected in their active involvement in discussions, their responses to the educational materials, and their participation during the direct demonstration of the pyrolysis unit. Participants were introduced to the environmental and health impacts of plastic waste, the basic principles of pyrolysis, the functions of the main equipment components, and the operational procedures required to convert plastic waste into liquid fuel.

The use of direct demonstration was particularly important because it enabled participants to understand the technology through practical experience rather than through theoretical explanation alone. This experiential learning approach facilitated interaction between participants and facilitators and helped participants relate the technology to local waste management practices (Kolb, 2015). The active interaction observed during the outreach and demonstration sessions is presented in Figures 1 and 2.



Figure 1. *Community outreach session on plastic waste management and pyrolysis technology.*

3.3 Technology Outputs and Institutional Transfer

The implementation of the pyrolysis technology produced two main outputs: a functional plastic waste processing unit and liquid fuel generated from the pyrolysis process. These outputs demonstrate that plastic waste, which is often regarded as an environmental burden with limited economic value, can be transformed into a potentially useful energy resource.

From a technical perspective, the pyrolysis unit was designed using relatively simple components that were accessible and suitable for community-level application. The design included a reactor drum, condenser, fuel collection container, and heating system. This configuration may facilitate replication in other communities with comparable conditions. However, the apparent simplicity of the equipment should not be interpreted as an absence of operational risk. Basic technical competence remains necessary to ensure safe handling, stable operation, and appropriate maintenance.



Figure 2. *Direct demonstration of the operation of the pyrolysis unit.*

The transfer of the pyrolysis unit to the TPS 3R managers represented an important stage in the institutionalization of the program. The equipment handover was accompanied by a technical explanation of its functions and basic operating procedures. A responsible local operator was also designated to support accountability and continuity.

The transfer process indicates an initial level of institutional readiness among the local managers. Rather than functioning as a symbolic activity, the handover established a basis for local ownership and independent management. Such ownership is essential for the sustainability of a community-based environmental intervention because the long-term use of the technology depends on local commitment, operational competence, and organizational support.



Figure 3. *Transfer of the pyrolysis unit to the TPS 3R managers in Mattirot Ade Village*

3.4 Social and Environmental Implications

The program generated positive outcomes from both social and environmental perspectives. Socially, the activities improved participants' awareness and understanding of plastic waste management. Community members were introduced to the possibility of processing plastic waste through an alternative pathway that differs from disposal or open burning. Their active participation also suggests that the technology was viewed as relevant to local environmental concerns.

Environmentally, the implementation of pyrolysis technology may contribute to reducing the accumulation of unmanaged plastic waste and discouraging open burning practices. This is important because uncontrolled burning can release hazardous pollutants and create risks for environmental and public health. The introduction of a locally operated pyrolysis unit also strengthened the function of the TPS 3R facility by expanding its role from waste collection and sorting to value-added waste processing.

The program further illustrates the potential relationship between community-based waste management and circular resource use. By converting selected plastic waste into liquid fuel, the intervention introduced an approach in which discarded materials can be recovered and utilized. However, the environmental benefits of this approach should be interpreted cautiously until further measurements are available. Future studies should assess energy consumption, emission levels, residual by-products, fuel quality, and the overall environmental performance of the system.

3.5 Program Achievement Indicators

The achievements of the program were assessed using three principal indicators: increased community understanding, successful technology implementation, and initial readiness for program continuity.

First, participants demonstrated a basic understanding of the principles and functions of the pyrolysis unit. They were able to recognize the main components of the equipment and describe the general process through which plastic waste is converted into liquid fuel.

Second, the pyrolysis unit was successfully operated during the demonstration stage and produced liquid fuel. This result served as an initial indicator of technical feasibility. It also strengthened participants' understanding by showing that plastic waste processing could generate a tangible output.

Third, the designation of a responsible operator and the transfer of the unit to the TPS 3R managers indicated initial readiness for continued implementation. These achievements suggest that the program established a foundation for community-based operation. Nevertheless, operational sustainability cannot be concluded solely from the initial handover. Continued mentoring, regular monitoring, and institutional coordination remain necessary to ensure that the technology is used consistently and safely.

3.6 Constraints and Study Limitations

Despite the successful completion of the program, several limitations should be acknowledged. The implementation period was relatively limited, and post-program technical assistance could not

be conducted extensively. As a result, the long-term operational consistency of the pyrolysis unit has not yet been evaluated.

The assessment of participant understanding was also qualitative. Although participatory observation provided useful information regarding involvement and responsiveness, the program did not administer pre-test and post-test measurements. Consequently, the magnitude of improvement in participant knowledge could not be quantified.

In addition, the technical performance of the pyrolysis unit was not evaluated using detailed quantitative indicators. Data on the volume and types of plastic waste processed, liquid fuel yield, conversion efficiency, fuel composition, heating duration, energy consumption, emissions, and operating costs were not available. These limitations restrict the extent to which the results can be generalized or compared with other pyrolysis initiatives.

Future implementation should therefore incorporate structured monitoring and evaluation. A more comprehensive assessment should include quantitative measurement of participant knowledge, operational performance testing, laboratory analysis of the resulting fuel, emission monitoring, economic feasibility analysis, and long-term observation of equipment use at the TPS 3R facility. Such evaluation would provide stronger evidence regarding the scalability, safety, and sustainability of community-based plastic waste pyrolysis.

4. Conclusion

The implementation of community-based pyrolysis technology in Mattiro Ade Village, Pinrang Regency, demonstrated that integrating appropriate technology with participatory empowerment can provide a practical approach to plastic waste management. The program improved community understanding of plastic waste processing, strengthened local participation, and produced a functional pyrolysis unit capable of converting plastic waste into liquid fuel at the TPS 3R level. Its principal strengths lie in the simplicity of the equipment design, the use of relatively accessible components, and the participatory process that encouraged local involvement and ownership. However, the program remains limited by the absence of quantitative measurements of knowledge improvement, fuel yield, conversion efficiency, emission levels, and long-term operational performance. Further development should therefore prioritize structured monitoring and evaluation, laboratory testing of the resulting fuel, emission assessment, economic feasibility analysis, and continued technical assistance for local operators. These measures are necessary to ensure that the technology can be operated safely, maintained independently, and replicated in other communities with similar waste management challenges.

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