ANNUAL INTERNATIONAL CONFERENCE
On Religious Moderation
e-ISSN: 3046-9775
by Zainul Hasan Genggong Islamic University

LOW SMOKE INCINERATOR INNOVATION TO REDUCE SUSTAINABLE WASTE ACCUMULATION IN MATEKAN VILLAGE, POROLINGGO

Amelia Nur Faiqoh[1], Diana Nafisa[2], Wasilah[3], Ummi Farida[4], Ivonne Hafidlatil Kiromi[5], Ursilatullaili[6], Uswatun Hasanah[7], Rosidatul Jannah[8], Ummi Nadiratul Faizah[9], Silawatul Hasanah[10]

[1,2,3,4,5,6,7,8,9,10,] Universitas Islam Zainul Hasan Genggong, Indonesia
faiqamelia63@gmail.com, diananafisa06@gmail.com, wsila130@gmail.com, ummifarida1912@g,ail.com, ivonnehafidlatil@gmail.com, ursilatullaili16@gmail.com, hasanahuswatun22560@gmail.com, rosidatuljannah68@gmail.com, Umminadiratulfaizah@gmail.com, silawatulhasanah7@gmail.com

Abstract:

Waste accumulation remains a significant environmental challenge, particularly in rural areas with limited waste management infrastructure. In many villages, household waste is commonly managed through open burning or disposal in vacant land, practices that contribute to air pollution, health risks, and environmental degradation. Desa Matekan, Besuk, Probolinggo, faces similar conditions due to the absence of adequate final disposal facilities and structured waste management systems. This study aims to describe the design and implementation of a low-smoke incinerator as an appropriate technology innovation to reduce sustainable waste accumulation in the village. The research employed a participatory descriptive approach, involving observation, interviews, documentation, and direct community engagement during the design, construction, and operational testing phases. The incinerator was designed using a closed combustion system with primary and secondary air circulation to improve combustion efficiency and minimize smoke emissions. The results indicate a significant reduction in waste volume after each combustion cycle, lower visible smoke intensity compared to open burning, and improved community participation in waste management practices. The innovation not only enhanced technical waste processing efficiency but also strengthened local awareness and collective responsibility toward environmental sustainability. It can be concluded that the low-smoke incinerator is an effective and adaptable solution for community-based sustainable waste reduction in rural areas.

Keywords: *low-smoke incinerator, sustainable waste management, appropriate technology, community participation, rural environment*

INTRODUCTION

The waste problem has become a global issue that affects environmental sustainability, public health, and socio-economic stability(Prayoga et al., 2024). Reports from various international institutions show that the increase in population and consumption patterns based on disposable products contribute to the surge in waste generation every year(Putri et al., 2025). The inability of the management system to keep up with the rate of waste production causes accumulation in various areas, both urban and rural. The impact is not only in the form of soil, water, and air pollution, but also an increased risk of disease due to exposure to pollutants and disease vectors. This condition emphasizes that waste management is not just a technical issue, but part of the sustainable development agenda that requires integrated solutions. Therefore, innovative technology-based approaches and community participation are urgent needs in responding to these challenges.

At the national and regional levels, the waste problem still faces various limitations, especially in the aspects of infrastructure and governance (Rokilah et al.,

*Corresponding author.
E-mail addresses: faiqamelia63@gmail.com

2025). Many regions, especially rural areas, do not have a structured and sustainable waste management system. The practice of dumping in open land and uncontrolled burning is still often carried out as an instant solution (Ramadhani et al., 2025). This method is indeed considered practical, but it has implications for air pollution due to the emission of harmful particles and gases produced from the imperfect combustion process. In addition to lowering the quality of the environment, this condition also has the potential to cause social conflicts due to disturbances in the comfort and health of residents. Thus, an alternative to waste management that is more effective, safe, and in accordance with the characteristics of the village community is needed.

Conceptually, sustainable development requires a waste management system that is oriented towards reducing environmental impact and increasing community capacity (Saputra, 2025). The principles of efficiency, sustainability, and local independence are important foundations in designing applicable technology solutions (Takari & Subagio, 2025). Appropriate technology is seen as relevant because it is designed according to the needs and capabilities of the local community, both in terms of cost, operation, and maintenance. In this context, waste management innovations are not only judged by their technical sophistication, but also by the extent to which the technology is able to reduce emissions, increase combustion efficiency, and encourage active participation of citizens in environmental management. The integration between technical and social aspects is a determining factor for the successful implementation of waste management programs at the village level.

Matekan Village, Besuk District, Probolinggo Regency, is one of the areas that faces the problem of waste accumulation due to limited processing facilities. Based on the results of field observations, household waste management is still carried out conventionally through open burning or disposal in empty areas. The absence of an adequate Final Disposal Site (TPA) and the absence of a centralized processing system cause the volume of waste to continue to increase. Open burning carried out by the community produces thick smoke that disrupts air quality and has the potential to endanger health. In addition, uncontrolled combustion processes are often unable to optimally reduce the volume of waste and leave residues that pollute the surrounding environment. This condition shows the need for innovation-based interventions that can be applied practically and sustainably.

Based on these problems, the innovation of a low-smoke incinerator is seen as an appropriate technological solution that is relevant to be applied in Matekan Village. Incinerators with a closed combustion chamber system and controlled air circulation settings allow the combustion process to take place more perfectly so that smoke emissions can be significantly reduced. The development of this tool is designed according to the capacity needs of the village and considers the aspect of ease of use by the community. More than just a technical device, the implementation of a low-smoke incinerator is directed to build collective awareness and independence of residents in managing waste responsibly. Therefore, this article aims to describe the design and implementation process of a low-smoke incinerator as an innovation in reducing sustainable waste accumulation in Matekan Village, Besuk Probolinggo, as well as analyzing its effectiveness and impact on environmental conditions and community participation.

RESEARCH METHODS

Community service activities carried out in Matekan Village, Besuk District, during the PKM period used the ABCD (Asset-Based Community Development) method. This approach is used to deeply recognize the environmental assets and social potential that exist in Matekan Village. The main goal is for students to be able to actively blend with the community, so as to create collaborative relationships that become a bridge in facilitating the running of environmental management programs.

Armed with this ABCD method, we decided to make the Local Waste Management System the main object of our service. The main focus of this innovation is directed at changing household waste handling practices in the community. If previously the community tended to burn waste openly (open burning) which produced thick smoke and pollution, then through this program we innovated by shifting the practice using Minimal Smoke Incinerator Technology. This innovation aims to provide a healthier and more organized technical solution for citizens. By changing old habits to appropriate technology-based management that is more environmentally friendly, it is hoped that the accumulation of waste in Matekan Village can be significantly and sustainably reduced through the active participation of the community as the owner of village assets.

RESULTS AND DISCUSSION

Based on the results of field observations before the implementation of innovation, the waste management system in Matekan Village is still traditional and unstructured. Household waste is generally collected independently by residents in the absence of a scheduled transportation system or integrated processing facilities. The unavailability of landfills (TPAs) and waste banks causes people to rely on open burning methods or disposal on vacant land as the fastest alternative. This practice has been going on for quite a long time and is considered a common habit in daily life. This condition shows that there are limited facilities and low access to waste management technology that is more environmentally friendly.

In composition, the waste produced by the community is dominated by organic waste such as food scraps and leaves, as well as inorganic waste in the form of plastic packaging and paper. Without a sorting process, all types of waste are burned at the same time. This open burning produces thick, dark-colored smoke that spreads to the surrounding environment, especially in the morning and evening. The impact felt by the community includes mild respiratory disorders, bad odors, and decreased environmental comfort. In addition, incomplete combustion leaves residues in the form of charcoal and melted plastic, so it does not completely reduce the volume of waste.

From an environmental aspect, the practice of open burning has the potential to increase the emission of harmful particles and gases that can pollute the air. Socially, this condition also causes potential conflicts between residents due to the spread of smoke to other residential areas. The reliance on conventional methods shows the need for more controlled and sustainable technological innovation-based interventions. These initial findings became the basis for designing solutions that were in accordance with the social conditions and technical capabilities of the village community.

Design and Technical Specifications of Minimum Smoke Incinerator

The design of the low-smoke incinerator is carried out through an appropriate technological approach that adjusts to the needs and capacity of the village. The design

of the appliance prioritizes a closed combustion system to optimize the oxidation process and minimize the release of fumes into the environment. The main structure consists of a primary combustion chamber, a secondary combustion chamber, an air duct, an exhaust chimney, and a fuel control door. The material used is a heat-resistant steel plate with a supporting iron frame to maintain the stability of the structure when high temperatures are reached. The selection of materials takes into account aspects of durability, local availability, and cost efficiency.

The air circulation system is the main component in reducing smoke emissions. Primary air is flowed from the bottom of the combustion chamber to support the primary combustion process, while secondary air is channeled at the top to re-ignite smoke particles that have not been fully oxidized. This two-stage combustion concept aims to increase the efficiency of reducing waste volume and reducing emission intensity. In addition, the chimney is designed at a certain height so that the airflow remains stable and does not spread directly to the area around the settlement.

The capacity of the incinerator is adjusted to the average daily volume of waste in the community. In a single combustion cycle, the device is able to hold an adequate amount of waste for the scale of a small community. The combustion process lasts for a relatively short duration because the temperature of the combustion chamber can increase steadily. This simple but controlled design makes the incinerator easy to operate by the community after going through a short socialization and training stage.

Implementation and Operational Tests

The implementation stage began with socialization activities regarding the importance of waste sorting and the working principles of incinerators. The public is given an understanding of the difference between open combustion and a more efficient closed system. The involvement of residents in the process of assembling equipment is part of the empowerment strategy to create a sense of ownership of the facilities being built. This participation also aims to ensure the long-term sustainability of the use of the tool.

Operational tests are carried out by including waste that has been sorted, especially dry waste that is flammable. The results of the observations show that the combustion takes place more stable than the conventional method. The smoke produced looks thinner and disperses quickly, without causing excessive pungent odors. The temperature in the combustion chamber gradually increases until it reaches optimal conditions for the perfect oxidation process.

In terms of efficiency, the volume of waste is significantly reduced after one combustion cycle. The remaining residue is in the form of much less ash than open combustion. This process shows that low-smoke incinerators are able to increase the effectiveness of waste reduction while reducing the impact of air pollution on the village scale. These results indicate that this innovation is feasible to be applied as an alternative solution to local waste management.

Environmental Impact and Community Participation

The implementation of a low-smoke incinerator provides a real change to the surrounding environmental conditions. The reduction in smoke intensity during the combustion process is the main indicator of the success of this innovation. The residential environment became cleaner and no longer filled with thick smoke as before. In addition, the reduction of combustion residue also minimizes the potential

for soil pollution due to plastic waste or materials that do not burn completely.

From a social perspective, this innovation increases public awareness of the importance of more responsible waste management. Residents began to do simple sorting before burning, so that the operational process became more effective. The involvement of village officials in the supervision and management of the schedule of use of the tools strengthens the community-based governance system. This shows that technology designed according to local needs is easier to accept and adopt by the community.

However, there are several limitations that need to be considered, such as limited combustion capacity and the need for regular monitoring to maintain temperature stability. Further development can be directed towards the improvement of additional filtration systems and the expansion of combustion chamber capacity to be able to handle larger volumes of waste. Overall, the results of the study show that the low-smoke incinerator innovation is effective in supporting the reduction of sustainable waste accumulation in Matekan Village, Besuk Probolinggo and has the potential to be replicated in areas with similar characteristics.

Documentation of Design, Build Results and Trials

Documentation of activities is an important part of ensuring that the design process and implementation of the incinerator runs systematically and measurably. In the initial stage, three alternative construction designs based on heat-resistant bricks as combustion chamber structures were prepared. The first design used a single combustion chamber configuration with a simple vertical chimney. The second design developed a two-combustion chamber system to improve the efficiency of smoke oxidation. The third design is a refinement of the previous design with the addition of a secondary air path and the reinforcement of the inner layer using heat-resistant bricks to maintain temperature stability. The three designs are documented in the form of working drawings, airflow schemes, and construction stages as a technical reference for development.

Figure 1 Planning Process

At the realization stage, the third design was chosen because it was considered the most effective in supporting perfect combustion and minimizing smoke emissions. The construction process was carried out in stages starting from the preparation of the

foundation, the installation of the fire room bricks, the installation of chimneys, to the installation of control doors and air ducts. The documentation shows that the brick structure provides good heat resistance and maintains temperature stability in the combustion chamber. Visually, the construction looks sturdy and is able to accommodate the volume of waste according to the planned capacity. This documentation also serves as evaluation material for future design improvements.

Figure 2 Realization Stage

Operational trials are carried out to assess the performance of each design component. The test results showed that the two-stage combustion system in the final design was able to produce thinner smoke than the original design. The volume of waste is significantly reduced after one combustion cycle, and the residue remains in the form of a minimal amount of ash. The test documentation includes visual observations of the smoke intensity, combustion duration, and combustion chamber temperature stability. Overall, the design documentation, construction results, and trials show that the use of heat-resistant brick structures with controlled air circulation systems is effective in supporting the sustainable reduction of waste accumulation at the village level.

Figure 2 Operational trials

CONCLUSION

Based on the results of the study, the low-smoke incinerator innovation has proven to be effective as an appropriate technological solution in reducing waste accumulation in Matekan Village, Besuk District, Probolinggo Regency. A closed combustion system with air circulation regulation is able to increase combustion efficiency and reduce smoke intensity compared to the open combustion method previously used by the public. A significant reduction in waste volume occurs in each combustion cycle, with less residue and a lower air pollution impact. This shows that the application of simple but controlled technology can make a real contribution to improving the quality of the village environment.

In addition to providing technical benefits, the implementation of incinerators also encourages increased awareness and community participation in waste management. The involvement of residents in the design and operation process of the equipment strengthens the sense of collective responsibility for environmental cleanliness. Although it still has limitations in capacity and advanced filtration systems, this innovation shows the potential to be developed and replicated in other regions with similar characteristics as a community-based sustainable waste management model.

REFERENCES

Prayoga, W. B., Manullang, N. A., & Rajib, R. K. (2024). Public Health in Environmental Damage: Efforts to Overcome Pollution in Environmental Damage and Biodiversity in Jakarta. *Scientific Journal of Education*, *10*(24.2), 810–817.

Putri, A. M., Sudrajat, A., Hadzami, F. A., Razak, G. R., & Muna, N. (2025). Analysis of the influence of human development index and population on the generation of plastic waste in Indonesia. *Triwikrama: Journal of Social Sciences*, *10*(4), 41–50.

Ramadhani, Y. K. I., Muslim, M. I., Rosadi, A. H., & Fadillah, N. A. (2025). *Towards a clean environment and empowered communities through incinerator-based waste management in the village*. Publisher Footprint CV.

Rokilah, R., Jannah, A. W., Leonardo, D., & Suryani, P. S. (2025). Sustainable Waste Management Model for the Prevention of Environmental Impacts on Drainage

and Water Sources. *National Seminar on Community Service*, *2*, 469–477.

Saputra, D. (2025). Community Empowerment in Community-Based Government Policies for Household Waste Management in Parepare City. *Journal of Community Service*, *1*(1), 23–35.

Takari, D., & Subagio, M. S. (2025). *Village Development Economics and Agroecotechnology: Synergy of Village Independence and Sustainability*. Deepublish.