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Utilization of Renewable Emission Neutral Garbage Solution Equipment (RENGSE) as Waste Management Technology in Mekar Jaya Village

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ABSTRACT

Background: This article presents the application of environmentally friendly renewable waste technology called RENGSE in Mekar Jaya Village, Tangerang Regency as part of a technology-based community service program.
Contribution: The initiative to create and operate RENGSE for the management of various types of waste (organic and non-organic) based on thermal combustion that is specifically designed so as not to produce harmful emissions.
Method: The methodology used is Participatory Action Research (PAR) with stages including counseling, technology operation training, mentoring and direct practice, as well as monitoring and evaluation.
Results: The results obtained from this service activity are that the use of RENGSE equipment in Mekar Jaya Village shows good technical performance, with an average combustion capacity of 95-100 kg/hour and an operational time of around 8 hours/day. For 30 days, this tool is able to process about 24 tons of waste. From the social side, there has been a significant change in people's behavior patterns, where households that sort waste have increased from 10% to 68%.
Conclusion: RENGSE utilization activities have succeeded in increasing the effectiveness of waste management in Mekar Jaya Village technically and socially with 87% positive responses. The application of this technology can be said to be efficient in reducing the volume of waste because it is able to reduce up to 70% of waste to landfills, as well as encourage changes in community behavior towards more responsible, independent, and sustainable waste management.

1. Introduction

The waste problem in Indonesia is one of the environmental issues that requires serious attention. Based on data from the National Waste Management Information System (SIPSN), the total waste generation from 317 districts/cities in Indonesia in 2024 will reach around 34.2 million tons [1]. Judging from the type, most of the waste consists of food waste as much as 39.25%, followed by plastic waste at 19.73%. Meanwhile, in terms of origin of generation, households are the largest contributor with a contribution of around 54.74% [2]. One of the main factors that causes the waste problem is the increase in population [3]. If not balanced with an adequate waste management system, this condition can result in environmental pollution and have a bad impact on public health.

Tangerang Regency is one of the regions in Indonesia that is still struggling to overcome waste management problems [4], [5]. According to population and employment data in 2024 published by the Population and Civil Registration Office of Tangerang Regency, the population of this region has reached 3.309 million people in 2024 [6]. This figure is certainly in line with the increase in the amount of waste produced. Waste problems in Tangerang Regency include an increase in the volume of waste, a lack of recycling practices, and limited capacity of Final Disposal Sites (TPA) [7].

The rapid population growth and economic activity in this region have added pressure to the existing waste management system [8]. One of the main obstacles is the limited capacity of the Jatiwaringin Landfill located in Mauk District. This 31-hectare landfill accommodates waste from 29 sub-districts, with a volume of around 1,300 tons per day, which causes excess capacity and interferes with its function [9]. This condition triggers various negative impacts, such as environmental pollution, floods, the spread of infectious diseases, and respiratory health disorders that are troubling the surrounding community [10].

The waste problem can be overcome by encouraging active community involvement through education on the importance of the 3R (Reduce, Reuse, Recycle) principle [11]. Counseling to the community has an important role [12] in increasing awareness of the importance of sorting waste from the source [13], [14]. The issue of waste management has become a crucial environmental problem, not only in urban areas but also in rural areas [15]. Mekar Jaya Village, Sepatan District, Tangerang Regency, which is experiencing rapid population growth, is also faced with challenges in managing household and domestic waste. Today, waste management in the region still relies on traditional methods, such as landfill and open incineration, which are not only inefficient, but also have the potential to have adverse impacts on health and the environment.

In response to these conditions, the Community Service (PKM) team seeks to present solutions through educational and applicative activities in the community. This program includes counseling and hands-on practice on more efficient and environmentally friendly waste management, accompanied by intensive assistance from the PKM team in the application of appropriate technology. Assistance is carried out from the manufacturing stage to the use of tools, with the aim of increasing citizens' awareness of the importance of sustainable waste management [16], [17]. The technology applied is in the form of a modern incinerator, which is a waste processing device designed with special features to accelerate the decomposition process of waste materials [18]. Based on various previous studies, the use of incinerators has been proven to be able to optimize waste management at the household and environmental levels [19], [20], as well as reducing the volume of waste sent to landfills. In

addition to improving management efficiency [21], this tool also has the potential to produce derivative products in the form of organic fertilizers (ash) [22] that are beneficial for agriculture and regional greening.

As an innovative step, this environmentally friendly incinerator technology is further developed from the previous version, namely the Rocket Eco Stove Incinerator (REST-I), which still has limitations in controlling smoke emissions [7]. Therefore, in this PKM activity, an improved version called Renewable Emission Neutral Garbage Solution Equipment (RENGSE) was developed. RENGSE is a thermal combustion-based waste treatment system designed to significantly reduce harmful emissions [23], as well as minimize health risks to the surrounding community [24], [25]. Through the application of RENGSE technology in Mekar Jaya Village, this service activity is expected to not only be able to become an alternative solution for waste management in accordance with local characteristics, but also make a real contribution to environmental conservation and strengthening the ecological awareness of the village community.

2. Method

The method of implementing this program is prepared systematically and participially, so that the main goal of service can be achieved optimally [26]. In this case, the PKM team uses Participatory Action Research (PAR) as the main approach in the implementation of activities. The PAR method was chosen because it emphasizes the active involvement of the community in every stage of activities, starting from planning, implementation, to evaluation. Through this approach, the people of Mekar Jaya Village not only become the object of activities, but also play a role as subjects who contribute directly to the process of identifying problems, making decisions, and implementing solutions that are relevant to local needs. This approach encourages a co-learning process between the implementation team and the community, strengthens a sense of belonging, and ensures the sustainability of program results after PKM activities end. The implementation consists of four main stages, namely:

a. Counselling

The initial stage of this activity is counseling to the residents of Mekar Jaya Village about the existing waste problem and the negative impact caused by an improper management system. This counseling aims to increase public understanding [27] regarding the importance of sustainable waste management and introduce the 3R concept. The material presented included environmental issues, potential dangers from open burning, and the importance of separating waste from sources. Counseling is carried out through presentation media, interactive discussions, and question and answer sessions so that the community is more active and involved in understanding problem [28], [29].

b. Technology Operation Training

After the counseling, the community was given technical training on the use of the RENGSE tool. This training includes an introduction to the main components of the tool, standard operating procedures (SOPs), and safety aspects in the use of incinerators. The trainees were directly involved in the demonstration of the use of the tool, both in the preparation, operation, and post-combustion process stages. The goal is for the community to

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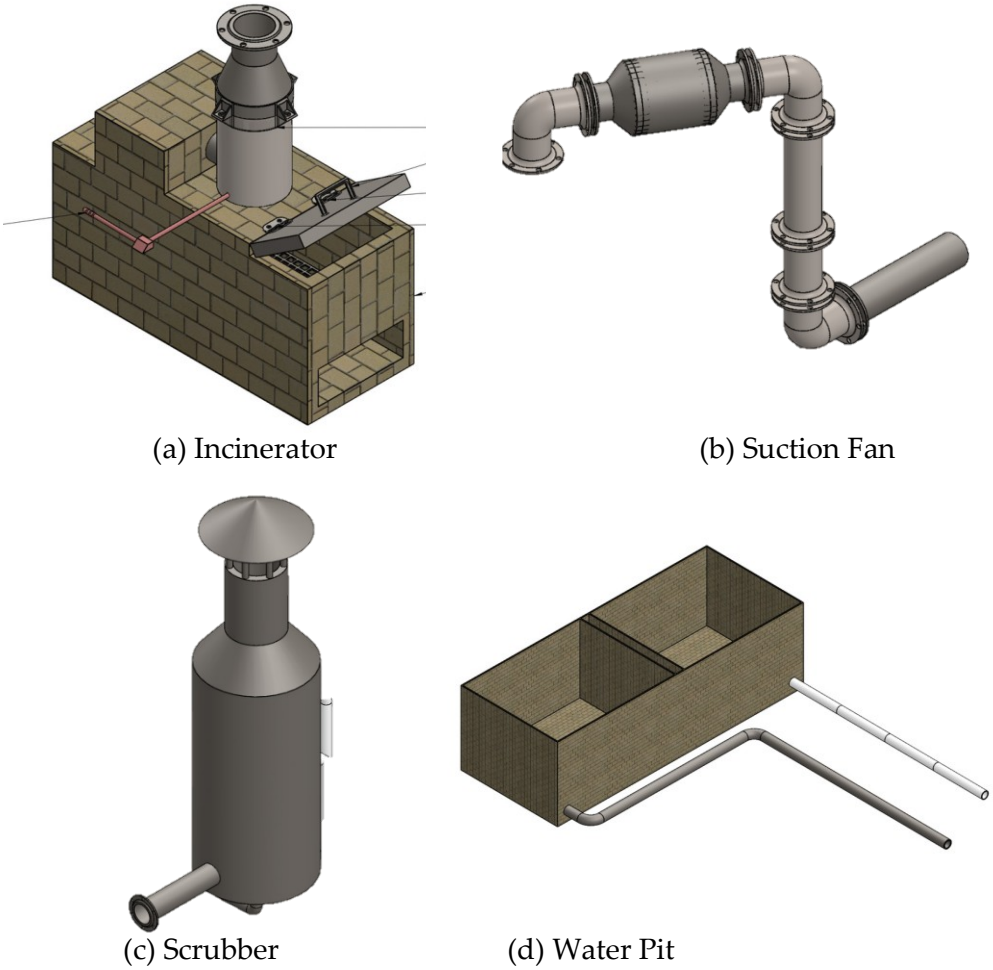
have enough technical skills to operate the tool independently without dependence on the implementation team.

As shown in Figure 1, RENGSE consists of four main components, namely: (a) incinerator, (b) suction fan, (c) scrubber, and (d) water pit. The incinerator component serves as the main incinerator chamber where the waste is treated through a controlled combustion process. Furthermore, the suction fan plays a role in draining the combustion smoke to the scrubber by sucking and regulating air circulation. Scrubber functions as an air filtration system that purifies smoke using activated carbon media, then the smoke is sprayed with water to reduce particulate matter and reduce emissions. Finally, the water pit acts as a container as well as a filter for wastewater from the scrubber process, where the water will undergo a follow-up filtration process to keep it from polluting the environment.



(a) Incinerator (b) Suction Fan

(c) Scrubber (d) Water Pit

Figure 1. RENGSE technology components

c. Mentoring in Direct Practice

As a form of strengthening of counseling and training materials, direct assistance was provided by the PKM team in the practice of waste management using RENGSE in the community. In this stage, the community is directed to implement the knowledge that has been obtained in real terms, starting from the collection, sorting, to the process of burning and utilizing residues (ash) as organic fertilizers. This assistance is collaborative, where the team

also assists the equipment maintenance process and helps the community prepare a schedule for the use of the tool in rotation at the RT/RW level.

d. Monitoring and Evaluation

The entire process will be evaluated periodically through direct observation, interviews, and quantitative and qualitative data collection regarding technology effectiveness, community engagement, and environmental impact. This evaluation was carried out not only to measure the success of the implementation of RENGSE technology, but also to understand the social dynamics of the community in dealing with changes in waste management patterns. The evaluation instruments include questionnaires, field notes, visual documentation, and quality tests of processed products (such as combustion residues in the form of ash and water).

In addition, monitoring was also carried out on the amount of waste that was successfully processed, the frequency of use of tools, and the level of citizen participation in the sorting and operation of tools. The results of this evaluation are the basis for continuous improvement and development of the program, both in terms of technical tools, educational strategies, and collaboration models between the PKM team, the village government, and the community. This evaluation is also used as a reference in the preparation of local policy recommendations and the development of replication models to other villages that experience similar challenges in waste management.

3. Results and Discussion

Before the PKM activities in Mekar Jaya Village, the waste problem was an issue that had not been handled optimally. People generally still use traditional methods in managing waste, such as burning garbage openly or piling it in the yard of the house. This method not only causes air pollution due to combustion fumes, but also increases the risk of health problems such as respiratory infections. In addition, the lack of understanding of the importance of waste sorting and the lack of proper waste management facilities makes the volume of household waste continue to increase without adequate handling.

The absence of an integrated waste management system also causes piles of garbage to often be seen around residential environments, especially in areas far from access to garbage transportation services. This is exacerbated by the low public awareness of the importance of the 3R (Reduce, Reuse, Recycle) principle, so that most organic and inorganic waste is mixed without sorting. This condition has an impact on the quality of the village community's environment which is slowly declining, especially in the aspects of cleanliness, comfort, and health.

The application of RENGSE technology has gone well as planned, as seen in Figure 2. The local community responded positively to the procurement of RENGSE. Awareness of the importance of waste management has also increased significantly, marked by the involvement of residents in training, participation in waste sorting, and enthusiasm in operating the tool in turn. Although the implementation went smoothly, there were several obstacles faced in the field, such as: the supply of waste that had not been properly sorted and the limitation of human resources (HR) who routinely operated the equipment. These obstacles are important evaluations in the context of future program development. The PKM team together with the village are committed to overcoming these challenges through advanced training, technical improvements, and continuous socialization so that the community can manage RENGSE independently and sustainably.

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Figure 2. RENGSE completed installation result

3.1. Application of Technology

The application of technology is the process of implementing the results of innovations or technical findings into real practice in order to solve problems and improve the efficiency of human activities. The application of the technology in question is the manufacture and operation of RENGSE as a tool to process waste more effectively, environmentally friendly, and sustainable. Where the tool works in three stages as follows: (a) ignition, (b) smoke treatment, and (c) water treatment.

At the ignition stage, the waste will be burned manually in the incinerator. Before the combustion process begins, the suction fan must be switched on first to ensure airflow into the appliance through the incinerator door. This air functions to support the optimal combustion process and maintain air circulation in the combustion chamber. During combustion, the smoke generated will be drawn by the suction fan and passed through the pipe to the scrubber unit. The scrubber functions to filter and neutralize exhaust gases so that the emissions released into the environment become more friendly and in accordance with set environmental standards.

Furthermore, at the smoke treatment stage, the smoke drawn by the suction fan will be directed into the scrubber. Inside the scrubber, the smoke first passes through a layer of activated carbon that serves to absorb heavy metals and solid particles contained in the combustion smoke. After going through the filtration stage, the smoke will be sprayed with a splash of water to lower the temperature. This process not only helps to cool the smoke, but also converts some of its contents into a liquid form. The condensed liquid will then be collected at the bottom of the scrubber and then flowed to the water pit for further processing. Meanwhile, the smoke that has gone through the filtering and cooling process will be released into the air through the exhaust chimney in a cleaner and more environmentally friendly condition.

The third stage (water treatment), is a stage where the water that settles at the bottom of the scrubber, the result of the cooling and smoke condensation process, is then transferred to

the water pit. This water pit serves as a temporary reservoir for combustion wastewater. Inside the water pit, the wastewater will undergo a filtration process to remove dirt and remaining particles, resulting in clearer and safer water for the environment before being disposed of or reused.

3.2. Comparison of RENGSE vs REST-I

A good incinerator is designed by minimizing negative impacts on the environment and ensuring that the combustion process takes place efficiently, safely, and sustainably [30]. The main principle is to destroy waste perfectly while controlling exhaust emissions and making optimal use of combustion results [31]. This incinerator must have a high combustion efficiency, with an ideal temperature between 800–1,200°C so that all organic materials burn perfectly without creating thick smoke or strong odors. In addition, these devices must be equipped with emission control systems such as scrubbers and activated carbon filters to capture harmful particles, fine dust, and toxic compounds (e.g., dioxins and furans) before the exhaust gases are released into the air.

A good incinerator design also pays attention to the multi-chamber structure, where the primary combustion chamber is used to crush solid waste and the secondary chamber ensures that the combustion gas is perfectly burned. The constituent material must be resistant to heat and corrosion so that the tool is durable and safe to use in the long term. In terms of energy efficiency, modern incinerators are able to utilize the heat from combustion for other purposes such as drying organic matter, heating water, or even electrical energy sources (waste-to-energy) [32]. Chemically safe combustion ash can be reprocessed into mixed paving blocks or light construction materials, so as not to add new waste loads.

In addition, environmental safety and social aspects are also an important part of designing a good incinerator [33]. This appliance must be tightly closed, equipped with temperature sensors and an automatic control system to prevent smoke leakage or fire risk, and not cause disturbances to the surrounding community. In REST-I, aspects related to a good incinerator cannot be fully fulfilled because REST-I uses the main component in the form of hebel (light brick) which has limitations to high heat resistance and structural stability. Hebel material tends to crack or undergo deformation if exposed to temperatures above 800°C continuously, so that combustion efficiency is less than optimal and the tool life is relatively shorter.

In addition, REST-I is not equipped with an integrated emission control system such as a scrubber or activated carbon filter, so the smoke from combustion still has the potential to contain fine particles and exhaust gases that are less environmentally friendly. The combustion chamber system is also still single-chamber, which makes the oxidation process of combustion gas imperfect. Although REST-I is quite effective for small scales such as households, schools, or educational activities, from a technical and environmental point of view, further development is still needed to meet the standards of good incinerators. In contrast, in RENGSE technology, these weaknesses have been overcome by the use of heat-resistant materials (firebricks and thick iron plates), multi-chamber design, as well as activated carbon scrubber and water spray systems that are able to reduce harmful emissions to close to zero. RENGSE is also equipped with liquid water pit treatment to prevent secondary pollution.

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3.3. Advantages and Disadvantages of RENGSE

Speaking of the advantages and disadvantages of RENGSE, it is important to look at it from a technical, environmental, and socio-economic perspective in order for the assessment to be more comprehensive, as illustrated in Table 1, below.

Table 1. Advantages and Disadvantages of RENGSE

Aspect	Advantages	Disadvantages
Environment	▪ Environmentally friendly, reducing harmful gas emissions through scrubber and water pit systems. ▪ Reduce air and water pollution.	Liquid waste from scrubbers needs further treatment so as not to cause harmful residues.
Waste Processing Efficiency	▪ Reduce the volume of waste by 60–70%. ▪ Able to process residues that are difficult to handle conventional methods.	Processing capacity is limited for large scale (villages are more ideal than cities).
Economic Benefits	▪ Producing derivative products such as liquid fertilizers and ash for building materials. ▪ Supporting the concept of circular economy in society.	The initial cost of manufacturing and installing the unit is relatively high.
Operations and Maintenance	▪ Simple mechanical system, easy to operate by the community after training. ▪ Energy consumption is relatively low.	Regular maintenance is required on activated carbon filters and water filters.
Community Engagement	▪ Encourage active participation of residents in waste management and recycling business development. ▪ Increasing community environmental awareness.	Requires ongoing technical assistance to maintain consistency of use and maintenance.
Replication and Scalability	▪ Can be adjusted to local needs (small to medium scale). ▪ Potential to be used as a model for an independent village for waste management.	Technology adaptation in new locations requires initial study and design adjustments.

3.4. Result Achieved

As seen in Table 2, after the process of making and operating RENGSE technology in Mekar Jaya Village, there was a significant increase in public awareness regarding the

importance of sustainable waste management. The community is beginning to understand the negative impacts of an uncontrolled waste management system, such as environmental pollution, health problems, and potential damage to local ecosystems. Through educational approaches and hands-on practice, residents become more involved [34] in the process of sorting and processing waste in their environment. One of the main results of this activity is the successful application of appropriate technology in the form of RENGSE incinerators as an effective, efficient, and environmentally friendly waste management solution. This technology has been tested and proven to be able to significantly reduce the volume of waste. 1 (one) RENGSE incinerator unit has a combustion capacity of up to 100 (one hundred) kg per hour. Assuming an operational working time of 10 (ten) hours per day, this tool is able to eliminate around 1 (one) ton of waste per day, so it has great potential to be applied in areas with a high volume of household waste.

As seen in Figure 3, as part of the sustainability of the program, the service team also compiled complete technical documentation in the form of the RENGSE Manual Book, which is a technical guide on how to assemble, operate, and maintain the tool. This handbook is given to the village government and the local community so that they can manage and maintain the equipment independently without being fully dependent on the proposing team. In addition, intensive technical training has also been provided to the designated citizen representatives, so that they now have basic competencies in the management of the equipment and are ready to play a role in similar programs in the future. The results of this activity have also been documented in the form of activity reports and are being processed to be published as scientific articles that can be used as a reference by academics, government agencies, and civil society organizations who have concerns about waste management issues. This activity not only provides short-term solutions to environmental problems in Mekar Jaya Village, but also opens up wider collaborative opportunities to duplicate these good practices in other areas that face similar challenges.

Table 2. Achievements of RENGSE utilization activities

Indicator	Access
Number of RENGSE units	1 unit (capacity ±100 kg/hour)
Total waste that has been processed (30 days)	± 24 ton
Number of households involved	160 households from 3 RTs (about 65% of the population of the trial area)
Number of people trained	28 people (operators, volunteers, environmental cadres)
Waste reduction to landfill	± 60–70% of the previous volume
Activity documentation	Manual Book, technical reports, and service articles (on process)
Advanced innovation	Testing of residual liquid waste as a medium liquid organic fertilizer material
Community response	Positively, 87% of respondents expressed satisfaction and supported the continuation of the program

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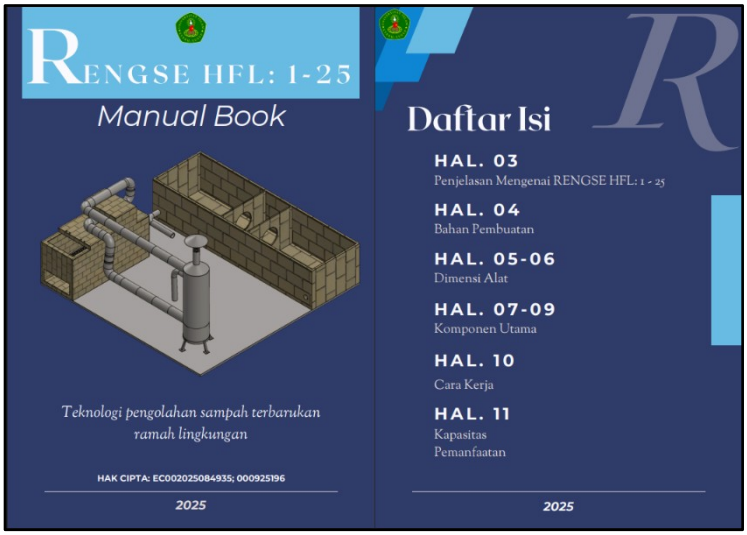

Figure 3. RENGSE Manual Book

Figure 4. RENGSE launch attended by the regent of Tangerang Regency

3.5. Next Stage Plan

After the manufacturing and operation of the RENGSE tool in Mekar Jaya Village, the next step is to carry out routine maintenance and monitoring to ensure that the tool continues to work optimally. This activity involves the active role of the village government and residents, which is scheduled regularly so that the monitoring system runs consistently. As part of the sustainability of the program, the community will also receive advanced training to deepen their skills in terms of maintenance, operation of equipment, and waste sorting according to their type. This approach aims to encourage the independence of village communities in sustainable waste management. The successful implementation of RENGSE technology is expected to be a model for other regions facing similar problems. Therefore, a plan to develop the program to other areas experiencing a waste crisis will be proposed.

As seen in Figure 4, after the program runs for a certain period of time, a thorough evaluation will be conducted to assess the effectiveness of the tools and the overall approach of the program. This evaluation includes testing the residue from combustion, which has the potential to be used as a liquid fertilizer. If weaknesses are found, both from the technical aspect and the extension strategy to the community, improvements will be made. In order to ensure the sustainability of the program, the PKM team collaborated [35] with the village

government and various external parties, such as universities, research institutions, and local governments. This collaboration includes support in the form of funding, ongoing training, and laboratory testing of residue products, to ensure that the technology used remains safe, efficient, and environmentally friendly.

4. Conclusion

RENGSE utilization activities have succeeded in increasing the effectiveness of waste management in Mekar Jaya Village technically and socially. The application of this technology can be said to be efficient in reducing the volume of waste because it is able to reduce up to 70% of waste to landfills, as well as encourage changes in community behavior towards more responsible, independent, and sustainable waste management. The active involvement of the community in the operation of the equipment and the increase in awareness of waste sorting and management indicate a transformation of environmental culture at the community level. However, there are still limitations in the aspect of laboratory tests on the content of liquid fertilizer elements processed by RENGSE. Therefore, further research is needed to improve and verify the quality of processed products, so that this technology can be used more optimally and sustainably.

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