Socialization of trials smelter machine for making paving blocks from waste in plastic Dawuan village, Tengah Tani district

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Abstract. Plastic waste management remains a critical challenge in global environmental preservation. In response to this issue, an innovative smelter machine was developed to convert plastic waste into eco-friendly paving blocks. This community service program was implemented in Dawuan Village, Tengah Tani District, with the aim of empowering local residents through hands-on training and the application of appropriate technology. The program followed three key stages: preparation, implementation, and monitoring and evaluation. A total of twenty participants engaged in the training and evaluation process. The results demonstrated a significant improvement in participants' knowledge and skills, with moderate learning gains observed across the group. The intervention was found to be particularly effective for participants with limited prior knowledge. Moreover, the program was conducted with high levels of community engagement and enthusiasm. Beyond enhancing environmental awareness, the initiative created tangible economic opportunities by enabling local production of durable paving blocks. This appropriate technology not only supports plastic waste reduction but also contributes to improving the quality of life within the community. The success of this program highlights the potential of localized technological solutions in addressing environmental challenges and fostering sustainable community development.

1 Introduction

Plastic waste is one of the major contributors to environmental pollution in many parts of the world. Efforts to recycle and reuse plastic often face significant challenges due to the complex nature of plastic materials. Plastic waste is a synthetic material that is notoriously difficult to degrade naturally. According to research, plastics can persist in the environment for hundreds of years without undergoing significant degradation [1]. Plastics are composed of polymers—long chains of interlinked atoms—that form repeating molecular units known as monomers. The term "plastic" generally refers to synthetic polymers, although some

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natural polymers also exhibit plastic properties. Resins, produced through organic condensation or polymer addition processes, may also incorporate other substances to create economically viable plastic products.

The accumulation of plastic waste poses a serious threat to soil, water resources, and even the food chain [2]. A major factor contributing to this pollution is the fact that nearly 50% of all plastics produced globally are designed for single-use applications [3]. To guide consumers and industries in understanding plastic types and their recycling potential, plastics are classified by The Society of the Plastic Industry (SPI) according to their types and recycling codes [4].

Efforts to manage plastic waste generally follow three primary approaches: first, by replacing plastic bags with reusable cloth-based alternatives; second, by processing plastic waste using fabrication methods; and third, by promoting the use of biodegradable plastics [5]. In addition to these methods, an emerging approach is to process plastic waste into value-added products, such as paving blocks. Previous studies have shown that paving blocks made from plastic waste exhibit greater durability than conventional cement and soil-based paving materials [6], [7]. They offer improved resistance to pressure and water, making them suitable for various construction applications.

An innovative and practical solution for this process involves the use of smelter technology to convert plastic waste into paving blocks. The aim of the current program is to introduce and implement this technology at the community level, enabling the production of economically valuable products while simultaneously raising awareness about sustainable waste management practices.

The rapid growth in global plastic production has exacerbated the waste problem, necessitating creative solutions. Paving blocks made from plastic waste represent a promising partial solution to the environmental and ecological challenges posed by plastic pollution. Owing to the binding properties of plastic, it is well-suited for use in paving block construction [8]. The inherent properties of plastic materials make them particularly suitable for processing as raw material in this application [9].

In this context, the development of a melting system for converting plastic waste into paving blocks constitutes an important advancement in recycling and resource utilization. The primary objective of this community service program is to offer an appropriate technological solution for plastic waste management and to enhance the community's capacity to transform waste into economically valuable products. The smelter machine used in this program employs heating and molding technology to process plastic waste. The system heats the plastic to a controlled temperature, after which it is molded into paving blocks [10]. The machine also features a stirring mechanism to facilitate the melting and mixing process.

Based on several experimental results, it has been observed that the machine can melt approximately 3 kg of plastic combined with 2 liters of used oil within one hour. Each paving block produced using this method is estimated to reduce plastic waste by 0.3 kg per unit. The resulting paving blocks can achieve a compressive strength of up to 230 kg/cm^2, which is competitive with, and in some cases superior to, traditional paving blocks made from sand-cement mixtures [11]. With these specifications, the smelter machine presents an effective solution for producing strong and durable paving blocks from plastic waste.

2 Methodology

The community service activities were conducted at the Dawuan Village landfill, located in Tengah Tani District, on January 14–15, 2025. The program involved the participation of village officials, members of the village headquarters, and local residents of Dawuan Village. The series of activities in this community service included six main stages: preparation of activities, socialization and education, collection and sorting of plastic waste, plastic waste processing, production of paving blocks, and finally, the evaluation of the entire program.

This community service employed the Participatory Rural Appraisal (PRA) method, a participatory approach designed to ensure that the local community is not merely the object of intervention but plays an active role in identifying problems, exploring potentials, and implementing solutions to improve plastic waste management. The PRA method encourages community empowerment through continuous involvement during all phases of the program: preparation, implementation, and monitoring and evaluation.

2.1 Preparation

The preparation phase began with a field survey at the Dawuan Village landfill. The primary aim of this survey was to identify the dominant types and volume of waste, particularly focusing on plastic waste with potential for recycling into paving blocks. The research team conducted interviews with village officials and community members to explore existing waste management practices and identify the key challenges faced by the community.

Simultaneously, coordination meetings were held with village government officials, community groups, and the local environmental agency to establish partnerships and promote collaborative planning. An implementation team was then formed, comprising waste management experts from the university, smelter machine technicians, Community Service Program (KKN) students, and representatives from the local community.

In preparation for the practical activities, a smelter machine was procured and installed at the landfill site. The necessary supporting materials—including cement, sand, and molds for paving block production—were also prepared. In addition, the research team developed training modules and socialization materials to guide the upcoming technical and educational sessions.

2.2 Implementation

The implementation phase began with a three-hour socialization and education session, attended by 20 community representatives. During this session, participants were introduced to the environmental and health impacts of unmanaged landfill waste and were familiarized with the concept of a circular economy, emphasizing how plastic waste can be repurposed into economically valuable products such as paving blocks. The educational session employed interactive lectures, group discussions, and visual aids such as infographics and video demonstrations of the paving block production process.

Following the socialization, technical training sessions were conducted. Participants learned to identify and sort suitable plastic waste, as well as the cleaning and preparation techniques required for optimal material processing. Subsequently, training on the operation of the smelter machine was provided, covering both operational principles and safety protocols. Participants engaged in hands-on practice of the plastic melting process and the mixing of materials in a ratio of 1 part cement, 2 parts sand, and 3 parts plastic waste.

The training culminated in a trial production session where participants were divided into groups responsible for various stages of the production process: sorting plastic waste, operating the smelter machine, and molding paving blocks. The collaborative effort resulted in the successful production of three variants of paving blocks with different material compositions. The entire process was carefully documented to serve as a reference for future community-led initiatives.

2.3 Monitoring and Evaluation

The monitoring and evaluation phase focused on two key dimensions: technical quality of the paving blocks and educational outcomes for participants. The quality of the paving blocks was evaluated through compressive strength testing, water resistance assessments, and visual inspections to identify density and surface defects such as cracks.

To assess changes in participant knowledge, the research team administered pre-test and post-test questionnaires. The analysis of knowledge gains was conducted using the Normalized Gain (N-Gain) formula, which provides a quantitative measure of learning improvement relative to the maximum possible score. The N-Gain formula is expressed as follows:

N-Gain=Spost−SpreS

$$\text{N Gain} = \frac{Spost - S\,pre}{S\,maks - S\,pre}$$

Information:

N Gain : Gain Normality
Test ValueSpost : Score Pre-Test
Spre : Score Post-test
S Maks : Score Maksimal

Tabel 1. Classification of gain normality values

No	Gain Normality Test Value	Criteria
1	$0{,}70 \leq n \leq 1{,}00$	High
2	$0{,}30 \leq n \leq 0{,}70$	Medium
3	$0{,}00 \leq n \leq 0{,}30$	Low

3 Results and Discussion

3.1 Activity preparation

The smelter machine used in this community service program was specifically designed to process plastic waste into raw material for paving block production. The machine consists of several key components that work in an integrated manner to ensure efficient and safe melting of plastic materials.

At the core of the system is a wood-fueled furnace, which serves as the primary heat source. This furnace provides a controlled and stable heat supply necessary to initiate the plastic melting process. Positioned above the main furnace is the plastic smelting chamber, where plastic waste is gradually melted under monitored temperatures. To assist with the melting process, the machine is equipped with a rotary lever. The lever allows operators to manually stir the melting plastic, ensuring an even distribution of heat. The ease of turning the rotary lever also serves as an indicator of the melting progress—once the plastic reaches the optimal molten state, the lever rotates with less resistance.

To improve the melting process, used oil is introduced through a dedicated injection port. The oil acts as a binding and lubricating agent, facilitating smoother melting and mixing of the plastic material. The machine is also designed with an inlet and exhaust funnel system to manage airflow and safely expel combustion gases generated during the process.

A steam reservoir, visually marked in yellow, is included to collect vapor produced during melting. Additionally, a white cooling pipe directs steam through a bucket filled with water, which helps to neutralize and reduce the temperature of the exhaust, preventing overheating and enhancing operational safety.

This integrated design not only allows for the efficient conversion of plastic waste into usable raw material for paving blocks but also prioritizes user safety and environmental considerations during operation.

Fig. 1. Smelter Machine Model

3.2 Activity implementation

3.1.1 Training and trial of smelter machines

The training phase began with an introduction to the operation of the wood-fueled smelter machine. The machine uses dry firewood sourced from non-resinous trees to minimize smoke production and maintain stable combustion. The controlled burning of firewood not only ensures consistent heating during the smelting process but also produces charcoal as a useful by-product.

Once the furnace reached optimal temperature, 1.3 kilograms of PET plastic was gradually introduced into the smelting chamber. To facilitate melting and mixing, 200 milliliters of used oil was added. The operational temperature was maintained at approximately 130°C during this phase. The melted plastic was continuously stirred using a rotary lever, which became noticeably easier to turn once the plastic reached a fully molten state, serving as a practical indicator for the operator. Upon achieving the desired consistency, the molten mixture was dispensed through the output mechanism into molds to form paving blocks.

Previous studies indicate that an optimal paving block mixture typically consists of 5 kilograms of HDPE plastic, 3 liters of used oil, and 2 kilograms of sand, processed at a temperature of 200°C, yielding approximately 8 liters of product per hour [13]. In this project, similar parameters were tested and adjusted according to the available materials and machine capacity.

Fig. 2. Used Oil Intake and Printing

The results of the machine trial demonstrated that the smelter is capable of efficiently melting plastic waste and producing paving blocks of high structural integrity. The paving blocks created were found to be suitable for various infrastructure applications, such as sidewalks and parking areas. Furthermore, the process significantly reduces the volume of plastic waste while simultaneously generating economic value for the local community through the production of a marketable product.

Durability tests showed that paving blocks manufactured from recycled plastic exhibited greater resistance to mechanical stress and weather exposure compared to conventional paving blocks. This innovation not only provides an environmentally friendly solution for managing plastic waste but also fosters new entrepreneurial opportunities within the community. However, the program also identified several challenges, including the need for further training to optimize the mixing process and standardize product quality, ensuring long-term sustainability and wider market acceptance [14], [15].

Fig. 3. Smelter Machine Trial

The results of this community service activity show that the Smelterment Machine can process various types of plastic waste into high-quality paving blocks. Durability tests show that plastic paving blocks are more resistant to pressure compared to conventional paving blocks. In addition, this technology significantly reduces the amount of plastic waste in the environment.

3.1.2 Demonstration and education on the use smelter machines

The demonstration and education sessions received an enthusiastic response from the community. Participants actively engaged in discussions and expressed numerous suggestions for expanding the application of this technology. During the sessions, emphasis was placed on the importance of occupational safety when operating the smelter machine. Given the high temperatures involved in the plastic melting process, participants were advised to use appropriate personal protective equipment (PPE), including heat-resistant gloves, boots, and to ensure adequate water supply on-site for cooling and emergency purposes.

Many trainees recognized the economic potential of the technology and its relevance in addressing the ongoing challenge of plastic waste in their village. Nevertheless, the demonstration also highlighted several practical considerations, such as the variability in plastic raw material availability and the need to carefully adjust temperature settings based on the type of plastic being processed. These factors must be managed to achieve consistent product quality and safe machine operation.

Fig. 4. Socialization and education on the use of Smelter machines

3.3 Monitoring and assistance on the use of smelter machine for paving block production

The monitoring and assistance activities conducted during this community service program were designed to enhance participants' understanding of the importance of managing plastic waste by transforming it into valuable products. This approach aimed to help the community reduce the potential risks of environmental pollution, improve local human resource capacity, and stimulate economic activities through waste-based entrepreneurship.

A total of 20 respondents participated in the program's evaluation phase. Their learning progress was assessed using a pre-test and post-test. The pre-test scores ranged from 11 to 20 out of a maximum score of 50. Following the intervention, post-test scores improved significantly, ranging from 27 to 30. To quantitatively measure the learning gains, Normalized Gain (N-Gain) values were calculated for each respondent. The resulting N-Gain scores ranged from 0.47 to 0.70, with an average of 0.62, which is classified as moderate effectiveness according to the standard categorization.

All participants showed positive N-Gain values, indicating that the intervention improved their understanding. However, no participant reached the high-effectiveness threshold (≥ 0.70). The respondent with the highest N-Gain score was Respondent 2 (0.70), while the lowest scores were recorded by Respondents 3 and 4 (0.47). Furthermore, analysis of score patterns revealed that participants who had lower initial pre-test scores (11–15) achieved higher N-Gain values compared to those who started with higher pre-test scores (18–20).

This finding suggests that the program was particularly effective for individuals with limited prior knowledge

Table 2. Community Satisfaction Score for Program Implementation

Responden	Pre test	post test	Score N gain	Criteria
1	13	27	0,64	medium
2	15	29	0,70	medium
3	18	26	0,47	medium
4	18	26	0,47	medium
5	16	28	0,63	medium
6	18	28	0,59	medium
7	15	28	0,65	medium
8	15	29	0,70	medium
9	20	30	0,67	medium
10	20	29	0,60	medium
11	19	28	0,56	medium
12	19	29	0,63	medium
13	15	28	0,65	medium
14	17	28	0,61	medium
15	11	27	0,67	medium
16	13	28	0,68	medium
17	15	27	0,60	medium
18	11	26	0,63	medium
19	20	29	0,60	medium
20	18	28	0,59	medium
Total	249,00	420,00	9,23	
Rata-rata	**16,60**	**28,00**	**0,62**	

Data source: primary data 2024

The results indicate that while the learning intervention was moderately effective, it did not yet achieve optimal outcomes. Several constraints were identified during the evaluation:

- Instructional limitations: The current training methods lacked advanced mechanisms to significantly accelerate learning among all participants.
- Ceiling effect: Participants who scored high on the pre-test (18–20) had less room for measurable improvement, which is a common limitation when assessing N-Gain.

Nonetheless, the overall improvement in knowledge demonstrates that the program effectively increased community awareness of plastic waste recycling and the operational use of the smelter machine.

Furthermore, evaluation of program success was not limited to knowledge gains alone. The assessment also considered participant engagement throughout all program stages—socialization, training, demonstration, monitoring, and assistance. One key success indicator was the level of community satisfaction with the smelter machine program and its potential to transform plastic waste into valuable paving blocks. Observations during the sessions reflected strong community enthusiasm and a willingness to adopt this technology for future economic and environmental benefits.

4 Conclusions

The results of this community service program demonstrate that the smelter machine is an effective and practical technology for transforming plastic waste into paving blocks of good structural quality. Beyond its technical feasibility, this innovation offers tangible economic and environmental benefits to the local community by promoting waste reduction, enhancing environmental awareness, and opening new income-generating opportunities. The training and assistance provided throughout the program resulted in measurable knowledge gains among participants, with the majority achieving moderate levels of learning improvement. The program proved particularly effective for individuals with limited prior knowledge, highlighting the importance of designing inclusive training strategies. However, several challenges remain, particularly regarding the need for continuous community training, refinement of production techniques, and the standardization of product quality to ensure long-term sustainability.

Overall, the development and application of appropriate technology—such as this smelter machine—represents an innovative solution to the plastic waste problem, while also contributing to broader goals of environmental conservation and community empowerment. With ongoing development and wider dissemination, this initiative holds the potential to significantly improve quality of life and promote sustainable practices within similar communities.

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