



Application of Appropriate Technology (TTG) for Processing Inorganic Waste at the Tasikmalaya Waste Bank (BST) in Singaparna District, Tasikmalaya Regency

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ARTICLE INFO

Article history

Received : 11-12-2024

Revised : 30-12-2024

Accepted : 02-01-2025

Keywords

Plastic recycling; plastic shredding machine; socialization and mentoring

ABSTRACT

The potential of plastic waste in Singaparna District, Tasikmalaya Regency, based on field observations, can reach up to 10 tons per month, with its utilization not yet optimal. The plastic waste collected at the Tasikmalaya Waste Bank (BST) typically consists of intact plastic bottles and cups. In addition to being used for handicrafts, the BST group sells it directly to plastic recycling factories at a price of IDR 8,000 per kg. According to their calculations, this price does not cover the operational costs of BST. Meanwhile, the price of plastic that has been shredded into granules can reach up to IDR 14,000 per kg. The Agricultural Tools and Machines Laboratory of the Department of Agricultural Engineering and Industrial Management at Padjadjaran University has developed a plastic shredding machine capable of reducing plastic to the smallest size with a sieve diameter of 14 mm, with a machine capacity of 30 kg/hour, which is expected to assist in addressing issues faced by the partners. The goal of this PKM (Community Service Program) activity is to assist the BST Tasikmalaya group in utilizing plastic waste, either as raw material for handicrafts or to be sold directly in the form of plastic granules. The implementation method for this activity includes the application of appropriate technology, specifically a plastic shredding machine in Singaparna District, Tasikmalaya Regency, which covers the production of the shredding machine, the application of the machine, socialization through lectures on utilizing plastic as a recyclable product to address waste problems, guidance and training on operating the plastic shredding machine, and maintenance procedures for the machine.

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A. INTRODUCTION

The Singaparna District is geographically located at 108° - 109° E and 60° - 70° S, with an elevation of 443 meters above sea level and an average annual rainfall of 1,310 mm. Singaparna District (Figure 1) is one of the districts in Tasikmalaya Regency, covering an area of 2,178.837 hectares. The land use distribution includes 1,140.349 hectares of built-up areas and 1,038.245 hectares of rice fields. Singaparna District is divided into 10 administrative regions, namely: Cikadongdong Village, Cikunir Village, Cintaraja Village, Cipakat Village, Sukamulya Village, Sukaasih Village, Singasari Village, Singaparna Village, Sukaherang Village, and Cikunten Village. (Badan Pusat Statistik Tasikmalaya, 2020).

The Singaparna District serves as the capital of Tasikmalaya Regency, West Java Province. The Singaparna District in Tasikmalaya Regency comprises 10 villages, with the distance between the villages and the Regency capital ranging from the shortest at 500 meters to the farthest at 6 kilometers..



Figure 1. Map of Singaparna District, Tasikmalaya Regency



Figure 2. Inorganic waste processing machine

Geographically, Singaparna District in Tasikmalaya Regency is bordered by:

- The north: Leuwisari District and Padakembang District.
- The east: Tasikmalaya City.
- The south: Sukarame District and Mangunreja District.
- The west: Cigalontang District.

In terms of livelihoods, the community in Singaparna District is predominantly composed of farmers and traders. Additionally, several waste bank managers in the area are continually developing, considering the potential of inorganic waste, which reaches



approximately 5 tons per month. However, the utilization of inorganic waste, particularly solid plastic waste, has not been optimized.

Therefore, our team proposes to implement appropriate technology for processing inorganic waste at the Tasikmalaya Waste Bank (BST) in Singaparna District, Tasikmalaya Regency. This technology has been developed at the Agricultural Equipment and Machinery Laboratory of FTIP UNPAD (Figure 2), with the hope of optimizing inorganic waste management among the partner groups.

B. LITERATURE REVIEW

1. Plastic

Plastic is a composite material or can be referred to as synthetic or semi-synthetic polymerization, resulting from organic condensation or polymer addition. It may also include other substances to enhance its added value (economic value). The formed polymer consists of long chains of atoms bonded together, creating a long chain (polymer) derived from monomers. (Azizay, 2004). Each type of plastic is designed with specific characteristics to meet particular needs, which is why plastic materials can be produced from various sources. The raw materials can come from fossil-based sources (crude oil, gas, etc.), renewable sources (sugarcane, starch, vegetable oils, etc.), or even mineral bases (salt), which are processed into natural polymers, synthetic polymers, or modified natural polymers to create plastic..

Since the discovery of semi-synthetic plastic in 1862 by Alexander Parkes, further developed for commercialization by John Wesley Hyatt in 1868, and later advanced into synthetic plastic by Leo Hendrik Baekeland in 1907, plastic has become the material of choice across various industries. Even today, its production continues to increase annually (Lintsen, H., Hollestelle, M., & Hölsgens, 2017). Since the discovery of plastic, traditional materials have gradually been replaced due to plastic's numerous advantages, including being lightweight, strong, easily molded or flexible, and affordable. However, these very characteristics have made plastic a significant environmental problem, as it is difficult to decompose and requires an exceptionally long time to undergo the recycling process. (Mahalik, N. P., & Nambiar, 2010)

Types of Plastic

Plastics are categorized into two main groups:

Thermoplastics

Thermoplastics are a category of plastics that melt when heated and harden when cooled. This process allows them to be reheated, reshaped, and solidified repeatedly as needed. Due to their moldability and recyclability, thermoplastics are commonly used in various packaging and container commodities. Examples of thermoplastics include: Polyethylene (PE), Polypropylene (PP), Polyvinyl Chloride (PVC), Polyethylene Terephthalate (PET), Polystyrene (PS), Expanded Polystyrene (EPS), Acrylonitrile Butadiene Styrene (ABS), Styrene Acrylonitrile (SAN), Polyamides (PA), Polycarbonate (PC), Poly Methyl Methacrylate (PMMA), Thermoplastic Elastomers (TPE), Polyarylsulfone (PSU), Fluoropolymers. Polyether Ether Ketone (PEEK), Polyoxymethylene (POM), Polybutylene Terephthalate (PBT) Ethylene Vinyl Alcohol (EVOH)

Thermosets

Thermosets are plastics that undergo a chemical change when heated, forming a three-dimensional network. Once heated and shaped, these plastics cannot be melted and reshaped. Examples of thermoset plastics include: Polyurethane (PUR), Unsaturated Polyesters, Epoxy Resins, Melamine Resin, Vinyl Esters, Silicone, Phenol Formaldehyde Resins, Urea, Formaldehyde Resins, Phenolic Resins, Acrylic Resins Thermoset plastics are less commonly

used due to their lower flexibility.

Classification of Recyclable Plastics

Currently, only thermoplastics are recyclable. Thermoplastic waste can be recycled due to its ability to melt when heated and harden when cooled, allowing it to be reshaped and reused multiple times. According to (Industry Molders Division The Society of the Plastics, 1998) and is divided into 7 categories, as presented in Table 1.

Table 1. Classification of Recyclable Plastics

No	Type	code Symbol	Explanation
1	<i>Polyethylene Terephthalate (PET)</i>		Single-use plastic, easy to recycle but with economic value – This type of plastic should not be exposed to hot water, as the polymer layer and carcinogenic substances in the plastic can dissolve. This symbol is commonly found on food and drink packaging.
2	<i>HighDensity Polyethylene (HDPE)</i>		Reusable plastic, recyclable with economic value – This symbol is typically found on milk bottles, soap bottles, packaging plastics, and gallons.
3	<i>Polyvinyl Chloride (PVC)</i>		Rigid plastic, difficult to recycle and toxic – This type of plastic should not be used for packaging. It is usually employed for protective items as it can withstand high pressure and impact, such as in water pipes, tiles, electrical cable protectors, toys, and more.
4	<i>Low Density Polyethylene (LDPE)</i>		Elastic plastic, durable, and reusable – This type of plastic is used in plastic bags (such as grocery bags), trash bags, and food wrappers.
5	<i>Polypropylene (PP)</i>		Strong plastic, safe at high temperatures – This type of plastic is commonly used for food and drink containers. However, it is difficult to recycle, so its use should be limited
6	<i>Polystyrene (PS) / Styrofoam</i>		This plastic is difficult to recycle and can release styrene (a carcinogenic substance) when exposed to heat. It is often used for food or drink containers..
7	<i>Other</i>		Plastic that doesn't fall into any of the other 6 categories – This type of plastic is not suitable for food or drink containers as it produces high levels of toxins. It is frequently found in baby bottles, sports drink bottles, cases, and Compact Discs (CDs).

The classification of plastics is done to facilitate processing, as these types of plastics are used for packaging both food and non-food products. This raises concerns about the increasing waste generated. The processing is part of a circular economy initiative aimed at extending the



lifespan of waste by transforming it into something useful. It can be repurposed as an alternative raw material or recycled into new products, helping to reduce production costs or creating new products with market value.(Badan POM, 2019).

Plastic Recycling Technology

The process of recycling plastic is carried out using plastic recovery technology, as outlined by the International Organization for Standardization (ISO) in the guidelines for the recovery and recycling of plastic waste. (ISO 15270, 2008) This can be carried out in 4 ways, as presented in Table 2.

Table 2. Types of Plastic Recycling Technologies

No	Process	Definition	Output
1	<i>Mechanical Recycling</i>	Recycling plastic waste into secondary raw materials or products without significantly altering the chemical structure of the material.	Recycled plastic
2	<i>Chemical or feedstock recycling</i>	Conversion into monomers or the production of new raw materials by changing the chemical structure of plastic waste through cracking, gasification, or depolymerization, excluding energy recovery and incineration	Chemical raw materials (monomers or other chemicals)
3	<i>Biological Recycling</i>	Controlled microbiological treatment of biodegradable plastic waste under aerobic or anaerobic conditions.	Compost, methane
4	<i>Energy Recovery</i>	Production of useful energy through direct and controlled incineration	Heat

This technology is applied based on several considerations, such as the type of waste, future utilization, and economic value. For example: Biological and organic recycling can only be applied to biodegradable plastics, energy recovery processes are used only when the waste is mixed, chemical or feedstock recycling produces high economic value because it is done to extract chemical components from plastics, but waste needs to be sorted, and the costs are very high, mechanical recycling is relatively inexpensive and comparable to the revenue from selling the recycled materials, but it must be performed on waste that has been properly sorted according to standards.

A. METHOD

The implementation method for this activity involves the application of appropriate technology for inorganic waste processing, which includes: Site surveys and interviews with partner groups, identification of priority issues within the partner groups, socialization on inorganic waste processing, assistance and training on how to operate the inorganic waste processing machines and machine maintenance training.

B. RESULTS AND DISCUSSION

Result Hopper Design

The hopper design functions as the inlet for feeding plastic into the shredding section before it enters the processing machine. (Hunt, 1983). The hopper design is tailored to accommodate the size of the plastic and the height of the operator for comfort when feeding the material into the hopper. The design of the hopper is as shown in Figure 3.

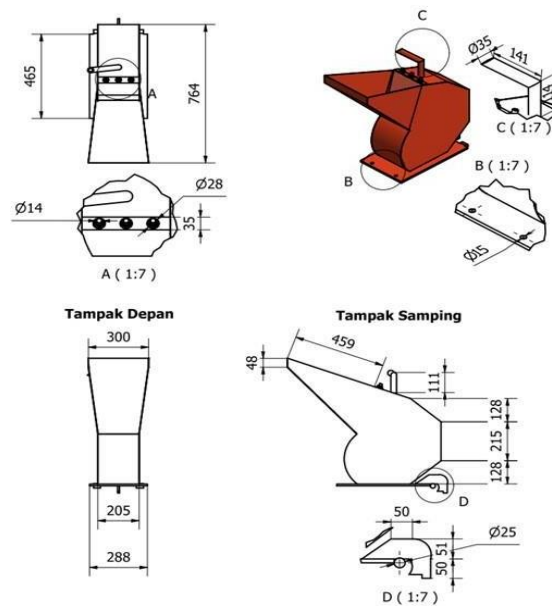


Figure 3. Design hopper

Shredder Blade Design

The shredder blade design functions as a component for chopping plastic into plastic shreds. The operating principle of the shredder blade involves three rotating blades moving in an angular motion, paired with one stationary blade (bed knife), as shown in Figures 4a and 4b. (Srivastava., 1993).

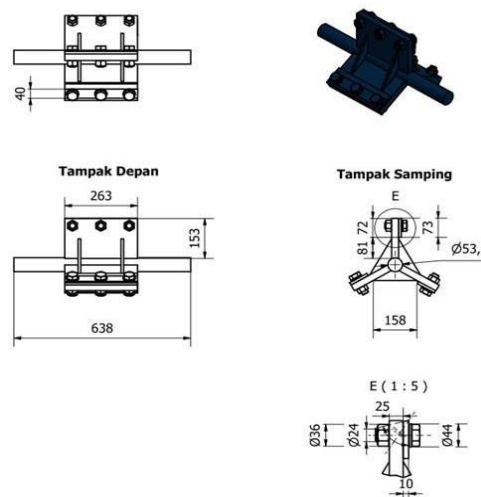


Figure 4a. Reel-type Blade Design

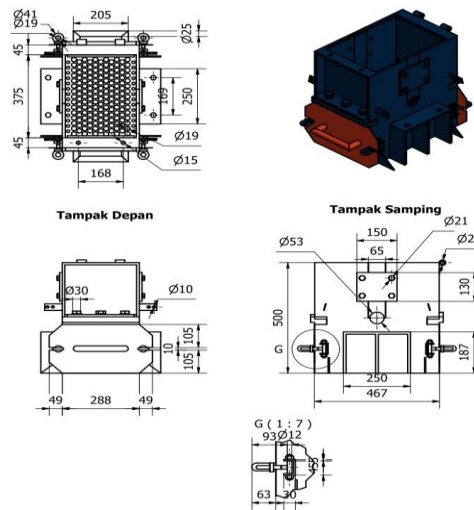


Figure 4b. Plastic Shredding Chamber

Frame Design

The frame serves to support all the components of the plastic shredding machine (Khurmi, 2002). The overall dimensions of the machine frame are 900 mm (length) × 700 mm (width) × 700 mm (height). The frame of this plastic waste shredding machine is made using U-shaped steel with dimensions of 70 mm × 40 mm × 3 mm, as shown in Figure 5.

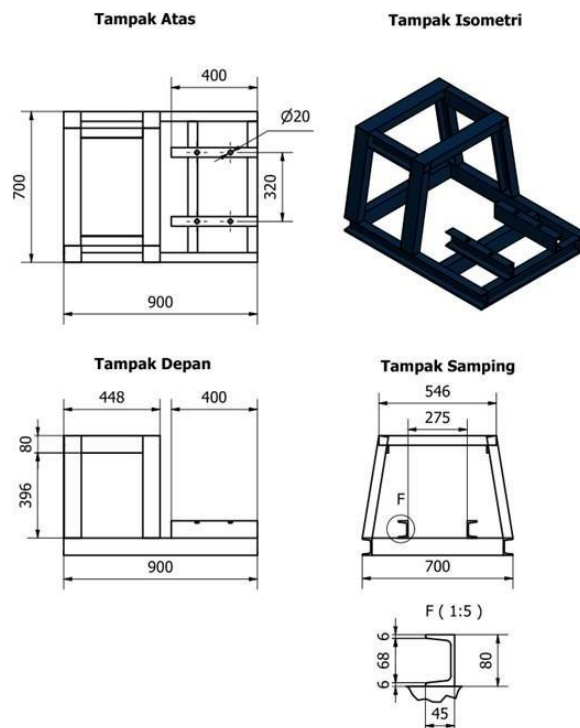


Figure 5. Frame Design

Outlet Hole Design

The outlet hole on the plastic shredding machine is a crucial part of the design, as it allows for the observation of the shredded plastic output. It is used to assess whether the plastic shreds meet the expected size and quality standards. (Sitkey, 1986). (Figure 6)

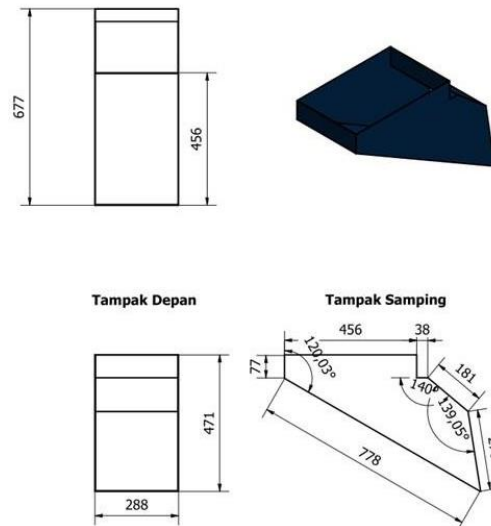


Figure 6. Hopper Design

Plastic Shredding Machine Fabrication

The plastic shredding machine is fabricated once the design drawings and technical analysis calculations have been completed. Each component is assembled and arranged according to the design specifications. For the frame construction, materials such as 4-angle iron, U-channel iron, and steel plates are used, considering the need to withstand the load during machine operation. These loads include the hopper, diesel motor, shredder blades, cover, screen, and outlet hole. (Smith, 2000). The fabrication of the plastic shredding machine is as shown in Figure 7.



Figure 7. Plastic Shredding Machine Fabrication

Plastic Shredding Machine Operation Training

Training on the operation of the plastic shredding machine, including the provision of materials and Standard Operating Procedures (SOP), is given to the BST community with the hope that they will become familiar with the plastic shredding and recycling process. The operation activities are as shown in Figure 8.



Figure 8. Plastic Shredding Machine Operation Trainin



They assist with the technical aspects from start to finish. The community's participation, in this case, the BST group, also helps prepare the activities from beginning to end, such as setting up the venue and preparing materials, including used plastic bottles and cups.

Program Success Indicators

Based on the conditions before and after the PPM activities, the evaluation results show an improvement in the participants' knowledge and skills regarding the plastic shredding process using the plastic shredding machine, as well as an increase in motivation and enthusiasm among the BST community members. The success indicators for this PPM activity are as presented in Table 3.

Table 3. Criteria and Success Indicators After the Activity

No.	Criteria	Base Line	Achievements after activities
1.	Farmers' knowledge about the plastic shredding process	Knowledge of manual plastic shredding process	1.Participants are knowledgeable about the plastic shredding process 2. Improved knowledge of the participants, especially regarding the plastic shredding system
2	Training materials provided to the BST Community group	Lack of exposure to the operation and maintenance of the plastic shredding machine	The training materials provided are highly relevant to the issues faced by the BST community group, particularly in relation to the plastic shredding system.
3.	Interest and participation of participants in the plastic shredding machine operation training activities	1. No extension activities about technology for using the plastic shredding machine to reduce the labor intensity of the BST communit 2. There have been no educational outreach activities aimed at introducing the technology of using the plastic shredding machine to reduce the labor intensity for the BST	1. Increased interest in using the plastic shredding machine 2.High attendance rate, with about 50% of invited participants present despite the distance from the event location 3.Active participation and enthusiasm during the PKM activity



		community.	
4	Plastic Shredding Machine Requirements	3. The plastic shredding process is still being carried out manually.	4. The plastic shredding machine provided is suitable because the shredded output matches the expected size.

The participants who attended were very enthusiastic throughout the entire application and implementation of the plastic shredding machine activities. This was evident from the many questions asked to the resource persons, followed by a discussion at the end of the session.

At the conclusion of the PPM TTG activity, the leader of the BST community expressed their appreciation, feedback, and gratitude for the event, hoping that this activity could continue in the coming years, as it greatly contributes to environmental development in their area.

The impacts of this community service activity are as follows:

1. For the partners, it can improve their living standards and income through the plastic shredding process with the plastic shredding machine, as the selling price of shredded plastic is higher compared to selling it in its whole form.
2. Nearby farmer groups can benefit from the plastic washing machine with proper management and good administration.
3. It supports the local government in advancing the BST community, particularly in Desa Cikunir, Singaparna District, Tasikmalaya Regency, and increasing local income.
4. For Unpad, this activity serves as a platform for faculty staff to apply their knowledge and technology to the community, and to implement one of the components of the Tri Dharma of Higher Education.

D. CONCLUSION

1. The capacity of the plastic shredding machine when implemented is 28 kg/hour.
2. The community service activity aimed at the target audience went well, with positive responses. This is evidenced by the attendance of 50% of the invited participants, the active involvement of the BST community in operating the plastic shredding machine, and the active participation of attendees in all the materials presented during the event.
3. There has been an increase in knowledge and skills post-harvest, particularly in the plastic shredding process.



D. ACKNOWLEDGEMENTS

We would like to express our sincere gratitude to the DRPMI of Universitas Padjadjaran for funding the entire Community Service activity.

E. KONTRIBUSI IMPLEMENTATION TEAM

The contributions of the implementation team (Wahyu K. Sugandi (WKS), Edy Suryadi (ESD), and Sophia Dwiratna (SDR)) in carrying out this community service activity are as follows: Survey: WKS, SDR ,Machine Construction: WKS, Socialization and Assistance Activities: WKS, ESD, SDR, Article Writing: ESD, Impact Analysis: SDR, ESD Activity Evaluation: WKS, ESD, SDR

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