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# Socialization and training on production of bio-charcoal made from biomass waste using a double-tube reactor

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**ABSTRACT**

Proper handling of biomass waste can turn waste into something beneficial for society. One way that can be done is to convert biomass waste into quality biochar for energy needs and agriculture as a planting medium. This partnership program is intended to provide education and practical knowledge to the community regarding utilizing biomass waste for biochar production using a double tube reactor. The activities consisted of socialization of the impact of the abandonment of biomass and the benefits of biomass for household energy needs, as well as practical experience of carbonizing biomass by directly involving partner communities. This activity was carried out at Pambulaan Jaya Village Hall attended by 32 community partners and 9 teams from Halu Oleo University. This partnership activity is very relevant for people in the village where most of the population lives as rice and field farmers. The practical knowledge on carbonizing biomass waste was conducted in two days for the two types of biomasses, namely wood chips and coconut shells. The community was very enthusiastic about continuing the carbonization process after they learned about the great benefits of this biochar product for household energy needs, growing media for plantations, and increasing their income.



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## 1. INTRODUCTION

Global energy demand continues to increase with the increasing population and the increase in people's economic energy use in the future. Even though new and renewable energy technologies have developed rapidly, the use of fossil energy continues to dominate the world energy market where this energy source is directly related to greenhouse gas emissions and global warming. Reserves of energy sources derived from fossils such as petroleum and coal are running low, so many countries are trying to develop renewable energy or alternative energy. Concerns about global warming and other impacts of the use of fossil energy, as well as advances in renewable energy technology have encouraged the use of biomass energy to be used as a renewable and sustainable energy source (Adams et al., 2018).

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Biomass energy is produced when biomass can be converted into electrical energy, heat and various other applications through a thermal system process (Sharma et al., 2020). This conversion process will also produce biomass waste in a sustainable manner (Ghodake et al., 2021; Salman, 2022). Biomass is an organic material produced through a photosynthetic process. Biomass can be renewed, because most of the biomass comes from trees or other plants that will grow back in a short time. Massive use of biomass, especially in the form of wood or plants, will have an impact on the environment and global warming (Ghodake et al., 2021). Logging can produce large amount of biomass waste. However, biomass waste that is allowed to decay naturally will produce methane gas into the air due to the activity of microorganisms and of course this is dangerous for increasing greenhouse gases or global warming (Shiralipour & Smith, 1984). Therefore, various efforts are needed to reduce the pile of biomass produced from various processed furniture industries and agricultural industries which are widely developed in Indonesia. This effort can be done with a thermal process to convert the remaining raw biomass into biochar through carbonization, pyrolysis and gasification processes (Basu, 2013; Dornburg et al., 2006).

Even though the calorific value of biomass is quite low compared to other fossil fuels, efforts to utilize it as an energy source are still being pursued. Biochar energy product is an energy source from biomass which has undergone a thermal process resulting in a reduction in mass and an increase in energy density. This energy content can vary depending on the biomass material, the setting temperature and the setting time (Nhuchhen et al., 2014; Pap et al., 2022; Sharma et al., 2020; Yilmaz & Selim, 2013). The higher the carbonization temperature, the greater the calorific value obtained, but the mass will decrease. After the casting process, the residual carbon mass and energy density obtained can be measured practically using the following simple formula (Sharma et al., 2020):

$$Mass\ of\ product = \frac{Mass\ of\ dry\ biochar}{Mass\ of\ raw\ materials} x100\% \tag{1}$$

Meanwhile, the energy density which is the energy density obtained after experiencing the carbonization process can be calculated using the following formula:

$$rgy\ density = \frac{Calorific\ value\ of\ biochar}{Calorific\ value\ of\ raw\ materials} x100\% \tag{2}$$

The energy efficiency of this coking product can be calculated from the combination of the two formulas above, ie:

$$Energy\ efficient\ products = Mass\ of\ product\ x\ Energy\ density\ x\ 100\% \tag{3}$$

For cooking and other lighting needs, some Indonesian people still use biomass such as firewood, leftover processed agricultural products, and so on (Sumaryati, 2017). Biomass like this in its use is usually burned directly and causes smoke pollution that is large enough so that it can cause health problems for the community, especially children (Goldemberg & Teixeira Coelho, 2004). Therefore, smart efforts are needed to utilize biomass as an alternative energy source in society.

One thing that can be done in a simple way is to convert biomass into biochar. Biochar is a dense, carbon-rich porous material produced by thermochemical conversion of various biomass feedstocks in conditions without oxygen (Ghodake et al., 2021; Kant Bhatia et al., 2021). This composition is intended to improve its energy density and reduce smoke pollution during combustion. With this process the water content is significantly reduced, and the carbon content is increased so as to produce better combustion (Basu, 2013). The results of the authoring can also be made into briquettes so that they are regular in shape, dense and easy to use (Adams et al., 2018). The use of biochar is not only for domestic energy use in the community but also as a fuel that can be substituted into coal for combustion in power plant boilers. (Pap et al., 2022; Wander et al., 2020). The process of coagulating biomass usually requires the right technique and treatment in order to produce good quality. In addition, the risks arising from this writing process are smoke which can be detrimental to health and low quality because it is completely burned so that all that remains is burning ash (Kant Bhatia et al., 2021; Poudel et al., 2018). This can make the community very limited in implementing biomass coagulation technology. To increase people's interest in making biochar from biomass, it is necessary to apply a composing technology that is easy to operate at a fairly low cost and is effective in composing.

The results of interviews and direct observations in the field show that public awareness of the benefits of biomass charcoal and how it is made is still lacking. Even rural communities and many small islands in Southeast Sulawesi still tend to feel comfortable using firewood as a means of cooking or heating their water needs. The community is not aware of the economic value of this biomass charcoal product and does not know the proper charcoal-making tools, so it is necessary to conduct socialization and training on making quality biochar from the remaining biomass which is widely available in the community such as wood chips, coconut shells, cashew shells, corn cobs, rice husk and other biomass. Through these activities it is hoped that the community will receive economic benefits and will be motivated to process the biomass waste into charcoal for energy needs.

The charcoal making model used in this activity is a double tube reactor model where the inner reactor contains the biomass to be charred while the outer reactor contains the biomass which will be used as a heater or burner for the inner reactor. The inner reactor will be closed after being filled with the biomass to be charred and at the bottom of the reactor there are four holes with a diameter of 12mm. The hole is intended to release the fuel gas produced when the biomass is heated. On the outside of the reactor there are several air holes at the bottom and the top of the wall. The air hole is intended to supply the air needed for burning biomass in the outer tube reactor. The results of burning the biomass on the outside can heat the biomass to be charred in the inner reactor. The schematic of the designed charcoal making tool can be seen in Figure 1.

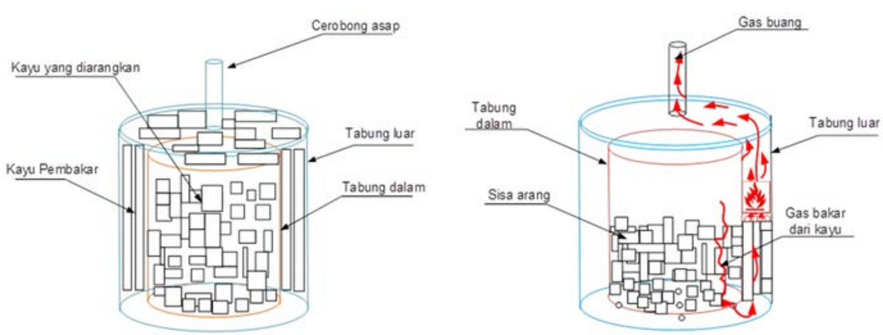


**Figure 1.** Schematics and sections of double-cylinder biomass composing

The main target of this partnership activity is housewives who use a lot of biomass for cooking needs at home. It is hoped that the involvement of participants in programs like this will bring positive changes to other family members and even their neighbors. This activity begins with providing socialization on how to use biomass around the house and education about the negative effects of letting biomass or burning freely from the rest of the biomass. The participants were also given material or knowledge related to the economic value of biomass processing. Biomass charcoal is very useful for the community, apart from being a fuel, it can also be used as a planting medium, for filtering water, burning satay or fish and so on. In addition, smoke pollution and other impacts from burning biomass can be directly reduced.

Community partnership activities have been carried out to help a rural community in Pambulaan Jaya Village, Konawe Selatan District in Southeast Sulawesi, in the process of making biochar from biomass waste. This paper contains the implementation of the partnership activities which consist of socialization activities on the use of biomass waste, training on making burners and training on using the double burner in producing quality bio-charcoal. The aim is to provide education to the public in the manufacture of biochar for energy needs and even the needs of plants as a planting medium. This activity will also encourage the community to reduce the pile of biomass around their homes.

## 2. METHODS

### Location

The place for this activity is Pambulaa Jaya Village, Konda sub-district, Konawe Selatan Regency in Southeast Sulawesi Province which is about 24 km from Halu Oleo University (Figure 2). The partners involved were housewives, youth and part of the Pambulaa Jaya Village apparatus, totaling 32 people. The socialization and production of biochar from biomass waste consists of two main stages, namely the preparation and implementation of the activity. This initial stage is intended to seek information regarding the potential use of the equipment to be used and at the same time socialize the importance of the activities carried out. The second stage is the implementation of activities consisting of making charcoal stoves and training on their use in the target community.


**Figure 2.** The activity location is about 18 km from Halu Oleo University Kendari.

### Tools and Materials

The tools used in this activity are machining tools in the Mechanical Technology Laboratory at Halu Oleo University such as Grinding Machines, Welding Machines, Drilling Machines and Plate Folding Machines. The materials used in the manufacture of the furnace reactor include 3mm plate, iron strip and 2.5" iron pipe. Meanwhile, the biomass materials tested in charcoal production consisted of teak wood and coconut shells, which are abundant in Pambulaa Jaya Village.

### Preparation Stage

This activity begins with a visit to the village of Pambulaan Jaya where most of the residents live by farming and gardening. During the visit, the implementation team collected information about the system for using biomass produced from wood waste or their agricultural product waste. This visit began with a meeting at the house of the Head of Pambulaa Jaya Village, Jafar, and continued to the houses of the surrounding residents. The implementing team sought information from housewives who had direct contact with the use of biomass for cooking at home. From the results of these interviews the activity implementing team began to understand or obtain information about the problems partners have been facing so far with the use of biomass as fuel. Partners generally complain about the thick smoke that is produced and the difficulty of starting to burn biomass wood when it is used for cooking. The team began to provide an overview of the solutions to their problems. After getting a clear picture, the implementation team began offering a charcoal making training that was easier to use for them at the Pambulaan Jaya village hall.

The implementation team together with village officials and partners have agreed to carry out activities at the Pambulaa Jaya Village Hall. Thus the implementation team from Halu Oleo University prepared the equipment and all the materials used in the charcoal making process (Figure 3). This preparation begins by discussing a composing model that is efficient, easy to obtain for the community and inexpensive. The writing model is then designed by considering several things including the materials and equipment for making it. The main material for this charcoal furnace reactor is leftover plates obtained from selling scrap iron in the city so the price is very cheap. The equipment to be used is welding equipment, drills, grinders and plate cutters borrowed from the Mechanical Technology Laboratory of Halu Oleo University. The biomass used in carrying out this activity is wood chips from one of the carpenters in the village and coconut shells from the grated coconut factory in the village community.


**Figure 3.** Preparation of double tube coagulation reactor

### Implementation Stage

The implementation of this activity was carried out after discussing with the village head as a government policy stakeholder in the village of Pambulaan Jaya. The housewives who participated in the activity looked very enthusiastic in learning new things that were beneficial to the community, especially the system for composing the biomass material (Figure 4). The main target of this activity is that partners can obtain economic benefits from the training held by the Team from Halu Oleo University. The implementation of this activity was carried out on Friday 29-30 September 2022 at the Pambulaan Jaya Village Hall. The training started from 8.30 – 13.30 and was attended by 32 participants from the Pambulaa Jaya Village community and 9 team of lecturers and students from Halu Oleo University.


**Figure 4.** The participants and the activity implementing team

The implementation of the activity begins with the socialization of the use of biomass which is widely available around residential areas. This activity also explains the stages that occur in the writing process until quality charcoal is formed. In addition, explanations and demonstrations were also carried out on how to adjust the combustion air so that the resulting biomass charcoal products did not burn completely in the charcoal reactor.

**Table1.** Socialization and training phase

| | |
|---|---|
| **Stage 1** | **: Socialization and Acquaintance** |
| Activities | - An explanation of the goals and objectives of the activities<br>- Introduction of the implementation team members<br>- Introduction of equipment to be used |
| Goals | - To convey the importance of the activity carried out<br>- To familiarize with community members<br>- Provide an introduction to the equipment used |
| **Stage 2** | **: Preparation of tools and materials** |
| Activities | - Preparation of materials to be used in the manufacture of charcoal, namely processed wood waste that is around the community<br>- Preparation of writing equipment<br>- Image preparation of equipment |
| Goals | - To be able to provide knowledge about the requirements of the biomass that will be used to produce good biochar<br>- Preparation for composing was carried out at the Halu Oleo University campus workshop and this was intended to make the work easier<br>- To facilitate the explanation of the components of the equipment |
| **Stage 3** | **: Charcoal making** |
| Activities | - Making charcoal from carpentry waste around the community environment<br>- Explanation of quality charcoal results/products |
| Goals | - To give a real picture of the making charcoal process that can produce good charcoal<br>- Explaining the criteria for quality charcoal such as a metal-like sound when dropped on the floor, no ash, easy to break and brownish black in color |
| **Stage 4** | **: Sharing** |
| Activities | - Discuss openly and freely with activity participants<br>- Additional explanation about the development of the equipment used |
| Goals | - To deepen the understanding of participants and strengthen brotherhood<br>- To encourage participants to innovate in developing composing tools |

At the end of this socialization activity, a question and answer session was held with the activity participants to be able to clearly find out the ability to accept the material that had been delivered At the end of this socialization activity, a question and answer session was held with the activity participants to be able to clearly find out the ability to accept the material that has been delivered. Questions and answers are not only carried out in the room, but especially during the execution of the writing. This is intended so that the participants can see directly and practice the process of creating biomass. The stages of socialization and training activities for Partners are presented in Table 1.

## 3. RESULTS AND DISCUSSION

Based on Figure 5, the socialization and training activities on the creation of biomass have been carried out at the Pambulaan Jaya Village Hall, Konda District, South Konawe Regency, Southeast Sulawesi province. This activity involves the Community Service Team, village officials, and partners. The activity participants consisted of village people with quite a variety of educational levels, starting from junior high school, high school, bachelor's degree and even master's degree.


**Figure 5.** Explanation of the function of charcoal and double tube coagulation reactor

The distribution of participants by age and education is shown in Figure 6. Most are aged 41-45 years with a high school education level of around 47%. The level of community education can be directly correlated with acceptance of an education, training or job, especially those that require certain skills.

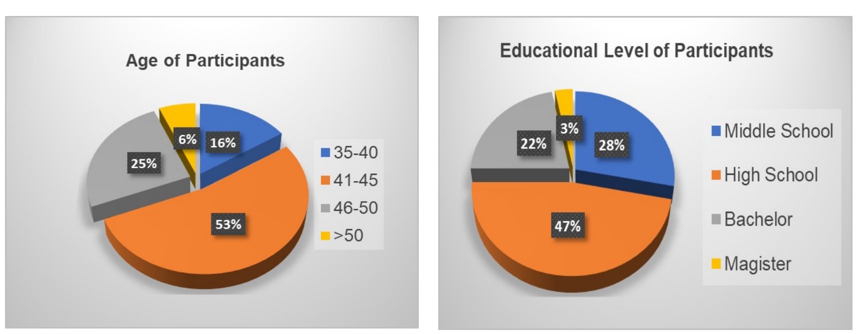


**Figure 6.** Categories of activity participants based on age and education groups

In this training the community is encouraged to form a business group that will run this writing program in every RW and is chaired by the RW mother so as to facilitate coordination. Housewives also stated that they were willing to voluntarily help implement the program in question. Not only that, the community is also given directions for the processing to the packaging and sales. The implementation of making the organization was also guided by the implementation team from Halu Oleo University which is shown in Figure 7.


**Figure 7.** Formation of a charcoal business management team with the village head

Figure 8 and 9 show a model of the reactor used in the biomass charcoal production process. This model of biomass charcoal-making reactor utilizes two chambers, namely the inner reactor and the outer reactor. The outer reactor is a place to burn biomass which will be a source of heat for the biomass to be charred in the inner reactor.

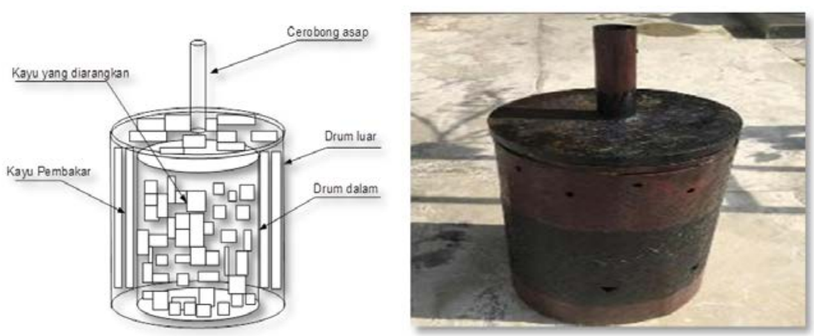


**Figure 8.** Writing model used: Schematic drawings and original designs

**Figure 9.** Inner and outer tubes of casting and filling of biomass for the casting process

The practice of writing is carried out outside the village hall taking into account the various risks posed, including puffs of smoke and heat that arise during the carbonization process. The smoke produced is highly dependent on the dry conditions of the biomass or wood used. When the wood is dry, the burning process is fast and the smoke generated tends to decrease (Figure 10).

**Figure 10.** The smoke that arises during the authoring process and the resulting charcoal products

The charcoal product produced in this writing practice can be weighed after the reactor cools down and the formed charcoal begins to cool. Based on Table 2, the results of the carbonization of biomass carried out on the first day using raw wood weighing 2.15 kilograms obtained 1.05 kilograms of very good wood charcoal. This means that the remaining mass is obtained by 48%. For coconut shells tend to be produced more than the mass of products from wood. By adding 2.45 kilograms of coconut shell, 1.47 kilograms of coconut shell charcoal or 60% of the remaining mass is obtained.

**Table 2.** The mass of charcoal produced from the process of making charcoal

| Description | Teak Wood Pieces | Coconut Shell |
|---|---|---|
| Raw Materials (kg) | 2.15 | 2.45 |
| Charcoal (kg) | 1.05 | 1.47 |

The results of the charcoal from the two materials were then taken to be analyzed at the Chemical Engineering Laboratory of Halu Oleo University. This is intended to see the increase in heating value and changes in other chemical properties through proximate analysis and calorific value tests. The carbon content increases significantly so that the heating value increases. Likewise, the content of water vapor and volatile matter has decreased, shown in Table 3.

**Table 3.** Characteristics of the product of the test results

| Material description | Moisture content | Fixed carbon content | Volatile matter content | Ash content | Calorific value (*HHV*) |
|---|---|---|---|---|---|
| Raw wood | 15.20 | 16.66 | 63.94 | 4.20 | 15.52 kJ/kg |
| Biochar | 6.42 | 39.05 | 52.11 | 2.42 | 19.57 kJ/gr |
| Coconut shell | 9.57 | 20.91 | 68.38 | 4.14 | 24.65 kJ/kg |
| Biochar | 5.74 | 35.13 | 56.07 | 3.12 | 28.14 kJ/gr |

Village community partnership program activities in the form of composting biomass waste for cooking needs at home and other needs have relevance to the needs and optimal utilization of biomass in the community. Implementation of the program in the form of socialization and training, aims to increase participants' knowledge regarding the use of remaining biomass to be processed into a clean and easy-to-use energy source. This is supported by the communication provided by the partners to residents around the implementation site regarding the impact that will be received by the participants. Therefore, the target participants who came from junior high school, high school, bachelor and master graduates thought that the existence of the PKM program in the form of socialization and training on the utilization of biomass waste was considered to be able to help them increase their knowledge regarding the techniques and processes of utilizing biomass waste to be able to used as quality charcoal products for household energy needs.

The results of unstructured interviews between the PKM implementing team and participants included with direct observation during the activity, the implementation of the PKM program activities by the implementation team from Halu Oleo University gave the following results: (1) The implementation of the PKM program activities has increased and added to the knowledge of the village community in understanding the importance of utilizing biomass waste for energy needs at home. They also directly experience this writing practice and work in producing good biocharcoal products. The success of this activity can be seen from the enthusiasm of the people who took part in this activity for two days; (2) Communities get knowledge about simple composing technology but of great benefit in producing quality biochar for cooking needs or for growing media in people's homes; (3) It is hoped that the formation of a writing management group can continue in the future so that these activities can provide added value to the target community in improving the economy of the village community.

**Figure 11.** Participants who are active as a supporting factor in the activity

In the implementation of this PKM program there are several inhibiting factors that occur during the implementation of activities such as the method of delivering material that may be unfamiliar to them as well as the process of making a writing reactor and the facilities used in making it. For people who are used to farming, the presence of biomass authoring technology like this is not attractive to makeSo that the participants still imagine the difficulty of making an essay as socialized to them. In addition to the above, the frequency of meetings with the community is also very limited, so that the transfer of knowledge and skills is very limited, especially since the community's education level is still relatively low.

## 4. CONCLUSION AND RECOMMENDATIONS

This community partnership program aims to provide knowledge and new skills to partners, who are mostly rice and field farmers in Pambulaan Jaya Village, regarding the utilization of biomass waste as material for making quality and efficient bio-charcoal. The target of this program is that participants are able to identify and process biomass in the form of wood scraps, rice husks, coconut shells and various types of biomass into more useful biochar products. In addition to cooking needs, the charcoal produced can also be used as a planting medium for ornamental plants in the yard of the house or for plantations and farmers' rice fields. The implementation of this program is able to change partners' views of biomass waste around the surrounding environment to be used economically and efficiently. This can be seen from the enthusiasm of the participants who took part in the activity from the beginning to the end of the activity. The partners were also equipped with skills in the process of producing good quality biochar using a double reactor which was demonstrated by the implementation team. The use of charcoal-making technology used can be easily accepted by partners, most of whom have high school education. The Partner Community fully understands the importance of utilizing biomass waste to become a new energy source and is able to make charcoal with a double tube system, so that this activity provides added value to partners.

In the implementation of this PKM activity there were several obstacles, both technical and non-technical. Technical constraints include the material of the iron plate used as the reactor tube which is thick enough to require certain manpower, time and expertise in its manufacture and assembly. Non-technical obstacles such as limited communication between the implementing party and partners, both the community and village officials in carrying out the intended activities. Therefore, it is necessary to do the following things: (1) The plates used for the reactor tube can be replaced with thin plates that are easily shaped and resistant to high temperatures; (2) Application of appropriate technology like this can be carried out intensely and sustainably for village communities in need; (3) Assistance and monitoring need to be carried out on an ongoing basis to partners so that this program can help the community's economy.

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