Effect of boric acid on the preservation of palm replanting wood waste

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Abstract. At present, the area of oil palm plantations in Indonesia is approximately 11 million hectares. In addition, to produce abundant palm oil, this palm plantation also produces waste in the form of replanted wood when regeneration is carried out. The aim of this research is the utilization of palm wood replanting waste by immersion treating with boric acid as a preservative with concentrations of 1; 2.5 and 5% and soaking time of 2, 4, 6 days. From the preliminary analysis of the replanting waste, the water content was obtained at 34.41%, flexural strength at 26.48 kg/cm², and compressive strength at 3.73 kg/cm². After the preservative treatment with boric acid with 2; 4; and 6 days immersion and drying process, it was found the decrease of water content, an increase of compressive strength and flexural strength. The 4 days immersion with boric acid 5% was the best treatment with the water content decreased to 0.31%, flexural strength increased to 47.60 kg/cm² and compressive strength increased to 8.21 kg/cm².

1. Introduction

Indonesia and Malaysia are the two biggest countries that supply almost 85% (53,500 million tons) of palm oil needs in the world. The palm land in Indonesia has been in 22 provinces. According to the Central Statistics Agency of Indonesia [1], Indonesia’s oil palm plantations reached 12.2 million hectares in 2017. From the distribution data, West Sumatera has 350 thousand hectares of oil palm plantations spread across several regencies.

Oil palm plants produce fresh fruit bunches, which are then processed into crude palm oil (CPO). However, these oil palm plants only produced fresh fruit bunches until the age of 25 years. Thus, we need to do replanting to have rejuvenation. Currently, the replanted oil palm plants are around 25,000 ha/year in West Sumatera. Usually, these replanted oil palm plants are left and eaten by insects, which can affect the plantation’s environment. Due to the low quality and very high water contents of the replanting waste wood [2], it has not been utilized until now.

Solid and liquid waste from the palm oil industry has excellent potential to be developed. Some of the simple technology has been successfully achieved. However, if we can upgrade some technology, these wastes can produce higher-value products [3]. For example, waste from Palm Oil Mill Effluent (POME) can be used as fertilizer after some treatment. If we developed some treatment, waste from POME could be processed into biogas, which has a higher value. An empty bunches that have only...
been used as a MULSA (a cover for cultivation plants to maintain the moisture of the soil and prevent the growth of weeds and diseases) to make the plant grow well can be developed into a composite, and fiber for building materials [4]. Another example is the stem of palm oil waste; it will become a pile of waste that can cause a bad environment and have not been utilized yet [5].

Up until now, the area of oil palm plantation is 11 million ha. Besides showing the prospect to produce a large amount of vegetable oil, the rise of waste after replanting has become one concern that needs to be solved. If 4% of the area is being replanted every year, there will be more than 100 million cubic of palm stem will be waste. Plantation manager often let the stem rot, lead to the unpleasant odor, make the stems moldy, and become a nest for an insect Oryctes rhinoceros and fungi Ganoderma. This condition will disturb the young oil palm plants and cause damage to the plantation. A way to destroy the replanting wood waste is to burn the woods [6], but it can make air pollution and prohibited by the law. Therefore, we need such an excellent treatment for wood waste utilization.

A large amount of unused replanting palm oil stems is necessary to use to provide higher value for the waste, and additional income to the palm oil farmers. Therefore, Institution for Research and Standardization of Industry - Padang cooperates with Bakri Pasaman Plantation Company, located in West Pasaman, which has 9720 ha of oil palm plantation, investigated the preservation of non-valuable wood to become valuable materials for furniture, accessories interior, and handicraft. Besides that, it can indirectly reduce the use of forest wood and increase business opportunities for residents around the plantation. One of them is by doing preservation.

Boric acid is a wood preservative. That is often used for wood preservation. Several studies that have been reported on the use of boric acid for wood preservation include preservation of sengon wood (Paraserianthes falcataria Nielsen) and pinewood (Pinus merkusii Jungh Et de Vries), red meranti wood [7], teak wood [8], aren wood [9]. Preservation of oil palm that is 18 years old has also been reported [11], but the preservation of oil palm replanting wood that is 25 years old has not been reported yet.

This study aims to preserve the palm wood from replanting so that it can be used as a raw material for forest wood which is commonly used for furniture, interior accessories, and handicraft products. In addition, this study also aims to improve the quality of the mechanical properties of replanting oil palm wood.

2. Material and methods
2.1. Materials and tools
Oil palm’s waste woods were obtained from Bakri Pasaman Plantation Company in Jorong Tanjung Babolik, Nagari Sungai Aur, Kecamatan Sungai Aur, Kabupaten Pasaman Barat. The palm trees are Dura variety and planted in 1992 and replanted in 2019. Other materials were boric acid (H₃BO₃) as a preservative. The tools used in this research were saw and chain saw. The test equipment was a drying oven and compressive strength machine.

2.2. Research method
2.2.1. Oil palm stems processing. The oil palm stem waste was cut into 1.5 m and split using a handsaw machine (BS-44”). The outer stems and the center stems were cut into 10 cm thickness, separated from each other, air-dried for 30 days until the water contents left 30%.

2.2.2. Research design. The beginning of this research was done by investigating the effect of several parameters; the type of stem section (A), the concentration of preservative chemicals (B), and the soaking time (C). The type of stem section consisted of outer stem and centre/inside stem. The
concentration of preservative chemicals was 1%; 2.5%; and 5%. The soaking time were 2 days, 4 days, and 6 days.

2.3. Observation. The observation is carried out after soaking and drying time consisted of water content, compressive strength, and flexural strength [10].

2.3.1. Water content. The stem wood sample was cut into (5 x 5 x 10) cm and weighed to know the initial weight. After that, it was placed into the oven at 103 ± 2°C for 24 h and weighed until constant. The wood's water content is obtained from the ratio of the amount of air-dried wood to the amount of dry wood as equation (1).

\[
\text{Water content} = \frac{\text{BB} - \text{BK}}{\text{BK}} \times 100\%
\]  

\(\text{BB} = \text{Initial wood weight}\)  
\(\text{BK} = \text{Dry wood weight}\)

2.3.2. Compressive strength. For measuring, we need a compressive strength machine, meter indicator, lumber in which, size (10 x 10 x 5) cm. The device is a compressive strength machine (Wekob 2153).

2.3.3. Flexural strength. For measuring, we use a flexural strength machine (Wekob 2153) and lumber in which, size (5 x 5 x 76) cm.

3. Results and discussion

3.1. Water content

The water contents of oil palm's waste woods after drying for 30 days before preservation for the outer stem and the center stem is 25.88% and 34.41%, respectively. Water content for the center stem is above the saturation points of fiber (<30%), in which the preservative will be difficult to get into the wood fiber. On the other hand, the water content of the outer stem is less than the saturation points of fiber, which will be easy for the preservatives to get into the wood fiber. This could happen because of the reduction of water content in the cell wall so that the preservatives will be quickly entering the empty hole of the cells. If the wood's water content is above the water saturation points of fiber, the preservatives soaking process will be difficult because of the presence of water in the cell wall.

This phenomenon shows that the water content is one of the crucial factors in transporting preservatives to the wood. According to [11], factors that affect the water content in the wood are temperature, humidity, and type of wood. If the cell hole contains a lot of water, the preservatives will be blocked and difficult to get into the wood. Thus, resulting only a few of preservatives will get into the wood. In contrast, if water contents in the cell hole have come out or less, the preservatives will quickly enter the wood. The optimum water content for preservatives will differ for each type of wood, type of preservative, and preservative method [12].

Boric acid \((\text{H}_3\text{BO}_3)\) was used as the preservatives. After soaking with \(\text{H}_3\text{BO}_3\) for 2, 4, and 6 days and drying process for 20 days there is a decrease in water content on each stem (center and outer stem). As shown in Figure 1, after soaking for two days and drying, the average water content is 14.68% and 13.94% for the center and outer stem, respectively. The water content after 4 days soaking is 10.45% for the center stem and 10.25% for the outer stem. For 6 days of soaking, the average water content for the center stem is 11.12% and 10.9% for the outer stem. From these data, we can conclude
that the lowest water content is in the outer stem with 4 days of soaking treatment using $\text{H}_3\text{BO}_4$. One of the characteristics of boron preservative is easy to come into the wood, however easy to wash again with water \cite{13}.

Figure 1. Water content of wood after soaking for 2, 4, and 6 days using Boric Acid

3.2. Flexural strength

The mechanical properties of wood strength are the ability of wood to resist any external forces. The external force is the forces outside of the objects that have a tendency to change the shape and amount of the object \cite{14}. Almost all of the wood's utilities require excellent compressive strength and flexural strength. The wood's flexibility is the ability of the wood to bend itself when resisting the pressure given to it. According to \cite{15}, flexural strength is a strength to withstand any forces that attempt to bend the woods. The maximum bending stress can be applied to the wood before it yields or breaks.

The results show that the oil palm's wood waste has low flexural strength based on the classification of wood from Indonesian Lumber Construction Regulations \cite{16}. It classifies as class V with flexural strength is less than 300 kg/cm$^2$. The initial flexural strength test before preservation for the center stem part is 26.48 kg/cm$^2$ and 47.16 kg/cm$^2$ for the outer stem. There are differences between the flexural strength of the center stem and the outer part. The outer part has higher flexural strength because the water content is less than the center part. The other effect is the density of the outer stem wood is higher than the center stem wood.

Figure 2 shows the flexural strength of woods after soaking for 2 days using boric acid. By comparing flexural strength before preservation, flexural strength after soaking for 2 days is slightly increasing. Flexural strength of center stem is around 9.92-28.15 kg/cm$^2$ and 43.08-47.19 kg/cm$^2$ for the outer stem.

The flexural strength of the outer and center stem at 4 days also increases compared to 2 days soaking time. The flexural strength is 27.30-32.29 kg/cm$^2$ and 46.33-47.60 kg/cm$^2$ for the center and outer stem, respectively. At soaking time for 6 days (Figure 2), the flexural strength was decreased, 26.49-29.41 kg/cm$^2$ for center stem and 37.26-47.19 kg/cm$^2$ for outer stem. These results could have happened because after soaking, salting would occur both inside and outside the wood. The use of
borax preservative has been proven to be effective in increasing the resistance properties of redwood [7].

![Graph showing flexural strength of wood after soaking for 2, 4, and 6 days](image)

**Figure 2.** Flexural strength of wood after soaking for 2, 4, and 6 days

### 3.3. Compressive strength

Compressive strength of wood is the strength of wood to withstand loads if the wood is used for a specific purpose. The compressive strength has a relationship with wood hardness. Our experiment showed that the compressive strength of the center woods and the outer woods before preservation is 3.73 kg/cm² and 5.47 kg/cm², respectively. Based on Indonesian Lumber Construction Regulations (PKKI), these woods include in class V, which has a compressive strength of less than 215 kg/cm².

After soaking for 2 days, the compressive strength for center woods is 3.28 – 5.47 kg/cm² (Figure 1). There is an increase in compressive strength from before the preservation as much as 1.64 kg/cm². Preservation for 4 days is giving an excellent result, which is 5.47 kg/cm² for center woods and 5.47-8.21 kg/cm² for outer woods. The increasing value of compressive strength at 4 days of soaking caused by the preservative could enter the fiber of the woods perfectly and be an adhesive for the woods. As the result, the compressive strength is increases. Figure 3 shows the compressive strength of the woods at 6 days soaking. The compressive strength for both of kind of the stem is decreasing, 2.74-4.91 kg/cm² for the center woods and 5.47-8.21 kg/cm² for the outer woods. These results could happen because after soaking for 6 days, salting will occur both inside and outside of the wood that causes lower compressive strength.
4. Conclusions
The study of the effect of boric acid on the preservation of oil palm waste wood has been achieved. It shows that the flexural strength and compressive strength of the outer stem wood is higher than the center stem wood. The variation of immersion time cannot be too long or more than 6 days. Because as longer the immersion times, will lead to salting both of the center and outside stem. Thus, resulting in low flexural and compressive strength, and increase the water content. We can conclude that the immersion time of 4 days gives better results in terms of high flexural strength, high compressive strength, and less water content.

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