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# Comparison between chemical and natural treatments for bamboo as building material towards sustainable construction method

E Setiyowati<sup>1,\*</sup> and A B Mappaturi<sup>1</sup>

<sup>1</sup>Architecture Department, Universitas Islam Negeri Maulana Malik Ibrahim Malang, Jalan Gajayana 50 Malang, 65144 Indonesia

\*E-mail: [ernaning@arch.uin-malang.ac.id](mailto:ernaning@arch.uin-malang.ac.id)

**Abstract.** This paper aims to compare these two different methods, which one is better yet easier to be used by the local community. This paper adopts a content analysis method in order to achieve the research objectives on bamboo as a sustainable construction material. The variables are determine better ways with low cost, short period of time, and the procedure of the treatment. This paper shows that the natural treatment for bamboo is better and much more friendlier to be practised by the local communities. Results of this study also inform that the procedures are complicated as compared to the chemical treatment but, it can be done easily by the local people who has more understanding of how to work with bamboo. The time needed for this natural process is the same as the chemical treatment, but the cost is cheaper. This study highlighted the importance of using the natural bamboo treatment for construction industry in Indonesia.

## 1. Introduction

Bamboo is a natural material that most environmentally friendly because it has rapid growth and can be found anywhere in a tropical area. The bamboo construction is easy to build, earthquake resistance, and has easy maintenance [1]. Along with the lack of wood availability, bamboo is an alternative natural material that can be one consideration. Traditional people have already used bamboo as building material centuries ago. They already found the traditional treatment for bamboo to keep its durability. Bamboo was soaked for three to six months in the river before they use it [2-4]. The age of bamboo building after using this treatment method can last until more than 30 years [5].

Nowadays, the traditional method treatment of bamboo is left behind. Some research has found a modern method to preserve bamboo. Most of the bamboo preservation use a chemical product because it can shorten the treatment time. While the traditional people need three to six months to protect bamboo, the chemical treatment only needs days to conduct a bamboo treatment [6].

This kind of treatment produces bamboo as good as the traditional ones, or even better. However, since people need to buy additional material, the price is higher. For a chemical product, this kind of treatment also must imply the building user's health and also give a bad impact for environment [7]. That is why some other researchers tried to find another material that has a quality as good as the chemical yet healthier for the user. Another material that has been chosen to be the formula of bamboo treatment is some local natural material.

There are many kinds of methods and material for bamboo treatments before they can be used for building. Some of them use chemical material, and some others use a natural one. The chemical material



for bamboo treatment commonly used is borax (*Natrium Tetraborat* ( $\text{Na}_2\text{B}_4\text{O}_7$ )) [8-11], Boric Acid [12], and CCB (*Copper-bichromated boron*) [13], while the natural ones are tobacco [14], Mimba leaves (*Azadirachta indica*) [15], mangrove skin (*Rhizophora mucronata*) [16], coconut shell [17,18], Accacia wood skin [19], *Melaleuca cajuputi* vinegar wood [20], and clove leaf extract (*Syzygium aromaticum*) [21].

Some researchers found that bamboo needs 6%-10% concentration of borax to do the preservation [22], while some others need 5%, 10%, 15%, and 20% concentration to preserve bamboo. The treatment for the preservation has done by cutting the bottom side of the bamboo and disposed the skin. Then the bamboo was soaked for five days in the borax solvent [23]. The research found that all of the penetration of the treatment could reach 100%. The retention varies according to the borax concentration, but the 15% of the concentration gives a highest value [6].

Another bamboo preservation using a chemical treatment used CCB (*Copper-bichromated boron*) as the additive material. The composition of CCB are Boric Acid ( $\text{H}_3\text{BO}_3$ ) 27,5%, Sodium Dichromate ( $\text{Na}_2\text{Cr}_2\text{O}_7$ ) 43,9%, and Copper(II) Sulfate ( $\text{CuSO}_4$ ) 28,6%. The bamboo segment was perforated for about 1,5 centimeters in diameter, except one segment in the bottom. The treatment process was done by leaning it through the wall and the unperforated segment was placed in the bottom. The CCB solvent was put into the bamboo through the hole from top to bottom and let it there until seven days [13].

For natural bamboo treatment, tobacco can be used as the additive solvent material. The tobacco was extracted in the water in the amount of 100, 150, and 200 grams in 1 liter of water in the temperature of 70-80 °C for three hours. The bamboo was cut in the bottom side, and was soaked in the tobacco extract for one, three, to five days. This research shows that the kind the treatment resulted 60% of the preservation [14].

Between all of the bamboo preservation research that has been done, the people needs to know which one is the cheaper, the easiest, and the most effective technique. So the objective of this research is to compare between two kinds of bamboo treatment (natural or chemical), which one is better to be applied in the society.

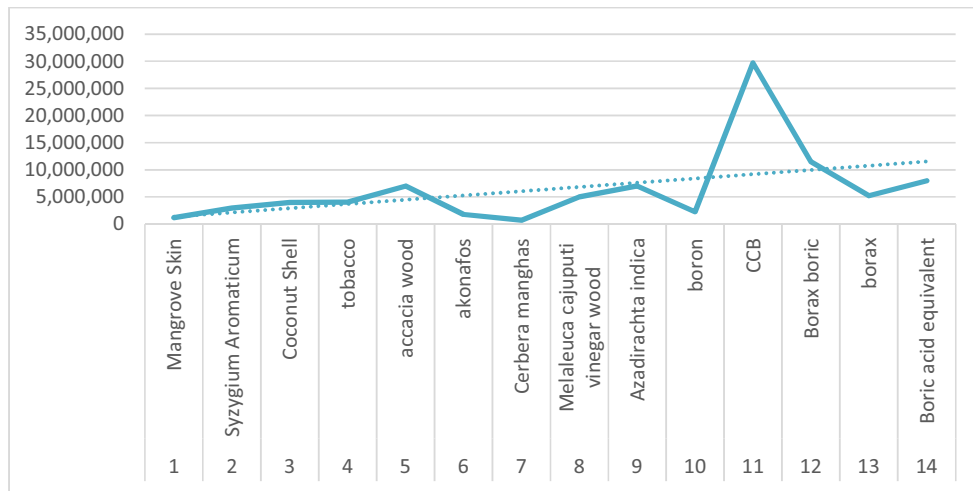
## 2. Methods

This paper uses content analysis method to achieve the objective of the research. Content analysis is a research tool used to determine the presence of certain words or concepts within texts or sets of texts. The bamboo treatments materials that is being compared in this research are borax (*Natrium Tetraborat* ( $\text{Na}_2\text{B}_4\text{O}_7$ )), Boric Acid, Borax Boric, Akonafos, and CCB (*Copper-Bichromated Boron*) for the chemical material, and tobacco, Mimba leaves (*Azadirachta indica*), Mangrove skin (*Rhizophora mucronata*), Coconut shell, Accacia wood skin, *Cerbera manghas*, *Melaleuca cajuputi*, vinegar wood and clove leaf extract (*Syzygium Aromaticum*) for the natural material. The variables that is compared between all materials are the cost, the preservation technique, and the test result.

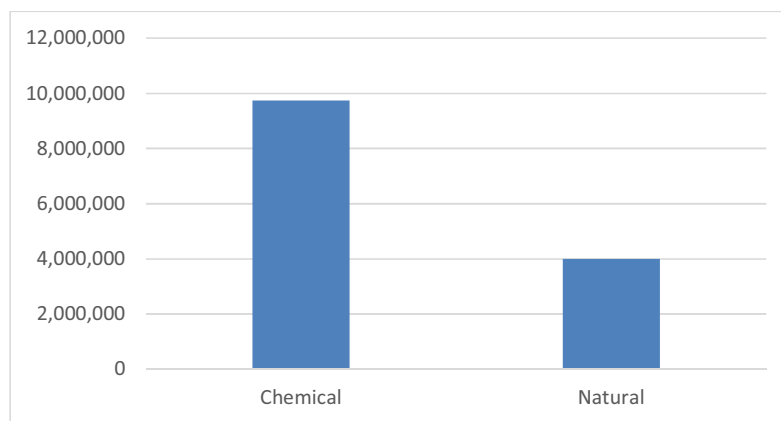
## 3. Results and Discussion

### 3.1. The cost of the bamboo treatments

The figure 1 shows that CCB takes the highest place of the bamboo treatment's cost, meanwhile the *Cerbera manghas* takes the lowest price. To make a solvent for 1000 litres water, people needs to spend IDR 29.700.000. The cost is too high for the common people. In the meantime, *Cerbera manghas* only needs IDR 735.000 for 1000 litres water. Another natural material which can be afford by the people is mangrove skin that only needs IDR 1.200.000 for the same amount of water. While the cheapest price for the chemical material is Akonafos that needs only IDR 1.762.500 for 1000 litres of water. The average cost for chemical and natural bamboo preservation can be seen in Figure 2. It clearly shows that natural material is much cheaper than chemical one. The deviation between both materials achieve IDR 5.745.625.



**Figure 1.** The Cost of Bamboo Treatments for 1000 Litres Water in IDR.



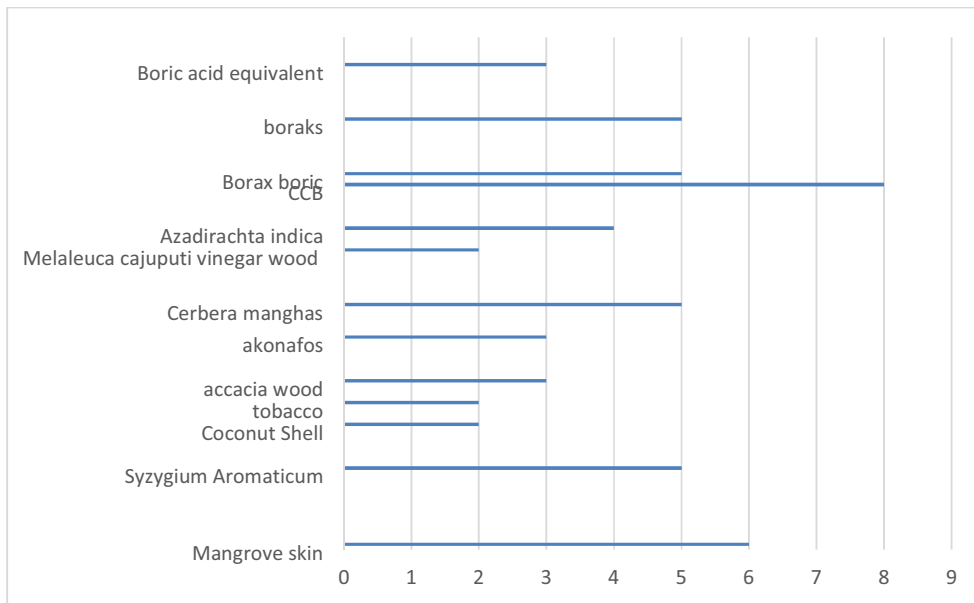
**Figure 2.** The Comparison of Bamboo Preservation Cost.

**3.2. The Treatment’s technique of Bamboo Preservation**

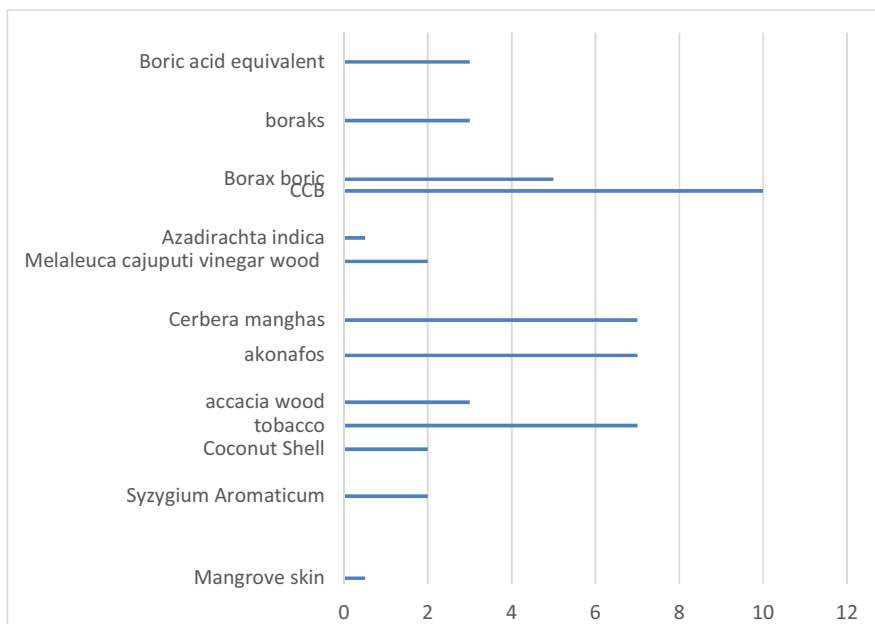
The kind of bamboo preservation technique can be seen in Table 1. The Table 1, Figure 3, and Figure 4 show that the most complicated steps for bamboo treatment is using CCB, while the longest time needed is also using CCB. The simplest way to treat bamboo is by using liquid Coconut Shell, *Melaleuca cajuputi* vinegar wood, and boric acid equivalent. They only need three steps, because the materials are available on stores. The people only needs to mix it with water in the tub and soak the bamboo inside the tub for days. The shortest time needed for those three easiest materials are the treatment by using liquid coconut shell and *Melaleuca cajuputi*. Both of them only needs two days for soaking the bamboo. On the other hand, there are some materials that only needs hours for the treatments. They are mangrove skin which needs five hours and *Azadirachta indica* that needs 12 hours. They need only one day for soaking, but the techniques are more difficult that the other three methods mentioned before. The bamboo needs to be dried before it is soaked. Figure 5 shows the comparison of the treatment procedures between natural and chemical material. It shows that the time needed for chemical is longer than the natural material, and the preservation steps are more complicated. The natural material needs shorter time and simpler procedures.

**Table 1.** The Preservation Technique for Bamboo.

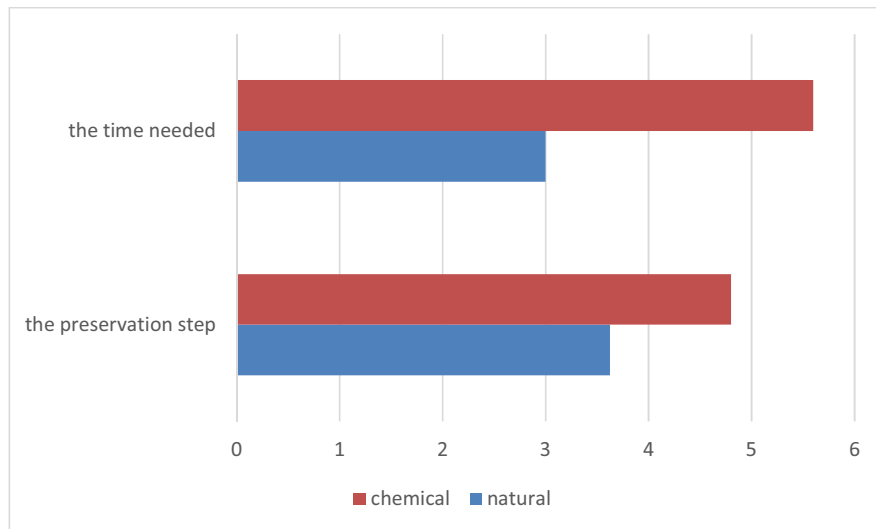
NO	Material	Treatment Technique
1	Mangrove Skin	<ul style="list-style-type: none"> <li>• Bamboo was dried for four hours.</li> <li>• The mangrove skin was cut, blended, filtered out, and boiled.</li> <li>• Bamboo was soaked and boiled in a mangrove skin extract in 60°C for one hour</li> </ul>
2	Syzygium Aromaticum	<ul style="list-style-type: none"> <li>• Syzygium Aromaticum was blended, filtered out, and boiled</li> <li>• The bamboo was soaked for two days</li> </ul>
3	Coconut Shell	<ul style="list-style-type: none"> <li>• Make the solvent</li> <li>• Soak the bamboo</li> </ul>
4	tobacco	<ul style="list-style-type: none"> <li>• The tobacco is boiled</li> <li>• The bamboo is soaked</li> </ul>
5	accacia wood	<ul style="list-style-type: none"> <li>• The accacia wood is cleaned and blended</li> <li>• The bamboo is soaked in a cold solvent for three days</li> </ul>
6	akonafos	<ul style="list-style-type: none"> <li>• the bamboo is dried in the oven</li> <li>• Make an akonafos solvent</li> <li>• Soak the bamboo</li> </ul>
7	Cerbera manghas	<ul style="list-style-type: none"> <li>• the bamboo is dried in the oven</li> <li>• The <i>Cerbera manghas</i> is blended and dissolved in the water</li> <li>• Soak the bamboo</li> </ul>
8	Melaleuca cajuputi vinegar wood	<ul style="list-style-type: none"> <li>• Make a solvent</li> <li>• Soak the bamboo for two days</li> </ul>
9	Azadirachta indica	<ul style="list-style-type: none"> <li>• The bamboo is dried for four hour</li> <li>• The solvent is made in 60°C of the temperature</li> <li>• The bamboo is soaked in 60°C of the temperature for an hour</li> <li>• The bamboo is dried in the oven</li> </ul>
10	CCB	<ul style="list-style-type: none"> <li>• The bamboo is boiled in the water until it can easily cut</li> <li>• Make a slice of a bamboo</li> <li>• Dehydrate the bamboo with the mix of alcohol-gliserin for three days</li> <li>• The slices are covered by the cover glass</li> <li>• The bamboo is dried in the oven</li> <li>• Make a hole in the bamboo segment</li> <li>• Stand the bamboo</li> <li>• The solvent is entered into the bamboo</li> <li>• Left aside for seven days</li> </ul>
11	Borax boric	<ul style="list-style-type: none"> <li>• Clean the bamboo</li> <li>• Make the solvent</li> <li>• Put the bamboo in the solvent place</li> <li>• The place is flowed by the solvent place</li> <li>• Soaked for five days</li> </ul>
12	Borax	<ul style="list-style-type: none"> <li>• Make a hole in bamboo to enter the preservation solvent</li> <li>• Make a borax solvent</li> <li>• Stand the bamboo</li> <li>• The solvent is placed inside the bamboo</li> <li>• The drying of the bamboo</li> </ul>
13	Boric acid equivalent	<ul style="list-style-type: none"> <li>• Clean the bamboo</li> <li>• Make the solvent</li> <li>• Put in the solvent tub</li> </ul>



**Figure 3.** The amount of the preservation steps.



**Figure 4.** The time needed for Bamboo Preservation Steps.



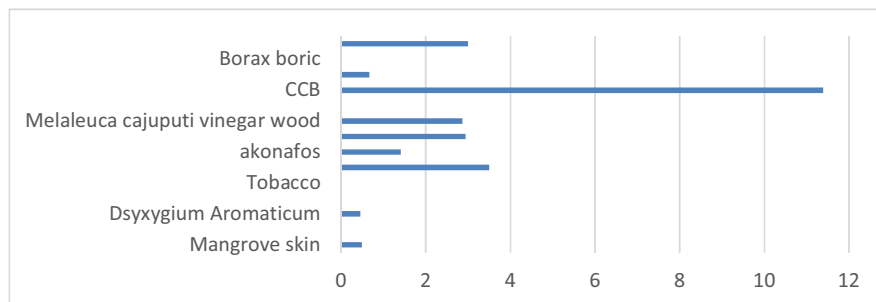
**Figure 5.** The comparison of natural and chemical procedures for bamboo preservation.

3.3. *The Test Result of the Treated Bamboo*

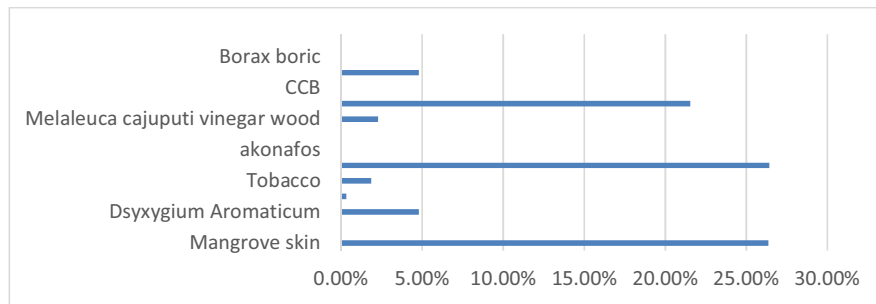
The Test Result of the Treated Bamboo can be seen in Table 2.

**Table 2.** The Test Result of the Treated Bamboo.

NO	Material	Retention test	The damage
1	Mangrove Skin	0,49	26,35%
2	Syzygium Aromaticum	0,459	4,8%
3	Coconut Shell	-	0,328%
4	tobacco	-	1,87%
5	accacia wood	3,5	26,42%
6	akonafos	1,41	
7	Cerbera manghas	2,94	
8	Melaleuca cajuputi vinegar wood	2,87	2,28%
9	Azadirachta indica	-	21,54%
11	CCB	11,39	-
12	Borax boric	0,67	4,8%
13	Borax	-	-
14	Boric acid equivalent	3	-

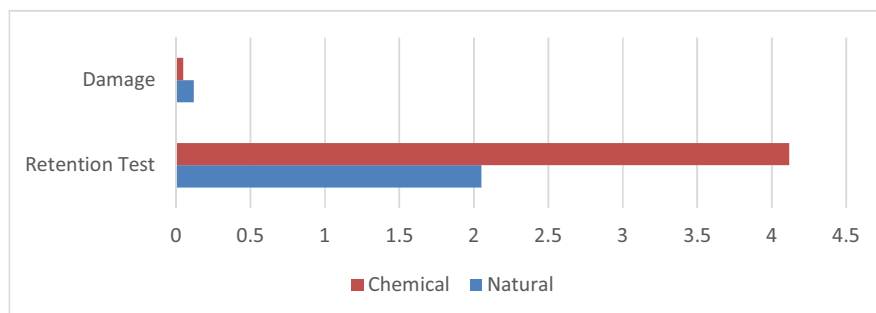


**Figure 6.** The retention test result.



**Figure 7.** The damage test result.

The retention test result can be seen in Table 2, Figure 6, and Figure 7. They show that the CCB has the highest value that means it is the stronger of all materials. The next stronger for the chemical material is boric acid equivalent. Meanwhile the strongest natural materials are accacia wood, while the second and third are *Cerbera manghas* and *Melaleuca cajuputi* vinegar wood that almost has the same value. In the other hand, the damage test result shows that *Syzygium Aromaticum*, Coconut Shell, tobacco, and *Melaleuca cajuputi* vinegar wood, and borax boric has the damage value under 5%. According to the SNI 7207:2014, it means that the material is very strong from the insect attack. While Mangrove Skin, accacia wood, and *Azadirachta indica* is the least strong among them.



**Figure 8.** The comparison of the test result.

Figure 8 shows the comparison of the test result. The test proved that the bamboo that used the chemical material as its preservation is stronger than the bamboo using the natural material.

#### 4. Conclusion

This research aims to find the bamboo treatment that is cheapest, easiest, and most effective to be used by common people. The research finds that the cheapest material is *Cerbera manghas*, while the most expensive is CCB. While the easiest procedure is by using liquid coconut shell and *Melaleuca cajuputi*, and the most complicated treatment is by using CCB. The strongest natural material is accacia wood, *Cerbera manghas*, and *Melaleuca cajuputi* vinegar wood. For chemical material, CCB is the strongest. The damage test result shows that *Syzygium Aromaticum*, Coconut Shell, tobacco, *Melaleuca cajuputi* vinegar wood, and borax boric has least damage among other materials. Overall, the research shows that

Natural material is easier and cheaper to be used by the community than the chemical one. The best material recommended is *Cerbera manghas*. Although the procedure is not the easiest, it is still possible to be done by the common people using simple tools. As for the industry, the CCB treatment material is suitable, because it is proved to be the strongest material, even though it is the most expensive and complicated.



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