

# The effect of clay nanoparticle on the retention and attack of drywood termite (*Cryptotermes cynocephalus* Light).

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**Abstract.** The application of clay nanoparticles as wood preservative was intended to examine its resistance to infestation of drywood termite (*C. cynocephalus* Light). Loam was crushed into small pieces as clay nanoparticles, which was used as wood preservative that was soluble in water. The material was dissolved with water in a given concentration and put it into anggerung (*Trema orientalis*), white meranti (*Shorea bracteolata*) and sengon (*Paraserianthes falcataria*) by full cell method or impregnation. The tested samples were preserved by clay nanoparticles at the air pressure 60 psi for 2 hours and then furnace-dried, and tested by infestation of drywood termites. Results of the research showed that mortality of the drywood termites on those three preserved woods with clay nanoparticles by concentration of 2.5% and 5%, which reached 96.4% and 100% on average, respectively, in comparison without preservation by average mortality value was 27.4%. The highest retention of clay nanoparticle was 24.89 kg.m<sup>3</sup> was obtained by concentration of 5% for white meranti and the lowest was 9.32 kg.m<sup>3</sup> by concentration of 2.5% for anggerung. The application of clay nanoparticle as effective wood preservative against the infestation of drywood termite by concentration of 5% has been proven by mortality 100%.

## 1. Introduction

The application of clay nanoparticle for wood preservation has been known by few people, as well as academician and practitioner because clay nanoparticles are particles that derived from loam crushing process. Loam is a kind of clays that contains poor nutrient, therefore it is so-called worst clay or acrysol. The particle size of loam ranges 50-2 micron and mostly contains iron, aluminium, and silica loam [1]. According to Sutandi et al [2] explain that loam has acid property, which may inhibit the growth of crops including oil palm (*Elaeis guineensis* Jack.). Size of the loam, as mentioned above, may become beneficial and valuable if it is processed into nanoparticle size, so that it will easily pass through the wood's cavities. Such clay nanoparticles contain more metallic elements, particularly iron, so that if such material is impregnated into the wood and fills the wood's cavities and cells, it will be poisonous for organism, which destroys the wood, particularly drywood termite (*Cryptotermes cynocephalus* Light). Anggerung (*Trema orientalis*) belongs to Ulmaceae family.



Anggerung has naturally low durability or less resistant to wood destroyer, and its specific gravity ranges 0.33–0.4 that included as durable class V. White meranti (*S.bracteolata*) is a species of commercial timber and belongs to Dypterocarpaceae family. White meranti grows at natural forest and it mostly utilized as building materials. White meranti has average densities that range between 0.4–0.6 and belong to durable class IV [3]. Sengon (*P. falcataria*) belongs to Fabaceae family. Sengon grows fast and mostly grown at timber estate and community forest in Indonesia.

Such timber can be utilized for light construction materials or non-structural. Densities of sengon range 0.28–0.37 and belong to durable class V or less resistant to drywood termite.

According to [5] drywood termite has the smallest size and belongs to Kalotermitidae family. It is a drywood termite, which lives in very low level of water. Mortality of termite is an amount of termite's death at definite time. The mortality values are determined and measured in accordance with death percentage of the drywood termites [6]. Objectives of the research were to prevent the infestation of drywood termite and to study the amount of clay nanoparticle retention on anggerung, white meranti and sengon.

## 2. Materials and method

Loam was taken from 80 cm depth, and then crushed with water and strained using 100 mesh strainers, and after that it was sun-dried. The dried loam was crushed into nanoparticles size using ball mill, which is so-called clay nanoparticle. Both chemical contents and pH of clay nanoparticles were analysed at Soil Laboratory of Pusat Rehabilitasi Hutan Tropika Universitas Mulawarman. The tested samples of anggerung, white meranti, and sengon were made in size of 2.5x2.5x0.5 cm from the timber, randomly and dry-aerated to achieve constant weight or balanced water content and then preserved by pressed-vacuum (impregnated) for two hour by clay nanoparticle material with concentrations 2.5% and 5%. Then, the retention values were counted. The tested samples after the preservation process and the tested samples without preservation, were furnace-dried at constant temperature of 103°C and weighed, then kept until it reached air-dried. Glass pipe by diameter of 1.8 cm and 3 cm height was attached on one side of the tested samples using paraffin (candle). Fifty healthy and active worker drywood termites taken from Wood Preservation Laboratory of State Agricultural Polytechnic of Samarinda were put into the glass pipe and covered with cotton. Then, it was put in a dark room at  $(25 \pm 2)^\circ\text{C}$  temperature and  $(70 \pm 5)\%$  humidity for 12 weeks and counted the dead termites [7]. Mortality and retention counted using equation as presented below.

### 2.1. Mortality equation

$$M = \frac{\sum dt}{\sum it} \times 100\% \quad (1)$$

$M$  = mortality worker drywood termite,  $\sum dt$  = sum of dead worker drywood termite,  $\sum it$  = sum of initial worker drywood termite.

### 2.2. Retention equation

$$R = \frac{W_2 - W_1}{V} \times C \quad (2)$$

$R$  = retention ( $\text{gram.cm}^3$ ) converted to ( $\text{kg.m}^3$ ),  $W_2$  = weight of wood after preserved (gram),  $W_1$  = weight wood before preserved (gram),  $C$  = concentration of clay nanoparticle solutions,  $V$  = volume ( $\text{cm}^3$ )

## 3. Results and discussion

The observed data concerned with chemical contents and pH clay nanoparticles, mortality of termite, reduced weight of the tested samples due to infestation of such drywood termites and retention of clay nanoparticles on those three kinds of timber, such as anggerung, white meranti and sengon.

### 3.1. The effect of clay crushing into clay nanoparticles against chemical content and pH clay nanoparticles

Chemical content and pH loam, as well as clay nanoparticles were presented in table 1.

**Table 1.** Chemical content and pH of loam and clay nanoparticle.

Number	Chemical element	Material content (mg/gram)	
		Loam	Clay nanoparticle
1	Iron (Fe)	27.89	32.53
2	Lead (Pb)	0.94	0.45
3	Zinc (Zn)	0.73	0.94
4	Aluminium (Al)	0.61	0.57
5	Copper (Cu)	0.37	0.54
6	Calcium (Ca)	0.16	0.21
7	pH	3.59	4.15

The chemical contents of loam and clay nanoparticle as presented in table 1 show that of chemical content clay nanoparticle for iron (Fe) has the highest level followed by Zinc (Zn), aluminium (Al), and copper (Cu), as well as lead (Pb) and calcium (Ca). All chemical elements from loam to clay nanoparticle increase, except for (Pb) and (Al), in which (Pb) from 0.94 milligrams .gram for loam becomes 0.45 milligrams .gram for clay nanoparticle while Al from 0.61 milligrams .gram for loam becomes 0.57 milligrams .gram for clay nanoparticle. The value of pH for loam was lower than clay nanoparticle, it may be correlated with Al content. According to [8] the higher content of Al in the clay, the lower pH of the clay is and vice versa. The highest content of Fe means that the clay is very infertile. Fe, Zn, Pb, Cu, and Al are macronutrients, which are required in small amount for the plant growth, and if they are excessive, they may harm and poison the plants. According to [9] suggested that impregnation of clay nanoparticle may increase mechanical properties or strength of sengon and white meranti timbers.

### 3.2. The effect of clay nanoparticles on mortality of drywood termites

Mortality of drywood termites on the tested samples of three timbers, anggerung, white meranti, and sengon were presented in table 2. Drywood termite mortality on resistant test against those three species of wood, which were preserved through pressed-vacuum. Such mortality percentage shows different mortality of the drywood termites in accordance with different concentration of clay nanoparticles, in which 5% concentration of clay nanoparticles on those three kinds of timber showed that mortality of the termites reached 100%, while at concentration 2.5% on those three kinds of timber, such as anggerung, white meranti, and sengon showed mortality values for about 95.93%, 94.81% and 98.52%, respectively. For the tested samples without preservation, mortality values for those three timbers were 28.89%, 28.89% and 24.44%, respectively. It showed some differences between the treatment of preservation using clay nanoparticles and without any preservation. According to [9] stated that the treatment of preservation and concentration of the preservative have significant effect on the increase of mechanical properties of wood.

Mortality values of the drywood termites, as presented in table 2 showed that sengon wood is more resistant to drywood termite attack than white meranti and anggerung, it can be seen in wood preserved with clay nanoparticle concentration for 2.5%. In which sengon Significant difference was found for mortality of termites on preservation in accordance with analysis of variance, which is shown in table 3. Values of count from analysis of variance on mortality of drywood termites. According to [11] suggested that timbers, which are treated by wood preservatives or being preserved, are more resistant to organisms that damage the timbers in comparison with the timbers without any preservation. Further test used Fairly Significant Difference (FSD) test for concentration factor of clay

nanoparticles was presented in table 4. Numbers followed by the same letter show no significant difference on Fairly Significant Difference at  $\alpha 0.05 = 6.684$

**Table 2.** Mortality of drywood termites on resistant test against three species of wood, which were preserved by pressed-vacuum for two hour.

Kinds of timber	Concentration (%)		
	0 (non preservation)	2.5	5
Anggerung	28.89b	95.93a	100a
White meranti	28.89b	94.81a	100a
Sengon	24.44b	98.52a	100a

**Table 3.** Analysis of variance on mortality of drywood termites.

Comparative material	Independent degree	Value of count
Treatment of preservation	8	122.30 **
Kinds of timber	2	0.03 ns
Concentration of clay nanoparticles	2	488.21 **
Combination between kinds and concentrations	4	0.48 ns

\*\* = very significant difference

ns = not significant

**Table 4.** Fairly significant difference (FSD) test for concentration factor on mortality of drywood termites.

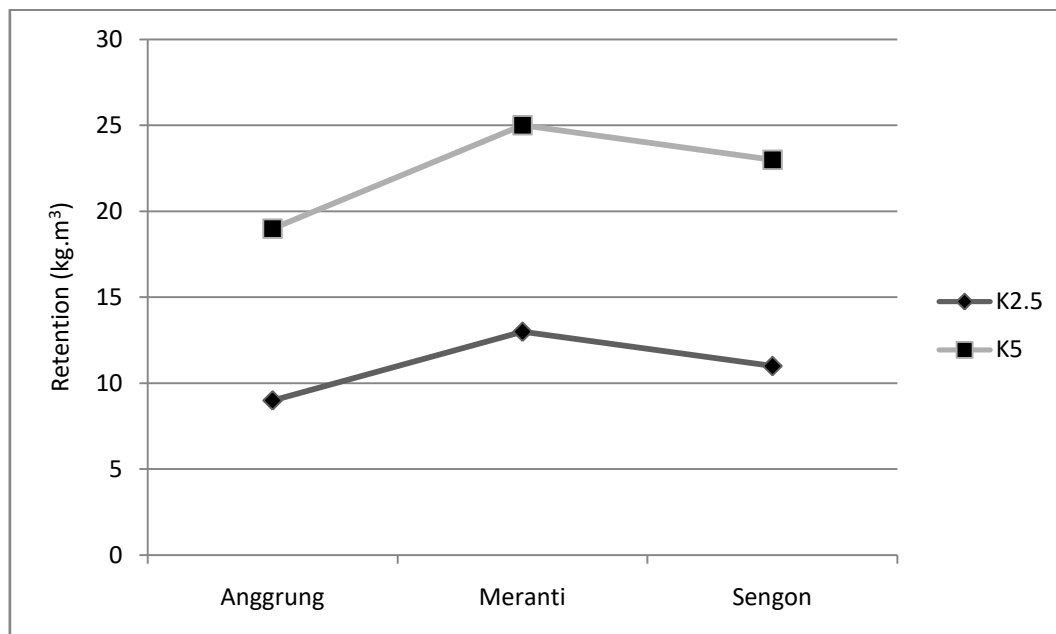
Concentration of claynanoparticle	Mortality
5%	100.00 a
2.5%	96.42 a
0 (without preservation)	27.41 b

Mortality of drywood termites on the tested samples from three kinds of timber along with the treatment of preservation using clay nanoparticle by concentrations 5% and 2.5% did not show any difference, but it was very different for timber without any preservation, and it meant that preservation using clay nanoparticles is effective to resist the infestation of drywood termites. The chemical content in the clay nanoparticle (Table 1) can be as toxic to drywood termite because chemicals such as iron (Fe), lead (Pb), zink (Zn), copper (Cu), aluminium (Al) and calcium (Ca) are termite chemicals. According to [14] natural resistant of the timber (without preservation) on white meranti and sengon against infestation of drywood termites.

### 3.3. The effect of clay nanoparticle on retention

The retention values of anggerung, white meranti, and sengon, which have been preserved by different concentrations of clay nanoparticles, are presented in figure 1. The retention values of anggerung, white meranti, and sengon, which have been preserved by different concentrations of clay nanoparticles, are stated in kilogram per meter cubic ( $\text{kg.m}^3$ ). It shows that clay nanoparticles are easily passed through the timber of white meranti, by higher retention than on sengon and anggerung. According to [10] suggested that requirement of retention for wood preservation is  $12 \text{ kg.m}^3$  by concentrations of 2-5%. Comparison of such retention values based on kinds of timber show that white meranti is higher than sengon by the same concentration. However, white meranti easily impregnated by clay nanoparticles. It indicates that the absorptive capacity of white meranti better than sengon and anggerung. Density measurement for white meranti is 0.47 sengon is 0.30 and anggerung is 0.37. The

absorptive capacity of each timber against the preservative is different. According to [15] impregnation of preservative in timber highly depends on absorptive capacity kind of timber due to different types (kinds) of timber may have different absorptive capacity of the preservative. The higher retention values mean that the timbers are easily preserved. According to [16] concentration of solution and properties of the wood structures may determine permeability and absorption of the preservative chemical solutions in the wood. Such permeability affects retention values of the preservative. The retention values are presented in figure 1.



**Figure 1.** Graphic for retention values of anggerung, white meranti, and sengon, which are preserved by clay nanoparticles with different concentrations.

The Figure above shows that white meranti produces higher retention than anggerung and sengon, by concentrations 5% and 2.5%, and the lowest retention is found on anggerung. According to [17] stated that retention of clay nanoparticle may increase strength on sengon. Based on the description above, it can be concluded that the application of clay nanoparticle, the concentration 5% in wood preservation using pressed-vacuum (impregnation) may resist or prevent infestation of the drywood termites effectively. The lowest clay nanoparticle retention is on anggerung for about 9.32 kg.m<sup>3</sup> by concentration 2.5% and the highest is on white meranti for about 24.89 kg.m<sup>3</sup> by concentration 5%. High concentration may result high retention values as well. Absorption and retention are highly dependent on the void cell of the wood and solution concentration [18].

The effect of nanoparticle retention on drywood termite mortality can be attributed to its concentration, where 5% clay nanoparticle concentration provides high retention result for three species of wood and so is the mortality of drywood termite reach 100%. It can be said that the retention of clay nanoparticle has an effect on drywood termite mortality.

#### 4. Conclusion

The application of clay nanoparticles in wood preservation in three species of wood, anggerung, white meranti and sengon can poison drywood termite (*C. cynocephalus* Light) mentioned in the concentration of 5% clay nanoparticles causing mortality of drywood termite to get 100%.

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