The Effect of Ammonia Fumigation on Subterranean Termites Mortality Percentage

by

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Abstract

In tropical areas like Indonesia, the decline in the quality of building materials made from lignocellulose is mostly caused by the humid climatic conditions, rainfall and high temperatures as well as by the high abundance of biologically damaging factors such as termites, beetles and fungi. Among these factors, termites are commonly known as the main damaging factor in woods of building construction including residential buildings. This study aimed to determine the effectiveness of fumigation method using ammonia on subterranean termites mortality. Wood tested samples used in this study included Sengon Wood (*Paraserianthes falcataria*), Rubber Wood (*Hevea brasiliensis*) and Acacia Wood (*Acacia mangium*). The wood tested samples with the size of 10x10x50 cm were fumigated using 2, 4, 6, 8 and 10 liters of ammonia solution for 4 days. Prior to this, they were perforated with a diameter of 0.5 cm with a depth of 20 cm at a distance of 1, 3 and 5 cm from the surface of the wood, and then 20 termites were put inside (*Coptotermes curvignathus*). After 4 days, the percentage of mortality of subterranean termites was calculated. All treatments showed an incline in the percentage of their mortality. Thus, fumigation with ammonia was proven effective against the attacks of subterranean termites.

Key words : Fumigation, Ammonia, Fast growing species, *Coptotermes curvignathus*

Introduction

In tropical areas like Indonesia, the decline in the quality of building materials made from lignocellulose is mostly caused by the humid climatic conditions, rainfall and high temperatures as well as by the high abundance of biologically damaging factors such as termites, beetles and fungi. Among these factors, termites are commonly known as the main damaging factor in woods of building construction including residential buildings (Nandika et al. 2003)

Economically, until the end of year 2000, termites attacked on building cost until 2,67 triliun rupiahs, with the average percentage of attack on the building reached over 70%. Each year increased by approximately 5%. Incredible (Anonim, 2010)

Fumigation is a common method used for pest control treatment. The use of this technique is widely known for warehouse pest eradication, wood pests, pre-shipping treatments and quarantine. At this time, the interests of fumigation treatment for wood pest control have increased significantly along with the enactment of internationally based regulations. For example, the FAO-Interim Commission for Phyto-sanitary Measure (ICPM) issued International Standard for Phytosanitary Measure/ISPM for wood packaging or better known as ISPM # 15 (Guidelines for Regulating Wood Packaging materials in International Trade) in March 2002. ISPM # 15 regulates the uniformity in the handling of wood packaging (harmonized regulation), avoids the issues of unilateral rules that hinder the process of international trade, as well as avoids the detrimental aspect in the use of wood packaging especially for the spread of pest organisms (wood destroying insects) inter regions or countries.

Previously, fumigation technique relied greatly on bromide metal as a fumigant. Currently, its use is increasingly restricted because of its effects, which cause damage to the ozone layer. The use of bromide metal has been banned for pest eradication treatments except for quarantine and pre-shipping. Pest eradication treatments in food warehouses, other agricultural commodities, seed storage, soil treatment, and others should use materials containing no ozone materials such as Hydroxide Ammonium (Ammonia).

However, information on the efficacy of the use of ammonia against wood-destroying insects that live in wood and their ability of penetration into the pores of the wood is still lacking. In fact, the information is very important to strengthen the recommendation on the use of ammonia for the eradication of wood destroying insects. Based on this idea, the study on the effect of fumigation method with Ammonia on subterranean termites mortality had to be carried out.

And based on previous researchs were carried out by Wahyudi *et al* (2007) and Rahayu *et al* (2010), we found that Acacia, Sengon and Rubber wood were classified into durability class V. They were very vulnerable to attacked by wood destroying factors including termites attack.

This study aimed to determine the effect of the fumigation method with ammonia on subterranean termites mortality.

Materials and methods

Materials and tools used in this study consisted of ammonia solution, *Coptotermes curvignathus*, sengon wood, rubber wood, acacia wood, plastic sheeting, duct tape, hose, and fumigation safety equipment (gloves, helmet, and fumigation mask). As much as 2, 4, 6, 8 and 10 liters of ammonia were used as for fumigation treatment for 4 days.

The test samples used with the size of (10 x 10 x 50) cm^3, which were cut into two parts equal in length. To test the penetration ability of fumigant gas, on one of its side, the wood sample was drilled with a depth of 20 cm, and the drill diameter was 0.5 cm at a distance from the top surface of 1 cm, 3 cm and 5 cm. The distance from the upper surface in this study was treated as the treatment. Furthermore, as many as 20 termites of *C. curvignathus* were inserted into the test holes, and the separated wood samples were attached again using the glue and covered with the duct tape. Each treatment was repeated for 3 times. The technique of laying the tested termites onto the sengon wood can be seen at Figure 1.

Fumigation application

The tested wood samples inserted with *C. curvignathus* termites for each treatment were put inside the airproof fumigation chamber of a square shaped box with a size of (2x1x1) m^3 made of wood sealed completely on the six sides by transparent plastic material (Figure 2).

Ammonia solution was inserted into the testing room after the test wood samples were already prepared inside, and then the hole used to pour the ammonia solution was sealed, and the exposure lasted for 4 days. For the control treatment, the test wood samples inserted with *C. curvignathus* termites with various distances from the surface were placed outside the testing room so that they were not exposed to the fumigant gas.

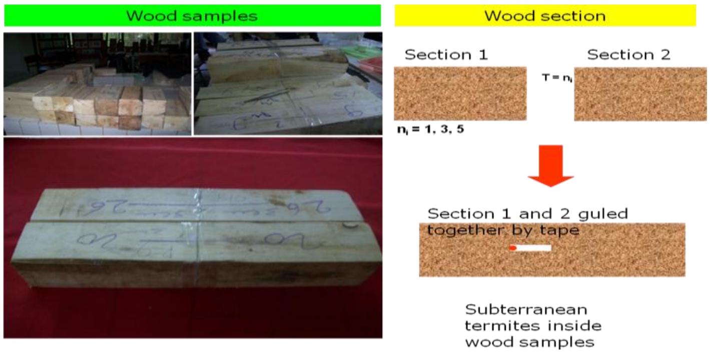


Figure 1 Technique of laying the tested termites onto the wood

Figure 2 Fumigation Chamber

After the room was exposed to fumigant gas for 4 days, gas aeration was conducted. The process of aeration was carried out by opening the closing doors so that the gas disappeared from the room, and this process was assisted by a blower and performed for 24 hours.

The data calculated included the mortality rate of the subterranean termites of *C. curvignathus*, which was calculated at the time of discharge by using the following equation:

$$\text{Mortality (\%)} = \frac{N1 - N2}{N1} \times 100\%, \text{ where:}$$

N1 = total number of termites before exposure

N2 = total number of termites alive after exposure

Data analysis

Data processing was done using a factorial design model CRD (Completely Randomized Design) with 3 factors: Factor A (wood species), Factor B (the volume of ammonia) and factor C (depth) with 3 replications. The model is as follows:

$$Y_{ijkl} = \mu + \alpha_i + \beta_j + \gamma_k + (\alpha\beta)_{ij} + (\alpha\gamma)_{ik} + (\beta\gamma)_{jk} + (\alpha\beta\gamma)_{ijk} + \varepsilon_{ijkl}$$

Where, Y_{ijkl} = observation value on replication-l which undergo wood species treatment-i, ammonia volume treatment-j and depth treatment-k

μ = population median value

α_i = wood species treatment-i

β_j = ammonia volume treatment-j

γ_k = depth treatment-k

$(\alpha\beta)_{ij}$= interaction between wood species treatment-i and ammonia volume treatment-j

$(\alpha\gamma)_{ik}$= interaction between wood species treatment-i and depth treatment-k

$(\beta\gamma)_{jk}$= interaction between volume ammonia volume treatment-j and depth treatment-k

$(\alpha\beta\gamma)_{ijk}$= interaction among wood species treatment-i, ammonia volume treatment-j and depth treatment-k

ε_{ijkl} = error effect from replication-l which undergo wood species treatment-i, ammonia volume treatment-j and depth treatment-k

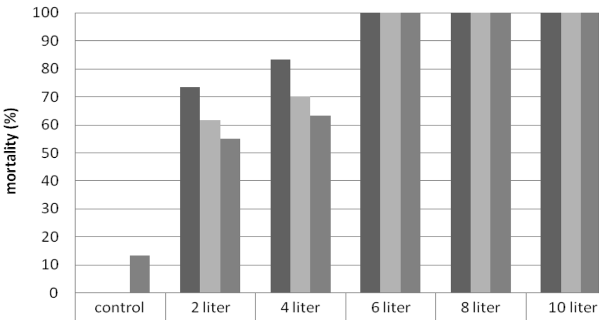
Results and discussion

In general, the fumigation treatment using 2, 4, 6, 8 and 10 liters of ammonia solution for 4 days showed significant differences in the percentage of mortality of termites in the three wood species when compared with the control. Based on statistics analyzes, wood species factor, ammonia volume and depth factors, each showed significant differences in the percentage of mortality of termites. The same things happened on interaction between two factors (wood species*ammonia volume, wood species*depth and ammonia volume*depth). However, the interaction among three factors showed unsignificant diffrences in subterranean termite mortality.

Fumigation treatment was able to increase the percentage of mortality of termites to 100% (at a depth of 1 cm) on rubber and sengon woods. It is assumed that ammonia vapor could penetrate the wood vessels up to the depth of 1 cm. According to Bowyer *et al* (2003), timber consists of various kinds of cells, and these cells have cell wall, cavity and pit. As a result, the vapor or gas can easily enter the wood because it is porous.

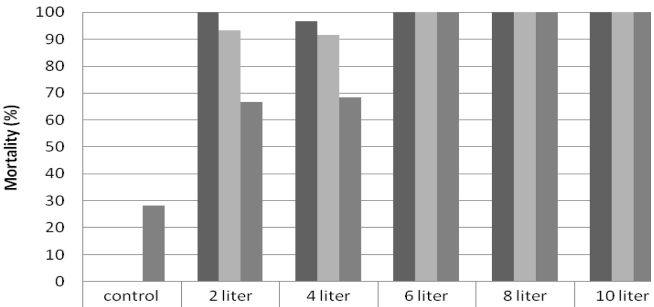
Rubber and Sengon woods have specific gravity values of 0.59 and 0.25 (Wahyudi *et al* 2007) respectively, in addition, they have a porous wood structure. These woods contain more cavities than the percentage of wood substance so that the ammonia vapor can penetrate the timber structure with ease. In contrast to mangium wood that has a specific gravity of 0.41, fumigation treatment was not able to reach a value of 100% of termite mortality at the depth of 1 cm; therefore, it is assumed that mangium wood has a different and unique structure. The difference in the structure of the three types of wood will make a difference in reaction to ammonia fumigation. On Acacia wood, 100% mortality percentage was acchieved (in each depth) on 6 liter ammonia volume treatment.

The following is the histogram of the percentage of termite mortality after fumigation treatment obtained using 2, 4, 6, 8 and 10 liters of ammonia solution for 4 days on acacia, rubber and sengon woods (Figure 3, 4 and 5).



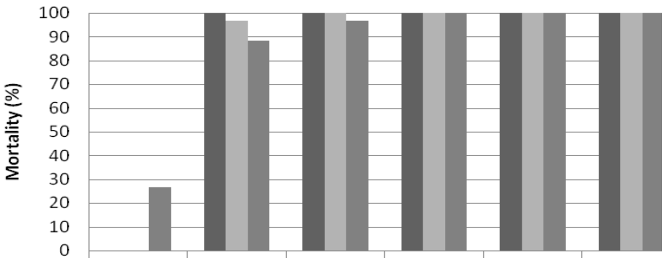
	control	2 liter	4 liter	6 liter	8 liter	10 liter
1 cm		73,33	83,33	100	100	100
3 cm		61,67	70,00	100	100	100
5 cm	13,33	55,00	63,33	100	100	100

Figure 3. Mortality percentage of *A. mangium*



	control	2 liter	4 liter	6 liter	8 liter	10 liter
1 cm	0	100	96,67	100	100	100
3 cm	0	93,33	91,67	100	100	100
5 cm	28,33	66,67	68,33	100	100	100

Figure 4. Mortality percentage of Rubber (*H.brasiliensis)*



	control	2 liter	4 liter	6 liter	8 liter	10 liter
1 cm	0	100	100	100	100	100
3 cm	0	96,67	100	100	100	100
5 cm	26,67	88,33	96,67	100	100	100

Figure 5. Mortality percentage of Sengon (*P. falcataria)*

Different results obtained at the depth of 3 and 5 cm, and the fumigation treatment was not able to reach 100 % mortality of termites in those woods in ammonia volume treatment under 6 liter. Presumably, this is because the ammonia solution used was not adequate to penetrate the vessels to the depth of 3 and 5 cm. Therefore, it takes more solution to produce 100% of mortality of termites at the depth of 3 and 5 cm. For example, on 6 liter ammonia volume treatment, subterranean mortality percentage reched 100% on each depth (1, 3 and 5 cm) in every wood species. It assumed because in that treatment, ammonia vapour was saturated enough inside fumigation chamber to penetrate woods until 5 cm depth.

The incline of ammonia volume (at the same depth) caused also an incline of subterranean termites mortality percentage. Presumably, this was because more ammonia concentrate inside fumigation chamber to penetrate woods. Therefore, more subterranean termites were killed. At 2 liter ammonia volume, the increasing of depth caused a decline in percentage of subterranean mortality in each wood species. It assumed because the distance of ammonia vapour to penetrate wood became much furthure. So that it needed more ammonia volume to penetrate 5 cm depth to achieve 100% mortality percentage. In this case 6 liter ammonia volume shoud be adequate to gain 100% mortality percentage in each wood spesies.

We would like to thank Directorate General of Higher Eduation, National Eduacation Ministry for funding this research. And also, all of staff of Forest Product Department of IPB and Laboratory of Biomaterial and Biodeterioration of Biological Resources and Biotechnology Research Center for their asistance and contribution so that we could fininsh this research.

Conclusions

Fumigation using ammonia as much as 2 liters for 4 days can increase the mortality of subterranean termites. Even in the rubber and sengon woods, this treatment could achieve the highest percentage of termite mortality i.e. 100% at the depth of 1 cm. However, the ammonia volume optimum to overcome subterranean termites attacked at 5 cm depth was 6 liter. Therefore, ammonia fumigation should be recommended as one method to cope with termite attack.

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