The Effectiveness of Boron Preservatives to Prevent Dry-wood Termite Attack on Mahogany Sapwood

Aryati Larasati and Joko Sulistyo

Abstract

Mahogany wood is utilized for many furniture products and construction purposes. The objective of this experiment was to prevent wood-destroying insects by using boron preservatives such as boric acid and borax. Materials used were mahogany sapwood planks (19 years) obtained from community forest in Kali Bawang District, Kulon Progo. Two preservation methods, i.e., hot-soaking (1, 2, and 3 hours) and the cold-soaking (12, 24, 36, and 48 hours) in 5% concentration, were used. The drywood termites (*Cryptotermes cynocephalus* Light) were used for observation. The result showed that the retention value ranges were 4.25 to 12.99 kg/m^3 for cold-soaking method and 3.09 to 9.53 kg/m^3 for heat-soaking method. Mortaliy rate and mass loss due to termite attacks ranged from 56.0 to 80.6 % (control values : 43.3%) and 850 to 1370 mg (control values : 1930 mg). Significant interaction between soaking time and the type of preservative was observed to discover its effect on the levels of retention (cold soaking) and mortality rate of termites (hot soaking). Boron preservatives tended to enhance the repellent properties than its toxicity.

Keywords: *Swietenia macrophylla*, wood preservation, borax, natural durability, non-pressure method

Introduction

Mahogany wood is one of the commercial woods that are often found in community forests. Mahogany population in Indonesia is concentrated in three provinces, namely West Java, Central Java, and East Java. Mahogany wood is in great demand due its beautiful appearance, good workability, and ability of being finished and dried without significant defects (Martawijaya *et al*. 2005). Nonetheless, the mahogany wood produced from community forests is assumed to have low quality because it is harvested at young stage. Most of the raw materials in the small-scale furniture industry are mahogany which comes from young stands. The concern is that the wood has a fairly high proportion of sapwood, which generally exhibits a low natural durability.

Wood preservation process is an effort to extend the duration of mahogany wood utilization. Boric acid and borax preservatives are commonly used due their water-borne properties, cheap price, and availability. In addition, it is also possible to accelerate their dissolving by increasing the temperature of the solvent. The easiest method to do is the soaking method, especially for communities around forests and small-scale industries. Cold soaking with borax and boric acid on several types of wood is quite effective in preventing termite damage (Abdurrahim 1994; Lelana *et al*. 2011; Sumaryanto *et al*. 2013). Therefore, this research was conducted on the preservation of mahogany wood using the active ingredient boron by cold soaking and hot soaking methods.

Materials and Methods

Material Preparation

The material used was wood from a 19-year-old mahogany tree from Kajoran Pelem Hamlet, Banjaroyo Village, Kali Bawang District, Kulon Progo Regency, Yogyakarta (Figure 1). The sapwood part was separated from the wood plank that previously was cut using a chainsaw. The size of the test specimens for preservation and termite resistance test was 3 cm (radial) x 3 cm (tangential) x 10 cm (longitudinal). The oil paint was used to to cover the transverse side (x) to avoid penetration from the longitudinal direction.

Figure 1. Boards (left side) of mahogany wood and mahogany logs (right side) from trees grown in community forest in Kulon Progo

Soaking Process

The commercial grade boric acid (H_3BO_3) and anhydrous borax (Na_2B4O_7) purchased from a local chemical store were prepared for the process. The concentration of preservative solution used in both preservative methods was 5%. The test samples were initially arranged, then were soaked completely in a solution tank. The test samples were soaked for a predetermined time variation of 12, 24, 36, 48 hours (cold-soaking method). The same procedure was applied to hot-soaking method. The tank was heated to a temperature of 80ºC for the specified time variations of 1, 2, and 3 hours. Experimental controls were untreated sapwood specimens. All treatments were replicated 3 times. After the soaking treatments, the samples were conditioned to the weather in order to determine the amount of retained preservatives (retention). The conditioning step was carried out by placing the test sample in an oven at 49ºC for 24 hours. This weather conditioning treatment was carried out for 10 days. After 10 days, the test samples were removed and air-dried at room temperature for 2 days. Retention value was determined by weighing the weight after treatment minus weight before treatment in a given volume (Baysal *et al*. 2006).

Termite Test

A glass tube with a diameter of approximately 2.5 cm and a height of 4 cm was installed on an unpainted wood cross section. The installation was carried out using a wood glue. The glass tube was used to prevent termites from spreading out of the attack area (Figure 2). After that, the test sample was weighed to determine the air-dry weight before feeding. As many as 50 active drywood termites (*Cryptotermes cynocephalus* Light.) at nymph stage (N) were used in each test sample. (Figure 3). The test samples were fed to dry wood termites and were placed in a cool and dark place for 28 days. To measure the termiticidal activity, dead termites were counted at the end of observation. The weight loss was measured to quantify the extent of the termite attack on the wood (SNI 2006).

Figure 2. Specimens of termite test

Figure 3. Dry-wood termite (*Cryptotermes cynocephalus* Light.)

Statistical Analysis

A two-way analysis of variance (ANOVA) test was carried out to determine the factors (soaking time and preservative type) that had a significant effect on the 5% test level. The two factors were arranged in a factorial design. The post-hoc Tukey HSD (Honestly Significant Difference) was applied to see the difference in the mean value of the treatment (Gaspersz 1991). SPSS 16 software for Windows was used to do all calculations.

Results and Discussion

Retention is measured to evaluate the effectivity of preservation process. The recommended retention of boric acid preservative is 8 kg/m^3 to prevent termites, other insects, and fungi in tropical countries such as Indonesia (SNI 1999). The results of ANOVA showed that the interaction between the type of preservative and soaking time factors showed a significant effect on the retention value ($p<0.01$). Tukey test showed that the highest cold soaking retention value was 17.26 kg/m^3 at 48 hours soaking time with borax, while the lowest retention value was 4.24 kg/m^3 at 12 hours with boric acid (Figure 4). The borax retention value in this study was lower than boric acid retention value. This is probably because boric acid is easier to dilute using hot-water to get more preservatives retained in the wood cells. Previously, Yamauchi *et al*. (2007) demonstrated that the aqueous solution impregnates the cell walls of wood with boric acid more easily than the methanolic solution.

The hot-soaking time showed a significant effect on the amount of retention ($p<0.01$), while the difference between the two preservatives was not significant. Based on Tukey tests, it was shown that the 3-hours hot soaking was significantly different from the 1-hour hot soaking in the retention value. Previous studies with the same preservative reached 3-12 kg/m^3 in teak with cold soaking (Sumaryanto *et al*. 2013) or in the cold soaking range with borax preservative (Abdurrohim 1992). The same trend in the soaking time factor was also observed by Barly and Lelana (2010), who observed cold soaking of tusam and sengon woods, and Rinaldi *et al*. (2014), who preserved sengon wood with hot and cold soaking of kecubung leaf extract. This tendency was also observed by Djarwanto and Sudrajat (2002) on mangium wood that was preserved with hot-cold soaking of boron-based preservatives.

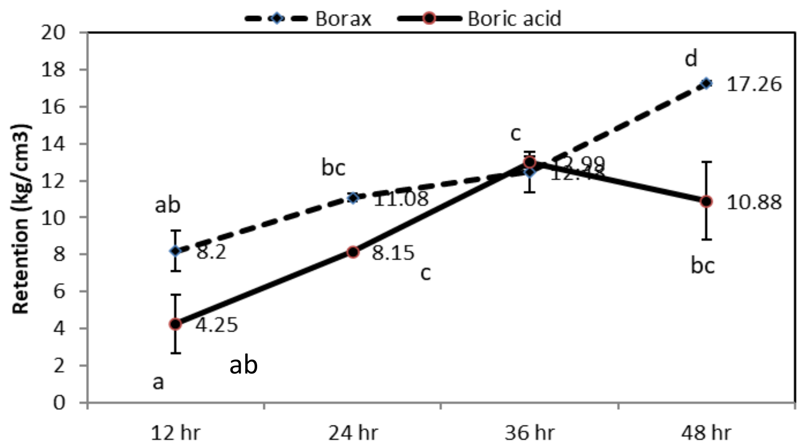

Figure 4. Retention of mahogany sapwood after cold soaking in boron preservatives (5% concentration). Average of 3 replications with the standard deviation error bar. The same letters are not statistically different at $p < 0.05$ by Tukey's test.

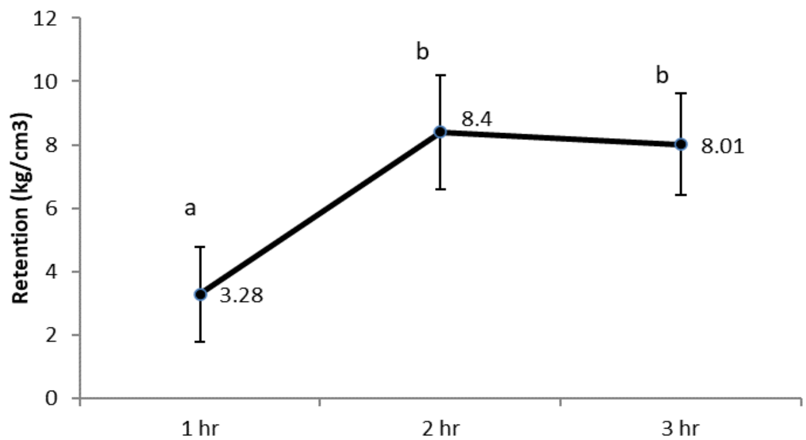

Figure 5. Retention of mahogany sapwood after hot soaking in boron preservatives (5% concentration). Average of 3 replications with the standard deviation error bar. The same letters are not statistically different at $p < 0.05$ by Tukey's test.

The drywood termite mortality and weight loss are presented in Table 1. The ANOVA results showed that the soaking time and the type of preservatives did not have a significant effect on the mass loss due to drywood termite attack in both methods. The cold soaking time and the type of preservative also had no significant effect on the mortality of dry wood termites. The interaction of the type of preservative and the duration of hot soaking showed a significant effect on drywood termite mortality ($p<0.01$). The results of the Tukey test between soaking time and type of preservative showed that the highest value (80.6%) was found in boric acid preservative with 3 hours of soaking time.

Comparison with controls without preservatives showed a drastic reduction in weight loss. However, there was no much increase in termite mortality because almost all treatments gave values below 70%. This indicates that the concentration used (5%) has more antifeedant effect than toxic effect. The tendency to increase retention with soaking time also cannot directly explain the effect on these two parameters. This is thought to be related to preservative penetration, which was unfortunately not measured in this experiment. Likewise, the type of preservative had no effect on the weight reduction parameters. This is because the active ingredients contained in both types of preservatives are the same (boron). It is asssumed that both preservatives have the same effectiveness against drywood termites. The same trend was also observed by Sumaryanto *et al.* (2013) in teak sapwood with boric acid and borax treatments. This indicates that the sapwood of teak and mahogany behaves the same towards boron preservatives. Further research needs to be done to explain this phenomenon.

Table 1. Termite test of mahogany sapwood after soaking in boron preservatives (5% concentration) and 28-day observation. Average of 3 replications. The same letters are not statistically different at $p < 0.05$ by Tukey's test.

Treatment	Mortality rate (%)		Weight loss (mg)	
Cold soaking (hour)	Borax	Boric acid	Borax	Boric acid
12	74.0	70.6	1090	850
24	62.0	69.3	930	900
36	66.6	65.3	940	870
48	72.6	67.3	920	940
Average	68.8	68.1	970	890
Hot soaking (hour)				
1	69.3 ab	56.0 a	960	1370
2	60.6 a	67.3 ab	1040	850
3	60.0 a	80.6 b	900	950
Average	63.3	68.0	970	1060
Control (untreated)	43.33		1930	

Conclusions

The interaction between soaking time and the type of preservative using the cold-soaking method gave a significant effect on the retention and mortality rate of termites, but did not have a significant effect on weight loss. The interaction between soaking time and preservatives with the hot-soaking method did not have a significant effect on retention and weight loss. The highest cold soaking retention value was 17.26 kg/cm^3 at 48 hours soaking time with borax whereas the 2-hours hot soaking obtained the highest retention value (8.04 kg/cm^3). The effective duration to prevent drywood termite attack was 1 hour of hot soaking in borax preservatives or 2 hours in boric acid preservatives while 12 hours of cold soaking with borax or boric acid preservatives was sufficient. Although the minimum retention has been achieved, the penetration of preservatives was not measured in this test although it is also an important factor for indicators of the effectivity of wood preservation.

References

Abdurrohim, S. 1992. Pengawetan tiga jenis kayu untuk barang kerajinan memakai dua jenis bahan pengawet boron secara rendaman dingin. Jurnal Penelitian Hasil Hutan 10(2): 54-58.

Abdurrohim, S. 1994. Pengawetan tiga jenis kayu secara rendaman dingin dengan bahan pengawet boraks dan asam borat. Jurnal Penelitian Hasil Hutan 12(5):157-163.

Badan Standarisasi Nasional. 1999. SNI 03-5010.1-1999. Pengawetan Kayu untuk Perumahan dan Gedung. Badan Standarisasi Nasional.

Badan Standardisasi Nasional. 2006. SNI 01.7207-2006. Uji ketahanan kayu dan produk kayu terhadap organisme perusak kayu. Standar Nasional Indonesia

Barly, N.E. Lelana. 2010. Pengaruh ketebalan kayu, konsentrasi larutan, dan lama perendaman terhadap hasil pengawetan kayu. Jurnal Penelitian Hasil Hutan 28(1):1-8.

Baysal, E.; M.K. Yalinkilic; M. Altinok. 2006. Determination of boron given to wood calculated by some expression types. Wood Research 51 (3):77-84.

Djarwanto; R. Sudrajat 2002. Pengawetan kayu mangium secara rendaman panas-dingin dengan bagan pengawet boron dan CCB. Buletin Penelitian Hasil Hutan 20(1):12-19.

Gaspersz, V. 1991. Teknik Analisis Dalam Penelitian Percobaan 1. Tarsito, Bandung,

Lelana, NE.; Barly, Ismanto, A. 2011. Toksisitas bahan pengawet boron-kromium terhadap serangga dan jamur pelapuk kayu. Jurnal Penelitian Hasil Hutan 29(2):142-154.

Martawijaya, A.; I. Kartasujana; K. Kadir; S.A. Prawira. 2005. Atlas Kayu Indonesia I. Pusat Penelitian dan Pengembangan Hasil Hutan, Bogor.

Rinaldi, N.A.; T. Listyanto; O. Karyanto; G. Lukmandaru 2014. Pengawetan metode rendaman panas dingin kayu sengon dengan ekstrak buah kecubung terhadap serangan rayap kayu kering Prosiding Seminar Nasional Mapeki XV (6-7 November 2012), Makassar, pp. 316-322

Sumaryanto, A.; S.A. Hadikusumo; G. Lukmandaru. 2013. Pengawetan kayu gubal jati secara rendaman dingin dengan pengawet boron untuk mencegah serangan rayap kayu kering (*Cryptotermes cynocephalus* Light.). Jurnal Ilmu Kehutanan 7(2):93-107.

Yamauchi, S.; Y. Sakai; Y. Watanabe; M.K. Kubo; H. Matsue. 2007. Distribution boron in wood treated with aqueous and methanolic boric acid solutions. Journal of Wood Science 53(4): 324-331.

Aryati Larasati and Joko Sulistyo*

Dept. of Forest Products Technology, Faculty of Forestry, Universitas Gadjah Mada,
Jl. Agro No. 1, Bulaksumur, Yogyakarta, Indonesia
Tel. : +62-274-6491428 ,
Fax. : +62-274-550541
*Email : jsulistyo@ugm.ac.id