Effectiveness of Used Motor oil and Sawdust Extract as Control Measures on three Lumber Species against Subterranean Termites and Fungal Damage

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Abstract

Damage of biodeterioration agents (Termite and fungi) on forest products including lumber and bamboo-based products in the areas of construction and wood industry sectors in Ethiopia is a serious problem. A research was conducted on the natural durability of *Eucalyptus pilularis*, *Eucalyptus viminalis*, and *Trichilia dregeana* lumber species, and the effectiveness of control measures against subterranean termites and fungal attack. A total of 165 lumber samples (stakes) having dimensions of 2 x 5 x 50 cm were treated using used motor oil with non-pressure treatment application methods namely hot and cold dipping and brushing. Stakes of *T. dregeana* lumber were treated with their sawdust extract using the hot and cold dipping method. Treated stakes were taken and installed at Bako, Adami Tulu, and Meisso grave-yards research stations. Damage of subterranean termites and fungi varies with lumber species, control measures, graveyard stations, and length of exposure years to biodegrading agents. Mean termites and fungal damage on stakes of *E. pilulalris* treated with used motor oil using hot and cold dipping method was 48% while that of fungi was 20.5% at five and half years. *E viminalis* stakes treated with used motor oil were damaged 55% by termites and 80% by fungi. Brushing with used motor oil and hot and cold dipping with sawdust extract from the *T. dregeana* was not better than the untreated control. *E viminalis* control stakes were more damaged (62.5%) by termites than *E. pilularis* (55%) and *T.dregeana* (60%) stakes. *E.viminalis* stakes were more damaged by fungi while *E. pilularis* and *T. dregeana were* damaged by termites. In general, the non-pressure method using used motor oil treatments increases the service life of lumber stakes up to four times compared to the untreated lumber stakes.

Keywords: Biodeteriorating agents, control measures, fungi, hot and cold dipping, lumber stakes, natural durability

Introduction

Damages caused by biodeteriorating agents (Termites, fungus, beetles, and marine borers) on forest products being utilized by construction and wood industries are serious problems that led to, destruction of valuable indigenous lumber species such as *Juniperus procera*, *Hagenia abyssinica*, *Cordia africana*, *Podocarpus falcatus*, and *Pouteria adolfi-friederici*. Biodeterioration damage is among the overlooked major causes (natural and seasoning defects, mechanical wear, and weathering) of the destruction of forest products in the country.

The potential damage of termites and fungi (families of Basidiomycetes-brown and white rots), (Ascomycetes and Deuteromycetes -soft rots) on forest products (wood and bamboo) is an important economic consideration throughout the tropics both in the selection and growth of plantation species, manufacturing and utilization of the resulting wood products.

Subterranean termites (Macro-and-microtermitinae) have been considered as the major causes for the damage of wooden houses and other constructions in Ethiopia, which led to partial or complete rebuilding in 3-5 years. However, destruction of wood and bamboo-culms-based constructions with soil and moisture contact applications in the different parts of the country have occurred, even within 1-2 years short time, which has been caused by subterranean termites and/or fungal mutual attack (Nicholas, 1985), (Wood, 1986), (Desalegn *et al.*, 2003), (Desalegn *et al.*, 2007), (Tadesse and Desalegn, 2008), (Kebede *et al.*, 2011), (Desalegn *et al.*, 2012), (Desalegn, 2013), (Desalegn *et al*., 2015), (Desalegn, 2015).

In Ethiopia, research activities have been carried out to evaluate termite and fungal damages on lumber and bamboo culms and the effectiveness of control measures against biodegrades. Moreover, these research activities have been conducted in a few agroecological zones and localities of the country and majority for short periods, less than five years (Wood, 1986), (Cowie, 1990), (Tsegay Bekele, 1996), (Desalegn *et al.*, 2003), (Desalegn *et al.*, 2007), (Wubalem Tadesse and Desalegn, 2008), (Kebede *et al.*, 2011), (Desalegn *et al.*, 2012), (Desalegn, 2013), (Desalegn *et al.*, 2015), (Desalegn, 2015).

The need for treatments on lumber and bamboo culms is to increase the service life of forest products and their aesthetic values, thereby decreasing frequent harvesting of the available scarce resource. They are also important to replace and maintain the degraded lumber and bamboo culms-based structures and to minimize and keep under the economic threshold. The lumber tree species selected for the study were *E. pilularis* and *E. viminalis*, which are homegrown exotic species, and T. *dregeana* an indigenous tree species. These species are fast-growing, good for plating on large scale, and sustainable utilization in the country. The lumber of *E. viminalis* is non-durable with permeable sapwood and heartwood which is extremely resistant to impregnation (Webb *et al*, 1984), (Brink, 2008b).

There is no adequate information in this regard related to the other species. The odor from *T.dregeana* lumber duringplanning and cross-cutting at Forest Products Innovation Research and Training Center was very irritating, sneezing, and was causing headache to the processors. The basic lumber characteristics of these tree species as alternative construction and industrial materials including natural durability and control measures against subterranean termites and fungal damage were not yet known by the development sectors, construction industry, and end-users in the country.

A research was conducted on the natural durability of lumbers from these species and the effectiveness of control measures against subterranean termites and fungal attack and the objectives of the study were to: (i) investigate natural (graveyard) durability of *E. pilularis, E. viminalis,* and *T. dregeana* sawn lumber species at fields (outdoors), (ii) evaluate the performance of control measures (used motor oil and sawdust extract from *T. dregean*) against biodegrades and application techniques that can improve natural durability and prolonged utilization of the three lumber species in their respective growing areas and similar sites.

Materials and Methods

Descriptions of the study sites

The study sites are compounds of Adami Tulu Agricultural Research Center, Bako Agricultural Research Center, and Miesso research station. The agroecological conditions of Adami Tulu Agricultural Research Center are hot to warm sub-humid (Mid rift valley) and that of Bako Agricultural Research Center is mid-altitude (sub-humid) and Miesso belongs to hot to-warm arid-lowland plains. Locations of the three study sites (hereafter, graveyard research stations) are indicated in figure 14 on the map of Ethiopia.

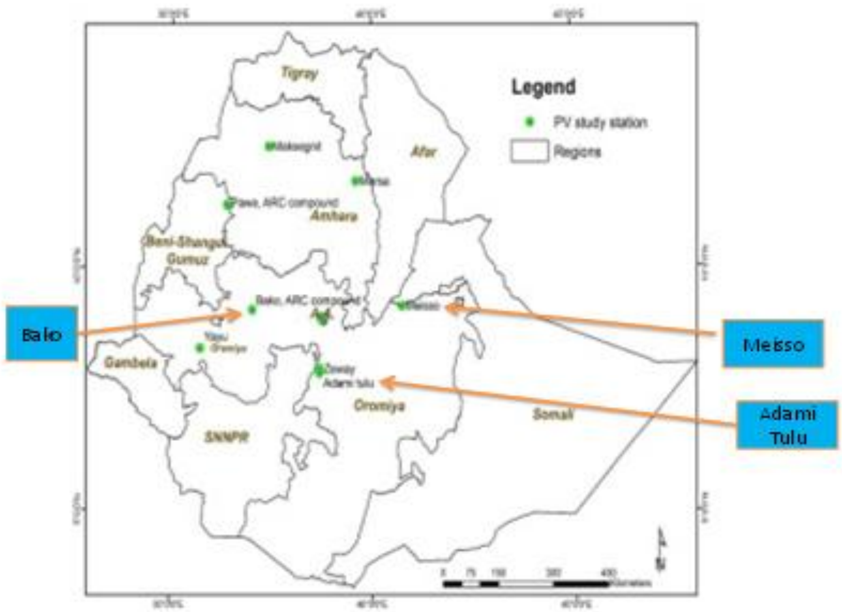

Figure 14: Location of graveyard research stations on the map of Ethiopia

Study species

The study lumber tree species were *Eucalyptus pilularis* Sm. and *Eucalyptus viminalis* Labill. [both belongs to the family Myrtaceae] and *Trichilia dregeana* Sond [Family: Meliaceae] that have fast growth, high yield (*E. viminalis* 10-20 m^3/ha/year), good performance (height, diameter, and clear bole), having versatile lumber and non-timber forest products, socio-economical/ cultural and ecological benefits and services, good site adaptability and coppice ability (*E. pilularis* and *E. viminalis*) in the country.

E. pilularis (blackbutt, pilularis gum) is a tree up to 70 m tall, with bole up to 4.1 m in diameter (Brink, 2008a). In Ethiopia, *E. pilularis* (Figure 15a) is available at the former research trial stations of Central Ethiopia Environment and Forest Research Center (CEE-FRC) namely Suba, Shashemene, Asella, and Belete. *E. Pilularis* has easy regeneration, quick growth, and fire-resistant abilities (http://www.publish. csiro.au/samples/ euclidsample/html/ Eucalyptus_ pilularis.htm),(http://en.wikipedia.org/ wiki/Eucalyptus_pilularis).

E. viminalis is an evergreen tree species up to 50 – 90 m tall, bole up to 120-150 cm in diameter (Brink, 2008b). *E. viminalis* is resistant to fire (Brink, 2008b). In Ethiopia, *E. viminalis* (Figure 15b) was planted at the former CEE-FRC research stations, namely, Suba, Shashemene, Asella and Belete research stations (Mihertu, 2004).

Trichilia dregeana is a tree species that can attain a height of up to 35 m, the tall main stem assuming a relatively straight trunk dividing into large branches and sometimes buttressed up to 1.8 m in diameter (Thirakul, 1993), (Bekele, 2007). *T. dregeana* is an excellent feature plant that is fast-growing and provides great shading for coffee and other perennial crops (http://www.gardeningeden.co.za/plants-trichilia-dregeana.html).

Figure 15: Tree species with the clear bole of E. pilularis, E. viminalis and T. dregeana

Harvesting, log sawing, and lumber stakes preparation for laboratory and field tests

The selected matured sample trees of *E. pilularis, E. viminalis* and *T. dregeana* were harvested from three different sites (Shahemene/ Hamulu, Asella/ Elena, and Dedessa river area, respectively) having 10 m^3 from each species. The harvested logs were representative of merchantable log sizes with good morphological quality, straight and cylindrical stem, relatively free from visible defects. The selected trees were felled, cut into a series of 2.5 m long logs, and up to a top merchantable diameter of 20 cm. The sample trees of *E. pilularis, E. viminalis* and *T. dregeana* had a mean height of 27, 36, and 15 m, respectively, and the mean diameter at breast height (DBH) was 50, 39, and 210 cm, respectively.

Harvested logs of *E. pilularis, E. viminalis* and *T. dregeana* while green (48.25%, 56.1%, and 65.45% moisture content, respectively) were transported to Addis Ababa, Forest Products Innovation Research and Training Center for testing. All the logs received proper handling during storage, transportation, and processing. Logs were sawn to 3 cm thick boards using a mobile circular sawmill by applying the flat (through-and-through) type of sawing method. This sawing method was used to obtain approximately equal proportions of sapwood and heartwood. The lumber was seasoned to about 15% MC to avoid discoloration and deterioration. A total of 165 lumber stakes having dimensions of 2 x 5 x 50 cm were prepared for the study.

Treatments applied on the sample lumber stakes

Two treatments namely used motor oil and sawdust extract was applied using non-pressure methods (hot and cold dipping, and brushing) to treat the lumber stakes against biodegrades.

Hot and cold dipping of lumber stakes

For the treatment of stakes with soil-borne type preventive measure namely used motor oil (UMO) was used. The stakes were treated using the hot and cold dipping (HCD) open tank method or thermal process (FAO, 1994) and brushing. In the case of *T. dregeana* lumber, sawdust extract from *T. dregeana* using hot and cold dipping techniques was applied in addition to UMO using HCD application method. The stakes were submerged in a dipping tank containing 25 litres of cold UMO. The fire was burned under the dipping tank and the oil was heated gradually to about 90°C to reduce the viscosity of the oil and maintained for four hours (FAO, 1994). The treated stakes were withdrawn from the dipping tank after one-day cooling. Finally, the stakes were cleaned from surplus oil using cloth rags and were air-seasoned for a week before installation at grave-yard stations.

Brushing of lumber stakes

UMO brushing was applied to half size of the stakes having a dimension of 2x5x50 cm. The treated stakes were left in the air for a week to dry.

Control lumber stakes

Lumber stakes as untreated controls for testing the natural durability of the lumber species were not treated with UMO and sawdust extracted from *T. dregeana* lumber. The natural durability of lumber species and performance of control measures were expressed from durable to very perishable based on the modified and adapted grades (Eaton and Hale, 1993).

Lumber stakes installation

The stations for the graveyard durability test were demarcated with an area of about 20 x 20 m² and fenced with barbed wire and live vegetation. For the installation of lumber stakes, pits were dug 25 cm deep having a spacing of 25 cm between the stakes and 50 cm between rows. The stakes were labeled and tagged with identification codes and were installed systematically in the prepared pits with half their lengths (25 cm) in the ground and the other half remaining above the ground (Figures 16 and 17).

3A 3B

Figure 16: Pictures showing: E. pilularis stakes (3A) and biodegraded (3B) at Bako Research Station

4A 4B

Figure 17: Pictures showing T. Dregeana stakes installed at Adami Tulu research station

Tests on the natural durability of stakes, performance of control measures, and application methods were conducted simultaneously at the three stations.

Evaluation of lumber stakes deterioration at trial stations

The deterioration rate of each lumber species stake against subterranean termites and fungal attacks were determined using visual inspection/observation supported by sounding and indenting methods. Earthen tunnels, termites mud tubes, and exit holes or galleries on the stakes were used to signify the presence and damage of subterranean termites. Fungal decay was characterized by color changes, softening, brashness, brittleness, and the development of hype growth/decayed external appearance (assessed visually) were used to indicate fungal damage (Nicholas, 1985), (Eaton and Hale, 1993).

The inspection and performance evaluation (data collection) of untreated and treated stakes with control measures was carried out at three, six, and twelve months after installation of the stakes and every year thereafter (Willeitner and Liese, 1992). Grades from one to five (1-5) were adapted and used to determine biodeterioration of lumber research stakes: 1= sound, no decay and/or termite attack (100% resistance), 2 = local, superficial/ moderate (75% resistance), (3= slight, limited (50% resistance), 4= sever and deep (25% resistance), (and 5= failure/complete attack (0% resistance) (Gjovik and Gutzmer, 1986), (Willeitner and Liese, 1992), (Eaton and Hale, 1993), (Highley, 1995), (Desalegn *et al.*, 2003), (Desalegn *et al.*, 2007).

During the inspection, mostly after the rainy season, each stake was carefully removed from its pit and the presence and extent of attack by termites and/ or fungi were assessed, evaluated, and recorded before its re-installation into the pit. Inspection at the trial station was continued until 50% of the underground parts of the untreated stakes were completely degraded and/ or fell to the ground.

Results and Discussion

The appearance of lumber tree species

Heartwood of *E. pilularis* has been yellowish brown to light brown. The heart wood of *E. viminalis* has been pale yellow or pink and was not clearly demarcated from sapwood (Figure 18) (Brink, 2008b). The wood of *T. dregeana* was a pale pink. The odor from *T.dregeana* lumber while planning and cross-cutting has a very irritating odor, sneezing, and headache to the processors.

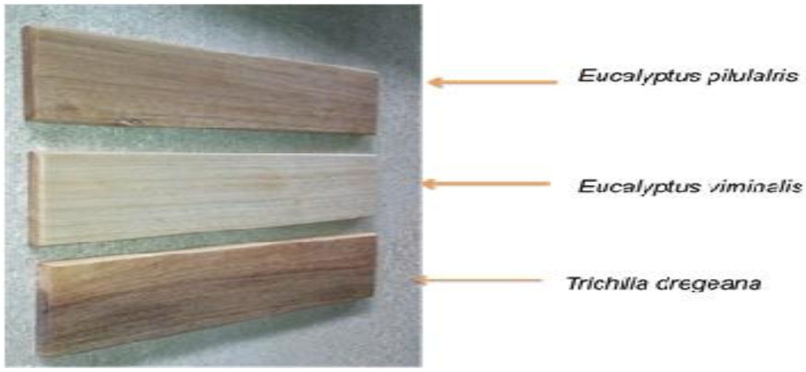

Figure 18: Lumber pictures of the studied tree species

Density of Lumber species

The density of *E. pilulalris* (780 kg/m^3) and that of *E. viminalis* (810 kg/m^3) at 12% moisture content were classified as very heavy (650-800 kg/m^3). The density of *T. dregeana* (530 kg/m^3) at the same 12% moisture content classified as light density (300-450 Kg/m^3) lumber species (Desalegn and Kaba, 2017), (Kaba and Desalegn, 2020).

Biodegrades damage and effectiveness of control measures

Subterranean termites and fungal damage rates vary with lumber species, treatments, trial stations/ locations, and length of exposure years to biodegrading agents (Table 15 and Figure 19). Subterranean termites damage on lumber stakes of *E. pilulalris* treated with used motor oil (using both hot and cold dipping and brushing methods) was 48% while that of fungi was 20.5%, at five and half years. Untreated control stakes were more attacked (60%) by subterranean termites and 27.5% by fungi.

E. viminalis lumber stakes treated with used motor oil were damaged to 55% by subterranean termites and 80% by the fungal attack at four and half years. Subterranean termites and fungal damage of treatments and at all grave-yard research stations (Bako, Adami Tulu, and Meisso) are presented in Table 15 and figure 19.

Table 15: Mean subterranean termites and fungal damage per treatment at Bako, Adami Tulu, and Meisso research stations

Treatments against Controlling damage	Lumber Species	Research station	Duration of graveyard tests (Year)	Mean subterranean termites damage (%)	Fungal damage (%)
B	EP	B	5.5	57.5	7.5
B	EP	AT	5.5	47.5	47.5
B	EP	M	5.5	40	7.5
B	EV	B	4.5	2.5	82.5
B	EV	AT	4.5	75	72.5
B	EV	M	4.5	87.5	87.5
B	TD	B	4	97.5	65
B	TD	AT	4	80	82.5
B	TD	M	4	47.5	52.5
C	EP	B	5.5	70	22.5
C	EP	AT	5.5	52.5	47.5
C	EP	M	5.5	57.5	12.5
C	EV	B	4.5	10	90
C	EV	AT	4.5	80	85
C	EV	M	4.5	100	50
C	TD	B	4	77.5	72.5
C	TD	AT	4	55	42.5
C	TD	M	4	45	2.5
D	EP	B	5.5	47.5	12.5
D	EP	AT	5.5	55	50
D	EP	M	5.5	42.5	-
D	EV	B	4.5	50	82.5
D	EV	AT	4.5	82.5	85
D	EV	M	4.5	92.5	7.5
D	TD	B	4	-	-
D	TD	AT	4	-	-
D	TD	M	4	40.	52.5
E	TD	B	4	92.5	100
E	TD	AT	4	60	40
E	TD	M	4	100	67.5

Note: Intact against fungal damage; Study tree species EP-*Eucalyptus pilularis*, EV-*Eucalyptus viminalis* and *TD-Trichilia dregeana), (*control measure treatments: D- Hot and cold dipping treatment with used motor oil, B- Brushing treatment with used motor oil, C- controls (Untreated stakes) and E- Sawdust extract from *T.dregeana), (* graveyard locations: B- Bako (West Shewa), AT-Adami Tulu (East Shewa) and M-Meisso (Eastern Hararge) as located on the map of Ethiopia (Figure 1)), (duration of lumber stakes at graveyard research stations: *Eucalyptus pilularis*(5.5 years), EV-*Eucalyptus viminalis*(4.5 years)and *TD-Trichilia dregeana*(4 years)

All treatments on *E. viminalis* stakes were less effective in resisting subterranean termites and fungal damages. This could be attributed to the high density (810 kg/m^3) of the species that could lead to less absorption and retention of treatments. Lumber stakes of *T. dregeana* treated with used motor oil using hot and cold dipping treatment method were damaged to 15% by subterranean termites and 17.5% by the fungal attack at year four. *E. viminalis* stakes treated with the same treatment using brushing were damaged to 75% by subterranean termites and 67.5% by fungal attack. Brushing with used motor oil and sawdust extract from the *T. dregeana* was less effective on *T. dregeana* lumber, not better than the untreated stakes.

Subterranean termites at Bako station were Microtermes and *Pseudocanthotermes militaris* while that of Adami Tulu, having the same agroecology as that of Zeway, was dominated by subterranean and mound-building termite species, *Marcotermes bellicosus* (Zewde Berhane and Yusuf, 1974), (Desalegn*et al.*, 2003), (Desalegn*et al.*, 2007). The subterranean termites at Meissio station were Microtermes.

E. viminalis untreated stakes were more damaged (62.5%) by subterranean termites than E. pilularis (55%) and *T.dregeana* (60%) stakes. The treatment using *T. dregeana* sawdust extract was not better than the untreated control of *T. dregeana* lumber.

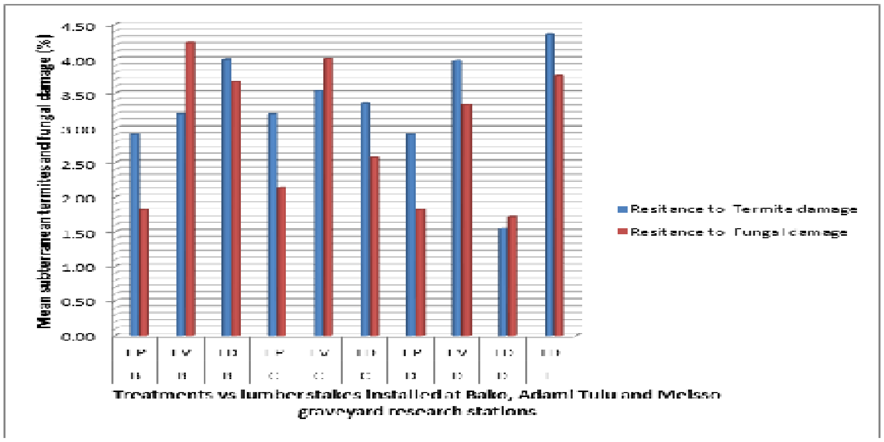

Figure 19: Mean subterranean termites and fungal damage (%) by treatment and locations at Bako, Adami Tulu, and Meisso graveyard research stations D- Hot and cold dipping treatment with used motor oil, B- Brushing treatment with used motor oil, C- Untreated stake

All treatments on *E viminalis* lumber stakes were less effective in resisting subterranean termites and fungal damages.

Conclusion and Recommendation

Used motor oil treatments using hot and cold dipping methods increased the life of the lumber in-ground and moisture contact up to four times compared to the untreated lumber stakes. Further applied research recommended, involving different commercial and traditional alternative controlling measures, at different graveyard research stations and for a prolonged time to fill the information and technological gaps on natural durability of lumber species, effective control measures and application techniques that can promote rational utilization of the resource in the different agroecological zones of Ethiopia where biodegradation and wood-based products utilization have economic relevance.

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