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Treatment of coconut palm wood using inorganic preservatives

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ABSTRACT: Freshly felled coconut wood is very much susceptible to wood boring insects, moulds and stain fungi as it has high levels of sugar, starch and moisture content throughout the trunk. The objective of this study was to develop appropriate preservative methods to protect sawn coconut palm wood from insects and other pathogens under the prevailing eco-climatic conditions in Kerala and to evaluate the effect of different preservative factors on the treatability of coconut wood. Wood samples were treated with inorganic chemicals like Copper Chrome Boron - CCB and Borax Boric Acid – BBA by diffusion and pressure treatment, of which pressure treatment performed better. Diffusion treatment of inorganic preservatives in high and medium density wood showed no significant difference in retention whereas significant difference was observed for penetration percentage. For pressure treatment, retention and penetration were significant in high density wood whereas medium density wood showed only significant retention. Solution concentrations and overall retention and penetration percentage were found to be significantly related. The study found that sawn coconut wood samples could be effectively treated with preservatives complying with the prescribed retention and penetration percentages as per the different standards and therefore, could be used as a potential substitute for conventional timbers and the insect damage was negligible. No incidence of insects, particularly termites and pin hole borers was observed during the graveyard studies.

KEY WORDS: Sawn coconut wood, diffusion, pressure treatment, preservatives, insects

INTRODUCTION

The coconut palm (*Cocos nucifera* L.) is found along the coastal and inlands regions of almost all tropical countries. The uses of coconut palms are almost limitless as it provides food, drink and shelter and raw material to a number of industries (Menon and Pandalai, 1958; Oduor and Githiomi, 2006; Djokoto, 2013). It is one of the world's most versatile and economically important palms (Moore, 1948; Subramanian, 2003). All the plant parts are used, on account of which, the palm has been regarded as *Kalapavriksham* or Tree of Life or Tree of heaven, a gift from nature to man (ENVIS, 2014). India is one of the largest producers of coconut which comprises 31 per cent of production and 17.6 per cent of the planted area (APCC, 2014). The bulk of country's plantation is concentrated in

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southern states. Kerala has 20.8 per cent of the total geographical area under coconut and accounts for 33 per cent of total coconut plantation in India (GOK, 2015).

Coconut exhibits no secondary growth but, the lateral increase of trunk is due to the multiplication of cells and enlargement of parenchymatic cells and vascular bundles (Killmann, 1993). The unique anatomical features of the coconut wood results in high variation in physical and mechanical properties. Based on density, coconut stem has three distinct zones such as the dermal zone, sub-dermal zone and core region and there is a decrease in the density of wood from the outer to inner as well as base to top portions of coconut (Killmann and Fink, 1996; Fathi, 2014). Density plays a significant role in determining the end use of coconut palm wood (Mead, 2001). Coconut wood has little resistance to wood degrading organisms including insects when it is exposed to the weather, particularly on ground contact. Freshly sawn coconut wood is extremely susceptible to the attack of termites and pin hole borers apart from sap stain fungi.

Seasoning is the first step in the efficient utilization of the timbers, especially in tropical countries. Protection against the ambrosia beetles could be secured after kiln seasoning of coconut wood (George, 1985). The efficacy of preservative treatment depends on the proper choice of preservative chemicals and the treatment process, which ensures the required absorption and penetration of the preservative. Seasoning prior to preservation makes preservative treatment easy and effective. Seasoning and preservation should be regarded as an integral part of timber utilization (ISI, 2001). The coconut trunk remained under-utilized due to its highly perishable nature.

The present study is an attempt to standardize the preservation technologies of coconut wood to increase the durability of coconut wood products with protection from insects and other organisms. The knowledge developed can be used for the industrial production of preserved timbers or manufacturing of products from treated wood. Increased utilization of coconut wood can reduce the dependency on forests or conventional plantation grown timber and can pave the way for an additional source of income to coconut farmers. Effect of various factors on the treatability of coconut wood as well as variation in retention and penetration in different parts of coconut wood were the objectives of this study.

MATERIALS AND METHODS

Coconut palms (*Cocos nucifera* L.) of age group (30-40 years) of "West Coast Tall" (WCT) variety grown in Thrissur district of Central Kerala (between N 10° 11' 8.16" and N 10° 41' 2.76" latitude; E 75° 58' 2.64" and E 76° 53' 29.04" longitude), was used for the study. Experiments were conducted in the Department of Wood Science, College of Forestry, Kerala Agricultural University, Vellanikkara, Thrissur district, India during 2015 – 2017. Wood was taken from 30 cm above the ground till 4 meters from the top of the palm. Palm trunk was converted into 2 meter logs after cross cutting with the help of a power saw and transported to a saw mill for sawing (Killmann and Fink, 1996). Coconut logs were converted to scantlings of 5 cm x 5 cm cross section and 50 cm length for further analysis Prophylactic surface treatment was carried out with Borax - Boric Acid (BBA) solution in the ratio of 1: 1.5 (parts per weight) in water at 3 per cent concentration level by dipping and samples were then air dried under shade.

For estimating moisture content, three sticks were taken from each stack randomly and small clear specimens of 2 cm× 2cm× 2.5 cm dimensions were made according to IS: 1708- - 1986. The samples were weighed with an accuracy of 0.001 in a weighing balance and dried in a hot air oven at a temperature of 103°± 2°c till constant weight. From the initial and final weight (oven dry weight), moisture content of each specimen was calculated.

Coconut wood samples were sorted into different grades such as low, medium and high density. A pilodyn was used to classify the samples into high and medium density wood materials (Schulte, 1991). Pilodyn is a handy tool weighing about 1 kg which

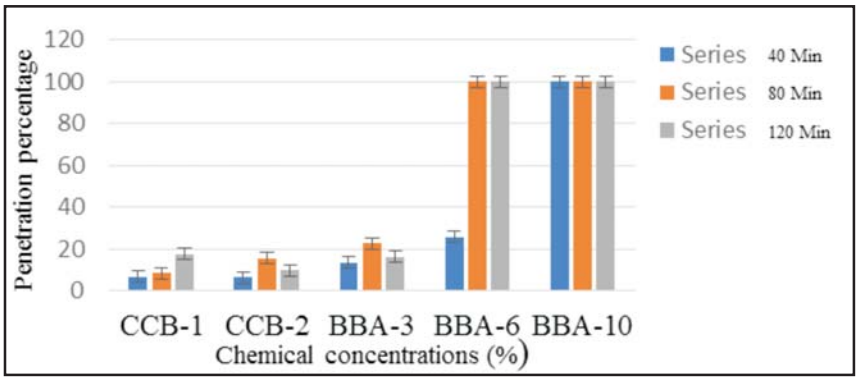

Fig. 1. Variation in DSR with respect to the duration of diffusion treatment in HDW

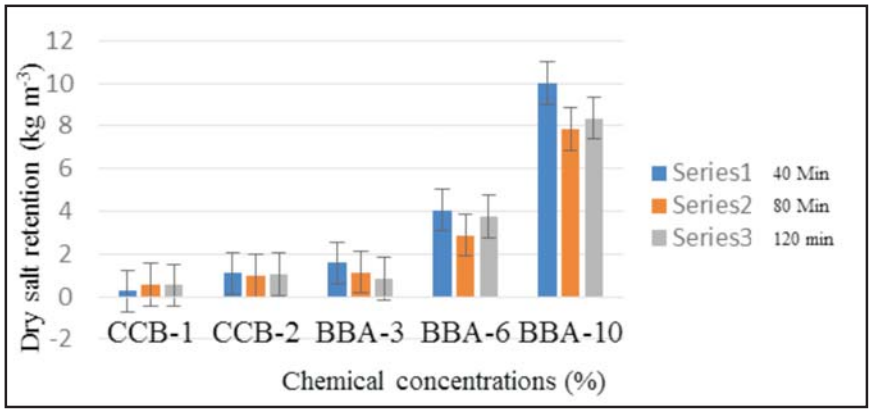

Fig. 2. Variation in penetration percentage with respect to the duration of diffusion treatment in HDW

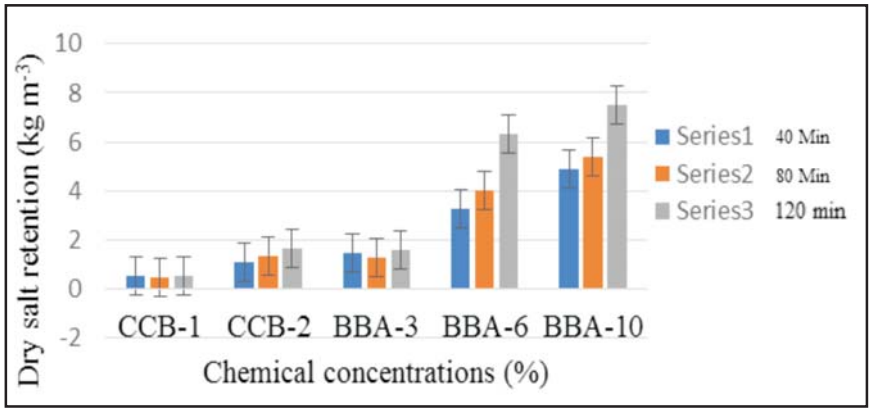

Fig. 3. Variation in DSR (kg m^{-3}) with respect to the duration of diffusion treatment in MDW

can be used for indirect non- destructive assessment of basic density of logs as well as standing trees. The pilodyn drives a steel pin which is driven into the wood by releasing a spring with a predetermined energy and the penetration (referred as pin penetration depth - PPD) is indicated on the instrument. The scale of PPD ranges from 0-40. The depth of penetration is inversely related to the density of the timber and in turn with its modulus of elasticity (MoE) and modulus of rupture (MoR). In

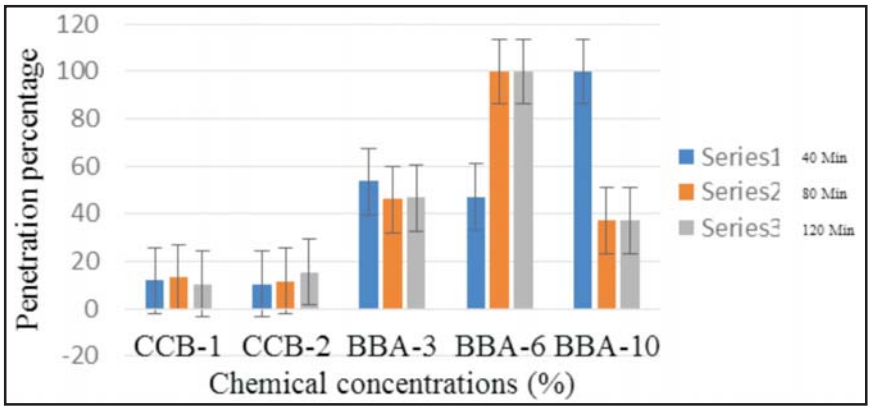

Fig. 4. Variation in penetration percentage with respect to the duration of diffusion treatment in MDW

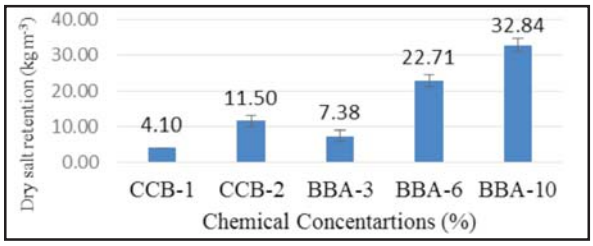

Fig. 5. Variation in DSR with concentration at constant pressure in HDW

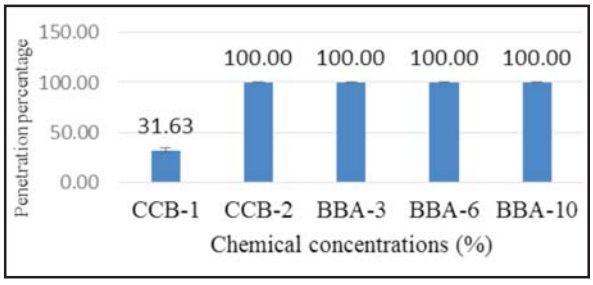

Fig. 6. Variation in penetration percentage with concentration at constant pressure in HDW

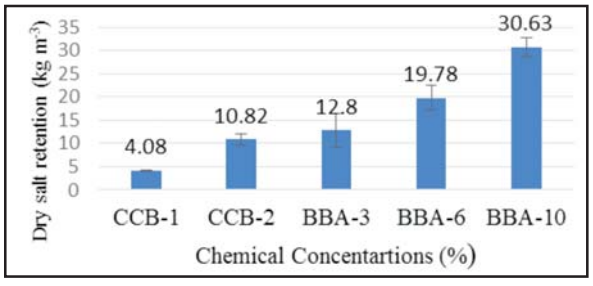

Fig. 7. Variation in DSR with concentration at constant pressure in MDW

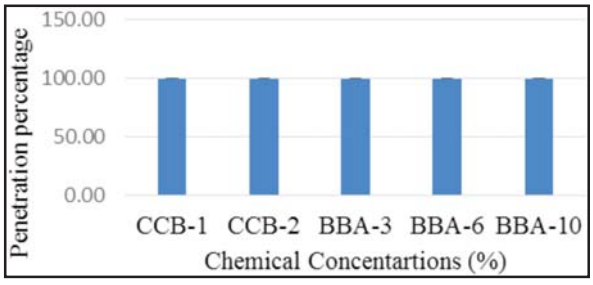

Fig. 8. Variation in penetration percentage with concentration at constant pressure in MDW

the present study, pilodyn (FUJI TECK, Tokyo, Japan) with 6 Joules and 2.5 mm pin diameter was used for taking measurements. The readings were taken at the middle point of each samples and grouped into high and medium density wood on the basis of PPD. All the samples that showed 20 PPD were sorted as high density wood and the readings between 20 to 28 PPD were graded as medium density wood. The samples having reading above 28 PPD were regarded as low density material which as such could not be used for structural purpose and were hence discarded.

Partially dried wood samples of two density (high and medium) classes were treated with inorganic preservatives - copper chrome boron (CCB) and borax – boric acid (BBA) at various concentrations. CCB was prepared by mixing Copper sulphate, Sodium dichromate and Boric acid in the ratio of 3:4:1.5 (parts per weight) respectively (ISI, 1986).

Two levels of concentration (1 and 2 per cent) were used in the investigation. BBA was prepared by mixing boric acid and borax in the ratio of 1: 1.5 (parts per weight) in water. Three levels of concentration (3, 6 and 10 per cent) were used in the investigation (Gnanaharan and Dhamodaran, 1989).

The treatment methods adopted for the impregnation of chemical into the wood were diffusion and pressure treatment. Duration of diffusion treatment was taken as 40, 80 and 120 minutes respectively. Pressure treatment plant located at the KFRI Substation, Palappally, Thrissur was used and Bethel's full cell process was employed. (Vacuum at 15 inch Hg for 10 minutes and pressure was maintained at 10 kg/cm2 for 30 minutes).

After treatment, the evaluation of treatment methods and chemicals were studied by different parameters like, dry salt retention (DSR), penetration depth, diffusion storage period and leaching factor. Treated samples were removed from the tank and excess liquid was drained off for 30 minutes and wrapped in polyethylene sheets for more penetration of chemicals into the wood. 374 samples were analysed and the effect of various diffusion periods on retention and penetration were analysed using two-way ANOVA. Effect of solution concentration at constant pressure was evaluated through one way ANOVA and LSD was used to compare the significance of means.

RESULTS

The effect of factors like chemical concentration, diffusion period and pressure on the treatability of coconut wood was evaluated in this study. Variation in dry salt retention and penetration percentage were compared with the recommended standards to assess potential utilities of the treatments for coconut wood. The major objective of the present investigation was to develop appropriate preservative treatment methods with inorganic chemicals (CCB and BBA) which might help to enhance the service life of coconut wood and protection from wood damaging insects and other organisms. Penetration depth of chemicals in wood is affected by many factors. Apart from solution concentration and diffusion period, moisture content in the wood, density of the material, temperature etc. also affect the penetration depth (Archer, 1991; Williams, 1991).

Diffusion Treatment

In High Density Wood (HDW), variation penetration percentage of individual samples did not follow any uniform pattern (Fig. 1). Dry salt retention with respect to the duration of diffusion treatment also did not follow any particular pattern (Fig. 2). The chemical concentration was directly proportional to the DSR. The value of DSR ranged from 0.82 kg $m^{-3}$to 10.76 kg m^{-3} for BBA and from 0.25 kg $m^{-3}$to 1.09 kg m^{-3} for CCB. For BBA, complete penetration was achieved at 10 per cent and lowest value for penetration was observed as 13.67 per cent at 3 per cent concentration ·The penetration percentage of CCB ranged from 6.53 per cent to 17.37 per cent. The achieved DSR was above 10 kgm^{-3} and the retention was achieved at 6 per cent concentration of BBA.

For Medium Density Wood (MDW), analysis of means depicted that with an increase in diffusion period, the chemical retention increased in the wood samples. DSR increased with increasing chemical concentrations for the same duration (Fig. 3). But the individual factors such as chemical concentrations and duration were significant. Chemical strength and interaction between chemical strength and duration were found to be significant for penetration percentage. No significant differences were observed between durations. The values for DSR ranged from 0.44 to 7.49 kgm^{-3} (Fig. 4).

Pressure Treatment

In the case of HDW, increase in chemical concentration of BBA and CCB was directly proportional to DSR (Fig. 5). All the chemical concentrations obtained complete penetration except at one per cent of CCB (Fig. 6). The value of DSR ranged from 5.27 to 35.18 kgm^{-3} for BBA and from 4.03 to 13.23 kg m^{-3} for CCB. Pressure

treatment showed complete penetration of chemicals except CCB at 1 per cent concentration. Chemical concentration was the factor considered in the analysis of DSR and penetration percentage in MDW (Fig. 7 and 8).

DISCUSSION

Diffusion of high and medium density wood showed significant difference for penetration percentage but no differences in retention. In pressure treatment, retention and penetration was significant in HDW, but MDW showed significant difference only in retention. Pressure treatment achieved complete penetration for all solution concentration of the chemicals used. Diffusion treatment of CCB obtained low retention compared to BBA. Only through the application of pressure, CCB attained the recommended retention suggested in the standards. Relation of diffusion period and retention in HDW showed no uniform pattern and followed increasing trend in MDW. Penetration depth followed an increasing pattern with respect to the increasing treatment duration in the two density classes. Low retention and penetration for CCB was achieved for both density classes through diffusion treatment. At 3 per cent BBA, retention achieved was 7.38 kgm^{-3} through pressure treatment which could be achieved through diffusion treatment using BBA at 10 per cent. As far as small scale preservation or furniture unit is concerned, desired retention could be achieved through diffusion treatment and the costs for the expensive pressure plant can be offset by an increase in solution concentration in both HDW and MDW. From the industrial point of view, pressure treatment is superior to diffusion treatment for both density classes. In the case of CCB, the desired retention was achieved at 2 per cent concentration and higher retention was needed for the use of coconut wood in external condition in contact with ground. Increasing concentration of solution or pressure applied can help to achieve higher retention of CCB. In general, the natural durability of coconut ranges from 6 months to 2 years and it needs significant up gradation to meet the requirements. No incidence of insects, particularly termites and pin hole borers was observed during the graveyard studies being undertaken in continuation of the present study to evaluate the effectiveness of the preservatives. Adequate intervention through preservation which was standardised through this study can expand the service life of coconut wood and thereby augment the supply of durable timbers with lesser durable timbers.

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