INBAR Working Paper

INTERNATIONAL BAMBOO AND RATTAN ORGANIZATION

Technical Manual

Post-Harvest Bamboo Treatment, Preservation and Storage Practices

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About the International Bamboo and Rattan Organization

The International Bamboo and Rattan Organization, INBAR, is an intergovernmental organization dedicated to the promotion of bamboo and rattan for sustainable development. For more information, please visit www.inbar.int.

About this Working Paper

This work is an INBAR publication produced as part of the Inter-Africa Bamboo Smallholder Farmers Livelihood Development Programme which is implemented by INBAR in four African countries namely Ethiopia, Cameroon, Ghana and Madagascar with funding from the International Fund for Agricultural Development (IFAD). This manual is put together by INBAR – West Africa Regional Office (WARO) to provide guidelines to actors in the bamboo value chain on basic techniques for treating and preserving post-harvest bamboo culms.

International Bamboo and Rattan Organization

P.O. Box 100102-86, Beijing 100102, China

Tel: +86 10 64706161;

Fax: +86 10 6470 2166

Email: info@inbar.int

Executive Summary

Globally, over 1,450 known species of bamboo are utilized for various products including food, craft, furniture and architectural edifices among others. The durability and longevity of bamboo products are heavily dependent on various processes, including harvesting, treatment, and storage techniques applied to the bamboo culm. Without any protective treatment, bamboo culms may have a short lifespan of less than two (2) years. Treating and preserving bamboo culms with the appropriate technique and preservatives can elongate the durability, enhance sustainability and increase the potential of bamboo culms for various applications. Currently, the majority of bamboo users have little or no knowledge of the importance of treating and preserving bamboo. Providing the necessary information on basic bamboo treatment techniques and preservation practices is essential for the sustainability of the bamboo industry in African countries. This manual explains the various post-harvest treatment and preservation methods that can be applied to bamboo culms to increase their lifespan and durability. The manual serves as a guide to assist artisans, harvesters, bamboo retailers and other actors in the bamboo value chain in preparing and treating bamboo culms for product development.

The treatment techniques are categorized into two (2) main sections in the manual. Firstly, the traditional methods namely, dry season harvesting, curing, smoking, drying (kiln or air), water soaking and lime-painting are indigenous and cost-effective techniques which could be employed in treating bamboo culms locally for short span usage. Secondly, the modern or chemical methods which include boron-based treatment, sap displacement, butt-end treatment, and pesticide treatments are thoroughly discussed and demonstrated herein in this manual. These methods have a high efficacy rate and are mostly used for treating bamboo culms intended for long-term applications. However, its operation is relatively cost-intensive and requires much labour, unlike the traditional methods.

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1. Introduction

1.1 Overview

For several decades, bamboo harvesting offered economic livelihood for many rural farmers in Africa as a supplementary occupation. With the growing use and value of bamboo for construction and several other products, harvesters, farmers and retailers are engaging the bamboo business as a full-time venture. These actors involved in the supply chain are yet to receive training or knowledge about the appropriate ways of harvesting, treating and storage of bamboo culms.

Bamboo culms serve multiple purposes including food, domestic furniture, craft and architectural edifices among others. However, products from bamboo have come under scrutiny due to the common scenario of insect infestation and the ensuing short lifespan when the bamboo culms used have not been treated well. This user-friendly manual provides relevant information about post-harvest bamboo treatment methods that could improve the value and durability of bamboo products. It is intended to serve as a Manual of Operation (MOP) to educate stakeholders and actors in the bamboo value chain including smallholder bamboo farmers, artisans, harvesters, retailers and end-users.

1.2 Biology of the bamboo plant

Bamboo belongs to the family of grasses and does not have the same properties as regular wood. There are about 130 herbaceous and 1,450 woody bamboo species known worldwide. Bamboo consists of a cylindrical hollow shoot or culm covered with a waxy surface that prevents moisture from escaping. At intervals, the culm has ridges known as nodes, from which the branches develop (Dhamodaran, 2020). The plant grows up from an underground stems and roots system called rhizomes. Some species can grow to a height of 30.5m with a diameter as wide as 305mm.

Bamboo is different from normal trees in both anatomy and morphology. The presence of stems, branches and leaves appear to be the only similarities between trees and bamboo plants. Bamboo is a hollow stem or culm with no bark or annual rings and does not increase in diameter as the plant gets older. Bamboo culm grows (i.e., increases in height) on average 25cm per day, and reaches its maximum height in just 6–7 months (some tropical bamboo species grow up to 30–40m). It is lignocellulosic biomass, which has similar properties to that of wood but with additional

properties like easy workability, excellent strength, high elastic behavior and resistance to abrasion.

The lower portion of the bamboo culm is considered more durable, while the soft inner part of the wall deteriorates faster than the outer harder portion. This is due to the anatomical and chemical nature of the woody cells. Unlike timber species such as teak, the structure of bamboo is void of toxic deposits. Bamboo culms are mature and ready for harvest in 4–6 years, after which new bamboo shoots develop naturally. Because of its amazing growth pattern, its numerous uses, and the renewable nature of bamboo plants, it is considered a sustainable natural resource in many parts of the world.

1.2 Uses of bamboo

All parts of the plant are usable. The shoots provide nutritious food while the leaves are used for preparing tea and as fodder for livestock. The culm is used as props and beams for construction, roofing, piping, fencing, and flooring. Other bamboo products include mats, baskets, musical instruments, medicine and charcoal.

1.3 Causes of post-harvest deterioration of bamboo culms

Bamboo contains a large amount of starch that makes it highly attractive to insect and fungal attacks. These insects thrive on the sugar and cause damage during drying, storage, and subsequent use. The causative agent of bamboo culm degradation can be categorized into biotic and abiotic groups as shown in Figure 1.

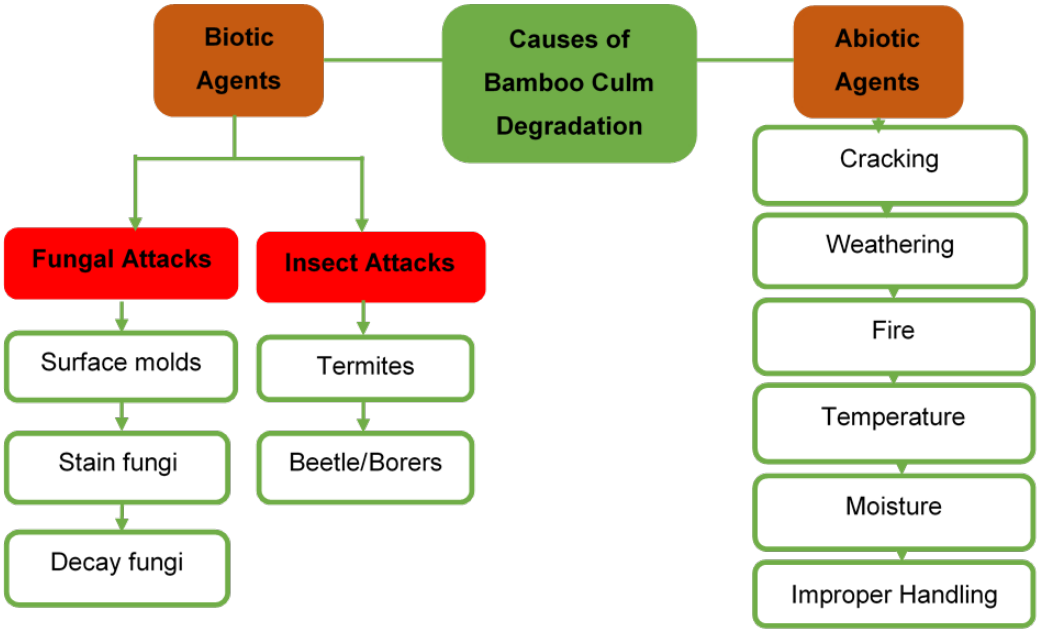

Figure 1. Flowchart of causes of post-harvest damage of bamboo culms (INBAR 2021)

1.4 Why treat/preserve harvested bamboo culm?

Most bamboo species, without any protective treatment, have average natural durability of less than two (2) years. However, when stored undercover, untreated bamboo may last 4–7 years. These variations in bamboo durability strongly depend on multiple factors including the species, the length of the culm, the thickness of the wall, and the time of harvesting. Ignoring these factors in the harvesting and processing of bamboo can influence the quality of bamboo products and reduce their longevity and economic value. Thus, bamboo culm for product development requires preservative treatment for the following benefits: extend durability and prolong the useful life of culms; errest and delay degradation of culms; preserve dimensional stability and retain strength; impact properties of bamboo such as fire resistance, luster, etc; and improve aesthetic qualities of bamboo products.

Increasing the shelve-life of bamboo to fifty (50) years or more is certainly possible by applying the appropriate treatments which are also more economical and sustainable (Ashaari and Mamat, 2000; Bebija, 2017; Onuorah, 2000).

2.0 Post-Harvest Treatment Techniques of Bamboo Culms

2.1 Overview of bamboo treatment and preservation

Bamboo is more susceptible to decay than timber due to a lack of natural toxins and its typically thin walls, which means that a small amount of decay can have a significant percentage change in capacity. Despite the enormous uses of bamboo, its applications are limited because of its high nutrient content, which makes it attractive to insects and fungi. Therefore, it is very important to give preservative treatment to bamboo culms to enhance their service life.

2.2 Terminologies and basic principles of bamboo treatment and storage

Shrinkage: This is when both cell wall thickens and cell diameter diminishes as moisture begins to decrease along the radial and tangential directions of the bamboo culm.

Quick note: The structural formation of bamboo culm and the components influence the treatment technique and process for bamboo culm and the efficacy of the technique.

Treatability: Bamboo is a difficult-to-treat material; especially round bamboo. The impermeable and hard outer wall and nodes with impermeable septa make the round poles difficult to treat (i.e., difficult to achieve the required chemical retention in the treated material). Split bamboos, slats, slivers, etc. are comparatively easy to treat.

2.3 Overview of natural and chemical treatment of bamboo culms

Bamboo culm treatment can be categorized into two (2) main groups namely, natural and chemical preservatives (Kumar *et al*., 1994). In choosing a particular method, the following few factors must be considered:

- Bamboo species type and the state of bamboo (i.e. dry or fresh)
- Intended application (i.e., prolonged contact with the ground, exposure to the atmosphere, undercover works etc.)
- Quantity to be treated (i.e., large or small scale) and available time

- Potential causes of degradation (i.e., whether biotic/abiotic factors)
- Availability of suitable skills and equipment as well as the budget or cost

3.0 Techniques in Post-Harvest Bamboo Treatment

3.1 Harvesting bamboo during the low-sugar content season

Description: The sugar content in the culm varies with the seasons. During the growing season, the culm reduces its carbohydrates in the parenchyma cells to provide building material for the expanding shoots. Thus, the carbohydrates are reduced. Therefore, the culms are harvested during the following dry season (Tang *et al*., 2009).

Procedure: Endeavour to harvest bamboo culms only during the dry season (i.e. November to March) when the sugar content is usually low as explained above (Figure 2).

Figure 2. Bamboo harvested during the dry season with low starch content. (Source: INBAR 2021)

Efficacy: Higher sugar content in bamboo culms makes them susceptible to insect and fungal attacks. Therefore, reduced levels of sugar could extend the life span of bamboo culms (BamCraft, 2012).

3.2 Smoking

Description: The culms are stored inside a house above a fireplace for some time so that the ascending smoke causes a blackening of the culm and reduction of its moisture content thereby restricting biological degradation. Toxic agents in the smoke destroy the starch in the bamboo, which leads to some resistance to insects and fungi attacks.

Procedure: Arrange/suspend bamboo culms horizontally over an open fire for extended periods (Figure 3).

Figure 3. Bamboo culms arranged over a fire source for smoking

Efficacy: Smoke from burning timber or bamboo contains a range of preservative and protective chemicals such as creosote and furans that can make bamboo significantly less attractive to a range of pests. The heating process kills off existing pest infiltrations whilst partially plasticizing the lignin in the bamboo and hence increasing its durability. However, smoking bamboo over an open fire is generally only suitable for small-scale applications such as handicrafts.

3.3 Water soaking/leaching

Description: This is described as curing bamboo through leaching the sap from within the culm. This process removes the sugars and starches that attract most pests. Leaching helps remove starch and also enhances permeability for future treatment. This process is said to leach out carbohydrates thus resulting in an enhanced resistance of the culm to pest attack.

Procedure: Place bamboo culm in running or stagnant water (Figure 4) for 1–3 months depending on the species (Kumar *et al.* 1994). Apply weight for complete immersion by tying stones to the culm. In the case of stagnation, change the water once every week to avoid bacterial growth, staining, and odor.

Figure 4. Soaking bamboo in stagnant water (left), and soaking bamboo culms in running water (right) (Source: www.guaduabamboo.com)

Efficacy: This method is appropriate for treating any quantity of bamboo. It is also recommended for craft and mat applications where pliability is required. This relatively simple process is undertaken as quickly after harvesting as possible because cells within the culm begin to close after 2–3 days.

3.4 Curing/Drying

Description: Bamboo can be air-cured by leaving the branches and leaves on for two to three days after cutting. The bamboo culms are cut at the bottom with branches and leaves at the clump and left for some time.

Procedure: Fell matured culms of about 3–4 years old and leave them in the felling site along with branches and leaves attached by leaning them to a nearby tree for three different periods (i.e., 15, 30 and 45 days). The bases of the felled culms must be put on a stone to avoid absorption of moisture from the ground. Branches should be kept free of ground contact throughout this period (Figure 5).

Figure 5. Horizontal stacking of bamboo culms for drying. (Source: INBAR 2021)

Efficacy: This method allows the bamboo to consume the remaining sugars and starches within the culm reducing its attractiveness to pests. As respiration of the tissues still goes on, the starch and sugar content in the culm is decreased. Thus, the infection by borers is reduced, but there is no effect on the attack by termites and less on fungi.

3.4.1 Air Drying

Description: Air drying is the process of removing moisture from bamboo by exposure to atmospheric conditions. There are two types: horizontal and oblique stacking. By proper stacking for air circulation, culms can be dried with no need to add energy above the capacity of the ambient air.

Procedure: Bamboo culms can be horizontally or vertically stacked (Figure 6) under shades or open spaces for 6–12 weeks depending on the species, initial moisture content and wall thickness (Kumar *et al.*, 1994).

Figure 6. Vertical staking of bamboo culms for air drying. (Source: INBAR 2021)

Efficacy: Shrinkage and swelling are directly related to the moisture content. Therefore, reducing the moisture content in the bamboo culm makes it easy to work with such as machining, glueing and painting (Bebija, 2017). However, the drying process can be long-ranging from several weeks to months. During air drying, splits can occur and culms can be infected by fungi, especially molds. The air drying depends largely on climatic conditions. Since the weather conditions are natural and cannot be regulated, there is little control over the drying process.

3.4.2 Kiln Drying

Description: Kiln seasoning is the drying of bamboo culms in a closed chamber with controlled temperature, relative humidity and air circulation.

Procedure: Stack bamboo culms in a closed chamber (kiln) where temperature and relative humidity could be regulated at different stages. As the moisture content decreases, the schedule is progressively made more severe. Kiln drying normally takes 6–15 days, depending on the bamboo species, the kiln and the schedule being used. Solar kilns that trap and store the energy from the sun, offer a low energy cost compromise of 3–6 weeks.

Figure 7. Horizontal arrangement of culms in an electric kiln for drying. (Source: INBAR 2021)

Efficacy: With a kiln, drying bamboo to any moisture content is possible. For large-scale operations with high-level bamboo quality, kiln drying is more efficient than air drying. Kiln drying may be necessary for the rainy season when mold attack during drying is common. It is worth noting that the practice can be expensive.

3.5 Lime Washing

Description: Bamboo culms and bamboo mats for housing are washed with slaked lime. Besides the ornamental effect of the white color, the process is expected to prolong the service life of the bamboo. The surface becomes alkaline, which delays fungal attack (Kaur *et al*. 2016).

Efficacy: Lime washing of bamboo may not inhibit fungal growth.

4.0 Modern Chemical Methods of Bamboo Treatment

4.1 Preamble

Treatment with chemicals for bamboo preservation is more effective than any non-chemical method and ensures a longer life for their structures (Akong *et al*., 2015; Obanda et al., 2008; Schultz *et al*., 2007; Shelter *et al*., 2018). Different methods of bamboo treatment exist. These include:

4.2 Soaking/washing (boron-based treatment)

Description: An open-tank treatment by soaking fresh culms, dried culms and splits is a rather simple method that leads to a protective effect. This method involves soaking the bamboo in a bath of the chemical (i.e., sodium borate, sodium tetraborate, or disodium tetraborate) (Figure 9).

Procedure: The materials are prepared to size, and soaked in a solution of 7% boron or 10% XM5. The treatment time takes about 2–3 days for splits and 7–9 days for the culm parts. For culm parts with skin, the solution penetrates by diffusion mainly into the ends, partly at the nodes and to a small extent through the outer culm wall. Culm parts without skin as well as splits can be treated easier than round bamboo. Split bamboo may require only a week, whereas round culms need 10–14 days. The system involves dissolving a combination of borax and boric acid in water in concentrations of around 5–10% and then soaking the bamboo in the liquid until the solution has penetrated completely throughout the bamboo. The nodal diaphragm needs to be punctured to allow the chemical to access the inside of the internodes; the chemical can be heated to speed up the process (Kartal *et al*., 2008). This requires fresh or almost fresh culms (up to seven days since harvesting) otherwise the cell walls will start to close. Bamboo should be stored upright for a minimum of one week after treatment to allow the boron to diffuse throughout the culm, followed by a further period of one to two weeks to partly season the bamboo. The bath liquid can be reused multiple times.

Figure 8. Bamboo culms soaked in a boron-based mixture. (Kaminski et al., 2016)

Efficacy: Bath treatment is the cheapest and simplest of the boron treatment methods, but it takes the most time. Penetration time varies greatly depending on the system. Borax is a relatively harmless compound whose minuscule particle size allows it to easily penetrate throughout the bamboo when dissolved. Borax and boric acid are naturally occurring boron-based compounds commonly available as sodium borate, sodium tetraborate, or disodium tetraborate.

4.3 Sap Displacement/Soaking

Description: Round bamboo, splits and slivers can be treated by keeping them submerged in a water-borne preservative solution. The preservative moves into the bamboo due to concentration gradient and the cell sap moves out due to osmotic pressure.

Procedures: Prepare the water-borne solution of preservative in a tank. A tank with an outlet at the base is required for draining of solution and cleaning.

- For round bamboo, puncture the diaphragm with a long rod to improve penetration.

- Bundle the material and submerge using a sinker load.
- Cover the tank to reduce water loss through evaporation.
- Sludge may form after a few days, especially in fixed type preservatives.
- Do not stir to disperse the sludge as this may facilitate the deposition of particles on the bamboo surface and hinder penetration.
- Keep the material immersed for 15–20 days for round bamboo, and 7–10 days for splits and slivers. Thin-walled culms may require less time.
- Drain and remove the treated material.
- Stack horizontally to facilitate further diffusion and air dry undercover.
- Check the solution regularly with a hydrometer.
- Top solution daily to replace uptake.
- Clean tank periodically (4–8 weeks) depending on use.
- Remove sludge and mix it with a chromic acid solution to retrieve preservatives. Filter in a muslin cloth and reuse the solution.

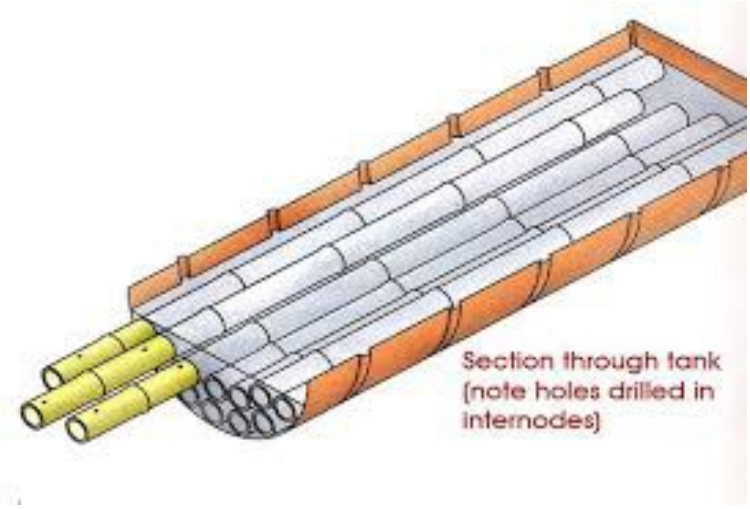

Figure 9. Bamboo culm immersed in treatment solution to replace sap

Efficacy: The method of diffusion can be varied by increasing the concentration of preservatives to reduce treatment time, using two salts to increase fixation and filling the lacuna of the culm with a solution by puncturing the nodes to fasten the diffusion process. The process is slow, requiring a large number of tanks. It is suitable for treating 50–100 culms a month.

4.4 Butt-end treatment

Description: In this method, green culms are placed vertically in the preservative (Figure 11). The solution penetrates the vessels by capillary action and subsequently by diffusion. The time for treatment will depend upon the moisture content and length of the culm.

Figure 10. Butt-end of bamboo culms immersed in the treatment solution. (Source: www.semanticscholar.org)

Procedure:

- Prepare a solution of water-borne preservatives such as boric acid: borax 1:1.4 (or CCB) in a container or cement tank.
- Cut bamboo sections of a maximum 2m length and remove foliage.
- Make a fresh base cut and immediately place sections in the solution.
- 25cm of the bamboo needs to be immersed in the solution.
- Depending on the length, keep the bamboo immersed for 7–14 days.

- Stir in between to prevent sedimentation.
- Drops of solution will appear at the nodes as the solution progresses upward.
- Invert the sections midway.
- Check the solution strength regularly with a hydrometer.
- Top the solution daily to replace uptake.
- Remove the treated bamboo culms.
- Season under shade.
- Alternatively, to accelerate the penetration of the solution, keep the foliage intact during treatment. But this will make handling and disposal of foliage time-consuming.

Efficacy: Medium-scale operation for both round bamboo and splits. Methods like butt-end treatment and diffusion are suitable for green bamboo only.

4.6 The Pressure Method

Description: The pressure method is mainly used for the treatment of dried bamboo (Figure 12). The principle behind the process is to force the preservative solution into the bamboo tissue. This can be done by a vacuum and/or by increasing the pressure upon the preservative in the treatment cylinder.

Procedure: The pressure method is mainly applied for bamboo culm parts and splits for making furniture and housing for export. Culm parts and splits are treated with 7% boron or 8% XM5 with a pressure of 7 kg/cm2 for 2–3 hours. This schedule is mostly applied to all bamboo species.

Figure 11. Treatment of bamboo using the pressure method. (Source: www,project.sare.org)

Efficacy: The pressure treatment should be conducted according to the properties of the bamboo species.

6.0 Basic Storage Techniques of Bamboo Culms

In rural areas, enormous quantities of bamboo culms stored on the forest floor often deteriorate and decay depending on the duration of storage, bamboo species, and environmental and storage conditions. Appropriate post-harvest storage of bamboo culms can be introduced to reduce loosing harvested culms. Bamboo can be stored by horizontal or vertical stacking of culms. Keep bamboo culms away from direct contact with soil to prevent fungal and termite attacks – place on a tarpaulin sheet or thick plastic sheet, or raised on a platform. To protect the culms from rapid changes in moisture – store them in a pond, tank or river (this will also help to leach the starch out), or cover the culms with a thin canvas sheet. The following actions can also be taken to improve drying and removal of starch from the culms:

- Provide good ventilation by storing the culm in a well-ventilated shelter and piling the poles in stacks of different diameters. Stack them with distance splits to allow airflow.
- Remove infected culms from the storage area.
- Categorize between the base and middle stem.
- After three (3) months you can achieve 20% humidity in the bamboo.
- Sort and classify the preserved culms according to size, diameter and quality.

Figure 12. A treatment tank at the Common Production and Training Centre at Obogu, Ghana. (Source: INBAR 2021)

The best way of storing treated bamboo culms is in horizontal racks (Figure 14). Bamboo should be stacked above ground, with gaps in-between the culms, allowing airflow, such that the bamboo can “breathe”. There should also be a roof covering to protect against rain and driving rain. These steps are particularly important with fresh bamboo which will have a high moisture content and therefore be particularly susceptible to rot.

Figure 13. Recommended horizontal stacking of bamboo culms. (Source: INBAR 2021)

7.0 Conclusion and Recommendation

One of the major aspects of bamboo processing and product development is the proper treatment and preservation of bamboo. Removing the water, cellulose and lignin among other components tends to increase the durability and longevity of the bamboo culms. Bamboo treatment and preservation can be classified into two (2) categories, namely, traditional or non-chemical and modern or chemical techniques. The traditional techniques include water-soaking, drying, smoking, lime-washing, etc. The modern or chemical methods include butt-end treatment, sap displacement, boron-based treatment, and pressure treatment methods. Irrespective of the type of application some level of bamboo treatment and preservation is essential. It is expected that artisans and other bamboo users will pay attention and apply treatment and preservation

techniques to bamboo. By applying these techniques, bamboo users will increase the quality and durability of their bamboo products.

References

Akong, F. O., Gerardin, P., Thevenon, M. F., and Charbonnier, C. G. (2015). "Hydrogel-based boron salt formulations for wood preservation," *Wood Science and Technology* 49(3), 443-456. DOI: 10.1007/s00226-015-0701-4

Ashaari, Z., and Mamat, N. (2000). "Traditional treatment of bamboo: Resistance towards white rot fungus and durability in service," *Pakistan Journal of Biological Sciences* 3(9), 1453-1458. DOI: 10.3923/pjbs.2000.1453.1458

Dhamodaran, T. K., Jino Johny T. M. and Ganesh Gopal (2020). A manual for preservative treatment of bamboo. KFRI Handbook No. 18. ISSN 0970-8103.

Kaminski, S., Lawrence, A., Trujillo, D. and King, C. (2016). Structural use of bamboo: Part 2: Durability and preservation. Technical note. Arup Advanced Technology & Research London

Kartal, N., Hwang, W. J., and Imamura, Y. (2008). "Combined effect of boron compounds and heat treatments on wood properties: Chemical and strength properties of wood," *Journal of Materials Processing Technology* 198(1-3), 234-240.
DOI: 10.1016/j.jmatprotec.2007.07.001

Kaur, P. J., Satya, S., Pant, K. K. and Naik, S. N. (2016). Eco-friendly preservation of bamboo species: Traditional to modern techniques. BioResources 11(4), 10604–10624.

Kumar S, Shukla KS, Dev I, Dobriyal PB (1994). Bamboo preservation techniques: a review. International Network for Bamboo and Rattan (INBAR) and Indian Council of Forestry Research Education (ICFRE), p 18–19

Liese, W. and Tang, T. K. H. (2015). Preservation and Drying of Bamboo: Bamboo. pp 257–297. DOI: 10.1007/978-3-319-14133-6_9

NMBA (National Mission on Bamboo Applications), (2004). Training Manual: Building with Bamboo. New Delhi: Tulika Print.

Obanda, D. N., Shupe, T. F., and Barnes, H. M. (2008). "Reducing leaching of boron-based wood preservatives – A review of research," *Bioresource Technology* 99, 7312-7322. DOI: 10.1016/j.biortech.2007.12.077

Onuorah, E. O. (2000). "Short communication: The wood preservative potential of heartwood Extracts of *Milicia excelsa* and *Erythrophleum suaveolens*," *Bioresource Technology* 75(2), 171-173. DOI: 10.1016/S0960-8524(99)00165-0

Schultz, T. P., Nicholas, D. D., and Preston, A.F. (2007). “Perspective – A brief review of the past, present and future of wood preservation,” *Pest Management Science*63(8), 784-788. DOI: 10.1002/ps.1386

Shelter and NFI Sector, Cox's Bazar, (2018). Technical Guidance Note 03: Durability and Treatment of Bamboo in Cox's Bazar. REP/079032-30/S0001

Tang, T. K. H., Schmidt, O., and Líese, W. (2009). “Environment-friendly short-term protection of bamboo against moulding,” *The Timber Development Association of India* 55, 8-1.

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