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Conservation of jack wood (*Artocarpus heterophyllus* Lamk.) sculptures in an ancient temple in Kerala, South India: identification of heritage wood samples, neem gum–cashew nut shell liquid application in consolidation and preservation

M. P. Sujith[1], L. Rajeswari[1], T. Sreelakhmi[1] and E. V. Anoop[2,*]

[1]Archaeological Survey of India, Thrissur Circle, Purathathva Bhavan, Pullazhy, Thrissur 680 012, India
[2]Department of Wood Science, College of Forestry, Kerala Agricultural University, Thrissur 680 656, India

This present communication deals with the anatomical identification of wood samples of an ancient archaeological monument in India, Sri Vishnu temple, Kadavallur in Thrissur (Kerala) and the consolidation of fissures and cracks formed due to seasoning over a period of time using neem gum and preservation using cashew nut shell liquid extract. Neem gum which has anti-bacterial qualities and CNSL organic extract which has anti-termite and anti-fungal preservative action are found suitable for conservation and preservation of these sculptures. The active ingredient in organic preservative, CNSL, was analysed using HPLC and compared using UV spectra. The peaks of monoene, diene and triene in anachardic acid are visible in the spectra. The preservative, CNSL, also enhanced the aesthetic appeal of the jack wood sculptures. CNSL-coated jack wood had lower moisture absorption as demonstrated by Karsten tube experiment. The results imply that the strength of the material formed out of neem gum and wood powder used for filling of cracks and fissures can be modified as per requirement using distilled water and that the application is reversible. This method of conservation was found suitable under warm and humid conditions to which these sculptures are subjected to.

Keywords: Conservation, CNSL, heritage wood, preservation, wooden sculptures.

THE dexterous consolidation and filling up of cracks finds much application in heritage sculptures. In the case of conservation of wooden sculptures the present methods largely depend on synthetic adhesives like cyanoacrylates and epoxy resins. The low compatibility and irreversibility of these materials and their synthetic nature make them less attractive for heritage conservation. Traditionally, the temples and other ancient structures of Kerala

*For correspondence. (e-mail: anoop.ev@kau.in)

resorted to complete replacement in the case of wood wreckage and in the recent past, wood varnishes and other polyurethane materials were used as preservative coatings. In Kerala, cashew nut shell liquid (CNSL) extract was used for coating in the exterior parts and floors of some old buildings at places where cashew industries were common. The CNSL can be extracted using several established methods[1,2].

Kadavallur, located in the Thrissur district of Central Kerala, South India is famous for the *Anyonyam* festival in which recital and interpretation of Vedic scriptures are performed. The locus point of this festival at Kadavallur is the ancient Vishnu temple, popularly known as Sri Rama Temple. The temple showcases magnificently carved wooden figures all around its sanctum in two stratums which carry the stories of *Kiratharjuneeyam*, a section of *Mahabharata* and portrayal of legends of Hindu mythology. These intricately carved figures had fissures and cracks in several places which demanded immediate requirement of conservation and preservation. The ancient Sri Vishnu temple at Kadavallur is a protected monument of the Archaeological Survey of India (ASI) since 1951.

The present study deals with identification of the species of wood used in the construction of wooden sculptures of the Kadavallur temple using anatomical techniques. It also experimentally analyses the composition as well as effectiveness of CNSL for application as a preservative coat since it has proven antifungal and antitermite activity due to its phenolic nature and ready solubility in a number of solvents[3,4]. Inherent hydrophobicity is an added advantage of this material[5]. Literature survey shows many earlier studies on CSNL[3,4,6]. The effectiveness of neem gum (*Azadirachta indica* A. Juss.)[7] treatment as a binder for filling materials is also attempted. The suitability of the technique employed using materials of organic origin in terms of its compatibility and reversibility under very warm and humid conditions, typical of the humid tropics in which the temple is situated was also assessed.

Wood samples for identification of the species used in the construction of sculptures were collected using a chisel and subjected to microtomy and image analysis. Microscopic sections (T.S and T.L.S, Figure 1) of size 15–20 µm were taken from wood samples using a sledge microtome (Leica, SM 2000 R). Permanent sections were prepared by double-staining and mounted on a glass slide using DPX mountant. Images of the sections were captured to measure various wood anatomical parameters using an image analysis system (Labomed Digi 2) running the software (Labomed Digi Pro 2) and analysed for identification of the timber species.

The sculptures had developed defects such as cracks and fissures (Figures 2 *a* and 3 *a*) due to the expansion and contraction caused by the movement of moisture under a climate characterized by warm humid conditions. (RH 61–87% with an average of 74% for Thrissur region). Moreover, the accumulation and general accretion of deposits like dust and dirt marred the natural beauty of the antique wooden craft over time. The following materials were practically evaluated for its efficacy on a trial wood piece of the same species for selecting the most suitable one for consolidation of the antique wooden sculptures: neem gum and teak wood powder; synthetic adhesive and teak wood powder; polyethylene glycol (PEG) and teak wood powder and paraffin wax.

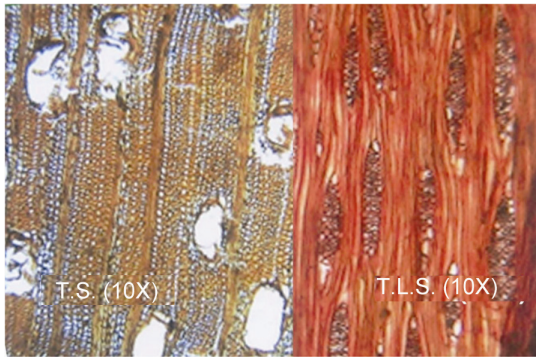

Figure 1. TS (10×) and T.L.S (10×) of Jack wood (*Artocarpus heterophyllus*), used in the construction of the sculptures.

Figure 2. Rear side of a sculpture (***a***) before consolidation and (***b***) after consolidation.

Figure 3. Face of a sculpture (***a***) before consolidation and (***b***) after consolidation and application of preservative coat.

To understand the efficacy of consolidation of the sculptures using selected organic compounds, trial treatments were carried out on old wood pieces available in the temple prior to its application on the sculptures. The experimental consolidation on old wooden pieces with various materials listed above was tried in several spells before selecting the most appropriate treatment. The consolidants were inserted manually using modeller's tools. Treatment materials were selected, considering the widely varying climatic conditions and the resultant expansion and contraction to which these antique sculptures were subjected to during monsoon and summer seasons.

Surface accretions and dirt on the sculptures were carefully removed using organic solvents, viz. 2 ethoxy ethanol, diacetone alcohol, butyl lactate, tolune and ethyl alcohol. Different combinations were tried for removal of dirts and accretion that stuck to the wooden sculptures as per requirement. The solvents were applied using cotton swabs. The cracks and fissures in the sculptures were consolidated using the selected combination of organic materials, viz. neem gum and teak wood powder.

To arrest the periodic attacks of termites and pathogens, Imidacloprid (0.21% in water) was injected all around the floor area of the monument and Chloropyrifos (0.25% dilution in emusifiers) was sprayed on infected wood raftors and reapers. Preservative treatment of antiques necessitates the retenion of original features such as size, shape and colour of the object, besides providing protection from termites, other insects and pathogens. Therefore, a locally available CNSL compound extract was applied using soft brushes over the sculptures as a single preservative.

Moisture absorption on specimens was tested using the Karsten tube method[8], an internationally accepted moisture absorption technique for heritage building masonry which gives information of water absorption by carrying out tests on experimental samples under the same climatic conditions along with a blank sample.

The method involved application of CNSL coatings on jack wood (*Artocarpus heterophyllus* Lamk.) samples (the anatomical tests conducted earlier had revealed the identity of the wood used in the construction of sculptures) of size 5 cm^3 under the same conditions and for the same duration, drying the coating in atmospheric condition for a day and noting down the intake of water for the wood samples from the Karsten tubes. The active ingredient in the organic preservative, CNSL, was analysed using HPLC and compared using UV spectra.

The following gross anatomical features of the wood were used for identification. Growth rings were indistinct and the wood was diffuse porous. Vessels were solitary and in radial multiples of two to three; large to medium-sized and clearly visible with a hand lens; few to moderately numerous (2–5 per mm^2), often filled with white chalky deposits. Soft tissues were forming halos around vessels and sometimes forming bands. Rays were moderately broad to fine, few and widely spaced, clearly visible to the unaided eye. From the above characters it was found that the species of wood used in the construction of wooden sculptures was jack wood (*Artocarpus heterophyllus* Lamk.), a common timber species of the region (Figure 1).

An analysis of the various consolidation trial treatments revealed differences in their efficacy. The formulations involving neem gum and teak wood powder; synthetic adhesive and teak wood powder turned out as better consolidations, with the latter providing good adhesive property; however it offered lesser chance of reversibility which is not favourable as per conservation principle. PEG requires adhesives as additives and gets dried up with much time, whereas wax offers no binding of the two widening parts. Therefore, it can be concluded that the first option is the best for consolidation, considering the fact that neem gum also has insecticidal properties.

Based on these results, a careful consolidation on the rear side of one of the sculptures was conducted followed by colour integration of the consolidated area. The tests on the rear side of one of the sculpture are portrayed in Figure 2. For filling, instead of jack wood powder, teak wood powder was used to perfect the colour combination of the conservation, which did not make any difference in the final results. The anti-termite treatment on the basement prevented infestations on the wooden beams and rafters of the monument which in turn protects wooden sculptures. The cases of termite infestation are practically nil for the past two years.

CNSL extract was applied over the sculptures as a single preservative coat since it has known anti-termite and anti-fungal preservative properties. The active ingredient anachardic acid in the preservative coat of organic extract CNSL with anti-termite preservative action was analysed by separation using HPLC and comparison made using an ultraviolet (UV) visible spectra. The peaks of monoene, diene and triene in Anachardic acid are visible in the spectra. UV spectra of the sample and of the standard are shown in Figures 4 and 5 respectively.

Moisture absorption test on the specimens was carried out using the Karsten tube method. Figure 6 shows the absorption of water through semi-permeable coatings in the jack wood samples used. The intake of water gets reduced marginally by the two coatings. CNSL, while acting as a coating still allows free movement of water in and out of the wood which can be further enhanced by dilution with a minimum quantity of turpentine oil.

The results of the consolidation and preservation treatments carried out on the different wooden sculptures can be observed in Figure 3 which clearly depict that the multidimension cracks are well consolidated and integrated to the totality of the wood. Also, the application of CNSL is found suitable for its usage as wood preservative which excels in retaining the aesthetic appeal of the sculptures.

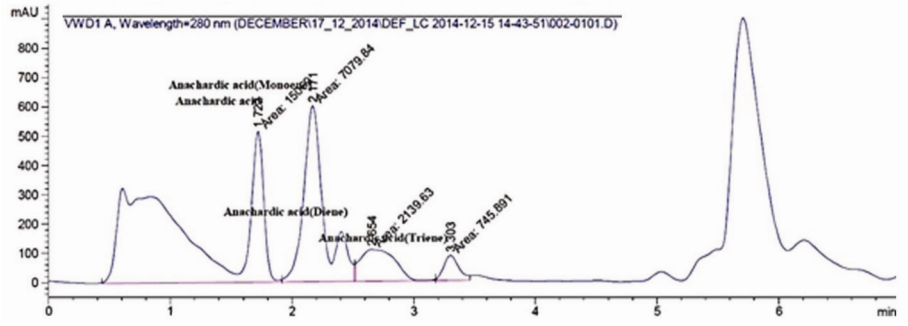

Figure 4. UV spectra of the sample.

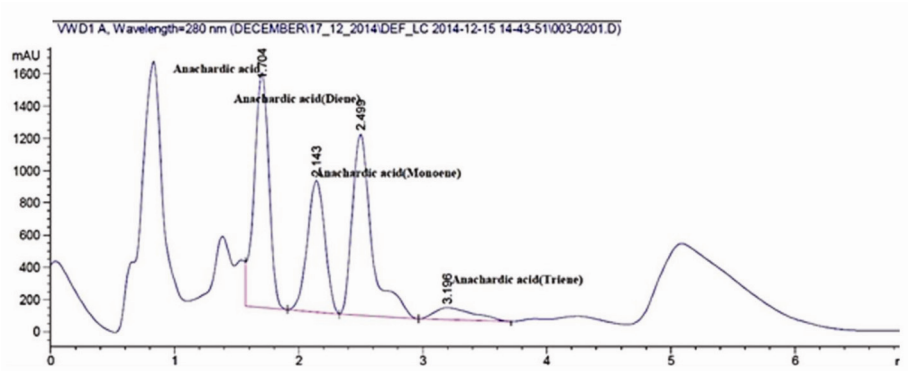

Figure 5. UV spectra of the standard.

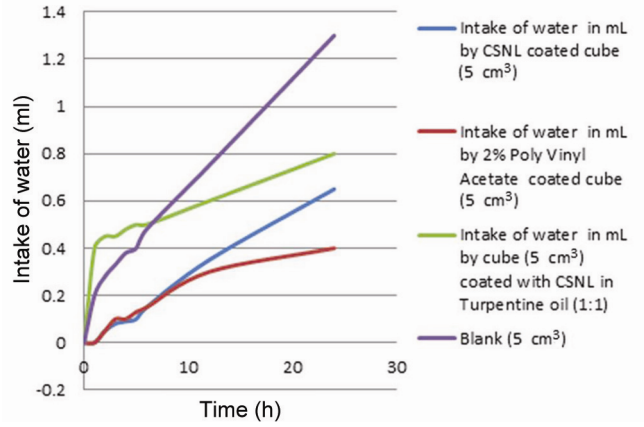

Figure 6. Absorption of water through semi-permeable coatings in jack wood *Artocarpus heterophyllus* samples.

The above method of consolidation and preservation of wooden sculptures at Sri Vishnu Temple, Kadavallur demonstrates that heritage wooden structures can be preserved using organic products which are natural origin with characteristics at par with synthetic products and are good at preventing fungal and termite attacks. This method of conservation was found suitable particularly under warm and humid conditions prevailing in the region.

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