

Investigating the causes of deterioration and the appropriate conservation treatment method of an excavated wooden schooner found in coastal area of Bangladesh

Rokonuzzaman S (Dept. of Conservation Laboratory, Bangladesh National Museum)
smrokon.chem@gmail.com

ABSTRACT

A waterlogged wooden schooner was collected from Kuakata, a famous coastal region of Bangladesh, during the excavation period from 23rd December, 2012 to 27th February, 2013 under the Directorate of Archaeology. This schooner was measured 72 feet in length and weighed about 90 tons in wet conditions. A lot of valuable information regarding trade relations with other countries in ancient times, migration of people of certain communities, species of wood etc. can be obtained from this artifact. Unfortunately, the schooner has been kept under a canopy in the open for nearly 10 years after excavation without any consultation from conservation experts. The condition of this artifact was found to be extremely damaged and fragile when visited on 21st September, 2022. Attacks of various types of microorganisms and insects were observed in most of the woods. Different types of physical changes were also found in the wood of the schooner. Even the original shape of the artifact was disfigured by shrinkage, cracking, twisting and splitting of wood. It is known that the conservation treatment of waterlogged wood consists of four steps such as dehydration, substitution, consolidation and controlled drying processes. These are very expensive and lengthy processes. Now it is impossible to apply a conventional conservation treatment method on the wooden schooner, because the artifact has already lost all characteristics of waterlogged wood. There are three objectives of this study: (i) to investigate the causes of deterioration of wood, (ii) to revive the characteristics of waterlogged wood and (iii) to recommend an easy and appropriate conservation treatment strategy for this waterlogged wooden schooner. Recommendation of treatment strategy is the most important part of this study. Considering the capability, time duration and financial cost, the treatment strategy will be introduced. After the successful completion of this study, the countries like Bangladesh will protect their waterlogged wooden heritage using the new method.

Keywords Waterlogged wood, Deterioration, Consolidation

List of Abbreviations

BNM	: Bangladesh National Museum
DoA	: Directorate of Archaeology
PEG	: Poly Ethylene Glycol
RH	: Relative Humidity
MC	: Moisture Content
ETP	: Effluent Treatment Plant
SS	: Stainless Steel

1. INTRODUCTION

Waterlogged wood refers to wood that has been under soil or water for a long time and whose internal pores, capillaries and micro capillaries are saturated with water. Besides, these places contain different types of harmful substances like mud, sand, microorganisms etc. along with the water. Waterlogged wood has special importance among the archaeological artifacts. Through scientific research, it is possible to uncover many exclusive information regarding ancient cultures and civilizations from the waterlogged wooden artifacts. Such as:

- (i) A clear understanding of the historical trade/other relations of one country with another country can be obtained.
- (ii) Information about the migration of a certain community or group of people in ancient times can be found.
- (iii) Important guidelines can also be derived from these artifacts in protecting ecological balance.

Wood is an organic material which is composed of cellulose (40% - 60%), hemicellulose (15% - 25%) and lignin (15% - 40%). Cellulose, hemicellulose both are polysaccharide polymer compounds and lignin is a phenolic polymer compound. Polysaccharides are high polymers of monosaccharides.

Each polymer compound plays the different role in wood. Cellulose is responsible for giving the strength to the wooden structure, hemicellulose gives the flexibility of wood and lignin is responsible for stiffness of wood. These three polymers combined together give the remarkable physical and mechanical support to the wood.

The molecular formula of cellulose is $(C_6H_{10}O_5)_n$. Cellulose participates in hydrolysis reaction with water in presence of acid, it gives D-glucose in 95-96 percent. As a result, cellulosic bonds are broken. If this type of reaction continues in waterlogged wood for hundreds of years, extensive decay occurs in the wooden artifacts. In addition, microorganisms and other harmful substances stay for a long time in the pore spaces, capillaries and micro capillaries inside the waterlogged wood and cause considerable damage to the internal structure of the wood. As a result, the wooden structure continues to weaken and eventually it is completely destroyed. Therefore, every step from excavation to conservation treatment period for any waterlogged wooden artifacts needs to be done with intensive care. Also the long-term management of waterlogged wood is a very important issue.

On site inspection, the mentioned problems have been found in the different parts of the waterlogged wooden schooner. The water has removed freely from waterlogged wooden parts in uncontrolled drying. But there has not been any conservation measures of the schooner. As a result, the wood fibers have compressed and the whole structure has converted into a distorted shape (Figures 1.1).



Figure 1.1: Disfigured structures of the schooner

2. CASE STUDY

2.1 Missing of Original Wood

As mentioned earlier, the schooner was left for long periods in different environments such as soil or water, underwent extensive decay and its strength was severely reduced. The various parts of the schooner were closely observed during the onsite inspection. At that time the original wood was missing from some parts of the schooner.



Figure 2. Excavation of shipwreck

2.2 Adding New Wood

New wood was added to the different parts of the schooner in order to facilitate its safe lifting and transport. Addition of new wood was the right decision during excavation period. Later, the new wood should have been removed and supports were used with the various parts of the schooner in the rehabilitation process to maintain its original shape. It is known that the stiffness of new wood is relatively higher than waterlogged wood. In this case, adding new wood of higher strength to the waterlogged wood of lower strength created additional stress on the waterlogged wood. But not removing new wood from the schooner caused various physical changes in it. The main structure of the schooner was not in its original shape. Many of the wooden parts have bent and distorted the structure. Though, there are many other reasons for distorting the schooner's main structure. Some new wood may be conditionally added to the missing parts when the schooner's conservation treatment is fully completed. According to the principles of restoration, the species, age and strength of the new wood must match the original wood. New wood should also be given a conservation treatment before being added.

2.3 Insects attack and Rotting

During the inspection several parts of the waterlogged wooden schooner were observed to be rotting, infested with insects. This attack is quickly spreading to other parts of the wood.

2.4 Microscopic Analysis and Salinity

A few places on the schooner, examined under a small microscope, showed extensive white coating on the surface of the wood (Figure 3). Despite several attempts with water, the white spots could not be completely removed. These appear to be salt deposits. It is possible to remove all these white coatings and other impurities by applying water to waterlogged wood for several years.



Figure 3: Microscopic observations

2.5 Moisture Content

The moisture content is an important part of wood. There are two types of moisture found in wood, one is 'free water' in the cell cavities and vessels, and other is 'absorbed water' bound in the cell walls. Free water evaporates up to the fiber saturation point, when the wood is air-dried. In this case the wood does not shrink. However, as waterlogged wood is very weak and its fiber loss is high. So, this rule is not applicable for waterlogged wood. At the fiber saturation point, wood contains only the 'absorbed water' from 20% to 36% of the total moisture content which varies the species of wood. If 'absorbed water' evaporates, then shrinkage starts in wood. Wood is a hygroscopic material whose moisture content fluctuates with the relative humidity of its environment (Table 2.1).

Table 2.1: Moisture content fluctuates with the relative humidity

SL No.	Relative Humidity (%)	Moisture Content (%)
1.	90	21-22
2.	70	13-14
3.	50	8-10
4.	30	6-7
5.	10	3-4
6.	0	0

The moisture content is determined by the following equation:

$$U = \frac{G_u - G_0}{G_0} \times 100\%$$

Here,

U = Moisture Content (%)

G_u = Weight of normal / waterlogged wood

G_0 = Weight of oven dried wood

Physical observation confirmed that the schooner had lost the characteristics of waterlogged wood. Now reviving its waterlogged wooden nature is very uncertain. But by keeping the schooner in water long enough, it is possible to revive its few waterlogged wooden characteristics. This can be confirmed by measuring the moisture content.

3. RESOURCES

Conservation treatment of waterlogged wood is very expensive and time consuming. Such treatments are usually initiated while the wood is still wet. There are many types of conservation treatment methods of waterlogged wood around the world. Five methods have been selected for this study, which are very much popular in conservation science. These are Poly ethylene glycol-4000 method, Poly ethylene glycol-2 steps method, Sucrose method, Cetyl alcohol method and Dammar method (Table 2.2). Implementation of these conservation treatments requires extensive technical capacity, which is not usually available in developing countries like Bangladesh. After analyzing the five methods, it was confirmed that the Dammar method can be modified and applied as suitable for Bangladesh. The modified dammar method must be applied to each part of the schooner separately.

Table 2.2: The popular conservation treatment methods over the world					
No.	Name of Treatment Method	Dehydration Step (alcohol in H ₂ O)	Substitution Step	Consolidation Step	Controlled Air Drying (RH in Drying Chamber)
1.	PEG-4000 Method	-	-	(i) 20% PEG-4000 in H ₂ O (ii) 40% PEG-4000 in H ₂ O (iii) 60% PEG-4000 in H ₂ O (iv) 80% PEG-4000 in H ₂ O (v) 100% PEG-4000 in H ₂ O	(i) At 80% (ii) At 60% (iii) At 40%
2.	Sucrose Method	-	-	(i) 20% Sucrose in H ₂ O (ii) 40% Sucrose in H ₂ O (iii) 60% Sucrose in H ₂ O (iv) 80% Sucrose in H ₂ O	(i) At 80% (ii) At 60% (iii) At 40%

3.	Cetyl – alcohol Method	(i) 20% Methyl (ii) 40%Methyl (iii) 60%Methyl (iv) 80% Methyl (v) 100%Methyl	-	(i) 20% Cetyl-alcohol in methyl alcohol (ii) 40% Cetyl-alcohol in methyl alcohol1 (iii) 60% Cetyl-alcohol in methyl alcohol1 (iv) 80% Cetyl-alcohol in methyl alcohol	(i) At 80% (ii) At 60% (iii) At 40%
4.	PEG-2 Steps Method	(i) 20% Ethyl (ii) 40% Ethyl (iii) 60% Ethyl (iv) 80% Ethyl (v) 100% Ethyl	(i) 50% t-butyl in ethyl (ii) 100% t-butyl in ethyl	(i) 20% PEG-4000 in t-butyl alcohol (ii) 40% PEG-4000 in t-butyl alcohol (iii) 20% PEG-4000 in t-butyl alcohol (iv) 40% PEG-4000 in t-butyl alcohol (v) 60% PEG-4000 in t-butyl alcohol (vi) 80% PEG-4000 in t-butyl alcohol	(i) At 80% (ii) At 60% (iii) At 40%
5.	Dammer-Method	(i) 20% Ethyl (ii) 40% Ethyl (iii) 60% Ethyl (iv) 80% Ethyl (v) 100% Ethyl	(i) 50% Xylene in ethyl alcohol (ii) 100% Xylene in ethyl alcohol	(i) 20% Dammar in xylene (ii) 40% Dammar in xylene (iii) 60% Dammar in xylene	(i) At 80% (ii) At 60% (iii) At 40%

4. FRAMEWORK

The pore spaces, capillaries and micro capillaries of waterlogged wood are filled with water and various kinds of contaminants when it is buried. All these impurities need to be compulsorily removed through the continuous cleaning process before conservation treatment. Cleanup can take up to several years depending on the thickness of the wooden parts. The wood must not be allowed to dry out in any way during the entire process. When the wood is completely ready for treatment, then the modified dammar method is applied (Table 2.3). After the conservation treatment, the wood is dried by vacuum-freeze-drying or a controlled air-drying process. In a controlled air-drying process, the wood is first dried at room temperature where the relative humidity is very high. Later the relative humidity is gradually reduced. On the other hand uncontrolled drying is fully prohibited for waterlogged wood to avoid any kind of deformation of wood like shrinking, twisting, cracking, splitting, warping etc.

Table 2.3: The modified Dammar method

Dehydration Step	Substitution Step	Consolidation Step	Naturally Drying	Time Duration
(i) 20% Ethyl alcohol solution in H ₂ O (ii) 60% Ethyl alcohol solution in H ₂ O (iii) 100% Ethyl alcohol solution in H ₂ O	(i) 50% Xylene solution in ethyl alcohol (ii) 100% Xylene solution in ethyl alcohol	(i) 20% Dammar solution in xylene (ii) 40% Dammar solution in xylene (iii) 60% Dammar solution in xylene	According to the climate of Bangladesh, RH gradually decreases from November to March. This is the perfect time to let the wood dry naturally. However, the wood should be kept under close observation.	Time duration of dehydration, substitution, consolidation and drying steps depends on the thickness of wood.
To ensure minimum use of chemicals, airtight SS containers and jute mats are used. Basically, the artifacts are wrapped with jute mats before being soaked in chemicals.				

5. **RESULTS**

The treatment of waterlogged wood is a very risky, expensive and difficult task. Most of the undeveloped or developing countries are not able to conserve their valuable artifacts of waterlogged wood through the conventional method. This is the main reason to modify the Dammar method so that every country can protect their valuable heritage. Modified Dammar method is comparatively easy and less expensive, but it is not the health and environment friendly method. Therefore, the appropriate precautions should be taken, when the modified Dammar method is applied for the conservation of waterlogged wood.

BIBLIOGRAPHY

Finar, I. L., Organic Chemistry (Volume Two), 3rd edn., (1964):224-225.

Harman, Kuhn, Conservation and Restoration of Works of Art and Antiquities, 3rd edn. 19, (1987): 176-179.

Plenderleith, H.J., The conservation of Antiquities and Works of Art, Reprinted 5, (1974): 124-126.

Desch, H.E., Timber Its Structure and Properties, Macmillan, London, 3rd edn., 1956.

In Museum 8, no. 3, 1955:139.

Museum and Monuments The Conservation of Cultural Property, The UNESCO Press, Reprinted (1975): 173.