Conservation of ancient writing material of Palm leaf manuscripts in Sri Lanka

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Introduction:

Evidence of the ancient writing medium of Sri Lanka is found in several historical records. According to the Pali chronicles such as the *Mahāvaṃsa* (great chronicle), the *Dīpavamsa* (history of the island), and Pali commentaries such as *Samantapāsādikā* and *Vinayaṭṭakathā*, there had been not only a spoken practice but also a writing practice since the arrival of prince *Vijaya* to ancient Sri Lanka or Ceylon from India in the 5th BCE. Later, he became a powerful monarch but could not be consecrated without a royal queen. As a result, *Vijaya* sent a letter with a delegation to *Madurpura* in India. *Pandi*, the king of *Madur*, sent his daughter to the island with a reply letter. The symbols used in these letters were not recorded, but it was obvious they had utilised a language and writing material, probably plant leaves, since the 5th century BCE. However, this writing tradition was developed systematically after the arrival of Ven. *Mahinda* Thero. He introduced a *Brāhmi* alphabet to expand the art of writing in Sri Lanka. After the introduction of Buddhism to Sri Lanka, some devotees who embraced Buddhism restored some caves, and those caves were offered to Buddhist monks. These meritorious activities were written on stone inscriptions. After the establishment of Buddhism on the island, Ven. *Mahinda* took various strategies to spread Dhamma with the help of King *Devānampiyatissa*. One was to introduce a new alphabet to expand the writing tradition, and the other was to translate Pali commentaries into Sinhala. This step caused Sinhalese literature to develop and spread palm leaf manuscripts among the public. The first recorded event where palm leaves were used for writing in Sri Lanka was in the first century BCE, when five hundred monks undertook the gigantic task of inscribing the entire teachings of the Buddha (Tripitaka) in Pali on talipot palm leaves at *Aloka Viharaya*, an ancient rock cave temple near *Matale* in the central hills of Sri Lanka.

The tradition of palm leaf manuscripts was interwoven with a number of elements of an ancient society, including religion, culture, economy, technology, art, rituals, etc. Therefore, it can be recognised as a widely spread manuscript culture, exceeding the limits of mere writing material. These palm leaf manuscripts are an invaluable source containing a great depository of knowledge and wisdom, which were acquired by our ancestors within thousands of years as a result of their experiences. A large amount of information can be revealed from these manuscripts regarding Buddhism, history, indigenous medicine, traditional agricultural methods, ancient technology, astrology, astronomy, demonology, language and literature, social condition, and economic status at the time. These manuscripts are subjected to deterioration very quickly due to a number of environmental factors, including natural disasters, negligence, and human activities. Unfortunately, some of these manuscripts, which were venerated in the past, are brought to foreign countries as antiques and aesthetic objects, and their ownership has become alienated, mostly being preserved in museums in western countries such as the former colonial rulers of the UK.

At present, several government institutions (Department of National Archives, National Library and Documentation Services Board, Department of Archaeology, Department of National Museums, and Central Cultural Fund) have launched several programmes to safeguard the existing palm leaf manuscripts in the country. The main aims of the above institutions are to prepare a national inventory of palm leaf manuscripts, create a database and a status report on palm leaf manuscripts available in the country, develop a descriptive catalogue of palm leaf manuscripts, train and develop skilled human resources, ensure physical protection of palm leaf manuscripts through proper infrastructure facilities, select nominations for submission to the UNESCO MOW register, develop national directives on intellectual property rights related to palm leaf manuscripts, create a digital repository of palm leaf manuscripts, and raise public awareness in addition to publishing the selected transcriptions as books.

Palm species used in preparation of palm leaf manuscripts

There are 2,400 species of palms distributed worldwide, although only several species have been identified as commonly used for preparing palm leaf manuscripts: *Borassus flabellifer* (palmyra palm), *Corypha umbraculifera* (talipot palm), *Corypha taliera*, and *Corypha utan*. According to the sources of the Library of Cornell University, the most frequently used leaves for preparing palm leaf manuscripts come from Borassus *flabellifer* and *Corypha umbraculifera* in the world (Eiserhardt *et al*., 2011). Palm leaf manuscripts in Sri Lanka are mainly from the Talipot palm (*Corypha umbraculifera*). According to the type of palm leaves, the following parameters were varied: colour, flexibility, smoothness, strength, reactions with the passage of time, and susceptibility to pest attacks and other damages.

Scientific name	**Common name(s)**	**Notes**
Borassus flabellifer	Palmyrah, Toddy palm, Wine palm	Thick, fairly flexible, leaves, become brittle with time, slightly waxy, usually incised writing, does not take surface writing (ink or paint) well. Large distribution (sub-tropical, tropical); widely cultivated in South Asia.
Corypha taliera		Leaves brownish with black spines, thick, not flexible. Extinct in the wild; only a small number of cultivated specimens remain
Corypha umbraculifera	Talipot palm, Fan palm.	Light in colour, thin, flexible, durable for centuries, leaves up to 16 feet across, takes surface writing (ink or paint) well. Exists in India, Sri Lanka, and in other parts of Southeast Asia.
Corypha utan	Gebang palm,	Takes surface writing (ink or paint) well

	Buri palm	Exists in Southeast Asia, Australia

Processing techniques of Palm leaf manuscripts

The palm leaves are usually harvested when young leaf bud, preferably during the dry season. They are processed or "seasoned" before they can be used for manuscripts. Partially opened young leaf bundles were preferred as writing supports. The exact seasoning process is varied according to the leaf types and local customs, but can include boiling in water, milk, or other liquids, heating in kilns, smoke treatment, air drying, burial in mud, sand, or wet rice straw, sanding, rubbing, or burnishing, and treating leaves with spices such as turmeric or oils and sesame seed oil (Bhattacharya, 1947).

According to local customs, palm leaf manuscripts are prepared from the tender, unopened leaf bud of *Corypha umbraculifera,* which is about 10–12 feet in length. Normally, a leaf bud consists of about 80–100 leaflets. Leaf buds are cut at an auspicious time while singing *Thal Kavi.* The midrib of each leaflet is removed, and the blades are rolled up. These leaf rolls, known as '*Vattu*', are placed in a clay vessel to form a layer. On top of the leaf roll, the *Ananas comosus merril* (pineapple) leaf layer is placed. Then another layer of rolls is placed, and so on alternately, till the pot is nearly full. The pot is filled with water, and on top, *Croton lacciferus (Keppetiya)* leaves are placed, and the clay pot is closed tightly with an earthen vessel (Gunawardana, 1990). In addition to the *Croton lacciferus* leaves, layers of Avexrhoa *bilimbi lindl* and *Carica papaya* leaves are used on some occasions for this process (Lagamuwa, 2009). Water in the clay vessel is boiled by firewood for a couple of hours over a slow fire. Then rolls are taken out, washed by spring water, and left in the open air for three consecutive days. The next stage is polishing the palm leaf strips using a long-rounded pole of *Gyrinops walla (Walla patta)* of the size of traditional '*Mollgaha*'. This pole is tied to two rods and placed six feet above the ground. Stones (around 800g) were tied on either side of the leaf strips. The leaf strip is placed over the wooden pole with the stone end hanging down. Coconut oil is applied to the leaf strip, and the leaf is rubbed up and down on the pole till the leaf strip gets flattened. At the end, the leaves are washed in cool water. Leaf strips were hung on the coir rope, which is hung as a cloth line outside, to catch the dew in the early morning for a week. Then leaves are cut into conventional sizes, with length varying from 6 inches to 32 inches and width ranging from 2-2 ¾ inches. Two holes in each strip are made by a heated iron rod; these are required for passing the '*Huya*' or cord for holding the leaves together of a palm leaf manuscript. The next step in the process of preparing the palm leaf manuscript is to press tightly the punched leaves together, and their sides and ends are singed with a hot iron so as to make all the leaves uniform in size. Then all the leaves assembled between two book covers known as "Camba'—wooden sheets made out of *Azadirachta indica* (Neem). A strong cord is passed through the punch hole to hold the leaves and covers together, and the manuscripts are securely tied up with the same cord. *Panhinda,* or stylus, is used to incise letters on the surface of processed palm leaves. After incising the letters on the surface of the leaf, the letters are to be inked. Charcoal powder obtained from *Trema orientales (Gadumba)* is mixed with *Dummala* (rosin) oil, which is obtained by distillation of *Vateria accminata* (*Hal Dummala*) resin. Palm leaf manuscripts are rubbed with a soft cotton cloth dipped in *Dummala* oil and a finely powdered

charcoal mixture. It is left to dry, and then the leaf surface is cleaned with finely powered *Dahaieya* (rice bran) or *kuran* (*Eleusine coracana*).

Deterioration of Palm leaf manuscripts

The palm leaf manuscripts are decayed primarily by a combination of oxidation and hydrolysis processes, which can operate either simultaneously or independently of each other. The deteriorating factors can be grouped into the following categories:

Chemical deterioration

It occurs due to the following causes:

1. Light,
2. Heat (Temperature)
3. Relative humidity
4. Darkness
5. Acidity (by natural ageing, acidic pollutants, microbial growth, etc.)
6. Environmental pollutants (acidic gases, etc.)

Physical deterioration

It occurs due to the following causes:

1. Dust and dirt
2. Bad storage and mishandling
3. Wear and tear

Biological deterioration

It occurs due to the following causes:

1. Microorganisms: fungus and bacteria
2. Macro-organisms: insects and rodents.

Others

1. Natural calamities: floods and earthquakes
2. Accidental calamity: fire and water -logging
3. Theft and vandalism

Chemical deterioration

Light

When palm leaf manuscripts are exposed to natural or artificial light or both, it falls over the palm leaf manuscript directly or indirectly and light energy is absorbed by the molecules within the manuscripts. This absorbed light energy can activate a series of chemical reactions, all of which damage the palm leaf manuscripts. The general term for this process is known as photochemical deterioration. To begin a chemical reaction within a molecule, each molecule requires a minimum amount of energy which is called activation energy. Different types of molecules have different activation energy. If the light energy from natural or artificial light or both is equal or exceeds the activation energy of a particular molecule, while molecule exists, commence sequences of chemical reactions. The energy can break bonds within the molecule and could cause a rearrangement of atoms within the molecule or the energy could be transferred to another molecule. It has been revealed that ultraviolet radiation of shorter wavelengths with greater frequency exceeds the required activation energy for many different types of molecules. Thus, they cause photochemical deterioration more quickly. Light strikes the glucoside bonds between monomers of cellulose and breaks down the linkage and forms small chain cellulose fibres. As a result, the cellulose materials lose their strength and become weak and brittle due to photochemical oxidation created by light. Light also causes the palm leaf manuscripts bleach and darken. The two processes, bleaching and darkling occur simultaneously due to the combined effect of light and heat. Darkening of palm leaf manuscripts is caused mainly by oxidation of photosensitizer like hemicellulose and lignin which are present in the palm leaf. This process is promoted by photosensitized degradation. Keto, aldehyde and carboxylic groups are formed by this type of degradation. The lignin in the palm leaf has a strong bearing on deterioration of manuscripts by light.

Heat and Temperature

The rise in temperature can enhance the rate of decay of manuscripts by increasing the rate of chemical reactions. The rate of chemical reactions doubles with a rise in temperature by 10° C. At high temperatures, the degradation of cellulose is caused by thermal oxidation. Initially, cellulose radicals are formed at an increased temperature, and this reacts with oxygen to produce hydroperoxide radicals. Secondly, the end groups of glucose units are easily oxidised to give aldehydes and carboxyl groups. It is to be noted that the presence of lignin in the palm leaf manuscripts makes them susceptible to oxidation and hydrolysis due to a rise in temperature and also yields acid derivatives. The general effect of heat on palm leaf manuscripts can be summarised as follows: it causes embrittlement of manuscripts, dries out *Dummala resin*, loss of mechanical strength, accelerates natural ageing, and influences biodeterioration.

Relative humidity

Humidity, or moisture content, in the atmosphere can be considered one of the major causes of the deterioration of palm leaf manuscripts. Hydrolysis and oxidation processes generally proceed more rapidly in the presence of moisture. Fluctuation of relative humidity causes damage to palm leaves due to expansion and contraction. It has been revealed that *Dummala* oil used for blackening palm leaf manuscripts, which are in excess, could make folios of manuscripts get attached to each other to form a solid block due to high relative humidity. A very large variation in moisture content will result in unequal dimensional changes on both sides of the folios of palm leaf manuscripts. Low

relative humidity causes brittleness due to the dehydration of cellulose chains in palm leaf manuscripts. Relative humidity lower than 40% for a long period causes cracking of folios.

Darkness

Most of the palm leaf manuscript collections stored in temple libraries have been kept in dark places. Light absorbs moisture to some extent because of its heat element. It also prevents the growth of fungi and keeps worms and insects out of their hidden places. Darkness attracts the growth of macro-organisms as well as micro-organisms, as it creates an environment suitable for breeding biological enemies and makes their hideouts. Biological organisms cause much damage to palm leaf manuscripts kept in darkness. When the relative humidity in the dark is high, dampness increases, which could lead to physical, chemical, and biological deterioration of palm leaf manuscripts.

Acidic pollutants of atmosphere

The major acidic pollutants in the atmosphere are sulphur dioxide (SO_2) and nitrogen dioxide (NO2), which are ubiquitous in city and urban air. Cellulose materials, being hygroscopic in nature, absorb these acidic gases from the atmosphere. In the presence of high moisture content and heat, sulphur dioxide (SO_2) and nitrogen dioxide (NO_2) convert to sulphuric acid (H_2SO_4) and nitric acid (HNO_3), respectively. These acids form hydrocellulose by attacking the glucoside linkages of the cellulose chain and causing cleavage in the cellulose chain. Acidic pollutants create acidity and lead to chemical deterioration.

Due to oxidation processes around the edges that have been most exposed, as well as repetitive handling, this may lead to splitting the structure around the binding holes. Hydrolysis and oxidation of cellulose in the plant matrix can contribute to horizontal breaks. Fluctuations in temperature and humidity contribute to deterioration by causing material deformations. Brittleness and loss of flexibility are mentioned as common problems in palm leaf manuscripts, leading to an increased potential for damage.

Physical deterioration

Dust and dirt:

Manuscripts could accumulate dust and dirt from the surrounding storage areas. Dust particles could lead to the abrasion of palm leaf manuscripts, which would disfigure the manuscripts and increase the surface area absorbing polluted gases. Dirt is a filthy substance that substantially damages manuscripts. It produces dark-coloured stains on manuscripts and may induce mould growth when it settles on the surface of manuscripts. In addition, dirt deposits on manuscripts may tarnish the manuscripts and make them invisible.

Bad storage and mishandling:

Wooden furniture like almirahs, racks, and showcases has been used for keeping manuscripts in storage. In the past, wooden materials were dried naturally and sufficiently until no resin was

emitted. At present, wooden materials are dried artificially and not seasoned properly. So, resin remains in the material. This resin is acidic in nature. When improperly seasoned wooden material is used to keep manuscripts in storage, the remaining resin sticks to the manuscripts, and this acidic impurity migrates from one cellulose material to another and can cause gradual discoloration and embrittlement of the manuscript.

Mishandling palm leaf manuscripts would lead to wear and tear as well as loose leaves and broken cords.

Wear and tear:

Manuscripts are subjected to wear and tear due to natural ageing with the passage of time as well as improper handling and storage. Natural ageing of manuscripts could occur due to the influence of several factors, such as improper lighting, fluctuations in temperature, high relative humidity, dust accumulation from the atmosphere, and/or their combinations, which eventually lead to wear and tear that results in physical deterioration.

Biological deterioration (biodeterioration)

As mentioned earlier, biological deterioration could occur due to micro-organisms as well as macro-organisms. Fungi develop on palm leaf manuscripts stored in damp places due to high temperatures and humidity, which will foster microbiological activity in a confined microenvironment. The metabolic products, which include various kinds of acids, play an important role in the hydrolysis of cellulose and proteinaceous materials, weaken and alter the substrate both physically and chemically, and stain the documents with coloured metabolites.

Biodeterioration occurs due to physical factors exerted by organisms as well as chemical factors. Physical damage to manuscripts is done by rodents, insects, etc. When biodeterioration occurs chemically, oxidation and reduction of materials are caused by organic acids released by the microorganisms. Biodeterioration can be broadly grouped into two categories: micro-biodeterioration caused by microorganisms and macro-biodeterioration caused by macro-organisms.

The organisms that cause damage to manuscript collections include bacteria and fungi belonging to micro-organisms and insects and rodents belonging to macro-organisms.

Fungi:

Fungi (mould) is a very common issue for palm leaf manuscripts located in warm and humid environments. They create spots along the surface of the leaves. Concerns about the safety, cost, and potential damage to manuscripts from the use of modern fungicidal and bactericidal chemicals have led to a re-examination of traditional methods for protecting palm leaves. Camphor oil, neem oil, castor oil, and citronella oil have the potential to control fungi and the growth of bacteria on the palm leaf surface. Thymol fumigation is widely used locally to overcome the fungal issue. Fungi and bacteria could be visible or not visible to the naked eye. Fungi consume cellulose, which is the main ingredient in palm leaf manuscripts, as their main source of food. Fungi (*Acrothecium*

sp., *Aspergillus* sp., *Cladosporiam* sp., *Doratomyces* sp., *Epicoccus* sp., *Mucor* sp., *Rhizopiis* sp., Semphylium sp., etc.) weaken the folios of palm leaf manuscripts.

Insect attacks

Bookworm beetles, termites, silverfish, cockroaches, and some insect larvae can perforate and rapidly destroy manuscripts. Rodents may also damage palm leaf manuscripts. Indicators of insect attacks include "the presence of pinhead-sized holes, irregularly eaten edges, irregularly eaten cavities, and the presence of larvae or adults' pests that eat the leaf. The insects can come from the environment where the manuscripts are located; sometimes the wooden covers themselves could be the source of insect infestation.

Preservation of palm leaf manuscripts:

Usage of proper raw materials:

When the leaves of Talipot are taken for preparing palm leaf manuscripts, it is necessary to take mature leaves as immature leaves tend to split near the holes of the manuscripts and the surface becomes rough with time due to the removal of the texture of the surface. *Camba* (wooden covers) need to be prepared either using "*Kumbuk*" (*Arjun; Terminalia arjuna*) or "*Kohomba*" (Neem; *Azadirachta indica*) for better protection and longevity.

Proper Storage:

Palm leaf manuscripts are to be stored in wooden cabinets or almirahs in a dust-free environment without excessive moisture (RH 55–60%) and at a proper temperature (20–25 °C). It is known that palm leaf manuscripts have been wrapped up in silk clothes for better protection from our ancestors' periods. Silk clothes in brown, red, and yellow provide protection for manuscripts from insect attacks, as these colours have insect repellent properties.

Good maintenance:

Regular checking and cleaning of manuscripts are to be done for proper maintenance of palm leaf manuscripts. At least once every six months, all palm leaf manuscripts are to be taken out of the storage cabinet or almirah and cleaned using sable hair brushes and cotton clothes. At the same time, we need to check the condition of the manuscripts by opening them and recording the condition. If there are problems such as illegible writing, sticking leaves, fungi attacks, insect attacks, weak codes, and *cambas*, immediate action must be taken for conservation. If the owner of the collection is not competent to identify the problems and do the necessary treatments, it is necessary to contact either the National Library Services Board, the Department of National Archives, or the Central Cultural Fund for necessary assistance.

Digitization

Digital cameras that can be used without damaging the manuscripts are recommended under controlled light. The use of a digital camera is more expensive than other options, such as face-up

book scanners. Once the images of palm leaf manuscripts are captured, a three-step process of cleaning and saving to various file formats takes place. First, the original raw images should be saved as a "raw master" image, which is an uncompressed Tiff. Then the raw image is to be processed "for removing dirt, patches of worms, water, noise, shadow, scratch marks, and patterns in addition to the adjustment of brightness and contrast, gamma correction, sharpening and blurring, and colours. This version should be saved as the "clean master," a compressed Tiff file. Finally, a JPEG/PDF-A image should be created for public access to the palm leaf manuscripts. Clean masters and public access copies of the palm leaf manuscripts are to be saved on properly maintained servers in two locations.

Conservation of palm leaf manuscripts

Re-blackening of palm leaf manuscripts

In cases where faded writing on the palm leaves is observed, blackening is to be done using rosin (*Dummala*) oil and *Gadumba* charcoal or lamp black. Excess rosin oil is to be removed by using either *kurahan* powder or rice husk.

Re-cording:

There is a possibility of breaking and/or weakening the cords in palm leaf manuscripts with usage and time passage. Re-cording using cotton is to be done, although it is time-consuming.

Putting a new *Camba*

When *cambas* are deteriorated, it is necessary to replace them with suitable recommended wood. The planks used to prepare *cambas* for the palm leaf manuscripts need to be seasoned properly and *cambas need* to be prepared according to the size of the palm leaf manuscript with ¼" excess on all four sides of the manuscript.

Removal of stuck folios

When the oil used for blackening within the palm leaf is melted at high temperatures and humidity, excess oil with the dirt accumulated on the folios causes them to stick together. When there are stuck folios, it is necessary to expose them to steam with pressure or dip the leaves in a suitable container with boiled water mixed with glycerine. That treatment will loosen the stuck folios of the palm leaf manuscript.

Treatment for brittleness:

The brittleness of the leaves could be observed in palm leaf manuscript collections, and it is necessary to remove the brittleness and obtain flexibility from the leaves. Various oils, such as lemongrass, rosin (*Dummala*), or *mee* oil, are currently used to reduce the brittleness of palm leaves. Also, brushing glycerine or diethyl glycol on leaves will render them flexible. Even then, when glycerine evaporates, the leaves might revert to their brittle condition.

Fumigation:

To control the insect pests, *dummala* oil, neem oil, or phosphate fumigation are used locally. When there are fungi attacks, it is necessary to clean them carefully using a soft brush without spreading spores on the palm leaves of the manuscript. After cleaning, manuscripts are kept in a specially designed fume cupboard (Figure 2). The 5g of Thymol (2-isopropyl-5-methylphenol; C10H14O) crystals are placed at the bottom of the cupboard made out of neem wood (H 6 x W 4 x D 2.5 feet). A tungsten bulb (70W) gives heat to evaporate 2-isopropyl-5-methylphenol in the vapour phase to penetrate through palm leaf manuscripts with loosening folios placed on the shelves of the cupboard. Shelves are designed to expose the manuscripts to the maximum amount of 2-isopropyl-5-methylphenol vapour in the cupboard. Palm leaf manuscripts are stored in such a cupboard with the aim of long-term preservation. Lighting the tungsten bulb for two hours per day for seven consecutive days is part of the fumigation process.

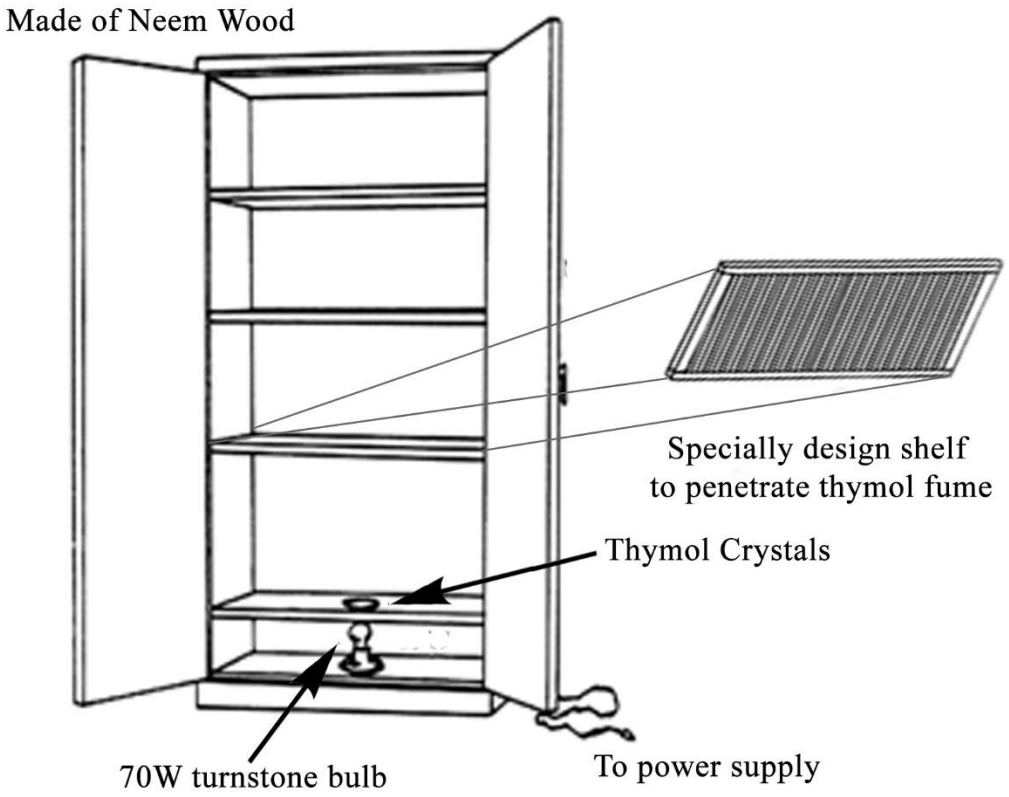

Figure: Plam leaf manuscripts storage cupboard/ Fumigation cupboard for palm leaf manuscripts

Fumigation with Phosphene gas is recommended in case of insect attacks to get rid of insects and larva. It needs to be done in a specially designed fumigation chamber with trained personnel wearing protective clothing, as a high phenol concentration will be harmful to human beings. After

fumigation, this phosphene gas is evacuated to a very high level (about 20 feet) through a chimney connected to the fumigation chamber.

Reference

Agrawal, O.P. 1984 Conservation of manuscripts and paintings of South-East Asia, Butterworths & Co.

Agrawal, O.P.1999 Preservation of arts objects and library materials, National Book Trust, India

Bhattacharya, B. 1947, "Palm Leaf Manuscripts and Their Preservation", The Indian, Archives, 1(3), 233-234

Coomaraswamy, A.K.1956 Mediaeval Sinhalese Art: a monograph on mediaeval Sinhalese arts and crafts mainly as surviving in the eighteenth century with as account of the structure of society and the status of the craftsmen, Please check Pantheon book Inc., New York

De Silva, C.M.A.1969 Production of books in Ancient Ceylon, Education in Ceylon from the sixth century BC to present day, A centenary volume part 1 Ministry of Education and Cultural Affairs, Sri Lanka

Eiserhardt W., Svenning J., Kissling D., and Balslev H., Geographical Ecology of the Palms (Arecaceae) 2011 Determinants of Diversity and Distributions Across Spatial Scales. Annals of Botany 108, no. 8

Kathpalia Y.P.1973 Conservation and Restoration of Archival materials, UNESCO Paris

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