



BIODETERIORATION IN TEXTILES: A REVIEW

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Abstract:

The article explores the agents responsible for biodeterioration causing damage to textile materials. Deterioration of textiles due to biological growth is a very serious problem in India as well as in many other countries. In the early stages of attack by the biological agents, it is easier to check the growth but once the malady has widespread, it is extremely difficult to deal with it. Organic material is a good nutrient for the micro-organisms. The paper introduces a few researches and practices by the conservation scientists and practitioners in the field of textile conservation. These contributors laid the foundation of textile conservation in museums. The paper deals with the types of fibres and their composition to comprehend the cause of decay due to deterrents. Preventive conservation is a first step of conservation and has significant role in preservation of textiles from biological growth. It includes the practices of preventive conservation to minimise remedial conservation. It enlightens the way of storing the textiles. The paper also describes the experiment done in textile museum, Bhutan conducted by Julia M. Brennan, a well known textile conservator in U.S. on the anoxic storage system to eradicate microbiological growth. The chemical and non-chemical methods of controlling pests have also been described which are being practised in other countries presently. At the end some conclusions have been drawn.

1. Introduction:

Biodeterioration is one of the most commonly encountered problems faced by museum collection. Biodeterioration can happen due to extremely high relative humidity, inadequate maintenance of storage and display areas as well as disasters for e.g. flood. Environmental conditions permit the growth of organisms. In India, for large part of the year, the temperature ranges between 25⁰C-35⁰C and the relative humidity remains higher than 70%, is very acute. These atmospheric conditions are highly conducive to the multiplication of insects and micro-organisms (Agrawal and Dhawan,1985).

Textiles can be divided into animal origin such as silk, wool or plant origin such as cotton etc. Textiles are organic in nature and therefore are liable to be attacked by moulds and bacteria, the commonest factors that promote decay especially in the country like India due to its tropical climatic conditions. It is favoured when there is a damp heat, lack of ventilation, and contact with decaying animal and vegetable matter (Plenderleith, 1956).

2. Biological Agents:

Biological Agents are divided into

- ✓ Micro-organisms such as fungus or moulds, bacteria, etc.
- ✓ Insects- moths, beetles
- ✓ Rodents- rats, mice

The biological agents that cause damage to textiles are mainly fungi and insects. Fungi are capable of secreting certain enzymes with the help of which insoluble organic substances such as starch, cellulose, lignin and protein are dissolved and absorbed.



Caterpillar of Corper Beetle

Clothes Moth

Silver Fish

Image 1: Biological Agents

Source (Kim, 2011)

Moulds are minute fungi which grow on the surface of textiles. A mouldy textile is often acidic, the acidity arising from the mould growth. Mould often leaves behind a mass of black or grey specks which are thousands of tiny fibrils inextricably mixed with those of the textile fibres (Landi, 1998). Fungal hyphae are the destructive phase of mould. Mould rapidly destroys fibers and makes holes. (Kim, 2011)

For bacteria to survive, water is needed in the form of continuous very high relative humidity (RH) and high moisture content in the substrate, which includes environments that are under water. Microorganisms

digest, stain, weaken, convey moisture (e.g. "dry rot" fungi), and attract insect pests by modifying and augmenting the nutritive value of an object.

Insects are normally present in the natural environment and find their way into collections by means of infected object or through trade and travel (strang & kigawa, n.d.). Textile pests are also known as protein feeders. Textile or fabric pests are among the very few animals that can digest keratin, the primary protein found in animal hair and horn or chitin which forms insect bodies. Fabric pests can be divided into three different groups these are carpet beetles, hide beetles and clothes moths. Carpet beetles and hide beetles are from family of Dermestidae.

The four most commonly encountered species of carpet beetles are the black carpet beetle, varied carpet beetle, furniture carpet beetle and common carpet beetle. The larval stage of all carpet beetle infestation results in feeding damage and cast larval skins. Caterpillars of the carpet beetle nibble away wool fabrics (Kim, 2011). Carpet beetles also attack silk textiles. This kind of pest causes damage by eating and soiling the textiles.

Clothes moth lay eggs on soiled wool or silk and caterpillars hatch out of eggs and nibble away textiles and leave their excrement behind (Kim, 2011). Textiles of animal origin are susceptible to insect damage more than plant origin textiles. Sizing, starch, gelatin, binding media, for pigments, soils, and stains are also attractive to pests (NPS Museum handbook, 2002).

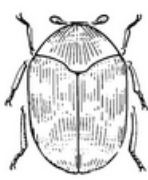

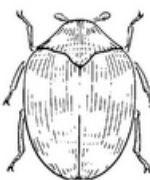



	Varied Carpet Beetle		Furniture Carpet Beetle		Black Carpet Beetle	
						
	adult	larva	adult	larva	adult	larva
number of eggs laid	40		60		90	
days before eggs hatch	10-20		9-16		6-16	
number days for larval stage	220-630		70-94		166-330	
days for pupation	10-13		14-17		8-14	
weeks as an adult	female 2-6; male 2-4		4-8		4-8	

Figure 1: Lifecycle of three species of carpet beetle

Source from <http://www.ipm.ucdavis.edu/pmg/pestnotes/pn7436.html>



Image 2: The beetles causing damage to woollen artefact

Source: <http://www.slayallpest.com>



Image 3: Shows adult, larvae and pupal case

Source: www.the-piedpiper.co.uk

Cotton and linen are more susceptible to micro-organisms than the insects. Dr. S.M. Nair & Dr. Shashi Dhawan identified species of cloth (Lepidoptera). It survives on proteinaceous material such as woollens and dermestid beetles that attack woollens. The most common pest in India is the case bearing cloth moth, *Tinea pellionella* which destroys mainly woolen fabrics (Bisht, 2010). According to S.M. Nair, it has been revealed that this species of clothes moth is a serious menace, particularly to woollen textiles and carpets. Case bearer

and webbing clothes moth are attracted to high protein material including wool, silk, hair, fur, feathers and skins.

Silverfish and firebrats prefer starchy foods and will eat fabrics, paper and sizing. They are omnivorous and will eat protein materials as well as cellulose.

For rodents, snap traps may be effective, and if needed, a professional exterminator should be called. Poison baited traps should be avoided, as the rodent could die somewhere inaccessible, and provide a breeding ground for further pests. (www.wow.com, 2017)

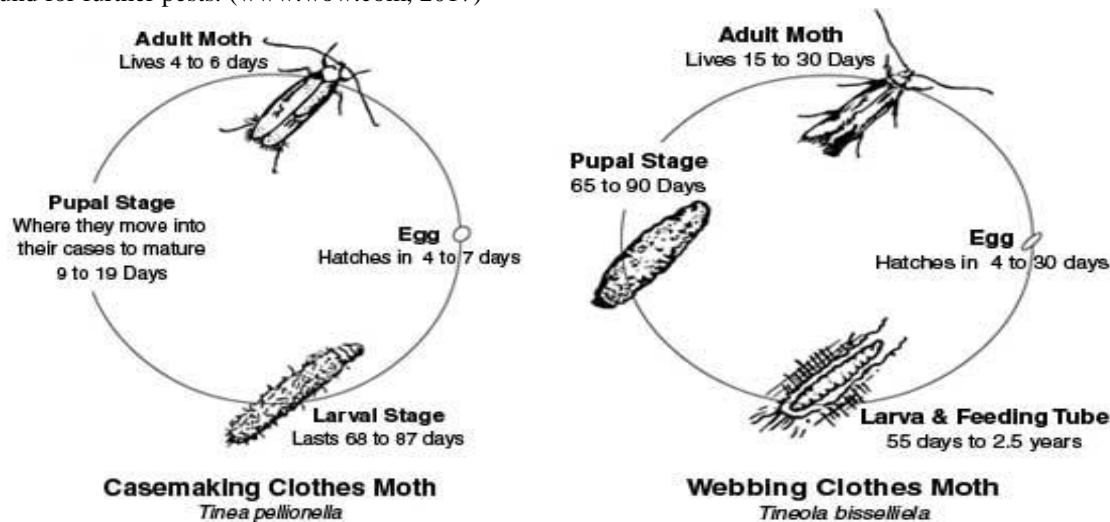


Figure 2: Life cycle of the case making clothes moth and webbing cloth moth
Source: www.mothkiller.co.uk

3. Causes of Decay and the Biological Damages:

Microbial growth on a textile causes loss of strength and elongation, discolouration and changes in appearance. They follow changes in oxidation state, degree of polymerization and breakdown of molecular structure. There are two main ways of textile protection - Control of environmental physical conditions and treatments with biocides. Discoloration may result from a chemical reaction, e.g. a by-product of an invading microorganism metabolism with a dye, or as a result of pigmented substances excreted by microorganisms. (Kotowa, 2004)

Bio deterioration caused to textiles can be also be seen in the form of particulates, weak seam, holes, embrittlement, shrinkage, drying out, breakdown of adhesives, development of odour, disfigurement and powder formation. Silk and wool are more susceptible to moisture damage than cotton or linen. RH required should be between 30% -50%. (Read, 1994).

In damp and dirty conditions all the organisms which remain inert in dry condition, will flourish, sustained and nourished on the same textile by weakening it and soiling it with excrement (Landi, 1998). Their frequent cause of decay are unchecked new acquisitions/loans, poor cleaning, attractants and food sources used in displays (e.g. plants and display props), damp (high relative humidity) etc.

4. The Investigations:

According to Kotowa (2004) degradation of cellulosic fibres largely depends on the degree of crystallinity of the cellulose in question, since amorphous cellulose is more easily attacked than crystalline cellulose, but other characteristics such as the degree of polymerization are also important. Moreover the degree of orientation, i.e. the angle at which fibrils are positioned in relation to the long axis of the fibre, affects the biodeterioration process as well. Cellulose fibres of a high degree of orientation are less susceptible to microbial attack. Investigations of deterioration of cotton and jute fibres showed that cuticle layer is subject to a digestion process first. In the case of bacteria the attack proceeds from the fibre surface towards the inside. Whereas fungi, after the removal of the cuticle layer, penetrate through a secondary wall into a lumen where they grow. On cotton fabrics the infection with fungi starts at the cut-off cotton fibres. Spores reach a fibre lumen via cracks in the wall, and then germinating hyphae grow into and form mycelium within the lumen. The mycelium grows from the inside towards the fibre wall, secretes cellulolytic enzymes that cause its destruction, and then begins to sporulate on the outer surface of the fibre (Basu and Ghose, 1962; Desai and Pandey, 1971). The species that degrade cellulose belong mainly to the genera *Cytophaga*, *cellulomonas*, *Cellvibrio*, *Bacillus*, *Clostridium* and *Sporocytophaga*.

As far as the wool is concerned, biodeterioration is caused both by bacteria and fungi. Keratin is degraded to a higher degree by fungi, especially those belonging to the genera *Microsporium*, *Trichophyton*, *Fusarium*, *Rhizopus*, *Chaetomium*, *Aspergillus* and *Penicillium*. Among Keratinolytic bacteria, species in the

genera *Bacillus* (*B. mesentericus*, *B. subtilis*, *B. cereus* and *B. mycoides*) and *Pseudomonas*, and some actinomycetes, e.g. *Streptomyces, fradiae* (Agarwal and Puvathingal, 1969) are particularly noteworthy.

Degradation of wool that is caused by fungi is hard to detect and is not noticed until degradation is well advanced. The fungi that grow on a fibre branch, causes mechanical defects. The first symptoms of their presence and growth are odour and staining in different colours. Extracellular proteolytic enzymes damage cortical cells and result in decreased fibre strength. In case of vigorous colonization the fibre breaks.

5. Insect Pest Monitoring (IPM):

An emphasis on IPM must be given to control problems of bio deterioration in a museum. Every museum must set some points of action in this matter. According to Rendell (2010), the core of an IPM is a system of good maintenance and housekeeping, a safe, practical and cost effective method of preventing collections being damaged by pests.

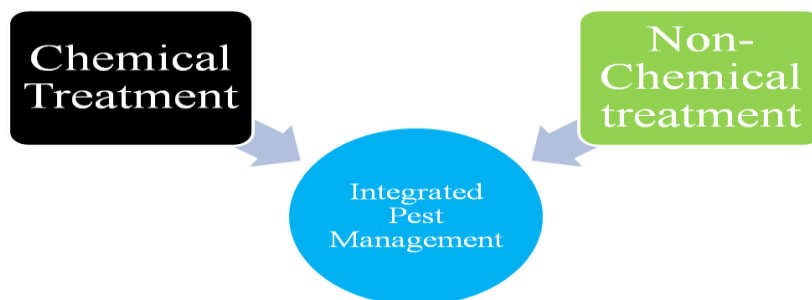


Figure 3: Two ways for treating pests

5.1 Chemical Methods: The Insecticidal Treatment

If the environment is not maintained within the tolerable limit, problems of bio deterioration are expected. Objects received from other institutions may be infected and spread infection in the gallery or a store. In such cases, fumigation is the best alternate. Fumigation and appropriate management of the environment are needed to protect textiles from vermin and microbes.

Museum objects prior to display should be free from insects and their larvae. Textiles that are normally immune from insect attack should be isolated from vulnerable materials (swarnakamal, 1975). While exhibiting in showcases, various insect repellents like camphor, sulphur-free naphthalene balls and para-dichlorobenzene may be used. A mixture of chloroform, creosote and naphthalene (C.C.N. in equal quantity) known as British Museum Mixture is used as a repellent in display and storage of dry preserved zoological specimens. Nair (1972) developed a formula which contains paradichlorobenzene, benzene, cresote (PBC) in equal quantities. It is also an effective repellent, for dermestid beetles, cockroaches, clothes moth, termites (Agarwal and Dhawan, 1985). Swarnakamal (1975) suggested the following formula to cure the fungus as well as insect attack on textile objects:

Naphthalene flake	...	100 gms
Sodium Pentachlorophenate	...	30 gms
Pyrethrum extract 2 per cent	...	20 c.c
Ethyl Alcohol	...	1000 c.c

This recipe was tested in a conservation laboratory of the Baroda Museum and found satisfactory. Author also reported that this mixture can also be sprayed on textiles as it does not cause stains on the specimens.

White tissue paper impregnated with lindane, or D.D.V.P., etc. is useful if piles of textiles are to be protected. It should be inserted between individual pieces of fabrics. As the insecticidal life of this paper is very short, periodical renewal will be necessary after a few months. Use of resistant wood for building materials and cupboards, etc. should be used. It is preferred that packing boxes, cupboards, frames for transit may be of deodar (*Cedrus deodara*), teak (*tectona grandis*), Indian rose wood (*Delbergia latifolia* Roxb) which have insect repellent properties. Cracks in the cupboards and display cases may be sealed with a mixture of paraffin wax and bees wax and powdered insecticides like D.D.T., boric acid or pyrethrum, etc. dusted on them regularly.

There are two forms of mothballs: Naphthalene which acts as a repellent. Paradichlorobenzene (PDB) which acts as a larvacide. Both are known animal carcinogens and possible human carcinogens. For safety, susceptible garments and furnishings stored with small quantities (about 3 1/2 oz. of PDB for every 21 cubic feet of container) must be sealed against out-gassing: use footlockers, galvanized tins or other containers from which fumes cannot leach. Odours are a potential harm to humans. To remove the smell safely, air garments out

of doors: heat and breeze will evaporate the odour. Fumigation will kill adults and larvae; it should kill all eggs but a second fumigation after a 20-30 day incubation period is prudent for a severely infested object.

Vacuuming or brushing is the suggested first step to removing eggs and residues from textiles. However, the brush or nozzle of the vacuum must be washed (with warm water and dishwashing liquid) and dried between objects or object groups so as not to spread the infestation.(www.si.edu, 2006)

The uses of insecticides, chemicals, toxic gases, fumigants and repellents have been observed being practiced in India in most of the museums. Then of course the fumes from these chemicals have to be released into the atmosphere contributing to the “Greenhouse Effect” and poisoning the air we all breathe. Not really a very responsible approach from a group of professionals charged with the responsibility of maintaining a responsible ethical public image. Health risks associated with the above gases are profound. These include Digestive disorders, headaches, sore eyes, sore throats, nausea, dizziness, allergies, asthma etc. (www.hampshire-antique-restoration.co.uk). Therefore, there is a need for the non-chemical approach

5.2 Preventive Measures for Avoiding Pests:

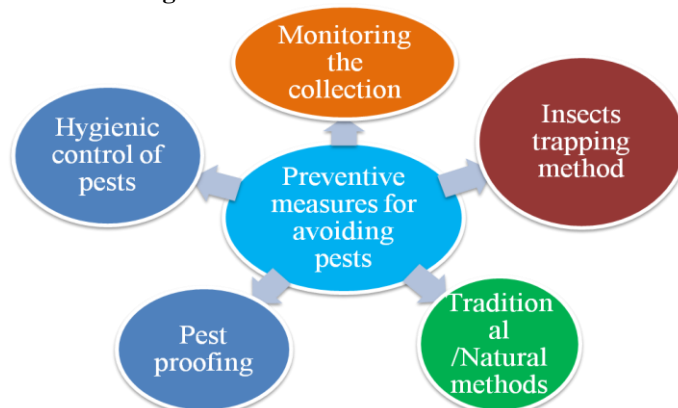


Figure 4: The types of preventive methods

5.2.1 Hygienic Control of Pests:

- ✓ Keep the area clean
- ✓ Throw away all the clutter into the bins.
- ✓ Regular monitoring
- ✓ Good housekeeping
- ✓ Food shouldn't be allowed in the museum galleries

5.2.2 Monitoring the Collections in Storage and Display:

- ✓ The micro climatic control inside the galleries.
- ✓ Installation of Temperature and Relative Humidity monitors in museums.
- ✓ Usage of Silica Gel, Heating Ventilation and Air Conditioning, dehumidifiers, humidifiers and hygro thermographs in museums.
- ✓ Monitoring the amount of light in the gallery – both inside and outside the showcases. The hand-held sensor is really useful for doing spot checks (www.spri.cam.ac.uk, 2014)
- ✓ Blue wool standard fading cards may also be used in the museums display.
- ✓ Light Shields, curtains and closed doors to protect the textiles from direct light.



Image 4: This kind of hand-held light meter can be used in the galleries
 Source: www.spri.cam.ac.uk



Image 5: The data monitoring systems or data loggers installed in the galleries.
 Source: www.testo.com

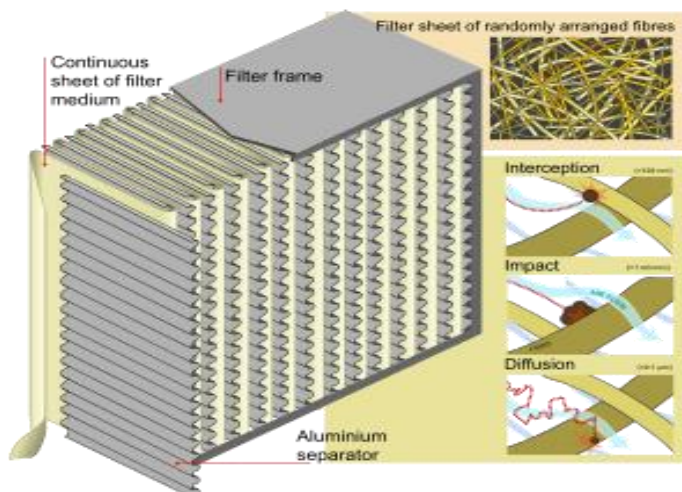


Image 6: HEPA (High efficiency particulate air) filter. Widely used in museums and private art galleries
Source:
<https://en.wikipedia.org/wiki/hepa>



Image 7: These cabinets recreate the microclimate needed for storing fragile items and valuable collections (ventilation slots, trays and windows on the doors). The drawers should also be lined by using Soft, un buffered and neutral PH tissues/paper. Neutral PH tissue has a pH from 7-7.5 and it does not contains any acid.
Image Source: <http://www.montel.com>

5.2.3 Traditional Practices for the Control of Insect:

According to Perumal (1996) citronella is a common ingredient in insect repellents sold over the counter at the chemist. Turmeric is also used as an insect repellent. Neem leaves, sandalwood powder, cloves and peppercorns are packed in sachets and provide a fragrant and effective repellent, together with sweet flag (Jasti Madhu) and camphor. These sachets are replenished every three months with the ratio of the contents altered slightly each time to prevent insects gaining immunity.

5.2.4 Pest-Proofing:

One of the best ways to limit unwanted intrusions by insects, rodents, birds, squirrels and other pests is to deny them entry, a procedure known as pest proofing. A building's integrity directly affects the pest movement. It should be ensured that all holes, gaps and voids are closed and that all possible wall, floor, and roof penetrations are appropriately sealed. This is the number one method for excluding pests from museum buildings (www.museumpests.net, 2014). Install door sweeps or thresholds at the base of all exterior entry doors. While lying on the floor, check for light filtering under doors. Pay particular attention to the bottom corners as this is often where rodents and insects enter. Gaps under sliding glass doors can be sealed by lining the bottom track with 1/2 to 3/4 inch-wide foam weather stripping. Seal utility openings where pipes and wires enter the foundation and siding. Caulk cracks around windows, doors, fascia boards, etc. Screen windows, air ducts and chimneys to prevent the entry of flying insects. Repair gaps and tears in window and door screens. The only way to deny entry to these tiny insects is to keep windows closed during periods of adult emergence. (<https://entomology.ca.uky.edu>)

5.2.5 Traps and Lures:

A variety of traps and lures mentioned below are also available (www.spnhc.org, 2010):

Sticky Sheet Traps ---- for flying insects

Monitoring Traps ---- for crawling insects

Pheromone Lures (e.g. Storgard) --- Targeted for the specific species, e.g. cloth moth, cigarette beetle.

All museum spaces should be regularly set with traps to detect the presence of pests, hopefully before their numbers are a problem. Window traps placed along the skirting boards (the usual insect run) can be very effective, cheap and long lasting. By carefully noting which traps have caught what insects, the source of the problem can be identified (Read, 1994).



Image 8: Front view of a pheromone blunder trap
(<http://museumstjohn.org.uk>)

5.3 Pest Control Treatments without Chemicals for the Pest Infested Specimens:

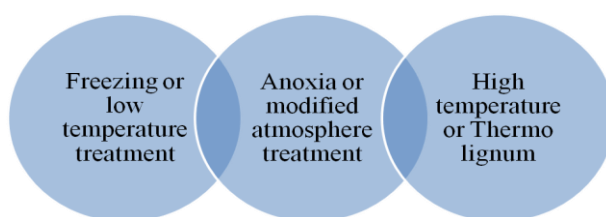


Figure 5: Non-chemical treatment for textiles

5.3.1 Freeze Drying or Low Temperature Treatment:

According to Jayaraj (2005) freeze drying is a very good method of treating the organic objects to save them from the biological agents. The organic objects are covered with polythene covers and deep-frozen at a temperature of about -22°C . This method keeps off all the biological agents from the museum and archaeological objects of organic nature. A survey of the pest control literature indicates an exposure of 6-10 days at -20°C will be sufficient for most museum pests (Strang 1992). It is recommended to avoid this treatment over very fragile textiles.

5.3.2 Anoxia Treatment or Controlled Atmosphere Treatment:

Brennan (2008) undertook an experimental research for the anoxic storage for textile collections in Bhutan. The goal of the project was simple – to create constant and reduced oxygen environments. This was done by making a sealed environment and displacing the air or oxygen in it with an inert gas. If the level of oxygen is maintained at less than 0.05%, then pests cannot survive, and most other aerobic biological growth is destroyed or halted. Oxygen scavengers or absorbers can be left inside the sealed system to ensure that any additional oxygen is consumed.

The implementation of anoxic microenvironments for long term textile storage in Bhutan was the highly sophisticated case for the storage of protein-based textiles, protecting them from insects, mould and airborne pollutants in a country where climate control is impossible to achieve. More than four hundred textiles were safely stored. Non-toxic Pest Control in museums is another method wherein low nitrogen atmosphere is created to the objects, which kills the insects and also saves the objects of organic nature.

5.3.3 Heat Treatment: Thermo lignum

Heating is quite a historical treatment for the eradication of pests. A short exposure of 55°C (130°F) is sufficient for eradication of all life stages of insects (Strang, 1992). Thermo-lignum® treatment is a proprietary method of eliminating insects with heat using a climate controlled heating chamber which controls moisture content during heating and cooling. Thermo-Lignum's treatment chamber controls its environment using very sensitive and responsive temperature and Humidity sensors. The Thermo-Lignum technique was developed in Germany and perfected between 1984 and 1989. A patent was granted in 1994 and a UK company formed. The operating system of thermo-lignum works on the principle stated as "The moisture is introduced in the heating cycle and removed in the cooling cycle" (Pining, 1994)

Warm air Treatment is being Used Routinely and the Insect Threats to the Museum Collections in U.K have Decreased:

To summarize there seem to have a 100% effective method of killing all insects living in any form of organic material,

- ✓ WITHOUT; Using any toxic chemicals,

- ✓ WITHOUT; imposing any health risks.
- ✓ WITHOUT; contributing to an environmental problem or creating a new one.
- ✓ WITHOUT; undermining the structural integrity of the object being treated
- ✓ Also WITHOUT affecting the surface whether inlaid polished or gilded.

The existence of this treatment is not just another alternative available to us. It is the only ethical safe and sensible choice for the next generation of Conservator/restorers.(www.hampshire-antique-restoration.co.uk). While treating textiles one needs to be cautious while maintaining the temperature as it should not harm the fibres and fragile textiles.



Image 9: The Thermo lignum Chamber
Source: www.thermolignum.com

6. Conclusion:

A good preventive conservation program minimizes the need for conservation treatment. Maintaining the appropriate temperature and Humidity is the primary concern of preventing damage. Therefore, preventive action should be taken to regularly monitor the traps, inspect all new acquisitions, isolate infested item immediately, keep store cool, avoid damp and humid areas, regular and thorough cleaning of stores and display areas, label and regularly inspect vulnerable items. Never use moth balls, moth crystals, or pesticide sprays, which can all damage fibers and dyes. Regular cleanliness and good housekeeping should be the best preventive practices.. An additional concern is the toxicity to humans and pets of the insecticide poisons that remains on the textile. Museums no longer recommend the use of mothproofing agents as many of them contain arsenic.(www.statemuseum.arizona.edu., 2012). Preservation encompasses all actions taken to prolong the life of an object. Preventive care is always the preferable way of ensuring protection of museum collections whereas curative conservation treatment carries inherent risk and is generally more resourceful and time intensive.

7. References:

1. Agarwal O.P., and Dhawan Shashi., 1985, Technical Note. 2, Control of Bio deterioration in Museums, NRLC, Lucknow, India, pg 1
2. Agarwal, P.N., Puvathingal, J.M., 1969. Microbiological deterioration of woollen materials. Textile Research Journal 39, 38.
3. Bisht, A.S., 2010, Conservation of Textiles, Bone and Ivory, Agam Kala Prakashan, New Delhi, pg 41, 65
4. Brennan, J.M. 2008. Simple anoxic storage for textile collections in Bhutan. In J. Bridgland (ed.), Preprints, ICOM-CC, 2008, New Delhi (pp.976-981). New Delhi: Allied.
5. Desai, A.J., Pandey, S.N., 1971. Microbial degradation of cellulosic textiles. Journal of Scientific and Industrial Research 30, 598.
6. D. Pinniger, 1994, Insect pests in Museums, 3rd ed., Archetype book
7. Kim, Sunyoung, 2011, Damage to & Conservation Treatment of Textile Cultural Properties, Conservation of paper and textiles, National research institute of cultural heritage, Korea. pp. 112-131.
8. Kotowa, Szostak Jadwiga, 2004, Biodeterioration of textiles, International Biodeterioration and Biodegradation 53, 165-170. doi: 10.1016/S0964-8305(03)00090-8
9. Landi Sheila, 1998, The Textile Conservator's Manual, Butterworth Heinemann, Oxford, pg 18.
10. National Park Service, 2002, "Appendix K: Curatorial Care of Textile Objects", Museum Handbook, Part 1, p 12.
11. Perumal, P., 1996, Traditional practices for the control of insects in India, Thanjavur, India.
12. Plenderleith H.J., 1956, The conservation of antiquities and works of art Treatment, repair and restoration, Oxford university press, New York Toronto, pg 93-115,

13. Rendell, Caroline, 2010, Preventive conservation solutions for Textile Collections, Textile conservation: Advances in Practice, eds. Lennard Frances & Ewer Patricia, Elsevier Ltd., U.K. pg 210, 213
14. Read Fergus, 1994, "Preventative Conservation", North West Museum Service, Meaco(U.K.) Limited, Meaco House, Parkland.
15. Strang,T., & Kigawa Rika, n.d., "Combatting Pests of Cultural Property, CCI Technical Bulletin No. 29, Canadian Conservation Institute, Ottawa.
16. Strang, T. 1992 "A Review of Published Temperatures for the Control of Pest Insects in Museums." Collection Forum 8, no. 2: pp 41-67.
17. Swarnakamal, 1975, Protection and conservation of museum collection, Museum and picture Gallery Baroda, The Department of Museum, Gujarat, pg 67
18. Jeyaraj, V., 2005, Museology Heritage Management, Director of museums, Govt. Museum, Chennai, pp. 186-190.
19. www.si.edu. (2006). Insects and Wool textiles. Available at: https://www.si.edu/mci/English/learn_more/taking_care/insects.html [Accessed 2 Sep 2017].
20. www.statemuseum.arizona.edu. (2012). Some comments on the care of Navajo Textiles.[online] available at http://www.statemuseum.arizona.edu/preserv/navajo_txtl.shtml [Accessed 2 Jan 2014]
21. www.hampshire-antique-restoration.co.uk. The Thermo-Lignum Process [online] available at: www.hampshire-antique-restoration.co.uk/P%20d%20f/the%20thermo.pdf [Accessed 3 Sep. 2017].
22. www.spnhc.org. (2010). Supplies and materials for museum collection (Canada). [online] Available at http://www.spnhc.org/media/assets/SPNHC_CND_Supplies.pdf [Accessed 25 Aug. 2017].
23. www.wow.com. (2017). Conservation and restoration of textiles. [online] Available at: http://en.wikipedia.org/wiki/conservation_restoration_of_textiles [Accessed 7 Oct. 2016].
24. museumpests.net. (2014). Building envelop tip sheet. [online] Available at: museumpests.net/wp-content/uploads/2014/03/building-envelop.pdf [Accessed 12 Aug. 2017].
25. www.entomolgy.ca.uky.edu. (2001). Clothes Moths. [online] Available at: <https://entomology.ca.uky.edu/ef609> [Accessed 4 Sep 2017].
26. Christina. (2014). Light relief, Part 1: Keeping an eye on things. [online] Available at: www.spri.cam.ac.uk/museum/news/conservation/2014/09/15/light-relief-part-1-keeping-an-eye-on-things/ [Accessed 6 Sept 2017].