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A CASE STUDY :

A study on techniques of evaluating museum environment and textile artifacts

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SUMMARY : In the past few years, museums all over the globe have started analysing contemporary approaches for integrating interactive exhibits in their premises. The stimulus has sparked the need for improved conservation techniques used for textile artifacts in any museum. Since textiles are one of the most fragile articles, these need to be attended before the spoilage starts. Fortunately, with advancements in technological field, there are a number of laboratory techniques available at this moment to identify and check the deterioration for the necessary action to be taken. The present paper not only explores various techniques and equipments used in this field while also throws light on their specific uses and applications in examining textile artifacts.

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KEY WORDS :
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BACKGROUND AND OBJECTIVES

A museum is an institution that cares for (conserves) a collection of artifacts and other objects of scientific, artistic, cultural, or historical importance and makes them available for public viewing through exhibits that may be permanent or temporary. The word "museum" comes from the Latin word, and is pluralized as "museums." It is originally from the Greek (Mousein), which denotes a place or temple dedicated to the Muses (the patron divinities in Greek mythology of the arts) and hence a building set apart for study and the arts (Singh *et al.*, 2014). The record of ancient and medieval Indian textiles exists mostly in literature and sculpture and a few fragments survive from much later periods (Wilson, 1979). Within the museum's empire of sight, objects are colonized by the gaze (Edwards *et al.*, 2006). Textiles produced since antiquity convey the history the culture and tradition of the past. A number of museums and individuals own immense wealth of rare textile artifacts collected or inherited over a period of time (Manek, 2012). Most of the extant textiles are dated after the seventeenth century, because the monsoon climate has been very destructive to early specimens (Wilson, 1979). Cultural heritage contains a large number of precious proteinaceous specimens, such as wool and silk textiles, leather objects, paper, paint, coatings, binders and associated adhesives etc (Araki and Moini, 2011). The sensory values of an artifact do not reside in the artifact alone but in its social use and environmental context (Edwards *et al.*, 2006). In an ideal world, conserved antiquities would be in an unchanged state for ever, however, most materials undergo slow chemical and physical changes (Blackshaw and Daniels, 1979). Textiles are among the world's most feeble antiquities and hard to preserve even under the best of conditions. There is a dire need that these surviving and rare pieces of textile artifacts be preserved (Blackshaw and Daniels, 1979). To minimize the degradation of and to preserve these artifacts, it is desirable to understand the fundamental factors that cause their degradation, to identify the deterioration markers that determine their degradation stage and their age, and to use technologies that can provide this information rapidly while consuming a minimal amount of sample (Araki and Moini, 2011).

Objective:

In the present paper, authors have intended to throw light on devaluation elements, touchstones for levels of decline and methods for utilization of automation that can obtain the relavent degradation report in the shortest duration.

Types of damages and degradation:

The rate of fading and degradation of textiles and other organic materials on display is influenced by the intensity and wavelength distribution of the light source to which they are exposed and by other environmental factors (Crews and Reagon, 1987). Below are the major reasons why materials change their properties.

Physical changes:

Physical damages are the most immediately apparent, frequent and avoidable of all the three categories of damages. These changes include changes in the degree or type of crystalization or in state of the original artifact.

Chemical changes:

Chemical changes occur in relatively unstable complex molecules present in organic materials. Chemical changes may also occur when reactive gases or vapours are present. Oxygen and water from the air and pollutant gases may all contribute towards degradation of materials. Hydrogen sulphide (H_2S) is responsible for the tarnishing of silver and or polished copper and the blackening of lead pigments. Sulphur dioxide is harmful to paper, leather and some types of stone. Organic acids, mainly acetic acid, are catalysts for the corrosion of lead. Some materials release gases and vapours when they are used in museum conditions. In the confined atmosphere of showcases, cupboards and packing cases ventilation is slow and significant concentrations of

Table 1 : Damage caused by physical, chemical and biological degradation

Sr. No.	Category of damage	Type of damage
1.	Physical damage	Permanent creases
		Permanent folds
		Raveling or fraying of yarns
		Water logged stains
		Abraided areas
		Tears at folds
		Breakage of yarns
2.	Chemical damage	Colour fading
		Yellowing
		Zari tarnish
		Holes due to ageing
3.	Biological damage	Insect holes
		Brown stains

(Manek, 2012)

pollutants may be found.

Biological changes:

Biological degradation includes spoilage and staining by insects, moths, beetles, cockroaches, termites, fungi, bacteria etc. Below table includes damage caused by physical, chemical and biological degradation (Table 1).

Consequently, it is part of conservator's task to prevent deterioration caused by an unwise choice of materials. Recognition of suitable materials requires that tests are available for assessing their long-term properties and understanding of the basic mechanisms of deterioration.

Monitoring the museum environment:

Temperature, humidity, light, pollutants and pests can cause severe damage to museum collections. The first step in preventing this is to find out what the actual levels of these factors are and this is done by monitoring them.

Psychrometer for monitoring temperature and humidity:

Humidity affects many properties of air, and of materials in contact with air. Water vapour is key agent in both weather and climate and it is an important atmospheric greenhouse gas. A huge variety of manufacturing, storage and testing process are humidity critical (Bell, 2011). Temperature and humidity are closely related and are, therefore, often measured with one instrument. Temperature is expressed in degrees Celsius (°C). Relative humidity is expressed as a percentage (% RH). A commonly used instrument is the aspirated hygrometer (also called psychrometer). Two thermometers, a wet bulb and a dry bulb, are used to measure the temperature and calculate the humidity. Although the measurement is very accurate, human error during use and calculation can easily give rise to misleading results. Other instruments and aids are thermohygrographs, dial hygrometers, electronic hygrometers and humidity indicator cards.

Light meter for light and ultraviolet radiation:

The intensity of visible light is measured with a light meter. It measures the light in lux: one lux is one light unit (lumen) per square metre. The light meter, which contains a photosensitive cell, must be able to match the way the human eye perceives light (the luminous efficiency must be similar). It should measure the light coming in from all directions without reflecting any of it. Ultraviolet radiation is measured with a UV monitor and is usually expressed in microwatts per lumen (µW/lm) (Anonymous, 2003). This indicates the amount of UV radiation within one unit of light wherever it falls in the room 5 to 10 footcandles (approx. 50 to 100 lux) is currently considered to be the maximum allowable light level for very sensitive materials, such as prints, drawings, watercolors, dyed fabrics, manuscripts and botanical specimens (McCormick,1990).

Sample testing for presence of pollutants:

There is no simple monitoring device for accurately identifying and measuring the level of pollutants. Polished lead, silver or copper strips, which corrode when exposed to polluted air, can be used to identify the presence of substances that are harmful to these metals. Another way of checking materials for the emission of harmful pollutants is to have a sample of the material tested.

Trap monitoring for pests:

Regular inspections of window sills, dark corners, cupboards and drawers are effective way of revealing an infestation before it is late. However, insects often only come out at night and may not be noticed until damage has been done. Insect traps can be used to check nocturnal activity. The sticky base of these small, inexpensive cardboard traps holds any insect that walks over it. It should be noted that they do not attract or kill insects, but are purely for monitoring purposes.

Electronic monitoring and data logging systems:

With technological advances, electronic data logging and computer-based monitoring systems are getting popular and affordable. Small equipments like electronic sensors for temperature, humidity, light, UV radiation and flooding can be positioned throughout the museum in display areas, stores and display cases. Readings can be taken for set intervals, and data can be transmitted directly to computer. The data can be assembled later to be analyzed in forms of graphs, charts etc. to summarize the findings (Anonymous, 2003).

Lab tests for investigation:

A number of studies have been carried out in the past in order to investigate the effect of time, temperature, light and other conditions on the historic textiles and artifacts. Major test methods used for such investigations are:

Apart form physical examination of the textiles and historical researches, a few laboratory testing techniques are also used to diagnose the causes and effect of envirnmental conditions on the museum artifacts. Stereomicroscopy and polarised light microscopy, scanning electron microscopy –energy dispersive X-ray analysis, ion chromatography, Raman spectroscopy, attenuated total reflection infrared spectroscopy, fluorescence spectroscopy and infrared photography are major laboratory tests used for such studies.

Analysis of the effect of D_5 on textile substrates employed attenuated total reflectance- fourier transform infrared (ATR-FTIR) spectroscopy, tensile strength tests.

Examination and photo-documentation of textiles using visible and invisible radiation:

Visible light :

Most conservation work and examination procedures are done under normal light conditions, in other words: daylight, incandescent or fluorescent light with the unaided eye. Ambient or directed light sources are generally the first means of looking at and documenting an object to assess overall condition and construction. Transmitted light, or light that is projected behind the object, is helpful in observing specific condition problems, such as abrasion, slits, and loss. Raking light, which is light cast across the object, can detect surface anomalies such as old crease lines, impressions from missing embellishments, or perforations from previous stitching (Mailand, 2000). Near-infrared observations have been made from ground based observatories since the 1960’s.

Infrared spectroscopy (FTIR) allows one to determine the constitution of wrappings of Egyptian mummies (Maksoud and Rahman, 2013).

Simple mono or stereo-microscope:

To analyze a textile’s weave structure, embroidery stitches, and the twist and ply of individual yam the unaided eye is possible, but more information is discernible through a simple mono or stereo-microscope with a 10 x to 20 x magnification and directed light.

Monocular instrument:

To determine an accurate thread, mesh, or knot count of a textile a monocular instrument with an interchangeable 7x or 14 x lens and touch control counter is used.

Photo-documentation:

Along with written records, photographic procedures are indispensable aids in documenting the physical components and condition of a textile. Photographic instrumentation can document what the eye can see under normal light and with appropriate filtration can record non-visible radiation. Most conservators use 35 mm colour slides, or work with professional photographers to obtain multiple colours 309 transparencies or black and white prints (Mailand, 2000).

Ultra-violet fluorescence:

The degree to which textiles absorb ultraviolet, as well as the amount of visible fluorescence they produce, is of interest to the conservator. By viewing a textile under ultraviolet light a conservator can discern irregularities on the surface, such as dyes, fabric finishes, repairs, previous treatments such as, bleaching, adhesives, or cleaning with optical whiteners or brighteners. A common “black light” fluorescent tube can detect such anomalies, and a camera which is fitted with a filter that absorbs other wavelengths can record visible fluorescence (Mailand, 2000).

X-Radiography:

X-rays are capable of penetrating substances that appear opaque to the unaided eye. Exposing film to x-rays as they pass through an object produces an x-radiograph. The different densities of the different materials, and their ability to absorb, or transmit the x-rays produces an image on the film. This method has proved useful in examining multi-layered textiles without physically separating and removing original material for analysis, and thus disrupts the historical integrity of the piece (Mailand, 2000).

The resulting X-radiographs allow conservators to look at features hidden below an object’s surface. The different attenuation values can also be used to distinguish between materials which look the same under visible light but have different X-ray absorptions (Anonymous, 2015a).

Computed tomography (CT) scanning :

Computed tomography is an effective technique for examination of interior parts of museum objects in 3 dimensions. A regular X-radiograph can provide image of object onto a flat plane (the film, phosphor plate, or digital detector). In some cases, X-radiographs become difficult to interpret, particularly when the object is made of many pieces with similar x-ray attenuation or when features in the object are overlapping. Computed tomography takes a series of X-radiographs from different angles around an object and then mathematically reconstructs the volume which would have caused this series of projections to appear. Medical CT scanners provide a convenient way of CT scanning many of the objects from the Anthropology collections. The results of CT scanning are usually delivered as a series of grayscale pictures of evenly spaced 'slices' through the object. The lighter grays represent more attenuating material and the darker grays represent less attenuating material. The stack of slices can be rendered in three dimensions and areas with similar X-ray attenuation can be segmented out and/or false-colored for further study (Anonymous, 2015a).

Examination of textiles with chemical dye tests:

Thin layer chromatography (*TLC*):

It is carried out by using a simple equipment to extract natural dyestuffs from old samples. Thin layer chromatography can be carried out with minute samples, and identification is made with known comparative materials (Mailand, 2000).

High-performance liquid chromatography with a photo diode array (HPLC-PDA) *detector*:

This technique is currently used to analyze dyes is high-performance liquid chromatography by using a diode array detector. Generally, when art objects are investigated, non-destructive methods are employed. If, however, samples are required to be taken, the amount of sample must be minute so that it does not destroy the integrity of the object. With HPLC-PDA, a small amount of yarn is taken from a textile and colorants are extracted from the sample yarn for analysis. In the chromatographic process, colorants or other materials extracted from a sample yarn are separated and, at the PDA detector, the UV-visible spectrum of the separated compound is measured. The UV-spectrum characteristic of each type of compound is matched with those of reference or standard compounds. When the colorant's spectra and time taken are compared to those of a reference compound, the colorant is identified (Shibayama, 2015).

Schweppe aniline dye test:

This approach was described this approach to determine the presence of aniline dyes found in the first ladies collection, smithsonian institution, Washington, DC. The purple dye in the supplemental wefts of the flowers in the gown worn by Mary Lincoln was tested using the Schweppe Aniline dye test method. A small thread sample was placed into a "watch glass"; sequential solutions of sulphuric acid and water were added, and the colour changes were noted. The dye in the supplemental wefts tested to be Perkin's Purple. This test revealed that it was an example of the first synthetic dye patented in 19^{th} century by Perkins (Mailand, 2000).

Specialized methods of examining textiles:

Atomic emission spectrographic analysis:

This test is used in order to know in detail about the precious metals and metal wires used in textile and costumes. A small sample of approx 3 mm length is removed and placed in a graphite electrode, packed with pure graphite, and subjected to atomic emission spectrographic analysis. The metal traces present are determined spectrographically and estimates of the relative amounts of gold, silver, copper, and other elements in each strip are obtained by comparing spectral line intensities with a series of known standards or references. Each element could therefore be identified as a major, minor, or trace amount (Mailand, 2000).

Scanning electron microscopy (*SEM*):

A scanning electron microscope (SEM) is a type of electron microscope that produces images of a sample by scanning it with a focused beam of electrons. The electrons interact with atoms in the sample, producing various signals that can be detected and that contain information about the sample's surface topography and composition. During study on textile heritage, SEM is used for:

– Analysis of the effect of D_5 on textile substrates.

– To identify the kind of fibres, their condition and surface morphology.

Interaction between the electron beam and the sample also generates soft X-rays which can be analyzed using energy dispersive X-ray spectroscopy (EDS or EDX). The field Museum's SEM is equipped with an EDS detector which also detects quantity of the elements present at the surface of a sample (Anonymous, 2015a).

Energy-dispersive X-ray fluorescence (*XRF*):

This technique is used for the characterization of metal alloys, glass, ceramics and pigments. It is an analytical technique that provides data about the elemental composition of a sample. The sample is illuminated with an X-ray beam and the atoms which are struck by the beam emit X-rays in response, usually at several different energies. Different elements will make different distributions of emitted X-rays so the spectrum of emitted X-rays can be used to identify which elements are present in a sample. This technique is very fast and entirely non-destructive for sample. Before Perkin's discovery of the artificial dye "mauvine" there were innovations in the 19^{th} c. that led to the development of "mineral dyes". These colorants were based on inorganic paint pigments that were applied to a textile surface. Efforts to create fast and inexpensive dyes were patented and documented in the textile trade literature (Mailand, 2000).

Raman spectroscopy:

Raman spectroscopy is a spectroscopic technique based on inelastic scattering of monochromatic light, majorly from a laser source. Inelastic scattering means that the frequency of photons in monochromatic light changes upon interaction with a sample. Photons of the laser light are absorbed by the sample and then reemitted. Frequency of the reemitted photons goes up or down in comparison with original monochromatic frequency, and it is known as Raman effect. This shift provides information about vibrational, rotational and other low frequency transitions in molecules.

Raman microscopy is used in characterization of soilings on historic textiles (Anonymous, 2015b).

FTIR spectroscopy:

Fourier transform infrared spectroscopy (FTIR) is a technique which is employed in order to obtain an infrared spectrum of absorption, emission, photo conductivity or Raman scattering of a solid, liquid or gas. An FTIR spectrometer simultaneously collects high spectral resolution data over a wide spectral range. This confers a significant advantage over a dispersive spectrometer which measures intensity over a narrow range of wavelengths at a time (Griffith and De Hasseth, 2007).

FTIR spectroscopy has been widely used in study of museum artifacts.

– Analyses to identify the chemical composition of some fragments taken from the body, bandages and cartonnage wrapping of Egyptian mummies (Maksoud and Rahman El-Amin, 2013).

– FTIR is most often used in the analysis and identification of organic compounds such as resins, starches and proteins, all of which are used in the construction of ethnographic objects (Anonymous, 2015a).

– FTIR spectroscopy is used in characterization of soilings on historic textiles.

– Determination of potential of chemical for preservation.

– Soil removal tests are analysed using calorimetry and FTIR (Anonymous, 2015b).

X-ray photoelectron spectroscopy:

X-ray photoelectron spectroscopy (XPS) is a surface-sensitive quantitative spectroscopic technique that measures the elemental composition at the parts per thousand range (Li *et al.*, 2011). In studies of museum heritage and deterioration, the test is used to identify mordants and dust (Alanine, 1989).

Polarised light microscopy :

Polarised light microscopy uses plane-polarised light to analyse structures that are birefringent; structures that have two different refractive indices at right angles to one another (e.g. cellulose microfibrils). The polarised light microscope must be equipped with a polarizer, positioned in the light path somewhere before the specimen and an analyser, placed in the optical pathway after the rear aperture. Image contrast arises from the interaction of plane-polarized light with specimen to produce two individual wave components. Dust and other soiling material can be tested for their composition (John Innes centre, 2016).

Reflectance spectroscopy:

Portable reflectance spectroscopy devices work in the UV, visible and near-IR region allow non-invasive and *in situ* conservation assessment of artworks. Reflectance spectrum in the visible range (380–780nm) forms the basis of colorimetric analysis, which we use to evaluate the chromatic changes an artwork experiences (such as discoloration, yellowing and darkening) and for monitoring these processes over time. Colorimetric analyses also play an important role in a class of sensors specifically developed for monitoring the museum environment (Cucci and Picollo, 2013).

Apart form this light ageing tests and wash fastness tests are carried out when finishes and paints are applied to sample to support the fabrics in museums. Tensile strength tester is commonly used to test the trength of various historic textiles. Surface pH is often calculated for preserved specimens.

Conclusion:

During researches, long term properties of the textile materials can be revealed by performing accelerated tests. Often, personnel in the conservation, scientific, educational and business communities have much to offer in the line of equipment and expertise, however, mostly these fields are unaware of the questions researchers may have in their minds. Likewise, historians, curators, educators, and conservators are not aware of their equipment and expertise nor how to apply it to our concerns (Mailand, 2000). A more approachable way should be applied in this case and the researchers and engineers should collaborate while working on such subjects so that, actual required equipment is used for detailed analysis.

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