

Preservation and Conservation Techniques of Manuscripts: A Bibliometrics Study

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Abstract

India's manuscripts, spanning 5,000 years, are critical cultural, religious, and intellectual assets at risk from environmental factors and neglect. This study examines global trends in the preservation and conservation of manuscripts, focusing on traditional and modern techniques to protect these fragile documents for future generations. This descriptive study uses a bibliometric approach to analyze global research trends in manuscript preservation. By reviewing literature from databases such as Scopus and Google Scholar, the study identifies key research areas and evaluates techniques like microfilming, digitization, and emerging technologies such as nanotechnology and nature-based methods. The analysis shows increasing interest in manuscript preservation, particularly post-2010, with contributions from countries like Italy, the UK, and India. Modern methods like digitization are widespread, though traditional practices using natural repellents persist. Emerging trends include non-invasive diagnostics and nanotechnology. Global collaborations play a crucial role in addressing preservation challenges. The study emphasizes the importance of protecting manuscripts through a combination of traditional and modern preservation methods. Despite challenges like environmental threats and technological limitations, global collaboration and the adoption of advanced technologies are essential for ensuring the long-term preservation of these cultural treasures.

Keywords: Cultural heritage, libraries, museums, monasteries, mosques

INTRODUCTION

India, with a history spanning over 5,000 years, has produced a vast collection of literature. This wealth of knowledge was recorded on various materials such as birch bark, palm leaves, cloth, wood, stone, and paper. India is home to one of the oldest and largest collections of manuscripts globally, many of which are held in libraries, museums, monasteries, mosques, and private collections. Unfortunately, a significant number have been lost or are in a state of decay. Massive collections of manuscripts were lost in Buddhist monasteries like Nalanda, Taxila, and Vikramshila. Taxila, located in the northwest of India, was destroyed by foreign invasions. The Nalanda library, known as Dharmganj, had three sections: Ratnadodhi, Ratnasagar, and Ratna Rajak. Ratnadodhi, a nine-story library, was partially damaged by the Hun king Michirkul between 450-470 AD and was completely destroyed in 1205 AD by Bakhtiyar Khilji, whose soldiers used the manuscripts as fuel for boiling water (Department of Culture, 2002; Rajan & Esmail, 2021).

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Indigenous manuscripts hold significant cultural heritage, offering both tangible and intangible connections to the beliefs and social values of past societies. They reveal how previous generations lived and understood the world. Preserving and conserving these manuscripts is a cultural necessity and a key responsibility. To ensure that the nation's rich manuscript collection remains accessible for

current and future generations, efforts must be made to preserve, conserve, and digitize them, thereby sharing the knowledge they contain (Tyagi, 2023).

India's vast manuscript collection reflects the accumulated knowledge, values, experiences, and practices of its cultural heritage. This heritage fosters a sense of unity and belonging, linking people to the customs, traditions, and norms of earlier societies. Manuscripts contain vital information about India's history, religion, art, language, and literature, serving as a bridge between the past and the present.

India's literary heritage spans a wide range of knowledge, with a wealth of religious and philosophical texts. Ancient Sanskrit and Prakrit inscriptions found across the country form a unique part of Indian literature. Manuscript collections in various languages, scripts, and materials, often adorned with illustrations and illuminations, are scattered throughout India.

Definitions

The word "manuscript" originates from the Latin terms "manu," meaning "hand," and "scriptus," meaning "to write." Initially, it referred to documents written by hand before the invention of printed books. Its definition grew throughout time to encompass any unpublished writing by a writer, whether it be typed or handwritten.

According to Merriam Webster dictionary, "a written or typewritten composition or document as distinguished from a printed copy".

A manuscript is a handwritten composition on paper, bark, cloth, metal, palm leaf, or any other material dating back at least seventy-five years that has significant scientific, historical, or aesthetic value," according to the National Mission for Manuscripts.

PRESERVATION AND CONSERVATION

The preservation of written records dates back to the origin of writing itself. Early Mesopotamians faced challenges from termites, which would bore through soft clay writing tablets before they were dried in the sun, and even gnaw at the surface of baked tablets, damaging the inscriptions. The clay tablets were susceptible to chipping and breaking when handled roughly. To address these issues, the tablets were stored in lidded jars, which were then systematically organized with straw labels for identification (Mukherjee, 1973).

Preservation aims to prevent the deterioration or decay of materials, while conservation involves actions to maintain and extend the lifespan of these materials (Patidar & Soni, 2016; Sawant, 2014; Gunselman, 2007). In literature, the terms "preservation" and "conservation" are used in distinct but interconnected ways. Preservation typically refers to protecting an object from harmful factors like loss, damage, or destruction. Conservation, on the other hand, involves three main elements: examination, preservation, and restoration.

According to Sarasvathy (2007), who referenced Young, Belanger, and Corbin (1983) in the ALA Glossary, the growing difference between conservation and preservation is that the former stresses techniques and processes meant to preserve the original physical state of books and other objects.

Preservation, while including conservation measures, also involves methods like rebinding and the conversion of original materials to other formats to retain their intellectual content to the greatest extent possible.

LITERATURE REVIEW

Manan et al. (2024) analyzed 1,340 publications to identify trends and gaps in botanical garden research. Their research, which focused on topics including botanical gardens, conservation, taxonomy,

biodiversity, and ex-situ conservation, showed a notable increase in publications between 1960 and 2023.

Influential researchers, including Sanja Kovacic, Elaissi, and Chemli, have directed research toward essential oils and ex-situ conservation. The Royal Botanic Gardens (UK), the New York Botanical Garden (US), and the Chinese Academy of Sciences are among the major contributors.

Thematic analysis identified enduring topics such as conservation and emerging ones like ecological restoration, climate change, and invasive species, reflecting the evolving scope of the field. The study points to a shift in research priorities and underscores the value of cross-disciplinary collaboration. It provides guidance for future research, encouraging exploration of biodiversity, taxonomy, and ex-situ conservation to enhance understanding of botanical ecosystems.

According to Perez-Gandarillas et al. (2024) conducted a literature review using bibliometric analysis and the Latent Dirichlet Allocation (LDA) technique to systematically map out scientific research related to the conservation and protection of cultural heritage. Drawing from data in the Scopus database, the study analyzed annual publications, countries, influential publications, authors, institutions, and keywords to identify research trends in this field. The results reveal a growing number of studies, especially since 2010, with Italy leading as the most prolific country due to its numerous UNESCO heritage sites. Much of the research focuses on protecting materials like metal, paper, and stone. Recent advancements include an improved understanding of deterioration processes through accurate diagnosis, alongside innovative conservation treatments. Notably, non-invasive diagnostic techniques, nanotechnology, and nature-based methods are emerging as the latest trends in heritage conservation.

Moid et al. (2023) investigates the manuscript collection and preservation efforts at Khuda Bakhsh Oriental Public Library (KBOPL). Both qualitative and quantitative data are incorporated into this study's mixed-methods methodology. Quantitative data was gathered via a questionnaire administered to the preservation chemist, while qualitative insights were derived from the library's preservation guidelines. The findings reveal an extensive collection of Persian and Arabic manuscripts, emphasizing KBOPL's pivotal role in safeguarding cultural heritage through its preservation initiatives. Furthermore, the library also functions as a community center, indicating its broader societal importance and potential avenues for future research.

Buragohain et al. (2022) examine the longstanding practice of preserving traditional manuscripts, emphasizing the increasing importance of digitization over the past two decades to protect endangered manuscripts. This initiative is inspired by the awareness that manuscripts play a crucial role in understanding culture and tradition. The study focuses on the conservation and archival policies implemented by the British Library for digitizing ancient manuscripts from the North-Eastern states of India, including Mizoram, Sikkim, Assam, and Arunachal Pradesh. It notes that these states have undertaken digitization projects tailored to their specific needs and timelines. The primary aim of the research is to highlight the urgent need to preserve these cultural heritages, as many manuscripts are at risk of extinction, potentially leaving future generations with only stories about them. Additionally, the study assesses both the quantitative and qualitative aspects of the preservation policies for these manuscripts as managed by the British Library.

According to Borah (2017) the term manuscript is derived from the Latin words manu ("by hand") and scribe ("to write"), referring to documents or books written by hand. Manuscripts have played a crucial role in preserving human history, created on diverse materials such as stone, clay, palm leaves, bark, animal skins, cloth, and paper. In India, Majuli, the world's largest river island, houses many **Satras**—monastic institutions that serve as important repositories for these valuable texts. Manuscripts are often considered the lifeblood of history, as their study provides insights into the social, cultural,

historical, artistic, and aesthetic developments of civilizations. Preserving these documents ensures the safeguarding of humanity's intellectual heritage.

LIMITATIONS OF THE STUDY

Although this bibliometric analysis offers valuable insights, it has many drawbacks. It relies on secondary sources from databases like Scopus and Google Scholar, potentially excluding important unpublished works or region-specific studies. Second, the study focuses on publications from countries such as Italy, the UK, and India, leading to geographic bias that may overlook preservation trends and challenges in other regions. Third, while modern techniques like digitization, nanotechnology, and non-invasive diagnostics are discussed, the study does not fully explore the practical challenges of implementing these methods in institutions, especially in resource-limited areas. The long-term sustainability of digital preservation, particularly given the short lifespan of storage media like CDs and DVDs, is also not adequately addressed. Lastly, the study is limited to bibliometric analysis, with no empirical research or field studies to validate the effectiveness of preservation techniques, thus reducing the practical applicability of the findings. These drawbacks show how important it is to do more thorough, inclusive research and validate new preservation techniques in real-world settings.

SIGNIFICANCE OF THE STUDY

This study is crucial for safeguarding cultural heritage and preserving centuries-old manuscripts that hold significant intellectual, cultural, and social insights. These fragile documents, vulnerable to environmental damage and improper handling, require effective preservation and conservation techniques to ensure their survival for future generations. Through a bibliometric analysis, the study examines global research trends, highlighting the evolution of traditional and modern preservation methods, such as indigenous techniques and advanced digitization technologies. It also identifies emerging trends like non-invasive diagnostics, nanotechnology, and nature-based conservation approaches. This study emphasizes the importance of interdisciplinary collaboration and global partnerships in manuscript preservation, as institutions across the world share resources and expertise to address the complex challenges of safeguarding these irreplaceable artifacts. By mapping current advancements and offering insights into future research directions, this study contributes to the ongoing efforts to enhance preservation techniques, ensuring that historical manuscripts remain accessible for scholars and researchers while preserving their intellectual content and cultural significance.

OBJECTIVES OF THE STUDY

The objectives of the study are:

- To analyze the global research trends and patterns in the field of manuscript preservation and conservation.
- To identify the importance of preserving manuscripts.
- To examine the frequency and distribution of publications on manuscript preservation and conservation techniques over time.
- To determine the primary focus of preservation efforts, particularly regarding manuscripts.
- To identify and discuss the latest trends in heritage conservation, including non-invasive diagnostic techniques, nanotechnology, and nature-based methods.
- To evaluate the growing interest in cultural heritage preservation supported by global collaborations and technological advancements.

RESEARCH METHODOLOGY

In the present study, the 'descriptive' form of research methodology has been applied which falls into the category of 'survey' as the research technique. The method used of the survey here has assisted or allowed a researcher to come into direct contact with the phenomena to be studied. A survey of this develops into a detailed search about the existing and accessible literature in respect of manuscripts existing on various types of databases like Google Scholar, Scopus etc. The paper mainly depends upon the review of online as well as print literature.

Preservation Techniques of Manuscripts

Manuscript Microfilming

Microfilming is a proven technique for document and manuscript preservation. An alternate method is microfilm, which allows a compact microfilm cabinet to hold thousands of manuscripts.

But proper care and attention should be paid in handling these microfilms. It is suggested to use clean white cotton gloves in using the same. Storage area of microfilm should also be the proper one, excessive heat and humidity is dangerous to film. Microfilm reader should be protected from dust. The air conditioner is the necessary factor of storage condition of microfilm (Borah, 2017).

Some 4190 manuscripts of importance have been microfilmed by Indira Gandhi National Centre for Arts (IGNCA) at SORI. One of the initiatives of the National Mission for Manuscripts, launched by the Indian government's Department of Culture, is the conversion of manuscripts into electronic records. In addition to catalog production, surveys are used to look for manuscripts in society, and a National Manuscript Library is established. The institution have been provided fund to start the mission. Rs.10 millions has been allocated to launch the mission. SORI has been designated as Manuscript Resource Centre (MRC) for all Madhya Pradesh for the preparation of accession catalogue, launch awareness programme in society (Shah and Kumar, 2004).

Digitization

The process of transforming an analog object to a digital one is called digitization, viz as generally to binary code 0 and 1. This process is a standardized, organized and a scientific system which can also support the conservation and access of the manuscripts and other documents. For manuscripts digitization, generally image files are created using scanner or digital camera; and in second process, scanned document is edited with OCR technology to identify each alphabetic letter or numeric digit, and each character is represented as an ASCII code. Digitization also has some limitations; besides that, CD and DVDs used for the storage of the digital surrogate do not have a long shelf life Microfilming the digital manuscript copies for long-term preservation is now emphasized (Borah, 2017).

Devices & Software needed for Digitization of Rare Manuscripts

- *Scanner*: It has great speed and can scan a page or folio in less than 30 seconds. Apart from this, Flatbed scanners are also applied for the purpose of scanning.
- *Digital Camera*: Digital cameras uses for Digitization purpose. Both Camera & Scanners are being used as per the requirement.

Process of Digitization

The Library is regularly scanning the manuscripts and rare books that are in very bad conditions. As these are rare & precious ones, the library wanted to digitize the manuscripts in the house itself. The digitized manuscripts have been made available to for reading the systems at the Manuscript Division premises of the scholars. The skilled employees of the library handle this kind of work. They normally follow the same process that is widely made use of by many Libraries.

1. STAGE-1 Bring out the Manuscript from the stacks.
2. STAGE-2 Check if already Digitized.
3. STAGE-3 Enter it into the record register with following information: Title, Call Number, Collection, Language and Folios.
4. STAGE-4 Start scanning.
5. STAGE-5 Scanned Manuscript is automatically saved in computer attached with the scanner.
6. STAGE-6 After scanning, a stamp/seal "DIGITIZED" and the signature of the person along with date are put on the manuscript.
7. STAGE-7 Fine tuning is done and saved in different folders separately collection-wise.
8. STAGE-8 Final manuscript is ready for retrieval as and when needed.

CURATIVE CONSERVATION

Cleaning of manuscripts

The manuscript should be cleaned with much care and under certain conditions. Cleaning can be done manually either with cotton scrub or with a soft brush. To clean the dust from a manuscript a solution of glycerin in water can be used on its ink.

Repairing of manuscripts

Another remedial procedure done to preserve manuscripts is hand repair. Special kinds of tables and tools are utilized in the mending department while repairing manuscripts by hand. However, the quality of the ink used to prepare the manuscripts should be examined before fixing these. If the ink is permanent, the mender can clean the manuscript page with regular water, hold a piece of chiffon on one side, and repeat the procedure for the other leaf sides. In case of manuscripts with ordinary ink, foil and colonic are used as adhesives.

Fumigation

Another treatment option is fumigation, which primarily combats insects that damage manuscripts. The insects and their eggs, which they deposit in the holes they make in the texts, are destroyed with the use of fumigation. This utilizes the fumigation room as well. Another efficient technique for getting rid of the harmful insects that are present in the manuscripts is vacuum fumigation.

Another method of killing the insect is keeping the manuscripts in the freezer under the temperature of minus 30° centigrade. This is the safest method of killing the insects.

Lamination

One technique for the curative conservation of manuscripts is lamination. The process of lamination involves sandwiching each manuscript folio between two laminating agents, which shields it from all outside threats and fortifies it sufficiently physically to allow for long-term preservation. For lamination generally the glassine paper is used for scaling on the manuscripts by means of heats and very high pressures. The laminating process has been found to be the cheapest method of rejuvenating the brittle and deteriorated manuscripts.

PALM LEAF MANUSCRIPTS: STABILIZATION IN ORIGINAL FORMAT

Preparing the leaves

Once fumigated, manuscripts should be lightly dusted to remove surface debris and insect parts. The original ties should be carefully relaxed and inspected. Whenever possible they should be retained, but if broken and deteriorated, should be replaced with a soft-fibered string of the same thickness. If the original wooden board covers are missing, basic protective board covers should be substituted. Chemically stable boards, such as blue/white barrier board (0.060" thick thickness, 32" x 40") needs to be cut 0.5 cm longer and wider than the manuscript. Make holes in the board corresponding to the manuscript's ends from dam age, to prevent the ties from cutting into the manuscript edge, and to allow the end to be retained [1, 2].

Making the manuscript case

The boarded manuscript is cased using a thin table board such as Archivart library board. Text and illustrations derived from instructions prepared by the author for the Cambodian archivists and librarians. Width of the case is three times the width of the boarded manuscript plus twice its thickness. Lightly score and then fold the board. Cut a flap for each end of the case. The width should be 0.1 cm less than the width of the case, and the length should be 5 cm. plus 2 cm plus the thickness of the case. Glue the flaps in place and insert the boarded manuscript.

Making the box

The separate manual guide describes the box-making formula which should be followed here. Starchfilled cloth or buckram should not be used, nor starch paste or animal glue. The most suitable material is pyroxylin coated/impregnated buckram used with Elvacepolyvinyl acetate adhesive. In general, the cased manuscripts may be packed in fours or sixes. In each box, some form of insect repellent, such as naphthalene or para-dichlorobenzene mothballs or crystals in a sachet, or a small section of Shell No-Pest strip, should be included [3-5]. To include the repellent, it will normally be better to build the box Slightly larger, and in this case include a board separation; the actual size of the repellent compartment will depend on which repellent is used.

PRESERVATION AND CONSERVATION METHODS IN INDIA

Indigenous Methods

India has a tradition of preserving its manuscripts with the help of local methods from decay. Wrapping of manuscripts in red or yellow cotton cloth is highly common in India. In relation to the usage of herbs and natural products as insect repellents, there is a compositum *Acorus calmus*, camphor, cinnamon, cumin, cloves, and pepper that has been used widely in different parts of India [6, 7]. The dried leaves of the neem tree are used to fight booklice. Turmeric is also applied as an insecticide. The fumes from burnt ajowan plant are used as a fungicide in southern India (Tyagi, 2023).

Methods that have been used since the beginning include dusting and cleaning manuscripts, covering them with clothing to keep dust and insects out, exposing them to sunlight, and using Ajwain powder, custard, apple seed, neem seed, and black cumin to keep insects away from them (Baquee & Raza, 2020).

Modern Methods

New technologies and chemicals used in the preservation and conservation of manuscripts have prolonged the life of manuscripts. In this, the use of chemicals is pretty radical and toxic. Microfilms, microfiches, and digitization are the latest technologies advanced that most libraries are embracing (Tyagi, 2023).

Moisture Absorbents, microfilming, and xeroxing of manuscripts. One of the cutting-edge methods that many libraries and organizations have been using is the digitalization of manuscripts (Baquee& Raza, 2020).

Procedures for the preservation of rare documents and manuscripts

The conservation procedures are adopted based on the environment, climate, and location. Such requirements can be fulfilled with an apt atmosphere and other techniques such as chemical treatment, fumigation, bleaching, restoration of faded inks, etc. (Moid et al, 2023).

1. Document Verification: This process involves assessing the documents' bibliographic information.
 - These details must be documented on a separate sheet especially designed to keep its record. It also helps in formulating a catalogue and /orbibliography of rare collection [8].
2. Fumigation: This pest control technique uses chemicals to eradicate insects and bacteria. For this procedure, thymol vapors are used. Papers are unaffected by its vapor, which destroys the fungus.
3. Condition Report: This pertains to the state of the item's collection and storage. The condition report is created by keeping a photographic record.
4. Pagination: We must separate each page for the conservation process before rebinding it. At this point, we number every page from start to finish before binding it.
5. Dry brushing: The surface of some documents may be covered in dust or dirt. We use a gentle, natural-fiber brush to clean it. The paper is easy to clean with a dry brush because it is made by separating the fibers into a suspension and then forming it into a sheet [9-11].

6. Test: The tests listed below are used to determine the acidity of paper:
 - PH Test: Using pH strips, the surface test of the paper is demonstrated. Blue indicates alkalinity, yellow indicates acidity, and green indicates impartiality. The formula for pH is $\text{pH} = \log_{10} [\text{H}^+]$, where H^+ is the hydrogen ion concentration. pH7 is neutral, pH1 is extremely acidic, and pH14 is strongly alkaline on this scale. With each pH reduction of 1.0, the concentration of hydrogen ions increases tenfold. For instance, the amount of active acid at pH4 is ten times more than that at pH5. Daniels (2006)
 - Test for Ink Solubility: The quality of the paints and inks used in manuscripts is assessed using this technique. This test lets us make decision to hold ink in situ on paper after deacidification process.
7. De-acidification: It is a process of immersing documents in plain and lime water solution of Calcium Hydroxide to neutralize acidity. Adhesives may occasionally be eliminated by the de-acidification procedure The following materials have been used to de-acidify: diethylzinc, carbonate of cyclohexylamine, morpholine, amines, ammonia, magnesium hydrogen carbonate, barium, magnesium methoxide, calcium hydroxide or magnesium oxide, and The majority of these can be used in large-scale procedures for the conservation of rare books and manuscripts since they are in the four liquid phases with relatively high vapour pressure or as gases.
8. Drying Process: When the pages have gone through de-acidification process then they are dried by using Blotting paper. This is absorption process.
9. Preparation of Gluten-free Starch Pest and Anti-fungal Glue: Two adhesives are employed in the book repair process: gluten-free starch pest and anti-fungal glue. 100g of ordinary flour, 1/2 litre of cold water, and two drops of thymol are combined in the recipe to make the bug. Since insects are drawn to gluten, the starch pest needs to be gluten-free.
10. Lining, Mending and Filling: Pages that have been torn out of a rare book can be fixed with pesticide alone, but the ragged edges need to be fixed and filled up with banana paper.
 - Lamination is done to strengthen fragile document with Japanese tissue.
11. Drying: The laminated documents are placed in a drying rack made especially for this use.
12. Cutting: Cutting of every page in proper equal size is required to afford uniform size to all pages separated and to be tied after doing all the above processes.
13. Page Sequence: Carefully organize each page in accordance with the page number that was assigned in step number 4 above.
14. Archival Binding: These pages will be bound in accordance with their appropriateness.
15. Pressing of rebound book: A rare book should be maintained under weight for a while to prevent blending and to prevent bending after binding.

REQUIREMENTS FOR CONSERVATION LABORATORY

Storage area

The storage area of the manuscripts should be compliant with all the disaster management norms. It should have all provisions for protection against light, heat, moisture, dampness, insect, fire vandalism, flood, and earthquake etc.

Temperature and Humidity

The control of heat and moisture is helpful to stop the decay of the manuscript and to increase their longevity. For keeping the manuscript safe, the temperature of the storage area should be in the range of 22-25° and relative humidity should be in range between 45-55%. Otherwise, the layer of birch bark may give way and palm leaves may curl up.

Controlling of light

Sufficient light should be there in the storage area, but the direct sunlight should be avoided to fall on the manuscripts. Heat should also be controlled in stack areas. Ultraviolet, light causes serious chemical deterioration of organic materials and should therefore be eliminated.

Air pollution

As a preventive measure, air pollution should be controlled by air filtration with the help of proper air conditioning system.

Defense from dirt and dust

The manuscript needs to be maintained dust- and dirt-free. To remove the dust from all corners and racks, a vacuum cleaner should be used. The manuscript can be displayed in glass cabinets as it can keep the manuscript away from dust as well as direct sunlight.

Skilled and Motivated Staff

It is necessary to have at least one fully trained employee who can handle rare documents more effectively during the conservation process. This individual will also need to start and finish the conservation process.

Furniture

The lab should be well-equipped with tables that have matt finish sun mica tops, ideally in an off-white hue so that pages can be added and deleted as needed. After the de-acidification process is complete, the de-acidified sheets can be arranged sequentially on one or more drying racks. The de-acidified paper is heated and the required temperature is maintained by a single lamp on the table. Depending on the weather, it could take up to two days to finish these papers. In addition to open and closed shelves for the safe storage of chemicals based on their nature and contents, cabinets should have shelves that can be adjusted to accommodate dry, de-acidified papers of different sizes. This can also be applied to the process of organizing different conservation-related instruments [15-21].

Tools and Equipment

The following tools and equipments shall be made available in a conservation laboratory.

- Round and flat brushes synthetic brushes in a range of sizes, sable hair, hog hair, and other materials for applying adhesive or pesticide to paper, boards, cloth, and other surfaces.
- An electric heater that raises the laboratory's temperature to the appropriate level.

Conservation Materials

The conservation materials needed to preserve rare materials and manuscripts include handmade paper of different thickness, textures, and colors as needed for the appropriate collections; Japanese repair tissue, also known as rice paper, is made of vegetable fiber and comes in several weights; blotter paper, a fully unsized sheet of paper made from rag or cotton liners, and is frequently used for moisture absorption; and binding materials, acid-free mount board, flour, gelatin, and eraser powders.

Chemicals

The chemicals needed for this process include antifungal drugs like thymol, solvents like methanol and ethanol, and insecticidal powders like borax, among others.

FINDINGS

Focus on Heritage Preservation

Manuscripts are increasingly recognized as a vital part of cultural heritage, embodying the history, beliefs, and social values of past societies. The study identifies that preservation efforts are aimed not only at safeguarding physical manuscripts but also at maintaining their intellectual content through digitization and microfilming, ensuring accessibility for future generations.

Conservation Techniques

Traditional and modern conservation techniques are being combined for manuscript preservation. While indigenous methods, such as using turmeric and neem leaves, are still practiced in some regions of India, modern techniques like microfilming, digitization, and fumigation have become more

widespread. Digitization, although essential, faces limitations in terms of long-term sustainability due to the short lifespan of CDs and DVDs.

Global Research Trends

The bibliometric analysis reveals an increasing global interest in the preservation and conservation of manuscripts. The trend has particularly gained momentum since 2010, with a substantial rise in publications from countries like Italy, the UK, and India. Italy, in particular, stands out due to its numerous UNESCO heritage sites, driving significant research and conservation efforts.

Emerging Trends in Conservation Science

New technologies such as nanotechnology, non-invasive diagnostic techniques, and nature-based conservation methods are becoming more prominent in the field. These innovations allow for more precise diagnosis of manuscript deterioration, leading to more effective preservation solutions.

Digitization and Digital Archiving

Digitization has emerged as a critical tool for preserving endangered manuscripts, especially in regions like North-East India. Institutions like the British Library have initiated large-scale digitization projects, which include creating digital archives to safeguard manuscripts from physical decay while enhancing access for researchers and the public.

India's Manuscript Preservation Efforts

In India, initiatives like the National Mission for Manuscripts and institutions such as the Indira Gandhi National Centre for the Arts (IGNCA) have played pivotal roles in preserving manuscripts through microfilming, digitization, and cataloging. Local preservation methods continue to be combined with modern technologies, showcasing a hybrid approach to manuscript conservation.

Collaborative Efforts

The study highlights the significance of international partnerships in manuscript preservation. Institutions worldwide are collaborating to exchange knowledge, resources, and techniques. These collaborations are crucial for tackling the intricate and diverse challenges involved in preserving ancient manuscripts.

Challenges in Manuscript Preservation

Despite technological progress, numerous challenges persist. Environmental factors such as humidity, pests, and dust continue to threaten manuscript collections, particularly in regions with inadequate storage conditions. The study highlights the need for proper disaster management systems and climate control in storage facilities to prevent further decay.

CONCLUSION

This study provides valuable insights into global research trends, emerging technologies, and the challenges associated with safeguarding cultural heritage. The study highlights the growing awareness of the importance of manuscripts as carriers of historical, cultural, and intellectual knowledge, underscoring the need for their preservation.

Traditional methods, including indigenous practices, continue to play a role in manuscript conservation, especially in countries like India. However, modern techniques such as digitization, microfilming, and the use of nanotechnology are becoming more prevalent, offering innovative solutions to combat manuscript deterioration. Despite these advances, challenges such as environmental factors, short-lived digital storage media, and the need for proper storage conditions persist.

The study underscores the importance of global collaborations and interdisciplinary research to enhance manuscript preservation. Institutions worldwide are working together to share resources and knowledge, which is crucial for addressing the complex issues surrounding manuscript conservation.

Sustainable long-term solutions are desperately needed going forward, especially in the areas of catastrophe management and digital archiving.

This study not only maps the current state of manuscript preservation but also provides direction for future research, emphasizing the importance of integrating traditional practices with cutting-edge technologies for a comprehensive approach to manuscript conservation.

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