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The ultraviolet component of light can be reduced if the light of fluorescent tubes not allowed falling directly for illumination. The light of the fluorescent tube is allowed to reflect from a surface coated with a phosphor material like zinc oxide or titanium trioxides before falling. Phosphors are such chemicals having capacity of luminance, i.e., Storing energy and later releasing it in the form of visible light. Fluorescent tubes should also be used in place of tungsten bulbs for internal lighting of showcases. But it is essential that auxiliary equipment such as chokes, Starters etc. should be mounted outside the showcases where they easily accessible for servicing. Sometimes in the case of very old and uneared documents, the writing becomes too faced to be read without the use of ultraviolet lamps. Ultraviolet rays produce fluorescence and hence badly faded writing writing becomes visible. But it is not advisable to expose such badly faded documents to ultraviolet light frequently. In order to avoid frequent exposure to ultraviolet lamps, such documents should be photographed by ultraviolet method of photography for reading them(Agarwal,Berkeshli,1997,pp.57-58).

Archival documents are important not only as the object of the past but also because of the information and knowledge, they contain. It is, therefore, one of the main duties of the present generation to save this form of national heritage and to pass them on to the future generation. Therefore, both preventive & curative precautions must be taken to protect archival documents from deterioration and to bring them back as close as possible to their original strength flexibility and legibility. Thus from the above discussion, we reach to the conclusion that we must protect archival documents from photochemical effects of light at any cost.

It is only hoped that the reader has gained a better understanding about the protection of archival material, preservation and conservation and how it affects archival collection. A sound preservation plan which includes environmental and storage conditions and a disaster plan will give any collection a solid base on which to survive. And knowing the details of various conservation treatments should help the archivist make decisions on how best to deal with damaged items in their collections. In either case, knowledge is power and with this power the archivist can help make their collections last for generations to come without the fear of its damage.

about 15 lux. So a level of 50 lux illumination is not too low of distinct visibility.

In order of minimize the destructive effect of light, documents and manuscripts should be exposed to light for a period as short as possible. Documents and manuscripts should be exhibited only temporarily. They should be replaced by others in about six months.

Important documents can be adequately protected most efficiently from injurious effect of ultraviolet rays by storing in cardboard containers. If the containers become brittle after exposure to light, new containers should replace them(Kriti,2007,pp.14-17).

Precautions to control the invisible but photochemical active ultraviolet rays of light:

Sunlight should be preserved from falling directly on paper because the sun is a great emitter of ultraviolet rays. So there should be deep windows in the room where documents are stored or displayed. Though ordinary colorless glass absorbs ultraviolet radiation, yet lemon yellow or green colored glass should be fitted in window panes because these are more effective in blocking ultraviolet rays. Special glass containing cerium and cobalt oxides affords very effective protection to written as well as printed papers by minimizing the entrance of ultraviolet rays to greater extent than even lemon yellow or green colored glasses. Ultraviolet radiation absorbing varnishes should be coated on the colorless glass panes of windows to filter out ultraviolet rays. One of the most effective of these varnishes is Oroglas-11 UF. This solution can either be brushed or sprayed on the panes. It is extremely good to fit acrylic plastic sheet (Perspex sheet) in the panes of the windows because it filters out ultraviolet rays to greater extent than colored glass or even Oroglas- 11 UF solution coated glass.

For lighting the roofs and walls of rooms and verandah where the documents are stored or displayed only florescent tubes should be used and in no case tungsten bulbs should be used. The reason behind this is that the major portion of ultraviolet rays is converted into visible light by fluorescent substance coated on the inner walls of the fluorescent tubs. In ordinary tungsten bulbs, only 20% of the electrical energy is converted into visible light whereas the fluorescent tubes convert about 60% of the electrical energy into visible light. That is why that a fluorescent tube of 40 Watt produces much more illumination than an ordinary tungsten bulb of 100 Watt. Another advantage of using a fluorescent tube in comparison to a tungsten bulb is that it is much cooler in operation(Mak,1980,pp.24-30).

when needed. This can be done with timers, but at the very least staff should be trained to turn off the lights when the space is unoccupied. Occupancy sensors can also be installed that turn off lights when no movement is sensed in the area. Lighting should be incandescent (tungsten) rather than fluorescent wherever possible.

Many situations are not ideal and space is often at a premium. If you cannot keep an object out of the light, keep the light from reaching the object. Boxes from archival suppliers made by professional box-makers to fit the exact dimensions of individual objects are useful. While boxes will prevent damage from direct light exposure, it is uncertain whether they will protect objects from the fluctuations in temperature and humidity that may be caused by solar heating.

The specifics of determining guidelines for exhibition lighting of objects have been discussed above. All windows in exhibit areas should be covered with drapes, shades, or blinds, in addition to being filtered for UV. Skylights should be covered to block the sun. Light levels should be low, and materials should never be exposed to direct sunlight. Never display objects permanently unless they are expendable.

Exceptionally fragile and vulnerable objects should not be displayed, and research use should be limited. If materials must be exhibited, great care must be taken to minimize damage. Books that are opened for display should have the pages turned weekly so that one page is not constantly exposed. Photographic and photocopy facsimiles of objects should be used whenever possible for display and research. Spotlights should never be trained directly on an object. Indirect and low lighting will spare the object, and it will also require less adjustment of the eye from areas of intense light to those of relative darkness, allowing the use of lamps with a lower wattage throughout exhibit spaces. A gradual diminution of light levels through a series of rooms may accustom viewers' eyes to lower exhibition light levels. Strategic placement of labels explaining the reason for low light levels can be used to educate patrons.

For this, the following precautions must be taken:

Intensity of light: Whether natural and artificial, falling upon the documents, manuscripts and books should be minimized. From a good deal of scientific works, it has been established that the maximum level of illumination for paper materials should not be exceed 50 lux. The minimum intensity of light needed for visibility of even multicolored painting executed on paper is

Factors responsible for the damaging effect of light on paper:

1. Nature of the light –

More the proportion of ultraviolet rays more the damage caused by it.

2.Intensity of light –

Intensity of the light is directly proportional to the photochemical degradation of paper, i.e. as the intensity of the light increases the rate of deterioration of the paper also increases.

3. Duration of exposure –

The duration of exposure of paper to light is directly proportional to its deterioration.

4. Distance from the source of light –

Distance between the source of light and later is universally proportional to the deterioration .More the distance less the damage. Certain other factors like temperature and humidity of the surrounding environment influence the rate of deterioration by light. The photochemical effect of light on paper is enhanced at high temperature, at high humidity and at high concentration oxygen of the surrounding environment(Gupta,1995,pp.46-47).

From the above discussion, we see that light, even though it is a potent factor of deterioration, is essential for reading archival documents, and may be considered a necessary evil. It is evident that the control of light is necessary in the places like archives, museums and libraries where manuscripts, documents, books, maps, diagrams, paintings, executed on paper etc., are stored and exhibited. It involves a careful analysis of the sensitivity of materials and selective application of controls to minimize the damage.

Controlling Visible Light:

It would be ideal to keep collections sheltered from all light, but this is clearly impractical. Even collections stored away from light must sometimes be used. Often, in fact, storage and research areas cannot be separated. Materials must be exhibited, particularly in a museum setting. A difficult balance must be maintained between the desire to protect materials and the need to make them accessible. Any reduction of visible light reduces long-term damage. Storage areas that are not routinely occupied by staff or researchers should be kept dark; they should be windowless, or the windows should be blocked. Lights should be turned off in such areas except

The main constituent in the structure of most of the manuscripts is cellulose, which is a long chain polymer, and the length of the chain indicates its quality and strength. The longer the chain (degree of polymerization), the more durable is the cellulose. When light falls over the manuscripts, the energy contained in it breaks some of the weak bonds of the cellulose chain, reducing its length and weakening it.

The light almost invariably contains some heat, which removes the moisture present in thee folio and makes them brittle. In addition, during the action of light on cellulose and other ingredients of paper such as sizing, some chromophoric (coloured) compounds are produced, which result in yellowing of paper and other support materials of manuscripts.

Quality of Paper:

All kind of paper is prone to deterioration (*heading towards a worse condition*) due to the photochemical effect of light, but the extent of photochemical action depends upon the quality of the paper. ***According to Launer and Wilson***, the photochemical stability of paper is related to the nature (length and breath of the cellulose fibers) of the paper, which depends upon the origin of the raw cellulose material utilized for its manufacture. It declines in the order- cotton or rag, esparto grass, sabai grass, hemp or jute, straw, bamboo, wood and bagasse.

Paper manufactured from rag has maximum resistance against the photochemical action. This is because of the large average length and average diameter of the cross-section of the cellulose fiber obtained from rag and of its maximum alpha- cellulose content. *Pure cellulose means cellulose almost free from contamination.*

From the quality point of view, as we have two different kinds of paper: Archival and Non-Archival papers. As some documents, papers for painting artists, governments, libraries need to be kept for a long periods of time. Paper producers make them with natural pH an a bit alkaline so that it will not lose the level of acid which normally exists in papers. This way papers won't get yellow in near future(prajapati,1997,pp.45-52).

Archives constitute the memory of nations and of societies, shape their identity, and are a cornerstone of the information.

'International Council on Archives'

of cellulose. The results are discoloration and brittleness in the paper. In tropical countries like India, where there is plenty both light and heat practically throughout the year, this problem is constantly encountered. Excessive moisture in the paper leads to rapid disintegration of the cellulose and relative humidity of 70% or above at a temperature in the range of 25 to 30 degrees Celsius provides deal condition for the growth of moulds and fungi. Electromagnetic radiation having wavelengths in the range from long X-rays to the violet end of visible light i.e. 40 A to 4000 A0 (4 nm to 400nm), are called ultraviolet rays. The longest ultraviolet rays have wavelengths just shorter than those of violet light, the shortest perceptible waves by the human eye. Such radiations are known as near ultraviolet and have wavelengths in the range 3000-40000 (300-400nm). The radiations in the range 2000-3000A0 (200-300nm) are known as far ultraviolet. Below 2000A (200nm) are known as the extreme ultraviolet or the vacuum ultraviolet. The Sun is a strong emitter of ultraviolet rays but only the near ultraviolet rays reach the earth's surface as the ozone present in the ozonosphere of the atmosphere absorbs all the electromagnetic waves having wavelengths below 2900 A0 (290nm). In this way, we find that the ultraviolet rays, having wavelengths in the range 2900-4000 A0 (290-400nm), reach the earth's surface and hence these ultraviolet rays play an important role as a photochemical agent in destroying paper by photochemical action(Gupta,1988,pp.61-62).

Deterioration due to light:

As we generally know that within visible light, different coloured lights have different wavelengths and hence have its different damaging effects;

Colour	Wavelength (m)
Red	6.60x10-7
Orange	6.10-10-7
Yellow	5.80x10-7
Green	5.40x10-7
Blue	4.80x10-7
Indigo	4.70x10-7
Violet	4.40x10-7

tungsten) that is heated until it produces light. Electrodeless lamps produce light in other ways, including the use of radio frequencies to excite a coil or microwave energy directed at the element sulfur to produce visible light. Electrodeless lamps produce a lot of illumination, so thus far they have only been used as sources of ambient light (the light produced by one electrodeless sulfur lamp equals more than 250 standard 100 watt incandescent lamps). They are more energy efficient than HID lamps, and they provide excellent color rendition, low infrared and ultraviolet light, and long life. It is expected that this technology will eventually be miniaturized for use in smaller exhibit spaces and in exhibit cases(Canadian Conservation,1988,p.10).

Photochemical Deterioration of Paper:

Laws of electromagnetism explain that the energy contained by light waves is inversely proportional to their wavelengths and so higher energy is produced at shorter wavelengths. It is, therefore, apparent that ultraviolet radiation of light is mainly responsible for photochemical degradation of paper. Photochemical deterioration of paper means conversion of cellulose of the paper into oxycellulose due to a chemical reaction produced by light particularly ultraviolet radiation because the main component of paper is cellouse. This photochemical degradation reaction of papers takes place rapidly when paper is exposed to sunlight in presence of air (oxygen). When some portion of cellulose is oxidized to oxycellulose, the paper becomes weak and brittle. Fading of ink used for writing and of the dye of the colored paper and yellowing of white paper also take place due to the formation of oxycellulose in paper. When some portion of cellulose is converted into oxycellulose, paper starts getting discolored even in dark(Mahap atra,Chakrabarti,2003,pp.18-32).

The effect of Ultraviolet Rays:

Ultraviolet light are most energetic form of electromagnetic radiation. High energy causes significant attraction and cellular deterioration of organic material. Ultraviolet radiation must be completely eliminated in Archives. The role played by light in causing the deterioration of celluloid material is well known. While photochemical processes, in which the ultraviolet range of the spectrum (below 350 mu) played an important part, are potent factor in several phenomena of decay such as the weakening of celluloid fibers, fading of pigments and dyes, etc. It is probably the combined action of light and heat that is the main cause of the breakdown

lamps used for exhibition lighting, such as the Reflectorized (R), Ellipsoidal Reflectorized (ER), and Parabolic Aluminized Reflector (PAR) lamps.

Tungsten-halogen lamps (also called quartz lamps) are a variation on the traditional incandescent lamp; they contain halogen gas inside a quartz bulb, which allows the light to burn brighter and longer. These lamps emit significant UV light and do require filtering. Filters can be expensive and special housings designed to accept the UV filters may be necessary. Tungsten-halogen lamps are also used in exhibition lighting; examples include the Halogen PAR and the Mirrored-Reflector (MR) lamp. Fluorescent lamps contain mercury vapor inside a glass lamp whose inside surface is painted with white fluorescent powder. When electricity is passed through the lamp (via a filament), the mercury vapor emits UV radiation which is absorbed by the fluorescent powder and re-emitted as visible light. Some UV light passes through most fluorescent lamps, however, so they are more damaging than incandescent lamps. The newest type of fluorescent is the compact fluorescent lamp; these are smaller, last longer, and have a more pleasant color than traditional fluorescents, and they can usually be used in incandescent sockets. These lamps must still be filtered, however.

Like fluorescents, high intensity discharge (HID) lamps contain a vapor inside a glass lamp coated with a fluorescent powder, but they are much more intense than normal fluorescents. There are two types. Mercury or metal halide HID lamps should not be used, since they have a dangerously strong UV output and filtering can be difficult. High-pressure sodium HID lamps are too intense for direct lighting (and do not provide good color rendering), but they can be used for indirect lighting (i.e., bouncing light off the ceiling) in large storage spaces with high ceilings. Sodium HID lamps have very low UV emissions, which can be further reduced by painting the ceiling with white titanium dioxide paint, a UV-absorber. Sodium HID lamps generate little heat, are efficient, and have low operating costs(Anson,1993,p.27).

Fiber optic lighting is an energy-efficient means of providing display lighting, particularly in exhibition cases. In a fiber optic system, light is transmitted from a light source through glass or acrylic fibers. The fibers do not conduct infrared or ultraviolet light, and unlike fluorescent lamps, fiber optic lighting does not cause buildup of heat within the case (provided the light source is mounted outside the case).

The electrodeless lamp is the newest type of light source. A normal incandescent lamp is subject to the eventual failure ("burn out") of its electrode, which is a piece of metal (usually

and artificial sources of light, having ultraviolet rays, are particularly destructive for paper. Rapid and serious deterioration of paper is caused by the oxidation of cellulose brought about by the ultraviolet rays in sunlight and fluorescent light.

There are two effects of light on paper that result in its ultimate embrittlerment and deterioration. First, it has a bleaching action that causes some whitening of paper and fading of colored papers and certain inks. Second, it causes any lignin, which may be presenting the paper, to react with other compounds and turns it yellow or brownish. This reaction results in newspapers' turning yellow on exposure to light. Certain invisible changes also occur at the same time when these visible effects of light are taking place. Fibers in the paper are broken into smaller to smaller units they are so short they can no longer maintain the bonds necessary to hold the paper together. Some woods bleach under the action of light; some turn "yellow" and some darken. Unfortunately, the reactions initiated by light continue after the source of the damage has been removed(Deptt. Of…, ***Conservation of Book***s, 2005-6 ,pp.43-44).

Sources of Light:

Light has two sources: natural and artificial. Libraries and archives should avoid natural light. Sunlight has a high percentage of ultraviolet. Daylight is also brighter and more intense, and therefore causes more damage, than most artificial light.

The two primary artificial light sources currently in use in libraries, museums, and archives are incandescent and fluorescent lamps. (The term "lamp" is used by architects and engineers to refer to the various types of light bulbs, rather than to the fixtures containing the bulbs.) Driven by the need for energy conservation and cost savings, manufacturers continue to refine lamp technologies to produce longer-lived lamps that consume less energy and provide better light. Compact fluorescent, tungsten-halogen, high intensity discharge (HID), and electrode less lamps have all been developed in response to these concerns.

Conventional incandescent lamps produce light when an electric current is passed through a tungsten filament, heating it to about 2700 degrees Celsius. Incandescent lamps convert only a small percentage of this electricity into light; the rest becomes heat. Conventional incandescent lamps emit very little ultraviolet light and do not require UV filtering. Examples of conventional incandescent lamps include the ordinary household light bulb and a variety of

cellulose (*the basic structural component of plant cell walls*), their interaction with water and their adherence to one another create the strength and flexibility that are characteristic of paper(Harvermans,1995,pp.6-7). The Chinese made the first paper from macerated tree bark, plants and grass in A.D. 105, and sizing (*filling the paper surface to reduce the spread of ink*) had been developed in China by A.D. 700. The art of papermaking traveled from China to Korea (A.D 345) & Japan (A.D 610) and then to the Arab world (A.D 751), where rags were first used as the raw material for the fibers(Agarwal,Berkeshli,1997,p.4).

We are fortunate that most of our history is recorded on paper. Because Books, manuscripts, photographs, documents and many works of art are connected to paper. Like all other materials, paper is also subject to degradation with time. Unless proper care is taken, the graphic records of our historical and artistic heritage do not survive far into the future. ***In other way, any direct or indirect action on a damaged or undamaged manuscript or collection of manuscripts aimed at enhancing the life of the manuscript (s) can be termed as conservation. Paper conservation is a term used to describe preventive and restorative methods employed to ensure the preservation of paper and thereby the history recorded on it***(Deptt. Of…,2005-6 ,pp.14-15). Unfortunately, most people do not recognize a potential problem until severe damage has already occurred. This information is offered to help you understand the challenges that paper faces and the possible remedies. Paper, is by its very nature, fragile. Paper can last for centuries if it is properly made but it is highly susceptible to damage caused by environmental conditions, insects, and people. Various internal and external factors are responsible for the deterioration of paper. The internal factors are based on the raw materials used for preparing the paper, which can hardly be changed. The external factors include the environment to which paper is exposed. The more important among the factor responsible for deterioration of paper are: (**1**) Light (**2**) Temperature & Humidity (**3**) Air Pollution (**4**) Insects (5) Handling & Storage. However, here, our focus is on photochemical effects on paper, and the mechanism of photochemical degradation and the measures to be adopted to control the destructive effect of light and heat on paper. Light, especially sunlight, direct or indirect, has a serious damaging effect on written or printed paper materials like documents, manuscripts, books, maps, sketch diagrams etc. One of the most important factors responsible for yellowing of white paper, fading of dye of the colored paper and fading of ink used for writing on the paper is light. It is also responsible for weakening and producing brittleness in paper. Sunlight

Protection of Archival Documents from Photochemical Effect

Syed Mohd Amir[1]

Archival documents are unique in nature, not only are they the only surviving copies but also they throw light on the period in which they originated. They should, therefore, be so restored as to preserve them for years to come. Through the centuries humankind has diligently recorded its efforts to perpetuate the inquisitive spirit, fortify history and culture, and illuminate the paths of future generations. Writing materials, of which library & archives collections are composed, have played a very prominent role in the development of cultures. They have helped not only in preservation of the history and culture of mankind, but also influenced the script, language as well as people's mode of thinking. Today paper is the main material used for writing throughout the world. But its origin was not in India. The paper as it is used today was a Chinese invention and the word 'paper' is derived from the Greek word papyrus, the tall paper- reed plant once very common in Egypt(prajapati,1997,pp.31-33) . The word Kaghaz (paper) has Persian origins. Paper has been in use in India only for about a thousand years. Before that, the main writing materials in our country were parchment, birch-bark, palm- leaves and copper- plates. Besides these, agaru-bark, bricks, earthenware, shell, ivory, cloth, wood etc. were also used for writing.

We know that paper is made by forming a felted mat of intertwining fibers. This is done by passing a liquid suspension of the fibers through a screen. When the water drains away the sheet is removed from the screen and allowed to dry. Because the fibers are mainly

Keywords:

light, photochemical degradation, ultraviolet rays, protection, precautions, controlling measures, records, archives

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■ Protection of Archival Documents from Photochemical Effect

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Purpose: The purpose of this paper is to highlight the destructive effects of light on archival documents/paper materials. The research aims to explain the mechanism of photochemical degradation and the damaging effect of light on paper. It also tells us about the measures to be adopted to control the deteriorating effects of light on paper step by step.

Design/Methodology/Approach: The research is descriptive. It methodically divides the whole article into different paragraphs i.e. causes, effects, controlling measures, and precautions, etc with the significance of paper and its conservation from time to time. The approach is very objective in nature.

Findings: The finding of the research indicates that archival papers are very important documents, fragile in nature. They should be properly kept, handled and preserved according to the rules of archival laws. Photochemical effects of light and ultraviolet rays are very dangerous for these documents. Prevention is better that cure. It is our prime duty to safeguard records. Ignorance is dangerous but negligence is unpardonable.

Conclusion: After studying this research, the reader hopefully gains a better understanding about the damaging effects of light on archival material, preservation and conservation and how it affects archival collections. A sound preservation plan which includes environmental and storage conditions and a disaster plan will give any collection a solid base on which to survive. Knowing the details of various conservation treatments should help the archivist make decisions on how best to deal with damaged items in their collections. In either case, knowledge is power and with this power the archivist can help make their collections last for generations to come without the fear of their damage. Both preventive and curative precautions must be taken to protect archival documents from deterioration and to bring them back as close as possible to their original strength, flexibility and legibility. Thus, we reach to the conclusion that we must protect archival documents from any sort of damage at any cost.

Archival Studies

Ganjine -ye Asnad: Vol.21, No.2, (Summer 2011), 12 - 24

Received: 3 Feb 2011 ■ Accepted: 5 Jul 2011