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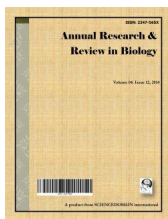
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Annual Research & Review in Biology

20(1): 1-10, 2017; Article no.ARRB.36605
ISSN: 2347-565X, NLM ID: 101632869

Library Materials and Human Health: Vulnerability and Preservative Measures

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Authors' contributions

This work was carried out in collaboration between both authors. Author POI designed the study, performed the statistical analysis, wrote the protocol and wrote the first draft of the manuscript. Author PAM managed the analyses of the study and the literature searches. Both authors read and approved the final manuscript.

Article Information

DOI: 10.9734/ARRB/2017/36605

Editor(s):

(1) George Perry, Dean and Professor of Biology, University of Texas at San Antonio, USA.

Reviewers:

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(3) Durdana Rais Hashmi, Pakistan.

(4) Izhar-ul Hasan, India.

Complete Peer review History: <http://www.sciencedomain.org/review-history/21968>

Original Research Article

Received 2nd September 2017
Accepted 20th October 2017
Published 18th November 2017

ABSTRACT

This manuscript documents a study on the materials and users of selected libraries in Nigeria, with a view to providing vital information on the effects of library-associated organisms on the library materials, and the health of people in its proximity. The study evaluated the modes of action of library-associated biotic (living) and abiotic (non-living) factors, stated the impacts of the activities of the organism(s) on library materials and users, and investigated the prevalent environmental factors necessary for the well-being of the organisms. The modes of action of the non-living degradation agents were also analyzed and preventive measures were implemented accordingly. Non-biodegradable library materials made from synthetic or inorganic sources might be a degradation-free option but on the other hand manufacturing of synthetic products would aggravate environmental pollution challenges. Organisms in the library depend on the ambient conditions to thrive, therefore strategic regulation of the library environment is important. Safety of library users and library materials can be guaranteed by the recommended precautions which were based on the study of the organisms.

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Keywords: Library materials; library users; degradation agents; allergic; preservative measures.

1. INTRODUCTION

What the library represents i.e., the very essence of library to humanity is the appreciation of learning. According to the Oxford's advanced learners' dictionary library can be defined as a building or room in which collections of books, CDs, newspapers, and other information storage materials are kept for people to study or borrow. A library is a repository of intellectual heritage of all fields.

Man's insatiable quest for knowledge and storage of information has made his social life intricately entangled with the library. However, the library is susceptible to attacks from a myriad of biotic (living organisms) and abiotic (non-living things). These are factors which degrade the storage materials, decreasing their usability. People are susceptible to these threats due to their use of the library. Understanding the biology of library-associated organisms provides basis for development of preservative measures. Studies have shown that organisms which degrade library materials [1] also impact the health of librarians and library users.

1.1 Types of Library Materials

Library materials come in different forms which offer users varied levels of durability, usability suitability and portability. All the forms have their specific hazard susceptibilities; therefore each has its unique way of preservation from these biological hazards or other factors causing deterioration.

1.1.1 Soft copy or electronic materials

1. A soft copy which can also be referred to as electronic or digital copy, is the unprinted digital document which can be viewed through an appropriate computer editing program such as productivity programs e.g., Microsoft packages such as Microsoft Word, database programs like Microsoft Access, Microsoft Excel, or presentation software like Microsoft Power Point, and other tools for videos, audios etc. Electronic files can be transported from one computer or device to another [2] through file transferring channels such as the internet, USB drives, Bluetooth etc. There appears to be a shift of preference to electronic documents over their printed counterparts [3].

This is due to the portability, duplicability, transferability, and editability of electronic document. However, the electronic documents are not free from hazards and require preservative measures. The various electronic devices have memory compartments or storage devices which are of varied sizes (measured in bytes) and the capacity to contain the electronic files. These storage devices are susceptible to computer viruses [4].

1.1.2 Printed or hard copy materials

Hard copies are tangible library materials containing readable printed texts. Such materials comprise of book/ paper, board, cloth, leather, thread, ink, adhesive etc. The basic constituents of the physical entity of most library materials are organic in nature, and are susceptible to degradation and/ or deterioration [1]. Library materials need protection from deterioration. However, most library materials are mainly books therefore much emphasis shall be laid on the deterioration factors and preservation methods of paper materials. The different types of deterioration of the paper-based materials are acidification, wear and tear, shrinkage, cracks, brittleness, humidification, warping, infestation, biodegradation, discoloration, abrasion, perforations, and dust and dirt deposition, etc. These processes shall be described in subsequent sections.

1.2 Significance of the Study

The study is aimed at improving the sense of value of library materials. The study encourages the appreciation of material information as vital to all aspects of human information on history, religion, science and technology, medicine, law, geology, etc. The study also promises to be a reference guide to librarians or information scientists, private library owners, and archivists. It is a source of information on preservation and conservation of library materials and protection of human health. This study will emphasize hardcopy biodegradation agents and their impacts on health. The study itemizes the major hazards that compromise the quality of library materials and pose potential threats to health of library users and librarians.

The idea being to encourage library stewardship and instilling affordable protective measures. This study investigates observes and identifies

the organisms that cause degradation of library materials and impact human health.

The specific objectives of this report are as follows:

1. To implement a study on the materials and users of selected libraries in Nigeria, with a view to providing vital information on the effects of library-associated organisms on the materials and the health of people using library materials.
2. To evaluate the modes of action of library-associated biotic and abiotic factors.
3. To state the impacts of the activities of the organisms on library materials and library users.
4. To investigate the environmental factors responsible for the well-being of library-associated organisms.
5. To manipulate the storage conditions to mitigate the prevalence of the organisms by recommending simple and affordable methods.

2. CASE STUDY

Respondents were recruited into the research study from the University of Benin Library, the

Ambrose Alli University Library, the Edo State Library, the Lagos State University Library and the Obafemi Awolowo University Library. Recruitment criteria were based on the responses from the study respondents. These criteria were presented as simple questions which formed the basis of the study.

2.1 Research Questions

1. How often do respondents use the library effectively?
2. What habits do the library users portray while using the library materials?
3. Are there any sanitary practices after the use of the library? If yes, what are they?
4. Are there any health challenges within period of library use? If yes, state them specifically?

2.2 Ethical Consent and Quality Assurance

A total of 200 respondents (male and female) were recruited from each sampled location. The consent of all correspondents was sought by thoroughly explaining the purpose of the study and its impacts on their health and safety of the library.

QUESTIONNAIRE ON USE OF LIBRARY MATERIALS

The questionnaire was created to analyze and investigate the relationship between habits of library users and possible exposure to contaminants. Findings of the study shall serve as basis for recommendation of guidelines in safe use of library materials.

USER'S INFORMATION

Name of Library:

Occupation of library user:

Gender:

Kindly mark the correct options below:

1. DO YOU WET YOUR FINGER BEFORE FLIPPING A PAGE?
(A) YES (B) NO
2. DO YOU INSERT YOUR PEN IN YOUR MOUTH DURING STUDY?
(A) YES (B) NO
3. DO YOU SANITIZE YOUR HANDS AFTER USING LIBRARY MATERIALS?
(A) YES (B) NO

Fig. 1. Template of questionnaires distributed to respondents

3. FIELD OBSERVATIONS

Results from questionnaires of the library users in the Nigerian universities showed that 62% (finger wetters) of total library users in Nigeria are in the constant habit of flipping through pages of books with the aid of their saliva (Fig. 2).

The wet finger can become contaminated with the excretion of the mice on the pages of the book along with other diseases from other book-dwelling organisms. Upon rewetting the finger with saliva, the contaminated finger is put into the mouth and this provides for the pathogens access into the secondary host (man). As seen in Fig. 2, 14% (pen biters/ chewers) of total library users have the habit of putting their pen in their mouth when they encounter challenging areas in the course of their study. In the process of brainstorming, they tend to bite the base of their pen; which might have been earlier contaminated by the soiled book. Approximately 8% of users (overlap; finger wetters and pen chewers) fall in the group of people who combine both habits of wetting their finger with saliva and biting their pen. This is the most susceptible group. Data obtained from Lassa fever (transmitted by

multimammate mouse) patients from Central Hospital, Benin City, showed that 92% of library users among the patients were finger wetters and/ or pen biters. Only 16% of library users do not fall in either category of pen chewers of finger wetters. However, 88% (14% of total users) of the 16% who are neither finger wetters nor pen chewers do not wash their hands after using the library. Only 12% (2.9% of total users) of the 'no habit' group wash their hands, and are free from all library exposure to diseases. Pathogens either directly enter the mouth of the non-sanitizers from the contaminated hand or the hand contaminates food eaten by the library users thereafter. Approximately 97.1% of library users within the area of study (Nigeria) are at risks of contacting disease contraction and might have contributed to the prevalence of major diseases such as Lassa fever in the urban areas in West Africa. This suggests training library patrons on the safe use of the library with respect to their hygiene habits.

4. DISCUSSION

Any factor which threatens the usability and suitability of library materials is a degradation factor.

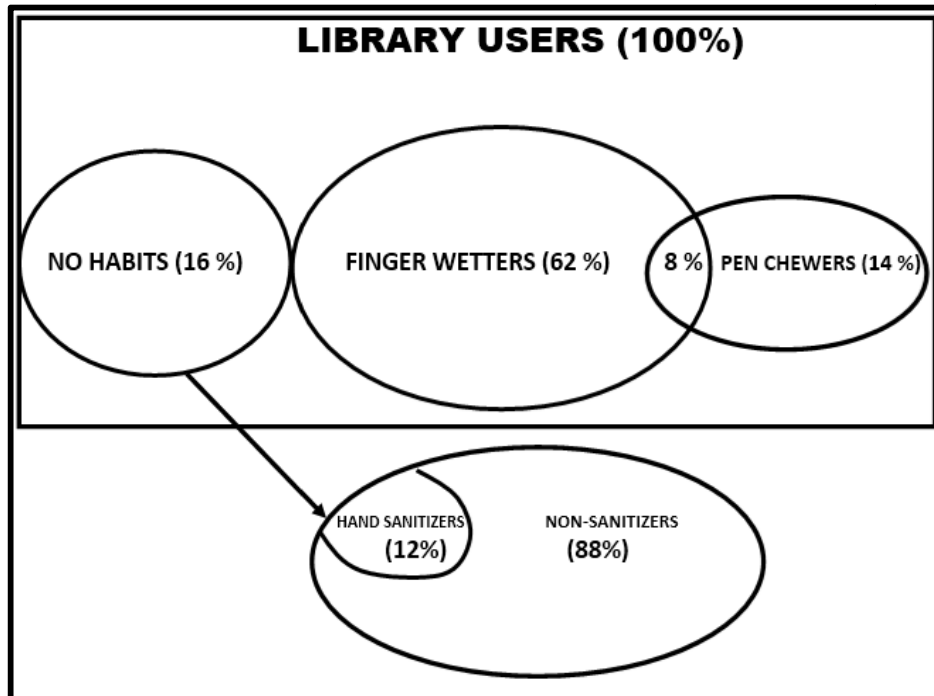


Fig. 2. Percentage of vulnerable and invulnerable library users

Hardcopy library materials face degradation that compromises its suitability for use. There is an imperative need to identify the factors that initiate and encourage this degradation. Degradation agents for hard copy materials can be grouped into biotic and abiotic factors. Biotic factors are organisms that feed on library material components such as cellulose and lignin. While abiotic factors are the physical and chemical (non-living) factors. The factors are grouped into environmental and biological factors.

4.1 Abiotic (Non-living) Factors

The abiotic factors or non-living factors are the ambient or atmospheric conditions (physical and chemical) surrounding the library materials. In unfavorable atmospheric conditions, the prevailing micro-climatic factors compromise the suitability of library materials for use [1].

4.1.1 Ultraviolet radiation

Ultraviolet rays from the sun serve as catalyst to many chemical reactions and this applies to constituents of paper such as lignin, cellulose, gelatin, starch etc. which are complex carbohydrates. Cellulose is the chief constituent of the cell walls of plants is a major component of fibrous plant products such as paper, linen fabric, cotton, etc. In the presence of oxygen, ultraviolet radiation catalyzes the photochemical oxygenation of cellulose [1]. Consequently, the long carbon chains of constituent cellulose are broken down, forming oxycellulose. This affects the flexibility and printability of the paper therefore the paper becomes weak and brittle. This also has a chromatographic effect on color pages disintegrating the colors and causing yellowing of the paper. Artificial lights such as fluorescent lights used in libraries also have impacts on the texture of books. Both natural and artificial light sources have photochemical degradation impact on paper materials. The basic unit of measurement light intensity is the Lux (1 lux = 1 lumen per square meter).

4.1.1.1 Preservative measures

Reading light should not be too bright while storage light should be relatively dim.

4.1.2 Humidity

Humidity can be defined as the amount of water in the form of vapor (water in the gaseous state) in the atmosphere. It can also be expressed in

simple terms as the degree of wetness of air. The wetness of the air around library materials has a vital role to play in their conservation. When the relative humidity of the library environment is relatively high for instance (above 60 percent), and the temperature of a library material is lower than the temperature of ambient air. Some amount of water in the air condenses on the surfaces of the library materials. Paper has a very high absorption tendency to moisture. This dampens the paper creating suitable environmental conditions for the generation of some micro-organisms which further aggravates the situation [5]. This shall be discussed in subsequent sections. A certain level of relative humidity is required for conservation of the constituent fibers of paper. Relatively humidity as high as 60% and above is unadvised and strictly discouraged [1]. It initiates physical, chemical and biological degradation of paper. It also weakens the general frame work of books, dissolves the adhesive that binds its spine, sticks pages of the book together and it smears the text rendering books unreadable [6].

4.1.2.1 Preservative measures

The relative humidity of the library environment should be kept between 45% - 55%. The lower the relative humidity within this given range, the better [1]. The relative humidity can be regulated using a dehumidifier. Before the use of this instrument, the actual relative humidity must be ascertained with the use of a hygrometer. The unwanted humid still air can be removed by opening up the library windows and moving the air with the use of electric fans.

4.1.3 Atmospheric temperature

Oxford Learner's Dictionary [7] defined temperature as the degree of hotness or coldness of a place or thing. The basic unit of measurement of temperature is Degree Centigrade (°C). This can be measured with the aid of a thermometer.

Light bulbs used for lighting the library increase room temperature. High atmospheric temperature in conjunction with relative humidity below 40% causes dehydration of cellulose fibers. The longevity, usability and flexibility of paper are compromised and consequently such paper becomes brittle. High temperature and relatively high humidity on the other hand create suitable condition for the growth of Molds and other organisms. A thermohygrograph is a

mechanical or electrical instrument used to measure the atmospheric temperature and relative humidity of the library simultaneously to help and regulate the atmospheric conditions of the library materials.

4.1.3.1 Preservative measures

The room temperature of the library can be regulated with aid of electric fans, air conditioner or with natural cross ventilation.

4.1.4 Particulate matter

The air also contains fine or microscopic sand particles, smoke and other suspended particulate matter. These particles are so minute that they are carried in the air and they settle readily on the surfaces they come in contact with. From a mechanical point of view, when the sand outside the library is disturbed, some of the fine particles are lifted into the air. The air conveys the particulate. The lighter particles move faster and travel farther. These fine suspended particulates find their way into the library through the windows and doors. Some are tracked into the library by the feet of the library patrons. The circulation of the particulates is enhanced by electric fans in the library. They land on the surfaces of books where they accumulate over time until they affect the books and health of the users. The dust is reintroduced into the air when the library users pick up the books. The particulates end up in the upper respiratory track of library users through inhalation.

A library environment unprotected from dust particles can lose its materials to abrasion [1]. The process of abrasion occurs when the fine particles on the surfaces of library materials are acted upon by circulating air and gravitational force simultaneously. While the force of the air tends to move them horizontally on the surfaces, the force of gravity tends to keep them at same spot. The result is the generation of minute frictional forces causing wear and tear on the surface of the materials. The degree of abrasion is a function of the amount of dust deposition and its duration [6]. When both factors are optimum, the consequence on the material is severe. Furthermore, dust deposition works in concert with moisture in the air. There are several gases in the air e.g. oxides of carbon, sulfur, and nitrogen which have a corrosive effect on book materials. The severity of the effect depends on the level of air pollution and the proximity of the library materials to the source of pollution.

4.1.4.1 Preservative measures

The source of dust particles is the sand outside the library. It finds its way in through the windows, doors, and feet of library users. The following preservative measures should be taken in order to ensure protection of library materials from particulate matters.

- 1) The library doors should be kept closed at all times and the windows should be dust-proof with nets having a very small mesh size (as low as 0.25 μm). This is very important in order to filter the dust particles and prevent them from entering the library.
- 2) The windows should be kept closed while the indoor temperature is regulated with air conditioner. The windows should only to be opened to regulate the relative humidity.
- 3) Librarians should ensure that visitors remove dust from their feet before entering the library. Information should be made available to library users to make them aware of this.
- 4) Library materials, floors, surfaces and furniture should be regularly (at least four times a week) cleaned, and face mask should be worn during the cleaning.

4.2 Biotic (living)/ Biological Agents

Biological degradation agents are a group of organisms for whom key components of books such as cellulose and lignin, have nutritional value. Examples of such agents are micro-organisms (fungi or molds, mildew and bacteria), and rodents and insects such as cockroaches, booklice, and silverfish [1].

There are sets of environmental or atmospheric conditions that are suitable for supporting these organisms [5]. These organisms cause damage to library materials and also have far reaching health implications. In-depth study of the biology of these organisms is therefore imperative.

4.2.1 Mice and rats

Mice belong to a group of animals generally called rodents, e.g., house mouse (*Mus musculus*), European harvest mouse- *Micromys minutus* (Pallas, 1771), multimammate mouse- *Mastomys natalensis* (Smith, 1834) etc. They are often confused with rats; which are larger in size. They are responsible for food shortages [8], degradation of library materials, and disease distribution to people, etc. Generally, male

rodents are called bucks, unmated females are called does, pregnant or parent females are called dams, and infants are called kittens or pups. Pups are notorious, due to their ability to access domestic compartments as a result of their flexible, small bodies. Mice gain access from the outside into the library through perforations in the roof, doors, windows and other openings in the building [8].

They are often referred to as commensals, because as opportunistic survivors, they live with and/ near humans. Mice are vectors for a number of pathogenic diseases that cause morbidity and mortality to man. They cause damage to library books by eating up the edges of the pages. In the process they contaminate the pages with their urine and feces. Diseases could be transmitted to library users through contact with the feces and urine of the infected mice. The most prevalent of the mice-mediated diseases in Africa is Lassa fever or Lassa hemorrhagic fever (LHF), which is an acute viral hemorrhagic fever; caused by the Lassa virus. The Lassa virus was first identified in 1969 in Lassa town, Borno State of Nigeria. Other debilitating diseases can also be contracted by humans from mice in the library environment [9,10].

The implication of this epidemiological information of mice and rats on the investigated library users in the current study is that only 12% (2.9% of total users) of the 'no habit' group are free exposure to these diseases. 97.1% of the total library users are liable to be exposed.

4.2.1.1 Preventive measures

It is important to protect library users from direct and indirect contacts with these biological degradation agents [11]. Hand wash basins or sinks should be provided in the library, with conspicuous instructions for library users on the necessity in hand sanitization. Samples from the materials in the library should be collected and analyzed regularly in the laboratory for pathogens. Experimental observations have shown that Integrated Pest Management (IPM) is the most reliable method of rodent control [12].

4.2.2 Insects

Insects are a group of small creatures with jointed appendages and an exoskeleton (external skeletal structure) made of cuticle. They belong to the class arthropoda and are referred to as

arthropods. Insects are the most successful group of creatures due to their existence in all areas of the earth [1].

Insects such as ants visit buildings and return to their nest, leaving a trail for others to follow. They are of major concern because in the process of traversing their nests and buildings, they pick up germs, bacteria and other parasitic diseases from the outside environment. And when the insects attack library books the parasitic diseases on their body can impact the health of those who come in contact with the books. Insects that attack library books include bookworms (Order: Coleoptera), booklice (Order: Psocoptera), silver fish (Order: Thysanura), etc. Constituents of paper, such as cellulose and resin have high nutritional and medicinal values for insects respectively.

Insects foraging on these library materials cause damages by boring holes, chopping off edges, and staining pages with excreted wastes. They eat the resins binding up books. There are certain atmospheric conditions that are suitable for insects. The insects become prevalent in the rainy seasons, and their abundance indoors is enhanced by relatively high humidity or moist environments [6]. Lice are known to be vectors of certain parasites to man, but no parasite have been found to be associated with booklice, and they are sometimes referred to as pseudo lice [6].

Common silverfish- *Lepisma saccharina* (Linnaeus, 1758) are group of insects that can be identified by their segmented, shiny, silvery grey, scaly, elongated and fairly flat body that tapers at the end. They are small wingless insects which possess two long antennae at the tip of their head and three long bristles at the posterior part of their body. Like other insects, a silverfish has three pairs of legs (six altogether). Adults are a quarter inch to half an inch long. Their major diet is starch and this explains their hunt for cellulose in books. They wriggle intermittently through book pages, foraging for cellulose. This leaves the book in fragmented pieces with an uninviting odour. The life span of silverfish spans from 2 to 8 years, depending on how favorable the library environment is. They thrive best in dark, humid, or moist environments [1]. A major book-eating insect is the tiny (under 1 mm) soft-bodied wingless *Psocoptera*s (usually *Trogium pulsatorium*), generally referred to as book or paper louse. They feed on microscopic molds and other organic matter

found in poorly maintained library materials i.e. in poor conditions such as cool, damp, dark and undisturbed corners of the library [6].

4.2.2.1 Preventive measures

The following are simple measures that can be taken to prevent insect invasion of the library and facilitate the preservation of library materials:

- 1) Destroying ant hills around the vicinity of the library may be helpful.
- 2) Lower the relative humidity below 50 %. This can be effectively achieved with the aid of a dehumidifier.
- 3) Most of the insects require cool still air, dark and damp conditions, therefore simply eliminating these conditions, i.e., keeping the library temperature regulated and circulating the air around the books with the use of electric fans can be helpful.
- 4) Affected books should be dried, dusted, and gently wiped using soft bristle brushes. The best way to treat the books is to expose them to direct sunlight for 2 to 5 hours, depending on the intensity of the sun. This simple method has proven to be effective and promising.
- 5) Chemical methods of insect control have shown good results in managing the pests in library materials. The major disadvantage of chemical method of insect control is the effects of the chemicals on non-target organisms, e.g. humans.
- 6) Recent findings have shown that Integrated Pest Management (IPM) are the most efficient, ecological and sustainable control of insects in libraries [13].

4.2.3 Mold and mildew

Mold and mildew are species of fungi which produce spores found on moist surfaces such as damp books in warm environments. Mold spores are black or sometimes green, while mildew spores are either gray or white [14]. There are about 16 mold species which cause allergic symptoms by secreting allergenic substances called mycotoxins that irritate the upper mucous membranes and upper respiratory system causing symptoms such as rhinitis, cough, sneezing, asthma, etc. [15]. In extreme cases, mold's impact may lead to bleeding, damage to internal organs, mental impairment, cancer, and death. However, such toxicity incidences of molds are rare and scanty information exists. The mold which has the highest toxicity

potentials is called *Stachybotrys chartarum*, also referred to as toxic black mold [1]. Black stains on book pages is indicative of black mold spores on book pages are released into the air as users flip through infected pages. The affinity of mold for biological membranes such as sinuses, particularly upper respiratory membrane is important [16,17].

Older and immuno-compromised people (particularly asthmatic patients) are highly susceptible to the consequences of mold infections which include hay fever, cold or flu-like symptoms, coughing, sneezing; sore; irritated, and itchy throat; rhinitis; nasal congestion; sinus congestion; recurrent headaches; uneasy breathing, and wheezing, particularly in asthmatic individuals [18,19]; itchy skin with associated rashes; irritated watery red eyes, and; hair loss and baldness. In extreme cases lung disease called pneumomycosis extrinsic asthma, and liver and kidney cancers have been reported. Common species of mold often encountered in libraries include *Aspergillus niger*, *A. flavus*, *A. japonicas*, *Cladosporium cladosporioides*, *Penicillium chrysogenum*, *P. citrinum*, *P. janthinellum*, *P. janczewskii*, *Curvularia eragrostidis* etc [20].

The wide spectrum of diseases caused by this species can be attributed to the relatively large size of its spores which get stuck in the upper respiratory tract, causing severe respiratory complications. The toxins produced by these molds have the ability to suppress the immune system; affecting the lymphoid tissue and the bone marrow. Besides inhalation through the respiratory system, toxins excreted by molds may also infect library users through oral contamination. This mechanism of infection is also highly associated with the habits of library users (Fig. 2). Laboratory rabbits under controlled conditions, injected with mold toxin, exhibited necrosis and hemorrhage within the brain, thymus, spleen, intestine, lung, heart, lymph node, liver, and kidney.

Mildew on the other hands, grows on materials with a high cellulose content and a low nitrogen content, explaining its high affinity for books. There is dearth research experiment on the toxicity impacts of mildew on organisms.

4.2.3.1 Preventive/ preservative measures

Humidity (amount of moisture in the air) is the major factor that determines the growth and

survival of mold and mildew. Environment with a relatively high humidity (above 55%) i.e. provides favorable conditions for mold and mildew, especially in the dark with still air [21].

The following are few simple precautions which offer protection of libraries from these enemies of library users:

- 1) Due to preference of mold and mildew for still air, electric fans such as standing fans, ceiling fans etc. should be in circulate the air in the library environment.
- 2) The environment should not be kept dark for too long, so as not to provide a favorable condition for growth of mildew [22].
- 3) The preference of mold and mildew for warm atmospheres necessitates the use of air conditioner in the library, so as to regulate the temperature.
- 4) Due to the fact that mold and mildew thrive best at relative humidity above 55%, dehumidifier can be used to regulate and maintain the humidity of the library.
- 5) Library materials should be dusted with a clean and dry piece of cloth regularly, at least 2 to 3 times a week, depending on the size of the library. This will prevent accumulation of spores in book surfaces. During these cleaning activities, library keepers should ensure to keep their nose and mouth protected with a face respiratory protector.

5. CONCLUSION

Use of non-biodegradable library materials made from synthetic or inorganic sources might resolve preservation challenges but on the other hand manufacturing of synthetic products would create more environmental pollution challenges. Organisms in the library depend on the ambient conditions to thrive, therefore strategic regulation of the library environment is important. Safety of library users and library materials can be guaranteed by the recommended precautions which were based on the study of the organisms.

ACKNOWLEDGEMENT

We profoundly appreciate the unparalleled financial support rendered by the Covenant University Centre for Research, Innovation and Discovery (CUCRID).

COMPETING INTERESTS

Authors have declared that no competing interests exist.

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