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# Evaluation of Deterioration of Library Materials at Olabisi Onabanjo University Library, Ago-Iwoye, Nigeria

**O.M. Bankole**
*Olabisi Onabanjo University Library*
*P.M.B. 2002, Ago-Iwoye, Nigeria*
olubankebankole@yahoo.co.uk

*and*

**Abiola Abioye**
*Department of Library, Archival and Information Studies,*
*University of Ibadan*
*Ibadan, Nigeria*



## Abstract

*The nature and extent of deterioration of four categories of library materials (newsprints, textbooks, dissertations and journals) at Olabisi Onabanjo University Library, Ago-Iwoye, Ogun State, Nigeria was investigated. The pH, fold endurance and the extent of mutilation were determined, while the microorganisms associated with decomposing library materials were isolated and identified. The library materials with acidic papers constituted 69.0% for textbooks, 52.2% for journals, 73.2% for dissertations and 85.3% for newspapers. About 93% of textbooks, 98% of journals and 89% of dissertations did not break up to six folds. The percentage of mutilated books was 11.9% for textbooks, 5.7% for journals and 10.4% for dissertations. The microorganisms associated with deteriorating library materials were Bacillus sp., Streptococcus sp. Staphylococcus sp., Pseudomonas sp. and Flavobacterium sp. for bacteria, while the moulds included Aspergillus niger, Aspergillus flavus, Aspergillus fumigatus, Penicillium sp., Cladosporium sp., Neurospora sp, Penicillium sp and Rhizopus sp. The ability of these microorganisms to degrade (utilise) native cellulose (filter papers) was investigated so as to be able to know whether these organisms could actually deteriorate papers. All the moulds except Neurospora sp. effectively utilised filter papers than the two bacterial species Bacillus sp. and Pseudomonas sp. that also degraded filter papers. A. niger and A. flavus most utilised the filter papers for growth among the moulds. Apart from the deteriorative effect, the health implications of the presence of microorganisms particularly the moulds on library materials to library users are discussed.*

## Introduction

The papers produced before the 19th century were made from fibres such as linen, cotton or rag flax with relatively few additives for the production of small quantities of physically and chemically strong papers that could withstand the wears and tears of age (Hunter, 1978). The additives in use then, animal glue and gelatin sizing or coatings, help the long-fibred papers to accept ink without bleeding. The increasing use of paper resulting in increased demand led to the development in the mid-nineteenth century of more efficient paper making technology with less durable papers. Ground wood pulp that is widely available and inexpensive replaced rags and linen for paper production. The mechanical grinding of wood during

manufacturing processes create short paper fibres, which is also highly acidic due to the retention of wood lignin. Lignin is a natural constituent of wood that darkens and decomposes to acidic products with time. The additives in use such as alum/rosin and chlorine bleach weaken paper resulting in the increased acidity, discolouration and brittleness of the paper.

Chemically, modern paper is made from cellulose and water with small amounts of organic, inorganic and dye additives (Paci *et al.*, 1995). It is perhaps one of the oldest and most used man-made materials. Paper deterioration refers to the loss in the quality of paper materials, which reduces its ability to carry out its intended function (Wessel, 1972). Williams (1971) observed that libraries nowadays have become hospitals for sick books and, in many cases, not much effort is devoted to treating these patients and books are not lasting as they should.

The degradation of paper may be due to different causes such as biotic factors and or chemical attack. The biotic factors are the living agents involved in the deterioration of library materials, and these include microorganisms (bacteria and fungi), insects, rodents and man (Harvey, 1992; Igbinosa, 2000). The biotic agents are the most important cause of paper deterioration in the humid tropics because the prevailing high ambient temperature and relative humidity provide excellent conditions for their proliferation and destructive activities (Davey and Elcoate, 1965). In chemical terms, the degradation of paper is essentially the conversion of fibrous or highly crystalline cellulose into a largely amorphous or degraded material. Such conversion is often of different, complex processes of which acid hydrolysis is by far the most important (Proietti *et al.*, 2004). However, the biological and chemical factors are interrelated because humid conditions and high temperatures (abiotic factors) favour the growth of moulds (biotic factor), and accumulation of dust and dirt (abiotic factors) will attract insects (biotic factor). The rate of book deterioration is particularly high in tropical countries where factors that aggravate deterioration are at optimum. All the factors that cause paper deterioration: physical (acid, heat, humidity, light), biological (moulds, insects, rodents) and careless handling methods are more pronounced in Africa than elsewhere in the world (Mwiyeriwa, 1988). Of the 2,511 total book acquisition of the University of Ghana in 1986, up to 600 books that were disintegrating physically were taken to the bindery section for repairs; and there were still many more disintegrating books on the shelves that had not been identified (Akussah, 1991). Mwangi (1994) reported that about 33.3% of bibliographic collections in selected Kenyan libraries had pH less than 4, and thus stood the risk of acid hydrolysis. Alegbeleye (1996) found that 67% of the Africana collections at the University of Ibadan had undesirable level of acidity (pH less than 5.4). According to Zyska (1997), while considerable effort has been devoted to research on degradation of library materials in Europe, there is paucity of such information on library materials in Africa. Zyska (1997) further stated in the review of fungi isolated from library materials that fungi of library materials in Africa are completely unknown.

The objective of this study was to determine the nature and extent of deterioration of library materials at Olabisi Onabanjo University (OOU), Ago-Iwoye, with emphasis on the role played by microorganisms. The University library started in January 1983 in a few classrooms before it was relocated to a temporary building that was completed in the latter part of 1983. At the time of this study, the library had a main library and a separate law library in Ago-Iwoye, Sir Hassan Odukale Library at the Permanent Site for the Faculties of Arts and Social and Management Sciences, and the College of Medicine Library at Sagamu for the Pharmacy and Medical students. Specifically, the study sought to determine the:

i level of acidity or alkalinity of the library collections;
ii proportion of brittle collections in the library;
iii proportion of collections that has tears or has been mutilated; and
iv types of microorganisms associated with deteriorating library collections and investigate the role of each organism in causing deterioration *in vitro*.

## Methodology

The survey of the extent and nature of deterioration of library materials at Olabisi Onabanjo University Library, Ago-Iwoye, Ogun State, Nigeria was carried out from April to July, 2002. At the time of the study, the total collections in the library were: textbooks and pamphlets, 45,232 volumes; theses and

dissertations; 3,912; journals, 18,962 volumes (2,774 titles); and the number of newspapers, 14,422.

The stratified random sampling (Peterson, 1985) was adopted to select library materials for the investigation. The materials were organised into homogeneous units and randomisation was now applied to each stratum. The samples of different library materials included in the study were textbooks, 1,265; journals, 230; dissertations, 280 and newspapers, 150.

The nature and extent of deterioration of the library materials was carried out by determining the level of acidity/alkalinity, the level of folding endurance, extent of mutilation, and by isolating the microbes associated with deteriorating materials. These four methods have been found to be very reliable determinants of the durability of library materials.

## Tests Used for the Study

*Determination of Acidity/Alkalinity.*

The acidity/alkalinity test was carried out by determining the pH of the paper materials. pH is a measure of the hydrogen ion concentration of a substance. Acids have pH values below 7 (1 – 6), while alkaline have pH values above 7 (8 – 14). The pH value is a very reliable determinant of paper permeance and durability.

The pH was measured by placing a drop of distilled water on the portion to be tested, and then the pH indicator was brought into contact with the tested portion. The colour that appeared in the indicator was compared to the colour on the standards of the plast box. After the test, a small tissue paper was put on the portion tested to dry the surface.

*The Folding Endurance Test*

The degree of brittleness of the materials was determined by the fold endurance test. The higher the number of folds that paper could survive, the less brittle the paper. Paper materials that are brittle could not be subjected to much circulation and photocopy. The top corner of the last page of each material was folded twice to obtain one double fold, then it was folded twice in the opposite direction. Further repetition of the folding in alternate direction was repeated up to the sixth fold. However, folding was terminated immediately any little breakage was observed in the corners even before the sixth fold. The fragile nature of newsprints did not allow us to carry out the folding test. The folding endurance test would have been made to proceed more than six folds but the library authority did not permit us to carry out the exercise beyond this level.

*Determination of the Extent of Mutilation*

The extent of mutilation of library materials is a very good indicator of the carefulness of librarians and users in the handling of library materials, though some other factors such as moulds and insects could cause mutilation. The growth of moulds could lead to the production of spores, which would impart colouration to library materials, while insects such as cockroaches could create holes in books and their excretory materials may give rise to stains.

To determine the extent of mutilation, five pages in each of the materials were randomly opened and observed for stains, scribbling, tears or marks. The percentage of mutilated materials in each category was calculated from the number of mutilated materials over total number of materials samples.

*Isolation of Microorganisms from Library Materials*

The library materials that had visible evidence of deterioration were used for the investigation. These materials had been removed from the shelves and they were packed in one room in the library. The media used for the cultivation of microorganisms were nutrient agar for bacteria and potato dextrose agar (PDA) for fungi. Appropriate quantities of the powders were dissolved in distilled water, and sterilised in the autoclave at 121°C for 15 minutes. Small portions (1cm) were cut from the deteriorating materials and placed on the agar. Fifty cut tissues were placed on petri dishes for each type of library materials. For the control, the media were left without any deteriorating paper materials on them. The petri dishes inoculated with the cut papers were placed in the incubator at 27°C, and examined for microbial growth after the incubation period. Nutrient agar plates were examined after 24-48hours for bacteria, and PDA plates were examined up to 5-7 days for fungi.

The fungi and bacteria that grew out from the cut papers on agar were repeatedly sub-cultured on fresh agar plates until pure culture of each microbe was obtained. The pure cultures of fungi were identified by using morphological characteristics and

by observing under the microscopes. The growth habits of fungi were observed under a wild binocular microscope. Portions of each fungus were put on a slide and teased apart (to spread the fungal structures apart so as to avoid overcrowding when viewed under the microscope) in distilled water, stained with cotton blue in lactophenol, then viewed under the light microscope and identified with reference to standard texts (Raper and Fennel, 1973; Barnett and Hunter, 1987) in consultation with mycologists in OOU, Ago-Iwoye.

For the identification of bacteria, colony characteristics such as shape, size, elevation, translucency and pigmentation were observed. The biochemical tests carried out on the bacterial isolates following the procedures outlined in Collins and Lyne (1976) and Fawole and Oso (1976) included Gram stain, motility test, spore staining, Voges-Proskauer test, gelatin hydrolysis, urease production, citrate utilisation, nitrate reduction, indole production, catalase test and oxidase test. The results of the biochemical tests were then used for tentative identification of the bacteria with the scheme of Bergey's Manual of Determinative Bacteriology (Buchanan and Gibbons, 1974).

*Ability of Isolated Microbes to utilise Paper in Vitro*

The ability of the isolated fungi and bacteria to degrade cellulose was investigated in order to know those organisms that were actually involved in the degradation. All the isolated fungi and bacteria were subjected to this test. The cellulose substrate used was Whatman No 1 filter paper, which is obtained from cotton 'linters' and can thus be regarded as pure cellulose. The method of Garrett (1962) was employed for the test. Three filter papers, each having a diameter of 9 cm, were folded together, and dried in the oven at 80°C to constant weight. One such wad was put in each of several Petri dishes to serve as the only source of carbon, and was enriched with 10 ml of nutrient solution of Pugh and Eggins (1962) of the following composition: $(NH_4)_2SO_4$, 0.5g; $MgSO_4.7H_2O$, 0.2g; KCl, 0.5g; $CaCl_2.2H_2O$, 1.0g and distilled water, one litre. For the fungi, mycelia disks measuring 10mm in diameter were cut from actively growing cultures and introduced onto the enriched filter paper, while in the case of bacteria, the inoculating loop was dipped in the culture and used in making zigzag lines on the surface of enriched filter paper. Three plates were inoculated for each microbe, while the control was also set up by introducing blank agar disk onto nutrient enriched filter papers. All the plates were incubated at room temperatures (28±2°C) for 21 days. Thereafter, the microbial growths were carefully removed, and the filter papers dried to constant weight. The weight loss was determined by subtracting the final weight of filter papers from the initial weight before incubation. The weight losses in the filter papers represented the amount of cellulose utilised for growth by the microorganisms.

## Results

### Acidity

Based on the criteria used to assess acidity/alkalinity, 4.90% of the books sampled in OOU Library were very acidic, 64% were acidic and 31% were slightly acidic, while none had neutral pH (Table 1). For the journals, 2.6% were very acidic, about 50% acidic, 46% slightly acidic while 1.7% had neutral pH. Among the dissertations used for our survey, none of the papers had very acidic pH, 73.2% had acidic papers while 26.8% had slightly acidic papers. In the case of newspapers, 2% had very acidic papers, 83.3% had acidic papers while 14.7% had slightly acidic papers. Altogether, if the materials with very acidic and acidic pH are added together, then, 69.0% of textbooks, 52.2% of journals, 73.2% of dissertations and 85.3% of newspapers were acidic in nature.

### Folding Endurance

Table 2 presents the results of the folding endurance test on different categories of library materials. The results shows that less than one per cent of books and dissertations broke after one double fold, while none of the journals sampled broke when subjected to one double fold. The percentage of books with broken corners increased when subjected to two double folds, but the value was still less than 1% in journals, 1.1% in books and 3.6% in dissertations. After the third double folds, 98.3% of journals, 93.4% of books and 89.3% of dissertations did not have broken corners.

**Table 1: The pH Values (Acidity Levels) of Library Materials Surveyed**

| Materials | n | pH values | Frequency | Percentage | Level of acidity |
|---|---|---|---|---|---|
| Books | 1,265 | <3.8 | 63 | 4.9 | Very acidic |
| | | 3.8 - < 5.4 | 809 | 64.0 | Acidic |
| | | 5.4 - <7.0 | 393 | 31.1 | Slightly acidic |
| | | ≥ 7.0 | 0 | 0 | Neutral |
| Journals | 230 | <3.8 | 6 | 2.6 | Very Acidic |
| | | 3.8 - < 5.4 | 114 | 49.6 | Acidic |
| | | 5.4 - <7.0 | 106 | 46.1 | Slightly Acidic |
| | | ≥ 7.0 | 4 | 1.7 | Neutral |
| Dissertation | 280 | <3.8 | 0 | 0 | Very Acidic |
| | | 3.8 - < 5.4 | 205 | 73.2 | Acidic |
| | | 5.4 - <7.0 | 75 | 26.8 | Slightly Acidic |
| | | ≥ 7.0 | 0 | 0 | Neutral |
| Newspaper | 150 | <3.8 | 3 | 2.0 | Very Acidic |
| | | 3.8 - < 5.4 | 125 | 83.3 | Acidic |
| | | 5.4 - <7.0 | 22 | 14.7 | Slightly Acidic |
| | | ≥7.0 | 0 | 0 | Neutral |

Keys for grouping the acidity of the library materials

| | |
|---|---|
| <3.8 | Very acidic paper |
| 3.8 - < 5.4 | Acidic |
| 5.4 - <7.0 | Slightly acidic |
| ≥ 7.0 | Neutral |

**Table 2: The Frequency and Percentage of Library Materials with Broken Corners after Different Folding Levels**

| | | Materials with Broken Corners | | |
|---|---|---|---|---|
| Materials | level of folding | Frequency | Percentage | Durability |
| Books | One double fold | 5 | 0.2 | Very Brittle |
| | Two double fold | 14 | 1.1 | Brittle |
| | Three double fold | 64 | 5.1 | Weak |
| | Not broken | 1182 | 93.4 | Not Brittle |
| Journals | One double fold | 0 | 0 | Very Brittle |
| | Two double fold | 1 | 0.4 | Brittle |
| | Three double fold | 3 | 1.3 | Weak |
| | Not broken | 226 | 98.3. | Not Brittle |
| Dissertations | One double fold | 2 | 0.7 | Very Brittle |
| | Two double fold | 10 | 3.6 | Brittle |
| | Three double fold | 18 | 6.4 | Weak |
| | Not broken | 250 | 89.3 | Not Brittle |

## Mutilation

The results in table 3 present the frequency and proportion of mutilated materials among library collections at OOU. For the assessment, a material was categorised as mutilated if it had stains, tears, scribbling or marks. The newspapers had the highest proportion of mutilation (22%), followed by textbooks (11.9%), dissertations (10.4%) and the lowest in journals (5.7%).

**Table 3. Frequency of Library Collections at OOU that had been mutilated**

| Materials | n | Mutilated Materials | |
|---|---|---|---|
| | | Frequency | Percentage |
| Books | 1,265 | 151 | 11.9 |
| Journals | 230 | 13 | 5.7 |
| Dissertation | 280 | 29 | 10.4 |
| Newspaper | 150 | 33 | 22.0 |

## Microorganisms

Five bacteria and seven fungi were isolated from deteriorating library materials (Table 4). The bacteria were tentatively identified as *Bacillus* sp. *Streptococcus* sp. *Pseudomonas* sp. *Staphylococcus* sp and *Flavobacterium* sp with *Bacillus* sp being the most common. The fungal isolates were *Aspergillus niger*, Aspergillus *flavus*, *Aspergillus fumigatus*, *Cladosporium* sp, *Neurospora* sp, *Penicillium* sp and *Rhizopus* sp. The most common fungi on deteriorating library materials were *A. niger*, *A. flavus*, Cladosporium sp, and *Penicillium* sp. The following microorganisms, *Bacillus* sp. *A. niger*, *A. flavus*, *Cladosporium* sp and *Penicillium* sp were found on all the four different types of library materials investigated.

The newsprints harboured the highest number of microorganisms, with the isolation of 12 microbes and 52 isolates, followed by textbooks (10 microbes and 49 isolates), while the least was found in journals (7 microbes and 33 isolates).

The test on the ability of microorganisms to degrade filter paper, which is a form of paper material, was carried out in order to know whether the organisms are just present as surface contaminants, or that they are actually involved in the biodeterioration processes. Of the five bacteria isolates, only two, *Bacillus* sp and *Pseudomonas* sp. utilised little quantity of the filter paper for growth (Table 5). Visual ratings of growth showed that the two bacteria had scanty growth on filter papers.

**Table 4: Frequency of Microorganisms Isolated from various Deteriorating Library Materials (n = 50)**

| Microbes | Textbooks | Journals | Dissertation | Newsprint | Total isolates |
|---|---|---|---|---|---|
| *Bacillus* sp | 6a | 6 | 4 | 7 | 23 |
| *Streptococcus* sp | 4 | - | - | 3 | 7 |
| *Pseudomonas* sp | 3 | - | 3 | 2 | 8 |
| *Staphylococcus* sp | 3 | - | 2 | 2 | 7 |
| *Flavobacterium* sp | - | 3 | - | 4 | 7 |
| *Aspergillus niger* | 8 | 6 | 8 | 7 | 29 |
| *Aspergillus flavus* | 9 | 6 | 7 | 5 | 27 |
| *Aspergillus fumigatus* | 5 | - | 2 | 4 | 11 |
| *Cladosporium* sp | 4 | 6 | 8 | 7 | 25 |
| *Neurospora* sp | - | 2 | 4 | 3 | 9 |
| *Penicillium* sp | 4 | 4 | 5 | 7 | 20 |
| *Rhizopus* sp | 3 | - | - | 2 | 5 |
| Total isolates | 49 | 33 | 43 | 53 | 178 |

a = Number of plated tissues yielding each microorganism out of a total of 50

The fungus *A. niger* effected the highest reduction (58.3mg) in the weight of filter papers followed by *A. flavus*. The net loss in weight caused by these two fungi was significantly higher ($p<0.05$) than those caused by other fungi. Visual ratings of growth also showed that these two fungi also recorded excellent growth on filter papers. The three other fungi that hydrolysed filter papers in decreasing order of effectiveness with the net loss in weight in parenthesis were *A. fumigatus* (41.0mg), *Penicillium* sp (38.7mg) and *Cladosporium* sp (22.5mg). These three fungi recorded moderate growth on filter paper. Two fungi *Neurospora* sp and *Rhizopus* sp, did not grow on filter paper, pointing to their inability to utilise cellulose for growth.

## Discussion

It is an established fact that acidity is a major cause of paper deterioration; and that the higher the acidity, the shorter the life-span of the paper. However, acidification is a very efficient cost- saving means of hydrolysing wood which is the first phase in the production of paper. The general belief is that that the origin of acidity in paper is from the acid used during the process of paper manufacturing. However, it is now realised that the absorption of oxides of sulphur and nitrogen from the environment could generate strong acids, while the spontaneous degradation of cellulose and hemicellulose during aging could generate weak acids. Alegbeleye (1996) was of the view that the pH of paper should be between 5.4 and 6.0 for durability. A considerable proportion of the library materials (69.0% of textbooks, 52.2% of journals, 73.2% of dissertations and 85.3% of newspapers) in OOU had pH below 5.4, indicating that the life-span of the materials might not be too durable. That the majority of those collections are acidic is to be expected because many of the books were products of acid hydrolysis of woods. Mwangi (1994) had pointed out that 73.3% of the books in selected Kenyan libraries had pH below 4.0 and thus stand the risk of acid hydrolysis.

The results of the folding endurance tests revealed that less than 10% of the OOU Library collections were in the brittle category. This is to be

**Table 5. Hydrolysis of Paper after 21 Days of Incubation at Room Temperature (28 $2^0$C) by Microbial Isolates**

| Isolates | Net loss in wt (mg) of filter papers | Visual estimation of growth | Rating of growth |
|---|---|---|---|
| *Bacillus* sp | 21.3 2.5b** | + | Scanty growth |
| *Streptococcus* sp | 0.0a | - | No growth |
| *Pseudomonas* sp | 13.7 1.8b | + | Moderate growth |
| *Staphylococcus* sp | 0.0a | - | No growth |
| *Flavobacterium* sp | 0.0a | - | No growth |
| *Aspergillus niger* | 58.3 3.5d | +++ | Excellent growth |
| *Aspergillus flavus* | 52.3 2.8cd | +++ | Excellent growth |
| *Aspergillus fumigatus* | 41.0 4.3c | ++ | Moderate growth |
| *Cladosporium* sp | 22.5 3.5b | ++ | moderate growth |
| *Neurospora* sp | 0.0a | - | No growth |
| *Penicillium* sp | 38.7 4.6c | ++ | Moderate growth |
| *Rhizopus* sp | 0.0a | - | No growth |

Keys for determination of visual growth of microorganisms on filter papers
- = no growth
+ = scanty growth
++ = moderate growth
+++ = excellent growth

Each value is a mean of three replicates ± standard deviations; the values represent the weight loss of filter papers due to its utilisation by microorganisms for growth and metabolic activities.

** Means followed by the same letter(s) are not significantly different at $p < 0.05$ using the Duncan Multiple Range test.

expected considering the fact that the age of the University was still less than 20 years at the time of the study and a majority of the collections were purchased new after the university began operations. In the Yale's collections, 37.1% of the collections had brittle papers (Walker, 1985). It therefore means that with time the proportion of brittle papers in the library will increase, and the library will need to take proper steps now to minimise the problem in future.

The present study has revealed the association of five bacteria identified as *Bacillus* sp, *Streptococcus* sp, *Pseudomonas* sp, *Staphylococcus* sp and *Flavobacterium* sp and seven fungi: *Aspergillus niger*, *Aspergillus flavus*, *Aspergillus fumigatus*, *Cladosporium* sp, *Neurospora* sp, *Penicillium* sp. and *Rhizopus* sp. with deteriorating papers at Olabisi Onabanjo University, Ago-Iwoye. The air spora contain many fungal spores that could colonise any surface if conditions are favourable. The fungi that were isolated in this study are ubiquitous, implying that they are found everywhere.

It was found that the fungi in decreasing order of ability: *A. niger*, *A. flavus*, *A. fumigatus*, *Penicillium* sp and *Cladosporium* sp were able to utilise filter paper for growth. The two bacterial isolates, *Bacillus and Pseudomonas sp.* grew mildly and utilised filter paper. The implication of this finding is that fungi are more important than bacteria as agents of paper deterioration. While the results confirmed that fungi play active roles in the deterioration of paper materials, it also implies that bacteria isolated from deteriorating books may have arrived at the surfaces as contaminants from dusts and that they do not play important role as causative agents of degradation.

The degradation of paper is a pointer to the production of a complex extracellular enzymes that could degrade cellulose collectively referred to as cellulases. The production of cellulolytic enzymes is a very rare attribute among microorganisms. That *A. niger* and *A. flavus* efficiently utilised filter papers for growth is to be expected because these organisms are often abundantly isolated from decaying plant materials in the soil (Alexander, 1978). Olutiola (1976) reported the presence of cellulases in the culture filtrates of *A. flavus*.

Apart from the destruction of materials, the presence of these fungi on book materials may pose some risks to the health of library users. In developed countries, microbial, and particularly mould-related health problems in homes, offices and public buildings including school libraries have gained recognition as one of the most common indoor environmental issues (Eckardt, 2004). *A fumigatus*, one of the prominent fungi isolate is known to cause a respiratory disease known as 'aspergillosis' with the symptoms resembling that of tuberculosis, and it is also known to produce the mycotoxin gliotoxin (Alexoupolus, 1979). *A flavus* produces numerous spores which can contaminate food and produce very potent secondary metabolites such as aflatoxins and cycolpiazonic acid. Aflatoxin is a strongly carcinogenic metabolite classified as a class 1 carcinogen (IARC, 1993), and it has also been shown to cause immunotoxicity and growth retardation in West African children (Gong *et al.*, 2002). Though the principal mode of infection of mycotoxins is by ingestion of contaminated food, however, they have been proposed to cause adverse human health effects after inhalation exposure to mould in indoor residential, school and office environments (Kelman *et al.*, 2004). The inhalation of the spores of moulds such as *Cladosporium* sp could elicit allergic reactions in compromised individuals. The tubercule bacilli (*Mycobacterium tuberculosis*) have been found on the dust on books and cloths used by carriers (Joklik *et al.*, 1984). The discharges from the throats and nasal passages of a library user that is a carrier of pathogenic microorganisms could contaminate books. The presence of microbes on books could thus constitute a potential source of health hazards to users, especially those that are used to putting their fingers in the mouth before using them to flip through the pages of books.

## Conclusion and Recommendations

The present work has shown that most of the paper materials in OOU Library had acidic properties, thus making them liable to deterioration. The work established the roles of biological agents (moulds and bacteria) in the deterioration of library collections. Physical evidence of deterioration in papers includes browning, tears, scribbling, marks and the visible presence of spores of fungi on papers. Deacidification technologies to remove acid in papers could be used, but it may not be cost-effective and also requires expertise. Also, deacidification can neither restore strength to papers that are already brittle nor remove colourations from papers. Thus, for acidic books that

have become brittle, reformatting techniques, which involve one of the following: microfilming, microfilming and digitisation and photocopy could be used to make these materials accessible.

The literature shows that the isolated fungi have strains that can produce toxic metabolites that may be toxic on inhalation and could also cause allergic reaction in man, thus constituting a danger to the health of library users. Thus, the deterioration of papers by biological agents, particularly moulds, should be accorded high priority in tropical countries including Nigeria, because the prevailing high ambient temperature (25-35°C) and relative humidity (³80%) particularly in the southern parts facilitate rapid proliferation of microorganisms. Library materials showing traces of deterioration due to microorganisms should be removed immediately from circulation because of their heath implications. Library users should be educated on the danger of putting their fingers into the mouth before flipping through paper materials as a human carrier of disease might have previously used these materials.

The proliferation of moulds and other biological agents such as moulds and insects in eating up paper is halted at low temperature; it is thus recommended that air conditioners be installed in all parts of the library, and they should be functional at all times because interrupted services of air conditioners will create temperature and humidity fluctuations that will do more harm than good.

The current drive of most libraries to develop their collection is worthwhile; it would also be desirable if preservation strategies for these materials to ensure their durability are also integrated into collection development. Thus, preservation criteria should be incorporated into collection decisions by academic libraries. The authors would also like to support the recommendations of Alegbeleye (1996) that academic libraries in Nigeria should now create positions for conservationists and preservationists whose duty would be the physical care of various library materials. Academic libraries should work hand in hand with scientists in relevant disciplines to be able to devise appropriate preventive and treatment strategies against paper deterioration.

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* Mrs Bankole is a Librarian in the University Main Library of Olabisi Onabanjo University, Ago-Iwoye. She holds a B.Sc (Hons) Degree in Microbiology from Olabisi Onabanjo University, Ago-Iwoye, and MLS Degree from the University of Ibadan.

Mr. A. Abioye is a Lecturer in the Department of Library, Archival and Information Studies, University of Ibadan, Nigeria. He attended the University of Nigeria, Nsukka and the University of Ibadan. He holds a Bachelor of Arts degree in History/ Archaeology, Bachelor of Law and a Master in Archival Studies degree. He is currently a doctoral student in records management at the University of Ibadan