PAPER IMPERMANENCE AS A CONSEQUENCE OF ACID-HYDROLYSIS RESULTING FROM POOR PAPER MANUFACTURE AND STORAGE IN SELECTED LIBRARIES AND THE NATIONAL ARCHIVES IN KENYA.

BY

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Paper impermanence as a consequence of

JUNE, 1992
DECLARATION:

THIS RESEARCH REPORT IS MY OWN ORIGINAL WORK AND HAS NOT BEEN PRESENTED FOR A DEGREE IN ANY OTHER UNIVERSITY.

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THIS RESEARCH REPORT HAS BEEN SUBMITTED FOR EXAMINATION WITH MY APPROVAL AS A UNIVERSITY SUPERVISOR.

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DEDICATION

To the memory of my late father, Duncan Mwangi and my mother, Josephine Waithira for the gift of life. To my little daughter Karen, who never knew what the mother was doing.
I wish to express my sincere thanks to my project supervisor, Edward Waiguru Muya, for his invaluable guidance, patience and encouragement throughout the period of writing this research report.

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A B S T R A C T

The study aimed at establishing: the level of acidity in library and archives paper-based materials; measures being taken to curb paper deterioration resulting from acidity; and the environmental control measures taken, in selected libraries and the Kenya National Archives. The levels of acidity of some locally manufactured papers before they are printed on were also investigated.

Acidity tests on books by use of universal indicator were carried out in Kenyatta University Moi Library, American Center Library, The International Centre for Insect Physiology and Ecology (ICIPE) Library, MacMillan Memorial Library and the Kenya National Archives. The research revealed that the levels of acidity in most materials are very high (an average pH of 2.4), an indication that the books are threatened by acid hydrolysis reactions on cellulose molecules in paper. Actually, 45.4% of all the materials tested were found to be brittle, while 40.6% have yellowed. This shows that 86% of the materials held in the selected libraries and the archives are in danger of becoming brittle and unusable in the near future.

The study found out that nothing is being done to save this unfortunate situation in the libraries. The librarians were not aware of the implications of presence of acid
in paper-based materials. The archivists knew the problem.

The Kenya National Archives takes some measures to curb acid hydrolysis though they are not carried out satisfactorily.

In addition, the environmental factors that increase the acidity level of paper and those that activate the rate of chemical reactions namely: temperature, humidity, air pollution and light, are not well taken care of in the libraries. A credit goes to the Kenya National Archives which has taken some measures though mainly in the records repositories.

Laboratory tests on the levels of acidity on unprinted papers used the hot extraction method. The results indicated high levels of acidity in the locally manufactured papers especially the newsprint brand.

A number of recommendations relating to deacidification, microfilming, replacements, and photocopying of the affected materials were given. Base standards of paper meant for permanent records that advocate for aid-free paper were also recommended.
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CHAPTER ONE

1.0 BACKGROUND TO THE PROBLEM

Information has been widely recognised as an essential commodity for social, political, scientific and technological development. As a result, the role of libraries, archives and documentation centres as important sources of information has been highlighted. These institutions house important information carriers which include maps, manuscripts, photographs, negatives, motion picture films, phonograph recordings, slides, microforms, periodicals, newspapers and books ranging from incunabula to paperbacks. These materials held in the national information systems of libraries and archives form part of our cultural heritage.

The materials are not static objects but are affected by internal and external factors such as dust, inks, bindings, glues, fastenings, defective storage, knocks, friction, micro-organisms, people, floods and fires. There is need therefore, to study these factors which threaten the recorded history of human civilization.

Information carriers are made out of various types of materials though generally, the paper-based carriers dominate in most libraries and these form the basis of this research.
Paper is threatened by many factors and hence the research will only consider the effects of acidity on the paper.

Paper is a felted sheet of cellulose fibres which are essentially polymers of glucose units that are formed by passing a liquid suspension of pulp through a fine screen. Early papers made by hand from long-fibred rags have survived in good condition to this day. Unfortunately, changes in papermaking technology since the 19th century have been producing poor quality paper which deteriorates fast, primarily due to its inherent acidity. The substitution of unpurified wood fibres for cotton and linen rags for example, not only produced weaker fibres but also left lignins within the paper which degrade to form acids. In his introduction, Barrow (1967) stressed this fact by stating that:

All who, whether as readers of books, book collectors or librarians have had much to do with the publications of the nineteenth century, are very conscious of the seriously weakened and deteriorated conditions of many of these books. It is usual to put blame on the extensive substitution of wood or other cheap fibres for rag in the manufacture of book papers after mid-century and to explain the better survival of the papers of the earlier decades.

Acids are also added in the form of alum-rosin size. Acidity has been established as the major cause of paper deterioration. Morrow (1983) quoted Barrow who experimented
on paper acidity as having concluded that "the acid from chlorine bleach, unpurified wood pulp and alum-rosin sizing were the major causes of paper deterioration".

Apart from the factors which are related to poor paper manufacturing, there are other environmental conditions that can make paper acidic or increase the rate of acid hydrolysis on the paper; some of which include air pollution, humidity, temperature and light. Other factors like inks, glues, dyes, among others can make paper acidic during the book production process.

As a result, most book papers produced today will not last more than 50 years; they become yellow, brittle and eventually crumble. The effects of acids are hard to detect in time; often they do not become obvious until the paper has reached a point where it will crumble at the slightest pressure.

However, it is possible to curb this deterioration through deacidification of the affected materials. One of the basic tests to predict paper permanence includes pH (acidity or alkalinity). The acidity of paper, like that of other materials, is expressed in terms of the concentration of hydrogen ions (pH), which can be read off from a pH meter or chart with a scale from 1 to 14, the first figure
indicating maximum acidity and the second, the highest degree of alkalinity, the neutral state having pH 7.

It is also possible to produce modern papers which are both permanent and durable by using chemically purified wood fibres with a high alpha cellulose content, neutral sizing and an alkaline buffer agent with a pH of 7.5 to 8.0.

Cunha (1983) summarizes the above comments by saying that:

the acid deterioration of paper must be curbed, preferably by the control of the manufacturing process, but also on the premises of the libraries for those books embrittled in storage.

Awareness and knowledge of the effects that acids have on the paper based materials is of great importance if we have to provide for the future generations. Acidity problems exist internationally.

1.01 THE INTERNATIONAL PERSPECTIVE

The imminent danger of losing much of the information that society has accumulated due to deterioration of paper on which this has been recorded has created a major problem both of national and international concern. In recognition of the
importance of preserving the world's written heritage. A proposal was made at the IFLA Nairobi meeting (1984) that IFLA should establish a new core programme that would focus its efforts on the issues of preservation and conservation. The IFLA core programme on Preservation and Conservation (PAC) was officially launched in 1986 in Vienna.

The mandate of PAC is:

- to encourage and promote the search for solutions to the serious problems of physical and chemical deterioration of library and information materials for the purpose of preserving these materials for future.

The major objective of the program is to ensure that library materials, regardless of the format, will be preserved in accessible form for as long as possible. To accomplish this and other objectives, PAC is expected to:

1. encourage and facilitate the training of technicians and professional conservators in the fields of book, paper and library conservation;

2. encourage scientific research on the causes of deterioration of library materials and on the application of science and technology to the preservation and treatment of deterioration;

3. promote the development of national and international standards that pertain to the production, preservation and treatment of library materials.
The Library of Congress in Washington DC, U.S.A. plans, coordinates and manages activities of PAC. In addition to this, other regional centres have been set up in Bibliotheque Nationale in Sable, France; Deutsche Bucherel in Leipzig, Germany; Caracas, Venezuela; Tokyo, Japan and Canberra, Australia.

With such efforts being made at the international level, there has been an awakening in Europe and America concerning the importance of having preservation and conservation programs as well as establishment of paper standards. Unfortunately, Africa has yet to realize the importance of preservation and conservation and the importance of production of good quality papers. Paper deterioration is more alarming in most tropical African countries where a large number of documents are in the advanced stages of deterioration due to the interplay of factors not very prominent in the countries where the awareness of preservation and the training of conservation personnel are accorded high priorities.

Mwiyerwa (1988) stressed the great need of a well established document repair and conservation units in Africa because in his view:

... with the exception of air pollution, all agents which cause paper damage-acid, heat, humidity, light, fungi, insect pests, rodents, normal wear and tear and people are more pronounced in that continent than anywhere else.
In this regard, creating awareness in Africa about the problems of the deterioration of books is essential. In libraries worldwide, virtually all books and documents published after the last 200 years are deteriorating due to acid content in paper.

Various activities of deacidification processes as well as establishment of permanent paper standards have been taking place in various countries such as United States of America, Canada, Britain among others.

1.02 THE KENYAN PERSPECTIVE

Studies have revealed that paper-based materials form the bulk of stock in the University libraries with very few non-book media. This research revealed that, most other libraries, largely stock paper based materials. Research has indicated that little is being done in the country to prevent these materials from deteriorating despite the evidence of brittleness being clear.

It is only the Kenya National Archives that undertakes various measures to control deterioration of records. Acidic records are deacidified and those that have deteriorated so much, are microfilmed.
The situation in our libraries is unfortunate especially now that there is a ban on the importation of primary and secondary school books. It is a fact that this is a good move which should be seen as a positive challenge to writers, publishers, paper manufacturers, bookshop owners and all other bodies involved in the production of textbooks.

However, something must be done about the quality of paper produced in the country, if the printing of the books is to be done in Kenya.

Frank Ngugi, (Sales and Marketing Manager of Longmans Kenya Limited) was quoted by the Daily Nation when he complained about the cost of paper. He questioned the Pan-African Paper Mills Webuye’s monopoly in newsprint trade by saying that:

This year [1989] they have already increased the price of paper twice and we are bound to buy from them since we are not allowed to import the commodity.

As a result of these price increases, the book prices also increase and this affects the students and other readers as well as the librarians who have to keep their libraries adequately stocked. The task of the librarians is indeed complex in that the paper used in printing deteriorates so fast that in future a lot will have to be done to save the books from crumbling.
In order to avoid future problems, there is need to encourage production of good quality paper which is largely acid-free. At the same time, the books held in our libraries should be tested for any acidity and if present, be deacidified with immediate effect.

This is not to say that it is only paper printed in the country that has deteriorated but also those from other countries especially from the Indian sub-continent.

In general, nothing is being done in Kenyan libraries to curb acid hydrolysis on paper based materials.

1.1 STATEMENT OF THE PROBLEM

It has been established that acidity is the major cause of paper impermanence. Deterioration of paper by acidity is reflected in the appearance of the yellow colour, a characteristic followed by increasing fragility. These characteristics had been observed by the researcher, which is a clear indication that we have acidic books in our libraries and archives.

The acidity problem is worsened by the fact that storage conditions of the materials in our libraries and
archives are not adequate. Most libraries and archive buildings are not designed to incorporate aspects that relate to conducive structures that would enhance preservation of the materials. Some of the buildings allow direct sunlight to fall on the materials, others are poorly ventilated and are thus hot and humid. These conditions can and do increase the rate of acid hydrolysis.

The other problem is as a result of poor site selection of the library and archive building. Some, inevitably, are situated near roads and/or industries where air-pollution abounds. Air pollution is harmful to books since they can absorb some of the acidic gases and become acidic.

Little is being done to curb acid hydrolysis reactions in our libraries and archives. This could be due to lack of awareness or appreciation of the existence of acidity and the danger it poses to the library and archives materials. What is more, not many libraries, even archives, if any, have staff with knowledge of paper chemistry.

Paper manufacturers in various countries continue to produce acidic papers and the papers produced by the Pan-African Paper Mills in Kenya are no exception. What this implies is that most local and imported books get into the libraries when they are already acidic.
The Kenya National Archives receives public records from the Government Ministries for permanent storage. Most records are printed or written on the locally produced papers which is very acidic.

It is very unfortunate that the Kenya standards for paper manufacture, for example, the Kenya Standard Specification for Newsprint Ks:03-421-1987 does not indicate the level of acidity required.

Books and records produced on acidic paper start deteriorating before they are even used.

1.2 OBJECTIVES OF THE STUDY

1. To establish the level of acidity of the books held in the selected libraries and archive.

2. To investigate the measures being taken to neutralize this acidity.

3. To identify the problems that hamper neutralization of acids on books.

4. To investigate the environmental control measures being undertaken by the libraries and archives.

5. To recommend possible solutions to problems of acid deterioration.

6. To establish the acidity level of locally manufactured papers before they are printed on.

7. To recommend base standards of paper for future materials.
1.3 SIGNIFICANCE OF THE STUDY

Every librarian would agree that any and every book thought worthy of publishing should last for ever on the library shelf. No library buys materials to discard later.

Library materials transmit information to a user. Thus deterioration is any action that interferes with that transfer. Deterioration is an irreversible process, and it must not be allowed to progress beyond a point where intellectual content cannot be reformatted or converted into a different medium when appropriate.

Since the library has to continue giving services to the users, replacements of deteriorated materials maybe necessary. With shrinking budgets, libraries have been unable to cope with replacements leave alone the normal orders. Most of the books held in our libraries, especially in academic libraries, are imported and therefore expensive. It is the contention of this study that a good conservation program especially for curbing acid hydrolysis on our library and archive materials, would save on regular replacements and will ensure that all materials are in a usable state. At the same time, lengthening the life span of these expensively acquired materials will benefit the national economy since it would reduce or eliminate book replacements, hence saving on some foreign exchange.
Even if the libraries could have enough finances to cope with book replacements, books are unique and a specific book may be published at a specific time and may be impossible to get the particular book because it is out of print.

The critical consequence of deterioration is the danger of losing not merely the original books but their intellectual contents as well. The primary importance of most books lies in the text itself, that is, the conventional meaning of the words and other symbols they contain. But books can be important in other ways from the intellectual content.

There are those in which the primary interest is in something outside the book, which itself only reflects this quality, for instance, its being a first edition, rare, printed or handwritten by, or owned by, some person of interest.

A copy cannot reproduce any of the qualities that make a book significant for any of the last class identified since some qualities are extrinsic to what can be copied, lying on the books firstness, or rarity. A copy can indicate but cannot reproduce precisely most of the qualities that make a book significant as an artifact, that is its letter forms, decorations, design, paper and binding. Microform copies, for example do not usually show the binding, end papers.
blank leaves at the beginning and end of work, watermarks in
the papers and so on.

Characteristics such as these are sometimes of critical
importance in evaluating the authenticity or priority of the
text, and sometimes are important and independent of the
text for the evidence they supply about the taste and
technology of the society that produced the book.

This study contends therefore, that care should be taken to
preserve the original text itself and that even though copies
of books are adequate for many uses, the availability of the
original is also necessary to verify the accuracy of the
copy. A further argument for preservation of the original
book for as long as possible is that a negative microform may
have a shorter life expectancy than the original work.

The study also indicates the need for a different
category of staff in our libraries and archives, thus
creating new job opportunities.

1.4 LIMITATIONS OF THE STUDY

The study was undertaken as a partial fulfillment of
the requirement for a masters degree. It was undertaken
along with course work and as such, there was a limitation on
the time spent on it.
The study did not take into account all libraries and archives in Kenya due to their numbers and geographical distribution, not to mention the financial constraints. The study only took into account some selected libraries and the archive in Nairobi area namely:

- Kenyatta University Moi Library (KU)
- MacMillan Memorial Library (MML)
- American Center Library (ACL)
- ICIPE Library (ICIPE) and
- Kenya National Archives (KNA)

The study focused on the degradation of the cellulose in paper fibres which is caused by acid-hydrolysis. It did not consider other causes of paper deterioration unless a very direct relationship with acid hydrolysis is involved.

The investigation assumes that the primary cause of the lack of permanence exhibited by book papers is acid hydrolysis reactions on cellulose.
1.5 DEFINITION OF TERMS

1. ACID
   A chemical substance which has a pH of below 7. If present in paper (in high concentration) for a long period of time, it becomes yellow and eventually brittle.

2. ACID-FREE PAPER
   Also known as alkali paper which has a pH of at least 7.5.

3. ALKALI
   A chemical substance which has a pH of above 7.

4. ALUM
   Chemical substance (aluminium sulfate) which is used to precipitate rosin sizing on the pulp and provides water resistant properties to the paper.

5. BLEACH
   Chlorine, or a similar chemical used in the paper industry to whiten the paper.

6. BOOK
   Any document on paper, including books, manuscripts, archives, records, typescripts, posters, playbills, newspaper etc.
7. BRITTLE
A weakened condition of paper due to acid deterioration. In extreme cases, brittle paper breaks off when it is flexed.

8. CELLULOSE
An unreactive chemical substance constituting the chief part of the cell walls of plant materials like paper.

9. CONSERVATION
The action taken to return a deteriorated or damaged material into a usable condition.

10. DEACIDIFICATION
A process of halting the destructive action of acid in paper through use of an alkaline substance.

11. DETERIORATION
Degradation of a material through loss of its initial chemical and physical properties leading to impairment of the intended function.

12. DURABILITY
The ability of paper to maintain its initial qualities such as wear and tear resistance under normal use.
13. HYDROLYSIS
Is a chemical reaction which involves splitting of a (cellulose) bond and ionization of water molecule.

14. INDICATOR
An organic substance which indicates by a change in its colour the presence or absence, (or the concentration) of some other substance.

15. INK
Fluids or pastes used for writing, printing and drawing with the help of techniques and instruments appropriate for each of these activities.

16. LIGNIN
The major non-carbohydrate constituent of wood which functions as a plastic binder for cellulose.

17. PAPER
An interwoven mat of hydrated cellulose fibres.

18. PERMANENCE
Ability of paper to maintain its original chemical properties for a long period of time.
19. pH

Is a value taken to represent the acidity or alkalinity of a substance on a scale from 1-14. 1-6 being acidic, 7 neutral whereas 8-14 is alkaline.

20. PRESERVATION

The action taken to prevent paper deterioration especially by providing the proper storage environment.

21. PULP

Fibrous substance resulting from the pulping process which requires further beating before it is usable for forming paper.

22. ROSIN

A chemical which is derived from distillation of turpentine, and is used in sizing paper.

23. SIZING

A treatment which gives paper resistance to wetting and penetration, thereby making it possible to write and print without blurring or fuzzing.
CHAPTER TWO

2.0 REVIEW OF THE RELATED LITERATURE

Cellulose, the primary constituent of paper fibres is a linear polysaccharide, consisting of anhydroglucose units of high molecular weight. It is the main solid constituent of woody plants and occurs widely elsewhere in the vegetable kingdom.

A cellulose molecule (chain) consists of an unspecified number of anhydrous glucose units connected through an oxygen bridge. The structure of cellulose can be represented as in figure 1.

![Cellulose molecule diagram](image)

Fig. 1: Cellulose molecule. Four anhydrous glucose units of \((C_6H_{10}O_5)_n\)

C stands for carbon, H for hydrogen, O for oxygen. The looped arrows at each end indicate that the molecule is continuous.

Cellulose is a relatively stable compound. However, there are several reactions which it will enter under normal conditions: oxidation, acid hydrolysis and photochemical reactions. These are the major reactions by which paper (cellulose) can deteriorate and they can be represented thus:
Total rate of deterioration = \text{Rate of acid} + \text{Rate of oxidation} + \text{Rate of Others}^{10} + \text{Rate of photochemical}

Conventional knowledge holds that acid hydrolysis is the major factor in paper deterioration, and it is estimated that 90% (even more) of the deterioration of cellulose is associated with acid hydrolysis. This study focuses on this major portion of the reaction given above: acid catalyzed hydrolysis.

Hydrolysis is most often brought about by hydrogen ions linked with the presence of acidic material in the paper. The hydrogen ion catalyses the rate of hydrolysis: the result is a chain scission. The reaction of acid-catalyzed hydrolysis of cellulose is expressed by figure 2.

![Diagram of acid-catalyzed hydrolysis of cellulose]

Fig. 2: Acid-catalyzed hydrolysis of cellulose.

With continuous attack, the fibre becomes progressively more brittle and finally may be reduced to a powder.
When the hydrogen ions are present in high concentration, the deterioration is faster and the faster the rate of hydrolysis, the less permanent the paper. The hydrogen ions act as catalysts and as such, they are not used up in the reaction and this implies that once hydrolysis begins, it does not stop as long as it can react with paper or until the acid is neutralized.

The cause of book deterioration due to acidity can be examined in two ways: according to the causes over which librarians and archivists exercise little or no control on paper manufacture and book production; and causes which librarians could exercise some control. This study aims at improvements in paper permanence to which librarians and archivists, book producers (printers) and paper manufacturers can contribute. The causes can be divided broadly as internal causes and external causes.

2.1 INTERNAL SOURCES OF ACID IN PAPERS

2.1.1 ALUM

Alum has been used by paper manufacturers for many years to precipitate rosin, the sizing agent, onto the fibres. Although alum itself does not contain hydrogen ions, when it is dissolved in water, it releases hydrogen ions which causes paper deterioration.11
Dohne and Libby are quoted by Casey (1981) as having reported that "the bursting strength of paper is reduced approximately 10 percent in going from a pH of 4 and 6 when alum is used for rosin size".12

To solve the problem of acidity originating from alum-rosin, synthetic non-acidic sizes such as alkyl succinic anhydrides and alkyl ketene dimers are now being used to some extent in the paper industry. This has led to the economic practicality of producing papers for publishing and recording that are less likely to suffer the acidic decay in the future. The 1984 American National Standards for Permanent Paper for Publishing gives some specifications on the type of sizing best suited for the production of permanent paper.13

2.1.2 LIGNIN

Lignin is a complex group of related materials which are very difficult to remove completely from pulp and these materials break down into acidic components, which ultimately cause darkening and embrittlement of paper.14

DeCandido (1979) elaborated this further by saying that:

Wood is composed of 20–35% lignin, 25–35% hemicelluloses and neither of these groups of chemicals are as stable as cellulose. As they decompose they may discolor and give rise to products which promote the deterioration of the cellulose
Some bleaching methods reduce lignin contents of the pulp while others do not.

Lignin left in paper makes it turn brown/yellow when exposed to heat or light.

2.1.3 BLEACHES

Bleach residues left in the pulp from the bleaching operation cause discoloration and loss of strength. Most papermakers use chlorine bleaches which despite being good bleaching agents, if not washed out, can cause paper deterioration, since it reacts with water to form an acid.

Chemical analyses have shown that:

bleaching is based on oxidation, and the oxidation of cellulose triggers off a process of acidification that breaks up the molecular structure of cellulose and hence weakens the paper.\(^{16}\)

2.1.4 INKS

Inks are internal elements inseparable from the paper and occasionally cause paper deterioration. Some inks contain acid which degrades paper while some have a tendency to fade.\(^{17}\) Metalloacid inks can be classified as harmful inks.
Metallo-acid inks comprise all inks containing a colour made up of a metal and an acid. The acid component used as a mordant to fix the ink to the salt whose metallic component acts as a catalyst, liberates sulphuric acid, an acid with the greatest corrosive effect of all.\(^{18}\) Examples of such harmful inks include those containing gallic acid, logwood, alizarin and vanadium.

Inks containing a high proportion of acid not only fade to a faint yellow colour but also tend to weaken the papers. Acidic inks 'bite' the paper to a point of piercing it. It is not a wonder to find works in archives and libraries in which the only usefully conserved parts are the blank margins, the text having been destroyed or converted into a blackish carbonized mass which crumbles into dust on the slightest movement of the sheet.

Books require an ink containing a permanent pigment, neutral, of which carbon-based inks are ideal. Carbon inks are the most stable because their basic colouring matter, carbon, is unchanged by acids or alkalis, light, water or microbiological agents.

It is the view of the researcher that control of the type of ink used for records is possible for archives but difficult for libraries.
2.2 DEVELOPMENT OF PAPER STANDARDS

In libraries worldwide, virtually all books and documents published in the last 200 years are deteriorating due to acidic paper. Efforts are being made internationally to produce acid-free papers; so that paper produced tomorrow will have a long life span than the paper produced yesterday.

In 1975, the National Historical Publications and Records Commission (NHPRC) in USA published Paper Standards for Historical Publications which call for a minimum pH of 7.5, a minimum alkaline reserve composed of either calcium or magnesium carbonate...19

In 1979, a National meeting was held in New York at which twenty representatives from fields of publishing, paper manufacturing and preservation of library materials formed a committee on Production Guidelines for Book Longevity which developed several guidelines to be followed in paper production. This committee adapted the standards set by NHPRC, the LC and ASTM/ANSI Standard Specification for Bond and Ledger Papers for Permanent Records. The guidelines served as the starting point for the subsequent work of a committee formed by the National Information Standards Organization (NISO). The result of NISO committee is the American National Standard for Information Science - Permanence of Paper for Printed Library Material (ANSI Z39
The ANSI standard establishes the criteria for permanence of uncoated paper and states that paper following these criteria should last at least several hundred years without significant deterioration under normal library use and storage conditions. The requirements in standard relate to pH (minimum pH of 7.5) ... alkaline reserve (minimum alkaline reserve equivalent of 2% calcium carbonate), and paper stock with no ground-wood or unbleached pulp.20

The standard also recommends that a statement of compliance should appear on the verso page a book's title page whenever paper is used that meets the standard. Such paper may also bear the symbol of compliance: the mathematical symbol of infinity set in a circle.

This study has found out that some of the books printed in USA in recent years bear this symbol. The International-News – A Newsletter of the IFLA Programme on Preservation and Conservation has the symbol and statement of compliance which states:

This publication is printed on paper which meets the minimum requirements of American National Standards for Information Sciences—Permanence of Paper for Printed Library Materials, ANSI Z39.48-1984.21
These campaigns have helped to promote the use of permanent paper as well as dialogue between preservation librarians and publishers. The standards have also helped to convince library directors and government agencies that the manufacture and use of permanent paper can have a major impact reducing the number of brittle books in the future.

More than thirty paper mills now produce alkaline paper in the US and 10-15% of all fine paper is alkaline.

The Joint Nordic Council for Scientific Information (NORDIFO) has also sponsored the development of standards.

In 1987, Technical Committee (TC) 46 on Information and Documentation of the International Standards Organization (ISO) established a subcommittee, SC10, to deal with among others paper for printed library materials with the ANSI standards as a proposed point departure.22

In Britain, permanent, acid-free paper has received some publicity over the last couple of years. The Publishers Association has been happy to lend its support to this crusade and hopes that acid-free paper, at no significant extra cost, will indeed be freely available and in time, become the norm of those books which are intended not be ephemeral.
In 1988, the British Library launched its "Adapt - a book" scheme to encourage book lovers and users to subscribe towards the cost of preserving a book. Jeffrey Archer was present at this launch and shocked by what he saw in the Library's Conservation Department, and mindful perhaps of the threat that his own literary immortality posed by acidic paper, he made the following comments:

I'm sure the thought of introducing acid-free paper would cause a riot in any publishing house, but I'm going to insist on it for my next novel.23

His publishers, Hodder and Stoughton duly obliged.

In 1988, a committee was established which drafted Australian standards broadly based on ANSI and the committee's greatest achievement was the heightened awareness among federal and state politicians of the need to use permanent papers. Standards for permanent papers in Canada call for a minimum pH of 4.8, Denmark and Finland for a minimum pH of 7.5, India pH of 5.5 and Pakistan 6.5-8.

Michael Roper in his RAMP study concerned with established of existence of standards related to archives administration and records management found out that almost all African countries did not have any standards for paper and ink.24
In Kenya, production of poor acidic paper continues to date. Recently, a Kenyan daily newspaper Daily Nation complained about the poor quality of paper by saying that the delays of their newspaper production are:

caused by very poor quality newsprint made by Pan Africa-Paper Mills... [who they] have to rely upon for all [their] newsprint...25

In an article "state should allow paper importation", the Daily Nation stated that printing and packaging are not only upset by the prices of paper from Pan African Mills but also "the quality of paper from the Webuye-based paper mill".26

The Kenya Standard Specification for Newsprint does not include the acidity requirements.27

Muttill (198-?) quoted the editor of Alkaline Paper Advocate as having said that:

Converting a mill to non-acid production can be done in less than 12 hours after suitable preparation.28

He goes on to say that it has been established that alkaline papermaking requires less fibre and water, yields wastes that are less polluting and results in paper that is whiter and brighter and reduces corrosion of papermaking machinery. He adds that the paper makers can recoup that investment
in less than three years through the reduced water and fibre consumption and waste treatment after the conversion.29

2.3 EXTERNAL SOURCES OF ACID IN PAPERS AND ENVIRONMENTAL ACTIVATORS OF PAPER DETERIORATION DURING STORAGE

Even if paper is made from pulp of high quality, it will not be permanent if storage conditions are not favourable. A controlled environment with appropriate levels of temperatures and relative humidities can slow down the rate of deterioration.

Paper can absorb substances from the atmosphere while at the same time, humidity, light and temperature can activate the rate of acid hydrolysis. These are factors which the librarian can control to some extent. Each of them will be discussed in relation to the effects it has on acid hydrolysis of paper.

2.31 ENVIRONMENTAL POLLUTION

Even relatively clean air can, in the fullness of time, be harmful to library materials, since oxygen can cause oxidation of materials, while water vapour it carries can provide the moisture for acid hydrolysis. But this is a fairly minor risk.
The atmosphere, especially of industrialized zones contains a series of impurities which undoubtedly do the greatest harm to documents. Urban atmospheres are far from pure and usually contain damaging quantities of sulphur dioxide, hydrogen sulphide, ammonia, ozone, nitrogen oxides and aerosols. The most harmful of these impurities is sulphur dioxide which reacts with oxygen and moisture to form sulphuric acid, causing stains and brittleness in paper.

Heller (1978) stresses this fact by saying that: Sulphur dioxide can be absorbed into your paper and converted to sulphuric acid, which will not evaporate even when removed from the source of the pollutant. Severe brown stains, brittleness and decomposition will follow in the wake of sulphur dioxide gas on your paper [and this] can be solved through putting alkalies in pulp to offset the acid danger.

A lot of research has been done to investigate the effects of sulphur dioxide on paper permanence as well as the absorption rate.

Ritcher (1931) after exposing papers to 2 per cent sulphur dioxide for six days at room temperature, the pH values which before exposure ranged from 5.8 and 4.8 changed to 4.0 and 3.4 respectively.

According to Smith (1969), Kimberly investigated sulphur dioxide attacks at the US Bureau of Standards under conditions approaching those which occur in many urban areas.
His findings indicate the surprising speeds with which many papers are attacked. He found that:

\[ \text{it takes only ten days for the average paper to lose about 15 per cent... of it's initial folding endurance.} \]

From these two observations, it can be concluded that rate of absorption of sulphur dioxide by paper is very high. Cunha (1988) makes the situation clearer by saying that:

\[ \text{sulphur dioxide from industrial chimneys is absorbed by paper as water is absorbed by a blotter.} \]

Carbon and other aerosols deposits carry other impurities with them which if they settle on books they enable the sulphur dioxide to work quickly.

Nitrous and nitric oxides from automobile exhausts when absorbed by paper become nitric acid which is as harmful as sulphuric acid.

Removal of such gaseous pollutants is a complex problem and there is no universally approved method save air conditioning.

Air-conditioning and air washing equivalent if they can be installed, will minimize the harmful effects of air-borne impurities. Water scrubbing devices in air conditioning
systems are effective means for gases from urban air though it is very expensive to keep. An activated carbon filters in the air circulation system are an alternative. They remove gaseous contaminants and when used in conjunction with glass wool filters to remove solid particulate from the recirculated air make a good combination.

2.3.2 TEMPERATURE AND HUMIDITY

Paper is a hygroscopic material. This means that it can absorb moisture from the air; the rate of absorption is dependent on the amount of moisture in the air and its temperature. Paper can also lose moisture to the air; the rate loss is dependent on the moisture content of the paper and its temperature.

The rate of acid hydrolysis depends upon the concentrations of cellulose, the hydrogen ions and water in the cellulose; thus the rate of acid hydrolysis will depend upon the relative humidity. High humidities are detrimental to permanence than low humidities. This was found by Tongren (1938) when he conducted tests at 100°C and relative humidities of \( \geq 25 \) per cent. He found that the rate of discolouration on aging increases linearly with relative humidity.

It is generally accepted that the rate of reaction
increases as the temperature rises and the opposite is true. Thomas (1987) states that:

for every increase in temperature of 10°C, the rate of chemical activity generally doubles and thus the rate at which library and archival materials decay doubles.

Richard Smith presented a table depicting how the rate of a reaction increases with increasing temperature or its correlate, how the permanence of a paper increases as the rate of deterioration reaction decreases. The table shows that "both pH and storage temperature have contributed to the deplorable condition of books in the libraries".

Sebera (1991) has done quite a lot on the anticipated permanence under a range of temperature and relative humidity storage conditions of bound serial periodicals. He says that this can be evaluated by utilizing a graphical method called the isoperm concept.

Generally, research on effect of humidity and temperature on paper permanence have shown that the "presence of excessive moisture at elevated temperatures promotes a hydrolytic attack on fibres."

Books and documents need a constant temperature ranging between 55°F–65°F and a relative humidity of between 55% and 65%.
2.3.3 LIGHT

All materials should be stored out of direct sunlight which, in addition to fading or yellowing them, causes overheating with other attendant troubles.

Lignin is sensitive to light and undergoes a photochemical reaction in sunlight, thus leading to darkening. It is the photochemical reactivity of lignin that is responsible for the rapid deterioration of groundwood papers, used in the manufacture of newsprint.

The effect of light on aging depends on wavelength. Groundwood papers have a characteristic heavy absorption of radiation in the ultraviolet region and this is why groundwood yellows in sunlight.

One effect of long exposure of paper to sunlight is a lowering of the pH of the paper. Direct sunlight and artificial sources of high in ultra-violet rays should be avoided for all paper records. Where direct sunlight cannot however be avoided, all windows should be provided with opaque shades or heavy curtains which will largely cut off and diffuse the light.

Florescence tube lighting is the most damaging and
where this is used, the tubes should be fitted with effective ultraviolet light filters. Incandescent tubes and tungsten filament lamps are less damaging.

2.4 DEACIDIFICATION

Promotion of the use of permanent paper does not solve the historical problem of the aging collections of books turning to dust on the shelves. The acid deterioration of paper must be curbed on the premises of libraries and archives for those books embrittled in storage. The acidic materials must be neutralized through deacidification.

Deacidification halts the destructive action of acid in paper. The process neutralizes acid in the paper, introduces an alkaline reserve that protects the paper from subsequent acid attack. Deacidification can thus extend the usable life of the paper three to five times.41

It is important to note that deacidification does not reverse the deterioration nor strengthen the paper already embrittled by acid hydrolysis. The neutralizer must not be too much so that the paper will not be subject to subsequent alkaline hydrolysis which is as dangerous as acid hydrolysis.42 The neutral salts should act as buffering agents to prevent future acid contamination from any source.

Both dry and wet methods are used for deacidification
of paper, and the choice is almost invariably determined by the solubility of the ink. The processes may chiefly be divided into the following categories:

1. Aqueous processes whereby the neutralizing agents are dissolved in water.
2. Non-aqueous processes whereby the neutralizing agents are dissolved in organic solvents.
3. Gaseous processes which make use of alkaline gaseous compounds.

2.4.1 AQUEOUS PROCESSES

This is a wet process whereby the book is immersed in the aqueous deacidifier. Aqueous deacidifiers have been used and have produced permanent results of proven effectiveness. These are numerous examples of salts that can be used for this process but the most common ones are the hydroxides, carbonates and bicarbonates of both magnesium and calcium. Sodium tetraborate commonly known as borax is also popular as it has additional fungicidal powers.

The magnesium and calcium salts can be used singly or combined. The most common combination was developed by the Barrow Restoration Shop popularly known as "The Barrow Two-Bath Deacidification".

The method makes use of calcium hydroxide and calcium
bicarbonate. Essentially, it involves treatment of a document for twenty minutes in each of two solutions. The first solution, which should be approximately 0.15 per cent calcium hydroxide, neutralizes any acids present in the document being immersed. The second solution, 0.15 per cent calcium bicarbonate converts the highly alkaline calcium hydroxide into a carbonate. When the sheet or book is dried, calcium bicarbonate, which exists only in solution, is also converted to calcium carbonate as a finely divided precipitate throughout the fibres of the document. The carbonate acts as a stabilizer against aging degradation as a buffer against any acidic environment.43

The two-bath process improves the folding endurance retention and tear retention, neutralizes the paper's acidity while conferring a reasonable level as reserve alkalinity. The method is safe.

Documents written with water-soluble ink however, need prior treatment with a solution of cellulose acetate film in acetone or alcohol. At the same time the processes are time consuming for the nature of application limits them to individual treatment of sheets.

2.4.2 NON-AQUEOUS PROCESSES

These are conveniently used for treating documents
written in water-soluble ink and extremely fragile documents that cannot be safely treated with aqueous methods.

Magnesium methoxide, methyl acetates and barium hydroxide are some of the examples of non-aqueous deacidifiers.

The non-aqueous solutions based on methyl magnesium carbonate are colourless, safe and effective. The solutions are suitable for the use of any types of cellulose material and vast majority of inks are unaffected. Methyl magnesium carbonate can be applied by spray, brush or immersion. This solution has the advantage of being able to deacidify a book without disturbing it.

Barium hydroxide (octohydrate) has come to be the most widely used non-aqueous deacidifier because of its low cost, effectiveness, ease of preparation as well as its solubility in methanol. However, barium compounds and methanol are slightly toxic and must be applied in a chamber or fume cupboard with a gas extractor.44

Non-aqueous processes require more careful control in operation than aqueous processes. Apart from their cost, they are very volatile, inflammable and toxic and must always be used in fume chambers. At the same time, most coloured inks and dyes are soluble in organic solvents like methanol.
2.4.3 GASEOUS DEACIDIFIERS

These offer obvious advantages over the liquid processes. It is a dry treatment which does not involve wetting of the documents. It is thus suitable for deacidifying documents written with water-soluble or alcohol-soluble inks and dyes. Gaseous deacidifiers make it possible to treat documents 'en masse' without having to disbind them or even having to remove them from the storage area. Moreover, the free acids are completely neutralized for the concentration from the alkaline gas is uniform though it takes long. The process however, requires well controlled conditions and careful handling of the fumes from the chemicals used.

Gaseous deacidifiers include ammonia (vapour), cyclohexylamine (CHC), diethyl zinc (DEZ) and morpholine.

The LC received a patent for the use of DEZ which is used under vacuum as vapour phase process. The zinc neutralizes acids during the bath, and some of it remains to protect the paper from acid that may appear later. DEZ process can deacidify 600 to 1,000 books a week. 45

DEZ is however a highly reactive explosive and irritant liquid that must be applied in a special vacuum chamber. Paper deacidified with DEZ is sensible to light though the
problem can be solved by introducing hydrogen iodide gas. Its widespread use is prevented by the high cost of the method.

In conclusion, expert advice should always be sought before any treatment involving solvents or any other chemical is undertaken.

The choice of materials to be deacidified first should be done intelligently with the most acidic being given the priority in the deacidification queue.
3.1 INTRODUCTION

The research aimed at determining the relationship between the present condition and status of books in our libraries and acidity levels. At the same time, the level of acidity of papers manufactured in Kenya before they are printed on was established for three different categories of papers. The research used both survey and experimental methods.

3.2 LOCATION OF THE STUDY

Financial and time constraints limited the research to Nairobi area libraries and the national archives. The study was also being carried out concurrently with course work which made outside travel difficult.

Selection of Nairobi Area libraries and archive was made because of the fact that Nairobi is an industrial city and the effects of air pollution are bound to be more severe than elsewhere in the country.
3.3 DESCRIPTION OF RESEARCH INSTRUMENTS

Data for this study was collected by use of questionnaire for interviewing librarians, observations and experiments.

3.3.1 OBSERVATION

The researcher visited each library namely: ICIPE Library, Kenyatta University Library, American Center Library, MacMillan Memorial Library and the Kenya National Archives.

Any notable effects of action of acids on the books were recorded. The indicative factors were

(i) colour changes of the book papers from white to a characteristic yellow/brown colour.

(ii) whether the books were fragile and brittle.

This was confirmed by folding the edge of a book paper and pressing it hard to see how resistant it was to tear. If it was easy to tear or it crumbled at a touch, it was concluded that the book was brittle.

The books that were observed were selected randomly in each library and archive. In total 180 books including
ICIPE and American Center Libraries had very few stacks and therefore two books were picked from every stack. The selection of the two was systematic in that they were picked from the first and last bays within the stacks. Within the bays, the two central shelves were identified. From the first bay, the first book (on the extreme left) and the last bay, the second book was picked from the central shelf on the extreme left.

A total of 15 books were selected.

Kenyatta University Moi Library, MacMillan Memorial Library and the Kenya National Archives (National Documentation Service and the repositories) had many stacks. In these libraries, 15 books were also selected from the general collection. The selection was one book from every other stack, the middle bay, the central self and within the shelf, the fifth book from the left side. These libraries and the archives had special collections which were treated separately. Ten books were selected from the Africana sections.
separately. Ten books were selected from the Africana sections in Kenyatta University Moi Library and MacMillan Memorial Library and the Murumbi collections of the Kenya National Archives.

Fifteen files were selected from three repositories in the Kenya National Archives whereby the files were being retrieved from every other stack in the central bay, the central shelf, first box and the middle file.

Journal and newspaper selection was done randomly also. In the American Center Library, 5 foreign newspapers were observed. These were selected randomly according to the titles. In the rest of the libraries and the archives, except ICIPE Library (which did not have a collection of newspapers), 5 (both local and foreign) newspapers were selected starting with the oldest of every title obtained. Except in MacMillan library, those observed in Kenyatta University library and the Kenya National Archives were local.

The periodicals and journals were selected by use of the letters of the alphabet, and within one letter, the first copy was selected. The researcher chose randomly the letters A, J, S, W, Z and in the situations where there was none starting with the chosen letters, the next nearest was picked.

A sample of the Kenyan printed material was also taken.
Five such books were picked in the legal deposit section in the Archives and another five from the teaching practice section of Kenyatta University library. Five books that had been newly received in University library from India (and printed there) were considered too. The books were received in November 1991.

3.3.1 ACIDITY TESTS ON BOOKS

This involved testing acidity of all the above selected samples.

Acidity tests were done by use of universal indicator. A small dot was being made by use of a very thin capillary tube on any inner page of a book, against the spine where it was as inconspicuous as possible. The researcher was waiting for about 30 minutes and any colour development was compared with colours in a pH chart.

3.3.3 INTERVIEW

After the tests and observations, interviews were conducted with the reference/circulation and acquisition librarians. Except in KU where the two were available, the rest of the libraries availed one librarian either because the other one was absent or he/she acts as both the acquisition and reference/circulation librarian. Two
respondents from the Archives were interviewed; one from the library section, and the other from the record (or archives) section.

The questionnaire that had been designed to guide the direction of the interview was used. The researcher was filling in the questionnaire and at times depending on the answers given by the respondent, different questions from those in the questionnaire were being posed to the respondent. Any answers given to such questions which was helpful to the research were noted down.

The areas which were being investigated through the use of the interview included:

i) awareness of the problem of acidity by the librarians and archivists.

ii) the measures being taken to curb the problem if they were aware.

iii) whether during their formal or informal training, they had undertaken a course on preservation and conservation.

iv) measures taken by the librarians and archivists to control temperature, air pollution, sunlight and humidity in their buildings.

v) survey of the availability of conservation and preservation devices, for example, air conditioners, dehumidifiers, light filters among
others.

vi) whether in selection of books, the quality of paper that a book is printed on is considered.

vii) whether once a book is received, there are any conservation measures taken.

ix) whether the librarians and archivists are aware of the conservation technique they could apply if the problem of acidity is recognized.

x) the effect that book deterioration has on use or the effects of use on deterioration.

3.3.4 ACIDITY TESTS ON THE UNPRINTED PAPER

The pH was determined by use of hot extraction. The researcher adapted the ISO 6588-1981(E)\textsuperscript{46} method of determination of pH of aqueous extracts.

3.3.4.1 REAGENTS AND APPARATUS

Distilled water was used throughout the experiments. Buffer 4 and 7 were used.

Apparatus included:

1) Ordinary laboratory apparatus and glassware of chemically resistant glass, flasks with ground glass joints, stoppers, beakers and water-cooled
reflux condensers. All glassware were rinsed with boiling distilled water and allowed to dry before they were used.

2) pH meter fitted with glass and calomel capable of reading to 0 in pH was used.

3) A thermometer.

3.3.4.2 SAMPLING

Various brands of paper used commonly by the Kenyan printers were collected. The locally manufactured ones included White Bank, Newsprint and white printing. The only imported one that was obtained was the Esparto Laws.

Out of the bunches of each brand, one leaf was selected at random. The middle part of the leaf selected was cut off.

3.3.4.3 PREPARATION OF THE SAMPLE

The sample was cut into pieces approximately 5mm x 5mm in size from portions that had not been touched by bare hands.

The pieces were placed only on clear and clean surfaces and were mixed thoroughly. The sample was not at any time touched with bare hands. Clean protective gloves
were worn at all times to protect the sample and the pieces prepared from it. The sample was stored in clean dry containers.

3.3.4.4 PREPARATION OF AQUEOUS EXTRACT

1g of the sample was weighed to the nearest 0 and placed into a flask of a suitable size.

100ml of water (distilled) was measured into a separate flask of similar size to that containing the pieces, with a pipette. The reflux condenser was then attached to the flask with water which was heated to boiling point. The condenser was then removed, and the boiling water was poured into the flask containing the pieces. The condenser was again attached to this flask and allowed to boil for 1 hour.

The contents in the flask were cooled to 20-25°C allowed to settle and the extract was decanted into a small beaker. The extract was divided into duplicates.

3.3.4.5 DETERMINATION OF pH

The pH meter was calibrated with buffers of pH 4 and 7. After the calibration, the electrodes were rinsed several times with distilled water and once in a small quantity of the extract. Before measuring the pH of the extract,
confirmation of whether the extract had the temperature of between $20^\circ-25^\circ C$ was done. The electrodes were then immersed in the extract and the pH value read. The same determination was done for the duplicate extract.

3.3.4.6 **EXPRESSION OF THE RESULTS**

The pH was expressed to the nearest 0 unit as the mean of the two determinations.

3.4 **DEACIDIFICATION OF ACIDIC BOOKS WITH CALCIUM HYDROXIDE**

Calcium hydroxide was prepared by suspension in water until saturation point was reached (approx. 1.5g per litre of water) at $25^\circ$. The mixture was decanted, and the supernatant liquid was poured in the bath where the book was immersed for about ten minutes. The document was then aired to activate the carbon dioxide before final pressing.

Before immersion of the book into the bath, tests of solubility of the ink in the solvent (water) were carried out. All the five books which had a pH of 2, had inks that were insoluble in water. The test was done by dipping some cotton wool in water and pressing it for sometime (about ten minutes) on a word on the book.
After the deacidification, pH tests were done again to confirm the absence of the acid.

3.5 DATA ANALYSIS

The data was analysed by use of descriptive statistics, that is, percentages, averages and use of tables. It was from these that conclusions were drawn.
CHAPTER FOUR

DATA PRESENTATION AND ANALYSIS

4.0 INTRODUCTION

The objective of this chapter is to report in detail the findings of the status of the publications in the libraries and archives, and the level of acidity of papers manufactured in the country. These factors were investigated through observations and experiments. The information about care and storage was established through interviews.

The observation method was set to establish whether there is a characteristic colour change in book papers - from white to yellow/brown as well as the strength of the papers.

Three experimental designs were carried out. The first involved acidity tests on books by use of universal indicator. The second was set to establish the level of acidity on unprinted paper that is manufactured in Kenya through use of hot extraction method. The third design was a set up of deacidifying five books out of those found with low pH with an alkaline solution.

A questionnaire was used to interview the reference/circulation and acquisition librarians (appendix A)
4.1 CODING OF DATA

For convenience, economy and ease of reference, the following codes were employed in this part of the study:

1. KU — Kenyatta University Moi Library.
2. MML — MacMillan Memorial Library.
3. KNA — Kenya National Archives.
4. REP — Repositories (in KNA).
5. NDS — National Documentation Services (in KNA).
6. ACL — American Center Library
7. ICIPE — International Centre for Insect Physiology and Ecology Library
8. N — Total number of samples
9. B — Brittle
10. NB — Not brittle.
11. Dash (-) — None
12. C — Collection

4.2 BRIEF INFORMATION ABOUT THE LIBRARIES AND THE ARCHIVES STUDIED

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<th>INSTITUTION</th>
<th>DATE OF ESTABLISHMENT</th>
<th>% OF PAPER-BASED MATERIALS</th>
</tr>
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<tr>
<td>KU</td>
<td>1972</td>
<td>99.8</td>
</tr>
<tr>
<td>KNA</td>
<td>1965</td>
<td>85.6</td>
</tr>
<tr>
<td>MML</td>
<td>1931</td>
<td>98.8</td>
</tr>
<tr>
<td>ICIPE</td>
<td>1973</td>
<td>93.5</td>
</tr>
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</table>
4.3 COLOUR, pH AND STRENGTH OF BOOKS

These three variables were investigated and their relationships were established. The results were tabulated in three different tables: Table 1 shows the relationship between colour and strength; Table 2: the relationship between the pH and strength of books and Table 3, the relationship between the colour, pH and the strength.
<table>
<thead>
<tr>
<th>INSTITUTION</th>
<th>COLOUR AND STRENGTH</th>
<th>TOTAL</th>
<th>% OF THE BRITTLE MATERIALS</th>
<th>% OF THE YELLOW NOT BRITTLE</th>
<th>TOTAL % OF THOSE IN DANGER</th>
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<tbody>
<tr>
<td></td>
<td>YELLOW B</td>
<td>NB</td>
<td>WHITE B</td>
<td>NB</td>
<td></td>
</tr>
<tr>
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<td>GENERAL C.</td>
<td>12</td>
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<td>8</td>
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<td>5</td>
<td>-</td>
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<td>GENERAL C.</td>
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<td>2</td>
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<td>AFRICANA</td>
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<td>-</td>
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<td>-</td>
<td>4</td>
<td>-</td>
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<tr>
<td>TOTAL</td>
<td></td>
<td>75</td>
<td>49</td>
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<td>41</td>
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TABLE 2: Relationship Between the PH and Strength of Books

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<th>PH VALUES AND STRENGTH</th>
<th>1</th>
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<th>4</th>
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<td>9</td>
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<td>2</td>
<td>4</td>
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<td>35</td>
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<td>GENERAL C.</td>
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<tr>
<td>AFRICANA</td>
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<td>5</td>
<td>5</td>
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<tr>
<td>KNA</td>
<td>3</td>
<td>13</td>
<td>7</td>
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<td>50</td>
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<td>GENERAL C.</td>
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<tr>
<td>MIRUMBI</td>
<td>3</td>
<td>6</td>
<td>1</td>
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<td>KDS</td>
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<td>8</td>
<td>2</td>
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<tr>
<td>GENERAL C.</td>
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<td>35</td>
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<td>MML</td>
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<td>10</td>
<td>25</td>
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<tr>
<td>ICIPE</td>
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<td>8</td>
<td>2</td>
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<td>1</td>
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<tr>
<td>TOTAL</td>
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<td>54</td>
<td>52</td>
<td>15</td>
<td>2</td>
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<td>9</td>
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<td>%</td>
<td>12.7</td>
<td>32.7</td>
<td>31.5</td>
<td>9.1</td>
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<tr>
<td>TOTAL % FOR EACH PH VALUE</td>
<td>12.7</td>
<td>64.2</td>
<td>9.1</td>
<td>1.2</td>
<td>5.5</td>
<td>7.3</td>
<td>58</td>
</tr>
<tr>
<td>COLOUR AND STRENGTH</td>
<td>1</td>
<td>2</td>
<td>3</td>
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<td>5</td>
<td>6</td>
<td>TOTAL</td>
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<tr>
<td>YELLOW</td>
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<tr>
<td>B</td>
<td>21</td>
<td>54</td>
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<td>124</td>
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<tr>
<td>NB</td>
<td></td>
<td>41</td>
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<tr>
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<td>B</td>
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<td>41</td>
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<tr>
<td>NB</td>
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<td>11</td>
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<td>2</td>
<td>9</td>
<td>12</td>
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</tr>
<tr>
<td>TOTALS</td>
<td>21</td>
<td>106</td>
<td>15</td>
<td>2</td>
<td>9</td>
<td>12</td>
<td>165</td>
</tr>
<tr>
<td>%</td>
<td>12.7</td>
<td>64.2</td>
<td>9.1</td>
<td>1.2</td>
<td>5.5</td>
<td>7.3</td>
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</tbody>
</table>
Table 1 shows clearly the relationship between colour and book paper strength. However, not all yellow books were brittle. Conversely, there was no book that was white and brittle.

A total of 35 books were selected from KU. Twenty five out of these were from the general collection (which included 15 books, 5 periodicals and 5 newspapers) and 10 from the Africana section. Twelve out of the 25 (48%) books in the general collection were brittle, 5 out of 25 (20%) were yellow, but not brittle. Fifty percent of the Africana collection sample was brittle, whereas the other 50% was yellow but not brittle. Overall, 48.6% of the total sample in KU were brittle, whereas 28.6% were yellow but not brittle.

In KNA, a total of 50 books were selected; 25 from the general collection, 10 from the Murumbi collection and 15 files from the repositories. The results were as follows:

1) In the general collection 16(64%) were brittle, 9(36%) were yellow but not brittle.

2) Nine (90%) of the sample from the Murumbi collection was brittle whereas the other 1(10%) was yellow but not brittle.

3) Thirteen(86.7%) of the materials tested in the repositories were found to be yellow and brittle, whereas the remainder (2) 13.3% was only yellow.
Thirty-five books were selected in MML: 25 from the general collection and 10 from the Africana section. In the general collection 14(56%) were brittle while 9(36%) were yellow but not brittle. Thirty per cent of those in Africana were brittle while 60% were only yellow.

In ICIPE and ACL, the samples were taken from the general collection only: 25 from ACL and 20 from ICIPE. ACL had no book which was brittle though 4 were yellow. In ICIPE, only 3(15%) were brittle.

Results in table 2 reveal that all books that had a pH of 1 were brittle. Those with a pH of 1 constituted 12.7% of the total sample (N=165) Those that were brittle and had a pH of 2 were 54(32.7%) while 31.5% had a pH of 2 but not brittle. None of the books had a pH value higher than three were brittle. The percentage of those with pH of less than four was 86% (N=165).

In KU, 21 out of 25 (84%) in the general collection sample had a pH of less that 4. All books in the Africana sample had a pH of 2.

In KNA, 24(96%) of the books in the general collection had a pH of less than 4. All books from the Murumbi collection and the repositories had a pH of less or equal to 2.
In MML, all the books from Africana section had a pH of 2 while those from the general collection had a pH of less than 4.

In ACL, 12 books (48%) had a pH of less or equal to 3 while there were 15 (75%) from ICIPE with a pH of less than 4.

The average pH of the materials was 2.4. Table 3 shows that all books that were yellow and brittle had a pH of less or equal to 2.

4.4 LEVEL OF AWARENESS OF ACIDITY PROBLEMS BY THE LIBRARIANS AND ARCHIVISTS

All respondents who were interviewed admitted having noted yellowing and fading of writings on books and especially the newspapers.

The two respondents from the KNA indicated correctly that the cause of yellowing was acidity. The rest, who were actually librarians had no idea of the cause.

4.5 PRESERVATION AND CONSERVATION MEASURES UNDERTAKEN TO CURB ACID–HYDROLYSIS ACTION BY THE LIBRARIES AND ARCHIVES STUDIED

Except in KNA, nothing is being done in all other
libraries to halt acid deterioration. The visibly
deteriorated materials that are meant for permanent retention
in the KNA repositories are deacidified by use of calcium
hydroxide and those that are too brittle are microfilmed.
It was learnt that the NDS which is within the KNA does not
deacidify the materials it holds. At the same time,
the major preservation measures taken on the materials in the
repositories do not include deacidification.

When the respondents other than those from the KNA
were asked why nothing was being done, their answers revealed
that the problem had not been appreciated. Further prodding
by the researcher elicited responses that indicate that even
if they knew about the cause of the problem, they had no idea
of how to solve it.

All the respondents indicated that the major
preservation measure that they take immediately materials are
received is binding of the poorly bound books. None of the
respondents from the libraries indicated that acidity tests
are carried out.

All the respondents rated the paper quality as among
the last in the criteria of selecting the books. All
admitted that they are usually cautious about books that are
printed in India.
4.6 EFFECTS THAT ACID DETERIORATION HAS ON USE OF THE AFFECTED MATERIAL

Respondents were asked whether the colour changes had any effect on the use of the paper-based materials.

All except two respondents (71%) admitted that the changes affected the use. They gave various reasons as to how use is affected as: illegibility due to faded writings; brittleness and the fact that they tear easily when in use.

Three of the respondents indicated that some users had complained about such books. Two respondents listed some of the complaints which were similar to those advanced above. The complaints had been raised in the KNA on records in files being illegible, in MML and in KU - Africana section.

4.7 STORAGE CONDITIONS

4.7.1 TEMPERATURE REGULATIONS

Except in KNA and ACL, the other libraries do not control the temperature of the building. The KNA has thermometers, hygrometers and air conditioners which measure and control the temperature. There are no temperature control devices in the NDS collection, they are only found in the repositories.
The air-conditioning machine in ACL was not installed with the idea of preservation of materials in mind. It was meant for users comfort in bid to avoid stuffiness.

All the respondents agreed that it is necessary to control temperature for preservation of materials. Two of the respondents also indicated the need to control temperature for user comfort.

4.7.2 HUMIDITY CONTROL

Humidity control is done only in KNA where there are humidity measuring and control devices which include the hygrometers and dehumidifiers. The devices (though some are out of order) are only in the repositories and not in the NDS collection.

All the other libraries do not control or regulate the humidity of their buildings.

4.7.3 AIR-POLLUTION CONTROL

Respondents from the KNA indicated that the air conditioner acts as an air pollution control device. Closing of windows and doors in the repositories, storing records in boxes were other measures taken in the KNA to control air pollution. Unfortunately, the windows in the NDS collection
are always wide open and the books are stored openly.

No measures are being taken by all other libraries. The MML library, which is in the central part of town where there are a lot of vehicle fumes, the windows, especially those in Africana are usually wide open.

4.7.4 SUNLIGHT AND ARTIFICIAL LIGHT CONTROL

All libraries and archives use curtains as a measure of controlling the amount of sunlight. The curtains, unfortunately are always open, therefore allowing the sun to fall on the materials. The KU's Africana section is a good example whereby some shelves are very close to the wall and the curtains are most of the time open. The books in these shelves have faded spines where the sunlight falls. ICIPE library building allows a lot of sunlight into the building.

Respondents from MML, ICIPE and ACL indicated that no measure is taken to control the amount of artificial light falling on the materials. The KNA, KU use light filters. KNA uses low voltage bulbs and light shades.

4.8 TRAINING IN THE AREA OF PRESERVATION AND CONSERVATION

Except the respondents from the KNA (archivists) no librarian had a formal or informal training on preservation
and conservation of library materials. At the same time, the staff involved in the actual deacidification of materials in KNA are not well trained and the researcher found out that they do not actually undertake the proper weighings of the calcium hydroxide that they use. They pour out any amount.

4.9 **LEVELS OF ACIDITY OF UNPRINTED PAPER MANUFACTURED IN KENYA**

Four different brands of paper were selected. These include:

1. White Bank which is used by the Government Ministries for printing of letterheads. They also are used elsewhere as typing papers.

2. White printing which is used to print most Government Ministries' publications and most locally produced books use this type of paper.

3. Newsprint is used to print dailies and the Kenya Gazette.

4. Esparto Laws is an imported paper that is used by the Government Printer to print the laws.
TABLE 4: ACIDITY OF SOME BRANDS OF PAPERS BEFORE BEING PRINTED ON

<table>
<thead>
<tr>
<th>BRAND</th>
<th>AVERAGE pH</th>
</tr>
</thead>
<tbody>
<tr>
<td>WHITE BANK</td>
<td>5.0</td>
</tr>
<tr>
<td>WHITE PRINTING</td>
<td>4.0</td>
</tr>
<tr>
<td>NEWSPRINT</td>
<td>4.0</td>
</tr>
<tr>
<td>ESPARTO LAWS</td>
<td>7.5</td>
</tr>
</tbody>
</table>

The table shows that the Newsprint has the lowest pH of 4.0. White Bank and White Printing have pHs of 5 and 4.8 respectively. Esparto Laws has a high pH of 7.5.

TABLE 5: LEVEL OF ACIDITY OF THE KENYAN & INDIAN PRINTED MATERIALS

<table>
<thead>
<tr>
<th>PH VALUES AND STRENGTH</th>
<th>1</th>
<th>2</th>
<th>3</th>
<th>4</th>
<th>5</th>
<th>6</th>
<th>TOTAL</th>
</tr>
</thead>
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<tr>
<td>INSTITUTION</td>
<td>B</td>
<td>NB</td>
<td>B</td>
<td>NB</td>
<td>B</td>
<td>NB</td>
<td>B</td>
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<tr>
<td>KU (teaching practice</td>
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<td>4</td>
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<td>collection</td>
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<td>4</td>
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<tr>
<td>NDS (Legal deposit books)</td>
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<td>5</td>
<td></td>
<td>5</td>
<td></td>
<td></td>
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</tr>
<tr>
<td>INDIAN BOOKS</td>
<td></td>
<td>3</td>
<td></td>
<td>1</td>
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</tr>
</tbody>
</table>
All the books in these three collections have a pH of below 4. All the Kenya & Indian books have pH levels of below 4 which is a dangerous level.

It was notable that despite the recency of the materials printed in India, they had very low pH. Actually all the books tested had been printed or reprinted between 1989 and 1991.

4.10 DEACIDIFICATION

The five books deacidified were tested and showed a level of pH of 8. A buffer was left which is meant to protect the book from acid attacks in the future.
CHAPTER FIVE

5.0 DISCUSSION OF THE FINDINGS, CONCLUSIONS AND RECOMMENDATIONS

5.1 INTRODUCTION

The major objectives of this study were as follows:

1) to establish the level of acidity of the books held in some libraries and the Kenya National Archives with a view to establishing whether the level was dangerous.

2) to establish whether the librarians and archivists are trained on how to handle the problem.

3) to investigate what is being done to contain the problem.

4) to establish the level of acidity in the locally produced papers before they are printed on.

5) to recommend possible solutions to problems posed by acid-hydrolysis.

6) to recommend base standards of paper for future materials.
5.2 LEVELS OF ACIDITY OF THE PAPER-BASED MATERIALS IN THE SELECTED LIBRARIES AND THE KENYA NATIONAL ARCHIVES

Literature related to the study in Chapter 2, revealed that acidity is the major enemy of books as it breaks down cellulose fibres, rendering the paper weak and eventually brittle, and that the lower the pH, the more dangerous the acid action on paper. 47, 48, 49

Tables 1, 2, 3 in chapter 4 show clearly the relationships between the pH, colour and the strength of the papers.

Table 1 indicated that all the books that were brittle, had a yellow colour, some books had a yellow colour but not brittle. Conversely, no book that had a white colour was brittle. From this, it can be concluded that brittleness comes after yellowing of papers; thus appearance of yellow colouring in a paper which was originally white, is a sign that acid-hydrolysis is taking place. These findings support what is in the literature that the first visible evidence of acid-hydrolysis in books is a slight discolouration (yellowing) of paper, which becomes intense as time goes by. 50

Table 2 indicate that all the books that had a pH of 1 were brittle; some had a pH of 2 and brittle, while others
had a pH of 2 but not brittle. There was no book that had a pH above 2 and brittle. Evidence available from the findings shows that the lower the pH, the more the books are at risk of becoming brittle.

Table 3 revealed that there were books that had a pH of 2 and 3, yellow, but not brittle. It has already been stated that yellowness is a sign of an acid action taking place, and since at pH 2 and 3 some materials are yellowing and the fact that all the brittle books had a pH below 2, the conclusion that can be drawn from this is that acid-hydrolysis action is a process that takes place slowly.51

Table 1 indicated that all books that had a white colour were not brittle. Table 2 revealed that some books had pHs as low as 2 and 3 but white. It can be inferred from this that, whiteness is not an indication that paper is safe from acid hydrolysis or that the paper has a high pH. This concurs with literature that acid contamination is undetectable visually. Its degree of contamination in not-yet-discoloured book must be tested. Discolouration becomes greater as time goes by and the acid content increases. The paper becomes deeply and uniformly brown/yellow stained and it is at this point that it is on the verge of embrittlement.52

Table 3 also revealed that all books that had a pH of 4 and above had no signs of yellowing and brittleness. From
this, it can be inferred that materials which have a pH of above 4 are not at risk of becoming brittle as long as they are stored in suitable environmental conditions.

The findings and the conclusions made from the three tables indicate that most of the books in the selected libraries and archives are in great danger of becoming brittle. Yellow coloured books constituted the highest percentages in Kenyatta University (77.2%), Kenya National Archives (100%), MacMillan Memorial Library (91.4%) and ICIPE (55%). American Center Library had the lowest percentage of the affected materials because most of the materials tested were not only new but were also printed on acid-free papers.

Special collections in the above libraries comprise unique and rare materials that are meant for permanent storage. The materials are stored in the Africana sections of the Kenyatta University Moi Library and MacMillan Memorial Library. In the Kenya National Archives, the Murumbi and the archives repositories have unique materials too. All these materials are in great danger of becoming brittle, as evidenced by the low pHs and yellowing in all books tested.

Overall, 75.2 percent of the materials in the selected libraries and archives are threatened with impermanence. The materials have a dangerous average pH of 2.4.
5.3 LEVEL OF AWARENESS BY THE LIBRARIANS AND ARCHIVISTS OF THE PROBLEM OF ACID HYDROLYSIS AND THE MEASURES BEING TAKEN TO CURB THE PROBLEM

This study found out that nothing is being done to curb acid-hydrolysis in the libraries except in the Kenya National Archives, which, however could not be said to be doing much, because only a small percentage of the materials are deacidified. At the same time, the deacidification process is not carried out effectively.

The study also revealed that librarians were not aware of the damage which can be caused by acidity on the paper. This could be due to the fact that none of the librarians interviewed had received any formal or informal training on the preservation and conservation of materials. Perhaps, this is why they had not appreciated this as a problem. However, when the researcher explained to them of the implications of presence of acid in papers, they conceded it is a problem worth looking into. These findings indicate the need to train librarians on conservation and preservation of materials.

The archivists were aware of the dangers caused by acidity on book papers. They were also aware of the methods which can be used to solve this problem. However, in the Kenya National Archives, the members of staff who do the actual deacidification do not take caution of the
concentrations of the chemical used. They pour out too much alkaline-hydrolysis which is as bad as acid-hydrolysis.\textsuperscript{53} This indicates lack of follow-up by those archivists who know what should be done. It may be thought that the deacidified materials have been saved from acid deterioration while they have been exposed to alkaline-hydrolysis.

The researcher also attempted to find out whether the effects of acid hydrolysis affect use of materials, through interviews. Most of the respondents (71\%) indicated that colour changes, fading of the writings and brittleness affect use of materials. It can therefore be argued that effects of acid hydrolysis can have adverse effects on use of the library and archives materials. Illegibility and fragility of the affected materials were some of the listed complaints that had been raised by users to the librarians. Library and archives materials are for use and if use is affected, the effectiveness of the service is lowered. This means that efforts to prevent this effects from taking place are paramount.

5.3.2 \textbf{RECOMMENDATIONS ON WHAT SHOULD BE DONE}

From the above findings, it is clear that something needs to be done. The only viable solution for those books that are not already too brittle, is deacidification. Just as cancer disease can be difficult to be cured at an advanced
stage, books can become unsalvageable, if acid-hydrolysis is not halted at the initial stages.

Early recognition of acid damage that is likely to occur is of utmost importance. Acid contaminated books are doomed unless something is done to neutralize the acid in them. Since acid contamination is undetectable visually, the degree of its manifestation (pH) in not-yet-discoloured book paper can be approximated by testing with pH test paper strips or careful use of universal indicator. Testing for acid is paper must be a standard practice when examining special collections.

Acidic materials must be deacidified as soon as possible. Deacidification neutralizes acidic components in paper and deposits alkaline buffer to counteract acidic build-up in the future. There are three basic types of deacidification processes: aqueous; non-aqueous and vapour phase. The choice of the method and chemical to be used are mainly governed by the type of ink on the document. No paper should be neutralized until the ink on it has first been tested for solubility in the deacidifier liquid. This test can be carried out by use of a small piece of cotton wool of not more than 5mm across, wetted with the deacidifier solvent, squeezed lightly on a suitably insignificant part of the writing. This should be left there for about 3 minutes and the moistened area examined through a small hand lens for
signs of feathering, bleeding, discolouration etc. The piece of wool should also be examined. Those found soluble in water should be deacidified with a non-aqueous solution or gaseous phase methods.

The other factors that govern the choice of the deacidification process to be used advocate that the treatment should:

1) reduce the active acidity (pH) to a level where other causes of paper deterioration define the limit of its useful life.
2) deposit a protective residue in the paper to act as a buffering and stabilizing agent.
3) not be harmful to paper, other book components or the book users.
4) have a simple procedure which is within the capabilities of non-professional staff.
5) be fast, cheap and lend itself to hand or mechanized applications.

Whichever process is chosen for deacidification, there is need for a properly equipped laboratory. Construction of such a laboratory has many financial implications in a way that it is virtually impossible for each library to have a well equipped laboratory. This study recommends that there
should be one central national conservation laboratory
equipped with the necessary materials (chemicals, equipments
e tc.) and services of qualified conservators whose advise
must always be sought. No chemical or similar treatment
of library and archives materials should be attempted except
under the guidance of an expert.

The state of the materials and library and archives
materials need immediate attention and since the central
national laboratory cannot be built overnight, this study
recommends that, with an agreement, the laboratory in the
Kenya National Archives, though small and not well stocked,
can be used to treat the most threatened materials in the
archives and other libraries. The laboratory may need
restocking and services of qualified conservators.

Considering the resources available and the fact that
mass deacidification will not be available in the country in
the foreseeable future, the researcher recommends that the
materials thought to be of extra importance to library or
archive should be selected for deacidification as soon
possible. The more acidic books should be given priority.

Libraries and archives should obtain (if they are
available) replacement copies or copies on microfilm of the
materials that are too brittle to be salvaged by
deacidification. It is also important for libraries to start
their own microfilming programs or use the services of the
microfilming section of the Kenya National archives.

The research recommends as of now, the use of calcium hydroxide solution for deacidification of the acidic materials, whose inks are not soluble in water. For those with inks that are soluble in water, the use of methyl magnesium carbonate is recommended. These two chemicals are effective because they leave a buffer on the papers, protecting them from further acid attack. The proper concentrations must be used. The major disadvantages of these two procedures is that they are time consuming and tedious.

Since the research revealed that librarians were not aware of the problem of the acid hydrolysis in paper based materials leave alone how to contain it, this research recommends that seminars and workshops be organized to educate them on preservation and conservation issues. All library studies and related courses, at all levels must incorporate preservation and conservation issues in the syllabi.

There was no library which had a trained conservator and this calls for the employment of a qualified member of staff in this area. Those who are trained in the Kenya National Archives must supervise the methods of selection of materials to be deacidified as well as
the proper procedures of preparations of the deacidifiers.

5.4 STORAGE CONDITIONS OF THE PAPER-BASED MATERIALS

5.4.1 TEMPERATURE AND HUMIDITY CONTROL

Literature related to the study revealed that controlled temperature and humidity are vital for proper protection of cellulosic materials.56,57,58

There is a simple rule of thumb in chemistry that chemical reactions generally go faster with an increase in temperature.59 Therefore, the rate of acid-hydrolysis reaction increases with increasing temperature, or its correlative, the permanence of paper increases as the rate of deterioration reaction decreases. Therefore, temperature and humidity are critical factors in the preservation of library materials.

High humidities are detrimental to permanence than low humidities. Water is necessary in the acid-hydrolysis of paper as it facilitates the action of industrial and urban-air pollutants.61,62

Temperatures and humidity working alone or together can cause great harm to library materials.
Therefore, the cooler the temperatures, the better for the library and archives materials. The lower the relative humidity the better for the materials. It should also be noted that fluctuations of these two factors are harmful to the materials. There is need therefore to keep them constant. The generally accepted storage conditions for proper preservation of paper range between 22-25°C and 45-55%, temperature and relative humidity respectively.

This study revealed that except the Kenya National Archives, most libraries do not control both the temperatures and humidities of their buildings, which indicates that the dangers caused by uncontrolled temperatures and humidities are prevalent in these libraries. There are hot and rainy seasons in Kenya that are characterized by high temperatures and humidities respectively. At the same time, these two factors are not constant, they fluctuate.

5.4.1.1 RECOMMENDATIONS FOR TEMPERATURE AND HUMIDITY CONTROL

Acid-hydrolysis as implied above, is activated by uncontrolled temperatures and humidities. It has been established by the study that most of the materials in the libraries are acidic. It goes without saying that control of both temperature and humidity is inevitable, if we hope to retain the library materials in a usable form for future generations.
Temperature control can be carried out by use of air conditioner, and a thermometer for keeping track of its steadiness. A dehumidifier is necessary for humidity control and periodical checks are important with a hygrometer. These instruments must be installed in Kenyatta university Moi Library, MacMillan Memorial Library and ICIPE library. The American Center Library which has the air conditioner only should have a dehumidifier fixed. Since some of the instruments are broken in the Kenya National Archives, they must be repaired with immediate effect.

5.4.2 AIR POLLUTION CONTROL

Most library and archive materials are affected by impure air. Urban areas are characterized by damaging quantities of sulfur dioxide, hydrogen sulphide, ozone, nitrogen oxides and aerosols. The most harmful of these impurities is the sulphur dioxide which reacts with oxygen and moisture to form sulphuric acid.66

These acidic gases are absorbed by paper at a very high rate.67, 68

Control of air pollution is paramount inorder to extend the life of the paper-based materials.
The selected libraries and the archives are in Nairobi area where air is not pure. Except the Kenya National Archives which tries to control the air pollution by use of air conditioners and packaging materials in boxes, the other three libraries are doing nothing to control. The American Center Library has an air conditioner which though not meant for preservation, does circulate the air. Large open windows allow polluted air into the library. Most windows are left open in MacMillan Memorial Library, Kenyatta University Moi Library, ICIPE Library and the National Documentation Services in the Kenya National Archives.

The conclusion that can be drawn from here is that the materials in these libraries are absorbing acidic gases thus increasing acidity levels in them, and this needs to be curbed.

5.4.2.1 RECOMMENDATIONS ON AIR POLLUTION CONTROL

Air pollution must be minimized in libraries and archives. Air conditioning and air washing equipment, if can be installed, will minimize the harmful effects of air-borne impurities. Water scrubbing devices in air conditioning systems are an effective means of removing noxious gases from the air though very expensive to keep. An activated carbon filters in the air circulation system are an alternative. They remove gaseous contaminants and when used in conjunction with glasswool filters, they remove solid particulate.
Installation of air conditioners should be a priority for libraries and archives located in industrial areas subject to high level of air pollution.

Windows should be closed especially in special collection storage areas to avoid polluted air into the buildings.

5.4.3 SUNLIGHT AND ARTIFICIAL LIGHT CONTROL

The radiant energy of light absorbed by the molecules in library materials can cause chemical changes that will damage them. The ultraviolet (UV) rays, which have very short wavelengths, are the most damaging. Sunlight and fluorescent lighting are the primary sources of ultraviolet radiation in libraries⁷⁰

Long exposure of light especially the sunlight, lowers the pH of the paper.⁷¹ Light is a form of energy, and it energizes the acid-hydrolysis reaction on the materials.⁷² There's need then to control the amount falling on the materials.

The findings indicated that except in Kenya National Archives, little is being done to control the amount of light falling on materials in the libraries. Even in the Kenya National Archives, the National Documentation Services section, a lot of light is allowed into the building. ICIPE library building allows a large amount of light from both sunlight and the artificial lights. Most of the libraries
visited, use fluorescent bulbs. The curtains which can reduce the amount of light falling on the materials are open most of the times.

5.4.3.1 RECOMMENDATIONS ON LIGHT CONTROL

Damage by light can never be entirely eliminated, but can be greatly reduced by following three basic rules:

1) Elimination of ultraviolet radiation. All sources of UV like daylight and fluorescent tubes must be eliminated and replaced with less damaging sources.

2) Reduction of illuminance to no more than necessary for comfortable viewing.

3) Reduction time of illumination as far as possible is important.

While windows cannot be covered with an opaque or translucent material, they can be curtained and the curtains should be drawn when the light from the sun is intense. While UV absorbing films are expensive, they can be applied directly to glass to cut off UV rays. Ultraviolet blinds are also available. Library materials of any permanence should not be kept in areas with many windows — preferably in areas with very dim lights.
Fluorescent lights is far more harmful than incandescent light. If it cannot be replaced, it can be covered with special filters to reduce the amount of UV rays.

Stack areas should be kept dim lighted when library is not in use.

5.4.4 A GENERAL RECOMMENDATION ON STORAGE CONDITIONS

The storage conditions demand quite a lot from the librarians and archivists. Many of them have to make the best of buildings that were constructed with little or no attention to the overall design of facilities for the care of the collections that they house. Renovations will have to be made to better the building. For those considering building or renovating libraries and archives, two major aspects to be considered are:

1) Air conditioning equipment, dehumidifiers and air filtering systems should be installed to inhibit atmospheric damage to library materials.

2) The building should be designed so that incandescent light with minimal illumination is installed in all areas where the materials are housed.

The librarians and archivists engaged in building or
renovation programs should be thoroughly familiar with the standards and specifications of libraries and archives buildings.

5.5 QUALITY OF PAPERS MANUFACTURED IN KENYA

The other objective of this study was to establish the level of acidity of the paper before it is printed on, in order to decide whether all the acidity found in the materials is absorbed in storage areas of libraries and archives, or they have acid even before they get into the library or archives.

Literature indicates that paper acidity can originate from poor manufacture. The chemicals added during the manufacturing process such as bleaching agents, alum rosin among others can be sources of acid in papers.\textsuperscript{74,75} Lignin is another substance that is found in wood and it breaks down to form acids.\textsuperscript{76} At the same time, oxidation of sulfur dioxide to sulfuric acid is aided by impurities in the materials such as iron, alum sizing and residual lignin.\textsuperscript{77}

The findings indicate presence of acid in the locally manufactured paper. The Newsprint brand has the lowest pH (4) followed by the White Printing (4.8) and lastly White

\[ \text{Equation} \]
bank (5). As a way of comparison, an imported brand Esparto Laws, was tested which had a surprising high pH (7.5).

From the above findings, one can conclude that the locally manufactured papers are acidic even before they are stocked in the library. The other conclusion that can be drawn is that since locally printed materials tested from the archives and libraries had a lower pH than those of the unprinted paper; there must be factors which increase the acidity in storage, which qualify the need to take care of the storage conditions.

The research could not establish whether the acid that originates from poor paper manufacture is a result of use of alum, chlorine or even lignin. But it could be one or a combination of these chemicals or even others.

At the same time, it was not possible to establish whether the lowering of the pH in the storage was as a result of use of acidic inks or dyes or absorption of air pollution by the paper. It can only be suggested that the lowering of the pH could be because of one or a combination of these factors, as well as the uncontrolled temperature and humidities. Most of the archives are open to the public.

The conclusion that can be made from these findings is that paper produced in the country is very poor, with low
acidity levels ranging between 4 and 5. It can also be inferred that materials in the libraries and archives absorb acids from the environment.

For comparison purposes, some few books that were printed in India had been selected. Most of the books had a pH of below 3; which confirmed the librarians' caution about buying books printed in India.

Most librarians expressed their dissatisfaction about books printed in India saying that they are poorly bound and they tear easily.

Despite the fact that the tested materials had been printed recently (between 1990-1992) they had very low pH and the papers were tearing easily. The most unfortunate thing was that these books which had been selected from Kenyatta University Moi Library, were passed for circulation immediately after processing before any preservation or conservation measures were taken.

5.5.1 RECOMMENDATIONS

From the foregoing discussion, it it clear that the paper manufactured in Kenya is of poor quality. This is the paper that is used for records creation by the government ministries. Most of the records are meant for permanent storage. It has been established that most of these which are stored in the Kenya National Archives have deteriorated very much due to paper quality. There is need therefore to have
publications and records with known enduring value at the time of their creation obviously produced on permanent paper. Judicial selection of paper and ink of standard quality is very necessary at the creation stage.

The local paper manufacturing plant should be converted, even if not the whole plant, into an alkaline plant. Literature has revealed that after conversion of such a plant, there are less expenses involved, unlike traditional acidic plants.77

Archivists should try and ensure that the papers used by government Ministries in future are permanent.

A National Council of Preservation and Conservation of Library and Archives Resources should be set up to discuss and provide useful guidelines about the production of permanent books. Its duties should be among others to:

1) lay down standards for acid-free paper. The council can use the American Standards as a base.

2) advice on what ought to be printed on permanent paper.

3) draw policy guidelines on all matters concerning preservation and conservation.

A dialogue between the paper manufacturer, publishers, librarians and archivists is of great importance to discuss the issue of paper permanence.
5.6 SUMMARY OF THE CONCLUSIONS AND RECOMMENDATIONS FOR SPECIFIC LIBRARIES AND THE KENYA NATIONAL ARCHIVES

5.6.1 KENYATTA UNIVERSITY MOI LIBRARY AND MACMILLAN MEMORIAL LIBRARY

Paper-based materials constitute the highest percentage in these two libraries: 99.8 and 98.8% in Kenyatta University Moi Library and MacMillan Memorial Library respectively. The research findings revealed that 77.2% and 91.4% of the paper-based materials in Kenyatta University Moi Library and MacMillan Library respectively are in danger of becoming brittle. Nothing is being done to curb this problem. At the same time, the storage facilities of these materials are not satisfactory. The staff were ignorant of the problems of acidity as well as their implications.

These libraries have got unique and rare old materials that are threatened by acid-hydrolysis reactions. Some examples of such unique materials include:

In KU: a) Dictionnaire Francais-Swahili, by R.P. Sacleux of 1891 which had a pH of 2 and brittle.
    c) A dictionary of the swahili language by L. Krapf, which had a pH of 2 and brittle.
In MML: a) The new African a journey up the... 1897. by A. Schulz. had a pH of 2, yellow and brittle at the edges.

b) History of Egypt. 1904; had a pH of 2, yellow and brittle.

c) Webster's dictionary of 1864. Had a pH of 1 and and very brittle. It is actually unusable.

This research therefore recommends that the following must be done with immediate effect:

1) Materials meant for permanent storage be tested and the acidic ones, be deacidified. Those that are too brittle must be microfilmed.

2) Any incoming material which is deemed to be of permanent value should be tested for acidity before being taken out for circulation.

3) Installation of air conditioning systems, dehumidifiers is necessary. Temperature and humidity measuring devices should be acquired in order to keep track of the environmental changes.

4) Fluorescent bulbs should have ultraviolet light filters and where possible, be replaced with incandescent light.

5) Curtains in the Africana sections should be drawn always to avoid large amounts of light falling on the materials.
6) Windows especially in the MML should be closed especially in the Africana section

7) It is necessary to have a member of staff who is well versed with the problems caused by acidity and ways of curbing them.

5.6.2 ICIPE LIBRARY

The library had a percentage of 55 which is threatened by acid-hydrolysis on paper. Just like in the other libraries, nothing is being done to solve the problem. There are no environmental control devices and the building allows a large amount of light.

The relatively lower percentage of the threatened materials is due to the fact that they are weeded frequently leaving the newer copies.

This does not however mean that no measure should be taken to preserve and conserve the threatened materials.

The library requires to:

1) reduce the amount of light that gets into the library through the glassy walls and windows by fixing good curtains.

2) move shelves, away from sunny areas. The current periodical shelf should be moved further away from the wall than it is now.
3) cover the fluorescent bulbs with an ultraviolet reducing devices.

4) curtains should be fixed and be drawn when the amount of light and heat is intense.

5) an air conditioner and a dehumidifier should be fixed.

The argument advanced as to failure of attention to conserve the materials was that these materials do not stay in the library for long they are donated to other libraries. This is a logical argument but since hydrolysis is a continuous process, if left to act on books, they will become weak. So, there is need to deacidify important materials immediately they got into the library if they are acidic.

5.6.3 AMERICAN CENTER LIBRARY

This library had a very low percentage of the threatened materials - 16%. Nothing is being done to deacidify these materials. Actually, most of the threatened materials were from the works of fiction.

The conditions which the materials are stored are satisfactory. The air conditioner, in spite of making the room more comfortable for the users, acts as a temperature control device, as well as for recirculation of air.

It was noted that most books tested had been printed on acid-free paper. Some of the books had indications of the
length of time that they will last.

The library should however, have a thermometer to be taking temperatures to ensure its steadiness. A dehumidifier is necessary for humidity control.

5.6.4 THE KENYA NATIONAL ARCHIVES

The paper-based materials in the Kenya National archives form 85.6% of the total materials. These materials are stocked both in the National Documentation Services (NDS) and the repositories.

Research findings revealed that 100% of the materials in the archives are in danger of becoming brittle. Actually, all the materials tested from the repositories and the Murumbi collection were yellowing while others were brittle.

The Kenya National Archives is taking some measures to curb the problems that arise from acid hydrolysis. The trained archivists are aware of the problems and an idea of how to solve it.

The KNA deacidifies acidic materials and environmental factors are controlled by use of air conditioners and dehumidifiers. Various measures are taken to control the amount of light falling on the materials.
Deacidification activities in the KNA are not carried out effectively. It was noted that the proper concentrations of the calcium hydroxide used are not measured. Tests are not taken of acidity before immersion of the document which means that even the very acidic materials are dipped which is disastrous as the books can get 'shock'. At the same time, a lot of alkaline substance can lead to alkaline hydrolysis.

The methods used for environmental control are satisfactory. The problem is that this control is actively done only in the repositories and therefore the NDS is ignored. At the same time, some of the machines have broken down. Windows in the repositories (unlike the NDS) are always locked to avoid air pollution. The intensity of light in the repositories is very low and when no people are using the stack areas, they are turned off. Lighting is not taken seriously in the NDS section where too much light is allowed which can be evidenced by the yellowing of the newspapers kept next to the windows. Windows are also usually wide open in the NDS.

The following recommendations are suggested in this study:

1) Deacidification should be carried out by members of staff who are qualified or the process must be supervised by a qualified member of staff; in order to ensure proper administration.
2) Before deacidification, the level of acidity must be established.

3) National Documentation Services (NDS) materials are important materials (especially those in the Murumbi collection), and therefore similar care as in the repositories should be taken. Temperatures, humidities, lighting, air pollution should be controlled.

4) The broken environmental control machines must be repaired.

5) The archives should try and ensure that the paper used by government ministries for records creation in future are acid-free.

6) Relocation of the national archives from the city centre is paramount.
5.7 GENERAL RECOMMENDATIONS

1. Librarians must be made aware of the problems posed by acidity through seminars and training.

2. There is need for the establishment of a national training facility in preservation and conservation in Kenya.

3. There should be a central national conservation laboratory which is well equipped with the necessary materials and qualified conservators.

4. A National Council on Preservation and Conservation of Library and Archives Resources should be set to address and provide useful guidelines on production of permanent books and records.

5. Both librarians and archivists must actively promote use of acid-free papers for permanent records.

6. Perhaps the librarians and archivists now are convinced that they need scientists' advice. Services of a conservators are needed for every library and archive.

7. Base standards for permanent and durable paper should include specifications for purified wood fibre, an alkaline pH (usually 7.5–8.5) requirements for folding endurance and tear resistance and an alkaline reserve (usually 3%-3.2%) left in the paper to resist acidic elements in the environment.
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APPENDIX A

Dear Respondent,

I am a post-graduate student taking a Master of Education course at Kenyatta University. I am undertaking research project on acidity problems in the Paper-based archive and library materials and would appreciate very much if you respond to my questionnaire.

Please respond to all the questions as honestly and accurately as possible. The information you will give will be strictly confidential and only for the purpose for which the study is done.

Put a tick (✔) against the information most applicable to you or fill in the blank spaces. Feel free to give the answer you find appropriate. Thank you.
SECTION A

(FOR CIRCULATION/REFERENCE LIBRARIAN)

1. Name (optional) ......................................................

2. Designation ............................................................

3. Name of library or archive ...........................................

4. Date of establishment ................................................

5. What is the size of your collection at the moment?
   (a) Books .........................................................
   (b) Journals .......................................................
   (c) Newspapers ...................................................
   (d) Audio-visual materials ......................................
       (i) Paper based ..............................................
       (ii) Film based ..............................................

6. Do you try to control the temperature of the archive or library building
   YES ( )
   NO ( )
   If NO, go to question No. 10

7. If YES, do you control the temperature of the whole building or some sections.
   If (a) whole building ( )
   If (b) some sections ( )

8. If you control temperature in some sections, please specify them
   (a) ........................................................................
   (b) ........................................................................
9. If you control temperatures, how do you do it?
   (a) By air conditioning  ( )
   (b) Manual ventilation  ( )
   (c) Any other specify .................................

10. Why would you try to control temperature?
    (a) for user's comfort  ( )
    (b) for preservation of materials  ( )
    (c) (a) & (b)  ( )
    (d) Any other reason specify  ( )

11. What temperature measuring devices do you have?
    (a) thermometer  ( )
    (b) None  ( )
    (c) Any other specify  ( )

12. Do you try to control humidity of the library or archive building?
    YES  ( )
    NO  ( )

   If NO, go to question No. 17.

13. If YES, do you control the humidity of the whole building or some sections
    (a) whole building  ( )
    (b) some sections  ( )
14. If you control humidity in some sections, please specify them.
   (a) ..........................................................
   (b) ..........................................................
   (c) ..........................................................

15. If you control humidity, how do you do it?
   (a) By air conditioner ................................
   (b) Dehumidifier ........................................
   (c) Any other specify ....................................

16. What humidity measuring devices do you have?
   (a) hygrometers ...........................................
   (b) None ....................................................
   (c) Any other specify ....................................

17. What measures do you take to control air pollution?
   (a) air conditioner ........................................
   (b) No measure ...........................................
   (c) Any other specify ....................................

18. What measures do you take to control direct sunlight on the Library or archive materials?
   (a) placing the shelves far away from the walls ........................................
   (b) curtains .............................................
   (c) No measure ..........................................
19. What measures do you take to control the intensity
23. If yes above, which among the items below could be the cause?

(a) Acidity ( )
(b) Sunlight ( )
(c) Old age ( )
(d) Worms (insects) ( )
(e) Any other specify

24. If you have noted these colour changes, is there anything that your Library is doing to curb this problem?

YES ( )
NO ( )

25. If NO, why do you think nothing is being done?

(a) The problem is not acute ( )
(b) Financial constraints ( )
(c) Because there is no idea of what should be done ( )
(d) Any other specify

26. If YES in No. 24, What is being done?

........................................................................
........................................................................
........................................................................
27. In your view, do you think this is the best solution to this problem?
   YES ( )
   NO ( )

28. If in No. 27, what do you think is the best solution
   (a) Establish of a conservation program ( )
   (b) No idea ( )
   (c) Specify any other ...........................................

29. Do these changes in colour affect the use of the materials?
   YES ( )
   NO ( )

30. If YES, how has it been affected?

31. Have there been complaints by users concerning the affected materials?
   YES ( )
   NO ( )

32. If Yes, list some of the complaints

33. Have you had any formal or informal training on preservation and conservation of Library materials?
   YES ( )
   NO ( )
34. If YES, at what level
   (a) Undergraduate ( )
   (b) Postgraduate ( )
   (c) Diploma ( )
   (d) Certificate ( )
   (e) Any other specify ........................................

35. Was it just a topic or a full course?
   (a) Topic ( )
   (b) ( )
   (c) A full course ( )

SECTION R

(FOR THE ACQUISITION LIBRARIANS)

36. Name (Optional) ..............................................

37. Designation ......................................................

38. What criteria do you use in selection of books?
   .................................................................
   (a) Cost ( )
   (b) Quality of the material which the book is printed ( )
   (c) Contents and relevance ( )
   (d) Any other specify ........................................

39. Have you come across some selection tools which
indicate the quality of paper the books have been printed on?

YES

NO

40. If YES, name them

(a) .......................................................... 

(b) .......................................................... 

(c) ..........................................................

41. On reception of the ordered books, what physical and chemical attributes do you check before passing them for processing?

(a) The type of binding whether good or poor ( )

(b) Whether the book is torn ( )

(c) Whether the book is acidic ( )

( ) Any other specify

..........................................................

..........................................................

42. What preservation measures do you take?

(a) binding ( )

(b) Deacidification of the acidic books ( )

(c) None ( )

(d) Any other, specify 

..........................................................

..........................................................

43. Have you had any formal or informal training on
preservation and conservation of materials?

YES

NO

44. What issues/topics were covered in your training or seminar attended?

(a) ..............................................................

(b) ..............................................................

(c) ..............................................................

45. In your view, is there need to conserve library and archive materials?

YES

NO

46. If YES, why?

..............................................................

..............................................................

..............................................................

47. If YES to No. 45, what are some of the measures that should be taken?

..............................................................

..............................................................

..............................................................