

Waves of knowledge

Trends in paper conservation research

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Abstract

From the early 19th century onwards the quality of paper became a major concern for librarians and archivists. In 1899 the causes of deterioration were already classified. The quality of the produced paper was influenced by new methods and materials. The effect of air pollution on the deterioration of books and documents was noticed. In 1959 research aims were “(a) to ascertain the present strength of 19th century book papers, (b) to identify the principle causes of deterioration, (c) to propose a simple method for identifying volumes requiring stabilisation, and (d) to recommend appropriate methods of stabilisation”. These aims continue as ‘waves in an ocean of paper conservation research’. New impulses were given by damage inventories and these promoted research projects for mass treatments. Preventive conservation became an all-important factor and induced new approaches. However, in 1999 the same problems still ask for our attention. More knowledge is acquired about the causes of decay, the understanding of the degradation mechanisms is deepening but does as yet not give answers to all questions. Transfer of knowledge from scientists and conservators to archivists, librarians and curators takes time. It still happens that management decisions are made on the basis of outdated knowledge. In the future archivists, curators, librarians, conservators and scientists should be able to communicate on the same level, respect each other’s profession and create an ongoing exchange of ideas and knowledge.

Zusammenfassung

Ab dem frühen 19. Jahrhundert fingen Bibliothekare und Archivare an, sich Sorgen um die Qualität von Papier zu machen. Die Qualität des damals produzierten Papiers war durch neue Methoden und Materialien beeinflusst. Man begann festzustellen, dass Luftverschmutzung einen Einfluß auf den Zerfall von Büchern und Dokumenten hatte. Im Jahr 1959 hatten Wissenschaftler folgende Ziele: “(a) die momentane Stärke von Buchpapier aus dem 19. Jahrhundert festzustellen, (b) die Hauptgründe für den Zerfall herauszufinden, (c) eine einfache Methode zur Identifikation von Büchern vorzuschlagen, die eine Stabilisierung brauchten, und (d) geeignete Methoden zur Stabilisierung zu empfehlen”. Diese Ziele setzen sich als ‘Wellen in einem Ozean von Forschung’ für die Papierrestaurierung fort. Neue Impulse entstanden während der Untersuchungen zur Quantifizierung von Papierzerfall, wel-

che wiederum Forschungsprojekte über Massenkonservierungsmethoden zur Ursache hatten. Präventive Konservierung wurde ein übergreifend wichtiger Faktor und führte zu neuen Herangehensweisen. Jedoch fordern heute, im Jahr 1999, dieselben Probleme unsere Aufmerksamkeit. Mehr Wissen bezüglich der Ursachen von Papierzerfall muss noch erlangt werden: das Verstehen der Zerfallmechanismen hat sich vertieft, was bis jetzt aber noch nicht alle Fragen beantworten kann. Das Weiterreichen des Wissens von Naturwissenschaftlern und Restauratoren an Archivare, Bibliothekare und Kuratoren braucht Zeit. Es passiert immer noch, dass Managemententscheidungen getroffen werden, die auf veraltetem Wissenstand basiert sind. In Zukunft sollten Archivare, Kuratoren, Bibliothekare, Restauratoren und Naturwissenschaftler fähig sein, auf gleichem Niveau zu kommunizieren, die anderen Berufsgruppen zu respektieren und einen kontinuierlichen Austausch von Ideen und Wissen herzustellen.

Introduction

In 1845 the Dutch van der Boon Mesch complained about the declining quality of the paper used for documents. He argued that the introduction of new machines for papermaking and new bleaching methods made the durability of paper decrease. Moreover, the papermaking machine left iron particles in the paper sheet that caused brown spots on ageing. He advised to initiate research into the durability of paper. Since then quality (durability) has been a continuing concern for papermakers as well as government officials [1].

Van der Boon Mesch was not the first to complain about the quality of paper. In 1823 John Murray warned of the declining quality of paper in *Gentleman’s Magazine* and later in a pamphlet in 1829 [2]. During the 19th century the warnings about the quality of paper came at regular intervals and at the end of the 19th century librarians and archivists faced a serious paper deterioration problem [3].

This deterioration was caused by several factors: firstly the quality of the produced paper, influenced by new bleaching methods, the mechanisation of the papermaking process and a change of raw material from rags to wood pulp.

Secondly, the effect of air pollution on the deterioration of books and documents was noticed. Already in 1843 Michael Faraday was lecturing at the Royal Institution in London. In this lecture he showed leather bound volumes that were in a shocking state of deterioration. He attributed this condition to the combustion of coal gas. Faraday’s observations seem to be the earliest on record concerning the influence of sulphuric acid on the decay of leather and paper [4].

Thirdly the influence of the writing materials was noticed. The problem of iron gall ink corrosion was already a topic at an international conference in St. Gallen in 1899 [5].

In 1897 an investigation was conducted by the Committee on the Deterioration of Paper appointed by the Society of the Arts (London), but in an influential report published in May 1898 the Committee reported that “the danger had been over-estimated” [6]. This remark sounds quite familiar to modern ears. Even nowadays important research programs are conducted; the results are greeted with concern, but forgotten quite soon.

From these historical sources it may become clear that already in the 19th century the knowledge of the influence of two different factors - an internal one and an external one - on the deterioration of paper objects was recognised. The internal factor was introduced by the paper production - preparation of the raw material and the sheet formation - and the external factor was the influence of air pollution. Also the degrading effects of writing material can be classified as an external factor. It is interesting that in this review the influence of the alum/rosin sizing is not yet mentioned. The topics papermaking and permanence, air pollution, humidity and temperature control and writing and printing materials already characterised today’s paper conservation research. The emphasis has changed, our knowledge is continually expanded, but the topics are still the same.

Paper Permanence/Durability

Research into paper conservation has always had a strong connection to research in the paper industry. Before the development of paper conservation as a real profession research was mainly carried out for the benefit of the paper industry. It was directed at raw materials and production processes. Since the end of the 19th century until the beginning of the 1950’s the basic process of papermaking stayed the same, although new and faster production methods were introduced. Various qualities were available and standards for papers for various purposes were developed. In the Netherlands a standard existed for paper to be used in the government and it was stated that rag paper had to be used for government documents [7]. These regulations were not only introduced in the Netherlands but in all European countries and in the United States. The concern for more permanent paper came not only from government officials but also more and more from librarians and archivists. Librarians were confronted with ever larger quantities of crumbling books.

The first impulse to conservation research was focussed more on the improvement of the durability of new paper than on the active conservation of already degraded paper in libraries and archives. William J. Barrow was one of the first scientists who conducted an investigation under auspices of the Virginia State Library to ascertain the cause and to explore the possible remedies for the deterioration of book stock in American Libraries in 1957-58 [8]. In his study 500 books from the period 1900-1945, that is 100 for each decade were investigated. In 1963 –1965 papers dating from the period 1800-1899 were investigated. Barrow mentions the follow-

ing aims of this research “(a) to ascertain the present strength of 19th century book papers, (b) to identify the principle causes of deterioration, (c) to propose a simple method for identifying volumes requiring stabilisation, and (d) to recommend appropriate methods of stabilisation” [9]. These aims were in fact the same as those of the Committee on the Deterioration of Paper in 1898.

The results of Barrow’s research were not so reassuring as those in 1898, but more to the contrary. He brought the disastrous influence of the acidity, caused by the use of alum/rosin sizing, into light, and the decrease of quality by the use of wood pulp as a raw material. Compared to the state of knowledge in 1898 the influence of the alum/rosin sizing was a new factor. The introduction of the pH as an all-important parameter for decisions on treatment was now established. Barrow concluded that 19th century book papers with a pH-value lower than 6.0 needed stabilisation.

Barrow was not unfamiliar with paper research. His laboratory started in 1936 but remained relatively small until the Council of Library Resources and the Ford Foundation made it possible to acquire facilities with the best paper-testing equipment. On the basis of the first investigations a larger program started into the “Permanence/Durability of the Book” and this program initiated the research into active conservation methods. The deacidification of paper as a conservation method was born. The method first developed was deacidification with aqueous solutions of calcium hydroxide and calcium bicarbonate. The work of Barrow and his laboratory continued until the beginning of the eighties and a series of publications on the “Permanence/Durability of the Book” came to light [10]. Several other initiatives were taken to develop deacidification methods, aqueous as well as non-aqueous ones, but none of them gave the ultimate solution [11].

Mass deacidification

A new wave of research into the extent of the problem was started in 1979 with a damage inventory by the Stanford University, followed by several others including the damage inventory in 1990 in the Netherlands [12]. The conclusions of these programs into the state of damage were the same: about 40% of the 19th century paper, in particular from the period 1870-1890 was seriously damaged. The use of bad quality wood pulp and the alum/rosin sizing were the causes for this condition. From the various damage inventories the extent of the problem became more and more clear and the only solution for deacidification on a large scale seemed to be a ‘mass treatment’ approach.

Research into mass conservation treatment started with magnesium methoxide, a solvent based deacidification method. In Canada, the US and France various facilities were set up and the effect of the method was investigated. At the same time the gaseous treatment with Di Ethyl Zinc (DEZ) was developed by the Library of Congress [13]. The methods of investigation were the standard methods from the paper industry: mechanical properties were measured, as well as the pH and the degree of polymerisation. To predict the effect of the treatment on the long term, accelerated ageing

methods were used. The first standard method for accelerated ageing was a dry oven method (105°C). At the same time the discussion on the relation between natural ageing and artificial ageing started. In 1980 an important study on this relation was published by Wilson and Parks [14]. New standards were developed and the ISO standard gave three different options for accelerated ageing: 105°C and 80°C at 65% RH; 90°C and 50% RH [15].

An extensive research program in the US compared the various mass treatments to make a definite choice. However, this research showed that none of the methods was without negative effects and the decision to start a mass treatment was postponed [16]. The research into new mass treatments went on and on and methods as promoted by Batelle and Bookkeeper are nowadays further developed. A mass treatment is still an utopia. The treatment of large amounts has started at several places but it is clear that in future different methods for different purposes will exist and choices and selections will have to be made.

Strengthening of brittle paper

The impulse for the research programs into the cause of degradation mentioned before was given by the physical state of 19th century paper. The crumbling of paper leaves asked for reinforcement. Traditional methods according to which tears were pasted with starch paste and supported with European paper were followed by the introduction of relining whole pages with Japanese paper and starch. Also thin silk fabrics in combination with gelatine were used to reinforce the strength of individual paper leaves. The development of synthetic materials led to the development of new conservation methods. However, knowledge about the durability of synthetic materials and their possible effects on the stability were non-existent.

As the amounts of materials to be treated were large, the leaf casting method was developed into a mechanised system. Today we are still confronted with the disastrous outcome of this wave of the all too speedy introduction of developments, which weren't investigated properly in advance. As the conservation profession developed rapidly from the seventies, this method was criticised by the conservation community but unfortunately still applied in institutions where well-trained conservators were absent. However, when the research into mass deacidification started, the need for reinforcement of brittle paper remained. As the deacidification process did not reinforce the strength of the paper which was already degraded into 'brittle paper', methods were developed to strengthen and deacidify in one process. The graft polymerisation process of the British Library is a good example, but it never came out of the laboratory stage.

Also in the German paper splitting method reinforcement and deacidification are brought about in one process. Started as a single item-method it developed into an automated process. The paper splitting method is used for large amounts of material. A mass conservation treatment method, which is generally applicable, has not been found yet.

Another problem related to acidic degradation of paper is that of writing and printing applied to paper. Particularly the

influence of iron gall ink on the stability of paper has been a major concern. As mentioned before, already in 1899 the first conference on the problems caused by iron gall ink was held. A second wave of research started in the 1980's in Austria where iron gall ink decay as well the effects of copper green were studied. However, an uncertainty remained about the cause and remedy of iron gall ink corrosion [17]. In the nineties a new research program started in the Netherlands which gave more insight into the degradation mechanism and which provided a method for stopping iron gall ink corrosion [18].

Preventive conservation

During research into mass deacidification and during the phase when damage inventories were made, the criteria for making decisions came into discussion. From the research it became clear that the pH-value could not be used any more as the single criterion. Paper from the 18th century (and earlier) often had a pH below 5.0 and was still in good condition. Thus also the time of production, the presence of lignin and a hand-folding number became criteria on which decisions for a possible deacidification treatment were made. The discussion which followed the damage inventories and the subsequent need for mass deacidification processes also resulted in the awareness of the need for more extensive preventive conservation methods.

The change from active conservation to preventive conservation became an important trend in the whole field of conservation. This tendency had various causes. On the one hand the interest in the intrinsic value of the object and in the object as a carrier of information became an important topic in the discussion on the ethics of conservation. On the other hand conservators were often confronted with the disasters caused by less trained predecessors. To keep your 'hands off' became the new trend in conservation practice. The research into possibilities and effects of preventive conservation went different ways. In the Netherlands, from 1990 onwards, the so-called "Deltaplan voor het Cultuurbehoud" was launched [19]. In this project the Dutch government gave extra money for proper registration, storage facilities and conservation projects. Research was focussed on the influence of the environment (air quality, temperature and humidity) on the deterioration of objects, the use of good quality storage materials and the influence of wrapping and packing on the lifespan of objects. However, not only in the Netherlands the focus on preventive conservation became important. In various countries standards for housing, humidity control and storage materials were developed [20].

In preventive conservation the fight against mould attack plays an important role in archives and libraries. As in many other conservation treatments the large amounts of material to be treated in case of a calamity influences the type of the treatment. Many research projects have been carried out on the influence of pesticides. Particularly the influence of ethylene oxide and the use of gamma irradiation were investigated. As the use of ethylene oxide is forbidden in most European countries and the US and the negative influence of a

treatment with gamma irradiation on ageing became known. The emphasis on preventive conservation and 'good house keeping' became even more important.

A large research program was started in the Netherlands, stimulated by the government, which investigated the influence of sulphur dioxide in combination with nitrogen oxide (ACBAM) as air pollutants. A new program in which research institutes in France, Sweden and the Netherlands co-operated continued this program. The influence of air pollution as well as the effects of various mass deacidification methods was investigated. The research program was funded by the European Commission [21]. The results of the investigations were comparable to those of 1898. However, the knowledge about why and to which extent a combination of SO₂ and NO_x has a serious effect on the permanence of paper increased substantially. These effects of environmental conditions were also shown in a research project in which book pairs in the New York Public Library and at The Royal Library in The Hague were compared. In this research air pollution as well as temperature and humidity changes showed their disastrous results [22].

New trends

The emphasis on preventive conservation has given new directions to research. The discovery of the yellowing of paper inside the cutout of a passe-partout (mat) raised questions about the effects of a microclimate inside boxes and frames [23]. The effects of changes of relative humidity and temperature on the oxidation of paper and its consequent yellowing are a topic for ongoing research. The research is focussed on the effects of both parameters in micro-systems as well as in climatised storage rooms. Is the strict climatisation as it is now advertised really necessary? To which extent is it necessary to keep the relative humidity absolutely equable in a situation where objects are stored in boxes? Or is it more important to keep the temperature constant?

Problems around the deacidification processes have raised questions on the effectiveness of the method. Questions about the necessary amount of alkaline reserve are raised and from a quick literature search it seems that the 2% alkaline reserve internationally used as a criterion is not based on specific research. Another question is to what extent large amounts of alkaline reserve can cause alkali-induced hydrolysis of paper. A literature research was recently finished but obviously more research is needed [24].

In view of mass deacidification librarians and archivists pose questions about the life expectancy of treated and non-treated books and documents. As 'mass treatments' ask for high investments, librarians and archivists want to know how long they can postpone the treatment. This question has started a new discussion on the effectiveness of methods for accelerated ageing. To what extent is it possible to predict the permanence of paper in years and the effects of a treatment in the long term? A critical literature study, in which the various accelerated ageing methods are scrutinised, is nearly finished [25].

As the existing mass treatment-methods are in reality not suitable for treatment on a very large scale, a method for selection of endangered objects is needed. During the dam-

age inventories various testing methods for selection were developed. However, these methods ask for relative large amounts of material and have their limitations in case of original objects. Therefore, a research project is started into micro-analytical methods for the quantification of the condition of paper [26]. Another project in this respect is the investigation of the 'sacred cow' in paper conservation, the pH of paper [27]. What does the pH mean, does it give information on the condition of paper? How can it be used in a selection process?

The surf effect

After several years of emphasis on preventive conservation a feeling of comfort has been created in the minds of archivists, librarians and curators. It is a fact that many objects, books and documents are stored in climate-controlled storage areas, adequate preservation methods have been developed, and science can give answers to many questions. However, problems still exist. More knowledge is acquired about the causes of decay, the understanding of the degradation mechanisms is deepening but does as yet not give answers to all questions. Each research project enlarges our knowledge and does often change our attitude to the problem under investigation. From the past I have learned that the transfer of knowledge from scientists and conservators to archivists, librarians and curators takes time. It still happens that management decisions are taken on the basis of outdated knowledge. The new knowledge obtained by conservators and scientists but not yet known to the decision-makers is washed over by what I would call the surf of decisions. This situation often causes tensions between decision-makers and conservators. For the conservation field one of the most important trends for the future should be the creation of a situation where archivists, curators, librarians, conservators and scientists are able to communicate on the same level, respect each other's profession and create an ongoing exchange of ideas and knowledge. In this way the preservation of our cultural heritage would be in good hands.

Notes

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Biography

Judith H. Hofenk de Graaff is a textile chemist and holds a doctorate in history from The Free University of Amsterdam. Since 1984 she was Co-ordinator of the scientific department of the Central Research Laboratory for Objects of Art and Science in Amsterdam (founded in 1963). Since 1999 she is Head of the Conservation Research Department of the Netherlands Institute for Cultural Heritage (Instituut Collectie Nederland, ICN) in Amsterdam. The research activities of the ICN are focussed on the preservation of objects of cultural value made of organic materials. Spear heads of the research in the ICN in relation to paper artefacts are: degradation of paper at the wet/dry interface, analytical micro-methods for the condition of paper, the development of standard specifications for storage materials, iron gall ink corrosion and research on the effects of indoor pollution and micro climates.

Drs. Hofenk de Graaff was a member of the directory board of the International Committee for Conservation (ICOM), Co-ordinator of the Textiles Working Group and Assistant Co-ordinator of the working group 'Graphic Documents'. She is currently a member of the Preservation Committee of the International Council of Archives (ICA). She is also Vice-president of the IADA, lectures regularly at the Scientific Principles Programme of ICCROM in Rome and is involved in an advisory capacity for UNDP/UNESCO and ICA/UNESCO.

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