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Rescuing Books

For decades, toxic substances have been employed to produce paper, a material that figures extensively in various aspects of our lives.

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Throughout history, people have preserved textual information using a range of materials, including pieces of slate, clay tablets, papyrus, parchment, and eventually paper. From the seventeenth century onward, the latter established itself as the predominant medium for manuscripts and all forms of printed documents. The demand for paper was huge, and grew rapidly at the turn of the eighteenth and nineteenth centuries. Rapid economic development and growing bureaucracy led to a burgeoning need for an affordable writing and printing material, easily available in large quantities. Universal education boosted literacy rates and heightened the demand for printed documents. The Industrial Revolution contributed to the expansion of cities, where access to information became especially valuable and instrumental in driving progress. During the nineteenth century, daily newspapers emerged as the primary source of information. By the end of that century, the largest newspapers boasted circulations of up to a million copies per day.

However, books produced in limited quantities up until the end of the eighteenth century (referred to as "old prints") have proven to be more durable than those printed later. This is because meeting the growing demand for paper required changes in technology. Transitioning from the production of individual sheets to a continuous roll of paper was pioneered by the Frenchman Nicolas Louis Robert in 1798. His innovation helped unleash an unprecedented surge in paper production in Europe from the 1820s onward. Such technological advancements that amplified output, however, came at the expense of compromising the quality and durability of the resulting product. Over time, these changes led to its eventual deterioration due to the use of "acidic" techniques in the production process.

These pages and bindings are visibly degrading due to the effects of acidic paper

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Toxic waste

After initial attempts involving straw, reeds, nettles, and even peat, the focus in paper production shifted towards wood. In the early nineteenth century, wood fibers were separated into wet pulp using machines called grinders. An optimal technique eventually discovered through successive experimentation and was employed from the mid-nineteenth century onward. This method involved acidic production of paper from pulp through the cooking of wood chips in

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Archive materials plagued by crumbling bindings

cooking liquor. An important step towards improved profitability was taken when expensive sodium hydroxide came to be replaced by more economical, acidic sulfur compounds, which could also be used to digest wood. However, the acidic compounds were often added in excessive amounts and were not always properly washed away from the pulp, resulting in paper becoming acidic.

To transform a pulpy mass into paper, it needs to be "sized" – which means adding adhesive substances that provide a seal against the penetration of liquids. Until the early nineteenth century, paper was traditionally sized using gelatin obtained from sheep's hooves. Sheets of handmade paper were sized manually or dipped in animal glue. Such glue penetrated the sheets and fortified their structure, preventing the ink from seeping across the surface or striking through the paper (becoming visible on the other side). In the nineteenth century, the depletion of natural materials prompted a shift to resin glue. The use of glue containing aluminum sulfate, however, resulted in high acidity in the final product.

The acidic method of obtaining cellulose proved successful due to its efficiency and cost-effectiveness. However, acidic paper shows limited resistance against moisture, acidic gases, and temperature. Moisture also causes chemical deterioration, leading to the swelling and cracking of cellulose fibers; the presence of acidic fillers further accelerates these processes. Consequently, such sheets of paper quickly turn brown and become brittle. Some documents produced in the nineteenth and twentieth centuries underwent such degradation even within a mere few years. Unfortunately, paper products created in this way are simply doomed to degrade. It was not until the 1960s that that the production of cellulose using the alkaline method increased dramatically, limiting the quantity of "self-destructive" acidic paper.

Paper production requires the use of bleaching agents and dyes. For a desired color to be obtained (typically white), the pulp must be bleached. This technology is responsible for the enormous scale of the environmental devastation caused by the pulp and paper industry. Using chlorine compounds for pulp bleaching forces paper mills to subsequently extract the pollutants containing organic chlorine compounds. When exposed to high temperatures, these compounds turn into poisonous substances called dioxins, which are present not only in post-production waste and wastewater but also in the paper itself.

Damage to book-bindings often leads to the detachment and degradation of individual sheets

Regarded as highly toxic, these substances are responsible for contaminating aquatic ecosystems. On a daily basis, an average paper mill generates tons and tons of chlorine waste. The use of sulfur dioxide in papermaking contributes to the acidification of waterways and lakes, whereas nitrogen compounds and phosphates accelerate the growth of algae and the degradation of water quality. While certain countries have shifted to oxygen bleaching, chlorine continues to be used on a large scale.

Aging bindings

Until the end of the eighteenth century, bookbinders bound together individual pages to form leather-bound books, or "codices," often turning precious manuscripts and prints into true works of art. The covers of utilitarian prints, made from less expensive materials, were also often crafted with meticulous attention and care. In the nineteenth century, other raw materials started to be used for the purpose of bookbinding. Efforts were made to minimize the time required to prepare leather to be used as book covers, which had previously taken around two weeks. For this reason, sulfuric acid was introduced as an additive in the leather tanning process. The effects were unfortunately similar to those of the use of acidic compounds in paper production. Book covers made of leather treated in this manner age faster, developing "red rot" and becoming brittle.

One of the elements of the bookbinder's craft involved securing the pages into folds in a way that allows easy page-turning. With the advent of mass production, the practice of stitching folded sheets together using linen thread was replaced with metal wire binding. Despite initially seeming to be much more practical, however, the use of this material created

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numerous challenges now faced by today's archivists and librarians. The rusting of the wire leads to paper degradation and the detachment of individual sheets. Various types of metal clips and staples used to hold together documents submitted to the archives also unfortunately have a similarly detrimental impact.

When inventors and visionaries introduced acids into paper production, they did so in response to the demand for affordable, mass-produced paper. What they did not anticipate, however, was the potential of those technologies to lead the irreversible and rapid loss of many documents printed or handwritten during the nineteenth and twentieth centuries.

Acidic paper stored in libraries, archives, and museums emits poisonous substances into the rooms where employees work. Table 1 shows the concentrations of pollutants in historic buildings that are permissible pursuant to Polish state norms

TABLE 1

Maximum limits of tolerance for air pollutants in libraries and archives according to ISO 11799:2003

Pollutant	Maximum limits of tolerance	
	ppb*	µg/m^3
Sulfur dioxide	5 to 10	–
Nitrogen oxides	5 to 10	–
Ozone	5 to 10	–
Acetic acid	< 4	–
Formaldehyde	< 4	–
Dust particles, including mold spores	–	50

* ppb – parts per billion = 0.0000001%

The "Acidic Paper" Program

The rapid degradation of written resources in the twenty-first century has prompted a search for solutions to deacidify paper and halt these destructive processes. In Poland, a research project entitled "Acidic Paper: Rescuing Endangered Polish Library and Archive Resources on a Mass Scale" was pursued as part of a long-term government program. The project embraced 90 libraries and 39 archives and was implemented by the National Library. It was estimated that acidification affects 90% of the collections in Polish libraries and archives, necessitating the deacidifica-

TABLE 2

Method and phase	Reagents used for deacidification	Emitted pollutants	MPC (mg/m^3)	Flammability limits (LFL)*
Bookkeeper (liquid)	magnesium oxide, perfluoroheptane	magnesium oxide, sulfates, magnesium chlorides and nitrates	magnesium oxide: – gaseous: 5 – particulate: 10	
Neschen (liquid, aqueous phase)	methyl cellulose, magnesium bicarbonate, fixatives, water	wood dust, magnesium bicarbonate, fire and explosion hazard	wood dust: 4	cellulose dust: 40 g/m^3

*LFL – lower flammability limit

During the deacidification of paper documents, pollutants get released into the rooms where such procedures are performed and into the atmosphere. Table 2 lists two selected deacidification methods used in Poland together with the chemical reagents used, the pollutants emitted, the maximum permissible concentrations (MPCs) of selected emitted chemicals, and the flammability limits for vapor-air mixtures (gaseous and particulate)

tion of 43 million volumes across these institutions. The project also revealed that around 65% of library storage rooms at the facilities examined are situated in basements, which are considered less suitable for collection storage due to their restricted ventilation capacity and higher susceptibility to dampness and flooding.

Due to the high costs, however, deacidification of all the Polish library and archival holdings that need it is simply not feasible. Polish libraries are therefore joining forces to preserve endangered publications using new technologies – materials stored in archives can instead be "rescued" through digitalization. The Internet offers invaluable possibilities of enabling public access to digital versions of hardcopy sources.

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Chemical hazards

Book collections release various substances, either ones originally present in the paper or new compounds resulting from chemical reactions among their components. These include cellulose fibers derived from paper and adhesive substances (sizing agents) such as gelatin and resin, as well as sulfate and sulfide fillers, metal salts, and natural and synthetic dyes. Once released from paper, these substances may react to form toxic products that may pose hazards to staff members. Volatile poisons are formed as a result of the interaction of moisture, temperature, radiation, oxygen, ozone, acidic air pollutants, and smog. When exposed to moisture, collections held in libraries and archives undergo irreversible and detrimental transformations. Research into the storage of materials that come from acidic environments typically revolves around the challenges of preserving and maintaining such resources in optimal condition. Very few studies, on the other hand, address the issue of the safety of the individuals who work at such institutions.

Library and archive documents can be harmed by a wide variety of environmental factors

This shortcoming has been recognized by Polish experts from the Central Institute for Labor Protection – National Research Institute (CIOP-PIB). They emphasize that the research literature chiefly focuses on the condition of documents and methods for rescuing them, and yet despite the numerous standards in force, no large-scale studies have yet investigated the effects of workplace exposure to acid paper. Scholars have indeed neglected to identify the types of substances harmful to human safety that are present in libraries and archives as a result of their use in deacidification, filtration, and ventilation systems.

The overall conclusion, therefore, is that the problem of contamination affects not only precious library and archive collections, but also the staff members who work hard to rescue them from the ravages of time. ■

Further reading:

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