Disinfestation by ionizing radiation: A chance for future of archives

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In the last century, the technological development produced huge quantities of written paper.
To the preservation of useful information, part of this written paper went to archives.

Some of may become part of cultural heritage.
**Work Safety in archives (Air contamination)**

<table>
<thead>
<tr>
<th>Workplace (Law Court Archive)</th>
<th>Mezophyles germs</th>
<th>Hemolytic germs</th>
<th>Temp. °C</th>
<th>R.H. %</th>
</tr>
</thead>
<tbody>
<tr>
<td>Archive 1</td>
<td>2953</td>
<td>83</td>
<td>21</td>
<td>69</td>
</tr>
<tr>
<td>Archive 2</td>
<td><strong>8746</strong></td>
<td>87</td>
<td>21</td>
<td>69</td>
</tr>
<tr>
<td>Archive 3</td>
<td>2588</td>
<td>79</td>
<td>20</td>
<td>67</td>
</tr>
<tr>
<td>Archive 4</td>
<td>3228</td>
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<td>68</td>
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<tr>
<td>Archive 5</td>
<td>1128</td>
<td>70</td>
<td>21</td>
<td>65</td>
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<tr>
<td>Archive 6</td>
<td>2598</td>
<td>72</td>
<td>20</td>
<td>67</td>
</tr>
<tr>
<td>Archive 7</td>
<td><strong>4472</strong></td>
<td>83</td>
<td>20</td>
<td>70</td>
</tr>
<tr>
<td>Archive 8</td>
<td>2576</td>
<td>61</td>
<td>21</td>
<td>67</td>
</tr>
</tbody>
</table>


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“Disinfestation by ionizing radiation: A chance for future of archives”
Paper has a limited life-time!

- The lifetime of newspaper is 1 day!

- Accelerating ageing does not give satisfactory results - NIST study of paper ageing over 100 years (started in 2000!)


- Paper is a food source for micro-organisms, insects, rodents.
Biological attack ...

- Insects

Religious book (XIX Century) from “Perspessicius” collection of Braila Museum

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Biological attack ...

- Microorganisms

Book and magazines (XX Century) from “Perspessicius” collection -Braila Museum

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Biological attack ...

- Rodents

Magazine (XX Century) from IFIF-HH archive
... coming after natural disasters ...

(Historisches Archiv der Stadt Köln - 3 Martie2009)
... coming after natural disasters ...

(Library of Colorado State University, July 28, 1997)
... or bad storage conditions ...

W. Horsley Gantt Collection, Medical archives of Johns Hopkins University (1980):

“The materials, however, had been stored in a dilapidated row house in Baltimore that was infested with insects, rodents, and dog and cat carcasses.[...] But what they found littered among the rubbish (which also included stray car fenders and giant balls of string) [...] “

(Sinco, P., *The Use of Gamma Rays in Book Conservation, Nuclear News, April 2000, 38-40*)
... or bad storage conditions ...
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PN2/C2/Partnership – Contract 92-083/2008

Goals:
- To establish a method of bio-decontamination appropriate for the conservation of documents from archives and cultural heritage
- To provide the archive owner with a decisional instrument regarding the action for eliminating the bio-contamination
Issues:
- Radiation dose
- Archive evaluation
- Effects of ionizing radiations on paper
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Steps:

1. Preliminary tests
   - Physical and chemical tests on “reference” paper irradiated in a large dose interval (IFIN-HH, CEPROHART SA)
   - Study of endogenous and exogenous factors affecting the ageing of paper (CEPROHART SA)
   - Identification and evaluation of work safety risks (INCDPM). Bioburden tests (INCPM, IFIN-HH)
   - Archive evaluation, sampling, conditioning of samples
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II. Testing over an experimental batch
- Physical and chemical tests on paper from archives and collections irradiated in the dose interval on interest (IFIN-HH, CEPROHART)
- Bioburden tests on samples from archives and collections (INCDPM, IFIN-HH)
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III. Testing over an extended batch
- Irradiation of experimental batch (Perspesiciuss” Colection of Braila Museum, IFIN-HH Archive)
- Validation tests (VDmax - ISO 11137 method)
- Post – irradiation tests

IV. Dissemination of the results
- Communications, patents
- Guidelines for the irradiation of archives
Radiation dose

“overkill” dose vs. $D_{10} –$ absorbed dose reducing bioburden by 10

The purpose of the treatment is not sterilization, but reducing the bioburden to an acceptable level.
Radiation resistance of microorganisms from archive paper

\[ y = 623.92e^{-3.8668x} \]

\[ D_{1\alpha} = 0.60 \]

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Archive evaluation

- Physical
- Chemical
- Biological
Archive evaluation

Existing guidelines:


AFNOR, Methode d’évaluation de l’état physique des fonds d’archives and et des bibliothèques, Norme Francaise NF-Z40-011, 2005
Radiation effects

scission of $\beta$-glycoside bonds of cellulose
Archive evaluation

Major categories:
- Paper made up to 1806 (old paper)
- Paper made between 1806 and 1990 (acid paper)
- Paper made after 1990 (permanent paper)
Methods of investigation

- TG/DTA
  - + GC/MS
  - Degree of polymerization
- FTIR, RAMAN
  - Degree of crystallinity
- Mechanical testing
  - Mechanical & chemical properties
- Chemical testing
  - Radiolysis products
  - Degradation mechanism,
- Colour testing
- ESR
- Computer modelling

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Preliminary results:

TENSILE TEST MD

Fmax (N/mm²)

Dose (kGy)

DTG peak Temperature - absorbed dose dependence

Sample | H2O % content | organic % content | inorganic % content
--- | --- | --- | ---
Whatman 42 | 2.5±2 | 97.5±2 | 0.00
Copier low quality | 6±2 | 75±2 | 19±2
Copier high quality | 4±4 | 77±4 | 19±1

(IFIN-HH, 2009)

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Preliminary results:

TENSILE - Old books

Fmax (N)

MD

CD

TENSILE - 1923 book

Fmax (N)

10 sets of samples (each 10 pages)

CEPROHART SA, 2009

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Conclusions

• (HS-TD) + (GC-MS) => same VOC reported in literature.
• Color changes are higher for artificially aged paper than for irradiated paper. Whatman paper is the most stable.
• Free radicals depletion became stable 4 weeks after irradiation.
• For doses lower than 10 kGy the results are hardly statistically discernable.
• Differences in vibrational spectra of copier paper and Whatman are very low.
• Correlation of thermo-gravimetric parameters and mechanical properties.
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Thank you for your attention!