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Fungal Biodeterioration of Paper: How are Paper and Book Conservators Dealing with it? An International Survey

Abstract: Paper biodeterioration by fungi has always been a concern in archives, libraries and museums. Several guidelines have been published regarding the prevention of fungal development in paper collections and recovery of affected objects, but what is actually being implemented from the literature by world-wide paper and book conservators? How common is this type of biodeterioration? What needs to be further studied? In order to access this information we conducted an online international questionnaire with participants from 20 different countries. The results show that fungal biodeterioration is highly common in paper collections. All of the respondents already had to deal with paper deteriorated by fungi, and although the vast majority uses active measures to prevent fungal development, most of them have already experienced active fungal infestations. The mainly used preventive measures are the ones concerned with the control of the environmental conditions in storage and display rooms. Drying the affected paper objects and applying 70% ethanol are the most preferred options to stop active fungal growth. The study of non-toxic and safer antifungals is considered here as the most relevant research topic in the area of paper biodeterioration by fungi, meaning that the options currently available are not totally satisfactory.

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1 Introduction

Paper biodeterioration by fungi has always been a common problem in archives, libraries and museums. The way conservators have dealt with this occurrence has changed throughout the years. Precautionary and curative disinfection procedures were performed routinely along the last century (Flieder 1965; Hengemihle et al. 1995). However, the acknowledgement of the risks that most of the used antifungal compounds, like ethylene oxide or formaldehyde, pose to health and to the treated objects has lead to an increasing implementation of alternative less interventive and less toxic options.

Following this tendency, there are currently several publications available on what to do to prevent and treat this kind of paper biodeterioration (Florian et al. 1994; Florian 1997, 2000, 2002; Guild et al. 2004; National Park Service 2007; Child 2011; Price 2013). In this literature, the recommendations to prevent fungal infestations consist primarily in the protection of heritage objects from dust, keeping the objects and facilities clean, controlling relative humidity (RH) and temperature (T), preventing microenvironments, implementing air ventilation systems, monitoring surface contaminations and fungal load in the environment and regular inspection of collections for signs of visible fungal growth.

To recover already infested collections, the literature generally advises to isolate the contaminated artefacts, inactivate the fungi (stop fungal development) by air drying, freezing, freeze-drying and clean those artefacts afterwards with dry surface-cleaning methods. Only a few authors advise the application of ethanol directly on the artefacts (Florian et al. 1994)

In this study we aimed to disclose what is actually being adopted from the published literature by worldwide paper and book conservators, if there is a general agreement among conservators, how often does this type of biodeterioration occur, and what topics are in need of further research according to their working experience.

This kind of information is difficult to obtain due to several issues like institution and company's policies, concerns with anonymity and telling something incorrect or compromising and the difficulty to reach and contact a broad spectrum of paper conservators globally scattered. To bypass such obstacles we used a survey to collect information, while maintaining the anonymity of respondents.

Surveys are a research method used in many and diverse fields to collect information about people's features and ideas (Richardson 2005; Kalantari et al. 2011; Kazi et al. 2012). There are several methods to collect data on surveys, like interviews (in person or by telephone), or postal, e-mail

and online questionnaires. Nowadays, electronic and internet surveys are becoming more common than the traditional methods due to their ability to reach larger groups of people, thus achieving more valid results, and also due to their speed of extraction and analysis of results, which improves scientific development (Kalantari et al. 2011).

For the first time, to our knowledge, a questionnaire was made to study the attitudes and experiences of conservators towards paper biodeterioration by fungi. The gathered information will help us to have a real panorama on the prevention and treatment of fungal biodeterioration in archives, libraries and museums. It will also aid conservation researchers aiming their research towards the needs of conservation-restoration practitioners, as an appropriately targeted research can reduce costs and improve the impact and practical use of science in conservation practice (Bradley 2002).

2 Methods

This survey was based on an electronic questionnaire designed using a formulary by Google Drive[®]. This type of questionnaire is filled online, is totally anonymous and the gathered data are automatically compiled in a database.

The questionnaire was composed mainly of close-ended questions – questions where the respondents are asked to choose among a set of answers (Kazi et al. 2012). These are eager and quicker to answer, require no writing, and its quantification and analysis is simpler (Oppenheim 2000). However, these type of questions can originate loss of spontaneity and expressiveness, and the choice of answers may fail to correspond to the respondents own ideas, so we included in all of them an “Other (please specify)” option, which was a free-response answer that enabled the respondents to add their own preference. A part of the questionnaire is given as example in Figure 1, where it is shown that the used software allowed marking the main questions as mandatory, meaning that one could not submit the questionnaire without answering those.

With a total of 14 questions, including the ones to determine the profile of the respondents, the survey focused on their experiences regarding the prevention, causes and management of fungal infestations, and treatment of paper biodeteriorated by fungi and also on their opinion about which topics need further research in this field.

With the exception of the answers Yes/No, Country and Year of experience, the participants were allowed to select more than one option from the set of answers, and so, the total number of responses in those ones will add up to more than 100%.

6 - Do you use preventive measures to control biodeterioration caused by fungi in your workplace? *

If not, jump to question #8

- ☐ Yes
- ☐ No
- ☐ Other:

7 - Which measures?

You can check more than one box if applicable.

- ☐ Controlling relative humidity (RH) and temperature (T) in storage rooms
- ☐ Air filtration system for micro-particulate matter
- ☐ Air circulation/ventilation system
- ☐ Periodical cleaning of storage facilities
- ☐ Periodical assessment of fungal load in indoor air
- ☐ Periodical assessment of fungal load on surfaces of documents and storage facilities
- ☐ Preventive fungal disinfection of incoming collections
- ☐ Periodical disinfection of collections and storage facilities
- ☐ Other:

8 - Have you ever experienced one or more active fungal infestations on paper based heritage objects in your institution/company? *

If not, jump to question #12.

- ☐ No
- ☐ Yes

Figure 1: Part of the questionnaire, as it appeared online. The asterisk indicates questions that were mandatory to respond in order to be possible to submit the filled questionnaire.

The first version of the finalized questionnaire was administered to a small sample of the population, which allowed the detection of unclear questions or options. These were corrected before distributing the final version.

The questionnaire was available in English and Spanish languages. The links to the two versions of the online questionnaire were distributed by Conservation DistList in September 2012 and remained active for 2 months.

Conservation DistList is an e-mail distribution list created in 1987 operated nowadays by the Foundation of the American Institute for Conservation. With 9559 registered users from 95 different nationalities by September 2012, this list is considered “the most efficient means of worldwide communication between conservators” (Bordalo 2009).

This questionnaire was directed only to paper and book conservators, starting with a screening question that excluded everyone that was not working or studying in the paper and/or book conservation field. From the totality of registered users, only 1034 users stated to be conservators with paper or book as their field of interest (data provided by the Conservation DistList manager). Although we can have access to these numbers, we cannot calculate an exact response rate, since we cannot quantify how many people did indeed receive this e-mail. According to the Conservation DistList manager it is not possible to have an exact figure, since there is no way of knowing how many of the messages have failed to be delivered, and also, many institutions forward these e-mails to other people.

The use of an e-mailing list as the distribution mean for a questionnaire has several advantages, like its anonymous character, its low cost of data collection and processing and ability to reach respondents who are dispersed all around the globe (Oppenheim 2000). Still, every distribution method has limitations and by choosing this mean we are limiting the survey to people who have access to the internet and who receive Conservation DistList. This has to be taken into account when interpreting the gathered data, as they will only be representative of this population.

In the treatment of the collected data, for each question of the questionnaire the respondents were divided by all profile segments (years of experience; working activity; geographic distribution and type of workplace) and the results examined in cross-tabulations to see if there was any relationship between the profile segments and the given responses. However, no patterns were observed and therefore none is presented.

3 Results and discussion

3.1 Respondents profile

Out of the 57 participants in this questionnaire, the great majority were Conservators-Restorers, followed by Preventive Conservators, Conservation Scientists and Archivists/Librarians. Most of them worked in the public sector and had between 10 and 20 years of working experience in the conservation field (Table 1).

The responses came from people working in 20 different countries (Table 2), with the United States of America leading with the highest number of participants, followed by Brazil and the United Kingdom. This broad spectrum of geographic locations shows that the method of distribution of the questionnaire

Table 1: Profile of the survey's respondents

	Segment	% of respondents
Professional activity	Archivist/Librarian	4
	Conservator-Restorer	79
	Conservation Scientist	7
	Preventive Conservator	19
Type of workplace (company/institute)	Public sector	68
	Private sector	21
	Both sectors	7
Years of experience	1–5	14
	5–10	25
	10–20	42
	>20	19

Table 2: Distribution of respondents per country

Country	% of respondents
Afghanistan	2
Argentina	5
Australia	4
Bolivia	2
Brazil	16
Canada	5
Colombia	2
Chile	4
Denmark	2
Germany	5
Greece	2
Guatemala	2
Ireland	2
Malta	2
Netherlands	5
Norway	2
Pakistan	2
Portugal	4
United Kingdom	11
United States of America	25

is efficient, although the percentage of respondents per country can be related to the limitations of this method pointed out in the Methods section.

3.2 Prevention of fungal infestations

Participants were firstly asked if they use preventive measures to control biode-
terioration caused by fungi in their workplace. The vast majority who answered
positively (Table 3) was then requested to specify which preventive measures
they use (Figure 2).

Figure 2 shows that most people selected the control of RH and T in storage
and display rooms. Following this option, the second most frequent was the use
of an air circulation/ventilation system.

Table 3: Frequency of responses to the questions that required a Yes/No response

Question	Yes (%)	No (%)	Other (%)
Do you use preventive measures to control biodeterioration caused by fungi in your workplace?	90	5	4
Have you ever experienced one or more active fungal infestations on paper based heritage objects in your workplace?	79	19	2
Have you ever noticed a reactivation of the fungal growth after the returning of the affected paper items into the storage facilities?	20	76	23

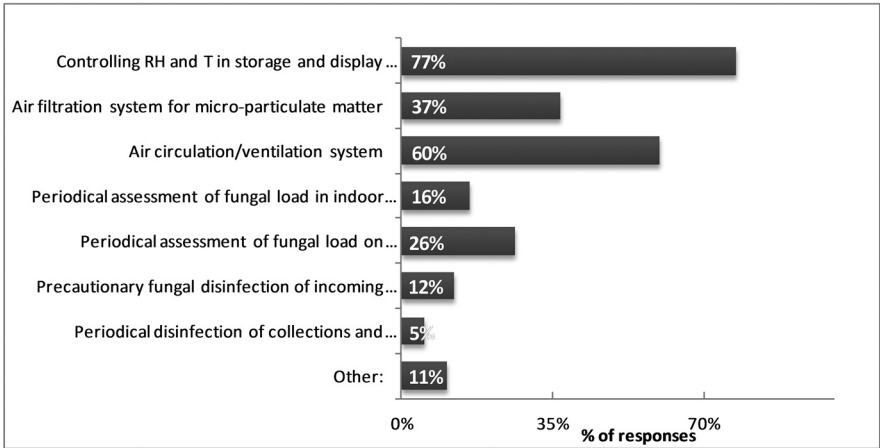


Figure 2: Frequency of responses to the question “Which preventive measures do you use to control biodeterioration caused by fungi in your workplace?”

These results reflect the fact that the control of the environmental RH and T is one of the best known and generalized preventive conservation methods, since it has influence in most types of deterioration processes, like chemical, physical and biological ones. Heating, ventilating and air-conditioning (HVAC) systems, generally used to control environmental conditions, constitute a high economic burden due to energy consumption and maintenance and therefore are not available to all institutions. Owing to the economic and environmental impact such energy waste represents, new more sustainable alternatives are being studied (Staniforth 2011; Casanovas et al. 2013).

A suitable air circulation around the documents/objects (chosen by 60% of the respondents) is very important since it helps to homogenize T and RH in those areas, preventing the formation of local microclimates with higher RH prone to fungal development. However, it is important to combine the air circulation system with a filtration system for micro-particulate matter, since air circulation/ventilation can increase the spreading of spores in the environment (Valentin 2007), and 37% of the respondents selected this option.

A periodical assessment of fungal load in air and surfaces can act as an indicator of fungal contamination and development, enabling the monitoring of fungal presence along time. The percentage of respondents who selected this procedure was 16% and 26% for indoor air and surfaces, respectively. These percentages may be in part attributable to the fact that this kind of procedures normally have to be done by external companies or institutions and therefore compose an additional expense.

Precautionary disinfection of collections, either performed in incoming collections or as a periodical procedure, were the least selected options in this question (Figure 2), which is in accordance with the published guidelines.

In the “Other” option, which was a free-response one, most of the answers included visual inspection, and cleaning of collections and storage facilities.

The responses obtained in this question illustrate the tendency that is evidenced in the published guidelines, which is acting on the environment surrounding the objects instead of using antifungals systematically as a precautionary measure – a common practice in the past (Hengemihle et al. 1995).

3.3 Causes of fungal infestations

In spite of the high percentage of people using preventive measures shown in the previous question, 79% of them have already experienced one or more active fungal infestations on paper based collections (Table 3). This fact shows that preventive conservation methods are not a 100% guarantee that

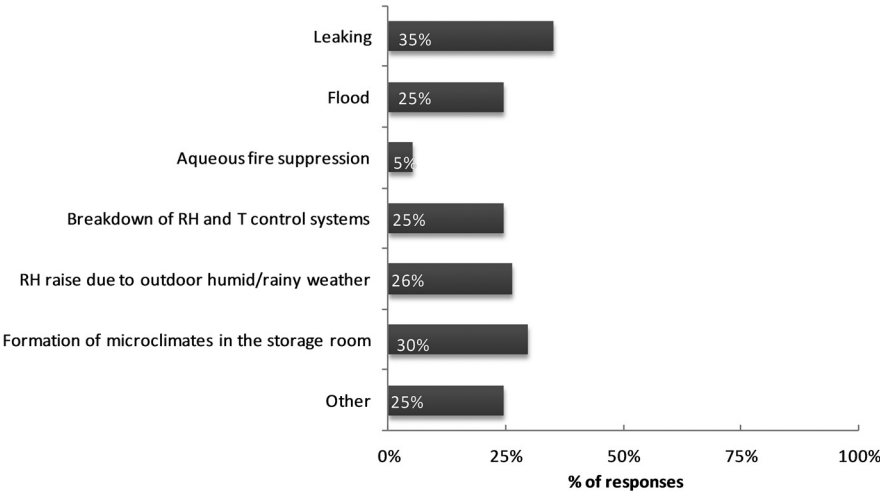


Figure 3: Frequency of responses to the question “Which were the causes of the active fungal infestations on paper based collections in your workplace?”

no fungal development will occur. When HVAC systems or electronic dehumidifiers fail, temperature and humidity levels can quickly rise up allowing fungal development. The regular inspection for fungal growth and formation of microclimates on linear kilometers of documentation in an archive or library is impractical, and water related emergency situations can occur at any time.

The causes pointed by the respondents for the experienced fungal infestations are summarized in Figure 3. Leaking and formation of microclimates were the most selected ones, although there is an evenly distribution of the causes, where only the aqueous fire suppression shows a distinctive lower value. On the “Other” option, the most predominant causes for fungal infestations pointed out were the introduction of mouldy artefacts into clean environments and poor hygiene/dust accumulation.

3.4 Deactivation of fungal infestations

Once faced with active fungal infestations in paper items, almost all of the surveyed conservators do take measures to stop further fungal development (Figure 4).

Drying the paper objects, either by interleaving them with dry absorbent paper or by lowering the environmental RH, together with application of a 70% ethanol solution were the most selected options, followed by freezing.

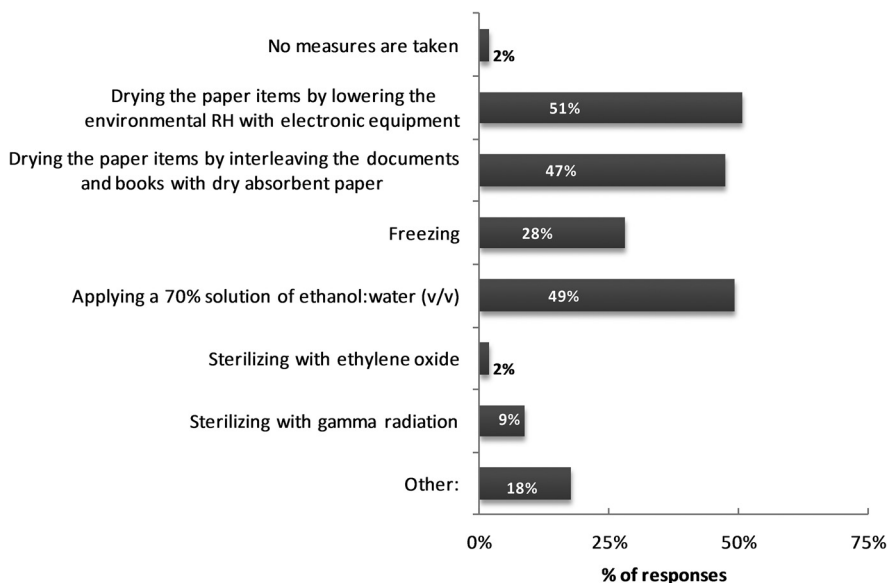


Figure 4: Frequency of responses to the question “Which measures do you usually apply to stop further fungal development on the paper items during an active fungal infestation?”

On the contrary, sterilization procedures (fumigation with ethylene oxide or gamma irradiation) were the least chosen ones.

These results are in general accordance with the procedures recommended in the published literature. However, the application of 70% ethanol directly on the paper artefacts – one of most frequently selected options in this question – is generally omitted in the referred literature.

The respondents were then asked if after treatment of fungal infestations they have ever noticed a reactivation of the fungal growth after the returning of the paper items to the storage facilities. Twenty percent of the respondents did so (Table 3), meaning that the levels of humidity were still high, that what caused the fungal infestation in the first place was not corrected and/or that the performed interventions were not successful. However, the majority of the surveyed conservators responded negatively to this question.

3.5 Recovery of paper biodeteriorated by fungi

When biodeterioration by fungi has already taken place, the majority of the surveyed chooses to isolate the affected paper objects, vacuum clean the entire page(s) and consolidate/reinforce them (Figure 5).

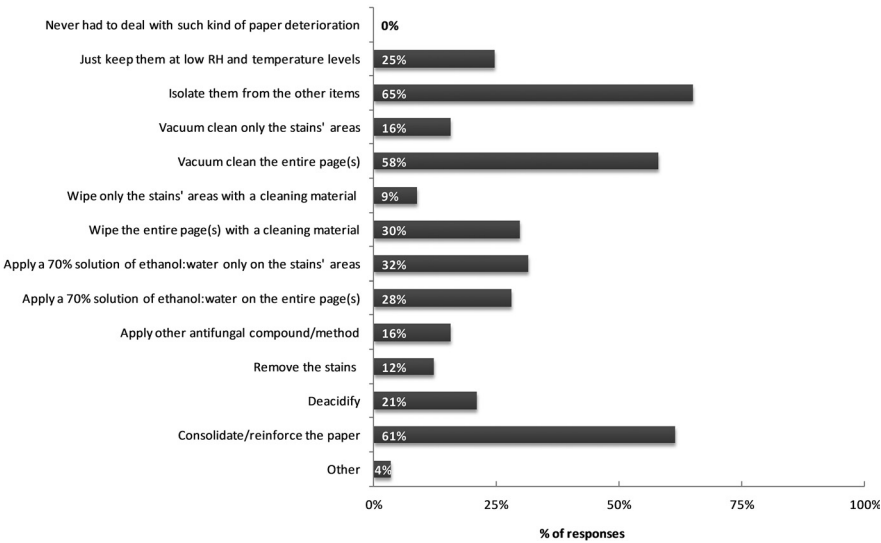


Figure 5: Frequency of responses to the question “How do you deal with paper based heritage objects that have already suffered biodeterioration by fungi (stained and with low mechanical resistance)?”

Regarding the given options of cleaning and applying 70% ethanol, there were two alternatives available: treating only the fungal stains or the entire page(s) (Figure 4). In the cleaning options, there was a clear preference for treating the entire page(s), probably with the intention of doing a more thorough cleaning. However, the material used to clean (e.g. vacuum nozzle, brush, sponge, cloth) is going to retain at least some part of the fungal spores. If we continue using the same material to clean non-affected areas, we will be spreading a great amount of spores in those areas, and in the case of high humidity conditions this can pose a serious risk of a worse new infection (Konkol et al. 2012).

On the other hand, when treating the objects with 70% ethanol, the localized application obtained a slight higher preference from the respondents. This may be due to the fact that this is a solvent and has a risk of dissolving paper or media components, and so the larger the areas where it is applied, the higher the risk of dissolution.

According to the gathered data, all the respondents of this questionnaire have already had to deal with paper based heritage objects deteriorated by fungi (Figure 5). These results can be due to the high occurrence of this kind of paper damage, but can also indicate that whoever returned this questionnaire had a particular interest in this subject due to their past experience in dealing with

fungus biodeterioration. According to the literature, there is a bias associated with mail surveys, since people who have a particular interest in the survey's topic are more likely to return the questionnaires than those who are less interested (Fowler 2002).

In a free-response query, the respondents were asked to specify which materials/methods they typically use to treat paper biodeteriorated by fungi, and the main results are presented in Table 4.

Dry cleaning sponge is the most used wiping material, and calcium hydroxide is the most used deacidification compound. From the respondents who had selected the option of paper consolidation/reinforcement, nearly 40% use Japanese paper/tissue with starch paste. Since most moulds can easily digest starch, and its nutrients are more easily available to fungi than cellulose itself

Table 4: List of the materials and methods specified by the respondents for wiping, deacidifying and consolidating/reinforcing of paper deteriorated by fungi (the percentages were calculated from the number of individuals who selected these treatments and not from the totality of the respondents)

	Method/materials	Frequency of responses (%)
Wiping material (<i>n</i> = 22)	Dry cleaning sponge (latex, rubber)	55
	Brush	27
	Eraser crumbs/gum powder	14
	Groom-stick	9
	Microfibre cloth	5
Deacidification (<i>n</i> = 12)	Aqueous CaOH ₂	42
	Bookkeeper deacidification spray	25
	Alkaline deionized water	8
	Magnesium ethoxide 0.05 M in alcohol	8
Consolidation/reinforcement (<i>n</i> = 35)	Japanese paper (JP) + starch paste	37
	JP + Methylcellulose (MC)	11
	JP + Klucel G in alcohol	11
	Resizing with gelatin or MC	11
	Heat-set tissue	6
	Encapsulation/isolation in polyethylene sleeves	6
	JP + carboxymethyl cellulose	6
	Lascaux acrylic adhesive ^a	3
	JP + mix of starch paste and MC	3
	Resizing with klucel G	3

Note: ^aReactivation of tissue with this adhesive using acetone.

(Nyberg 1987; Florian et al. 1994), by adding this type of adhesive, we may be enhancing the susceptibility of the treated paper to fungi.

The respondents who claimed to use other antifungal compounds besides the ones given as options (nine individuals) reported the use of isopropanol (by local treatment or immersion), sodium hypochlorite, quaternary ammonium compounds, azoles, immersion in ethanol 100% or calcium propionate 0.35% in ethanol. Each of these methods was only mentioned by a single respondent, except the use of isopropanol, which was mentioned by two, and so its percentages are not presented in Table 4. It is worth mentioning that some of these compounds can have deleterious effects on paper, like sodium hypochlorite that is a strong oxidizing agent of cellulose (Smith 2012) and quaternary ammonium compounds that can cause depolymerization and acidification of paper (Sequeira et al. 2012).

Fungal stain removal was selected only by 12% of the totality of the respondents (seven individuals), and among them, the majority claimed that it was only done when the objects were to be displayed in an exhibition. Bleaching with hydrogen peroxide was chosen by two of the seven respondents, and the following methods were selected only once: bleaching with sodium hypochlorite, with chlorine dioxide (solution or gas) or with sodium borohydride and washing with ethanol/water solutions or with demineralized water with calcium hydroxide.

3.6 The need for further research

In the end of the questionnaire, we intended to enquire in which topics people consider there is a higher need for further research in the area of fungal biodeterioration of paper according to their working experience. Four options were given, plus an open response option “Other”. The respondents had to classify each topic from 1 (lower need of research) to 5 (higher need of research).

Figure 6 shows that the topic “Non-toxic/safer antifungals” was considered the one with the higher need for further research by the majority of the respondents and is clearly detached from the other topics.

The other three given topics obtained an average similar punctuation, although the “Removal of fungal stains” had a more pronounced score in level 4. This one could be considered the second topic in higher need for research.

The option “Other” was chosen by only a few respondents. Nevertheless, the respondents who selected this option mostly rated it with “5”, the highest level. This indicates that in order to specify another research topic besides the given options, people had to consider it very important. Among these “Other” topics of

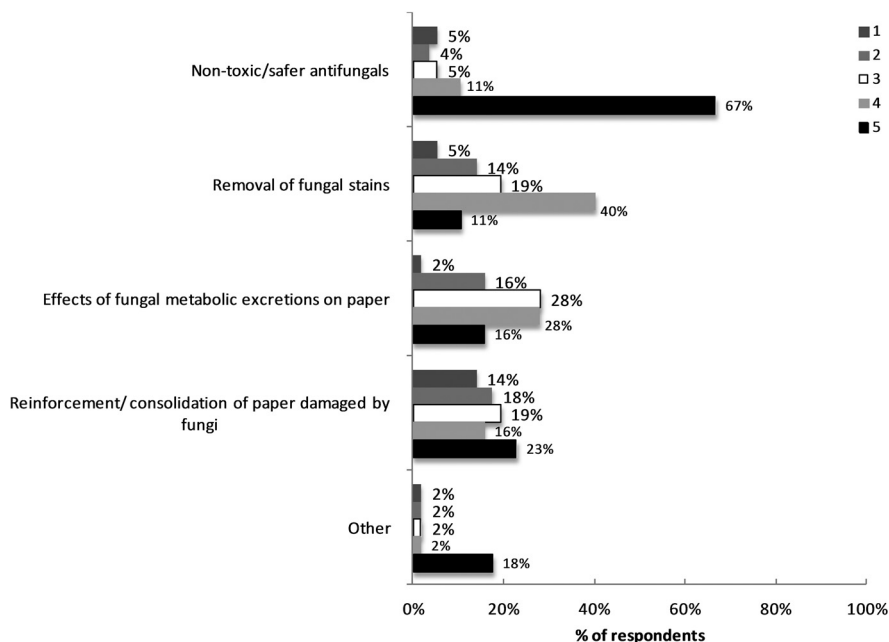


Figure 6: Results obtained for the question “In which areas do you think there is a higher need for research in the field of biodeterioration of paper by fungi?”. The punctuations vary from 1 (lower need of research) to 5 (higher need of research)

research, the respondents referred mainly to safety measures for staff, and the effects and effectiveness of specific antifungal compounds and cleaning methods.

4 Conclusions

With this survey we indented to have an insight into the real panorama of fungal biodeterioration of paper collections through the perspective of paper and book conservators distributed worldwide. We wanted to know how often does this type of biodeterioration occur, how do conservators deal with it, if there is any general agreement, if it follows the published guidelines and what do conservators consider more important to be further studied according to their practical experience.

The obtained results show that fungal biodeterioration is very common in paper based collections. Even though almost the totality of the respondents use

preventive measures to control fungal biodeterioration, all of them have already had to deal with paper deteriorated by fungi, and the great majority has already experienced active fungal infestations in paper collections in their workplace. Preventive conservation should always be the first choice to control fungal biodeterioration, nonetheless the results obtained indicate that preventive conservation is not a 100% guarantee that no fungal biodeterioration will occur.

Among the population of conservators studied in this survey, the most frequently used methods to prevent fungal development on paper collections are the ones related with environmental control (T, RH and ventilation), which is in agreement with the current published literature.

When faced with active fungal infestations most of the respondents stop fungal development by drying the affected paper objects, applying a 70% ethanol solution and/or freezing them. The use of sterilization procedures are the least selected actions. There is a general agreement between conservators on this matter and it follows the recommendations existent in the literature, with exception of the use of ethanol directly on the objects which is rarely mentioned in the published guidelines.

To treat paper objects that have already suffered from fungal biodeterioration, most of the conservators choose to isolate them from the other items, vacuum clean them and apply a consolidation/reinforcement treatment.

In both these situations (stopping fungal development and treating paper deteriorated by fungi) a trend of using less interventive and toxic methods is observed: rarely any antifungals (besides ethanol) or removal of fungal stains are applied, contrary to that was usual in the past.

Even so, the respondents considered the study of non-toxic/safer antifungals the topic that most needed further research. This information shows that the products and methods now available to prevent and suppress fungi are not fulfilling the requirements of conservators according to their own experience. Therefore, this is a topic that should be further developed.

Surveys regarding the practical experiences and opinions of conservators are not common. With this study we have shown some of the potentials of surveys in this field and expect they will become more frequent. They can aid conservation practitioners to compare experiences with their peers and learn from them and also help conservation researchers to target their research towards the needs of conservators. Besides, the documentation of this kind of data is very important not only for the present time but also to aid future studies on the history of paper conservation.

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Zusammenfassung

Biologische Abbauprozesse von Papier aufgrund von Pilzbefall. Wie gehen Papier- und Buchrestauratoren damit um? Eine internationale Umfrage

In Archiven, Bibliotheken und Museen ist der biologische Abbau von Papier ein häufiges Problem. Zwar gibt es mehrere Richtlinien zur Vermeidung von Schimmel und Pilzbefall und dafür, wie man betroffenes Archivmaterial reinigen kann. Doch es fehlen umfassende Informationen über die möglichen Ursachen bei biologischer Zersetzung von Papier. Wie häufig kommt der biologische Abbau vor? Welche Präventionsmaßnahmen gibt es? Wie kann man befallenes Papier in seinen ursprünglichen Zustand wiederherstellen? Was muss in diesem Bereich untersucht und entwickelt werden? Wo gibt es noch Forschungsbedarf?

Um Zugriff auf diese Informationen zu bekommen, ließen wir Papier- und Buchrestauratoren einen internationalen Fragebogen zukommen. Es wurde von der Conservation DistList verteilt und wurde von Teilnehmern aus 20 verschiedenen Ländern beantwortet.

Aus den Antworten ging hervor, dass biologischer Abbau durch Pilze in Papiersammlungen ein relativ häufiges Problem ist. Nahezu alle Befragten

gaben an, von Pilzen befallenes Papier bereits behandelt zu haben. Die Mehrzahl nutzt zwar vorbeugende Maßnahmen, um die Entwicklung von Pilzen frühzeitig zu verhindern, doch die meisten haben Pilzbefall an Papier bereits erlebt. Gegenmaßnahmen kamen vor allem während der Kontrolle von Lager- und Ausstellungsräumen zur Anwendung. Die meisten gaben an, das Papier zu trocknen oder es mit Ethanol (70%) zu behandeln, um das Pilzwachstum zu stoppen.

Wie die Untersuchung zeigt, sind die genannten Maßnahmen gegen Pilzbefall nicht zufriedenstellend. Auf dem Gebiet des biologischen Zerfalls von Papier gibt es hinsichtlich Präventions- und Gegenmaßnahmen demnach weiteren Forschungsbedarf.

Résumé

Biodétérioration fongique du papier: Comment sont les conservateurs en train de traiter ça? Une enquête internationale

Biodétérioration de papier par des fungus est un problème fréquent dans les archives, bibliothèques et musées. Actuellement, il existe plusieurs lignes directrices publiées pour la prévention du développement fongique et la récupération des collections affectées, mais il n'y a aucune information concernant le véritable panorama de la biodétérioration fongique des collections de papier. Quelle est la fréquence de ce type de biodégradation? Quelles sont les méthodes préventives et curatives mises en place? Que faut-il davantage étudié et développé?

Afin d'accéder à cette information, nous avons mené un questionnaire international aux conservateurs de papier et livres. Il a été distribué par Conservation DistList et a eu des participants de 20 pays différents.

Les résultats montrent que la biodétérioration fongique est très commun dans les collections sur papier. Tous les répondants ont déjà dû faire face à papier détérioré par des fungus, et bien que la grande majorité utilise des mesures actives pour prévenir de développement des fungus, la plupart d'entre eux ont déjà connu des infestations fongiques actives. Les mesures préventives principalement utilisés sont ceux concernés par le contrôle des conditions environnementales dans les locaux de stockage et d'affichage. Le séchage des objets en papier affectés et l'application d'éthanol à 70%, sont les options plus privilégiées pour arrêter la croissance des infestations fongiques actives. L'étude des antifongiques non-toxiques et plus sûr, est considéré ici comme sujet de recherche le plus pertinent dans le domaine de la biodégradabilité du papier par des fungus, ce qui signifie que ceux actuellement disponibles ne sont pas totalement satisfaisantes.

Authors

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