Assessing the impact of air movement on hyphal growth

Morena Ferreira[a*], Josep Grau-Bové[a], Hector Altamirano[b], Nigel Blades[c]

aUCL Institute for Sustainable Heritage, London, United Kingdom
bUCL Institute for Environmental Design and Engineering, London, United Kingdom
cNational Trust for England, Wales and Northern Ireland, London, United Kingdom

Abstract

Increased ventilation is widely reported to reduce the incidence of mould growth, mainly when it reduces the water activity (a_w) of surfaces. However, it is unclear whether drying of surfaces is the only mechanism that relates ventilation and air mould. It has been hypothesized that air movement, even in conditions of moisture equilibrium between the surface and the air, can reduce mould growth. The impact of air movement was tested on hyphal growth of *Aspergillus versicolor* and *Penicillium brevicompactum*. Results show that the presence of air movement does not seem to have an impact on hyphal growth. However, the presence of air movement (unfiltered air) increased the variability of the measured hyphal growth, indicating a potential relationship that should be further explored.

Peer-review under the responsibility of the organizing committee of the ICMB23.

Keywords: Air movement; mould; preventive conservation; buildings

1. Introduction

Mould growth is an issue affecting many historic materials, from paper and parchment [1] to inorganic materials such as wall paintings [2]. At the same time, despite implementing environmental control strategies historic buildings face mould issues recurrently, particularly in microclimates with high relative humidity (RH) [3]. Ventilation and, consequently air movement can be used to dissipate these microclimates and prevent biological growth [4]. This study aims to explore the effect of air movement on mould development independently of changes in environmental conditions. In other words, it considers whether air movement by itself has an effect, even in situations of moisture equilibrium between the surface and the surrounding air. Because of the clear contribution to ventilation to drying of wet surfaces, this phenomenon has been under-studied. If this relationship were to be significant, it could expand the toolbox of environmental managers interested in mitigating mould growth. In the case of heritage, this is important for designing preventive conservation strategies using air movement. If air movement can have an impact on mould growth that is independent of changes in environmental conditions, and consequently on the moisture and temperature (T) conditions of surfaces, this could contribute to developing preventive strategies that are less reliable on environmental control, focused on microenvironments, and thus more energy efficient. In fact, environmental control of humidity is one of the most energy-intensive aspect of heritage preservation in historic buildings and also has the highest operative cost [5].

2. Methodology

Hyphal growth was the parameter selected to assess the impact of air movement on the development of *A. versicolor* and *P. brevicompactum*. These are some of the most common species found in historic buildings in the UK [6] and the genera Aspergillus and Penicillium affect collections in different countries [7]. Experiments were conducted in two purpose built chambers (84 l; L 82 x D 30 x H 35 cm). In chamber 1, air movement was included using electric fans (Noctua NF-B9, 1600 RPM, 92 mm diameter). Air velocities of approx. 1.5 m/s (±0.015 m/s) were used and air velocities were calibrated done with a hot wire anemometer (Velocicalc® model 9565). Ideal conditions of RH, T, substrate and substrate a_w were used to reduce the possible interference of suboptimal growth conditions and decrease the experiments' length. In chamber 2, still air was tested. Both chambers were kept in a walk in test chamber for T control throughout the experimental work: 27° C (±0.21° C) for *A. versicolor* and 25° C for *P. brevicompactum*. RH was controlled at 98% RH (±2.5%) in the two chambers with a glycerol-water solution (14% glycerol (w/w)). The a_w of the potato dextrose agar substrate (PDA) was controlled at 0.98 a_w (9.10% glycerol (w/w)) and measured with a a_w meter (Rotronic® HygroPalm 23-AW-A). Hyphal growth was assessed over time, up to 20 hours after inoculation.

* Corresponding author. Morena.ferreira.16@ucl.ac.uk

 DOI: 10.14293/ICMB230028

3. Results and discussion

For both species, hyphal growth was visible under the microscope within 14 hours of inoculation, with and without air movement. Hyphae reached a length of approximately 60 µm in 20 hours, at which point measurements were halted for both species due to branching and the increase of hyphal density. An exponential curve was fitted to the experimental data assuming a constant growth rate between 14 and 20 hours (Figure 1). 135 measurements were used to calculate the average length per sampling time. The coefficient interval (CI) was used to evaluate the differences in growth of the two populations (hyphal growth with and without air movement) over time for each species. The following equation was used to calculate the CI: $X - s \cdot t < X < X + s \cdot t$, where X are the experimental averages of the hyphal lengths, s represents the absolute standard deviation and t is the t-student variable with NE-1 degrees of freedom and 95 % confidence level, where NE represents the number of measurements used to calculate the averages. For *A. versicolor* the confidence intervals of both populations overlap, indicating that the presence of air movement did not present an important influence on the experimentally measured growth. The same was observed for *P. brevicompactum*. However, for *A. versicolor* a standard F-test showed that the variance ratio at 20 h was found to be outside the F interval suggesting that the experimental error at this sampling time was statistically different between the two tested air conditions, and therefore that the presence or absence of air movement could present a significant effect. The calculated standard deviations of the hyphal lengths were higher than the error previously calculated for measurements (0.5%). This suggests that this error calculated with the standard F-test is not associated with the measuring method and the software used. In the case of *P. brevicompactum*, the variance ratio falls outside the F interval for the first two sampling times, 14 and 16 hours, suggesting that the presence and absence of air movement presented a significant effect. For the second part of the experiment, 18 and 20 hours, the variance was inside the F interval. The results from this study suggest that under the achieved moisture conditions (environmental RH and substrate a_w), T and provided nutrients (PDA), air movement does not have an impact on hyphal growth of the tested fungal species. However, the variability detected in the error of the results means that there could be a link between the standard deviation of the growth measurements and the air movement conditions. This should be explored in future tests to understand if air movement has in fact an impact on hyphal growth. The impact of other T and RH (including fluctuations) and air velocities should be studied, as well as real materials. The methodology developed in this study can be the basis of future work on the relationship between mould growth and near-surface air velocity.

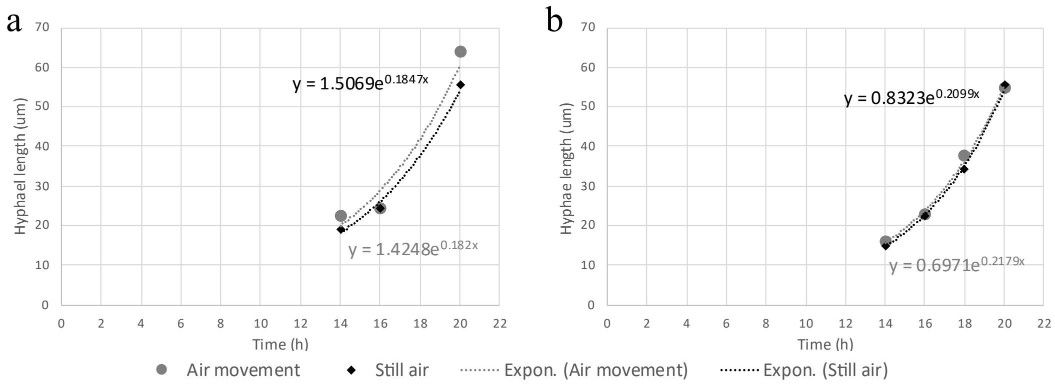

Figure 1. (a) Hyphal growth up to 20 hours of *A. versicolor*; (b) Hyphal growth up to 20 hours of *P. brevicompactum*.

References

[1] O. E. Okpalanozie, S. A. Adebusoye, F. Troiano, C. Cattò, M. O. Ilori, and F. Cappitelli, "Assessment of indoor air environment of a Nigerian museum library and its biodeteriorated books using culture-dependent and independent techniques," Int. Biodeterior. Biodegrad., vol. 132, no. March, pp. 139–149, 2018.

[2] K. Sterflinger and F. Pinzari, "The revenge of time: Fungal deterioration of cultural heritage with particular reference to books, paper and parchment," Environ. Microbiol., vol. 14, no. 3, pp. 559–566, 2012.

[3] J. Leplat, A. Francois, and F. Bousta, "White fungal covering on the wall paintings of the Saint-Savin-sur-Gartempe Abbey church crypt: A case study," Int. Biodeterior. Biodegrad., vol. 122, pp. 29–37, 2017.

[4] F. Pinzari and M. Montanari, "Mould Growth on Library Materials Stored in Compactus-Type Shelving Units," in Sick Building Syndrome in Public Buildings and Workplaces, S. A. Abdul-Wahab, Ed. Springer, 2011, pp. 193–206.

[5] S. Maekawa and F. L. Toledo, "Controlled Ventilation and Heating to Preserve Collections in Historic Buildings in Hot and Humid Regions," Getty Conserv. Inst., pp. 1–17, 2002.

[6] K. Lithgow and H. Lloyd, "Direct preventive conservation – Using information from the past to prevent small issues in the present from becoming bigger problems in the future," in ICOM-CC 18th Triennial Conference Preprints, Copenhagen, 4–8 September 2017, 2017.

[7] S. Downes, "The Interactions between Fungi and British Heritage Buildings: The Effects of Fungal Growth on Organic Collections and Conservation Impplications," Brikbeck, University of London, 2017.