Journal of Cultural Heritage 16 (2015) 934–938

Available online at
ScienceDirect
www.sciencedirect.com

Elsevier Masson France
EM|consulte
www.em-consulte.com/en

Case study

# Towards a better comprehension of biodeterioration in earthen architecture: Study of fungi colonisation on historic wall surfaces in Brazil

Alejandra T. Fazio[a,*], Andrea Cavicchioli[b,1], Daysi S.A. Penna[b,2], Felipe S. Chambergo[b,2], Dalva L.A. de Faria[a,3]

[a] Laboratorio de Espectroscopia Molecular, Instituto de Química, Universidade de São Paulo, Av. Professor Lineu Prestes, 748, 05508-000 São Paulo (SP), Brazil
[b] Escola das Artes, Ciencias e Humanidades, Universidade de São Paulo, Av. Arlindo Bettio, 1000, 03828-000 São Paulo (SP), Brazil

ARTICLE INFO

*Article history:*
Received 30 September 2014
Accepted 7 April 2015
Available online 5 May 2015

*Keywords:*
Biodeterioration
Fungi
Earthen architecture
Coffee cycle
Brazil

ABSTRACT

This study was aimed to describe fungal communities found in biofilms growing on earthen walls (rammed earth, wattle-and-daub and adobe) of rural and semi-urban historical buildings representative of the first phase of the Brazilian coffee cycle (1820–1880), in the upper basin of the *Paraiba do Sul* river, São Paulo State. The relationship between substrates and such surface-associated microbial communities was also investigated. Fungal biodiversity was significantly higher in rammed earth with respect to the other two techniques. Granulometric analysis showed that rammed earth also contained a higher percentage of coarse soil fraction which is likely to favour the accumulation of water and organic matter. Cellulolytic activity tested positive for the majority of fungi and acidification test showed that fungi exhibit elevated acidifying capacity suggesting that biodeterioration may occur through acid metabolites.


## 1. Introduction and research aims

Fungi biodeterioration is one of the most important decay mechanisms acting in the progressive loss in aesthetical and functional properties of building materials on both organic and inorganic substrates [1]. The main aggression pathways include:

- degradation of organic and mineral substances to obtain nutrients and extract energy;
- production of molecules, such as acids or complexing agents, mainly aiming at abating the cohesion of the substrate;
- excretion of metabolic waste, which can cause aesthetically undesirable effects [2].

In Brazil, earthen techniques like rammed earth (*taipa de pilão*), wattle-and-daub (*pau-a-pique*) and adobe predominated until the late XIX century [3,4], before the introduction of brick on a large-scale. Earthen architecture was almost the exclusive choice in building practice in rural Rio de Janeiro and São Paulo states during the first phase of the so-called coffee cycle (approximately 1820–1880). This was a time of extraordinary economic growth based on the large-scale production of coffee grains along the upper basin of the river *Paraiba do Sul* (Fig. 1), resulting in a considerable ensemble of elegant country houses and a few small urban agglomerates (Fig. 2).

This exceptional heritage is today subjected to a number of vulnerability factors that create environments propitious to all kinds of biological activity. This state of things reinforces the need of accurately identifying decay agents, assessing their mechanisms of action and tailoring *ad hoc* conservation strategies, also in the light of the exacerbation of climate conditions in the forthcoming decades.

The present work – the first study on biodeterioration of earthen walls – reports the preliminary results on fungi presence in biofilms formed on uncapped earthen walls of selected historic buildings of the study area and discusses the correlations between the sort of deterioration that they are causing and the features of the different constructive techniques.

* Corresponding author. Tel.: +55 11 30913853.
*E-mail addresses:* fazio.alejandra@gmail.com (A.T. Fazio), andrecav@usp.br (A. Cavicchioli), daysi_andrade@hotmail.com (D.S.A. Penna), fscha@usp.br (F.S. Chambergo), dlafaria@iq.usp.br (D.L.A. de Faria).
[1] Tel.: +55 11 30911058.
[2] Tel.: +55 11 30918922.
[3] Tel.: +55 11 30913853.

http://dx.doi.org/10.1016/j.culher.2015.04.001
1296-2074/

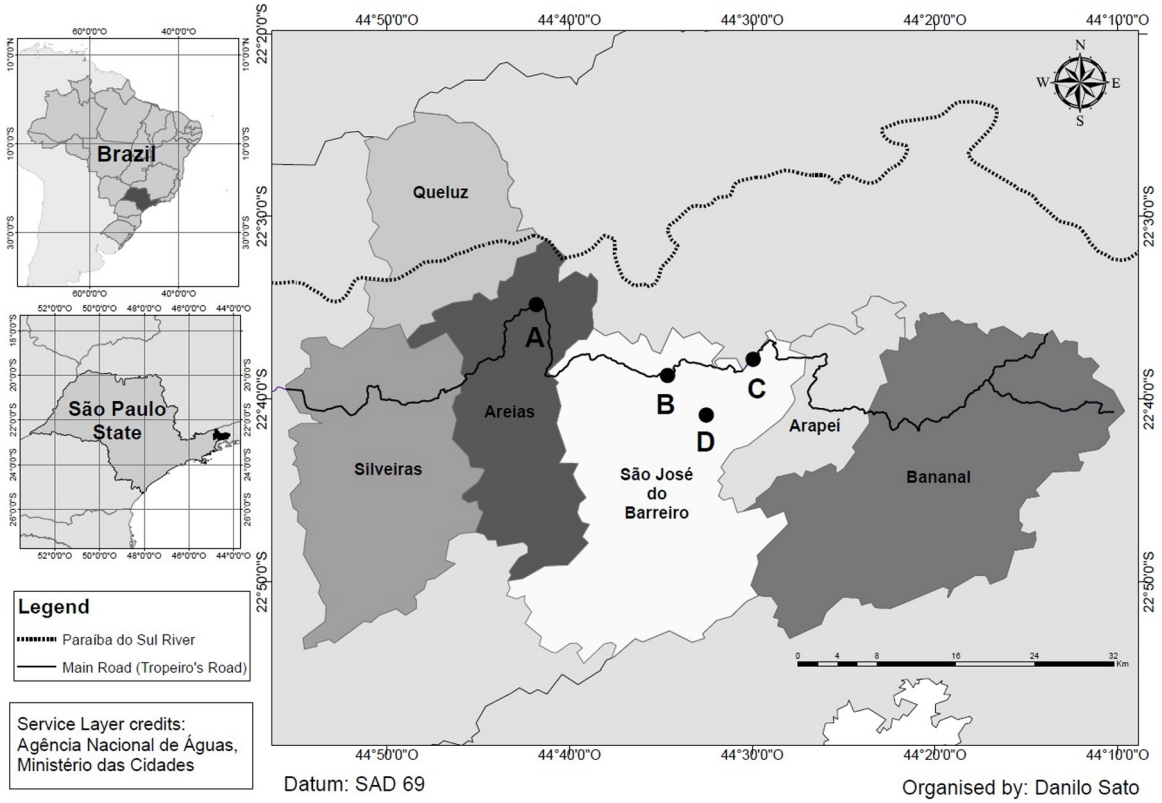


**Fig. 1.** Map showing the location of the upper basin of the *Paraiba do Sul* river in São Paulo state (Brazil), with the identification of the sites where earthen wall samples were collected. A. Urban area of the district of Areias. B. Urban area of the district of São José do Barreiro. C. Remains of the historic farm *Fazenda República*. D. Historic farm *Fazenda da Barra*. All sites exhibit a typical altitude tropical climate, characterised by two main seasons: a rainy hot summer (with 22 °C mean temperature and 232 mm mean precipitation) and a drier cool winter (with 16 °C mean temperature and 49 mm mean precipitation). Climatic values are 1980–2010 averages obtained from the closest weather station located at approximately 100 km SW.

## 2. Materials and methods

Small pieces of the earthen substrate, with and without biofilm (Fig. 3), were collected from colonial-style buildings at the end of spring. The samples (see details in Table 1) were taken at a height of 1–2 m above the ground by gently scraping the surface with a sterile spatula and transferred immediately to Petri dishes containing two different types of solid culture medium: Bold's basal medium (BBM) and potato dextrose agar (PDA). Plates were incubated at 30 °C and hyphal tips were periodically transferred to new Petri dishes containing PDA solid culture medium to obtain pure cultures. The isolates were maintained on PDA solid culture in a climatic chamber at 30 °C. This is a standard procedure (e.g., see [5]) which does not guarantee that settled airborne fungal spores are not collected together with true biofilm formers. Yet, the fact that non-biofilm samples hardly resulted in fungi development allow to realistically assume that the majority of the fungi gathered in this study were effectively vegetative forms present on the walls.

The fungal species were identified according to taxonomic literature for these genera [6–14]. DNA sequencing was used with the more complex genera.

Ribosomal DNA (rDNA) was extracted, purified and amplified using commercial kits. The PCR product was sequenced using an ABI Prism 377 sequencing machine, following the manufacturer's protocol (Applied Biosystems, USA). The electrophoretic profile of each sequential sample was interpreted by means of the BioEdit

**Fig. 2.** Photographs of historic buildings dating from the XIX century that are representative of earthen architecture of the first phase of the coffee cycle in the study area. Left: example of an urban residence (*Solar do Major Manoel da Silva Leme*, district of Areias, ca. 1800); right: example of a rural farmhouse (*Fazenda Catadupa*, district of São José do Barreiro, 1837).