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MICROBIOLOGICAL IMAGE

Fungi observation in deteriorated wooden heritage: analysis using different imaging techniques



Observación de hongos xilófagos en madera perteneciente al patrimonio histórico deteriorada: análisis utilizando diferentes técnicas de obtención de imágenes

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This study was based on the current deteriorated status of wood slats from a locomotive turntable at the La Plata Provincial Railway Station⁶ (Fig. 1). Wood species of the slats was *Schinopsis* spp. and was determined by conventional methods, while the fungal species was *Phellinus chaquensis* (white-rot fungus) and was determined morphologically. Determination of the fungus and its in vitro cultural features was based on Iaconis and Wright¹ and Robledo and Urcelay⁴.

Fungal degradation requires to be measured by non-destructive methods²: the area occupied by mycelium and basidiomata was observed by using X-rays and computed tomography (CT) and was quantified by image analysis using ImageJ software. Grayscale of the images obtained indicated density changes, being the black scale the less dense and the white scale the densest. To establish microstructural wood deterioration (cell wall), scanning electron and optical microscopy (SEM and OM) images were analyzed.

The radiographic images were analyzed using ImageJ to determine the affected area by wood decay fungi: the mycelium area was 84.6%, while the basidioma occupied 12% of the total wood area, which confirms that the external deterioration did not correlate with the internal status. To substantiate this fact, a CT scan was performed. CT images showed the wood structure loss (dark plates in the images, Fig. 2), which was correlated with the presence of fungal hyphae along the entire slat.

Finally, the wood microstructure was analyzed by SEM and OM images (Fig. 3), in which the advanced deterioration status of the wood structure could be observed, evidencing a high rate of fungal colonization (hyphae, panels A and B) and wood microstructure loss (cell wall degradation, panels C and D).

It was concluded that using images for assessing wood deterioration is a non-destructive alternative methodology, which allows to measure the structural condition of the material. This is essential in heritage conservation because it allows to correctly define the deteriorated status, which is useful for planning a conservation strategy that would prevent the loss of heritage assets^{3,5}.

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Figure 1 Actual photographs of La Plata Provincial Railway Station. Panel A: Front view of the central station building. Panel B: Back view of the central station building. Panel C: Aerial view of the location of the locomotive turntable ($34^{\circ}56'16''$ S and $57^{\circ}56'13''$ W) and Panel D: locomotive turntable status.

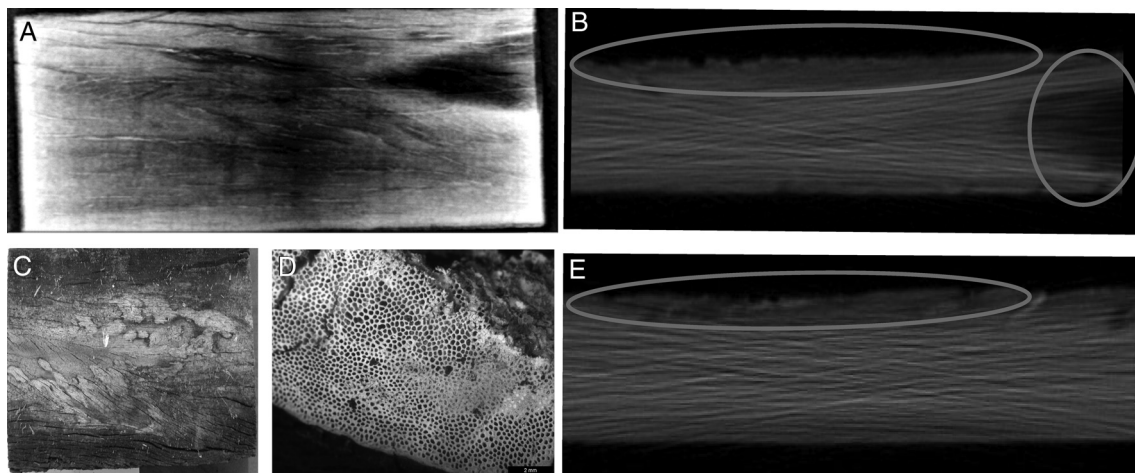


Figure 2 Locomotive turntable wood status. Panel A: X-ray images (RX) of the deteriorated wood. Panel A: RX image of deteriorated wood where the dark parts of the image represents a loss of wood material correlating with the presence of fungal hyphae. Panel B and E: Computed tomography (CT) scan of deteriorated wood to analyze internal wood status; dark areas of the image are less dense due to the loss of material and the dark area of the image coincides with the presence of fungal mycelium. Panel C: Photograph of slats in an advanced status of deterioration caused by environmental and biological factors subjected to RX and CT. Panel D: Detail of basidioma.

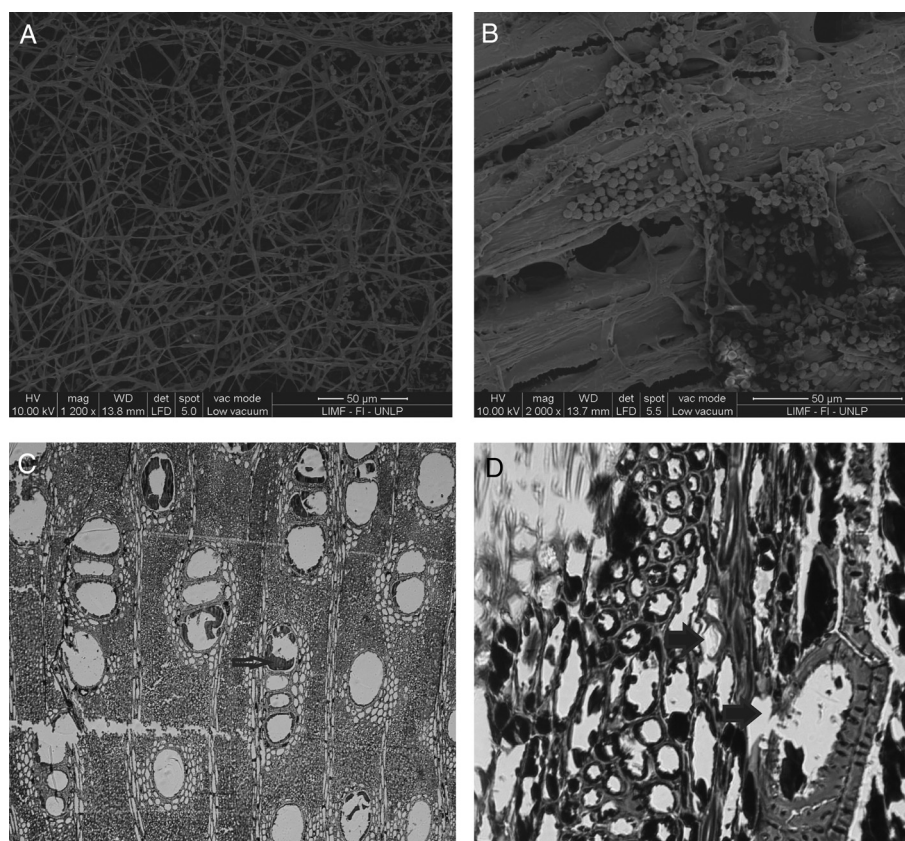


Figure 3 Microscopy of deteriorated wood samples. Panel A: scanning electron microscopy (SEM) images of ultra slim cut of dark area observed in RX and CT, dense presence of hyphae. Panel B: SEM image of ultra slim cut of gray zone where microstructure loss and the presence of spores are observed. Panel C: Optical microscopy (OM) images of the dark area observed in RX and CT: altered wood appeared compartmentalized by dark secretions deposited in axial/radial parenchyma and in vessel and cell lumina. Panel D: OM images where generalized cell wall erosion is evident (arrowheads holes in vessel elements and erosion of wood cell walls are observed).

Ethical disclosures

Protection of human and animal subjects. The authors declare that no experiments were performed on humans or animals for this study.

Confidentiality of data. The authors declare that no patient data appear in this article.

Right to privacy and informed consent. The authors declare that no patient data appear in this article.

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