VIII Congresso Nazionale di Archeometria
Scienze e Beni Culturali: stato dell'arte e prospettive
Bologna 5 - 7 Febbraio 2014

BIOLOGICAL ENVIRONMENTAL MONITORING IN PREVENTIVE CONSERVATION OF PAPER HERITAGE

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In museums, libraries and archives, paper heritage (books, prints, drawings, photographs) are sources for growth and dispersal of bioaerosol, especially fungi. Airborne biological spores are potential biodeteriogens and play an essential role in the processes of biodeterioration; once deposited on the surface of artwork, may accumulate in the dust and whether there are favorable microclimatic conditions, they develop and can cause serious damage.
The present article discusses the proposal of an integrated system of biological and microclimatic monitoring [1] which represents the first step to estimate the biological risk for paper heritage. It is based on a methodological model for the analysis of: 1) airborne microorganisms with active and passive methods; 2) microbiological sampling of surface of artwork with non-destructive techniques based on nitrocellulose membrane; 3) air fungal spores with a spore trap (Hirst type) and microscope; 4) surface and airborne allergens with immunoenzymatic assays; 5) airborne particles with a laser particle counter; 6) microclimatic monitoring with multi data-logger for continuous measurements of: air temperature, relative humidity, air velocity, air radiant temperature; 7) transient simulations for indoor climate and air quality investigation with the application of Computational Fluid Dynamics (CFD).
We describe the application of a part of the integrated system, the biological environmental monitoring, performed before a removal intervention of dust, at the National Institute of Graphic Arts, museum institution to preserve graphic arts. The investigation was carried out into two days (on 8-9 August 2011) in the repository n.1, which preserves in metal cabinets the collections of the *Gabinetto Disegni e Stampe.*
Air monitoring was performed by: 1) DUO SAS-360 impactor (180 L/min); 2) spore trap (Hirst type, 10 L/min for 24 h), the results were expressed as CFU/m^3; Petri dishes (9 cm in diameter with agar culture media) exposed to air for 1h, to determine the Index of Microbial Air Contamination (IMA). The samplings were carried out in five points: four in repository, one outside (Fig 1).
Surface monitoring was performed on two shelves of metal cabinet n. 6 which preserves the precious collections of drawings in volumes of *Fondo Corsini*, on four volume and three ancient drawings (Fig. 2). The sampling was carried out in a non destructive way, by

nitrocellulose membrane that was pressed on the surface and then transferred on solid culture media in Petri dishes. To evaluate microbial surface contamination, two parameters were examined: Microbial Buildup (MB, the number of microorganisms accumulating on a surface after an unknown preceding period of time) and Hourly Microbial Fallout (HMF, the number of microorganisms that settle on a specific surface during one hour). The results were expressed as CFU/dm^2.
The solid culture media used, both for air and surfaces sampling, was the SDA (Sabouraud Dextrose Agar) + chloramphenicole.
The results of air and on surfaces monitoring showed: higher contamination outside of the repository than inside; in the sampling on the shelves and volumes the contamination was greater at the bottom; on the surfaces of the drawings was much lower the presence of contaminants. The environmental microbial contamination highlight a critical situation (Fig. 3,4,5). The qualitative analysis showed the presence of different cellulolytic fungal species, involved in the biodeterioration of paper heritage (Fig. 4,6).
The indoor microclimate monitoring was carried out using a data-logger for continuous measurements of air temperature and relative humidity (hourly data acquisition), outside and inside the repository, inside metal cabinets and also into some volumes and drawings. Experimental data on termohygrometric parameters during a week, were quite stable (Fig.7). The air temperature was high while the relative humidity fell within the band-width recommended by the standards or the preservation of paper [2]. This situation confirms that any air conditioning plant is not necessary.
As for paper heritage the biological environmental monitoring is essential for preventive conservation strategy. The future application of transient simulations based on CFD approach using the Finite Element Method (FEM) are in progress for construction of predictive models of biological risk connected to microclimatic data.
The integrated multidisciplinary approach, proposed here, is a starting point to study the complex "*environment - cultural heritage*" and it is a contribution toward the definition of standardized methods to assess the biological and microclimatic parameters and the best preservation conditions for cultural heritage.

References

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MIBAC, *Atto di indirizzo sui criteri tecnico-scientifici e sugli standard di funzionamento e sviluppo dei musei.* D.M. 10/05/2001,D Lgs. 112/1998, art.150, Sup. ord.G.U. 244, 19/10/ 2001.

Fig.1. Sampling points of air

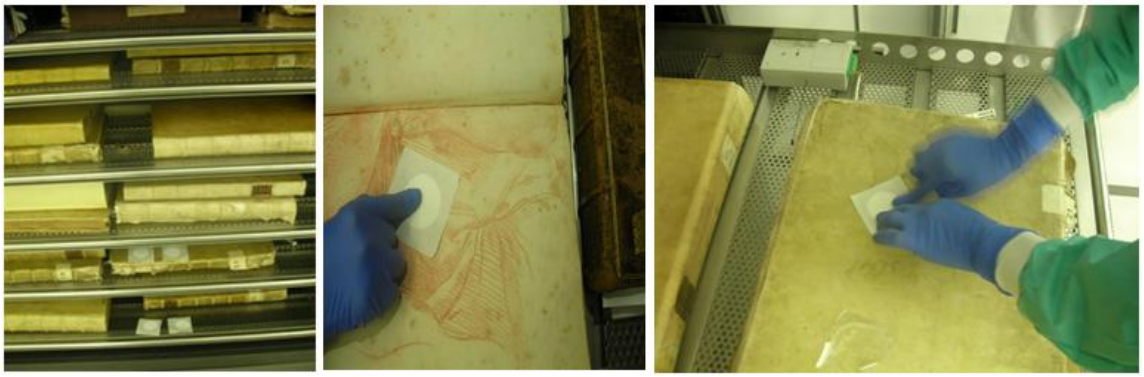

Fig. 2. Examples of surface sampling

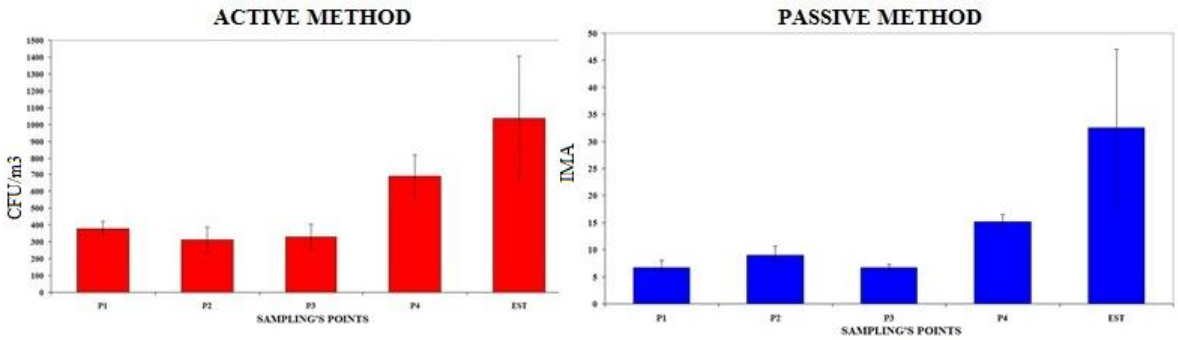

Fig. 3. Air fungal contamination in different sampling points

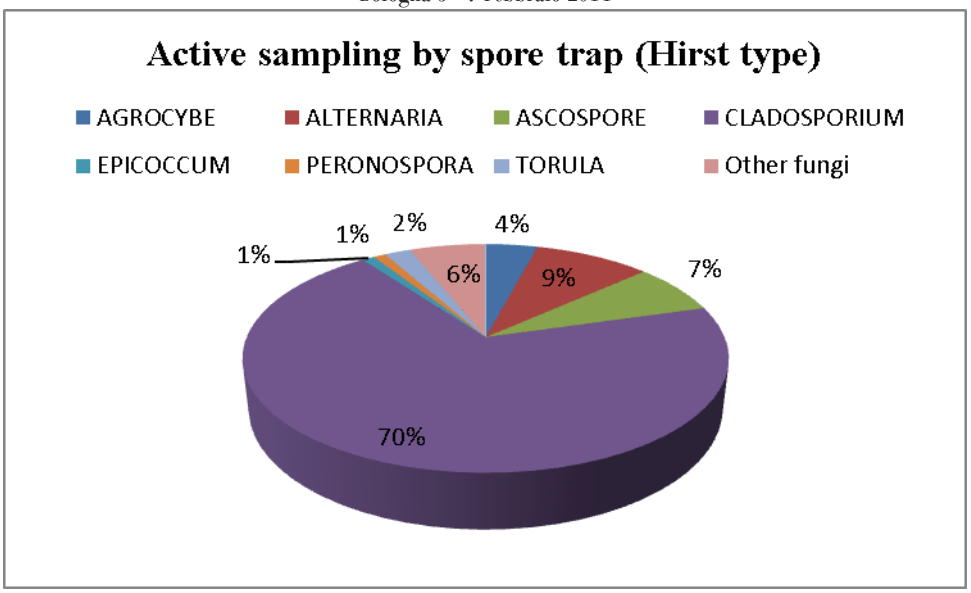

Fig. 4. Fungal spores isolated by spore trap Hirst type

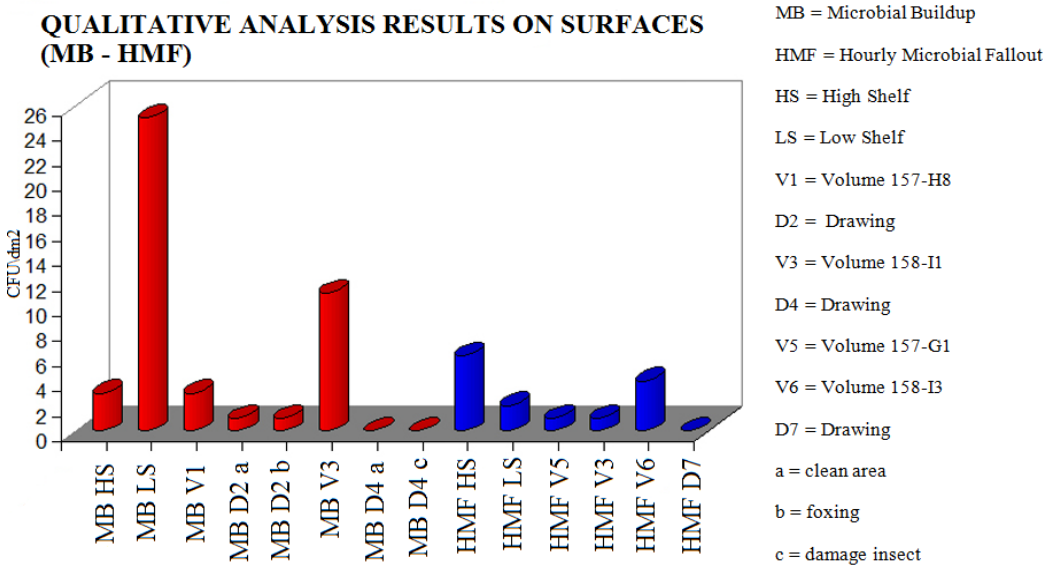

Fig. 5. Fungal contamination on surfaces

FUNGAL SPECIES	SAS	IMA	SURFACES
Acremonium strictum	X		
Acremonium terricola			X
Alternaria alternata	X	X	X
Alternaria sp.		X	X
Arthrinium phaeospermum			X
Aspergillus niger			X
Cladosporium cladosporioides	X	X	X
Cladosporium cucumerinum	X	X	X
Cladosporium herbarum	X	X	X
Cladosporium sphaerospermum			X
Epicoccum nigrum		X	
Humicola sp.			X
Yeasts			X
Penicillium spp	X	X	X
Phoma sp.			X
Mycelia sterilia hyalina			X
Mycelia sterilia pigmented			X

Fig. 6. Fungal species pointed out with air and surface sampling

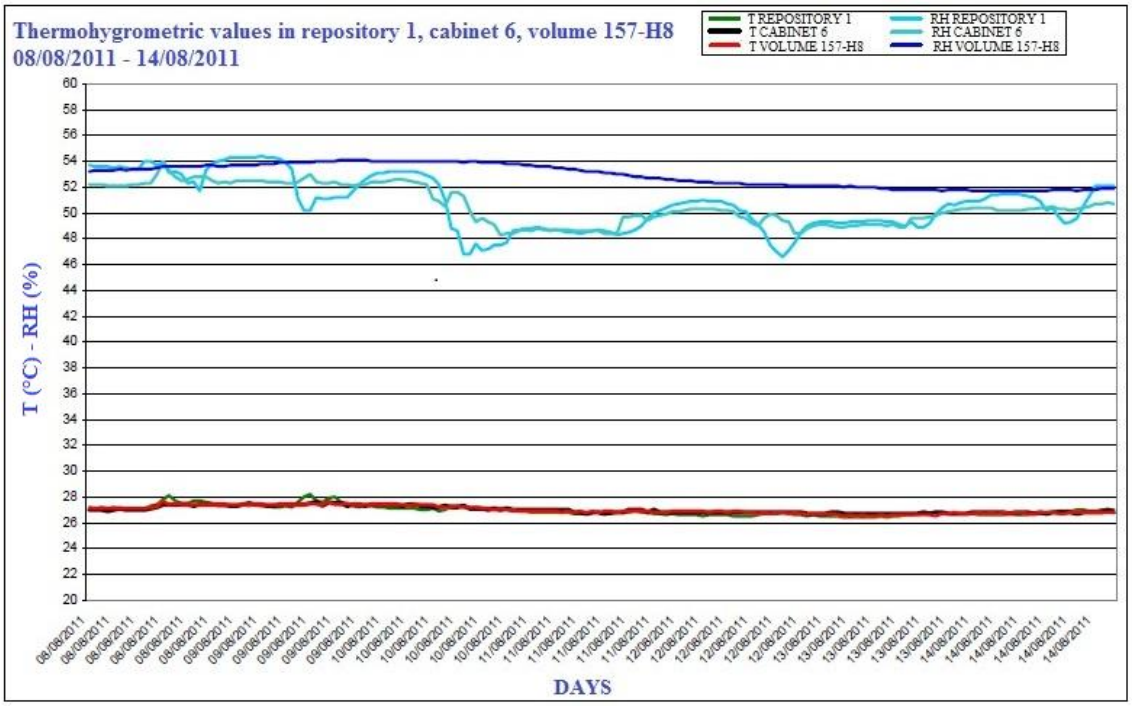

Fig. 7. Thermohygrometric values in repository n.1, cabinet n.6, volume 157-H8 in the week of the sampling