e-PS, 2010, **7**, 55-58
ISSN: 1581-9280 web edition
ISSN: 1854-3928 print edition

www.Morana-rtd.com

e-PRESERVATIONScience

published by MORANA RTD d.o.o.

SHORT COMMUNICATION

A MUSEUM STORAGE AREA: MICROCLIMATE AND AIR QUALITY SHORT-TERM MONITORING PROGRAMME

Elisabetta Giani*, Annamaria Giovagnoli , Maria Pia Nugari

Istituto Centrale per il Restauro, Piazza San Francesco di Paola, 9 – 00184 Rome, Italy

corresponding author:
elisabetta.giani@gmail.com

The National Gallery of Modern Art in Rome is located near the Villa Borghese Park. The storage is an underground area of the building. Different kinds of modern artworks are conserved. The study regards the environmental conditions with the aim of improving the preservation of the collection.

The method used consists in short-term monitoring programs (microclimate and air quality) carried out in four rooms with different significant aspects. On the basis of climatic data of Rome geographic area, the microclimatic monitoring has been performed during the most critical period (summer to autumn). For chemical control, the total deposited particulate matter was evaluated using a prototype instrument to estimate the brilliance variation of 15 white marble samples exposed to the deposition. The soluble salts in the deposited powder layer were determined by ion chromatography. Aero-diffused microorganisms were detected by aerobiological analyses.

The results have pointed out the need of improving the insulation of the masonry in one of the four rooms. Successively further environmental investigations should be planned to assess the effectiveness of the intervention on the walls and to evaluate the efficiency of HVAC system under the new, improved conditions.

received: 14.05.2008
accepted: 26.02.2010

key words:
storage areas, microclimate, air quality, museum, monitoring

1 Introduction

The National Gallery of Modern Art in Rome is located in the city, near the Villa Borghese Park. Different kinds of modern artworks, such as paintings on wood and on canvas, textiles, sculptures, etc. are exhibited. The 75 rooms display the largest collection of 19th and 20th century Italian painters and also many works of Italian and foreign optical and pop art artists. The storage area of the Gallery, located in the underground level, houses several masterpieces and it can be visited by appointment.

Decay phenomena observed on some frames and canvas paintings have highlighted the need to plan an environmental monitoring programme. On the basis of our experience[1,2] and in order to reduce the cost of the analyses, chemical, biological and microclimatic monitoring have been performed in 2007 during a short period in accordance with the storage management. The aim of the study was to improve the environmental management of the collection in the storage area and to control the efficiency of heating, ventilating, and air conditioning system (HVAC).

2 Materials and Methods

In the museum storage area, four rooms with different characteristics have been investigated:
- Room A with one of the walls affected by evaporation phenomena, probably due to the embankment behind the wall;
- Room C in the central part of the storage area with low microclimate fluctuations;
- Room F with ascending dampness in the wall and the efflorescence of salt;
- Room G, the entrance of the storage area with several objects being housed here.

The method used consisted in a short-term monitoring programme carried out during the most critical period of the year, chosen on the basis of references and historical climatic data of Rome geographic area.[3,4]

Microclimatic parameters (temperature and relative humidity) have been measured continuously for three months, from July to September; the HVAC system was running for the whole period. The interval between microclimatic measurements is one hour. Battery data loggers ESCORT-10D16, placed in the four rooms were used.

For chemical control, the evaluation of the total deposited particulate matter was carried out considering only the most critical room (room F). A prototype instrument[1,2] has been used to estimate the brilliance variation (tri-chromatic parameters L*, a*, b*) of 15 white marble samples exposed to the deposition. The monitoring lasted 90 days, the colorimetric measurements have been done twice a day. The presence of soluble salts in the deposited powder layer was determined by ion chromatography.

Aerobiological analyses have been carried out at the end of September in rooms A, C and F to detect aero-diffused microorganisms. The air sampling has been performed by an active impactor sampler (Andersen cascade sampler). Heterotrophic bacteria and fungi were considered. Culture media adopted were Mycological Agar (DID) for both microorganisms groups.[3] After incubation at 28 °C under aerobic condition, the cultures were controlled at 7, 14 and 21 day time points.The results were expressed as colony forming units related to cubic metres of air (CFU/m^3). Microbiological analyses of the colonization of humid walls and some paintings were also carried out. Fungal genera were identified by microscopic observations and according to the monographs of Barron, Domsch *et al.* and Ellis.[5-7]

3 Results

Microclimatic monitoring has pointed out values frequently near the upper threshold for paintings conservation (RH > 60%, T > 20 °C, Figure 1) despite the operation of the HVAC system. In the analyzed period the day-night fluctuation determines a daily average variation of about 1 °C of temperature and 5% of relative humidity, as highlighted in graphs for the months of July (Figures 2 and 3).

The total microbial charge in all analysed rooms is very low (48-107 CFU/m^3). The average quantity of fungi is larger than that of bacteria (Figure 4). The source of airborne fungi should be related to the colonisations on humid walls. The highest airborne spores diffusion was detected in room F with predominance of species isolated from the wall

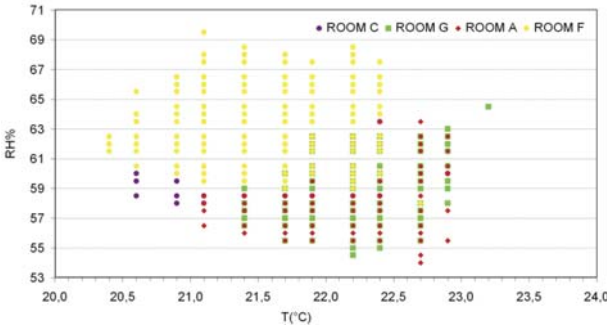

Figure 1: Temperature and relative humidity range of the entire monitoring period (July-September 2007).

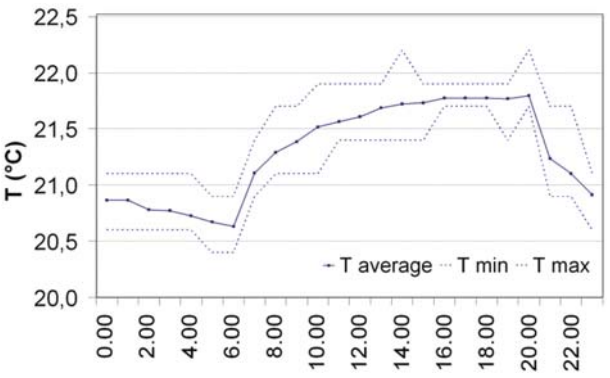

Figure 2: Temperature daily average of room F (during July 2007).

(Cladosporium, Penicillium) whereas the species growing on paintings appertained mainly to the genus *Aspergillus* (Figure 5).

In room F, during the period of investigation of 90 days, no significant variation of brilliance has been recorded although a layer of dust has been detected on the surface both of samples and artefacts (Table 1). For this reason the nature of deposited particulate matter has been investigated by ion chromatography. The presence of soluble salts in the dust has been determined; the results are expressed in μg/cm^2 as average calculated on the

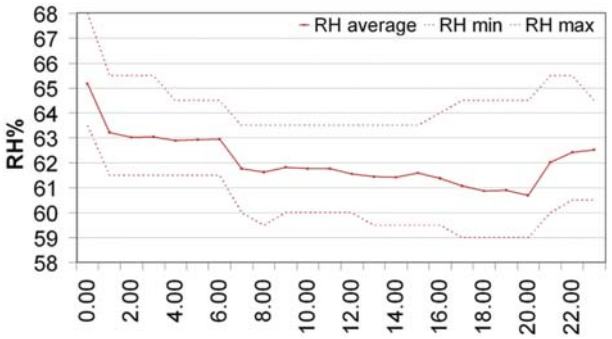

Figure 3: Relative humidity daily average of room F (during July 2007).

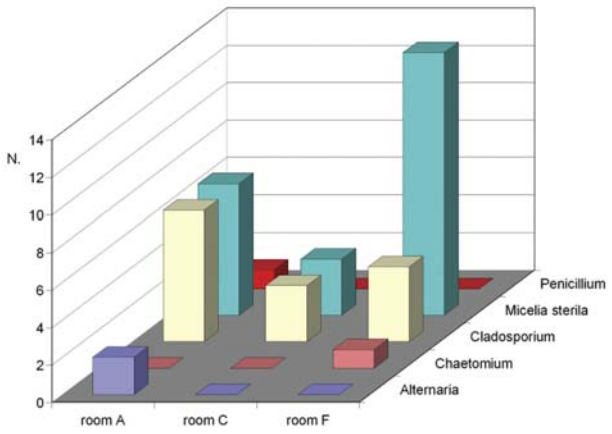

Figure 4: Average of microbial charge in the storage rooms.

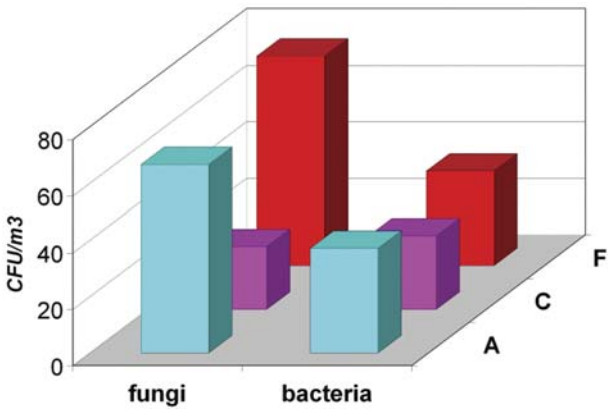

Figure 5: Number of different genera of airborne fungi in the storage rooms.

Room	*Sample*	*Y*$_{t0}$*	*Y*$_{t90\ days}$*	*ΔY**
F	Carrara Marble	21.0 ± 0.9	22.8 ± 0.7	1.8 ± 1.1

Table 1: Variation in brillance of the marble samplers.

Cl^-	NO_3^-	SO_4^{2-}	Na^+	NH_4^+	K^+	Ca^{2+}
3391	818	1479	2298	228	1038	48465

Table 2 : Average concentration of ions deposited to the sampler surface (μg/cm2).

fifteen samples exposed. The principal ions are calcium, potassium, sodium, sulphate and chloride (Tab. 2); the results are expressed as salts deposition per cm^2 of sample surface. Probably these ions are present as sulphate and chloride; this hypothesis could confirm the white colour of the dust and could be the cause of any brilliance variation. Their presence in the particulate matter could be related to the efflorescence constituted by calcium sulphate and potassium- and sodium-chloride found on the walls.

From the results some conclusions may be drawn. The microclimatic behavior of the storage area is rather stable during the whole analyzed period but the air conditioning system should be improved to provide better control of the relative humidity which constantly exceeds the accepted range for paintings conservation. In spite of the low airborne fungal concentration, these conditions favor microbial colonization on paintings, especially in room F, where the most critical conditions exist from the thermohygrometric point of view.

The presence of soluble salts in the deposited powder layer is likely to be associated with the covering plaster and with evaporation processes which can cause the diffusion of efflorescence-inducing compounds in the air.

4 Conclusions

The results of the environmental monitoring have first of all pointed out a critical environmental situation for some storage areas of the museum. The evaporation phenomena of the walls in contact with the embankment of the upper garden give rise to unsuitable indoor microclimatic conditions (RH > 65%). In particular the room F needs a structural intervention on the masonry to remove the wall's dampness and, moreover, a general revision of the insulation of the external walls should be done. Indeed this situation represents a constant threat, especially in rainy periods, when water infiltrations may occur with severe consequences on the RH values.

Successively further environmental investigations could be carried out to assess the efficiency of the interventions in relation with the actual HVAC system. In fact, during the investigated seasons, the values of T and RH%, did not completely match the suggested range for paintings conservation[8] so it is possible that with a better wall insulation the actual HVAC system will be able to maintain T and RH% inside the suitable range.

5 Acknowledgements

We would like to acknowledge Dr. Maria Vittoria Marini Clarelli - the Director of National Gallery of Modern Art in Rome - for her helpfulness and support in providing us all the information necessary for the research.

6 References

1. G. Accardo, C. Cacace, E. Giani, A. Giovagnoli, M.P. Nugari, *Museum collections: data sheets for improved management,* in: J. H. Townsend, K. Eremin, A. Adriaens, Eds., *Conservation Science 2002 Papers from the Conference held in Edinburgh, Scotland, 22-24 May 2002*, Archetype Publications, London, 2003, 39-43.

2. E. Giani, A. Giovagnoli, M.P. Nugari, E. Ruschioni, L. Gordini, *The use of an environmental data sheet: the case of Musei Civici of Pesaro (Italy),* in: R. Fort, M. Alvarez de Buergo, M. Gomez-Heras, C. Vazquez-Calvo, Eds., *Proceedings of the International Conference on Heritage, Weathering and Conservation. Madrid, Spain, 21-24 June 2006 ,* Vol. 1, Taylor & Francis, London, 2006, 463-467.

3. P. Mandrioli, G. Caneva, C. Sabbioni, Eds., *Cultural Heritage and Aerobiology, Methods and Measurement Techniques for Biodeterioration Monitoring*, Kluwer Academic Publisher, Dordrecht, 2003, 107-144.

4. G. Caneva, M.P. Nugari, O. Salvatori, Eds., *La Biologia Vegetale per i Beni Culturali. Biodeterioramento e Conservazione*, Nardini Editore, Florence, 2005.

5. G.L Barron, *The genera of Hyphomycetes from soil,* The Williams & Wilkins Company. Baltimore, 1968.

6. K. H. Domsch, W. Gams, T. Anderson, *Compendium of soil Fungi*, Academic Press, London, 1993.

7. M.B. Ellis, *Dematiaceous Hyphomycetes,* Commowelth Mycological Institute, Kew, 1971.

8. G. Thomson, *The Museum Environment*, Butterworths, London, 1986.