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An indoor air quality study at the Ambrosiana Art Gallery (Milan)

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1. Introduction

Indoor air quality in historical buildings and museums is receiving increasing concern nowadays among the scientific community. Many sources of pollutants, both gases and particles, are responsible for the accelerated decay of the works of art. Knowing the levels of indoor pollutants is of critical importance to apply conservation and preservation strategies of cultural heritage [1, 2].

Air quality at the Ambrosiana Art Gallery in Milan has been monitored (in the two periods October-November 2017 and March 2018) inside the room where the preparatory cardboard of the School of Athens (1509-1511), one of most important masterpieces by Raffaello Sanzio, is stored. The cardboard is currently undergoing restoration and will be exposed in a new showcase that will be realized according to the specific environmental and microclimatic conditions of the room. The objective of this study was to monitor the concentration and chemical composition of the aerosol particulate matter (PM) up to the nano fraction, which represents the most dangerous fraction for the works of art surfaces. The monitoring campaigns have been carried out in parallel in the Raffaello room (at present not accessible to visitors) and in a nearby room open to visitors. The set of instuments employed included: a TSP sampler (total suspended particles) (Tecora, Pollution Check, Bravo M2); a DustMonit (Contec) analyzer that measures the concentration of dust up to PM1 and provides 13 granulometric classes (up to 300 nm); a NanoScan Nanoparticle sizer 3910 (TSI) instrument that measures particles concentration up to 10 nm; two instruments for the determination of black carbon (BC) in continuous and in particular a SILIIS instrument (Sphere-Integrated Laser Induced Incandescence Spectroscopy) and a micro aethalometer (AE51 Magee Scientific).

Quartz fiber filters have been employed to collect TSP samples to be submitted to chemical analysis. The filters have been fully chemically characterized: main ionic constituents and the carbonaceous fraction (i.e organic carbon, OC and elemental carbon, EC) have been analyzed by IC (ion chromatography) and TOT (thermal optical transmittance) respectively. A particles morphological characterization has been carried out on PM collected on polycarbonate filters by means of SEM-EDX (scanning electron microscopy coupled with energy dispersive X-ray spectroscopy).

Outdoor PM concentrations, obtained for the two seasons (autumn 2017 and spring 2018) from ARPA monitoring stations placed in the city center, have been correlated with indoor data.

2. Results and Discussion

The results obtained have shown that outdoor environment can significantly affect indoor air quality. The presence of the numerous visitors contribute to increase TSP concentrations even if a linear correlation between visitors number and PM has not been observed: it is possible to hypothesize that there is a threshold for the visitors number, above which PM concentrations are independent from the number but instead the exchanges of air with the outdoor environment are important. TSP concentrations in the two monitored rooms are quite similar and are on average 40 μg / m³ and 16 μg / m³ during the day, respectively in autumn and in spring. It is worth noting that PM10 values, acquired by the Dust Monit instrument, are half of those registered outdoor confirming that in both seasons and regardless of the operation conditions of the air ventilation systems, the main PM source is the particles penetration from outdoor.

In fig. 1 PM10 values measured with the Dust Monit instrument during the autumn campaign have been compared with the current limits suggested by legislation for museums [3] (i.e. a maximum of 20 and 30 µg / m³): in both rooms there are days during which the limits are exceeded. On the contrary, during spring, thanks to the lower concentrations registered outdoor, the limit are not exceeded.

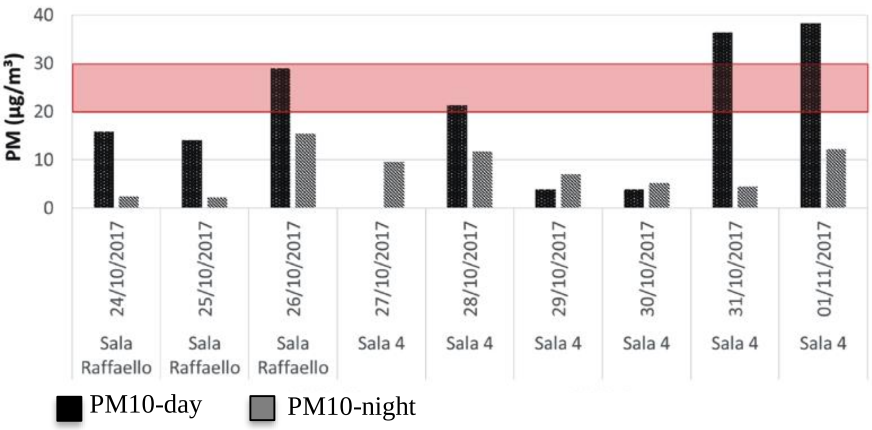

Fig. 1: comparison between PM10 measured in the two rooms and concentration limits suggested for museum environments (the limit range not to be exceeded is reported in red in the figure).

Furthermore Dust Monit instrument shows that that PM2.5/PM10 ratio is in most cases very close to 1 indicating a predominance of the fine fraction. Particles number distribution analysis has shown how the larger number of particles is the range 0.3-0.5 micron. This is of great concern since the very fine particles are easily adsorbed by surfaces.
It is worth noting that the contribution of EC to PM is not negligible. The values obtained from the chemical speciation by TOT analysis on quartz fiber filters, are in a fairly good agreement with black carbon measured by SILIIS instrument and the micro-aethalometer. Furthermore comparing BC values with particles distribution determined by Nano Scan, it is quite evident that BC is mainly present within the fraction with diameter lower than 200 nm, which represent a serious threat for the works of art stored in the gallery. A relatively high concentration of organic carbon (OC) has been also evidenced and this must raise some concern for paper supports.

3. Conclusions

In the present study, the problem of monitoring indoor air quality within the Ambrosia gallery (Milan) was addressed. Particles penetration from outdoor represents the main indoor source and indoor air quality is greatly affected by outdoor sources in both seasons. During autumn, the concentration limits suggested by the legislation for PM10 are sometimes exceeded.
The fact that finer particles (0.3-0.5 micron) are by far the most abundant must be of concern, since they are the ones most able to interact with the porosity of the surfaces of works of art.

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