

Assessment of gaseous and particulate air pollutants in various European museums and cathedrals

Velichka Kontozova¹, Felix Deutsch^{1,2}, Anna Worobiec¹, Zoya Spolnik¹, Ricardo Godoi¹
and René Van Grieken¹

¹ Department of Chemistry (MiTAC), University of Antwerp, Universiteitsplein 1, B-2610 Antwerpen, Belgium; velichka.kontozova@ua.ac.be

² Flemish Institute of Technological Research, Integral Environmental Studies, Boeretang 200, B-2400 Mol, Belgium; felix.deutsch@vito.be

Airborne pollutants exhibit a wide range of adverse effects on objects connected to our cultural heritage. Both gaseous and particulate air pollutants are responsible for deteriorating processes. Some of these pollutants encountered in indoor atmospheres have their main sources in the outdoor environment and enter the indoor environment mainly via air exchange. Other pollutants are in contrast mainly produced indoors. For an integrated assessment, concentrations of pollutants and their sources have to be investigated along with possible ways of deterioration of the objects of art.

Levels of pollutants were measured in four museums in Belgium and two churches in France, the Sainte Chapelle in Paris and the Basilica Saint-Urbain in Troyes. The main subject of interest in the museum studies was the influence of gases on works of art exposed in exhibition galleries and in showcases. The studies in the churches were connected to the influence of gaseous and particulate air pollutants on historic stained glass windows.

Passive diffusion tubes were used for sampling of NO₂, SO₂, O₃, acetic and formic acid. The small size of the tubes and their independence from electricity allowed sampling to be performed even inside the interspace between the protective glazing and the ancient stained glass panels and within museum showcases. The analyses were performed by means of ion chromatography and UV/VIS-spectrophotometry.

Bulk aerosol samples were collected on Nuclepore[®] filters (0.4 µm pore-size) and analysed by means of energy-dispersive X-ray fluorescence analysis (EDXRF). For the collection of size-segregated aerosol samples, a 9-stage Berner cascade impactor was applied. The used stages, with cut-off diameters of 0.25, 0.5, 1, 2, 4 and 8 µm, respectively, were analysed by an electron probe microanalyser equipped with an ultra-thin window Si(Li) detector.

The results show that NO₂, SO₂ and O₃ enter the churches and museums to different extents; their threatening effect is lower inside than outside. On the opposite, the adverse effects of acetic and formic acid are inside higher than outside, as these pollutants are emitted by the wooden construction material of many showcases and by the objects of art themselves, especially when the objects are placed in showcases.

Fine particulate matter is introduced into the churches with the outdoor air but is also produced indoors by deterioration of the building, burning candles and visitors. In the Sainte Chapelle, important additional sources for particles seem to be the works carried out in connection with the restoration of the stained glass windows. The results from the Basilica Saint-Urbain indicate outdoors higher concentrations of the analysed elements than indoors.

The obtained results show that the levels of indoor and outdoor air pollutants and the relation between them are dependent on the investigated church. Indoor/outdoor ratios of the air pollutants seem to be larger in the Sainte Chapelle than in the Basilica Saint-Urbain. This was observed both for gases and for particles. The reason for this can be seen in the different extent of air exchange and the different density of visitors at the two churches. The effect of the protective glazing with ventilation of the interspace with indoor air is certainly more advantageous if the indoor atmosphere is clean in comparison to the outdoor atmosphere.

The sampling of pollutant gases and particles with diffusion tubes, filter membranes, impactors with subsequent micro-analysis of the samples gives valuable results for the assessment of the threatening of the stained glass windows by air pollutants and of the efficiency of the protective glazing. Also for showcases, interesting results for the conservation of objects of art were achieved. The chosen approach to combine various sampling and analytical methods for different gases and components of the particulate matter seems to deliver a comprehensive picture about the air content in various kinds of air pollutants outside and inside the churches, and in the interspace between ancient stained glass window and protective glazing.