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## AIR QUALITY CHARACTERIZATION IN THE SANCTUARY OF THE BEATA VERGINE DEI MIRACOLI IN SARONNO, ITALY.

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### 1. Introduction

The sanctuary of the Beata Vergine dei Miracoli is a marian sanctuary located in the small town of Saronno, in the province of Varese, Italy. According to the inscription carved on the door that once represented the entrance to the sanctuary and that now connects the church to the cloister, the laying of the first stone took place on May 8<sup>th</sup> 1498. Construction was completed in 1525, when Bernardino Luini and Alberto da Lodi received the commission for the frescoes in the main chapel and the anti-presbytery. Finally, Andrea da Milano was commissioned to create two large wooden sculptures ("Cenacolo" and "Compianto sul Cristo morto") to be placed in the two main internal chapels [1]. Throughout the years these statues have been restored several times, the last one in 1995. In view of the artistic richness of the Sanctuary, environmental monitoring is essential for the preventive conservation of the works of art in order to limit the deterioration phenomena linked to poor air quality. Moreover, the lack of regulations regarding the concentration of air pollutants in indoor spaces such as sanctuaries further highlights the importance of the issue.

### 2. Results and Discussion

In order to achieve a complete characterization of the air quality, the presence of several air pollutants and the microclimatic conditions were monitored in different sites inside the Sanctuary (Figure 1). Data was also compared with outdoor values in order to evaluate potential sources and study accumulation phenomena. During the course of the different monitoring campaigns carried out throughout the year, temperature and relative humidity values were collected using data loggers (USB Mini TH, XS Instruments) and the results showed a large variability depending both on outdoor microclimatic conditions and indoor factors, such as the use of heating. Daily average values of the thermohygro-metric variables were often outside the suggested ranges for the conservation of cultural heritage in museums [2], indicating poor microclimatic conditions in the Sanctuary.

Particulate matter was sampled using an optical particle counter (P-Dust Monit, conTec Engineering Srl) and indoor concentrations were consistently higher than outdoor values, indicating the presence of specific indoor sources in addition to the penetration of particles from outdoors. Indeed, a significant correlation was observed between the number of people attending religious ceremonies and the concentration of particulate matter. Moreover, several gaseous pollutants were detected inside the Sanctuary (CO, NO, NO<sub>2</sub>, SO<sub>2</sub>, O<sub>3</sub>, and H<sub>2</sub>S) thanks to the use of an air quality monitoring unit (MQA, conTec Engineering Srl). In particular, the nitrogen dioxide levels exceeded the 4.7 µg/m<sup>3</sup> limit suggested by the Italian Ministry for the conservation of cultural heritage [2]. These concentrations were mainly due to the proximity of the Sanctuary to a very busy road which resulted in the penetration of outdoor polluted air. The hypothesis of the vehicular traffic source was further supported by the presence of other pollutants belonging to the BTEX family, such as benzene and toluene, which were collected using diffusive passive samplers (Radiello®, Fondazione Salvatore Maugeri-IRCCS). In fact, these compounds are considered to be tracers of vehicular exhaust [3].

Finally, preliminary studies aimed at the evaluation of the damage induced by poor air quality on the works of art were conducted on some of the wooden sculptures. On-site analysis using X-Ray Fluorescence (XRF) was performed in order to obtain the elemental composition of the pictorial coating. The atmospheric dust deposited on the surface of these statues was also characterized using Scanning Electron Microscopy coupled with Energy-Dispersive X-ray spectroscopy (SEM-EDX) and revealed the presence of several elements that make up the pictorial coat, such as calcium, sulphur and iron. These results highlight the poor conditions of the work of art and possibly suggest the need for further restoration processes.

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### 3. Conclusions

In this study a complete chemical characterization of the air quality inside the Sanctuary of the Beata Vergine dei Miracoli was carried out. The main air pollutants were monitored in different sites, along with temperature and relative humidity. The results obtained indicate poor indoor air quality, with many parameters falling outside the suggested ranges for the conservation of cultural heritage in museums. Also, the indoor concentration of pollutants often exceeded the outdoor values, indicating that both outdoor and indoor sources contribute to worsening air quality. Preliminary studies conducted on the recently restored wooden sculptures suggest the need for the application of mitigation strategies in order to better preserve the works of art.



Figure 1. a) Street view of the Sanctuary; b) P-Dust Monit and MQA; c) Diffusive passive samplers

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### References

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