Living Sensors based on Sansevieria Cylindrica for Microclimate Monitoring in the Santuario della Beata Vergine dei Miracoli

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Indoor air quality and microclimatic conditions contribute to the degradation of the works of art [1]. Limits for air quality parameters and physical quantities of interest for microclimate, in order to assure the longest conservation of the works in time, have been widely suggested for museums [2]. In particular, temperature, humidity, illuminance, particulate matter and gaseous pollutants concentrations arouse interest in the context of the monitoring. The study here presented aimed at monitoring ambient conditions through the adoption of innovative green and mimetic sensors based on plants, in the *Santuario della Beata Vergine dei Miracoli* [3]. This sanctuary was built between the 15th e 17th centuries, following a miraculous event, in Saronno, a small town of northern Italy. It hosts works of art from some of the most renowed and influential artists of the time. Bernardo Luini decorated the apse and presbytery of the church with some masterpieces such as the *Marriage of the Virgin*, while the dome was entirely frescoed by Gaudenzio Ferrari. The sculptor Andrea da Corbetta carved the marvelous *Deposition* and *Last Supper*. Following the nature of the place, it is not easy to keep ambient conditions under control and to perform measurements, considering the large number of people involved in the sanctuary. Keeping in mind the importance that the visual impact of the ambient has on the worshipers, classical measurement systems cannot be adopted for monitoring the area. The developed device regards a living sensor based on *Sansevieria cylindrica* plant for measurements of radiations, both visible and UVA, which could affect paintings inside the sanctuary, thus they represent important parameters to be considered for preventive conservation of cultural heritage. The working principle of the sensor is based on the metabolic processes of plants and the activity of soil micro-organisms [4-5]. This solution goes beyond "classical" approaches such as microelectronic devices and silicon devices, having several advantages: low cost, biodegradable, eco-friendly, nontoxic and capable to reduce the CO_2 during the working phase by using photosynthesis processes. It is worth noting that this family of devices is able to operate without the adoption of batteries, by using its self-generating transduction property, and it is also mimetic. Thanks to this latter characteristic, the device is capable to avoid any form of visual pollution and, for this reason, the proposed solution is suitable for indoor and outdoor applications of historical and artistic interest. It is worth noting that several sensors have been applied, since October 2022, in the *Santuario della Beata Vergine dei Miracoli* with the aim to monitor the level of radiation with the objective to ensure that its value does not cause damage to the work of art in accordance with the legislation.

References

[1] Chianese, E.; Riccio, A.; Duro, I.; Trifuoggi, M.; Capasso, S.; Barone, G. Measurements for Indoor Air Quality Assessment at the Capodimonte Museum in Naples (Italy). Int. J. Environ. Res 2012, 6, 509–518
[2] Ministero per i Beni e le Attività culturali. Decreto 10 Maggio 2001. Atto di Indirizzo sui Criteri Tecnico-Scientifici e Sugli Standard di Funzionamento e Sviluppo dei Musei (Art. 150, Comma 6, D.L. n. 112/1998); Ministero per i Beni e le Attività culturali: Rome, Italy, 2001
[3] Gatti P., M.L. Il Santuario Della Beata Vergine dei Miracoli di Saronno, 1° ed.; ISAL: Milan, Italy, 1996.
[4] Trigona, C. (2023). Living Sensors: The Greenest Paradigm in Instrumentation and Measurements. IEEE Instrumentation & Measurement Magazine, 26(1), 35-41.
[5] Trigona C., Napoli G., Pasquale S., Puglisi I., Baglieri A., Gueli A.M. (2021). A Plant-Based Sensor for UV-A Radiation Measurements, 2021 IEEE International Instrumentation and Measurement Technology Conference (I2MTC), May 17-20, 2021, Glasgow, Scotland.