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Heritage Research to Conservation Practice

Impact of Visitor Traffic on the Indoor Environment of the Church St. Georg at the UNESCO World Heritage site Monastic Island of Reichenau in Germany

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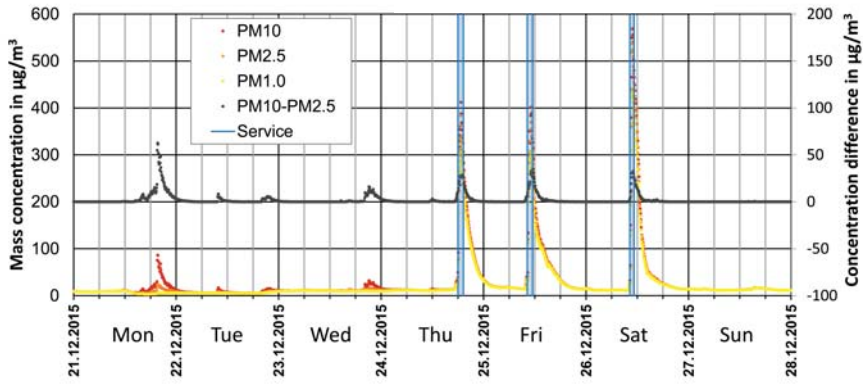
Introduction

St. Georg is one of the three Romanesque churches on the island of Reichenau at Lake Constance, Germany, built between the 9th and 11th century. UNESCO inscribed the monastic island of Reichenau in the World Heritage List in 2000. St. Georg has meticulously restored wall paintings which are exposed to a very humid indoor environment. In co-operation with the State Office for Monument Conservation Baden Württemberg, the Materials Testing Institute University Stuttgart (MPA) initiated a national research project partly funded by the German Federal Environmental Foundation (DBU). The project has started in 2015 with the aim of identifying anthropogenic risks and preventive mitigation measures to improve the environmental stress.

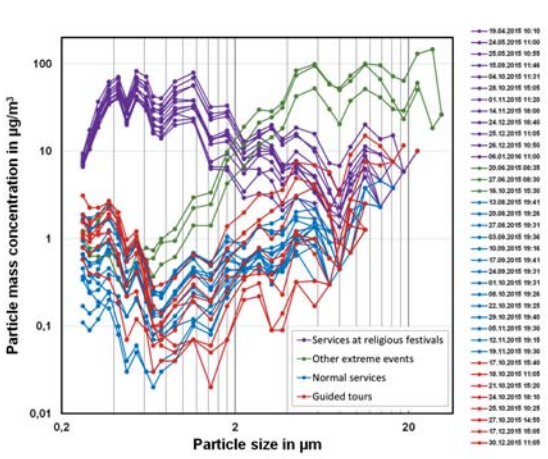
One aspect of research is the impact of visitor traffic on the indoor environment. Within the project a survey on particulates (time series of mass concentrations, composition of deposited particles) and VOCs (sources, concentrations) was performed in nave and crypt. Additionally dust samples were collected to assess type and potential impact. The nave is open to public visits, whereas the crypt is not. The surveys provide a possibility to discriminate between the effects of visitors, other anthropogenic influences, and inherent risks due to the material condition of the building.

Survey on particulates

Within three series mass concentrations of particulates were measured in the nave at the north window of the west apsis with a Grimm Optical Particle Counter (OPC 1.109). During summer period the only possibility to visit the church is at public or booked guided tours and services. The particle concentration is mostly below 20 µg/m³, but the PM10 concentration shows clearly a rise compared to PM2.5 and PM1.0 at times of visit (see difference PM10 - PM2.5). At extreme events (services at religious festivals, e.g. Pentecost, Christmas) the concentration rises up to 800 µg/m³. Though all particle classes show a rise, a difference between PM10 and PM2.5 is still visible. A comparison of the mass concentration and size distribution at maximum PM10 concentration is given. Extreme events (ecclesiastic and others) show different distributions than guided tours and normal services which can be separated clearly.

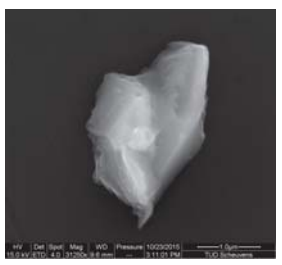


Particle mass concentration in the Christmas week.

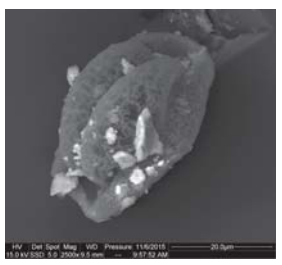


Particle mass concentration and size distribution at different events with high PM10 values.

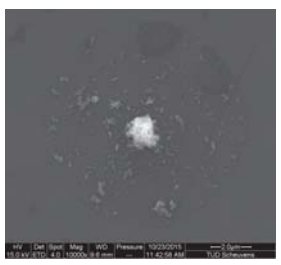
Passive sampling device with boron and carbon pads.



Aluminosilicate (mica)



Pollen or spore



Dried droplet with sulphate

Passive sampling of particulates

To assess different types of particles passive sampling devices were exposed within nave and crypt. Two vertical and two horizontal samplers (one carbon and one boron pad each) were exposed on a monthly period. The particle types range from biological (pollen or spores), to anthropogenic (soot, tire wear), and inorganic compounds (aluminosilicate, quartz, gypsum, calcite, carbonaceous, dried droplets with sulphate).

Dust samples

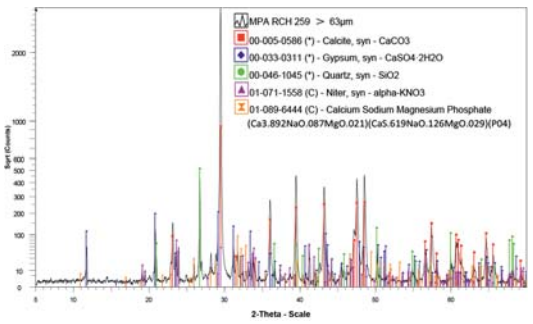
Between July 2015 and January 2016 dust samples were repeatedly taken from three window recesses in the crypt and two in the nave in the direction of the western apsis. The samples were divided up in two fractions with particles smaller resp. larger than 63 µm and analysed by ion chromatography. Though the size of the cleaned areas was comparable, the amount of ions in the crypt was about one order of magnitude higher than in the nave. In the crypt potassium and nitrate, as well as sodium and chloride were found. Compared to the crypt in the nave occurred higher amounts of ammonium and phosphates. A possible source of nitrates and phosphates is intense farming near to the church.

Volatile organic compounds (VOCs)

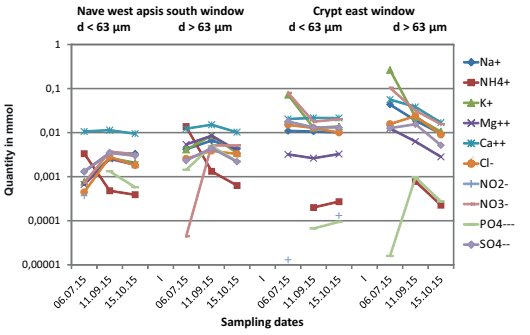
Microbial infestation is one of the problems arising in the nave and crypt of St. Georg. Therefore several air samples were drawn on TENAX tubes and analysed by GC/MS for Microbial Volatile Organic Compounds (MVOC). Some of the detected substances, especially dimethyl disulphide and 3methyl-1-butanol, are considered as indicators for the presence of microbial pollution. The highest concentration (0.63 µg/m³ dimethyl disulphide) was found at the crypt wall plaster where a spot with microbial infection was identified. A high furfural concentration (7 µg/m³) can be discussed as a degradation product of organic additives in the plaster by microorganisms.

Conclusion

The indoor environment of St. Georg is affected by visitors and services (particulates), anthropogenic influences (e.g. salts arising from intense farming activities, soot and traffic), and microbial infestation (MVOCs). In the second period of the project a deep analyses will be performed to assess the different impacts with respect to the precious wall paintings and historic substances.



Example of x-ray diffraction of dust samples.



Ion chromatography of a series of dust samples in nave and crypt.

Acknowledgement

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