THE PROGRAMME

Wednesday (10.10.2018)

14.00–16.00	Registration of participants
16.00–16.15	Greeting to the participants of the Symposium by the Rector of Cracow University of Economics
16.15–16.30	organizational information
16.30	catering

Thursday (11.10.2018)

9.10–9.15	Welcome and messages from committee
09.15–10.00	Plenary Speech – **Jean Tétreault** *Evolution of pollutant standards for museums and archives: from Thomson 1978 to ASHRAE 2019*
10.00–10.15	call for ideas, gaps, questions – **Jean Tétreault**
10.15–11.00	coffee break/poster session
11.00–13.00	Session 1 Chairman – **Jean Tétreault**
11.00–11.20	**David Thickett** *Effect of temperature on off-gassing and corrosion*
11.20–11.40	**Michael J. Samide** *The dose makes the poison: measuring harmful sulfurous VOCs emitted by rigid PVC used in museum construction*
11.40–12.00	**Imme Hüttmann** *Gaseous pollutant source determination: The University of Tsukuba Library Rare Books Collection*
11.35–11.55	**Michael J. Samide** *The dose makes the poison: measuring harmful sulfurous VOCs emitted by rigid PVC used in museum construction*
12.00–12.20	**Marianne Odlyha** *Evaluation of microclimate conditions within museum enclosures and assessment of damage to art objects*
12.20–12.40	**Olivier Schalm** *New generation of monitoring systems for heritage guardians: detection of a larger range of undesired situations and corresponding material behavior*
12.40–13.00	Presentation of SIFT – MS system
13.00–14.15	lunch break/poster session
14.15–16.00	Session 2 Chairman – **David Thickett**
14.15–14.30	Flesh poster presentations
14.30–14.50	**Diana Leyva Pernia** *Impact of the guidelines selection for indoor air quality assessments in cultural heritage preservation*
14.50–15.10	**Willemien Anaf** *An IAQ-index for cultural heritage applications*
15.10–15.30	**Jan Callier** *A work process to support decision making concerning mitigating actions*

15.30–15.50	**Vera Hubert** *10 years of indoor air quality management at the Collection Centre of the Swiss National Museum*
16.00–18.00	Visit the Clinic of Paper at the Jagiellonian Library, as well as The Laboratory of Analysis and Nondestructive Investigation of Heritage Objects at The National Museum in Cracow
19.30	Conference Diner in "Plac Nowy 1" restaurant. It has two entrances from Plac Nowy 1 street and from Estery street

Friday (12.10.2018)

09.30–10.15	Plenary Speech – **David Thickett** *MEMORI – bringing it all together*
10.15–11.00	coffee break/poster session
11.00–13.00	Session 3 Chairman – **Tomasz Sawoszczuk**
11.00–11.20	**Matija Strlic** *VOC in Museums: a case for "good" pollution*
11.20–11.40	**Manuela Reichert** *Impact of dust from various sources on the wall paintings of the church St. Georg at the UNESCO World Heritage site Monastic Island of Reichenau in Germany*
11.40–12.00	**Marcin Strojecki** *Particulate matter in historic churches – sources, deposition and soiling*
12.00–12.20	**Toshiya Matsui** *Air quality changes in a museum damaged by a tsunami*
12.20–12.40	**Signe Hjerrild Smedemark** *Trouble in store? Presentation of a Ph.D. project examining the dynamics of air pollution in repositories with cultural heritage collections and its consequences for air filtration*
12.40–13.00	**Andrea Marchetti** *Field testing of low-cost sensors for the monitoring of PM and gaseous pollutants for heritage applications*
13.00–14.15	lunch break/poster session
14.15–16.00	Session 4 Chairman – **Matija Strlic**
14.15–14.30	Flash poster presentation
14.30–14.50	**Andrea Cavicchioli** *Bacterial consortium as biodegradation agents in indoor traditional mortars: XIX century farmhouse in Brazil*
14.50–15.10	**Adam Pyzik** *Air microbiome analysis of Wawel Royal Castle in Krakow*
15.10–15.30	**Justyna Syguła-Cholewińska** *Integrated Pest Management (IPM) one of the preventive conservation tools at the National Museum in Krakow: schemes for assessing the risk of microbial contamination of objects*
15.30–15.50	**Magdalena Dyda** *Microbiological air pollution in correlation with microclimate parameters in the main museums and archival institutions in Warsaw*
16.00	**Jean Tétreault** Summary of the conference

COMMITTEES

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Dario Camuffo, National Research Council – Institute of Atmospheric Sciences and Climate, Padua, Italy
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Jadwiga Szostak-Kot, the head of Microbiology Department, FCS and PM

ABSTRACTS

Evolution of pollutant standards for museums and archives: from Thomson 1978 to ASHRAE 2019

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The conservation community has always been interested in updating environmental standards or guidelines, especially those related to the control of relative humidity, temperature and light. Less discussion however, has surrounded the issue of pollutants.

The process of determining the maximum level of pollutants has evolved in a few waves over 40 years. First, it started with observing the advantages of keeping books in non-polluted areas compared to polluted urban cities. The second wave was prompted by technology that made it possible to request lower limits of pollutants. The third wave demanded zero tolerance to an extended list of volatile compounds. The fourth wave was based on risk assessment or/and sustainability. The last wave is similar to the fourth but the message delivered was reconsidered for better access or acceptability. PAS 198 (2012) and the ASHRAE 2019 chapter on museums and archives, are based on the last wave where less focus is placed on pollutant concentration limits and the focus is now on proposing a set of strategies to achieve adequate control of pollutants. The five waves described above are mainly introduced chronologically. However the most drastic wave, zero tolerance, tends to occasionally show up in parallel with other waves.

The goal of this presentation is to review the different standard documents related to the museum and archive environment, focusing on the control of airborne pollutants and underlining the rationale presented for proposed limit levels. Recommendations on particle filter efficiency are excluded from this review.

ASHRAE: American Society of Heating, Refrigerating and Air-Conditioning Engineers
PAS: Publicly Available Specification (a document from the British Standards Institution)

Hazing on showcase glasses

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Material emissions of showcase construction materials and indoor air quality in museum showcases are belong to the key issues within preventive conservation. Since several years, streaks and opaque deposits are observed on the inner sides of showcase glasses. This phenomenon concerns mainly new showcases. Very rarely deposits could also be observed on the surfaces of the items on display. Just few studies have been performed until now which have focused on the composition and origin of these deposits. Skytte *et al*. (2017) assumes that waterborne soluble ions are adsorbed on the glass surface. At the last IAQ in museums and archives, which was held 2016 in Birmingham/UK, Gianaris and co-workers (2016) gave a review about observations made concerning hazing on glasses in different museums throughout the UK.

The speech will summarize and review the findings published and presented so far, complemented by own research results, which have been obtained from several scientific investigations of "fogging" phenomenons in new showcases. The speech will give first approaches about how this effect will be formed and how it will be influenced. The author will also try to clarify the kind of substance group which can be detected in most cases. It will also be discussed if material emission analysis of showcase construction materials has to be extended to a larger range of volatile organics with different physical properties.

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Effect of Temperature on off-gassing and corrosion

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Temperature can have a strong effect on off-gassing. The effect on wood products is well known and dramatically impacts on acetic and formic acid concentrations in showcases in naturally ventilated spaces. Cold storage is often thought to slow the critical off-gassing from autocatalytic materials such as certain synthetic plastics and paper. A series of measurements have been undertaken using active sampling for chloride, nitric and acetic acid in a freezer with deteriorating plastics. Diffusive sampling was undertaken for the ten species reported to accelerate paper deterioration in archival boxes in Historic England's archive at 7°C and at ambient temperature. The freezer measurements showed major reduction in nitric and acetic acid concentrations (compared to the freezer not running) and some, but less reduction of airborne chloride from PVC. The low temperature storage reduced, but did not eliminate acetic and formic acid, 1,4 diethylbenzene and Iso butyl benzol from paper storage. There is no objective way to assess these reductions, due to lack of knowledge on the exact concentrations that drive autocatalysis for these materials. However the results suggest that freezer storage is effective for cellulose nitrate and acetate plastics, but perhaps less so for PVCs. For paper the reduction in pollution is probably beneficial above the improved permanence for low temperature storage.

Temperature also increases the rate of many chemical reactions. This is one of the effects considered in damage functions, and consideration of the published functions gives an indication of the effect. Silver tarnish is expected to be amongst the most strongly affected of the common heritage metal corrosion processes. Investigations into anomalously rapid tarnishing under tungsten lamps on open display at Walmer castle indicated a two fold increase in tarnish rate (measured using an Aircorr logger) compared to other locations in the room. The air and surface temperatures of the silver were measured contemporaneously.

The results show that temperature is indeed an important parameter in a number of pollution situations. It needs to be carefully considered on display and can provide a highly valuable storage solution.

The Dose Makes the Poison: Measuring harmful sulfurous VOCs emitted by rigid PVC used in museum construction

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Determining the suitability of materials for use in a museum setting is an essential first step in the design and construction of gallery spaces. Many materials can emit volatile organic compounds or inorganic gases that can have a deleterious effect on artwork. Assessment of materials is most often accomplished using a metal corrosion test, commonly known as the Oddy test. In this procedure, a sample of the material to be studied is exposed to three metal coupons in a chamber that accelerates emission of volatiles and may promote accelerated degradation of the material. After 28 days, the coupons are examined and any material that causes significant corrosion on the coupons is deemed unsuitable for use in a museum environment. Instrument-based variants for material testing have been explored and include gas chromatographic techniques coupled to headspace sampling, solid-phase microextraction, thermal desorption, or evolved gas analysis. Using these methods, potential pollutants can be identified, and assessment of suitability can be made on the basis of functional group reactivity.

In this paper, we present an evolved gas analysis sampling method coupled to gas chromatography mass spectrometry for the analysis of rigid poly(vinyl chloride) (PVC) sheets. Rigid PVC is being adopted for museum casework primarily due to its low cost and machinability. However, these products are not 100% poly(vinyl chloride), but contain significant amounts of additives consisting of inorganic fillers as well as organic modifiers, solvents, and stabilizers. In addition, formulations can be different from one manufacturer to another and can vary based on the quality of product chosen for use. The main concern over the years has been potential off-gassing of HCl, but other compounds have been shown to migrate from the PVC material and cause tarnish on copper and silver. One such compound, 2-ethylhexyl thioglycolate, has been detected in the chromatogram obtained during the EGA-GC-MS analysis of most rigid PVC boards. This compound has been studied using a modified Oddy test and has been implicated in the tarnishing of silver and copper objects. Data from this research will be presented, which includes analysis of objects stored in cases constructed of rigid PVC.

Gaseous Pollutant Source Determination: The University of Tsukuba Library Rare Books Collection

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We investigated the source of gaseous pollutants found in the safe that holds the rare books collection of the University of Tsukuba. The collection has works that date back to the 8th Century.

A preliminary investigation with passive indicators indicated the presence of ammonia in the safe, while organic gas levels were under the detection range. Different results were obtained for a box stored in that safe. Indicators showed the presence of organic acids in the box, while ammonia levels were under the detection range.

Building on these findings, GC-MS and IC analyses were carried out for some of the stored materials, separately from their covers or boxes. Although a clear source for the pollutants was not determined, results indicated that the adsorption and release of pollutants by stored objects is a phenomenon that needs consideration when carrying out environmental studies. Based on the results, mitigation of the pollutants was carried out using activated carbon sheets.

Evaluation of Microclimate Conditions within Museum Enclosures and Assessment of Damage to art objects

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The challenge in the preservation of cultural heritage in indoor environments is to be able to monitor the corrosivity of the air and to evaluate resulting damage to the art objects. In English Heritage, in historic houses, such as Apsley House, London, the preservation of the historical Portuguese silver service has relied both on monitoring of indoor conditions and then on the use of a protective coating on the silver surface. The physico-chemical state of the coating was then evaluated with non-invasive infrared spectroscopy. In this paper we present applications of lead coated piezoelectric quartz crystals (L-PQC). These had been first used to provide information on the effect of corrosivity of organic acids on lead-based organ pipes [Bergsten et al, 2010] and then to monitor conditions in micro-climate frames [Grøntoft *et al*. 2010]. Lead-coated PQC crystals [L-PQC] (10MHz) were prepared as previously described by thermal evaporation of lead onto each side of the crystal [Odlyha *et al*. 2010]. They were then exposed with lead coupons in three commercial box frames specially modified to give different values of air exchange rate (AER). Exposure was also performed within frames of paintings. The PQC crystal legs were either clamped between stainless steel supports or placed into a purpose-built holder connected to a battery operated data acquisition system for continuous recording of measurements at pre-selected time intervals. Results of several exposures will be presented of locations on display, in storage, and in transport. Exposure in mc-frames of paintings revealed that gradients of volatile organic acids exist. Where L-PQC dosimeters registered values exceeding 20% change, this resulted in alterations in model varnish films studied in the MEMORI project (Dahlin, 2013). Current use of PQC dosimeters with modified coatings and upto-date electronics are being developed for remote sensing (Agbota *et al*., 2014) and to monitor volatile emissions from archaeological wood on display (Hunt *et al*., 2017). This dosimeter (using another coating) is currently being used for monitoring environments within daguerrotypes (English Heritage).

The further challenge is to optimize environmental conditions and reduce levels of pollutants to those which match recommended threshold levels for different pollutant gases, where known, and which correspond to levels at which no damage occurs. Understanding of these levels has been recently promoted within the MEMORI project [http://www.memori.fraunhofer.de/] and studies were undertaken for selected pigments, varnishes, paper, parchment and leather. Results will be reported for collagen-based materials (parchment and leather) that were subjected to different levels of organic acids (acetic, formic and mixtures of acetic and formic). Threshold levels of damage will be interpreted in terms of the traffic signal system used in the MEMORI project. In addition, the protocol developed for damage assessment will be used to evaluate effects

of novel conservation treatment. The aim was to adjust the pH where necessary using alkaline-based nanoparticles. This treatment was studied within the NANOFORART project [http://www.nanoforart.eu/] and included samples of model accelerated aged and historical samples of parchment and leather. Ageing of treated samples was also performed to test the efficacy of treatment.

Keywords: Microclimates, Piezoelectric quartz crystals, Dosimetry, Transit frames, Transport cases

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New generation of monitoring systems for heritage guardians: detection of a larger range of undesired situations and corresponding material behaviour

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Most monitoring campaigns in the heritage community are focused on the temporal visualization of temperature and relative humidity, and to a lower extent the intensity of visible light and the intensity of UV-A radiation. During the analysis of line graphs, features such as trends, peaks, drops or any other change play an important role. However, undesired situations with elevated risk might remain invisible when only these parameters are monitored. For example, housekeeping or moving actions in a museum environment may cause a sudden rise in particulate matter (PM). NO_2 and black carbon concentrations may significantly increase inside buildings due to traffic rush hours.

There is an enormous amount of low- and mid-price sensors available on the market. This means that in principle a much larger range of parameters can be measured. For that reason, we developed a multi-sensor tool (see Fig. 1) that combines off-the-shelf sensors for the previously mentioned parameters with sensors that are able to measure VOC, CO_2, NO_2, O_3, particulate matter, air speed, and human activity to a multi-purpose data logger [1, 2, 3]. The study demonstrates that many of these additional sensors are able to produce valuable information and can be used to identify additional undesired situations.

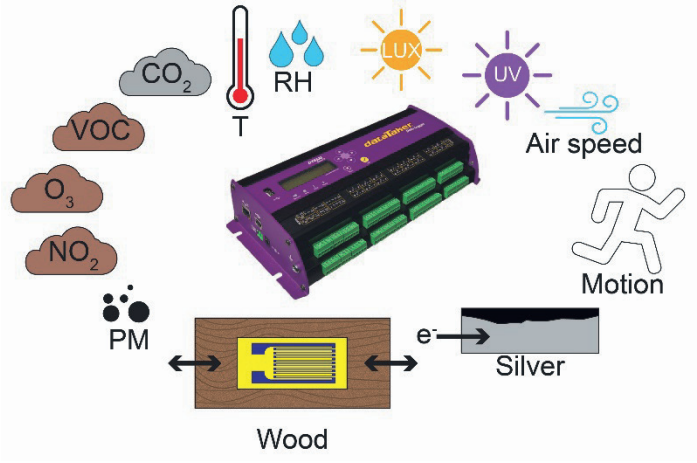

Fig. 1. Overview of the multi-sensor tool and the parameters it is able to monitor

The measurement of a larger number of environmental parameters give meaningful information about the environmental dangers to which the heritage collection is exposed to. However, we have a larger interest in the continuous behaviour/degradation of materials in a collection because it gives us more direct information about the preservation conditions. That approach has been explored with the monitoring of two totally different materials. Wood is hygroscopic and therefore, sensitive to changes in RH. An in-house developed wood sensor based on 16th century oak on which a strain gage has been

applied is used to monitor the shrinkage and expansion behaviour of wood. Silver, on the other hand, is mainly sensitive to pollution, and more specifically to sulphide reducing compounds. The corrosion rate has been monitored with an electrical resistance sensor. All sensors for material behaviour are connected to the same multipurpose data logger and measured simultaneously in combination with all environmental parameters.

The possibilities of the multi-sensor tool to identify undesirable situations are explored with a pilot study. By identifying undesirable situations, mitigation actions are suggested to avoid hazards to reoccur in future.

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Impact of the guidelines selection for indoor air quality assessments in cultural heritage preservation.

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The assessment of indoor air quality (IAQ) plays a crucial role in cultural heritage preservation. Achieving certain environmental conditions in a room can minimize the degradation rate of the objects contained inside, therefore the need for an accurate IAQ assessment to correctly identify whether or not favourable conditions for preservation are being reached. The typical approach for the assessment relays on the comparison of measured environmental data and corresponding acceptable values. Guidelines (or norms) are usually applied to settle these acceptable values. However, a significant number of different guidelines can be found in literature, and their recommendations tend to vary. As a direct consequence of these variations, the assessment of the same environmental data will depict different results depending on which recommendations are being followed. We present in this contribution a case study that reflects how considerable can be the impact of the guideline selection in the outcomes of the IAQ

assessment. To evaluate and compare this impact, we use an IAQ index that assigns a numerical value from 0 to 1 depending on how hazardous or safe the environment might be for heritage conservation. Our analysis is focused on five illustrative guidelines that direct their recommendations for temperature and relative humidity. We use datasets from two different measurements campaigns, one held in an exhibition room of a museum and the other held in a late gothic church, both in Belgium.

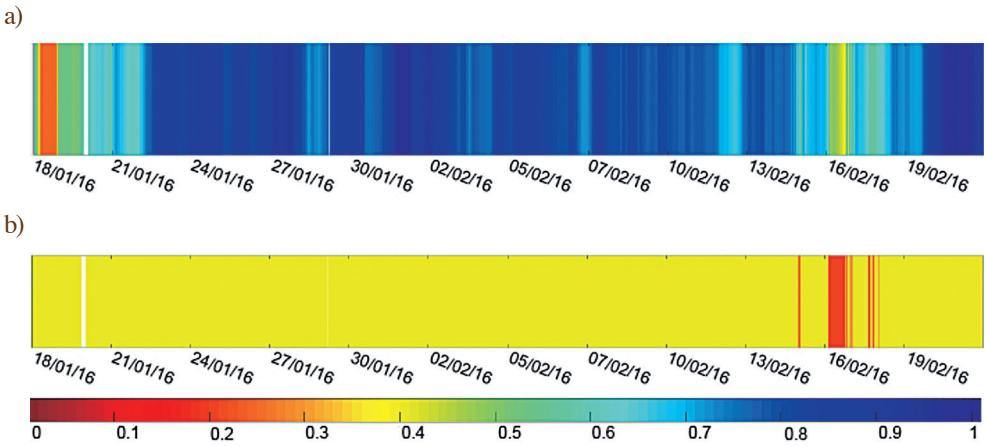

Figure 1. IAQ index determined for the same dataset with the Bizot Interim Guidelines for Hygroscopic Materials (a) and the ASHRAE guidelines for general collections (b) [1, 2]

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An IAQ-index for cultural heritage applications

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The importance of indoor air quality assessments for heritage preventive conservation is widely recognized [1]. However, the monitoring of relevant environmental parameters

such as relative humidity, temperature, light and pollutants generates large data sets, and heritage guardians are often lost in the analysis of the data [2]. To facilitate data interpretation and evaluation, we introduce an indoor air quality (IAQ) index. The proposed index is time-dependent and material specific. It is a relative number that indicates periods where heritage assets might be at risk of degradation.

The algorithm of the IAQ-index passes several steps (Fig. 1).

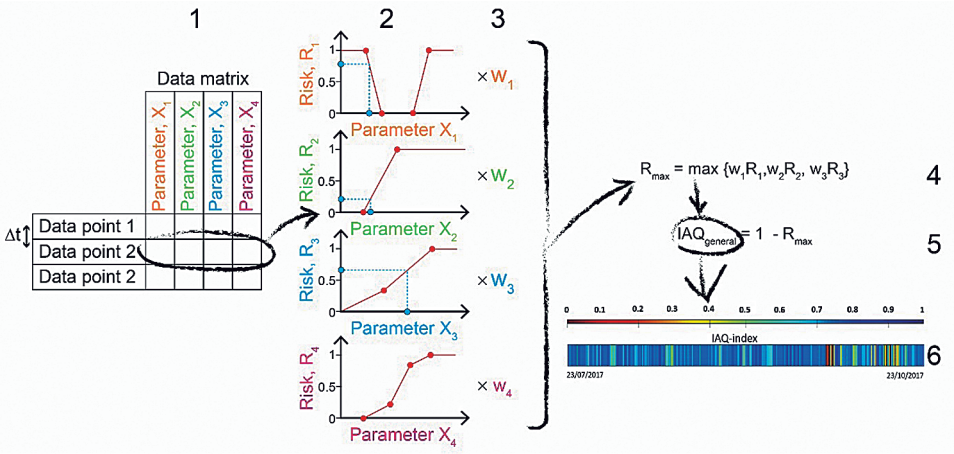

Fig. 1. Schematic visualisation of the steps considered by the IAQ-index algorithm

1. **Set up of a data matrix**. The algorithm gathers the data from simultaneous measurements of several environmental parameters at fixed time intervals, and conforms a data matrix.
2. **Conversion of measurements in level of risk**. Conversion functions are defined for each environmental parameter. They describe the level of risk when a certain material is exposed to a specific environmental parameter. Four different behaviours are identified. They are described by nodes that are determined from existing standards and guidelines. Based on the conversion functions, the estimated risk for each parameter is calculated at each data point. The level of risk is described by a number between 0 and 1.
3. **Association of a parameter weight.** Since not every environmental parameter has the same impact on the degradation rate of a certain material, a material specific weight is attributed to each parameter. The weighting factors are set based on extensive literature study, information from previous projects (e.g., [3]) and experience. They are described with five categories: negligible (0.05), low (0.25), moderate (0.5), high (0.75) and extremely high (1). For each parameter, the level of risk is multiplied with the weighting factor.
4. **Calculation of the overall risk.** The overall risk is determined by the parameter with the highest value for the multiplication *risk*weight*. The overall risk results in a value between 0 and the weight of the determining parameter.

5. **Calculation of the IAQ-index**. The IAQ-index is calculated by subtracting the overall risk from 1. This makes the IAQ-index a positive approach: the higher the index, the better the preservation conditions. The IAQ-index algorithm is repeated for each data point in time.
6. **Visualization.** The evolution of the IAQ-index over time is visualized using colour bars.

The IAQ-index algorithm could be considered a standard evaluator. Although several personal/human decisions (e.g., selection and interpretation of standards and guidelines, definition of weighting factors etc.) are introduced in the algorithm, the algorithm itself is a standardized procedure that leads to a reproducible and quantitative judgement of the IAQ.

The IAQ-index algorithm simplifies the analysis and interpretation of large data streams. It is a versatile tool that enables the introduction of relevant environmental parameters. Data visualization by using colour bars makes the output intuitive, and heritage guardians can easily use it as a decision support system to help them in selecting appropriate mitigation actions.

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A work process to support decision making concerning mitigating actions

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Heritage guardians have several concepts and work processes at their disposal to assess preservation conditions through visual inspection(s) and experience. These approaches consider the material, objects and the collection as the central (starting) point; e.g. 10 agents of deterioration (CCI, 2017), 6 layers of enclosure (ICCROM & CCI, 2016), ABC-method (Michalski, 2016), and QuiskScan (Brokerhof and Bulow, 2016) are

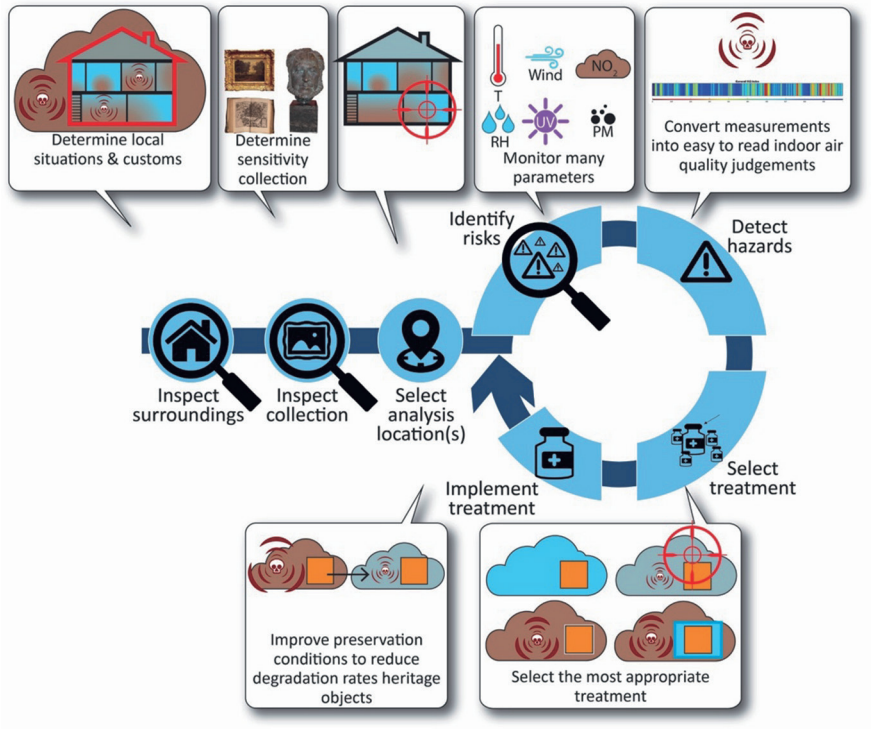

Fig. 1. Overview of the work process. It visualizes the 3 consecutive steps in the linear part and the 4 recurrent steps in the circular part. The work process contains 2 decision points: where to install the monitoring system in a building (i.e., last step in the linear part) and the decision which mitigation action will be applied (i.e., the step 'select treatment' in the circular part). At those decision points the work process provides support for the heritage guardian

perceived as user-friendly. An alternative approach is to measure the indoor climate conditions, and compare the values with guide lines and standards. The improvements in the preservation conditions suggested by these methods range from simple good practices to invasive interventions that require the refurbishment of the (entire) building.

An important bottle neck in this continuous process of improving preservation conditions is that heritage guardians do not act alone and that mitigating actions need the support of decision makers and the complete network of stakeholders in general. In this sometimes very technical advisory procedure, heritage guardians are often confronted with two problems:

- How do they convince decision makers to use the scarce resources to invest in 'invisible' mitigating actions that only have an effect in the long run?
- How can decision makers be convinced that proposed mitigating actions have a positive effect on the preservation conditions and that the investment is therefor useful?

We propose a work process (see Fig. 1) that supports heritage guardians in their work, and in their communication to stakeholders. It integrates the well accepted risk management

methods with monitoring campaigns. The linear part of the work process assists heritage guardians in finding weak spots in buildings and inappropriate environmental conditions that need to be improved. In the circular part, the continuous workflow provides easy to read visualizations of the indoor air quality by means of colour bars. In this contribution, the use of such colour bars as a convincing communication tool has been explored. In particular, the possibility to visualize the impact of mitigating actions on the preservation conditions has been studied. This work process directly links assessments to monitoring. This link is essential in argumentations for mitigating actions, and can enlighten difficult indoor air quality issues for all stakeholders.

10 years of indoor air quality management at the Collection Centre of the Swiss National Museum

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The National Museum Zurich, Château de Prangins, the Forum of Swiss History Schwyz and the Collection Centre are united under the umbrella of the Swiss National Museum. In 2007, the newly built Collection Centre of the Swiss National Museum was opened. With an inventory of more than 890,000 objects, it contains Switzerland's largest collection of items relating to Swiss cultural history and arts and crafts.

During the construction planning phase extra emphasis was laid on the indoor air quality facilities. Air conditioning is providing stable relative humidity and temperature; the air exchanging rate can be changed due to special requirements. Not only all storage materials were tested (and are still routinely checked), but also space was reserved for different kind of filters. For instance fine dust filters were installed from the first day on.

In order to identify possible air pollution either from inside (the collection itself) or outside sources: metal coupons, passive samplers and a Corrlog real time corrosion monitor prototype [1] were used in the past for precise indoor air quality assessments. After identifying pollutants from outside additional filters (impregnated activated charcoal) were installed.

In this paper the advantages of air pollutants monitoring measures are presented. They are obtained by using AirCorr data loggers that were developed in the MUSECORR project [2]. The following examples / cases studies will be discussed:

- Monitoring in a showcase of the permanent exhibition opened in 2009 at the National Museum in Zurich for proving measures taken in order to prevent silver objects from tarnishing;

- Monitoring of the air conditioning system of the Collection Centre to access the efficiency and capacity of now built-in impregnated active charcoal filters;
- Various cases studies, set-up in collaboration with the restorers to obtain insight on preventive conservation issues.

[1] https://cordis.europa.eu/project/rcn/75056_en.html

[2] https://cordis.europa.eu/project/rcn/91251_en.html

MEMORI – bringing it all together

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In order to effectively manage pollution in heritage institutions, a knowledge of which pollutants to target sparse measurement resources at, is key. Once measurement data is available, a knowledge of damaging levels is essential for remediation. Unfortunately both these sets of information are not readily available. Much work exists only in internal reports and grey literature. One aim of the MEMORI project was to collate, interpret and make accessible such information for the common acid and oxidative gases. Over 60–80% of reported damage instances have been attributed to acetic or formic acid, or ozone or nitrogen dioxide. The uncertainty in the figure is caused by infrequent reporting of the number of objects affected.

A forward literature search was made from all the references in Jean Teterault's excellent but now slightly dated book (2003). This was combined with the references supplied by the 13 project partners' databases. A systematic way of comparing 'damage' across materials was developed. For each main material a Red Amber Green (Grey) indication system was created to indicate relative risk at a given pollutant concentration. The colours indicate different required response times to an identified problem and consider the time scales generally required within heritage institutions to initiate change. The information for 30 common material types was incorporated into the developed decision support model, which is freely available on the web. Systematic research was undertaken into identified critical knowledge gaps, mainly the impact of organic acids on organic materials and pigments. This information was used to expand and improve the decision support tool. Useful material information such as aspect of deterioration, most appropriate analytical methods for the deterioration products and instances were materials occur but may not be obvious was included. Significant sections on measurement campaign planning and execution and mitigation were also developed. Measurements in showcases have several pitfalls due to changing diurnal and seasonal pollutant concentrations. Situations where

location within a showcase or frame may give different results were also investigated and advice provided.

The decision support tool has also found use as a teaching aid and has been used in 8 international workshops to over 250 students and professionals.

Field testing of low-cost sensors for the monitoring of PM and gaseous pollutants for heritage applications

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It is widely acknowledged that the conservation state of works of arts is strongly influenced by the quality of their conservation environment. The overall environmental quality is ideally evaluated by considering both physical (e.g. temperature, relative humidity, intensity of visible light) and chemical parameters (e.g. concentration of gaseous pollutants and airborne particulate matter – PM). Several low-cost and easy-to-use commercial systems are available on the market to monitor these parameters with high-time resolution. However, these sensors are very often originally designed for settings other than museums and historical buildings. Commercial systems for the monitoring of physical environmental parameters have already been extensively tested and used for a long time in heritage applications, while the development of low-cost sensors for pollutants only started recently, and technology is still changing fast. As a consequence, the accuracy and employability of commercial PM and gas sensors in measuring low levels of pollutants (as expected in conservation environments) is not to be taken for granted.

In this study, five low-cost systems were tested in the context of an 8-months long monitoring campaign in the St. Martin's church in Aalst, Belgium: two commercial sensors for the monitoring of PM levels (Shinyei PPD20V and Dylos DC1100 - PRO) and three sensors for the measurement of common indoor gaseous pollutants (Alphasense NO2 A43F, Alphasense O3 A431, Alphasense PID AH2). In order to test the accuracy of the sensors, the results were compared with more expensive, well-calibrated methods. The results of the PM sensors were set against the high-time resolution data collected with

a Lighthouse Handheld 3016-IAQ particle counter. This device is designed to respect the ISO 21501-4 directives in terms of accuracy and precision for the measurement of size and concentration of particles suspended in air. Particles in the range of 0.3 µm – 10 µm are resolved into 6 particle size channels, allowing a correct comparison with the two different particle sizes detected by Shinyei and Dylos. The concentrations of gaseous pollutants were analysed with Radiello ® passive samplers, providing average values for sampling periods of one week. The comparison with the high-time resolution sensors was therefore based on the weekly averages of the data collected. For gaseous pollutants, the sampling was performed over a period of six subsequent weeks.

During the measurement period, different renovation works took place inside the church, and a newly installed heating system was switched on. Therefore, the response of the different sensors on different climatic conditions and perturbation events was investigated.

The low-cost sensors for both gaseous and particulate pollutants showed promising results. The advantages and disadvantages of the tested systems will be thoroughly discussed. The study demonstrates that a critical approach towards the choice and use of commercial sensors for gaseous and particulate pollutants in cultural heritage applications is required.

Impact of dust from various sources on the wall paintings of the church St. Georg at the UNESCO World Heritage site Monastic Island of Reichenau in Germany

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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 funded by the German Federal Environmental Foundation (DBU).

The Project started in 2015 with the aim of identifying anthropogenic risks and preventive mitigation measures to improve the environmental stress. One aspect of research was 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 the nave and in the crypt. The nave is open to public visits, whereas the crypt is not. The surveys will provide a possibility to discriminate between the effects of visitors, other anthropogenic influences, and inherent risks due to the material condition of the building.

First results have been presented at IAQ 2016 in Birmingham. Now, after the end of the project in 2017 the final results will be summarized. These include also the impact of salt compounds in dust samples collected from time to time in the nave and crypt. Possible sources were identified and the harmfulness in relation to the indoor climate was analysed by salt mixture simulation using ECOS/RUNSALT.

Particulate matter in historic churches – sources, deposition and soiling

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Particulate matter (PM) suspended in the air penetrate from outdoor through the building envelope and deposit on internal surfaces and objects. This effect is especially important for historic religious buildings with a leaky structure resulting in high penetration and for particles from the accumulation size mode.

This presentation report on particle sources, transport and deposition in the interiors of several historical religious buildings differing in size and construction materials, location (urban or rural), confession and type of the heating. This set of chosen temples uses various heating systems like: continuous – maintaining the temperature at a selected constant level (both underfloor heating and local radiators heated with electricity or hot water), intermittent heating operating mainly for the time of liturgical services (electric overhead radiant heaters, electric heaters installed in the pews and centralized warm air heating).

Particle transfer mechanisms, sources and deposition of PM were analysed through long-term monitoring of several environmental parameters:

- particle number concentration (in two size modes: from 0.3 to 1 μm and > 1 μm),
- concentration of carbon dioxide to assess the tightness of building envelopes,
- air temperature and relative humidity to characterize indoor microclimate,
- air flow rate.

The analysis of obtained data allowed robust values of the key parameters like:

- air exchange rate between the external and internal space (*AER*),
- particle penetration factor through the building envelope (*P*),
- deposition loss rate (*k*),
- deposition velocity (V_d)

to be determined.

Relationships between PM of outdoor origin and from internal sources were identified. This led to several main conclusions:

- high outdoor PM concentration was the main factor affecting the soiling rate of internal surfaces,
- the primary indoor source of PM was emission from burning incense and candles,
- particle resuspension and emissions due to visitor debris and movement were negligible,
- the heating systems operating had generally little effect on PM deposition velocity,

the time period after which soiling of the architectural surfaces would become visible was estimated at between 7 and 30 years.

Air Quality Changes in a Museum Damaged by a Tsunami

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We investigated the air quality of the "Whale and Sea Museum" located in Yamada Town of Iwate Prefecture, after it was damaged by the tsunami that followed the 2011 Tōhoku earthquake of Japan. With ongoing restoration works, the museum reopened in July 2017. The results of tracking air quality changes in the facility are reported in this presentation.

The analyzed factors were acidity, acid and alkali components, organic matter, aldehydes, and floating bacteria. We also carried out an air quality survey of the temporary collection facilities that were newly built at the time of the restoration.

The results indicated that relatively clean air quality was kept in the museum hall due to the open convection of air generated with the outside. However, after the restoration works, the air quality worsened because of various actions related to the restoration, such as cleaning, the construction of new facilities, interior works, and others. Additionally, there was a remarkable change of VOC in the temporary storage facilities. The materials used for renovation, changes in temperature and humidity, and radiation tests are also reported on.

Trouble in Store? Presentation of a Ph.D.-project examining the – dynamics of air pollution in repositories with cultural heritage collections and its consequences for air filtration

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The reason to maintain acceptable environmental conditions inside repositories for long-term preservation of cultural heritage collections is well-founded. An environmental factor such as the level of carboxylic acids in air accelerate the deterioration of collections causing paper to lose is physical strength and become brittle, efflorescence on seashells leading to severe pitting and disruption of the surface, corrosion on metals [1–4] etc.

Air filtration in heating, ventilation and air-conditioning (HVAC) systems can efficiently remove a large portion of contaminants from air [5]. It is however, associated with high operational costs and energy consumption to ensure acceptable environmental conditions for the preservation of collections using air filtration and conditioning in HVAC systems. Additionally is it currently unclear whether carboxylic acids in air are removed by sorption onto internal surfaces before reaching the filters. This has implications for the efficiency and justification of air filtration in cultural heritage institutions and more importantly for the preservation of collections.

To enable a long-term investment in repositories that ensure a high degree of preservation and increase energy efficiency, it is essential to know the conservation protection, the effectiveness, and the energy consumption of the methods used to control environmental conditions. This Ph.D.-project (ongoing, by S. Smedemark) examines the air distribution inside repositories with passive climate control and conventional HVAC systems to assess the effectiveness and energy demand of air filtration. The aim is to develop a general model for the route and fate of internally generated contaminants, which will reveal the fractions of carboxylic acids removed by filtration and the fraction re-adsorbed back onto internal surfaces. The model will be based on field measurements in existing unoccupied repositories and include removal by air exchange, sorption onto internal surfaces and filtration in HVAC systems. Results will be validated against computational fluid dynamics simulations. The model can be used for new repositories, as well as for the upgrade of existing facilities, in the design and selection of an ideal air quality control strategy. It will further contribute to the ongoing discussion on the use of air filtration for carboxylic acid removal [6] also presented previously at the Indoor Air Quality in Museum and Archives Conference. The project is ongoing (2017–2020), preliminary results will be presented.

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VOCs IN MUSEUMS: a case for »good« pollution

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Work on volatile organic compounds (VOCs) emitted by historic objects has traditionally focused on potential damage to collections and visitors.

Recent research [1] shows that the presence of certain VOCs in a museum, in concentrations detectable by the human nose, does not pose a threat to collections and can provide valuable information on material change [2]. This work focuses on another, often unexplored, aspect of VOC presence in the museum and historic spaces: their value in heritage interpretation.

In a heritage space, certain smells are associated with the identity of the place, such as the ‘smell of knowledge’ in a historic library or the ‘smell of decay’ of a historic object. It could be argued that the presence of VOCs, and therefore the experience of the associated smells by visitors has the potential to a) add a sensory dimension to the interpretation of heritage; b) contribute to a better understanding of history via the information carried by the smell (e.g. the practices and materials associated with its source), presenting not just a physical object from the past but also an ‘atmosphere’, and c) increase visitors’ memories and engagement with the exhibits [3].

Following a newly proposed framework for the identification, analysis and documentation of smells with cultural significance [4], two sources of VOCs in heritage spaces were selected for investigation. Firstly, the smell of old books, well documented as a familiar and valued aroma, was chosen in the context of a historic library in London, and its sensory analysis correlated with the extensive research on VOCs of ageing paper [2,5]. Secondly, the smell of mould was identified as closely associated with the role of conservators [6] and the VOCs emitted by mould have also been studied in connection with heritage materials and sites [7].

For the study, VOCs were sampled using headspace solid phase microextraction (HS-SPME) and analysed with gas chromatography–mass spectrometry (GC-MS). Odour characterisation was achieved by presenting visitors with a sample of the aroma and collecting their descriptions through a written survey. Hedonic tone (pleasantness) of the scent was also tested with human evaluators in the context of a heritage space.

Keywords: heritage, olfaction, smell, historic, paper, VOCs, mould, decay, interpretation, pollutants

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Bacterial consortium as biodegradation agents in indoor traditional Mortars: XIX century farmhouses in Brazil

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It is well known that biodeterioration represents an important variable in the conservation of the tangible cultural heritage. This is particularly important in tropical climates, due to the conditions of temperature and humidity that favour the development of biodeterioration agents like fungi and bacteria, as well as other types of pests, e.g., wood-feeding insects.

This paper focuses on bacteria biodegradation in indoor environments, namely on bacteria biodiversity found in wall mortars of XIX-century country houses in the historical valley of São Paulo. This is the district that staged the first economic phase of coffee production in the state of São Paulo and whose built heritage encompasses some of the most representative examples of XIX-century earthen architecture (i.e. houses built with unfired clay) in Brazil. In these historical manor houses not only are the structural walls made of rammed earth, adobe or wattle and daub, but also the wall renderings comprise materials obtained from a mixture of sand, lime and clay or, sometimes, just sand and clay. Such traditionally-made mortars become a particularly suitable habitat for microorganisms which can trigger specific biodegradation mechanisms.

In this work, mortar samples were obtained from the indoor walls of five historical buildings, of which three are made of adobe, one of rammed earth and one of wattle and daub. Two of the mortars exhibited the presence of calcium carbonate in substantial amount, thus were made with lime, whereas the other three contained sand and clay only.

In order to obtain the bacterial consortia, two approaches were adopted. In a conventional culture-dependent method, the isolation of bacteria was carried out by washing the substrate with ultrapure sterile water. An aliquot of this solution was then sprinkled onto the culture plate and incubated at room temperature. In this process, two media were employed: a standard Luria Bertani (LB) agar medium and a LB medium incremented with 1% (w/w) of a finely ground powder obtained from the same mortar material,

previously autoclaved. After approximately 7 days of culturing at 30°C, single colonies were isolated and counted. In all cases, the number of colonies retrieved from the incremented LB medium was higher than in the conventional LB medium, suggesting that bacteria growth was dependent on nutrients present in the mortar mixture. A total of 400 single colonies were then isolated from the plates and grown for 24 h at 30°C in the same medium used for platting. This collection of bacteria was subsequently tested for metabolism of inorganic nutrients typically presents in the mortars and H^+ and $C_2O_4^{2-}$ anion production, resulting in the definition of a core group of bacteria that were identified by DNA genotyping.

Since culture-dependent processes are typically very selective and therefore poorly effective in the identification of the overall biodiversity of bacteria actually present in the substrate, a metagenomic procedure (culture-independent) has been also employed. In this case, DNA was directly extracted from the mortar samples and sequenced.

The two approaches exhibit complementary potentials for gaining a better understanding of the biological agents acting in mortar biodegradation and for developing mitigation strategies aiming at optimizing the conservation of indoor built heritage.

Air microbiome analysis of Wawel Royal Castle in Krakow

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Microorganisms are known to be able to colonize and modify various environments, including cultural heritage objects. Their metabolic activity often results in the degradation of material to which the microbes are adhered. This process is called biodetorioration and it seems that fungi and bacteria contribute the most to the destruction of valuable historical objects.

The aim of our study was to investigate air microbiome of Wawel Royal Castle in Krakow. The knowledge about microbiological pollution can provide valuable information relevant to deterioration processes and epidemiological risk. The analysis was made by air sampling onto various microbiological media. At the same time microclimatic parameters such as temperature, humidity, dust fractions and pollution by different substances were measured. After cultivation of microorganisms all colonies grown on agar plates specific to a given location was used for metagenomic DNA isolation. Microbial composition was determined by amplifying and sequencing hypervariable

regions of rDNA genes of bacteria (16S region V3V4) and fungi (ITS2). The bacterial and fungal diversity was correlated with abiotic factors in order to estimate the conditions threatening the preservation of cultural heritage.

Integrated Pest Management (IPM) – one of the preventive conservation tools at the National Museum in Krakow: schemes for assessing the risk of microbial contamination of objects

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The National Museum in Krakow (MNK) is the oldest museum in Poland with around 900,000 objects in its collection. Their protection is both a museum mission and a challenge. Preventive conservation provides many tools for the protection of collections. One of them is the Integrated Pest Management (IPM). The protection of museum collections against biological threats such as insects, rodents, birds, fungi, bacteria is a serious problem in cultural heritage institutions. As part of a comprehensive preventive program, the MNK implements long-term protection strategies elaborated together with experts, minimizing the risk of destroying objects, as well as limiting the use of biocides to necessary situations. The authors will focus on presenting the method and subsequent components/steps necessary to build and implement a correct strategy for the protection of museum collections, including schemes of hazard estimation of microbial contamination of objects at the NMK, which distinguish objects due to the chemical structure and their susceptibility to microbiological attack.

Microbiological air pollution in correlation with microclimate parameters in the main Museums and Archival Institutions in Warsaw

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Museums, archives and libraries are the most important institutions for preserving cultural heritage. The activity of microorganisms is one of the factors negatively affecting the state of historical objects. Despite the fact, that knowledge about biodetetiorative and pathogenic potential of bacteria and fungi is common, there is a lack of comprehensive analyses of contamination levels and diversity of microorganisms in the air in the prestigious Museums and Archival Institutions in Warsaw.

The main goal of this study was to determine the correlation between the concertation and diversity of microorganisms isolated from the air and microclimate parameters characteristic for a given museums and archival institutions in Warsaw.

Microbiological contamination of the air in the Museums and Archives was measured using impact method. Samples were taken once a month from February to April 2018 in at least 12 different locations (rooms) and outside of each examined institution on at least 10 various agar plates. Simultaneously measurements of the temperature, humidity and particulate matter concentration in the air were carried out. The total DNA was isolated and purified from all colonies of microorganisms grown on various agar plates. Subsequently amplification and sequencing of the V3-V4 region of the 16S rRNA gene

for *Bacteria* were performed for each sample. Illumina MiSeq technology was used for sequencing of each of the obtained amplicons. The identification of mould fungi was based on microscopic analyses. The statistical analyses considered the type of institution, the purpose of the room (warehouse, exhibition), type of ventilation, microbiological contamination levels, microbiological biodiversity and physicochemical parameters in each location.

This is one of the first studies so widely comparing the microbiological and physicochemical parameters of air in the main museums and archival institutions in Warsaw.

Mould in microclimates: simulating heating and dehumidification scenarios to inform preventive conservation strategies

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Mould is both a cause of deterioration of organic materials in historic houses and a health hazard for everyone in contact with contaminated materials. In historic buildings microclimates commonly occur in locations where environmental control by space heating is not always effective in controlling temperature (T) and relative humidity (RH) in order to prevent mould development.

This research is part of a wider project exploring alternative measures to prevent mould development in historic buildings in the United Kingdom. The aim is to understand which of the two following strategies results in a more homogeneous and RH-controlled environment: a heating source or dehumidifier in a typical room, such as a library in a historic house.

2D Computational Fluid Dynamics (CFD) transient simulations were conducted using Fluent exploring the evolution of the spatial profiles of the air temperature, relative humidity and velocity achieved throughout the room and in microclimates under constant heating and dehumidification.

The simulated environment is a room with features that are common to historical libraries in National Trust properties. In this space, both a radiator and a dehumidifier are mounted on the wall opposite a book press. There is a gap between the wall and the book press, which does not reach the ceiling. Of particular interest are the changes occurring

behind the book press as well as any increases in air movement, and how they depend on the dimensions of the system. Different dimensions are tested: gap between wall and press, width and height of the room, and size of the book press. Initial simulations have been carried out with initial environmental conditions typical of warmer and colder months in a property.

In order to maintain the simulations close to the environmental control of a National Trust property the heating or dehumidification is allowed to operate until the RH read on the humidistat control sensor falls below 58%. The heating runs until the maximum room temperature of 22°C is reached, above which the heating turns off. For these conditions the air quality (measured in terms of RH, T, and mean age of air) will be obtained. T and RH sensor is located in a central point of the room, in agreement with monitoring procedures of the National Trust.

Comparing the simulation results achieved with heating and dehumidification will inform on the energy needed to reduce the RH, and consequently reduce the risk of mould development, in microclimates and inform decision making in preventive conservation strategies. Data achieved will also be compared with experimental work developed in the laboratory where different air velocities are being tested in impacting mould development.

Future work will involve simulating environmental conditions monitored in historic properties that represent conditions throughout the year. Environmental conditions will also be used, including air velocities, monitored in historic properties to validate the results obtained with 2D CFD. Finally, different geometries will be simulated including air quality behind other types of furniture and paintings on walls, different sizes of rooms and location of heating source/dehumidifier.

Issues in conservation microenvironments in tropical climate

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Indoor microclimates within buildings of tropical and subtropical climates – and therefore conservation issues within such areas – exhibit specific features that generally attract less attention by conservation scientists who deal with this topic. In view of this, the aim of this paper is to present and critically discuss data collected in several indoor microenvironments of urban and rural contexts over the past few years in conservation institutions located in the state of São Paulo, Brazil.

This region of Brazil features subtropical climate (Cwa, Cwb, Cfa and Cfb), therefore, typical meteorological conditions with relatively higher annual average temperature and reduced temperature variations between summer and winter. Furthermore, the pluviometry is characterised by intense rainfalls in summer, thus with high relative humidity levels, versus dry winters. This overall climatic framework is, to a large extent, responsible for a number of architectural specificities and for typical indoor space management practices that, in turn, explain the dynamics of indoor microenvironments that were highlighted in this research.

The monitoring programs consisted in the continuous record of temperature and relative humidity in indoor spaces for periods covering, in the majority of cases, at least one full year, using battery-driven dataloggers (Onset Hobo, USA). Data on local climate from official meteorological stations were used for comparison. In addition to that, periodic series of monitoring of photochemical smog pollutants in indoor areas were also carried out and also cross-checked against outdoor levels. Likewise, atmospheric contamination by bioaerosols was assessed in at least two seasons of the year.

Results showed that in general there are similar issues to face in these microenvironments (e.g. the tendency to an overall increase in RH in summer and drastic fluctuations in winter, alongside with outdoor conditions). In the majority of the buildings, established forms of indoor space management, more often than not, are barely effective in tackling with the negative aspects of such microenvironments. Yet, there are a number of possibilities for taking advantage of existing architectural features in order to implement measures of passive environmental control that might bring significant improvements in terms of preventive conservation strategies.

Advanced techniques of cleaning of books and manuscripts

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Cleaning the surface of archive and library materials is one of the basic conservatory interventions which aims to improve appearance of documents and stop degradation processes. The main goal of the project, supported in 2018–22 by the Ministry of Culture of the Czech Republic, is to develop advanced techniques suitable for restoration of library and archival collections in particular by a) laser cleaning and b) pneumatic cleaning.

The basic requirement is to remove pollution without damage of cleaned material. Laser cleaning will be done by a pulse excimer ArF laser emitting radiation in wavelength 193 nm or a TEA CO_2 laser tunable in the range of 9.6 – 10.6 μm. In the first phase will be set a radiation threshold for the ablation of pollutants and also the radiation threshold for the degradation of materials. In the first phase radiation thresholds for the ablation of pollutants and for the degradation of materials will be set. Pneumatic cleaning uses a two-phase spray – carrier gas stream with the carbon dioxide particles. Both techniques will be used at different materials such as paper, lather, parchment, plastics and textile. The project includes tests of both laboratory-prepared samples as well as real library materials e.g. contaminated by the growth of micro-organisms of affected by natural disasters (floods, fires). The results of developed methods will be compared with the common cleaning procedures.

Selection of microbiological medium adapted for the isolation of the largest diversity of bacteria from the air in museums – application of metagenomic methods

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Microbiological activity is one of the causes of the destruction of the collection in Museums. Despite the fact that in biodeterioration processes both fungi and bacteria are involved, and both groups include species pathogenic to humans, in microbial analysis bacterial diversity is often ignored. Accordingly, there is a need to determine, which of the commonly used microbiological media enable isolation of the largest diversity of bacterial from air in museums.

The aim of the study was to select microbiological solid media, the use of which will allow for the isolation of the largest diversity and abundance of bacteria from the air in museums.

Microbiological contamination of air in the Museum of King John's III Palace at Wilanow in Warsaw (Poland) was measured using impaction method. Samples were taken once a months from November 2017 to January 2018 in 25 different locations (rooms) on 7 various agar plates dedicated to bacterial growth. Total DNA was isolated and purified from the grown colonies of microorganisms grouped together from a particular type of microbiological agar media. Amplification of the V3-V4 region of the 16S rRNA gene for *Bacteria* was performed for each sample. Illumina MiSeq technology was used for sequencing of each of the obtained amplicons.

This is one of the first studies using metagenomics as a tool to determine the diversity of bacteria isolated from the air of a museums.

Comparative analysis of microbial biodiversity in the Wawel Royal Castle – impact of the applied methodology on the identified potentially harmful microorganisms

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Identification of microorganisms in the cultural heritage buildings and historical objects are usually done by classical microbiology techniques which involves sample collection by swabs or air sampling onto agar plates. However, it is commonly known that we are unable to cultivate majority of the environmental microbes due to obstacles in ensuring appropriate growth conditions. Furthermore, microbial growth is the resultant of activities of multiple microbes and thus the knowledge of proper microbial community composition and its metabolic potential is essential to estimate the biodetorioration risk for cultural heritage objects.

In our study we performed microbiological analysis of Wawel Royal Castle in Krakow with the use of culture-dependent and culture-independent methods. Cultivation experiments were done for airborne microbes which were sampled (50 litres of air) onto various types of media. Simultaneously, two types of samples for culture-independent methods were also collected : I) 12 000 litres of air sampled onto saline and II) dust from historical surfaces. Analysis of different types of samples allows to determine and compare the reservoir of microorganisms in the air and those deposited on the surfaces of historically important objects. Microbial composition was determined by analysis of hypervariable regions of rDNA genes of bacteria (16S region V3V4) and fungi (ITS2).

Non-Destructive Scientific Analysis of Paper-Based Cultural Heritage

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An interdisciplinary approach, combining science and humanities, has become a vital component in the preservation and conservation of cultural heritage. Results of non-destructive analysis can assist cultural heritage professionals in assessing how indoor air quality, amongst other stimuli, impact historic objects and environments.

Scientific research involving imaging, microscopy, XRF spectrometry, and microfading testing has been conducted on a *Pinkas*, an eighteenth century hand-written Hebrew manuscript of judicial proceedings in the Jewish community, from the holding of the National Archives in Krakow. The non-destructive scientific techniques utilized were chosen in order to provide in-depth knowledge of the materiality – paper substrate, fiber identification, ink composition, microbiological presence, and material degradation – and environmental sensitivity – light stability, water solubility, and pollutants – of the *Pinkas*.

The preliminary findings indicate the *Pinkas* requires limited and delicate preventative conservation treatment, environmentally controlled storage conditions, and a minimal exhibition timeframe.

KRAKOW

Krakow is one of the biggest and most important academic and research centers in Poland. Its academic traditions go back to the 14th century when the Jagiellonian University was founded (in 1364 year). Currently, thanks to numerous higher education institutions, both public and private, every year the city of Krakow welcomes many new students. Besides institutions of higher education, there are nearly 100 research institutes in the city. The most ancient institution of scientific research is Polish Academy of Arts and Sciences, which continues the work of Krakow Learned Society founded in 1815.

Krakow is situated in southern Poland, in the close vicinity of the Beskidy and Tatra Mountains. The city, the former capital of Poland, has a history of more than one thousand years. The number of its inhabitants amounts to nearly 800,000.

During the last decade Krakow became one of the most appreciated tourist destinations in Europe. Many people settle down here for good, falling in love with the city and adding different ideas to the centuries-lasting tradition of Krakow. So, it is truly an international city.

Krakow is famous for its beautiful old architecture, boasting Europe's largest medieval market square. The city's unique atmosphere, however, is not only created by its amazing architecture but, in the first place, by numerous cultural events and great night life. Krakow hosts a great number of festivals throughout the year, including film, classical music and photography, as well as the internationally famous Festival of Jewish Culture or Jazz Festival. The city also boasts some of the most renowned galleries and museums in the country and one of the European greatest theatre districts. There are over a hundred pubs and bars in the vicinity of Krakow's Market Square alone, most in the cellars of historic buildings, hosting to exhibitions, jazz concerts or experimental drama.

Kraków has many green areas that provide opportunities for recreation and active rest, including the Botanical Garden of the Jagiellonian University and the Zoological Garden in the Wolski forest complex which is a traditional place of recreation for the inhabitants. The rich and constantly expanded recreational base (ice rink, swimming pools, including the Aqua Park, tennis courts, and systematically expanded network of cycling paths) and other venues encourage people to practice sports and spend their time actively in the open air.

In recent years, Krakow has become one of the most frequently visited places in Europe, so you can meet here interesting people from all over the world. No wonder Krakow received the title of the European City of Culture in 2000.

More information is available at **www.krakow.pl**

CRACOW UNIVERSITY OF ECONOMICS

- In 1882, thanks to the efforts of the Chamber of Commerce, industry and the Cracow congregation of merchants, the Municipal School of Trade was established
- In 1896 the Higher Trade School was set up
- In 1924 the Institute of Commodities was established at the Higher Trade School and a two-year commodity studies program was begun. This gave rise to the Higher College of Trade (HCT) in 1925
- On 1st October 1925 the co-founder and the first director of HCT conducted the inauguration of the first academic year. This moment is considered the birth of today's Cracow University of Economics
- On 1st September 1938 the act of 1937 came into effect, classifying HCT as an academic school and changing its name to the Trade Academy (AT)
- In March 1945 the Trade Academy was re-opened after the war
- In early September 1950 AT was transformed into the State Higher School of Economics
- In 1959, more rigorous standards were imposed on the institutions of higher learning, and the Higher School of Economics was transformed into a one-faculty school named the Faculty of Production and Commodity Turnover
- After 1972, study centers were established for students in different cities of south Poland.: Dębica, Gorlice, Kielce, Nowy Targ, Tarnów, Wadowice
- In 1974, Polish schools of economics were renamed academies of economics
- In August 2007, the Academy of Economics was given the official name of Cracow University of Economics