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Importance of Air Quality Monitoring in the Long Term Preservation of Art Masterpieces from Microbiological Degradation

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Abstract

When considering the damage that could possibly affect art masterpieces, the most common are pigmentation and physical damage. However, biodeterioration is another less well-known source of damage. Although human occupancy is a known source of airborne bacteria and molds in closed environments, such as hospitals and schools, the art masterpieces of museums are often not considered at risk in this respect. Many fungi and bacteria produce enzymes such as cellulases, proteases, ligninases, and organic acids that can decompose and cause serious damage to these historic treasures. Fungi are of particular concern because they show a substantial tolerance to environmental conditions. In addition, they require lower relative humidity (RH) than bacteria for their development and produce spores that are easily dispersed by air movement. Oil paintings and other art masterpieces can be gradually damaged by microorganisms brought by humans or contaminated heating, ventilation, air conditioning (HVAC). Excessive humidity in the storage or display space of the masterpiece may also encourage the potential for microbial contamination.

In this study, air samples (300 liters) from several locations of the museum were captured via automated air sampling devices (Orum International, Milan, Italy) that have petri dishes attached to the device. Besides different locations, air samples at different hours (initial hour of Museum operations, mid-day, and end of operation hours) were also assessed during 30 days. After sampling 300 liters of air, each agar plate is processed using the standard microbiology methods for bacterial and fungi identification.

Overall, there were large oscillations of CFUs among the data collected (ranging from 100 to 1300 CFU/m³) which expectedly correlated with higher visitor traffic peak hours and also days that HVAC were damaged or dirty. However, the majority of the data points showed organism counts ranging from 400 to 650 CFU/m³. Monitoring enclosed spaces of a museum or art gallery should be evaluated regularly to allow the awareness of the overall air quality and trend, set a baseline, thus enabling appropriate actions that may be correlated to the number of visitors, residents, air conditioning hygienic conditions, and cleaning activity. These methods for airborne microbial detection/monitoring are crucial for the long term preservation of art masterpieces.

Introduction

While museums provide a great educational experience for the public, many art masterpieces and other displays are sensitive to biodegradation that can be caused by bacteria and fungi. Bacteria and fungi are naturally present on people, their clothes, shoes, and in the air. An enclosed space with many visitors may increase the risk of art masterpieces becoming damaged due to increased mold and bacteria exposure. Having an effective HVAC that filters the air as well as monitoring microbial load in the air during peak visiting hours is critical to prevent biodegradation of art. Enclosed environments that receive high volumes of visitors even when the HVAC is well cleaned or disinfected regularly should be monitored for several reasons:

(a) To evaluate the disinfection efficacy of the cleaning activity or filter
(b) To identify whether or not actions need to be taken to reduce the number of people present during visiting hours of the art masterpieces
(c) To evaluate the flow of visitors coming and going from the room
(d) To teach the staff about the correct use of a disinfection system in order to reduce microbial load in the air
(e) To teach the staff about the correct interpretation of the results from air sampling methods

An air sampler with two aspirating heads (TRIO.BAS™ DUO) samples air actively by impaction; once an agar plate has been placed within each aspiration chamber, air is forced over the agar surface. Heavier particles in the air, such as bacteria and fungi, are unable to follow the air stream and collect on the agar surface. The agar plates can then be incubated at the appropriate temperatures for bacterial or mold recovery.

Methods

An active volumetric portable microbial air sampler with two sterilized aspirating heads (TRIO.BAS™ DUO), two 90mm Tryptic Soy Agar (TSA) culture plates for total bacteria count and two 90mm SabDex (Sabouraud Dextrose) Agar culture plates for fungi count were used for the sampling process. A tripod was used for positioning of the air sampler between the surface of the painting and the nearest visitor. Prior to use, the air sampler was disinfected and programmed to take up 300 liters of air. The air was sampled in the initial hour of opening, during the middle of museum opening, and at the end of the day.

After samples were collected, the culture plate was removed from the air sampler and transferred into the incubator (32 °C for Total Bacterial Count for 48 hours and 25 °C for Total Fungi Count for 5 days). After incubating, colonies were counted. The test was repeated for 2 months to prepare a graph for trend evaluation in order to determine the colony count over time. This may indicate whether or not CFU counts fluctuate throughout the tourist season or during particular events.

Results

Table 1. Summary of Data to Collect for Air Sampling Method

Day	Sample ID #	Temperature (°C)	Hour	Location	Air Volume	Medium	CFU/Plate	CFU/m3
1	1	22	11am	Location 33	300 L	TSA	125	410
2	2	22					198	660
3	3	23					280	935
4	4	22					180	600
5	5	22					205	683
6	6	21					301	1000
7	7	22					208	693
8	8	23					192	640
9	9	23					234	780
10	10	23					196	653
						Average	194	646

Table 2. Total CFU Counts for First Month of Air Sampling

Day	CFU/Plate	Day	CFU/Plate	Day	CFU/Plate
1	125	11	193	21	185
2	198	12	251	22	208
3	280	13	230	23	167
4	180	14	109	24	154
5	205	15	198	25	189
6	301	16	170	26	205
7	208	17	185	27	164
8	192	18	150	28	210
9	234	19	208	29	254
10	196	20	245	30	196

Table 3. Results from the Second Month of Air Sampling

Day	CFU/Plate	CFU/m³
A	208	693
B	195	650
C	286	953
D	108	360
E	105	350
F	410	1366
G	350	1166
H	202	673
I	302	100
L	189	630
M	170	566

Figure 1. CFU/m³ Results for First Month Testing

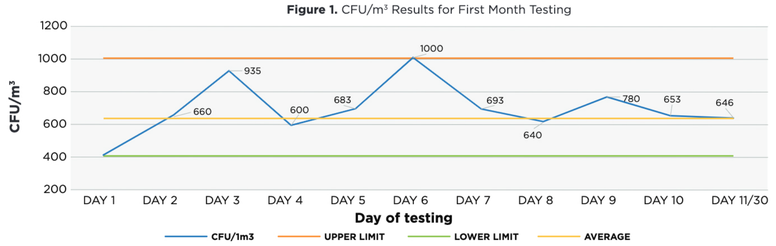
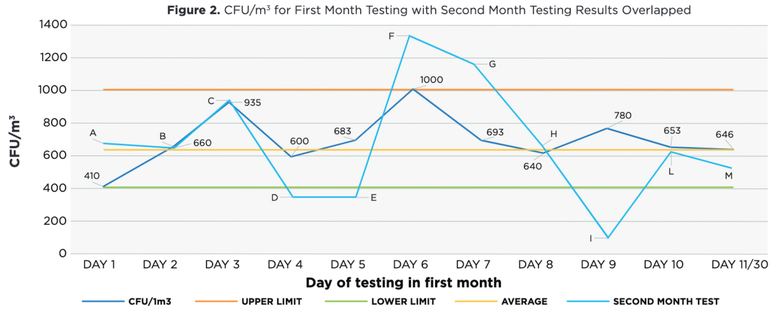
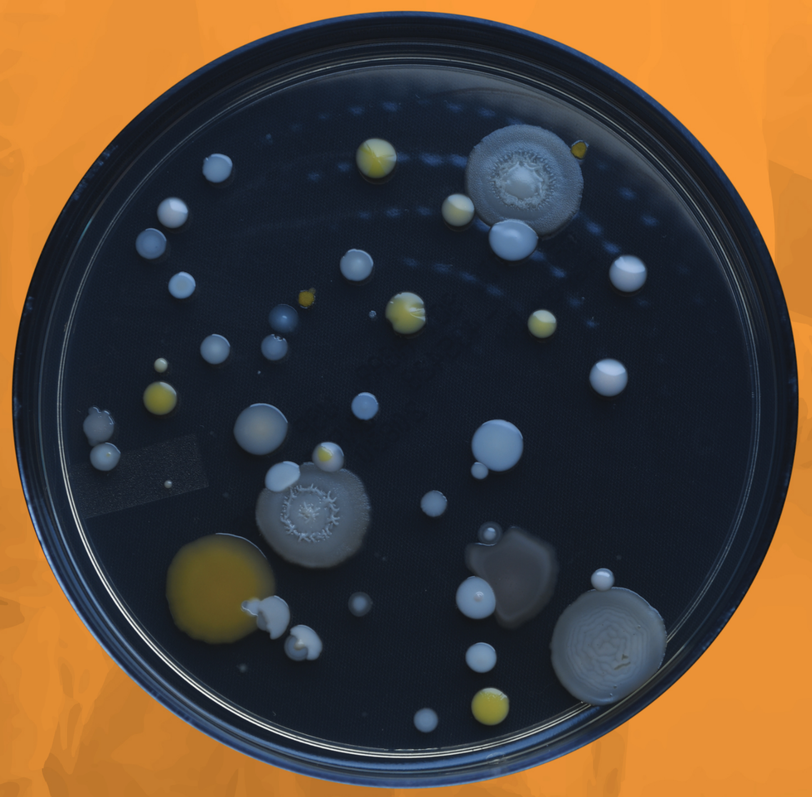


Figure 2. CFU/m³ for First Month Testing with Second Month Testing Results Overlapped



The overlay of the second month's test results in Figure 2 indicates that days F and G were above the upper limit from the first month of air sampling. Actions should be taken to reduce the microbial load in the air as these results are above the upper limit obtained in the first month of testing and may increase the risk of damage to the art masterpieces. **Figure 1** shows the results from the first month of testing and the values in regard to the upper limit, lower limit, and average CFU/m³. **Figure 2** shows an overlay of the first month and second month of air sampling in order to identify any trends from month to month.



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Conclusions

- Days "F" and "G" (**Figure 2**) indicate an abnormal microbial load which could cause museum preservationists to take action to verify the number of visitors that day or if the HVAC is damaged or dirty.
- TRIO.BAS™ air samplers deliver an active method to analyze the microbial load in the air via impaction and have 1 to 3 sampling heads to best suit the needs of the environment that requires air sampling.
- Regular monitoring of the air in closed environments to evaluate the microbial trend from one month to the next is an effective preventive strategy to avoid the biodegradation of art masterpieces over time.
- Routine environmental monitoring would allow museums or other environmentally sensitive areas to set an expected baseline for the microbial load in the air and aid in identifying issues when culture results are outside of the baseline trend.

Bibliography

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