Pollutants & Collections

Introduction

If you are familiar with the 10 Agents of Deterioration, you know that pollutants can cause damage to collections. In this context, pollutants are the chemicals that deteriorate or accelerate deterioration of collection objects. Pollutants can be generated outside and migrate into collections spaces (nitrogen oxide compounds from vehicle exhaust), but they can also be generated inside collections spaces (aldehydes generated by wood furniture). In some cases, collections, themselves can be the source of a pollutant that damages objects around them (nitric acid produced by cellulose nitrate based film). Damage caused by pollutants can include physical soiling in addition to chemical changes like the tarnishing of metals, the fading of dyes, the weakening of cellulose, or the formation of crystalline compounds or droplets on the surface of objects.

Collection pollutants may differ from pollutants in a human health and safety context. For some collections, sodium chloride, oxygen, and water are pollutants. Common collection pollutants, their sources, and affected materials are summarized in Table 1.

Table 1: Summary of common collection pollutants adapted from Tétreault 2021

Pollutant	Collections Affected	Common Indoor Sources
Ammonia	Metals, cellulose nitrate, ebonite	Concrete; certain sealants, adhesives, and paints; some cleaning products; humans
Acetic acid	Metals, paper, shell specimens, stone, soda-rich glass, paper-based objects	Cellulose acetate; certain sealants, adhesives, and paints; linoleum; some cleaning products; humans
Formaldehyde	Metals, some artists' colorants, stone, ceramic, shell specimens, glass, paper-based objects	Composite wood products like fiberboard; solid wood; wet specimens
Nitrogen oxide compounds	Metals, paper-based objects, leather, some artists' colorants, photographs	Cellulose nitrate; gas heaters
Sulfur dioxide	Metals, paper, leather, some artists' colorants	Degradation of sulfur-containing materials: proteinaceous fibers, sulfide minerals, vulcanized rubber
Ozone	Some artists' colorants, paper-based objects, rubber, dyes, digital prints	Photocopiers; laser printers; ultraviolet light sources; electronic air cleaners; electrostatic filtered systems
Hydrogen sulfide	Metals, photographs, lead pigments	Sulfide minerals; visitors; fuel and coal combustion; plastic degradation; vulcanized rubber

Particulates	All, especially magnetic media, metals, natural varnishes	Concrete; laser printers; construction; humans; cooking and food; burning candles; coal combustion; aerosol humidifiers

The risk of pollutant damage increases in microenvironments (like sealed cases) because pollutants cannot escape, elevating their concentrations. This can be damaging to human health and safety in the case of pollutant-producing collections. For example, ventilated storage is recommended for collections made of malignant plastics such as cellulose nitrate.

Monitoring

There is currently no pollutant equivalent to a temperature/relative humidity datalogger that can be read in house within the budgets of many collecting institutions. A relative humidity monitor actually *is* a pollutant monitoring device, but it only monitors for a single pollutant: water vapor. Because there are so many different pollutants and there are so many different components of air, it is, at this stage, impossible to have one monitoring device that can accurately measure all the pollutants collections stewards are worried about. Institutions must "pick their battles." Are you most concerned about a specific collection? Are you worried about the potential that a new material has for off-gassing? Do you have the resources to pursue implementing a monitoring system that is expensive and extensive?

There are a wide range of pollutant monitoring techniques that vary in their accessibility, specificity, and ability to produce quantitative results. Some examples are presented in Table 2.

Table 2: Sample of pollutant monitoring techniques

Type of Technique	Purpose	Example	Notes
Material-Specific	Screen for pollutants that are damaging to a specific collection material.	Placing metal coupons among collections to indicate if the environment is corrosive.	Does not identify or quantify pollutants.
Pollutant-Specific	Measure concentrations of specific pollutants or families of pollutants.	Placing ozone badges among collections to measure ozone exposure.	Careful attention must be paid to interferences and detection limits.
Holistic	Identify and quantify multiple pollutants.	Running air samples through gas chromatograph to separate and measure components.	Not all pollutants detected. For example, detecting hydrogen sulfide using GC requires specialized set-up.

Techniques of varying costs and detection limits are outlined in the 2006 book by Cecily Grzywacz, *Monitoring for Gaseous Pollutants in Museum Environments*, and Jean Tétreault's 2021 technical leaflet, "Control of Pollutants in Museums and Archives – Technical Bulletin 37".

While it is preferable that pollutants be intercepted before damage occurs, monitoring sensitive collections can also be informative. Deterioration of these sensitive materials can be an indicator that a specific pollutant is present. Table 3 lists examples of sensitive materials and the pollutants that commonly affect them.

Table 3: Examples of hypersensitive materials and corresponding pollutants. Adapted from Tétreault 2003, 2021

Material	Condition	Pollutants Indicated
Cellulose acetate	Vinegar smell, embrittlement, film shrinkage	Acetic acid (self-produced), water vapor
Cellulose nitrate	Yellowing, sticky residue, image fading	Nitrogen oxides (self-produced), water vapor
Lead	Corrosion	Acetic acid
Natural rubber	Embrittlement, cracking; spongey, sticky	Ozone, oxygen
Fine silver	Tarnish	Hydrogen sulfide
Polyurethane magnetic tape	Sticky shed syndrome	Water vapor, particles

Particulates can be monitored directly because they are visible. Simple dust collectors made with tape and label stock or paper can provide a baseline for dust accumulation that informs housekeeping policies and allows later comparison following mitigation activities.

Mitigation

Mitigation depends on the pollutant and the form it takes, but a general rule of thumb for pollutant mitigation is to avoid, block, dilute, filter, or sorb pollutants in that order. Figure 1 shows examples of mitigation strategies that fall within those five categories.

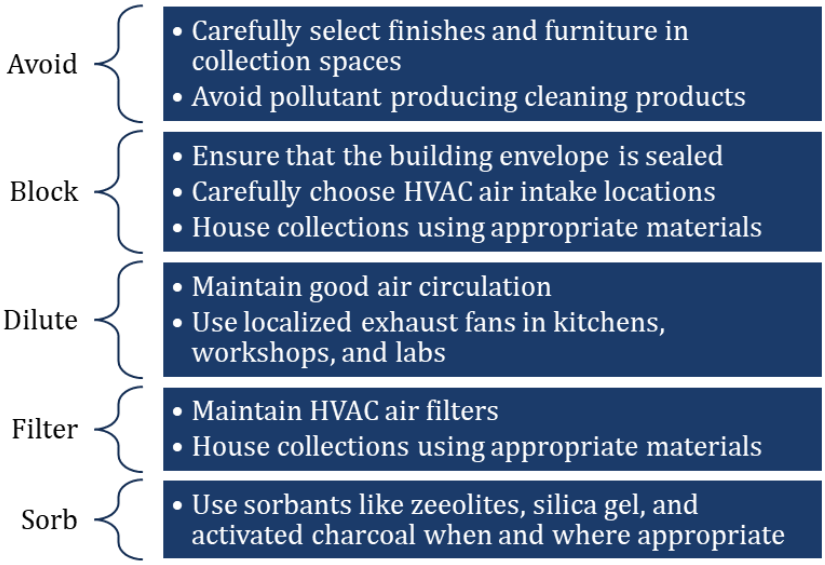

Figure 1: Examples of pollutant mitigation strategies

Some collection materials also adsorb and desorb pollutants. This increases the importance of keeping temperature and relative humidity stable to minimize spikes in pollutant levels.

If you have further questions or concerns about potential monitoring and mitigation options for pollutants in your institution, consult a professional conservator. The "Find a Professional" database of the American Institute for Conservation can help you identify a professional who has expertise with the type of collections under review. https://community.culturalheritage.org/expertsearch

Additional Resources

Brimblecombe, Peter. "Air Quality, Monitoring, and Management," in Elkin, Lisa and Christopher Norris, eds. Preventive Conservation: Collection Storage. New York: Society for the Preservation of Natural History Collections, 2019.

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Hatchfield, Pamela. Pollutants in the Museum Environment. London: Archetype Publications, 2002.

Hatchfield, Pamela. "Pollutants in the Museum Environement: Practical Strategies for Problem Solving in Design, Exhibition, and Storage." WAAC Newsletter, vol. 26, no. 2, May 2004, pp. 10–22. https://cool.culturalheritage.org/waac/wn/wn26/wn26-2/wn26-204.pdf

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Weintraub, Steven. "Specialized Macroclimates and Microclimates: Options for the Control of Temperature, Relative Humidity, and Pollutants," in Elkin, Lisa and Christopher Norris, eds. Preventive Conservation: Collection Storage. New York: Society for the Preservation of Natural History Collections, 2019.

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