Maine Indoor Air Quality Council

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Mold and Indoor Air Quality
A Guide for Building Owners and Indoor Environment Professionals

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Introduction

This guide is intended to serve as a basic reference for anyone concerned with the effects of mold growth on indoor air quality (IAQ) and the possible effects of airborne mold spores on human health. A basic grasp of the fundamental biology of fungi and mold is important for anyone considering mold testing, and a review of basic facts and concepts is provided. Air sampling for mold and other airborne particulates is sometimes necessary. This guide helps clarify the questions to be asked in determining whether to sample or not. It also provides recommendations and guidelines for conducting indoor air sampling. Data interpretation is often a poorly understood aspect of an indoor air quality test and guidelines for evaluating spore trap data are provided here, along with several representative case studies.

Bioaerosols: Mold and Other Airborne Particles

The spores of molds and other fungi are one of several kinds of **bioaerosols**. Bioaerosols are small, airborne particles of biological origin. They are normal components of both indoor and outdoor air. Because they may be biologically active some kinds of bioaerosols may affect human health. They may

be carriers of infectious disease or triggers for asthma and allergic reactions. The major varieties of bioaerosols and their properties are described below:

- *Pollen*: Pollen grains are released into the air by plants to fertilize the structures that will become the seeds. Pollen is particularly prevalent in the spring both indoors and outdoors. Pollen is a common cause of allergies.
- *Plant Debris*: Fragments of live or decaying plants are commonly found in outdoor air and indoors where houseplants are present. There are no known health effects.
- *Insect, Spider and Mite Fragments*: These are commonly present in low concentrations both indoors and out. They may occur at higher concentrations indoors in damp areas such as basements or crawlspaces. They may cause respiratory problems in sensitive individuals. Dust mites in particular are known to cause allergic reactions. House dust mites may be present in high numbers in bedding and pillow fabrics.
- *Human and Animal Skin Cells & Fragments*: The average person sheds a large number of skin cells every day. Such cells and fragments commonly occur in high concentrations in the indoor air. There are no known health effects resulting from inhalation of human skin, although some people are allergic to animal dander.
- *Spores of Molds and Other Fungi*: All fungi propagate by means of spores. They correspond to the pollen of green plants, but fungal spores are much smaller. This means they can remain suspended in the air for longer and can thus travel enormous distances. Fungal spores are common constituents of outdoor and indoor air. They tend to occur in the highest numbers in warm and wet or humid environments since the growth of fungi is limited by cold and lack of water. In spring and summer in temperate climates outdoor spore counts may be extremely high. However because they can travel great distances it is possible to detect spores even in climates unfavorable for fungal growth. The inhalation of airborne mold spores has been implicated in several pathologies, but by far the most common are allergies. The health effects of mold are discussed in detail below.
- *Bacteria and Viruses*: The vast majority of bacteria and viruses do not cause diseases in humans. Normal air contains a large assortment of these extremely small particles. They are lifted into the air column from their primary growth habitats, the soil, water, plants and animals. Some bacteria and viruses are the cause of a variety of infectious human diseases and their concentrations tend to be higher where the human population is concentrated, both indoors and in crowds. Bacteria are too small to be visually detected by the spore-trap sampling devices commonly used to detect airborne mold spores, and culture techniques must be employed. It is only possible to detect the presence of viruses using highly sophisticated laboratory techniques.

Basic Biology of the Molds

In order to understand the significance of indoor mold growth for human health, to decide whether or not to conduct an IAQ test, and to intelligently interpret the results of mold testing it is necessary to understand the basic biology of mold. Homeowners and inspectors should also be familiar with a few key terms used by biologists and others involved in public health microbiology.

Molds are a kind of fungus and share the basic characteristics of the other members of the kingdom Fungi such as mushrooms, shelf fungi and yeast.

Basic Facts

- Fungi are the major decomposers of organic material.
- Unlike the green plants, fungi do not require light in order to grow.
- They are essential components of all terrestrial ecosystems.
- They exhibit an enormous diversity of forms and life cycles.
- There are over 100,000 known species.
- Only a tiny fraction of them are human pathogens (capable of causing disease.)

Life Cycle and Basic Anatomy

The body of a mold or fungus is called the **mycelium**. This system of root-like threads or **hyphae** may be widely dispersed and formless, or fairly dense and developed in a wide variety of shapes and sizes. When the mycelium is dispersed the hyphae function as the nutrient gathering "root system" for the organism, absorbing food from the material on or in which the fungus is growing. In the large fungi a densely packed and well-formed mycelium forms the **fruiting body** that produces the minute wind-dispersed "seeds" of the fungus, the **spores**. For example, mushrooms and the protruding "shelf" often seen on dead or dying trees are the fruiting bodies of commonly encountered fungi. These visible bodies are produced by what may be a vast "root system" of hyphae that grow deep into the tissues of the soil or the organism on which the fungus is feeding. The spores are the dispersal stage of the fungi and they will sprout to produce new hyphae, mycelium and fruiting bodies when they settle on a suitable material in a warm, moist environment.

The molds are fungi that produce a microscopic fruiting body. What often appears as the brown or green or other colored "fuzz" or mat visible to the unaided eye is in reality a vast number of spores produced by the microscopic fruiting body structures arising from the mycelium of the mold. Like all fungi, molds are decomposers of organic matter. They are ubiquitous in the outdoor environment. They are major components of soils, are important causes of diseases in all plants including food crops, and are the main agents of the decomposition of dead plants and animals everywhere. In the home, they are the major cause of rot in foods, and are often present on building surfaces such as sheet rock, ceiling tile and wood in areas of high humidity. They can be found growing on nearly any kind of organic substance if the moisture and temperature conditions are adequate, but they cannot grow in non-biological substances such as masonry, metal or glass, unless there is sufficient dirt and debris to support growth.

Basic Facts About Airborne Spores

There are at least 100,000 different kinds of mold, but only a small number of them are commonly found indoors. There are no exclusively "indoor" molds. All molds found indoors have natural habitats outdoors, and their spores may all be found in the outdoor air. Some names that are commonly seen on indoor mold test results are: *Aspergillus, Cladosporium, Chaetomium, Penicillium, Stachybotrys* and *Ulocladium*.

- Mold spores are ubiquitous indoors and out, except in winter in cold climates or in very dry environments.
- Unfiltered indoor air is expected to contain at least some spores.
- All mold spores can be found outdoors. There are no exclusively indoor molds.
- Outdoor spore and pollen concentrations can be extremely high in the summer in a rural environment.

- Indoor spore distributions are normally dominated by spores carried in from the outside.
- Most spores are associated with plants and soils, either indoors or outdoors.
- Indoor spore concentrations are typically at or below those found outside. One common exception to this is during or just after a rain shower.
- Indoor sites should be free of or have very low levels of the common "indoor" molds unless there are high concentrations of these outdoors as well.

Mold Biology Summary

- Molds can grow indoors on moist surfaces of many types.
- They do not require light in order to grow.
- Rapid growth is common on cellulose-based materials, such as drywall, ceiling tile and wood.
- They will not grow on masonry, metal or other inorganic substrates unless biodegradable dust or dirt is present.
- Molds commonly found indoors include: *Aspergillus, Cladosporium, Chaetomium, Penicillium, Stachybotrys,* and *Ulocladium.*
- Indoor air should be free of or have very low levels of the common "indoor" molds unless there are high concentrations of these outdoors as well.

Naming and Identifying Molds

An indoor air quality laboratory report will contain data on the prevalence of spores of various kinds of molds and fungi. In order to interpret the report it is necessary to know some basic facts about how they are classified and named.

There are three major groups of fungi important for interpreting an IAQ data report. The **Ascomycetes** are common, often mushroom-like fungi that release **ascospores**. The **Basidiomycetes** include the common mushrooms and shelf fungi and they release **basidiospores**. Both ascospores and basidiospores are often found in high numbers in outdoor air. The molds comprise a very large and diverse group called the **Deuteromycetes**. There is no single term used to cover the vast array of shapes, colors and sizes that characterize the mold spores.

The Names of Molds

In addition to the general categories described above, the ascomycetes and basidiomycetes, a spore trap data sheet will list the types of molds spores present according to the **genus** to which the organism belongs. It is therefore useful to know something about how the molds are named. Molds, as is true of all organisms, are assigned a species name and a genus name.

- A **species** is composed of individuals that share the same genetic material and are essentially identical in form and behavior.
- A **genus** is a group of closely related species. (The plural of genus is **genera**.)
- Some genera contain many species (*Aspergillus* has about 200).
- Some genera contain only one (*Serpula* has only *lacrimans*).
- Spores from species in the same genus are often very difficult to differentiate and are usually grouped together on a spore trap data sheet.

Identifying Mold Spores

- The *genus* of many common molds can be determined by the characteristics of the spores alone. This allows the identification of molds from spore trap samples.
- Identification of *species* is generally not possible on the basis of spores alone and requires that the organism be grown on a culture plate. Such species-level discrimination is rarely necessary.
- There are however also many kinds of mold with very similar spore characteristics and these cannot be distinguished on a spore trap. This is the reason for the general category **other colorless spores** which is commonly found on the Spore Trap Data Report.
- The data sheet may also contain the category **unknown dematiaceous spores**. These are dark-colored spores that cannot be confidently identified from the spore or spores present.
- It is also not generally possible to distinguish the genera *Aspergillus* and *Penicillium* and the spore counts for these are reported together. (Might be shown on lab report as *Aspergillus/Penicillium, Penicilliaum/Aspergillus* or occasionally *PenAsp.*)
- Although many basiomycetes and ascomycetes can be distinguished by spore characteristics this is not usually necessary in an indoor air quality report and the spore counts for these groups are reported as a cumulative total.

Mold and Human Health

Some molds and other fungi have the potential to cause human pathologies of three basic kinds: **allergies** and other immune system responses, **infections**, and **poisoning** from fungal toxins.

1. Allergies & Immune Mediated Responses

Allergic reactions are the result of the normal immune response to foreign substances. The inflammatory response may include swelling of tissues and the release of fluids causing runny nose, watery eyes and inflammation of respiratory system tissues.

- The most common allergic-type responses are asthma and hay fever.
- Only 5% of the general population is expected to show clinical symptoms.
- There is insufficient evidence to rank mold species according to their ability to produce allergic reactions.
- ~~There is insufficient evidence to support the claim that mold exposure can *cause* asthma, though it can be a trigger for pre-existing asthmatic disease.~~ Mold is likely a causative agent of asthma as well as a trigger of asthma events.
- Prolonged exposure to very high concentrations of mold can cause hypersensitivity pneumonitis. Such mold concentrations are extremely rare except in certain agriculture-related activities.

2. Infections (Mycoses)

Serious fungal infection (**mycosis**) is rare among healthy people. Infection requires the growth of fungal hyphae in the tissues of the host. The only people who need to be concerned about fungal infection are those with compromised immune systems.

- The few potentially pathogenic fungi do not normally cause infections in healthy people.

- There are a few dermatophyte fungi that cause common superficial infections such as ringworm and athlete's foot, which are usually easily treated.
- Only severely immuno-compromised persons need be concerned about indoor mold as a possible source of infection.

3. Poisoning: Toxicity and Toxicosis

Certain molds naturally produce compounds that may be highly toxic to humans. However, pathology caused by fungal toxins (**mycotoxicosis**) is only known in cases of ingestion. There is no reliable data linking human disease to the inhalation of mold spores or mold toxins. Mold toxins do not readily evaporate, and a moldy smell does not indicate the presence of toxins in the air. Neither does the presence of toxin-producing (**toxigenic**) mold prove the presence of toxins, since such molds may only produce toxins under specific conditions.

- Presence of toxigenic molds does not prove presence of toxins or of toxic effects in humans.
- Mycotoxicosis is very rare and there is no reliable scientific data to suggest a link between indoor mycotoxins and human illness.
- Toxigenic molds indoors should be eliminated as is the case with any mold.

Indoor Humidity and Human Health

Damp or water-damaged homes are associated with a variety of immune-response type respiratory disorders, especially in children. These include asthma, wheezing, cough and phlegm production. Dampness is associated with the growth of *mold*, *bacteria*, *dust mites* and *insects*. All of these may play a role in producing illness. While it has proven difficult to determine a cause and effect relation between indoor *mold* and human pathology, there is no doubt that elevated indoor humidity *is* a cause of respiratory illness. Indoor humidity levels above 40% should be avoided to inhibit the growth of all of these suspect organisms.

Summary of the Health Effects of Indoor Mold

- Molds are common but not dominant allergens.
- 5% of persons are expected to have allergic reactions to mold spores.
- Outdoor airborne mold spores are generally more abundant than indoor airborne spores.
- Pathogenic fungi are rare and do not normally grow or propagate indoors.
- Mycotoxin-related health effects of indoor mold have not been proven.
- Indoor mold growth should be removed because of the possibility of allergic reaction and because it may destroy building materials.
- Damp or water-damaged buildings are associated with a variety of respiratory disorders, especially in children.
- Dampness contributes to the growth of mold, bacteria, dust mites, spiders and insects, all of which may contribute to respiratory problems.

Recommendations

- Allergy-prone people and asthmatics should minimize exposure to mold spores, animal dander, dust mites, pollen and other airborne allergens. Air filtration, frequent cleaning, and dust mite covers are effective in reducing allergen exposure.

- Humidity levels over 40% in winter and 60% in summer should be avoided in order to minimize the growth of mold and other potentially allergenic organisms.
- Indoor mold growth should be eliminated.

Mold Testing Overview and Guidelines

Prior to Testing: The Comprehensive Building Walk-Through

Prior to conducting any IAQ test, the Maine Indoor Air Quality Council recommends a thorough inspection of the property. The intent of a preliminary survey is to identify sources for or potential contributors to the perceived concern. This may indicate a need to test for specific contaminants. Such an inspection can often provide as much information about the healthfulness of the property as an indoor air quality test.

About Mold Testing

If the survey confirms the presence of mold (you can see it, smell it, or have experienced moisture leaks), the next logical step is to fix the cause of the moisture leak and remove the wetted/moldy materials. There are potential health risks associated with high indoor moisture levels, and the presence of mold in significant quantities is a cause for concern.

Because of the lack of standards for comparison, testing for mold may only be necessary in certain limited circumstances. For example:

- to confirm that black or dark patches are mold and not soot from candles or faulty combustion of appliances;
- to determine specific mold species so that a physician can help diagnose or treat an allergy or other health symptoms;
- if there is suspected mold contamination in the building which was not located in the walk-through inspection, some testing may be necessary.

Why Are There No Standards for Indoor Mold Spore Levels?

- There are insufficient data to prove a causal relation between airborne spores and human pathologies except at extremely high concentrations.
- Individual responses to bioaerosols vary.
- There is an enormous variety of bioaerosol particles and nothing is known of their possible synergistic effects.
- There are as yet no standardized sampling protocols to determine the effective concentrations of bioaerosols present or control for the variability of results due to the complex dynamics of the release of spores and bacteria into the air.

When is Sampling Not Required?

- If there are clearly visible areas of contamination and no question that mold is present.
- If there is no suspicion that hidden mold is involved.
- If the transport of spores from one site to another is not suspected.
- If no legal issues are likely.

When is Sampling Useful?

- To demonstrate the transport of spores from one location to another.
- To determine presence of specific allergens in rare cases where this is necessary.
- To find hidden contamination.
- If litigation may be involved.

If you do decide to sample the air:
Close the windows to the outside air a few hours before the sampling time. This minimizes the number of outdoor spores in the indoor air.

Surveying and Sampling Indoor Mold Growth

Sample Types

If you do decide to test for the presence of mold there are several possible types of sample that can be taken. Their intended uses here are reviewed here.

Surface Samples are collected from suspected areas of contamination. There are two common types, the *Tape Lift* and the *Surface Swab*. The tape lift is simply a piece of clear plastic adhesive tape on a glass microscope slide. The tape is lifted up and touched lightly to the suspected contamination. The Laboratory analyst can then do a microscopic *direct exam* to determine the presence and type of mold. The Surface Swab is a sterile fiber-tipped swab that can also be used for a direct exam by transferring the material on the swab to a microscope slide. In addition, the swab samples may be used to supply material for a *culture plate* to determine the presence and identity of *viable* (live) mold in the sample. Cultured samples are incubated from three to five days before colonies can be counted and identified.

Bulk Samples are any samples sent to the lab on or in which there is suspected mold growth. These typically include pieces of building material, such as sheetrock, insulation or wood, and fabric or carpet samples.

Air Samples may also be collected for two types of laboratory analysis, direct exam and culture. For direct exam and identification of airborne mold spores various types of *spore trap cassettes* are used. Commonly used brands include Allergenco, Air-O-Cell, Burkhard, Cyclex, and Micro-5. They are all used in conjunction with an air pump that passes a determined volume of air through the cassette. The spore trap itself consists of a thin glass slip covered with a thin film of adhesive. Any particles in the air will stick to the adhesive, which can be examined under the microscope. Direct exam allows a direct count of the spores present in the air sampled. For *air sample culture* the inspector uses an *Andersen Sampler*, which is a device for passing a determined volume of air onto a culture medium plate to allow deposit of any mold spores present. As for swab samples, the plate is then incubated for three to five days and any resulting colonies are counted and identified.

Uses of Different Sample Types

Bulk and Surface Samples

- To distinguish stains and debris from mold.
- To differentiate types of mold.

Air Samples

- To differentiate spore distributions between sites.
- To compare indoor spore concentrations with those outdoors.
- To determine quantities of airborne spores.
- To suggest the presence of hidden mold.
- To demonstrate active transmission from a visible source.

Air Samples - Direct Exam

- Uses spore-trap cassettes of various brands: Allergenco, Air-O-Cell, Burkhard, Cyclex, Micro-5.
- All have an adhesive surface that traps spores and airborne debris.
- Advantages: All spores and fragments are detectable, including non-viable & difficult to grow spores; Speed; Cost.
- Disadvantage: Identification less accurate than culture analysis since many spores look the same.

Air Samples – Culture

- Uses Andersen Sampler and Culture Plates
- Advantages: Only Viable Spores will be counted; identification more accurate.
- Disadvantages: Longer turn-around times; more costly.

Sampling for Hidden Mold

One of the portential uses of air sampling is to discover the location of mold that may not be readily visible. These locations may include basements, crawlspaces and the surfaces inside walls or flooring. It is possible for spores to disperse into the living spaces from these locations. Air samples may be used to determine the general area of hidden sources of airborne spores, and to detect whether spores are dispersing from one area to another. If mold growth is suspected inside wall cavities, then wall cavity samples should be collected. This requires drilling a small-diameter hole into the wall surface and inserting a plastic tube into the wall cavity so that air can be withdrawn. The volume of air sampled in such cases is lower than normal to prevent debris overload on the spore trap.

The Outdoor Control

It is standard practice to sample the outdoor air as well as sites indoors. This provides baseline data against which to assess the indoor data. The outdoor control data are compared with the indoor data so that the inspector can determine if spores indoors have an outdoor source. Ascospores and basidiospores discovered indoors are nearly always found outdoors in higher concentrations. Some genera, *Cladosporium* is a common example, are found routinely both indoors and out, and it is important to know whether the outdoor counts are higher or lower than the indoor. Indoor data alone are not conclusive determinants of the source of any spores and are worthless if litigation is a possibility. In the winter in colder climates outdoor samples will likely contain no spores at all, and may be dispensed with unless litigation is involved.

Interpreting the Spore Trap Data Report

Summary of Relevant Spore Ecology

- Molds are normal indoor flora. Unfiltered indoor air is expected to contain at least some spores.
- All mold spores normally occur outdoors.
- Outdoor spore and pollen concentrations can be extremely high in the summer in a rural environment.
- Most spores are associated with plants and soils, either indoors or outdoors.
- Indoor spore distributions are normally dominated by spores carried in from the outside.
- Indoor spore concentrations are typically at or below those found outside. One common exception to this is during or just after a rain shower.
- Indoor sites should be free of or have very low levels of the common indoor molds unless there are high concentrations of these outdoors as well.
- Many spores do not readily disperse into the still air in an indoor environment. It is common to find *Stachybotrys* and *Chaetomium* growth on indoor surfaces but to detect few or no spores at all in the air.
- The most common indoor mold genera to watch for include: *Aspergillus* and *Penicillium, Chaetomium, Cladosporium, Stachybotrys* and *Ulocladium*.

Data Analysis Guidelines

1. Raw data are important.

- A single spore could originate anywhere, but several spores at one site, or a single spore at multiple sites could indicate a potential indoor growth source.
- Calculated volumetric data (counts/m^3) should interpreted cautiously: Low spore counts have large margins of error and can produce widely fluctuating values for spore concentrations in spores per cubic meter.

2. Site comparisons should never be based wholly on total spore counts.

- There is no advantage to collecting spore trap data if the distribution of genera is not analyzed.
- Generic identification in air samples can be correlated with surface sample or wall cavity data revealing the source of the spores.
- A site may have elevated levels of one type of spore while the overall level of spores is lower than outside, particularly in the summer when outdoor spore counts can be enormous.

3. Note the debris rating: The higher the number the more difficult it is for the analyst to detect the spores and the greater the chance that the reported spore counts are underestimates of the actual numbers.

4. Be aware that any spore trap data are time-limited: They represent spore distributions at a particular time.

5. Spore trap data are always estimates no matter how good the lab. Even if 100% of the trace is read, the data are still samples of a particular volume of air at a particular time.

Interpreting the Spore Trap Data Sheet

AIHA Environmental Microbiology ACCREDITED LABORATORY

Client:	Date Sampled:
	Date Received:
Address:	Date Reported:
	Project:

Sample Type: Allergenco-D — Analysis Report- Spore Trap Direct Exam

Volume Sampled	75		75		75		75		75		75	
Sample Description	Outdoors		Living Room		Bedroom		Bathroom		Kitchen		Basement	
Lab Number	MG 12345		MG 12346		MG 12347		MG 12348		MG 12349		MG 12350	
	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3
Total Mold Spores	**818**	**43,626**	**27**	**1,440**	**332**	**17,706**	**45**	**2,826**	**81**	**4,320**	**1,029**	**54,879**
Ascospores	205	10,933	6	320	105	5,600	3	160	30	1,600	40	2,133
Aspergillus/Penicillium							10	533	28	1,493	850	45,333
Basidiospores	600	32,000	21	1,120	220	11,733	22	1,173	21	1,120	135	7,200
Cladosporium	13	693			4	213			2	107		
Chaetomium sp.					3	160					4	213
Stachybotrys							18	960				
Background Debris	**2**		**3**		**3**		**2**		**2**		**4**	
Comments												

The spreadsheet above is an example of a typical Spore Trap Data Sheet that is the end result of the laboratory analysis of air samples. In this example there were 6 locations sampled, including the outdoor control. The column on the far left indicates the nature of the data in the cells for each sample. The *Volume Sampled* in liters (L) is determined by the sample collector. A typical value is 75 liters. This number is used in the computation of the numbers of spores per unit volume of air. The *Sample Description* is provided by the inspector and each spore trap is labeled accordingly. The *Sample Condition* indicates whether the sample was damaged upon arrival. The *Lab Number* is assigned by the laboratory doing the analysis – every sample is assigned a unique number. Further down the column, rows are assigned for the individual types of spores that were found on the traps. In the sample above these begin with Ascospores and end with *Stachybotrys*. Below these is a row for the qualitative evaluation of *Background Debris* on a scale from 0-5, where 5 indicates complete coverage of the sample trace by debris of various kinds. The debris rating is important. First, because it gives an idea of the level of particulates in the air, and second, because it indicates the accuracy of the spore count data. If the background debris is scarce then the analyst will be able to see all the spores that have been deposited on the slide. If there is considerable debris then it is likely that some spores will have been missed and the spore count data reported will be lower than the actual number of spores. Debris ratings of 4 or 5 should be considered high.

In the column for each sample there are two sub-columns, one labeled *Raw Ct.*, for *Raw Count*, and the other *Ct/m^3*, for *Counts per cubic meter*. The Raw Count for each type of spore is the actual number counted by the analyst. There is some variability between labs in the microscopic analysis of spore traps. Some, but not all, count the spores on 25% of the trace (this is indicated on the sample data sheet at the upper right). This number is then simply multiplied by 4 to give an estimate of the total. Such a partial survey gives results that are accurate within reasonable limits and minimizes the cost of reading a higher percentage of the trace. The Raw Count is then multiplied by a factor that accounts for the total volume of air actually sampled (in our case, 75 liters) to give an estimate of the

number of spores in one cubic meter of air. Then both the Raw Count and the calculated volumetric data are summed and the total is displayed above in the row labeled *Total Mold Spores*.

Case Studies

Interpreting Spore Trap Data: Case 1
The Poorly Vented Bathroom

AIHA Environmental Microbiology ACCREDITED LABORATORY

Client:	Date Sampled:
	Date Received:
Address:	Date Reported:
	Project:

Sample Type: Allergenco-D — Analysis Report- Spore Trap Direct Exam

Volume Sampled	75		75		75		75		75		75	
Sample Description	Outdoors		Living Room		Bedroom		Bathroom		Kitchen		Basement	
Lab Number	MG 12345		MG 12346		MG 12347		MG 12348		MG 12349		MG 12350	
	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3
Total Mold Spores	690	36,799	172	9,172	133	7,093	673	35,893	181	9,653	526	28,054
Ascospores	135	7,200	54	2,880	4	213	6	320	15	800	59	3,147
Aspergillus/Penicillium			13	693	64	3,413	625	33,333	115	6,133	125	6,667
Basidiospores	450	24,000	91	4,853	56	2,987	32	1,707	40	2,133	200	10,667
Cladosporium	69	3,680	11	587	9	480	5	267	2	107	21	1,120
Myxomycetes	4	213	1	53			1	53	1	53		
Mycelial Fragments											6	320
Other colorless spores									5	267	12	640
Unknown dematiaceous sp	6	320					2	107	1	53	4	213
Alternaria	7	373	1	53			1	53				
Bipolarus	2	107									1	53
Curvularia	4	213	1	53			1	53				
Fusarium	13	693							2	107		
Basidiospore X											98	5,227
Background Debris	2		3		3		2		2		4	
Comments												

These results illustrate some fundamental principles of data interpretation. Notice first the data for the Outdoor sample. A competent inspector will always take at least one outdoor air sample as a control for comparison with the indoor air. The total spore counts, both raw and volumetric data, are fairly high. The dominant spore types by far are the ascospores and basidiospores. This is typical of warm weather outdoor air. The next most prevalent spores are those of the genus *Cladosporium*. This genus quite commonly grows indoors but it also very often is found outdoors in fairly high numbers. The raw data for the rest of the spores counted on the outdoor sample show that they occur in relatively low numbers. The diversity of spores outdoors is expected to be much higher than indoors. Spores that occur in low numbers outdoors are generally insignificant.

The next step in reading the report is to compare the outdoor spore counts with those indoors. Note that the ascospores and basidiospores are represented indoors but in significantly lower numbers. Therefore we can assume that these spores originated in the outdoor air. The same is true of the other spore types, with a few important exceptions. First and most important, are the *Aspergillus/Penicillum* group. These are only found indoors in this example, which indicates an indoor source. From these data alone we must assume that this source is somewhere in the bathroom since that is where the spore counts are highest. This makes sense because the bathroom is likely to be more warm and humid than

other areas of the house. From these data alone there is no way to know whether the mold is growing only in the bathroom and the spores dispersing elsewhere in the house, or whether there is some degree of growth elsewhere. Such determinations must be made by the IEP. Notice too that all this information is lost if we only look at the total spore counts: the outdoor air and the Bathroom air are equivalent in total spores per cubic meter, but the distribution of kinds of spores is quite different.

Next, notice the row labeled "Basidiospore X." Basidiospores are released by mushrooms and related fungi. A vast array of different basidiospores are normally grouped together by the lab analyst. A trained mycologist can distinguish many of these. In this example there was one kind of basidiospore that occurred in the basement but *not* outdoors and this was noted by the analyst. It is not uncommon for "mushrooms" to grow in a damp basement and they can release ascospores or basidiospores.

Interpreting Spore Trap Data: Case 2
The Wet Basement

This example is quite simple and easy to interpret. Outdoor spore counts are normal for a temperate climate in warm seasons. We can infer that the windows in the bedroom were left open, since the outdoor spore concentrations are elevated there with respect to the other rooms. The only significant departure from the outdoor spore distribution occurs in the basement where the *Aspergillus/Penicillum* spores are high. We can infer that there is significant moisture in the basement. It also is likely that the *Aspergillus/Penicillum* spores in the bathroom and the kitchen have come from the basement, either directly via airflow from that area or by proximity to damp wall or floor cavities. It is of course also possible that there is mold growth in both upstairs locations. The low spore counts are consistent with either scenario. Note finally that the reported spore counts in the basement are likely to be

AIHA Environmental Microbiology ACCREDITED LABORATORY

Client:	Date Sampled:
	Date Received:
Address:	Date Reported:
	Project:

Sample Type: Allergenco-D — Analysis Report- Spore Trap Direct Exam

Volume Sampled	75		75		75		75		75		75	
Sample Description	Outdoors		Living Room		Bedroom		Bathroom		Kitchen		Basement	
Lab Number	MG 12345		MG 12346		MG 12347		MG 12348		MG 12349		MG 12350	
	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3
Total Mold Spores	594	31,680	28	1,493	329	17,546	36	1,920	85	4,533	1,767	94,240
Ascospores	225	12,000	6	320	105	5,600	3	160	30	1,600	59	3,147
Aspergillus/Penicillium							12	640	28	1,493	1,500	80,000
Basidiospores	340	18,133	21	1,120	220	11,733	21	1,120	21	1,120	195	10,400
Cladosporium	21	1,120			4	213			2	107		
Mycelial Fragments											4	213
Other colorless spores									1	53	9	480
Unknown dematiaceous sp	3	160							2	107		
Bipolarus	2	107										
Curvularia	1	53	1	53					1	53		
Fusarium	2	107										
Background Debris	2		3		3		2		2		4	
Comments												

underestimated because of the high background debris rating. This makes visual detection of all the spores on the trap quite unlikely.

Interpreting Spore Trap Data: Case 3
The Leaking Roof

Although there is of course no way to know with certainty from the data alone, we might suppose that this house has a leaking roof, or a plumbing leak somewhere in the wall between the bathroom and the bedroom. The four groups marked in red are all characteristic of damp indoor environments. It is rare to find *Chaetomium, Stachybotrys* and *Trichoderma* in outdoor air in any significant numbers. These, along with *Aspergillus* and *Penicillium* are common indicators of indoor moisture.

The outdoor air has relatively low spore counts and the outdoor spores are found indoors in concentrations that suggest the windows have recently been open. The fact that the basidiospores are higher in the basement than outdoors may or may not be significant. A difference of 90 spores in the raw data is not enough to cause alarm, and there are no other basement spore counts that are

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Client:	Date Sampled:
	Date Received:
Address:	Date Reported:
	Project:

Sample Type: Allergenco-D — Analysis Report- Spore Trap Direct Exam

Volume Sampled	75		75		75		75		75		75	
Sample Description	Outdoors		Living Room		Bedroom		Bathroom		Kitchen		Basement	
Lab Number	MG 12345		MG 12346		MG 12347		MG 12348		MG 12349		MG 12350	
	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3
Total Mold Spores	236	12,587	441	22,559	12,321	653,641	943	48,373	200	10,627	292	15,574
Ascospores	29	1,547	31	1,653	40	2,133	3	160	53	2,827	9	480
Aspergillus/Penicillium			156	8,320	12,000	640,000	675	36,000	41	2,187	35	1,867
Basidiospores	105	5,600	82	4,373	65	3,467	87	4,640	62	3,307	195	10,400
Cladosporium	86	4,587	43	2,293	11	587	7	373	19	1,013	30	1,600
Myxomycetes	7	373	2	107							12	640
Mycelial Fragments			12	640	27	1,440	2	107			3	160
Other colorless spores									1	53	5	267
Unknown dematiaceous sp	9	480							2	107	3	160
Chaetomium			16	853	32	1,707	21	1,120	8	427		
Stachybotrys			24	320	87	1,160	48	640	1	13		
Trichoderma			75	4,000	59	3,147	100	5,333	13	693		
Background Debris	2		3		3		2		2		5	
Comments												

particularly high.

The bedroom seems to be the center of the problem area. We cannot know from the data here whether the mold growth is visible or hidden. It is reasonable to assume that either the spores are dispersing from the bedroom to the bath and living rooms, or that residual moisture from a bedroom-associated leak is causing growth in those areas in lesser amounts. The kitchen and basement are also involved but only the on-site IEP will be able to assess whether there is growth in these areas or whether the spores have come from the high concentration source.

The spores of *Chaetomium, Stachybotrys* and *Trichoderma* all occur in modest numbers and the variations in these counts do not allow us to determine a likely source. Only visual inspection, or perhaps a wall cavity check will be able to resolve that question.

Interpreting Spore Trap Data: Case 4
Some Special Issues

AIHA Environmental Microbiology ACCREDITED LABORATORY

Client:	Date Sampled:
	Date Received:
Address:	Date Reported:
	Project:

Sample Type: Allergenco-D — Analysis Report- Spore Trap Direct Exam

Volume Sampled	75		75		75		30		75		75	
Sample Description	Outdoors		Living Room		Bedroom		Bedrm SW Wall		Kitchen		Basement	
Lab Number	MG 12345		MG 12346		MG 12347		MG 12348		MG 12349		MG 12350	
	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3	Raw Ct.	Ct./m^3
Total Mold Spores	82	4,373	223	11,894	319	17,014	7,102	946,933	114	6,080	100	3,974
Ascospores	9	480	35	1,867	6	320			6	320	3	160
Aspergillus/Penicillium			21	1,120	275	14,667	7,000	933,333	21	1,120	15	800
Basidiospores	38	2,027	125	6,667	17	907	14	1,867	66	3,520	29	1,547
Cladosporium	13	693	42	2,240	21	1,120	12	1,600	9	480	6	320
Smuts/Myxomycetes/Perico	16	853									2	107
Mycelial Fragments							69	9,200				
Unknown dematiaceous sp	6	320					7	933			5	267
Chaetomium											5	267
Rhizopus									12	640		
Serpula											34	453
Stachybotrys											1	53
Background Debris	1		2		3		5		2		4	
Comments	Rain?											

There are several special circumstances to be noted in these data. First, notice that the "outdoor spores" are more concentrated in the living room than outdoors. While it is possible that this is a random fluctuation, it is not unlikely that there has recently been a rain shower that has lowered the over-all particulate concentration in the outdoor air. Next, note that the inspector has done a wall cavity check of the southwest bedroom wall. For this kind of sample the volume of air is reduced to 30L to prevent an overload of the spore trap with debris. This wall is the likely source of the *Aspergillus/Penicillium* spores in the indoor air.

Finally, there are some genera that suggest particular conditions. The kitchen sample here contained a few *Rhizopus* spores. Although it may grow on a variety of substances, this genus is a common mold of breads and other foods. It is possible that this is the source of these spores, especially since they were found only in the kitchen. The basement was found to contain spores of *Chaetomium, Serpula and Stachybotrys. Chaetomium* and *Stachybotrys* are indicator molds and are a reliable sign that there is a moisture problem in this location. *Serpula lacrimans* is the only species in this genus, and it is the cause of what is commonly known as "dry rot" in wooden building material. The presence of these spores in the air should be a sign to the inspector that some degree of wood rot exists in or near this location.