

Overview

- **Mould Biology**
 - Growth requirements, reproduction, examples of moulds
- **Health Effects of Indoor Mould**
 - Mechanisms of exposure
 - Allergic reactions, toxic reactions, infectious disease
- **Controlling Mould Growth**
 - Sources of moisture (structural, occupant generated)
 - Cleaning and remediation

Mould Biology

Belong to the Kingdom Fungi; 75 000 identified Species - Mycologists suggest a million unidentified.

Mould

- Microscopic fungi grow into visible colonies

Mildew

- Often used term applied to mould; powdery mildew

Yeasts

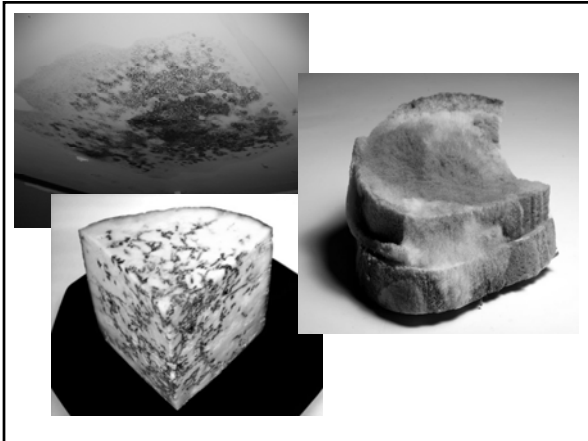
- Beer, wine, bread, Rhodotorula

Mushrooms

- Fruiting bodies of mycelia; Portobello, Shitake

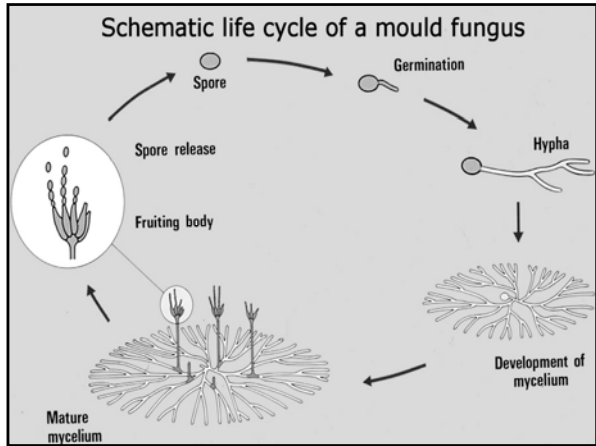
Growth Requirements

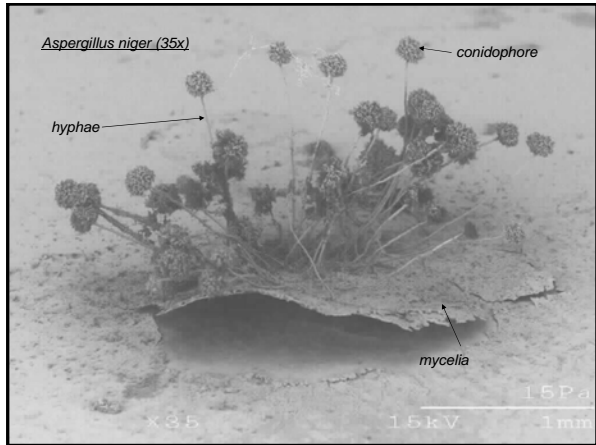
- Food (all organic material and some minerals)
- Suitable temperature range
- Oxygen
- Enough **moisture** to allow growth and digestion to take place
- Once established most moulds require $RH > 60\%$

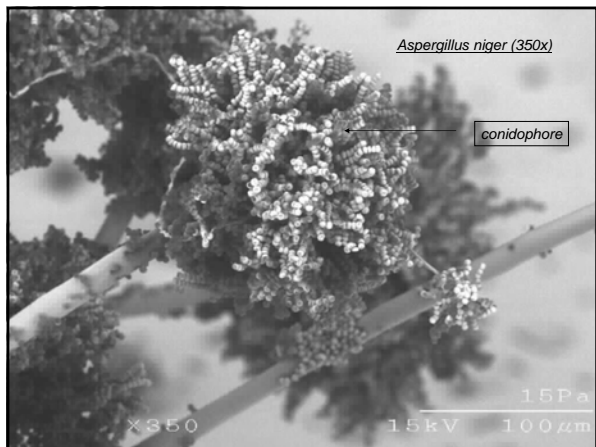


Mould Reproduction

- Moulds reproduce by making spores
 - Spores become airborne or transported (house dust)
- Mould spores are everywhere
- Where there is moisture spores will germinate
- Moulds secrete an enzyme that dissolves the material they are growing on to obtain nutrients









Aspergillus
Approx. 200 species.

Toxins:

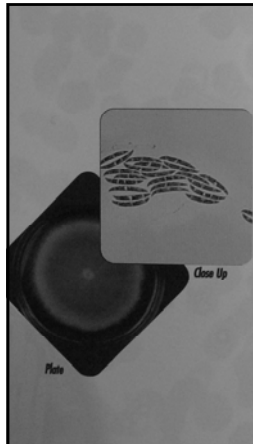
- A. flavus*: aflatoxin B1 & B2, cyclopiazonic acid, kojic acid
- A. fumigatus*: ergot alkaloids, fumigacilvins, gliotoxin, fumigatoin, fumigillin, fumitremorgens, helvolic acid, tryptoquinoline tremorgens, verrucologen.
- A. niger*: malformin C, oxalic acid.
- A. ustus*: austocystins.
- A. versicolor*: aspercalorin, averufin, cyclopiazonic acid, sterigmatocystin, versicolorin.

There are approximately 200 different species of *Aspergillus*, sixteen of which have been documented as etiological agents of human disease. The diseases caused by these species rarely occur in individuals with normally functioning immune systems. Toxin production is dependent on the species or a strain within a species and on the food source for the fungus. These fungi are found in soil, compost piles, plant debris and stored grain, as well as on water damaged building materials.

Cladosporium
Approx. 40 species.

Toxins: Some Species, Cladosporin, Emodin, Epicladosporic acid.

Cladosporium is the most frequently found genus of fungi in outdoor air in temperate climates. The conidia, borne in very fragile chains, easily become airborne and are transported over long distances. The natural high season for outdoor air concentrations is typically late summer and autumn and low season is typically winter and early spring. It has been isolated from many different types of soil and is a major colonizer of plant litter. The enzymes of *Cladosporium* are especially suited for breaking down cellulose, pectin and lignin, which are the major components of plant litter. Due to its ability to rapidly invade many different ecological niches, *Cladosporium* is considered ubiquitous and therefore sometimes problematic. The ability to sporulate heavily, ease of dispersal, and buoyant spores makes this fungus an important fungal airway allergen, and together with *Alternaria*, commonly causes asthma and hay fever in the Western Hemisphere. It is found indoors as well, but usually in less numbers, unless there is an indoor source of contamination. Indoors this fungus may be encountered in dirty refrigerators, especially in reservoirs where condensation is collected, and on moist window frames as a result of condensation. *Cladosporium* often discolors interior paint, paper, and textiles stored under humid conditions. Houses with poor ventilation and houses located in dump environments may have heavy concentrations of *Cladosporium*.

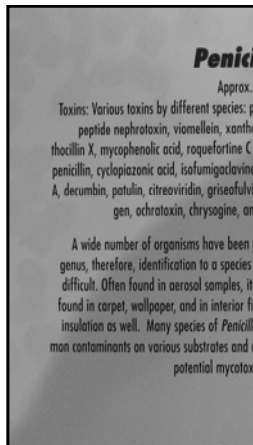


Fusarium

Approx. 50-70 species.

Toxins: Trichothecenes (type B); T-2 toxin; zearalenone (F-2 toxin), vomitoxin, deoxynivalenol, and fumonisin.

Most *Fusarium* species are soil fungi and have a world-wide distribution. Found on a wide range of plants, some are pathogens that cause root and stem rot, vascular wilt or fruit rot. Other species cause storage rot and are important mycotoxin producers. Several species, notably *F. oxysporum*, *F. solani* and *F. moniliforme*, are recognized as being pathogenic to man and animals causing mycotic keratitis, onychomycosis and hyalohyphomycosis, especially in burn victims and bone marrow transplant patients. This fungus requires extremely wet conditions, and is often found in humidifiers.

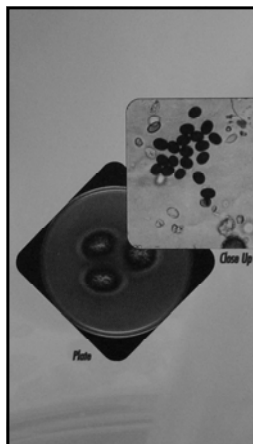


Penicillium

Approx. 200 species.

Toxins: Various toxins by different species: penicillic acid, peptide nephrotoxin, viomellein, xanthomegin, xanthocillin X, mycophenolic acid, roquefortine C & D, citrinin, penicillin, cycloiazonic acid, isofumigadavine A, penitrem A, decumbin, patulin, citreoviridin, griseofulvin, verruculogen, ochratoxin, chrysogine, and meleagrin.

A wide number of organisms have been placed in this genus, therefore, identification to a species is sometimes difficult. Often found in aerosol samples, it is commonly found in carpet, wallpaper, and in interior fiberglass duct insulation as well. Many species of *Penicillium* are common contaminants on various substrates and are known as potential mycotoxin producers.

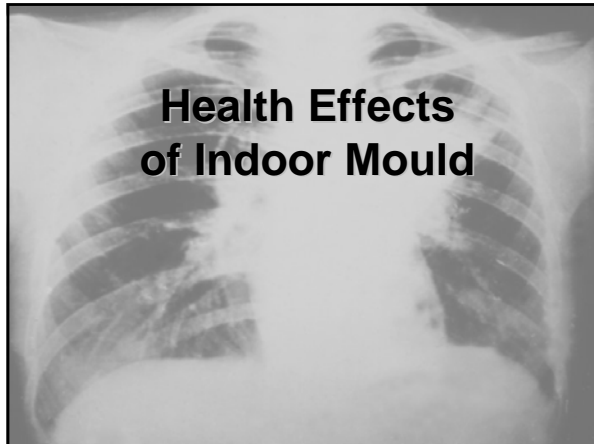


Stachybotrys

Approx. 15 species.

Toxins: Macrocytic trichothecenes: verrucarin J, roridin E, satratoxin F, G & H, sporidesmin G, trichoverrol; cyclosporins, stachybotryolactone.

Stachybotrys, a dark colored fungi, thrives on water damaged cellulose rich materials such as sheet rock, paper, ceiling tiles, cellulose containing insulation backing and wallpaper. The presence of this fungus in buildings is significant because of the mold's ability to produce mycotoxins, which are extremely toxic. Exposure to these toxins can occur through inhalation, ingestion or dermal exposure and can include these symptoms: dermatitis, cough, rhinitis, nose bleeds, a burning sensation in the mouth and nasal passage, cold and flu symptoms, headache, general malaise, and fever.



Health Effects of Indoor Mould

Mechanisms of Exposure

Source of exposure:

- Spores, hyphae fragments, mycotoxins

Route of exposure:

- Inhalation, eyes, broken skin, ingestion

Health effect dependant on:

- Dose, duration
- Susceptibility (higher risk individuals)
 - Infants, elders, immuno-compromised
 - Asthma, lung disease, recent surgery

Allergic Reactions

Common health effects associated with mould

- Aggravation of pre-existing asthma
- Upper-respiratory tract symptoms
 - Nasal congestion or runny nose
 - Eye irritation
 - Sore throat
 - Coughing, congestion, wheezing
- Hypersensitivity Pneumonitis

Toxic Effects

Exposure to large volumes of mould contaminated materials may cause ODS (Organic Dust Toxic Syndrome).

- Abrupt onset of fever, flu-like symptoms and respiratory impairment
- At risk are farm workers and mould remediation workers

Infectious Disease

Moulds capable of causing infectious disease:

Aspergillosis (*Aspergillus* sp.)

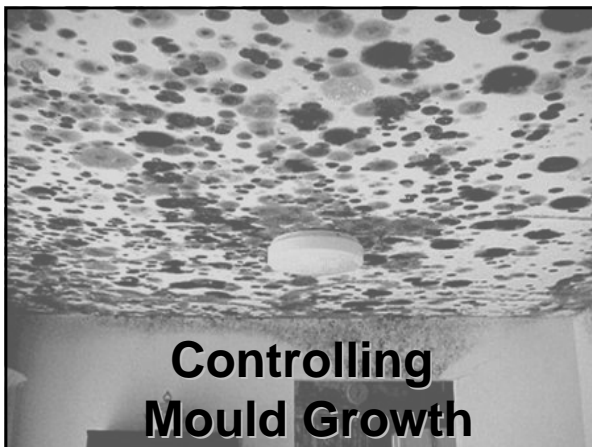
- Decaying leaves, vegetation, compost

Blastomycosis (*Blastomyces dermatitidis*)

- Undisturbed moist soils

Histoplasmosis (*Histoplasma capsulatum*)

- Accumulated bird and bat droppings



Moisture = Mould

Sources of Moisture

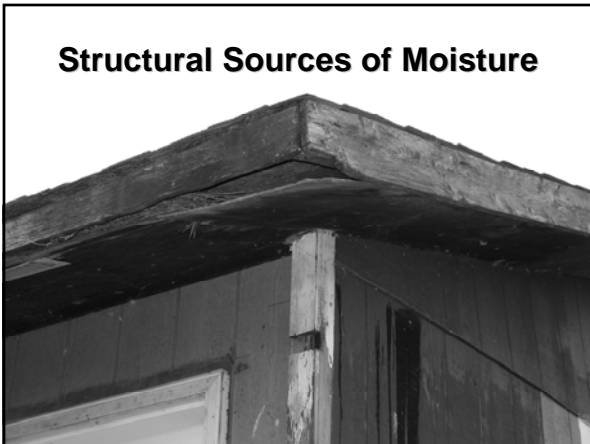
Water accumulation from sources of moisture is THE precursor for mold growth.

Remediation is a WASTE of time until the sources of moisture are identified and corrected.

Moisture accumulation can be a function of:

- a) *Structural sources*
(poor design, bad construction, damage, age)
- b) *Occupant generated sources*
(lack of moisture and air flow management)

Structural Sources of Moisture



Roof and Attic

Insufficient insulation and air sealing

- Ice-damming
- Improperly sealed bathroom vent duct
- Air leaks through perimeter and partition walls
- Air leaks around stacks, vents and chimneys
- Damaged or inadequate flashing

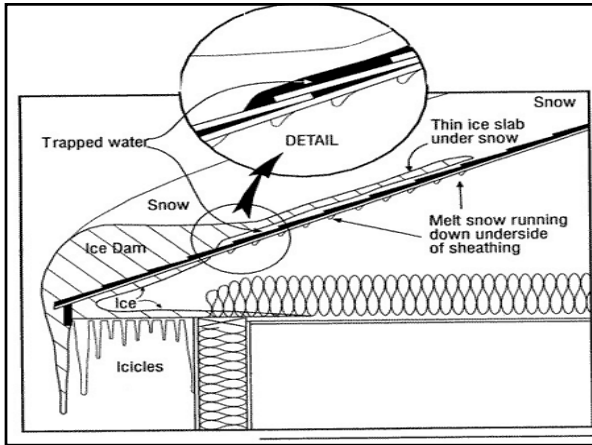
Evidence of air leakage in attic

- Light observed at night in attic
- Discoloured insulation that have been acting as filters









Building Envelope

Moist air penetrating through faulty sealing

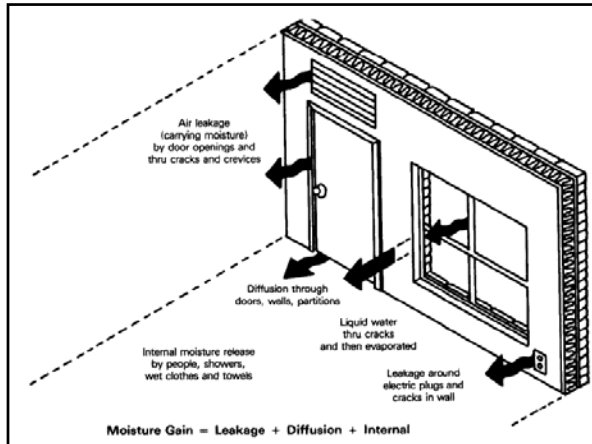
- *Causing moisture to accumulation at penetration points*
- *Usually around windows, doors, vents, electrical*

Evidence of leakage through building envelope

- *Icicles on exterior of windows, unevenness or heaving of window frames*
- *Lifting drywall tape and nail pops*
- *Doors jams freezing, visible ice build-up*
- *Mould at the base of walls*

May be difficult to detect visually

- *Use of a protimeter*





Foundations

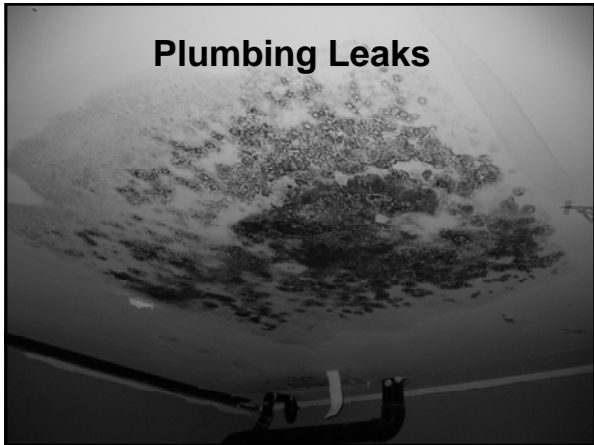
Surface water penetration

- *Grade not sloping away from foundation*
- *Sump effluent not directed away from foundation*
- *No eaves-trough with downspout and extensions*
- *Malfunctioning or blocked weeping tile*
- *Improper sealing around window wells*
- *Winter months can freeze cracking the foundation*

Evidence of penetration through foundation

- *Discolouration of walls or floor*
- *Strong earthy or musty smell*
- *Mould forming on stored items*





Plumbing Leaks

Can cause devastating structural damage and extensive mould growth.

Periodically inspect all plumbing fixtures

- *Look for discolouration beneath plumbing connections at sinks*

Measures to minimize risk of flooding

- *Inspect sump-pump for secure connections*
- *Consider a back up power supply for sump pump*
- *Ensure washing machine connections are secure*
- *Turn off water main and drain lines when homes is vacant for extended periods of time*
- *Turn off supply valves to outdoor faucets in winter*



Crawl Spaces

Can contribute very large amounts of moisture through wicking or capillary action of ground water.

Closed crawl space (preferred design)

- *Treated like a short basement (conditioned space)*
- *Proper drainage (weeping tile and sump pump)*
- *Ground is sealed with vapour barrier and concrete*
- *Walls are air-sealed and insulated*

Open crawl space

- *No ducts, well vented, good drainage, no storage*
- *No service connections to home*



Thermal Bridges

Thermal bridges or thermal breaks are usually seen in the corners or rooms and ceilings.

- These areas of high conductivity lead to cold spots that are prone to condensation of moisture
- Best to eliminate at the design stage of home
- Difficult and costly to correct
- Mould avoided through management of occupant generated moisture and good air flow







Occupant Generated Moisture

Controlling Moisture

Large volumes of moisture are introduced on a daily basis through occupant generation.

- *Cooking*
- *Showering*
- *Drying Laundry*
- *Respiration (5 L of water from a family of 4)*
- *Potted Plants*

Controlling Moisture

Maintain air flow around furniture

- *Maintain a separation of 15 cm (6") from walls*

Control sources of mould spores in house dust

- *Regular vacuuming with a HEPA (high efficiency particulate air) filter*
- *Try to avoid carpeting, especially in basements*
- *Reduce the number of indoor potted plants*
- *Store wood outdoors*

Windows

Windows are much colder than adjacent walls. Condensation of moisture occurs when humid air contacts a cold surface.

- *Condensation on glass drips onto window frame causing mould growth and rotting the frame*
- *Ensure the windows are properly caulked and insulated*
- *Can use thermo-plastic film in winter to minimize heat loss and condensation*
- *Keep drapes or blinds open to maintain air flow*
- *Ideally replace single pane with energy efficient double pane windows*

Kitchen

Large volumes of moisture generated through cooking.

- *Stove should have a fan that is ducted to the outside*
- *Avoid prolonged and uncovered boiling*

Control sources of mould spores in house dust

- *Regularly clean the dust off the back of the refrigerator coils*
- *Clean the refrigerator drip pan regularly*

Bathrooms

Largest source of daily moisture added to the air.

- *Ensure the bathroom has an exhaust fan that is vented directly outside (not just into the attic)*
- *Use the fan every time you shower/bath and let it run for five minutes after you finish*
- *Leakage and overflow from tubs and showers can be corrected by ensuring bathtub surround is tightly sealed and caulked*
- *Condensation from toilets and tanks can be corrected by insulation liner for tank*
- *Avoid carpeting*



- Mold under vinyl sheet flooring in bathroom.
- Mold growth in grout and sealant around bathtub.

Laundry

- Avoid hanging laundry indoors to dry
- Ensure the exhaust from the dryer is sealed tightly at all connections with metal tape
- Dryer ducts can ice over at night in the winter and melt when it warms (draft blocker)
- Don't allow laundry to accumulate
- Remove lint after each use

Basement and Crawlspace

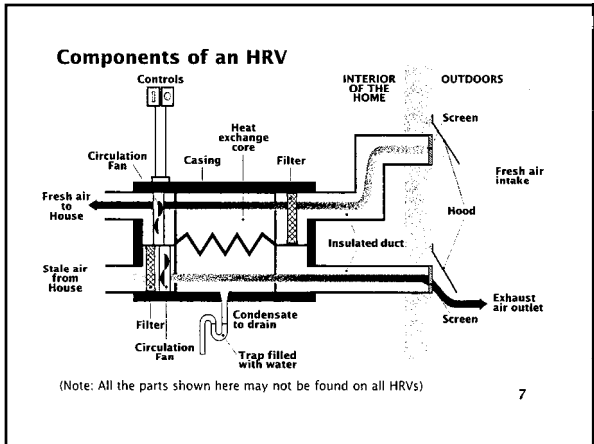
These spaces are usually the coldest part of a home and prone to condensation of moisture.

- Keep your basement neat & organized to allow for air circulation
- Seal sump-pump pit
- Get rid of old papers, clothes, furniture
- Control Relative Humidity with a dehumidifier
- Only store items that are easily cleaned
- Dispose of water damaged and musty smelling items
- Avoid carpets in basements



Heat Recovery Ventilators (HRV)

- Insulated ducts for incoming (fresh) and outgoing (stale) air
- Ductwork distributes fresh air throughout the house, and returns stale air to the HRV
- Fans circulate fresh air throughout the house and exhausts stale air to the outside
- A heat exchange core transfers heat from outgoing stale (warm) air to incoming fresh (cold) air







Cleaning and Remediation

Is it Mould?

Your best tools are your eyes and nose.

- A "musty" or "earthy" smell can be present
- Mould can be black, white, gray, green
- It may look like a stain. If its mould it can be smeared or wiped away with a paper towel

Look for mould in damp places.

- Basement, crawlspace, under sinks, bathroom, around windows, corners of rooms

Common Mould Questions

Q: *Should I use bleach for cleaning mould?*

A: *Bleach is hazardous. Mild detergents or baking soda will work fine.*

Q: *Do I need to have the air tested for types of mould?*

A: *No...It's expensive, unnecessary, lack of standard. ANY mould can cause potential health effects.*

Q: *What about mould cleaners or growth inhibitors?*

A: *Moisture = Mould.*

Remediation Plan

- 1) Identify and correct the sources of moisture.
- 2) Assess the level (area) of contamination.
 - Includes visible and concealed.
- 3) Protect the health of workers and occupants.
- 4) Remove or clean contaminated material in a way that prevents mould, or dust contaminated with mould from leaving a remediation area.

Small Area of mould < 1 m²

Occupant can carry out cleaning.

Surfaces:

- Washable surfaces: mild detergent solution, allow to dry.
- Drywall (painted): same as washable surface.
- Drywall (bare): replace.
- Use a vacuum with a HEPA filter.
- Dispose of mouldy papers, books or unwanted items.

Personal Protective Equipment (PPE):

- Respiratory protection (N95).
- Gloves and eye protection.

Waste Removal:

- Bag waste and remove to outdoor disposal.

Medium Area of Mould < 3 m²

Regular maintenance staff can assist in clean up.

Surfaces:

- Washable surfaces: detergent solution, allow to dry.
- Drywall (painted): same as washable surface.
- Drywall (bare): replace.
- Use a vacuum with a HEPA filter.
- Dispose of mouldy papers, books or unwanted items.

Personal Protective Equipment (PPE):

- Respiratory protection (N95).
- Gloves and eye protection.

Dust Suppression:

- Cover (isolate) work area with plastic sheet.

Waste Removal:

- Bag waste and remove to outdoor disposal.

Extensive Area of Mould > 10 m²

Personnel trained in mould remediation only.

Strict Health & Safety measures.

No occupancy during remediation.

Surfaces:

- Considerable volumes of materials will be removed.
- HEPA vacuum.

Personal Protective Equipment (PPE):

- Half-face respirators with charcoal canisters.
- Gloves, disposable full body coverall.

Dust Suppression:

- Drop sheets, seal ducts, negative pressures, air locks and decontamination areas.

The Key to Controlling Mould
is
Controlling Moisture
