

## How to remove mould

### Influence of mould on health

Mould growth in an indoor space is a health risk, even without a quantitative and causal connection between the prevention of individual types of mould or certain biogenic contaminations and health problems could be determined with certainty.

Conversely, there are many population surveys that amply prove that people who have been exposed to mould in house are at greater risk for different conditions of the airways. Especially with children, mould increases the risk of asthmatic conditions. There are also signs that mould can be carcinogenic.

There are approximately 100.000 kinds of mould defined. Probably there are about 1.000.000 kinds of mould. Of which some, about 100 kinds, are really dangerous for healthy people. People with a good immune system can process the mould spores which are inhaled or consumed through food well. If the mould quantities increase it becomes worrying. Especially with people with a weakened immune system. On average, 25% of people has a weakened immune system. Mould does not belong in a human body.

Doctors and scientist are inconclusive, what is more dangerous: the mould or her toxin? What mould does is make dead organic material inorganic, this way they sustain different cycles of nature. But is you have a weakened immune system, then mould doesn't know if you're a branch in the woods or a sick person. Humans are also very good feeding grounds.

Almost every mould emits a toxin fitting for her kind. For *Aspergillus flavus* that is the carcinogenic Aflatoxin. Foods that contain more than 2 microgram Aflatoxin per kilogram ( $>2\mu\text{g}/\text{kg}$ ) can no longer be sold in the EU. For *Aspergillus ochraceus* that is Ochratoxin. And *Aspergillus fumigatus* and *Aspergillus niger* produce multiple toxins like Gliotoxin and Funigacine.

The mould family Penicillin, of which the well-known Penicilline is made, produces Citrinin and Patulin. The moulds *Fusarium* and *Mucor* are common on grain and in plants and produce Fumonisin, Vomitoxin and Zearalenon.

The very dangerous mould *Stachybotrys* produces multiple strong mycotoxins like Satratoxin, which damages the nervous system, causes lung bleeding and damages the mucous membrane.

Each of the approximately 400 mycotoxins known to date has its own specific effect. The health harmful mycotoxins which occur with moulds and mould spores stay active unchanged for many years, even after the mould has died. That is why it is so important to remove the mould and their spores very well and not just try to kill it with disinfectant.

Mycotoxins can, opposed to moulds itself, penetrate very deep into materials. That is why it is of great importance to remove the underlaying material on which the mould is present very well. Not just the wallpaper, but also the plasterboard where the wallpaper is stuck to has to be removed.

A big problem of moulds is that they are capable of creating a lot of spores. These spores float through the air, land on surfaces, get into house dust, are inhaled or swallowed and become new moulds under good circumstances. All microorganisms, which are seen as relatively harmless in normal quantities, can cause different allergic reactions.

The German Bundesgesundheitsministerium considers mycotoxins just as dangerous as pesticide. More and more research makes it clear that mycotoxins have very harmful effects on health.

In addition to damaging the skin, mucous membranes, organs, immune system and nervous system, almost all moulds are also carcinogenic. Especially liver, kidney and stomach cancer. In America the deadly victims of *Stachybotrys* are recorded. A lot of children die in Cleveland/Ohio of lung bleeding. The quantity of *Stachybotrys* spores in indoor air is usually 10x higher than in the outside air.

### **Assessment visible mould contamination**

Mainly mould spores in indoor air is caused by mould infected or contaminated materials. The assessment whether a mould contamination is small and not negative, is determined by the size and class of use. Small mould contaminations produce little biogenic harmful substances compared to large contaminations. Mould in a garage is less harmful than mould in a bedroom.

#### **Category 1, minor mould contamination**

Size of mould spot < 20 cm<sup>2</sup>, barely or very minor micro biogenic biomass. Taking immediate precautions is not necessary. The cause must be determined and precautions for removing the mould must be taken. Some examples of small mould contaminations are mouldy joints in bathrooms, windows and mould on soil of house plants.

#### **Category 2, minor to small mould contamination**

Size of mould spot < 50 cm<sup>2</sup>, deeper contamination only locally visible, small micro biogenic biomass.

The release of mould spores must be stopped quickly. The cause of the contamination must be found quickly. The mould contamination must be removed.

#### **Category 3, large mould contamination**

Size of mould spot > 50 cm<sup>2</sup>, deeper layers can also be infected. Large micro biogenic biomass. The release of mould spores must be stopped immediately. The cause must be found as fast as possible. The affected persons must be informed immediately. The remediation must be carried out by a specialist.

This division is not absolute and serves as an orientation. When assessing the situation on-site and environment are always of influence.

## **Measures with damage**

Firstly, the cause of the mould contamination must be found and removed. In almost all cases the cause of the mould growth is a leakage. It never is occupant behaviour. The use of biocides or another chemical substance is not necessary. If the mould and the mould spores are removed, nothing is left to be disinfected.

## **Classes of use**

The division of classes of use is important to determine the remedial works. The risk of the mould contamination is determined by the classes of use and with that is also determined which works must be carried out. Whether the mould contamination is in a living room, bedroom, garage, cavity wall or hospital, does not matter a lot.

### Class of use 1

Class of use 1 are spaces with special hygienic circumstances which are required for patients with a suppressed immune system. The necessary works for mould remediation are not described as it regards very specific measures like in hospitals.

Example: hospital, operation room.

### Class of use 2

Class of use 2 are spaces which are often or temporarily used. Think about living rooms, bedrooms and offices. But also storage rooms, dressing rooms, attics if these are situated next to living rooms or other rooms often used. These spaces are part of class of use 2 because mould spores travel easily to the living room.

The described works mainly relates to class of use 2.

Example: living rooms, offices, schools, day-cares, bedrooms.

### Class of use 3

Class of use 3 are for example cellar levels of flats or office buildings if these have a separate entrance. There cannot be a connection between both spaces.

A garage of a house is class of use 3 if this is separate from the house and class of use 2 if you can go to the house from the garage.

Attics which are only accessible through a hatch or closable door from within the stairwell are class of use 3. Stairwells in flats or office buildings are also class of use 3.

Example: not permanently used spaces of houses, offices and schools. Like cellars, storage rooms (if these don't have direct access), garages and stairwells.

### Class of use 4

Class of use 4 are spaces and cavities which are closed off and are air and diffusion proof. This is the case with complex roof structures. If the mould growth is located on the side of the living area that is closed off with a vapour barrier, simple measures are required. If the mould is located between the house and the vapour barrier, then first has to be examined whether the mould has moved to surrounding spaces.

Example: cavity spaces of roofs and walls.



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### **Remediation of small mould contamination**

Mould contamination smaller than a half square metre <math><0,5\text{m}^2</math> with a known cause can be removed by the user themselves if they are not allergic or have a weakened immune system. With larger mould contaminations it is important to hire a specialised firm.

*It is important to start immediately with the mould remediation so the contamination cannot spread. Very important is to work as dust free as possible with every mould remediation. This to prevent the spread of mould spores through the air. When cleaning with water, dry afterwards. Only use vacuum cleaners of an A-brand with a HEPA filter. With such a vacuum cleaner it is possible to go directly over the mould contamination. Swiping is always out of question because it brings dust with mould spores unnecessarily into the air.*

### **Measures which you can take yourself.**

- **Smooth surfaces.** With smooth surfaces like: tiles, glass, metal and tile joints it is sufficient to remove the contamination, the contaminated dust and other contaminations with water and a domestic cleaner. Renew rinse water multiple times to avoid a controlled division. In the bathroom mouldy silicon joints have to be renewed as these are not cleanable. Tenants need to indicate this to the lessor. Choose a special low-emission sanitary kit.

- **Porous surfaces.** Plastered or painted walls can be cleaned with an alcoholic 70-80% of other household cleaner (not cleaning vinegar) with a microfiber cloth. For these remediation works, a vacuum of an A-brand with HEPA filter can be used. The dust bag of the vacuum can be thrown out with the domestic waste. Ensure good ventilation when cleaning with alcohol. Concerning fire hazard only use small quantities. Do not smoke and don't have an open fire nearby.

- **Furniture.** Contaminated back walls of cabinets can be cleaned with moisture. Has the mould obviously penetrated into the material – for instance strongly mouldy or by moisture swollen particle boards – then throw away the furniture. To prevent the spread of mould spores the mouldy piece of the furniture can be taped off with foil. Solid wooden furniture is generally not thoroughly contaminated and can be cleaned.

- **Upholstered furniture.** A distinction has to be made between the mouldy furniture pieces where the mould grows upon and the furniture are in the same room and are secondarily contaminated. Mouldy upholstered furniture is very hard to clean because the mould can grow deep into the furniture. This furniture must be thrown out. Upholstered furniture which is not mouldy but is in the same room and therefore contaminated with mould spores, can be cleaned by intensively vacuuming with an A-brand vacuum cleaner with HEPA filter. The dust bag of the vacuum can be thrown out with the domestic waste.

- **Wallpaper and textile.** Mouldy wallpaper must be moistened and removed. Contaminated textile like curtains, bed linen and clothing must be removed carefully and washed multiple times in the washing machine on the highest possible temperature. Or have these cleaned chemically. Spots and odour cannot always be removed, in which case it must be thrown out.

### **Measures for specialised firms**

With small or middle large mould contamination (category 2) a specialised firm has to be hired. Especially when the mould has penetrated deep into the building material and the plaster has to be removed or if the cause of the mould contamination is unknown.

### **Remediation of a large mould contamination**

Remediation of a large mould contamination (category 3) must be carried out by a specialised firm. Specialised firms have the necessary expertise and the right equipment to execute the remediation well.

However, it can be necessary for the user of the space that immediate measures are carried out to bridge the time until the remediation works. Like shielding the space, ventilating or cleaning furniture (see immediate measures).

During the remediation it is absolutely essential to take personal precautions (see personal precautions).

#### The remediation process follows these steps:

- The execution of immediate measures (see immediate measures)
- Determination of the size of the mould damage, if possible by independent experts (see assessment size of the damage)
- Determination of the cause of the mould contamination (see determination of the cause)
- Removing the cause
- Executing the mould remediation:
  - Removing the mouldy materials (see removing of mouldy materials)
  - If necessary drying of building materials (see drying measures)
  - Cleaning the object after removing the contaminated materials. Especially removing dust (see cleaning after removing mouldy material)
- Inspection by independent experts (see inspection of the remediation)
- Construction (see construction)
- Inspection by independent experts (see measures after completion works)

The order can vary and is not compulsive. Before starting the remediation it has to be checked whether the processing of the contaminated materials can be carried out safely. And if the heightened mould exposure has to be taken into account. The risk inventory determines which precautions must be taken.

With mould growth in class of use 3 the damage circumference and cause are treated as class of use 2. Other points like immediate measures, removing the cause, executing the remediation up to the inspection can be assessed by the function of the space.

### Personal precautions

During the removal of the mouldy materials by which dust is released like chopping off plaster, high concentrations of dust and micro biogenic organisms are released. This can lead to health damage especially with long-term exposure or very high concentrations. The goal is, by choice of work method, to produce as least dust as possible so no mould spores are released.

Persons who remediate the mould have to protect themselves from infections, sensitising and toxic load of the mould.

<u>Measures</u>	<u>Category 1</u>	<u>Category 2</u>	<u>Category 3</u>
Closing off workspace	-	Dust-tight closure possibly with personnel lock	Dust-tight closure with personnel lock
Ventilation	-	If possible mechanical ventilation	Mechanical ventilation
Respiratory protection	-	Mouth mask with P2 filter	Full mask with respiratory support and P3 filter
Eye protection	With splash water or working overhead	With splash water or working overhead	Always
Dust clothes	-	Dust-tight clothes	Dust-tight clothes
Hand protection	Watertight gloves	Watertight gloves	Watertight gloves

### Selection of suitable precautions

- Work as dust free as possible
- Moisten the contaminated surfaces previously
- Use of machinery with integrated suction
- Use of mechanical ventilation with HEPA filters
- Use of industrial vacuum cleaners of dust class H

This means that major mould remediation works require similar precautions as with asbestos remediation. Close the space with dust partitions, place the space under negative pressure so no dust can escape, work with full respiratory protection.

### Immediate measures

With major mould contamination it can be necessary to take measures immediately. Especially because the remediation cannot be started immediately. By taking these measures the exposure to the user is reduced. The immediate measures depend on the class of use of the space and the duration of the stay in the space. In spaces with class of use 3 the importance of immediate measures is less important than in spaces with class of use 2.

### Immediate measures can be:

- Inform affected persons
- Restrict the duration of use of the space
- Prohibit the use of the space and close the contaminated space, seal the joints of the doors around with adhesive tape. Hang a sign: Forbidden entrance.
- Avoid transference of micro biologic particles, mould spores and dust. Leave contaminated goods or remove well packed.
- Seal the mould contamination with for instance foil. Be aware of condensation.
- Seal the mould contamination by painting over it with paint or varnish as intermediate solution.
- Clean contaminated, non-micro biological contaminated goods which can be removed from the space
- Place air cleaners with a HEPA filter or aerate the space if no movement of micro biological particles and mould spores to other spaces is possible.

### Assessment of the size of the damage

For a good competent mould remediation in class of use 2 and class of use 3 it is of great importance that an independent expert can determine the cause of the mould contamination. If the moisture and mould damage in a building is not found and removed competently, a good mould remediation is not possible. There remains a risk of consequential damage with negative effects on the user and building materials.

It is necessary to investigate where the moisture entered the building. Especially materials which are vulnerable to moisture like glued wood and plasterboards and the hollow spaces that are not immediately visible like shafts have to be inspected well.

When determining the moisture and the intensity, not only the path of the water in the liquid state must be examined, it must also be examined in the form of water vapour through the building construction. A leakage can be hidden and barely measurable. But a long-term humidity of approximately 70 % is sufficient for xenophilic mould types to sprout and grow.

### Determining the cause of the mould contamination

The causes of the moisture and mould problems must be found and removed. Construction defects must be repaired. Moisture damage must be dried as soon as possible to prevent mould growth. Detect a pipe leakage and repair competently.

A mould remediation always starts with removing the cause. Mould growth is not occupant behaviour. With normal occupancy it is not possible to produce that much moisture so mould growth occurs. There always is a third cause. And it almost always is a leakage like for example ground level zone, roof, wall, pipe (drainage, supply, heating, rainwater etc.).

### Removing the mouldy materials

It is important to remove the mouldy materials because the mycotoxins can penetrate deep into the material.

Before starting the removal of the mouldy materials it is important to have optimal work conditions and have taken safety precautions into account like the correct personal precautions. The area where the remediation will occur has to be sealed with dust partitions and there must be a technical aeration and ventilation in negative pressure. Just like asbestos remediation. There cannot be contamination to other surrounding spaces.

#### Important aspects when removing the mouldy materials are:

- During the removal of the mouldy materials large quantities of dust, mould spores and other micro biological particles can be released. The keep the dust formation as low as possible, materials can be moistened during the demolition works. The use of biocide is not necessary there the materials are removed. This applies to all classes of use.

- Light walls that are contaminated with mould like pre-walls which are often made from plasterboards, must be removed completely. The rule is that also the used insulation material, usually glass wool or rock wool, must be removed there these are also contaminated with mould spores. Minimally 40 cm from the visible mould contamination the wall must be removed. In some cases the easiest way is to remove the whole wall.

- When removing the finishing floor with the underlying contact sound and warmth insulation and when removing the metal stud walls (plasterboard and mineral wool) precautions must be taken to work dust free. For instance by moistening the to be removed materials. The working area must be brought into negative pressure like with asbestos remediation. No dust, mould spores or other micro biological particles can transfer to other surrounding spaces.

- If joints are affected after long-term moisture influence (salts, deterioration, saponification, softening) then the joints have to be removed. Use equipment with a HEPA filter.

- The exposed masonry or the concrete wall must be carefully vacuumed with an industrial vacuum cleaner class H and can be, if safely, be flamed.

- Mould growth on massive wooden beams can be removed by planing. Here also applies the rule that no dust can be released and sucking with HEPA filters is necessary.

- Released contaminated material must be packed airtight and removed by the shortest route through the building to a closed container.

#### Drying measures

*As fast as possible drying measures have to be started after water damage so the mould doesn't have the time to sprout and make the damage even larger. The mould spores are already there and are waiting for ideal conditions. In houses and buildings are good conditions present for mould growth. Temperature, ventilation, light, nutrients, acidity etc. all play a part. The most important cause of mould growth is water.*

*Water always penetrates a house through leakage. Form the ground level zone, roof, façade or pipe (all kinds). The occupants of a house or the users of a building cannot produce that much moisture that mould growth occurs. There is always a third cause.*





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*Are the construction materials contaminated with mould, care must be taken during the drying to ensure that the micro biological particles (mould spores, bacteria) are not released and moved. Precautions must be taken for countering the movement of mould spores, insulation fibres and other particles. If necessary, the space must be sealed with partitions and be placed under negative pressure.*

*The removal of the contaminated materials must be done before the drying!*

In all situations where the moisture damage is so large that it is not possible to dry by aeration and heating, drying with the help of technical aids like dehumidifiers is necessary. Depending on the temperature and the material, the drying after moisture damage takes multiple days or weeks. In This period mould growth must be taken into account.

Before installing the dryers, it must be determined where the moisture has penetrated and whether there is already a micro biological contamination. Drying isn't useful for: paper, wallpaper, wooden plates (OSB, multiplex, hardboard, softboards, etc.). Wet insulation must be removed. There are different methods for drying: condensational dryer, absorption dryer, infra-red transmitter. If the space is in use while drying, then only apply suction.

A technical drying is ready when the moist construction part is so far dried that no micro biological contaminations can occur. Drying can be measured. Measure the humidity during the drying. When the humidity does not reduce anymore, then further drying is useless.

### **Cleaning after removal of contaminated material**

*After removing the contaminated material it is necessary to execute a good cleaning of the surfaces of the concerning spaces. The use of biocide or other means to kill the micro biological contamination in the contaminated material is not necessary! This is not necessary before the cleaning.*

During the remediation, by rule, micro biological contaminated dust is released which causes contamination of the air and surfaces in the space. Therefore it is necessary to clean the space thoroughly before removing the dust partitions and such to prevent the exposure to mould spores and such which are released during the remediation.

The cleaning after the removal of the contaminated materials is a precision cleaning of all corners and edges. The goal of the cleaning is to remove all dust, mould and micro biological particles. The dust partitions and access lock are also included.

It is of importance to work cautiously so the cleaned surfaces are not secondarily contaminated by floating dust. The use of biocide or other means to kill micro biological contamination is not necessary there the mould particles are removed by vacuum cleaning and wiping.

### Important aspects for removing and cleaning the spaces well are:

- Difficult to access or hard to clean parts like radiators, acoustic ceilings, textile wall covering must be wrapped airtight before removing the contaminated materials. Just like asbestos remediation.
- Use a vacuum cleaner class H. Vacuum of class M are only to be used if the air can be directly transported outside.
- Wipe smooth surfaces like windows, doors and the dust partition of foil with a household cleaner.
- During the cleaning it is useful to use an industrial vacuum cleaner of class H as extra support to reduce the concentration of the floating mould particles and dust.
- It is important to also clean the dust partitions and aids before removing them to prevent contamination to surrounding spaces.
- The use of biocide or other means to kill micro biological contamination like atomisation is not necessary.
- All present materials need to be cleaned and made dust-free. This means that every little thing has to be cleaned, after that vacuum clean the floor, walls, ceiling and again the floor.

### Inspection of the remediation

After completion of the remediation works, the condition of the measures must be inspected and documented before removing the dust partitions, dust locks and other closing methods. The removal of the cause must be determined by inspection and supported by measurements. Depending on the cause, the right craftsmen must be hired who can inspect the work and who can indicate whether the seals of the building, the newly applied insulations and the repairs of the leakages, roof, façade or ground level zone are executed well.

To determine whether the technical drying is well done, measurements have to be taken and documented.

Before reconstruction can begin, the space must be inspected for the presence of mould spores. This can be done with adhesive samples which are examined in a specialist laboratory for moulds. If this inspection indicates that the space is clean, it can be released and constructional works can begin.

### Construction

The mouldy or damaged by remediation work surfaces and construction parts must be repaired. After the release of the space, work under normal circumstances can be done.

Be aware that the newly applied plaster is dry before painting, applying wallpaper or any other finish. This also applies to finishing floors, these must be dry before a new floor is applied.

### **Measure for completing the remediation**

Before all things can be placed back into the room, these must be cleaned very well so no micro biological contamination can be brought back into the room.

A few days after completing the remediation and placing all furniture, books and other things back into the room, it is useful to execute measurements of the air in the remediated space and surrounding spaces. The purpose of this measurement is to check whether all remediation works have been carried out properly. If a heightened concentration of mould spores is found in the remediated space or the surrounding spaces, then the space must be cleaned again. Wipe all things, vacuum everything with a vacuum cleaner with a HEPA filter, after which the floor, walls, ceiling and floor again must be vacuum cleaned again.

### **The use of biocides**

Disinfectant is per definition a measure where germs are killed to prevent infections. Disinfectant measures are taken for immune weak patients in hospitals. This is of importance in class of use 1, like hospitals and operation rooms. The measures and works for class of use 1 are not described here.

### **The effect of biocides with mould contamination**

The effect of biocides is determined in fixed laboratory test in situation that do not correspond to practice. Studies to the effect of biocides in practice show that in most cases there is no to very little effect. Even after there is a decrease of mould concentration with a biocide treatment, a few weeks later there was a higher mould concentration again.

Depending on the kind of mould and bacteria and the characteristics of the building material and factors like humidity and temperature, some kinds of biocides can slow down or diminish the growth of the mould. A significant reduction is not to be expected because the mould contamination is not removed by the biocide.

An exception is hydrogen peroxide (H<sub>2</sub>O<sub>2</sub>) is a high concentration > 10%. Hydrogen peroxide does kill moulds and bacteria. Use with mould is limited because of the highly oxidising function which can discolour materials strongly.

The use of vinegar solutions is discouraged with diffusion open building materials. Possibly a chemical reaction can occur and an extra nutrition source could be created.

### **Use of biocides with mould contamination.**

With a mould remediation in spaces from class of use 2 and 3 disinfection is not the purpose, the use of biocides is therefore not necessary.

During the remediation of micro biological damage a biocide treatment is not necessary, because this treatment is of minor importance to the targeted removal of the biomass and the remediation of the damage cause.

The use of biocide is not useful:

- If the moisture damage can be dried quickly
- Which visible mould on surfaces like wallpaper, plaster which can be removed with simple means.
- With a clear contamination, a biocide treatment will only reduce the concentration of colony forming units but won't affect the quantity of biomass and also the activity.

Mopping floors with biocide is not a durable remediation measure. There is no indication that a long-term inactivity of moulds and bacteria is reached.

There are few exceptions where a biocide treatment can be useful. For instance, when a material cannot be removed because it is part of a monument. Or when a fast drying is not possible. For example vaporising hydrogen peroxide in hard to reach hollow spaces like cavity walls.

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