

# **German guide for the prevention, investigation, evaluation and remediation of indoor mould growth ('mould guide')**

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## **ABSTRACT**

The German Federal Environmental Agency has published a 'mould guide', which aims at harmonizing procedures to investigate and evaluate indoor mould contamination.

The policy behind the guide is not to make a health assessment for every individual case based on the absolute number of fungi detected but to determine whether fungal growth is present indoors. The guide provides tables for assessing culturable and total fungi in indoor air samples compared to outdoor air samples with the aim of detecting sources of fungal growth. Classification of the fungal species present is considered more relevant than the mere concentration of fungi for this assessment.

If sources of fungal growth are detected in the indoor environment, the guide recommends remedial measures. Growth of fungi in indoor environments should be regarded as hygienic risk and should not be tolerated since epidemiological studies have clearly established the link between dampness and/or growth of fungi in indoor environments, and health risks of the occupants.

## **INDEX TERMS**

German mould guide; Microbial growth; Fungi; Mould; Source identification; Remedial measure

## **INTRODUCTION**

The exposure to filamentous fungi (the moulds) in indoor environments has become a growing concern over the last decade. The German Federal Environmental Agency has elaborated a 'mould guide', which presents recommendations on how to prevent, investigate, evaluate and eliminate indoor mould growth (Umweltbundesamt, 2002).

The guide is addressed to all persons in charge of preventing, investigating, evaluating and eliminating mould exposure from buildings. This includes experts from surveillance authorities (environmental, health and building authorities), several occupational groups (building experts, analysts, public health specialists and microbiologists), and building owners as well as building managers (property management, house-building associations, etc.).

The guide is basically limited to the problem of mould exposure in areas or buildings, which are 'naturally' ventilated, that means by opening doors and windows. The specific problems related to mechanical ventilation systems are only shortly addressed. Hospitals as well as indoor working areas related to production activities (such as waste recycling plants) are not dealt with.

The guide is organized as follows:

Part A gives background information on the characteristics of fungi and their occurrence in indoor air environments. The health effects caused by fungi and their metabolic-products are also addressed.

The issue of prevention of mould growth in buildings is discussed in part B. Advice is given regarding the proper way in which people should use their dwellings and how buildings should be constructed in order to prevent fungi from growing.

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Part C refers to the inspection of buildings for mould growth using harmonized methods. Assistance is given on how to assess the hygienic risk of mould growth. Measures to reduce its growth and to eliminate mould problems in the area concerned are indicated.

Part D presents appropriate ways to proceed in practice to investigate and evaluate indoor mould exposure by describing a number of case studies.

The intention of the guide is to harmonize (i) the methods for the detection and enumeration of fungi in indoor environments and (ii) the assessment of the hygienic risk of fungal growth and the subsequent need for remedial actions.

## **METHODS FOR DETECTION AND ENUMERATION OF FUNGI**

The guide gives recommendations on how to detect a source of fungal growth in indoor environments. The first step should always be a thorough professional inspection of the building or rooms followed, if necessary, by specific measurements. Harmonized methods for the detection of fungi in indoor air (culturable and total number) and on/in materials have been elaborated and are described in the guide. The data for the assessment scheme for culturable fungi are based on the following method: sampling by impaction followed by cultivation on DG 18- and Malt Extract Agar.

The methods for the enumeration of culturable fungi includes the classification of important fungi to the genus or species level. The classification is considered more important than the mere concentration of fungi. Especially the detection of species with pathogenic or toxic potential (*e.g. Aspergillus fumigatus, Aspergillus flavus, Stachybotrys chartarum*) or which indicate high moisture content (moisture indicators) is of importance.

## **ASSESSMENT OF INDOOR MOULD GROWTH**

The use of harmonized methods for the detection of fungi in indoor environments is the basis for an assessment of indoor mould growth. However, the task of evaluating the concentrations of fungi that have been measured is difficult because limit values based on health risk assessment are absent and fungi are naturally present in the environment.

Epidemiological studies conducted in several countries revealed that dampness and/or mould growth in dwellings and health problems affecting occupants are closely related. The health effects included irritations of the throat and eyes, allergies and asthma, as well as general symptoms such as tiredness, dizziness and headaches. Furthermore, in some single cases, the presence of moulds in dwellings has been identified as the cause of serious diseases.

However, no environmental epidemiological studies have enabled the establishment of a dose–response relationship between the measured concentrations of fungi and the registered health problems. Subsequently, these studies enable neither quantitative risk assessment nor the identification of standard values which set the ‘acceptable’ concentration of fungi in indoor environments.

Another problem is the natural occurrence of fungi in the environment. Fungi are active in the decomposition of organic substances and may be found in natural environments in rather high concentrations. These concentrations vary greatly over time and according to place. Even if no fungal growth has been detected indoors, fungi originating from outdoor air will always be present. As a consequence, in order to assess the concentration of fungi indoors, outdoor concentrations must always be taken into consideration.

Given the problems mentioned above, the aim of the ‘mould guide’ is not to derive individual health risk assessments based on the absolute number of fungi detected indoors but to determine whether sources of fungal growth can be found indoors recognizing environmental background concentrations.

If sources of fungal growth are detected in the indoor environment, remedial measures should be taken. The ‘mould guide’ gives general information on how to minimize or

eliminate the growth of fungi in indoor environments. Growth of fungi in indoor environments should be regarded as hygienic risk and should not be tolerated. Epidemiological studies have clearly established the link between dampness/growth of fungi in indoor environments and health risks of the occupants. Even if a dose–response relationship could not be derived, the precautionary principle should be applied.

### **Culturable Fungi in Indoor Air**

The most commonly used method to detect problems with moulds in indoor environment is the determination of culturable fungi in the indoor air. The ‘mould guide’ provides a harmonized enumeration method (see above) and a table for assessing the results in order to detect sources of fungal growth.

The table describes three concentration ranges for the assessment of culturable fungi in indoor air (see Table 1):

- background concentration range for fungal genera or species of significance;
- a transitory range in which the concentrations for fungal genera or species exceed the background level, which may indicate the presence of sources of indoor mould contamination;
- a concentration range which presents concentrations higher than those characterizing the transitory range. Levels in this range indicate the presence of an indoor contamination source with a high probability.

**Table 1** Assessment scheme for culturable fungi in indoor air samples.  
All three lines of the table have to be included for a comprehensive assessment

Parameter	Indoor source unlikely Background level	Indoor source possible Further investigations required	Indoor source probable Immediate further investigations required
<i>Cladosporium</i> and other genera which may reach high concentrations in the outdoor environment (sterile mycelia, yeasts, <i>Alternaria</i> , <i>Botrytis</i> ).	Concentration (cfu/m <sup>3</sup> ) of one genus in the indoor air is lower than 0.7–1.0 times the concentration in the outdoor air $I_{typ A} \leq A_{typ A} \times 0.7 (+0.3)$	Concentration (cfu/m <sup>3</sup> ) of one genus in the indoor air is lower than $1.5 \pm 0.5$ times the concentration in the outdoor air $I_{typ A} \leq A_{typ A} \times 1.5 (\pm 0.5)$	Concentration (cfu/m <sup>3</sup> ) of one genus in the indoor air is more than 2 times the concentration in the outdoor air $I_{typ A} > A_{typ A} \times 2$
Sum of the concentration for those species that are unlikely to occur in the outdoor environment	Concentration in the indoor air is not more than 150 cfu/ m <sup>3</sup> above the concentration in the outdoor air $I_{\Sigma untyp A} \leq A_{\Sigma untyp A} + 150$	Concentration in the indoor air is not more than 500 cfu/ m <sup>3</sup> above the concentration in the outdoor air $I_{\Sigma untyp A} \leq A_{\Sigma untyp A} + 500$	Concentration in the indoor air is more than 500 cfu/ m <sup>3</sup> above the concentration in the outdoor air $I_{\Sigma untyp A} > A_{\Sigma untyp A} + 500$
Concentration of one species that is unlikely to occur in the outdoor environment (!)	Concentration in the indoor air is not more than 50 cfu/ m <sup>3</sup> above the concentration in the outdoor air $I_{Euntyp A} \leq A_{Euntyp A} + 50$	Concentration in the indoor air is not more than 100 cfu/ m <sup>3</sup> above the concentration in the outdoor air $I_{Euntyp A} \leq A_{Euntyp A} + 100$	Concentration in the indoor air is more than 100 cfu/ m <sup>3</sup> above the concentration in the outdoor air $I_{Euntyp A} > A_{Euntyp A} + 100$

cfu, colony forming units; I, concentration in indoor air in cfu/m<sup>3</sup>; A, concentration in outdoor air in cfu/m<sup>3</sup>; *typ A*, species that are likely to occur in the outdoor environment; *untyp A*, species that are unlikely to occur in the outdoor environment (e.g. indicator species for dampness like *Acremonium* sp., *Aspergillus versicolor*, *A. penicillioides*, *A. restrictus*, *Chaetomium* sp., *Phialophora* sp., *Scopulariopsis brevicaulis*, *S. fusca*, *Stachybotrys chartarum*, *Tritirachium (Engyodontium) album*, *Trichoderma* sp.);  $\Sigma untyp A$ , sum of species that are unlikely to occur in the outdoor environment; *Euntyp A*, one species that is unlikely to occur in the outdoor environment; !, these concentrations apply to species with highly mobile spores. Lower concentrations have to be considered for species producing spores, which do not spread easily in the indoor air as well as for thermotolerant species.

A high level of expertise is required to use Table 1. Not only the concentration ranges but all information available—including the results of the building inspection—must be taken into consideration for an adequate assessment. Indeed, in some cases, the results obtained through the enumeration of culturable fungi may indicate that there is no presence of mould sources indoors in spite of existing damage.

### Total Fungi in Indoor Air

A corresponding table concerning the total number of fungi in indoor air is given in the ‘mould guide’ (Umweltbundesamt, 2002).

### Fungi on Materials

Investigation of fungi on or in contaminated materials gives information on the source and extent of the damage. Again, the classification of fungal genera and species is considered more important than the concentration of fungi. The mould guide provides a table to assess the extent of fungal growth and gives recommendations for remedial actions (see Table 2).

It is considered unnecessary to measure mould concentrations in indoor air when significant mould growth is clearly visible and the origin of the damage identifiable. In this case, remedial measures should directly be taken.

The extent of mould growth on materials is classified as follows (see also Table 2):

- *First category*: normal condition or very little damage. It is not generally necessary to take action.
- *Second category*: little to medium damage. The dissemination of fungal fragments must be stopped and the cause of the fungal growth must be located and eliminated.
- *Third category*: serious damage. The dissemination of fungal fragments must be stopped and the cause of the fungal growth must be immediately located and eliminated. The affected occupants should be properly informed and appropriate health checks are recommended. After the remediation has been completed, control measurements should be performed to evaluate the effects of the remedial actions.

**Table 2** Assessment scheme for mould growth on materials (see also text below)

	Category 1*	Category 2*	Category 3*
Extent of the damage (visible and non visible material damage)	No or very little biomass	Medium biomass	Large biomass
	Small damage on the surface <0.2 m <sup>2</sup>	Damage mainly restricted to the surface, <0.5 m <sup>2</sup> , deeper layers only locally affected	Large damage at the surface, >0.5 m <sup>2</sup> , deeper layers may be affected

The values given in Table 2 are not meant as absolute limit values. All additional information available must be taken into consideration for the classification of a damage as, for example, the following:

- Not only the surface extension of the mould damage but also the amount of fungi on the surface (colony growth versus growth covering the whole area) has to be considered.
- The spreading of fungal growth in deeper layers especially when cracks are present in the material should result in a classification in a higher category.
- The composition of the fungal species is also to be taken into consideration. The predominant occurrence of fungal species with pathogenic or toxigenic potential (such as *Aspergillus fumigatus*, *Aspergillus flavus*, *Stachybotrys chartarum*) should result in a classification in a higher category.
- One must differentiate between active growth and dried old damage or spore contamination. Detection of active growth may lead to a classification in a higher category.

## CONCLUSIONS AND IMPLICATIONS

The ‘mould guide’ of the German Federal Environmental Agency provides information on the prevention, investigation, evaluation and elimination of indoor mould growth. The policy behind the guide is not to make a health assessment for every individual case but to detect and eliminate sources of fungal growth in indoor environments. Fungal growth in buildings is considered as a potential health risk and should, therefore, not be tolerated (precautionary principle).

A high level of expertise is required to detect sources of indoor mould growth. The harmonized detection methods and assessment schemes presented in the guide will contribute to a more consistent detection and assessment of mould sources present indoors.

## REFERENCES

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