D.6.10 Instructions for adequate monitoring equipment for living quality assessment

Last updated 01.06.2021 by Max Maier

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This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 957175. The presented contents are the author's sole responsibility and do not necessarily reflect the views of the European Union. Neither the EASME nor the European Commission are responsible for any use that may be made of the information contained therein.

Contents

1. OVERVIEW

Deep retrofits offer the unique advantage to not only reduce energy consumption to sustainable levels and cover a large part of the residual demand with on-site RES but also implement a holistic improvement of the indoor environment. While improved air tightness and ventilation concepts reduce the carbon dioxide and humidity levels the improved thermal performance of the building fabric results in greatly increased inner surface temperatures. Ultimately the risk for mould is minimised and thermal comfort maximised. All this means health benefits, improved productivity and avoided spending in public health. The basic mechanism has been proven in a number of projects in detail, including measurements of thermal comfort according to EN ISO 7730. As the latter is immediately tied to the physical properties of the building envelope, which are subject to much attention in the design phase and verified in the field in the scope of the energy monitoring the activities shall focus on temperature, relative humidity, carbon dioxide levels and, if viable, spot checks on microbiological indicators of air quality. Microbiological sampling in external vs room air as well as on selected surfaces in ventilation systems (only after refurbishment) will give an insight into the aspects of indoor air quality that are not readily recorded with electronic sensors. The large number of projects in a wide geographical area that are investigated as demonstration projects of the outPHit project offer the unique opportunity to apply a uniform sampling and evaluation method and derive comparable results. UIBK will develop and document the methodology of sampling and evaluation. This will be applied by the local partners with the aid of laboratories that are subcontracted to this end. The results will be analysed and compared by UIBK and documented in a report. Data acquisition in the demonstration projects must ideally start an entire year before any refurbishment is carried out thus sampling an in-situ reference for the monitoring of the refurbished condition. Ways will be sought to come as close to this ideal as practically possible. As construction projects are frequently delayed or otherwise out of schedule deviations from the ideal might be unavoidable. In case the long-term monitoring equipment were not usable a set of stand-alone data loggers for temperature, relative humidity and carbon dioxide level will be procured and deployed. If possible a critical spot on the inner surface will be identified (visual inspection for mould, thermal imaging or educated guess) and either a data logger will measure temperature there for some time or, exterior conditions permitting, thermal images may be a source of a detailed record of that situation.

Within D.6.1 a pre- and post-monitoring process is defined and described. Because the measurement of air quality should be done simultaneously with the collection of energetic measurement data, this document refers on Deliverable 6.1 whereas the measurement of the air quality is depicted in more detail.

Table 1 provides an overview of the monitoring equipment for the measurement of the living quality in the outPHit project. It is intended to gather as much data and experience as possible about the observed buildings and the renovation process, also if not all of the described measures can be done.

Table 1: Overview equipment Monitoring of the living quality

Measured Value	Device / equipment	Remarks
Temperature **Relative air humidity** **CO_2 - concentration**	data logger or automated measurement system (post-monitoring)	Depicted in D.6.1
Air quality	Impact sampler/air sampler	
	Petri dishes (MEA, DG18)	4 per measure point + reference measurements (2 x MEA, 2 x DG18)
	Sellotape	
	Photo tripod	
	Forensic UV lamp	
Surface temperature	Infrared camera	
	Surface thermometer	

2. PREPARATION OF THE MONITORING

2.1. Measuring period

The most interesting period for the monitoring is during the heating season. Due to closed windows and cold outside temperatures the parameters of the air quality (temperature, CO_2-concentration, relative humidity) are probably the worst of the whole year. Also the measured data of the air quality could be merged and compared to energy consumption data. The preparation of the monitoring takes up to 2 to 3 months.

If data can only be gathered in the summer months, these values are also interesting when it comes to the evaluation of overheating and air quality.

To provide reliable data, a measuring period of six weeks is recommended for the pre-monitoring and as long as possible for the post-monitoring.

2.2. General Data Protection Regulation (GDPR)

The monitoring process includes the handling of personal data. Therefore the most time-consuming part of the preparation is a safe data handling process according to the General Data Protection Regulation (GDPR). The national implementation differ across Europe due to the national legislation. At least the following steps are assumed to be essential:

- **Agreement of tenants** and information (legal reason for processing personal data, example is attached)
    - Easy to understand
    - Explanation of the project
    - Purpose of gathering data
    - Inform about a responsible person in your company
    - Inform about the right to withdraw from the agreement
    - Ask for energy bills of the last years
- If more than one party handles the gathered data:
  Agreement on data security and data handling between parties
- Consultation of the **data protection officer** of your company
- Preparation of **data handling**
    - Storing data (protected, limited access)
    - Data exchange (only if necessary, protected)
    - Preparation of a document/Excel-file to document every step of data processing
    - Preparation of technical and organisational measures (TOMs)
- Information about **data breach process** in your company
- **Ensure individual rights** of affected persons
- Consider to **anonymise data** as soon as possible

2.3. Energy consumption data

To evaluate the buildings energy efficiency consumption data should be gathered. If the pre-monitoring takes place during the heating season, access to energy meters enable to merge the collected data of the room temperature and energy consumption. Therefore, the agreement of the tenants is mandatory (paragraph 2.2). The data could be collected by the property manager.

Annually (or better monthly) bills of the energy consumption (as many of the last few years as possible) can be requested in the letter to the tenants/owners to cover a large period of the building's energy performance.

2.4. Preparation of the equipment

Examples and requirements for the monitoring equipment are described in D.6.1. The shipping of the devices could take up to 2-4 weeks.

For the measurement of the air quality a microbiological laboratory is needed and should be contacted early.

3. TEMPERATURE, RELATIVE AIR HUMIDITY AND CO_2 – CONCENTRATION

Due to the upcoming renovation of the monitored buildings, standalone data loggers are considered to be most effective for the pre-monitoring. A logger that is independent of the electricity grid for a period of six weeks is recommended. At least one data logger for every measured unit (flat/apartment) of the building is needed. If more data loggers are available, more rooms of one unit of a building can be investigated at the same time.

To evaluate CO2-concentration, one more data logger is placed outside of the building to provide reference values. This logger must be placed at a dry and safe place (e.g. roof of a building entrance). If there is a nearby weather/climate station this data can also be used as a reference.

Figure 1 shows an example of a data logger that fulfils the requirements of the measurement. Data sheets and the user manual can be found attached. The listed price for one device is € 908.53 (excl. VAT).

Figure 1: Data logger: Humlog 20 TCO (company E+E Elektronik)

Table 2 shows the technical data of the data logger "Humlog 20 TCO" and the considered minimum accuracy for the monitoring. The accuracy of the Humlog 20 TCO is depicted as specified in the technical data sheet of the manufacturer.

Table 2: Technical data of data logger: Humlog 20 TCO

Measured Value	Unit	Sensor	Accuracy	Minimum accuracy
Temperature	[°C]	NTC	± 0,3	± 0,5
Relative humidity	[%]	capacitive	± 2	± 2,5
CO_2-conentration	[ppm]	NDIR	± (50 + 3 %)	± 50

The "Humlog 20 TCO" must be set up within the software "SmartGraph3". "SmartGraph3" can be downloaded as freeware here:
http://www.smartgraph3.de/DownLoad/
A manual for the software is included in the programme.

The following settings are recommended for the pre-monitoring:

Table 3: recommended settings for the pre-monitoring, using the "Humlog 20 TCO"

Setting	Value	remarks
Duration	6 weeks	If possible: During heating season
Power supply	Battery	Battery lifetime tested > 6 weeks No grid supply needed at measuring point Data does not get lost at the end of battery lifetime
Measuring point	On Cupboard in the bedroom	Room is used for a long time during sleep (CO_2-concentration)
Active Channel 1	Act. Temperature	SmartGraph3 -> Devices –> Manage Devices ->Storage Settings -> Select Active Channels
Active Channel 2	Act. Relative Humidity	SmartGraph3 -> Devices –> Manage Devices ->Storage Settings -> Select Active Channels
Active Channel 3	Act. CO2 Concentration	SmartGraph3 -> Devices –> Manage Devices ->Storage Settings -> Select Active Channels
Sample Interval	1 min	Open Window can be detected SmartGraph3 -> Devices –> Manage Devices ->Storage Settings
Store Interval	1 min	SmartGraph3 -> Devices –> Manage Devices ->Storage Settings -> Select Active Channels
Local altitude	Altitude of monitored building	SmartGraph3 -> Devices –> Manage Devices ->Information
Device mode	M3 Rec	Button on the backside of the device Press short to change mode, Press long to confirm
Clock	Sync Clock	Make sure that time is displayed right when starting the measurement (compare Figure 1: values for actual date and time instead of "Set time" on the bottom of the device should be displayed) SmartGraph3 -> Devices –> Manage Devices ->Sync Device Clock Icon

For the post-monitoring an automated and persistent measurement system is described in D.6.1. The accuracy of the sensors and their specifications should correspond to those of the standalone data loggers of the pre-monitoring.

3.1. Inside surface temperature - Infrared thermography

To evaluate the air quality and energy performance of buildings, the surface temperatures of the coldest spots (thermal bridges) can be recorded with an infrared camera. A significant difference between inside and outside temperature is essential for good measurements results.

If the accuracy of the thermal camera is considered too low to provide reliable data, the camera could be used to identify the coldest spots on the surrounding walls. Moreover a thermometer for surface temperatures can provide more accurate values.

The surface temperature and surface humidity are the decisive factors for mould. Therefore, room temperature and humidity (data logger) and surface temperature of the coldest spot of a room should be recorded at the same time.

4. AIR QUALITY – MOULDS, CULTIVABLE AIRBORNE FUNGAL SPORES

For the detection and enumeration of moulds in the air, a measurement according to “DIN ISO 16000-18: Sampling by impaction” is proposed. The entire measurement process and mandatory materials are depicted in the DIN ISO 1600-18.

To investigate moulds in the observed buildings, air samples must be evaluated in a microbiological laboratory. The necessary equipment and the date of the measurements should be discussed early in cooperation with the laboratory.

The air sampling can be done by the outPHit project partner himself, at the same time when installing/removing the data loggers. This reduces expenditure of the outPHit project partner and the expenditure of time for the tenants of the observed building.

A reference measurement of the outdoor air is mandatory each day. Furthermore, the surface temperature (thermography), room temperature and relative humidity (data logger) should be gathered at the same time. Additionally, a forensic UV-lamp can detect mould visually on the walls. Therefore, the room must be dark.

Inform the tenants that the windows of the evaluated rooms must have been kept close for 8h (as long as possible) before the measurement is taken.

Approximately up to 5 apartments can be measured per day.

The following measurement process can be used as an example.

4.1. Air sampling

Figure 2: Impact Sampler

- As many rooms as possible of a flat should be measured, at least the one that was equipped with a data logger for the monitoring
- Windows should have been kept close for as long as possible before the measurement (min. 8 hours)
- Place the photo tripod with the air sampler in the middle of the measured room (approx. 1 – 1,5 m above the floor)
- Flush air sampler, use an air volume of 50 l
- Repeat the following with 4 petri dishes (2 x MEA, 2 x DG18):
    - Insert petri dish (including nutrient medium)
    - Use a Volume of 100 l for one sample (approx. 3 minutes)
    - Label air sample: Name of sample, date, nutrient medium, air volume
- Transport samples not airtight (e.g. stacks of 4 corresponding samples, surrounded by sellotape)

4.2. Additional data

Figure 3: Picture of a measured dwelling

Note for every measured room:

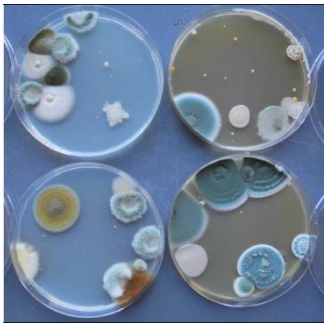
- Temperature and humidity
- Visible mould on walls (pictures and contact samples), use a UV-lamp for further detection
- Presence of plants
- Surface temperatures of walls (surface thermometer/Infrared camera), thermal bridges?
- Ask for visible humidity on surfaces (e.g. on windows)

4.3. Reference measurement

A reference measurement of the outdoor air is mandatory each day of an indoor measurement.

- Reference measurement should be taken at a dry place without influence of wind
- Additionally: Note the actual weather conditions (precipitation, wind, humidity, cloudiness)
- Use the same procedure as inside

4.4. Evaluation



(left) and MEA

The laboratory's evaluation should contain the following information that is summed up in a report:

- Germ density in colony forming units per type of mould
- A professional judgement if the measured concentration of mould and bacteria in the indoor air is an indicator for mould growth in the dwelling (compared to the outdoor reference measurement)

An example for a report will be provided for all project partners by UIBK.

5. APPENDIX

- Example of a report of a consulted laboratory

Outphit – Measurement of moulds, cultivable airborne fungal spores

Original report:

Author: Mag. Dr. Martin Kirchmair, University of Innsbruck

Language: German

Date: 27.05.2021

Translated: Max Maier, University of Innsbruck, 02.06.2021

Task description

The quality of the air with regard to spore contamination is to be assessed. For this purpose, air samples were taken on 19.04.2021, 21.04.2021 and 22.04.2021 from indoor areas and on all measurement days also from the outdoor air as a reference. The samples were taken by Mr. Max Maier (MEng) from the *Institut für Konstruktion und Materialwissenschaften of the University of Innsbruck*.

Methods

Air sampling

Air samples (indoor, reference: outdoor air) were collected using an MBASS30 air sampler on malt extract agar (MEA) and DG18 agar according to ÖNORM DIN ISO 16000-18 (*Innenraumluftverunreinigungen-Teil 18: Nachweis und Zählung von Schimelpilzen - Probennahme durch Impaktion*) (collection volume moulds 100l; collection height in the room approx. 1.5 m above floor level). The plates for the mesophilic moulds (MEA, DG18) were incubated at 25 °C for 7 days. The growing colonies can thus be observed. The colonies were counted as CFU = colony forming units.

Findings

The following germ densities of the air could be measured.

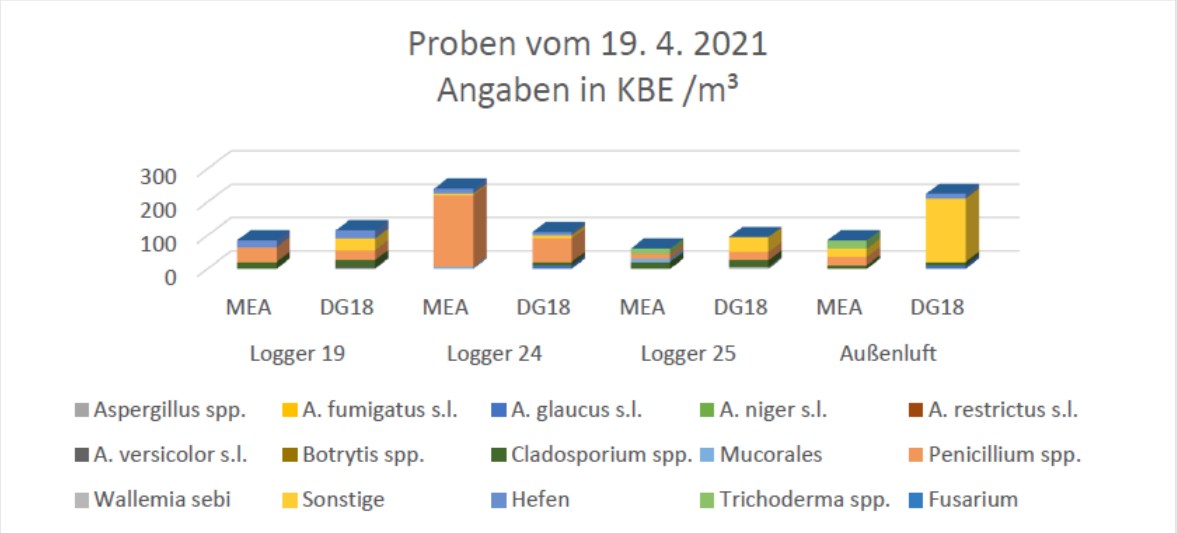
Samples, taken on 19.04.2021

Germ densities of the air (CFU/m^3). Noticeable values are printed in bold.

	Logger 19		Logger 24		Logger 25		Außenluft	
	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18
Aspergillus spp.	0	0	0	0	0	5	0	0
A. fumigatus s.l.	0	0	0	0	0	0	0	0
A. glaucus s.l.	0	0	0	10	0	0	0	10
A. niger s.l.	0	0	0	0	0	0	0	0
A. restrictus s.l.	0	0	0	0	0	0	0	0
A. versicolor s.l.	0	5	0	0	0	0	0	0
Botrytis spp.	0	0	0	0	0	0	0	0
Fusarium spp.	0	0	0	0	0	0	0	0
Cladosporium spp.	20	20	0	10	20	20	10	10
Mucorales	0	0	5	0	10	0	0	0
Penicillium spp.	45	30	**215**	**70**	15	25	25	0
Trichoderma spp.	0	0	0	0	15	0	25	0
Wallemia sebi	0	0	0	0	0	0	0	0
Sonstige	0	35	5	10	0	45	25	190
Hefen	20	25	15	10	0	0	0	15
Gesamt	85	115	240	110	60	95	85	225

Germ density of the air (% of the overall germ density).

	Logger 19		Logger 24		Logger 25		Außenluft	
	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18
Aspergillus spp.	0,0	0,0	0,0	0,0	0,0	5,3	0,0	0,0
A. fumigatus s.l.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
A. glaucus s.l.	0,0	0,0	0,0	9,1	0,0	0,0	0,0	4,4
A. niger s.l.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
A. restrictus s.l.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
A. versicolor s.l.	0,0	4,3	0,0	0,0	0,0	0,0	0,0	0,0
Botrytis spp.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Fusarium spp.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Cladosporium spp.	23,5	17,4	0,0	9,1	33,3	21,1	11,8	4,4
Mucorales	0,0	0,0	2,1	0,0	16,7	0,0	0,0	0,0
Penicillium spp.	**52,9**	**26,1**	**89,6**	**63,6**	**25,0**	**26,3**	29,4	0,0
Trichoderma spp.	0,0	0,0	0,0	0,0	25,0	0,0	29,4	0,0
Wallemia sebi	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Sonstige	0,0	30,4	2,1	9,1	0,0	47,4	29,4	84,4
Hefen	23,5	21,7	6,3	9,1	0,0	0,0	0,0	6,7
Gesamt	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0



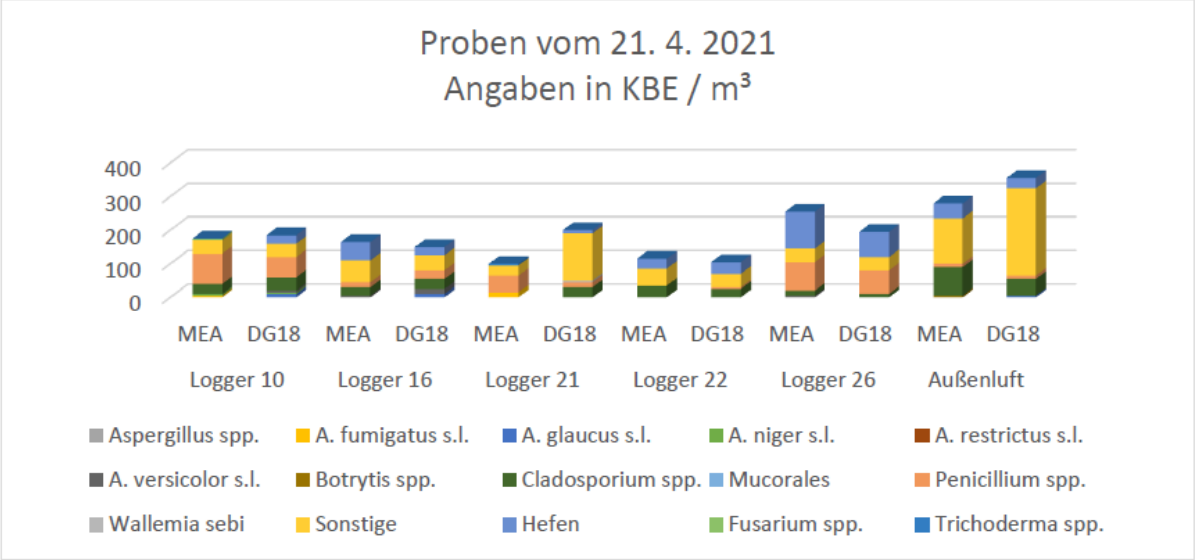
Samples, taken on 21.04.2021

Germ densities of the air (CFU/m^3). Noticeable values are printed in bold.

	Logger 10		Logger 16		Logger 21		Logger 22		Logger 26		Außenluft	
	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18
Aspergillus spp.	0	0	0	0	0	0	0	0	0	0	0	0
A. fumigatus s.l.	5	0	0	0	15	0	0	0	0	0	0	0
A. glaucus s.l.	0	10	0	10	0	0	0	0	0	0	0	5
A. niger s.l.	5	5	0	0	0	0	0	0	0	0	0	0
A. flavus	0	0	0	0	0	0	0	0	0	0	0	0
A. restrictus s.l.	0	0	0	0	0	0	0	0	0	0	0	0
A. versicolor s.l.	0	5	5	15	0	0	0	0	5	0	0	0
Botrytis spp.	0	0	0	0	0	0	0	0	0	0	5	0
Fusarium spp.	5	0	0	0	0	0	0	0	0	0	0	0
Cladosporium spp.	30	40	25	30	0	30	35	25	15	10	85	50
Mucorales	0	0	0	0	0	0	0	0	0	0	0	0
Penicillium spp.	**90**	**60**	**15**	**25**	**50**	**15**	0	5	**85**	**70**	10	10
Trichoderma spp.	0	0	0	0	5	0	0	0	0	0	0	0
Wallemia sebi	0	0	0	0	0	5	0	0	0	0	0	0
Sonstige	40	40	65	45	30	140	50	40	40	40	135	260
Hefen	0	25	55	25	0	10	30	35	110	75	45	30
Gesamt	175	185	165	150	100	200	115	105	255	195	280	355

Germ density of the air (% of the overall germ density).

	Logger 10		Logger 16		Logger 21		Logger 22		Logger 26		Außenluft	
	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18
Aspergillus spp.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
A. fumigatus s.l.	2,9	0,0	0,0	0,0	15,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
A. glaucus s.l.	0,0	5,4	0,0	6,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,4
A. niger s.l.	2,9	2,7	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
A. restrictus s.l.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
A. versicolor s.l.	0,0	2,7	3,0	10,0	0,0	0,0	0,0	0,0	2,0	0,0	0,0	0,0
Botrytis spp.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,8	0,0
Fusarium spp.	2,9	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Cladosporium spp.	17,1	21,6	15,2	20,0	0,0	15,0	30,4	23,8	5,9	5,1	30,4	14,1
Mucorales	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Penicillium spp.	**51,4**	**32,4**	**9,1**	**16,7**	**50,0**	**7,5**	0,0	4,8	**33,3**	**35,9**	3,6	2,8
Trichoderma spp.	0,0	0,0	0,0	0,0	5,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Wallemia sebi	0,0	0,0	0,0	0,0	0,0	2,5	0,0	0,0	0,0	0,0	0,0	0,0
Sonstige	22,9	21,6	39,4	30,0	30,0	70,0	43,5	38,1	15,7	20,5	48,2	73,2
Hefen	0,0	13,5	33,3	16,7	0,0	5,0	26,1	33,3	43,1	38,5	16,1	8,5
Gesamt	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0



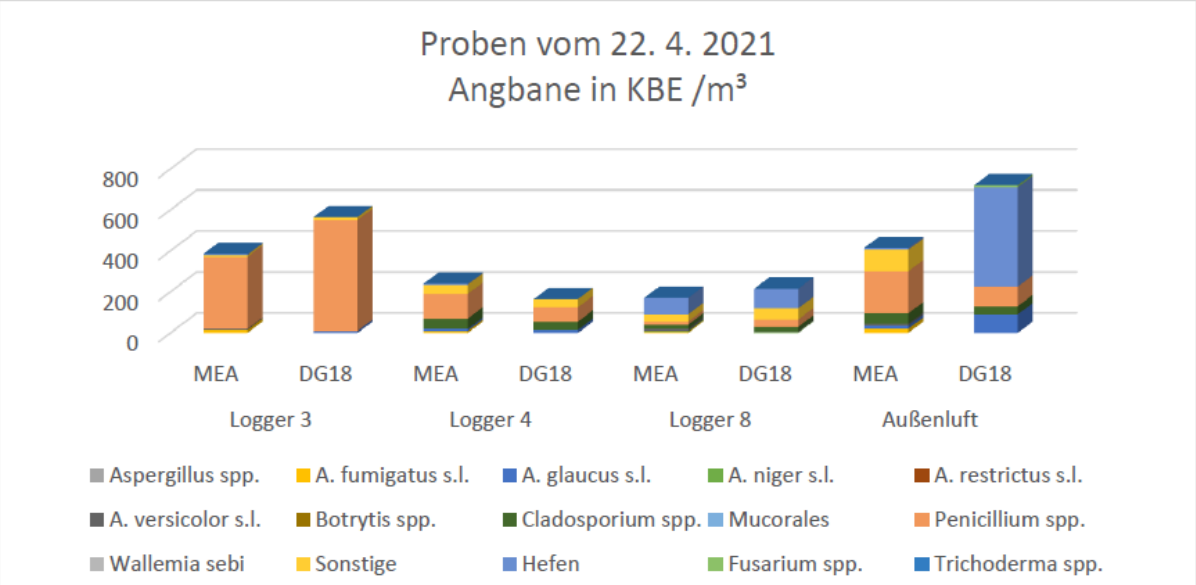
Samples, taken on 22.04.2021

Germ densities of the air (CFU/m³). Noticeable values are printed in bold.

	Logger 3		Logger 4		Logger 8		Außenluft	
	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18
Aspergillus spp.	0	0	0	0	0	0	0	0
A. fumigatus s.l.	15	0	10	0	5	0	20	0
A. glaucus s.l.	0	10	10	15	0	0	15	90
A. niger s.l.	0	0	0	0	5	5	0	0
A. restrictus s.l.	0	0	0	0	0	0	0	0
A. versicolor s.l.	5	0	0	0	10	5	10	0
Botrytis spp.	0	0	0	0	0	0	0	0
Fusarium spp.	0	0	0	0	0	0	0	10
Cladosporium spp.	0	0	50	40	20	20	50	40
Mucorales	0	0	0	0	0	0	0	0
Penicillium spp.	**350**	**540**	120	70	15	35	205	95
Trichoderma spp.	0	0	0	0	0	0	0	0
Wallemia sebi	0	0	0	0	0	0	0	0
Sonstige	10	15	45	40	35	55	105	0
Hefen	5	0	5	0	80	95	10	485
Gesamt	385	565	240	165	170	215	415	720

Germ density of the air (% of the overall germ density).

	Logger 3		Logger 4		Logger 8		Außenluft	
	MEA	DG18	MEA	DG18	MEA	DG18	MEA	DG18
Aspergillus spp.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
A. fumigatus s.l.	3,9	0,0	4,2	0,0	2,9	0,0	4,8	0,0
A. glaucus s.l.	0,0	1,8	4,2	9,1	0,0	0,0	3,6	12,5
A. niger s.l.	0,0	0,0	0,0	0,0	2,9	2,3	0,0	0,0
A. restrictus s.l.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
A. versicolor s.l.	1,3	0,0	0,0	0,0	5,9	2,3	2,4	0,0
Botrytis spp.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Fusarium spp.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	1,4
Cladosporium spp.	0,0	0,0	20,8	24,2	11,8	9,3	12,0	5,6
Mucorales	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Penicillium spp.	**90,9**	**95,6**	50,0	42,4	8,8	16,3	49,4	13,2
Trichoderma spp.	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Wallemia sebi	0,0	0,0	0,0	0,0	0,0	0,0	0,0	0,0
Sonstige	2,6	2,7	18,8	24,2	20,6	25,6	25,3	0,0
Hefen	1,3	0,0	2,1	0,0	47,1	44,2	2,4	67,4
Gesamt	100,0	100,0	100,0	100,0	100,0	100,0	100,0	100,0



Expertise

At the sampling points Logger 3, Logger 10, Logger 24 and Logger 26 a clearly increased spore load especially of *Penicillium spp.* could be detected. Comparing the spore load of *Penicillium* with data from measurements of recent years, a medium but clear load of fungal spores is given (Kirchmair M. 2020; Mycoses 61, Sl Suppl. 1, p.4). At the sampling points Logger 16, 19 and 21 a slightly increased load of spores of Penicillium spp. was detectable.

Prerequisites for mould growth

In addition to the suitable substrate and temperature range, moulds also require special moisture conditions in or on the substrate for their growth. Thus, completely different moulds grow under very moist conditions than under dry conditions. The moisture requirements of fungi are usually expressed in terms of water activity (=aW-value). Here, aW=1 corresponds to a relative humidity of 100% above the substrate. An aW of 0.7 therefore means 70% relative humidity above the substrate.

Schimmelpilzart	Minimale aW-Werte
Wallemia sebi	0,69-0,75
Aspergillus restrictus	0,71-0,75
Aspergillus versicolor	0,78
Penicillium chrysogenum	0,78-0,81
Aspergillus fumigatus	0,85-0,94
Cladosporium cladosporioides	0,86-0,88
Fusarium solani	0,87-0,90
Rhizopus stolonifer	0,93
Stachybotrys chartarum	0,94
Hefen	>0,9

Quelle: Northolt, Frisvad, Samson (1995): Occurrence of food-borne fungi and factors for growth. In:Samson et al. (ed.) Introduction to food-borne fungi., CBS, Baarn, NL

Possible health impairments due to mould infestation

There are a lot of half-truths on the Internet regarding mould. Although effects on health are conceivable and mould infestation must be remediated properly, scaremongering is not appropriate.

In principle, the following health impairments are possible:

i. Infections

Various moulds can cause superficial ("fungus parasitic on the skin") or deeper infections (e.g., aspergillosis). Fungus parasitic on the skin are usually not associated with indoor mould infestations. Moulds that cause deeper infections, e.g. of the lungs, must be able to grow at least at 37°C (body temperature). Various *Aspergillus* species (e.g. A. *fumigatus*) are considered to be the most common pathogens in this case. In the vast majority of cases, such infections affect persons with weakened immune systems. No evidence of an increased incidence of *Aspergillus fumigatus* or other opportunistically pathogenic moulds could be found. **A possible risk from infections is therefore very unlikely.**

ii. Poisoning

Various moulds can produce very potent toxins. These poisons are most effective when ingested orally (eaten). Indoors, inhalation of airborne particles (spores and other fungal constituents) does not reach concentrations of fungal toxins that are expected to pose a health hazard. Although there are repeated claims on the Internet that special molds (e.g. *Stachybotys chartarum*) can lead to poisoning via the respiratory tract, this has repeatedly been clearly refuted. **Poisoning therefore does not count as a health hazard from moulds.**

Often mentioned in this context is the "organic dust toxic syndrome (ODTS)", which can lead to clinical symptoms such as fever, muscle pain, chills, chest tightness or headaches when inhaling organic dusts. **Indoors, concentrations that trigger ODTS are rarely reached, even in the presence of significant mould infestation.**

iii. Allergic reactions

Like all organic particles, components of moulds can cause allergies. It must be noted here that there is no dose-response relationship here. Even low concentrations can trigger allergic reactions in people who are sensitive to them. Whether allergies are present can be determined by appropriate allergological examinations by specialists.

Essentially, the following reactions are possible in the case of moulds.

(a) Type I allergies (immediate reactions).

These would be typical hay fever symptoms (sneezing, burning eyes, etc.), but also rashes or conjunctivitis. Whether such an allergy is present can be determined by allergists using RAST or prick tests.

(b) Type III allergies (exogenous allergic alveolitis)

In chronic cases, this can lead to a scarring of the lung structure, resulting in permanent respiratory problems. **This form of allergy is relatively rare in indoor mould infestation.**

iv. Immunomodulatory effect

There is evidence that increased exposure to moulds, their constituents, or their metabolites may increase susceptibility to various diseases. However, the evidence base here is relatively poor. To my knowledge, clear evidence has not yet been found.

Odours that can be generated by the growth of microorganisms are not directly hazardous to health, but very annoying. Little is known about the exact impact of volatile substances (MVOC: microbiological volatile organic compounds) on health. The perception of unpleasant odours is very individual. Not everyone always perceives these annoying odours in the same way. Especially constantly perceivable odours can be very stressful for the occupants of the affected premises and lead to stress symptoms. Odour nuisances must therefore be taken seriously - even if they are only perceived by individuals.