Indoor Air Quality Monitoring

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Indoor Air Quality Facts & Figures

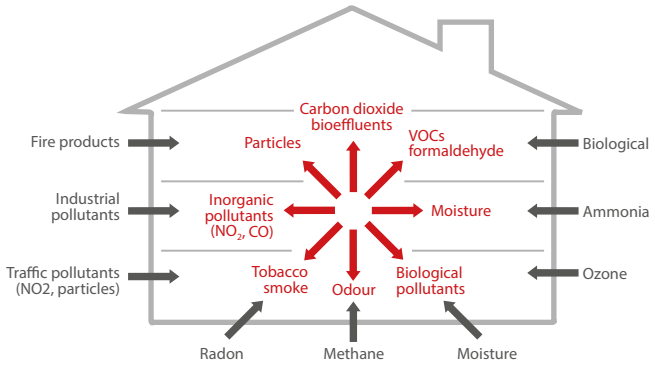
Air pollutants are important risk factors for various diseases such as allergies, heart disease, lung cancer and respiratory infections.

Air pollutants & their sources

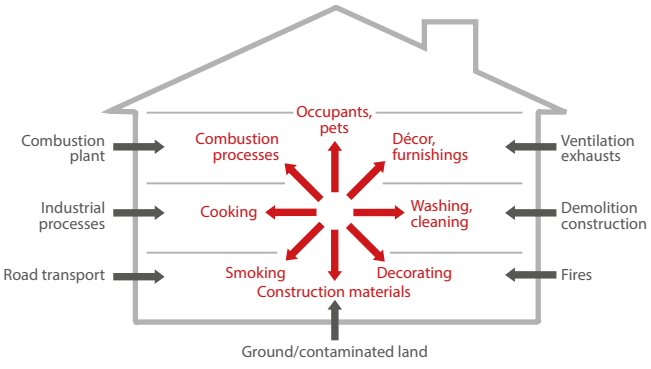
- Spores
- Germs
- Pollen
- Dust
- Microbes
  bacteria, viruses & microorganisms
- Carbon Dioxide

Air pollutants around us are generated through external and internal factors.

For instance, pets and humans living indoors, as well as activities such as cooking, washing and cleaning, smoking are the internal pollutant sources, while cars and factories are the most known external pollutants affecting the indoor air quality.



External and internal pollutants



Sources of pollutants affecting IAQ

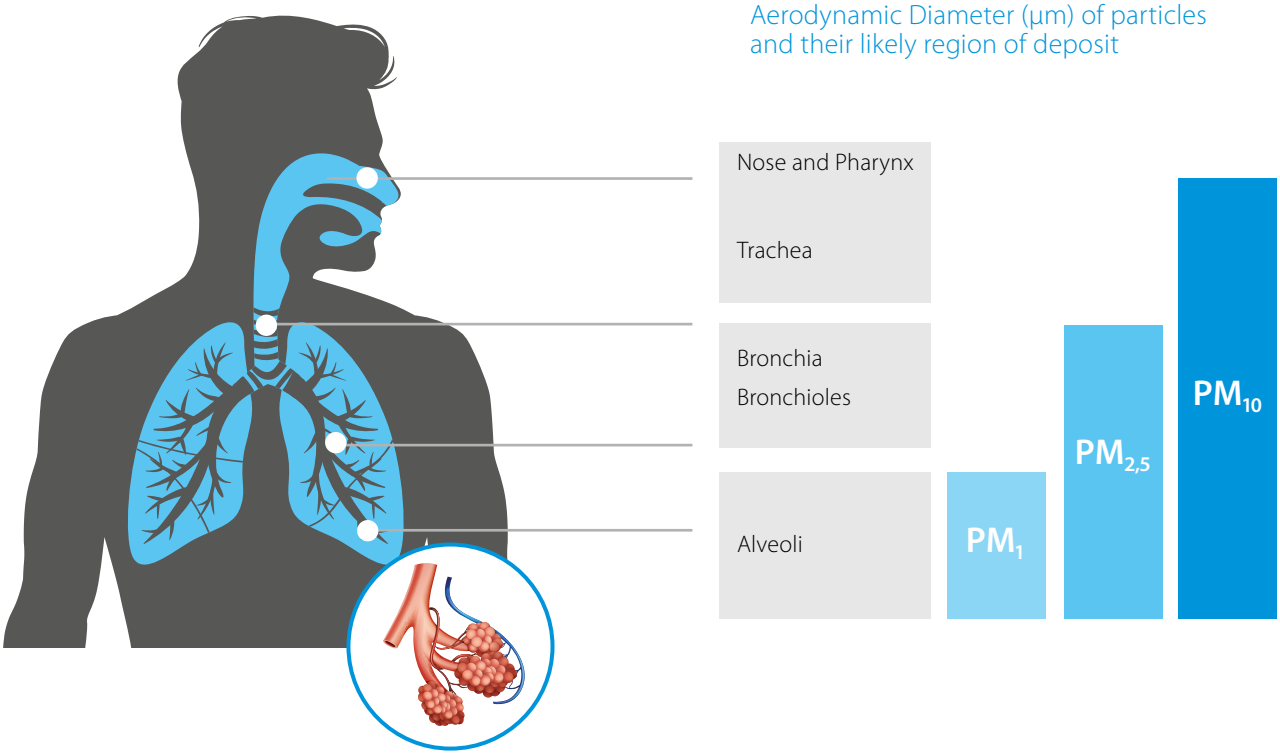
- external pollutants
- internal pollutants

Particulate Matter

While breathing, we expose our lungs to various invisible pollutants which are called particulate matter (PM).

Particulate matter are categorized based on their size. PMs can be as big as a human hair or as small as a virus. The smaller the particle, the more dangerous for our health.

Pollutants can go deep into the human body

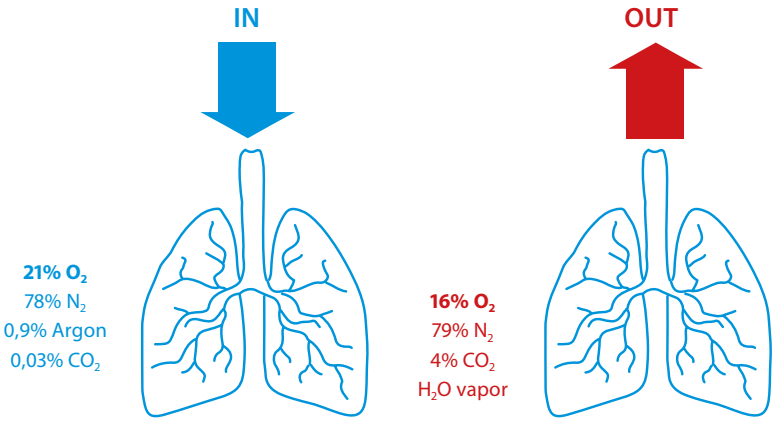


Why is air supply in a closed room essential?

Humans need fresh air to survive:

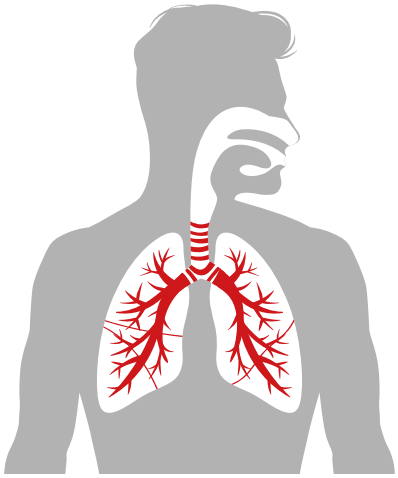
› An adult male is breathing typically 8 litres per minute
(in 16 in/ex-hale movements) or 11.000 litres per day
› Oxygen consumption: 250~350 ml/min

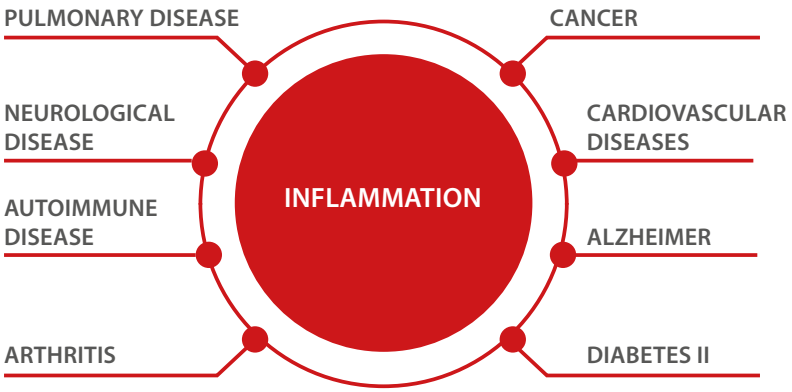
Low levels of oxygen concentration in an indoor environment or high CO_2 concentration levels can lead to drowsiness, headaches, poor concentration and even to increased heart rates.



How pollution is impacting our lives

Long term exposure causes a constant inflammatory state and toxicity





Carbon dioxide

A high concentration can displace oxygen in the air. If less oxygen is available to breathe, symptoms such as rapid breathing, rapid heart rate, clumsiness, emotional upsets and fatigue can result. As less oxygen becomes available, nausea and vomiting, collapse, convulsions, coma and death can occur.

Carbon monoxide

Breathing CO can cause headache, dizziness, vomiting, and nausea. If CO levels are high enough, you may become unconscious or die. Exposure to moderate and high levels of CO over long periods of time has also been linked with increased risk of heart disease.

Oxides of nitrogen (NOx)

Low levels of oxides of nitrogen can irritate eyes, nose, throat and lungs, possibly leading to coughing, shortness of breath, tiredness and nausea. Exposure can also result in a build up of fluid in the lungs for 1-2 days after exposure.

Formaldehyde

When formaldehyde is present in the air at levels exceeding 0.1 ppm, some individuals may experience adverse effects such as watery eyes; burning sensations in the eyes, nose, and throat; coughing; wheezing; nausea; and skin irritation.

Pollen

Short-term pollen exposure significantly increases the risks of allergic and asthmatic symptoms.

…and many more!

Typical health impacts of some common pollutants found indoors

Pollutant	Impact on health
Carbon monoxide (CO) & dioxide (CO_2)	Carbon monoxide & dioxide can **cause headaches, dizziness, nausea and at very high levels, death.** Elderly people, pregnant women, young children and people with **heart disease and lung disease** are more sensitive to the adverse effects of carbon monoxide & dioxides.
Formaldehyde (VOC)	Formaldehyde can cause **eye, nose and throat irritation** and is considered a potential human **carcinogen** (substances which causes **cancers**).
Nitrogen dioxide (NO_2)	Exposure to nitrogen dioxide can cause inflammation of the **airways, respiratory illnesses and possibly increases the risk of lung infections.** Young children and people with asthma are the most sensitive to NO_2. It plays a major role in the development of chronic obstructive pulmonary disease in adults which will affect more people than heart disease by 2020 (Environmentalist 2012). Long-term exposure may also affect lung function and can enhance responses to allergens in sensitised individuals.
Odour	Odorous discharges are subjective and cause **nausea and irritation** for some people.
Ozone (O_3)	Ozone exposure can cause **asthma**, irritation and **damage to the eyes, nose and airways.** Prolonged exposure to high levels may result in **damage to the lungs and airway linings.**
Particulate matter (PM)	Inhalable particles have been linked with a number of **respiratory illnesses, including asthma and chronic bronchitis**. Long-term exposure to fine particles can cause **premature death from heart disease and lung disease, including cancer**. Short-term exposure to higher levels of fine particle concentrations have also been linked with **cardio-vascular problems** and increased death rates. Exposure to fine particles has also been linked to prevalent **anxiety and hypertensive disorders.**
Volatile organic compounds (VOCs)	Key symptoms associated with exposure to VOCs include **eye irritation, nose and throat discomfort, headache and allergic skin reaction.**

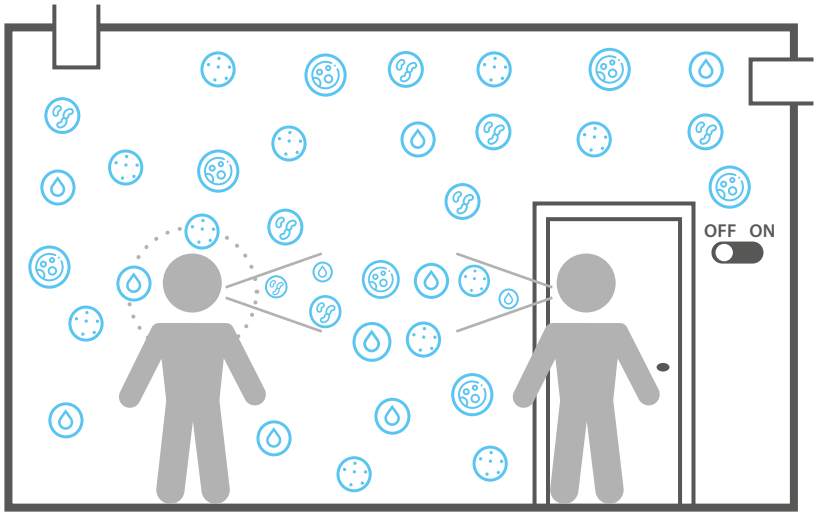
Particulate matter (PM) as virus carrier

Viruses require a carrier to move around within a room. Particulate matter such as cough or sneeze droplets are potential carriers for viruses.

Small droplets are more dangerous since they are more likely to hang (suspend) in the air. It therefore makes them the perfect carriers for the virus. Larger droplets are heavier and will fall down with gravity or deposit on surfaces.

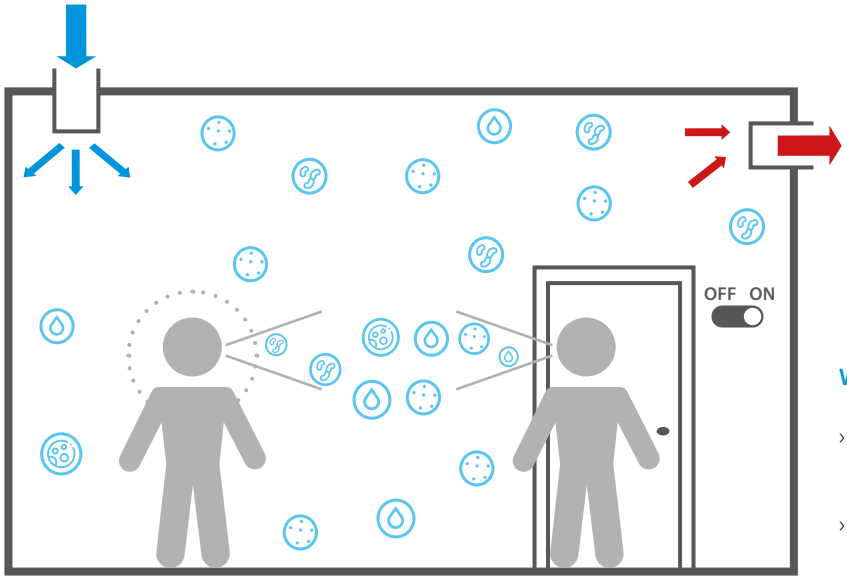
Source: Dynamics of respiratory droplets carrying SARS-CoV-2 virus in closed atmosphere, Results in Physics, ELSEVIER. https://www.sciencedirect.com/science/article/pii/S2211379720319392

Reducing the particulate matter indoors will lower the chances for viruses to find a carrier & travel within the room.



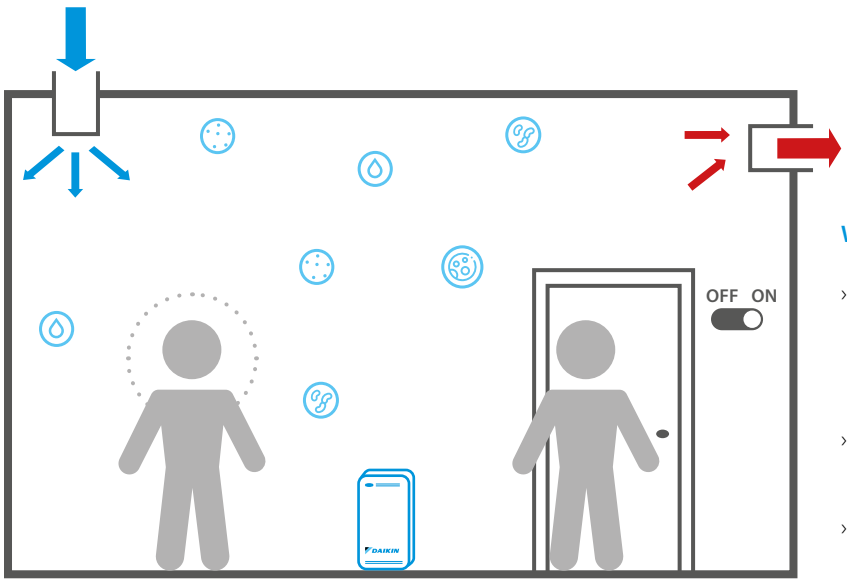
Without ventilation, Without air purifiers

› Various invisible particles and respiratory droplets will be floating in the room when there is no active ventilation system running or no windows are frequently opened to allow fresh air circulation.
› Without adequate ventilation, CO_2 concentration levels will also be high.



With ventilation, Without air purifiers

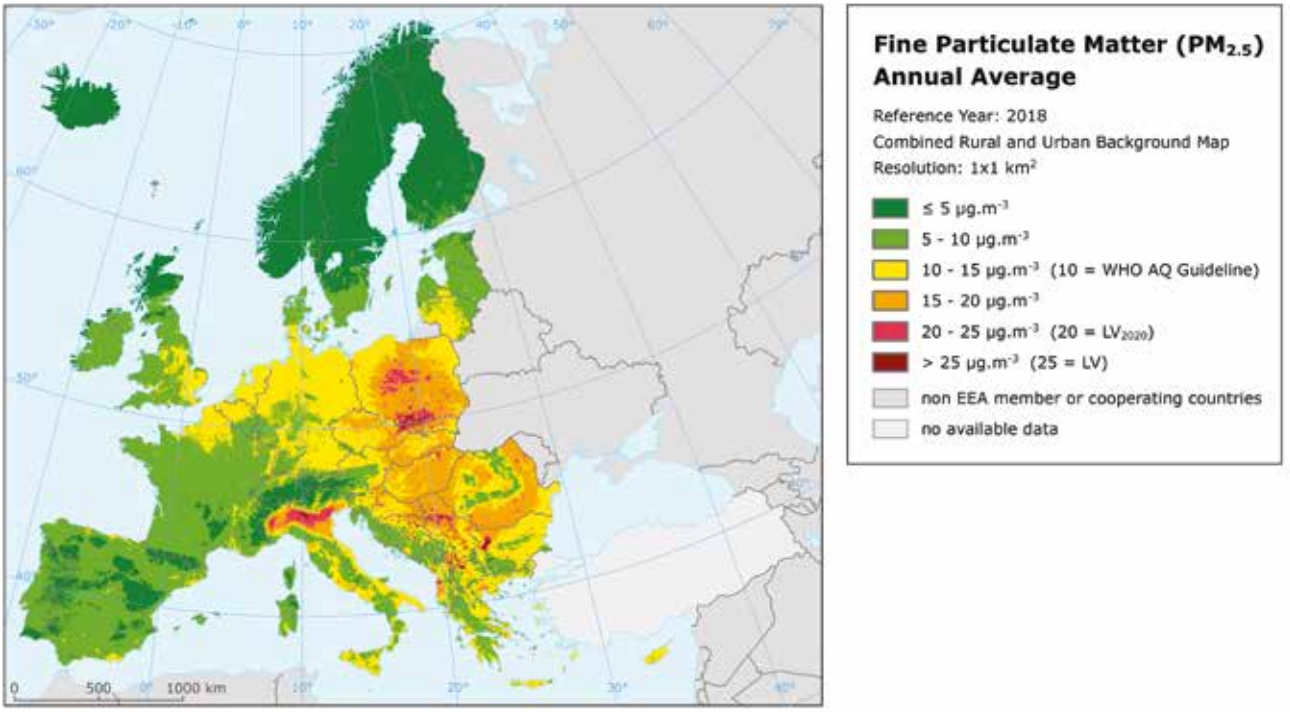
› Through ventilation (fresh air supply and elimination of stale air) less particulate matter will be present in the room.
› CO_2 concentration levels will be reduced.



With ventilation, With air purifiers

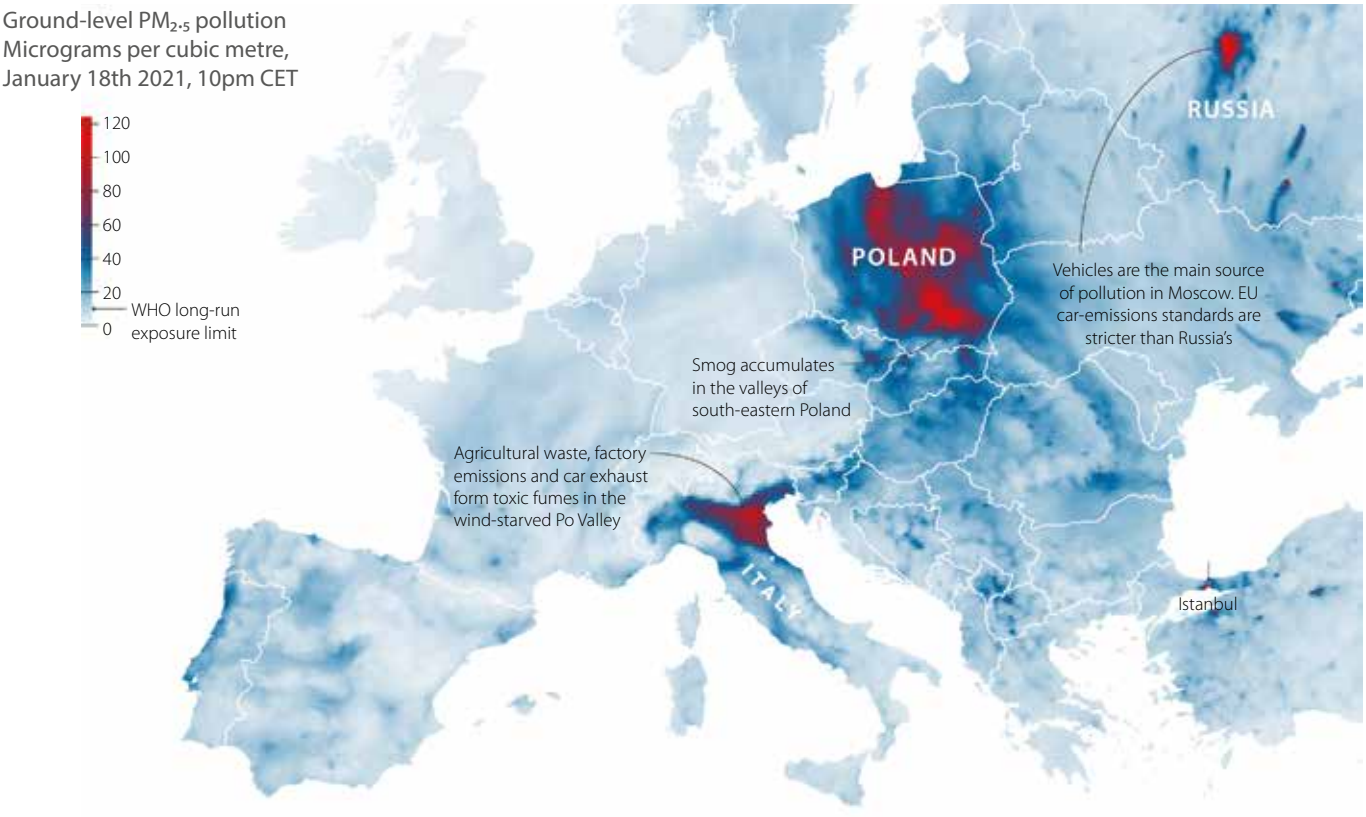
› When proper ventilation (either via a ventilation system or opening the windows frequently) is complemented with air purifiers, the amount of particulate matter in the room will reduce even more.
› CO_2 concentration levels will still be low thanks to the ventilation. Air purifiers do not have an effect on CO_2 levels.
› Proper ventilation and air purification solutions are key to reach high indoor air quality.

Air Quality in Europe



Source: European Environment Agency (EEA); https://www.eea.europa.eu/

Coal-fired home heating creates widespread pollution



Source: https://www.economist.com/graphic-detail/2021/01/30/polands-coal-fired-home-heating-creates-widespread-pollution

Why is Indoor Air Quality so important?

› In average, **people spend 90% of their lives indoors.**

› The level of **indoor pollutants** can be **2 – 5 times higher** than outdoor levels.

› Some **indoor pollutants can be 100 times more damaging** than outdoor equivalents.

› Indoor air pollution can lead to serious **health problems** in short & long-term.

› WHO data shows that **4.3 million people die annually** because of substandard IAQ.

› Poor air quality results in a **loss of productivity** estimated to be worth tens of billions Euro worldwide.

› IAQ becomes more and more part of the experience in **stores, hotels, public and commercial buildings** but also **a growing concern for customers and visitors.**

› Invisible particulates within a room can be the carrier for viruses, increasing the transmission risks.

What is good Indoor Air Quality?

IAQ Standards: WHO & EN 16798

European air quality standards and World Health Organisation guideline values for particulate matter

The main air quality standards for particulate matter are defined in the World Health Organisation (WHO) Air Quality Guidelines (AQG) and the European Union Ambient Air Quality Directive (EU, 2008).

Pollutant	Concentration measured as:	EU Ambient Air Quality Directive	WHO AQG
Particles PM10	24h mean	50 µg/m³ not to be exceeded more than 35 times a year	50 µg/m³
	annual mean	40 µg/m³	< 20 µg/m3
Particles PM2.5	24h mean		25 µg/m³
	annual mean	25 µg/m³	10 µg/m³
Particles PM1	no recommendations for PM1 concentration for the time being		

Source: https://www.eea.europa.eu/publications/air-quality-in-europe-2020-report

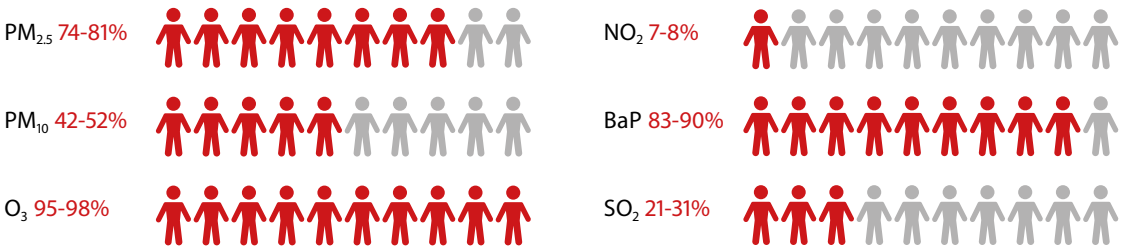
Through Directive 2008/50/EC* the European Union introduced additional PM2.5 objectives targeting the reduction of the exposure of the population to fine particles. These objectives are set on national level and are based on the average exposure indicator (AEI). The AEI is defined as a 3-year running annual mean PM2.5 concentration in urban areas**.

Even through the EU has imposed national reduction targets for particulate matter exposure to member states, the WHO recommendations are generally more severe than the EU limit values imposed.

*https://eur-lex.europa.eu/legal-content/EN/TXT/?qid=1486474738782&uri=CELEX:02008L0050-20150918

**https://ec.europa.eu/environment/air/quality/existing_leg.htm

Urban Population exposed to air pollutants concentration above WHO air quality guideline (average 2015-2017)



Source: European Environment Agency

BaP: Benzo[a]pyrene is a polycyclic aromatic hydrocarbon and the result of incomplete combustion of organic matter at temperatures between 300 °C (572 °F) and 600 °C (1,112 °F). The ubiquitous compound can be found in coal tar, tobacco smoke and many foods, especially grilled meats.

Air Quality - How is it classified?

World Health Organisation (WHO) thresholds

The well-established and generally accepted recommendation on thresholds for PM concentrations in the air we breathe were published by the World Health Organisation (WHO) in the 'Air Quality Guidelines – Global update 2005'.

These limits aimed to achieve the lowest concentration of PM possible, since no threshold has been identified below which no damage to health is observed.

The recommended mean limits to not be trespassed:
› Annual mean for **$PM_{2.5}$ < 10 µg/m³ - 25 µg/m³** 24-hour mean
› Annual mean for **PM_{10} < 20 µg/m³ - 50 µg/m3** 24-hour mean
› At the time being, there are no recommendations for PM1 concentration

Next to these:
› Annual mean for **NO_2 < 40 µg/m³ – 200 µg/m³** 1-hour mean
› Annual mean for **SO_2 < 20 µg/m³ - 500 µg/m³** 10-minute mean
› Daily 8-hour mean for **O_3< 100 µg/m³**

Source: https://www.who.int/news-room/fact-sheets/detail/ambient-(outdoor)-air-quality-and-health

World Health Organization

EN 16798-3:2017

› According to previously applicable EN 13779, IAQ was expressed as the required level of ventilation or CO_2 concentrations.
› The new EN 16798-3:2017 standard, which supersedes the globally known EN 13779, classifies outdoor and indoor air quality with the use of WHO air thresholds.
› It is perceived as the **main guidance for HVAC consultants on how to design ventilation systems** and more particularly **the required filtration.**

Outdoor Air Quality (EN 16798)

For non-residential buildings, the standard EN16798 on Energy performance of buildings – Ventilation for buildings defines three categories of **outdoor air (ODA)**, from **ODA1** for the purest air to **ODA3** for the most polluted air, as well as four categories of supply air (SUP), from SUP1 to SUP4, where SUP1 is the purest air.

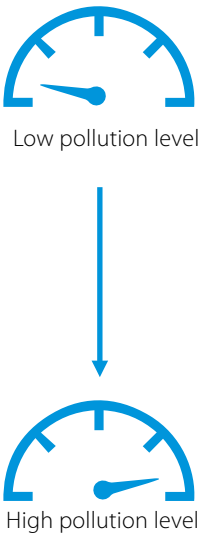
ODA1 ODA2 ODA3

Depending on the environment, i.e. the ODA category, and according to the desired supply air quality, the standard specifies which filter efficiency must be used to guarantee the required indoor air quality. In order to ensure good, if not the best indoor air quality, legislators are imposing stricter requirements based on the standard EN16798.

Indoor Air Quality (EN 16798)

The classification of the air to be supplied inside the building is divided into 5 categories, from SUP1, the highest quality, to SUP5, which indicates low-quality indoor air.

SUP 1	Refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 0.25 (annual mean for PM2.5 ≤ 2.5 µg/m³ and PM10 ≤ 5 µg/m³).
SUP 2	Refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 0.5 (annual mean for PM2.5 ≤ 5 µg/m³ and PM10 ≤ 10 µg/m³)
SUP 3	Refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 0.75 (annual mean for PM2.5 ≤ 7.5 µg/m³ and PM10 ≤ 15 µg/m³)
SUP 4	Refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values (annual mean for PM2.5 ≤ 10 µg/m³ and PM10 ≤ 20 µg/m³)
SUP 5	Refers to supply air with concentrations of particulate matter which fulfilled the WHO (2005) guidelines limit values multiplied by a factor x 1.5 (annual mean for PM2.5 ≤ 15 µg/m³ and PM10 ≤ 30 µg/m³)



Category	General Ventilation	Industrial Ventilation
SUP 1	-	**Applications with high hygienic demands.** Examples: Hospitals, pharmaceutics, electronic and optical industry, supply air to clean rooms.
SUP 2	**Rooms for permanent occupation.** Examples: Kindergartens, offices, hotels, residential buildings, meeting rooms, exhibition halls, conference halls, theaters, cinemas, concert halls.	**Application with medium hygienic demands.** Examples: Food and beverage production.
SUP 3	**Rooms with temporary occupation.** Examples: Storage, shopping centers, washing rooms, server rooms, copier rooms	**Applications with basic hygienic demands.** Example: Food and beverages production with a basic hygienic demand.
SUP 4	**Rooms with short-term occupation.** Examples: restrooms, storage rooms stairways.	**Applications without hygienic demands.** Example: General production areas in the automotive industry.
SUP 5	**Rooms without occupation.** Examples: Garbage room, data centers, underground car parks.	**Production areas of the heavy industry.** Examples: Steel mill, smelters, welding plants.

IAQ assessment based on ventilation rate per person or per m^2 floor space

Category	Airflow		Airflow for building emission pollution (l/s/m^2)		
	Expected % Dissatisfied	l/s/person	Very low polluting	Low polluting	Non low polluting
I	15	10	0,50	1,00	2,00
II	20	7	0,35	0,70	1,40
III	30	4	0,20	0,40	0,80
IV	>30	<4			

The values per person assume that the occupants are the only source of pollution.

The values per floor area assume only the pollutions from material emissions

Source: As per (EN 15251) - https://www.sysecol2.ethz.ch/OptiControl/LiteratureOC/CEN_06_prEN_15251_FinalDraft.pdf

IAQ classification based on CO_2 concentration levels

Mass balance equation for CO_2 concentration (EN 13779)

Classification of indoor air quality

Category	Description	CO_2-level above level of outdoor air (ppm)	Rate of outdoor air (m^3/h/person)
		Typical range	Typical range, non-smoking area
IDA 1	High IAQ	≤ 400	> 54
IDA 2	Medium IAQ	400 - 600	36 - 54
IDA 3	Moderate IAQ	600 - 1000	22 - 36
IDA 4	Low IAQ	> 1000	<22

Daikin Indoor Air Quality Monitoring

Air quality parameters & HVAC

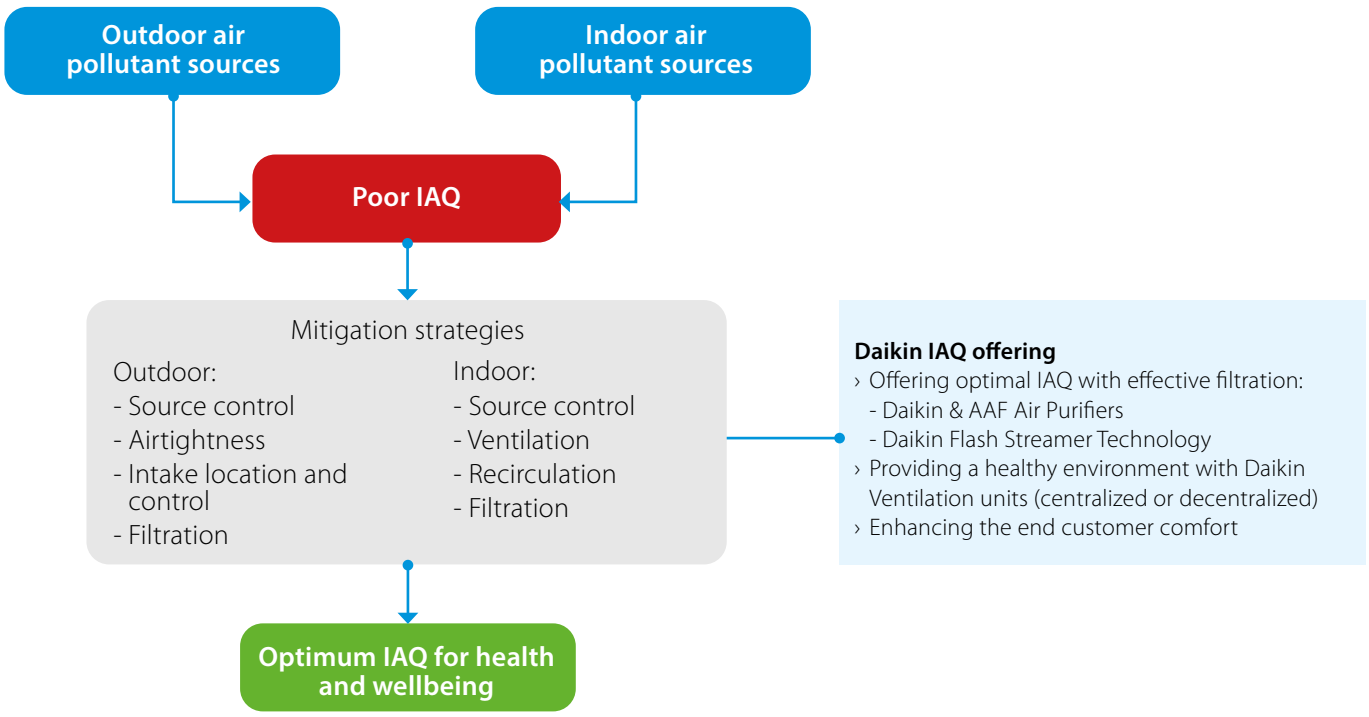
Measuring and assessing indoor air quality can help to identify improvement areas for a facility's HVAC system performance, which when resolved will enhance building occupants comfort level and experience.
Different air quality parameters come into play and need to be assessed and addressed:

Temperature and Humidity	CO_2	Particulate matter (PM) VOCs
Comfort Analysis	Productivity	Pollutant Source Identifications
Heating / Cooling Efficiency	Analysis Ventilation Effectiveness	Filtration Effectiveness
Microorganism and virus activity	Energy Efficiency	Ventilation Effectiveness

PM = virus carrier

Air pollution mitigation strategies to improve indoor air quality

After the assessment of indoor air quality and analysis of air pollution sources (indoor and outdoor pollutants) different mitigation strategies can be applied to improve IAQ. Those mitigation strategies again either focus on outdoor or indoor factors.



Why is an Indoor Air Quality Audit essential?

It is an important first step to start monitoring the indoor air quality within your daily environment in order to prevent harmful consequences which can be caused by invisible pollutants.

As technical experts we can assess your indoor air quality based on European norms & WHO guidelines and make necessary technical audits on your HVAC system to take countermeasures, lowering the risk of airborne infections.

We are focused on providing technical solutions and support that adhere to the guidelines established by local authorities.

Benefits for you

1 Improve IAQ with our strategic approach and know-how

› Providing a technical audit enables the client to assess the state of the indoor air quality and HVAC system in view of it's impact on the IAQ. The audit report can serve as a risk assessment but also as a supporting document for future improvements that will eventually lead to optimised safety and air quality.

2 Technical solution and support that adheres to local guidelines

› The audit will assess if the HVAC system is compliant with local guidelines and will offer technical solutions for improvements.
› The audit will assess the current state of indoor air quality based on EN norms and WHO guidelines and will offer suggestions and recommendations for improvements.

3 Our expertise at your fingertips

› Our technicians will carefully examine your facility by taking surface & air samples to be analyzed in a European microbiology lab and identify how you can improve your air quality and lower the risk of spreading infectious aerosol recirculation.
› After the visit and monitoring your indoor air quality for 2 weeks, we will provide you with a status assessment report on your current HVAC system and IAQ status, as well as solution proposals to improve these.

Good indoor air quality is essential to maintain a healthy and productive workplace.

How does Daikin IAQ Monitoring work?

The Daikin Indoor Air Quality Monitoring process comprises several steps.

Step 1

IAQ monitoring via IAQ Sensor

Monitoring the most critical areas within the building with Daikin IAQ sensors.

Step 2

IAQ assessment

1. Data Collection & Analysis
2. IAQ Assessment report

Generation of a tailor-made IAQ report after 2 weeks of indoor air data collection.
Report contains the current IAQ status based on various parameters such as CO_2, PM and VOC, as well as solution proposals with alternatives.

Step 3

IAQ improvement with Daikin solutions & services

Implementation of solutions based on the IAQ assessment report in case of poor indoor air quality is detected.

Improvements done on the IAQ will be monitored and recorded.

Indoor Air **Quality** monitored by DAIKIN

Step 4

Based on the results, some of the solutions could be:

- HVAC indoor units and filter assessment
- Fresh air supply units and filter assessment (for centralised or decentralised ventilation systems)
- Optimal fresh air requirement analysis
- Air purification solutions

Step 4

Continuous IAQ monitoring & support

Further monitoring of the indoor air quality is also offered in order to continuously evaluate the status-quo and take necessary countermeasures if needed.

The result

Peace of mind for your customers

Continuous visualization of the IAQ via a digital screen in your premises in order to provide peace of mind for your customers. Daikin also provides an IAQ quality seal which can be placed on any surface.

Daikin AirSense Pro+ IAQ Sensor

The Daikin IAQ Sensor measures your well-being by tracking indoor air quality values, environmental comfort, and electromagnetic pollution. It is available with 12 sensors and 15 parameter measures, and connects through your Wi-Fi network or via NB-IoT technology.

Complete Standalone Installation

Monitoring with the Daikin IAQ Sensor (AirSense Pro+) does not have to be paired with another product, for an **extremely easy and completely standalone installation** that takes about a minute. The device can be powered up with **microUSB power supply (included).**

Caelum Monitoring Platform

The device connects to Caelum, Daikin's monitoring platform, at daikiniaq.com. This **enables you to easily monitor Indoor Air Quality levels and create regular reports based on the data detected by the sensor.** You can even use the platform to show your indoor air quality levels to your visitors.

Configuration App

The **configuration app is available as Daikin AirSense on both the App Store and Play Store.** Once installed on your mobile device and logged in, scan the QR code on the IAQ sensor and **the app will guide you through the entire configuration process.**

Connectivity

The IAQ sensor ensures **perfect integration with Daikin on Site and Daikin Cloud Service, Daikin's remote monitoring and smart maintenance platform.** It gives you perfect control over the entire heating, ventilation and air conditioning system installed in your building.

Green Building Certification

Installing the Daikin IAQ sensor can help you achieve better sustainability ratings and green building projects certified with **LEED and WELL certification** thanks to **Indoor Environmental Quality credits.**

Video wall

The video wall is a great tool to have a general overview of the measurements conducted by the device. This screen can be shared with the occupants of the buildings to show in each moment the Indoor Air Quality status.

Communication capability

IotNB: Good penetration. Complete standalone installation. This is a perfect solution for service purposes where access to local Wi-Fi is not allowed or not available.

Wi-Fi: Easy. Complete standalone installation.

85 x 85 x 60 mm

AMBIENT LIGHT
Range: 0 lux to 120000 lux
Precision: ±10%
Resolution: 0,1 lux

TEMPERATURE
Range: -40 °C a 85 °C
Precision: ±1 °C (nel range 0/65 °C)
Resolution: 0,1 °C

HUMIDITY
Range: 0 to 100% RH
Precision: ±3% RH
Resolution: 0,1% RH

AIR PRESSURE HPA
Range: 300 to 1100 mbar (hPa)
Precision: ± 1 mbar (hPa)
Resolution: 0,18 mbar (hPa)

SOUND PRESSURE
Range: 35 to 120 dBspl
Frequency: from 50 Hz to 20 KHz
Precision: ±1 dBspl
Resolution: 0,1 dBspl

FINE DUST
Concentration Measure PM10/PM2.5:0 µg/m^3 to 1000 µg/m^3
Precision: (from 0 µg/m^3 to 100 µg/m^3) : ±15 µg/m^3
Precision: (from 100 µg/m^3 to 1000 µg/m^3) : ±15%
Resolution: 1 µg/m^3

ELECTROSMOG
LF Range: 0-400000 nT - Range: 5 Hz - 120 Hz
Precision: ±5% - Resolution: 25nT
HF Range: 0 - 10 V/m - Range: 50 MHz - 300 GHz
Precision: ±10% - Resolution: 0,1 V/m
Measurements performed on 3 axes

AIR QUALITY
Range: 0 to 500
Precision: ±10%
Resolution: 0,1

CO_2
Range: 0 to 5000 ppm
Precision: ±30 ppm (da 0 a 1000 ppm)
±3% (over 1000 ppm)
Resolution: 1 ppm

TVOC
Range: 0 ppb to 1187 ppb
Resolution: 1 ppb
Precision: ±10%

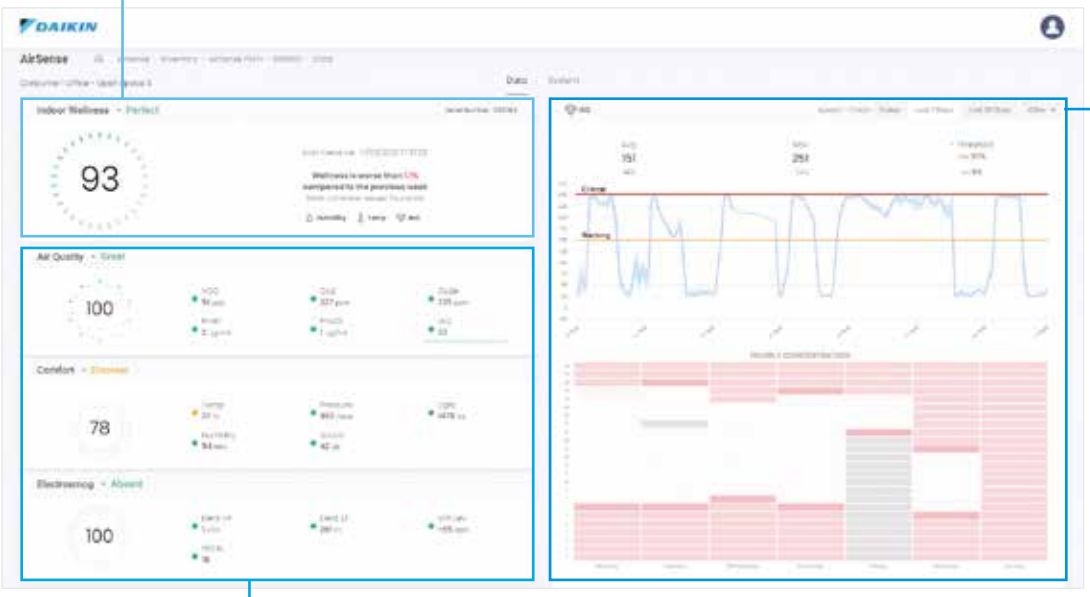
CO_2e
Range: 400 to 8192 ppm
Precision: ±10%
Resolution: 1 ppm

Wi-Fi NETWORKS & LEVEL
(2,4GHz band)
Detects Access Point n° in band 2.4Ghz and overall signal level
(from 0 to -100 dBm)

IAQ Monitoring Deliverables

Indoor Air Quality dashboards

Summary indicator on the indoor wellbeing



Detailed views available for each measured parameter

› Indications on **Air Quality**, **Comfort** and **Electromagnetic radiation**
› Easy to identify attention points based on red/orange/green color indicators

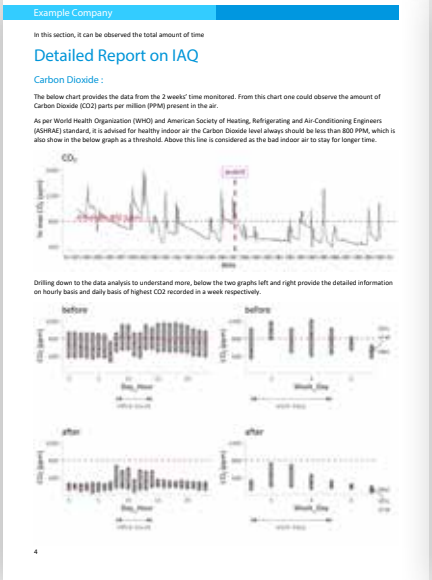
› Quick mobile access to the IAQ measurements
› Simple indicators on wellbeing, air quality & comfort

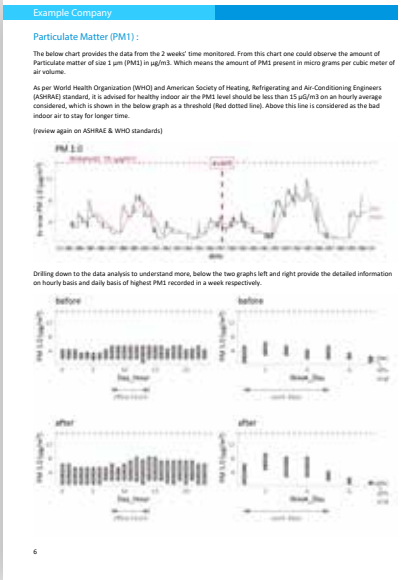
Give peace of mind to your customers by visualising the Indoor Air Quality within your premises!

Customized IAQ assessment report with improvement recommendations

The Daikin IAQ Assessment report provides a comprehensive overview and the detailed analysis of all IAQ parameters monitored. It also includes interpretation of the data observed and improvement recommendations to take necessary action.
Current ventilation rates are assessed and compared with required European Air Quality standards and norms.

Comparison of IAQ parameter results before vs. after IAQ monitoring and improvement actions.
Current ventilation rates are assessed and compared with required European Air Quality standards and norms.





Detailed assessment of all parameters measured:
› Total time measured
› Full week cycle (daily values)
› Full day cycle (hourly values)

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For your home & for your business

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› Pure air thanks to active plasma ion flow out and flash streamer technology
› **Removal of 99.98% of the coronavirus**
› High performance HEPA filter to catch fine particles of dust
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› Air flow rate 330 m³/h
› For areas up to 82 m²

AAF AstroPure 2000

› Self-contained stand-alone recirculation unit (1628 mm height)
› Standard high efficiency HEPA H14 filters
› Optional UV germicidal irradiation
› Plug & Play
› Air flow rate 2000 m³/h
› For commercial areas up to 200 m²

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Clean the air from

Viruses and bacteria

Fine particles of dust

Odors and allergens

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