Particulate matter: Some are more concerning than others

Dust is in the air

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Current legal limits for fine dust in the air are based on the mass and size of the particles. For health effects, however, not only the amount of dust is decisive, but also its chemical composition. Empa researchers have now compared the noxious potential of particulate matter in Switzerland and in China.

Hazardous particulate matter penetrates deeply into the lungs. A simple surgical mask does not protect the airways from fine particles. Photo by Liam Burnett-Blue on Unsplash

Content matters

Images of particulate matter in air samples from China (left) and Switzerland. Coloured SEM images.

Limits for particulate matter

The Swiss Ordinance on Air Pollution Control permits 20 micrograms of particles ("Particulate Matter", PM for short) per cubic meter of air for PM10, with a particle size of up to 10 micrometers. Dust particles of this size can be inhaled. In addition,

Anyone who is suddenly shaken by an uncontrollable cough attack on a cloudy day may suffer from the consequences of high fine dust load in the air. Breathing problems, cardiovascular disease and even lung cancer can be caused by these tiny particles. They include soot, metals and engineered nanoparticles. In order to control air quality more widely, a stricter Ordinance on Air Pollution Control has come into effect in Switzerland on 1 June 2018. Since then, PM2.5 has been created as the second standard for even finer suspended solids in addition to PM10. However, both values are only based on the amount of particles smaller than certain size limits – i.e. 10 or 2.5 micrometers in diameter. Empa researchers have now shown in a study that the amount of fine dust alone does not necessarily indicate the noxious potential of the polluted air.

How dangerous is particulate matter - An analysis

the new PM2.5 standard limits the total weight of granules up to a diameter of 2.5 micrometers to 10 micrograms per cubic meter of air. The finer particles can penetrate even deeper into the respiratory tract. Both limits apply to an annual average, but may be exceeded by a factor of 2.5 once a year. However, in many places the short-term particulate matter pollution is significantly higher, especially in winter. The National Air Pollutant Monitoring Network (NABEL) operated by Empa as well as cantonal and municipal monitoring networks keep current pollutant levels under surveillance. Higher limits apply in the EU; for PM10 this is 40 micrograms on average per year, for PM2.5 25 micrograms. Exceedances are particularly measured in Areas of high population density.

Further Information

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Air samples from Switzerland and China

Jing Wang and his team from Empa's Advanced Analytical Technologies lab examined air samples from Switzerland and China. As expected, the air quality of the metropolitan Beijing region performed worse than the samples from Switzerland. With their detailed analyses, however, the researchers also revealed that the composition of fine dust differs. «If we look at the so-called oxidative potential of particulate matter, for example, the effect of some Swiss samples with comparable particle quantities was more severe and therefore more momentous than in China,» says Wang.

The oxidative potential is a measure of the damaging effect of fine dust, as aggressive substances trigger oxidative stress and reactions of the body's immune system. Oxidative stress can be caused by metals such as cadmium and arsenic or soot particles. In China, large quantities of ultrafine arsenic particles indicated an increased health risk. Samples from the Zurich suburb of Dübendorf, on the other hand, contained significantly more iron particles in the 10 micrometer range. «The iron particles originate from the abrasion of the nearby railway line,» says the researcher. Together with copper and manganese, the iron dust in the Dübendorf air contributed to the oxidative potential of the air samples.

Another Swiss value attracted the attention of the Empa researchers: The air sample from a Swiss farm fared worse than that from a busy road in the middle of Beijing, at least as far as the contamination with certain bacterial products was concerned. It is known that such endotoxins are abundant in the air in the surroundings of cows and Co. And especially for people with a weakened immune system, particles contaminated with bacterial endotoxins can pose a serious health risk.

«The effects of fine particles on air quality and health cannot be assessed solely on the basis of their amount,» says Wang. «But if the composition of particulate matter is known, a regionally adapted health protection can be implemented.» Otherwise one runs the risk of underestimating the regional air pollution or of taking measures that don't reduce the health risk. Jing Wang and his team are now working on developing standards for more precise analyses of particulate matter. The aim should be to identify dangerous components more easily and to prevent health risks with optimized strategies.

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Additional Media

Literature

Y Yue, H Chen, A Setyan, M Elser, M Dietrich, J Li, T Zhang, X Zhang, Y Zheng, J Wang, M Yao; Size-Resolved Endotoxin and Oxidative Potential of Ambient Particles in Beijing and Zürich; Environmental Science and Technology (2018); DOI: 10.1021/acs.est.8b01167

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