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Tackling the invisible pollution in homes, schools and workplaces

We spend most of our time indoors, but how much do we know about the air we breathe? EU-funded researchers are looking for answers and practical ways to improve it.

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Europeans spend up to 90% of their lives indoors, according to official estimates. Yet while outdoor air pollution has become a familiar public concern, the air inside our homes, schools and workplaces has largely gone unnoticed.

That is changing. Researchers across Europe are investigating what is really in indoor air, how it affects our health and what can be done about it.

“Since the COVID-19 pandemic, we have heard more about indoor air quality because people have become aware that aerosols could transport viruses,” said Jose Fermoso, a chemical engineer at Spanish research

centre CARTIF and coordinator of K-HEALTHinAIR, one of seven EU-funded projects working together to investigate indoor air quality.

“Thanks to this development, something invisible became visible.”

But that greater awareness has not necessarily translated into concern about indoor pollution. Most contaminants have no noticeable smell, are difficult to detect and people tend to adapt to their presence, Fermoso explained.

“Until not so long ago, we were all used to breathing cigarette smoke indoors.”

The researchers have spent the past several years tracking pollutants in homes, schools, hospitals, offices and other buildings across Europe. They are now turning their findings into tools and recommendations to improve the air we breathe every day.

What is really in the air?

Cigarette smoke and cooking fumes remain major sources of indoor pollution. They contain particulate matter – tiny particles and droplets that can travel deep into the lungs and, in some cases, enter the bloodstream.

But there is much more to indoor pollution than smoke.

“We see there is an immense diversity of chemical pollutants indoors. Some of them are well studied, but for many others we don’t have enough knowledge of exposure and potential health effects,” said Pernilla Bohlin Nizzetto, research director at NILU in Norway, and coordinator of the EU-funded INQUIRE project.

Her research team looks beyond routinely monitored indoor air pollutants to investigate chemical and biological exposures, their sources and potential health effects.

The chemicals can be released into the air and household dust as soon as products enter our homes – from sitting on a sofa to walking on a carpet or a child playing with a toy.

“Household dust is a chemical fingerprint of the home,” she said.

The research suggests that indoor environments can have their own distinct chemical profile. The INQUIRE team collected air, dust, product and urine samples from 200 homes with small children in eight European countries. They found measurable biological effects from dust in laboratory tests, including effects on lung cells and hormone-related markers.

“We don’t have the full picture yet,” Bohlin Nizzetto said.

For some substances, early results show a link between what is found in the indoor environment and what is measured in urine. The findings also show that homes have distinct chemical profiles, with many chemicals occurring at higher concentrations indoors.

Another study by K-HEALTHinAIR monitored more than 350 homes, as well as hospitals, schools and university spaces in six countries. Around 10% of the homes had higher-than-expected concentrations of formaldehyde, a chemical released by furniture and building materials that can irritate the eyes and airways and is classified as a human carcinogen.

Children among the most vulnerable

Children are among the most vulnerable to poor indoor air quality and exposure to chemicals in products and household dust, especially those under five. They spend more time at home and on the floor than adults,

which brings them into closer contact with dust and the chemicals in household materials, said Bohlin Nizzetto.

“They don’t necessarily make you sick in a few days or weeks, but some chemicals can have long-term hormonal or neurological effects. Children may be more vulnerable to these effects because their bodies are still developing.”

Researchers are also looking at how indoor air affects children with asthma. In the EDIAQI project, scientists have studied ventilation habits and the microbiome – the mix of bacteria and fungi living in household dust.

“We are trying to understand all the DNA present in the dust, because there are both good and pathogenic bacteria and fungi,” said Mario Lovrić, a senior research associate at the Lisbon Council, a Brussels-based think tank that leads EU-funded research projects. He also holds a position at the Institute for Anthropological Research in Zagreb, Croatia.

His team has found an early link between indoor fungi and road traffic-related pollutants. The researchers are investigating whether some fungi may metabolise these pollutants, potentially helping to break them down before they reach the lungs.

The finding also points to a counter-intuitive lesson: a varied mix of indoor microbes may be beneficial.

“We don’t necessarily recommend excessive cleaning. A diverse indoor microbiome is good. Keeping everything sterile might not benefit children,” Lovrić said.

Children can also be exposed to different pollutants at school. Researchers studying European schools found that pollution levels and types varied considerably between countries, buildings and times of day. Pollution often peaked at predictable moments, including the morning rush when parents dropped children off.

Children with allergies appeared particularly sensitive to even average pollution levels, said Nikolaos Papadopoulos, professor of allergy and paediatric allergy at the University of Athens and coordinator of the SynAir-G project.

“We haven’t shown that pollution has a direct health impact across the board, but we see that children with allergies are much more sensitive to even average levels of pollution, which often leads to airway inflammation.”

What can people do?

The researchers are designing tools to make indoor pollution easier to understand and tackle.

K-HEALTHinAIR has developed an air monitoring tool using a traffic-light system and explored an indoor air quality index. EDIAQI has created an online simulator that estimates household air quality based on location and other factors. Researchers in SynAir-G have also tested a “green wall” filtration system using live plants, with preliminary data suggesting a positive health impact.

The seven projects work together through the EU-funded IDEAL cluster. Across the projects, researchers are developing and testing air monitoring technologies, including low-cost sensors and multi-sensor systems.

Depending on the setting, they can measure fine particles, carbon dioxide, volatile chemicals, temperature and humidity. The work could help make indoor air measurements more reliable and easier to use.

“We want to make the interpretation easier and empower users to take action,” said Fermoso.

There are simple things people can do now: ventilate while cooking and cleaning, use extractor fans or cooker hoods where possible, and avoid smoking indoors.

But good indoor air also depends on the buildings themselves: how they are designed, ventilated and maintained.

This is particularly difficult to address in private homes, Lovrić said. “We never see our households as a potential danger. It is a sacred space. But, in essence, each household is a chemical reactor.”

Towards a European standard

The researchers argue that improving indoor air quality will ultimately require political and individual action.

Defining what constitutes “good” indoor air is not straightforward, Fermoso noted. Conditions can vary enormously between buildings, and even between rooms in the same building.

The IDEAL cluster has produced guidelines that bring together research findings and practical recommendations on managing indoor air quality. It is developing a roadmap for future European guidance and standards, showing how the projects’ findings could lead to healthier indoor spaces.

“Measuring indoor air quality should become standard – at least in some settings,” Papadopoulos said. The challenge now is to make people see indoor air as something worth measuring and protecting.

Better tools can help, but the researchers say Europe also needs a clearer framework linking health, buildings, energy and environmental policy. That could help ensure that the spaces where people spend most of their lives receive the same attention as the air outside them.

The EU has already begun to address this through its zero-pollution agenda and new building rules. The challenge now is to connect these strands and turn growing scientific evidence into healthier indoor spaces.

***Some findings described in this article come from analyses that are still underway and have not yet been published in peer-reviewed journals.*

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More info

- IDEAL cluster
- SynAir-G (CORDIS)
- SynAir-G project website
- K-HEALTHinAIR (CORDIS)
- K-HEALTHinAIR project website
- EDIAQI (CORDIS)
- EDIAQI project website
- INQUIRE (CORDIS)
- INQUIRE project website
- LEARN (CORDIS)
- TwinAIR (CORDIS)
- INCHILDHEALTH (CORDIS)
- EU Zero Pollution Action Plan