

BACKGROUND

The U.S. Environmental Protection Agency's (EPA) Indoor Environments Division (IED) commissions research and disseminates technical and consumer-level indoor air quality (IAQ) information to the public using nonregulatory approaches.

IED has voluntary guidance on multiple IAQ topics, including chemicals, volatile organic compounds (VOCs), environmental tobacco smoke, combustion products, mold and other biologicals, and radon, as well as IAQ in homes, schools and commercial buildings. IED guidance on IAQ employs three basic strategies: source control, improved ventilation, and supplemental air cleaning and filtration.

This poster will present some elements of the microbiomes materials under development. These products are in draft status and should not be construed as representing official EPA policy.

APPROACH

People in developed countries spend most of their time indoors, but there is limited knowledge about the effects of human interaction with indoor ecology. In addition, outdoor environmental changes continue to impact both functional building parameters and human behaviors indoors. Consequently, IED is creating a suite of materials based on currently available scientific information that will provide both technical and consumer-friendly language and images on what is known about the impacts of the indoor microbiome on human health and the built environment.

Key resources that are informing EPA's approach on microbiomes:



Microbiomes of the Built Environment (2017)

This National Academies of Sciences, Engineering, and Medicine (NASEM) consensus study report addresses how emerging knowledge about communities of indoor microbes might be used to inform building design and operation to create and maintain more healthful indoor environments.



Environmental Chemicals, the Human Microbiome, and Health Risk (2018)

This NASEM consensus study report provides a research strategy to improve understanding of the interactions between environmental chemicals and the human microbiome and the implications of those interactions for human health risk. In addition, it identifies barriers to such research and opportunities for collaboration.



Health Risks of Indoor Exposure to Particulate Matter (2016)

This NASEM report discusses the state of the science on the health effects of indoor exposure to particulate matter and associated health impacts. Topics discussed include:

- Sources of indoor particulate matter
- Particulate dynamics and chemistry
- Exposure levels and characterization
- Exposure mitigation
- Identified and emerging health concerns
- Interventions and risk communication



Residential Air Cleaners: A Technical Summary (2018)

This technical summary provides general information about:

- Types of pollutants affected by air cleaners
- Types of air-cleaning devices and technologies available
- Metrics that can be used to compare air-cleaning devices
- Effectiveness of air-cleaning devices in removing indoor air pollutants
- Information from intervention studies on the effects that air cleaners can have on health and health markers

HIGHLIGHTS FROM THE NASEM REPORTS

IED identified several highlights from the NASEM reports, including those below, which may help in explaining the role that the microbiome plays in human health and the built environment, including the role of common IAQ strategies for the general public.

Fundamentals of the Built Environment Microbiome

- Air, water and surfaces are primary reservoirs of microbes in buildings.
- Primary entry of microbes into buildings occurs by occupant shedding, transport by air or water, and growth indoors.
- Building design, construction, operation and maintenance, as well as occupant behaviors can impact the indoor microbiome.
- Different building types — including single-family residential, multifamily residential, commercial, mixed use and others — have very different microbiomes.
- “Normal” indoor microbial ecology is not yet established.

Microbiome Effects on Humans and the Built Environment

- Microorganisms may have beneficial, adverse or neutral effects in different people.
- Improving understanding of what humans encounter in their indoor environments, how these exposures affect them, and how their environments can be modified to affect these exposures has the potential to contribute to future health and well-being.
- Microorganisms affect building materials, systems and human health in various ways, including through degradation, corrosion and fouling as a result of biofilm formation and production of VOCs.

Interventions That Influence the Built Environment Microbiome

- Interventions in the built environment can include occupant behavior, health impacts, potential trade-offs with energy consumption and economic factors, and other built environment and microbiome characteristics.
- It is not entirely clear what building characteristics and parameters are ideal to optimize the indoor microbiome.
- Potential physical interventions include:
 - Increasing outdoor ventilation rates mechanically, naturally or both.
 - Particle filtration in the ventilation system or portable air cleaners.
 - Following humidity control requirements of the building.
- Some interventions to reduce particulate matter may impact certain components of the indoor microbiome. Particulate matter includes biological components, which are a subset of the indoor microbiome.

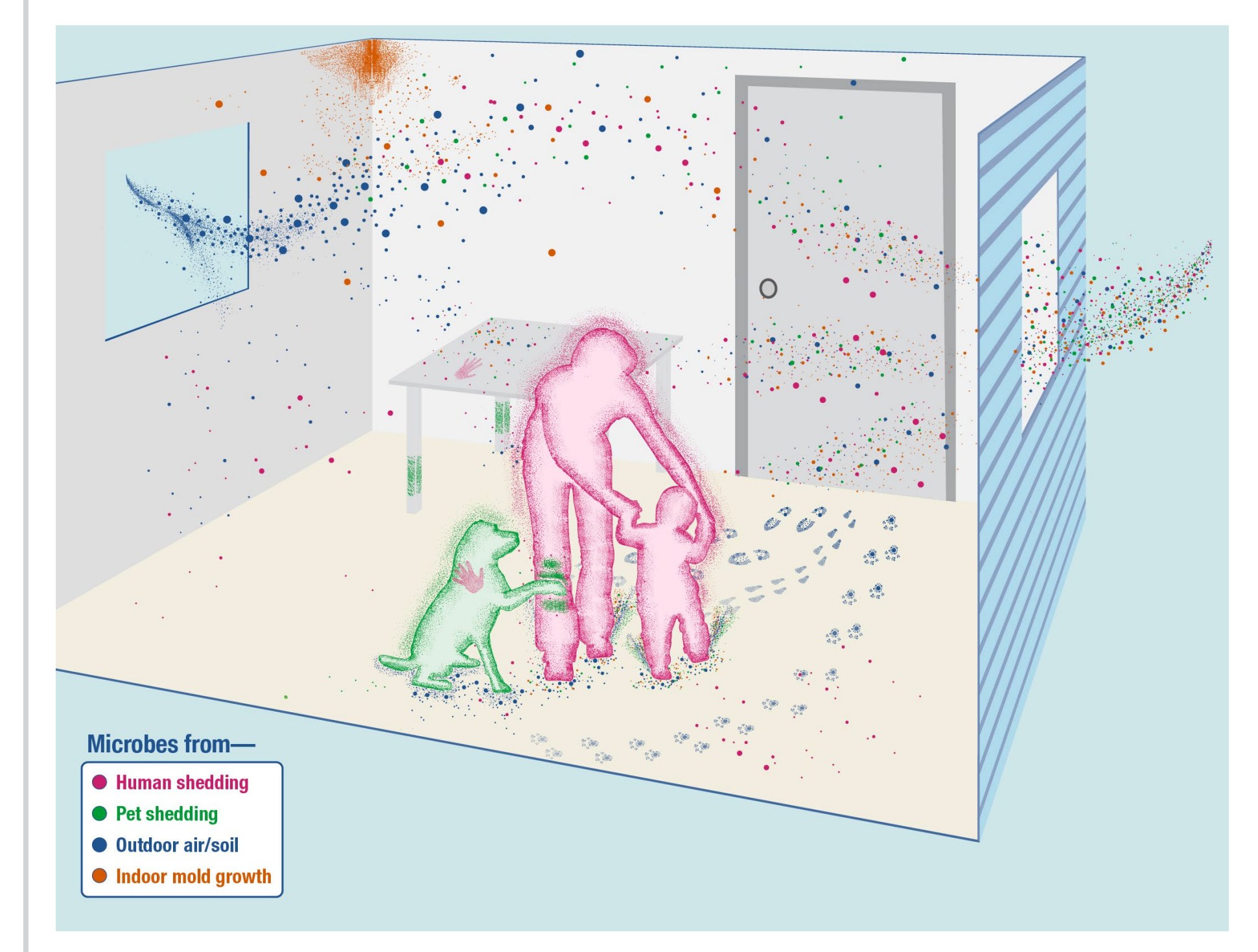
Indoor Environmental Chemicals and Human Microbiomes

- The human microbiome can be affected by chemicals in the indoor environment, but no conclusive evidence is available to predict outcomes of the interaction between the human microbiome and chemicals in the environment.
- The scope of exposure science may need to incorporate the emerging understanding of the roles of the human microbiome and its components as agents that influence exposures to and risks posed by environmental chemicals.

MICROBIOMES WEB PAGES UNDER DEVELOPMENT

IED is developing content and graphics that provide information about the indoor microbiome and additional technical resources. **Figure 1** shows a still image of an animated graphic and accompanying consumer-friendly language that describes the indoor microbiome.

Figure 1. IED's indoor microbiomes web content (DRAFT).



What is the indoor microbiome?

The indoor microbiome is a complex community made up of all the living microorganisms and their fragments and byproducts found in an indoor environment. The microbiome that surrounds humans is diverse and dynamic. It is made up of bacteria, viruses, fungi and other single-celled organisms. These microorganisms may be growing or inactive and may be present in different life stages, such as spores. The indoor microbiome also includes nonliving things, such as materials produced by microorganisms and fragments of microorganisms.

What's a “normal” indoor microbiome?

Every building has a microbiome, but there is no single normal or typical community of microorganisms found in all homes or buildings. The community of microorganisms in an individual home or building depends on many things, including the people and pets that occupy it and their behaviors; the type, design, maintenance and location of the home or building; climate and other local conditions; and the age of the building. Although microorganisms' growth can be controlled indoors, some microorganisms will always be present.

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FUTURE DIRECTIONS

Understanding the relationship of the human microbiome, the microbiome of the built environment, and the interactions between the two — in combination with exposure to environmental chemicals — is evolving.

Progress will likely be a result of collaboration among many stakeholders, including architects, builders, standards organizations, building scientists, microbiologists and public health practitioners. EPA is interested in communicating the state of the science, supporting research and leveraging collaboration to provide the best available guidance to our stakeholders with regard to the microbiome of the indoor environment.

RESEARCH NEEDS

Fundamentals of the Built Environment Microbiome

- How are typical microbial ecologies identified or defined?
- What is known about death, persistence and removal rates of different types of microorganisms in the built environment?
- To what extent are local microbial communities and the individual species within those communities determined by the building versus the external environment?
- How do environmental gradients define the ecological niches available for microbes in the built environment?

Microbiome Effects on Humans and the Built Environment

- How do we determine whether a microbial community will have an adverse/neutral/positive outcome on human occupants?
- What is known about the kinds of nutrients available for microbial growth or persistence in the built environment?
- How does exposure to combinations of pollutants in the built environment (including microbes, particulate matter and environmental chemicals) influence human health outcomes at different lifestyles?
- If a microbiome component needs to be incorporated into a risk-assessment framework, how should that be done?

Interventions That Influence the Built Environment Microbiome

- How can we effectively communicate what we know about the interaction between microbiomes and the built environment (including insights about exposure to particulate matter and environmental chemicals) to diverse audiences?
- What interventions could promote exposure to beneficial microorganisms?
- What set of building and environmental data would be needed to assess built environment-microbiome interventions?

Indoor Environmental Chemicals and Human Microbiomes

- What are the differences and similarities between model-organism and human-host responses to environmental chemical exposures?
- Which environmental chemicals in the indoor environment affect the human microbiome? To what extent?

References

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