S U S T A I N A B L E J E R S E Y
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Sustainability Brief: Indoor Environmental Health Hazards

Most Americans spend the majority of their time indoors whether at work, school, shopping or home, where they are exposed to a variety of pollutants and toxins on a daily basis. Some originate outdoors and are transported inside through the air or from physical transportation on people and objects while many others originate from the materials and activities common indoors, including tobacco smoking, building products, synthetic paints, glues, polishes and waxes, cleaning products, personal care products, and plastics.

Indoor environmental threats are critical to public health. Individually these pollutants are known to pose a serious health threat. However exposure is frequently to multiple pollutants. Current research has begun to look at the chemical reactions between the pollutants and toxins to determine their true comprehensive health impacts. Significant debate still remains over the health impacts of different levels and lengths of exposure. There are three primary modes of exposure to indoor pollutants and toxins: breathing the air *(inhalation)* and physical contact either through *ingestion* or *dermal absorption*. While most exposures are low level, over time they may have significant health impacts due to *bioaccumulation,* the buildup of the pollutant or toxin within an organism, and *bio magnification,* the increased concentrations of pollutant or toxin along the food chain.

1 Background

1.1 Indoor Air

Indoor air quality is the most common indoor environmental health issue. Indoor air pollution can come from a variety of sources, and often more than one source will exist together. "Indoor air can contain radon, environmental tobacco smoke, and thousands of other chemicals and biological contaminants that pose serious risks to health." (IOM, 2012)

1.1.1 Common Indoor Air Pollutants

Most air pollutants can be categorized into three broad types: criteria pollutants (which include particulate matter, ozone, carbon monoxide, nitrogen oxides, sulfur dioxide and lead); volatile organic compounds (VOCs); and biological pollutants such as molds and pollens.

Of the criteria pollutants[1] "particle pollution (PM) and ground-level ozone (O_3) are the most widespread [air quality] health threats". (US EPA, 2012) *See the Sustainability and Air Quality paper for more on criteria air pollutants*. Volatile organic compounds, a large component of air quality pollutants, are emitted from a wide array of common products including paints and lacquers, paint strippers, cleaning supplies, pesticides,

[1] The US EPA calls these pollutants "criteria" air pollutants because it regulates them by developing human health-based and/or environmentally-based criteria (science-based guidelines) for setting permissible levels.

building materials and furnishings, office equipment, and graphics and craft materials such as glues, adhesives and permanent markers. "Concentrations of many VOCs are consistently higher indoors (up to 10 times higher) than outdoors." (US EPA, 2012) Biological pollutants, such as molds and pollens, are naturally occurring hazards. The built environment and seasonal weather patterns frequently help to dictate their impacts. Molds issues are commonly found in homes that are sealed too tightly and improperly ventilated.

1.1.2 Effects on Children

"Children, in particular, are at risk of harm from indoor and outdoor air pollution, and the impact can be life-long." (IOM, 2012) Asthma is especially a concern. "There is sufficient scientific evidence to establish an association between excess moisture, dampness, and mold in buildings and adverse health outcomes, particularly asthma and respiratory symptoms, among children and adults." (NRC, 2006) The effects on children do not apply only to poor neighborhoods or old schools, however. Even supposedly high-tech schools raise concern. "Green" schools generally have been designed for energy efficiency to reduce environmental impacts. One method of energy efficiency is to reduce energy losses through air exchange (NRC, 2006), which may trap pollutants where they do the most harm. "Mitigation measures to reduce energy use in buildings could lead to systematically lower ventilation rates that would cause higher concentrations and exposures to secondhand smoke and other indoor pollutants." (IOM, 2011)

1.2 Heavy Metals

Exposures to heavy metals (magnesium, mercury, lead, arsenic, cadmium, copper, nickel, chromium) are a persistent environmental health hazard. Widely used in indoor paints until 1978, lead in particular has been a persistent problem in the United States. "Lead poisoning affects an estimated 442,000 children younger than 6 annually in the United States." (About Lead, 2012) "When lead dust is ingested or inhaled, even in miniscule amounts, it can cause significant and irreversible brain damage as well as other health problems. Lead dust equivalent of only three granules of sugar can begin to poison a child." (About Lead, 2012)

1.3 Endocrine Disrupter Compounds

Recent attention has been given to Endocrine Disrupter Compounds (EDCs) found in common household products, such as toys, flooring, plastics for food, and receipt paper. EDCs are a large grouping of compounds which mimic natural hormones and interfere with the body systems responsible for physical development, behavior, fertility, and cell metabolism and can cause a wide range of reproductive and other health issues. Many endocrine-related diseases and disorders are on the rise. "The speed with which the increases in disease incidence have occurred in recent decades rules out genetic factors as the sole plausible explanation." (IOMC, 2013)

While exposure to EDCs occurs at all points in the life cycle, the most sensitive window of exposure is during critical periods of development such as fetal development and puberty. "Developmental exposures can cause changes that, while not evident as birth defects, can induce permanent changes that lead to increased incidence of diseases throughout life." (IOMC, 2013)

2 Sustainability Issues

2.1 Regulatory Jurisdiction

Indoor air quality lacks a strong regulatory framework. The federal Clean Air Act does not regulate indoor air pollution per se. However, USEPA has initiatives for decreasing radon, mold and other pollutants that threaten health. New Jersey has similar programs, with NJDEP having lead responsibility for radon and the

NJ Department of Health and Senior Services and local health boards focusing on issues such as mold. NJDEP also can and does regulate emissions from architectural coatings, consumer products, and portable fuel containers. Other NJDEP programs also affect air quality, including for pesticides (application controls to avoid drifting to non-target receptors), solid and hazardous waste management facilities (migration of odors and hazardous substances through the air), and hazardous sites (migration of hazardous substances through the air or from ground water into buildings).

2.2 Scientific Uncertainty

"Close to 800 chemicals are known or suspected to be capable of interfering with hormone receptors, hormone synthesis or hormone conversion. However, only a small fraction of these chemicals have been investigated in tests capable of identifying overt endocrine effects in intact organisms." (IOMC, 2013) The vast majority of the tens of thousands of synthetic chemicals produced worldwide have not been screened for endocrine disrupting potential. The 1996 Food Quality Protection Act and Safe Drinking Water Act Amendments charged the US EPA with the task of screening pesticide chemicals for their endocrine disrupting potential; testing began in 2009 on an initial list of approximately 10,000 chemicals. (US EPA, 2012) Even when EDCs are identified, proving the associations between the chemical and health effects can be difficult. "For a large range of human health effects, such as female reproductive disorders and hormonal cancers, there are no viable laboratory models. This seriously hampers progress in understanding the full scale of risks." (IOMC, 2013)

2.3 Inequity in exposure

Poor neighborhoods tend to have greater problems than more affluent neighborhoods, in part due to the age of buildings, but also due to less-effective public space and building sanitation, degraded utilities, poor ventilation and moisture control, and inadequate pest control. "Indoor environmental conditions exert considerable influence on health, learning, and productivity. Poor environmental conditions and indoor contaminants are estimated to cost the US economy tens of billions of dollars a year in exacerbation of illnesses, allergic symptoms, and lost productivity." (IOM, 2011)

3 Sustainability Responses

There are two ways to decrease or eliminate exposure to indoor environmental health hazards: one, *prevent their introduction to the environment*; and two, *remediate already polluted environments*. An array of actions and policies can be taken at both national and local levels.

3.1 Bans or Limits

Banning (use and/or production) of a chemical shown to cause toxicity or disease is one option that has been shown to have clear health benefits for both humans and wildlife. "Following the residential [organophosphate insecticide chloropyrifos] ban in the USA, children's [chloropyrifos] blood levels in New York declined significantly within one year and were reduced to less than half within two years." (IOMC, 2013). Federal and state limits placed on the emissions of certain criteria pollutants and heavy metals are another method to reduce introduction of certain pollutants and toxins to the environment. In December 2012, the EPA finalized Clean Air Standards for Industrial Boilers, Incinerators and Cement Kilns that aim to achieve extensive public health protections by slashing toxic air pollution, including mercury and particle pollution. "EPA estimates that for every dollar spent to reduce these pollutants, the public will see $13 to $29 in health benefits, including fewer instances of asthma, heart attacks, as well as premature deaths." (US EPA, 2012)

3.2 Market Change

Market based change through purchasing choices of educated consumers is another way to reduce the introduction of certain pollutants and toxins into the environment.

> "The United States federal government is one of the world's largest consumers. Indeed, it is the single largest consumer of goods and services within the United States, with total spending estimated at $350 billion for goods and services each year. This purchasing power exerts a tremendous influence on which products and services are available in the national marketplace. The Environmentally Preferable Purchasing Program works to ensure that federal government's buying power is working to the greatest extent possible to increase availability of environmentally preferable products, which in turn minimizes environmental impacts." (US EPA, 2010)

The State of New Jersey purchases a variety of recycled products for its government operations, including recycled copy paper, paper towels, garbage bags, toner cartridges, antifreeze, traffic cones, and road construction aggregate.

3.3 Building Codes

Updated building codes, such as the International Building Code (IBC) 2009 which is adopted statewide in New Jersey, have ventilation requirements with increased air exchange rates and fresh air mixtures which are viable options to deal with mold and pollen issues and can help reduce indoor concentrations of other air borne pollutants and toxins.

3.4 Remediation

Environmental remediation deals with the removal of pollutants and toxins from the air, soil and water, and has many forms. In addition to traditional methods environmental remediation technologies include *bioremediation* techniques that utilize bacteria, plants (*phytoremediation*) and fungi (*mycoremediation)* which chemically alter the pollutant or toxin to an easily-removed or non-toxic compound. In a project in Detroit that utilized sunflowers, "the lead concentration in the soil was reduced 43 percent, bringing it down below federal and state limits. The project cost $900,000…more than $1 million less than it would have cost to cart the 5,700 cubic yards of soil to a hazardous waste landfill." (Revkin, 2001)

4 Implications

4.1 Bans and Limits

While certain chemical compounds, such as DDT and PCBs, have been successfully banned in the United States, most governments and private enterprises have yet to come to grips with the full impact of these pollutants that are integrated throughout our economy and lives. Additional wide scale bans may be unlikely in the near term because there is little political appetite and because solutions are technically challenging given the scope of the problem. Furthermore, bans of chemicals, such as EDCs, could cause the market to switch to other compounds with possibly worse consequences, "a phenomenon familiar enough to be lamented in government parlance as 'regrettable substitution' (Urbina, 2013)

4.2 Market Change

Market based change is usually slow and incremental; changes in consumer preferences are necessary before changes in manufacturing processes will occur. However, while slow, market changes usually precede governmental interventions such as bans or emission limits. In 2012 a Food and Drug

Administration prohibition of bisphenol A (BPA) in baby bottles and children's drinking cups followed "[r]eports of potentially negative health effects[that] made BPA notorious, especially among parents, and led to widespread shunning of products thought to contain the chemical." (Tavernise, 2012)

4.3 Building Codes

Building codes are constantly evolving based on new data. Many of the code requirements for ventilations systems and air exchange rates that worsened the mold and pollen issues have already been updated to correct the issues they caused. However, buildings built under older codes are often still in use. Unless they are renovated their inhabitants are still exposed to unhealthy air.

4.4 Remediation

Remediation of existing pollutants close to population centers is critical to reducing indoor exposures. Large scale remediation of heavily polluted sites can be very expensive and usually does not occur unless there are laws in place requiring polluters to pay for the clean-up, or the site, by location or potential use, is valuable enough to be worth remediation. Bioremediation techniques are most cost effective for sites with "low, dispersed, but harmful levels of contamination – that has proven least amenable to conventional technologies". (Revkin, 2001)

5 Defining & Tracking Sustainability

The following statements are offered to define sustainability for this area:

- **Indoor Air Quality** is sustainable when it poses no significant direct or indirect health threats for the general population or specific socioeconomic groups, as measured by effects on residents, workers, and especially sensitive populations such as children, the elderly and immune-compromised populations.
- **Heavy Metals** are sustainable when National Air Quality and Safe Drinking Water Act Standards are achieved throughout New Jersey and when they pose no significant direct or indirect health threats for the general population or specific socioeconomic groups, as measured by effects on children or other sensitive populations.
- **Endocrine Disrupting Compounds** are sustainable when they pose no significant direct or indirect health threats for the general population or sensitive populations such as children or pregnant women, as measured by incidence rates of EDC related diseases. Significant research into identifying EDCs, associations between the chemical and health effects and determining "safe" exposure levels still needs to be undertaken before a sustainable state can be achieved.

The major sustainability issues regarding indoor environmental health hazards revolve around the common questions: What chemicals or pollutants present a public health risk? How great is that risk? Who is most at risk? What could be considered a "safe" and sustainable level of exposure? Major scientific uncertainties still exist in determining the public health risks of indoor environmental health hazards; particularly for EDCs. For criteria air pollutants and heavy metals, where there is already a greater scientific understanding of the risks, the national system is a proven framework for establishing ambient (but not indoor) air quality standards as a definition of sustainability.

Table 1 provides a preliminary set of indicators and targets for the sustainability statement above.

6 Conclusions

Historically, the scientific community has examined the effects of environmental pollutants or toxins in isolation, focusing on outdoor ambient exposure.

> "More recently, we have begun to look at the relationship between the built environment and humans as a complex interplay between building occupants (who they are and what they do) and an array of physical, chemical, biological, and design factors. This evolution in understanding has profound implications for the design and operation of buildings, how the buildings are used, and the prevention and management of health problems that occur in building occupants." (Mitchell, et al., 2007)

"Much remains to be learned about exposure assessment in indoor environments. Part of the challenge is to account for the relative contributions of both indoor and outdoor exposures. This has important implications, as indoor and outdoor exposures are often regulated very differently." (Mitchell, et al., 2007) The new emphasis on researching indoor environmental exposure risks and the cumulative health impacts of prolonged low-level exposure needs support. Targets and indicators that will lead us to a healthier more sustainable indoor environment need development. Continued consumer education and alternative product markets are necessary to phase out many of the pollutants and toxins. Eventually with sufficient scientific backing and citizen reporting there will be additional bans on recognized hazardous chemical compounds.

Table 1: Preliminary Air Quality Sustainability Indicators and Targets

Sustainability Definition	Preliminary Sustainability Indicator	Preliminary Target	Scale of Analysis	Availability and Period of Data
Indoor Air Quality poses no significant direct or indirect health threats for the general population or specific socioeconomic groups, as measured by effects on residents, workers, and especially sensitive populations such as children, the elderly and immune-compromised populations.	• Asthma rates in children by neighborhood category and socioeconomic group • Asthma rates in sensitive adult populations by neighborhood category and socioeconomic group	• Reduced incidence of air quality related health issues • Health outcome comparison of urban and poor neighborhoods to national benchmark states by socioeconomic group		• Health outcome data compiled by NJDOH • National benchmark data
National Air Quality and Safe Drinking Water Act Standards are achieved throughout New Jersey and heavy metals pose no significant direct or indirect health threats for the general population or specific socioeconomic groups, as measured by effects on children or other sensitive populations.	• Incidence rate of acute heavy metal poisoning in children under 6 by neighborhood category and socioeconomic category • Blood levels of selected heavy metals in vulnerable population	• Reduced incidence of heavy metal related health issues • Health outcome comparison of urban and poor neighborhoods to national benchmark states by socioeconomic group	• Case by case basis	• Lead poisoning data, statistics and surveillance compiled by CDC
Endocrine Disrupting Compounds (EDC) pose no significant direct or indirect health threats for the general population or sensitive populations such as children or pregnant women, as measured by incidence rates of EDC related diseases.	• Incidence rate of endocrine related diseases and health issues	• Reduced incidence of EDC related health issues • Health outcome comparison of urban and poor neighborhoods to national benchmark states by socioeconomic group		• Data definitively linking EDCs with health outcomes is lacking • USEPA pesticide chemicals screening for EDCs is ongoing

7 Resources

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