Indoor Air Pollution

Mercer University
EVE 486

Fact: There's increasing interest in assessing and controlling AQ in residences and office buildings

Why?

- 80-90% of an average person's time is spent indoors, 5-7% in transit, and < 5% outdoors
- Urban populations and many susceptible groups (elderly, kids, sick) typically spend > 95% of their time indoors
- There are MANY sources of indoor air pollution

Thus…EVEN IF INDOOR CONCENTRATIONS ARE RELATIVELY LOW, LONG EXPOSURE PERIODS MAKE INDOOR AQ VERY IMPORTANT

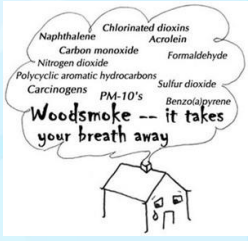
A quick tangent: Other "non-ambient" environments are worthy of consideration, too

- [VOCs] inside a car during rush-hour traffic can be 6X higher than ambient
- Dangerously elevated [NOx], [CO], and particulate in homes with unvented cooking stoves
- Elevated pollutant concentrations in passenger cabins of airplanes due to air recirculation (roughly 50:50 recycled/fresh mix)
  - This is mostly problematic with older aircraft (newer ones have quite efficient filters)

Indoor Sources

- Products of combustion: CO, CO_2, NOx, particles
  - Gas stoves/fireplaces or other gas appliances
  - Kerosene heaters or wood-burning stoves/fireplaces
  - Auto emissions enter homes from attached garage
  - Levels can be 2-7 times higher than the NAAQS
- Note: wood (as a fuel) is *much* "dirtier" than either oil or gas
  - Wood smoke contains ~100 different chemicals
  - 10-20 of which are carcinogens

Indoor Sources, wood smoke



Indoor Sources, continued

- Microorganisms and allergens: fungal spores bacteria, animal dander, pollen, mold, dust mites, …
  - Can enter through problematic air handling system
    - 1976 Legionnaire's Disease outbreak in Philadelphia (handout)
  - Damp, natural fibers or paper products can produce a toxic fungus

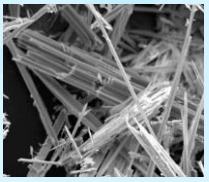
Indoor Sources, continued

- Organic compounds (including formaldehyde): common ingredients in many bldg. materials (plywood, particle board)
  - Very wide range of conc. levels within home (temp. dependent)
  - Associated health effects: headaches, dizziness, a suspected carcinogen; 10-20% of US population experiences some form of irritation due to HCHO exposure

The resin used to hold layers/ chips together contains HCHO

Indoor Sources, continued

- Asbestos fibers: a naturally-occurring silicone mineral used extensively as a building material until ~1980
- Exposed workers have developed lung and GI tract cancers
  - Problematic only when fibers are "shedding" (minimal exposure typically); best to leave in place, otherwise

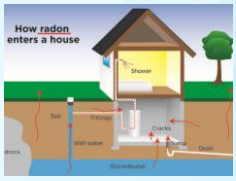


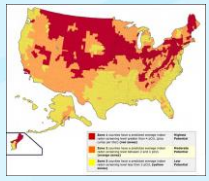
Indoor Sources, continued

- Environmental tobacco smoke (ETS): "second-hand smoke" is probably the most significant source of indoor air pollution
  - 5000 compounds have been identified in cigarette smoke (many irritants and 20+ known carcinogens)
  - Wide range of concentrations
  - Highest source of particulate exposure for young children
  - Highest source of exposure to benzene (C_6H_6) indoors
  - Health effects
    - Heart disease, cancer, stroke, depression, SIDS
  - National Center for Health Statistics (NCHS) data brief on ETS

Indoor Sources, continued

- Radon: naturally-occurring radioactive gas
  - Rn-222 and decay products account for 55% of exposure to radiation
  - Some homes have [Rn] above remediation limits
  - Health impact uncertain (5000-20,000) lung cancer deaths per yr





Illnesses caused by poor indoor AQ

- Sick building syndrome (SBS): the discomfort or sickness associated with poor indoor air environments with no clear identification of the source substances
  - Symptoms: irritation of sensory organs (eyes, nose, throat, ears, skin), fatigue, headache, respiratory disorders, nausea
- Building-related illness (BRI): a specific, recognized disease entity caused by some known agents that can be identified clinically
  - Symptoms: hypersensitivity pneumonitis (inflammation of the lungs caused by microbes), humidifier fever (similar to above), asthma, legionella
- Note: once the cause of illness can be identified, SBS becomes BRI
- Note: Approximately 1 million buildings in the US are "sick," where 70 million people live or work

Poor indoor AQ illnesses, continued

- Agricultural buildings (animal facilities, grain elevators, etc) are even worse
- PM in these buildings is different from most other building dusts
  - High biological activity: wide range of bacteria, microbes, fungi
  - High concentrations: 10-100 times higher than office and residential buildings
  - odor
- Specific health effects
  - Certain bacteria (listeria monocytogenes and streptococcus suis) have caused fatal diseases in people
  - Many acute respiratory symptoms

Top 10 occupational diseases/injuries

1. Lung dysfunctions and asthma
2. Musculoskeletal injuries (back ache, carpal tunnel syndrome)
3. Cancers (other than lung cancer)
4. Amputations, eye losses
5. Cardiovascular disease (including stroke and hypertension)
6. Reproductive problems
7. Neurotoxic illness
8. Noise-induced hearing loss
9. Dermatologic problems
10. Psychological disorders

7 of the top 10 are air-related

Threshold Limit Values (TLVs)

A TLV is the maximum concentration of a pollutant that nearly all workers may be repeatedly exposed (day after day) without adverse health effects

1. Time-weighted average TLV: the time-weighted average concentration (for a conventional 8-hr workday and 40-hr workweek) to which nearly all workers may be repeatedly exposed without adverse effect
2. Short-term exposure limit TLV: the concentration to which workers can be exposed (on average) for a short period of time without suffering from (a) irritation, (b) chronic tissue damage, (c) narcosis
3. Ceiling TLV: the concentration that should not be exceeded during ***any*** part of the working exposure

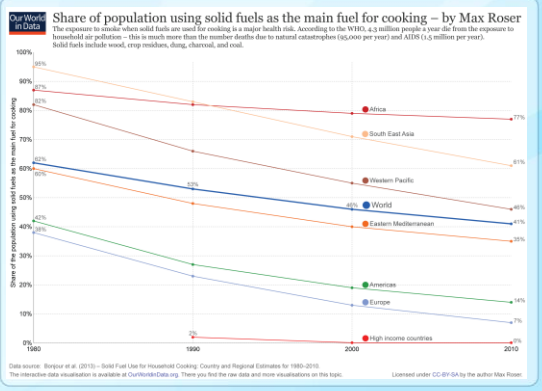
Effective control measures

- Ventilation: dilution of indoor air with fresh outdoor air
- Source removal/substitution: removal or substitution of hazardous materials
- Source modification: reduce emission rates by changing process design
- Air purification: filters, cyclones, etc
- Behavioral adjustment: modification of personal behavior patterns (smoke-free zones, etc)

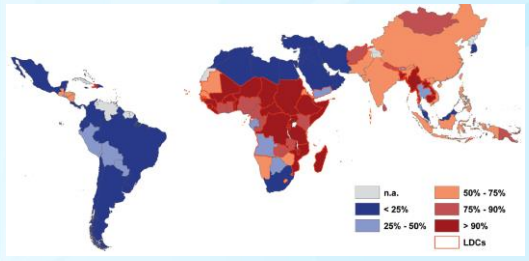
ourworldindata.org/indoor-air-pollution

Indoor air pollution is by far the biggest environmental problem of the world. Every year, 4.3 million people die prematurely due to exposure to household air pollution caused by indoor open fire (WHO, 2012). To bring this in perspective, this is 45-times the number of the global annual deaths from natural catastrophes (~95,000 in the 2010s). And more than twice the number of people dying from AIDS (1.5 million in 2013). It might be the most unreported of the world's big problems.

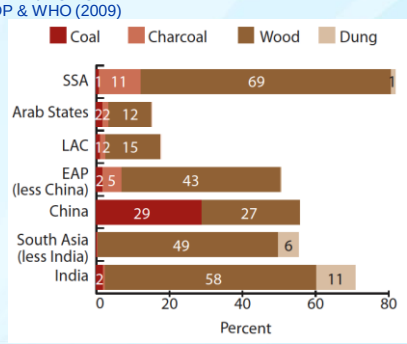
It is predominantly women and young children who are killed by indoor air pollution.



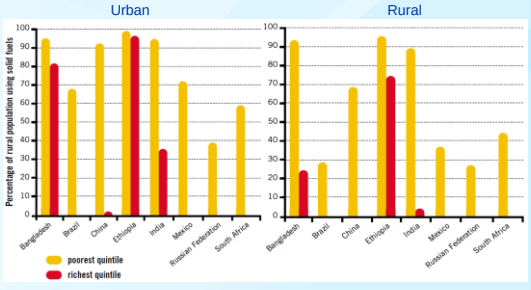
Share of population without access to modern fuels in developing countries, 2007 – UNDP & WHO (2009)



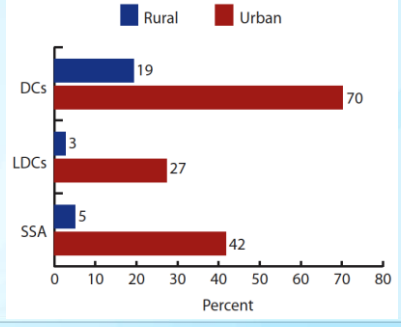
Share of population relying on different types of solid fuels for cooking by developing regions, 2007 – UNDP & WHO (2009)



Percentage of population using solid fuels in some of the world's largest countries by income quintiles in urban (left) and rural (right) locations, 2003 – WHO (2006)



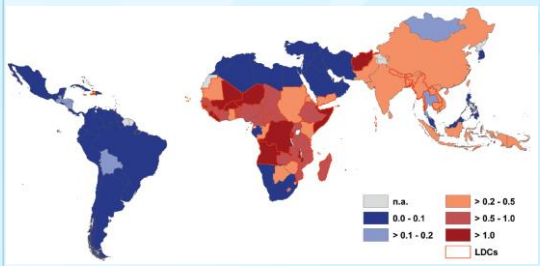
Share of population with access to modern fuels in rural and urban areas of developing countries (DCs), least developing countries (LDCs) and Sub-Saharan Africa (SSA), 2007 – UNDP & WHO (2009)



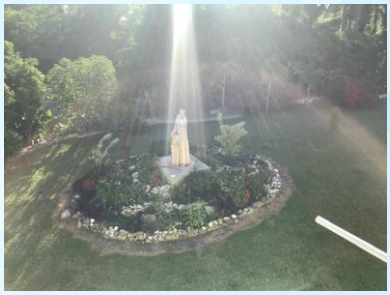
Health impacts of indoor air pollution – WHO (2006)

Health outcome	Evidence[1]	Population	Relative risk[2]	Relative risk (95% confidence interval)[3]	
Acute infections of the lower respiratory tract	Strong	Children aged 0–4 years	2.3	1.9–2.7	SUFFICIENT
Chronic obstructive pulmonary disease	Strong	Women aged ≥ 30 years	3.2	2.3–4.8	
	Moderate I	Men aged ≥ 30 years	1.8	1.0–3.2	
Lung cancer (coal)	Strong	Women aged ≥ 30 years	1.9	1.1–3.5	
	Moderate I	Men aged ≥ 30 years	1.5	1.0–2.5	
Lung cancer (biomass)	Moderate II	Women aged ≥ 30 years	1.5	1.0–2.1	INSUFFICIENT
Asthma	Moderate II	Children aged 5–14 years	1.6	1.0–2.5	
	Moderate II	Adults aged ≥ 15 years	1.2	1.0–1.5	
Cataracts	Moderate II	Adults aged ≥ 15 years	1.3	1.0–1.7	
Tuberculosis	Moderate II	Adults aged ≥ 15 years	1.5	1.0–2.4	

World map of the number of deaths per 1000 capita per year attributable to indoor air pollution from solid fuel use, 2004 – UNDP & WHO (2009)



MoM- DR 2018-19 IAQ images



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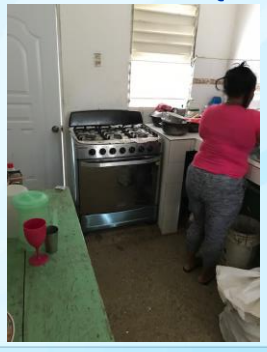

Preliminary Data

- **Peak $PM_{2.5}$ concentrations (10-15 minutes)**
  - Over 2000 $\mu g/m^3$
- **Daily average $PM_{2.5}$ concentrations (6-8 hrs of sampling)**
  - 500-900 $\mu g/m^3$
- **$PM_{2.5}$ NAAQS**
  - 12 $\mu g/m^3$ (annual mean)
  - 35 $\mu g/m^3$ (24-hr mean)
- **Next step: additional monitoring and respiratory testing (spirometry) to investigate statistical correlation between $PM_{2.5}$ exposure and COPD**

Can the EPA save us?

- **Short 60 Minutes video**