How Pollution and Climate Affect Human Health

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Consider Energy from a Life Cycle Perspective

All parts of the life cycle have the potential for pollutant releases to air and water.

http://energyeducation.ca/encyclopedia/Life_cycle_assessment
Main source of (stationary) energy: COAL

COAL burning releases (air):
- Particulate matter (PM)
- NOx, SOx (Indiana coal is high sulfur)
- Heavy Metals (mercury, lead, cadmium...)
- Radioactive Metals (uranium, thorium)
Particulate Matter (PM) pollution is visible

Indianapolis Haze Camera

June 16, 2002
Hourly PM$_{2.5}$ levels < 10 µg/m$^3$

June 21, 2002
Hourly PM$_{2.5}$ levels at 60 µg/m$^3$
Heavy Metals & Particulate Matter end up in the **air we breathe**, the dust in our houses, the **soil we play on**

- American Lung Association ranked Indianapolis **13th** worst metro area in the nation (2018)
  - Marion Cty grade for particulate matter air pollution: **F**
  - Marion Cty grade for ozone air pollution: **F**

- NRDC ranked Indiana’s air **4th** most toxic due to air pollution from coal-fired power plants (2012)
WITH Particulate Matter — ALL ABOUT SIZE

Particles: What Are They?
Airborne particles are a complex mixture of extremely small solids and liquid droplets.

Acute and long-term health effects of PM: eye irritation, respiratory tract infection, asthma trigger, bronchial irritation, heart disease, lung cancer, increased hospital visits and mortality.
Lung System

< ~ 2 micrometers to reach alveoli
Air pollution remains a major danger to the health of children and adults.

Health risks from:
- OZONE POLLUTION
- PARTICLE POLLUTION

- Premature death
- May cause developmental harm
- May cause reproductive harm
- Asthma attack
- Lung cancer
- Wheezing and coughing
- Shortness of breath
- Cardiovascular harm
- Susceptibility to infections
- Lung tissue redness, swelling

American Lung Association
International Agency for Research on Cancer considers

Air Pollution to be a Known Carcinogen

- Air pollution from power plants combines with air pollution from traffic
- The problem is worst for people living in lower income, inner city communities
NOx, SOx turn to acid in the lungs

Inhalation increases severity of respiratory diseases and allergies from any source
NOx contributes to OZONE FORMATION

VOCs + NOx + Sunlight = O₃

The diagram illustrates the formation of photochemical smog involving volatile organic compounds (VOCs) and nitrogen oxides (NOx), which react with sunlight to produce ozone (O₃) and peroxy nitrate (PANs) as products.
Air pollution remains a major danger to the health of children and adults.

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American Lung Association
Heavy Metals cause damage to most parts of the body...

- Nervous system
- Immune system
- Kidney
- Liver
- Reproductive systems

Any LEAD in your body is causing adverse health effects, especially in children
Lead is especially harmful to kids...

Low levels of lead is linked to:

• Behavior and learning problems
• Lower IQ and Hyperactivity
• Slowed growth
• Hearing Problems
• Anemia

And slow growth and premature birth of fetus

Photo by kinkate from Pexels
Researchers attribute 250K annual Cardiovascular Disease deaths in US to lead exposure
Mercury Affects: Nervous System Immune System Kidney and Liver

**ADULT Effects**

- Nervous System
  - Tremors
  - Headache
  - Visual field constriction
  - Numbing
  - Muscle weakness
  - Incoordination
  - Difficulty walking, talking
  - Memory Loss
Mercury Effects on Infants and Young children is more severe and permanent

CHILDREN
The Nervous System is still developing...

- IQ deficits
- Learning disorders
- ADHD
- Decreased cognitive thinking
- Decreased fine motor skill
- Decreased spatial thinking
- Slower to learn language
Coal Mining: Acid Mine Drainage

- Coal mines release ACID MINE DRAINAGE
- The acid releases heavy metals from the rock
- Toxicity to wildlife and fish is due to both the acidified water and the heavy metals
- We ingest the heavy metals when we eat the fish
SOURCES OF HEALTH HARM FROM ENERGY SOURCES: COAL

- **Mining** – accidents, air and water pollution from coal mines (leakage) and surface impoundments (wash out)
- **Coal ash storage** – water pollution from leakage / breaks → ecological harm, human harm from drinking polluted water, eating polluted biota
- **Transportation** – air pollution, accidents
- **Combustion** – air pollution
SOURCES OF HARM FROM ENERGY

SOURCE: Solar

- **Mining**
  - Rare earth metals used in panels are mined, some from war torn areas → water and air pollution

- **Transportation**
  - air pollution, accidents

- **In use**
  - potential ecological damage (large installations)
  - incidents of wildlife adversely affected
SOURCES OF HARM FROM ENERGY SOURCES: Wind

- Processing or raw materials
  - potential air and water pollution

- Transportation
  - air pollution, accidents

- In use:
  - Ecological: bird and bat mortality (can be endangered species or migrating birds)
  - Human nuisance: noise, vibration reported to affect sleeping, mental health of nearby residents

Thank You

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Indiana mortality due to air pollution

Lelieveld et al 2015
Nature 525:367
Causes of North American mortality by source

LEGEND: IND, industry; TRA, land traffic; RCO, residential and commercial energy use (for example, heating, cooking); BB, biomass burning; PG, fossil fueled power generation; AGR, agriculture; and NAT, natural

Lelieveld et al 2015 Nature 525:367
Mortality due to air pollution
SOURCES OF HARM FROM ENERGY

SOURCE: Nuclear

- Processing or raw materials
  - air and water pollution; tailings contamination

- Transportation
  - air pollution, accidents

- In use:
  - Ecological: increased water temperature in receiving streams, water bodies
  - Human: accidents (relatively low risk, USA)

- Waste: The Big Problem
Causes of Global Mortality by Source
Global emission of anthropogenic emissions of Hg (2005)

Causes of Air Pollution mortality by source

Table 2 | Top 15 ranked countries of premature mortality linked to outdoor air pollution in 2010

<table>
<thead>
<tr>
<th>Country</th>
<th>Deaths ($\times 10^3$)</th>
<th>Residential energy</th>
<th>Agriculture</th>
<th>Natural</th>
<th>Power generation</th>
<th>Industry</th>
<th>Biomass burning</th>
<th>Land traffic</th>
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<td>1,357</td>
<td>32 (76)</td>
<td>29 (7)</td>
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<td>2 (1)</td>
<td>57 (23)</td>
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<td>8 (16)</td>
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<td>5 (5)</td>
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</table>

Columns 3–9 show contributions (%) of the seven main source categories, the leading one in bold. For details and additional countries, see Extended Data Table 3. In parentheses are shown sensitivity calculations with carbonaceous particles having a five times larger impact than inorganic aerosol compounds.
Mercury (Hg)
3 Forms Cycle through our Environment

- $\text{Hg}^0$ – elemental
  - Vaporizes
- $\text{Hg}^2$ – ionic
  - Water soluble
- Methyl (or ethyl) Hg
  - Most bioavailable
  - Partially water soluble, partially lipid soluble
  - Incorporates into proteins as they are made