

NETA PowerPoint® Slides

to accompany

prepared by
Ian Dawe

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Chapter 20**Air Pollution**

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Key Concepts

Structure and composition of the atmosphere

Outdoor and indoor air pollution

Photochemical smog

Acid deposition

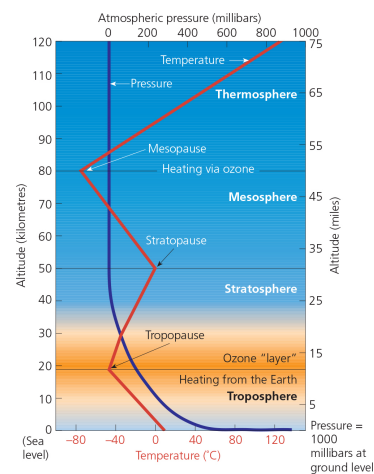
Respiratory system as protection

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Structure and Science of the Atmosphere

Thin layer of gases surrounding Earth
Layers characterized by abrupt changes in temperature and atmospheric pressure



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What Is the Troposphere?

Where weather happens

Innermost layer

78% N₂, 21% O₂

75% of Earth's air mass

Involved in chemical cycling

Responsible for weather and climate

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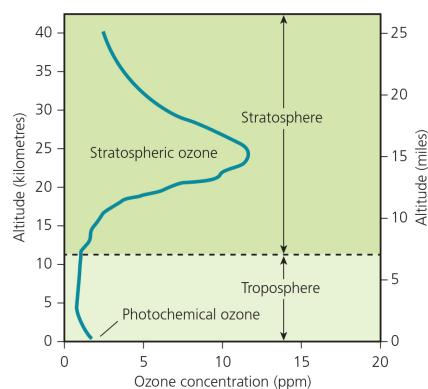
What Is the Stratosphere?

Ozone (O₃) filters

95% of harmful

UV radiation

Similar composition to troposphere, except more O₃ and less H₂O



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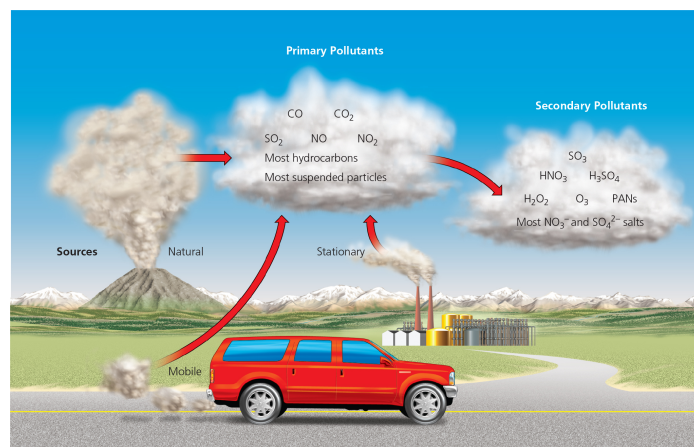
Major Types of Air Pollution

Carbon monoxide (CO)
 Nitrogen dioxide (NO₂)
 Sulfur dioxide (SO₂)
 Suspended particulate matter (SPM)
 Volatile organic compounds (VOC)
 Photochemical oxidants
 Radioactive substances
 Hazardous air pollutants

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Outdoor Air Pollution



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Should CO₂ Be Classified as an Air Pollutant?

Could be classified as a pollutant

- High concentrations
- Increasing faster than can be compensated by trees growing back
- Contributes to global warming via the greenhouse effect

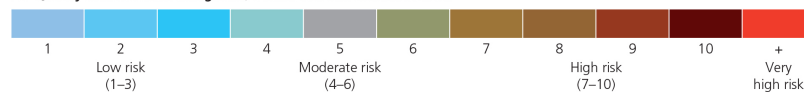
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Air Quality Health Index

AQHI is based on concentrations of ozone, nitrogen dioxide, and fine particulates, combined with the exposure-response relationship between these pollutants and the relative health risk.

Air Quality Health Index Categories, Values and Associated Colours

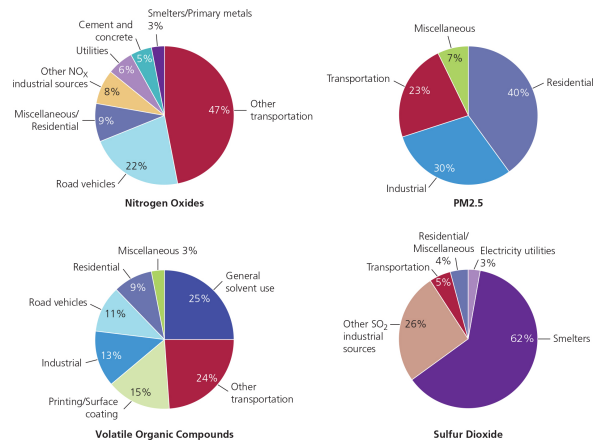


Source: Ministry of the Environment, Monitoring Air Quality, <http://www.airqualityontario.com/press/faq.php#a9> © Queen's Printer for Ontario, 2010. Reproduced with permission.

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Major Sources of Outdoor Air Pollutants (2013)



Source: Ministry of the Environment and Climate Change, Air Quality in Ontario, 2013 Report (PIBS 6795e), Figure 2, p. 5 <http://www.airqualityontario.com/downloads/AirQualityInOntarioReportAndAppendix2013.pdf> © Queen's Printer for Ontario, 2013. Reproduced with permission.

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Sources of Major Air Pollutants

Carbon monoxide

Colourless poison gas

Found in cigarettes, car exhaust

Nitrogen dioxide

Reddish-brown gas in smog

From fossil fuel burning and industrial plants

Can damage health, ecosystems, and structures

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Sources of Major Air Pollutants

Sulphur dioxide

- Colourless, irritating gas

- Mostly from coal burning

- Breathing problems, ecological damage, and structural damage

Suspended particulate matter (SPM)

- Variety of aerosols

- From coal, diesel burning, and road paving

- Health, ecological, and physical damage

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Sources of Major Air Pollutants

Ozone

- Highly reactive gas forms in troposphere

- Made from chemical reactions between emitted compounds and nitrogen oxides

Lead

- Solid toxic metal

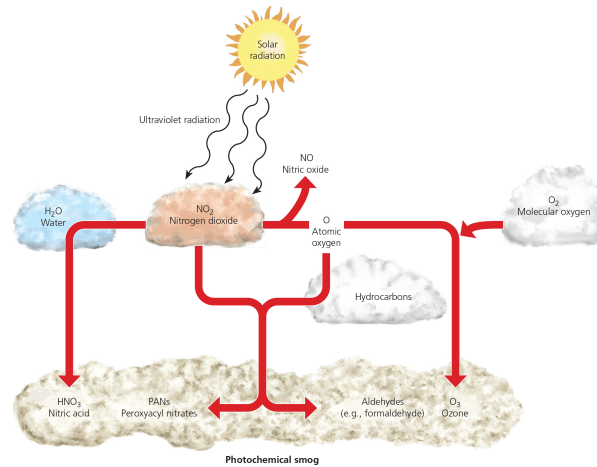
- Paint, manufacturing, batteries

- Accumulates in the brain and causes serious problems

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What Is Photochemical Smog?



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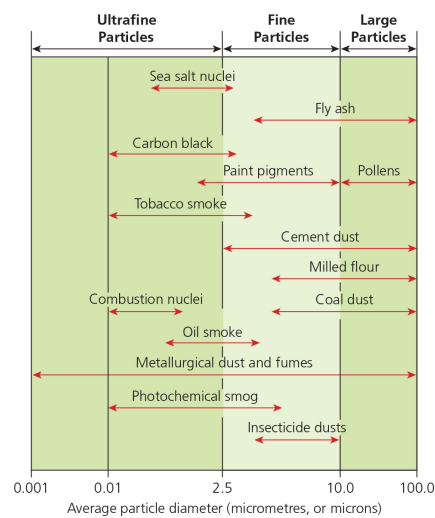
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What Is Industrial Smog?

“Grey-air smog”

A mixture of

- Sulfur dioxide
- Sulfuric acid
- Particulates



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What Factors Influence Photochemical and Industrial Smog?

Factors that **reduce** formation

- Rain and snow
- Salty sea spray
- Winds

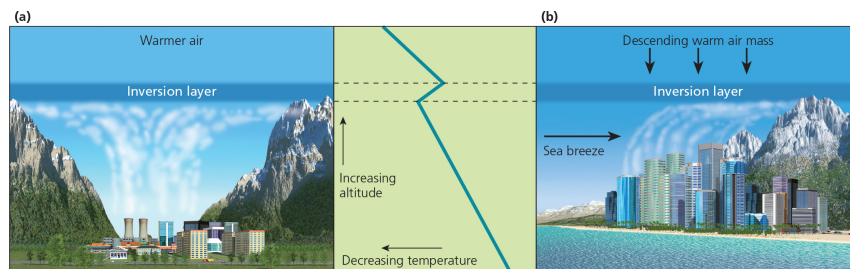
Factors that **increase** formation

- Urban buildings
- Hills and mountains
- High temperatures
- Grasshopper effect

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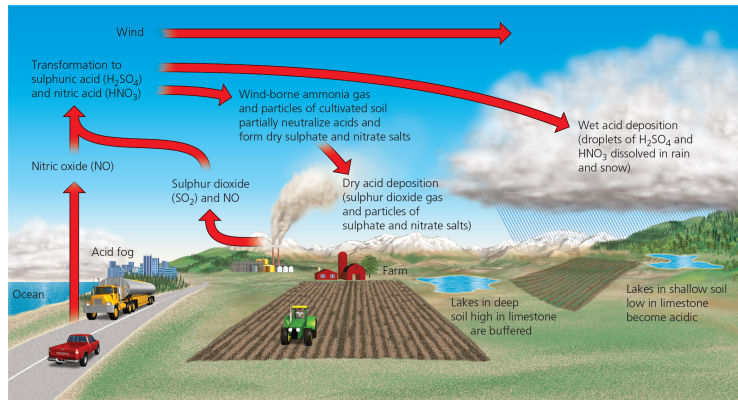
How Can Temperature Inversions Increase Outdoor Air Pollution?



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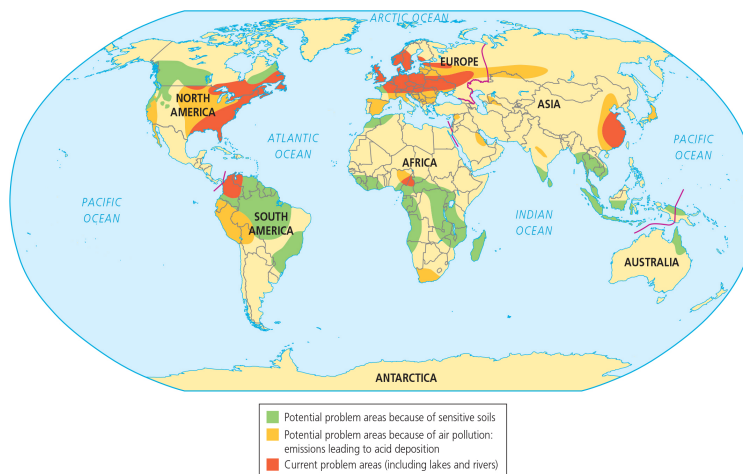
What Is Acid Deposition?



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Where Does Acid Deposition Occur?



Source: World Resources Institute and U.S. Environmental Protection Agency.

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What Are the Harmful Effects of Acid Deposition? Human Health and Society

Respiratory diseases
Toxic metal leaching
Structural damage to CaCO_3
– Limestone, sandstone, marble
Decrease atmospheric visibility
Decreased productivity and profitability of fisheries, forests, and farms

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What Are the Harmful Effects of Acid Deposition? Aquatic Systems

Fish population declines at $\text{pH} < 6$
Asphyxiation of fish due to Al^{3+} in water
Acid shock in minimally buffered lakes
7000 acidified lakes in Canada

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What Are the Harmful Effects of Acid Deposition? Plants and Soils

Nutrient leaching

– Nutritional deficiencies accumulate up the food chain

Reduced buffering capacity of soils

Harmful synergistic effects of multiple pollutants

Heavy metal dissolution and release

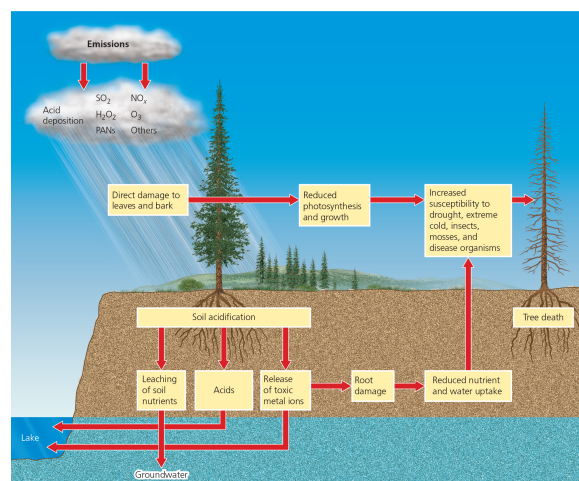
Promotes growth of acid-loving mosses

Weakens plants toward other stresses

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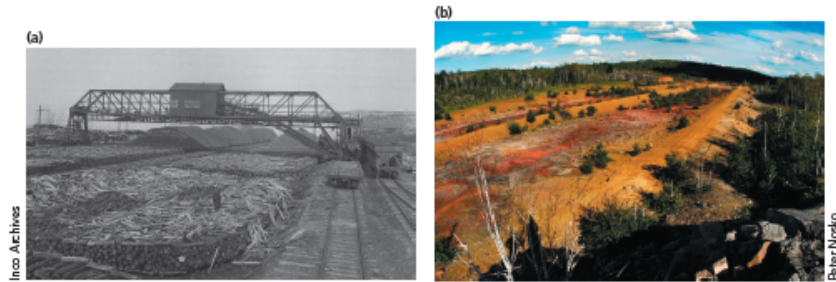
What Are the Harmful Effects of Acid Deposition? Plants and Soils



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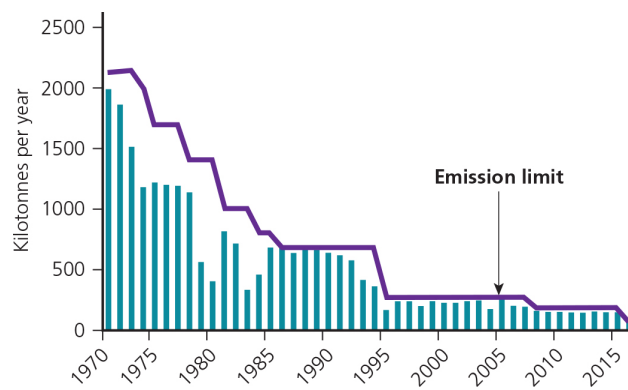
Case Study: Transforming Sudbury from Black to Green



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Case Study: Transforming Sudbury from Black to Green



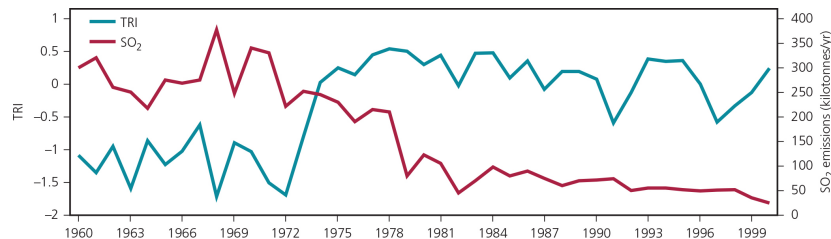
Source: Courtesy of Vale

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Case Study: Transforming Sudbury from Black to Green

Improved smelting technology and the closure of the Falconbridge scinterring plant has improved things.



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Acid Deposition: Solutions

FIGURE 20-19 SOLUTIONS

Acid Deposition

Methods for reducing acid deposition and its damage



Prevention

- Reduce air pollution by improving energy efficiency.
- Reduce coal use.
- Increase natural gas use.
- Increase use of renewable energy resources.
- Burn low-sulphur coal.
- Remove SO₂ particulates and NO_x from smokestack gases.
- Remove NO_x from motor vehicular exhaust.
- Tax emissions of SO₂.



Cleanup

- Add lime to neutralize acidified lakes.
- Add phosphate fertilizer to neutralize acidified lakes.
- Add powdered limestone to neutralize acid soils.
- Plant acid-resistant grasses, shrubs, and trees.

(Left): Photo: iStockphoto.com
(Right): SOI/Land Use Management

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Indoor Air Pollution

Levels of 11 common pollutants are
2–5x higher indoors

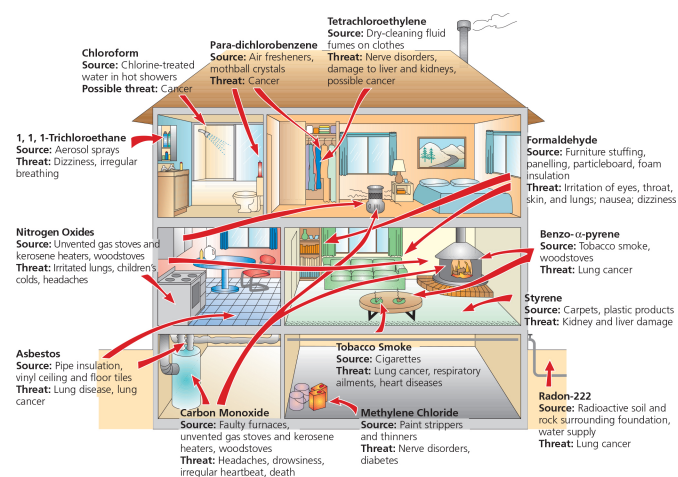
Pollution levels inside cars 18x higher

Health risks are magnified by spending
70–98% of time indoors

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Some Important Indoor Pollutants



Source: Data from U.S. Environmental Protection Agency.

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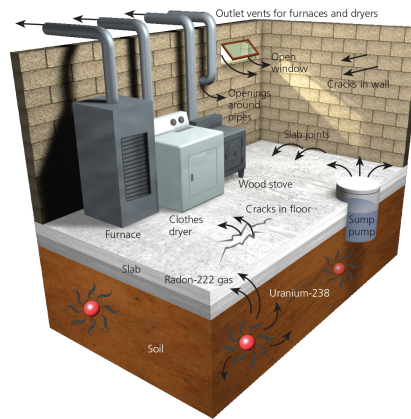
Case Study: Are You Being Exposed to Radioactive Radon Gas?

Radioactive radon-222

Lung cancer threat

Occurs in certain areas based on geology

Associated with uranium and organic material in rock

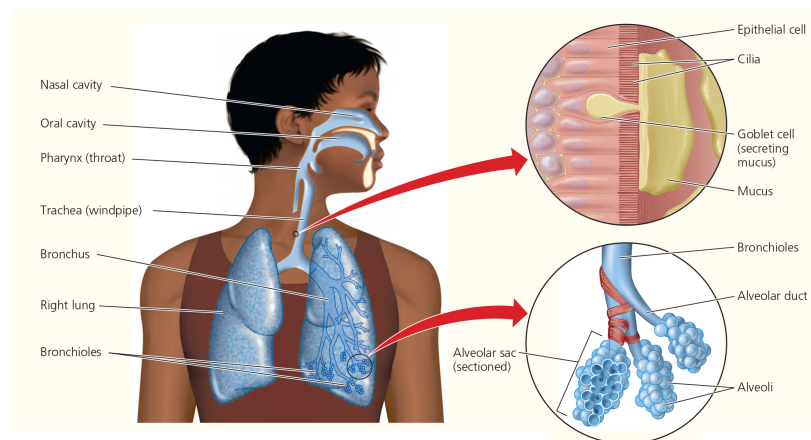


Source: Data from U.S. Environmental Protection Agency.

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Science Focus: Air Pollution and the Human Respiratory System



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Science Focus: Air Pollution and the Human Respiratory System

Asthma

Lung cancer

Chronic bronchitis

Emphysema

~6580 premature deaths/day are due to effects of air pollution; 66% due to indoor pollutants)

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Reducing and Preventing Air Pollution

Prevention and capture

Emissions trading

Between 1990 and 2012, trading reduced SO₂ emissions by 78% in the United States

Burn less and different kinds of coal

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Stationary Air Pollution: Solutions

FIGURE 20-24 **SOLUTIONS**

Stationary Source Air Pollution

Methods for reducing emissions of sulphur oxides, nitrogen oxides, and particulate matter from stationary sources such as coal-burning electric power plants and industrial plants



Prevention

- Burn low-sulphur coal.
- Remove sulphur from coal.
- Convert coal to a liquid or gaseous fuel.
- Shift to less polluting fuels.



Cleanup

- Disperse emissions above thermal inversion layer with tall smokestacks.
- Remove pollutants after combustion.
- Tax each unit of pollution produced.

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Motor Vehicle Air Pollution: Solutions

FIGURE 20-26 **SOLUTIONS**

Motor Vehicle Air Pollution

Methods for reducing emissions from motor vehicles



Prevention

- Mass transit
- Bicycles and walking
- Less-polluting engines
- Less-polluting fuels
- Improving fuel efficiency
- Getting older, polluting cars off the road
- Giving buyers large tax write-offs for buying low-polluting, energy-efficient vehicles
- Restricting driving in polluted areas



Cleanup

- Emission control devices
- Car exhaust inspections twice a year
- Stricter emission standards

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Case Study: Transboundary Air Pollution: Acid Deposition in the 1980s

1980s: U.S. SO₂ emissions acidifying Canadian lakes and forests

1985: U.S. took no action; Canada reduced emissions

1990: U.S. Clean Air Act amended to reduce SO₂ emissions

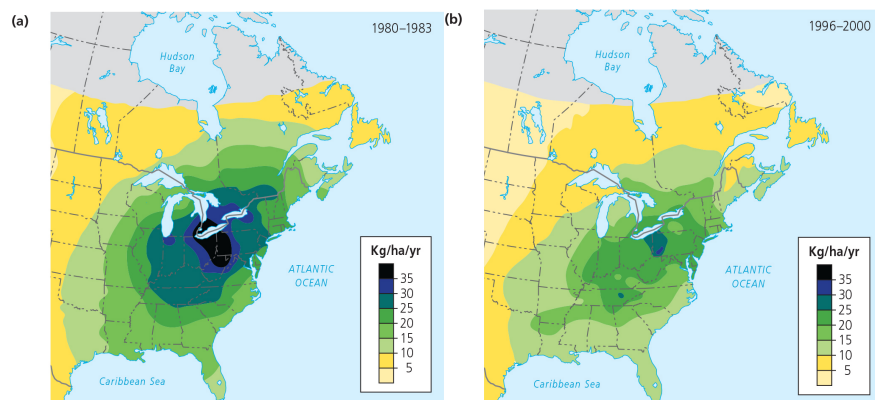
1991: Canada–U.S. Air Quality agreement

Present day: U.S. still produces 90% of transboundary emissions

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Case Study: Transboundary Air Pollution: Acid Deposition in the 1980s

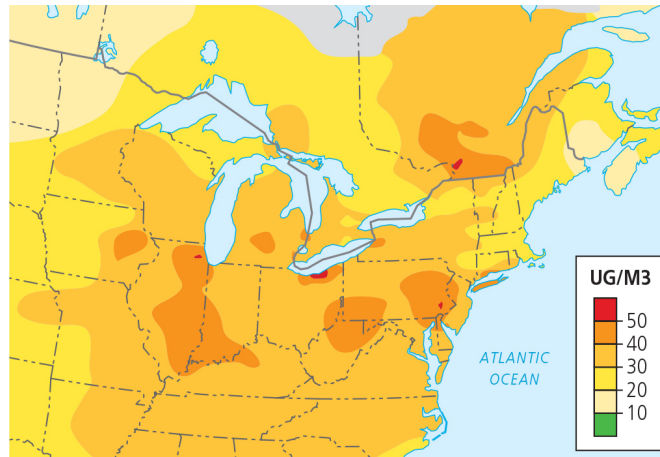


Source: Canadian National Atmospheric Chemistry Database, Meteorological Service of Canada, and Environment Canada.

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Case Study: Transboundary Air Pollution: Acid Deposition in the 1980s



Source: Data from Ministry of the Environment 2005.

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Indoor Air Pollution: Solutions

FIGURE 20-29 SOLUTIONS

Indoor Air Pollution

Ways to prevent and reduce indoor air pollution



Prevention

- Cover ceiling tiles and the lining of AC ducts to prevent release of mineral fibres.
- Ban smoking or limit it to well-ventilated areas.
- Set stricter formaldehyde emissions standards for carpet, furniture, and building materials.
- Prevent radon infiltration.
- Use office machines in well-ventilated areas.
- Use less-polluting substitutes for harmful cleaning agents, paints, and other products.



Cleanup

- Use adjustable fresh air vents for work spaces.
- Increase intake of outside air.
- Change air more frequently.
- Circulate a building's air through rooftop greenhouses.
- Use exhaust hoods for stoves and appliances burning natural gas.
- Install efficient chimneys for wood-burning stoves.

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Air Pollution: Solutions

FIGURE 20-30 **SOLUTIONS**

Air Pollution

Ways to prevent outdoor and indoor air pollution over the next 30–40 years



Outdoor

- Improve energy efficiency to reduce fossil fuel use.
- Rely more on lower-polluting natural gas.
- Rely more on renewable energy (especially solar cells, wind, and solar-produced hydrogen).
- Transfer technologies for latest energy efficiency, renewable energy, and pollution prevention to developing countries.



Indoor

- Reduce poverty.
- Distribute cheap and efficient cookstoves to poor families in developing countries.
- Reduce or ban indoor smoking.
- Develop simple and cheap tests for indoor pollutants such as particulates, radon, and formaldehyde.

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Conclusion

Air pollution affects health, ecology, and physical security.

Some pollutants are generated from interactions with atmosphere; others are toxic on their own.

Indoors and outdoors, remedies need to be applied to reduce them.

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