Chapter 18
Air Pollution
Core Case Study: South Asia’s Massive Brown Cloud

- South Asian Brown Cloud
  - Causes
  - Chemical composition
  - Areas impacted

- Air pollution connects the world
  - Affects west coast of the United States

- China and India need stricter air pollution standards
The Asian Brown Cloud

Fig. 18-1, p. 465
Air Pollution in Shanghai, China

Fig. 18-2, p. 465
18-1 What Is the Nature of the Atmosphere?

- **Concept 18-1** The two innermost layers of the atmosphere are the troposphere, which supports life, and the stratosphere, which contains the protective ozone layer.
The Atmosphere Consists of Several Layers

• Density varies
  • Decreases with altitude

• Atmospheric pressure
  • Decreases with altitude
Air Movements in the Troposphere Play a Key Role in Earth’s Weather and Climate

- **Troposphere**
  - 75–80% of the earth’s air mass
  - Closest to the earth's surface
  - Chemical composition of air
  - Rising and falling air currents: weather and climate
  - Involved in chemical cycling
Natural Capital: The Earth’s Atmosphere Is a Dynamic System with Four Layers
Atmospheric pressure (millibars)

Temperature

Thermosphere

Mesosphere

Stratosphere

Ozone layer

Pressure

Troposphere

Pressure = 1,000 millibars at ground level

Fig. 18-3, p. 467
Case Study: The South Asian Brown Clouds, Melting Glaciers, and Atmospheric Cooling

• 2008 UNEP study on South Asian Brown Clouds
  • Causing gradual melting of Himalayan glaciers
  • Particles absorb sunlight and warm air above the glaciers
  • Reflect some sunlight back to space
  • Overall cooling affect on earth’s atmosphere
The Stratosphere Is Our Global Sunscreen

- **Stratosphere**
  - Similar composition to the troposphere, with 2 exceptions
    - Much less water
    - $O_3$, ozone layer

- **Ozone layer**
  - Filters 95% of harmful UV radiation
  - Allows us and other life to exist on land
18-2 What Are the Major Outdoor Pollution Problems?

- **Concept 18-2** Pollutants mix in the air to form industrial smog, primarily as a result of burning coal, and photochemical smog, caused by emissions from motor vehicles, industrial facilities, and power plants.
Air Pollution Comes from Natural and Human Sources (1)

- **Air pollution**
  - Concentrations high enough to harm human health or alter climate

- Natural sources
  - Dust blown by wind
  - Pollutants from wildfires and volcanoes
  - Volatile organics released by plants
Air Pollution Comes from Natural and Human Sources (2)

- Human sources: mostly in industrialized and/or urban areas
  - Stationary sources: power plants and industrial facilities
  - Mobile sources: motor vehicles
Burning Fossil Fuels Causes Air Pollution

Fig. 18-4, p. 468
Some Pollutants in the Atmosphere Combine to Form Other Pollutants

• **Primary pollutants**
  • Emitted directly into the air

• **Secondary pollutants**
  • From reactions of primary pollutants

• Air quality improving in developed countries

• Less-developed countries face big problems
  • Indoor pollution: big threat to the poor
Sources and Types of Air Pollutants

- Primary Pollutants:
  - CO
  - CO₂
  - SO₂
  - NO
  - NO₂
  - N₂O
  - CH₄ and most other hydrocarbons
  - Most suspended particles

- Secondary Pollutants:
  - SO₃
  - HNO₃
  - H₂SO₄
  - H₂O₂
  - O₃
  - PANs
  - Most NO₃⁻ and SO₃²⁻ salts

- Sources:
  - Natural Source
  - Stationary (Factories)
  - Human Source
  - Mobile (Vehicles)

Fig. 18-5, p. 469
Primary Pollutants
- CO
- CO$_2$
- NO
- NO$_2$
- CH$_4$ and most other hydrocarbons
- Most suspended particles

Secondary Pollutants
- SO$_3$
- HNO$_3$
- H$_2$SO$_4$
- H$_2$O$_2$
- O$_3$
- PANs
- Most NO$_3^-$ and SO$_4^{2-}$ salts

Natural Source
Stationary
Human Source
Mobile

Fig. 18-5, p. 469
Indoor Air Pollution in Bangladesh

Fig. 18-6, p. 469
What Are the Major Outdoor Air Pollutants? (1)

- **Carbon oxides**
  - Carbon monoxide (CO)
  - Carbon dioxide ($CO_2$)
  - Sources
  - Human health and environmental impact
What Are the Major Outdoor Air Pollutants? (2)

- **Nitrogen oxides (NO) and nitric acid (HNO₃)**
  - Sources
  - Acid deposition
  - Photochemical smog
  - Human health and environmental impact

- **Sulfur dioxide (SO₂) and sulfuric acid (H₂SO₄)**
  - Sources
  - Human health and environmental impact
What Are the Major Outdoor Air Pollutants? (3)

- **Particulates**
  - Suspended particulate matter (SPM)
    - Fine
    - Ultrafine

- **Sources**
  - Human health and environmental impact
What Are the Major Outdoor Air Pollutants? (4)

- **Ozone** ($\text{O}_3$)
  - Sources
  - Human and environmental impact

- **Volatile organic compounds (VOCs)**
  - Hydrocarbons and terpenes
  - Sources
  - Human and environmental impact
### Chemical Reactions That Form Major Outdoor Air Pollutants

**Table 18-1**

<table>
<thead>
<tr>
<th>Pollutant</th>
<th>Chemical Reaction</th>
</tr>
</thead>
<tbody>
<tr>
<td>Carbon monoxide (CO)</td>
<td>$2C + O_2 \rightarrow 2CO$</td>
</tr>
<tr>
<td>Carbon dioxide (CO$_2$)</td>
<td>$C + O_2 \rightarrow CO_2$</td>
</tr>
<tr>
<td>Nitric oxide (NO)</td>
<td>$N_2 + O_2 \rightarrow 2NO$</td>
</tr>
<tr>
<td>Nitrogen dioxide (NO$_2$)</td>
<td>$2NO + O_2 \rightarrow 2NO_2$</td>
</tr>
<tr>
<td>Sulfur dioxide (SO$_2$)</td>
<td>$S + O_2 \rightarrow SO_2$</td>
</tr>
</tbody>
</table>
Statue Corroded by Acid Deposition and Other Forms of Air Pollution, RI, U.S.
Case Study: Lead Is a Highly Toxic Pollutant (1)

- In air, water, soil, plants, animals

- Does not break down in the environment

- Human health and environmental impact
  - Children most vulnerable
  - Can cause death, mental retardation, paralysis
Case Study: Lead Is a Highly Toxic Pollutant (2)

- Reduction of lead (Pb)
  - Unleaded gasoline
  - Unleaded paint

- Still problems
  - 15-18 million children have brain damage
  - Need global ban on lead in gasoline and paint
Solutions: Lead Poisoning, Prevention and Control

**Lead Poisoning**

**Prevention**
- Phase out leaded gasoline worldwide
- Phase out waste incineration
- Ban use of lead solder
- Ban use of lead in computer and TV monitors
- Ban lead glazing for ceramicware used to serve food
- Ban candles with lead cores
- Test blood for lead by age 1

**Control**
- Replace lead pipes and plumbing fixtures containing lead solder
- Remove leaded paint and lead dust from older houses and apartments
- Sharply reduce lead emissions from incinerators
- Remove lead from TV sets and computer monitors before incineration or land disposal
- Test for lead in existing ceramicware used to serve food
- Test existing candles for lead
- Wash fresh fruits and vegetables
Solutions

Lead Poisoning

Prevention

- Phase out leaded gasoline worldwide
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Science Focus: Detecting Air Pollutants

- Chemical instruments
- Satellites
- Lasers and remote sensors
- Biological indicators
  - Lichens
Natural Capital: Lichen Species, Vulnerability to Air Pollutants

Fig. 18-A, p. 473
Burning Coal Produces Industrial Smog

• Chemical composition of *industrial smog*

• Reduction of this smog in urban cities of the United States

• China and smog
  • Human deaths
  • Need strong standards, especially for coal burning
How Pollutants Are Formed from Burning Coal and Oil, Leading to Industrial Smog

Fig. 18-9, p. 474
Ammonium sulfate \([\text{(NH}_4\text{)}_2\text{SO}_4]\)

- Ammonia (NH\(_3\))
- Sulfuric acid (H\(_2\)SO\(_4\))
- Water vapor (H\(_2\)O)
- Oxygen (O\(_2\))
- Sulfur trioxide (SO\(_3\))
- Sulfur dioxide (SO\(_2\))
- Carbon monoxide (CO) and carbon dioxide (CO\(_2\))

Burning coal and oil

- Sulfur (S) in coal and oil
- Carbon (C) in coal and oil
Burning coal and oil

Ammonium sulfate [(NH₄)₂SO₄]

Ammonia (NH₃) →
Sulfuric acid (H₂SO₄)

Water vapor (H₂O) →
Sulfur trioxide (SO₃)

Oxygen (O₂) →
Sulfur dioxide (SO₂)

Carbon monoxide (CO) and carbon dioxide (CO₂)

Sulfur (S) in coal and oil

Water vapor (H₂O)

Oxygen (O₂)

Carbon (C) in coal and oil

Steffed Art

Fig. 18-9, p. 474
Industrial Smog in India

Fig. 18-10, p. 474
Sunlight Plus Cars Equals Photochemical Smog

- Photochemical Smog
  - Chemical composition
  - Sources

- VOCs + NO$_x$ + Heat + Sunlight yields
  - Ground level O$_3$ and other photochemical oxidants
  - Aldehydes
  - Other secondary pollutants

- Human health and environmental impact
A Model of How Pollutants That Make Up Photochemicals Are Formed

Fig. 18-11, p. 475
PANS and other pollutants

Volatile organic compounds (VOCs)

Ozone \( (O_3) \)

Oxygen \( (O_2) \)

Nitric oxide (NO) + Oxygen atom (O)

Water vapor \( (H_2O) \)

UV radiation

Peroxyacyl nitrates (PANs)

Nitrogen dioxide (NO\(_2\))

Oxygen \( (O_2) \)

Nitric oxide (NO)

Oxygen \( (O_2) \)

Burning fossil fuels

Nitrogen (N) in fossil fuel
Global Outlook: Photochemical Smog in Santiago, Chile

Fig. 18-12, p. 475
Several Factors Can Decrease or Increase Outdoor Air Pollution (1)

- Outdoor air pollution may be decreased by
  1. Settling of particles due to gravity
  2. Rain and snow
  3. Salty sea spray from the ocean
  4. Winds
  5. Chemical reactions
Several Factors Can Decrease or Increase Outdoor Air Pollution (2)

• Outdoor air pollution may be increased by
  1. Urban buildings
  2. Hills and mountains
  3. High temperatures
  4. Emissions of VOCs from certain trees and plants
  5. Grasshopper effect
  6. **Temperature inversions**
     • Warm air above cool air prevents mixing
A Temperature Inversion
18-3 What Is Acid Deposition and Why Is It a Problem?

• **Concept 18-3** Acid deposition is caused mainly by coal-burning power plants and motor vehicle emissions, and in some regions it threatens human health, aquatic life and ecosystems, forests, and human-built structures.
Acid Disposition Is a Serious Regional Air Pollution Problem

- **Acid deposition**, acid rain
  - Chemical sources
  - Formation
  - Local versus regional problems
  - Effects of prevailing winds
  - Buffers
  - Where is the worst acid deposition?
Natural Capital Degradation: Acid Deposition

Fig. 18-14, p. 477

Transformation to sulfuric acid ($H_2SO_4$) and nitric acid ($HNO_3$)

Nitric oxide (NO)

Sulfur dioxide ($SO_2$) and NO

Windborne ammonia gas and some soil particles partially neutralize acids and form dry sulfate and nitrate salts

Dry acid deposition (sulfur dioxide gas and particles of sulfate and nitrate salts)

Wet acid deposition (droplets of $H_2SO_4$ and $HNO_3$ dissolved in rain and snow)

Lakes in deep soil high in limestone are buffered

Lakes in shallow soil low in limestone become acidic
Windborne ammonia gas and some soil particles partially neutralize acids and form dry sulfate and nitrate salts.

Wet acid deposition (droplets of H$_2$SO$_4$ and HNO$_3$ dissolved in rain and snow).

Nitric oxide (NO)

Nitrogen compounds: 
- Sulfur dioxide (SO$_2$)
- SO$_2$ and NO

Acid fog

Dry acid deposition (sulfur dioxide gas and particles of sulfate and nitrate salts)

Acid fog

Lakes in deep soil high in limestone are buffered.

Lakes in shallow soil low in limestone become acidic.

Lakes in deep soil high in limestone are buffered.

Fig. 18-14, p. 477
Current and Possible Future Acid Rain Problem Areas
Acid Deposition Has a Number of Harmful Effects (1)

- Human health
  - Respiratory disorders
  - Toxins in fish

- Release of toxic metals

- Aquatic ecosystems affected
  - Lowers pH and kills organisms
Acid Deposition Has a Number of Harmful Effects (2)

- Leaching of soil nutrients
- Lower crop yields
- Forest damage
- Damage to buildings, statues, and monuments
Natural Capital Degradation: Air Pollution Damage to Trees in North Carolina, U.S.
Emissions

Acid deposition

SO₂, H₂O, NOₓ, O₃, PANs, Others

Direct damage to leaves and bark

Reduced photosynthesis and growth

Increased susceptibility to drought, extreme cold, insects, mosses, and disease organisms

Soil acidification

Leaching of soil nutrients

Acids

Release of toxic metal ions

Root damage

Reduced nutrient and water uptake

Tree death

Lake

Groundwater
We Know How to Reduce Acid Deposition

• Prevention approaches

• Cleanup approaches
Solutions: Acid Deposition

**Acid Deposition**

**Prevention**
- Reduce coal use
- Burn low-sulfur coal
- Increase use of natural gas and renewable energy resources
- Remove \( \text{SO}_2 \) particulates and \( \text{NO}_x \) from smokestack gases and remove \( \text{NO}_x \) from motor vehicular exhaust
- Tax emissions of \( \text{SO}_2 \)

**Cleanup**
- Add lime to neutralize acidified lakes
- Add phosphate fertilizer to neutralize acidified lakes

Fig. 18-17, p. 480
Solutions

Acid Deposition

**Prevention**

- Reduce coal use
- Burn low-sulfur coal
- Increase use of natural gas and renewable energy resources
- Remove SO$_2$ from smokestack particulates and NO$_x$ gases and remove vehicular exhaust NO$_x$ from motor
- Tax emissions of SO$_2$

**Cleanup**

- Add lime to neutralize acidified lakes
- Add phosphate fertilizer to neutralize acidified lakes

Fig. 18-17, p. 480
What Are the Major Indoor Air Pollution Problems?

- **Concept 18-4** The most threatening indoor air pollutants are smoke and soot from the burning of wood and coal in cooking fires (mostly in less-developed countries), cigarette smoke, and chemicals used in building materials and cleaning products.
Indoor Air Pollution Is a Serious Problem (1)

- Developing countries
  - Indoor burning of wood, charcoal, dung, crop residues, coal
  - Poor suffer the greatest risk
Indoor Air Pollution Is a Serious Problem (2)

• Developed countries
  • Indoor air pollution is greater than outdoor air pollution

• Why?
  • 11 of the common air pollutants higher inside than outside
  • Greater in vehicles than outside
  • Health risks magnified: people spend 70–98% of their time is indoors or in cars
Indoor Air Pollution Is a Serious Problem (3)

- Who is at greatest risk from indoor air pollution?
  - Children under 5 and the elderly
  - Sick
  - Pregnant women
  - People with respiratory disorders or heart problems
  - Smokers
  - Factory workers
Indoor Air Pollution Is a Serious Problem (4)

- Four most dangerous indoor air pollutants
  - Tobacco smoke
  - Formaldehyde
  - Radioactive radon-222 gas
  - Very small particles

- Sources of these pollutants

- Human health risks
Indoor Air Pollution Is a Serious Problem (5)

• Other possible indoor air pollutants
  • Pesticide residue
  • Pb particles
  • Living organisms and their excrements
    • E.g., Dust mites and cockroach droppings
  • Airborne spores of molds and mildews

• Sick-building syndrome
Some Important Indoor Air Pollutants

- **Chloroform**
  - **Source:** Chlorine-treated water in hot showers
  - **Possible threat:** Cancer

- **Para-dichlorobenzene**
  - **Source:** Air fresheners, mothball crystals
  - **Threat:** Cancer

- **Tetrachloroethylene**
  - **Source:** Dry-cleaning fluid fumes on clothes
  - **Threat:** Nerve disorders, damage to liver and kidneys, possible cancer

- **1,1,1-Trichloroethane**
  - **Source:** Aerosol sprays
  - **Threat:** Dizziness, irregular breathing

- **Nitrogen oxides**
  - **Source:** Unvented gas stoves and kerosene heaters, wood stoves
  - **Threat:** Irritated lungs, children’s colds, headaches

- **Particulates**
  - **Source:** Pollen, pet dander, dust mites, cooking smoke particles
  - **Threat:** Irritated lungs, asthma attacks, itchy eyes, runny nose, lung disease

- **Asbestos**
  - **Source:** Pipe insulation, vinyl ceiling and floor tiles
  - **Threat:** Lung disease, lung cancer

- **Carbon monoxide**
  - **Source:** Faulty furnaces, unvented gas stoves and kerosene heaters, wood stoves
  - **Threat:** Headaches, drowsiness, irregular heartbeat, death

- **Tobacco smoke**
  - **Source:** Cigarettes
  - **Threat:** Lung cancer, respiratory ailments, heart disease

- **Formaldehyde**
  - **Source:** Furniture stuffing, paneling, particleboard, foam insulation
  - **Threat:** Irritation of eyes, throat, skin, and lungs; nausea; dizziness

- **Styrene**
  - **Source:** Carpets, plastic products
  - **Threat:** Kidney and liver damage

- **Benzo-α-pyrene**
  - **Source:** Tobacco smoke, wood stoves
  - **Threat:** Lung cancer

- **Radon-222**
  - **Source:** Radioactive soil and rock surrounding foundation, water supply
  - **Threat:** Lung cancer

- **Methylene chloride**
  - **Source:** Paint strippers and thinners
  - **Threat:** Nerve disorders, diabetes

Fig. 18-19, p. 482
Chloroform Source: Chlorine-treated water in hot showers Possible threat: Cancer

Para-dichlorobenzene Source: Air fresheners, mothball crystals Threat: Cancer

Tetrachloroethylene Source: Dry-cleaning fluid fumes on clothes Threat: Nerve disorders, damage to liver and kidneys, possible cancer

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Radon-222 Source: Radioactive soil and rock surrounding foundation, water supply Threat: Lung cancer

Tobacco smoke Source: Cigarettes Threat: Lung cancer, respiratory ailments, heart disease

Methylene chloride Source: Paint strippers and thinners Threat: Nerve disorders, diabetes

Fig. 18-19, p. 482
Case Study: Radioactive Radon Gas

- Sources
- Human health risks
- Testing for radon
- Correcting a radon problem
Science: Sources and Paths of Entry for Indoor Radon-222 Gas
18-5 What Are the Health Effects of Air Pollution?

• **Concept 18-5** Air pollution can contribute to asthma, chronic bronchitis, emphysema, lung cancer, heart attack, and stroke.
Your Body’s Natural Defenses against Air Pollution Can Be Overwhelmed

- Respiratory system protection from air pollutants
  - Role of cilia, mucus, sneezing, and coughing

- Effect of smoking and prolonged air pollution exposure
  - Chronic bronchitis
  - Emphysema
Major Components of the Human Respiratory System
Epithelial cell

Cilia

Nasal cavity

Oral cavity

Goblet cell (secreting mucus)

Pharynx (throat)

Mucus

Trachea (windpipe)

Bronchus

Right lung

Bronchioles

Alveolar duct

Alveolar sac (sectioned)

Alveoli
Air Pollution Is a Big Killer

• 2.4 million deaths per year world-wide
  • Mostly in Asia; 750,000 in China
  • 150,000 to 350,000 in the United States
  • Role of coal-burning power plants

• EPA: proposed stricter emission standards for diesel-powered vehicles
  • 125,000 die in U.S. each year from diesel fumes
  • Emissions from one truck = 150 cars
Premature Deaths from Air Pollution in the U.S.

Fig. 18-22, p. 485
How Should We Deal with Air Pollution?

- **Concept 18-6** Legal, economic, and technological tools can help us to clean up air pollution, but the best solution is to prevent it.
Laws and Regulations Can Reduce Outdoor Air Pollution (1)

- United States

- EPA
  - National ambient air quality standards for 6 outdoor pollutants
  - National emission standards for 188 hazardous air pollutants (HAPs)
    - Toxic Release Inventory (TRI)
Laws and Regulations Can Reduce Outdoor Air Pollution (2)

- Good news in U.S.
  - Decrease in emissions
  - Use of low-sulfur diesel fuel
    - Cuts pollution

- Less-developed countries
  - More air pollution
Case Study: U.S. Air Pollution Can Be Improved (1)

- Rely on prevention of pollution, not cleanup

- Sharply reduce emissions from power plants, industrial plants, and other industry

- Raise fuel-efficiency for cars, SUVs, and light trucks

- Better regulation of emissions of motorcycles and two-cycle gasoline engines
Case Study: U.S. Air Pollution Can Be Improved (2)

• Regulate air pollution for oceangoing ships in American ports

• Regulate emissions at U.S. airports

• Sharply reduce indoor pollution

• Increased and more accurate monitoring of air pollutants
We Can Use the Marketplace to Reduce Outdoor Air Pollution

• Emission trading or cap-and-trade program
  • Mixed reactions to program
  • SO$_2$ emissions down significantly
  • NO$_x$ now in effect
  • Mercury plan strongly opposed for creating toxic hotspots

• Many problems with making cap-and-trade effective
There Are Many Ways to Reduce Outdoor Air Pollution

• There are ways to deal with
  • Stationary source air pollution
  • Motor vehicle air pollution
    • New cars have lower emissions

• Less-developed countries far behind developed countries in implementing solutions
**Solutions: Stationary Source Air Pollution**

**Prevention**
- Burn low-sulfur coal or remove sulfur from coal
- Convert coal to a liquid or gaseous fuel
- Phase out coal use

**Reduction or Disposal**
- Disperse emissions (which can increase downwind pollution) with tall smokestacks
- Remove pollutants from smokestack gases
- Tax each unit of pollution produced
Solutions

Stationary Source Air Pollution

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Solutions: Motor Vehicle Air Pollution

**Prevention**
- Walk, bike, or use mass transit
- Improve fuel efficiency
- Get older, polluting cars off the road

**Cleanup**
- Require emission control devices
- Inspect car exhaust systems twice a year
- Set strict emission standards

Fig. 18-24, p. 487
Motor Vehicle Air Pollution

Solutions

**Prevention**
- Walk, bike, or use mass transit
- Improve fuel efficiency
- Get older, polluting cars off the road

**Cleanup**
- Require emission control devices
- Inspect car exhaust systems twice a year
- Set strict emission standards
Reducing Indoor Air Pollution Should Be a Priority

• Greater threat to human health than outdoor pollution

• What can be done?
  • Prevention
  • Cleanup
**Solutions: Indoor Pollution**

**Indoor Air Pollution**

**Prevention**
- Ban indoor smoking
- Set stricter formaldehyde emissions standards for carpet, furniture, and building materials
- Prevent radon infiltration
- Use less polluting cleaning agents, paints, and other products

**Cleanup or Dilution**
- Use adjustable fresh air vents for work spaces
- Circulate air more frequently
- Circulate a building’s air through rooftop greenhouses
- Use efficient venting systems for wood-burning stoves

Fig. 18-25, p. 488
Indoor Air Pollution

**Prevention**
- Ban indoor smoking
- Set stricter formaldehyde emissions standards for carpet, furniture, and building materials
- Prevent radon infiltration
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**Cleanup or Dilution**
- Use adjustable fresh air vents for work spaces
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- Circulate a building’s air through rooftop greenhouses
- Use efficient venting systems for wood-burning stoves
Turbo Stove in India

Fig. 18-26, p. 488
What Can You Do? Indoor Air Pollution

Test for radon and formaldehyde inside your home and take corrective measures as needed
- Do not buy furniture and other products containing formaldehyde
- Remove your shoes before entering your house to reduce inputs of dust, lead, and pesticides
- Switch to phthalate-free detergents
- Use baked lemons as natural fragrance
- Test your house or workplace for asbestos fiber levels, and check for any crumbling asbestos materials if it was built before 1980

Do not store gasoline, solvents, or other volatile hazardous chemicals inside a home or attached garage
- If you smoke, do it outside or in a closed room vented to the outside
- Make sure that wood-burning stoves, fireplaces, and kerosene and gas-burning heaters are properly installed, vented, and maintained
- Install carbon monoxide detectors in all sleeping areas

Fig. 18-27, p. 489
We Need to Put More Emphasis on Pollution Prevention

• Output approaches

• New shift to preventing outdoor and indoor pollution
  • Pressure from citizens
Three Big Ideas

1. Outdoor air pollution, in the forms of industrial smog, photochemical smog, and acid deposition, and indoor air pollution are serious global problems.

2. Each year, at least 2.4 million people die prematurely from the effects of air pollution; indoor air pollution, primarily in less-developed countries, causes about two-thirds of those deaths.
Three Big Ideas

3. We need to put our primary emphasis on preventing outdoor and indoor air pollution throughout the world.