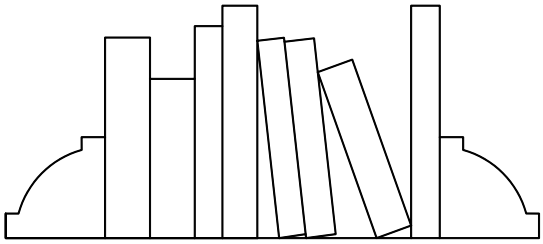
Environmental Science 101 *Fall 2012*

Air Resources

Lecture Outline:

10. AIR POLLUTION
    A. The Atmosphere—An Introduction
    B. Background Information About Air Pollution
    C. Six Principal Pollutants
    D. Air Toxics
    E. Pollutant Sources and Control Strategies
    F. Indoor Air Pollution



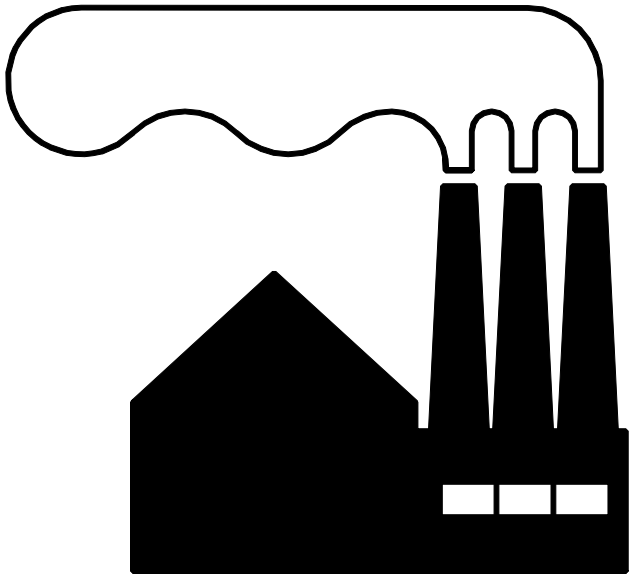
Learning Objectives:

When you are finished with this unit you should be able to:

1. Describe the various layers of the atmosphere and understand the temperature gradient within each layer.
2. Describe the processes that cause air pollution.
3. Trace the origins of industrial smog and photochemical smog.
4. Describe the Clean Air Act of 1970 and 1990 and how implementation affected air quality.
5. Name the six major air pollutants.
6. Describe the effects of pollutants on humans, crops, forests, and materials.
7. Analyze the costs and benefits associated with air pollution controls.
8. Describe the major sources of indoor air pollution and compare its impact to outdoor air pollution.

Terms You Should Know:

- Air pollutants
- Threshold level
- Industrial smog
- Photochemical smog
- Temperature inversion
- Clean Air Act of 1970
- Ambient standards
- Suspended particulate matter
- Volatile organic compounds
- Troposphere
- Stratosphere
- Mesosphere
- Carbon monoxide
- Nitrogen oxides
- Sulfur oxides
- Ozone
- Photochemical oxidants
- Radon
- Synergistic effect
- Primary pollutants
- Secondary pollutants
- Criteria pollutants
- Clean Air Act of 1990
- Catalytic converter
- Tropopause
- Stratopause
- Thermosphere



Reading Assignment:

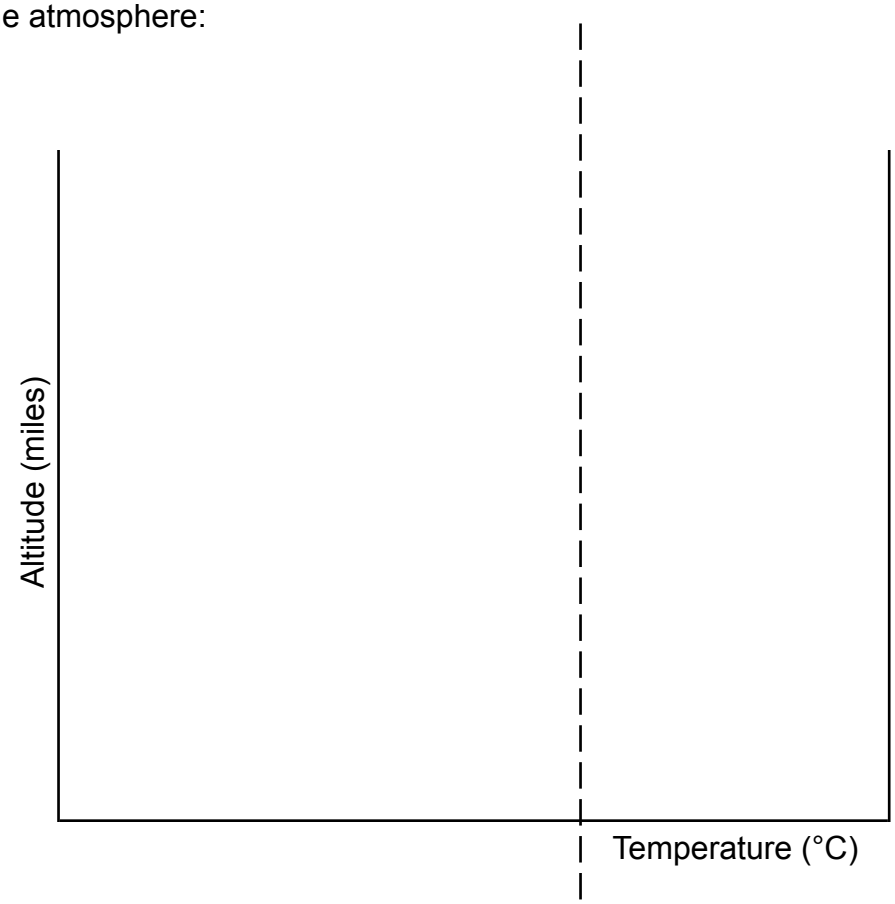
Brennan and Withgott:
Chapter 17; pages 460-490.

10. AIR POLLUTION

A. THE ATMOSPHERE—AN INTRODUCTION

The atmosphere is composed of several layers:

Diagram of the atmosphere:



TROPOSPHERE—the lowest layer

- Up to 7 miles (11 km) above the Earth's surface
- Gets colder with increasing altitude
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- Contains most of the water vapor in atmosphere
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- Pollution can be washed back to the Earth's surface as precipitation

TROPOPAUSE—caps the trophosphere

-

STRATOSPHERE—layer between 7 and 31 miles (11 to 50 km) above the Earth's surface

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- Temperature increases because of ***OZONE***
- Contains the ***OZONE SHIELD***
- O_3 (ozone) absorbs high energy radiation emitted by the sun
-
-

MESOSPHERE—layer above the stratosphere

THERMOSPHERE or CHEMOSPHERE—layer above the mesosphere

- Most of our concern is with things happening in the troposphere and stratosphere
- 3 major areas of concern:
  -
  -
  -

B. BACKGROUND INFORMATION ABOUT AIR POLLUTION

AIR POLLUTANTS—substances in the atmosphere that have harmful effects

THRESHOLD LEVEL—the pollutant level below which no ill effects are observed

- Effect caused by pollutant depends on:
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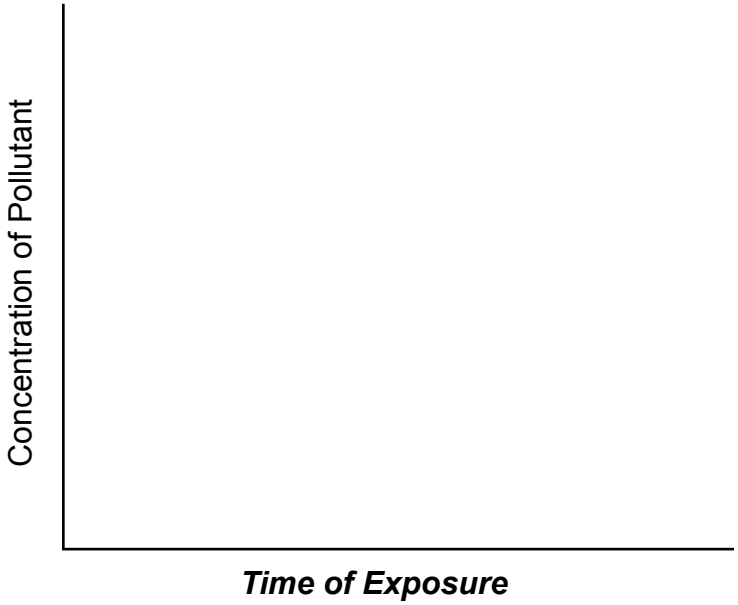
  -

-

DOSE—concentration X time of exposure



Three factors determine the level of air pollution:

1.
2. Amount of space into which the air pollutants are dispersed
3. Mechanisms that remove pollutants from the air

- Natural pollutants:
  -
  -
  -
  -

INDUSTRIAL SMOG—grayish mixture of soot, sulfurous compounds, and water vapor

PHOTOCHEMICAL SMOG—brownish haze; over cities, results from sunlight driven chemical reaction among N oxides and hydrocarbons, mainly from auto exhausts

Certain conditions intensify smog:

TEMPERATURE INVERSION—cooler air below warmer air layer; traps smog

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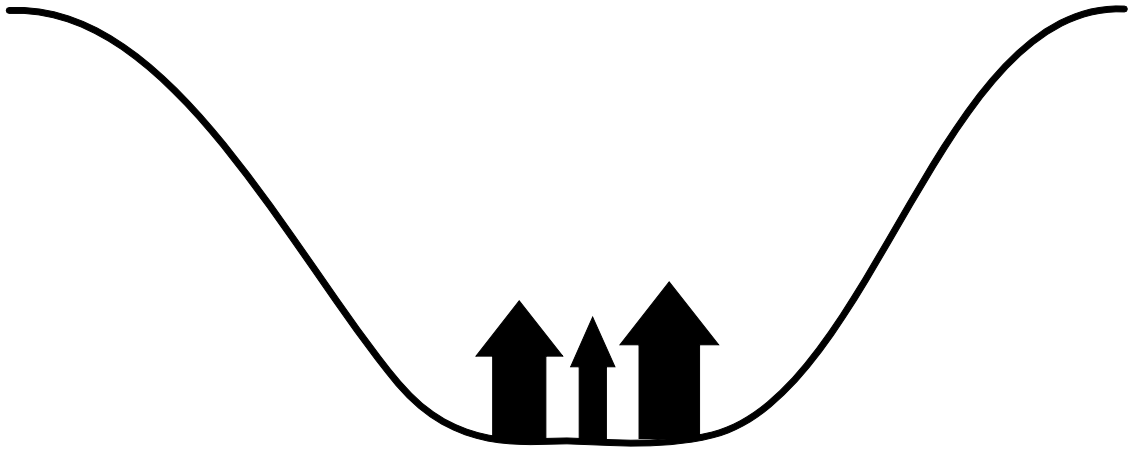

- Long-term temperature inversions can result in dangerous conditions—***AIR POLLUTION DISASTERS***

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- Air pollution can also impact plants:

  –

  –

- Clean Air Act of 1970 (CAA) (amended in 1977 and 1990)

  –

  –

  – sets ***AMBIENT STANDARDS*** — levels that need to be achieved to protect the environment and human health

Four stages involved in meeting standards:

1.
2. Tie pollutants to health effects, so that a standard may be set
3.
4.

- Air quality is better in most large cities today than in the mid-1900s

C. SIX PRINCIPAL POLLUTANTS

Six major pollutants

1. Carbon Monoxide (CO)

   -

   - Poisonous — forms when carbon in fuel is not burned completely
   - Component of motor vehicle emissions (60% of all emissions)
   - Particular problem in cities with cold air inversion in winter (SPOKANE)

   i. CO Trends

   -

   - Transportation still accounts for 77% of emissions

2. Lead

   - Pb is toxic (affects kidneys, nervous system, other organs)
   - In the past the major source was leaded gasoline

-

i. Pb Trends

-

- 99% decrease due to highway vehicles

3. Nitrogen Dioxide (NO_2)
   - NO_x describes NO and NO_2
   - Major sources include:
     –
     –
     –
   -
   -
   -

i. NO_x Trends

-

-

4. Ground-Level Ozone (O_3)
   - Highly toxic to plants and animals
   -
   -

Formed by reaction of:

- VOCs are emitted from motor vehicles and industrial sources

-

i. O_3 Trends

- Ozone concentrations decreased 19% between 1988 and 1998

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5. Suspended Particulate Matter (SPM)

- Also called the PM–10 standard

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- Dust, smoke, soot, combustion in motor vehicles and power plants

-

- In 1997 EPA proposed changing the standard to PM–2.5

i. SPM Trends

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- Switch to PM–2.5 standard would put many cities out of compliance

6. Sulfur Dioxide (SO_2)

- SO_2 gas is poisonous to plants and animals

-

-

-

i. SO_2 Trends

- 12% decrease in emissions between 1988 and 1997

D. AIR TOXICS

- Are chemicals known to cause serious health effects or environmental problems

Sources:

–

–

–

200+ air toxics identified

–

–

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- Emission standards exist for 27 air toxics

<u>Large Emissions</u>:

Bhopal, India 1984

✓

✓

✓

✓

<u>Small Emissions</u>:

✓ the norm

✓

✓ over 8,000,000 tons/year in USA

1. Adverse effects of air pollution on humans, plants, and materials

   a. Effects on human health

   •

   • ***SYNERGISM:*** 2 + 2 = 7

     alcohol + drugs =

     air pollution + disease =

Chronic effects of pollution:

Poland—has world's worst air (Upper Silesia)

– respiratory disease is 47% higher than in rest of country

• Lead has special interest—deadly!

E. POLLUTANT SOURCES AND CONTROL STRATEGIES

• Most air pollutants are direct and indirect byproducts of burning:

–

–

–

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• With complete combustion:

but combustion is seldom complete!

When you burn fuels and wastes:

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• At high combustion temperatures:

$N_2 \longrightarrow$

- Coal + combustion →
- Pb is treated separately — leaded gasoline

PNW States — Percentile Ranking

Pollutant	ID	WA	OR	AK	CA
CO					
NO_x					
PM-10					
SO_2					
Ozone					

Non-attainment areas (counties)

–

WA –

ID –

OR –

AK –

PM–2.5 –

Air Toxics –

See 1997 trends report at:

www.epa.gov/air/airtrends/aqtrnd97/

2. Control strategies

1970 CAA strategy was to:

- Regulate air pollution to the point that ***CRITERIA POLLUTANTS*** remained below primary standard levels

Today:

- Total pollutants have been reduced by 34%, while population and economic activity have increased

CAA of 1990 addresses failures of the 1970 and 1977 bills:

- Targeting specific pollutants more directly
-

a. Particulates (SMPs)

- Prior to 1970 most SMPs were from open burning of refuse and industrial stacks
- Stack emissions reduced by installing filters or electrostatic precipitators—WORKED
- Wood stoves are a major problem!
- Pollutants from motor vehicles
  - autos, trucks, buses
  -
  -
  -
  - CAA of 1970 wanted a 90% reduction in auto emissions by 1975; unrealistic ... but, a 95% reduction occurred between 1970 and 1992

Technology:

Computerized control of fuel mixture and ignition timing

CATALYTIC CONVERTER—oxidizes VOCs to CO_2 + H_2O; oxidizes CO to CO_2; no NO_x control

1990 act emphasizes:

1.

2.

3.

3. Evaluation

   a. The cost of controlling air pollution

      1990 poll:

      – 75% of Americans agree that environmental improvements should be made regardless of cost

   Idahoans:

   - Pollution control costs—

      – Health?

b. Future directions

   - 1970s—Los Angeles

   - 1990s—Los Angeles

      – emission free vehicles

      – no BBQ fluids in CA

F. INDOOR AIR POLLUTION

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Threefold problem:

1. Increasing numbers and kinds of products producing hazardous fumes
2. Building better insulated homes—pollution traps
3. More exposure to indoor than outdoor pollution (average American spends 90% of life indoors)

1. Sources of indoor air pollution
   - Formaldehyde and synthetic organic compounds
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     –
     –
     –
     –
   - •
   - Incomplete combustion and impurities from fuel fired heating systems
     –
     –
     –
     –
   - Fumes from household cleaners
   - •
   - Pesticides
   - •
   - Aerosol sprays

-
- Asbestos
- Smoking

2. Importance of Indoor Air Pollution

a. Deaths (annual)

Indoor

Outdoor

Daily basis:

* huge issue in HDCs, MDCs, and LDCs

LDCs —

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–

–

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b. Lung cancer

Radon —

c. Mold, fungi, and bacteria

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