

# 1 ☐ Air Quality Issues: Part 1 - Air Pollution, Indoor Air Pollution

EVPP 111 Lecture

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## 2 ☐ Air Quality Issues

- Air Pollution
- Indoor Air Pollution
- Acid Deposition
- Greenhouse Gases & Global Warming

## 3 ☐ Air Quality Issues

- Air Pollution
- Indoor Air Pollution
- Acid Deposition
- Greenhouse Gases & Global Warming

## 4 ☐ Air Quality Issues: Air Pollution

- Air quality
  - degraded by
    - natural events
      - volcanic gases & particulates
      - dust
      - gases from decomposition of organic material
    - activities of humans
      - automobile emissions
      - industrial process emissions

## 5 ☐ Air Quality Issues: Air Pollution

- Air quality
  - **air pollution**
    - degradation caused by human activities
    - related to
      - number of people
      - kinds of activities
    - material into the air is not disposed of
      - it is diluted, moved around

## 6 ☐ Figure: Air Quality

## 7 ☐ Air Quality Issues: Air Pollution

- **air pollution** results in
  - reduced aesthetic value of scenery

- human health problems
- damage to ecosystems
- international conflicts
- damage to structures
- increased costs

## 8 ☐ Air Quality Issues: Air Pollution

- **air pollution**
  - incidents
    - Donora, PA in 1948
      - pollutants from zinc plant and steel mills became trapped in valley
        - » temperature inversion
        - » formed dense fog
      - within five days
        - » 17 people died
        - » 5,910 people became ill

## 9 ☐ Air Quality Issues: Air Pollution

- **air pollution**
  - extremely poor air quality
    - common in megacities of developing countries
      - such as
        - » Mexico City, Beijing, Seoul, Cairo
      - due to
        - » open fires
        - » large numbers of poorly maintained vehicles
        - » poorly regulated industrial plants

## 10 ☐ Air Quality Issues: Air Pollution

- **air pollution**
  - air pollutants in US
    - accumulate due to predominant west to east winds
      - as air mass moves from west to east
        - » each population center adds pollutants to total load

## 11 ☐ Figure 17.3: Accumulation of Air Pollutants

## 12 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - 5 major types of materials
    - **primary air pollutants**
      - **carbon monoxide**
      - **volatile organic compounds (VOC) (hydrocarbons)**
      - **particulate matter**
      - **sulfur dioxide**
      - **nitrogen oxides**

13  Figure: Sources of Air Pollutants

14  Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - interact with one another in presence of sunlight to form
    - **secondary air pollutants**
      - ozone
      - other PANs (peroxyacyl nitrates)

15  Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **carbon monoxide (CO)**
    - produced when organic materials (gasoline, coal, wood) are incompletely burned
    - single largest source is automobiles
      - automobile CO emissions have ↓
        - » increased fuel efficiency
        - » use of catalytic converters

16  Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **carbon monoxide (CO)**
    - emissions still a problem because of
      - ↑ # automobiles
      - ↑ # km driven
    - 2nd largest source is tobacco smoke

17  Figure: Sources of Air Pollutants - Carbon Monoxide

18  Fig. 17.5

19  Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **carbon monoxide (CO)**
    - not a persistent pollutant
      - natural processes convert it to non-harmful compounds
        - » combines with O in air to form CO<sub>2</sub>
      - air can be cleared if no other new CO is introduced

20  Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **carbon monoxide (CO)**
    - toxic to humans and other animals
      - strongly attracted to hemoglobin in blood
        - » takes up CO nearly 250 times more rapidly than O<sub>2</sub>

- death can result from several hours of exposure to air containing only 0.001% of CO

## 21 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **carbon monoxide (CO)**
    - from 1970-2000
      - CO levels decreased ~25%

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## 23 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **volatile organic compounds (VOCs)**
    - primarily composed of C and H
      - also referred to as **hydrocarbons**
    - produced by
      - evaporation from fuel supplies
      - incomplete combustion of fuels
    - contribute to formation of secondary air pollutants in smog

## 24 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **volatile organic compounds (VOCs)**
    - sources of emissions
      - major
        - » internal combustion engine
      - additional
        - » oil refineries and other industries
        - » oil based paint
        - » charcoal lighter fluid

## 25 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **volatile organic compounds (VOCs)**
    - modifications to automobile engines help reduce emissions
      - recycling some gases through engines
      - using higher O concentrations in fuel-air mixture
      - using valves to prevent escape of gases
      - catalytic converters burn exhaust gases more completely

## 26 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **volatile organic compounds (VOCs)**
    - from 1970-2000
      - VOC quantities decreased ~43%

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28  **Air Quality Issues: Air Pollution**

- **Primary air pollutants**
  - **Particulate matter**
    - minute solid particles and liquid droplets dispersed into atmosphere
    - grouped by particle size
      - <10 microns (PM<sub>10</sub>)
      - <2.5 microns (PM<sub>2.5</sub>)

29  **Air Quality Issues: Air Pollution**

- **Primary air pollutants**
  - **Particulate matter**
    - <10 microns (PM<sub>10</sub>)
      - sources
        - » travel on roads
        - » agricultural activities
        - » construction
        - » industrial processes
        - » smoke from fires
        - » desertification
        - » volcanoes

30  **Figure: Sources of Air Pollutants - Particulates**

31  **Air Quality Issues: Air Pollution**

- **Primary air pollutants**
  - **Particulate matter**
    - <2.5 microns (PM<sub>2.5</sub>) sources
      - mostly secondary pollutants that form in atmosphere from interactions of primary pollutants

32  **Air Quality Issues: Air Pollution**

- **Primary air pollutants**
  - **Particulate matter**
    - produce variety of problems
      - “visual” pollution
        - » smoke
        - » obstructed views
        - » soot settling on surfaces
        - » caused by smoke

33  **Air Quality Issues: Air Pollution**

- **Primary air pollutants**
  - **Particulate matter**
    - produce variety of problems
      - health

- » accumulate in lungs and interfere with ability to exchange gases
- » serve as deposition centers for other harmful substances

### 34 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **Particulate matter**
    - from 1970-2000
      - <10 microns (PM<sub>10</sub>)
        - » decreased ~88%
    - from 1991-2000
      - <2.5 microns (PM<sub>2.5</sub>)
        - » decreased ~6%

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### 36 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **Sulfur dioxide (SO<sub>2</sub>)**
    - produced
      - combustion of sulfur-containing fossil fuels
    - react with water, other materials to form sulfur-containing acids
      - involved in acid deposition
      - affect health
        - » acids become attached to particles that are inhaled
        - » very corrosive to lung tissue

### 37 ☐ Figure: Sources of Air Pollutants - Sulfur Dioxide

### 38 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **Sulfur dioxide (SO<sub>2</sub>)**, some incidents
    - in 1306, Edward I of England, in London
      - banned burning of “sea coles”
        - » coals from seashore high in sulfur content
        - » responsible for London’s poor air quality
        - » may be earliest environmental legislation concerning air quality

### 39 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **Sulfur dioxide (SO<sub>2</sub>)**, some incidents
    - in 1952, London killer fog
      - covered for several days by dense “killer” fog
      - air didn’t mix because of temperature conditions
      - factories continued releasing smoke & dust
        - » producing “smog” (mixture of smoke and fog)

40 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **Sulfur dioxide (SO<sub>2</sub>)**, some incidents
    - in 1952, London killer fog
      - within few weeks 4,000 people died
        - » deaths attributed to high level of sulfur compounds in smog
    - 1000's of others suffered from
      - » severe bronchial irritation, sore throats, chest pains

41 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **Sulfur dioxide (SO<sub>2</sub>)**
    - from 1970-2000
      - levels have decreased ~44%

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43 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **Nitrogen oxides (NO<sub>x</sub>)**
    - produced
      - when N & O in air react under high temperatures associated with combustion
    - most common are
      - nitrogen oxide (NO)
      - nitrogen dioxide (NO<sub>2</sub>)
        - » really a secondary pollutant because it forms from interaction of NO with oxygen
      - mixture of NO and NO<sub>2</sub> is called NO<sub>x</sub>

44 ☐ Air Quality Issues: Air Pollution

- **Primary air pollutants**
  - **Nitrogen oxides (NO<sub>x</sub>)**
    - noteworthy because of role they play in production of
      - secondary air pollutants (photochemical smog)

45 ☐ Air Quality Issues: Air Pollution

- **Nitrogen oxides (NO and NO<sub>2</sub>)**
  - primary source
    - automobile engine
      - catalytic converters help reduce amount released
        - » ~ 75% of NO is converted back to nitrogen gas and oxygen gas

46  Figure: Sources of Air Pollutants - Sulfur Dioxide

47  Air Quality Issues: Air Pollution

- **Nitrogen oxides (NO and NO<sub>2</sub>)**
  - from 1971-2000
    - NO<sub>x</sub> levels increased ~20%
      - due to increased automobile traffic

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49  Air Quality Issues: Air Pollution


- **Secondary air pollutants**
  - compounds that result from interaction of various primary air pollutants
  - **photochemical smog**
    - mixture of pollutants resulting from interaction of nitrogen oxide with UV light (sunlight)
  - two secondary air pollutants, most destructive components of photochemical smog
    - **ozone**
    - **peroxyacyl nitrates (PANs)**

50  Air Quality Issues: Air Pollution

- photochemical smog
  - ozone & peroxyacyl nitrates (PANs)
    - excellent oxidizing agents
      - react readily with many other compounds, including those in living systems, causing destructive changes
  - ozone
    - destroys chlorophyll in plants
    - injures lung tissue in animals
  - PANs
    - eye irritants

51  Air Quality Issues: Air Pollution

- Typical photochemical smog event
  - morning traffic produces lots of NO
    - $N_2 + O_2 \rightarrow 2NO$
  - NO reacts with molecular O<sub>2</sub> from atmosphere to form NO<sub>2</sub>, gives photochemical smog its reddish-brown haze
    - $2NO + O_2 \rightarrow 2NO_2$
  - later in morning, NO<sub>2</sub> reacts with UV in sunlight to form atomic O
    - $NO_2 \xrightarrow{\text{UV light}} NO + O$
  - molecular O<sub>2</sub> in atmosphere reacts with atomic O to form ozone
    - $O_2 + O \rightarrow O_3$

52  Fig. 17.8

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54  Air Quality Issues: Air Pollution

- Typical photochemical smog
  - problem varies by region due to
    - climate, geography, population and activities



- Los Angeles, Salt Lake City, Phoenix
  - ringed by mountains
  - prevailing winds from west
  - cool air flows into valley, pushes warm air up, becomes trapped between two layers of cool air, creates thermal inversion
  - cool air can't move out of valley because of mountains

55  **Figure 17.7: Thermal inversions**

56  **Figure: Thermal inversions**

57  **Air Quality Issues**

- Air Pollution
- Indoor Air Pollution
- Acid Deposition
- Greenhouse Gases & Global Warming

58  **Air Quality Issues: Indoor Air Pollution**

- **Indoor air pollution**
  - scientific evidence indicates indoor air is more seriously polluted than outdoor air

59  **Air Quality Issues: Indoor Air Pollution**

- **Indoor air pollution**
  - indoor air pollutants
    - asbestos
    - formaldehyde
      - wood products, aerosols
    - pesticide residues
    - chloroform
    - perchloroethylene
      - dry cleaning

60  **Air Quality Issues: Indoor Air Pollution**

- **Indoor air pollution**
  - indoor air pollutants
    - paradichlorobenzene
      - mothballs, air fresheners
    - organisms
      - disease-causing
      - allergy-producing
    - lead
    - carbon monoxide

61  **Air Quality Issues: Indoor Air Pollution**

- **Indoor air pollution**
  - indoor air pollutants
    - radon

- source is uranium-238
- inert radioactive gas, half-life of 3.8 days
- associated with increased risk of lung cancer
  - » ~15,000 deaths annually attributed to radon

## 62 ☐ Air Quality Issues: Indoor Air Pollution

- **Indoor air pollution**
  - indoor air pollutants
    - radon
      - forms in rocks, diffuses upwards into soil, water, atmosphere
      - can enter homes through foundation
        - » ~10% of US homes have potential radon problem
        - » homes with levels >4 picocuries/liter should implement corrective actions
        - » risk varies by area of country

## 63 ☐ Env. CU p.413

## 64 ☐ Air Quality Issues: Indoor Air Pollution

- **Indoor air pollution**
  - indoor air pollutants
    - tobacco smoke
      - most important air pollutant in US in terms of human health
      - estimated 350,000 die in US annually from tobacco smoke
        - » emphysema, heart attacks, strokes, lung cancer, other related diseases
      - banning smoking would probably save more lives than any other pollution-control measure

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## 66 ☐ Air Quality Issues: Indoor Air Pollution

- **Indoor air pollution**
  - contributing factors
    - people spend on average 70-90% of our time indoors
    - energy-efficient buildings
      - trap air pollutants
      - complete air exchange every 5 hours
        - » older hours complete exchange occurred every hour

## 67 ☐ Air Quality Issues: Indoor Air Pollution

- **Indoor air pollution**
  - in 1990
    - EPA placed indoor air pollution at top of list of 18 sources of cancer risk
  - sick buildings
    - EPA states at least 1/5 of all buildings in US are “sick”

## 68 ☐ The End