

## Exercise and Air Pollution

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## Two Major Groups of Air Pollutants

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- Primary
  - From a single source of pollution
  - CO, sulfur oxides, nitrogen oxides, hydrocarbons, particulants
- Secondary
  - Result from an interaction with the environment and a primary pollutant
  - Ozone, aldehydes, sulfuric acid, peroxyacetyl nitrate (PAN)

## Effective Dose

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- Damage is related to dosage
- ED = exposure time (min) x concentration (ppm) x ventilation (L/min)
- ED also is affected by
  - Temp and humidity
  - Route of inspiration (nose or mouth)

## Exercise and Air Pollution

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- Exercise worsens the effect of air pollution
  - increases  $V_e$
  - Increases mouth breathing
  - one 30-min training session is equivalent to 8 hr of sedentary living

## Paths of Air Pollution

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- Primarily affects the respiratory tract
  - Mucous membranes of the nose remove large particles and soluble gases
  - Smaller particles or low soluble gases reach deeper airways and lung tissue
  - Some can reach the alveoli and enter the blood
- Some affect the eyes
- Some cross the skin

## Respiratory Effects

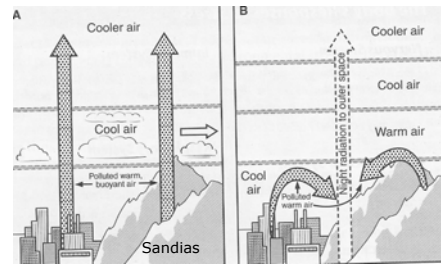
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- Bronchoconstriction
- Reduced alveolar diffusing capacity
  - inflammation
- Reduced O<sub>2</sub> transport
- Will lead to reduced exercise capacity
- Some people are more susceptible
  - Impaired immune function
  - People with pulmonary disease
  - People with cardiovascular disease

## Outdoor Pollution

- 70% from fossil fuels
  - CO, sulfur and nitrogen oxides
  - Hydrocarbons, particles
- Most from automobiles and industry
- Severity depends on the environment
  - Winds
  - Hot and humid-- promote photochemical rns
  - Cold—promotes heating fuel
  - Geography and climatic inversion

## Thermal Inversion



## Rural Air Pollution?

- Dust from plant or animal proteins, organic dusts
- Farmer's lung
  - Dust from moldy hay
  - Spores of bacterium
  - Hypersensitivity pneumonitis



## Carbon Monoxide

- Most common pollutant in urban regions
  - Sources: cars, power plants, burning, industry
  - Notable indoor occurrences
    - Ice skating rink
    - Tunnels
    - Smokers side stream smoke
  - $VO_2\text{max} \downarrow$  directly  $\sim$  %CO
    - Critical level is  $\sim$ 4% HbCO



## Carbon Monoxide Levels

- Levels are higher during morning and evening rushes
  - 4% smokers baseline levels
  - 5% HbCO in heavy traffic
  - 2%, earlier onset of angina in CAD
  - 6% arrhythmias in CAD patients
- Exercise in traffic for 30 min = equivalent of 10 cigarettes!

## Sulfur Oxides ( $S_xO$ )

- Sources: sulfur containing fuels, sulfuric acid producing facilities
- Mainly  $SO_2$  or acid sulfides
- Irritate the upper respiratory tract
- Nasal mucosa removes 99.9% of  $SO_2$
- Threshold effect 1-3 ppm
- People with asthma are 5x as sensitive

## Nitrogen Oxides ( $N_xO$ )

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- ❑ Sources: power plants, cars, forest fires, trains, planes, volcanos, industry, burning
- ❑ Soluble—absorbed by the mucous lining of nasopharyngeal cavity to form nitrous and nitric acid
- ❑ Can cause respiratory illness, reduced resistance to respiratory infection, bc in asthmatics
- ❑ 200-4000 ppm  $NO_2$  causes death

## Particulates

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- ❑ Sources: dust, power plants, diesel trucks, industry, pollen, wood smoke, bacteria
- ❑ Solid or liquid particles in air
- ❑ Associated with airway constriction
- ❑ Effect depends on size
  - $<3\mu m$ , reach alveoli
  - 3-5  $\mu m$ , upper respiratory tract
  - $>5\mu m$ , removed by coughing, sneezing

## Aerosols

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- ❑ Mixtures of fluid and particles
- ❑ May cause airway irritation
  - Sulfates
  - Sulfuric acids
  - Nitrate aerosols
  - aldehydes



## Ozone ( $O_3$ )

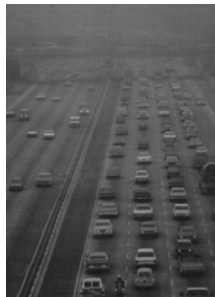
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- ❑ Secondary pollutant
  - Sunlight electrical arcs and oxygen
- ❑ Absorbed by mucous membranes
- ❑ Cause throat irritation, cough, nausea, headaches, chest pain
- ❑ Asthmatics especially sensitive
- ❑ 0.3 ppm levels can cause pulmonary dysfn
- ❑ 0.08 ppm for 7 hrs can cause problems
  - Levels fairly common
- ❑ Adaptation with repeated exposure

## Peroxyacetyl Nitrate (PAN)

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- ❑ Secondary pollutant
- ❑ Nitrogen oxides + organic compounds
- ❑ Eye irritation at levels  $< 0.27$  ppm



## Indoor Pollution

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- ❑ Major indoor pollutants
  - Soil gases: radon, methane, hydrogen sulfide, organic compounds from building materials
  - Combustion products: CO, nitrogen dioxide, heating appliances
  - Formaldehyde: from lumber, adhesives, foam insulation
- ❑ Most serious are formaldehyde, tobacco smoke

## Interactions

- Air has many pollutants
  - Additive effects: CO and PAN; O3 and SO2; SO2 and NO2
  - Additive effects: Heat stress and CO, PAN and O3
  - Synergistic effects: Humidity and dust mites, molds, fungi in indoor environments; dry air and SO2
  - Additive effects: CO and altitude

## Prevention

- Avoidance of exposure
  - Indoors
    - Fireplaces, humidity 30-70%, cleaners and building materials
  - Outdoors
    - Timing of exercise
      - CO—avoid traffic
      - O3—avoid peak sunlight
    - PSI standards (pollutant standards index)

## EPA PSI

- Converts pollutant concentration to a number on a scale 0-500
- 100 = threshold under Clean Air Act above which indicates pollution in an unhealthy range
- Threshold for acute health effects (24 hr), rather than chronic

## PSI Values

Table 25.3. The PSI and Implications for Short-Term Health Effects

Index Value	PSI Description	GENERAL HEALTH EFFECTS	CAUTIONARY STATEMENTS
Up to 50	Good	None for the general population.	None required.
51-100	Moderate	Few or none for the general population.	None required.
101-200	Unhealthy	Mild aggravation of symptoms among susceptible people, with irritation symptoms in the healthy population.	Persons with existing heart or respiratory ailments should reduce physical exertion and outdoor activity. General population should reduce vigorous outdoor activity.
201-300	Very unhealthy	Significant aggravation of symptoms and decreased exercise tolerance in persons with heart or lung disease; widespread symptoms in the healthy population.	Elderly and persons with heart or lung disease should stay indoors and reduce physical activity. General population should avoid vigorous outdoor activity.
>300	Hazardous	Early onset of certain diseases in addition to significant aggravation of symptoms and decreased exercise tolerance in healthy persons. At PSI levels above 400, premature death of ill and elderly persons may result. Healthy people have adverse symptoms that affect normal activity.	Elderly and persons with diseases should stay indoors and avoid physical exertion. All PSI levels above 400, general population should avoid outdoor activity. All people should remain indoors, keeping windows and doors closed, and minimize physical exertion.

## EPA Air Quality Standards

Table 25.2. National Ambient Air Quality Standards as Provided by the Environmental Protection Agency

POLLUTANTS	TIME PERIOD FOR AVERAGING	STANDARD LIMIT LEVEL
Carbon monoxide	8 hr	9 ppm
	1 hr	35 ppm
Ozone	1 hr	0.12 ppm
	8 hr	0.08 ppm
Nitrogen dioxide (NO <sub>2</sub> )	AAM	0.053 ppm
Sulfur dioxide (SO <sub>2</sub> )	AAM	80 µg/m <sup>3</sup>
	24 hr	365 µg/m <sup>3</sup>
Particulates (PM-2.5) (<2.5-micron diameter)	AAM	15 µg/m <sup>3</sup>
	24 hr	65 µg/m <sup>3</sup>
Particulates (PM-10) (<10-micron diameter)	AAM	50 µg/m <sup>3</sup>
	24 hr	150 µg/m <sup>3</sup>

AAM, annual arithmetic mean.  
For pollutants with high hourly or daily fluctuations, longer duration averages and short-term peak level limits are provided. The numbers correspond to a pollution standards index (PSI) of 100.

## Room ventilation standards

- Use CO2 levels as an indicator for sufficient ventilation
  - Outdoor limit: 1000 ppm (0.1%)
  - Indoor limit: 350 ppm minimum, 650 ppm better (.06%)

## Infectious Disease

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- Bacterial or virus infections that spread from person to person
- Viral mutations
  - In people (most commonly in malnourished people with weak immune function) ebola virus in Africa
  - In animals, then transfer to humans

## 1918 Influenza Pandemic

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- New influenza virus raced around the world in 4 months: unusually virulent
  - Chinese laborers-military camps-troop ships—Europe. As many influenza deaths in American soldiers as war deaths.
- 50% of world population infected
  - Quarantines, closed schools and businesses
- 40 to 50 million deaths between 1918 and 1920 (3% of world population)
- Healthy young adults had highest fatalities

## H5N1 Bird Flu Virus

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- 1997:H5N1 virus is discovered in Hong Kong
- 2004: N5N1 is transmitted from birds to humans in Thailand and Vietnam
- 1997-2004: 126 people contract N5N1, 64 died