Atmospheric Pollution

Lecture 5

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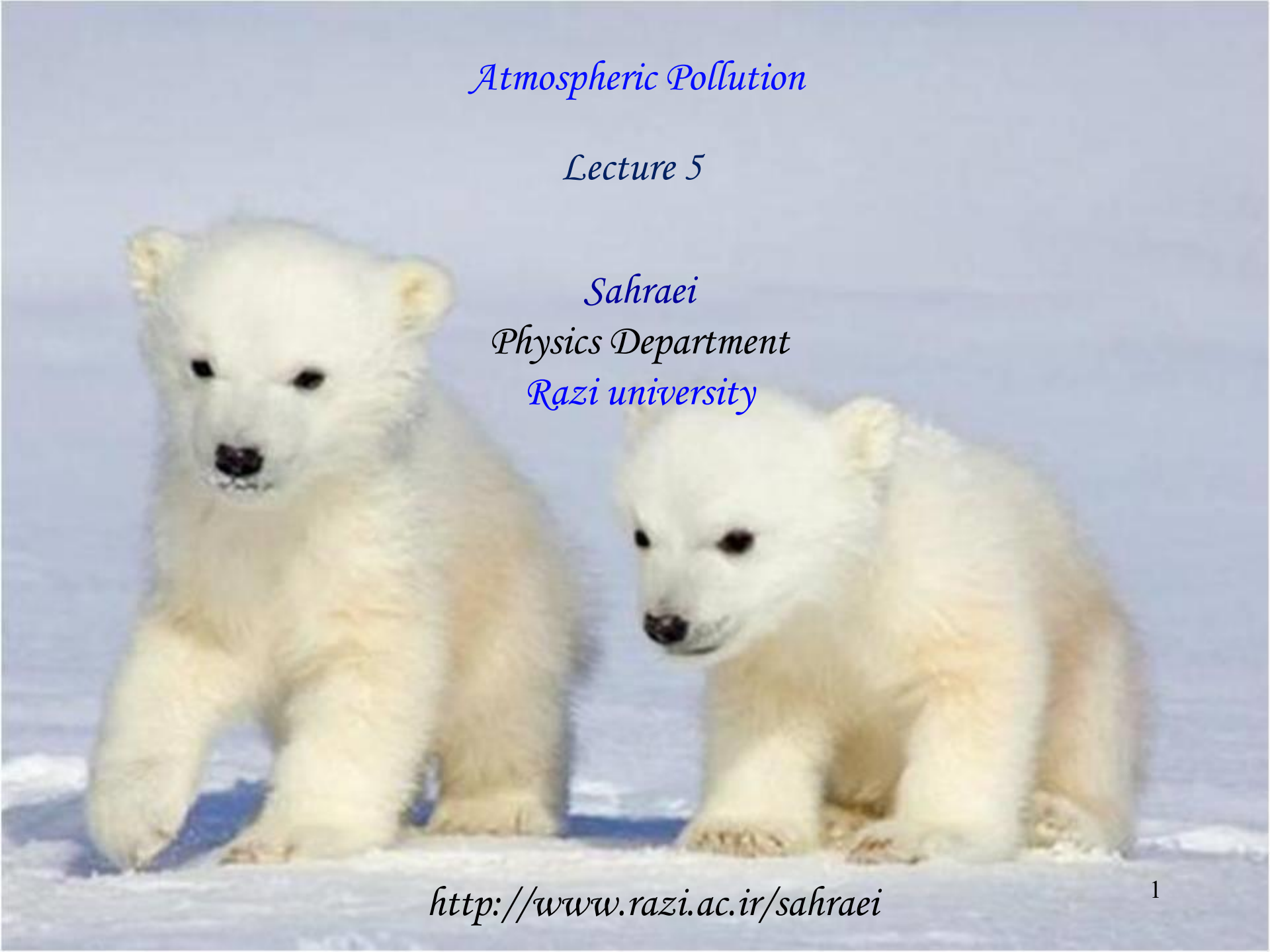

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Carbon Monoxide

Carbon Monoxide

Carbon monoxide [CO(g)] is a tasteless, colorless, and odorless gas. Although CO(g) is the most abundantly emitted variable gas aside from CO2(g) and HO(g), it plays a small role in ozone formation in urban areas.

Table 3.8. Sources and Sinks of Atmospheric Carbon Monoxide

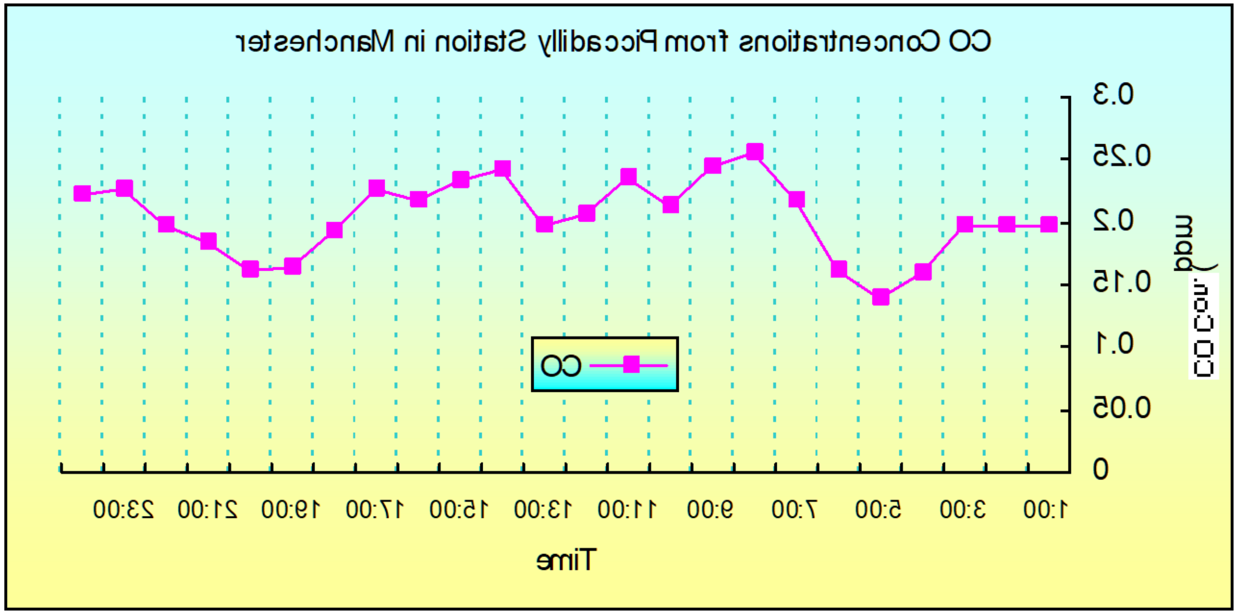
Sources	Sinks
Fossil-fuel combustion	Kinetic reaction to carbon dioxide
Biomass burning	Transfer to soils and ice caps
Photolysis and kinetic reaction	Dissolution in ocean water
Plants and biological activity in oceans	

Table 3.9. Estimated Total Emissions and Percentage of Total Emissions by Source Category in the United States in 1997

Substance	Chemical Formula or Acronym	Total Emissions (10^6 short tons per year)	Industrial Processes (area sources; percentage of total)	Fuel Combustion (point sources; percentage of total)	Transportation (mobile sources; percentage of total)	Miscellaneous (percentage of total)
Carbon monoxide	CO(g)	90	6.9	5.5	76.6	11.0
Nitrogen oxides	NO_x(g)	24	3.9	45.4	49.2	1.5
Sulfur dioxide	SO_2(g)	20	8.4	84.7	6.6	0.3
Particulate matter ≤10 μm[a]	PM_{10}(aq,s)	37	3.9	3.2	2.2	90.7
Lead	Pb(s)	0.004	74.1	12.6	13.3	0
Reactive organic gases	ROGs	20	51.2	4.5	39.9	4.4

[a]PM_{10} is particulate matter with diameter ≤10 μm. Miscellaneous PM_{10} sources include fugitive dust (57.9 percent of total PM_{10} emissions), agricultural and forest emissions (14.0 percent), wind erosion (15.8 percent), and other combustion sources (3.0 percent).

Source: U.S. EPA (1997).


CO Concentrations from Piccadilly Station in Manchester
0
0.05
0.1
0.15
0.2
0.25
0.3
CO Con. ppm
1:00
3:00
5:00
7:00
9:00
11:00
13:00
15:00
17:00
19:00
21:00
23:00
Time
CO

Methane

Table 3.10. Sources and Sinks of Atmospheric Methane

Sources	Sinks
Methanogenic bacteria (lithotrophic autotrophs) Natural gas leaks during fossil-fuel mining and transport Biomass burning Fossil-fuel combustion Kinetic reaction	Kinetic reaction Transfer to soils and ice caps Methanotrophic bacteria (conventional heterotrophs)

Ozone [$O_3(g)$]

Smell > 20 ppbv; clear at low and faint purple at high mixing ratio

Source

Atmospheric chemical reaction

Sinks

Atmospheric chemical reaction and photolysis

Dissolution into oceans, lakes; transfer to ice caps, soil

Mixing ratios

20-40 ppbv clean air; 40-500 ppbv pollution; 10 ppmv strat.

Health effects

>150 ppbv --> headache

>250 ppbv --> chest pain, sore throat, cough, short breath

Affects vegetation, rubber, textile, dyes, fibers

Nitrogen Oxides (Nox)

$NO_x\,(g) = NO\,(g) + NO_2\,(g)$

Major Atmospheric Pollutants

4 – Oxides of Nitrogen

Combustion of fossil fuels containing nitrogen results in oxidation of nitrogen, producing a family of nitrogen oxides, No_x.

Nitrogen Dioxide

>80 ppbv: sore throat

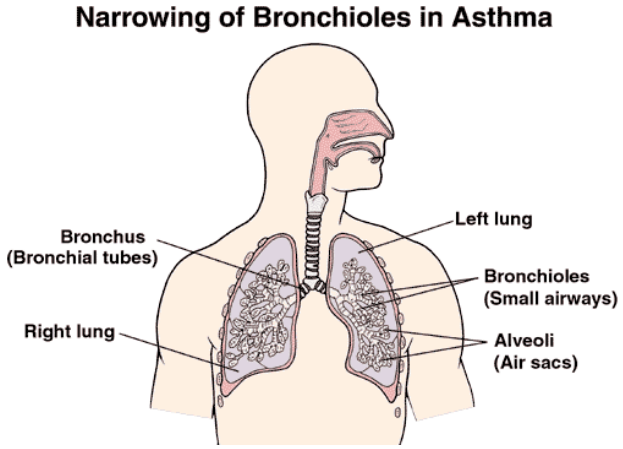
150-250 ppbv typical for polluted air

300-800 ppbv reduced lung capacity

> 150 ppmv death

Table 3.13. Sources and Sinks of Atmospheric Nitric Oxide

Sources	Sinks
Denitrification in soils and plants Lightning Fossil-fuel combustion Biomass burning Photolysis and kinetic reaction	Kinetic reaction Dissolution in ocean water Transfer to soils and ice caps



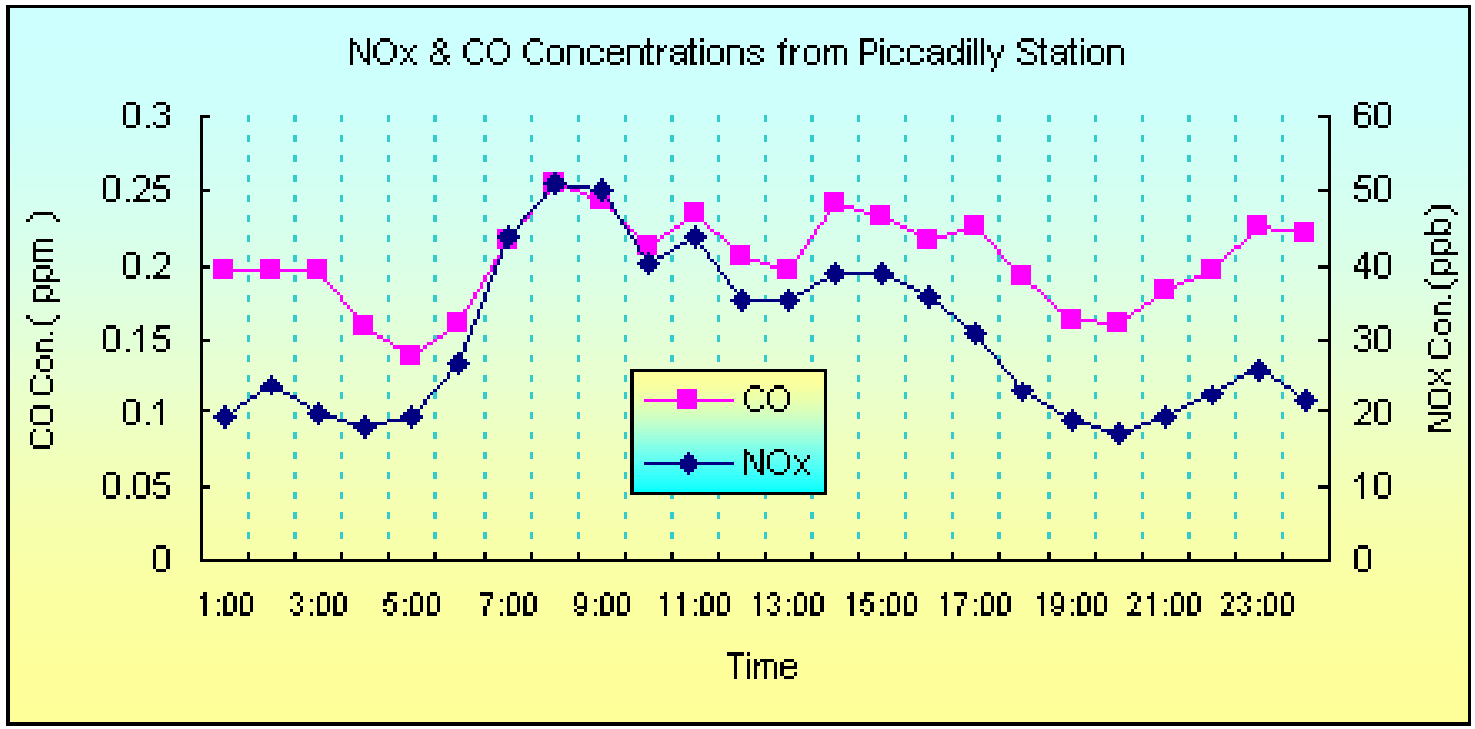
Other effects are: shortness of breath, tiredness, and nausea

Nitrogen oxides cause direct damage to plants and animals.

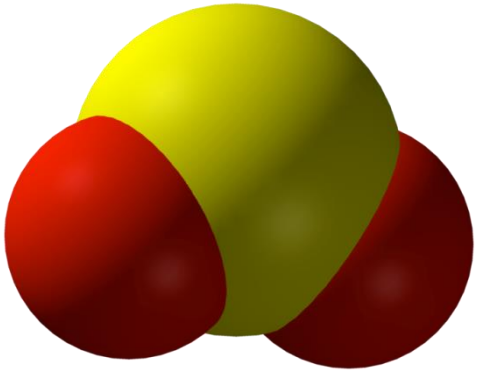
In plants, nitrogen oxides cause :loss of leaves and even reduce a plant's growth rate.

These chemicals can even reduce the growth rate in animals

Hourly averaged NOx and CO concentrations from Manchester City Centre.



Sulfur Dioxide [$SO_2(g)$]



1-30 ppbv: typical for polluted air

>300 ppbv: taste

>500 ppbv: odor

>1500 ppbv: bronchial restrictions

> 40,000 ppbv: death

Sulphur Trioxide as Secondary pollutant

$$SO_2 + OH \longrightarrow HOSO_2$$

$$HOSO_2 + O_2 \longrightarrow SO_3 + HO_2$$

$$SO_3 + H_2O \rightarrow H_2SO_4$$

Table 3.12. Sources and Sinks of Atmospheric Sulfur Dioxide

Sources	Sinks
Oxidation of DMS(g) Volcanic emission Fossil-fuel combustion Mineral ore processing Chemical manufacturing	Kinetic reaction to H_2SO_4(g) Dissolution in cloud drops and ocean water Transfer to soils and ice caps

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Air Pollution in Lungs

http://www.sciencephoto.com/image/88071/530wm/C0023802-Lung,_post-mortem-SPL.jpg

$$CaCO_3 + H_2SO_4 \rightarrow CaSO_4 + CO_2 + H_2O$$

Calcium carbonate *Sulfuric acid* *Calcium sulfate* *Carbon dioxide* *Liquid water*

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Hourly average SO_2 concentration from two monitoring stations