Lecture 04

Air Pollution

CONTENTS

01

Air Pollution in the Lower Atmosphere

1.1 Stationary and Mobile Sources of Air Pollution

01

Stationary sources

- Point sources点源污染
- Fugitive source 无法定位的污染源
- Area sources面源污染

02

Mobile sources

Mobile sources of air pollutants include automobiles, trucks, buses, aircraft, ships, trains, and anything else that pollutes as it moves from place to place.

1.1 Stationary and Mobile Sources of Air Pollution

1.2 General Effects of Air Pollution

Visual quality, animals, soil, water quality, natural and articial structure, and human health

Air pollution's numerous effects on vegetation include

Damage

to leaves, needles, and fruit, reduced or suppressed growth, increased susceptibility to diseases, pests and adverse weather, and disruption of reproduction process

Human Health

Some of the primary effects are cancer, birth defects, eye and respiratory system irratation, greater susceptibility to heart disease, and aggravation of chronic diseases, such as asthma and emphysema(肺气肿)

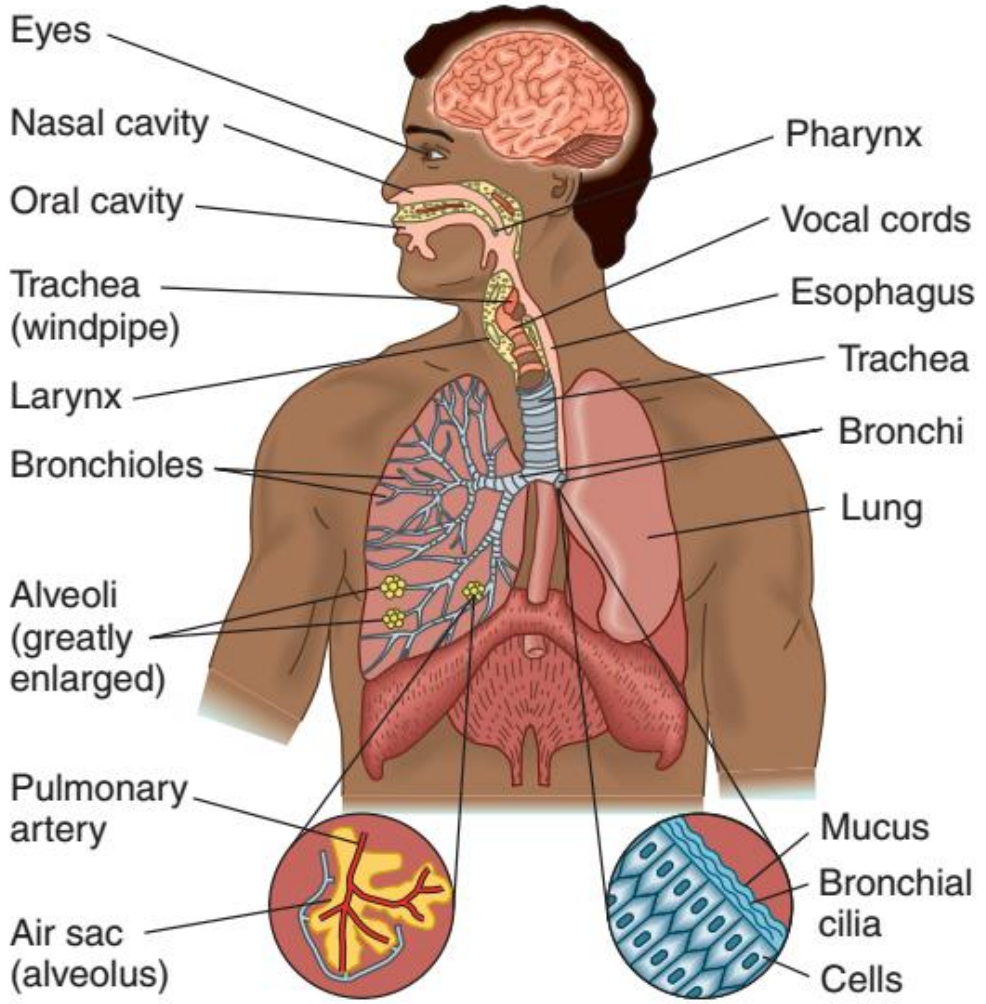


FIGURE 21.3 Idealized diagram showing some of the parts of the human body (brain, cardiovascular system, and pulmonary system) that can be damaged by common air pollutants. The most severe health risks from normal exposures are related to particulates. Other substances of concern include carbon monoxide, photochemical oxidants, sulfur dioxide, and nitrogen oxides. Toxic chemicals and tobacco smoke also can cause chronic or acute health problems.

1.3 The Major Air Pollutants

Nearly 200 air pollutants are recognized and assessed by the EPA and listed in the Clean Air Act. They can be classified as primary or secondary. **Primary pollutants** are emitted directly into the air. They include particulates, sulfur dioxide, carbon monoxide, nitrogen oxides, and hydrocarbons. **Secondary pollutants** are produced by reactions between primary pollutants and normal atmospheric compounds. For example, ozone forms over urban areas through reactions of primary pollutants, sunlight, and natural atmospheric gases. Thus, ozone is a secondary pollutant.

产生

1.3 The Major Air Pollutants

- PM: particulate matter (3%)

very small particles of solid or liquid substances and maybe organic or inorganic

- Gaseous pollutants

Sulfur dioxide (SO_2, 13%)

Nitrogen oxides (NO_X , 15%)

Carbon monoxide (CO, 58%)

Ozone (O_3)

Volatile organic compounds (VOCs, 11%), such as hydrocarbon, hydrogen sulfide (H_2S), hydrogen fluoride (HF).

Table 21.1 MAJOR NATURAL AND HUMAN-PRODUCED COMPONENTS OF SELECTED AIR POLLUTANTS

AIR POLLUTANTS	EMISSIONS (% OF TOTAL)		MAJOR SOURCES OF HUMAN-PRODUCED COMPONENTS	PERCENT
	NATURAL	HUMAN-PRODUCED		
Particulates	85	15	Fugitive (mostly dust)	85
			Industrial processes	7
			Combustion of fuels (stationary sources)	8
Sulfur oxides (SO_x)	50	50	Combustion of fuels (stationary sources, mostly coal)	84
			Industrial processes	9
Carbon monoxide (CO)	91	9	Transportation (automobiles)	54
Nitrogen dioxide (NO_2)		Nearly all	Transportation (mostly automobiles)	37
			Combustion of fuels (stationary sources, mostly natural gas and coal)	38
Ozone (O_3)	A secondary pollutant derived from reaction with sunlight NO_2, and oxygen (O_2)		Concentration present depends on reaction in lower atmosphere involving hydrocarbons and thus automobile exhaust	
Hydrocarbons (HC)	84	16	Transportation (automobiles)	27
			Industrial processes	7

PM 10 & PM 2.5

PM 10: particles up to 10 micrometers (μm) in diameter. By comparion, the diameter of a human hair is about 60 to 150 μm.

PM 2.5: particles between 2.5 and 0.18 microns;

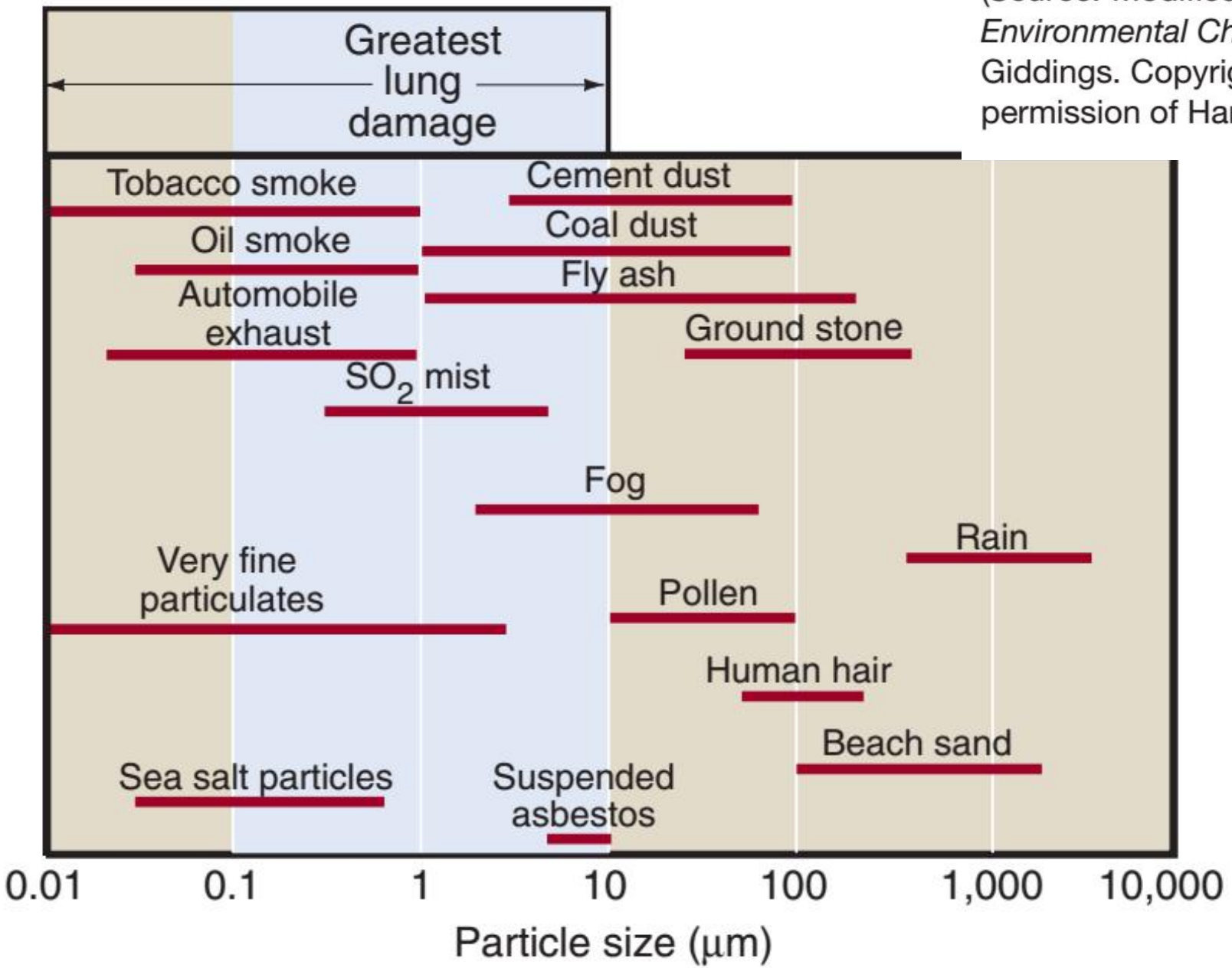


FIGURE 21.4 Sizes of selected particulates. The shaded area shows the size range that produces the greatest lung damage. (*Source:* Modified from Fig. 7–8, p. 244 in *Chemistry, Man and Environmental Change: An Integrated Approach*, by J. Calvin Giddings. Copyright © 1973 by J. Calvin Giddings. Reprinted by permission of Harper Collins Publishers, Inc.).

1.4 Acid Rain

Acid rain is precipitation in which the pH is below 5.6.

- Acid Rain's Effects on Forest Ecosystems
- Acid Rain's Effects on Lake Ecosystems

  damages auqtic species (fish, amphibians, and crayfish)
  dissolves chemical elements necessary for life in the lake
  leaches metals such as aluminum, lead, mercury, and calcium from the soil and rocks in a drainage baisin and discharges them into rivers and lakes

- Acid Rain’s Effects on Human Society
  (building materials, classical buildings …)

1.5 Air Toxics

- Toxic air pollutants, or Air Toxics, are among those pollutants known or suspected to cause cancer and other serious problems after either long-term or short-term exposure.

Hydrogen Sulfide (H_2S)

Hydrogen Fluoride (HF)

Mercury

Volatile Organic Compounds

Methyl Isocyanate(异氰酸甲酯, C_2H_3NO)

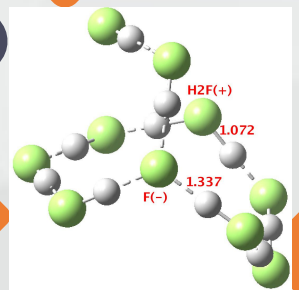
Benzene (C_6H_6)

Acrolein (丙烯醛, CH_2CHCHO)

02 Controlling Common Pollutants of the Lower Atmosphere

The most reasonable ways to control the most common air pollutants in our cities include

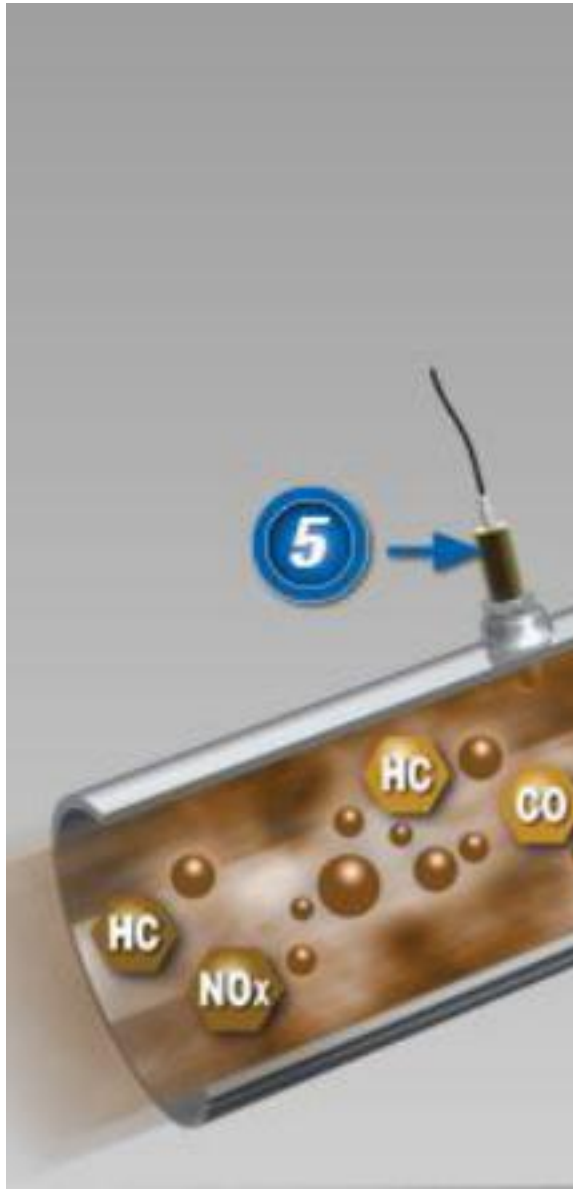
- reducing emission
- capturing them before they reach the atmosphere
- removing them from the atmosphere



2.1 Automobiles

- Notrogen oxides from automobile exhausts are controlled by recirculating exhaust gas and diluting the air-to-fuel mixture burned in the engine.
- 机动车尾气产生的一氧化氮由尾气再循环与稀释引擎中的空气与燃料的混合物而实现。
- The exhaust system's catalytic converter is the device most commonly used to reduce carbon monoxide and hydrocarbon emission from automobile.
- 尾气的催化式排气进化器广泛用于减少机动车的CO与碳氢化合物的排放。

2.1 Auto



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Bringing together 75 years of Toyota quality and innovation, the 10th generation Toyota Corolla sets the standard with its powerful performance and superior engineering. The new 1.3 L Corolla now comes with a Catalytic Converter* for lower emission and reduced ecological impact, making it a Euro II Compliant vehicle**.

75 TOYOTA

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*The Catalytic Converter in actual vehicle may differ from the image shown.
** The Catalytic Converter is already installed in 1.6 GLi Automatic & Toyota Corolla Altis.

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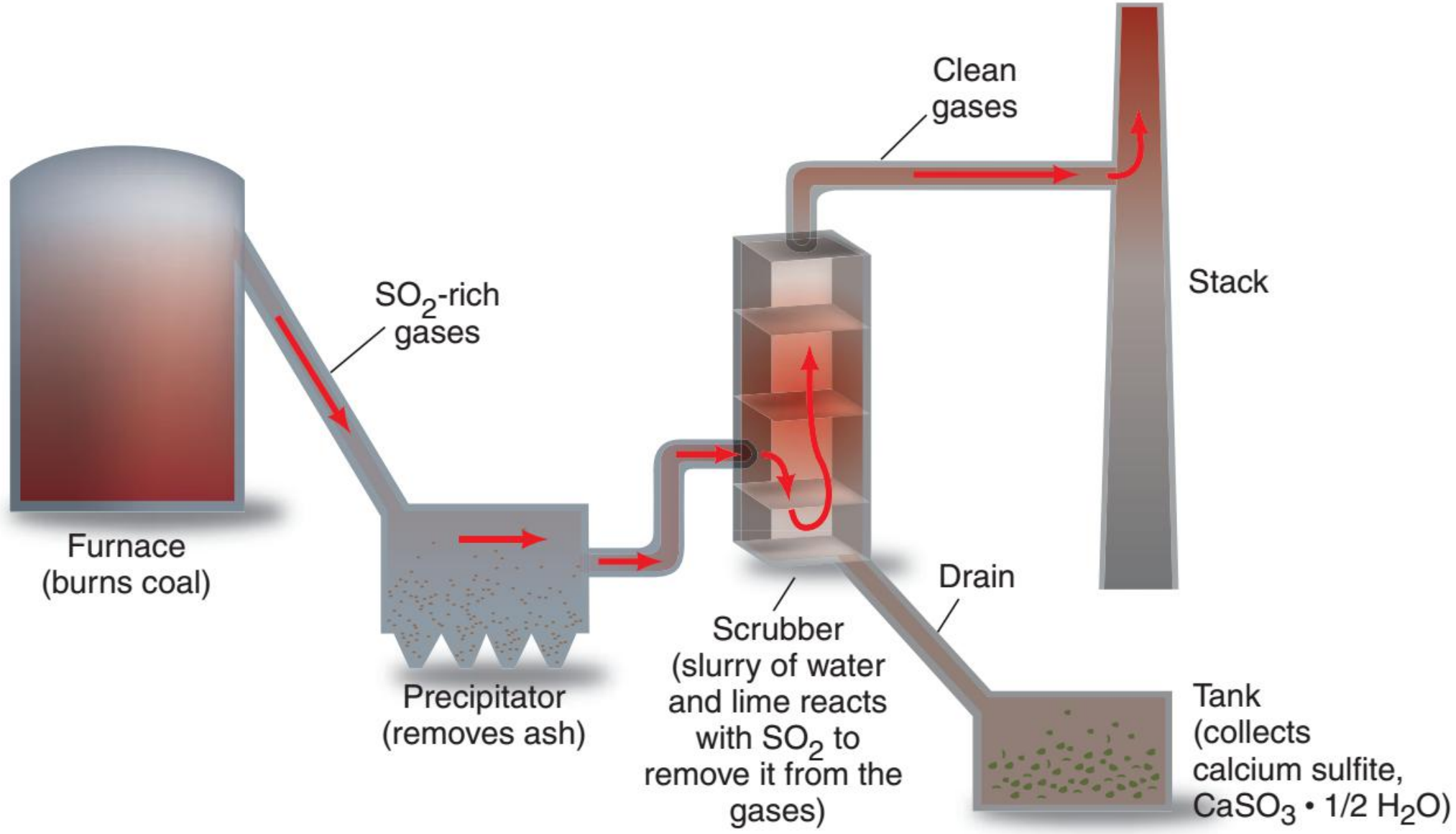
2.2 Sulfur Dioxide



中华人民共和国环境保护部 数据中心

Ministry of Environmental Protection of the People's Republic of China

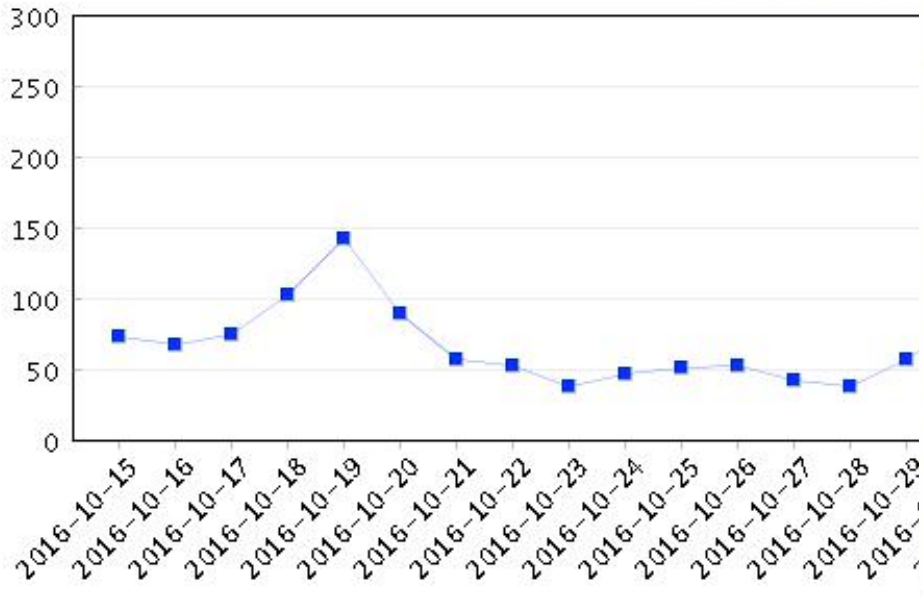
您的位置： 首页 -> 数据中心 -> 西安市空气质量日报分析

城市： 西安市 日期：

西安市空气质

西安市的AQI指数为 226 ， 空气质量级别为 重度污染 ， 空气中首要

历史30天内空气污



历史30天内空气质量详细列表

序号	日期	城市	AQI指数	空气质量级别	首要污染物
1	2016-10-15	西安市	74	良	PM2.5
2	2016-10-16	西安市	68	良	PM2.5
3	2016-10-17	西安市	75	良	NO2, PM10
4	2016-10-18	西安市	103	轻度污染	PM2.5
5	2016-10-19	西安市	143	轻度污染	PM2.5
6	2016-10-20	西安市	91	良	PM10
7	2016-10-21	西安市	58	良	PM10
8	2016-10-22	西安市	54	良	PM10
9	2016-10-23	西安市	39	优	
10	2016-10-24	西安市	48	优	
11	2016-10-25	西安市	52	良	PM10, PM2.5
12	2016-10-26	西安市	54	良	NO2
13	2016-10-27	西安市	43	优	
14	2016-10-28	西安市	39	优	
15	2016-10-29	西安市	58	良	NO2
16	2016-10-30	西安市	83	良	PM2.5
17	2016-10-31	西安市	75	良	PM10
18	2016-11-01	西安市	104	轻度污染	PM2.5
19	2016-11-02	西安市	170	中度污染	PM2.5
20	2016-11-03	西安市	229	重度污染	PM2.5
21	2016-11-04	西安市	219	重度污染	PM2.5
22	2016-11-05	西安市	239	重度污染	PM2.5
23	2016-11-06	西安市	209	重度污染	PM2.5
24	2016-11-07	西安市	68	良	PM10
25	2016-11-08	西安市	76	良	PM10
26	2016-11-09	西安市	132	轻度污染	PM2.5
27	2016-11-10	西安市	183	中度污染	PM10
28	2016-11-11	西安市	177	中度污染	PM10
29	2016-11-12	西安市	147	轻度污染	PM10
30	2016-11-13	西安市	226	重度污染	PM2.5

2.3 The Cost of Controlling Outdoor Air Pollution

- With increasing air pollution controls, the capital cost for technology to control air pollution increases.
- As the controls for air pollution increase, the loss from pollution damages decrease.
- The total cost of air pollution is the cost of pollution control plus the environmental damages of the pollution.

03

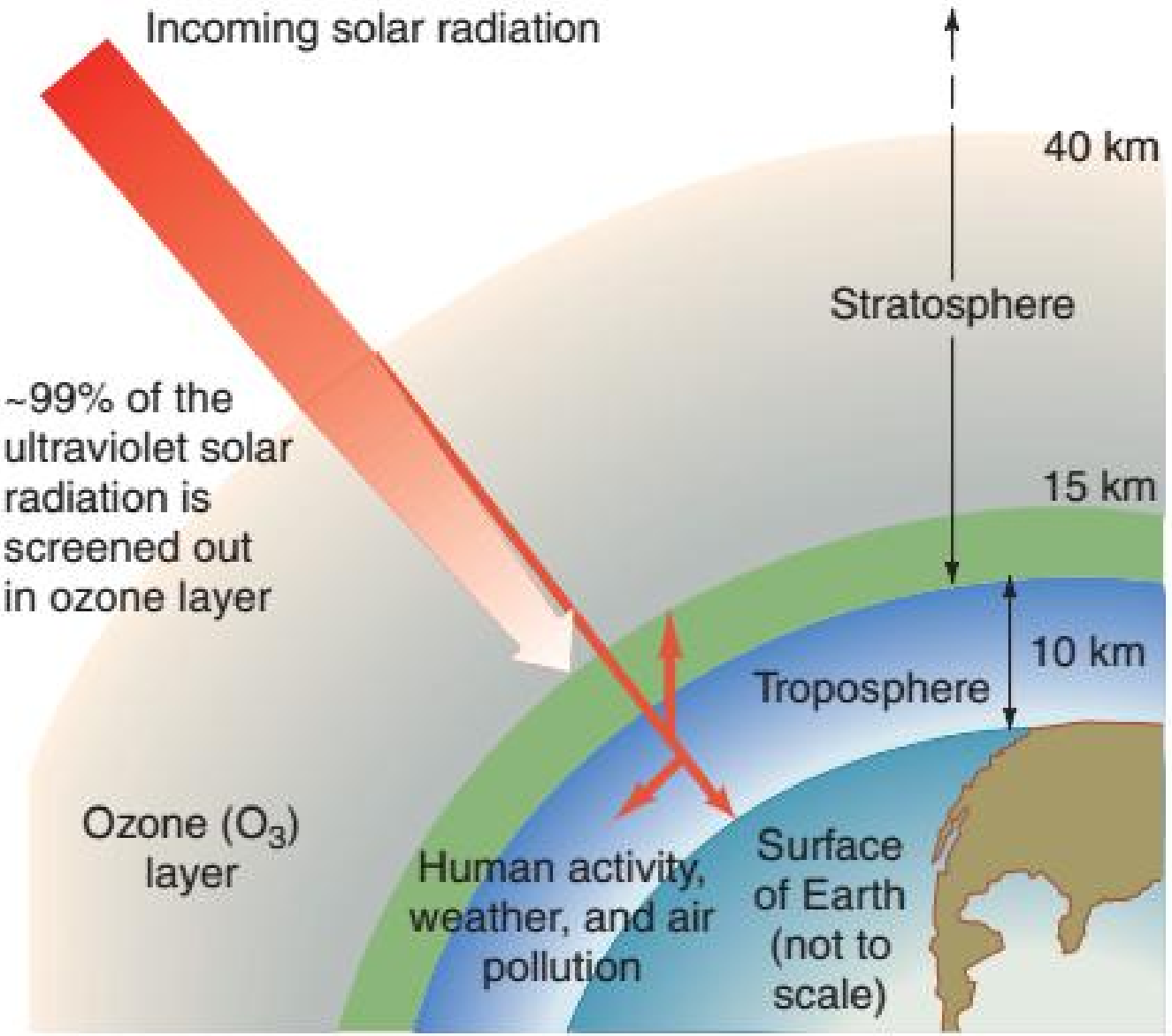
High-Altitude (Stratospheric) Ozone Depletion

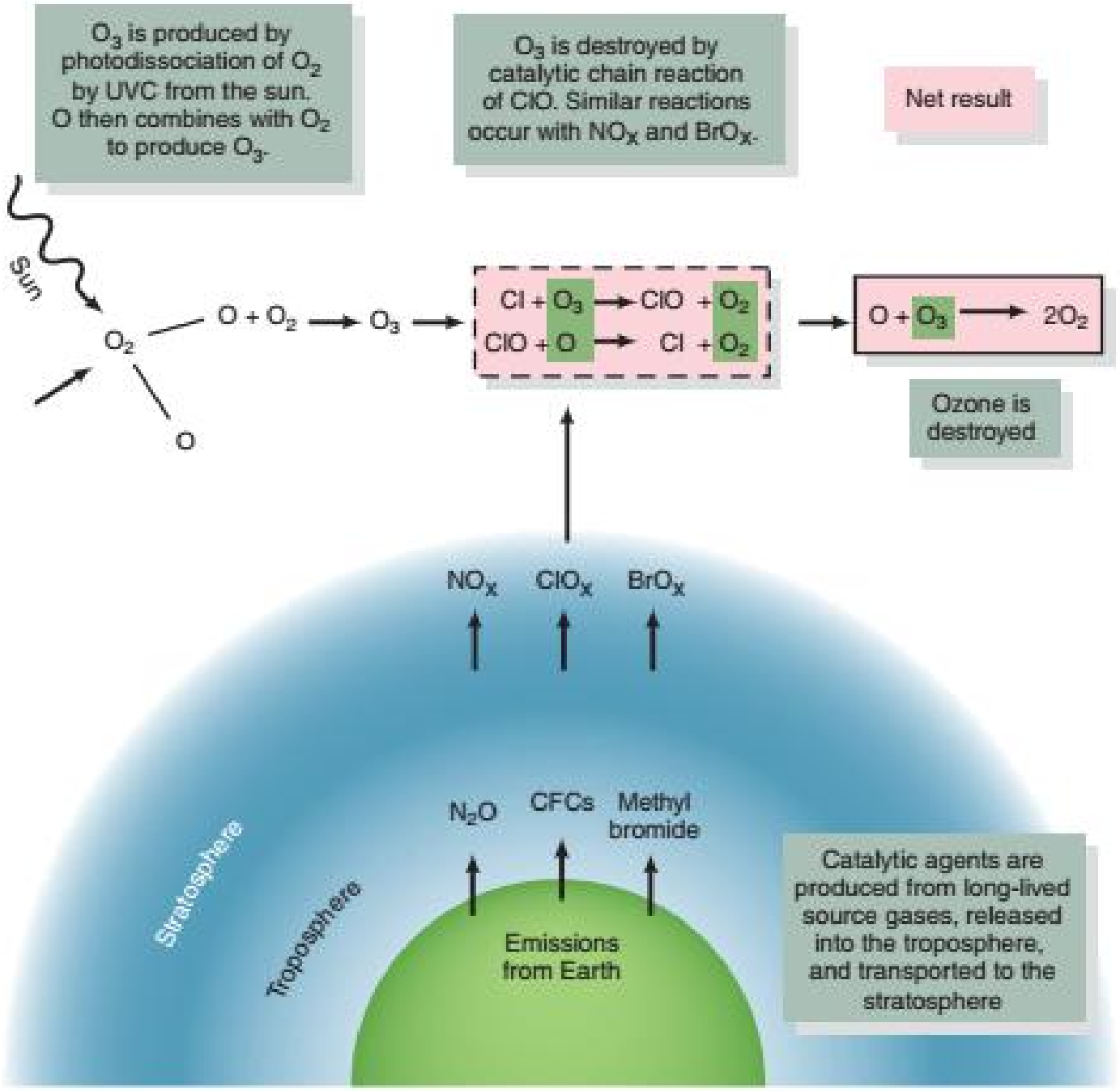
3.1 Ozone (O_3)

- In the lower atmosphere, ozone is a pollutant produced by photochemical reactions involving sunlight, nitrogen oxides, hydrocarbons, and diatomic oxegen. In the stratosphere, however, ozone plays an entirely different role, protecting us from ultraviolet radiation.

3.2 Ultraviolet Radiation and Ozone

The ozone layer in the stratosphere is often the ozone shield because it absorbs most of the potentially hazardous ultroviolet radiation that enters Earth's atmosphere from the sun.





Processes of natural formation of ozone and destruction by CFC_S, N_2O, and methyl bromide.

3.3 Measuring Stratospheric Ozone

- Scientists first measured the concentration of atmospheric ozone in the 1920s from the ground, using an instrument knowns as a Dobson ultraviolet spectrometer.
- Satellite measurements of atmospheric ozone concentrations began in 1970 and continue today.
- Ground-based measurements first identified ozone depletion over the Antarctic. Members of the British Antactic Survey began to measure ozone in 1957, and in 1985 they published the first data that they suggested significant ozone depletion over Antarctica.

Ozone hole

The Dobson unit is still commonly used to measure the ozone concentrations; 1 DU equales a concentration of 1 ppb O_3.

1957~1970	300 DU
1986	140DU

Ozone hole, no actural hole, describes a relative depletion in the concentration of ozone that occurs during the Antarctic spring.

3.4 Ozone Depletion and CFCs

- The hypothesis that ozone is the straosphere is being depleted by chlorofluorocarbons (CFCS) was first suggested in 1974 by Mario Mollina and F. Sherwood Rowland.
- This hypothesis, based on physical and chemical properties of CFCs and knowledge about atmospheric conditions, was immediately contraversial and vigorously debated by scientists, companies producing CFCs, and other interested parties.

3.5 Simplified Stratospheric Chlorine Chemistry

Highly energetic ultraviolet radiation (UVC) splits up the CFC, releasing chlorine.

$$(1)\ Cl + O_3 \rightarrow ClO + O_2$$
$$(2)\ ClO + O \rightarrow Cl + O_2$$

These two equations define a chemical cycle that can deplete ozone.

3.6 Environmental Effects of Ozone Depletion

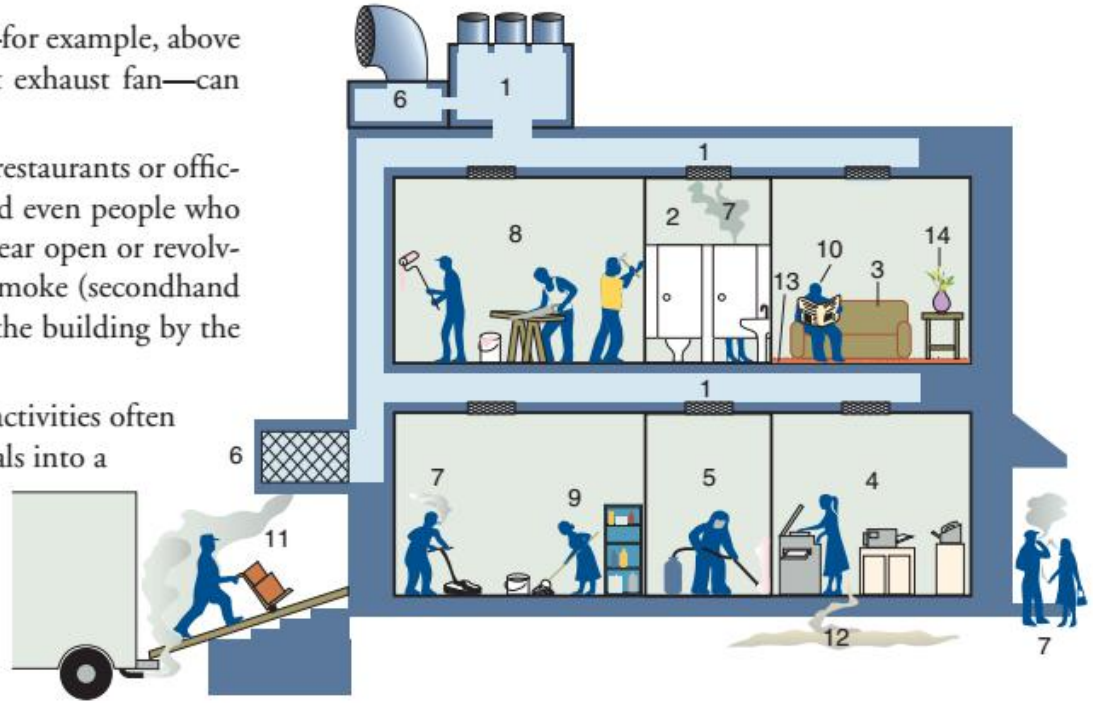
Ozone depletion damages some food chains on land and in the oceans and is dangerous to people, increasing the incidence of skin cancers and cataracts and suppressing immune systems.

- Limit exposure to the sun between 10 A.M. and 4 P.M., the hours of intense solar radiation, and stay in the shade when possible.
- Use a sunscreen with an SPF of at least 30 (but remember that protection diminishes with increased exposure), or use clothing to cover up.
- Wear UV-protective sunglasses.
- Avoid tanning salons and sun lamps.
- Consult the UV Index before going out.

04

Indoor Air Pollution

1. Heating, ventilation, and air-conditioning systems may be sources of indoor air pollutants, including molds and bacteria, if filters and equipment are not maintained properly. Gas and oil furnaces release carbon monoxide, nitrogen dioxide, and particles.
2. Restrooms may have a variety of indoor air pollutants, including secondhand smoke, and also molds and fungi due to humid conditions.
3. Furniture and carpets often contain toxic chemicals (formaldehyde, organic solvents, asbestos) that may be released over time in buildings.
4. Coffee machines, fax machines, computers, and printers can release particles and chemicals, including ozone (O_3), which is highly oxidizing.
5. Pesticides can contaminate buildings with cancer-causing chemicals.
6. Fresh-air intake that is poorly located—for example, above a loading dock or first-floor restaurant exhaust fan—can bring in air pollutants.
7. People who smoke indoors, perhaps in restaurants or offices, pollute the indoor environment, and even people who smoke outside buildings, particularly near open or revolving doors, may cause pollution as the smoke (secondhand smoke) is drawn into and up through the building by the chimney effect.
8. Remodeling, painting, and other such activities often bring a variety of chemicals and materials into a building. Fumes from such activities may enter the building's heating, ventilation, and air-conditioning system, causing widespread pollution.
9. A variety of cleaning products and solvents used in offices and other parts of buildings contain harmful chemicals whose fumes may circulate throughout a building.
10. People can increase carbon dioxide levels; they can emit bioeffluents and spread bacterial and viral contaminants.
11. Loading docks can be sources of organics from garbage containers, of particulates, and of carbon monoxide from vehicles.
12. Radon gas can seep into a building from soil; rising damp (water), which facilitates the growth of molds, can enter foundations and rise up walls.
13. Dust mites and molds can live in carpets and other indoor places.
14. Pollen can come from inside and outside sources.



Some potential sources of indoor air pollution.

Table 21.6 SOURCES, CONCENTRATIONS, OCCURRENCES, AND POSSIBLE HEALTH EFFECTS OF INDOOR AIR POLLUTANTS

POLLUTANT	SOURCE	GUIDELINES (DOSE OR CONCENTRATIONS)	POSSIBLE HEALTH EFFECTS
Asbestos	Fireproofing; insulation, vinyl floor, and cement products; vehicle brake linings	0.2 fibers/mL for fibers larger than 5 μm	Skin irritation, lung cancer
Biological aerosols/ microorganisms	Infectious agents, bacteria in heating, ventilation, and air-conditioning systems: allergens	None available	Diseases, weakened immunity
Carbon dioxide	Motor vehicles, gas appliances, smoking	1,0000 ppm	Dizziness, headaches, nausea
Carbon monoxide	Motor vehicles, kerosene and gas space heaters, gas and wood stoves, fireplaces; smoking	10,000 $\mu g/m^2$ for 8 hours; 40,000 $\mu g/m^3$ for 1 hour	Dizziness, headaches, nausea, death
Formaldehyde	Foam insulation; plywood, particleboard, ceiling tile, paneling, and other construction materials	120 $\mu g/m^3$	Skin irritant, carcinogen

Controlling Indoor Pollution

Indoor concentration of air pollution are generally greater than outdoor concentration of the same pollutants.

- Indoor Air Quality Standards
- Making Homes and Other Buildings Radon Resistant
- Designing Buildings to Minimize Indoor Air Pollution

THANKS!