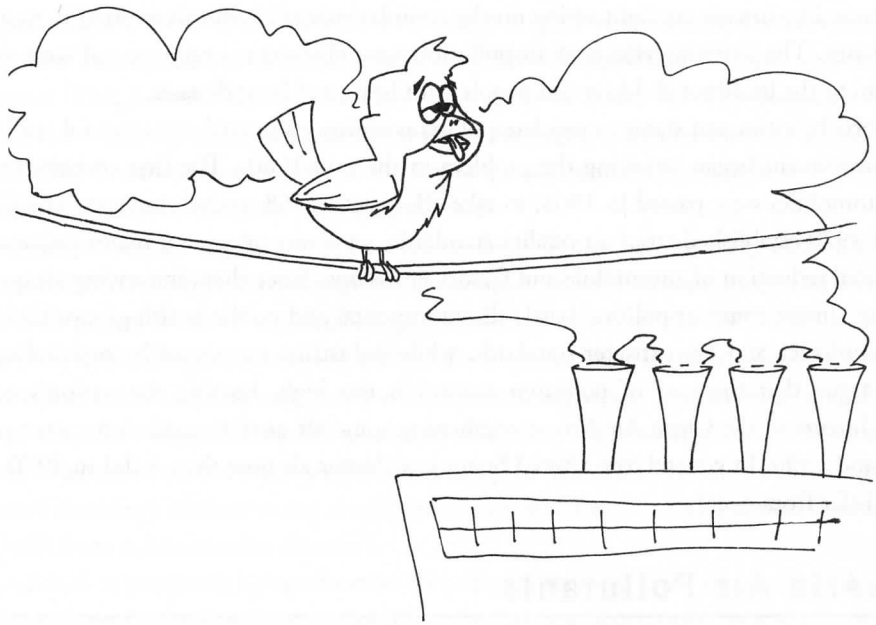
CHAPTER

20

Clean Air: Is it Safe to Breathe?



Air Pollution

Air pollution caused by coal burning was a problem in London as early as the 17th century. With the advent of the Industrial Revolution in the 18th and 19th centuries, the air of many cities was blackened with smoke from industrial and household furnaces and railroad locomotives. In 1952, an unusual weather pattern caused a particularly severe air pollution crisis in London. A layer of cold, moist air hung motionless over the city for five days, and smoke, fumes, and motor vehicle exhaust accumulated. More than 4000 deaths from both respiratory and heart disease were attributed to the foul air. Britain's first clean air act was passed soon afterward.[1]

Earlier, in 1948, the United States had been shocked by a similar deadly air pollution crisis caused by a similar weather pattern. A five-day atmospheric inversion trapped the smoke and fumes of a heavily industrialized Pennsylvania valley. In the small town of Donora, population

14,000, residents suffered eye, nose, and throat irritation and breathing difficulties resulting in 20 deaths.[1] The event gained national attention and helped raise awareness about the health consequences of air pollution. In 2008, on the sixtieth anniversary of the event, the town opened the Donora Smog Museum with the slogan "Clean Air Starts Here."[2]

For most cities, the effects of air pollution were not so dramatic, but air quality was noticeably deteriorating in the United States during the 1950s and 1960s. Increasingly, this was due to automobiles. Los Angeles became known for its photochemical smog, the yellowish-brown haze caused by intense sunlight acting on the complex mix of chemicals emitted in motor vehicle exhaust. The irritating effects of air pollution were obvious to everyone and were especially harmful to the health of children and people with heart and lung diseases.

Efforts by cities and states to regulate pollutant emissions proved unsuccessful, and the federal government began attacking the problem in the mid-1960s. The first emission standards for automobiles were passed in 1965, to take effect with 1968 model-year cars. The Clean Air Act of 1970 established strict air quality standards, set limits on several major pollutants, and mandated reduction of automobile and factory emissions. Since then, improving air quality has been an almost constant political battle. Environmental and public health groups have pressed for compliance and even stricter standards, while industries, supported by political conservatives, argue that the cost of pollution control is too high, hurting the nation's economy. Amendments to the Clean Air Act, strengthening some air quality regulations, were passed in 1977 and 1990. In general, the United States has cleaner air now than it did in 1970, but the battle is far from over.[1]

Criteria Air Pollutants

The Clean Air Act and its amendments require monitoring and regulation of six common air pollutants, called criteria air pollutants, known to be harmful to health and the environment: particulates, sulfur dioxide, carbon monoxide, nitrogen oxides, ozone, and lead.[1] All of these substances enter the air as a result of combustion—for energy in power plants or motor vehicles, or for solid waste disposal or industrial processes.

Particulate matter is the most visible form of air pollution—the smoke, soot, and ash that were so typical of the Industrial Revolution. Aesthetically, particulate matter is objectionable because it reduces visibility, forms layers of grime on buildings and streets, and corrodes metals. Epidemiologic studies have shown that particulates in the air also have harmful health effects. A groundbreaking cohort study conducted by Harvard epidemiologists compared the health of adults and children over the period 1975 to 1988 in six cities with markedly different amounts of particulate pollution in their air.[3] Residents of Steubenville, Ohio, the most polluted city in

the study, were more likely to suffer from respiratory symptoms and had poorer lung function than residents of Portage, Wisconsin, the least polluted city. Death rates in Steubenville were 26 percent higher than those in Portage. In a larger study of 151 cities, death rates were increased by 15 percent in the cities with the dirtiest air.

Early air pollution regulation focused on limiting total particulate matter. However, a number of studies, including the study of six cities, suggest that the smallest particles are the most dangerous because they can evade the body's natural defenses and penetrate deeply into the lungs, becoming a chronic source of irritation. In 1987, the Environmental Protection Agency (EPA) revised the standard so that the smaller particles—those with a diameter less than ten micrometers (PM_{10})—were limited. In 1997, and again in 2006, the EPA focused on even smaller particles, issuing increasingly stringent limits for particles smaller than 2.5 micrometers ($PM_{2.5}$). Public health advocates believe the limits are still not strict enough, and they have gone to court, where the issues are still being debated.[1,4]

Opponents of stricter regulations tried hard to discredit the six-city study and other data, but the evidence has continued to strengthen, showing increased hospitalizations and deaths associated with higher levels of the smallest particles. Opponents of the 1997 $PM_{2.5}$ standard sued the EPA, demanding a cost–benefit analysis for implementing the new rules.[5] In 2001, the Supreme Court ruled unanimously that a cost–benefit analysis was not necessary and that the EPA must consider only public health and safety in setting the standards.[6] The importance of $PM_{2.5}$ was affirmed in several other studies, including the Women's Health Initiative, which in 2007 found that every increase of ten micrograms per cubic meter in $PM_{2.5}$ almost doubled the risk of death from cardiovascular disease.[7]

Sulfur dioxide is produced by combustion of sulfur-containing fuels, especially coal. It irritates the respiratory tract, but its most significant impact is as a precursor to acid rain, a major threat to the environment. Sulfur dioxide reacts with water vapor to form sulfuric acid; it also tends to stick to fine particulates in the air, both mechanisms that increase this pollutant's potential for causing respiratory damage.[1] Sulfur dioxide levels, which are highest in the vicinity of large industrial facilities, have declined by 71 percent since 1980.[8]

Carbon monoxide is a highly toxic gas, most of which is produced in motor vehicle exhaust. It interferes with the oxygen-carrying capacity of the blood and is therefore especially harmful to patients with cardiovascular disease, who are more likely to suffer heart attacks when exposed to higher concentrations of the pollutant. Carbon monoxide also affects the brain, causing headaches and impairing mental processes. Carbon monoxide levels, which generally are highest in areas of high traffic congestion, have decreased by 79 percent since 1980.[8]

Nitrogen oxides are the chemicals responsible for the yellowish-brown appearance of smog. Like sulfur dioxide, nitrogen oxides are respiratory irritants that contribute to acid rain. They also contribute to the formation of ozone. The main sources of nitrogen oxides are on-road motor vehicle exhaust, off-road equipment, and power plant emissions.[9] Nitrogen oxides levels have declined by 40 percent since 1980.[8]

Ozone, a highly reactive variant of oxygen, is produced by photochemical reactions in which sunlight acts on other air pollutants including nitrogen oxides. It is very irritating to the eyes and to the respiratory system, and chronic exposure can cause permanent damage to the lungs. A study of 95 large urban communities in the United States, published in 2004, found that even short-term increases in ozone levels lead to increases in mortality from cardiovascular and respiratory diseases.[10]

Ozone levels in the air are an indicator of various other chemicals produced by motor vehicles, and they are often used as a general measure of air pollution. As discussed later, ozone is an important protective component of the upper atmosphere, but at low altitudes its effects are harmful. Although ozone levels tend to be high in many urban areas, many rural and wilderness areas may also be affected, because the wind carries the pollutants hundreds of miles from their original source.[11] In 2008, the National Parks Conservation Association and the Environmental Defense Fund filed suit to force the EPA to clean up emissions responsible for the haze that obscures the views in many national parks.[12]

Lead is a highly toxic metal that can damage the nervous system, blood, and kidneys, posing a special risk to the development of children's intellectual abilities. The main source of lead as an air pollutant was the use of leaded gasoline, which was phased out in the United States during the 1980s.[1] While environmental lead from other sources is still a threat to children, the amount of lead in the air has decreased dramatically, having dropped by 91 percent between 1980 and 2008.[8]

When an area does not meet the air quality standard for one of the criteria pollutants, the EPA may designate it a nonattainment area and may impose measures designed to force the area to attain the standard. According to the EPA, 116 areas in 35 states and the District of Columbia were classified as nonattainment areas for one or more criteria pollutant in 2009.[13] Poor air quality that is due to ozone levels is especially widespread, affecting broad areas in California, Texas, the East Coast from Boston to Atlanta, and parts of the Midwest. In 2008, more than 115 million people lived in counties with poor air quality.[8]

In addition to the criteria air pollutants, which are widespread, a large number of other toxic and carcinogenic chemicals are released into the air by local factories, waste disposal sites, and other sources. The Clean Air Act of 1970 directed the EPA to identify and set emission stan-

dards for such hazards, but as of 1993, only eight had been acted upon: asbestos, mercury, beryllium, benzene, vinyl chloride, arsenic, radionuclides, and coke-oven emissions.[1] As described in Chapter 19, legal battles over each standard have made progress painfully slow.

Clean Air Act amendments passed in 1990 contained a number of provisions designed to speed up the process. Congress identified 188 specific chemicals for the EPA to regulate. Rather than addressing each chemical individually, however, the agency was to identify major sources that emit these pollutants and to develop technical standards that will reduce the emissions. Since then, the EPA has issued rules covering over eighty categories of major industrial sources, including chemical plants, oil refineries, aerospace manufacturers, and steel mills, as well as categories of smaller sources such as dry cleaners.[14] It has also identified 33 toxic air pollutants that pose the greatest threats to public health in the largest number of urban areas and developed health risk assessments on them, producing maps of county-level risk for cancer, respiratory effects, and neurological effects.[15]

Strategies for Meeting Standards

Motor vehicles are the primary source of air pollution in urban areas, and the number of motor vehicles is increasing far more rapidly than the population. The standard approach for limiting air pollution from motor vehicles has been limitation of tailpipe emissions by mandating changes both in automobile engineering and in fuel. Significant improvement was achieved by the use of catalytic converters, devices that have been repeatedly improved to meet increasingly strict standards. The newest cars have reduced emissions of carbon monoxide and ozone-producing chemicals by about 90 percent and nitrogen oxides by 70 percent below those of cars without emission controls.[1] The ban on leaded gasoline has almost eliminated lead as an air pollutant.

Because of the continuing increase in the number of cars, however, and because older cars and poorly maintained vehicles continued to emit high levels of pollutants, a number of other requirements were included in the 1990 Clean Air amendments. Special attention was paid to geographic areas that fail to meet standards for one or more criteria pollutants. These requirements include use of less polluting alternative fuels such as ethanol and reformulated gasoline, installation of vapor recovery systems on gasoline pumps, and inspection and maintenance programs that require annual measurement of tailpipe emissions on each car, with mandatory remediation on cars that fail the test. Another mandate that has proved highly controversial is that automakers should develop and market "zero-emission" vehicles—electric cars—a goal that has not as yet been achieved for practical use, although hybrid vehicles have grown in popularity. Complicating efforts to reduce tailpipe emissions has been the increase in the number of

pickup trucks and SUVs, for which the standards for passenger cars did not apply. The rules were changed in the 1990s to require all new vehicles to meet the same standards by 2009, but vehicles manufactured under the old rules will still be on the road for years.[1]

Ideally, the number of cars on the road in highly populated areas should be reduced. Public transportation undoubtedly benefits air quality in New York City and Washington, D.C., but too many American cities—including Los Angeles—are not designed for efficient public systems. While Americans support most measures to ensure cleaner air, they consistently resist efforts to move them out of their private automobiles. Many urban areas have developed, with modest success, policies to encourage carpooling by providing high-occupancy vehicle lanes and by taxing parking spaces. Substantially higher taxes on gasoline, such as those in most European and Asian countries, would undoubtedly discourage unnecessary driving; but raising gas taxes seems to be considered political suicide by most politicians. Efficient public transport systems require some assistance from public funds—the dreaded increase in taxes. Spikes in gasoline prices in recent years due to market forces have had some beneficial effects in encouraging people to buy smaller, more fuel-efficient and less polluting vehicles.

A variety of strategies have been effective in reducing industrial sources of pollution. Foremost among them have been installation of scrubbers on smokestacks and a move to less polluting fuels, especially away from high-sulfur coal. A new approach included in the 1990 Clean Air Act amendments is the creation of pollution allowances that can be bought and sold. Instead of requiring each factory or power plant to meet defined standards, an overall national or regional emissions goal is set, and that goal is set lower each year. Each potential polluter is assigned a fraction of that amount as an allowance, which can be used or sold. Plants that choose to clean up their technology can recoup some of their investment by selling their allowances to plants that find cleanup too expensive. This market approach was expected to achieve Clean Air Act goals with a maximum of flexibility and a minimum of political pain.[1]

A provision of the 1977 Clean Air Act Amendments that has generated a great deal of controversy is called "New Source Review." When the original Act was passed in 1970, it set standards for newly built power plants but did not require changes to existing plants. Because this provision led the companies to improve existing facilities without cleaning up their emissions, the 1977 rules required that companies that substantially upgraded their old plants had to bring them into compliance with the standards. Many companies, however, ignored the rules. In the mid-1990s, after years of negotiations with the industry, the Clinton administration sued seven electric utility companies in the Midwest and the South to force them to comply with the law and launched investigations of dozens of others.

When the younger President Bush took office in 2001, his administration responded to the complaints of the utilities by setting out to weaken the environmental laws. In 2002, the President proposed the "Clear Skies Initiative," which replaced the New Source Review require-

ment with a market-based trading system that clearly set weaker emissions standards than those required by the Clean Air Act. Congress did not act on the proposal, so the Bush administration began to administratively change the rules. It also dropped the investigations of noncompliant companies. In late 2003, attorneys general of fifteen states, in cooperation with national environmental organizations, filed their own lawsuits against a number of the polluting power plants. Most of the states that sued were in the Northeast, where air is polluted by emissions blown in from the Midwest. The legal battles continued throughout Bush's term in office; by the end of his term, the New Source Review rule was still in place, but power plant emissions were still major sources of pollution.[16,17]

The Bush administration also issued rules on mercury pollution by coal-burning power plants that were later found by the courts to be inadequate and ineffective. The Bush rules used the cap-and-trade system that has been effective for air pollutants that disperse in the atmosphere; but mercury is heavy and tends to settle near the source of emission, causing local deposits that pollute soil and surface waters. Power plants, which produce more than 40 percent of mercury emissions, had lobbied heavily against strict rules requiring state-of-the-art technology at each site. The Obama administration has promised to tighten the rules for mercury in accordance with the court order.[18]

There was one exception to Bush's attempts to weaken air quality rules, however: in May 2004, the administration announced rules that require vehicles using diesel fuel to meet stricter standards on emissions. Engine makers are required to install emission control systems, and refineries are required to produce cleaner-burning diesel fuel. The new regulations, which should all be in effect by 2012, apply to nonroad vehicles such as tractors, bulldozers, locomotives, and barges, as well as to buses and trucks. The change is expected to significantly cut emissions of particulate matter and also, because diesel fuel contains high concentrations of sulfur, to reduce levels of sulfur dioxide in the air, helping to reduce acid rain.[1]

A modest law that took effect in 1988, the Emergency Planning and Community Right-to-Know Act (EPCRA), has had unexpectedly beneficial effects in prodding companies to voluntarily restrict their discharge of air pollutants. The law was passed in response to the infamous Bhopal disaster of 1984, in which a leak of isocyanate gas occurred at a Union Carbide pesticide factory in India, killing over 10,000 people who lived nearby. EPCRA requires businesses to report the locations and quantities of chemicals stored at their sites. This allows communities to prepare for emergencies such as leaks and chemical spills. The law also requires that manufacturers disclose information on the kinds and amounts of toxic pollutants they discharge into the local environment each year.[19] Frequently, local communities, alarmed by the information, pressure the industry to cut back on their emissions. The program, known as the Toxics Release Inventory, is credited with reducing industrial releases of toxic chemicals in the United States by 61 percent as of 2007.[20]

Even before September 11, 2001, some industries were pressuring the EPA to relax requirements of EPCRA, claiming, among other reasons, that publication of such information would increase communities' vulnerability to terrorism. After September 11, the EPA has gone much further in trying to restrict public access to environmental information. Some critics claim that the terrorism argument is being used as a smokescreen to protect industry from lawsuits or bad publicity. As one of these critics is quoted as saying, "What's tricky is finding the right balance between protection from terrorists on one hand and providing information for the neighbors so they can be safe."[21(p.107)]

Urban areas that are having the most difficulty meeting air quality standards by requiring controls on motor vehicles and factories must consider regulating sources of pollution that have thus far been left alone. For example, Los Angeles banned the use of charcoal lighter fluid for barbecues and regulates the exhaust of gas-powered lawnmowers. Dry cleaners, auto body shops, and furniture refinishers are also significant sources of toxic air pollutants that are regulated in the Los Angeles area.[22] In 2004, the region announced a program through which residents could turn in old gasoline lawnmowers in exchange for new, nonpolluting electric mowers.[23] Southern California still struggles with pollution associated with its ports, caused by cargo ships and the trucks that crowd the dock areas to move imported goods inland. The area's air pollution control agency is taking measures to replace some of the older diesel trucks with newer, cleaner models.[24] On a national scale, the Obama administration's 2009 program, nicknamed "Cash for Clunkers," which provided rebates to people who turn in old vehicles for new, more fuel-efficient ones, proved popular and helped to reduce pollution in areas with high emissions from motor vehicles.[25]

Overall, the United States has made substantial progress in fighting air pollution. As shown in **Figure 20-1**, emissions of most common pollutants have decreased significantly since 1970 despite significant increases in the nation's population and economic growth. In Los Angeles, concentrations of ozone, historically the most difficult pollutant to control, are now only one half of what they were in the mid-1970s; still, ozone levels in Los Angeles air violated federal standards on 120 days in 2008.[26]

Indoor Air Quality

While most public concern and political action have focused on outdoor air pollution, the 1980s saw increased attention paid to indoor air quality. In fact, most people spend more time indoors than out, and concentrations of many pollutants trapped inside a building may exceed those outdoors in all but the most polluted cities. The problem is exacerbated by energy conser-

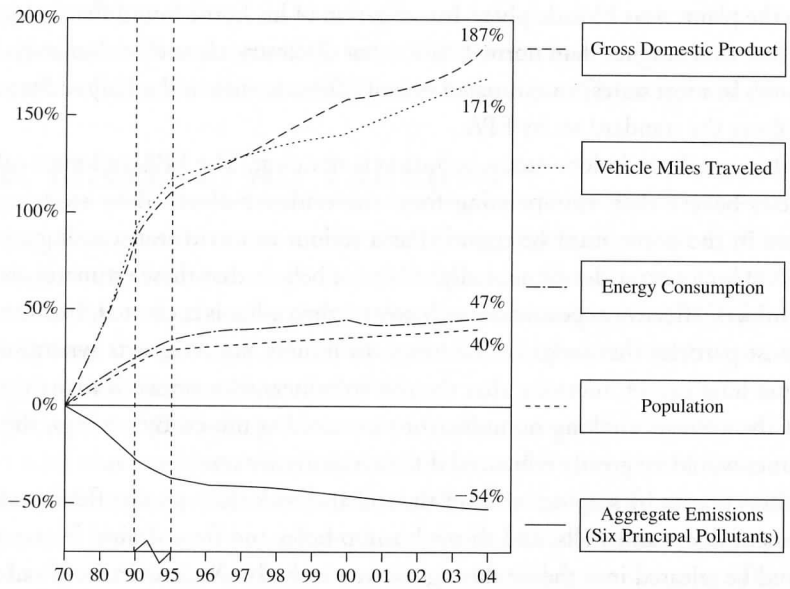


FIGURE 20-1 Air Pollution Trends in Comparison with Growth Areas. *Source:* U.S. Environmental Protection Agency. www.epa.gov/air/airtrends/images/comparison70.jpg

vation measures that minimize the quantity of outdoor air allowed inside. In the extreme, the lack of sufficient ventilation may lead to "sick building syndrome," in which building occupants develop an array of symptoms that disappear when they go outdoors.

The most common indoor air pollutants are tobacco smoke, other products of combustion, radon gas, consumer products that release chemicals into the air, and biological pollutants, including bacteria, mold, dust mites, and animal dander. "Secondhand smoke" has become a political issue in recent years, and many states now ban smoking in various public places. In the homes of smokers—beyond the arm of laws and regulations—tobacco smoke may be the most significant air pollutant and the main source of particulate pollution for children. Smoking also increases levels of carbon monoxide in indoor air and is a source of benzene, which is toxic and carcinogenic. Wood-burning stoves and fireplaces emit significant amounts of particulate matter and gases into the air. Gas ranges and furnaces burn more cleanly than wood stoves, but they produce carbon monoxide and nitrogen oxides.[1]

Radon is a radioactive gas emitted by the decay of radium and uranium. Radon has long been known to be a major health threat to uranium miners, who had a high risk of developing lung cancer. Then in 1984, a nuclear power plant worker set off radiation detection alarms on

his way into the plant, near Philadelphia.[1] Investigation of his home found that radon gas levels there were 1000 times higher than normal. Since that discovery, elevated radon levels have been found in homes in most states; an estimated one of fifteen homes in the United States has concentrations above the standard set by EPA.

The health threat from indoor radon pollution is not clear. The EPA and most other public health agencies believe that, extrapolating from the evidence obtained by studying uranium miners, radon in the home must be regarded as a serious cancer threat, causing an estimated 7000 to 30,000 lung cancer deaths annually.[1] Skeptics believe that these estimates are too high, noting that miners' effective exposure is much greater than what is measured, because the radon adheres to dust particles that lodge in the lungs. In miners, smoking acts synergistically with radon to cause lung cancer, meaning that the risk to miners who smoke is many times greater than that of the average smoking nonminer or nonsmoking miner. By analogy, the danger of radon in homes would be greatly enhanced if the residents are smokers.

Radon enters homes by seeping up from the soil and rock through dirt floors, crawl spaces, cracks in cement floors and walls, and through sump holes and floor drains. It may dissolve in well water and be released into the air during showers or baths. Measurement of radon is easily done with inexpensive kits and, in most homes where elevated levels are found, measures to seal cracks and openings are effective in reducing levels.

Other common indoor air pollutants include formaldehyde, a possibly carcinogenic gas that irritates the respiratory system and is contained in insulation, particleboard, plywood, some floor coverings and textiles, and tobacco smoke. In the past, elevated levels of formaldehyde were common in prefabricated and mobile homes. Although the Department of Housing and Urban Development specifies that plywood and particleboard must conform to specified emissions limits, formaldehyde turned out to be a significant problem in mobile homes supplied by the Federal Emergency Management Agency to victims of the 2005 hurricanes Katrina and Rita. Since then, the Sierra Club and other organizations have noted that high levels of formaldehyde are more widespread in manufactured housing than previously thought, and the organization has petitioned the EPA to tighten regulations.[27] Drywall imported from China turned out to be a significant source of foul odors and health complaints in newly built houses, especially in those built in 2006 and 2007 during the housing boom that resulted from the hurricanes. The problem with the drywall appears to be emissions of sulfur compounds that also cause corrosion of metal objects in the homes. Thousands of lawsuits have been filed as a result, and the Consumer Product Safety Commission is conducting an investigation.[28] Other chemicals that may pollute indoor air and may have adverse health effects include pesticides, dry-cleaning solvents, paints and paint thinners, carpet glues, hair spray, and air fresheners. While most biological air pollutants, such as mold, house mites, and animal dander, are a problem

only for people who are allergic to them, airborne microbes can pose serious health hazards: witness Legionnaire's disease, caused by bacteria vaporized from air-conditioning systems, and hantavirus released into the air from rodent urine or feces (see Chapters 4 and 10).

Global Effects of Air Pollution

Because air pollutants are the most mobile of all forms of pollution, their ill effects may spread far beyond the immediate area where they are released. In fact, evidence is mounting that human activities are actually changing the composition of the atmosphere. The ultimate effects on public health from these changes are still a matter of speculation and controversy, but it has become clear that the effects may be quite harmful.

Acid rain is produced when two common air pollutants—sulfur dioxide and nitrogen dioxide—react with water to form sulfuric acid and nitric acid. In the United States, the industrial areas of the Midwest are a major source of the pollutants that acidify rainfall in the East, since prevailing winds blow from west to east. Acid rain in eastern Canada resulting from U.S. air pollution has been a cause of diplomatic tension between the two countries. The environment in Europe, the former Soviet Union, and southern China—everywhere that coal and oil are intensively used—is also seriously affected by acid rain.

Acid rain damages forests, reduces crop yields, and corrodes surfaces of buildings and statuary. It turns the water in lakes and rivers acidic, killing freshwater shrimp, wiping out bacteria on lake bottoms, and interfering with fish reproduction. Some lakes are so acidic that they can no longer support life: all fish species disappear, as do most frogs, salamanders, and aquatic insects. Because many metals, such as aluminum, lead, copper, and mercury are soluble in acid, the increasing acidity of water may lead to toxic levels of metals in drinking water supplies. There is evidence that regulations on industrial pollutants in the United States have helped to bring down levels of sulfur dioxide in the air and have begun to reduce the acidity of rainfall in the Northeast. Improvements in the acidity of lakes and streams are expected to lag behind changes in rain and snow, but a 2003 EPA publication reported that approximately one-quarter to one-third of formerly acidic surface waters in the Adirondacks, the Upper Midwest, and the Appalachian Plateau were no longer acidic.[29]

Depletion of the ozone layer is another manifestation of the global effects of certain air pollutants. Ozone, which is so harmful to respiratory systems at ground level, is a natural component of the upper atmosphere that provides a layer of protection against ultraviolet radiation. The detection of chlorofluorocarbons (CFCs) in the ozone "hole" which opened over Antarctica in the early 1980s convinced scientists that these chemicals, which were used as refrigerants and spray can propellants, were responsible for the breakdown of ozone. Being very stable, CFCs drift upwards to the ozone layer, where they may cause damage for many decades.

The increased ultraviolet radiation that reaches ground level is causing greatly increased rates of cataracts, already a major cause of blindness in the world, and skin cancer. It also has harmful effects on other organisms, including food crops, and could be a major threat to life on the planet.

This global problem clearly required international action. After several years of controversy and denial, diplomats from 29 nations met in Montreal, Canada, in 1987 to sign an agreement aimed at reducing the production and use of CFCs.[1] As evidence of ozone depletion continued to mount, the Montreal Protocol has been strengthened several times, now calling for the elimination of chemicals that deplete ozone.[1] The protocol has been signed by 191 nations.[30] The United States has ended production of CFCs and many other ozone-depleting substances. However, millions of pounds of CFCs already in use will continue to be released into the atmosphere for years. The ozone layer appears to have stabilized, and it is expected to recover by the middle of the 21st century.[30]

Carbon dioxide is not strictly an air pollutant—along with nitrogen, oxygen, and argon, it is one of the four major components of the atmosphere—but its increasing proportion in the air has ominous implications for the future of the earth's environment. Carbon dioxide levels have been rising since the beginning of the Industrial Revolution due to the burning of fossil fuels. They are now about 30 percent higher than they were at the beginning of the Industrial Revolution, and they are increasing rapidly.[1]

Atmospheric carbon dioxide acts like the glass of a greenhouse, allowing sunlight to enter but trapping the heat inside. The resulting "greenhouse effect" leads to warmer temperatures at the earth's surface. Evidence is growing that global warming is already under way. It has been hard to definitively prove that the average temperature of the earth's surface is increasing because of the normal fluctuations from year to year and even from one decade to another, but the evidence is now quite strong that the average temperature of the earth increased by about 1.3°F between 1906 and 2005.[31] The temperature is expected to continue increasing, and the extent of warming is dependent upon how successful we are in curbing further emissions of greenhouse gases. The causes and effects of global warming are discussed further in Chapter 24.

Conclusion

Air pollution, while a conspicuous problem in cities for more than two centuries, was recognized as a severe threat to health in the 1940s and 1950s. Weather-related events together with smoke from the burning of fossil fuels in England and the United States caused local air pollution crises that led to deaths from respiratory and heart disease.

Because air pollution does not respect political boundaries, interventions, to be effective, must be implemented on a national and sometimes global scale. The United States began establishing regulations to control air pollution beginning in the 1960s. Regulations on both automobile and factory emissions have been repeatedly strengthened since the Clean Air Act of 1970. Each new standard has been highly controversial, opposed by industry, congressional conservatives, and the Bush administration. The Obama administration has signaled an intention to support stricter rules against air pollution.

Six criteria air pollutants were identified by the Clean Air Act: particulate matter, sulfur dioxide, carbon monoxide, nitrogen oxides, ozone, and lead. These pollutants must be monitored by the EPA, and levels in the air have fallen since 1970. A larger number of other chemicals have also been identified as toxic pollutants. The Clean Air Act amendments of 1990 required the EPA to identify major sources of these emissions and to set emission standards for the source categories rather than for individual pollutants.

Strategies for meeting air pollution standards include technological improvements in motor vehicles and factory smokestacks. Congress has encouraged a flexible approach by creating pollution allowances that can be bought and sold, permitting industries to cooperate in meeting the standards. Requirements that industries disclose information on their emissions often result in pressure on companies from local communities to reduce the pollution.

Indoor air may have even more significant effects on health than outdoor air, since most people spend more time indoors than out, and many indoor pollutants are trapped inside buildings at high concentrations. Common indoor air pollutants include tobacco smoke, radon gas, consumer products that release chemicals into the air, and biological pollutants such as bacteria and mold.

Air pollution can create acid rain, which profoundly affects the environment. Depletion of the ozone layer by CFCs increases risk of skin cancer and cataracts and has harmful effects on other organisms. Increases in carbon dioxide concentrations in the air lead to the greenhouse effect, resulting in global warming.

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