Ch. 18 - Air Pollution

Air pollution detectors:

canaries: died in mines when there was too much methane

lichens: fungi and alga living together that can live almost anywhere for long periods of time

The Atmosphere

Atmosphere - thin envelope of life-sustaining gases surrounding the earth

divided into several spherical layers

troposphere: innermost layer extending about 17 km above sea level

- contains about 75% of the mass of earth's air - weather occurs here

- 78% nitrogen / 21% oxygen / 1% argon / 0.036% carbon dioxide

- average pressure exerted by gases in the atmosphere decreases with altitude because average density (mass of gases per unit of vol.) decreases with altitude

tropopause: top zone of the troposphere where temperature declines with altitude but then abruptly begins to rise

stratosphere: atmosphere's 2nd layer extending from 17-48 km above earth's surface - contains less matter than the troposphere but has similar composition

calm air, little mixing - good for flying planes

ozone: "global sunscreen" keeps about 99% of UV radiation from reaching earth 1) allows humans and other life to exist on land and 2) helps protect humans from sunburn, cancer, cataracts, damage to immune system, and 3) prevents oxygen in the troposphere from being converted to ozone, a harmful air pollutant which causes smog and damage to plants

stratopause: top zone of the stratosphere and the beginning of the mesosphere where temperature reverses after rising with altitude

Important natural processes in the atmosphere

Greenhouse Effect: traps heat in the troposphere

global warming: caused by the addition of heat-trapping chemicals to the atmosphere

ozone shield: part of the stratosphere which filters out most UV radiation

ozone depletion: reduction of the concentration of ozone

Disruption of Earth's gaseous nutrient cycles - Burning fossil fuels and clearing forests

disrupts carbon cycle and can alter global climate and food-producing regions, cause huge heated air masses (heat islands) and dust domes over urban areas

nitrous oxides are converted to nitric acid which falls as acid rain

sulfur dioxide from petroleum refining and burning of oil and coal causes acid rain

Air pollution: the presence of 1 or more chemicals in the atmosphere in quantities and duration that cause harm to humans, other forms of life, and materials

primary pollutants: potential pollutants that have been directly added to the air by natural events or humans activities.

secondary pollutants: harmful chemicals formed in the atmosphere when a primary pollutant reacts with normal air components or other air pollutants

stationary sources of pollution: power plants and factories

mobile sources of pollution: cars (responsible for 80-88% of air pollution)

more than 1.1 billion people live in urban areas where the air is unhealthy to breathe

cities have higher air-pollution levels than rural areas although prevailing winds can spread long lived primary and secondary pollutants

photochemical smog: (brown-air smog) a mixture of primary and secondary pollutants formed under the influence of sunlight

nitrogen and oxygen in air react at high temps found in automobile engines and boilers in industrial plants to produce colorless nitric oxide which reacts with oxygen to form nitrogen dioxide. Nitrogen dioxide causes the brownish haze over cities on sunny afternoons.

worst on hotter days - can irritate eyes and respiratory tracts

present in virtually all cities

photochemical oxidants: NO_2, O_3 and PANs (peroxyacyl nitrates)

react with (oxidize) certain compounds in the atmosphere that normally aren't oxidized by reaction with oxygen; irritate the respiratory tract, damage plants

industrial smog: (gray-air smog) consists of sulfur dioxide, suspended droplets of sulfuric acid, and a variety of suspended solid particles and droplets

when burned, carbon in coal & oil is converted to CO_2 and CO. Unburned carbon ends up in the atmosphere as suspended particulate matter (soot). Sulfur dioxide (colorless, suffocating gas) and sulfur trioxide (SO_3) produce sulfuric acid

rarely a problem in today's developed countries but bad in countries where large quantities of coal are burned with inadequate pollution controls

Factors influencing the formation of photochemical and industrial smog

local climate and topography, population density, amt. of industry, and the fuels used in industry, heating, and transportation

hills, mountains, and cities reduce air flow and allow pollutants to build up at ground level

temperature inversion / thermal inversion: a layer of dense, cool air trapped under a layer of dense, warm air preventing upward-flowing air currents from developing

prolonged inversions cause air pollution in the trapped layer to build up to harmful levels

L.A. is the air-pollution capital of the US because the area has ideal conditions for photochemical smog formation and frequent thermal inversions

"dilution solution" to air-pollution: to reduce local air pollution and meet government standards without having to add expensive pollution control devices, most coal-burning plants, ore smelters, etc., use tall smokestacks to emit sulfur dioxide. This increases pollution downwind

chemicals reach ground:

wet - acid rain, snow, fog, cloud vapor

dry - acidic particles

mixture causes acid deposition (acid rain)

Regional Outdoor Air Pollution from Acid Deposition

pH: a numerical measure of the concentration of hydrogen ions in a solution

pH < 7 - acidic (natural precipitation)

pH > 7 - basic/alkaline

typical rain in east US is now about 10 times more acidic (pH 4.3)

What areas are most affected by acid deposition?

occurs on a regional rather than global basis because acidic components only remain in the air for a few days

areas downwind from coal and oil-burning power plants, industrial plants and urban areas

ecosystems containing thin, acidic soils without natural buffering of acids

growing problem in China (40% of its land), former Soviet Union, India, Nigeria, Brazil, Venezuela, Columbia

What are the effects of acid deposition?

medium-risk ecological problem, high-risk to human health

human respiratory diseases (bronchitis, asthma), damages statues, buildings, metals, car finishes, etc.

damages tree foliage, makes trees more susceptible to cold temperatures, diseases, insects, drought, fungi

harmful to fish

How serious is acid deposition in the US?

1980s study called the problem a serious, but not yet at a crisis stage

coal companies and industries claim that pollution control equipment costs more than the resulting health and environmental benefits are worth

1997 study shows that environmental and health benefits in reductions of SO_2 from 1995-2030 will generate more than $12 in benefits for every $1 spent on pollution control.

Clean Air Act of 1990 - decreased sulfur dioxide emissions

What can be done to reduce acid deposition?

prevention

1) reducing energy use & thus air-pollution by improving energy efficiency

2) switching from coal to cleaner-burning natural gas

3) removing sulfur from coal before it is burned

4) burning low-sulfur coal

5) removing SO2 particles, particulates, and nitrogen oxides from smokestack gases

6) removing nitrogen oxides from motor vehicle exhaust

reducing coal use is economically & politically difficult

clean-up approaches are expensive and mask symptoms w/ out treating causes

acidified lakes can be neutralized by treating them or the surrounding soil with large amounts of limestone or lime. This is an expensive and temporary remedy.

Indoor air-pollution

levels of 11 common pollutants are generally 2-5 times higher inside homes and commercial buildings than outdoors

health risks high b/c people spend 70-98% of their time indoors

source of cancer risk

greatest risk people - smokers, infants & children under 5, the old, the sick, pregnant women, people with respiratory or heart problems, factory workers causes dizziness, headaches, coughing, sneezing, nausea, burning eyes, chronic fatigue,

sick building syndrome - flu-like symptoms from indoor pollution

a building is “sick” when at least 20% of its occupants suffer persistent symptoms that stop when they go outside new buildings are more commonly sick b/c of reduce air exchange, chemicals from building materials costs about $100 billion per yr. in absenteeism, reduced productivity, and health costs

caused by mineral fibers, fiberglass, formaldehyde (extremely irritating gas)

burning of wood, dung and crop residues in open fires in developing countries is responsible for many respiratory illnesses

What should be done about asbestos?

asbestos: several different fibrous forms of silicate minerals widely used since the 1940s for fireproofing and thermal insulation

if inhaled, they can remain in the lungs for years

used for fireproofing, soundproofing, insulation of heaters & pipes, brake linings, etc cause asbestosis: a chronic, sometimes fatal disease that eventually makes breathing nearly impossible

causes mesothelioma: an inoperable cancer of the chest cavity lining; can cause lung cancer for those affected. Asbestos miners, insulators, pipe fitters, shipyard employees, workers in asbestos-producing factories. Most asbestos factories have gone out of business or moved to other countries

Is your home contaminated with radon gas?

Radon-222: a colorless, odorless, tasteless, naturally-occurring radioactive gas produced by the radioactive decay of Uranium-238

if inhaled, it can expose lung tissue to large amounts of ionizing radiation

lifetime exposure in a home responsible for 13,600 deaths a year.

How is human health harmed by air pollutants?

1) lung cancer

2) asthma: typically and allergic reaction causing sudden episodes of acute shortness of breath

3) chronic bronchitis: persistent inflammation and damage to the cells lining the bronchi and bronchioles, causing mucus buildup, painful coughing and shortness of breath

4) emphysema: irreversible damage to air sacs or alveoli leading to abnormal dilation of air spaces, loss of lung elasticity, and acute shortness of breath CO reduces the ability of blood to carry oxygen which impairs perception, things, causes headaches, dizziness, nausea, and can trigger heart attacks, damage fetuses

How many people die prematurely from air pollution?

outdoor pollution deaths : 65,000 - 200,000 / yr

total pollution deaths : 150,000 - 350,000 / yr

How are plants damaged by air pollutants?

breaks down waxy coating that prevents water loss and damage from diseases, pests, drought, frost

interferes with photosynthesis and plant growth, reduces nutrient uptake, causes leaves to turn yellow and brown; conifers at high elevations are especially vulnerable

forest diebacks in the Appalachian Mountains.

How can air pollutants damage aquatic life?

acid shock: caused by the sudden runoff of large amounts of highly acidic water & aluminum ions into lakes and streams, when snow melts or after unusually heavy rains.

decline in net primary productivity

kill all fish

in US 9,000 lakes are seriously threatened (Great Lakes)

What are the harmful effects of air pollution on materials?

costly cleaning needed, break down exterior paint on cars and houses, deteriorate roofing

deface irreplaceable marble statues, historic buildings, stained glass windows

$5 billion per yr. damage in the US

How have laws been used to reduce air pollution in the US?

Clean Air Acts (1970, 1977, 1990) - federal regulations enforced by each state

require standards set for 7 outdoor pollutants that specify a max level, averaged over a specific period, for a certain pollutant prevention of significant deterioration

national emission standards for toxic air pollutants

How could US air-pollution laws be improved?

rely on pollution prevention rather than cleanup

sharply increase the fuel efficiency standards for cars and light trucks

require stricter emission standards for fine particulates

don't give municipal trash incinerators 30-yr permits setting strict standards for air-pollution emissions from incinerators

reduce emissions of carbon dioxide and other greenhouse gases

Should we use the marketplace to reduce pollution?

a power plant is given a certain # of pollution credits or rights each yr that allow it to emit a certain amount of SO_2. If they emit less SO_2 than the limit they receive more pollution credits.

advantages and disadvantages

get older, high-polluting vehicles off the road; stricter emission laws for lawnmowers, chainsaws, leaf blowers, etc.

California's South Coast Air Quality Management District Council developed a drastic program to produce and 80% reduction in ozone, photochemical smog, and other major air pollutants in L.A. by 2009

How can we reduce indoor air pollution?

rooftop greenhouses, breathing wall to absorb dirty air and exhale clean air

How can we protect the atmosphere?

emphasize pollution prevention

improve energy efficiency reduce use of fossil fuels (coal & oil)

slow population growth

integrate air-pollution, water-pollution, energy, land-use, population, economic, and trade policies

regulate air quality for an entire region or air shed

phase in full-cost pricing, mostly by taxing the production of air pollutants

distribute cheap & efficient cook stoves & solar cook stoves in developing countries

transfer latest technologies to developing countries