Environmental Sustainability

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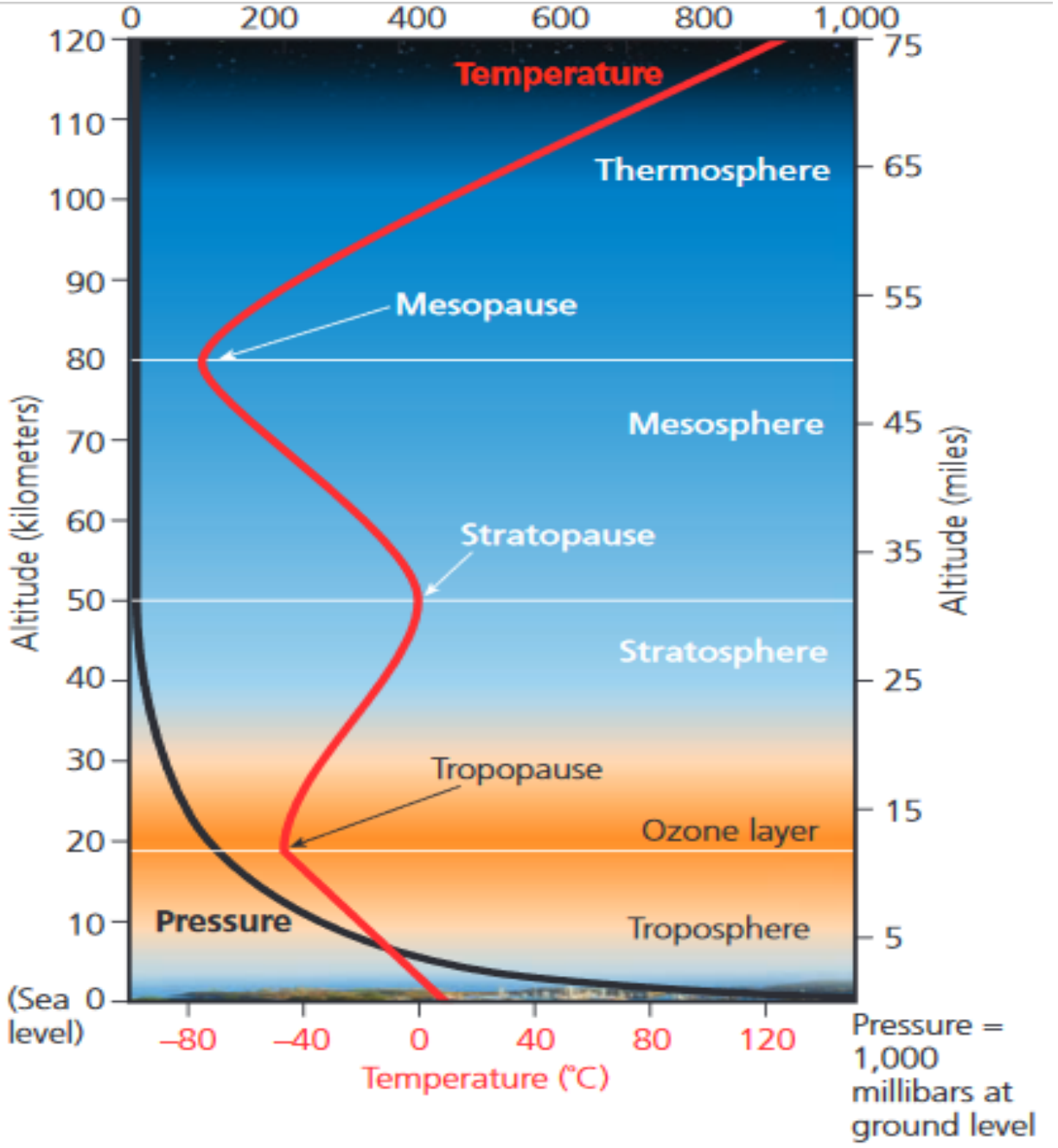
Air Pollution: Massive Brown Cloud

Asia's Massive Brown cloud: The massive dark brown cloud of pollution—called the Asian Brown Cloud—stretching nearly continuously across much of India, Bangladesh, and the industrial heart of China to the western Pacific Ocean.

It is estimated that pollution in this cloud contributes to at least **700,000 premature deaths every year.**

Air Pollution: Atmospheric Structures



Air Pollution: Sources

Chemicals added to the atmosphere by natural events or human activities in high enough concentrations to be harmful

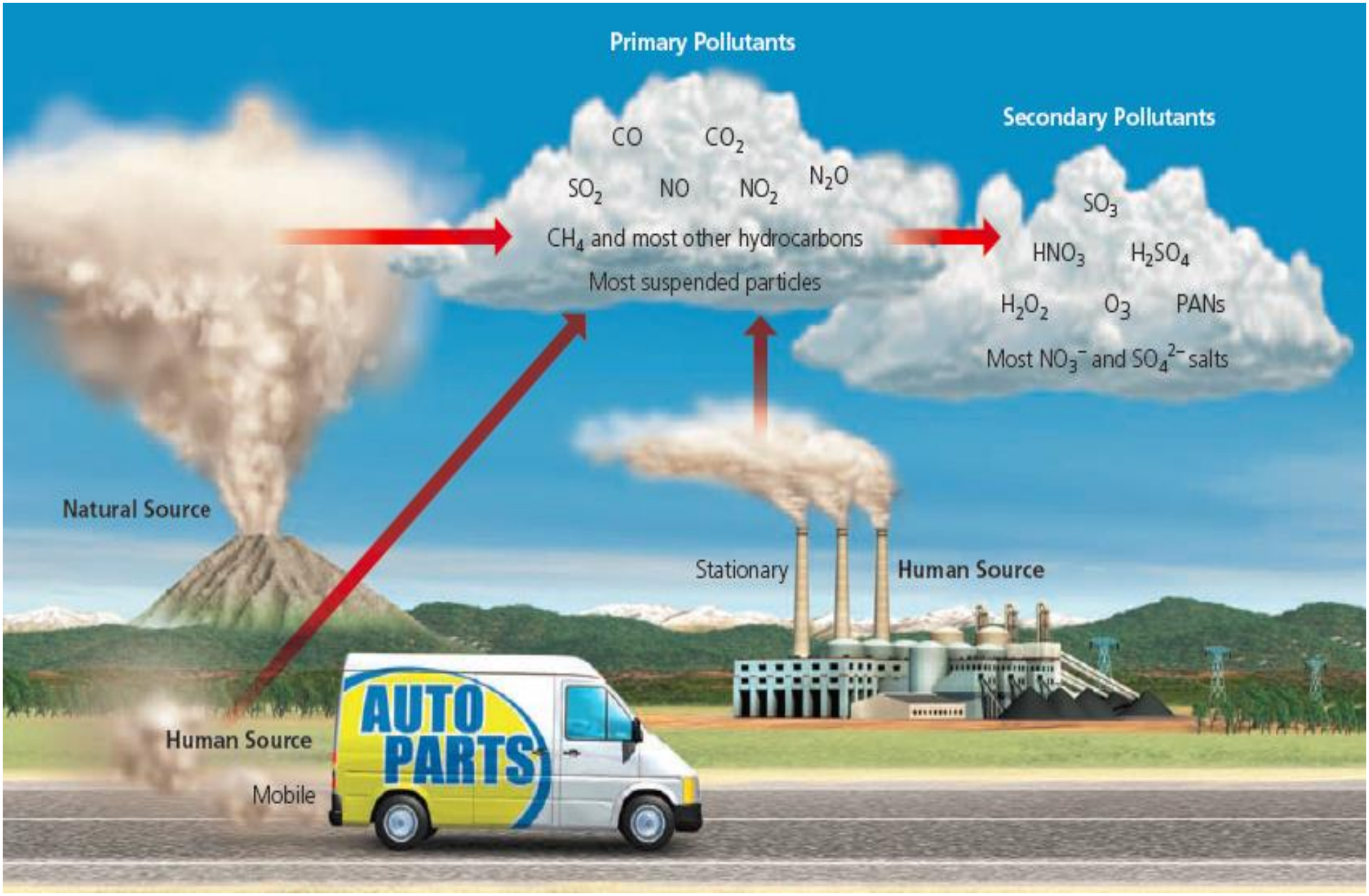
- **Primary Air Pollutant**
  - **Harmful substance that is emitted directly into the atmosphere**

    CO_X, NOx, SOx, HC

- **Secondary Air Pollutant**
  - **Harmful substance formed in the atmosphere when a primary air pollutant reacts with substances normally found in the atmosphere or with other air pollutants**

    O_3, H_2SO_4

Air Pollution: Sources



Major Air Pollutants

Pollutant	Composition	Primary or Secondary	Characteristics
Particulate matter			
Dust	Variable	Primary	Solid particles
Lead	Pb	Primary	Solid particles
Sulfuric acid	H_2SO_4	Secondary	Liquid droplets
Nitrogen oxides			
Nitrogen dioxide	NO_2	Primary	Reddish-brown gas
Sulfur oxides			
Sulfur dioxide	SO_2	Primary	Colorless gas with strong odor
Carbon oxides			
Carbon monoxide	CO	Primary	Colorless, odorless gas
Carbon dioxide*	CO_2	Primary	Colorless, odorless gas
Hydrocarbons			
Methane	CH_4	Primary	Colorless, odorless gas
Benzene	C_6H_6	Primary	Liquid with sweet smell
Ozone	O_3	Secondary	Pale blue gas with acrid odor
Air toxics			
Chlorine	Cl_2	Primary	Yellow-green gas

Particulate Matter

Aerosol : General term for particles suspended in air

Mist: Aerosol containing liquid droplets e.g., H_2SO_4 mist

Dust: Aerosol containing solid particles

Smoke: Aerosol containing mixture of solid and liquid particles produced by chemical reaction such as fire

Fume: Same as smoke by produced by condensation of hot vapors of metals e.g. Zinc and Lead fumes

Plume: Smoke coming out of chimney

Fly ash: Finely divided non-combustible particles present in the gases arising from fuel combustion. It contains inorganic metallic or mineral substances released when the organic part of the coal is burnt.

Natural particulates: Natural particulates are pollen grains spores bacterial, viruses, protozoal, fungal spores and volcanic dusts.

Particulate Material

Thousands of different solid or liquid particles suspended in air

- Includes: soil particles, soot, lead, asbestos, sea salt, and sulfuric acid droplets

Dangerous for 2 reasons

- **May contain materials with toxic or carcinogenic effects**
- **Extremely small particles can become lodged in lungs**

Nitrogen and Sulfur Oxides

•Nitrogen Oxides

- Gases produced by the chemical interactions between atmospheric nitrogen and oxygen at high temperature
- NO_2 reacts with water vapor in the air to form nitric acid (HNO_3) and nitrate salts (NO_3^-)
- Both NO and NO_2 play a role in the formation of photochemical smog
- Problems
  - ***Greenhouse gases***
  - ***Cause difficulty breathing***

•Sulfur Oxides

- SO_2 in the atmosphere comes from natural sources such as volcanoes
- Causes acid precipitation
  - *In the atmosphere, SO_2 can be converted to , which consist of microscopic suspended droplets of sulfuric acid (H_2SO_4) and suspended particles of sulfate (SO_4^{2-}) salts that return to the earth as a component of* ***acid deposition.***

Carbon Oxides and Hydrocarbons

Carbon Oxides

- **Gases carbon monoxide (CO) and carbon dioxide (CO_2)**
- **Greenhouse gases**
- *CO can combine with hemoglobin in red blood cells, which reduces the ability of blood to transport oxygen to body cells and tissues*
- *At high levels, CO can cause headache, nausea, drowsiness, confusion, collapse, coma, and death*
- *increase in CO_2 levels is a major cause of atmospheric warming.*

• Hydrocarbons

- The diverse group of organic compounds that contain only hydrogen and carbon (ex: CH_4- methane)
- *Some are related to photochemical smog and greenhouse gases*

Ozone

Tropospheric Ozone

- Man- made pollutant in the lower atmosphere
- Secondary air pollutant
- Component of photochemical smog

Stratospheric Ozone

- Essential component that screens out UV radiation in the upper atmosphere
- Man- made pollutants (ex: CFCs) can destroy it

Industrial Smog: Burning Coal

Industrial smog is the original "smoke and fog" that gave this type of air pollution its name. *It has plagued the city of London since the beginning of the Industrial Revolution and is sometimes called* ***London smog.***

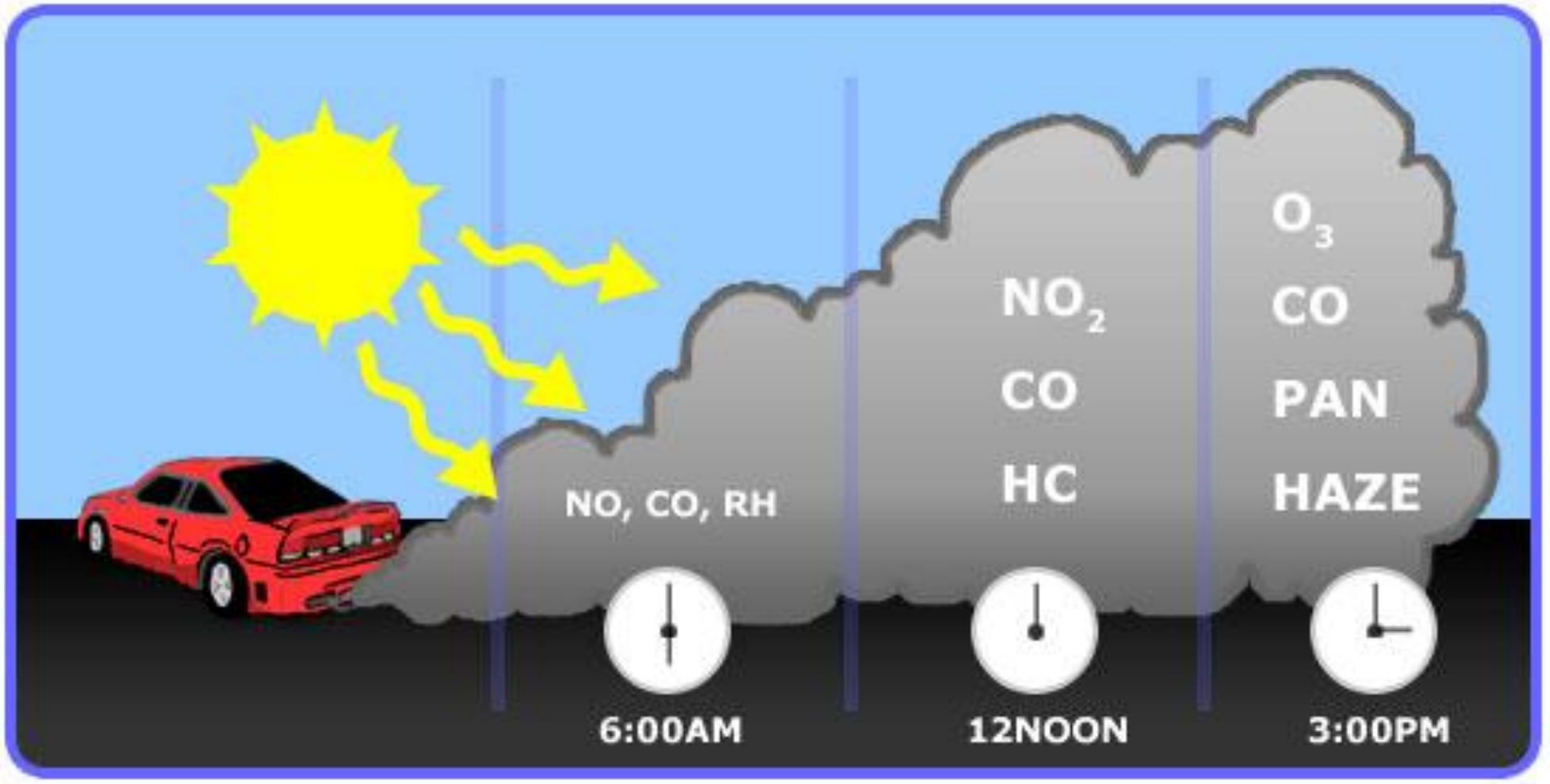
The major contributor of the Asian brown cloud.

Photochemical Smog

A photochemical reaction is any chemical reaction activated by light. **Photochemical smog is a *mixture of primary and secondary pollutants formed under the influence of UV radiation from the sun.***

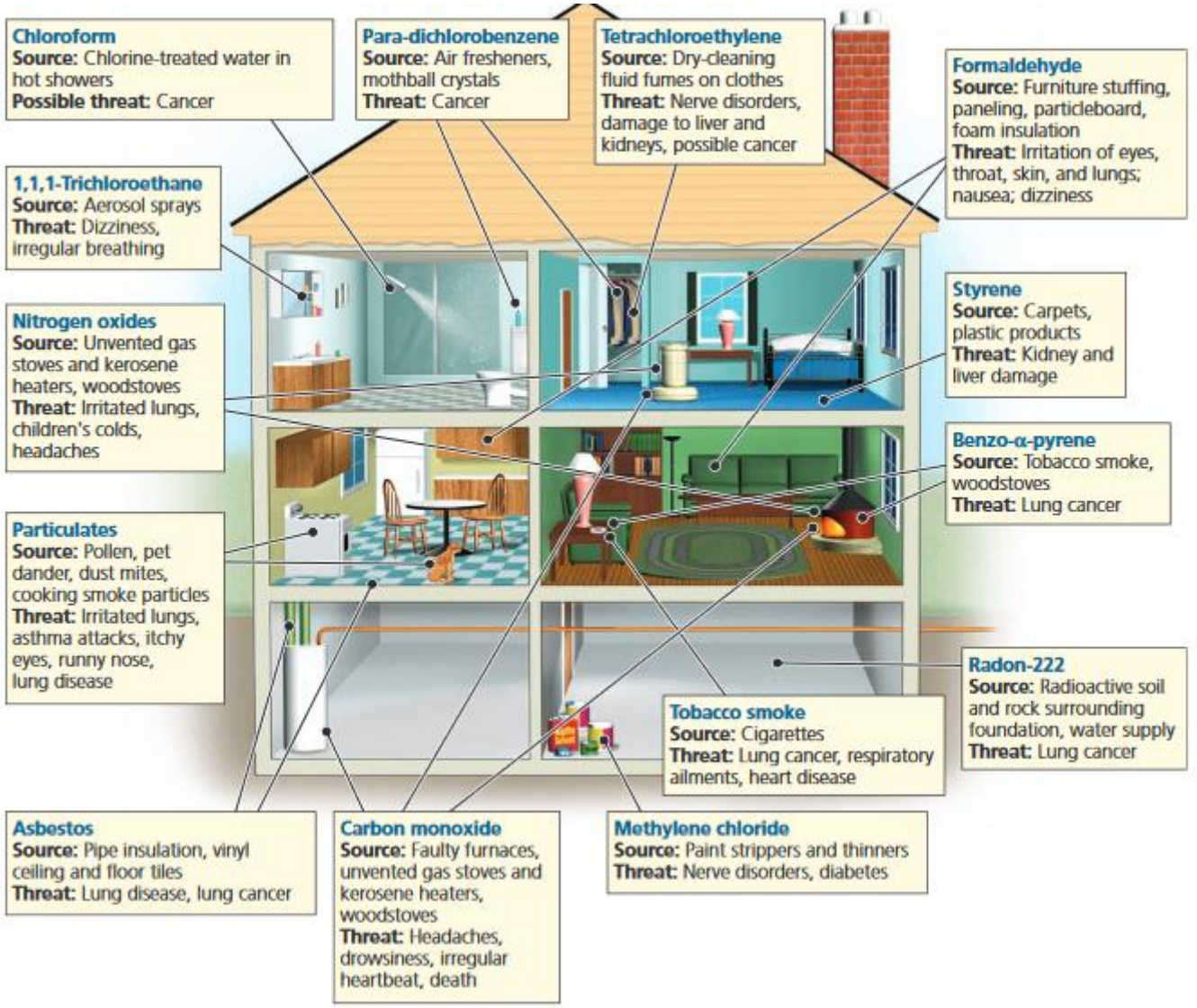
Photochemical Smog

Sunlight + Cars = Photochemical Smog



Indoor Air Pollution

Indoor air pollution is the world's most serious air pollution problem, especially for poor people. Indoor air pollution is also a serious problem in developed areas of all countries, mostly because of chemicals used in building materials and products. The figure shows some typical sources of indoor air pollution in a modern home.



Indoor Air Pollution

Alarming facts about indoor air pollution:

- 11 common pollutants generally are two to five times higher inside U.S. homes and commercial buildings than they are out-doors, and as much as 100 times higher in some cases.

- pollution levels inside cars in traffic-clogged urban areas can be up to 18 times higher than outside levels.

- **the health risks from exposure to such chemicals are magnified because most people in developed urban areas spend 70–98% of their time indoors or inside vehicles**
- **World-wide deaths due to indoor air pollution total about 1.6 million per year, or 1 every 20 seconds. At greatest risk are smokers, children younger than age 5, the elderly, the sick, pregnant women, people with respiratory or heart problems, and factory workers**

Effects of Air Pollution

Low-level exposure

- Irritates eyes
- Causes inflammation of the respiratory tract

Can develop into chronic respiratory diseases

Pollutant	Source	Effects
Particulate	Industries, electric power plants, motor vehicles, construction, agriculture	Aggravates respiratory illnesses; long-term exposure may cause increased incidence of chronic conditions such as bronchitis; linked to heart disease; suppresses immune system; some particles, such as heavy metals and organic chemicals, may cause cancer or other tissue damage
Nitrogen oxides	Motor vehicles, industries, heavily fertilized farmland	Irritate respiratory tract; aggravate respiratory conditions such as asthma and chronic bronchitis
Sulfur oxides	Electric power plants and other industries	Irritate respiratory tract; same effects as particulates
Carbon monoxide	Motor vehicles, industries, fireplaces	Reduces blood's ability to transport oxygen; headache and fatigue at lower levels; mental impairment or death at high levels
Ozone	Formed in atmosphere (secondary air pollutant)	Irritates eyes; irritates respiratory tract; produces chest discomfort; aggravates respiratory conditions such as asthma and chronic bronchitis

Acid Rain: Serious Regional Air Problem

Acid Deposition Has a Number of Harmful Effects: Acid deposition damages statues and buildings, contributes to human respiratory diseases, and can leach toxic metals (such as lead and mercury) from soils and rocks into lakes used as sources of drinking water.

Acid deposition harms aquatic ecosystems. Because of excess acidity, several thousand lakes in Norway and Sweden and 1,200 in Ontario, Canada, contain few if any fish. In the United States, several hundred lakes (most in the Northeast) are threatened in this way.

Acid deposition effect on the forests in two ways.

(1) leaching essential plant nutrients such as calcium and magnesium from soils

(2) releasing ions of aluminum, lead, cadmium, and mercury, which are toxic to the trees.

Acid Rain: Solutions

Solutions

Acid Deposition

Prevention

Reduce coal use

Burn low-sulfur coal

Increase natural gas use

Increase use of renewable energy resources

Remove SO_2 particulates and NO_x from smokestack gases

Remove NO_x from motor vehicular exhaust

Tax emissions of SO_2

Reduce air pollution by improving energy efficiency

Cleanup

Add lime to neutralize acidified lakes

Add phosphate fertilizer to neutralize acidified lakes

Effect on Plants

- The pollutants present in the air diffuse through the leaf pores (stomata) and destroy the chlorophyll and affect the photosynthesis

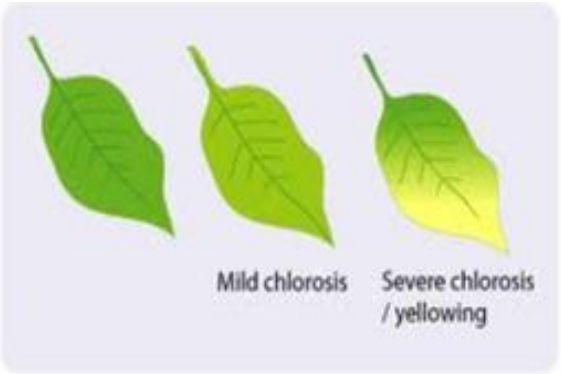
- During day time the ***pores are wide open to facilitate photosynthesis and hence pollutants easily diffuse and affect the plants***

- They also erode the cuticle (waxy layer on the leaves) which prevents the excess water loss

- It causes the following diseases

(i) necrosis – dead areas of leaf (ii) chlorosis – yellowing of leaf due to loss of Chlorophyll (iii) epinasty – downward curling of leaf (iv) abscission – dropping of leaves

necrosis



chlorosis

Epinasty

Abscission

Prevention/mitigation

- Proper environmental impact assessment before setting up a industry
- Using low sulfur content coal
- Using exhaust gas analysis and its treatment before being let out in to the atmosphere
- Regular tuning of engine and installing catalytic converters for the oxidation of CO
- Using mass transport and using clean fuels
- Planting more trees

Solutions

Stationary Source Air Pollution

Prevention

Burn low-sulfur coal

Remove sulfur from coal

Convert coal to a liquid or gaseous fuel

Shift to less polluting energy sources

Dispersion or Cleanup

Disperse emissions above thermal inversion layer with tall smokestacks

Remove pollutants after combustion

Tax each unit of pollution produced

Solutions

Motor Vehicle Air Pollution

Prevention

Use mass transit

Walk or bike

Use less polluting fuels

Improve fuel efficiency

Get older, polluting cars off the road

Give large tax write-offs or rebates for buying low-polluting, energy efficient vehicles

Cleanup

Require emission control devices

Inspect car exhaust systems twice a year

Set strict emission standards

Solutions

Indoor Air Pollution

Prevention

Clean ceiling tiles and line AC ducts to prevent release of mineral fibers

Ban smoking or limit it to well-ventilated areas

Set stricter formaldehyde emissions standards for carpet, furniture, and building materials

Prevent radon infiltration

Use office machines in well-ventilated areas

Use less polluting substitutes for harmful cleaning agents, paints, and other products

Cleanup or Dilution

Use adjustable fresh air vents for work spaces

Increase intake of outside air

Change air more frequently

Circulate a building's air through rooftop greenhouses

Use efficient venting systems for wood-burning stoves

Use exhaust hoods for stoves and appliances burning natural gas

Factors decrease outdoor air pollution

Heavier Particles

Rain and Snow

Salty sea spray

Winds

Chemical reactions

Factors increase outdoor air pollution

Urban Buildings

Hills and Mountains

Temperature

Grasshopper effect

Temperature inversion

Water Pollution

Water pollution is any change in water quality that can harm living organisms or make the water unfit for human uses such as drinking, irrigation, and recreation.

It can come from single (point) sources or from larger and dispersed (nonpoint) sources.

Point sources discharge pollutants into bodies of surface water at specific locations through drain pipes, ditches, or sewer lines.

factories, underground mines, oil wells, and oil tankers.

Nonpoint sources are broad and diffuse areas where rainfall or snowmelt washes pollutants off the land into bodies of surface water.

runoff of eroded soil and chemicals such as fertilizers and pesticides from cropland, feedlots, logged forests, urban streets, parking lots, lawns, and golf courses.

Major Water Pollutants and Their Sources

Major Water Pollutants and Their Sources

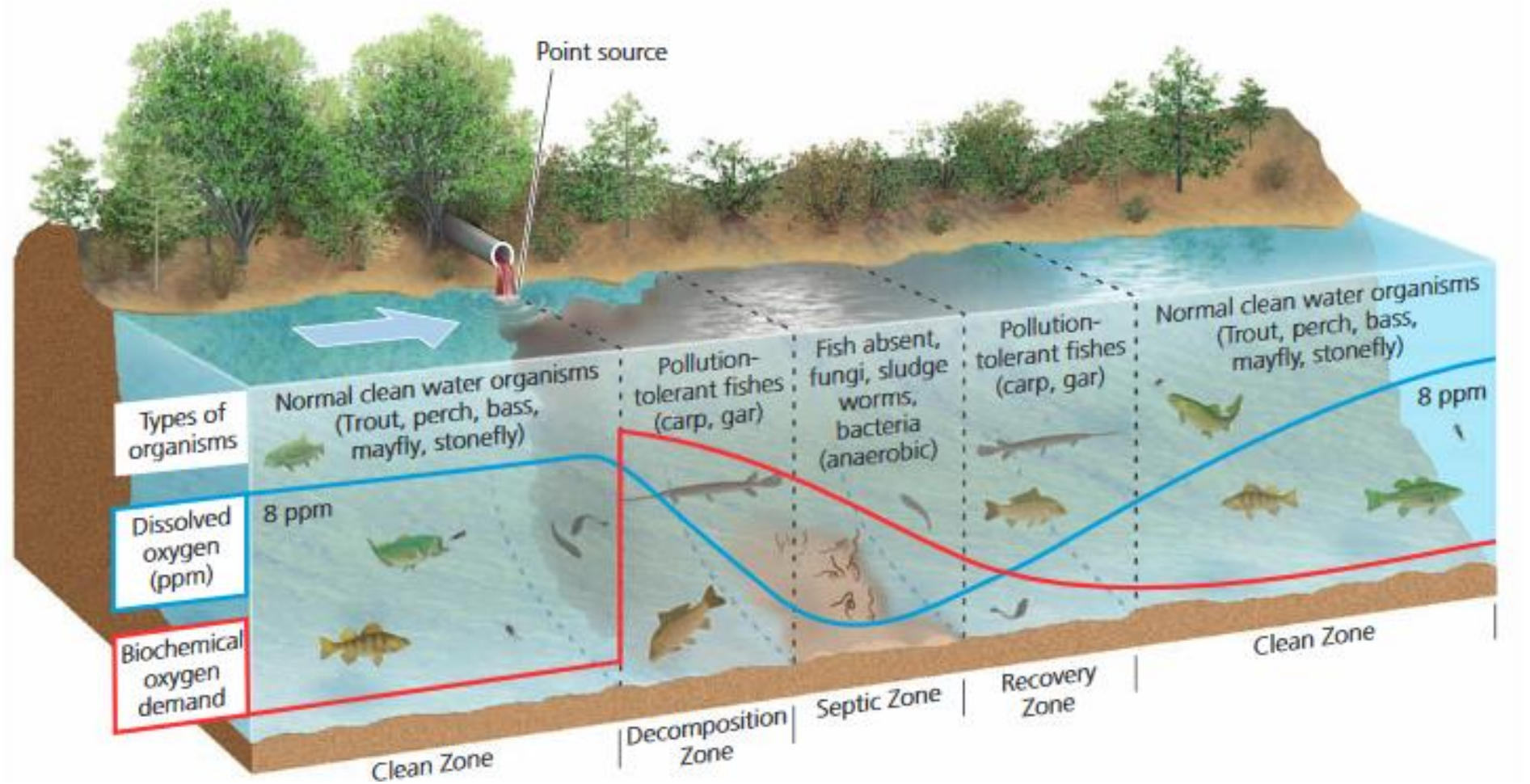
Type/Effects	Examples	Major sources
Infectious agents (pathogens) *Cause diseases*	Bacteria, viruses, protozoa, parasites	Human and animal wastes
Oxygen-demanding wastes *Deplete dissolved oxygen needed by aquatic species*	Biodegradable animal wastes and plant debris	Sewage, animal feedlots, food processing facilities, pulp mills
Plant nutrients *Cause excessive growth of algae and other species*	Nitrates (NO_3^-) and phosphates (PO_4^{3-})	Sewage, animal wastes, inorganic fertilizers
Organic chemicals *Add toxins to aquatic systems*	Oil, gasoline, plastics, pesticides, cleaning solvents	Industry, farms, households
Inorganic chemicals *Add toxins to aquatic systems*	Acids, bases, salts, metal compounds	Industry, households, surface runoff
Sediments *Disrupt photosynthesis, food webs, other processes*	Soil, silt	Land erosion
Heavy metals *Cause cancer, disrupt immune and endocrine systems*	Lead, mercury, arsenic	Unlined landfills, household chemicals, mining refuse, industrial discharges
Thermal *Make some species vulnerable to disease*	Heat	Electric power and industrial plants

Water Pollution: Seriousness

The WHO estimates that about **1 billion people—almost one of every seven in the** *world—do not have access to clean drinking water.* As a result, in 2007, ***the WHO estimated that each year more than 1.6 million people—equivalent to the entire population of the U.S. city of Phoenix, Arizona, or of Barcelona, Spain—die from largely preventable waterborne infectious diseases that they get by drinking contaminated water or by not having enough clean water for adequate hygiene.*** This amounts to an average of nearly 4,400 premature deaths a day, 90% of them children younger than age 5. Diarrhea alone, caused mostly by exposure to polluted water, on average, kills a young child every 18 seconds.

Water Pollution: Cleaning of Waste

Flowing rivers and streams can recover rapidly from moderate levels of degradable, oxygen-demanding wastes through a combination of dilution and biodegradation of such wastes by bacteria



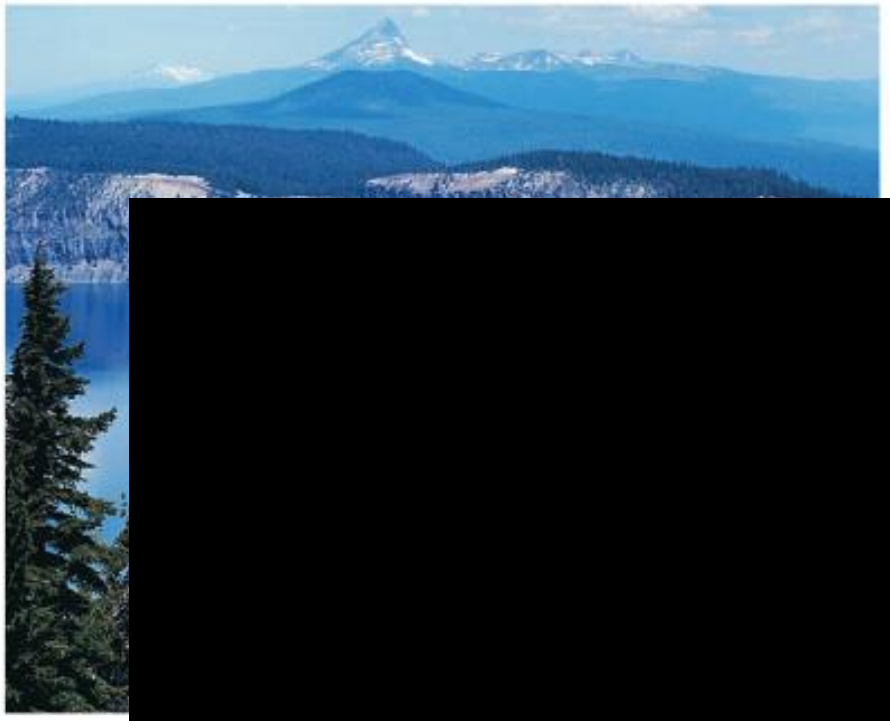
Water Pollution: Flow of Water is Important

Lakes and reservoirs are generally less effective at diluting pollutants than streams. Why?

- Stratified layers that undergo little vertical mixing.
- They have little or no flow.

The flushing and changing of water in lakes and large artificial reservoirs can take from 1 to 100 years, compared with several days to several weeks for streams. As a result, lakes and reservoirs are more vulnerable than streams are to contamination by runoff or discharge of plant nutrients, oil, pesticides, and non-degradable toxic substances such as lead, mercury, and arsenic.

Lakes and Reservoirs Vulnerable to Water Pollution

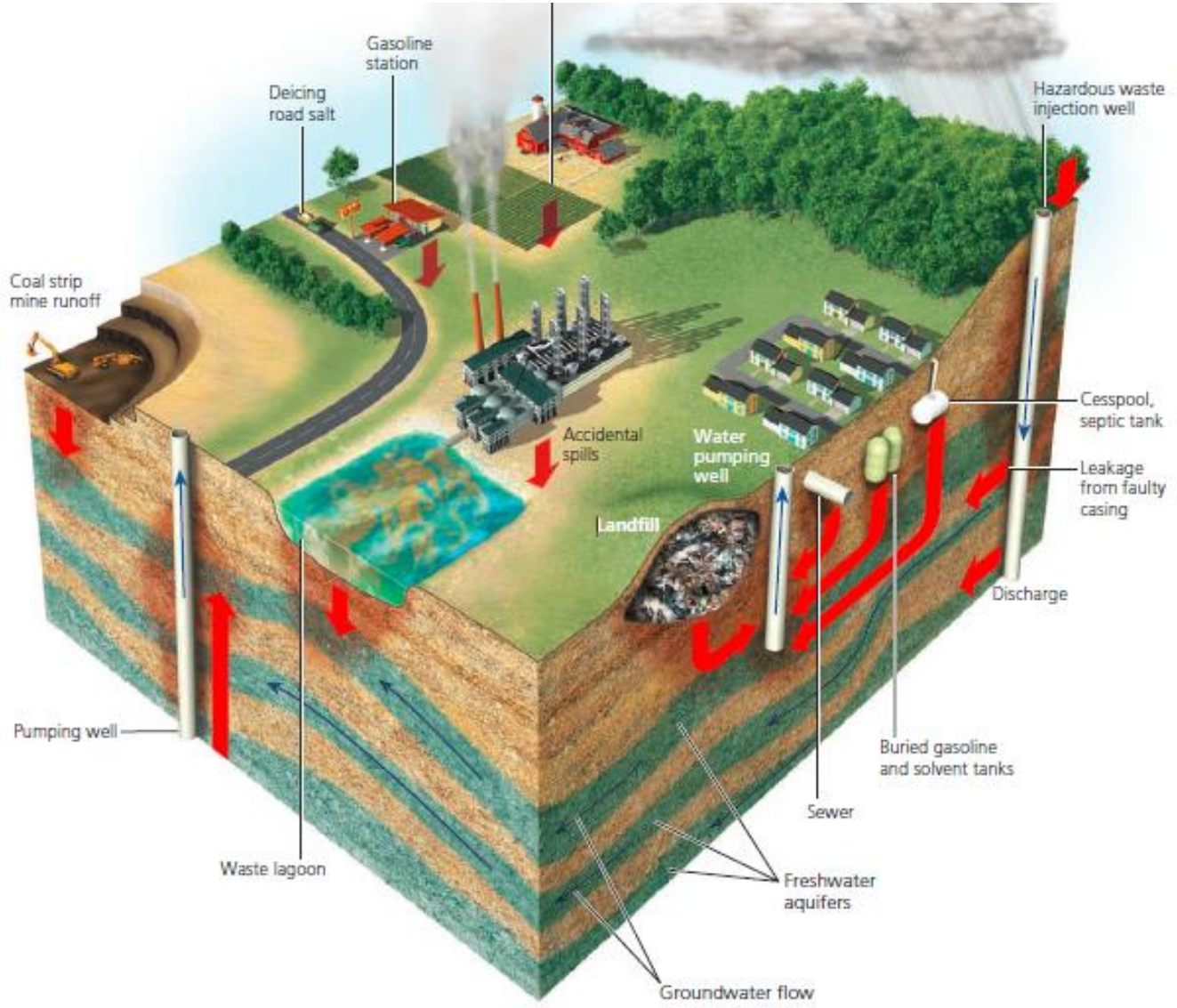


- **Eutrop** of a shallow lake, a
- It is c phosphates from land bordering such bodies of water.
- Over time, some lakes become more eutrophic as nutrients are added from natural and human sources in the surrounding watersheds.

Groundwater Pollution

Is groundwater Safe?

Common pollutants such as fertilizers, pesticides, gasoline, and organic solvents can seep into groundwater from numerous sources



Ocean Pollution

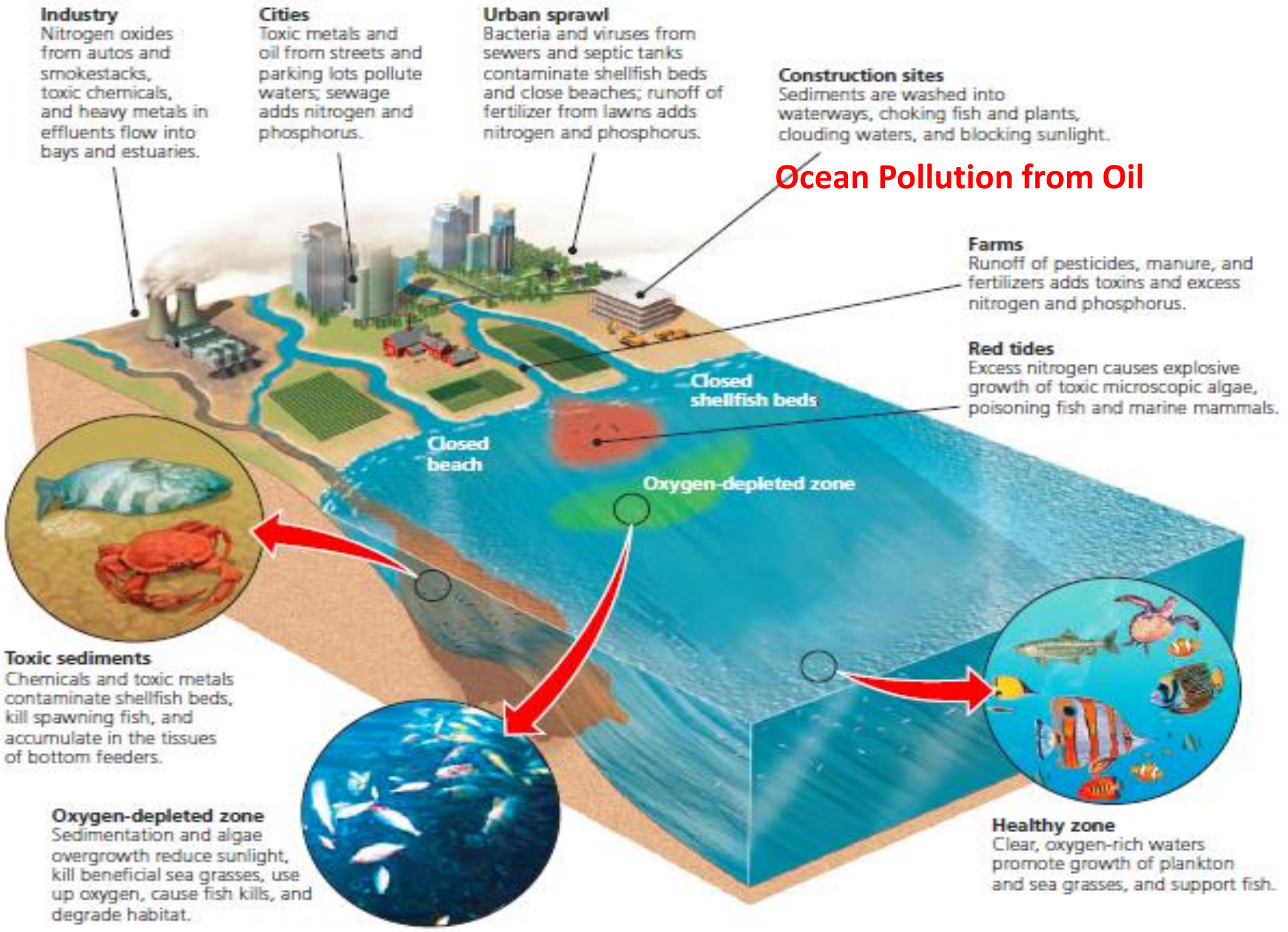
Why should we care about the oceans?

Water cycle
Affect weather
Regulate the earth's temperature
Absorb carbon dioxide

"Even if you never have the chance to see or touch the ocean, the ocean touches you with every breath you take, every drop of water you drink, every bite you consume. Everyone, everywhere is inextricably connected to and utterly dependent upon the existence of the sea."

Sylvia A. Earle

Ocean Pollution



Ocean Pollution: Life Straw

The LifeStraw, designed by Torben Vestergaard Frandsen, is a personal water purification device that gives many poor people access to safe drinking water.

Do you think the development of such devices should make prevention of water pollution less of a priority? Explain.

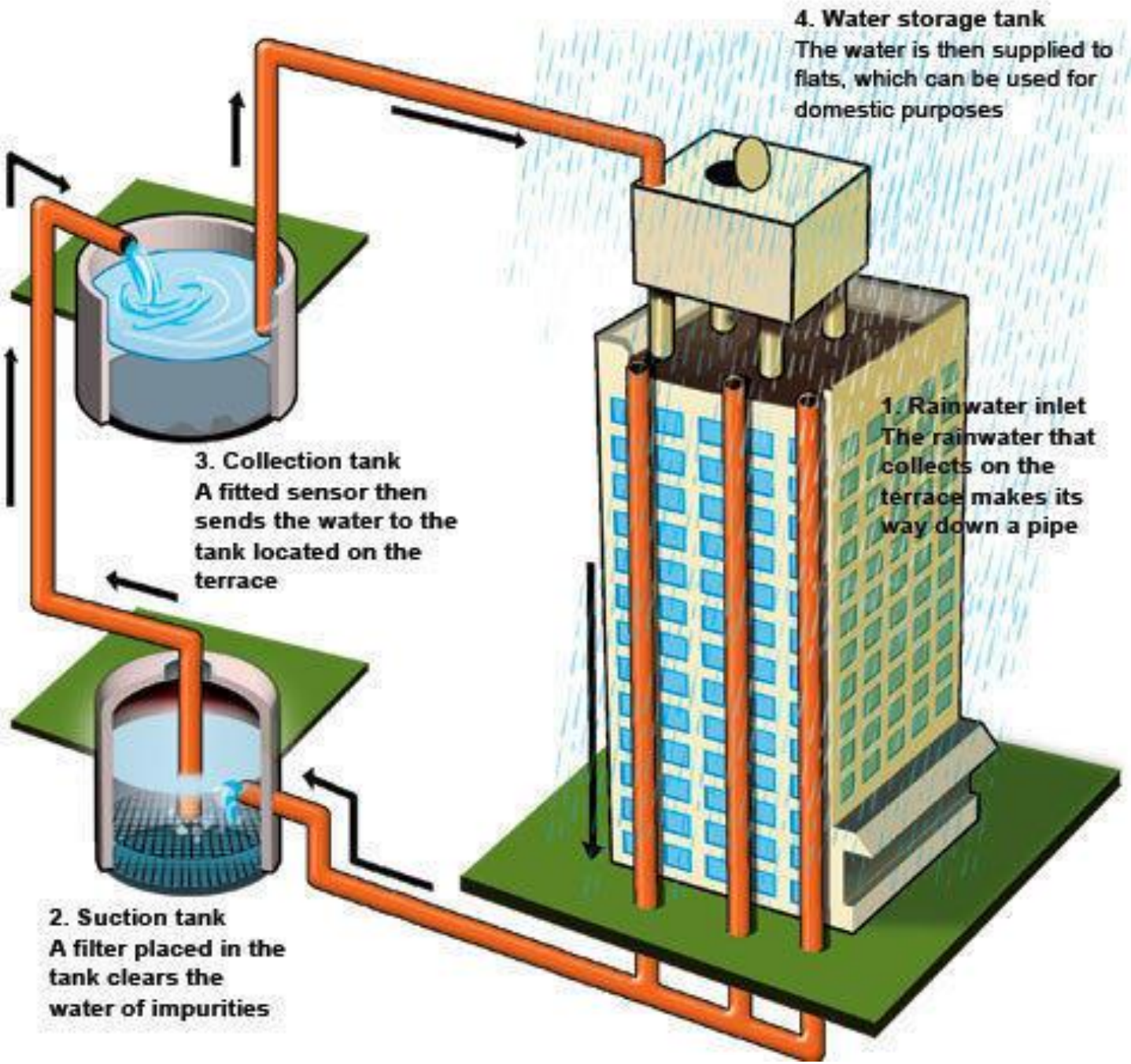
Reduce Water Pollution

- Prevent groundwater contamination
- Reduce nonpoint runoff
- Work with nature to treat sewage and reuse treated wastewater
- Find substitutes for toxic pollutants
- Practice the four Rs of resource use (refuse, reduce, reuse, recycle)
- Reduce air pollution
- Reduce poverty
- Slow population growth

Reduce Water Pollution

- Fertilize garden and yard plants with manure or compost instead of commercial inorganic fertilizer
- Minimize use of pesticides, especially near bodies of water
- Prevent yard wastes from entering storm drains
- Do not use water fresheners in toilets
- Do not flush unwanted medicines down the toilet
- Do not pour pesticides, paints, solvents, oil, antifreeze, or other harmful chemicals down the drain or onto the ground

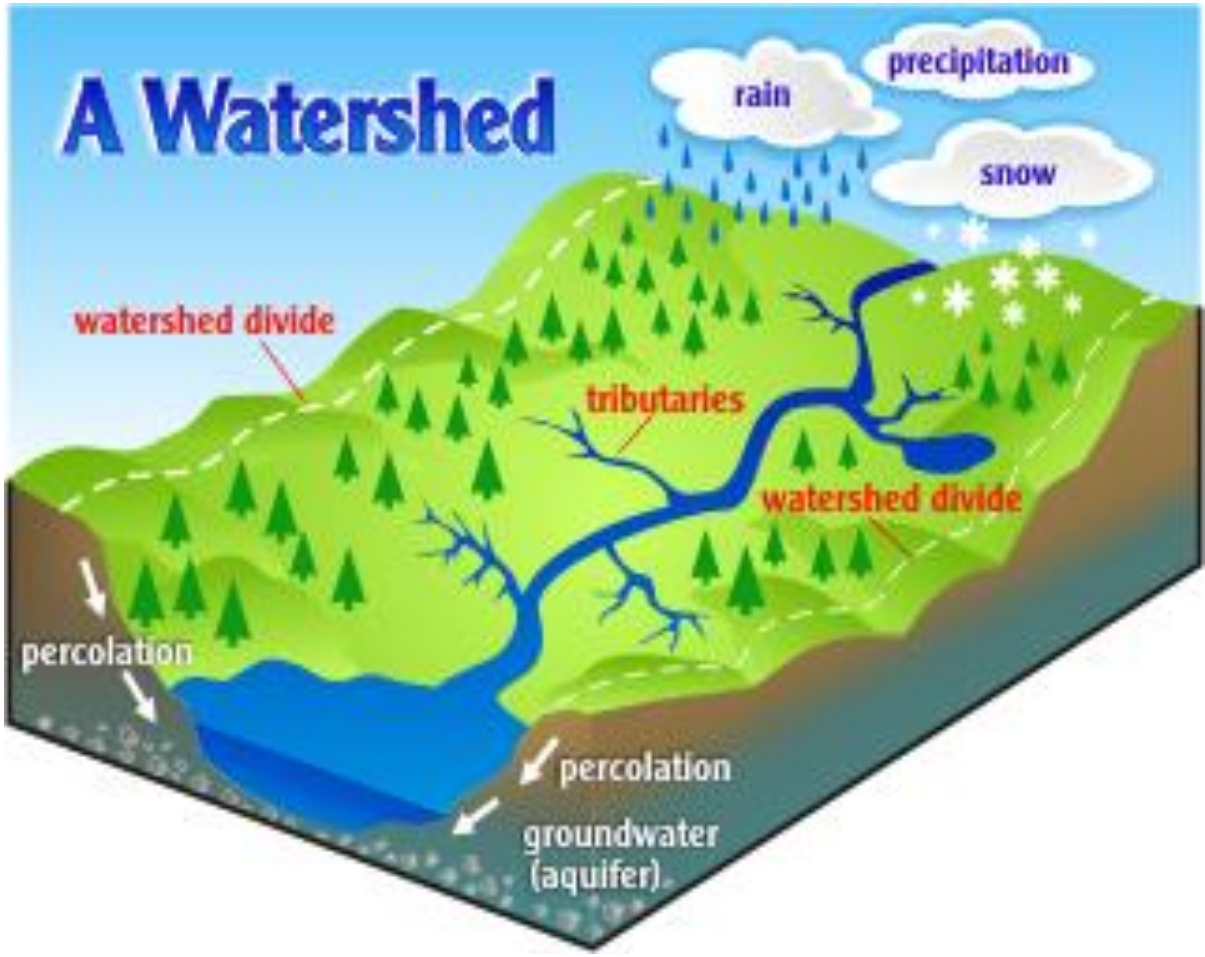
Rain Water Harvesting



Watershed

A watershed is an area of land that feeds all the water running under it and draining off of it into a body of water. It combines with other watersheds to form a network of rivers and streams that progressively drain into larger water areas.

Watersheds are interconnected systems of land, water, air, and the plant and animal species they support—including humans. ***A watershed is specifically defined as an area of land that is bound by ridges or hills (watershed divide) and creates a basin in which water drains to a common point (river, lake, ocean, etc)***



51 Wonderful Ways to Conserve Water

1.Turning the water off when brushing your teeth or washing your hair.

2. Purchase water-efficient products and appliances for your home.

3. Plant your garden in the spring.

4. Do not use water to defrost foods.

5. Check for leaks.

6. Stop using extra water when you flush by avoiding placing anything in the toilet.

7. Insulate your pipes.

8. When washing clothes, make sure that you are washing full loads of laundry only.

9. Same rule applies when using the dishwasher –keep it full.

10. Take shorter showers.

11. When washing your dishes do not leave the water running to rinse.

12. Keep water in a jug in the fridge instead of running the tap when you want water.

13. Minimize the amount of time spent watering the lawn.

51 Wonderful Ways to Conserve Water

18. Have regular inspections from a plumber or water specialists.
19. Teach your kids how to conserve water and help them do it.
20. Use brooms or other tools to clean gutters instead of the water hose.
21. Keep in mind those hidden water sources.
22. Use a layer of mulch around your plants.
23. Consider all decorations used outside including water fountains.
24. Adjust your water techniques with the season.
25. Use only one drinking glass for your water for the day.
26. Consider purchasing a dual-flush toilet.
27. Use the car wash to wash your vehicle.
28. Match the water fill to the appropriate size of laundry that you are doing.
29. Using a water sensor is a smart idea.
30. Use rainwater to water the plants in the house.
31. Using the right size pans when cooking.
32. Check your hoses and pipes for leaks, cracks, and other damage.
33. Reuse your towels.
34. Do not plant in areas that are hard to water.

51 Wonderful Ways to Conserve Water

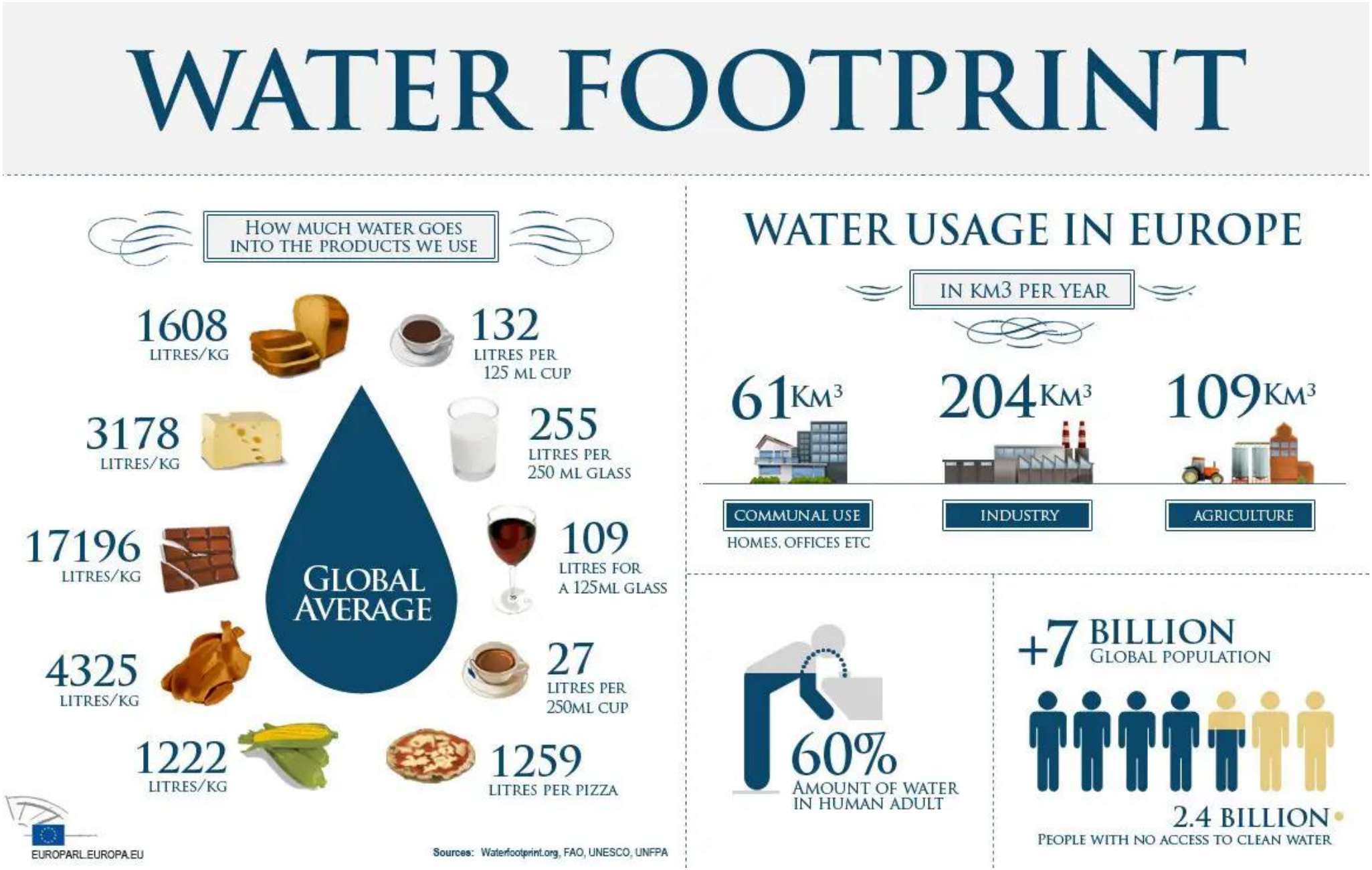
35. Try to water the small lawn by hand rather than using sprinklers.
36. Install water saving devices.
37. Try to use fewer plates and cups.
38. Don’t let water go down the drain.
39. Read your house water readings at regular interval.
40. Install covers on pools to avoid loss of water evaporation.
41. Water your lawn during early parts of the day.
42. Use broom instead of hose to clean your driveways or sidewalks.
43. Don’t use your toilet as a trash can
44. Don’t run the washer until you have full load of laundry to wash.
45. Fill the sink with soapy water in the sink when washing dishes by hand.
46. Use energy efficient washing machine.
47. Never put the water down the drain. Reuse if possible.
48. Teach your kids to turn the faucets off tightly after each use.
49. Don’t over-water your lawns and don’t water any faster than the soil can absorb.
50. Do not brush teeth in the shower.
51. Provide useful suggestions to your employer

Water footprint

- The water footprint of a product (good or service) is the **volume of fresh water used to produce the product**, summed over the various steps of the production chain.

- 'Water use' is measured in terms of water **volumes consumed (evaporated) and/or polluted**. The water footprint is a geographically explicit indicator, not only showing volumes of water use and pollution, but also the locations and timing of water use.

Water footprint



Water footprint

- **The blue water footprint** is the volume of freshwater that evaporated from the global blue water resources (**surface water and ground water**) to produce the goods and services consumed by the individual or community.

- **The green water footprint** is the volume of water evaporated from the global green water resources (**rainwater stored in the soil as soil moisture**).

- **The gray water footprint** is the **volume of polluted water** that associates with the production of all goods and services for the individual or community. This is calculated as the volume of water that is required to dilute pollutants to such an extent that the quality of the water remains above agreed water quality standards.

Virtual Water

Virtual water is the amount of water that is embedded in food or other products needed for its production.

Trade in virtual water allows water-scarce countries to ***import high-water-consuming products*** while ***exporting low-water-consuming products*** and in this way ***making water available for other purposes***

Let us understand what is virtual water with the help of a simple example:

Consider that to produce one ton of wheat, close to 1,300 cubic meters of water is required. *When a country imports this tonne of wheat grains, it can use the existing indigenous water it saves for other purposes instead. However, if the exporting country is water-scarce, the shipped virtual water will be no longer available for other purposes.*

Virtual Water

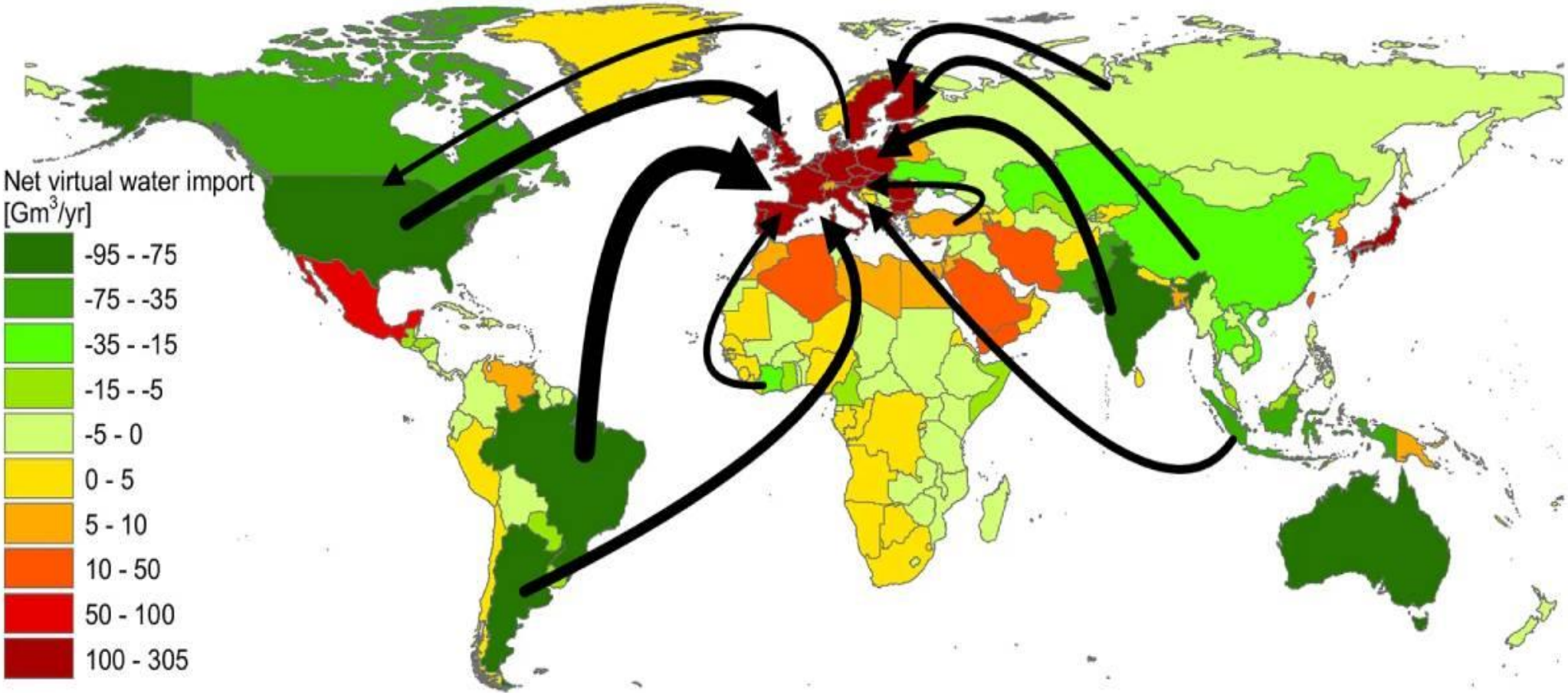
Similarly, about 16,000 tons of water are essential to produce a ton of beef. Therefore, someone consuming beef often is likely to absorb substantially more water than someone on a vegetarian diet.

Several nations strategically conserve their domestic water resources by *importing water-intensive products* and, in return, *exporting relatively less water-intensive commodities*. Some others also discourage the export of certain goods, such as oranges in Israel.

Now, this is where the importance of the virtual water trade comes into the picture.

Virtual Water

Virtual Water Trade: Virtual water trade exactly means what the name implies – the import and export of ‘hidden’ water present in various products, such as textiles, machinery, livestock, and crops. All these require water inevitably for their production.



Virtual Water

Virtual Water Trade: India exported nearly 26,000 million liters of virtual water every year. The most exported products were rice, buffalo meat, and maize.

In a nutshell, India's net imported virtual water during this period was 237.21 trillion liters, while exported virtual water was close to 500 trillion liters.

Thank you