Omaha Water Treatment Plant

Recycling Wastewater

- Water treatment technology is capable of making even sewage wastewater fit to drink (called toilet-to-tap)
- Toilet to tap:
  - Water is drawn from aquifer, treated if needed, and used;
  - The wastewater is cleaned (chemically chlorine chloramine, etc.) then pumped back into the aquifer.
  - The water follows a circular path, but you aren't drinking purified toilet water; it goes back to the aquifer.
- Successful examples—Tampa Bay area, Florida and Orange County, California.
- In Tampa Bay area by 2001 reclaimed water met 42% of St. Petersburg's needs.
- Orange County, California recycled water with goal of drought-proofing its water supply with a toilet-to-tap treatment and recycling system
- Omaha's water is drawn from underground, then used, then cleaned, and discharged into the Missouri River. (not toilet to tap)

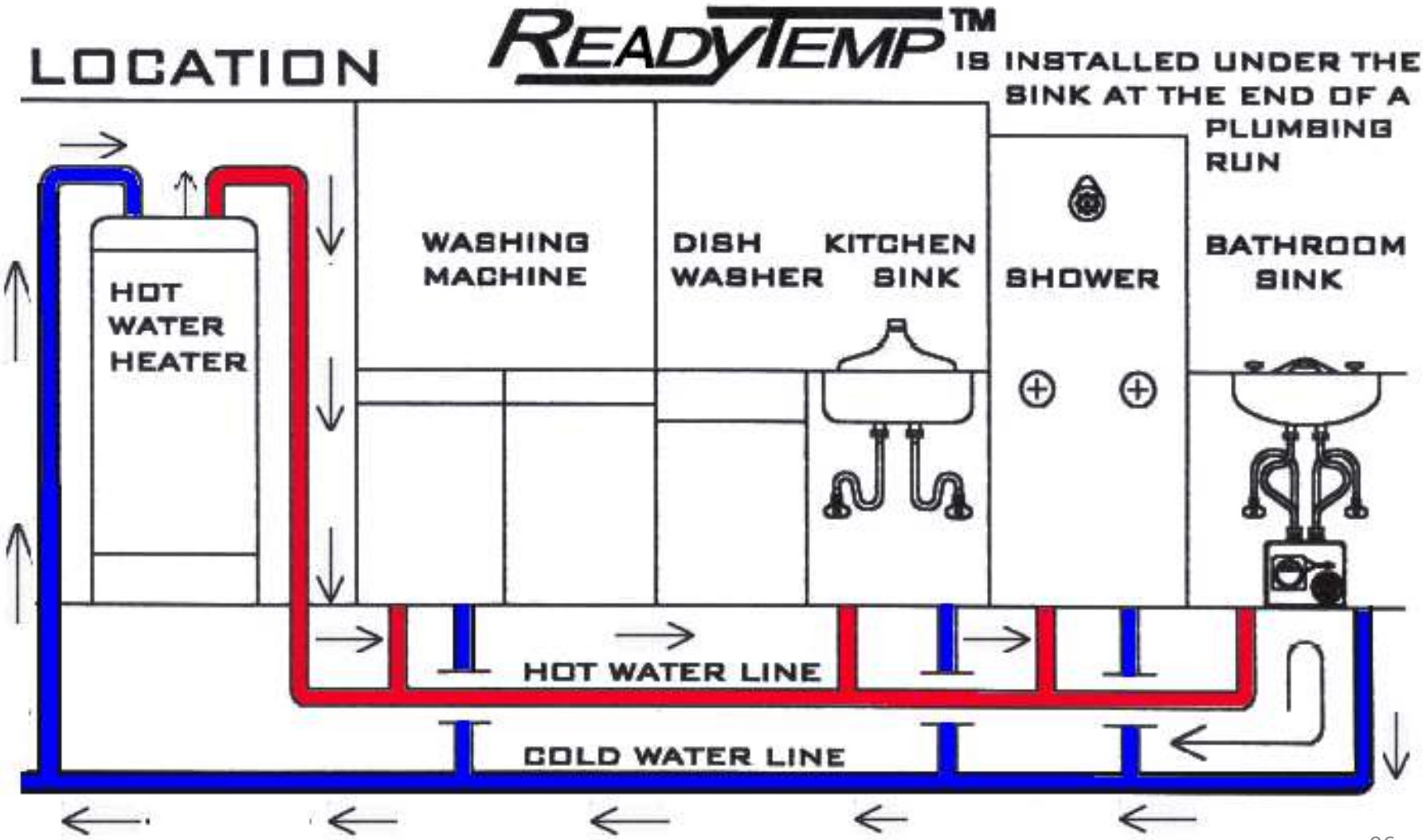
Conserving Water—Some Practices

- Household water conservation
  - Using water-saving fixtures and appliances
    - Low-flow toilets
    - Hot water recirculators
    - Automatic/motion shut-off facets
  - Avoiding water-wasteful gardening
- Community water conservation
- Water saving agriculture:
  - **Xeriscaping** – using plants (native or non-native) requiring little or no additional water.
- **Drip irrigation**
  - Above-ground systems
  - Subsurface systems

Figure 10-30 Xeriscaping Conserves Water

Figure 10-31 Irrigation Technology Can Conserve Water

Hot Water Recirculation System



https://readytemp.com

Water conservation

- Agriculture, could reduce water withdrawals by 20-30% with:
  - Lined and covered irrigation ditches
  - Night irrigation (less evaporation)
- More efficient bathroom fixtures
  - Low flow toilets
  - Hot water recirculating pumps
- Metering
- Change peoples perception
- Recycle water
  - Use greywater from washing machines and dishwashers to irrigate lawn, etc.
- Catch rainwater from roofs
  - Rain barrels
- Xeriscaping
  - Using plants that don't require extra water from humans
    - Native or non native species
    - Example: Bur oak trees are native to the Midwest and don't need any extra water to survive. Planting bur oak trees as maintenance-free landscaping is xeriscaping

- Tucson – 160 gpd/person
- Phoenix – 1000 gpd/person

Results of Water Recycling

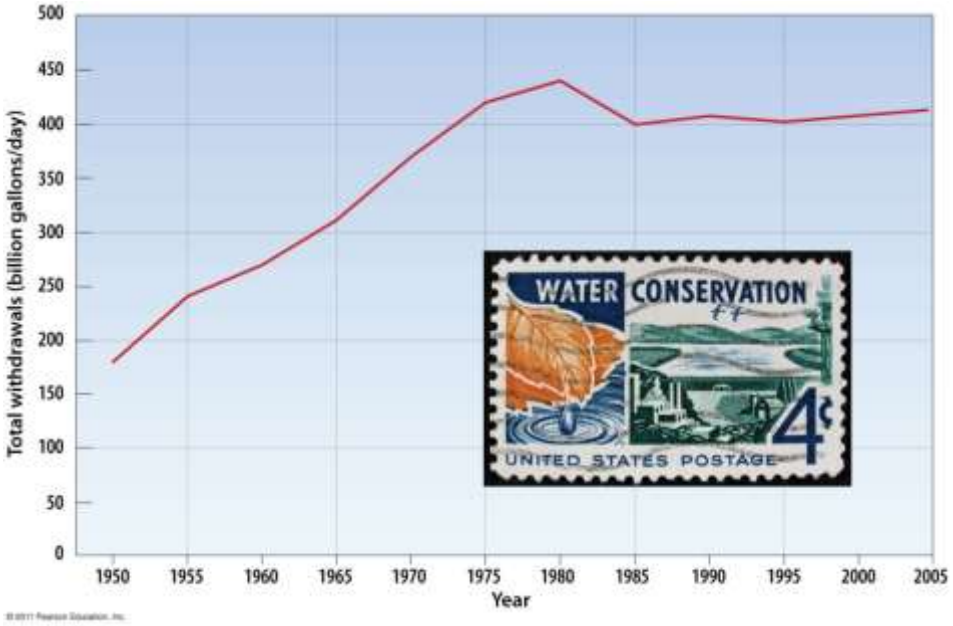


Figure 10-32 Annual Water Use in the United States

- Water conservation is working!
- Although publicly supplied water has gradually increased, irrigation and electric power generation use has leveled off. Water withdrawals have been at about 1.5 trillion liters (400–410 bill. gal.) a day since 1985.
- Even in the face of increasing population, water use leveling off is attributed to water recycling in industry (especially the electric power industry) and conservation such as low-flow plumbing and low-pressure directed irrigation.

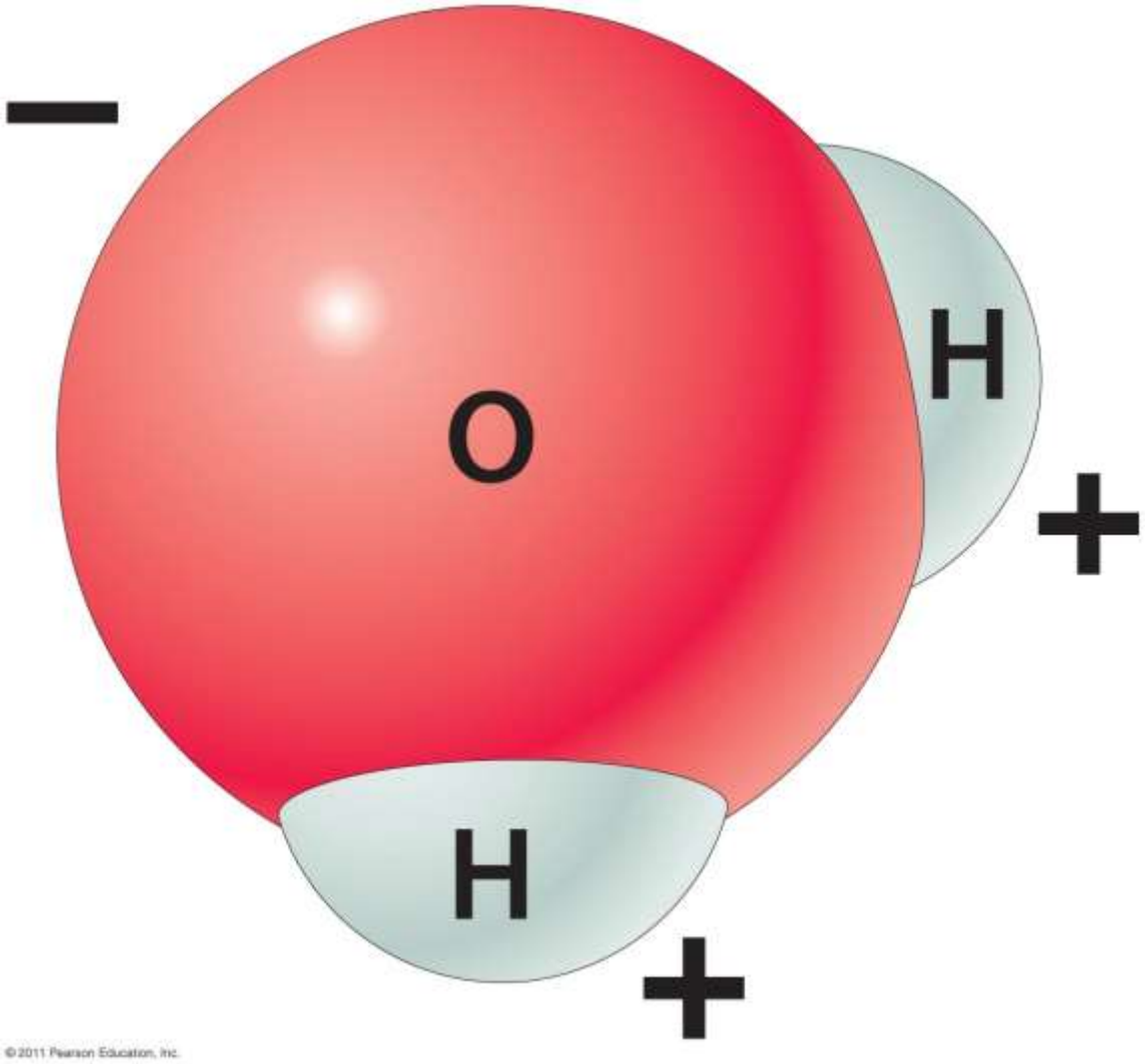
Water management

- It is unlikely that new supplies of water will be found in the future.
- Need better management of water resources as they become more expensive.
  - **U.S. citizens already pay more per gallon for bottled water than gasoline at the pump.**
- Must plan for excesses and lack. (save aquifers for drinking, not textile crops)
- Plans should include geologic, geographic, and climatic factors (as well as economic and political factors).

Dipolar molecule

Special properties of water

- Dipolar
  - Can be attracted to other water molecules
  - Thin films on soil
- Clay minerals tend to be negative, and attract water. Causes clays to:
  - Be slippery
  - Swell
- A Solvent
  - Positive and negative ends attract ions (- or +)
  - Aids in dissolution of soluble minerals (salts, carbonates, etc.)
- Often naturally acidic
  - (carbonic acid) aids chemical weathering (dissolving calcite and other carbonates)



Natural Water Quality vs. Polluted Water

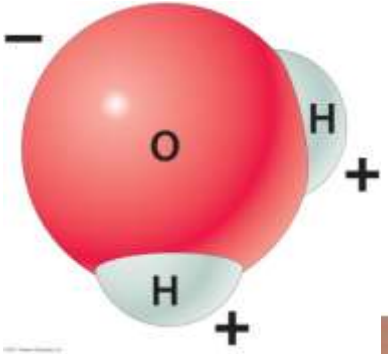


Figure 10-22

Figure 10-23 Chronic Arsenic Exposure Is Harmful Taiwan and Bangladesh have well water that is naturally contaminated with arsenic. Drinking the water can result in skin lesions and skin cancer.

- In nature water is not really pure. Why? Because water has a special chemical characteristic—it's a dipolar molecule. Its resulting asymmetrical charge distribution allows water molecules to interact with many substances (an excellent solvent).
- Because of CO_2 in air, natural rainwater is slightly acidic
- Many metals (lead, arsenic, mercury, uranium) and other contaminants (toluene, Polychlorinated biphenyls, 2,4-D, atrazine, etc.) pollute water and can have negative health effects on people.

Water Quality and Pollution—a Case Study—Cholera in London

- The idea that polluted water could be a source of disease is linked to the work of **Dr. John Snow** in London, England—he made the connection between bad well water and an 1854 **cholera epidemic** in parts of London through **mapping** (a).
- When the pump handle was removed from the Broad Street well, the outbreak subsided**.**
- (b) A replica of the original Broad Street pump was installed in 1992 to honor Snow's pioneering scientific investigations—he's known as the **"Father of epidemiology."**

Figure 10-21 Tracing the Source of a Water-Borne Disease

Here is the map Dr. John Snow created to understand where the disease was spreading from.

(a)

Taking the handle off of the Broad Street Pump slowed the spread of cholera by stopping people from using polluted water and getting sick.

Vaccines, self-quarantine, wearing masks, and limited social interaction for COVID-19 are the medical equivalent of taking pump handles off of wells with cholera.

We are slowing the spread of disease once we find the source and mode of transmission.

Mapping disease is critical to understanding how to stop it from spreading…

We discussed mapping of flood zones, and mass movements, and sinkholes…Maps are critical to understanding most phenomena.

Is Clear Water Clean Water?—Consideration of Parasites and Microbes

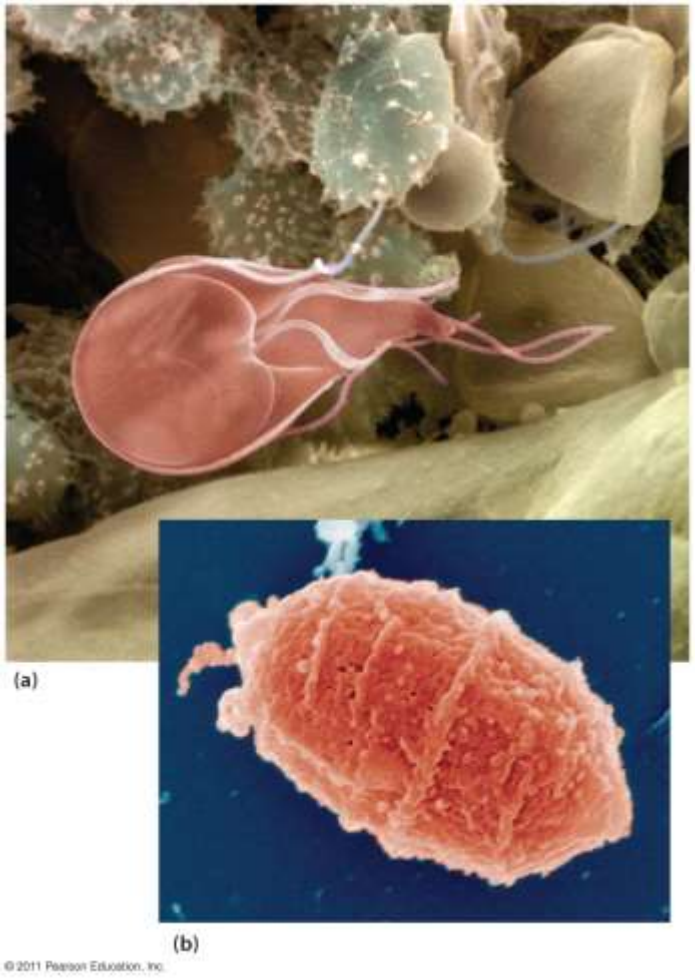


Figure 10-24 ***Giardia lamblia*** Active form **(a)** and cyst form **(b)**.

- Even clear mountain streams can have water quality problems such as when the microbe ***Giardia lamblia*** is present.
- *Giardia* is the most common intestinal parasite in U.S. waters.
- Some strains of *E. coli bacteria* or *Cryptosporidium,* a parasite that causes gastrointestinal distress, are also found in sewage- contaminated water—not an uncommon water-quality problem.
- **Don't drink untreated water** from sources such as :
  - Streams
  - Lakes
  - Ponds
  - Springs
  - Ditches/holes
- I found out the well at my rental house had both *E. coli* and coliform bacteria in it before I drank it (I didn't trust it until I tested it). I would have been really sick if I'd have just drank it…
  - Free water test from the county!

Water Pollution and Water Quality—EPA Benchmarks

- EPA now sets drinking water standards for about 90 contaminants.
- Most of these contaminants fall into three general categories:

  (1) microbes,

  (2) inorganic contaminants, and

  (3) human-made chemicals.
- Municipal water treatment plants and septic systems are designed to remove harmful organisms from water after people use it.

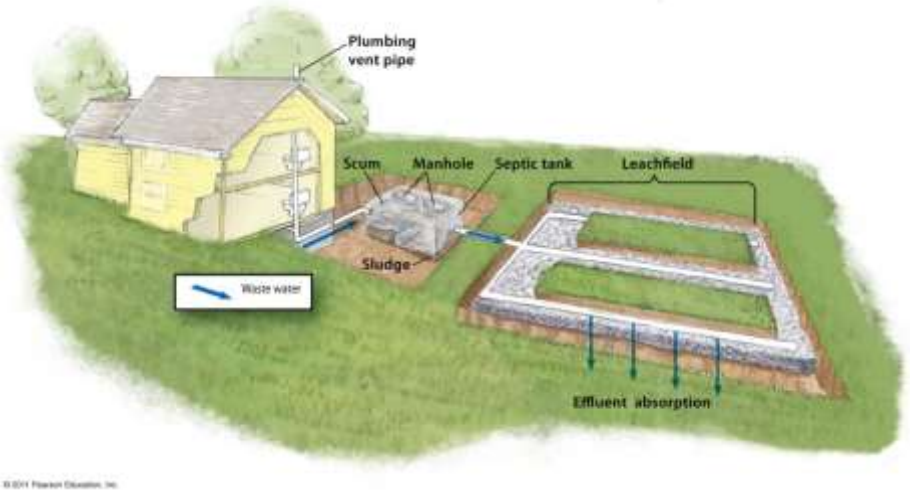
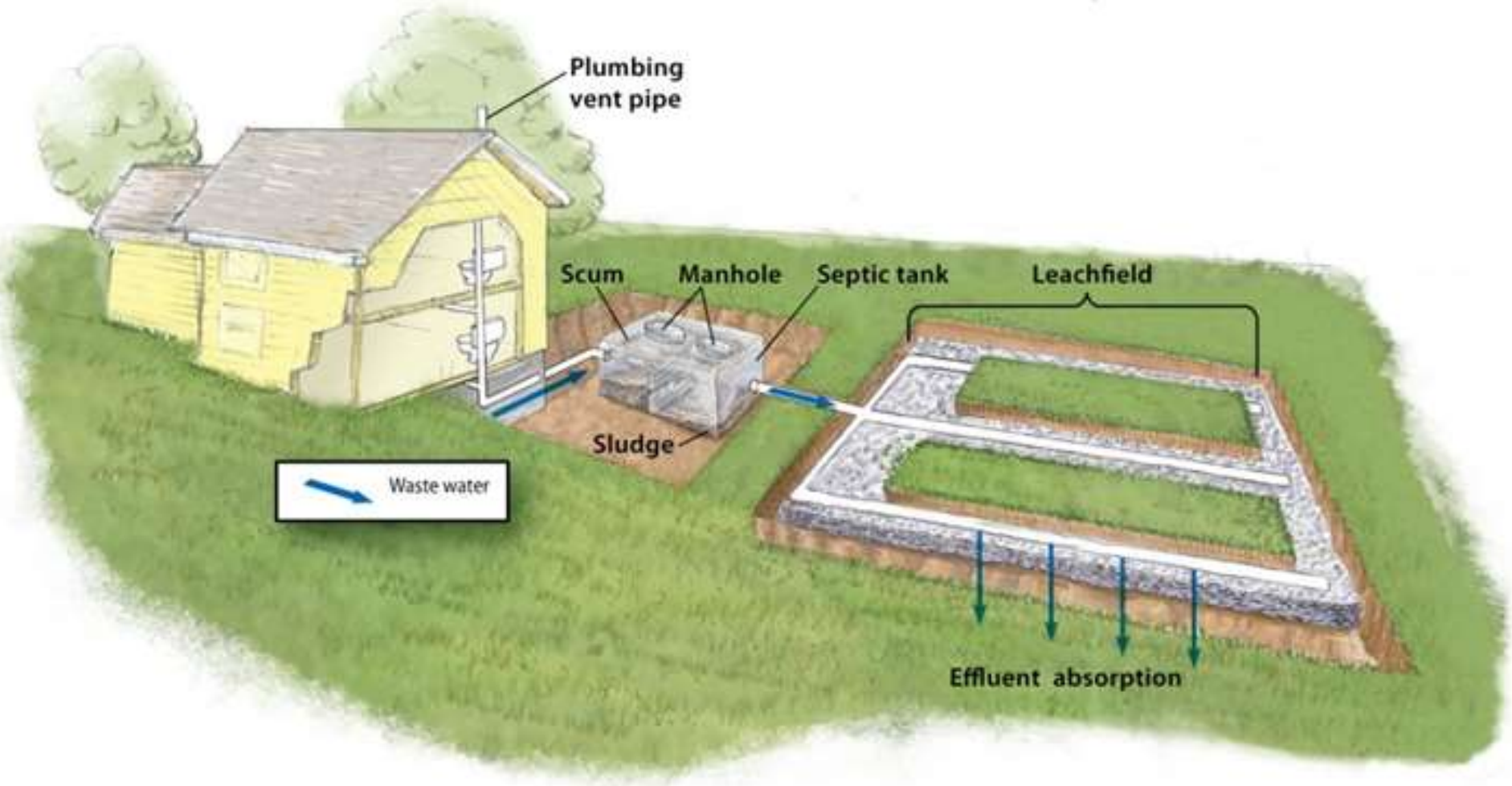


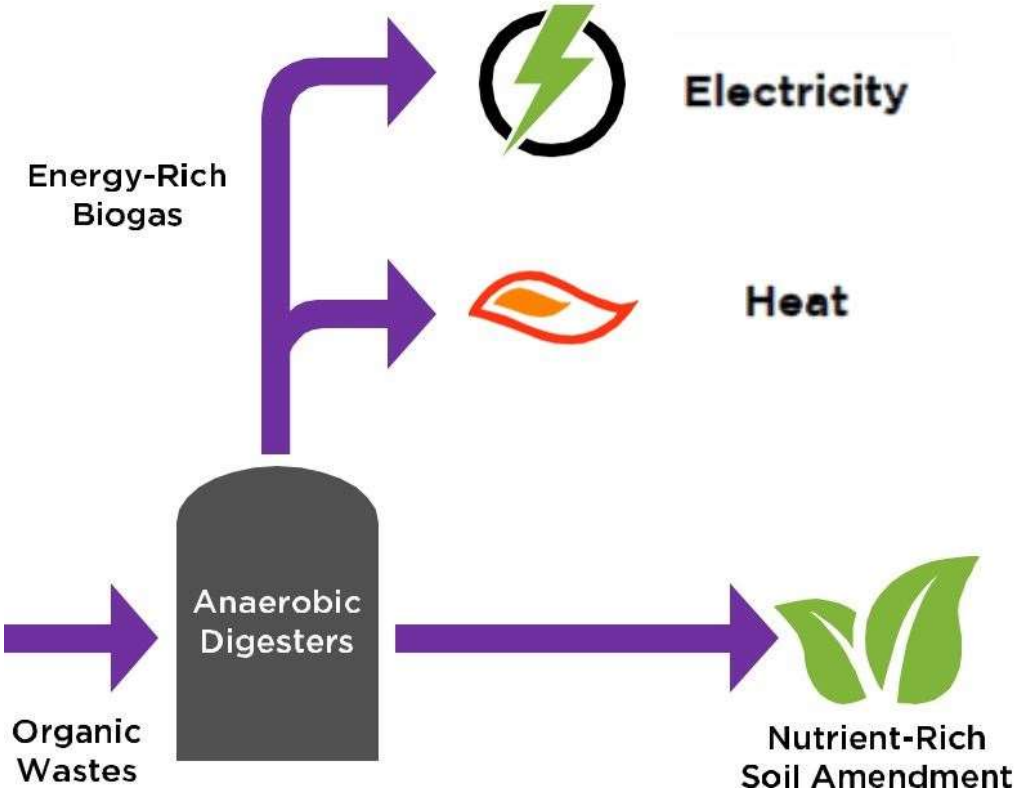
Figure 10-25 How a Septic System Works
Wastewater and sewage collected and transferred to septic tank where bacteria digest organic material. Liquids move to drainfield and are filtered via infiltrating through soil. Septic systems can be overloaded when too many people use a small system…

Septic Systems are used in Rural (country) places that don't have municipal sewer systems (city)



St. Cloud, MN Biofuel from Waste Water

- https://ci.stcloud.mn.us/1512/Energy-Efficiency-Biofuel-E2B-Recovery-P
- **Vítězová et al., 2020. Methanogenic Microorganisms in Industrial Wastewater Anaerobic Treatment.**
- **Qiao et al., 2015. Methanogenesis from wastewater stimulated by addition of elemental manganese.**



https://youtu.be/Du8ZNFIiL8A

More Water Contaminants…

- **Inorganic contaminants—** mostly metals (e.g., arsenic, lead, mercury) and nitrogen compounds; Many older pipes have lead that contaminates water. Hard water buildup can protect us from the lead in old pipes. Flint, Michigan's lead problem started with anti corrosion agents not being added to the water supply, thereby exposing old lead pipes to modern water.

- **Human-made chemicals—** e.g., pesticides and herbicides, gasoline with MTBE, PCBs

- **Sediment—**increased sediment loads are a form of pollution commonly from construction sites and agriculture.

Figure 10-26 Lead Plumbing
Lead pipes were once used to bring water to homes. They can contaminate water with lead and should be replaced, as is being done for this older home.


(b)

Sources of Pollutants

- **Point sources**
  - Occur at a specific point or small area on the landscape where pollutants are discharged from such as:
    - Drainpipes
    - Ditches
    - Ships
    - Smokestacks
    - Feedlots (yes these are areas, but concentrated operations)
    - Thermal pollution


(a)

Figure10-27 Point Sources of Pollution (a) Untreated wastewater discharge; **(b)** many feedlots are large but still considered a point source of organic contaminants.

Sources of Pollutants (cont.)

- **Nonpoint sources**
  - **Occur over an area or entire region**
  - **Examples**
    - **Pesticides**
    - **Herbicides**
    - **Fertilizers**
    - **Acid Rain**
    - **Runoff through garbage or from urban areas**
    - **Sediment**
      - **Construction**
      - **Agriculture**
      - **Streams**
      - **Deforested/burned areas**
    - **Plastics (such as in the oceans)**

(b)

(a)

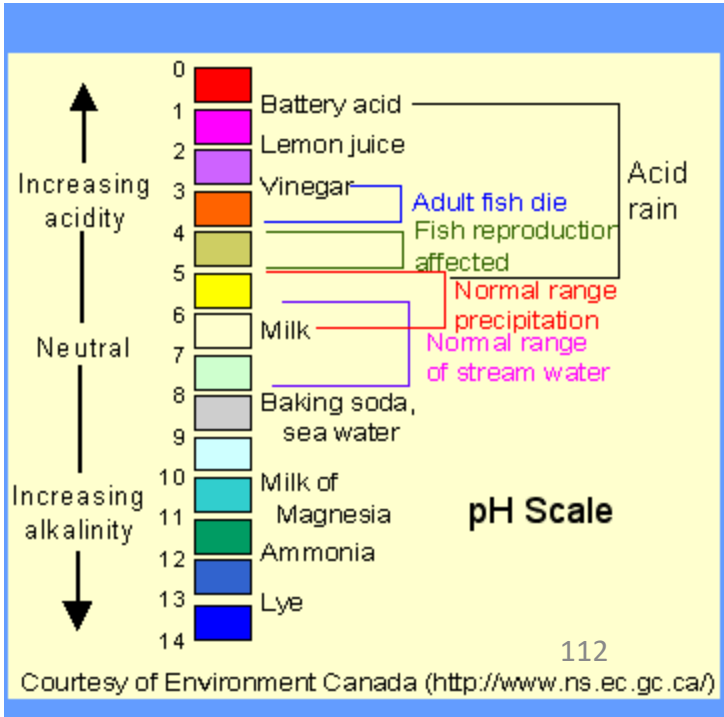
Figure 10-28 Nonpoint Sources of Pollution
(a) Surface runoff through garbage; **(b)** widespread pesticides.

Acid Rain

- Acid rain
  - NO_x and SO_2 react with water (atmosphere) to form droplets of acid
  - SO_2 emissions = principal cause of acid rain
  - Coal-burning power plants—release 70% of SO_2 emitted each year

- Acid rain has a ph less than 5.6; NE U.S.—rain can have ph = 3.6 !!

- Acid rain in NE U.S. has affected vegetation, aquatic systems, buildings—damaging plant leaves, degrading soil, dissolving nutrients



Formation of Acid Rain

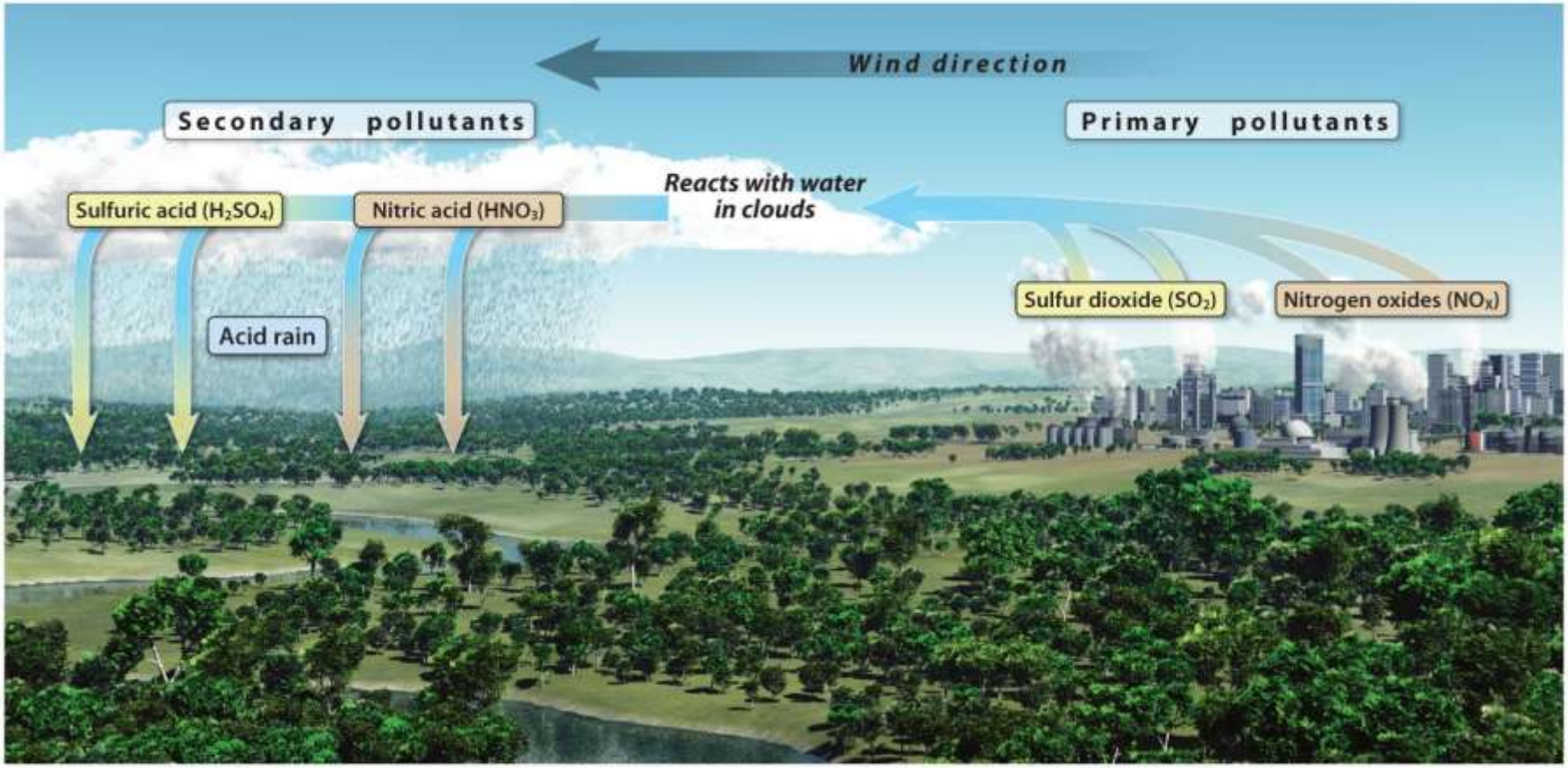


FIGURE 14-11

Both NO_x and SO_2 can react with water in the atmosphere to form droplets of acid, but SO_2 emissions have been the principal cause of acid rain

Acid Rain in the NE U.S.

Where acid rain accumulates in surface waters, acidity can reach levels that are unhealthful for fish and other aquatic life. Some lakes in the northeast U.S. have pH levels <5. Acid rain falls on limestone and marble (buildings, tombstones, etc.) and dissolves bits of the building stone and pits, etches, and discolors the building surfaces. In places, structural components are weakened and need to be replaced.

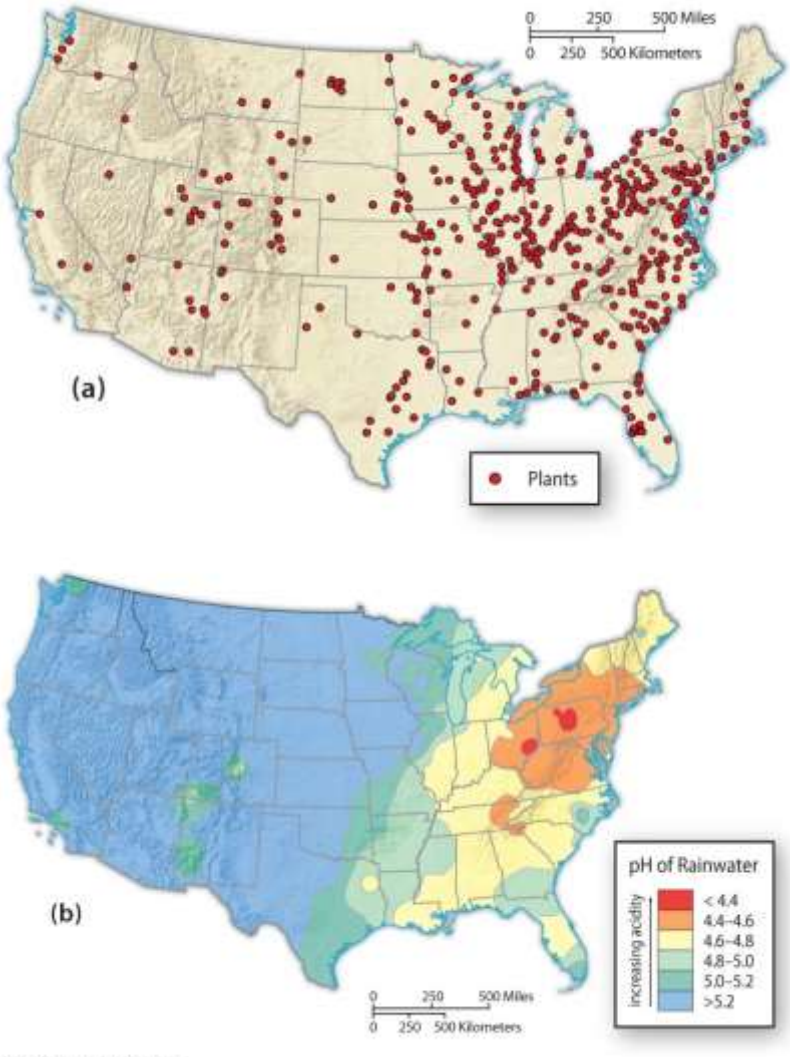
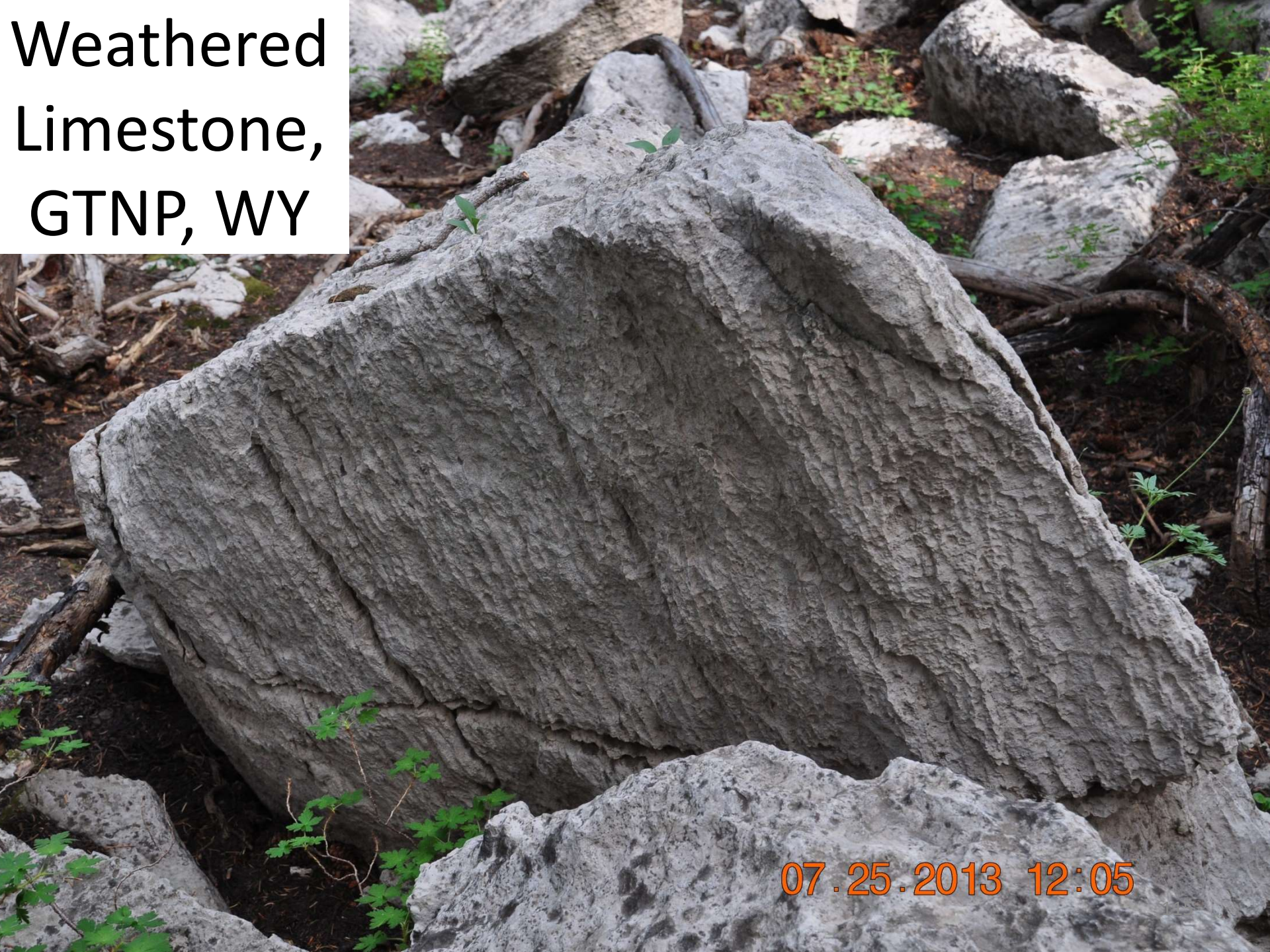


FIGURE 14-13 Acid Rain and Power Plant Emissions (a) The location of coal-burning power plants. **(b)** The acidity of rainwater in different parts of the United States. The distribution of plants combined with prevailing winds (from west to east) make acid rain common in the east and northeast parts of the country.


Weathered
Limestone,
GTNP, WY
07.25.2013 12:05