Lesson 17. Water Quality

Water Resources & Health

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How much fresh water is available?

- Ocean water - 97.4%
- Most of the remaining 2.6%
- locked up in ice caps or glaciers
- Very deep groundwater
- too salty to be used
- What’s left for us to use?

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Available Water
Hydrologic Cycle

- How does fresh water cycle through the biosphere?

Key Terms

- Evaporation
- Transpiration
- Condensation
- Precipitation
- Infiltration
- Percolation
- Runoff
Random Water Facts

- Most precipitation ever recorded?
  - Mount Waialeale on Kauai, Hawaii.
  - Annual average rainfall = 460 inches
- That’s 38.3 feet of water!!
- Seattle = 36 inches / year

Random Water Facts

- Driest place on record?
  - Arica, Chile
  - Averages 0.03 inches / year of rain
  - Out of the 61 years of data, 14 of those years had no rain at all

What is surface water?

- Fresh water that arrives by precipitation
- Rivers, Lakes, Streams, Wetlands
What is Groundwater?

- Precipitation infiltrates the ground and percolates downward through voids in soil and rock.
- Moves from high elevation to low elevation.
- Moves slow – 3 feet / year.

Zone of Saturation

- Where the voids are completely filled with water.
**What is a Water Table?**

- Located at the top of zone of saturation.
- This table rises with wet weather, lowers with dry weather.

**Aquifers**

- “water layer”
- Porous, water-saturated layers of sand, gravel, or bedrock through which groundwater flows.
- Like long sponges through which groundwater seeps.
Aquifers

- Unconfined - no confining layers above it. Top of water table.
- Confined - water layer is bounded above and below it with impervious soils (clay).
  - Water is under pressure.

Aquifers

- Recharge area - area of land through which water passes downward or laterally into an aquifer.
Groundwater Overdrafts:
- High
- Moderate
- Minor or none

Water Supply vs. Demand: Areas of possible conflict over available water:
- Highly likely conflict potential
- Substantial conflict potential
- Moderate conflict potential
- Unmet rural water needs
Stressed Water Resources

Saltwater Intrusion

Ogallala Aquifer
Ogallala Aquifer Facts

- Largest groundwater system in N. America
- If pumped out over the US, would cover all 50 states with 1.5 feet of water.
- If completely drained, it would take more than 6,000 years to refill.
- 170,000 + wells pump out water from the aquifer.
- 50,000 of these wells are in NW Texas.

How much water do Americans use?

Question

- Estimate how much water you use a day.
### Water Usage

<table>
<thead>
<tr>
<th></th>
<th>United States</th>
<th>China</th>
</tr>
</thead>
<tbody>
<tr>
<td>Agriculture</td>
<td>43%</td>
<td>87%</td>
</tr>
<tr>
<td>Power cooling</td>
<td>38%</td>
<td></td>
</tr>
<tr>
<td>Industry</td>
<td>11%</td>
<td>7%</td>
</tr>
<tr>
<td>Public</td>
<td>10%</td>
<td>6%</td>
</tr>
</tbody>
</table>

### How much do you use?

**Typical Household Water Use**

<table>
<thead>
<tr>
<th>Activity</th>
<th>Water use</th>
<th>%</th>
<th>Gal/person/year</th>
</tr>
</thead>
<tbody>
<tr>
<td>Toilets Flushing</td>
<td>38</td>
<td>38</td>
<td>13,000</td>
</tr>
<tr>
<td>Bathing</td>
<td>31</td>
<td>31</td>
<td>10,600</td>
</tr>
<tr>
<td>Laundry &amp; dishes</td>
<td>21</td>
<td>21</td>
<td>6,800</td>
</tr>
<tr>
<td>Drinking &amp; Cooking</td>
<td>6</td>
<td>6</td>
<td>2,000</td>
</tr>
<tr>
<td>Teeth brushing etc</td>
<td>5</td>
<td>5</td>
<td>1,700</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td><strong>100</strong></td>
<td><strong>100</strong></td>
<td><strong>34,200</strong></td>
</tr>
</tbody>
</table>

### Daily Water Use:

<table>
<thead>
<tr>
<th>Activity</th>
<th>Gallons</th>
</tr>
</thead>
<tbody>
<tr>
<td>Flushing toilet</td>
<td>1.5 - 7</td>
</tr>
<tr>
<td>Taking a shower</td>
<td>25 - 50</td>
</tr>
<tr>
<td>Taking a bath</td>
<td>36</td>
</tr>
<tr>
<td>Washing Clothes</td>
<td>35 - 60</td>
</tr>
<tr>
<td>Washing dishes (machine)</td>
<td>10</td>
</tr>
<tr>
<td>Brushing teeth</td>
<td>2</td>
</tr>
<tr>
<td>Washing hands</td>
<td>2</td>
</tr>
<tr>
<td>Watering the lawn</td>
<td>5 - 10 gal / minute</td>
</tr>
</tbody>
</table>
**Total Daily Water Usage in the U.S.A.**

- Utilities = 187 billion gal/day
- Irrigation = 137 billion gal/day
- Public supply = 36 billion gal/day
- Industry = 26 billion gal/day
- Rural & Livestock = 8 billion gal/day
- Total = 394 billion gal/day

**Another way of looking at it ...**

- USA - taking in account all water usage (agriculture, industry, & public) and dividing it by the number of people = 1,300 gals/person/day.
- Haiti = 8 gals/person/day

**Leaky faucets....**

- Slow dripping spigot wastes 15 gals/day
- Slow stream can waste 400 gals/day
Global Water Use

Questions

- Do you prefer bottled water or tap water? Why?
- Which do you think is safer?
Lesson 17: Water May 30, 2006

**Bottled Water Classifications**

- **Artesian Well Water** - from a confined aquifer.
- **Mineral Water** - from an underground source that contains at least 250 ppm total dissolved solids. Minerals and trace elements must come from the source, not added later. Can be confined or unconfined.
- **Spring Water** - derived from an underground formation from which water flows naturally to the earth's surface. Must be collected at the source.
- **Well Water** - from an unconfined aquifer.

**Who's in charge?**

- FDA sets regulations for bottled water
  - Federally mandated, weaker laws, allows higher amounts of contaminants in water
  - No treatment requirements
- EPA sets regulations for tap water
  - Federal and state enforced (remember state can always make these laws stricter), laws stricter

**Where do we get our tap water from?**
If you live south of Greenlake, your water comes from the Cedar River. Supplies water to 1.3 million people. System has the capacity of 68.5 million gallons per day (MGD). System brought online 1901.
Tolt River Watershed

- If you live North of Greenlake or on the Eastside, this is where your water comes from.
- Can supply up to 100 MGD.
- System brought online in 1964.

Tolt River

The steep slopes surrounding the Tolt Reservoir form the boundaries of the South Fork Tolt River Watershed and are being reforested to preserve water quality.
Drinking Water Treatment

Ground Water Treatment

Water Storage facilities

- Adequate pressure for proper delivery
- Uniform pumping rate and water supply
- Detention time for disinfection
- Reserve water to meet peak demand
- Water for fire protection
- Blending of water sources
- Backwashing
Lesson 17: Water

Water Quality

- Health Effects
- Treatment

Water Quality

- Aesthetics
  - Color
  - Odor
  - Taste
- Biological
  - Microorganisms
- Chemical
  - Organic & Inorganic
- Physical
  - Radiation Standards

Water Contamination
Health Effects

- **Indirect**
  - Drought
  - Floods
  - Insanitary conditions

- **Direct**
  - Disease

Health Effects

- Two main transmission routes
  - Contamination of drinking water supplies
  - Water contact

Waterborne Disease

- Chemical Contamination
  - Agriculture
  - Industry
  - Transportation
  - Residential

- Fecal Contamination
  - Human Wastes
  - Livestock
  - Wildlife

- Soil
  - Bacteria
  - Minerals, etc.
  - Radioactive Elements
Waterborne Diseases

- Acute Diarrhea
- Amebic Dysentery
- Cholera
- Cryptosporidiosis
- Giardiasis
- Infectious Hepatitis
- Legionellosis
- Shigellosis
- Typhoid Fever
- Viral Gastroenteritis
- Neurological and Systemic Poisonings

Exposure

- Ingestion
- Skin Absorption

Causative Agents

- Amebic Dysentery
  - Entamoeba histolytica
  - 20 cysts
- Cholera
  - Vibrio cholerae
  - 100,000,000 - 1,000,000,000 organisms
- Diarrheal Disease
  - Escherichia coli
  - 100,000,000 organisms
Causative Agents Continued

- Giardiasis
  - *Giardia lamblia*  
  - 100 organisms
- Shigellosis
  - *Shigella dysenteriae*  
  - 10 - 100 organisms
- Typhoid Fever
  - *Salmonella typhi*  
  - 100,000 organisms

Causative Agents Continued

- Viral Gastroenteritis
  - Miscellaneous Viruses  
  - 1 organism
- Chemical Contaminants
  - Inorganics -- systemic toxicity
  - Organics -- chronic diseases

Disease Transmission

- Approximate Survival Time of Certain Pathogens in Water
  - *Vibrio cholerae*: 3-9 days
  - *Salmonella typhi*: 1 day - 2 months
  - *Entamoeba histolytica*: 1 month
  - *Shigella sp.*: 1 - 24 months
Waterborne Disease
United States, 1999-2000

- From Drinking Water:
  - 39 Outbreaks
    - 38 in 25 states
    - 1 spanned 10 states
  - 2,068 Cases
  - 2 Deaths
- From Recreational Waters:
  - 59 Outbreaks in 23 states
  - 2,093 Cases
  - 4 Deaths

Waterborne Disease
United States, 2001-2002

- From Drinking Water:
  - 31 Outbreaks
    - 38 in 19 states
    - 1 spanned 10 states
  - 1,020 Cases
  - 7 Deaths
- From Recreational Waters:
  - 65 Outbreaks in 23 states
  - 2,536 Cases / 81 Hospitalized
  - 8 Deaths

Drinking Water Outbreaks

U.S., 2001-2002 (n=31)
Drinking Water Outbreaks

**FIGURE 3.** Number of waterborne-disease outbreaks (n = 754) associated with drinking water, by year and etiologic agent — United States, 1971-2013

*Beginning in 2004, Legionnaires’ disease was added to the surveillance system, and Legionella species were considered separately.*

*Some gastrointestinal illness of unknown etiology.*

Drinking Water Outbreaks

**FIGURE 4.** Number of waterborne-disease outbreaks (n = 758)* associated with drinking water, by year and type of water system — United States, 1971-2002

*Excludes outbreaks of Legionnaires’ disease.*

Drinking Water Outbreaks

**FIGURE 5.** Number of waterborne-disease outbreaks (n = 31) associated with drinking water, by etiologic agent and month — United States, 2001-2002

*Acute gastrointestinal illness of unknown etiology.*
Waterborne Outbreaks

By Type of Agent, U.S., 2001-2002 (n=31)

- Unknown: 27%
- Legionella spp.: 13%
- Bacterial: 10%
- Chemical: 16%
- Viral: 15%
- Parasitic: 14%

Waterborne Outbreaks

By Type of Source Water

- Individual: 32%
- Community: 28%

By Type of Water System

- Groundwater: 92%
- Surface Water: 8%

Waterborne Outbreaks

By Type of Deficiency, U.S., 2001-2002 (n=25)

- Distribution System: 33%
- Treatment Deficiency: 21%
- Untreated Groundwater: 40%
Recreational Waterborne Disease Outbreaks

FIGURE 1. Number of waterborne-disease outbreaks (n = 445) associated with recreational water by year and illness — United States, 1978–2002

- 1978
- 1979
- 1980
- 1981
- 1982
- 1983
- 1984
- 1985
- 1986
- 1987
- 1988
- 1989
- 1990
- 1991
- 1992
- 1993
- 1994
- 1995
- 1996
- 1997
- 1998
- 1999
- 2000
- 2001
- 2002

* Includes hepatitis, conjunctivitis, Gilles, bronchitis, meningitis, hepatitis, leptospirosis, Pontiac fever, and acute respiratory illness.

* Also includes data from report of diseases (source: Division of Surveillance and Epidemiology, Centers for Disease Control and Prevention) and three-lining serotype infections.

* From CDC Vital and Health Statistics. 2005.

Recreational Waterborne Disease Outbreaks

FIGURE 2. Number of waterborne-disease outbreaks (n = 65) associated with recreational water, by illness and month — United States, 2001–2002

- January
- February
- March
- April
- May
- June
- July
- August
- September
- October
- November
- December

* Acute respiratory illness, Pontiac fever, or chemical exposure.
Recreational Waterborne Disease Outbreaks

By Etiologic Agent
United States, 2001-2002
n = 30

Recreational Waterborne Disease Outbreaks

By Type of Water
United States, 2001-2002
n = 30

Recreational Waterborne Disease Outbreaks

Lesson Summary

- Water is a vital & finite resource
- Most of the Earth’s Water is unavailable
- What is available can be a vehicle for disease transmission
- Waterborne Disease Transmission
  - Drinking water
  - Recreational water

Questions

Next Lesson

Wastewater