
















- 1  **Introduction to Environmental Geology, 5e**  
Chapter 14  
*Water Pollution*
- 2  **Water pollution: summary in haiku form**  
The hydro cycle –  
water returns from the sea.  
All "toilet to tap."
- 3  **Case History: NC Bay of Pigs (1)**
  - Hurricane Floyd through NC in Sept 1999, forcing 48,000 people into shelters and killing 50 people
  - Estimated 30,000 hogs, 2 million chickens, and 735,000 turkeys died
  - Catastrophic water pollution as a result of the floodwater from Hurricane Floyd
  - More than 38 pig waste lagoons washed out, 250 million gallons of pig wastes into creeks, rivers, and wetlands
  - North Carolina has a long history of hog production, the population of pigs swelled from about 2 million in 1990 to over 10 million by 1997. Approximately 250 pig operations flooded out
  - Polluted water through schools, churches, homes, and businesses
- 4  **Case History: NC Bay of Pigs**  
Figure 14.1
- 5  **Case History: NC Bay of Pigs (2)**
  - In 1997, a state law was enacted that prohibited building new waste lagoons and sewage plants on floodplains
  - In the spring of 1999, the governor proposed a 10-year plan that would phase out the state's 4,000 animal waste lagoons
  - Hurricane Floyd occurred before these changes could be enacted
  - In 2007, the state passed legislation to ban construction or expansion of new lagoons and spray fields
  - On-site treatment facilities to replace swine lagoons
- 6  **Water Pollution**
  - Water pollution: Refers to degradation of water quality as measured by biological, chemical, or physical criteria
  - Pollutants: Any substance that, in excess, is known to be harmful to desirable living organisms
  - The greatest water pollution problem in the world today is lack of disease-free drinking water for about 20 percent of the world's population
  - Waterborne diseases that kill about 2 million people a year, and most of the deaths are of children under the age of 5
- 7  **Common Pollutants (1)**
  - Oxygen-demanding waste (common organic waste)
  - 
  - Pathogenic waste (pathogenic microbes)
  - 
  - Nutrients
  - 
  - Petroleum (oil)
  - 
  - Toxic waste (chemicals, heavy metals, radioactive waste)
  - 
  - Sediment
  -

- Thermal plumes
- 8  **Common Pollutants (2)**
  - Oxygen-demanding waste
    - Dead organic matter decomposed by bacteria, an oxygen-demanding process
    - 
    - BOD: High BOD associated with a high level of decaying organic matter in water, reducing DO (dissolved O) for other healthy organisms
    - 
    - Sources of oxygen-demanding waste: Natural processes, agricultural applications, urban sewage, and runoff
- 9  **Common Pollutants (3)**
  - Pathogenic microbes
    - Fecal coliform bacteria
    - Harmful risks (diseases and death ) of *E. coli*
    - Billions exposed to waterborne diseases, especially in poor countries
    - Outbreaks do occur in developed countries (e.g., GA's water park in 1998; Walkerton public water supply, Ontario in 2000; CA spinach contamination in 2006)
    - Epidemic risks of waterborne diseases during natural disasters, such as earthquake, tsunami, flooding
- 10  **Common Pollutants (3)**
  - Nutrients
    - Two important nutrients: N, P
    - 
    - Major problems: Cultural eutrophication — algae bloom, triggering BOD problem
    - 
    - Major sources for nutrients: Fertilizer, feedlots, and discharge from wastewater treatment plants
    - 
    - Areas of certain land use: Agriculture and urban
- 11  **Common Pollutants (4)**
  - Oil
    - Major problems: Polluted water, ecosystem damage, interrupted socioeconomic conditions of a community
    - 
    - Major sources: Oil spills from tankers and pipelines, on- or off-shore oil production, war (e.g., the Gulf war, 2006 war in Lebanon)
- 12  **Common Pollutants (5)**
  - Toxic waste
    - Synthetic organic chemicals, up to 100,000 chemicals in use, especially those POPs (persistent organic pollutants)
    - 
    - Heavy Metals: Pb, Hg, Zn, Cd (e.g., lead contamination)
    - 
    - Radioactive materials
- 13  Table 14.2
- 14  **Common Pollutants (6)**
  - Sediment pollution
    - Sand and smaller particles
    - 
    - Polluted streams, lakes, reservoirs, even ocean water
    -

- Major sources: Soil erosion, dust storms, floods, and mudflows

- 

- Greatest water pollutant by volume

15  **Common Pollutants (7)**

- Thermal pollution

- Temp increases, less dissolved oxygen

- 

- Adverse changes to the habitats of organisms

- 

- Economic impacts

- 

- Major sources: Hot-water discharge from industrial operations, power plants, abnormal ocean currents

16  **Surface Water Pollution and Treatment (1)**

Point sources of pollution

- Point sources are discrete, confined, and more readily identifiable

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- Common sources: Landfills, discharge from wastewater treatment plants, discharge from industries, power plants, storm water runoff, etc.

- 

- Identify sources, on-site treatment and mitigation, prevention

17  **Surface Water Pollution and Treatment (2)**

- Nonpoint sources of pollution: Influenced by such factors as land use, climate, hydrology, topography, native vegetation, and geology

- Nonpoint sources are diffused, intermittent, and hard to specifically identify

- Causes of nonpoint pollutions often regional, cumulative and compound

- Influenced by land use, climate, hydrology, topography, and geology

- Common sources: Urban runoff, agricultural, mining (acid rain and acid drainage)

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Figure 14.15

19  **Acid Mine Drainage**

- Acid mine drainage: refers to acidic water with elevated concentrations of dissolved metals that drains from coal or metal mines

- Acid mine drainage is water with a high concentration of sulfuric acid ( $H_2SO_4$ )

- Acid mine drainage is produced by complex geochemical and microbial reactions

- The acid water is extremely toxic to plants and animals in aquatic ecosystems

- The Tar Creek area in Oklahoma was at one time designated by the EPA as the nation's worst example of acid mine drainage

20  **Acid Mine Drainage**

Figure 14.A

21  **Groundwater Pollution (1)**

- Why care about ground water pollution?

- Most abundant freshwater source

- 

- Growing dependency on groundwater

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- About 50 percent of people in United States depend on groundwater for drinking water

- 

- Triggers other environmental problems: Water pollution, subsidence, saltwater intrusion, etc.

22  **Groundwater Pollution (2)**

- It is estimated that 75 percent of the 175,000 known waste-disposal sites in the country may be producing plumes, or bodies of contaminated groundwater
- 
- Groundwater pollution hazard impact depends on
  - Amount of contaminant discharged
  - 
  - Chemical concentration or toxicity
  - 
  - Degree and duration of exposure of people or other organisms to the pollution

### 23 **National Water-Quality Assessment Program**

- In the past 25 years, great improvements in manufacturing, processing, and wastewater-treatment facilities
- 
- The program integrates both surface-water and groundwater systems that monitor and study aquatic ecosystems
- 
- The goals of the program are to:
  - Carefully describe current water-quality conditions for many of the freshwater streams and aquifers in the United States
  - Monitor and describe water-quality changes over time
  - Increase understanding concerning the human and natural factors that affect the nation's water quality

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Table 14.3

### 25 **Groundwater Pollution versus Surface Water Pollution**

- Residence time difference
- 
- Environmental conditions: Inflow, flow rate, dissolved oxygen, sunlight
- 
- Harder to track pollution sources
- 
- More difficult and expensive to clean up
- 
- May pose long-term risks

### 26 **Infiltration of Urban, Industrial, and Agricultural Runoff**

The Delaware River basin: A large water systems under study

- Effects of the river system on the distribution, fate, and effects of contaminants in water, sediment, and living things
- Relationships between the water flow in the river and concentrations of nutrients, contaminants, and pathogens
- Presence of contaminants, including pathogens and pesticides, in drinking water supplies and recreational activities
- Development of management plans and strategies for the protection of river basin that have high water quality
- Effects of septic systems on water quality and river ecology
- Effects of groundwater withdrawals on water quality
- Effects of discharge from coal mines on water quality

### 27 **Water Quality and Stream Ecosystems in the United States**

Figure 14.18

28  **Saltwater Intrusion**

- More than half of the world's population lives in or near the coastal zones
- 
- Groundwater pollution from saltwater intrusion is not a local isolated problem
- 
- Causes major water supply problems in NY, FL, CA
- 
- Case History: Long Island

29  **Saltwater Intrusion Mechanism**

- Water table is inclined toward the ocean
- 
- Wedge of saltwater is inclined toward the land
- 
- Over-pumping of groundwater
- 
- Severe drawdown of groundwater causes saltwater ascension

30  **Saltwater Intrusion**

Figure 14.19

31  **Groundwater Treatment (1)**

- Pretreatment studies
  - Identify contaminants and their characteristics of transport behavior
  - Identify the characteristics of aquifer geology (factors controlling groundwater flow—physical dimensions, structure)
  - Determine the hydrologic characteristics of polluted aquifer(s)—flow direction, flow rates, discharge and recharge conditions
  - Select possible treatment strategies and methods


32  **Groundwater Treatment (2)**


Table 14.4

33  **Water Quality Standards**

- MCLs—Maximum Contaminant Levels
- 
- Permissible limits for 83 contaminants
- 
- MCLGs—Maximum Contaminant Level Goals
  - The maximum level at which no adverse health effects from a lifelong exposure
- 
- SMCLs—Nonenforceable limits for contaminants that affects aesthetic qualities in drinking water

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Table 14.5

35  **Wastewater Treatment**

- Law: Used wastewater must be treated
- 
- Break the potential vicious cycle of wastewater entering the general water cycle
- 
- Tier treatment and reuse system
  - Septic system—rural residential areas
  - Water treatment plant for towns and urban cities
  - Innovated ways for recycling and reclaiming

wastewater

– New technologies for innovative wastewater treatment


36  **Septic Tank Sewage Disposal System**

Figure 14.20

37  **Idealized Diagram for Wastewater Treatment Plant**

Figure 14.21

38  **Wetlands as WW-Treatment Sites**

- Both natural and human-constructed wetlands: good places to treat or partially treat wastewater (WW)
- 
- For communities with difficulty purchasing expensive WW treatment plants or desire a good alternative
- 
- Warm-humid and hot-dry climates had successful experiences


39  **WW Renovation and Conservation Cycle**

Figure 14.22

40  **Federal Legislation**


- The Clean Water Act of 1972 (amended in 1977)
- 
- Survey after survey show strong public support for a clean environment in the United States today
- 
- The Water Quality Act of 1987 established national policy to control nonpoint sources of water pollution
- 
- In July 2000, President Clinton imposed new water pollution controls, The plan will take at least 15 years to implement completely

41  **Reduce Effects of Water Pollution**

- Develop and refine better ways to evaluate water pollution problems and their impact on aquatic life and the health of people
- 
- Implement new and innovative, cost-effective water treatment technologies
- 
- Develop products and processes that minimize production of water pollutants and their release into the environment

42  **Critical Thinking Topics**

- What can individual citizens do to reduce groundwater pollutants?
- 
- Does surface water contamination automatically trigger groundwater pollution at a given location?
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- What are the major point and nonpoint sources of water pollution in your community?
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- What current water laws and legislation are you familiar with? Are there any problems with them?

43  **Chapter 14 figures follow...**





































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84	 <b>End of Chapter</b>