

Botkin & Keller: *Environmental Science: Earth as a Living Planet*- 8th Ed.

APES- Chapter #19- **Water Pollution and Treatment**- Guided Reading

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**Learning Objectives:** **Degradation of our surface-water and groundwater resources** is a serious problem. After reading this chapter, you should understand the following:

- \* *What constitutes water pollution and what the major categories of pollution are*
- \* *Why the lack of disease-free drinking water is the primary water-pollution problem in many locations around the world*
- \* *How point and non-point sources of water pollution differ*
- \* *What biochemical oxygen demand is, and why it is important*
- \* *What eutrophication is why it is an ecosystem effect, and how human activity causes it*
- \* *Why sediment pollution is a serious problem*
- \* *What acid mine drainage is, and why it is a problem*
- \* *How urban processes can cause shallow-aquifer pollution*
- \* *What the various methods of wastewater treatment are, and why some are environmentally preferable to others*
- \* *Which environmental laws protect water resources and ecosystems*

**Read: Case Study: America's "First River": A Success Story**

Summarize the story of the Hudson River and PCB's:

**Water Pollution**

- 1: How is **water pollution** defined?
  - The degradation of water quality.
- 2: What are some of the *common water pollutants*?
  - Heavy metals, sediment, certain radioactive isotopes, heat, fecal coliform, bacteria, phosphorus, nitrogen, sodium, other useful elements, bacteria, and viruses
- 3: What is the *primary water pollution* problem in the world today?
  - A lack of clean, disease-free drinking water
- 4: How many people are exposed to *waterborne diseases* worldwide?
  - Several billion people
- 5: Name **3 sources of Surface Water** and **3 sources of Groundwater Pollution** from the chart (19.1)
  - SURFACE: Runoff, accidental chemical spills, leaks of storage tanks/pipelines
  - GROUNDWATER: Waste disposal site leakage, seepage from accidental spills, saltwater intrusion into coastal aquifers

**A Closer Look 19.1: What is the Value of Clean Water to New York City?**

*What is the main idea of this story?*

-Treating the issue at the source is more effective, cheap, and healthy than building treatment plants that are expensive to maintain. Most importantly, don't pollute in the first place.

## Biochemical Oxygen Demand (BOD)

1: What is **BOD** and what are some *sources of it*?

-BOD is the amount of oxygen required for biochemical decomposition processes. It is used in water quality management as a measure of the amount of oxygen consumed by microorganisms. BOD is measured at discharge points into surface water, such as treatment plants.

2: Where does approximately **33% of all BOD** in streams come from?

-Agricultural activities

3: What about in **urban areas (BOD)**?

-Urban areas increase BOD in streams, especially areas with old sewage systems that have stormwater and sewage in the same line.

4: What is the *relationship between BOD and dissolved oxygen levels*? (**What happens when BOD is high?**)

-When BOD is high, the dissolved oxygen content of water becomes low.

5: Explain the **3 zones of BOD**:

\* Pollution Zone: Where waste is decomposed; uses a lot of oxygen to break down

\* Active Decomposition Zone: Where DO reaches minimum owing to rapid decomposition by microorganisms as the waste is transported downstream

\* Recovery Zone: Where DO increases and BOD reduces, because decomposing finishes and natural system processes are replenishing oxygen

## Waterborne Disease

1: What is **Fecal Coliform Bacteria** and *where does it come from*?

-Bacteria that are usually harmless that reside in the intestines of animals. They are present in waste and they are used as an indicator of disease potential and feces.

## Nutrients

1: How do urban streams get *high concentrations of Nitrogen and Phosphorus*?

-Due to fertilizers, detergents, and products of sewage treatment plants.

## Eutrophication

1: Define **Eutrophication**:

-The process by which a body of water develops a high concentration of nutrients, causing aquatic plants to grow and block light. This kills plants and increases BOD when these plants decompose.

2: What is the solution to **artificial or cultural eutrophication**?

-Ensure that human nutrient sources do not enter lakes and other bodies of water by using phosphate-free detergents, controlling runoff, disposing of wastewater, and using more advanced water treatment methods.

## A Closer Look 19.2: Cultural Eutrophication in the Gulf of Mexico

*What is a dead zone and how is it created?*

-An area of water with low concentrations of dissolved oxygen (<2 mg/l) that is created by cultural eutrophication that promotes light-blocking algae, which kills organisms and increases BOD

## Oil

- 1: Which *Environmental Act* was created after the **Exxon Valdez** disaster?  
-Oil Pollution Act of 1990

## Sediment

- 1: Why is *sediment pollution* considered to be a two-fold problem?  
-Because it results from erosion, which depletes land resource, and it reduces the quality of water.
- 2: What are some of the techniques employed by a sediment control program?  
-On-site erosion control, filtering

## Acid Mine Drainage

- 1: Define **Acid Mine Drainage** and *explain how it occurs*:  
-Acid Mine Drainage is water with a high concentration of sulfuric acid that drains from mines. This is made when pyrite mined from coal rocks is dissolved in water.
- 2: What is the **general equation** for acid mine drainage?  
$$4\text{FeS}_2 + 15\text{O}_2 + 14\text{H}_2\text{O} \rightarrow 4\text{Fe}(\text{OH})_3 + 8\text{H}_2\text{SO}_4$$
 (Pyrite+Oxygen+Water-> Ferroc Hydroxide+Sulfuric Acid)
- 3: What site was once designated by the U.S. Environmental Protection Agency as the *nation's worst hazardous waste site*?  
-The Tar Creek area in Oklahoma

## Surface Water Pollution

- 1: What are some **point sources** of surface water pollution?  
-Pipes, outflows from sewage systems
- 2: What are some **non-point sources** of surface water pollution?  
-Runoff from streets or fields
- 3: What are the 2 *approaches to dealing with* surface water pollution?  
-Reduce the sources and treat water to remove pollutants or convert them to forms that can be disposed of safely

## Groundwater Pollution

- 1: **75** % of the 175,000 known waste disposal sites in the United States may be producing plumes of hazardous chemicals that are migrating into groundwater resources.
- 2: What is **bioremediation**?  
-Using microorganisms that break down or consume a pollutant
- 3: What are the 5 important points about groundwater pollution?  
-Some pollutants are lighter than water, and thus float on groundwater; Some pollutants have multiple phases: liquid, vapor, and dissolved; Some pollutants are heavier than water and sink or move downward through groundwater; The disposal method of a water pollutant must take account the physical and chemical properties of the pollutant and its interactions with surface or groundwater; Emphasis should be put on preventing pollutants from entering groundwater in the first place
- 4: What is saltwater intrusion of well water?  
-The migration of saltwater into wells and aquifers

## Wastewater Treatment

1: Summarize how **Septic Tank Sewage Disposal Systems** work.

-Septic tanks store waste, separating solids and liquids and filtering the waste. It then dispels the waste into the soil, and natural processes filter it until it is safe enough for other uses.

2: What happens during **primary treatment** of sewage?

-Raw sewage is processed through a series of screens and filters that filter out sediment, organic matter, and solids. All particulate matter forms sludge, which is transported to a digester. 30-40% of BOD is removed.

3: What happens during **secondary treatment** of sewage?

-Sludge bacteria is used to remove BOD in wastewater, and the process is repeated thoroughly. The sludge is then dried and disposed of in landfills.

4: When is **advanced wastewater treatment** used?

-When it is particularly important to maintain good water quality

5: What are some of the risks associated with **Chlorine** treatment of wastewater that is later discharged?

-The chemical byproducts that are produced with chlorine usage, which reduces fertility in fish, and possibly humans

## Land Application of Wastewater

1: Explain the process of wastewater renovation and conservation cycle.

-Wastewater could be used to supply plants with nutrients by being filtered, and using the beneficial organic matter on crops (waste is simply a resource out of place)

## Wastewater and Wetlands

1: How can applying treated sewage to wetlands be helpful to the wetland ecosystem?

-Applying sewage to wetlands can treat water quality problems such as municipal wastewater, stormwater runoff, industrial wastewater, agricultural wastewater and runoff, mining waters, and groundwater seeping from landfills.

## Water Reuse

1: What is the difference between indirect and direct water reuse?

-Indirect water reuse is planned, and direct water use is pumped directly from a treatment plant to be used in industry and activities.

## Environmental Laws

☐ Make sure to *memorize the following laws*:

☐ Clean Water Act

☐ Federal Safe Drinking Water Act

☐ Water Quality Act

*How safe do you believe the drinking water is in your home? How did you reach your conclusion? Are you worried about low-level contamination by toxins in your water? What could the sources of contamination be?*

-I believe that the drinking water in my home is pretty safe, considering it is all bottled. I am not worried about contamination in my drinking water because bottling companies most likely use thorough filtering techniques, but the water I use to bathe and wash may be unfiltered from chemicals that leak from wastewater, or from cleaning.

**Read, “Is Water Pollution from Pig Farms Unavoidable” and answer the following:**

1: Why was pig farming such a controversy in North Carolina during this time?

-Because pigs generated a ton of a waste (a shitton?), and waste was often dumped into lagoons, which caused the Hurricane Floyd Bay of Pigs incident to occur.

2: What did pig farmers do with the pig waste? *Why was this allowed?*

-Farmers dumped the waste into lagoons, because there were no restrictions on pig farm locations, so pig farms were often situated near floodplains.

3: What is the lesson learned from North Carolina’s “Bay of Pigs”?

-Wastewater should be treated instead of being left in floodplains to accumulate and eventually flood, especially in industrial agriculture

4: What legislation has been created as a result of this catastrophe?

-Led to formation of the hog roundtable, a coalition bent on controlling pig farming and waste lagoons, mandate waste and buffers between waste and water wells

### **Study Questions:**

1: Do you think outbreaks of waterborne diseases will be more common or less common in the future? *Why? Where are outbreaks most likely to occur?*

-I think waterborne diseases will become more prevalent in the future because of an increase in population and a possible failure in some areas to maintain waste treatment for said large population. Outbreaks are more likely to occur in countries that have inadequate healthcare and waste disposal.

2: How does water that drains from coal mines become contaminated with sulfuric acid? *Why is this an important environmental problem?*

-Water that gets saturated with pyrite sediment produces sulfuric acid. This is an important environmental problem

3: Do you think our water supply is vulnerable to terrorist attacks? *Why? Why not? How could potential threats be minimized?*

-Yes, I think our water supply could be susceptible to terrorist attacks because anyone that is responsible for maintaining a treatment plant can sabotage its process by meddling with mechanisms or switches. Threats can be minimized by switching to natural treatment, like New York’s Catskill Mountain area.

4: How would you design a system to capture runoff where you live before it enters a storm drain?

-I would design a system that funnels runoff into a vat, where it is processed naturally by bacteria that can treat organic and synthetic waste (like primary and secondary treatment in wastewater plants).