CHAPTER 17 WATER USE AND MANAGEMENT

Chapter Overview

Water is a vital resource that is essential to life. Where water is stored on Earth is important to the study of AP Environmental Science. Knowing that agriculture uses the greatest amount of water worldwide is fundamental information. Dams provide both benefits to humans and causes problems for people as well as ecosystems. Issues surrounding water diversion projects are very significant ideas. Conservation is a topic that will become increasingly important to the study of Environmental Science.

Topics and Key Concepts

Earth Systems and Resources

- Identify major sources of freshwater on a map of the world.
- Explain the relationship between an aquifer and its recharge zone.
- Explain why salt water intrusion can occur in coastal areas.
- Explain the societal and economic benefits of storing water in a reservoir.

Energy Resources and Consumption

- Differentiate the concepts of water scarcity and water stress.
- Discuss major water diversion projects, and the environmental consequences associated with each.
- Determine environmental impacts of overdrawing surface and groundwater resources.
- Discuss methods to reduce consumptive water use.

Key Terms

aquifers
artesian well
consumption
*consumptive water use
discharge
groundwater
hydrologic cycle
infiltration
*nonconsumptive water use
rain shadow
recharge zones
renewable water supplies
residence time
saltwater intrusion
subsidence
water scarcity
water stress
water table
withdrawal
zone of aeration
zone of saturation

Pacing Guide

You will need to address this material in two places: first, when you discuss earth systems and material cycling and, again, when you examine the pollution of water resources. Plan to spend 5–7 days on this material.

Approach and Tips

Make sure students recall the hydrologic cycle at the outset of this chapter. Use the hydrologic cycle to explain where water is stored on Earth. Global water supplies and deficits are determined by three factors: topography, proximity to bodies of water, and atmospheric circulation and latitude. Explain that there is very little fresh water on Earth. There are many visuals/demos on the internet that can help explain this concept. The importance of groundwater supplies, particularly aquifers, needs to be stressed.

You can demonstrate how water is held in aquifers using plastic beads in a container. Add water and the students will see how the water fills in the pore spaces between the beads. To illustrate point source and nonpoint source pollution, add drops of food color in different areas while students are not looking. When viewed from the side and bottom, the pollutant travels and spreads. Use an eyedropper or a syringe to withdraw water from a "clean" area to illustrate how the pollutant can be drawn into a previously uncontaminated area. The concept of an aquifer can be a difficult one for students to grasp. Use Figure 17.9 to help explain this concept.

If you do not have access to a stream table, use a plastic storage container that fits underneath a bed and sand or diatomaceous earth to create one. Clay can be used as an aquiclude to prevent water from moving from one part of the model to another. Students can construct dams, wells, and irrigation system models to study the effects of these structures on the ecosystem.

Withdrawal and consumption are two very important topics about water use. Students need to know the basics. In other words, they need to know for what most of our water resources are used. You may ask the students "Does industry, agriculture or households use the most water?" Note that these answers will vary geographically.

Stress that water shortages do occur. Students should realize the role of weather and the hydrologic cycle to these shortages. Describe what happens when more water is withdrawn than can recharge. Sinkholes, land subsidence, and salt water intrusion are three major consequences of overdrawing groundwater.

Water diversion projects have played a key role in the acquisition of freshwater resources. Illustrate the costs and benefits of these projects by using a specific example. Examples of water diversions include the Aral Sea, Three Gorges Dam, Hoover Dam, Aswan Dam, and the Everglades.

Particular attention should be paid to water diversion projects. The Case Study on page 377 of the textbook is a good place to start, but there are numerous topical case studies such as the Hoover Damn, Aral Sea, Mono Lake, or Aswan Dam.

The Aral Sea warrants discussion. Explain the reasons for this disappearing sea. Show students the graphic of Figure 17.20 in the textbook or find a video online which shows a time-lapse of the sea shrinking. This should be an important lesson to future generations about water diversion for agriculture.

Point out the major uses of water in the home using Figure 17.14 in the textbook. Have students design a project monitoring their household water use and a personal plan to conserve water in their homes.

Stress that methods of water conservation are mostly common sense. While water cycles through the environment, there are some methods that will bring freshwater to places with low supplies. Desalination is used in several locations throughout the world with great success, as cogenerative power is used to remove portable water from a salt water reserve. However, conservation is more economical and environmentally friendly. The various water diversion case studies should be addressed in detail, as the ecology upstream and downstream of a water diversion is dramatically altered. Students need to understand the biotic and abiotic changes in the water resulting from damming a river.

Common Mistakes and Misconceptions

Students do not always understand the consequences of water diversion projects. Dams are good because dams bring water/electricity to where we want it, like cities; however, dams create a huge environmental problem causing fish kills, biodiversity loss, sediment issues, disease outbreaks, increased methane release, increased water temperatures, reduced downstream DO, and can displace people as well. Often they have a difficult time addressing the environmental problems caused by the construction and implementation of a dam.

Activities

Water Quality Testing

It is important for students to perform water quality tests and evaluate the results. Below are several options, and many procedures are available online.

Abiotic	Biotic
Temperature	Biochemcial Oxygen Demand
Turbidity / Total suspended solids	Fecal coliforms
DO	Benthic macroinvertebrates
Salinity / hardness	Biodiversity analysis / index
Macronutrients - NO_3^-, $PO4^{3-}$, K, S	
Conductivity / Total dissolved Solids	
Color	
Dissolved Carbon Dioxide	
Micronutrients – Cl, Se, Fe	
Heavy metals – Pb, Hg, Cd	

Drop by Drop Water Activity

The purpose of this activity is to quantify water waste. By simulating a leaky faucet, students will be asked to do a series of calculations. An activity worksheet can be found at the end of this teacher's manual chapter.

Water Diversion Activity

In this activity, the students will be assigned a specific water diversion project. Both the historical significance of the project along with the future implications of the project will be investigated. The students can either make a poster or a PowerPoint of their particular project. Students should include a cost/benefit analysis from both an economic and environmental standpoint.

Questions for Review

1. What activity, in the United States, accounts for the largest water consumption? In the world?
   In the U.S. the largest water consumer is industry. Worldwide, agriculture accounts for the largest consumption of water supplies.

2. What three factors control global water deficits and surpluses?
   Three factors that control water supplies are global atmospheric circulation, proximity to water sources influencing precipitation, and topography.

3. What is an aquifer? How does it function to maintain water supplies?
   An aquifer is a cracked or porous layer of rock usually with an impervious layer of rock below. This is a storage compartment for groundwater. Water infiltrates through an area known as the recharge zone and can be withdrawn using wells.

4. What are water diversion projects? How are they useful in providing freshwater? How are they harmful to natural ecosystems?
   Water diversion projects consist of dams, canals, pipelines, and any method that diverts water from its natural progression. A dam, canal, and pipeline can directly supply cities with fresh drinking water. However, there are several environmental issues surrounding these projects. When a dam is constructed, natural habitat is destroyed and altered. Sediments build up behind the dam and are not allowed to make their way downstream.

5. One of the suggestions for conserving water is, "Don't dump anything down a storm sewer that you wouldn't want to drink." How does the message in the statement relate to the hydrologic cycle?
   Water and anything dissolved in it can infiltrate the ground and empty into aquifers. Aquifers are a main source of groundwater for drinking. This could have adverse effects on the population if the groundwater is contaminated with a harmful chemical, such as a pesticide.

Practice Questions

Multiple Choice:

Directions for questions 1-5: The lettered choices below correspond to the descriptions given in questions 1-5. Select the one lettered choice that best fits each statement. Each choice may be used once, more than once, or not at all.

(A) artesian well
(B) subsidence
(C) saltwater intrusion
(D) aquifer
(E) drip irrigation

1. usually results in a sinkhole

2. occurs in coastal areas

3. often results when water is overdrawn from a ground source

4. pressurized water source resulting in a spring

5. porous rock layer below the water table

6. The area where water infiltrates into an aquifer is called a(n) _____.
   (A) zone of aeration
   (B) zone of saturation
   (C) recharge zone
   (D) water table
   (E) artesian well

7. Lake Mead loses 1.3 billion m^3 of water due to evaporation every year. How many years will it take for Lake Mead to lose 13 billion m^3 of water?
   (A) 5 years
   (B) 8 years
   (C) 10 years
   (D) 20 years
   (E) 30 years

8. What is the smallest compartment by volume for water storage?
   (A) oceans
   (B) glaciers
   (C) atmosphere
   (D) aquifers
   (E) lakes, ponds, rivers and streams

9. All of the following are consequences of drought EXCEPT
   (A) topsoil loss
   (B) vegetation loss
   (C) greater infiltration of water
   (D) animal migration
   (E) disruption of native plants undermining natural adaptations to low moisture levels

10. The IPCC has warned of threats to exacerbate water shortages due to _____.
   (A) global climate change
   (B) ozone depletion
   (C) agricultural production
   (D) the underuse of water supplies
   (E) the use of drip irrigation

Free-Response Question:

Directions: Answer all parts of the following question. Where explanation or discussion is required, support your answers with relevant information and/or specific examples. When a calculation is required, be sure to show how you arrived at your answer.

1. The Leaky family is comprised of 4 individuals. Each person showers daily for 5 minutes. Their shower head flows at 20 gallons per minute. The price of their water is $0.10 per 100 gallons.

   (a) How much water does the family use showering daily?

   (b) Calculate the cost of the family's showers for one month (assume a 30-day month).

   (c) Suppose the family has a "leaky" faucet. The faucet leaks at a rate of 1 drop per second. 5 drops equal 1 mL. Calculate the volume of water wasted from the leaky faucet in one minute.

   (d) Describe THREE actions the family can take to conserve water.

Answers to Practice Questions

Multiple Choice:

1. B
2. C
3. B
4. A
5. D
6. C
7. C
8. C
9. C
10. A

Free-Response Question:

This question is based on 10 points.

1. (a) 2 points total. One point for correct set-up and one point for the correct answer.

   20 min. x 20 gal/1 min = 400 gallons

   (b) 3 points total. 1 point for calculating the total time. 1 point for set-up and 1 point for final answer.

   20 minutes/1 day x 30 days = 600 minutes

   600 minutes/month x 20 gal/1 minute x $.10/100 gal = $12/month

   (c) 2 points total. 1 point for set-up and 1 point for the correct answer.

   60 drops/1 min x 1 mL/5 drops = 12 mL/min

   (d) 3 points, 1 point for each conservation measure. Possible answers include: shorter showers, fix leaks, don't run water when brushing teeth, don't water the lawn, don't wash the car.

Answers to questions in the Student Edition:

Case Study AP Document-Based Question (p. 378)

(A) Dams endanger fish populations because the reservoirs they create could be drained below sustainable levels and fish populations without adequate food or space have nowhere to go because they are trapped in the reservoirs. Dams also stop normal stream flow and in the case of migrating species like salmon, populations will not be able to go back and forth from their breeding grounds (as seen in the Chapter 13 example of the Elwha dam).

(B) Two environmental impacts of damming the Colorado River include are a buildup of sediments and nutrients that would otherwise help prevent shoreline erosion further downstream and the lack of available clean water flows to sustain ecosystems downriver.

Use the Math (p. 379)

The continents with the greatest amount of precipitation are South America, Africa, and Asia (Southeast Asia). The wettest locations are found between 30 degrees north and 30 degrees south. These latitudes receive the most precipitation because warm, moist air (due to heat and evaporation) from the NE and SE trade winds meet at the Inter Tropical Convergence Zone and rise. As the air rises, it cools, condenses into clouds, and forms rain. The interior of South America experiences the phenomenon described above, but the west coast experiences what is called a 'rainshadow desert', due to the Andes Mountains along the west coast. All of the warm, moist air condenses and falls on the Atlantic side of the mountain, leaving little rain for the western side.

Use the Math (p. 382)

Only 0.37% of the fresh water in the world is in rivers and streams or freshwater lakes and reservoirs (0.6% and 45.7% of the total 2.4% fresh surface water). That means that only approximately 0.009% of water in the world is in streams, rivers, lakes, and reservoirs. (46.3% of 0.8% = 0.37% and 0.37% of 2.4% freshwater = 0.00888%

If students interpret this question as asking for rivers and streams ONLY, then it would be 0.6% of 0.8% or 0.0048% of the freshwater in the world; and then 0.0048% of 2.4% freshwater = 0.00012% of the water in the world.

AP Connections Review Answers (pages 69-71)

Multiple-Choice Questions

1. a. Removal of excessive amounts of groundwater in coastal areas may result in saltwater intrusion.

2. c. Reduced water flow through the Everglades has caused a reduction in biodiversity.

3. d. The greatest amount of freshwater is found in ice and snow.

4. a. Increasing water costs to reflect water shortages would be a disincentive, or "stick," that would encourage water conservation in a municipality. The other choices would be incentives, or "carrots."

5. e. Stream discharge is the volume of water the river holds at any given time.

6. c. Flushing toilets uses the most water in municipalities. This water use can be decreased by installing low-flow toilets or putting something in the water tank to take up some of the volume.

Data Analysis & Free-Response Questions

1a Low population projection: 2 billion/7.6 billion = about 26%. High population projection: nearly 7 billion/10.6 billion = about 65% of the global population. The percent increase of people facing water stress under high population projections is 160%. (65-25/25*100)

1b i. l400gal* 1L/0.26gals = 5,384.6 L
ii. Answers will vary but can include shorter shower times, only washing dishes or laundry with full loads, using low-flow toilets, and capturing and using rainwater runoff.

1c Answers will vary, but answers could include increasing prices (a disincentive), or providing incentives such as reusing reclaimed water, providing rebates for purchases that help to conserve water, providing rain barrels, or giving tax breaks for homes that xeriscape.

2a Climate change induced alterations to the hydrologic cycle include reduced precipitation in some areas and incereased participation in other areas (due to changes in atmospheric circulation) and higher evaporation rates (due to higher temperatures).

2b Plants are adapting to drier climate by increasing transpiration rates, they could also develop thicker, waxy surfaces to retain water or have narrower leaves or spines to reduce surface area exposure.

2c Reduced surface water leads to reduced groundwater storage. Impervious cover also causes flash flooding situations where water that would normally absorb into the ground and end up being stored is instead flushed downstream.

Drop by Drop Water Activity

*Student:*_____

Procedure:

1. Obtain an eye dropper, a 10-mL graduated cylinder, and a container of water.
2. You are simulating a leaky faucet. You will pretend that your eye dropper is your faucet. Discharge 1 drop per second for 30 seconds into the graduated cylinder.
3. Record the volume of the leaky faucet.
4. Repeat steps 2-3 two more times.
5. Average your volume for all three trials.

Calculations:

1. Calculate the volume of water from your leaky faucet for one day.

2. What would be the volume of water wasted if you did not repair your faucet for one year?

3. If the density of water in 1.00 gram/mL, calculate the mass of the wasted water in one year.

4. For your answer in 3, calculate the mass in pounds. There are 454 grams in one pound.

5. Calculate the number of cubic feet of water wasted in one year, if one cubic foot of water weighs approximately 60 lbs.

6. How much money did the wasted water cost in one year? Your utility company charges $2.00 per 100 cubic feet.

Conclusions:

1. Find out the source of your tap water. Is it city or well water?

2. If you have city water, find out how much your water costs per cubic foot.

3. What are the implications of wasting water? Does it really matter if your faucet drips?

4. What would happen to your water supply if your area suffered from a drought? Does your answer to conclusion 3 change? Why or why not?

5. What are some water conservation techniques that you could use in your home in order to save water?