Lesson #6: Water Treatment

Driving Question: What are some ways that humans pollute the water? What are some ways that humans and nature can clean-up water?

Learning Goal: Nature has some ways of cleaning up pollution (NSES 9-12F4b, c p. 198). Many of these processes are active in wetlands. Humans have developed some ways to clean-up some pollution; some of these techniques are similar to natural clean-up processes. Human drinking water and wastewater treatment plants utilize processes that are similar to clean-up processes that occur in wetlands (LPG). However, most human techniques for cleaning up pollution are difficult and expensive.

Objectives:
O9 -Compare the processes that take place in drinking water and wastewater treatment plant with natural water clean-up processes (telling the story).

Assessment:
A9 Develop a concept map/mind map of a wastewater treatment plant and explain how the plant uses clean-up processes similar to natural processes.

Lesson Purpose:
This lesson connects back to Lesson #2 by completing the examination of the question, "Where does water come from and where does it go?" Students also make connections to what they have learned in lessons 3, 4 & 5 about sources of water pollution. This lesson requires students to compare and contrast processes (natural & WWTP, WWTP & DWTP). Students use modeling skills to understand schematic diagrams and compare diagrams. Finally, this lesson requires students to show their thinking in the concept map.

Lesson Overview:

Activity Number	Label	Function	Description
6.1	Daily Journals	Elicit Student Ideas / Establishes Purpose -	Students respond in journals to daily question. This activity is repeated each day of this lesson, using different questions.
6.2	What is in the water? - Small Group Work	Elicit student ideas This activity allows students to think about what is in the water. It sets up the problem of cleaning water by identifying what needs to be removed. It also requires students to think back to what they have learned about pollution.	Working in groups, students complete a table that identifies what is in the water and where it comes from.

Activity Number	Label	Function	Description
6.3	What is in the water? - Large Group Sharing	Establish the problem This activity allows students in groups to share ideas among groups. It allows the teacher to focus student attention on significant student responses. It ends with establishment of the problem - how does water get cleaned up?	Students share ideas for what is in the water. Class discusses similarities and differences among group answers. Class identifies the problem: How does water get cleaned up?
6.4	How does nature clean up water?	Construct understanding Part of understanding how Wastewater Treatment Plants work is understanding how they compare to natural clean-up processes. Also, an important goal of this unit is to help students think about the impact of human actions on natural processes. The video format is important because some students may not understand what a wetland is or looks like.	Students watch a video that explains what wetlands are and read a short reader about how wetlands function to clean water. Emphasis is on dilution, filtration, biodegradation, and precipitation.
6.5	How do people clean it up? - Purposes	Review /Construct understanding This activity connects back to Lesson #2 when students saw the big picture about where our water comes from and where it goes. This activity emphasizes that there are two water treatments involved in human use of water.	Class identifies differences in purpose and actions between drinking water treatment and waste-water treatment.
6.6	WWTP - order the test tubes.	Elicit Student Ideas This activity engages students in the WWTP process by providing a visual of how water improves as it moves through the steps. It also serves as a hypothesis-forming step for understanding WWTP process	Students work in groups to arrange sealed test tubes of waste water in the order that represents what happens in the water treatment plant.

Activity Number	Label	Function	Description
6.7	Treating Waste Water	Constructing Understanding Students engage in hands-on process of cleaning up the water. They learn how to read a schematic diagram and relate the steps to a schematic. A schematic represents another type of model.	Students follow color-coded schematic diagram of a WWTP. Each part of the WWT process is color-coded to match one of the test tubes. For each process marked on the diagram, students model the process using "prepared" waste water (water with grit, bread crumbs, soap, and cooking oil). Students identify what is added and what is removed in each step of the WWTP process. Finally, students compare their own water to test-tubes.
6.8	Bacteria and Biological Oxygen Demand (BOD)	Constructing Understanding and Using Understanding This activity explains the concepts behind the aeration step of the WWTP process. Students apply understanding of aerobic and anaerobic bacteria to answer questions.	This activity is actually embedded within the previous activity. Students read about aerobic and anaerobic bacteria and answer a few questions.
6.9	Drinking water treatment.	Constructing Understanding and Using Understanding This activity requires students to use their understanding of schematic diagrams to compare WWTP to DWTP	Students compare schematic diagrams of drinking water treatment plants and waste water treatment plants to identify differences in the processes and discuss why the two processes are different.
6.10	Waste Water and Wetlands	Synthesis & Assessment This activity allows students to compare and contrast human waste water treatment systems to natural systems. This activity also serves as an assessment of the key ideas.	Students develop a concept map or similar diagram to show how a waste water treatment plant is similar to a wetland.

Preconceptions:
The research literature documents the following student ideas that are not congruent with a scientific understanding of groundwater. This lesson addresses these some of these preconceptions by building on student ideas. The idea is to help students move their understanding towards a more scientific understanding, rather than simply correcting misconceptions. You should be aware of these preconceptions, but it does not mean that all of your students will hold these ideas. It is important for you to elicit your own students' ideas and build on their ideas during this unit.

Common Preconception	Goal Conception	Activity that Addresses this Preconception	What to emphasize
1. Anything natural is not pollution 2. Pollution is primarily chemical 3. Biodegradable materials are not pollution	Pollution is anything, natural or human-made, that makes the environment harmful to living things.	6.1 – Journal Question on What is Pollution	Emphasize that pollution is anything that is harmful to normal life processes and includes natural (sediment, manure, etc) and human sources.
		6.2 – What is in the Water?	Emphasize that pollution is anything that is harmful to normal life processes and includes natural (sediment, manure, etc) and human sources.

Materials:

Activity Number	Per Student	Per Group	Per Class
6.1	Journals		• Journal questions
6.2	Student Resources 6.2/6.3		
6.3	Student Resources 6.2/6.3		• "What is in the Water" Overhead
6.4	Student Resources 6.4		• Video
6.5	None		None
6.6	Student Resources 6.6/6.7	• Set of four sealed test tubes with samples of waste water. See directions for requirements for water samples • Test tube rack	• "How Waste Water Gets from Your House to the Waste Water Treatment Plant" Overhead
6.7	Student Resources 6.6/6.7	• 300 ml or 500 beaker with prepared waste water • wire screen • spoon • test tube with stopper • bacteria/enzyme powder • eye dropper • chlorine bleach	• Schematic diagram of the Waste Water Treatment Plant
6.8	Student Resources 6.8 (Biological Oxygen Demand Reader and Questions)		
6.9	Student Resources 6.9	• Waste water Treatment	• Waste water

		Schematic • Drinking Water Treatment Schematic	Treatment Schematic • Drinking Water Treatment Schematic
6.10	Student Resources 6.10	•	•

Activity 6.1: Daily Journals (10 minutes)
Function/Rationale:
This activity
1) Allows the teacher time to take roll and complete administrative duties while students enter the room. Students should be expected to complete the journal activity everyday without prompting.
2) Elicits student ideas and previews the new lesson for the day.

Directions
1) Post journal questions on the overhead projector or chalk board.
2) Students should respond individually in their journals to the daily journal questions.
3) Review the questions. Lead a short discussion asking for sample student responses.
4) There will be new journal questions for each day. The following are suggested journal questions. You should adapt the questions to your students' needs and the specific logistics of the lessons. Use the journal questions as opportunities for embedded assessment and re-teaching, if necessary.

Suggested questions:
A. What is in the water when it leaves your house?
B. Define pollution. *This question is more than just a recall exercise. Pollution is a word that we use frequently without often considering its meaning. This question gets at student ideas about what pollution is. Consider that pollution can be natural or human-made. The American Heritage Dictionary(1982) defines "pollute" as "To make unfit for or harmful to living things" (p.960).*
C. There are many sources of pollution in water that are not human made. List at least three sources. How do you think nature cleans up these pollutants? *Nature uses bacteria to decompose organic materials and recycle them as part of the nutrient cycle.*
D. What is the difference between a drinking water treatment plant and waste water drinking plant? Would you drink water from a waste water treatment plant? *Drinking water treatment plants purify water to make it drinkable (potable) for humans. Waste water treatment plants clean up water that humans have used enough so that it can be released back into the environment and not harm the plants and animals that rely on it. Cities and towns often draw water from rivers that include water from waste water treatment plants for their drinking supplies. They run the water through their drinking water treatment plants first.*

Activity 6.2 What is in the Water – Small Group Work (10-15 minutes)
Function/Rationale:
This activity:
1) Establishes the problem of cleaning water by identifying what needs to be removed.
2) Elicits student ideas by allowing students to think about what is in the water.
3) Requires students to think back to what they have learned about pollution.

Directions:
1) Distribute Student Resources 6.2.
2) Have students work in groups to complete the table. Some of the cells are already completed to help student begin brainstorming.
3) Possible entries are shown below. Students will not generate all of these entries. There may be other possibilities beyond the ones listed below.

1. What is in the water? (Think about what goes down drains or washed into rivers)	2, Where did it come from?	3. How do we (or nature) remove it?	4. How could we (or nature) prevent or reduce it in the first place?	5. Initials
Trash	Streets, people flushing stuff down the toilet	Filter it out	Throw trash in trash cans	
Soap, & other household chemicals	Kitchens, laundry, bathrooms.	Degradation over long periods of time; absorption by plants	Use biodegradable soaps. Use phosphorous-free detergents.	
Food waste	Kitchens	Bacteria eat it	Throw food into a compost pile, not the sink.	
Animal waste	Toilets, animals	Bacteria eat it		
Leaves & other organic waste	Yards, parks, forests, streets, etc.	Bacteria eat it	Compost the leaves	
Fertilizers and other yard and farm chemicals	Yards, gardens, parks, farms	Chemical neutralization or removal	Use less	
Oil & gas	Streets, leaking gas station tanks	Degradation over long periods of time; absorption by plants	Keep car well-maintained, have a settling barrier between roads and rivers, monitor and replace leaking gas tanks.	
Other Chemicals	Industrial pollution washing into rivers or soaking into groundwater. Also from landfills	Degradation over long periods of time; absorption by plants	Responsible handling and use of chemicals	
Sediment	Washes in from recently disturbed areas (roads, construction sites, landslides, etc.)	Settling, filtration	Disturb smaller areas, cover with groundcovers quickly.	

Group Suggestions:
1. Remind students that all group members must participate by making a contribution to the table.

Activity 6.3: What is in the Water? – Large Group Work
Function/Rationale:
This activity
1) Establishes the problem - how does water get cleaned up?
2) Allows students in groups to share ideas among groups.
3) Allows the teacher to focus student attention on significant student responses.

Directions:
1) Place the "What is in the Water" Overhead on the projector or draw the table on the board.
2) Ask for group suggestions to complete the table. Complete the table on the overhead as groups make suggestions.
3) Highlight similarities and differences among group responses.
4) Lead the discussion to the identification of the problem: How does water get cleaned up?
5) Emphasize that natural degradation does occur, but takes place over very long periods of time. For some synthetic materials, it may take place over hundreds and thousands of years. Therefore, natural degradation is not really effective for cleaning-up pollution that humans generate.
6) Have each person record the question on their Student Resources Sheet.

Activity 6.4: How Does Nature Clean Up Water? (Video) (20 minutes)
Function/Rationale:
1) In order to understand how Waste Water Treatment Plant works, it is important to understand how they are similar and different from natural clean-up processes. Watching this video will provide students with a model of natural clean-up with which to compare the waste water treatment plant in later activities.
2) An important goal of this unit is to help students think about the impact of human actions on natural processes. The video format is important because some students may not understand what a wetland is or looks like.

Directions:
1) Show the video "Fabulous Wetlands" (8 minutes)
2) Have students read the short reading in their Student Resources Packet
3) Students may work individually or in groups to answer the questions:
   a. What is a wetland? Describe it. *A wetland is anywhere that is covered with water at least part of the year. It includes marshes, floodplains, tide flats, etc.*
   b. List at least three reasons why wetlands are important.
      i. *Habitat for wildlife*
      ii. *Flood control*
      iii. *Cleans the water*
   c. List at least three ways wetlands clean-up water naturally.
      i. Filters sediments and pollutants out of the water
      ii. Wetland plants can absorb some pollutants
      iii. Bacteria break down organic matter
      iv. Sediment settles out
      v. Chemical reactions cause heavy metals to filter out.

Group Work Suggestions
1) Students may work on the questions independently or together as a group. However, remind students that they are responsible for helping each other learn. Therefore, they need to figure out how to make sure that everyone in the group has learned how nature cleans up the water. The last question on the Student Resources Page asks students to explain how they know that everyone in the group understands how nature cleans up water. Encourage students to do more than just tell their group members the answer. Encourage them to teach and explain the concepts to each other.

Activity 6.5: How Do People Clean Up Water? (10 minutes)
Function/Rationale:
This activity:
1) Connects back to Lesson #2 when student saw the big picture about where our water comes from and where it goes.
2) Emphasizes that there are two types of water treatment involved in human use of water – drinking water treatment and waste water treatment.
3) This activity also corresponds to journal question option #D (What is the difference between a drinking water treatment plant and waste water drinking plant?). This activity could be done as a journal question with teacher review of the main concepts.

Directions:
1) Lead a short discussion with students about the differences between a drinking water treatment plant and a waste water treatment plant.

Drinking water treatment plants purify water to make it drinkable (potable) for humans. Waste water treatment plants clean up water that humans have used enough so that it can be released back into the environment and not harm the plants and animals that rely on it. Cities and towns often draw water from rivers that include water from waste water treatment plants for their drinking supplies. They run the water through their drinking water treatment plants first.

Activity 6.6: Order the Test Tubes (10 minutes)
Function/Rationale:
This activity:
1) Is an introduction to the waste water treatment plant process;
2) Engages students in the WWTP process by providing a visual of how water improves as it moves through the steps;
3) Serves as a hypothesis-forming step for understanding WWTP steps.

Preparation:
1) Prepare sets of four sealed test-tubes of waste water for each group. Try to get these from the local waste water treatment facility. The difference between these waters should be plainly visible.
    a. Waste water directly from sewage pipes, before any type of treatment. Red label.
    b. Waste water from which grit and other hard insoluble matter has been removed (by gravity and filters). Yellow label.
    c. Waste water from which soft organic solids (called sludge) have been removed by sedimentation. Orange label.
    d. Final water that is discharged from the facility. Blue label.
2) Be sure test tubes are securely stoppered. As a precaution, secure the stoppers with tape.
3) Use a colored label to distinguish each test tube. Do not identify the contents of each test tube.

Directions
Place the overhead "How Waste Water Gets from Your House to the Waste Water Treatment Plant" on the projector.
1) Explain that in cities, waste water from each house flows into the main sewer and into the waste water treatment plant. Most cities have one or two plants for the whole city.
2) Explain that there are several steps to cleaning up waste water in the waste water treatment plant.
3) Distribute the sets of test-tubes to the groups. Emphasize that under no circumstances should the test tubes be opened.
4) Have groups work together to place their tubes in order based on what they perceive as the dirtiest water to the cleanest water.
5) Have students record on their Student Resources Sheet the order of the test tubes.

Activity 6.7: Treating Waste Water (30 minutes plus overnight wait time, 15 minutes following day)
Function/Rationale:
This activity:
1) Engages students in the hand-on process of cleaning the water.
2) Teaches students how to read a schematic diagram. A schematic represents another type of model.

Preparation
For each group, prepare a beaker of "waste water"
1) 300 ml of tap water
2) a small handful of gravel (grit)
3) 2 ml (or 1 Tbs) of cooking oil
4) 2 ml (or 1 Tbs) of dish soap
5) Small bread crumbs

Directions
1) Place the large schematic diagram of the waste water treatment plant on the overhead projector.
2) Explain how to read the schematic diagram. There are four main steps in waste water clean-up. Each step is represented in the diagram with a different shape and a different color. Notice that the labels on the test tubes of waste water correspond to the steps of the waste water treatment on the schematic diagram, except the red test tube, which is untreated waste water.
    a. Filter – removes the grit
    b. Primary Clarifier (sometimes there are a secondary & tertiary clarifiers). Soft solids (bread crumbs to settle to the bottom). Fats and oils are scraped off the top.
    c. Oxidation
    d. Chlorination
3) Students will follow the steps on their Student Resources sheet to clean-up the waste water. Each step is color coded to match the schematic. The student steps are listed below.
4) For each step, students must complete the table by recording what they observed, deciding what was added to the waste water, what was removed from the waste water, and what should be done with what is removed.
5) During step 2, students should let their "waste water" settle. During this time, students can read the Biological Oxygen Demand Reader and answer the questions (Activity 6.8).
6) During step 3, students add the bacteria/enzymes, pour off the water into a test tube, stopper it, and let it sit overnight. This is an important deviation from the waste water treatment process. In a waste water treatment plant, the bacteria work aerobically. The waste water treatment process includes an aerator that bubbles oxygen through the water. The aerobic bacteria that eat the dissolved organic waste require large amounts of oxygen in order to work. However, in the lab model that the students are using, the bacteria that are used are anaerobic bacteria intended for septic tank use. Therefore, the test tubes are stoppered. You should emphasize to your students that in the test tubes, they are using anaerobic bacteria, but that the waste water treatment plant relies on aerobic bacteria.
7) After letting the stoppered test tubes sit overnight, have students remove the stoppers and add the bleach. It will take a while for the bleach to work. After about 20-30 minutes, have students compare their treated water to the test tube of treated water (green) from the waste water treatment plant. Also, have one member of each group bring their group's completed test tube up to the front of the room so that the class can see which group cleaned up their water the best.

Waste Water Treatment Steps

Step #	Step Name	What to Do	What Happened? Describe what your water looks like now.	What was added to the water? Why?	What was removed from the water? What should be done with it?
1	Filter (Yellow)	A. Pour the "waste water" through the screen into the empty beaker.		*Nothing*	*Gravel/grit, some sludge (soft organic matter). This material goes to the landfill*
2	Clarifier (Orange)	A. Allow the water to settle in the beaker. While you wait, go to step 3. B. Blot up the oil on the top with the paper towel or scoop out with a spoon C. Carefully pour off the water into a test tube. Fill the test tube completely and stopper it. Do not allow the settled sludge to go into the test tube.		*Nothing*	*Oil – taken to landfill* *Sludge (soft organic matter) – taken to landfill or city compost.*
3	Aeration (green)	A. Read the paragraphs about Biological Oxygen Demand B. Answer the questions C. Finish step 2 D. Add 1 tsp of bacteria & enzymes to your water. E. Let it sit overnight.		*Bacteria – to eat the dissolved organic waste* *Oxygen – to help the bacteria eat the waste*	*Nothing*
4	Chlorination (blue)	A. Add 5 drops of chlorine bleach to your water		*Chlorine – to kill the bacteria and all other organic matter*	*Remaining sludge – goes to the landfill*

6. When you return, compare the water in your test tube to water in the green test tube. How well did your water compare?
7. Which group had the cleanest waste water?
8. Is this water clean-enough to put into the river? Explain your answer.
9. Would if be clean-enough if it came from the waste water treatment plant? Explain your answer. *Most of the time, water from a waste water treatment plant is of similar quality to the water that it flows into. Waste water treatment plant operators are required to test their water to make sure it meets standards. However, during times of high rainfall, waste water treatment plants may overflow untreated sewage into a river or lake.*
10. Would you drink this water? Explain your answer.
11. How well do you think this model of waste water treatment worked? Be sure to explain why.
12. Explain how your model is similar to a real waste water treatment plant. *This model includes filtration, settling (clarifier), bacterial decomposition, and chlorination.*

13. Explain how your model is different from a real waste water treatment plant *Waste water treatment plants use aerobic bacteria and include an aerator.*
14. Compare your order of your color-coded waste water test tubes to the schematic diagram and correct their order, if necessary.

9) Have students compare the order of their color-coded waste water test tubes to the schematic and determine if they ordered their test tubes correctly. By now, students have probably figured out that the colors on the test tubes match the colors on the schematic diagram.

Group Work Suggestions
1) Remind students that each person in the group is responsible for completing at least one step.
2) Remind students that at the end of the waste water treatment process, the class will judge which group cleaned up their water the best. Groups that work together will have a better chance at cleaning up their "waste water" most effectively.

Activity 6.8: Bacteria and Biological Oxygen Demand (BOD) (15 minutes embedded within Activity 6.7)
Function/Rationale:
This activity:
1) Explains the concepts behind the aeration step of the WWTP process.

Directions
1) This activity is embedded within Activity 6.7. It should be completed while students wait for the "sludge" to settle in their "waste water treatment" beakers.
2) Have students read the Biological Oxygen Demand Reader. Remind students to consider what they learned in biology class about aerobic and anaerobic bacteria.
3) Students should work in groups to answer the questions.

1. What is the difference between aerobic and anaerobic bacteria? *Aerobic bacteria need oxygen in order to eat dissolved waste. Anaerobic bacteria do not need oxygen.*
2. Explain why a septic tank uses anaerobic bacteria but a waste water treatment plant uses aerobic bacteria. *Septic tanks are in low oxygen environments, so anaerobic bacteria are used. Waste water treatment plants use aerobic bacteria because anaerobic bacteria produce poisonous gases that kill all other forms of bacteria that could help in breaking down the waste.*
3. Explain why a waste water treatment plant uses aeration? *Waste water treatment plants rely on aerobic bacteria to eat the dissolved waste. Aerobic bacteria need lots of oxygen in order to eat the high volumes of organic waste in the waste water.*
4. What happens to the BOD when there is more waste in the water? Explain why. *When there is more waste, the aerobic bacteria require more oxygen in order to be able to eat all of the waste.*
5. Does high quality water have a high or low BOD? Explain. *High quality water has a low BOD because it does not have much waste in it and does not require very much oxygen in order for the aerobic bacteria to eat the waste.*

Group Management Suggestions
1) Remind student to share their answers to the questions with the group, choose the best answer among those offered, and write down the best answer.
2) At the end of Activity 6.8, the group must complete a table that tells how each person contributed to the group work.

3) Explain how each member of the group contributed to the answers to the questions.

Group Member	Contribution

Activity 6.9: Drinking Water Treatment. (15 – 20 minutes)
Function/Rationale:
This activity:
1) Requires students to use their understanding of schematic diagrams and model-based reasoning to compare WWTP to DWTP.

Directions
1) Place the schematic diagram of the waste water treatment plant on the overhead projector.
2) Have students identify the steps of waste water treatment.
3) Place the schematic diagram of the drinking water treatment on the overhead projector.
4) Briefly explain the steps of drinking water treatment.
5) In groups, have students compare their schematic diagrams of the waste water treatment plant and the drinking water treatment plant.

Drinking Water Treatment Plant			**Waste Water Treatment Plant**		
Step Name	**What Happens**	**Why**	**Step Name**	**What Happens**	**Why**
1 Clarifier	*Removes sediment, floating debris and organic solids*	*If the water comes from a river or lake, it may contain sediment or other material*	*1 Filter*	*Removes large grit*	*Waste water may contain gravel or sand washed into the sewers*
2 Softener	*Removes Mg & Ca ions*	*Softens the water so that soap will lather better*	*1 Clarifier*	*Removes sediment, floating debris and soft organic solids*	*This is where the sludge is removed.*
3 Chlorinator	*Adds chlorine*	*Disinfects the water – kills bacteria*	*2 Aerator*	*Aerobic bacteria eat the dissolve waste*	*Waste water has organic waste dissolved in it*
4 Fluorinator	*Adds fluoride*	*In small amounts, fluoride protects teeth from cavities*	*3 Chlorinator*	*Adds chlorine*	*Disinfects the water – kills bacteria*

Have students complete the table on the Student Resources 6.9 page.

Question	Your Answer	Group Answer
How are drinking water treatment and waste water treatment similar?		*Both clean the water; both have clarifiers to remove solids, both use chlorine to kill bacteria*
How are drinking water treatment and waste water treatment different?		*WWTP has to remove more waste; WWTP uses bacteria to eat waste; DWTP adds fluoride and softens water; water is potable after a DWTP and not a WWTP.*
Explain how the water from a waste water treatment plant might someday end up in a drinking water treatment plant		*Water from a WWTP may be released into a river or lake. A community downstream may pull their drinking water from the same river or lake. OR, treated waste water may be released from a river and infiltrate into the aquifer. A community may pump its drinking water from the same aquifer.*

6) Students should answer the last question independently.
What did you learn from this lesson about waste water treatment and drinking water treatment, that you did not know before? Describe a situation in which this knowledge is useful.

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Group Management Suggestions
1) When completing the comparison table, allow students to work in groups.
2) When students complete the questions table, have each person write an answer independently. Then have students compare answers, decide on the best answer as a group, and record the group answer.

Activity 6.10: Waste Water Treatment and Wetlands (20 minutes)
Function/Rationale:
This activity:
1) Allows students to compare and contrast human waste water treatment systems to natural systems.
2) Serves as an assessment of the key ideas in previous activities.

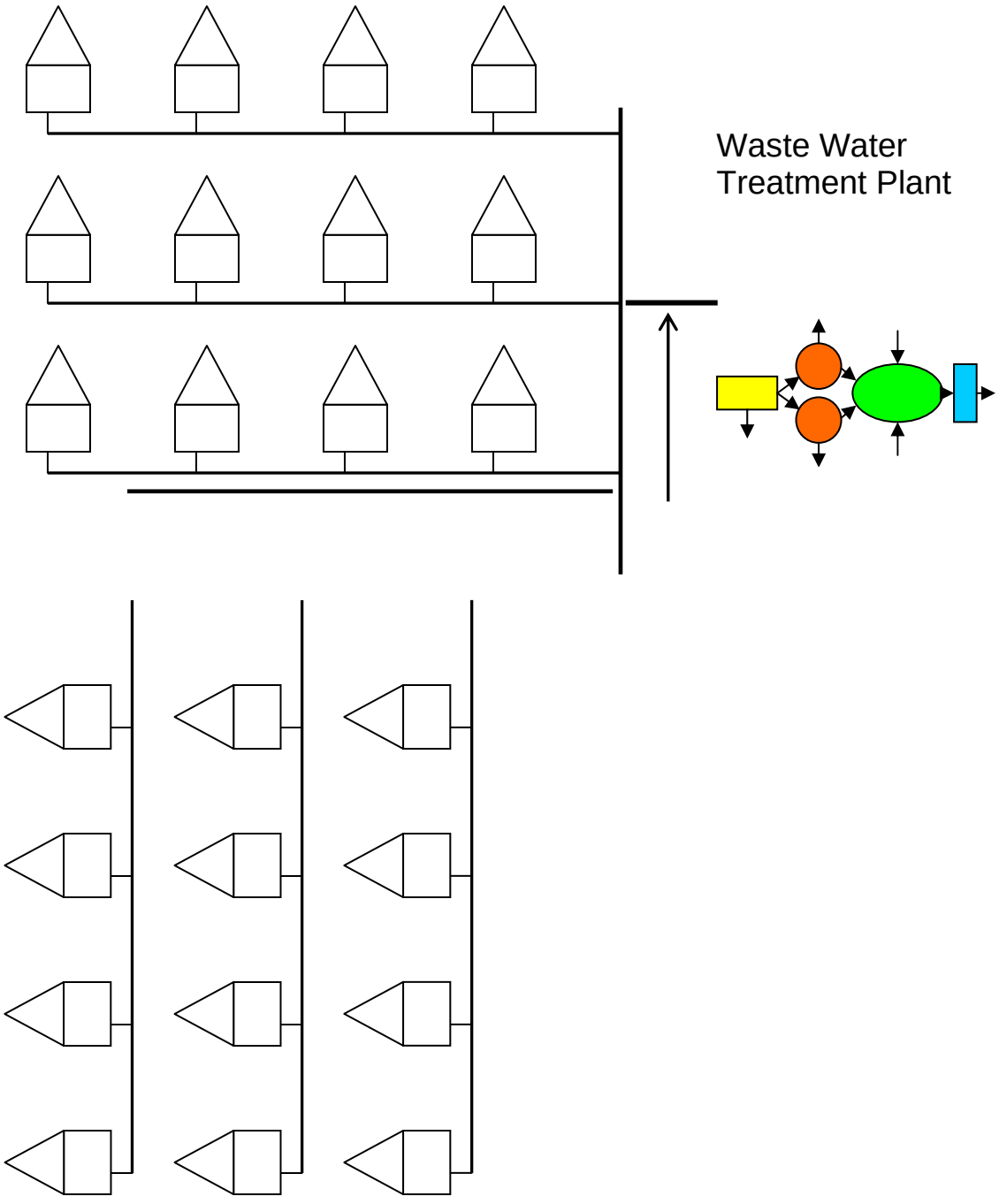
Directions
1) Briefly review with the class what they learned about wetlands and how wetlands clean water.
2) Briefly review the waste water treatment process.
3) Have students work in groups to complete the table.
4) Have students work independently to develop a concept map or similar diagram to show how wetlands and waste water treatment systems are similar.

	Wetland	Waste Water Treatment Plant
How is sediment removed?	*Filtered slowly through sediment Sediment and solids filter out*	*Filtered slowly through clarifiers, sediment and solids settle out*
How is organic waste removed?	*Bacteria eat it*	*Bacteria eat it*
How are chemicals removed?	*Chemical reactions can neutralize and precipitate some harmful heavy metals.*	*We did not address this*

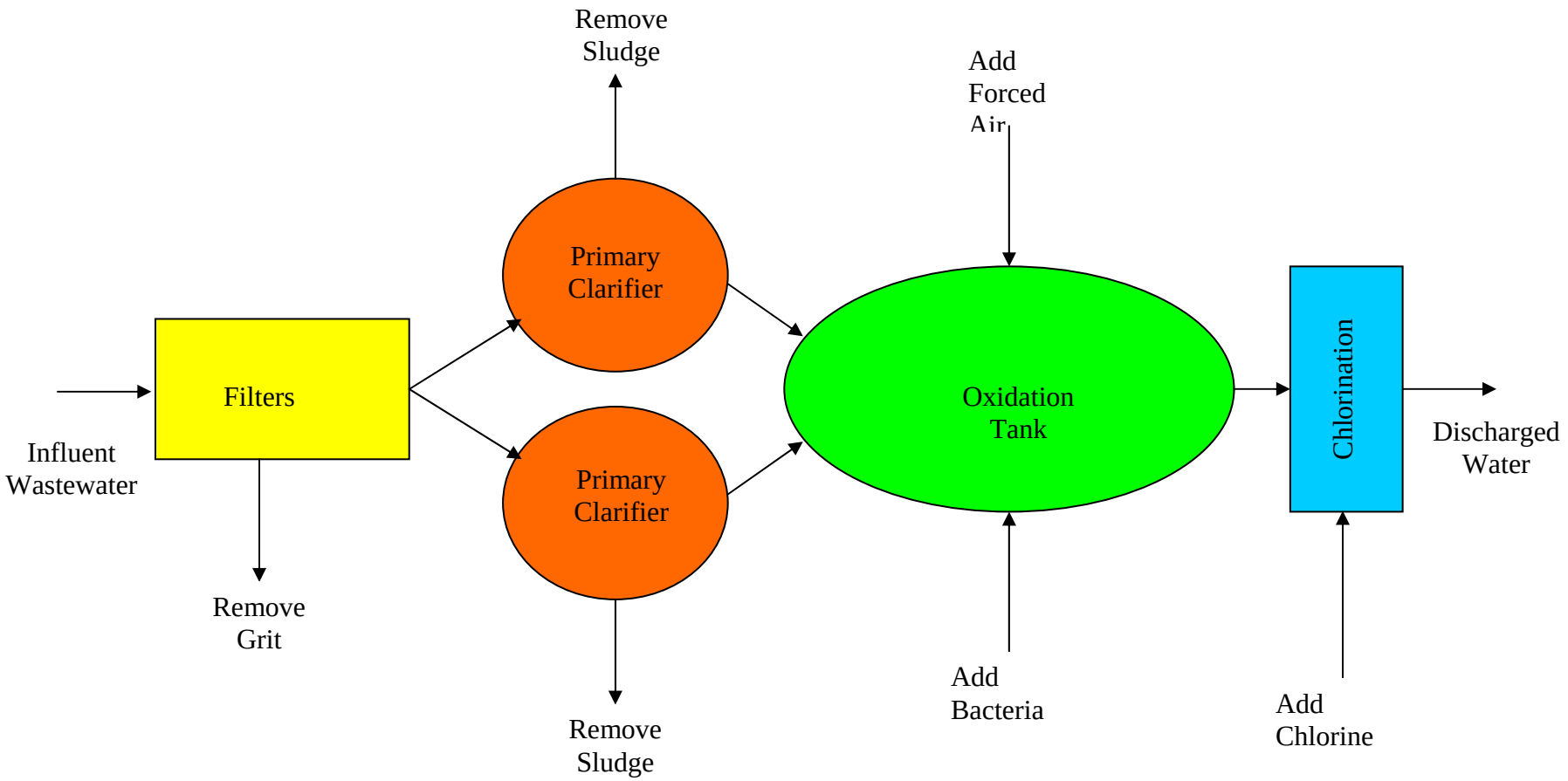
What is in the Water?

1. What is in the water? (Think about what goes down drains or is washed into rivers)	2, Where did it come from?	3. How do we (or nature) remove it?	4. How could we (or nature) prevent or reduce it in the first place?	5. Initials
Trash				
	Yards, parks, farms, gardens			
		Bacteria eat it		
			Use non-phosphorous detergents or bio-degradable soaps	
Food Waste				
			Keep car well-maintained	

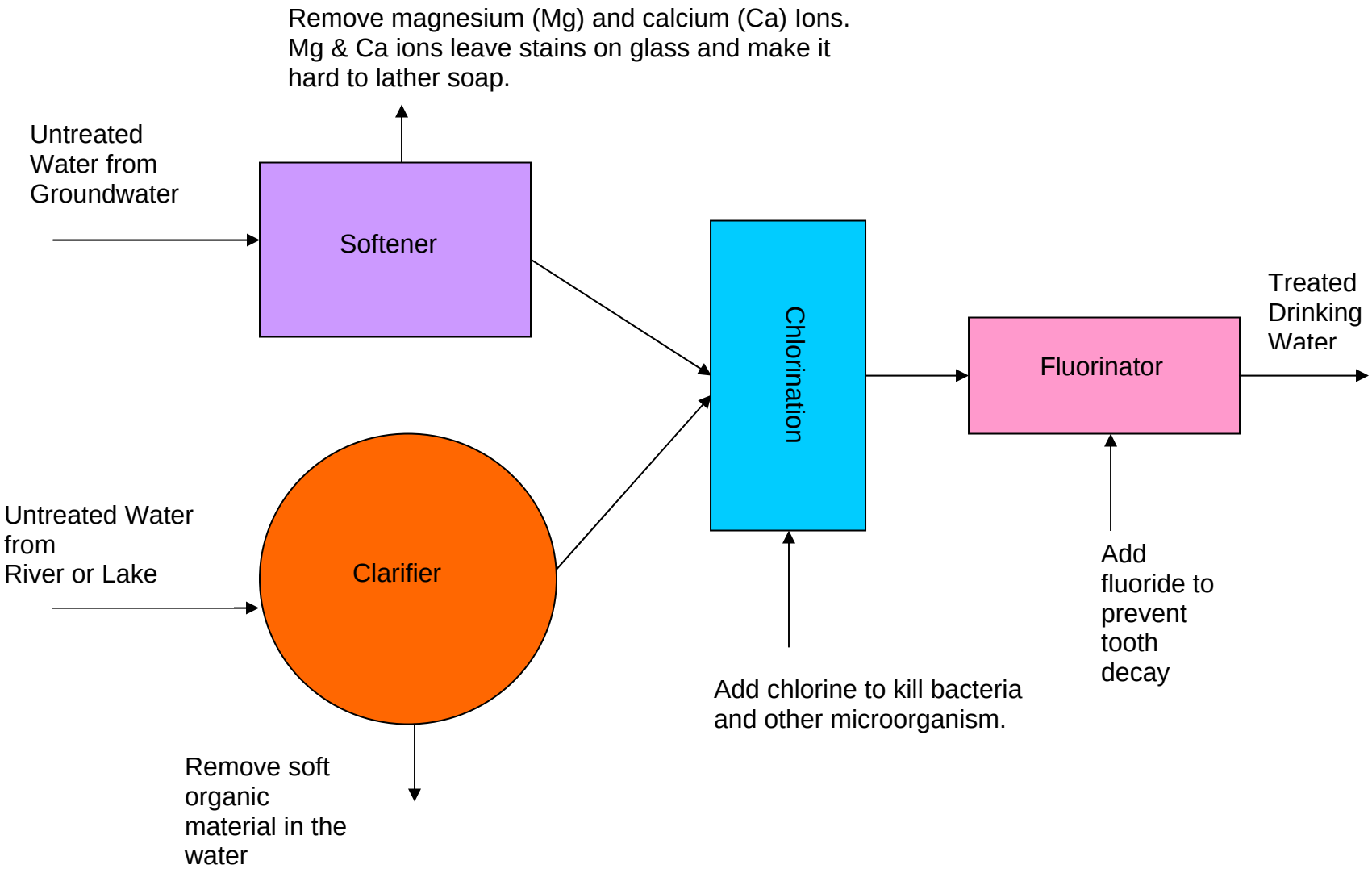
How Waste Water Gets from Your House to the Waste Water Treatment Plant



Waste Water Treatment Plant Schematic Diagram



Schematic Diagram of Drinking Water Treatment



Name:_____Hour: _____

Lesson #6: Water Treatment

Activity 6.2/6.3: What is in the Water?

Purpose: Have you ever thought about what is in the water that leaves your house? It might be more than you first thought. If we are going to clean-up the water, we first have to know what is in it.

Directions:

1. As a group, fill in the table below.
2. Each person in the group must offer a suggestion for at least one row. If you don't have an idea for column three, use a question mark.
3. Be sure to initial each person's row.
4. The completed cells are there to help you think of things that might be in the water.

What is in the Water?

1. What is in the water? (Think about what goes down drains or washed into rivers)	2, Where did it come from?	3. How do we (or nature) remove it?	4. How could we (or nature) prevent or reduce it in the first place?	5. Initials
Trash				
	Yards, parks, farms, gardens			
		Bacteria eat it		
			Use phosphorous-free detergents or bio-degradable soaps	
Food Waste				
			Keep car well-maintained	

6.3 What is the problem?

_____

_____

Name:_____Hour: _____

Lesson #6: Water Treatment

Activity 6.4: How Does Nature Clean Up the Water?

Purpose: Not all pollution is from human sources. Nature has ways of cleaning up water that is polluted. This video will introduce you to one environment nature cleans water. Understanding how nature cleans-up water is important for understanding how waste water treatment plants work.

Directions:

2. Watch the video "Fabulous Wetlands."
3. Read the short paragraph below.

Wetlands as Nature's Water Treatment Plant

As water runs across the land in rivers and finds its way to lakes, it can pick up lots of material that can eventually cause harm to the plants and animals that depend on the water. Sediment (silt and sand) can cloud the water and make it so that fish and aquatic animals cannot breathe. Animals living in or near the water defecate in the water. Plants and animals also die in the water. All of these events can pollute the water. Nature needs a way to clean it up.

Wetlands serve many functions in the ecosystem, but one important function they serve is in cleaning the water. Water in wetlands moves very slowly. Any silt or sand carried into a wetland settles out. Plants that grow in the wetlands can absorb some of the natural pollutants, including the excess nutrients from decaying animals and plants. Many different types of bacteria live in the wetland soils and water. These bacteria will eat any organic waste in the water. The bacteria in the soils and muds thrive in environments that are low in oxygen. They are called anaerobic bacteria. When anaerobic bacteria feed, they produce hydrogen sulfide, which gives some wetlands a distinctive "rotten egg" smell. In wetlands, the water often has a high pH, making it slightly alkaline. As a result, some chemical reactions can occur that will cause some heavy metals (iron, copper, zinc) to precipitate out of the water. Finally, water slowly seeps through the wetland soils into the groundwater. This action filters the water even more and helps to recharge the aquifer with clean water.

Name:_____Hour: _____

4. Answer the following questions using what you saw in the video and what you read in the paragraphs above. You may work on these questions alone or as a group. Remember, however, that each person in the group is responsible for making sure that everybody in the group learns how water is cleaned up.

   a. What is a wetland? Describe it.

_____

_____

_____

_____

   b. List at least three reasons why wetlands are important.

_____

_____

_____

_____

   c. List at least three ways wetlands clean-up water naturally.

_____

_____

_____

_____

5. Grade your group – How do you know that everyone in your group understands how nature cleans up the water?

_____

_____

Name:_____Hour: _____

Lesson #6: Water Treatment

Activity 6.6: Order the Test Tubes

Purpose: What does waste water look like? The water in these tubes came from a waste water treatment plant. Each sample was taken from a different stage in the waste water treatment process. What order do you think they go in?

Directions

1. Do not open the test tubes!
2. Arrange the test tubes in order from dirtiest to cleanest.
3. Record the colors of the labels on the test tubes from dirtiest to cleanest:

Dirtiest: _____
_____
_____
Cleanest _____

Activity 6.7: Treating Waste Water

Purpose: In this activity you will model the steps of waste water treatment by cleaning some "waste water." This waste water contains: Gravel (called grit), cooking oil; bread crumbs (floaties); soap

Directions

1. Each person in your group is responsible for completing at least one step in the process.
2. Refer to the Waste Water Treatment Plant Diagram. Each step in the process matches a step on the diagram.
3. As you complete each step, complete the table below.
4. Notice that at step 2 you must let your "waste water" sit for a while to let the sludge settle out. While you wait, go to step 3 to read the Bacteria and Biological Oxygen Demand sheet and answer the questions. Then return to step 2.
5. After step 3 you will have to wait overnight.
6. When you return, compare the water in your test tube to water in the green test tube. How well did your water compare?

---

7. Which group had the cleanest waste water?

_____

8. Is this water clean-enough to put into the river? Explain your answer.

_____

_____

9. Would if be clean enough if it came from the waste water treatment plant? Explain your answer.

_____

_____

Name:_____ Hour: _____

10. Would you drink this water? Explain your answer.

_____

_____

11. Explain how your model is similar to a real waste water treatment plant.

_____

_____

_____

12. Explain how your model is different from a real waste water treatment plant

_____

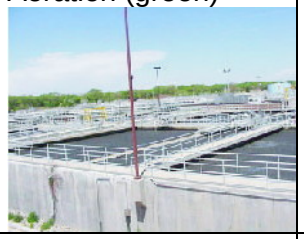
_____

_____

13. Compare your order of your color-coded waste water test tubes to the schematic diagram and correct their order, if necessary.

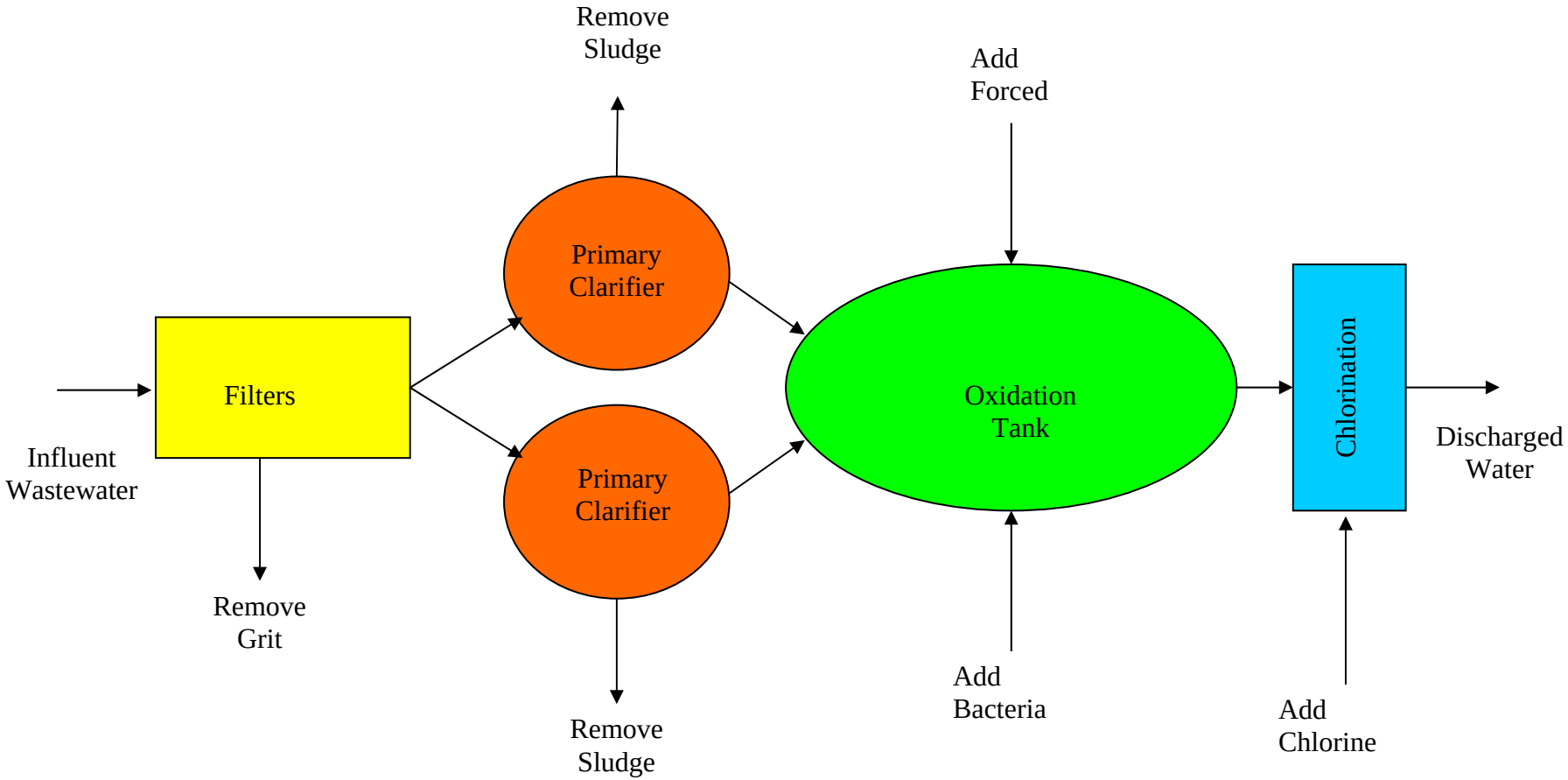
Name:_____Hour: _____

Waste Water Treatment Steps

Step #	Step Name	What to Do	What Happened? Describe what your water looks like now.	What was added to the water? Why?	What was removed from the water? What should be done with it?
1	Filter (Yellow) 	B. Pour the "waste water" through the screen into the empty beaker.			
2	Clarifier (Orange) 	D. Allow the water to settle in the beaker. While you wait, go to step 3. E. Blot up the oil on the top with the paper towel or scoop out with a spoon. F. Carefully pour off the water only into a test tube. Fill the test tube completely and stopper it.			
3	Aeration (green) 	F. Read the paragraphs about Biological Oxygen Demand G. Answer the questions H. Finish step 2 I. Add 1 tsp of bacteria & enzymes to your water. J. Let it sit overnight.			
4	Chlorination (blue) 	B. Add 5 drops of chlorine bleach to your water			

Name:_____Hour: _____

Waste Water Treatment Plant Schematic Diagram



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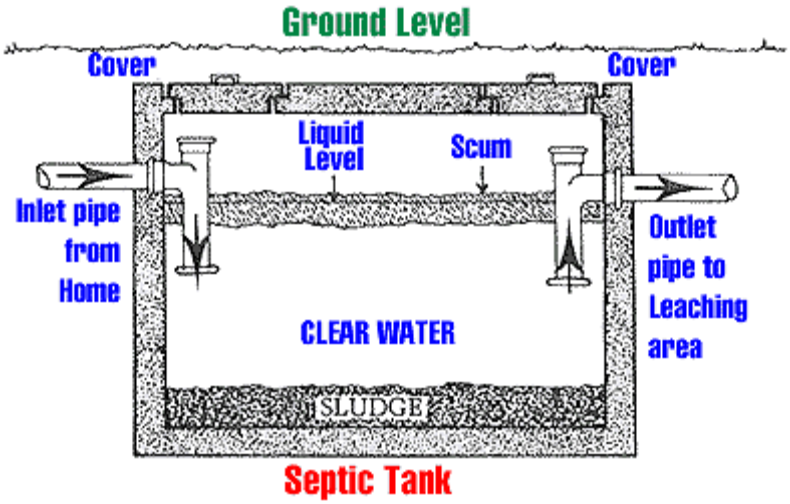
Lesson #6: Water Treatment

Activity 6.8 Bacteria and Biological Oxygen Demand

Bacteria break down the dissolved matter in waste water by using it as a source of food. You may remember from biology class that, in general, there are two classes of bacteria: aerobic bacteria which need oxygen in order to digest the dissolved waste and anaerobic bacteria which do not need oxygen.

Both types of bacteria use waste dissolved in the water as their food. There is an ongoing competition between the aerobic and anaerobic bacteria to see who gets to eat the dissolved waste. The more oxygen there is dissolved in the water, the better the aerobic bacteria will get at digesting the waste matter, at the expense of the anaerobic bacteria. The opposite is also true; when there is little oxygen dissolved in the water, the anaerobic bacteria take control.

Anaerobic bacteria work well for breaking down waste in places where there is little oxygen available, such as swamps and septic tanks. In septic tanks, waste water is piped into one end of an underground concrete tank. Anything more dense than water sinks to the bottom of the tank as sludge. Anaerobic bacteria feed on all of the organic matter. The water then flows out of the other end of the tank into the ground. Anaerobic bacteria release methane and hydrogen sulfide in the process of digesting waste matter. Hydrogen sulfide smells like rotten eggs, which is the smell we usually associate with sewage.



Name:_____Hour: _____

Both methane and hydrogen sulfide are poisonous to aerobic bacteria and to any form of life that “breathes” oxygen. Therefore, once anaerobic bacteria take control, they essentially kill just about every other form of life. For this reason, waste water treatment plants use aerobic bacteria to break down the dissolved waste. Engineers have worked out a way to increase the amount of oxygen dissolved in the waste water at the treatment facility. This way is called aeration and it means blowing air into the water. When air is forced through the water, some of the oxygen in the air is dissolved in the water. The rest of the air rises to the water’s surface as bubbles.

If there is only a little bit of waste dissolved in the water, the aerobic bacteria will need only a small amount of dissolved oxygen in order to digest the waste. The more waste there is in the water, the more oxygen is required in order to aerobically digest it. Therefore, from knowing how much oxygen is needed to break down the waste dissolved in some water using aerobic bacteria, we can tell how much waste there is (or was) dissolved in the water. Scientists call this measure of how much waste there is dissolved in the water BOD, which stands for Biochemical Oxygen Demand; it represents the amount of oxygen required to break down the dissolved waste in a given volume of water. A higher BOD means more dissolved waste or dirtier water. Water with a high BOD is water of poor quality.

Name:_____Hour: _____

Lesson #6: Water Treatment

Activity 6.8 Bacteria and Biological Oxygen Demand Questions

Purpose: This article will help you understand how bacteria are used to clean up waste water.

Directions:
1. Read the Biological Oxygen Demand Reader
2. As a group, discuss each question.
3. Decide on the best answer for each question.
4. Write down the best answer from the group.

Questions:

1. What is the difference between aerobic and anaerobic bacteria?

2. Explain why a septic tank uses anaerobic bacteria but a waste water treatment plant uses aerobic bacteria.

3. Explain why a waste water treatment plant uses aeration.

4. What happens to the BOD when there is more waste in the water? Explain why.

Name:_____Hour: _____

5. Does high quality water have a high or low BOD? Explain.

6. Explain how each member of the group contributed to the answers to the questions.

Group Member	**Contribution**

Name:_____Hour: _____

Lesson #6: Water Treatment

Activity 6.9: Drinking Water Treatment

Purpose: Waste water treatment and drinking water treatment are two different processes and happen at two different places. This activity will help you understand the differences.

Directions:
1. As a group, look at the two schematic diagrams of the waste water treatment plant and the drinking water treatment plant.
2. Complete the table below.
3. Be sure to record the initials of each person who adds to the table.

Drinking Water Treatment Plant			**Waste Water Treatment Plant**		
Step Name	**What Happens**	**Why**	**Step Name**	**What Happens**	**Why**
1			1		
1			2		
2			3		
3			4		

4. Answer the question in the table on the next page by yourself.
5. Compare your answers to the answers of the rest of the group.
6. If there is disagreement, discuss it as a group. Decide on the best answer.
7. Record the group answer next to your answer.
8. Finish the last question independently.

Name:_____ Hour: _____

Lesson #6: Water Treatment

Question	Your Answer	Group Answer
How are drinking water treatment and waste water treatment similar?		
How are drinking water treatment and waste water treatment different?		
Explain how the water from a waste water treatment plant might someday end up in a drinking water treatment plant		

What did you learn from this lesson about waste water treatment and drinking water treatment that you did not know before? Describe a situation in which this knowledge is useful.

_____

_____

_____

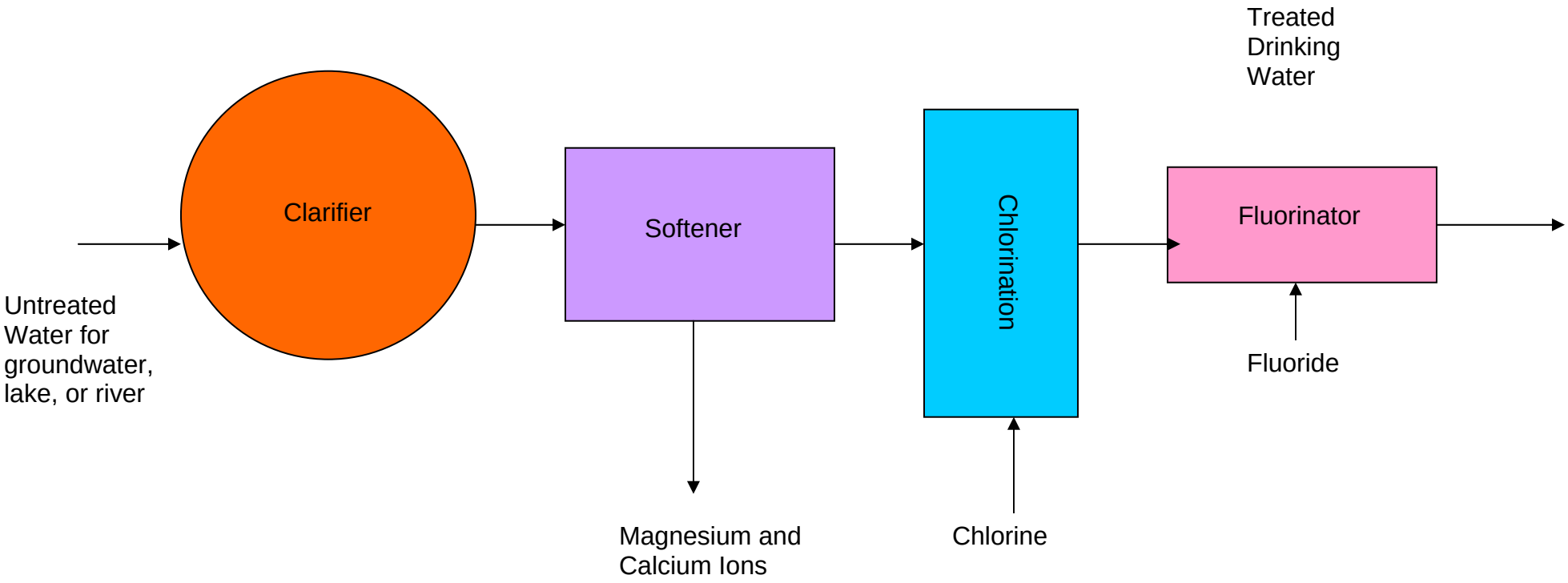
_____

_____

_____

Name:_____Hour: _____

Schematic Diagram of Drinking Water Treatment



Name:_____Hour: _____

Lesson #6: Water Treatment

Activity 6.10: Wetlands and Waste Water Treatment

Purpose: We saw a video about how wetlands clean water. We also looked at how waste water treatment plants work. Many of the processes are similar. How have people borrowed from nature to clean water?

Directions:

1. As a group, complete the table below.

	Wetland	Waste Water Treatment Plant
How is sediment removed?		
How is organic waste removed?		
How are chemicals removed?		

2. Working independently, make a concept map, diagram, or picture that shows how wetlands and waste water treatment plants are similar.