WATER SESSIONS

Materials provided by speakers from the following sessions:

- **Drinking Water Needs Standards for Green & Healthy Living**
  - What Is Your Standard?
- **Rain Barrel Use in Outdoor Classrooms**
  - Why a Rain barrel
  - Advantages of a Rain Barrel
- **Construct A Rain Barrel for Healthy Streams**
  - Rain Barrel Fact Sheet
  - Materials, Costs & Sources
- **Water-Wise Landscapes: Let's Play the Water Wise Guy Game**
  - The Water Wise Guy Game
- **Water Conservation: Making the Leap to Conserve Georgia's Water Resources**
  - Every Drop Counts

What Is Your Standard?

Grade:
Upper Elementary, Middle School

Subject Areas:
Science, Physical Education, Language Arts, Math

Duration:
90 minutes warm up and field activity. 30 minutes classroom activity

Setting:
Outdoors (preferred) or large open space indoors

Skills:
Organizing, Analyzing, Interpreting, Comprehending, Synthesizing, Application

Charting the Course:
The Warm-Up Activity from the Project WET lesson *Reaching Your Limits* done prior to this lesson helps students understand parts per million. Review the drinking water quality report,

Vocabulary:
bacteria, chemical, Clean 'Water Act, coagulation, Environmental Protection Agency (EPA), parts per million (ppm), parts per billion (pph), additive, Safe Drinking Water Act, sedimentation, virus, water quality standard, .filtration, disinfection

Summary

Students simulate Atlanta's drinking water treatment processes in order to better understand the effort and cost involved in meeting water quality standards.

Objectives

Students will:

- demonstrate the process used to meet Atlanta's drinking water standards through a physical activity.
- understand the relationship between water treatment and water quality standards.
- understand that there is a relationship between clean water and what it costs to keep the water clean and safe for drinking.

Assessments

- Give the students questions from the post-test - 8, 9, 10, and 11.
- Ask the students to write a story about what happened to them as "raw" water. What contaminants did they pick up? What additives did they pick up? Did the class meet the standard? How much did it cost the City to clean the water and where did the City get the money to do it? (Rubric)

Materials

- Copy of the Georgia Water Quality Report
- Ziplock bags labeled C for contaminant or A for additive
  ~ 1 C bag labeled and 1 A bag labeled per student
- Contaminant and Additive cards. It's best to laminate and color them.
- Small containers (buckets, bowls, bags, recycled containers) to hold the contaminants and additives. Provide one container for each contaminant and additive
- 1 student standards score card per person
- 1 contaminant total class and 1 additive total class score card per player ~ 1 pencil or crayon for each student
- Hula hoops/yarn or chalk to designate a circle around each contaminate and additive bucket or bag and make the contaminate circles different from the additive circles
- 1 large process card for each process labeled coagulation, sedimentation, filtration, and disinfection.
- 1 whistle for the Treatment Plant Operator
- Clips to affix contaminant and additive labels to each bucket, bowl, bag etc.
- 1 cup of "Chattahoochee River" water to begin the lesson (water should contain sediment, rocks, sand, leaves, and twigs)

Making Connections

Students may be aware that clean water comes from the faucet but they may have no idea how that happens and who sets the standards for safety and quality. They may not have thought about the connection between clean water, health, and cost to the consumer that comes with drinking water treatment.

Background

Each day the Atlanta Water System provides approximately 120 million gallons of treated drinking water to nearly 1 million residents in the Atlanta metropolitan area. All the water processed is surface water that is pumped from the Chattahoochee River. The raw water intake for the Chattahoochee and Hemphill Water Treatment Plants is located on the Chattahoochee River, north of Peachtree Creek. The Chattahoochee Plant receives the water directly from the river. The Hemphill Plant processes raw water that has been pumped from the river to a reservoir. These two plants supply about 75% of Atlanta's drinking water. The remaining water is supplied by the Atlanta- Fulton County Water Treatment Plant, which also processes water from the Chattahoochee River. This plant supplies treated (finished) water to the northeast area of the Atlanta distribution system.

Drinking water must meet or exceed all safety and quality standards set by the State of Georgia and the U.S. Environmental Protection Agency (EPA). Since 1970 the U.S. Environmental Protection Agency (EPA) has had the major Federal responsibility for protecting the quality of the American environment and controlling the effects of pollution on public health. There are also laws that help protect citizens concerning water quality. The Federal Water Pollution Control Act was amended and became a law that came to be known as the Clean Water Act in 1977. The Clean Water Act established the structure for regulating discharges of pollutants into the waters of the United States. It gave EPA the authority to implement pollution control programs such as setting wastewater standards for industry. The Clean Water Act also mandated requirements to set water quality standards for all contaminants in surface waters. The Act made it unlawful for any person to discharge any pollutant from a point source into navigable waters, unless a permit was obtained under its provisions. It also funded the construction of sewage treatment plants under construction grants programs and recognized the need for planning to address the critical problems posed by nonpoint source pollution (pollution carried by runoff during heavy rains that ends up in storm drains and eventually our waterways where the source is not easily identifiable).

Another law that protects our water quality in Georgia is the Safe Drinking Water Act (SDWA), which requires water systems to monitor for unregulated parameters in order to assist the EP A in determining where certain contaminants occur and whether additional regulations may be necessary. Annually, over 12,000 samples of untreated (raw) and treated (finished) water are collected and over 50,000 tests are conducted that screen for more than 150 potential contaminants. Water quality standards are set and contaminants are carefully monitored. Each contaminant has a standard or level at which in can be in the water without causing harm to human and aquatic health. The City of Atlanta Water System and the Atlanta Regional Commission (ARC) have done a source water assessment itemizing potential sources of surface water pollution to the drinking water supply. The results can be found at: www.atlantaregional.com!swap/

As Atlanta's stormwater travels over various surfaces it picks up contaminants along the way. These contaminants include: bacteria and viruses, pesticides and herbicides from agriculture and lawn care, stormwater runoff that carries many types of nonpoint source pollution, salts and metals from industrial or domestic wastewater discharges, oil and gas production, sediment from erosion and development, organic chemicals from urban runoff, septic tank pollutants, and radioactive waste from oil/gas production and mining.

To remove contaminants from the water, the raw river water enters the water treatment plant pipe. Control room operators add lime for pH control, potassium permanganate for disinfection, and powdered carbon

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for taste and odor control. Then the alum and other chemicals are added to the water causing coagulation to occur. Tiny sticky particles form that are called "floc" and the "floc" attracts other particles. The "floc" finally gets heavy and settles to the bottom during sedimentation. The clear water moves to the filtration process where water passes through filters that help to remove even smaller particles. The next step is disinfection where a small amount of chlorine is added to kill any remaining bacteria or microorganisms, phosphate to prevent any corrosion contamination, and fluoride to prevent tooth decay. Water is then placed in a closed tank or reservoir and sent on through the water delivery system that takes water to homes, schools, and businesses in the community.

Procedure:

WarmUp

Begin by asking students if they have standards they set for themselves. Write their answers on a board. Then explain that there are also standards for water quality that are set by laws and by the State of Georgia. Consider using the warm up activity in the lesson *Reaching Your Limits* from the Project WET Curriculum and Activity Guide. The warm up activity gives students a visual of what parts per million might look like. Since removing all the pollutants is economically impractical, explain that the government sets standards to define how much of each pollutant is allowable in the water while remaining at safe levels for human health. Most of these standards are set in parts per million (ppm) or parts per billion (ppb). Hold up the glass of Chattahoochee River water and ask students if they would like to drink it. Ask them why they wouldn't like to drink it. Tell the students that it is easy to say no when you see the sediment, rocks, wood, litter, debris etc. but you also want to be cautious of possible contaminants and bacteria that cannot be seen. Therefore water treatment is needed. You can ask students what has to be done to the Chattahoochee River water prior to becoming the drinking water that comes from their faucets.

The Activity (Field)

1. Tell students they are going to do an activity that simulates the effort required to clean Atlanta's water for drinking and meeting water quality standards. Ask students to brainstorm possible contaminants they might find in raw water prior to water treatment. Tell them they are going to be raw water from the river and they are going to go through water treatment. They will be trying to get rid of their contaminants and they are going to be picking up the additives.

2. Use the contaminant/additive copy pages and copy enough contaminants so that each student will have at least 14 contaminants in their zip lock contaminant bags and at least one additive each to be picked up in the additive areas. Students will need to make 21 stops if they are to get contaminants cleaned and get the additives needed. Give each water student a zip lock bag that has the contaminants (14) in it. Ask students to find a contaminant in their bag and read it to the class. Ask the class where the contaminant might come from. You can have students do research on the contaminants by going to http://www.epa.gov/safewater/hfacts.html Do this until you have covered the contaminants. The water students will also have a zip lock bag that has nothing in it. This is the additive bag and will be used to gather all the additives, one card for each additive. Use a hula-hoop to start the action. Have water students begin play by moving through the hula-hoop that has been placed vertically at the beginning of the field area to represent a pipe coming into the water treatment plant carrying raw water from the river. Students will enter the field area one at a time while the plant manager holds the hula-hoop in a vertical position.

3. Designate a field area for the water treatment facility and place cones around the perimeter of the water treatment/field area. Make the field area large enough to accommodate the 14 contaminant containers and the 7 additive containers and enough space for students to move around freely, the larger the space, the more difficult the challenge to clean the water. Place 14 buckets/bags in the center of the field randomly that have a different contaminant label on each container. (See field diagram). Place the hula-hoops or yarn around the designated contaminant or additive buckets in the field. Make the additive area look different from the contaminant area. Use different colored hoops or yarn to help students distinguish between contaminants and additives.

4. Set up 4 additives near the beginning of the water treatment facility/field area placed randomly and labeled, carbon, lime, potassium, and alum and 3 near the end of the treatment process to represent the additives in the disinfection area. Label each of these three additives, fluoride, chlorine, and phosphate. Each hoop area container has its own label. Place a container or bag in each hula-hoop to hold the additives that each student must get in their travels or just put the additive cards on the ground if it is not windy. There should be at least one additive card for each student in the container/hoop area. Students will pick up one additive from each area and add it to their additive bag during treatment.

5. Select a Water Treatment Manager. The remaining students in the class will represent raw water in the field activity and the water treatment budget in the class portion of the activity. The Water Treatment Manager is in charge of the process moves. The Water Treatment Manager begins by having everyone enter the field through a hula hoop to represent water moving through a pipe from the river. Water students will also leave the field through a hula hoop at the end of the treatment process for distribution
to homes, schools and businesses. The Treatment Manager will collect all the contaminant score cards after the water students have filled them out. Managers are held accountable for standards and for any fines.

6. Select a time keeper (this can be done by the teacher or the plant manager) and you can give the water students 3-5 minutes to move through the treatment plant. However if it is too easy, you can reduce the time factor or make the field area larger. To provide more safety you can have the students walk through the water treatment facility.

7. Students are given these instructions: "You are now "raw" water moving through water treatment and you will need to get rid of the contaminants in your bag if you can in the next few minutes. You will walk/run to the buckets and drop in the contaminant that is labeled for that bucket. Fecal Coliform goes in the Fecal Coliform bucket and Oil goes in the Oil bucket for example. You will also notice that you have to get some things in your journey. These are additives that the treatment plant puts in the water to disinfect, or to protect your teeth or to make the water clump together for example. The additives are in the containers in the hula-hoops. There are 7 additives, 4 up near the front of the treatment process (Pre-Treatment) that include: lime, alum, potassium; and carbon, and three before water leaves the treatment plant (Post Treatment) as "finished" water. Water students will need to get one of each of these additives and put it in their additive bag: alum, lime, potassium, carbon, chlorine, phosphate, fluoride (7 additive areas in the field). At the same time you are moving, you will go through the treatment process. The Water Treatment Manager will blow a whistle and say" coagulation". That means that something is added to the water to create a clumping of particles that is called "floc". Students will need to find 2 partners and walk in hand to the next stations. Then the water treatment manager will blow a whistle and will say "sedimentation." Students will sit down and count to 10, which represents the settling of particles on the bottom. (Students are no longer holding hands in groups when they sit down) Then at some point in the process the water treatment manager will blow the whistle and say "filtration." Students will need to circle at least 3 other students to represent filtration
of the water. Finally the water treatment manager will blow the whistle and say "disinfection." All raw water students must go to the 3 hula hoops at the end of the field and gather phosphate, chlorine, and fluoride before going to storage tanks and then to homes, schools, and businesses. If students have released contaminants and have all their additives they can pass through the pipe (hula hoop) at the end of the treatment plant (field) area. The timekeeper calls time.

8. At the end of the time period each finished water student will count the contaminants in their bag and record (check them) them on the contaminant score card. They will also record the additives they do not have. If any additives are missing, put an X on those that are missing. If time permits, students can do a second round of treatment. All water students will need to put the additives back in the hula-hoop areas and get their 14 contaminants back in their contaminant bucket!
bag. After the second round, Water Treatment Plant Managers will collect all the score cards to compile the data and see if they have met standards.

The Activity (Classroom)

8. The teacher will tell the class that they are now all part of the water treatment facility and have a budget for the year. The water treatment facility budget is $10,000 for the year. Each person in the class will work with the teacher to add up the fine for any standards not met. Ask the students to look at their contaminant and additive score cards. The teacher will remind students that water treatment must meet water quality standards set by the State and by EPA. The teacher will ask the class to look at their score cards and raise their hand if they had oil left as a contaminant not cleaned and record the total number on the board and continue to put the class totals down for each contaminant. Note on the contaminant score card that each contaminant has a standard and it will say 20 ppm or 10 ppm for example. That means in this activity that the treatment plant cannot exceed more than 20 ppm of that contaminant or it will not be an acceptable standard and be considered unsafe and unhealthy for consumption and out of compliance With the law. Therefore the plant will be fined according to the amount listed for every number over 20. If Oil is listed at 12 ppm and the class had 10 Oils total, the treatment for oil met standards. However if the standard for oil is 10 ppm and the class totaled 15 ppm, the Oil is **(10-5 = 5)** or 5 over the limit. The fine is $10.00 for each number over the standard. The treatment plant is fined 5 X **$10.00 = $50.00** just for oil. Ask the students to get out their Treatment Plant Worksheet. Work through the rest of the totals for each contaminant with the students.

9. The worksheet will have the contaminant category total and the allowable standard. Does the contaminant total exceed the standard? If so, subtract the number over standard from the total. Then multiply that number times the amount of money owed for each number over standard and you will have the total owed for that contaminant. The teacher can help students with the grand total owed by listing the amount of money owed for each contaminant and then totaling this amount. For every additive missed add another $10.00. If one person missed 4 additives then that person adds $40.00 to the total.

10. If the class played 2 rounds, the second round of play will also have to be added to the first total. When the total fine is assessed then the treatment plant will determine if they can pay the fine within their budget. ($10,000 for the year)

Wrap Up

Each standard has a number of parts per million that is acceptable. If they go over that number during treatment they will be fined by the State EPD (Environmental Protection Division-EPD) They will add up the money that must be paid if they are out of compliance and not able to clean the water. The Water Treatment Plant has no money in the budget to pay a fine so EPD will send the fine to the Mayor. The Mayor will go to the City, the Department of Watershed Management, and ask for the funds. If the City cannot pay the fine, the Mayor and City Council will have to find another way to pay it, which could include a rate increase for citizens. Students can role-play using actors for the City and the Mayor, City Council, and residents. The students in their roles can decide how they will pay for the water treatment upgrades. The Mayor and City Council will have to make the final decision if no one else has a plan.

Centennial Elementary 4th grade students pilot *What is Your Standard?* Activity (coagulation)

What is Your Standard Rubric for Assessment

Assessment 2: Ask the students to write a story about what happened to them as "raw" water. What contaminants did they pick up? What additives did they pick up? Did the class meet the standard? How much did it cost the city to clean the water and where did the city get the money to do it?

Category	4	3	2	1
Organization	Information is very organized in a well constructed story; each paragraph has a clear introduction, ewlanation, and conclusion.	Information is organized in a fairly well constructed story. Most paragraphs have an adequate introduction, explanation, and conclusion.	The paragraphs contain related information, but the story is not well constructed. Introduction, explanation, and/or conclusion sentences are frequently missing.	The information is disorganized. Paragraph structure is not clear and sentences are not typically related within the paragraphs.
Comprehension	Student is able to clearly demonstrate the process used to meet drinking water standards, including the roles of contaminants and additives.	Student is able to demonstrate the process used to meet drinking water standards and the roles of contaminants and additives for the most part.	Student is only partially successful in demonstrating the process used to meet drinking water standards OR only partially understands the roles of contaminants and additives.	Student is unable to successfully demonstrate the process used to meet drinking water standards AND does not understand the roles of contaminants and additives.
Comprehension	Student completely understands the relationship between water treatment and water quality standards.	Student mostly understands the relationship between water treatment and water quality standards.	Student partially understands the relationship between water treatment and water quality standards.	Student does not understand the relationship between water treatment and water quality standards.
Comprehension	Student clearly understands the economic costs of clean water.	Student mostly understands the economic costs of clean water.	Student partially understands the economic costs of clean water.	Student does not understand the economic costs of clean water.

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Field Diagram For What's Your Standard?

Raw water students enter the field through a hula hoop/pipe. The pipe is the hula hoop in a vertical position where students enter the water treatment plant/field. Additive and Contaminant containers are put inside the hula hoop area or yarn in a circle or chalk circle.

O Raw water students enter the field/water treatment facility.

4 Additives in area where students first enter treatment: (forward field placement)

A Lime A Potassium Permanganate

A Alum A Powdered Carbon

Students pick up additives in this area

Contaminants

C C C C

C

C C

C

C

C

C

C

C C

Place 14 contaminant containers in a random pattern throughout the field area and add a yarn or hula hoop to designate the area. Label the containers by clipping on the contaminant or additive card label on the bucket

3 Additives for disinfection area:

A Phosphate A Chlorine A Fluoride

O Students exit field through pipe (hula hoop) to leave water treatment area and go to clear wells, a pumping station, and a storage tank before delivery to homes, schools, and businesses.

Additives For Water Treatment:

Lime _____ (pH control)

Potassium Permanganate _____ (disinfection)

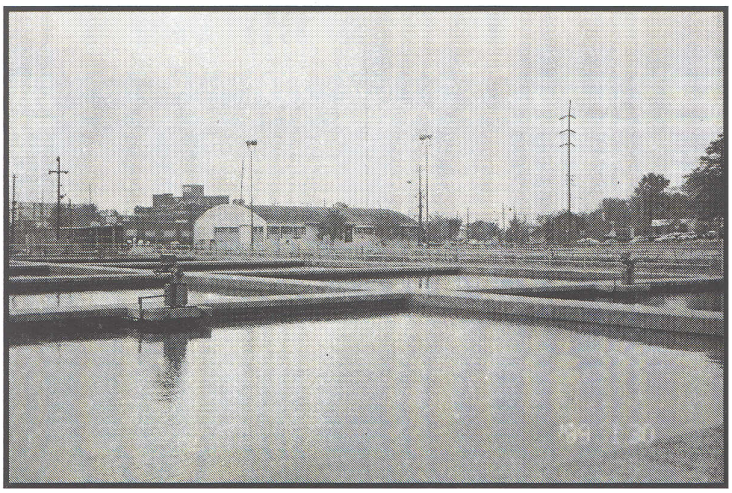
Powdered Carbon _____ (taste and odor control)

Alum _____ (coagulation of water! clumping)

Phosphate _____ (corrosion control)

Chlorine _____ (disinfection)

Flouride _____ (tooth decay prevention)



Atlanta Water Treatment Facility Today

Student Standards Scorecard

Contaminants: Put a check by the contaminants that are STILL IN your bag at the end of the activity.
Oil
Gas
Fertilizer
Pesticide
Lead
Copper
Arsenic
Fecal Coliform
Cryptosporidium
Viruses
Turbidity
Fluoride
Chlorine
Barium

Additives: Put a check by the additives that are NOT IN your bag at the end of the activity.
Lime
Potassium Permanganate
Powdered Carbon
Alum
Phosphate
Chlorine
Fluoride

Contaminant Total Class Scored

Contaminant	Class total for this contaminant	Standard	Is your class total more than the standard for this contaminant? (If your answer is "No", then go to next contaminant)	If you answered "Yes", then calculate: (class total) - (standard) =	Multiply your calculated answer by $10 to get the amount you owe. If the contaminant is marked Very toxic, multiply by $10001
Oil (chemical found in water: Xylene)		10 ppm			
Gas (chemical found in water: Dioxin)		Oppm			
Fertilizer (chemical found in water: Nitrate)		10ppm			
Pesticide (chemical found in water: Alachlor)		2ppb			Very Toxic Contaminant!
Lead		15 ppb			Very Toxic Contaminant!
Copper		1ppm			
Arsenic		10 ppb			Very Toxic Contaminant!
Fecal Coliform		0			
Cryptosporidium		0			
Viruses		0			
Turbidity		1NTU			
Fluoride		4ppm			
Chlorine		4ppm			
Barium		2ppm			
TOTAL amount OWED					$

Remember that Chlorine and Fluoride can be BOTH contaminants AND additives! Standards are based on the EPA's National Drinking Water Regulations, which can be found at www.epa.gov/safewaterlmcl.html

Student Copy Page

Additive Total Class Scorecard

Additive	Number of students that did NOT use this additive	Multiply this number by $10 to get the amount you owe
Lime		
Potassium Permanganate		
Powdered Carbon		
Alum		
Phosphate		
Chlorine		
Fluoride		
TOTAL amount OWED		$

Remember that Chlorine and Fluoride can be BOTH contaminants AND additives!

Combined total of Contaminant and Additive costs = _____

This is the fine owed by the Water Treatment Plant!

Is there enough money in the Water Treatment Facility Budget to pay the fine?

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