Water Quality Module
Kaizen: Continuous Improvement

I. Introduction: How Clean Is the Water?

(Activity adapted from "Water Filtration", from Safewater published by EPA.)

Background: Water pollutants are defined as anything that reduces the quality or purity of water. These pollutants are typically grouped into ten major categories: industrial wastes, agricultural wastes, bacteria, petroleum products, hazardous waste, heavy metals, sediment, air pollution, soil pollution, and thermal pollution. In order to make polluted water safe for human consumption it must be purified or cleaned. This process typically consists of aeration, coagulation, sedimentation, filtration, and disinfection.

The following websites give additional information on the categories, sources, and methods of water pollution:

- http://www.ewashtenaw.org/content/dc_st_appendixb.pdf
- http://library.thinkquest.org/C0111040/Types/water.php
- Http://library.thinkquest.org/C0111040/Popups/pop_table_water1.htm

Subject Area: Practical Living, Science, Social Studies

Kentucky Connections:

- Learner Goals: #1, #2, #6
- Academic Expectations: 1.3, 2.1, 2.3, 2.10, 2.31, 6.1,
- Core Content 4.1: PL-06-3.1.05, PL-07-3.1.05, PL-08-3.1.05 SC-06-1.1.1, SC-06-1.1.2, SC-06-4.7.1, SC-07-1.1.1, SC-07-4.7.1, SS-06-4.4.1, SS-06-4.4.2,

Materials:

- Polluted water from a ditch, pond, old aquarium, or a similar source.
- Ring stand with 3 inch ring (borrowed from science class)
- 3- Two liter plastic soft drink bottles: One with a lid, one with the bottom cut off, one with the top cut off
- 2- One liter beakers
- 2 tablespoons of alum (potassium aluminum available at the grocery store)
- 1 ½ cups fine sand

- 1 ½ cups coarse sand
- 1 cup small pebbles
- 1 piece filter paper (coffee filter may be used)
- 1 rubber band
- Stirring rod
- Tablespoon
- Clock or watch with a second hand. (A stopwatch may be used if available.)

Length of Lesson: One 60 minute class period

Vocabulary Words:

- Pollutant: Foreign impurities that degrade the quality of water.
- Aeration: Process that allows trapped gases in water to escape and adds oxygen to water.
- Coagulation: Process by which dirt and other suspended solid particles chemically stick together.
- Sedimentation: Process that occurs when gravity causes the solid particles to settle out of solution.
- Filtration: A process of passing a liquid through a filter to separate solid particles from the liquid.
- Disinfection: Process that destroys or prevents the growth of disease-carrying bacteria.
- Filtrate: Liquid that has been passed through a filter.
- Floc: Clumps of alum and sediment.
- Settling beds: Large vats used by water treatment plants for separating floc from the water.

Essential Question: How do municipal water plants purify water for drinking?

Guiding Questions/Outcomes:

- Students will construct a model of a filtration system.
- Students will be able to describe the five steps of the filtration process.

Skills Used:

- Analyze
- Collect
- Communicate
- Discuss
- Observe

Activity:

- Construction of filter using a two liter bottle with the bottom cut off:
    - Remove the cap from the bottle and discard.
    - Use a rubber band to attach the filter paper to the neck of the bottle covering the small opening.
    - Turn the bottle upside down and inset the narrow end through a 3 inch ring supported by a ring stand.
    - Pour one cup of pebbles into the inverted bottle.
    - Pour the coarse sand over the pebbles.
    - Pour the fine sand over the layer of coarse sand.
    - Place the 1 L beaker under the bottle to catch the filtrate
    - Using half a liter at a time, carefully pour at least 3 L of clean water through the filter. Empty the beaker between each half liter.

- Aeration:
    - Carefully pour one liter of the polluted water into a two liter bottle with a cap. Students should record the appearance and odor of the polluted water on their data sheet.
    - Place the lid on the bottle and shake vigorously for 30 seconds to aerate the water.
    - Remove the lid and continue the aeration process by pouring the water back and forth between the bottle and a 1 L beaker ten times.
    - Continue the mixing until all bubbles are gone.
    - Pour the aerated water into the bottle with its top cut off.

- Coagulation:
    - Add two tablespoons of alum to the aerated water.
    - Stir slowly for 5 minutes.
    - Particles in the water should begin to cling together forming a floc.

- Sedimentation:
    - Allow the water to stand undisturbed for 20 minutes.
    - Observe the appearance of the water at 5 minutes intervals and record your observations on your data sheet.
    - Treatment plans have settling beds that collect floc that floats to the bottom allowing clean water to be drained from the top of the bed.

- Filtration:
    - After 20 minutes carefully decant (pour off) half the water on top of the floc.
    - Pour this water through the filter.
    - Collect the filtrate in the beaker.
    - Compare the treated and untreated water.

- Disinfection:
    - Chemicals that are used as disinfectants are caustic and require special handling.
    - The teacher may decide to do a class demonstration of this process using chemicals available for treating water in swimming pools.

Assessment:

- Have students create a poster illustrating the steps in the water treatment process.

Extensions:

- Plan a field trip to the local water treatment facility.
- Invite guest speakers to discuss the local problems dealing with water pollution.

***<u>**Remember to recycle or reuse all plastic soft drink bottles after completing the activity.**</u>

TMMK Connection

1. TMMK has an on-site waste water treatment plant for treating industrial wastewater before it is released to the Georgetown Municipal Water and Sewer Service, Wastewater Plant #2. Treatment consists of coagulation with lime to remove the heavy metals followed by sedimentation, and finally filtration.
2. Sanitary sewage is piped separately to the Georgetown Wastewater Plant #2.
3. Wastewater from TMMK accounts for 85% of the flow to the Georgetown plant. Communication between TMMK and Georgetown Water and Sewer Service is constant and necessary to ensure proper treatment of all wastewaters. The Georgetown Wastewater plant consists of primarily biological treatment, followed by a new system of carbon and resin filtration, before a final effluent disinfection with ultra-violet light. The carbon strips the wastewater of organic compounds while the resin focuses on metals removal. This treatment plan has been very effective in treating the wastewater before discharge to Lane's Run Stream.
4. All chemicals used at TMMK are piped above ground to prevent leaks from contaminating the ground water.
5. TMMK's Environmental Management System requires chemicals to be loaded or unloaded only in contained dock areas to prevent spills from entering the environment.
6. TMMK's Environmental and Safety Sections approve all chemicals coming into the TMMK plant. All chemicals are screened for environmental impact, containment procedures, and effect on wastewater treatment.
7. Stormwater run-off from parking lots and rooftops drain into one of four retention ponds for control of flow. The outfall pipe provides a perfect point to sample and test the stormwater once a month during a rain event. In the event of a leak or spill to the stormwater system, the ponds can provide containment. The water can be treated on the spot or pumped out and treated in the wastewater treatment plant.
8. TMMK conducts quarterly tests on 28 groundwater wells and 3 streams to compare levels of organics and metals with previously established baselines. Some of the groundwater wells are located as much as ½ mile from the plant.
9. Groundwater sumps located throughout the plant are tested monthly to ensure containment integrity around different processes.

Student Data Sheet

Name _____

Date_____

1. Describe the appearance and odor of the polluted water.

2. What was the purpose of the vigorous mixing of the polluted water during the aeration process?

3. What is floc?

4. Sedimentation table

Time	Appearance
0 minutes	
5 minutes	
10 minutes	
15 minutes	
20 minutes	

5. Comparison of treated and untreated water.

	Untreated Water	Treated Water
Odor		
Physical Appearance		

II. TMMK fieldtrip observations:

1. What are the two categories of industrial wastewater produced by TMMK?
   1. _____
   2. _____

2. There are three separate sources of wastewater piped to Georgetown Municipal Water and Sewer Service, Wastewater Plant #2 by TMMK. What are they?
   1. _____
   2. _____
   3. _____

3. TMMK is committed to the reduction of water consumption in the plant. Give one example.

_____

4. Why is it important for TMMK to establish a baseline of water pollutants in the ground water and streams surrounding the plant: _____ _____

_____

5. Paint Shop uses a phosphate dip for car bodies. Why? _____

III. Conclusion: How Clean Is the Water?

Background: Two common ions found in polluted waterways are nitrates and phosphates. Common sources for nitrates are animal wastes and fertilizer. Fertilizers and detergents produce phosphates. Both pollutants are considered to be nutrient pollutants causing an overgrowth of aquatic plants especially algae. In central Kentucky, phosphorus is also occurs naturally in the soil and rock layers.

Algae, simple non-vascular aquatic plants, contain the green pigment chlorophyll and produce their food by photosynthesis. Excessive amounts of nutrient pollutants stimulate rapid algae growth resulting in the takeover of large areas of water by masses of blue-green algae. This rapid increase is followed by a decrease in the oxygen level in the body of water. Decomposition of dead algae further consumes the oxygen dissolved in the water and increases the mortality rate of the flora and fauna found in the aquatic ecosystem. At the same time, the decomposition of algae, aquatic plants and animals will turn the water murky and may eliminate large numbers of aquatic organisms.

Subject Area: Science, Social Studies, Writing, and Math

Kentucky Connections:

- Learner Goals: #1, #2, #5, #6
- Academic Expectations: 1.1, 1.2, 1.3, 1.11, 2.1, 2.30, 5.1, 5.4, 6.1, 6.3
- Core Content 4.1: Ma-06-1.1.1, MA-06-1.1.3, MA-07-1.1.1, MA-07-1.1.3, MA-08-1.1.1, MA-08-1.1.3, SC-06-4.6.2, SC-06-4.7.1, SC-07-4.6.4, SC-07-4.7.1, SS-06-3.1.1, SS-06-3.3.1, SS-06-3.4.1, SS-06-3.4.2, SS-06-4.4.2, SS-06-4.4.4, WR-M-1.1.0, WR-06-1.1.3, WR-07-1.1.3, WR-08-1.1.3, WR-M-1.2.0, WR-06-1.2.3, WR-07-1.2.3, WR-08-1.2.3, WR-M-2.3.0, WR-06-2.3.3, WR-07-2.3.3, WR-08-2.3.3, WR-M-2.4.0, WR-06-2.4.3, WR-07-2.4.3, WR-08-2.4.3, WR-M-3.5.0, WR-06-3.5.3, WR-07-3-5-3, WR-08-3.5.3, WR-M-3.6.0, WR-06-3.6.3, WR-07-3.6.3, WR-08-3.6.3

Materials:

- 4 plastic water bottles (soft drink bottles)
- Laundry detergent with phosphates
- Laundry detergent without phosphates

- Lawn fertilizer
- Distilled water
- Pond water/lake water (Water from a classroom aquarium may also be used.)
- Graduated cylinder (obtained from the science lab)

Length of Lesson: The activity will require six days to complete. The first day will require one 60 minute class period to set up the activity. The next 4 days will require five minute observations at the end of a regular class period. The sixth day will require approximately 30 minutes.

Vocabulary Words:

- Algae: A form of various chiefly aquatic, eukaryotic, photosynthetic organisms, ranging in size from single-celled forms to the giant kelp.
- Nutrient pollutants: An element or compound, such as nitrates and phosphates, necessary for plant growth. In water, too many of these nutrients may cause excessive plant growth resulting in pollution.
- Phosphates: Compounds containing a phosphate group (PO_4^{-3}).
- Nitrates: Compounds containing a nitrate group (NO_3^-).
- Point source pollution: Pollution that can be traced to a single point source, such as a drainpipe.
- Nonpoint source pollution: Pollution that cannot be traced to a single point because it comes from a widespread area.

Essential Question: What effect do detergents and fertilizers have on algae growth in water?

Guiding Questions/Outcomes:

- Students will be able to identify common examples of nutrient pollutants.
- Students will evaluate the amount and types of pollutants common detergents produce.

Skills Used:

- Observation
- Measurement
- Collecting Data
- Analyzing Data
- Graphing
- Observation

Activity: Divide the students into groups of six. Further divide the small groups into three groups of two. Designate these as group A, B, and C. Group A will conduct the experiment using detergent with phosphates, Group B will conduct the experiment using detergent without phosphates, and Group C will conduct the experiment using lawn fertilizer. During the week of observations, all six students will observe and record data for each of the three nutrient pollutants.

- **Day 1**:
    - Each Group of students will obtain 50 mls of their assigned nutrient pollutant.
    - Prepare the following solutions
        - 10 ml of 100% nutrient pollutant.
        - 10 ml of 75% nutrient pollutant (7.5 ml of pollutant and 2.5 ml of distilled water)
        - 10 ml of 50% nutrient pollutant (5 ml of pollutant and 5 ml of distilled water)
        - 10 ml of 25% nutrient pollutant (2.5 ml of pollutant and 7.5 ml of distilled water)

    - Obtain 5 plastic bottles
        - Label one bottle as Control
        - Label one bottle 100%
        - Label one bottle 75%
        - Label one bottle 50%
        - Label one bottle 25%

    - Add the following solutions to each bottle
        - Control: 400 ml of distilled water and 50 ml of pond water
        - 100%: 400 ml of distilled water, 50 ml of pond water, and 10 ml of 100% pollutant
        - 75%: 400 ml of distilled water, 50 ml of pond water, and 10 ml of 75% pollutant
        - 50%: 400 ml of distilled water, 50 ml of pond water and 10 ml of 50% pollutant
        - 25%: 400 ml of distilled water, 50 ml of pond water, and 10 ml of 25% pollutant

Place all bottles in direct sunlight or under strong artificial light.

- **Day 2**:
    - Each student should observe all bottles prepared by their group.

    - Students should record their observations on the Student Data Sheet
- **Day 3**: Repeat activities from Day 2.
- **Day 4**: Repeat activities from Day 3.
- **Day 5**: Repeat activities from Day 4.
- **Day 6**:
    - Repeat activities from Day 5.
    - Empty all bottles.
    - Save bottles for reuse or put them in the recycling bin.
    - Complete the questions on the Student Data Sheet.

Assessment:

- Ask the students to list the different types of detergent found in their home. Have them list the concentration of phosphates and nitrates in each one. Which detergent would cause the least amount of damage to water?
- Write an advertisement/commercial for the most environmentally friendly product.

TMMK Connection

1. TMMK dips the car body in a phosphate solution to prevent rusting. The excess phosphates are removed during treatment in the on-site wastewater treatment plant.
2. All project proposals undergo an Environmental Impact Assessment before being approved by Environmental Engineering.

Student Data Table
Detergent with Phosphate

Bottle	Amounts	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Control	0% pollutant						
25%	25% pollutant						
50 %	50% pollutant						
75%	75% pollutant						
100 %	100% pollutant						

Student Data Table
Detergent without Phosphate

Bottle	Amounts	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Control	0% pollutant						
25%	25% pollutant						
50 %	50% pollutant						

75%	75% pollutant						
100 %	100% pollutant						

Student Data Table
Detergent with Phosphate

Bottle	Amounts	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6
Control	0% pollutant						
25%	25% pollutant						
50 %	50% pollutant						
75%	75% pollutant						
100 %	100% pollutant						

1. Which detergent had the smallest amount of algal growth?

2. Which bottle had the greatest amount of algal growth?

3. Which detergent produced results most similar to the fertilizer?

Conclusion:

4. What affect does the amount of nutrient pollutant have on algal growth?