Water Treatment- Would You Survive the Elements?

Overview

- Wastewater treatment facilities play an important role within a community as it purifies the water. In this activity, students will conduct a small scale version of water purification. The sample they use will be from the creek that is on campus near the greenhouse on campus. Wastewater treatment plants purify water from our residential homes in a multi-step process. Students are going to go through this multi-step process with some regular household items and observe how water is purified through a wastewater treatment center. Students get to have a hands-on experience to see how difficult it truly is to separate contaminants like phosphates, nitrates, and more.

Key Search Words

- Water quality, pollution, conservation, compounds, earth and environmental science, middle grades science, secondary science, stewardships, human impact, biosphere, rivers, basin, watershed

Learning Objectives

- Students will be able to describe how human interaction affects aquatic life.
- Students will be able to describe humans' environmental impact and ways to improve it.
- Students can explain the differences between fresh and wastewater treatment processes.
- Students can interpret how humans and the environment influence each other.

Curriculum Alignment

NGSS Standards:

- *HS-ESS3-1: Construct an explanation based on evidence for how the availability of natural resources, occurrence of natural hazards, and changes in climate have influenced human activity.*

NC Common Core Standards:

- *EEn.2.4.2 Evaluate human influences on water quality in NC's river basins, wetlands, and tidal environments*
- *EEn.2.8.2 Critique conventional and sustainable agriculture and aquaculture practices in terms of their environmental impacts*

Classroom time required

- 55-70 minutes

Materials & Technology

- Cleartouch
- Lenovo Thinkpad
- 4 Liters of *creek water (Water supply from a local creek)*
- 2 Liter soda bottle with its cap attached
- 2- 2 Liter soda bottles with one having the bottom cut off and the second one will have the top cut off
- 1 large beaker that can hold 2 cups of water.
- 2 tablespoons of alum
- 1 ½ cup of fine sand
- 1 ½ cup of course sand
- 1 cup small pebbles
- 1 coffee filter (any size)
- 2 rubber bands
- 1 tablespoon
- Stirring rod
- Stopwatch
- Science journals

Safety

- Students will be provided with the following PPE for the in-class activity: gloves, goggles, and possibly lab aprons when handling some of the materials.

Teacher Preparation for Activity

- The teacher should have all items on hand a few days before the activity. Make sure to collect enough empty bottles beforehand. Ask around the building for the recycling to determine where to locate them.
- Collect the sand samples from the local beach department store to have enough for all class periods.
- Have some notes to review before the activity if students need some sort of review.

Student Preparation for Activity

- Students should have a common knowledge or some background knowledge on water ecosystems and the different methods in water purification.
- They should have been taught this material in early middle school and later reinforced.
- Students should make sure to wear closed toed shoes and wear the appropriate clothing for the activity.

Procedure

- Step 1: Introduce the activity with a probing question pertaining to their own water source they may receive at home. In areas out in the country, what type of water system do they have at home and how does it affect their daily tasks? Explain the importance of water and how without water, there would be no life like the planet Mars (that we know of). Have a student read the background information on the handouts. Students should focus on water filtration through the following processes like aeration, coagulation, sedimentation, filtration, and disinfection.
- Step 2: Students will be split into small groups of 2-3 students. There should be all of the activity items at each group station when the students arrive. They will be asked to demonstrate some of the procedures that the local water treatment plants might use to purify the water of some harmful chemicals.
- Step 3: Have one student from each group grab two empty 2L bottles. Instruct them to walk outside to the agriculture building and make a visit to the creek that is found on campus. Students are going to fill both 2L bottles with creek water and use that as their sample. Once all groups have the samples required we will return to class to conduct the activity.
- Step 4: Once all students have the necessary items and understand the challenge at hand, they will need to purify a water sample from the creek. The sample found near the greenhouse on campus is put into the empty 2 liter soda bottle that has not been modified. Once they have it poured out, have the students observe, describe, and illustrate the appearance of the creek water.
- Step 5: Students will then begin their process, where the first step in the treatment of the water is to add air to the water sample, which in this case is their creek water. This allows for the gasses trapped in the water to escape and adds oxygen to the water. From there, they need to put the cap back onto the bottle. Once it is tightly closed, they need to shake the bottle with some force for close to 30 seconds. They can shake the bottle in any direction they deem necessary.
- Step 6: Once all the gas bubbles have settled, they will need to pour out the creek water into the 2 liter bottle that has its top cut off. This is where students will imitate the coagulation process where suspended particles stick together when combined with certain chemicals. Students will add 2 tablespoons of alum into the solution and slowly stir with the stirring rod provided. They will need to stir this mixture slowly for about 5 minutes. (If they do it too fast, it will not allow enough time for everything to react and bond properly). Students will observe the change in the solution where there will be large clumps starting to form. Have students not only observe but also illustrate what is occurring in their solution in their science journals.
- Step 7: Students will replicate the sedimentation process in their bottles. This process uses the force of gravity to pull the particles down to the bottom of the cylinder, so students will need to place their bottle on the lab table and let it rest for 5-20 minutes allowing for the sediments to begin to settle. Have students also illustrate what they are observing at each time increment during the sedimentation process of 10, 15, and 20 minutes. Students should be able to see the gradual sinking of sediments within their bottle.
- Step 8: At this point, the students need to construct the filtration system in which the solution will go through in order to be purified. With the coffee filter attached to the outside neck of the bottle that has the bottom cut off. The filter will be strapped tightly with the provided rubber band while the third member will hold it over the beaker or bowl for the filtered water to land. Before they are allowed to filter the students must make sure to add a small layer of small pebbles to the bottle with the filter attached. Once the pebbles are in place, add a layer of coarse sand on top of the pebbles. After the course sand, add a layer of fine sand on top of the course sand. Lastly, before the students filter their creek water they must rinse their filtration system with some clean tap water while trying to not disturb any of the sandy layers.
- Step 9: Students will pour their creek water solution through the opening of the filtration system. They will need to do this very slowly and carefully, as not to pour out any of the settled debris at the bottom of their bottles (as those will lead to impurities in the water). The collected water should land in the beaker below the filter as the sand, pebbles, and coffee filter work to filter out any of the remaining contaminants. Once students have poured the clean water into the collection container, have students observe, smell, and illustrate the treated water. Once reviewed, move it aside and now add a separate empty beaker. Pour out the remaining creek water over the filtration system. Students should notice the difference in smell, vision, and appearance. Have students illustrate this in their notebook. Once finished, instruct students to dispose of the materials and clean up.

Differentiation

- English Language Learners- Provide the handout or give the instructions in native language with a translator app or allow built-in translation through Canvas.
- Academically gifted students- Provide students an extra opportunity to express how efficient this process of water filtration is compared to that of the ones that an actual water treatment facility is. How effective are the detergents that they add to the water source compared to that of the sample that comes upstream before the treatment facility?
- Students with learning disabilities- Provide extra supporting material to possibly reinforce the students' understanding of the activity. Make sure they are paired and participate in student-led small groups discussion.

Assessment/Check for Understanding

- Students are checked for assessment throughout the class period with probing questions. Students informal assessment is in the form of drawing the different steps or processes in their science journals.

Required resources

- Water Filtration PDF

Author comments

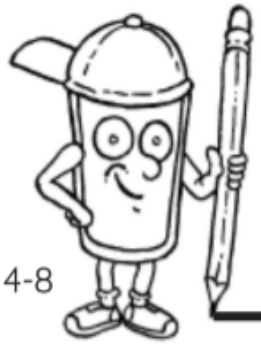
- This activity can be done solo or in combination with a presentation pertaining to water quality and how water is filtered through a wastewater purification system. My students have the opportunity to connect this with the Cape Fear River which is only a few miles away from the school's campus and the PWC wastewater treatment center is only a few miles from the school as well. Something to consider would be to plan out a field trip to the wastewater facilities itself.
- The treated creek water is ***not*** safe to drink, please keep an eye on the students as they will try to.

Sources

- *Lesson adapted from Water Filtration Lesson, June 2004 - US EPA*. (n.d.). Retrieved July 7, 2022, from https://www.epa.gov/sites/default/files/2016-03/documents/activity_grades_4-8_waterfiltration.pdf

Appendices

- *Water Filtration Lesson, June 2004 - US EPA*. (n.d.). Retrieved July 7, 2022, from https://www.epa.gov/sites/default/files/2016-03/documents/activity_grades_4-8_waterfiltration.pdf



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Water Filtration

BACKGROUND:

Water in lakes, rivers, and swamps often contains impurities that make it look and smell bad. The water may also contain bacteria and other microbiological organisms that can cause disease. Consequently, water from most surface sources must be "cleaned" before it can be consumed by people. Water treatment plants typically clean water by taking it through the following processes: (1) **aeration**; (2) **coagulation**; (3) **sedimentation**; (4) **filtration**; and (5) **disinfection**. Demonstration projects for the first four processes are included below.

✍ OBJECTIVE:

To demonstrate the procedures that municipal water plants may use to purify water for drinking.

MATERIALS NEEDED:

- ✔ **5 Liters of "swamp water"** (or add 2 1/2 cups of dirt or mud to 5 liters of water)
- ✔ **1 Two liter plastic soft drink bottle** with its cap (or cork that fits tightly into the neck)
- ✔ **2 Two liter plastic soft drink bottles**, one with its bottom cut off and one with the top cut off
- ✔ **1 large beaker (2 cups) or measuring bowl** that will hold the inverted two liter bottle or you can use another two liter plastic soft drink bottle with its top cut off so the other bottle will fit inside of it.
- ✔ **2 tablespoons of alum** (potassium aluminum sulfate available in the spice isle at grocery stores)
- ✔ **1 1/2 cups fine sand** (white play sand or beach sand)
- ✔ **1 1/2 cups coarse sand** (multi-purpose sand)
- ✔ **1 cup small pebbles** (washed, natural color aquarium rocks work best)
- ✔ **1 coffee filter**
- ✔ **1 rubber band**
- ✔ **1 tablespoon** (for the alum)
- ✔ **1 large spoon** (for stirring)
- ✔ **A clock** with a second hand or a stopwatch

PROCEDURE:

1. Pour your "Swamp Water" into the two liter bottle with a cap. Have students describe the appearance and smell of the water.

2. **Aeration** the first step in the treatment process, adds air to water. It allows gases trapped in the water to escape and adds oxygen to the water. Place the cap on the bottle and vigorously shake the bottle for 30 seconds. Continue the aeration process by pouring the water into another bottle or the beaker, then pouring the water back and forth between them about 10 times. Once aerated, gases have escaped (bubbles should be gone). Pour your aerated water into your bottle with its top cut off.

3. **Coagulation** is the process by which dirt and other suspended solid particles to chemically "stick together" into floc (clumps of alum and sediment) so they can easily be removed from water. Add two tablespoons of alum to the aerated water. Slowly stir the mixture for 5 minutes. You will see particles in the water clinging together to make larger clumps. This makes it harder for them to get through a filter at the plant.

4. **Sedimentation** is the process that occurs when gravity pulls the particles of floc to the bottom of the cylinder. Allow the water to stand undisturbed in the cylinder. Observe the water at 5 minute intervals for a total of 20 minutes. Write down what you see - what is the appearance of the water now? At a treatment plant, there are settling beds that collect floc that floats to the bottom, allowing the clear water to be drained from the top of the bed and continue through the process.

5. Construct a filter from the bottle with its bottom cut off as follows (see illustration below):

   a. Attach the coffee filter to the outside neck of the bottle with a rubber band.
   Turn the bottle upside down placing it in a beaker or cut-off bottom of a two liter bottle. Pour a layer of pebbles into the bottle - the filter will prevent the pebbles from falling out of the neck.

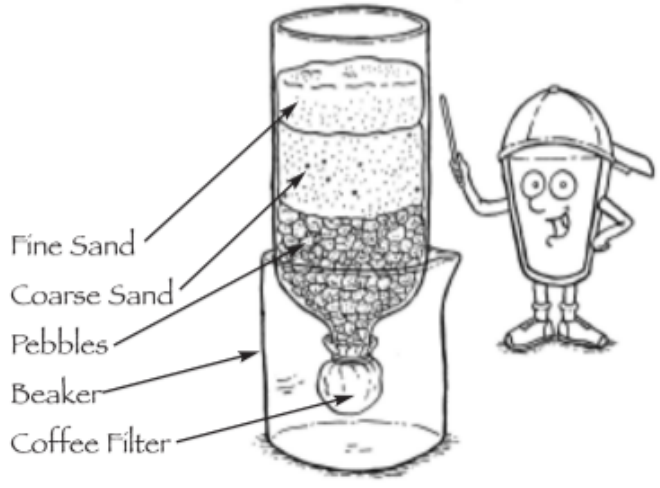
   b. Pour the coarse sand on top of the pebbles.

   c. Pour the fine sand on top of the coarse sand.

   d. Clean the filter by slowly and carefully pouring through 3 L (or more) of clean tap water.
   Try not to disturb the top layer of sand as you pour the water.

6. **Filtration** through a sand and pebble filter removes most of the impurities remaining in water after coagulation and sedimentation have taken place. After a large amount of sediment have settled on the bottom of the bottle of swamp water, carefully - without disturbing the sediment - pour the top two-thirds of the swamp water through the filter. Collect the filtered water in the beaker. Pour the remaining (one-third bottle) of swamp water back into the collection container. Compare the treated and untreated water. Ask students whether treatment has changed the appearance and smell of the water.

Advise students that the final step at the treatment plant is to add disinfectants to the water to purify it and kill any organisms that may be harmful. Because the disinfectants are caustic and must be handled carefully, it is not presented in this experiment. The water that was just filtered is therefore unfit to drink and can cause adverse effects. It is not safe to drink!



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