Gravity Water Filter Lab

Summary

Subject(s)

ESS2.C: The Roles of Water in Earth's Surface Processes

Grade/Level

Grade 4

Activity Type

Develop a model to describe unobservable mechanisms

MN Science Standard

4E.3.1.1.1

SEP / CCC

SEP: Developing & using models

CCC: Systems & System Models

Est. Lesson Time

60 minutes

Implementation

Introduction

Soil is the world's most abundant water filter. When water hits the ground and is able to soak down through the soil, it undergoes filtration. Water filtration is the process of removing everything from water that is not water. Everything that is not water will, in this lab, be referred to as pollution (sediment, minerals, chemicals). There are three types of filtration: physical, chemical, and biological. Physical filtration is the process by which soil collects large pollutants (sediment) as water filters through the pores (holes between the soil particles). Chemical filtration is the process by which the elements in the soil filter out chemical pollutants by bonding with them and trapping them in the soil. Biological filtration is the process by which bacteria in the soil decompose chemical pollutants, breaking them down into safer natural materials.

Different types of soil have different filtration capabilities depending on the size of their pores, and the amount of bacteria and elements present. As water soaks deep into the ground it is filtered by permeable soils and bacteria. Eventually it soaks deep enough that it hits impermeable bedrock and begins to collect in an underground pool of water called an aquifer. Water in an aquifer is referred to as groundwater.

Seventy-five percent of Minnesotans drink groundwater, which is pumped out of an aquifer through a well. Water that is pumped from an aquifer is usually safe to drink. However, it is possible for groundwater to become contaminated, so it is important to test the well regularly for contaminants.

The other twenty-five percent of Minnesotans drink surface water collected from lakes, and rivers. Before it is safe to drink, surface water is sent to a water treatment plant. Water treatment plants vary in their water filtration methods, but many use membrane filtration. A membrane, in this case, is a thin barrier with pores microns wide. Water is forced through the membrane and the membrane catches anything that does not fit through its pores. The size of the pores allows the membrane to filter out sand, bacteria, and viruses. Once it is filtered it is then sent through pipes and plumbing to your house.

After it is used it becomes wastewater, which includes water from your sink, shower, and toilet. This is carried through the sanitary sewer to the wastewater treatment plant. At the plant it goes through many types of filtration including: screening out large waste, holding it in pools to allows finer particles to settle to the bottom, holding it in pools filled with bacteria that consume most of the remaining waste, filtering it through a small membrane, and passing it through Ultraviolet light which kills any remaining bacteria/viruses. Once it meets specific levels for its chemical content, it is released back into the environment, usually into rivers.

Key Term

- **Water Filtration** - The process of removing everything from water that is not water.
    - Physical - The process by which a permeable substance removes physical pollutants from water by blocking its passage through the substance, but allowing the water through.
    - Chemical - The process by which a substance removes chemical pollutants from water by forming chemical bonds with them, making the pollutant insoluble with water.
    - Biological - The process by which bacteria consume pollutants, breaking them down into safer chemicals, and removing them from the water.
- **Permeable Surface** - A surface that allows water to pass through it.
- **Impermeable Surface** - A surface that does not allow water to pass through it.
- **Surface Water -** Water above ground in lakes, rivers, streams, & wetlands.
- **Groundwater** - Water in an aquifer that has filtered through the ground and collected above the bedrock.
- **Aquifer** - A collection of groundwater above bedrock.
- **Wastewater** -Water that has been contaminated by human use. Homes generate wastewater through sink, shower, and toilet use. Industrial operations also generate wastewater.

Objective

Develop a model to describe ways the geosphere (rock/soil), biosphere (flora/fauna), hydrosphere (water), and atmosphere (air/weather) interact.

Essential Questions

- What are the three types of water filtration? How do they work?
- How does clean water for humans differ from clean water for plants and animals?
- How is drinking water filtered? What types of materials/substances are filtered out of water before we drink it?
- What materials can filter water? How does each material filter water?`
- Why do humans have to filter wastewater before it is released back into the environment?
- How do wetlands play a role in water filtration?
- Can you identify water filtration occurring in your town? Are different or multiple types of filtration needed ?
- How can you play a role in filtering water?

Materials & Resources

- 2 Colorless Plastic Bottles, between 1-2 liter in size, with a spout smaller than the rest of the bottle
- 1 Coffee Filter/Cheesecloth
- Rubber Band
- Cutting Tool (Exacto-Knife, Scissors)
- Crushed Charcoal (approximately 1 cup/8 oz)
- Fine Sand (approximately 1 cup/8 oz)
- Small Pebbles/River Rock (approximately 1 cup/8 oz)
- Clean Water (1 L)

- "Dirty Water" - Split 1 L into two 0.5 L samples of water mixed with dirt/grass/pollutants

Teacher Preparation

To prepare for this lab, make sure you have enough plastic bottles for each group of students. Cut off the bottom of the plastic bottle so they function as a funnel when turned upside down. It may help to demonstrate permeable and impermeable surfaces before students put their filter together.

Procedure

A. Cut the bottle horizontally in half with an Exacto-Knife, creating a funnel half and a collection half.
B. Using a rubber band, secure the cheesecloth or coffee filter to the small end of the funnel half.
C. Place the funnel half, cloth side down, so it is resting in the opening of the collection half of the bottle. This creates the structure for our filter, and should be ready to be filled with the natural filtering materials.
D. Fill the funnel with materials in the following order, so the first is nearest the cloth, and the last is near the opening of the funnel.
    a. Crushed charcoal
    b. Fine Sand
    c. Pebbles
E. Run clean water through the filter to rinse some of the loose charcoal dust out. Dump the collected water.
F. Mix up a sample of dirty water. Slowly pour it through the water filter. Compare the collected water to the other sample of dirty water.

Large Group Discussion (15 Minutes): As a whole class, consider and share answers to the following questions:

A. How does this water filter represent the natural environment?
B. What differences (if any) do you notice between the dirty water sample and the water that has run through the filter?
C. How do the large pebbles help filter the water?
D. How does the sand help filter the water?
E. How does the charcoal help filter the water?
    a. Adsorption is the process by which charcoal bonds with chemical impurities removing them from the water.
F. What types of filtration are present in this water filter? Are there any not represented?
G. Are these materials permeable or impermeable? How would this filter be different if we used impermeable materials?

Wrap-up (5 Minutes): The Key Ideas from the lesson are:

- Permeable soils naturally filter water through physical (gravity driven) chemical (chemical reaction driven), and biological (bacteria driven) processes.
- Water that filters through soil is called groundwater. When it collects in pools on the impermeable bedrock it forms what is called an aquifer.
- The permeability of a substance, and the density of its pores determines how thoroughly it filters water.
- Human's have long processes to filter drinking water and wastewater, that use all three types of filtration.