Colorado Springs Utilities
It's how we're all connected

Teacher info and answer key

Water Filtration Experiment - Making Drinking Water

Grade level: 2nd – 6th
Standard/GLE Code: SC.7.3.2, SC.4.3.2, SC.5.1.1, SC.MS.1.5
Time commitment: 30 minutes
Materials Needed:
Per group or classroom)

- 1 cup of water with approximately ½ teaspoon dirt (You can substitute with river or creek water.)
- 2 clear plastic cups holding approximately 10 oz. each
- 2 pieces of cheesecloth
- 1 teaspoon powdered alum from the grocery or drug store

Educational Messages:

- Students will be able to describe the methods of purifying water as used by the pioneers, as well as those being used today by water treatment facilities.
- Students add alum to dirty water to observe coagulation, and filter water to clean it up.

Background: The pioneers learned to drink from flowing waters and not from still waters. And while water in lakes, rivers and streams often contain impurities that make them look and smell bad, the water could be "cleaned" to make it safer to drink. The pioneers would use citric acid or alum which took suspended particles and allowed them to sink to the bottom of the bucket. Sedimentation or allowing the water to sit for several hours also took out some impurities. Finally, the pioneers would strain the water through material to take out additional nasties. To further purify the water, especially if diseases were suspected, they boiled the water before drinking. Several of these methods are currently used by water companies to treat our drinking water today. The water that is processed comes from lakes, rivers, streams or groundwater and has usually been transferred and stored before processing. The following steps are typical in a water treatment plant:

Coagulation: To remove dirt suspended in water, powdered alum is dissolved in the water and it forms tiny, sticky particles called "floc" which attach to the dirt particles. The combined weight of the dirt and alum particles becomes heavy enough to sink to the bottom during the next process of sedimentation.

Sedimentation: The heavy particles sink to the bottom and the clear water above the particles pours on to the filtration beds.

Filtration: The clear water passes through layers of charcoal, sand and gravel to remove smaller particles.

Chlorination: The final process where a small amount of chlorine gas is added to kill any bacteria or microorganisms that may be in the water. The pioneers generally boiled their water to kill bacteria and microorganisms.

Procedure:

1. Pass out 1 clear plastic cup that has ½ teaspoon of dirt mixed in the water (or use water from your local river or creek), 2 clear, clean plastic cups and 2 pieces of cheesecloth.
2. Have the students add ½ teaspoon of alum and watch the floc form (flocculation). Allow the cup to sit undisturbed for several minutes (sedimentation).
3. Have the students hold a piece of cheesecloth (representing the charcoal, sand and gravel filter) over the empty cup. Gently pour the top layer of water from the sedimentation cup into one of the empty cups. Pour the water into the second clean, clear plastic cup using the second, clean piece of cheesecloth to cover the top of the cup. Compare the two pieces of cheesecloth (filtration).
4. Discuss with the students the final step necessary to make the water safe to drink (disinfection). How did the pioneers disinfect their water? How do we disinfect our water today?

Extensions:

- Try constructing a water filter using coal, sand, and gravel like the materials in Colorado Springs Utilities water treatment plants (see last page).
- Go on a field trip to your local water treatment plant or invite someone from Colorado Springs Utilities to visit your class.
- Read settler journal entries taking note of references to water quality, quantity and water borne diseases.

Colorado Springs Water System information:

Snowmelt, streams, and rivers are the source of Colorado Springs drinking water. The water is captured in the mountains, stored in reservoirs (human-made lakes) and transported up to 100 miles to town through pipelines. Three river basins supply water to Colorado Springs: 65% from the Colorado River basin, 30% from the Arkansas River basin (this includes water captured from Pikes Peak drainage basins), and 5% from the South Platte River basin. This water is known as "first-use," meaning it comes directly from nature's water cycle process and has not been previously cleaned by humans or used in households or industry. Although this raw water is fairly clean, it is not clean enough for human consumption and must be treated. Raw water is a mixture; the goal of water treatment is to separate the water from other particles, such as bacteria or chemicals, to make it potable. Utilities operates five water treatment plants to clean the water to drinking water standards before they distribute it to customers. Colorado Springs Utilities provides an average of 68 million gallons of water a day.

Also, see Student worksheet

Inquiry Questions

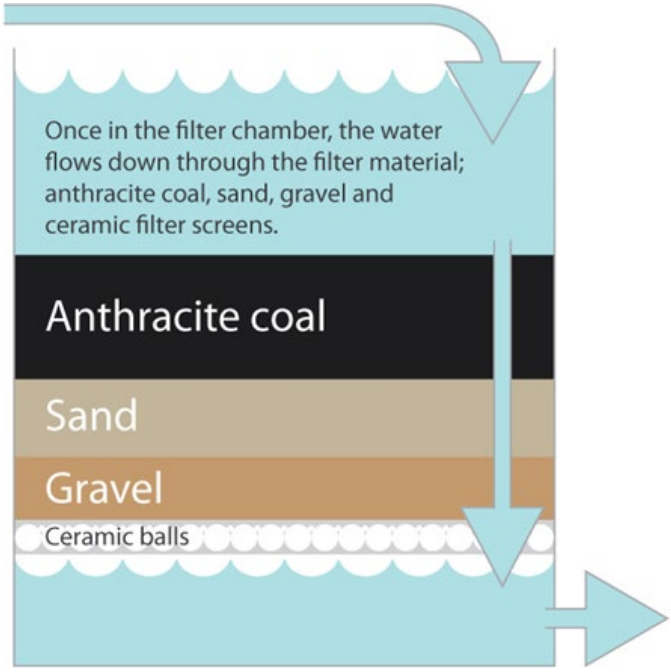
How does the alum make suspended particles stick together?
Alum is the name used for aluminum sulfate, or $Al2(SO4)_3$. Alum's main function is to clarify or floc the water. When alum is rapidly mixed into the water with a pH near 7.0, it forms a gel-like precipitate that bridges or sticks together (coagulation). The precipitate is aluminum hydroxide, chemical formula $Al(OH)_3$. The alum precipitate then forms small bundles (called flocs) that trap suspended particles as they fall through the water. This bridging process is known as flocculation. The water is now mixed slowly so all the particles can collide with each other. Particles are charged, and when those with opposite charges come in contact, they stick together and form larger floc. Imagine two magnets – if you face the two positive ends together or the two negative ends together, they push apart. However, if a positive end meets a negative end, they attract each other.

Why is coal used in the filter? Wouldn't the coal make the water black and dirty?
Not just any coal will do. Colorado Springs Utilities uses anthracite coal because it is very hard (doesn't release coal powder) and can be ground to similar-sized pieces with large surface areas. In the sedimentation step, gravity is not sufficient to remove all of the suspended impurities from water. About 5 percent of the suspended solids may still remain as non-settleable floc particles. These remaining floc particles can cause noticeable cloudiness in the water and may shield microorganisms from the disinfection process. In order to produce a crystal-clear potable (drinkable) water, an additional treatment step, called filtration, is needed. Filtration involves the removal of suspended particles from the water by passing it through a layer or bed of porous, granular material such as sand and coal. As the water flows through the filter bed, the suspended particles become trapped within the pore spaces of the filter material. The pore spaces of anthracite coal are larger than the pore spaces of the sand layer and traps the larger particles and remaining floc. In addition, coal can absorb organics, so bacteria and chemical impurities are trapped in the coal layer.

Is chlorine bad for people? Can the water be disinfected a different way?
Colorado Springs Utilities follows National Drinking Water regulations set by the Environmental Protection Agency (EPA) that require chlorine for disinfection of drinking water supplies. The maximum concentration of chlorine allowed in drinking water is 4 mg/L (EPA standard, the level deemed safe for human health), however, the chlorine levels leaving the water treatment plant are much lower (between 0.6 – 0.7 mg/L). Chlorine at this level meets regulatory requirements and serve the purpose of killing bacteria, without causing health or aesthetic (smell and taste) concerns. There are other ways to disinfect water, such a boiling or using ultra-violet light, however these methods do not meet regulatory requirements.

Colorado Springs Utilities
It's how we're all connected

Colorado Springs Utilities uses anthracite coal, sand, and gravel in our water filter:



Source - Nebraska Groundwater Foundation; Colorado Springs Utilities