Lesson Name: Upcycling – Environmental Engineering – Water purification and erosion (Two-week module)
Lesson Type: Exploration/ Challenge
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Week 1: The water cycle – distillation and purification

Materials
This list is for two distillation apparatuses

- Two hot plates
- Two large Erlenmeyer flasks (or any heatable container)
- Water
- Impurities: anything solid.
  Examples: rocks, soil, grass, salt, sugar
- Distillation heads (or container lids with a tube pre-inserted)
- Two extra containers for collecting the water

The materials could be more easily found with the help of the Chemistry department

Agenda

1. Guided Exploration ~ 10 min
2. Activity ~ 25 min
3. Discussion ~15 min

Total: 50 min
The exploration is meant for mentees to contribute what they know about environmental engineering and how water is specifically related. The activity centers on principles of distillation and condensation in the water purification process and is important for students to understand due to its importance in both the water cycle as well as commercial water purification protocols. Afterwards, the activity will visually demonstrate how water can be isolated from impurities using a distillation apparatus. Finally, the discussion will expand to how distillation is used in everyday life and why water purification is a fundamental process in environmental engineering.

Introduction
People use on average 80-100 gallons of water per day. When you consider all the billions of people that live on this planet, that's a lot of water! However, water is not an indefinite resource; it must be recycled and re-used. The natural phenomenon for this is called the *water cycle*. Some of you may know it as the process by which dirty water is heated by the sun, evaporated, and re-introduced to the earth in the form of precipitation (rain, snow, etc). Essentially, this is Nature's way of recycling water, and people have re-created that process in laboratories. This process is called *distillation*.

Today's activity is a demonstration of distillation. We will be heating water that has been

tainted by a variety of impurities and collecting the resulting vapors. The goal is to produce water that is hopefully clean enough for people to drink. This is an important process that allows life to continue on earth and for us to have enough fresh water to live our lives. As we perform this activity, think about how important water is for all living things and why the water cycle and distillation are important.

Take Home Activity

What happens to water when it gets really hot? Think about the last time you cooked with water. Write down 4-5 observations about what happens when the water begins to bubble. Things to consider: what happens to the water? Why does this happen? What happens to the stuff already present to the water as the water begins to boil?

Activity

Pour about 250 mL of water into each of two containers. Then add the desired impurities. Swirl the water well so that the impurities are well distributed within the mixture. Note that salts and sugars will dissolve into the water.

Place the flasks onto the hot plates. Turn on the hot plate and bring the liquid to a boil. Place the distillation head over the distillation flask and place the tube end into a collection container. Observe as the water gradually leaves the distillation flask and collects in the other container. When all of the water has boiled away, turn off the hot plate and make notes about the contents of each respective chamber. What does the distilled water look like? (Taste like…?) What is left in the distillation flask?

Clean up by throwing away all impurities and washing out the equipment.

An example of the experimental set-up. The heating flash is on the left, which is attached to a

stopper with a tube pre-inserted. The steam travels through the tube and condenses in the flask on the right, which is placed in a cooler environment.

Discussion Questions

What is the water cycle? What is it called when it is performed by humans? When would distillation be useful? Can you think of a situation in which it would be impractical to use distillation to purify water?

Background

Water boils at 100°C and at this temperature and standard pressure, turns into gaseous steam. This principle, although elementary, is a fundamental concept in water purification, which relies upon the specific value of water's boiling point to separate water from impurities. When water leaves the evaporation chamber, whatever impurities were mixed in solution are left behind, and this allows for the water to be recovered in a relatively pure form. This purification process is called *distillation*. For solid impurities, such as salts, gravel, and dirt, distillation is extremely effective because solids do not contribute to the overall vapor pressure of the liquid chamber, and thus are not in danger of boiling away with the water (Recall that the boiling point is defined as the temperature at which the vapor pressure of the liquid equals the environmental pressure). Unfortunately, distillation is much more complicated when other liquid impurities are involved, such as in an ethanol and water mixture. For the purposes of this activity however, where only solid impurities are involved, distillation will be effective in demonstrating how water is purified.

References

1. "Water Q&A: Water Use at Home." *United States Geological Survey*. 14 Dec 2010. 27 Dec 2010. <http://ga.water.usgs.gov/edu/qahome.html>
1.

Week 2: Environmental Engineering: Erosion prevention

Materials

This is enough material for four teams of students

- Approximately 16 feet of a PVC pipe (or other hemispherical tube) cut into 4 ft. sections
- 4 dry measuring cups (for sand)
- 4 liquid measuring cups (for water)
- Sand (~20 lbs)
- Large quart-sized Ziploc bags (need 4)
- Coarse gravel
- Rocks
- Bark, leaves, other types of riprap
- Stopwatch
- Place to dump water, sand and rocks (A clear cup/bucket with measuring marks)

These materials can be found at gardening or home improvement stores.

Agenda

1. Guided Exploration ~ 10 min
2. Activity ~ 25 min
3. Discussion ~15 min

Total: 50 min

The exploration should be directed at asking mentees about erosion and what examples of erosion they can recall from their experiences (good examples include the grand canyon, cliff formation, water damage during floods, etc.). Brainstorm some ideas about how erosion can be limited and explain that the addition of *riprap*, or rock can be used to limit the effects of erosion in water-filled environments. The activity is a challenge in which teams of students select riprap and attempt to limit water erosion using their experimental setups. Finally, the discussion should address what worked and what didn't work for the students. Questions should be taken and centered on the student's experiences with the activities and how environmental engineers use those concepts to limit erosion.

Take Home Activity

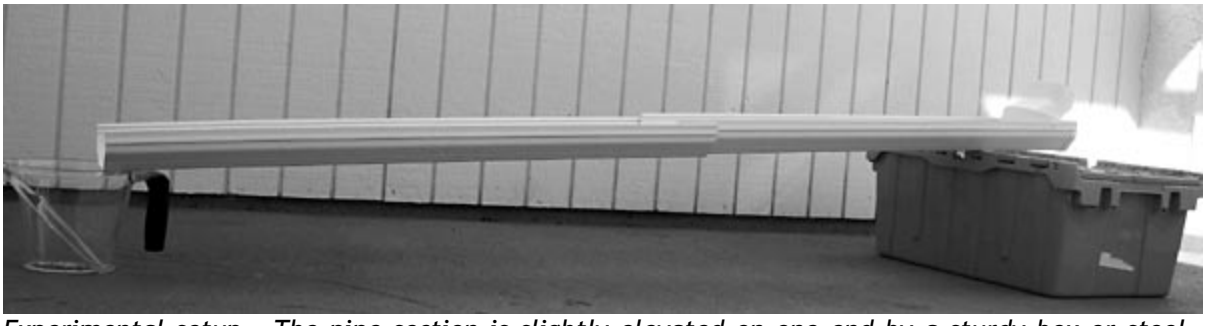
What is erosion? Name an example of erosion (Hint: think about how powerful rivers can be!) Write down a brief explanation for how water affects rocks and beaches.

Introduction

When you play at the beach, isn't it annoying when a giant wave comes along and washes away your sandcastle? What if that water washed away your home as well? Water erosion is a big problem for both animals and people, and environmental engineers work hard to limit the effects of erosion along rivers and oceans. You may have seen people using sandbags to protect sensitive areas from floods. Erosion protection works on similar principles: using large, relatively immobile objects to anchor earth and limit the effects of erosion. Today's activity is a challenge: teams of students will work together to design a sand-filled pipe with varying types of riprap. Water will be poured down the tube, and the goal is to limit the amount of sand and rocks that are washed off along with the water.

Activity

Set-up the equipment by placing one end of a 4-ft long piece of rain gutter on a chair and resting the other end in a large liquid measuring cup. The ideal angle should be around 15 degrees. Pour one cup of sand along the length of the gutter and try and keep the amount of sand present consistent in between trials. One way to do this is to premeasure the sand with the measuring cup. First perform a control experiment by pouring one cup of water down the rain gutter, starting the pour at the top of the pipe. Record the amount of water and sand that flows through.



Experimental setup - The pipe section is slightly elevated on one end by a sturdy box or stool. The pipe runs downward into a container that can collect water and sand

Next, let students select what types of riprap to use. The limit is that the riprap must be able to fit in one large Ziploc bag. Additionally, each team of students can be given the same

materials so as to make the challenge even between teams. Afterwards, the riprap should be poured along the length of the gutter. Repeat the experiment with another cup of water, remembering to replace the sand that was lost from the previous trial. This time, compare the amount of sand that is able to run through. Which set-up is able to reduce the amount of flow through the most? Set-ups that are successful at reducing erosion should be able to reduce the amount of sand that flows through.

Discussion Questions

What made each design successful? What was not so successful? Why does riprap reduce the amount of erosion? How could your design be improved?

Background

Erosion is a common phenomenon where solids, such as rock and sediment are transported by water, wind, or ice to other locations. It is responsible for the formation of canyons and cliffs, but at the same time is a big problem for environment engineers. Without careful prevention, erosion by rivers and oceans can cause the loss of valuable soil from water shores and damage to the ecosystem as a result.

Erosion occurs when the sediments being washed away are overcome by the force of water and dislocated from their original positions. Riprap works by disrupting the flow of water and lowering the threshold of force such that less soil or earth is carried away.

References

1. "Riprap: It's not hip hop but erosion stop." *Science Buddies*. Accessed 27 Dec. 2010. <http://www.sciencebuddies.org/science-fair-projects/project_ideas/EnvEng_p024.shtml?from=Home>