Water Un-Mix-ology & Purification!

Subject Area(s): water, physical properties, temperature, mixing

Associated Unit: Properties of Water (Grade 4, NYC PS)

Associated Lesson: Water Un-Mix-ology & Purification! (Lesson Plan)

Activity Title: Water Un-Mix-ology & Purification! (Activity)

Figure 1
ADA Description: An image of two clear glasses—one containing dirty water and the other containing clean iced water
Caption: Dirty & Clean Water Comparison
Image file name: dirty water.jpg
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Grade Level: 4 (3-5)

Activity Dependency: None

Time Required: 45 minutes

Group Size: 4

Expendable Cost per Group: US $5

Summary

Students will learn the principals behind how water filtration systems can change visibly dirty water to visibly clean water. Students will accomplish this by two means—a fast, percolation based filter modeled on the filtration which occurs in soils, as well as a slower, evaporation based filtration model modeled on the filtration which occurs for rainwater. Students will gain greater experience with use of the scientific method by making predictions about effective their filters will be at cleaning water, and comparing these predictions to the changes actually observed. Changes in the water's cleanliness will be measured both visibly, and with a mechatronic light sensor.

Students will actively learn how mechatronic sensors can enhance their own senses, by observing that the mechatronic light sensor can very precisely measure the relative purity of water both

before and after filtration, while their eyes can only give a much less precise measure of the water's relative purity. This will help illustrate how, in some cases, our own senses are not precise enough to observe differences in materials, while engineered sensors are able to measure such properties.

Finally, students will also gain practice with the use of synthesizing information, and presenting it to share what they've learned with their classmates. After completing the investigation of the effectiveness of both their percolation based, and evaporation based filters, the students will use chart paper they've used to collect information throughout their investigation to display what they've learned, and make a presentation to the rest of the class so that other students listening can benefit from the work and knowledge of their peers.

Engineering Connection

The engineering connection of this lesson is two-fold: (1) the active use of mechatronic and human sensors, as well as (2) learning about how one can engineer an effective water filter using different methods.

(1) Sensors—students will learn how to use mechatronic light sensors in order to measure changes in water cleanliness, and students will compare the abilities of the mechatronic temperature sensor with their own abilities to measure water cleanliness.

(2) Water Purification Engineering—students will employ engineering principals to design two water purification systems. They will observe the effectiveness of their initial purification schemes, and after seeing this, develop ideas for how to improve their current systems.

Engineering Category

(#1) relates science concept to engineering

(#3) provides engineering analysis or partial design

Keywords

water, mechatronics, sensors, senses, light, sight, relative, purity, purification, contaminants, evaporation, percolation

Educational Standards (New York City Public Schools)

State science: PS 2.1c, PS 3.2a,b,c, PS 3.1e,f, 4.1d
State math: 4.RP.7, 4.CM.1, 4.CM.3, 4.CM.6, 4.CM.10

Pre-Requisite Knowledge

A familiarity with water filters such as Brita pitchers, etc., and a rudimentary familiarity with the fact that rain can purify water.

Learning Objectives

After this lesson, students should be able to:

- Understand that mechatronic sensors can be used to detect light, and use mechatronic light sensors to measure light penetration through water (and thus the relative purity of water).
- Understand some pros and cons of mechatronic versus human sensors
- Understand that there are multiple methods—including percolation, and evaporation—which can be used to purify water.

- Use the scientific method to make hypothesis about experiments, and use experimentation to investigate their hypothesis
- Provide experience with engineering design and analysis by suggesting improvements to the filters they've experimented with.
- Further their experience with the use of presentations to share information

Materials List

Each group needs:

- a mechatronic light sensor (Lego Mindstorms NXT)
- 2 clear water bottles with twist off tops
    - Both emptied of water
    - One cut in half
    - One with 2 popsicle stick sized holes cut at the halfway mark
- 1 large piece of parafilm
- 1 popsicle stick
- 1 piece of tape
- 1 very small pebble or marble
- 1 plastic baggie
- 1 rubber band
- 2 pieces of chart paper
- 1 set of markers
- filter materials
    - 1 clear solo cup filled with sand
    - 1 clear solo cup filled with rocks
    - 1 clear solo cup filled with charcoal
    - 1 clear solo cup filled with cotton balls
- 2 clear solo cups filled with equal amounts of visibly dirty water
    - dirty water recipe (to be shared amongst groups):
        - 1 gallon of water
        - 1 coffee filter's worth of coffee grounds
        - ¼ cup of chocolate sauce or powder
        - 30 drops of red food dye

Introduction / Motivation

Discussion & Lecture with Students—Pt. 1 Water Purification

Today, we're going to investigate how we can make clean water from dirty water! This is a pretty important lesson—we use and rely on having clean water every day. If the tap water coming from your kitchen faucet at home had brown water coming out of it, you probably wouldn't be so interested in drinking it, right? [Wait for responses.] I thought not. Has icky water ever come from anyone's faucet at home? [Wait for responses]. If yes, what did you and your family do to make it cleaner? [Wait for responses] Did anyone use a water purifier? Does anyone use a water purifier currently? What does it look like? How do you use it? [Wait for responses]

Water filters can purify dirty water so that it's clean, and good to drink. A lot of water filters work by having water flow through a water purifier which gradually removes contaminants by causing the contaminants to stick to some filter material, and having this cleaned water flow past the filter where it can be collected to drink. If any of you have seen or used a Brita water filter, you'll know that this sounds kinda similar to how it works—you pour water in the top of the pitcher, where it is funneled through a hole with a filter, and comes down to the pitcher portion below. The water in this pitcher portion can be used for drinking. The process of water dripping through some material is called percolation. So what is it called when water is filtered through a Brita? [Wait for responses]. That's right! Percolation!

Some water filters can work by using a principal similar to that used by the sky every time it rains. Does rainwater look pretty clear & clean when it comes down? [Wait for responses] Yeah, right? When rainwater falls down, it's clean enough that you don't feel weird putting your head back and drinking as many drops as you feel like. But the rainwater originally comes from sources of water that might not be so clean, like the Hudson River. You wouldn't want to drink water from the Hudson, right? [Wait for responses]. I didn't think so. But rainwater? That's cool to drink. Rainwater is pure as a result of processes called evaporation and condensation, which we'll learn more about today, hands on.

Today, we're going to try to engineer two filters of our own! One of our filters will work using a principal similar to a Brita water filter, and the other filter will work using a principal very similar to that used by the rain.

Discussion & Lecture with Students—Pt. 2 Is it Clean? Our Senses, and Enhancing our Senses

How do we know if water's clean or not? If we look at muddy water, we can tell that the water is dirty because it looks brown, instead of being clear. What about slightly muddy water? We know that slightly muddy water is less dirty than muddy water because it looks less brown than the muddy water. But how much less dirty is the slightly muddy water? We can only give a relative guess, and say "slightly". But what if we needed to know more precisely how much cleaner this water was? Say, for example, that if on a scale of one to ten, with muddy water being a ten, and clear water being a one, that only water dirty at a level of 5 or lower was safe to drink, how would we know what water we could drink? It's a bit harder for us to tell using our eyes, since a "five" which is safe to drink, and a "six" which isn't safe to drink would look fairly similar.

A tool we could use to distinguish muddy water that was a "five" from a "six" is a mechatronic light sensor. By using this sensor, we could get a quantitative measure of how dirty the water was, since with dirtier water, less light would get through, and the sensor would tell us exactly how much light could get through. Similarly, with very clean water, a lot of light would get through, and the sensor would also be able to tell us this! Thus, a mechatronic light sensor can complement our abilities to see by giving us a second, more precise measure of water cleanliness.

Discussion & Lecture with Students—Pt. 3 Making Predictions

We've discussed a bit about purifying water, and how we can determine the relative level of water purity by using either our own senses or enhanced mechatronic sensors. Now, we'll discuss a bit about how we make predictions of how effective our filters will be.

Before we use either of our two filters, we can make a prediction how clean the water will get after being filtered. The change in cleanliness will indicate how effective our filter is. Making a prediction about what will happen is useful, so you can compare what actually happened with what you thought would happen, and thus learn more about your system by comparing the differences between what you predicted and what you observed.

Vocabulary / Definitions

Word	Definition
mechatronic sensor	A type of electrical sensor which can measure temperature by converting an electrical reading to a digital display.
contaminants	Some undesired material present within another desirable material.
percolation	A process by which some liquid flows through a solid material.
evaporation	A process by which liquid water becomes vapor.

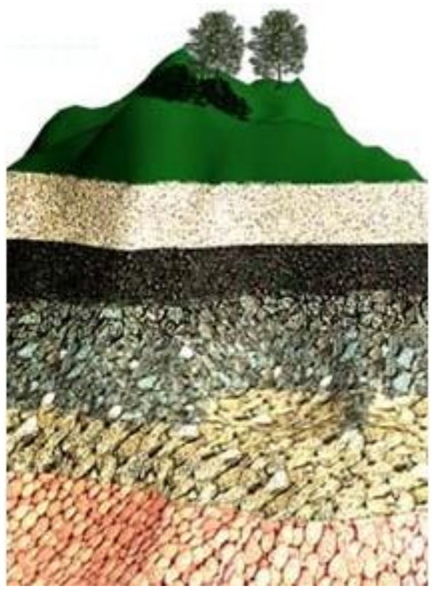

Figure 4

ADA Description: A cross section of earth ground filtration showing 5 different rock layers of filtration

Caption: Ground Water Filtration

Image file name: system.jpg

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Procedure

Background

The background information required to successfully carry out this lab is:

- A familiarity with the Lego Mindstorms NXT kit (specifically, the light sensor component)

Before the Activity

Assign Students into Groups

- Assign each into a group of 4 students
- Assign each group

Assemble Materials for each Group onto Group Desks

- On each group desk, place one set of all materials listed on the Materials section

With the Students

- Complete the Introduction/Overview Section Discussion (Pre-Activity Assessment)
- Prepare the "visibly dirty water" mix (found in "Materials") as a group with the students, emphasizing how dirty the water gets, and taking initial light sensor readings with the students before making the water dirty, and then after the water's dirty.
- Pass out 2 solo cups filled with this dirty water mix to each group.
- Instruct the Groups to Complete the Following Procedure**:**

  PROCEDURE:

  Day 1

  1. Have the group members make and record initial observations of the water cups:
     - How dirty does the water visually look?
       - Does the water look visually similar in each cup? Is the water in one cup dirtier than the water in the other? Or are both cups similarly dirty?
     - How dirty does the water look in the eyes of the mechatronic light sensor? How much light passes through the cups?
       - Record how much light passes through the first cup
       - Record how much light passes through the second cup
       - Determine if the light passing through each cup is similar
  2. Have the group members prepare the percolation based purification device:
     - Allow the group members to decide on what arrangement of their provided materials they will use (i.e. rocks first, or cotton balls first, etc.), and have some theory as to why they decided that arrangement.
     - Have students write on their chart paper their predictions for how clean their water will become after passing through their percolation based filter.
  3. Have the students pour in the dirty water through the percolation based filter
  4. Have the students record how effective their water became after passing through the percolation based filter on chart paper:

- How dirty does the water visually look?
- How dirty does the water look in the eyes of the mechatronic light sensor? How much light passes through the cups?
- How close were their predictions of resulting dirtiness to the actual dirtiness of the percolation filtered water?
- What could be added or rearranged in the percolation filter to make it more effective, and get the water cleaner?

5. Have the group members prepare the evaporation based purification device:
   - Using the model of the evaporation based purification device prepared by the teacher, have students construct a similar device.
   - Have students write on their chart paper their predictions for how clean their water will become after passing through their percolation based filter.
6. After the device is constructed and predictions of effectiveness have been made, have the students pour in the second cup of dirty water.
7. Allow the students to plan their first presentations based on their percolation purification devices.
8. Allow the students to make brief presentations based on their percolation based purification devices.

Day 2

1. Have students observe how effective their evaporation based filtration devices were:
   - How dirty does the water visually look?
   - How dirty does the water look in the eyes of the mechatronic light sensor? How much light passes through the cups?
   - How close were their predictions of resulting dirtiness to the actual dirtiness of the percolation filtered water?
     - What could be added or rearranged in the percolation filter to make it more effective, and get the water cleaner?
   - How clean was the water from the evaporation based filter compared to the percolation based filter?
2. Allow the students to plan their second presentations using the chart paper from both their evaporation and percolation based purification devices.
3. Allow the students to make presentations based on the results of their evaporation based purification devices, and comparing their results to those achieved with the percolation based purification devices.
4. Proceed to the lesson summary assessment.

Attachments

None

Safety Issues

None

Troubleshooting Tips

If students are having difficulties reading their BASIC Stamp Temperature probe, make sure the temperature probe is completely submerged in liquid, otherwise the probe will not be able to effectively measure the temperature of the solution.

Investigating Questions

- How can we purify dirty water?
- Does water evaporate?
- Does dirty water evaporate?
- Does clean water evaporate?
- What is percolation?
- How can percolation be used to purify water?
- Why is developing and testing a hypothesis useful?

Assessment

Pre-Lesson Assessment

Call-out Question & Answer Session

During the initial introduction of the lesson, students will be presented with a narrative and question & answer session regarding water purification, purification methods, and the scientific method. This introduction will stimulate the students thinking along the appropriate context lines for participation in this activity. Example text of possible questions integrated with introductory content can be found in the "Introduction/Motivation" section of this TeachEngineering Activity.

Lesson Summary Assessments

Development of Chart Paper Presentation on Findings

Students use their three pieces of filled out chart paper to understand how their predictions of property changes compared to their observed changes.

Presentation Chart Paper Presentation

Students will present their filled out chart paper to the class, so that each student can learn from the work of the other groups by seeing their experiments, and the results of their experiments synthesized by their peers.

Discussion of Groups Work, and Recapping of Concepts Learned

Complete a brief discussion of the work they did:

- Purification of water
- Percolation
- Evaporation
- Use of the scientific method
- Use of presentations to share information

Activity Extensions

“Water Mix-Ology”—A pre-cursor activity in which students learn about how adding materials to water can change water’s properties.
“How Cold Can You Go?” – Another pre-cursor activity which applies the material property of a depressed freezing point (via salt addition to water) to the making of ice cream.

Activity Scaling

- For lower grades, emphasize the scientific method, and hypothesis development more, as these students will be far less familiar with this than the grade for which this activity is intended.
- For upper grades, include significant discussion of the process of evaporation as a phase transition, and ask students to include this scientific understanding information in their presentation of results.

Additional Multimedia Support

None

References

None

Other

None

Redirect URL

None

Contributors

Primary Developer: Ursula Koniges
Teacher Contributors: Kesha Townsel

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None

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