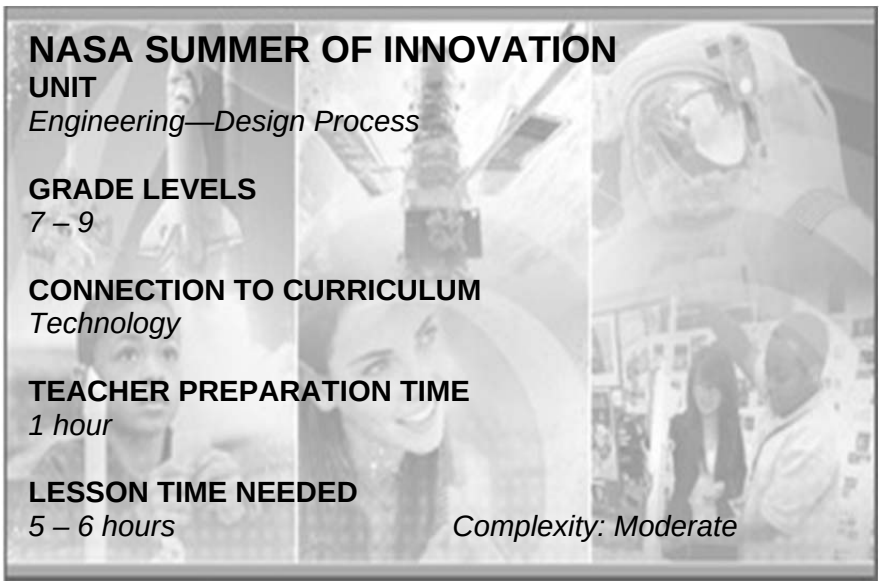
Water Filtration System



NASA SUMMER OF INNOVATION
UNIT
Engineering—Design Process

GRADE LEVELS
7 – 9

CONNECTION TO CURRICULUM
Technology

TEACHER PREPARATION TIME
1 hour

LESSON TIME NEEDED
5 – 6 hours *Complexity: Moderate*

LESSON THEME
This lesson challenges students to create and test a water filtering system. The activities in this lesson focus on water recovery and management.

OBJECTIVES
Students will

- Design and build a water filtration device
- Test the device, make observations, and collect data
- Collaborate as they analyze results and attempt to identify the best filter media to use
- Based on their analysis and on study of other filtration devices, they will make modifications to their model and repeat the process in an effort to produce the most effective filtration apparatus possible
- Compare individual results and communicate their results to the larger community

NATIONAL STANDARDS

National Science Education Standards (NSTA)
Science as Inquiry

- Understanding of scientific concepts
- An appreciation of "how we know" what we know in science
- Skills necessary to become independent inquirers about the natural world
- Dispositions to use the skills, abilities, and attitudes associated with science

Life Sciences

- Organisms and environments

Science in Technology

- Abilities of technological design

ISTE NETS and Performance Indicators for Students
Creativity and Innovation

- Apply existing knowledge to generate new ideas, products, or processes

Critical Thinking, Problem Solving, and Decision Making

- Plan and manage activities to develop a solution or complete a project

Research and Information Fluency

- Plan strategies to guide inquiry
- Locate, organize, analyze, evaluate, synthesize, and ethically use information from a variety of sources and media
- Evaluate and select information sources and digital tools based on the appropriateness to specific tasks
- Process data and report results

Technology Operations and Concepts

- Understand and use technology systems
- Select and use applications effectively and productively

MANAGEMENT

Safety—Remind students the importance of classroom and lab safety. Review the rules for smelling (wafting) in the science lab. Students should wear eye protection during this activity. Materials Safety Data Sheets (MSDS) are required for this experiment. You can find MSDS at http://www.msdssearch.com/msdssearch.htm. This activity requires proper clean up.

- Send a note home to parents telling them about the project a week or two ahead of time. Include the materials list and ask them to send in materials from this list.
- Students will work in teams of two or three and are encouraged to think of their entire class as a single design team working cooperatively and learning from the efforts.
- Discuss properties of liquids such as how different liquids and materials interact, surface tension, and viscosity, so students will know what to look for while making observations.
- Review the scientific process and how to design an effective experiment. Discuss ways students should have access to information-gathering and research equipment.
- Students should have room for small group and whole class discussions.

CONTENT RESEARCH

The astronauts onboard the International Space Station (ISS) join those of us on Earth in the recycling effort. This recycling is different from that which may take place in your home or school. The astronauts recycle their water. This includes the moisture they exhale and sweat, as well as the water they use to shower and shave. These wastewaters are purified and then used as drinking water. The ISS uses filtration and temperature sterilization to ensure the water is safe to drink. Water is checked often to ensure it meets the water quality requirements and monitored closely for bacteria, pollutants, and proper pH. The pH scale ranges from 0 to 14 and is a tool used by scientists to measure the strength of an acid or base. Proper pH balance of 7 is important to a human body.

Public water systems have to meet a pH level of 6.5 to 8.5. The ISS water is required to be within the range of 6.0 to 8.5. The recycled water on the ISS is sterile, and there is no odor or bad taste. Water recycling will be imperative for long-duration missions such as on the ISS or possible trips to the Moon and Mars. A spacecraft on a lengthy trip to the Moon and Mars would be limited to the amount of water it could carry because of weight restrictions. In this experiment, you will create and test a water filtration system.

MATERIALS

For the class:

- Triple beam balance (2 – 3)
- Conductivity tester (3)
- Graduated cylinder (1 – 2)
- PH strips (3 – 4 per team)
- Plastic cups (6 – 8 per team)
- Newspaper
- Sharpie marker

For each conductivity tester:

- Multimeter (1 digital)
- 9-volt battery (1)
- Battery snap connector
- Electrical tape, black (15 cm)
- Wire stripper

For each filtration device:

- Plastic water bottle
- Rubber band (2)
- 10- by 10-cm section cheesecloth (4)
- 10- by 10-cm section plastic wrap (4)
- 10- by 10-cm section window screen
- Filtered waste container
- Utility knife
- Masking tape
- Paper clip (straightened)

For filter media (each student team)

- Cotton ball (10 – 15)
- Coffee filter (6)
- Activated carbon (200 g)
- Gravel (200 g)
- Sand (200 g)
- Uncooked macaroni (100 g)

For the simulated wastewater

- Vinegar (400 ml)
- Food coloring (1 to 2 drops)
- Sand (50 g)
- Salt (1 tbsp)
- Hair (handful)
- Dust (handful)
- Tap water (2 liters)
- 2-liter beaker
- Stirring device

For each student team:

- Poster board
- Markers
- Scissors
- Glue or tape

Key Concepts

- **Acid:** Any of a class of substances that yields hydrogen ions (H+) when dissolved in water. The greater the concentration of hydrogen ions produced, the more acidic the substance is. Acids are characterized by a sour taste and the ability to react with bases and certain metals to form salts.
- **Base:** Any of a class of substances that yields hydroxide ions (OH-) when dissolved in water. The greater the concentration of hydroxide ions produced, the more basic the substance is. Bases are characterized by a bitter taste, a slippery feel, and the ability to react with acids to form salts.
- **Conductivity**: Conductivity is a measure of a material's capacity to conduct electricity. Conductivity is a standard method to measure the purity of water, specifically the quantity of inorganic contaminants (which conduct electricity). Completely pure water will not conduct electrical current. Thus, the smaller the amount of current that flows through the treated wastewater, the lower the concentration of inorganic contaminants. The water recovered and purified by the Water Recovery System (WRS) on the ISS has an average conductivity of approximately 1 µmho/cm, most of which is due to the residual iodine added to the water.
- **International Space Station (ISS)**: Internationally developed research facility with 16 partner countries that was begun in 1998 and completed in 2011.
- **Litmus Paper**: Indicator used to determine whether a substance is acidic or basic. The pH scale lets you determine the relative acidity of a substance. The pH scale ranges from 1 to 14 where 7 is neutral, greater than 7 is basic, and less than 7 is acidic.
- **Water**: The water recovered and purified by the WRS on the ISS has a pH of 4.5 to 7. This lower pH is a result of the addition of iodine to the filtered water

LESSON ACTIVITIES

Introduce the Challenge—Understand the design challenge and become familiar with the materials. Watch and discuss NASA's KSNN™ 21st Century Explorer 30-second newsbreak, "Where would a space explorer find water and oxygen?" (Download the newsbreak at http://ksnn.larc.nasa.gov .)

Design and Test a Filtration Device—Design the team's device and become familiar with the conductivity tester and pH strips.

Design a Class Filtration Device—Combine the best features of all of the teams devices.

Construct Posters—Summarize and reflect on results.

Student Presentations—Share the outcome.

All lesson activities can be found at
http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Water_Filtration_Challenge.html

ADDITIONAL RESOURCES:

- Filtration activity:
  http://www.nasa.gov/audience/foreducators/topnav/materials/listbytype/Cleaning_Water_Activity.html

- NASA article on new filtration device in space with photographs:
  http://www.space.com/8141-nasa-test-medical-device-sick-astronauts-space.html

- Mission to Mars water filtration activity embedded in PowerPoint:
  http://quest.arc.nasa.gov/test/speakersnotes/ITP/912/examples_spsci.html#Start

- Clean Water; Where Does It Come From? Activity:
  http://virtualastronaut.tietronix.com/teacherportal/pdfs/WaterPurificationfortheISS.pdf

DISCUSSION QUESTIONS

- What happened to the water as it passed through the different layers of the filter? What changes occurred to the properties of the gray water as it was filtered (pH, appearance, odor)? *Answers will vary.*

- Compare your filtered water to the clean water. Did your gray water become "clean"? Did your gray water become clean? What properties told you it was or was not clean? *Answers will vary.*

- Does this data support your hypothesis? Why or why not? *Answers will vary.*

- If you could build a water filtering system by using any of the materials available in the class, which three materials would you use and in what order would you layer them? Why*? Answers will vary.*

- Based on your findings, what would you suggest to NASA scientists and engineers designing filtration systems and water recycling methods? *Answers will vary.*

ASSESSMENT ACTIVITIES

Once the test and the Design and Evaluation Sheet are completed, instruct the students to discuss the results and what they have learned. If you elected to have two or three designs, compete in a run-off and determine the best design from the data collected. There may be time to complete posters during filtration so an additional day will not be needed. Each team can create a poster about their design and test results. Select two to three students to make a poster for the class-designed filtration device.

ENRICHMENT

- Collect and filter other samples of water. (e.g., rain water, hand wash water, stream or pond water, etc.)
- Try using other filter media such as Styrofoam™ pieces, potting soil, marbles, and popcorn.
- Ask the students to research how the water in your town is filtered/treated. Maybe take a field trip to thewater treatment plant, or check into someone from the water treatment plant visiting to speak to your class.
- Because weight is always an issue when launching into space (the heavier it is the more it costs to launch it), set a weight limit for the filtration device (including filter media). Hold a competition to see which team has the purest water (lowest conductivity and most neutral pH) using the lightest filtration device.
- If equipment is available, instruct student teams to videotape, film, or photograph their work. This can then be used to create an electronic diary and presentation of their filtration device and results. Instruct the teams to share their creation with the class.
- Investigate other water treatment methods, such as desalination, and conduct classroom experiments using these methods.