    - packing materials (Styrofoam “popcorn”)
- gray water
    - Italian dressing
    - tap water or bottled water

  See how to make gray water in the Pre-Lesson Instructions Section.

Per group (3 – 4 students working together)

- 1 water filtering system structure
    - 2-liter bottle with bottom cut off
    - cheese cloth
    - rubber bands

  See how to make the water filtering system structure in the Pre-Lesson Instructions Section.
- 3 filtration materials (to be chosen during the test procedure)
- 5 litmus paper strips
- pH color chart with a range from at minimum 4-10
- 1 metric ruler
- 3 large, clear plastic cups (at least 480 ml.) with a hole punched just below the rim (See diagram in the Pre-Lesson Instructions Section.)
- 3 paper plates
- 1 metric liquid measuring cup
- 500 ml of clean water
- 500 ml of gray water (to be made in advance)

Per student

- 1 pair of safety glasses
- Cleaning Water Student Section

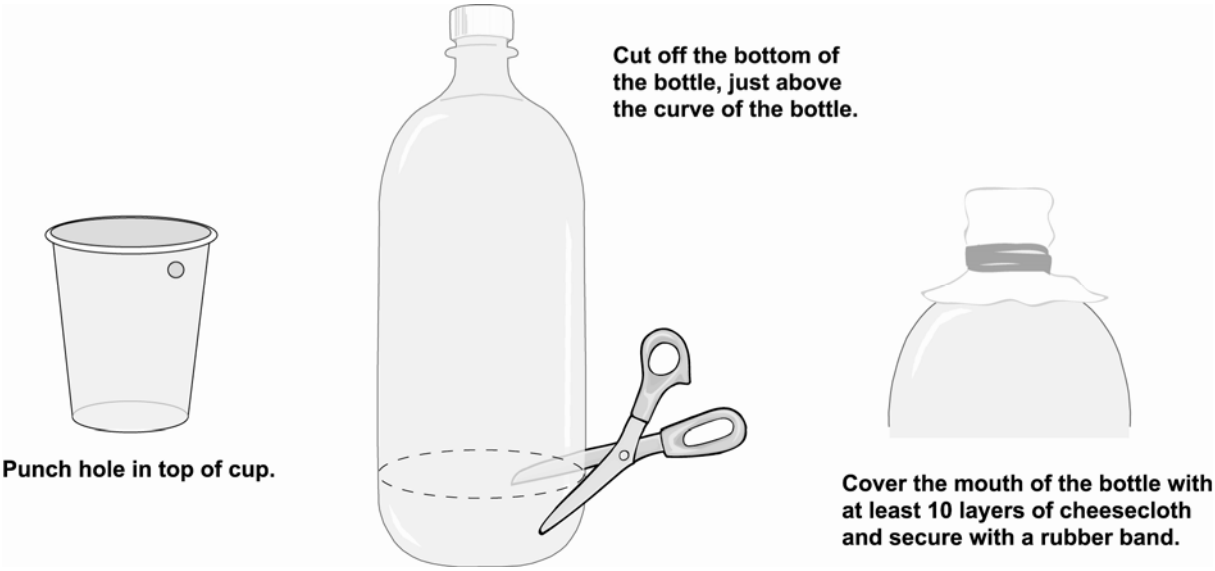
Safety

Remind students about 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 activity. You can find MSDS at http://www.msdssearch.com/msdssearch.htm. This activity requires proper clean up.

Pre-lesson Instructions

- Students should work in groups of 3 or 4.
- Write the names of the 7 different filtering materials on 7 individual small slips of paper and place them in a hat or basket. In addition, write “free choice” on several small slips of paper. Add enough “free choice” slips for each group to choose a total of 3 filtering materials.
- Gather materials for this activity. Each filtration material needs to fill the water filtering system to a depth of 5–8 cm. There should be enough of each filtration material for several groups to use. Make sure to have extra material for students to chose their “free choice” options.
- Wad-up enough coffee filters for multiple groups to use as a filtration layer.
- Rinse the activated charcoal granules in advance to remove the dust.
    - Put the granules in a mesh bag (panty hoses work well) and rinse with tap water.

- Construct the water filtering system structure: (one per group)
    - Punch a hole in the top of each cup, just below the rim to avoid a vacuum.
    - Remove the labels on the 2-liter bottles and then cut off the bottom of the bottle, just above the curve of the bottle.
    - Construct the structure of the water filtering system by covering the mouth of the bottle with at least 10 layers of cheesecloth and secure with a rubber band. See diagram:



- Make “gray water”:
    - Test your tap water before making the gray water solution. You want to start this solution with “clean water”. Your clean water should have a pH between 6.5 and 7.5. If your tap water is not between pH 6.5 and 7.5, then use store-bought drinking water.
    - Mix 1 part Italian salad dressing (vinegar and oil with seasonings, shaken) to 5 parts water in a large, clean container.
    - Make enough gray water for each group to have about 500 ml.
    - Note the pH of the gray water, it should be around 4. If needed, you can add vinegar to the gray water to drop the pH.
- Reserve enough clean water (either tap water or store-bought drinking water with a pH between 6.5 and 7.5) so that each student group has about 500 ml.
- At least one day before conducting this activity:
    - Discuss “purifying and filtering materials” with the class. Encourage students to bring in other materials to add to the list of materials supplied. These will be “free choice” items.
    - Review pH, acid, base and neutral with your students and show them how to pH test using litmus paper. Review the pH color chart.

Lesson Development

To prepare for this activity, the following background information is recommended:

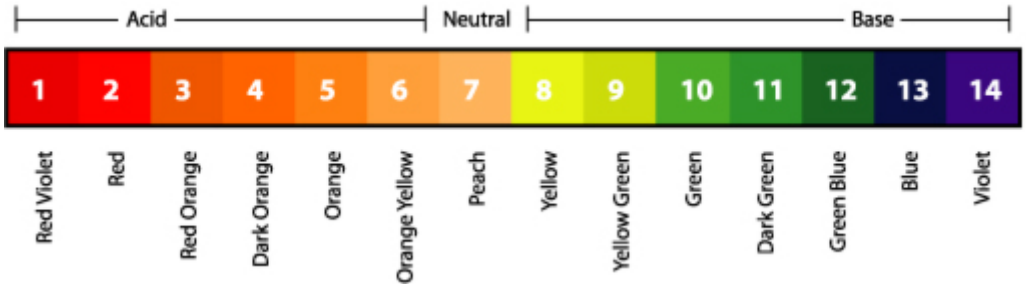
- Read NASA’s 21st Century Explorer Web Text Explanation titled “Where would a space explorer find water and oxygen?” at http://ksnn.larc.nasa.gov.
- Read the following text taken from the Observation Section of the Cleaning Water Student Section.

Observation

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.

pH COLOR CHART



pH SCALE (Summary)

Measure	Type	Examples
Below 7	Acid	citrus juices such as lemon, orange, or lime sodas such as cola
7	Neutral	pure, clean water
Above 7	Base	toothpaste, baking soda

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 activity, you will create and test a water filtration system.

- If needed, additional research can be done on the following science topics:
    - pH, including base, neutral, and acid

- pH testing using litmus paper
- pH color charts

Instructional Procedure

1. Throughout this lesson, emphasize the steps involved in the scientific method. These steps are identified in ***bold italic*** print throughout the Instructional Procedure Section and in **bold** print throughout the Cleaning Water Student Section.
2. Preview the Scientific Investigation Rubric with the students, highlighting each Performance Indicator.
3. Show NASA's 21st Century Explorer newsbreak "Where would a space explorer find water and oxygen?" to engage students and increase student knowledge about this topic.
4. Remind students about pH including base, neutral, and acid. Also reference pH testing using litmus paper and pH color charts.
5. Review the problem with the students.
   Problem: What can I do to make clean water?
6. Have the students read the ***Observation*** Section in the Cleaning Water Student Section and discuss in their groups.
7. Encourage your students to discuss and make ***observations*** about this topic by completing the first two columns in the KWL (KNOW/WANT TO KNOW/LEARNED) chart on the Cleaning Water Student Section. Use the KWL chart to help students organize prior knowledge, identify interests, and make real-world connections. As students suggest information for the "KNOW" column, ask them to share how they have come to know this information.
8. Ask your students if they have predictions relating to this activity and the "problem question". Help them refine their predictions into a ***hypothesis***. In their Student Section, they should restate the "problem question" as a statement based upon their ***observations*** and predictions. Encourage students to share their hypothesis with their group.
9. Students will ***test*** their hypothesis following this procedure.
   (The following steps are taken from the Student Section. Educator specific comments are in italics.)

    1. Put on your safety glasses.

       Stress the importance of keeping eye protection on during this lesson.

    2. Place the bottle upside down with its mouth over the clear plastic cup to catch the filtered water. (See diagram of the Cleaning Water Filtering System.)

       Make sure the cup underneath the system is large enough to "catch" the water to be filtered through.

    3. Choose three slips of paper from the teacher.

       Allow each group to choose three slips of paper with designated filtering materials or "free choice" written on them.

       The items written on these papers will be the materials you layer in your water filter. If you choose a "free choice" slip, you and your group may choose what material to use for this filtration layer.

    4. Gather your filtration materials on the paper plates; one on each plate. As a group, decide the order in which to layer your materials.
    5. Fill the bottle with the first filtering material to a depth of 5–8 centimeters (cm).

       Note: Coffee filters and cotton balls will need to be packed down.

    6. Place the second filtering material to a depth of 5–8 cm on top of the first one.

7. Place the third filtering material to a depth of 5–8 cm on top of the second filtering material.
8. Obtain 350 ml of clean water. Observe the properties of the water before you filter it. Use the wafting technique to smell the water. Measure the pH of the water with litmus paper and compare it to the pH color chart. ***Collect data*** and ***record*** your observations on the Cleaning Water Data Sheet. Remember smelling rules in the science lab and do not taste.

   This pH measurement will serve as the control. When filtering the gray water, students will know the gray water is cleaned when it matches the control pH.

9. Run the clean water through your water filtering system to make sure it will allow water to flow through.

   Students should run approximately 10-16 oz. of clean water through their water filtering system to make sure it will allow water to flow through. Make sure the cup underneath the system is large enough to "catch" all the water passing through.

10. While you are waiting for the clean water to run through the water filtering system, draw and label your diagram to match your filtration system.

    Have each student sketch in the filtration materials and label each layer on the diagram in the Cleaning Water Student Section.

-- SUGGESTED PLACE TO STOP ACTIVITY. RESUME AT NEXT CLASS PERIOD. --

If you stop the activity here, the filtering materials may dry-out before you resume. The filtration system will need to be "wet" again with another 500 ml. of clean water when you are ready to resume the activity.

11. Once the clean water has gone through the water filtering system, replace the clear plastic cup with a new one. If the water is sandy, it should be disposed of outside. Otherwise, it can be disposed of in the sink.

    The cup can be reused in the next step.

12. Get 350 ml of gray water. Observe the properties of the water before you filter it. Check the odor of the water. Measure the pH of the water with litmus paper and compare it to the pH color chart. ***Collect data*** and ***record*** your observations on the Cleaning Water Data Sheet.

    Remind students to use the wafting technique to smell the water. They should also measure the pH of this water sample. Go over the rules of the science lab regarding smelling and tasting.

13. Run the gray water through your water filtering system. Observe the properties of the water after it has been filtered once and record your observations on the Data Sheet. Measure the pH of the water with litmus paper and compare it to the pH color chart. ***Collect data*** and ***record*** your observations on the Cleaning Water Data Sheet.

    Remind students the rules of the science lab regarding smelling and tasting.

14. Replace the clear plastic cup with a new one. Pour the filtered water back into the water filtering system.
15. Filter the water again. While the gray water is running through the water filtering system, discuss in your group what each layer in your filtration system did to the water.
16. Observe the properties of the water after it has been filtered for the second time. Check the odor of the water. Measure the pH of the water with litmus paper and compare it to

the pH color chart. ***Collect data*** and ***record*** your observations on the Cleaning Water Data Sheet.

Remind students the rules of the science lab regarding smelling and tasting.

Make sure the students compare the properties of their filtered water to the control (clean water) to determine if their gray water was "cleaned" by their water filtering system.

Dispose of all material by wrapping in newspaper and placing the material in a trash receptacle.

Study Data

After recording all data, students should study the data on the Cleaning Water Data Sheet by answering the questions on the Student Section.

Conclusion

- Discuss the answers to the Cleaning Water Student Section questions.
- Have the students update the LEARNED column in their KWL chart.
- Have students write a conclusion by restating their hypothesis and explaining how the results do, or do not, support their hypothesis.
- Ask students how their findings relate to the development of new water filtration systems and recycling for space exploration?
- Ask students what they wonder now and encourage students to design their own activities.

Assessment

- Assess student knowledge through questioning.
- Observe and assess student performance throughout the activity using the attached Scientific Investigation Rubric.

Activity Alignment to National Education Standards

National Science Education Standards
National Science Teachers Association/National Research Council (NSTA/NRC)
Content Standard A: Science as Inquiry

- Abilities necessary to do scientific inquiry (K-8)
- Understandings about scientific inquiry (K-8)

Content Standard F: Science in Personal and Social Perspectives

- Personal health (K-8)

National Health Education Standards
American Alliance for Health, Physical Education, Recreation and Dance (AAHPERD)
Health Education Standard 3: Students will demonstrate the ability to practice health-enhancing behaviors and reduce health risks.

- 4: demonstrate strategies to improve or maintain personal health

National Mathematics Education Standards
National Council of Teachers of Mathematics (NCTM)
Number and Operations Standards:

- Compute fluently and make reasonable estimates

- develop fluency in adding, subtracting, multiplying, and dividing whole numbers;

Measurement Standard:

- Understand measurable attributes of objects and the units, systems, and processes of measurement
  - understand such attributes as length, area, weight, volume, and size of angle and select the appropriate type of unit for measuring each attribute;
- Apply appropriate techniques, tools, and formulas to determine measurements
  - select and use benchmarks to estimate measurements;

Curriculum Explorations

To extend the concepts in this activity, the following explorations can be conducted:

Language Arts

Ask students to explain the activity. How might students improve this activity? Where might there have been mistakes made? How might these mistakes have affected the results?

National English Language Arts Education Standards
National Council of Teachers of English (NCTE)

- Students conduct research on issues and interests by generating ideas and questions, and by posing problems. They gather, evaluate, and synthesize data from a variety of sources (e.g., print and non-print texts, artifacts, people) to communicate their discoveries in ways that suit their purpose and audience.

Sources and Career Links

Thanks to subject matter experts Jitendra Joshi, Michele Perchonok, Debbie Berdich, Frederick Smith and Julia Hains-Allen for their contributions to the development of this education material.

Jitendra Joshi is the Lead Technologist for the Human Systems Research and Technology Program. You can find out more about what Mr. Joshi does at http://www.dsls.usra.edu/joshi.html.

More information about Michele Perchonok, a food scientist at NASA's Johnson Space Center, can be found at http://www.ift.org/cms/?pid=1000543.

Debbie Berdich is the biomedical systems support for the JSC Habitation Systems Project. More information about her work can be found at http://esrt.jsc.nasa.gov/taehdt/project_overview/project_overview_main.htm and http://www.nasa.gov/vision/earth/everydaylife/real_glass.html.

Frederick Smith is the Advanced Air Monitoring lead from Engineering Crew and Thermal Systems Division. More information about Mr. Smith can be found at http://quest.arc.nasa.gov/people/bios/space/smithf.html and http://advlifesupport.jsc.nasa.gov.

Julia Hains-Allen is the Education Manager at NASA's Specialized Center of Research and Training (NSCORT) focusing on "advanced life support". You can find out more about the projects and research being conducted in the area of advanced life support at http://www.alsnscort.org.

This activity was adapted from NASA educational products.

Lesson development by the NASA Johnson Space Center Human Research Program Education Outreach team.

Scientific Investigation Rubric

Activity: CLEANING WATER

Student Name _____ Date _____

Performance Indicator	0	1	2	3	4
The student developed a clear and complete hypothesis.					
The student followed all lab safety rules and directions.					
The student followed the scientific method.					
The student recorded all data on the data sheet and drew a conclusion based on the data.					
The student asked engaging questions related to the study.					
The student described at least one recommendation for NASA in the area of water recycling and water filtration.					
Point Total					

Point total from above: _____ / (24 possible)

Grade for this investigation _____

Grading Scale:

A = 22 - 24 points

B = 19 - 21 points

C = 16 - 18 points

D = 13 - 15 points

F = 0 - 12 points

Cleaning Water Filtering System