# Science Unit: *Water Quality*
# Lesson 4: *Water Filtration Challenge*

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| School year: | 2004/2005 |
| Developed for: | Laura Secord Elementary School, Vancouver School District |
| Developed by: | Steven Ralph (scientist) and Dick Griffin (teacher) |
| Grade level: | Presented to grade 6; appropriate for grades 4 - 7 with age appropriate modifications |
| Duration of lesson: | 1 hour and 20 minutes for the challenge, plus additional time to construct water filtration units |
| Notes: | Lead-in experiments are *Water Filtration* and *Water Filtration with Plants.* |

## Objectives

1. Building on prior knowledge about how plants, soils, sand, pebbles and rocks can be used to filter contaminated water (*Water Filtration* and *Water Filtration with Plants* lessons), challenge your students to construct the best possible filtration unit using these materials.

## Background Information

For background information please see the lessons entitled *Water Filtration* and *Water Filtration with Plants* in the Water Quality science unit, Earth Science curriculum area, available from the Scientist in Residence Program website http://www.scientistinresidence.ca).

## Vocabulary

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| Turbidity: | A cloudiness or haziness of water (or other liquid) caused by individual particles that are too small to be seen without magnification. |
| Biofiltration: | A pollution control technique using living material to filter or chemically process pollutants. |
| Filtration: | The process of using a filter to mechanically separate a mixture. |
| Sedimentation: | The deposition by settling of a suspended material. Sediment is any particulate matter than can be transported by fluid flow and which eventually is deposited as a layer of solid particles on the bottom of a body of water or other liquid. |

## Materials:

- vegetable oil
- mud
- liquid dish soap
- grass seed (or seeds for other plants)
- clean pebbles of varying sizes (may rinse with clean water in advance)
- coarse, clean sand (may rinse with clean water in advance)
- clean rocks, larger than pebbles (may rinse with clean water in advance)
- 1-litre clear plastic pots with drainage holes
- 1-litre graduated cylinders
- potting soil
- small pebbles (potting stones)
- fine, plastic mesh

- fine, clean sand (may rinse with clean water in advance)
- duct tape

Each group of students will need the following:

- 2-litre and/or 1-litre clear plastic pop bottles (two per student)

## In the Classroom

### Introductory Discussion

1. Prior to conducting the *Water Filtration Challenge* the students should have already completed the *Water Filtration* and *Water Filtration with Plants* lessons.
2. Remind the students of previous discussions as to where they obtain their drinking water (e.g. lakes, rivers, rainwater, underground wells, etc.) and that these sources of water are generally not safe to drink without prior purification or treatment.
3. Remind the students of the methods that are used to purify drinking water in municipal water treatment plants (i.e. aeration, coagulation, sedimentation, filtration and chemical disinfection). Also remind the students that water is purified or filtered in nature as it passes through forests, woodlands, wetlands and natural grasslands (i.e. reduced water flow allows for particulate matter to settle and for the absorption and biodegradation of contaminants by plants, bacteria and fungi).
4. Rather than designing a traditional science experiment to test the effect of altering a single variable, the objective of this exercise is to challenge the students to be creative and utilize their prior knowledge of filtering materials to construct the best possible water filtration unit. Therefore, the key points to reinforce for the lesson are:
    - Think about your results and conclusions from the two previous experiments on water filtration and how this information can be used to construct the best possible filtration unit. What were the best filtering materials among the fine and coarse sand, pebbles and rock? Which types of contaminants were trapped by each of these physical filtering materials? Was the use of plants as a biofilter effective to remove contaminants?
    - Given the results of the first two filtration experiments, how would you improve upon the filtration units designed? For example, using different combinations of filtering materials in layers, trying new filtering materials, increasing the volume of filtering materials, using different types of plant material, reducing the speed at which the contaminated water passes through the filtration unit, etc.
    - Design the filtration unit on paper in advance before beginning construction. Write down what you think will happen. This is your prediction.
    - During the challenge the students will collect data, record and examine results as in a typical scientific experiment and should think about why things happened the way they did.
    - Make conclusions and explain results (compare results to predictions to help you think deeper).
5. Communicate results and conclusions (i.e. your lab report).

Experiment Title: Water filtration challenge.

Purpose of Experiment: To utilize prior knowledge of filtering materials to construct the best possible filtration unit to purify contaminated water.

Experimental Treatments:

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| Test treatment 1 | Uncontaminated water |
| Test treatment 2 | Contaminated water |

Methods:

Several weeks in advance of the lesson:

1. If plants are to be used as part of the *Water Filtration Challenge* these can be grown from seed in 1-litre clear plastic pots with drainage holes, lined with a layer of small pebbles at the bottom of the pot and topped with 500 mL of potting soil. Any plant that provides a thick layer of growth should be suitable as a biofilter. Grass grown from seed is suggested because it can be grown quickly and easily using seeds purchased from any hardware store or garden centre.

The day of the lesson:

Divide the class into groups of 3-4 students. Each group will design a single filtration unit.

1. It is recommended that teachers have students prepare a scale diagram of their proposed filtration unit before any construction begins.

2. The actual construction of the filtration units can either take place over the course of a week or two when time permits in class, or a teacher may prefer to place a time limit on the construction and provide just a single class to build the filtration units.

3. Teachers may choose to provide each group of students a fixed amount of filtering materials (i.e. 2-litre bottles, sand, plants, etc.) or alternatively, the scale of the filtration units could be limited only by the availability of filtering materials and classroom space. To promote creativity, teachers may also consider allowing students to incorporate new types of filtering materials into their filtration units, after prior approval by the teacher at the design stage.

4. For any filtration unit, students should be aware to incorporate layers of the different filtering materials, utilize as many types of filtering materials as possible, design filters that allow for the slow passage of contaminated water, consider the order of filtering material, and consider the volume of filtering material.

5. To reduce the rate of water flow while minimizing the volume of filtering materials, students could be offered the option of using 1-litre pop bottles or any other narrow plastic tubing, in addition to 2-litre bottles.

6. Since each group will only construct a single filtration unit for the challenge it is recommended that only one type of contaminated water be utilized (i.e. mud and water, soap and water, oil and water). For details on the preparation and volume of contaminated water to be used please see the *Water Filtration* lesson. As a control for particulate matter released from the filtration unit itself, it is suggested that each group first test uncontaminated water.

7. The effectiveness of each filtration unit in the *Water Filtration Challenge* can be evaluated using several possible criteria including: quantity of starting water volume recovered, quality of contaminated water recovered, rate of water recovery. Each of these criteria could be ranked on a scale of 1 to 10, for a total possible score of 30. Alternatively, water quality could be emphasized by ranking this performance from 1 to 10 and the other criteria from 1 to 5, for a total possible score of 20. Remind students that by slowing the flow of water through their filtration unit they will likely improve the quality of water recovered, but will also reduce the rate of recovery and possibly the volume recovered in the time allotted. In other words, there may be a tradeoff between the performance criteria. Before asking the students to design their filtration unit it is best to inform them as to how performance will be graded.

8. Please note that the filtered water recovered is not safe to drink.

Science Journal: Activity sheets with different sections can be prepared for students to record:

- The important features and types of filtering materials used in their filtration unit
- Drawings of their filtration units
- Their observations should include the volume recovered, rate of recovery and a qualitative description of the turbidity or quality of the water recovered
- Their conclusions (what happened and why did it happen)

**Closure Discussion**

1. Discuss predictions and observations for the effectiveness of the filtration units designed by the different student groups.
2. Discuss what happened and why it happened.
3. Discuss how the filtration units could be improved if resources were unlimited?

**References and Extension of Lesson Plan**

For references and extensions or lead-ins to this lesson, please see the following lessons:

*Water Filtration* (lesson 2) and *Water Filtration with Plants* (lesson 3) in the Water Quality science unit, Earth Science curriculum area, available from the Scientist in Residence Program website http://www.scientistinresidence.ca).