Science Unit: *Water Quality*
Lesson 3: *Water Filtration with Plants*

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
Notes:	Lead-in experiment is *Water Filtration* and follow-up experiment is *Water Filtration Challenge*

Objectives

1. Introduce how to do a science experiment.
2. Learn about how both soil and plants contribute to the purification of contaminated water in nature.
3. Test plant materials for their ability to filter water containing different contaminants (e.g. mud, soap, oil).

Background Information

Vegetation performs a significant role in the filtration and purification of contaminated waters. Forests, woodlands, wetlands and natural grasslands act as sponges to slow the movement of water from where it falls as precipitation to where it enters streams, lakes and estuaries. The longer water takes to cross land the greater the chance that biological processes performed by bacteria, fungi and plants will clean the water. Many contaminants are absorbed by plants and used as a food source, thus removing contaminants from the soil. For more background information see the lesson entitled *Water Filtration*.

Vocabulary

Independent variable:	The variable which is manipulated or selected by the experimenter to determine its relationship to an observed phenomenon (the dependent variable). In other words, the experiment will attempt to find evidence that the values of the independent variable determine the values of the dependent variable (which is what is being measured).
Dependent variable:	The factor whose values in different treatment conditions are compared. That is, the experimenter is interested in determining if the value of the dependent variable varies when the values of another variable – the independent variable – are varied, and by how much.
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.
Constructed wetlands:	An artifical marsh or swamp created to filter or purify contaminated discharge such as wastewater, storm water runoff or sewage treatment, and as a habitat for wildlife, or for land reclamation after mining or other disturbances.

Materials:

- vegetable oil
- mud
- liquid dish soap
- grass seed (or seeds for other plants)
- 1-litre clear plastic pots with drainage holes
- 200 mL graduated cylinders
- 500 mL measuring cups
- potting soil
- small pebbles (potting stones)

In the Classroom

Introductory Discussion

1. Begin by asking the students where they obtain their drinking water. Common sources include nearby lakes, rivers, rainwater, underground wells, etc.
2. Ask the students if water taken from these sources is safe to drink without any type of purification or treatment. In most cases, water from the sources listed above must first be treated before it is safe for use as drinking water.
3. Ask the students how water is purified or filtered in nature. When rainwater or water from fast-moving rivers and streams passes through forests, woodlands, wetlands and natural grasslands the speed of the moving water is slowed, which allows particulate matter to settle. In addition, plants utilize the contaminated water for their growth, and in the process, contaminants are absorbed by the plants and biodegraded.
4. Review how to do a science experiment.
    - Make an observation and then ask a question OR start with a question: do plants act as effective biofilters to clean contaminated water?
    - Think about what will happen if water contaminated with mud, soap or oil is slowly passed through a bed of plants. Write down what you think will happen. This is your prediction.
    - Set up an experiment (water filtration), and treat everything the same way except for one thing - what you want to test (exposure to plants). Discuss why you only change one thing (a variable).
    - Make observations.
    - Collect data, record and examine results (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: Effectiveness of plant material as a biofilter to clean contaminated water.

Purpose of Experiment: To evaluate the ability of plants to filter or purify different types of contaminated water.

Experimental Treatments:

Test treatment 1	Soil only
Test treatment 2	Soil plus a bed of plants

Methods:

Several weeks in advance of the lesson:

1. Plants 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 test four biofiltration units, two consisting of soil only and two consisting of soil plus plants.

1. At the time of the experiment the pots with soil only or soil plus plants should be moderately dry, with no water added for a few days prior to the experiment. Plants with saturated soil will not absorb water, and very dry plants will absorb it all.

2. Assign each group to test one type of contaminated water (i.e. mud and water, soap and water, oil and water), as well as uncontaminated water alone. The latter option is required to determine how much of the potting soil is released from the pots during the filtering process. During test runs in advance of the class, if too much potting soil is recovered in the eluted water then a thicker layer of pebbles should be added inside the bottom of the pots.

3. Provide each group with two biofiltration units with soil only and two with soil plus plants. The independent variable is whether or not plants have been added to the biofiltration unit.

4. The teacher or scientist can prepare the mixtures of mud and water, soap and water, and oil and water for the entire class. The total volume required for each contaminated water mixture is: 100 mL X 2 biofiltration units X the number of groups in the class testing that type of contaminated water mixture. To minimize “messiness” in the experiment, only add a small volume of mud (e.g. 50 mL), oil (e.g. 25 mL) or liquid soap (e.g. 1 mL) per each 500 mL volume of water.

5. To test the effectiveness of vegetation as a biofilter, have each group very slowly add 100 mL of their contaminated water mixture to one soil only and one soil plus plants biofiltration unit and separately collect the eluted liquid into sufficiently large measuring cups. The volume can then be measured using 200 mL graduated cylinders. Note: each group will test only one type of contaminated water (i.e. mud and water, soap and water, oil and water). The data from all groups can then be pooled for a class-wide comparison. In addition, each group will also add 100 mL of clean water to one soil only and one soil plus plants biofiltration unit and collect the eluted liquid as above. This control is incorporated to evaluate how much potting soil is released into the eluted water.

6. To maximize the effectiveness of the plant biofiltration units we need to maximize the amount of time that the plants are exposed to the contaminated water. To do this, the eluted water can be collected over a 5-10 minute period and then passed through the biofiltration units again. Time permitting, this process could be repeated multiple times. Each time the eluted water is collected a few mL should be set aside and labeled as passage 1, passage 2, passage 3 …etc. In doing so, the students will likely observe that after each passage of their contaminated water through the biofilter more contaminants will be removed and the eluted water will have fewer contaminants. Have the students carefully track how much water is recovered after each passage, as well as how much is set aside after each passage to evaluate water quality.

7. After the original clean and contaminated water sources have been subjected to several rounds of filtering [(1) clean water - soil only biofilter, (2) clean water - soil plus plants biofilter, (3) contaminated water - soil only biofilter, (4) contaminated water – soil plus plants biofilter], have the students compare the turbidity of their eluted liquid from each round of passage against an unfiltered tap water control and the three unfiltered starting mixtures. This is a qualitative

measurement. The dependent variable is the qualitative assessment of water purity after passage through the biofiltration units.

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:

- Their predictions for the effectiveness of the two types of biofiltration units
- Their drawings of the biofiltration units
- Their observations should include the volume recovered after each passage through the biofiltration units 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. Review how plants and soil act as biofilters to purify contaminated water in nature.
2. Discuss predictions and observations for the effectiveness of the two biofiltration units used to clarify the three types of contaminated water mixtures.
3. Discuss what happened and why it happened.
4. Discuss how the biofiltration units could be improved? For example, using different types of plant material, designing biofilters with multiple layers, reducing the speed at which the contaminated water passes through the biofilters.
5. Review how to do a science experiment and discuss variability in the results across the class and possible sources of error in the experiment.

Reference

1. http://www.epa.gov/safewater/kids/teachers_4-8.html (U.S. government Environmental Protection Agency site with several activities on water resources).
2. http://www.epa.gov/owow/wetlands/education/ (U.S. government Environmental Protection Agency site with activities, teaching tools and web links related to wetlands education).
3. http://ag.arizona.edu/AZWATER/arroyo/094wet.html (detailed introduction to constructed wetlands prepared by the University of Arizona Water Resources Research Center).

Extension of Lesson Plan

1. A follow-up to this experiment is the *Water Filtration Challenge* (see lessons 4 in the Water Quality science unit, Earth Science curriculum area, available from the Scientist in Residence Program website http://www.scientistinresidence.ca).
2. Other plant materials could be evaluated for their effectiveness as biofilters. Suggested plants could include those growing in nearby local wetlands, if these plants are available as seed or seedlings from commercial garden centres.
3. To extend the lesson a field trip to a local wetland is a very effective method to introduce the concepts of biofiltration and reinforce the importance of wetlands as a natural process to purify contaminated water.

4. A longer-term project would be to create your own constructed wetland in an aquarium or outdoor school garden.