Water Treatment in Greater Victoria

Key Concepts

- Water resources in Greater Victoria are managed for their quality and quantity.
- Responsibility for water is everyone's concern.

Method

Students will learn about water disinfection at the CRD Japan Gulch Disinfection facility and can make an optional model water treatment filter.

Activity Information Box:

Time Required: 50-60 minutes

Grade Level: Grades 8-12

Key Words: *Disinfection, water treatment, Ultraviolet disinfection, Biofilm*

Materials:
- *Water Treatment in Greater Victoria* PowerPoint (PDF) presentation
- Student worksheets

Setting: indoors

Skills: data collection, observation, analysis, interpretation

Subjects: Science 8-10
Chemistry 11-12

Learning Outcomes:

It is expected that the student will:

- Describe the process that the Japan Gulch disinfection facility uses to purify water for drinking;
- Explain how water moves through the disinfection process to their tap.

Optional Materials:
- 2 litre pop bottles
- washed sand
- large and small gravel
- tubing
- water
- student work sheets
- filter diffuser material
- 500g yogurt (or other) plastic lids
- microscope
- silicon sealant

Background

Water treatment is the process of making water safe for people to use, especially for drinking. Water is not always clean and safe enough for people to drink. Water that looks clean may contain bacteria and other organisms that can cause disease. In the past, waterborne diseases were a major public health concern but today, thanks to improved water treatment, these diseases are no longer a health threat.

CRD Water Services and the municipal water suppliers in the Greater Victoria Drinking Water System must comply with the British Columbia Drinking Water Protection Act and Drinking Water Protection Regulation. CRD Water Services also uses the water quality parameters of the federal government's Guidelines for Canadian Drinking Water Quality. In addition to the Provincial and Federal regulations, on a voluntary basis, CRD Water Services also complies with most of the more stringent United States Environmental Protection Agency (USEPA) rules and regulations for surface water. Some of the limits in the USEPA rules are used as the basis for the Department's water treatment goals.

CRD Water Treatment

The Greater Victoria Drinking Water System is an unfiltered[1] drinking water system that continues to meet the stringent USEPA criteria to remain an unfiltered surface water supply. The treatment process consists of primary disinfection of the source water entering the treatment plant and secondary disinfection that provides a residual disinfectant that remains in the distribution system.

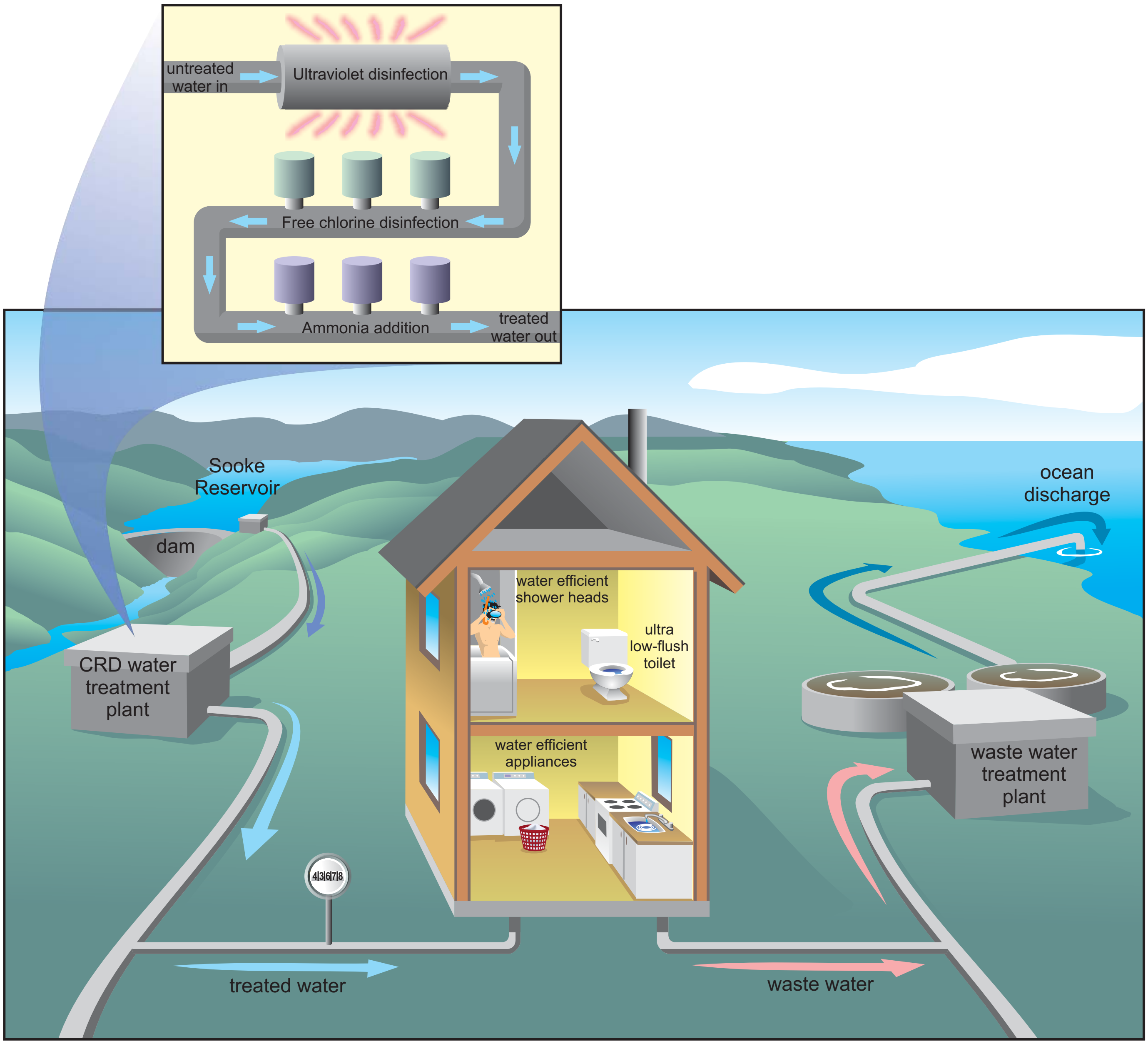
The treatment system employs two facilities: the larger one at Japan Gulch Disinfection Facility which disinfects all of the water in the Greater Victoria Drinking Water System except for Sooke and East Sooke, and the small one at Sooke River Road which disinfects the water for Sooke and East Sooke. At the Japan Gulch and Sooke River Road Disinfection Facilities the water passes through a three part disinfection process in sequential order:

- UV Disinfection. Ultraviolet (UV) disinfection provides the first step in the primary disinfection process (disinfection of the water entering the plants), which inactivates parasites such as Giardia and Cryptosporidium as well as reducing the level of bacteria in the water.
- Free Chlorine Disinfection. Free chlorine disinfection provides the second step in the primary disinfection process using a free chlorine dosage of approximately 1.5 mg/L for approximately 10 minutes (depending upon flow) of contact time between the free chlorine and the water. The free chlorine disinfection step inactivates bacteria and provides a 4-log (99.99%) kill of viruses.
- Ammonia Addition. The final step in the primary disinfection process is the addition of ammonia to form chloramines at a point "downstream" in the piping where the water has been in contact with the free chlorine for approximately 10 minutes or more. The ammonia is added at a ratio of approximately 5 parts chlorine to 1 part ammonia. In the water, these chemicals combine to produce chloramine, which is also a disinfectant, and is known as the chloramine residual. This residual (secondary disinfection) remains in the water and continues to protect the water from bacterial contamination as it travels throughout the pipelines of the distribution system.

$$HOCl + NH_3 \rightarrow NH_2Cl + H_20$$

1. Many water supplies in North America require a complex facility that passes water through a series of filters to remove organic materials, sediment, high levels of bacteria and other disease causing organisms and chemicals. The water in the Greater Victoria Water Supply is of such high quality that filtration is unnecessary.

GREATER VICTORIA DRINKING WATER SYSTEM AND WASTEWATER SYSTEM



After the water is treated, it is safe to drink straight from the tap, meeting federal and provincial standards for drinking water. Not all parts of the world have such effective water treatment as we have in Greater Victoria. In developing countries many millions of people – half of them children and teens – die each year from diseases related to unsafe drinking water. Water contamination is closely linked to bacterial, parasitic and other water-borne diseases, especially cholera and diarrhea.

Procedure

1. Ask students "who used tap water today?" and make a list of water uses. Then discuss with students "how do you know the water you used today is safe?" Explain that the water that comes out of our taps is safe because it is treated and monitored by CRD Water Services and meets both provincial and federal, and USEPA standards for safe water.
2. If students live in a home that is on a well, ask them to ask to find out if their water is tested for water quality? Do they have an in-home filtration or treatment system?
3. Show the PowerPoint® (PDF) presentation of the CRD Water Services treatment process and discuss how water is treated. Include information on the three steps of the process (UV Disinfection; Free Chlorine Disinfection; and Ammonia Addition – see background information above). For further information on UV disinfection, see Resources.
4. Have students complete the Student Worksheet.

Evaluation

Have students:

- Describe the process that the CRD water disinfection plants use to purify water for drinking;
- Draw a diagram showing how water gets from the source (Sooke Reservoir) to their tap.

Extensions

1. Grades 8/9. Have students make a simple water filter. A simple sand filter is commonly used in water treatment facilities to trap particles and impurities in the water. However, filtered water requires further treatment before it is suitable for drinking water supply. A student worksheet outlines how to make a simple sand filter.
2. Grades 10-12. Have students make a BioSands Filter Model as a project. They can save the BioSands model for two to three weeks to allow the biological layer or 'schmutzdecke' (as it is called in German) develop following instructions on the Student Worksheet.

Community Connections

1. Ask students to research water quality in developing countries. Find out if there are any local organizations - local chapter of Water for People, for example: **http://www.waterforpeople.org** - and what they could do to help.

Additional Resources

BC Science 8. 2006. See section on Science Skills – Scientific Inquiry (pages 476-479)

CRD Water Services. *Refreshing Information About Drinking Water Quality* Brochure available from **http://www.crd.bc.ca/water/**

Green Teacher, Spring 2008. Clean Water for the World activity (pages 31-34)

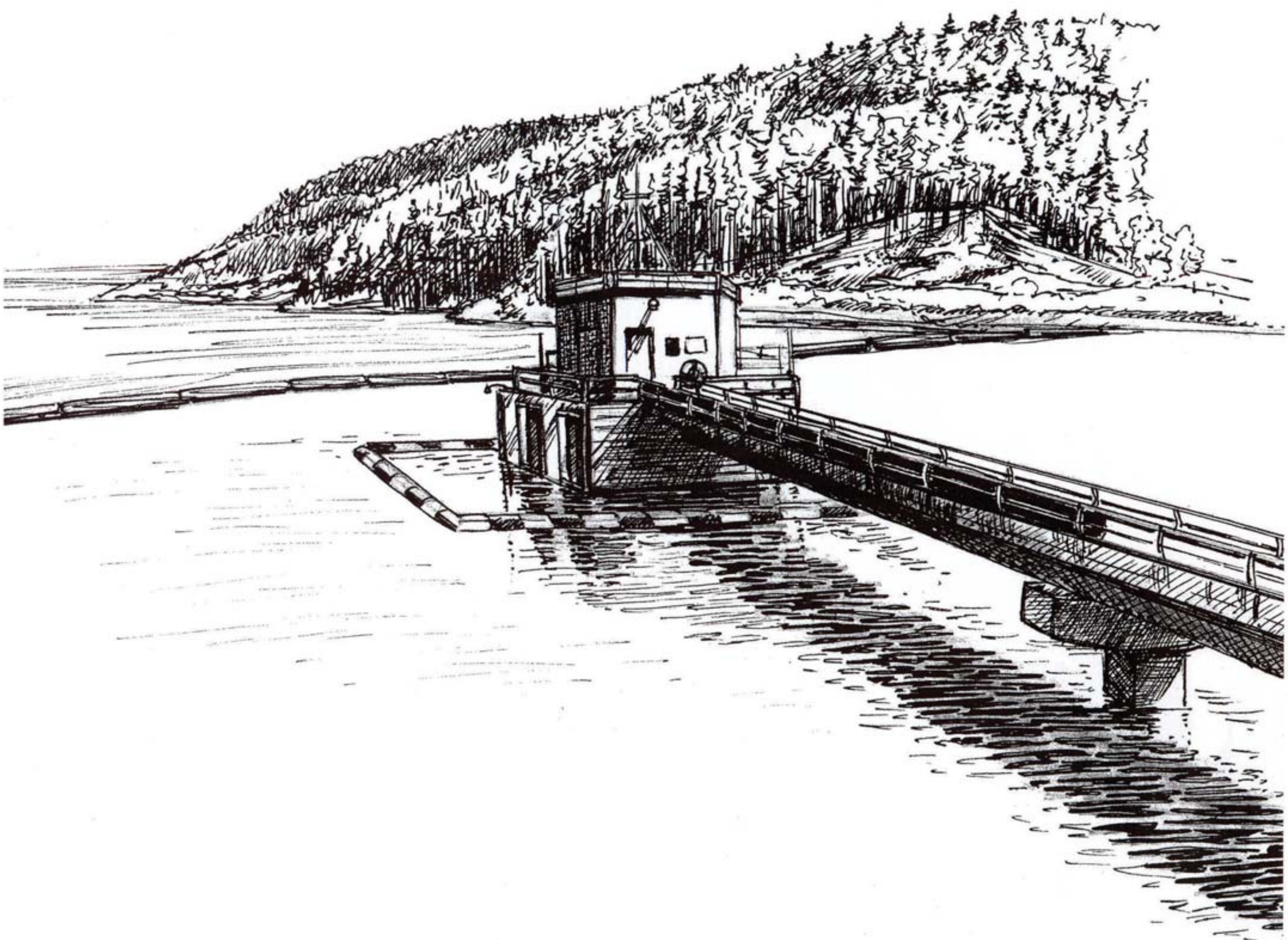
References

CRD Water Services: 2007 Annual Overview of Greater Victoria's Drinking Water Quality

CRD Water Services Website: **http://www.crd.bc.ca/water/**

Centre for Affordable Water and Sanitation Technology: **http://www.cawst.org/**

EPA Water Source Books. *Drinking and Waste Water Treatment* grades 9-12. **http://www.epa.gov/safewater/kids/wsb/**



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WATER TREATMENT IN THE CRD – STUDENT WORKSHEET

1. Draw a simple diagram showing how water gets from the Sooke Reservoir into your home.

2. Describe and make a diagram of the three processes which are used to disinfect our drinking water.

3. Imagine you are hiking in a remote area. Describe and draw a personal water purification system that you can bring with you on your hikes.

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SIMPLE WATER FILTER EXPERIMENT - PROJECT INSTRUCTIONS:

AIM:

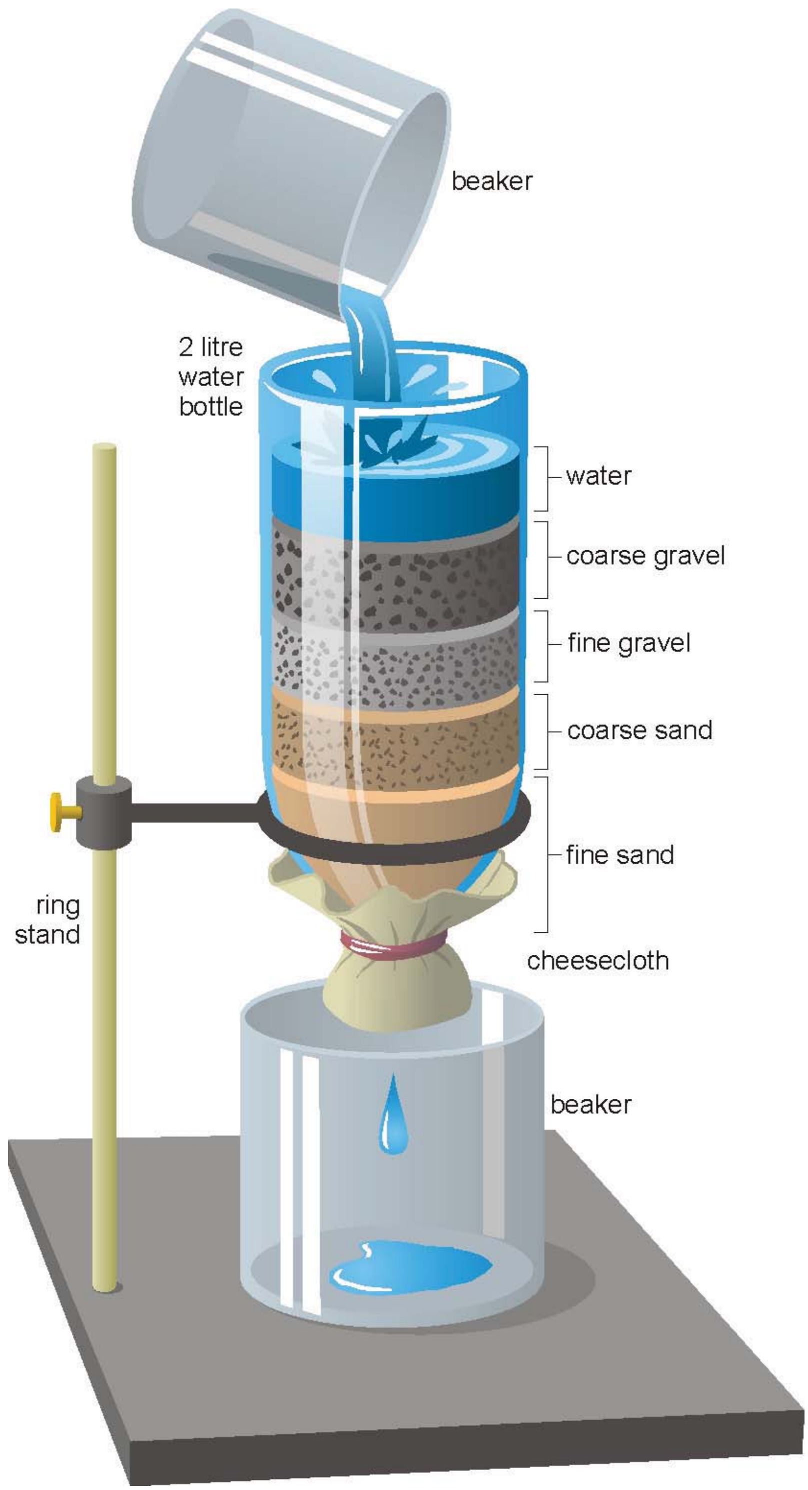
to make a model simple water filter for use in a water treatment experiment.

MATERIALS:

- pop bottle
- water samples
- cotton
- scissors
- cheesecloth
- beaker
- gravel (coarse and fine)
- sand (coarse and fine)
- elastic band

PROCEDURE:

1. Remove label from a 2-litre pop bottle.
2. Draw a line around the bottom ridge of the bottle and cut along the line so that the main part of the bottle remains.
3. Turn the bottle upside down so that the bottle spout is facing down. Place the cheesecloth over the bottle spout and secure with elastic. Place a small amount of cotton in the spout next to the cheese cloth. Follow with layers of fine sand, coarse sand, fine gravel, and coarse gravel as shown in the diagram. Place unit in ring stand.
4. Get a sample of "dirty" water (soil and water from a stream other natural water) and a sample of tap water from your teacher.
5. Compare the tap water and dirty water: look for differences in appearance and colour. Record your observations.
6. Examine your water samples with a microscope. Record your observations.
7. Pour dirty water in slowly to fill your filter so that water comes out of the spout.
8. Observe and record data on appearance, colour, and microscope obsevations of the filtered water sample.



EXTENSION:

1. Add garlic powder to the water sample, filter & then observe results.

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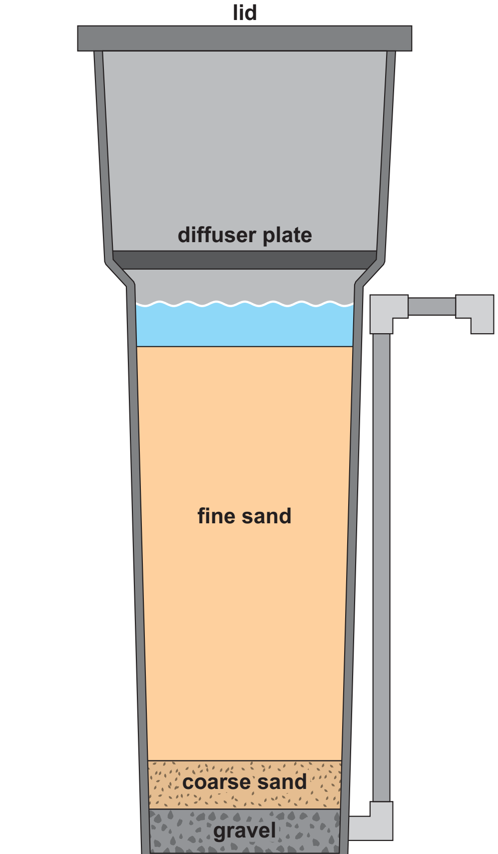
BIOSAND FILTER EXPERIMENT - PROJECT INSTRUCTIONS:

AIM: to make a model BioSands water filter for use in a water treatment experiment.

MATERIALS:

- pop bottle
- scissors
- beaker
- water samples
- gravel
- sand (coarse and fine)
- nylon stocking fabric
- elastic band
- plastic lid (diffuser plate)
- flexible tubing
- silicon sealant
- duct tape

PROCEDURE:



BIOSAND FILTER

1. Remove labels from a 2 litre pop bottle.
2. Draw a line around the top ridge of the bottle and cut along the line so that the main part of the bottle remains.
3. Measure 3 cm down from the cut and mark a line around the outside of the bottle. This is the line where your diffuser plate will sit.
4. Make a hole for the tubing about 5 cm from bottle bottom. Thread the tubing through the hole into the middle of the bottle. Seal with silicon sealant.
5. Secure the tubing in place with duct tape on outside of bottle – the tape should be placed just below where the diffuser plate will sit. This is your spout.
6. Place 6 cm depth of gravel at the bottom of the bottle, covering the tubing.
7. Fill the remainder of the bottle with washed coarse and fine sand, leaving a space (at least 1 cm) between the tubing exit and the top level of the sand (see diagram).
8. Prepare the diffuser plate. Using scissors, punch at least 15 holes in the plastic lid.
9. Keeping the bottle upright, place the nylon fabric over the opening, securing with the elastic on the outside of the bottle. Push the diffuser plate down to the 3 cm mark on the bottle. Secure with smaller pieces of duct tape if necessary.
10. Get a sample of "dirty" water and a sample of tap water.
11. Compare the tap water and dirty water: record differences in appearance and colour.
12. Slowly pour dirty water to fill your filter so that water comes out of the spout.
13. Record observations in appearance, colour, and microscope observations of the biosands filtered water and compare with tap water.

EXTENSION

1. Now it is time to have your filter develop its "biofilm" – like a yogurt culture. This layer is the most important part of the filter. It acts as a fine filter and actually 'eats up' some of the disease-causing microbes in the water. Everyday for the next 2 weeks, add untreated water (not tap water) to the filter.
2. While your filter is activating, research slow sand filters and how they work. You can go Centre for Affordable Water and Sanitation Technology: http://www.cawst.org/ or Water Tiger: http://www.watertiger.net/ to begin your research.
3. After two to three weeks your model is ready for your final observations. Complete the steps above with water treated with an active biosands filter. Record your observations and note any differences between the two samples of biosands treated water.

Student Background Information on the BioSands Filter Model

The BioSand Filter was developed by University of Calgary professor, Dr. David Manz.

The BioSand filter is an innovation on the traditional slow sand water filter. This is in contrast to a simple sand water filter. A simple sand filter is commonly used in water treatment facilities to trap particles and impurities in the water. However, water treated by a sand filter requires further treatment before it is suitable for drinking water supply.

The BioSand Filter works by removing pathogens through a combination of mechanical and biological processes. When water is poured into the top of the filter, the organic material it is carrying is trapped at the surface of the fine sand, forming a biological layer or '*schmutzdecke*' (as it is called in German).

Four processes remove pathogens and other contaminants in this filter:

- Mechanical trapping: sediments, cysts and worms are removed from the water by becoming trapped in spaces which lie between the sand grains. When additional chemicals are added to the incoming water as part of the process to form precipitates, the filter can also remove some inorganic compounds and metals from the water.
- Adsorption: viruses are adsorbed (become attached) to the sand grains. Certain organic compounds are also adsorbed to the sand and thus removed from the water.
- Predation: the *schmutzdecke* micro-organisms consume bacteria and other pathogens found in the water, thereby providing highly effective water treatment.
- Natural death: pathogens are removed due to food scarcity and less than optimal temperatures.
- Although the filter does eliminate 98% of bacteria, further disinfection is recommended for households with infants or elderly residents.

The BioSand filter is patented and made available to world aid organizations; it can be produced locally anywhere in the world because it is built using materials that are readily available. The BioSand Filter is a concrete container, enclosing layers of sand and gravel whose purpose is to eliminate sediments, pathogens, and other impurities from the water. It has been shown to be highly effective if maintained properly. It has uses for both developing countries and rural areas across Canada where large treatment plants are not suitable.