Water Monitoring Around the World

Key Concepts

- Responsibility for water is everyone's concern.
- Water supply is monitored in the reservoirs and water distribution lines.
- Water resources in Greater Victoria are managed for their quality and quantity.

Method

Students complete a water monitoring activity in their local watershed and can compare their results with monitoring stations around the world.

Activity Information Box:

Time Required: 120 minutes plus optional half day at a stream.

Grade Level: Grades 8-12

Key Words: *water quality, monitoring, pH, temperature, turbidity, dissolved oxygen, Invertebrate, biodiversity, Indicator species*

Materials:

- pencils
- paper
- hand sanitizer
- latex gloves
- buckets
- WWMD* test kit

  OR

  - field thermometer
  - dissolved oxygen test
  - Secchi disk /Turbidity wedge
  - pH paper

Setting: indoors and outdoors

Skills: gathering information, applying skills, analysis

Subjects: Science 8-10
Chemistry 11

** World Water Monitoring Day*

Learning Outcomes:

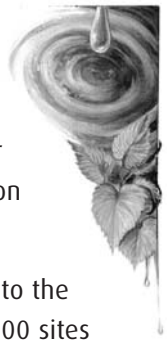
It is expected that the student will:

- Describe pH, dissolved oxygen, turbidity, and temperature monitoring methods;
- Explain how water quality can impact many facets of life;
- Practice water monitoring skills;
- Compare their results with results in other communities around the world. (optional)

Optional Materials:

- Surber sampler or D-Net
- macroinvertebrate ID sheets
- ice cube trays
- plastic pipettes/eye droppers
- dip net
- camera
- stream keepers manual / video

Background



Clean water in a watershed tells the story of watershed health. Knowing this and acting to protect water resources in Greater Victoria includes understanding how a watershed's water quality affects many facets of our lives. The action of water monitoring promotes social responsibility and community involvement in the protection of our water resources.

In this activity, students will monitor water quality in a stream near their school. They can also send their data to the World Water Monitoring Day (WWMD) database and join in the nearly 1,000 sites monitored in Canada and 4,000 sites around the world. Students can then compare their data with other sites in Canada and around the world. Site registration begins in July of each year and monitoring should be done between September 18th and October 18th if you want to participate in WWMD. However, this activity can be done at any time of year without registering with WWMD as an active site. Go to **http://www.worldwatermonitoringday.org** for more information on World Water Monitoring Day.

Or, teachers can collect water samples from a nearby stream and students can do the water testing in the classroom.

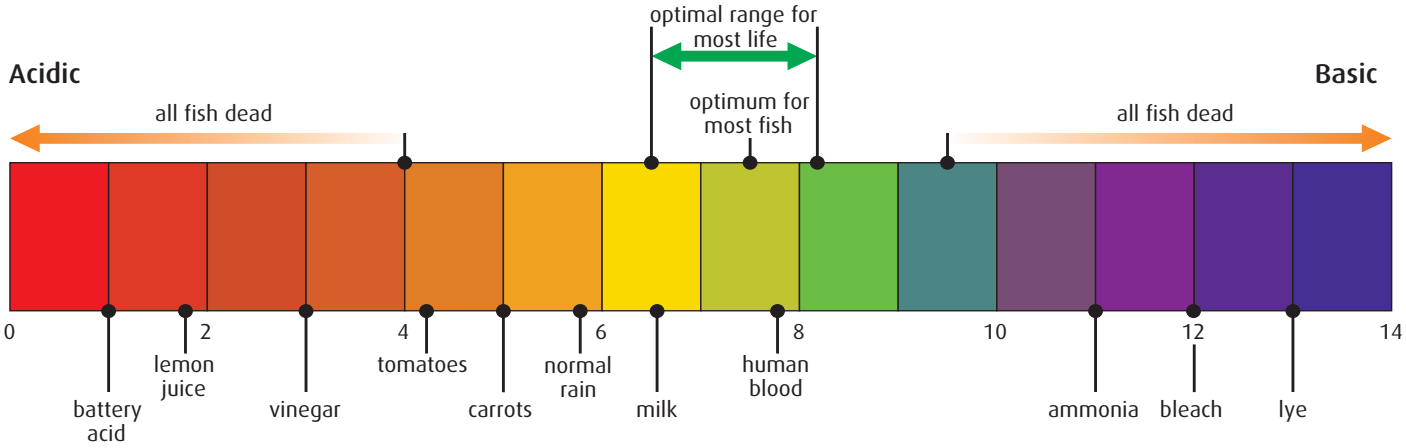
There are four simple monitoring tests that teach students about some of the more common indicators of water and watershed health. These tests, plus more sophisticated tests, are conducted regularly by CRD Water Services on water in the Greater Victoria Water Supply Area on a regular basis. The following four basic tests are the parameters that will be used as indicators of watershed health:

- pH
- Temperature
- Turbidity
- Dissolved Oxygen

Another excellent way to study water quality is through the use of a benthic macroinvertebrates study. This type of study gives students the opportunity to identify and classify aquatic organisms according to their tolerance to pollution and other conditions found in the stream.

pH

pH is a measure of where a liquid is on a scale from basic to acidic. It is measured on a scale of 1 to 14 where 0 is the most acidic and 14 is most basic or alkaline. A value of 7 pH units is considered neutral. Waters with a range from 6.5 to 8.5 are favourable to supporting most aquatic life. pH can be measured using pH paper dipped into the sample or with the addition of reagents to a water sample then comparing the results to a colour scale.



(after Streamkeepers 2000)

Temperature

Temperature measures the warmth or coldness of a water sample using degrees Celsius (ºC). This test is important because it indicates how the sampled water is able to support photosynthesis and other chemical reactions, the amount of dissolved oxygen, and the aquatic ecosystem (food chain). Water that is too cold or too warm can have significant impacts on fish and other aquatic life. Different species of fish and other aquatic organisms have different optimal temperature ranges; some prefer colder water, while others prefer warmer water. The Sooke Reservoir, for example, can have algae "blooms" when water temperature rises. These blooms can cause unpleasant taste and odours in drinking water, even though the water is still safe to drink. In Greater Victoria, most streams are considered cold water systems and have an optimal range of 5 - 12 ˚C.

Water temperature is measured in field sites using a field thermometer.

Description	Optimal Range ˚C
Warm	20˚ to 25˚
Cool	13˚ to 19˚
Cold	5˚ to 12˚

(chart adapted from: Bridging the Watershed, 2006)

Turbidity

Turbidity is a measure of the cloudiness or clarity of water. Erosion, debris, silt and sand can make water less clear or more turbid. Increased turbidity can affect aquatic life by decreasing light penetration and photosynthesis, increasing respiration, and affecting the availability of food sources and success of reproduction. Clarity of water is measured using a Secchi disk or turbidity wedge to determine how far light will penetrate in the water. A wedge or Secchi disk is used primarily for its simplicity and the results are recorded in units of distance (e.g., metres). Turbidity is measured using a turbidity meter that gives results in specialized units known as NTU (short for Nephelometric Turbidity Unit). Turbidity meters are very expensive and more complicated to operate compared to a simple wedge/Secchi disk. For this reason, the Secchi disk or a turbidity wedge are more commonly used with the understanding that the measurement of water clarity gives an indication of turbidity. At sites where water is too shallow or has limited access, a test such as the one in the WWMD test kit is used. This measures Jakson Turbidity units (JTU). Some waters are naturally turbid, such as waters coming out of a glacier, and aquatic organisms have adapted to those conditions. Optimal turbidity for a particular steam is usually done by comparing sampling locations (e.g. upstream and downstream of a disturbed site).

Dissolved Oxygen

Dissolved Oxygen (DO) is a measure of how much oxygen is present in the water. DO is measured by mixing a water sample with a chemical reagent. The results are measured in units of milligrams of oxygen per litre (mg/L). Oxygen is important to fish and other aquatic life. A higher DO reading indicates higher levels of oxygen in the water – water which is able to support the oxygen demands of a diverse ecosystem. Water with low levels of DO can support a less diverse ecosystem as it cannot supply enough oxygen for species that need high DO levels. Water with dissolved oxygen levels of less than 5.0 mg/L puts many species of aquatic life under stress. Oxygen levels below 1 to 2 mg/L for a few hours can result in large fish kills.

Stream Macroinvertebrate Study

The study and identification of stream macroinvertebrates found on stream bottoms can provide an indication of stream health. These creatures are mostly immature stages of insects (pupae, larvae, nymphs); however worms, snails, and clams can also be found. Some species of invertebrates require good water quality while others are more tolerant of a variety of stream conditions. When doing a macroinvertebrate study, organisms can be broken into three groups.

Group One organisms are generally pollution intolerant and their dominance signifies good to excellent water quality.
Group Two organisms can exist in a wide range of water quality conditions; members of this group are not as useful as indicators of water quality.
Group Three organisms are generally tolerant of pollution and their dominance generally indicates fair to poor water quality.

Further information on how to conduct a stream invertebrate study and a field identification chart can be found in Fisheries and Oceans Canada *Streamkeepers Module 4: Stream Invertebrate Stud*y. Go to: **http://www.pskf.ca/publications/download.html to download module 4.**

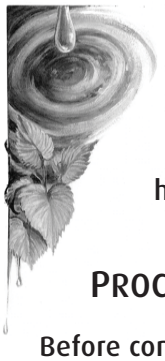
Streamside Field Study Etiquette

A visit to a nearby stream or pond can be an enriching experience for students. Check with your school district for any specific guidelines and permission forms as part of trip planning.

It is very important to prepare students to safely visit this sensitive ecosystem. It is a good idea to visit your proposed stream site before your field sampling day and scout out an area where stream banks are not steep and where students have plenty of room to conduct the tests. Look for potential risks from unstable banks, deep or fast moving water, wildlife, plants, etc. Be sure to get permission from private landowners first if you want to have your field site on private property. There are many streams around the CRD in local and regional parks, where permission is not needed. For a list of local streams nearby middle and secondary schools in Greater Victoria, see Appendix B of this learning resource.

Streamside Safety Rules:

- Bring a first aid kit;
- Define field study boundaries – make sure students understand where they can and can't go to safely gather water samples;
- Bring soap or hand sanitizer and towels so that students can clean their hands after the field work;
- Students should wear appropriate field gear – dress for the weather(rain gear) and stream conditions (rubber boots or old runners are preferable);
- Students should not enter the water without supervision;
- Students should not touch wildlife nor drink from the stream;
- Students should use care when collecting water samples: stream bottoms can be are slippery, can contain deep pools or sink holes, sensitive habitats that should not be damaged or destroyed;
- Students should be careful of stream.



Monitoring Protocol

If your class chooses to enter your data in the World Water Monitoring Day database, it would be useful to review the instructions for database entry prior to your field study. Go to:
http://www.worldwatermonitoringday.org/docs/instructions.pdf for complete instructions.

Procedure

Before conducting a water sampling lesson:

1. Decide whether you will complete the water sampling in the classroom or in the field. Field sampling will produce more accurate results and give students a greater appreciation of the stream you visit. If a field day is not practical, collect and refrigerate water samples from a nearby stream before class.
2. Gather your water sampling materials: review the equipment in the water monitoring kits available from World Water Monitoring Day and make copies of the water sampling instruction sheets or gather the required number of thermometers, pH paper, DO tests, a Secchi disk/turbidity wedge and the (optional) macroinvertebrate field identification charts and other equipment.
3. Before going conducting the water sampling, ask students how they think water quality might affect quality of life in the stream and watershed that they will be sampling. Post their answers on the board in the classroom.
4. Clearly explain the purpose of the water sampling: to join in with thousands of others around the world to monitor four indicators of water and watershed health. Note that the data they collect can be entered into a world-wide database as part of World Water Monitoring Day.
5. Explain the four monitoring tests that they will be conducting: pH, temperature, turbidity, and dissolved oxygen using the information provided.
6. Review how to use the macroinvertebrate field identification charts if using this method. The Pacific Streamkeepers program (**http://www.pskf.ca/video/**) has some excellent training videos that you can view beforehand:
   - Introduction to the Streamkeepers – 6 minutes
   - Module 3: Water Quality (temperature, pH, Dissolved Oxygen, and Turbidity) – 16 minutes
   - Module 4: Stream Invertebrate Study – 15 minutes

Note that although the equipment used in the Streamkeepers kit is not exactly the same as in the WWMD kits, the methods used are similar.

7. **Review Streamside Field Study etiquette and safety instructions from WWMD test kit with students.**

Water sampling:

8. Set up the sampling stations and divide the class into four groups – one for each test. If you are going to do the optional invertebrate study at a field site, divide the class into five groups.
9. Each group will rotate through the four or five test stations, gathering one type of data at each station. It might be useful for each group to have student(s) in the following roles: "facilitator": reads instruction sheet; "recorder": records results; "testers": conducts test. **ALL USED CHEMICAL REAGENTS IN WATER SAMPLES SHOULD BE COLLECTED IN A BUCKET AND DISPOSED OF PROPERLY (E.G., BACK IN THE SCHOOL SCIENCE LAB) - NOT DIRECTLY BACK INTO THE STREAM.**
10. Each station should have an instruction sheet, the test materials, and a reagent bucket (for DO and pH).
11. After all students have completed each station, make sure the field site is clean of all monitoring materials and garbage.

Back in the classroom:

12. Debrief the water sampling activity – what were the challenges and successes? Was the water quality what they expected? Refer back to the students expectations.
13. Make a summary table of all results. Did all students get the same results? Why or why not? What sources of error might influence the results?
14. Results should be submitted by December 18th of each year if participating in WWMD.
15. Discuss the implications of their findings: how might the water quality of the stream they studied impact the local watershed ecosystem? Now that they know the quality of the water in the stream discuss:
    - What changes could be made to improve water quality? (if necessary)
    - What kind of pollution upstream or downstream might be present in this stream/watershed? What indicators are present?
    - How does the stream compare to other streams? (see WWMD website) how does it compare to water quality in the Sooke Reservoir? (see Table 1 - *2006 Untreated (Raw) Water Quality at Japan Gulch* included or **http://www.crd.bc.ca/water**)
    - How might this stream/watershed have been used by First Nations people? Is the water quality sufficient for this type of use today? Why or why not?
    - If the optional invertebrate study was completed – ask students to evaluate the stream on the basis of their findings. Which group of invertebrates was predominant? What might this indicate about water quality and the health of the watershed?
16. (Optional) Report your data by submitting your results on the WWMD website. Go to **http://www.worldwatermonitoringday.com/sitereg/database.html** to register and report your data.

EVALUATION

Have students:

- Complete the water monitoring study data sheets;
- Understand and be able to define pH, temperature, turbidity, dissolved oxygen;
- Compare their results with other monitoring stations around the world using the WWMD database.

EXTENSIONS

1. Have students do further research on their stream's watershed. Go to **http://www.crd.bc.ca/watersheds/protection/index.htm** for detailed information on the local watersheds that includes information on plants and wildlife, geology, and First Nations historical uses. Or, explore local watersheds using Google Earth.
2. Compare the results from their field study site to a site in another country or region.
3. Invite a local First Nations Elder into the classroom to talk about the traditional uses of the stream or watershed. Alternately, ask students to interview an Elder or someone they know who has lived nearby the stream for a long time to find out how the stream or watershed has changed over the years.

Community Connections

1. Go to **http://www.crd.bc.ca/water/waterquality/sooketrends.htm** and view the reports on water quality trends in the Sooke Reservoir. Compare the reservoir water results with your field study results.
2. Contact your local Streamkeepers group for assistance with the field activity. See Additional Resources for more information.
3. Invite a speaker from a local laboratory that does water quality testing to discuss water contaminants such as heavy metals or other pollution.

Additional Resources

Project WET – Macro-Invertebrate Mayhem Activity

The Streamkeepers Handbook – Fisheries and Oceans Canada. Available for down load at:
http://www.pskf.ca/publications/download.html

Lost Streams of Victoria Map. This Fisheries and Oceans Canada poster is a full colour map on side one; and side two features ways to take part in stewardship activities, including stories of streams and creeks that need stewardship today. It is available, free of charge, from:

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For Streamkeeper Training, contact:

Don Lowen; Education Coordinator, Fisheries and Oceans Canada
250-388-4756 or h2oship@shaw.ca

For links to local watershed maps go to **http://crd.bc.ca/maps/index.htm** and go to Natural Areas Atlas.

World Water Day. Go to: **http://www.worldwaterday.org/**

References:

World Water Monitoring Day: **http://www.worldwatermonitoringday.com**

Operation Water Drop: **http://www.safewater.org**

Pacific Streamkeepers Federation: **http://www.pskf.ca/**

Bridging the Watershed: **http://www.fergusonfoundation.org**

Table 1. 2006 Untreated (raw) Water Quality at Japan Gulch Plant

Parameter		2006 Analytical Results				2006 Canadian Guidelines	Ten Year Results (1997 -2006)			
Parameter Name	Units of Measure	Median Value	Samples Analyzed	Range		(provides reference only for untreated water)	Ten Year Median	Samples Analyzed	Range Minimum - Maximum	Sampling Frequency
				Minimum	Maximum					
Physical Parameters										
Alkalinity, Total	mg/L	15.0	23	9.1	17		14.7	316	7.0 - 17.6	26/yr
Carbon, Dissolved Organic	mg/L as C	2.4	14	2.2	3.3		2.5	81	1.8 - 7.0	12/yr
Carbon, Total Organic	mg/L as C	2.6	14	2.2	3.0	No Guideline Required	2.5	172	1.8 - 9.6	12/yr
Colour, True	TCU	7.9	57	4.4	17	≤ 15 AO	7.9	586	2.8 - 18	52/yr
Conductivity @ 25˚c	uS/cm	42.2	50	34.7	45.8		41.3	527	26.2 - 47.0	52/yr
Hardness	mg/L	17.4	20	15.5	34.7	No Guideline Required	17.1	130	9.3 - 34.7	24/yr
pH	pH units	7.29	50	6.68	7.51	6.5 - 8.5 AO	7.3	531	6.46 - 7.72	52/yr
Tannins and Lignins	mg/L	0.24	4	0.19	0.29	No Guideline Required	0.26	25	0.07 - 0.37	2/yr
Total Dissolved Solids	mg/L	25.4	43	20.5	34.2	≤ 500 AO	25.4	202	8.0 - 49.0	36/yr
Total Suspended Solids	mg/L	1.0	43	<0.1	6.0		0.7	201	0.1 - 7.7	36/yr
Total Solids	mg/L	26.5	43	22.0	35.0		26.4	202	8.0 - 53.0	36/yr
Turbidity, Grab Samples	NTU	0.41	247	0.26	2.8		0.36	2,151	0.12 - 2.8	250/yr
Ultraviolet Absorbtion, 5cm	Abs@254nm	0.322	50	0.247	0.575		0.325	397	0.215 - 0.656	52/yr
Ultraviolet transmittance	%	86	232	76	90		86	1,241	75 - 91	250/yr
Water Temp, Field	˚C	9.9	272	4.5	19.6	≤ 15 AO	10	2,772	3.0 - 23.0	250/yr

mg/L = milligrams per Litre
ug/L = micrograms per Litre
ng/L = nanograms per Litre

CFU = colony Forming Units
NTU = cNephelometric Units

TCU= True Colour
MAC = Max. Acceptable Conc.

Water Monitoring Data Sheet

Group Members:	Date:
	Stream Name:
	Location:

Station #1: pH	pH Results:
pH is measured on a scale of 1-14 where 0 is the most acidic and 14 is most basic. A value of 7 is considered neutral. Waters with a range from 6.5 to 8.5 are favourable to supporting most aquatic life.	

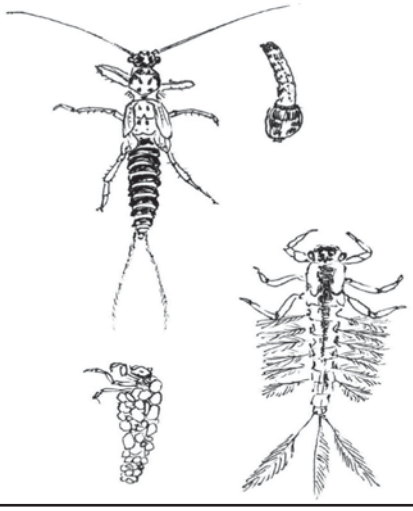
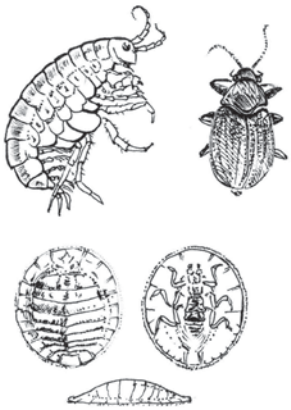
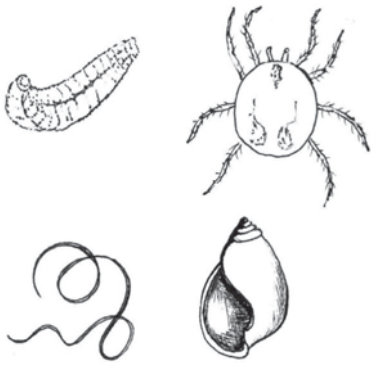
Station #2: Temperature	Air Temperature:
Temperature measures the warmth or coldness of a water sample using C°. It is important to measure both air and water temperature as the air temperature affects water temperature. Use only a dry thermometer to measure air temperature (dry a wet thermometer with a handkerchief or tissue). Water Temperature should be in the 5 - 12˚C range for most Greater Victoria streams.	Water Temperature:

Station #3: Turbidity	Water Clarity:
Turbidity is a measure of a water's clarity or cloudiness. Clarity is measured in cm using a Secchi disk or a Turbidity Wedge.	

Station #4: Dissolved Oxygen	Dissolved Oxygen::
Dissolved Oxygen (DO) measures how many molecules of oxygen are in the water. DO should be greater than 5 mg/L for healthy ecosystems.	

Station #5: Invertebrate Study

Group Members:	Date:
	Stream Name:
	Location:

Type	Number Counted	ID Sketches	Common Name
Group One: Pollution intolerant – good to excellent water quality			Mayfly, Stonefly, Caddis fly and the like: 2-3 tails; gills, can make its home with small twigs and rocks
Group Two: Wide range of tolerance			Aquatic beetle, Clam, Mussel, Scud and the like: Beetle-like, clam or mussel shape; scud looks like a shrimp
Group Three Pollution tolerant – Fair to poor water quality			Aquatic worm, Leech, Water mite and the like: Worm-like shape, water mite looks like a small tennis ball with legs

(adapted from Streamkeepers field data sheet, page 26)