Cleaning our water

You just learned that water comes from our homes, businesses and restaurants and is 'cleaned' at a wastewater treatment plant. We create wastewater every day by adding trash (toys, wipes, cell phones, etc.), organics (food, poop, pee, etc.), chemicals (soap, cleaning products, medicines, etc.), and germs to our water. The wastewater treatment plant takes most of these things out of the water and then puts the cleaned water back into Puget Sound. In the world outside of our homes and businesses, water can be contaminated by both natural and man-made sources. For example, our waterways such as rivers, creeks, and lakes can get filled with sediment from erosion during a heavy rain or contaminated with oil, trash, or chemicals as water runs off our roadways. This water doesn't go to a treatment plant to be cleaned; it goes directly into our waterways and needs to be 'cleaned' by our natural systems. Plants, soil, and bacteria all help clean our water. Sometimes our natural systems do a great job of keeping the water in our rivers and streams clean, but sometimes there are too many contaminates and nature can't keep up! In this lesson, you will be testing the quality of water in a natural waterway.

What is water quality?

Generally when we look at water our initial impression runs the gamut from "clean" to "dirty". In our country, our point of reference for "clean" is the water that leaves our tap as cool, clear water with nothing floating in it; water that is safe for us to drink. This makes sense, of course. After all, the presence of dirt, bugs, algae, and plant matter in our tap water might lead us to question what our water bill is actually paying for! When we're analyzing water quality we need to focus on that word, quality, and distance ourselves from our preconceived notions of what qualifies as "dirty" and what qualifies as "clean". In a natural system such as a creek or a pond, a cool, clear, and barren ecosystem may initially appear more pleasant to us than a murky, brown, and plant-filled marsh, but the reality behind those differences may be more sinister.

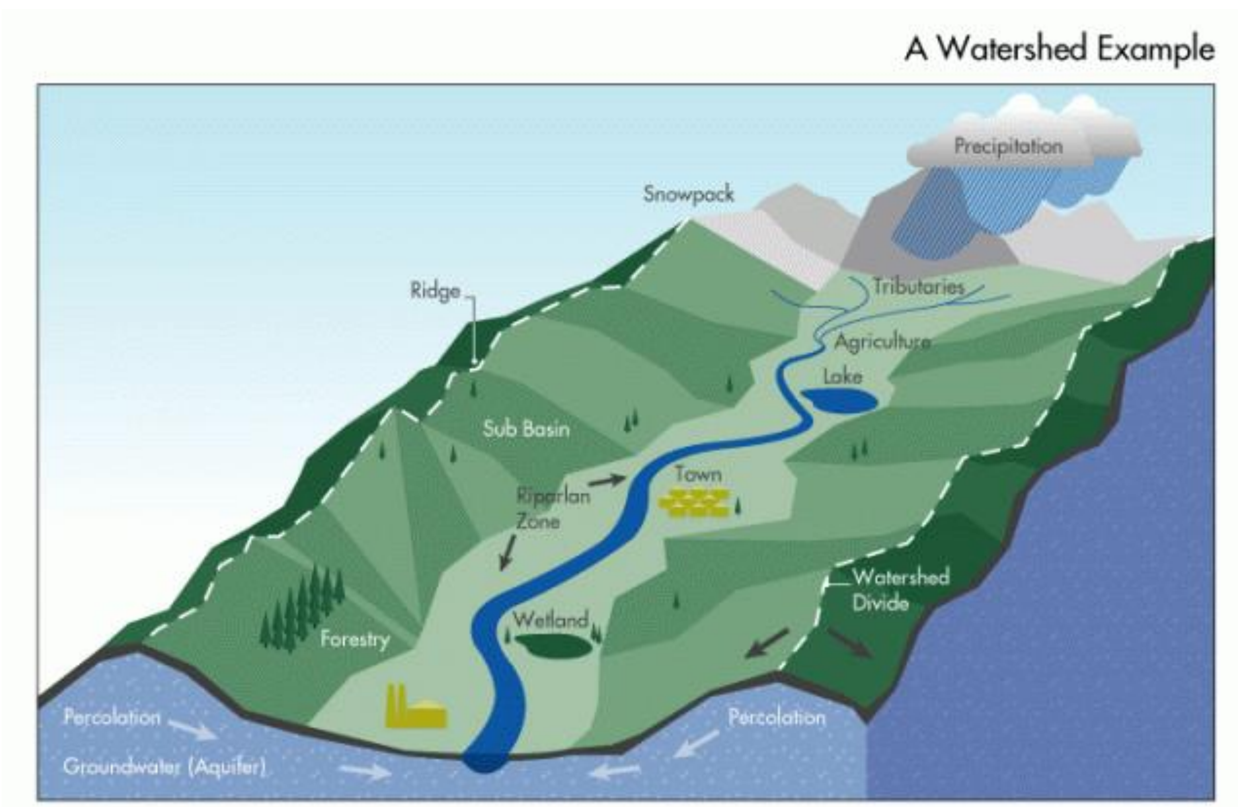
Water quality can be affected by many factors, not all of which are caused by humans. Pollution and deforestation may be the most dramatic and easily deducible cause of poor water quality, but seasonal changes, forest fires, and decomposition all can change water quality as well. As you move through the lessons in this binder, you'll further explore how our actions can affect water quality and what we can do to help maintain healthy habitats not only for our use, but for use by plants and animals as well. You'll test the biotic (macroinvertebrates) to develop a more complete picture of water quality.

Water is important, we all know that. We drink it, we cook with it, and we bathe in it (hopefully!). There are a lot of people working very hard to make sure that we have clean water for our use and we can't be blamed for sometimes taking that for granted, especially in a region where we are so inundated with water that most of the time we don't know what to do with all of it. Think about it this way; no one is creating new water. In fact, the water that we're using right now is the same water that was here when the dinosaurs were around. No joke. So keeping it clean has to be a priority. Otherwise we're up a certain sewage-filled creek without a paddle.

There is no escaping the water cycle. Everyone one of us lives, goes to school, plays, and works in a watershed and sometimes in even more than one! To get an idea of what a watershed is, imagine that you are standing anywhere in the entire Puget Sound region. If you placed a drop of water in any given spot and followed its journey, the body of water where it ended up would be the watershed that you were standing in. If it ended up in the Snohomish River, you are in the Snohomish River watershed. If it ended up in Little Bear Creek, you are in the Little Bear Creek watershed. If you repeated this experiment an infinite number of times and mapped where every drop flowed, you would have a complete map of all of the watersheds of the entire region. Every body of water has an associated watershed. A watershed is the entire area of land where the water ends up in that particular waterway, be it a lake, river, pond, creek, or drainage ditch. A small creek likely has a small watershed, but as it flows into another body of water, it is itself part of that water's watershed and so on. Think of Russian nesting dolls. You get the idea.

Eventually, all of our water winds up in the Puget Sound and the Puget Sound is connected to the Pacific Ocean, so it's part of the Pacific Ocean watershed and the Pacific Ocean is connected to…wait for it…all of the oceans around the entire planet! Our huge planet becomes very small, very quickly and we begin to realize that we're all part of something much bigger than just our local stream or lake.

These lessons provide a step-by-step procedural description of the activity and also some questions that can help to challenge your students to think deeply about the topics that are being covered. We'll start by making some predictions about water quality based on our assumptions and then well test those predictions; by analyzing the organisms that live in the water.



Lesson 1: Observe and Predict

Here's an idea!
Have your students create Water Quality Journals that can be used throughout your unit. This way, all of their data and observations will be located in the same place.

Introduction

In this lesson, your students will record observations of their watershed and make predictions about the quality of the water. This lesson serves as an introduction to the water ecosystems and a way to involve your students in the scientific processes of making observations and predicting outcomes.

Time	**15-20 minutes**
Materials Needed	• Copies of field worksheets • Pencils or colored pencils
Location	At the site of the water that is being tested.

Background Information

Good scientific work is based on accurate observations. Observations provide scientists with the raw information that will help to guide their research and the questions that they will attempt to answer. It may not seem like hardcore science to your students, but simply taking the time to look around and note what they see provides the foundation for meaningful research.

Description - Sketching your watershed

When you go into the field to collect data, you first need to record any information that might possibly affect the results of the data you are collecting. What is the date? What is the weather like? Where are we? Who are we? It may be useful here to have your students work in small groups or in pairs.

1. On the attached field worksheet, fill out the observational information at the top.
2. Take a couple of minutes to really look around the site. Do you notice anything that may directly affect the quality of the water (homes nearby, storm drains, etc.)? If so, make note of it (you can use the back of your sheet as well if needed).

The next step is to make a sketch of our immediate watershed. Make sure to include the following; direction that water is flowing, location of any buildings or other structures, any different habitats within the water (pools, riffles, waterfalls, etc.), vegetation. Remember that this is just a sketch; it doesn't have to be museum quality. Depending on whether it has been covered with your students or not, you may want to reinforce the concept of abiotic, biotic, and cultural factors and have your students label or color code the ABC's that they add to their sketch.

1. Start by drawing the water. Which way is it moving? What shape is it? If you notice anywhere that water is moving, such as seepage from a hillside or water flowing off of concrete then make sure you include that as well.
2. Now add in different habitats within the water. Logs or large rocks can create shelter. Deep pools or riffles (areas where the water is shallow and moving quickly, like rapids) create different conditions that are needed by a variety of creatures.
3. Next draw in the vegetation that you see around the water. Where are the large trees that might shade the water? Why is shade important for water quality? Where are there grasses and other plants in the shallow water that might provide shelter for aquatic creatures? Are there any other food sources around?
4. Be sure to include any cultural (man-made) structures as well. Are there houses nearby? A road or a trail? A lawn or a parking lot? How might each of these things affect the water quality?
5. Again, make sure to note anything else that you observe that might affect the water quality. An area with a high level of erosion is a good example.
6. Working in small groups, have your students make a prediction about the water quality. Remember that scientists have to justify their predictions so make sure your students are prepared to explain their answer.

Discussion Questions

- Based on your observations, how healthy is this watershed? If you had to guess on a scale of 1 to 10 with 1 being poor and 10 being excellent, what would it be? Why?
- If you were an animal, would you choose this as a place to live and raise your children? Why or why not?
- Where is the water in this creek/pond/river coming from? Where is it going?
- What types of pollution are humans adding to this water? Where are they adding it? What effect will that have on the water quality?

Lesson 2: Testing your Water – Macroinvertebrates (Biotic – living)

Introduction

In this lesson, students will be able to make a prediction regarding water quality of a local water source and test their prediction with water sampling. They will be able to compare data, reach conclusions and describe the factors that might influence water quality in a variety of water sources.

Did you know?

The green darner dragonfly is the state insect of Washington. Green darners migrate to follow warm weather, traveling as far south as Mexico in the winter.

Time	**45-60 minutes**
Materials Needed	• Blue dip nets • Plastic sampling trays • Plastic spoons • Small plastic tubs • Macroinvertebrate ID sheets • Copies of the field worksheet
Location	This activity can be done in one of two ways. You can take your students to the waterway that is being tested or, if that's not possible, you can collect the macroinvertebrates in a large bucket and bring them into the classroom. Keep in mind that it gets a little messy!

Background Information

Scientists study the health of a habitat by taking measurements of the biodiversity and numbers of organisms in an area. When a scientist goes into the field and collects data, they are "sampling" or taking a sample of organisms in a specific area.

Why do scientists need to sample?

Scientists try to create a reference collection for further study, appreciation and education. They document diversity, frequency, locations and variability of species and monitor the changes of populations due to environmental threats.

Sampling is a way to save time by not having to measure everything. If scientists want to know what kind of environmental changes are happening in an area, it is usually impossible to go and count the total number of organisms and sampling gives them an idea of the total amount while only counting a portion of the total.

What is a macroinvertebrate?

The easiest way to understand the word is to break it down into its smaller components. Most of your students probably have some sense of what "micro" means. While something that is classified as "micro" is relatively very small, "macro" is relatively very large. To give some sort of perspective, a "microdog" might be a Chihuahua while a "macrodog" might be a Great Dane. Of course, we're talking about bugs here, so our definition of macro is anything large enough to be seen with the naked eye. Next we have the word invertebrate. A vertebrate is any organism that has vertebrae which in simpler terms is just any organism with a spine. The prefix "in" means "not" or "lacking". Following this logic, an invertebrate is simply an organism without a spine. Finally, we can put the three pieces of our word together; a macroinvertebrate is a spineless animal that you can see without a microscope. Basically, they're just big bugs.

Some of the most common macroinvertebrates that you might see include; dragonfly nymphs, damselfly nymphs, caddisfly larvae, water beetles, water striders, water boatmen, mayflies, stoneflies, scuds, freshwater clams/snails, black fly larvae, freshwater worms, etc.

What do macroinvertebrates tell us about water quality?

Although macroinvertebrates are super cool to look at and studying them is a noble endeavor in and of itself, we do actually have ulterior motives for collecting them. Scientists sample macros all the time because they are effective indicators of water quality. The table below summarizes some of the basic observations that can be made of a macro sample and what that means for water quality.

OBSERVATION	ANALYSIS
High diversity, high numbers, many sensitive species such as stoneflies, caddisflies, and mayflies	No problem, good water quality
High diversity, low numbers	Possibly due to poor habitat conditions
Low diversity, high numbers	Organic pollution (nutrient enrichment) or sedimentation; excessive algal growth resulting from nutrient enrichment
Low diversity, low numbers	Toxic pollution (e.g., chlorine, acids, heavy metals, oil, herbicides, insecticides)

From "Guide to Aquatic Insects & Crustaceans", Izaak Walton League of America[2]

The data sheet that is provided with this lesson emphasizes two things; pollution tolerance and species richness (the total number of different species). Certain species are very sensitive to pollution in the water while others can live in relatively polluted habitats. By cataloging the pollution tolerance and the calculating the species richness, we can get a pretty good indication of the health of the aquatic habitat that we're sampling from.

Lesson Procedure

If you plan on sampling macroinvertebrates with your students at the site, read through the following set of steps first. If not, you'll have to collect the macroinvertebrates yourself and bring them into the classroom and you can skip over this first set of instructions.

1. For dipping, it's best to separate your students into small groups. This way, each group can share nets and a bucket.
2. First, explain the proper "dipping and dumping" technique. Each time a student dips, the contents of the net should be added to the bucket by inverting the net and shaking the cloth into the water. Students should scoop as close to the bottom of the water as possible while being careful not to scoop up too much dirt and mud as this can make the buckets a bit of a mess.
3. Each student should dip once and pass the net the next person in their group.
4. Continue dipping for 5-10 minutes.
5. When finished, have your students shake the nets in the water as much as possible to remove any excess muck. Return to the classroom with the buckets and start at step number 2 below.

If you're not dipping with your students, start reading here:

1. Before the activity, collect a bucket of water from a nearby creek, pond, or waterway. A dip net can be used to ensure enough macroinvertebrates are sampled. When collecting, try to get water from different areas as each waterway can contain many different habitats.
2. In class, review the student's trip to Brightwater and their experience sampling macroinvertebrates in the pond (if applicable). Ask the students how they think analyzing macroinvertebrates can help scientists to determine water quality.
3. It's helpful to have your students work in table groups for this activity.
4. Have each table group write down a prediction about the quality of this water including their reasoning behind the prediction.
5. Before you start, address proper "macro etiquette":
    - The macroinvertebrates need to stay in water at all times. Remember, most of them can't survive outside of it!
    - Be gentle when using the pipettes or spoons. We want to observe, not destroy.
    - Use a tray to sort the macros. Make sure that each section of the tray has enough water to ensure survival.
    - Remind the students that the macros will be returned to their habitat when they're done.
6. Explain to your students that they will be cataloging the different types of macros that they find. Introduce the ID sheets and the data sheets that are provided with the kit. Make sure that you emphasize the importance of identifying each macro that they find and cataloging it on the data sheet. Have your students use hash marks to tally each individual macro that they find.
7. The instructor will divide the students into small groups each with their own sample of water and begin the macroinvertebrate identification.

8. Most likely, your students won’t be able to catalog every macro in their water sample. That’s okay. 20-30 minutes is usually sufficient to get a pretty good data set.
9. Start your cleanup. Once the area is clean and all of the macros are returned to the front of the class, the discussion phase of the lesson can begin.
10. Have your students calculate species richness. Species richness is not the total number of individuals, but the total number of different species that were found. Generally speaking, high species richness is always a good thing.

Discussion Questions

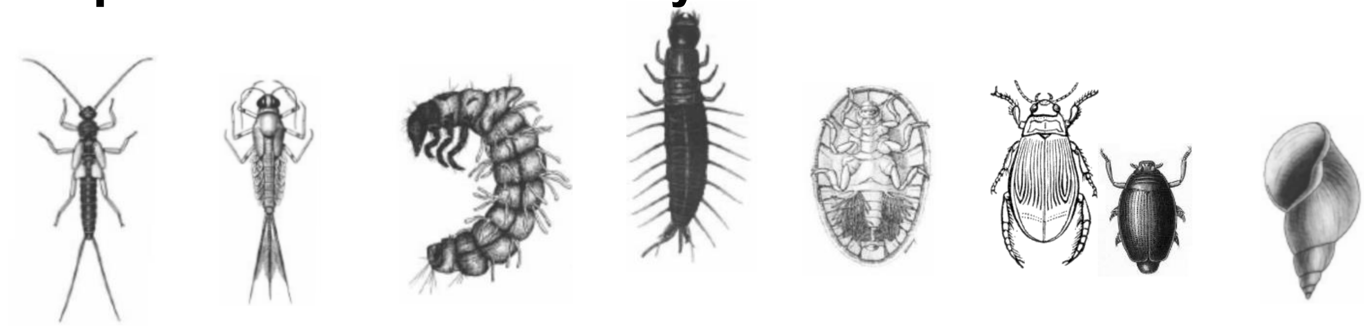
- How do your results compare to your prediction?
- Looking at what we’ve collected and our species richness, what does this tell us about the quality of our water? Would you drink it? If you were a macroinvertebrate, would you live in it?
- If you did chemical (abiotic) testing, how do your macro collection results compare with your results from the chemical testing? What is different? What is the same?

Extensions

1. An optional activity is to create a graph to visually represent your data. Each square represents one individual species. Alternately, you could have students come up with their own method for representing their data visually.
2. Have each student choose one macroinvertebrate. The students then research their macroinvertebrate and create a species information card which includes a drawing of the macroinvertebrate and interesting information. The cards can then be displayed around the classroom or presented by each student to the class.

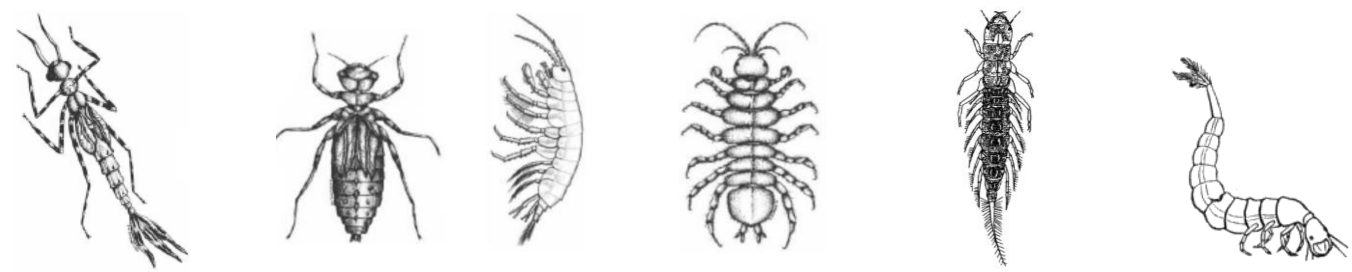
Macroinvertebrates: How healthy is your water?

Group 1: Low tolerance – Can only live in clean water



Stonefly Nymph | Mayfly Nymph | Caddisfly Larva | Dobsonfly Larva | Water Penny | Aquatic Beetles | Gilled Snail

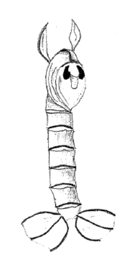
Group 2: Medium tolerance – can live in clean or somewhat clean water



Damselfly Nymph | Dragonfly Nymph | Scud | Aquatic Sowbug | Alderfly | Diving Beetle Larva

Midge Larva | Black fly Larva | Flatworm | Leech | Crane Fly | Water Flea | Water Mite

Group 3: High tolerance – can live in all types of water



Pouch or lung Snail | Water Boatman | Backswimmer | Nematode | Copepod | Aquatic Worm | Glassworm

Water Quality (Biotic Testing) Worksheet

Name: ______________________________ Date: _________

Location______________________________ Weather: ________________________________

Goals for the Day

1. **Learn what makes a waterway (creek, pond, lake, etc.) more or less healthy.**
2. **Learn some ways that people (including YOU) can help make our creek healthier**
3. **Have Fun!**

Waterway Mapping

Focus Question:
What affects water quality and living things (biotic organisms) in an ecosystem?

Map Key

➘ = Fast water

≈ = Slow water

E = Erosion

G = Gravel Deposition

Your map should include:

- ❑ Shape and size of the creek
- ❑ Fast, slow water
- ❑ Erosion areas
- ❑ Gravel deposits
- ❑ Sand deposits
- ❑ Plants and Trees
- ❑ Other landmarks

Map Scale:

1 inch = 3 feet

Water Quality

Focus Question: *Is the waterway healthy based on the types of macroinvertebrates found?*

A. Discussion: Before starting your investigation, you will discuss as a group what kinds of things could be in the water that would be good, or bad. Based on your map and observations, what is your prediction about the water quality? ____

B: Gather Data (follow your instructor's directions, use the identification sheet to classify what macroinvertebrates you find as low, medium and high pollution tolerant; find the total of each type)

List the different types of macroinvertebrates found by your group and # of each type

Type of Macroinvertebrate	#	Type of Macroinvertebrate	#

Types of Macros	Student Groups				
	1	2	3	4	5
	Total Number of Macroinvertebrates				
Group 1 Low Tolerance					
Group 2 Medium Tolerance					
Group 3 High Tolerance					

C. Analysis: *Does the waterway have more low, medium or high tolerant macroinvertebrates?*

D: Conclusion: *Was your prediction correct*

- ❑ **Yes**
- ❑ **No**

because____

E: Human Impacts:

1) What human impacts would decrease the water quality in this waterway?

2) What can people do to improve water quality?