Stormwater Pollution

StormFest Contributors

Curriculum adapted from Drain Rangers by

Stormwater Pollution (Macroinvertebrate Station)

Overview: Students will investigate aquatic macroinvertebrates and their pollution tolerance levels to assess stream health. After analyzing results, students will discuss best practices to keep harmful pollutants out of our watershed.

Objectives: Students will

- define stormwater and describe sources of pollution;
- learn how macroinvertebrate diversity and tolerance relates to water quality;
- create a pollution tolerance index using macroinvertebrates from a local creek; and
- share at least one action students can do at home to keep stormwater clean.

Vocabulary:

- *Stormwater* - rain that falls on streets, parking areas, sports fields, gravel lots, lawns, rooftops, or other developed land and flows into nearby creeks, lakes, rivers, and Puget Sound
- *Pollution tolerance*- the ability of an organism to survive in a polluted habitat
- *Aquatic macroinvertebrate*- animals that live in water, are large enough to see without a microscope, and have no backbone
- *Pollutant*- any substance that harms the environment
- *Water quality*- refers to chemical, physical, biological and other characteristics of water that describe the qualities necessary to sustain life
- *Habitat* - the natural home or environment of an animal, plant or other organisms

Lesson Overview:

Intro (5 minutes)

- What is stormwater?
- How can we measure the health or water quality of a stream? Today we will measure it by examining the organisms that live here.
- What is tolerance? Explain the messy room or wildfire smoke analogy. We can use pollution tolerance to measure the health of a stream.
- What is an aquatic macroinvertebrate?

Activity: Identify Macroinvertebrates (20 minutes)

1. Have students work in 6 groups to capture macroinvertebrates from their sample and identify them. Remind students to be careful. These animals are alive and will be returned to the stream!
2. Have students find the laminated example of their aquatic macroinvertebrate and add it to the tolerance board in the appropriate location.

Discussion: Stormwater Pollution (10 minutes)

1. Discuss the pollution tolerance index of streams and compare it to real data on other streams.
2. Show storm drain photo and discuss pollutants that could enter a storm drain and then flow into a creek, river, lake, etc.
3. Some examples include soap from washing cars on pavement, vehicle oil leaks, pet waste, and yard chemicals (e.g., pesticides and fertilizers).
4. What are some actions that we can take at home to decrease or eliminate these sources of pollution?

STATION NOTES

- Scientific Collection Permit is required for anyone collecting macroinvertebrates from local streams.
- Collect macroinvertebrates as close to festival time as possible. Aerate samples with electric pump.
- Resampling may be necessary to keep refresh samples depending on the number of station rotations.
- Assign one volunteer to take D-net around to each station for a quick demo

Title: Stormwater Pollution (Macroinvertebrate Station) Lesson Plan

Overview
Students will investigate aquatic macroinvertebrates and their pollution tolerance levels to assess stream health. After analyzing results, students will discuss best practices to keep harmful pollutants out of our watershed.

Objectives
Students will:
- define stormwater and describe sources of pollution;
- learn how macroinvertebrate diversity and tolerance relates to water quality;
- create a pollution tolerance index using macroinvertebrates from a local creek; and
- share at least one action students can do at home to keep stormwater clean (e.g., natural yard care, scoop pet waste, fix car leaks, avoid car washing on pavement, etc.).

Vocabulary
- *Stormwater* **-** rain that falls on streets, parking areas, sports fields, gravel lots, lawns, rooftops, or other developed land and flows into nearby creeks, lakes, rivers, and Puget Sound
- *Pollution Tolerance*- the ability of an organism to survive in a polluted habitat
- *Aquatic macroinvertebrate*- animals that live in water, are large enough to see without a microscope, and have no backbone
- *Pollutant*- any substance that harms the environment
- *Water quality*- refers to chemical, physical, biological and other characteristics of water that describe the qualities necessary to sustain life
- *Habitat* - the natural home or environment of an animal, plant or other organisms

Materials
MACROINVERTEBRATE SAMPLING (sampling can be completed for all stations)
- 1 D-net
- 2 buckets (5-gallon, one for sample, one for gear)
- 1 aeration pump (to keep bugs alive in holding tank)
- 1 extension cord
- 1 poly pump sprayer (to clean net and other gear)
- 1 water pitcher (for filling sprayer)
- 1 filter funnel (with mesh lining)
- 1 ladle (to scoop out bug samples into trays)

STATIONS (each station will have these materials)
- 4 folding tables (1 for display upfront, 3 for activity)
- 1 felt board – Pollution Tolerance Index (aka Tolerance Board)
- 1 poster of macroinvertebrates
- Small bin of laminated Velcro bugs
- Preserved bug display (in bubble wrap)
- 1 copy of scientific collection permit
- 6 trays filled with bug sample and water (1 per group)
- 6 ID sorting placemats
- 60 petri dishes (10 per group) – *set up on placemat and partially filled with water*
- 1 small pitcher of water (to fill petri dishes)
- 18 viewing boxes (3 per group)
- 18 spoons (3 per group)
- 12 fine-tipped paint brushes (2 per group)

- 12 laminated ID sheets (2 per group)
- 1 small chalkboard

Figure 1. Macroinvertebrate display and pollution tolerance index

Figure 2. Sorting and identification placemat layout (2 per table and 6 per station): Petri dishes filled with water (10), spoons (3), paintbrushes (2), and viewing boxes (3) on sorting placemat (1), laminated ID sheets (2), tray (1) – to be filled with sample.

Lesson

Macroinvertebrate Sampling: Collect sample from stream ~1 hour before lesson. Depending on abundance of macroinvertebrates and number of class rotations, additional samples may be collected periodically throughout the day to "refresh" samples. Ensure individuals collecting samples have obtained a Scientific Collection Permit from Washington Department of Fish & Wildlife. This should be applied for several months in advance of event.

Station Preparation: Set up macroinvertebrate display, including pollution tolerance index board and preserved macroinvertebrate display (Figure 1). Set up 6 sorting and identification placemats (Figure 2.). Distribute macroinvertebrates equally between sample trays.

Station Educators: 2-3 individuals required.

Introduction (5 min.)
Self-introduction:
Hello, my name is ___________, and at this station today, we are going to learn how stormwater pollution can affect the water quality of streams in our watershed. Make sure you know who the chaperones are in your group and explain how they can help during this station.

Explain station layout and activities:
Have students line up near the stream so they each have a clear view of the water. "This is "--------" Creek. Do you think this stream is healthy? How could we measure its health or water quality?" Take suggestions from students. "Today, we are investigating the water quality of this creek by examining the organisms that live in it."

Introduce concept of tolerance:
"Has anyone heard the term *tolerance* or *intolerance* before?" Give enough waiting time for English language learner (ELL) students. "Tolerance refers to an organism's ability to survive environmental stressors like pollution or warming temperatures. Intolerance is the opposite."

> Messy-room analogy: "Raise your hand if you have a super clean, spotless room. You can't stand it when there are books and papers lying around. Everything must be in its place at all times… These students represent the very intolerant organisms. They are extremely sensitive to pollution and cannot live in unhealthy streams. Their presence means the water quality is excellent. Raise your hand if you have a really messy room, and you have toys on the floor and clothes in piles… These students represent the very tolerant organisms. They are *not* sensitive to pollution, and can live and actually thrive in dirty, polluted waters. Their presence, especially when abundant, means poor water quality. Now raise your hand if you have a room that's in between super clean and super messy… You all represent the somewhat tolerant or somewhat intolerant organisms. Somewhat tolerant organisms can tolerant pollution for a short length of time. For example, you may tolerate a messy room for a couple days then you need to do laundry. There are many organisms that are between extremely tolerant and intolerant. If a lake or stream becomes polluted through stormwater, for example, organisms that cannot tolerate that pollution (i.e., intolerant) will either die or move to a healthier habitat. Tolerant organisms will stay. By looking at the community of organisms present, we can see if the water quality has been impacted."

Explain aquatic macroinvertebrates (hold up macro poster):

"The organisms we are investigating are called *aquatic macroinvertebrates*. Has anyone ever heard of macroinvertebrates? *Macro-* refers to being large enough to see without a microscope (opposite of micro), and *-invertebrate* means animals without backbones. *Aquatic* means they live in the water. Many of the organisms we see flying around every day (e.g., flies, mosquitoes, dragonflies) start out their larval phase in the water then go through a dramatic change or metamorphosis and emerge from the river as winged insects. These organisms can be fairly large, like a mussel or a snail (point to picture on poster), or be as tiny as a flea (point to mayfly larvae). Some live attached to leaves and rocks, and some swim freely or crawl at the bottom of the stream. These organisms are an important component of the local food chain/web. Can anyone tell us about food chains/webs? Macroinvertebrates feed on organic matter in the creeks. Juvenile salmon rely on these organisms for food. If they disappear, it can impact salmon and other species higher up on the food chain, like orcas."

Explain sampling process:
"Scientists use a variety of methods to collect these macroinvertebrates and determine stream health. Trained naturalists collected our samples earlier today using a D-net, in a way so as not to harm the organisms or their habitat." Quickly demonstrate sampling process if D-net is available.

Explain activity and demonstrate sorting and identifying bugs:
Have your group line up so they can see the table, but not close enough to touch the materials. "This is where *our* investigation begins. You will work in teams to sort and identify these macroinvertebrates to determine the health of the creek. Watch for movement in your sample. Once you spot an organism, gently scoop it into one of the viewing boxes to identify it. Remember these are aquatic organisms! Make sure there is water in the bug box when you are identifying an organism. Look at the body shape, the number of legs and antennae it has, etc. Use your laminated ID sheet to identify the bug. Once you identify it, place it in the correct petri dish on your team's place mat. Another team member will come up to the Pollution Tolerance Index board. (Go to board and show them the laminated bug cards). That person must find the laminated bug that matches the bug in your team's sample and stick it on the correct level of the tolerance board. Then repeat with all the other bugs you find. Please be very careful when handling the organisms! They are an important piece of the food chain and ecosystem of this stream. Remember, they are aquatic and cannot live long without water, so try and be quick identifying. Once you are finished with the activity, we will return the macroinvertebrates back to their homes."

Activity – Identify Macroinvertebrates from the creek (20 min.)

1. Divide students into 6 groups and assign them to a sample tray (3-4 students at each tray with placemat and ten petri dishes)
2. Start a timer and let students begin. Walk around and assist with collection and ID. Remind teams to place matching laminated bugs on the Tolerance Board. Have one volunteer assisting with tolerance levels.

3. When time is up, ask students to put all tools down and gather around the Tolerance Board. IMPORTANT: direct one volunteer or educator set up station for next group during closure discussion!

Closure (10 min.)
Have students gather around the pollution tolerance index board. "Let's look at our results. What type of species did we observe? What does this tell us about the water quality of the creek?

Calculate Pollution Tolerance Index:
"Let's talk about the Pollution Tolerance Index. An index is a way to categorize different features (like tolerance to pollution) so we can calculate a score for the stream we are investigating." Ask students "Which bugs did you observe the most in your sample? Which did you observe the least?" Give them a minute to discuss with their group members. "Ask students which organisms were the most abundant?" Assign a number 3 to those organisms on the board. "Which organism was the least abundant?" Assign a number 1 to those organisms on the board. Which organisms were somewhat common (in the middle of most abundant and least abundant)? Assign a number 2 to those organisms. For very intolerant macroinvertebrates, multiply each observed grouping's abundance ranking (3, 2, or 1) by 4. Then add up the total score for very intolerant macroinvertebrates to get their "Group Score." For intolerant macroinvertebrates, multiply each observed grouping's abundance ranking by 3 and then add up the total score for intolerant macroinvertebrates. For tolerant macroinvertebrates, multiply each observed grouping's ranking by 2 and then add up the total score. For very tolerant macroinvertebrates, multiply each grouping's ranking by 1 and then add up the total score. Using the chalkboards, calculate the final pollution index score as a group by adding the four "Group Scores" together. Scores 100-76 represent excellent water quality; 75-51 represent good water quality; 50-26 represents fair water quality; 25-0 represents poor water quality.

If you are running short on time, you can skip the calculation and facilitate a general discussion about the diversity of bugs and relative abundance on very intolerant, intolerant, tolerant, and very tolerant organisms. If the macroinvertebrate sample is characterized predominately by tolerant and very intolerant organisms with very few intolerant organisms, what does that tell us about stream health? That would be a relatively unhealthy stream that is impacted by water pollution. A sample characterized by a high diversity of organisms with large amounts of very intolerant organisms would reflect a health stream with clean and cool water.

Stormwater pollution discussion:
Show storm drain picture. "Have you seen one of these before? This is a storm drain cover. When it rains, all the water from the road goes into the storm drain and to the nearest creek or lake. Can you think of some things we have on our roads that could be potential sources of pollution to the macroinvertebrates we just explored?" Take answers from students. Sources of pollution include:

1. Car washing on pavement - oil, soap (which often contains phosphates), tire rubber, heavy metals from brake pads can all rinse off of the car and go straight into the storm drain.
2. Pet waste - when we don't pick up our pets' waste, the rain picks up bacteria and nutrients like nitrates and eventually transports them into local stream and lakes.
3. Yard chemicals – pesticides and herbicides are used to kill unwanted pests (e.g., insects, weeds, fungus, etc.), but these deadly chemicals do not break down easily in the environment, and end up killing other non-targeted organisms (i.e., beneficial organisms that are not pests). Aquatic macroinvertebrates are especially sensitive to pesticides herbicides. Fertilizers contain nutrients like nitrates and phosphates to help plants grow. High levels of nutrients can also contribute to poor water quality.
4. Vehicle leaks - even small oil leaks can add up to a huge amount of pollution when you think about the number of people driving with leaks across the entire Puget Sound watershed.

"Now that we know how stormwater gets polluted and enters our waters, what are some actions we can take at home to keep our watersheds clean?"
1. Avoid car washing on pavement. Instead, take to commercial car wash.
2. Always scoop pet waste! And don't forget the poop bag.
3. Natural yard care – you can help adults avoid pesticides, herbicides, and fertilizes by hand-pulling weeds and helping with yard chores. You can also ask them to store the chemicals properly in the garage or shed to prevent spills and leaks.
4. Ask adults to fix their vehicle leaks. If you're handy, offer to help fix it. Don't drip and drive!

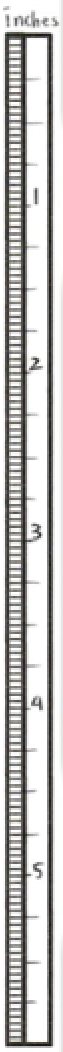
Optional exercise if time permits

Compare student's data to Puget Sound Benthic Index of Biotic Integrity scores for the stream (if available).

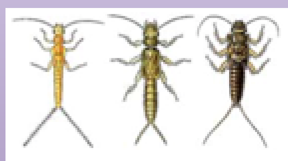
The *Pollution Tolerance Index* is one of many ways to score and assess the health of a body of water. Biologists in the Puget Sound area use an index that has been adapted specifically for this region called the *Puget Sound Benthic Index of Biotic Integrity* (Puget Sound B-IBI for short). The Puget Sound B-IBI requires using a standardized collection method (i.e., different government agencies and research groups all use the same methods to collect, preserve, and count the bugs) and an adapted formula based on our region's bugs and their evolved behaviors or characteristics. To learn more and see all previously uploaded scores, visit: www.pugetsoundstreambenthos.org.

Show students Puget Sound B-IBI data for the local stream and ask students how the data they collected compares to data scientists collected at this creek? If B-IBI results are significantly different than the student's results, ask why the data sets could be so different? The score may differ because scientists conduct a more detailed analysis looking at diversity within each group of macroinvertebrates (e.g., how many different types of stoneflies, not just abundance). They may have also sampled a different location within the watershed. You may also compare the score to those of a more protected/intact watershed (e.g., Cedar River). Why would the B-IBI score be higher in a protected watershed? Discuss how even though a sampling area may appear forested, you have to think about the entire watershed – especially what is located upstream. Runoff from upstream in the watershed flows into the creek and eventually impacts the water quality at this location.

Stream Organisms ID Card - Side **A**



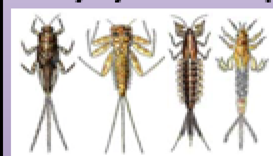
Group 1: **Very Intolerant** (Needs clean water)



- ½"-1½"
- 6 legs (hooked tips)
- no gills on abdomen
- 2 hair-like tails

Stonefly: Order Pleocoptera

Mayfly: Order Ephemeroptera



- ¼"-1"
- 2-3 hair-like tails
- 6 hooked legs
- plate-like or feathery gills on abdomen
- tails may be webbed together

Group 2: **Intolerant** (Needs somewhat clean water)

Caddisfly: Order Trichoptera

- up to 1"
- 6 hooked legs on upper 1/3 of body
- no gills on abdomen

Hellgrammite (dobsonfly), Fishfly, & Alderfly: Order Megaloptera

- ¾"-4" • 8 pairs of feelers along abdomen
- 6 legs • 2 hooks on tail OR 1 spikey tail
- large pinching jaws

Gilled Snail: Order Gastropoda

- up to ¾" • shell opening covered by thin plate (operculum)
- shell opens to right (with helix pointed up)

Scud: Order Amphipoda

- ¼" • white to gray
- body higher than wide
- more than 6 legs
- looks like small shrimp

Group 3: **Tolerant** (Can handle pollution)

Dragonfly and Damselfly: Order Odonata

- ½"-2" • large eyes
- 6 hooked legs
- 3 oar-shaped tails OR wide oval to round abdomen

Most True Flies: Order Diptera

- ¼"-2"
- bodies plump like maggots
- may have "legs" like caterpillars
- may have lobes or conical tails on end

Group 3 continued on Side B

Illustrations from: Voshell, J.R. Jr. 2001. Guide to the Common Freshwater Invertebrates of North America. MacDonald and Woodward Publishing Co.

Stream Organisms ID Card – Side B

Group 3: **Tolerant** (Can handle pollution)

Beetles: Order Coleoptera

- ¼"- 1"
- disk-like oval body (6 small legs on underside) OR
- small black beetle OR

- comma-like brown hard body (6 legs on upper 1/3) OR
- other rare forms

Clam: Class Bivalvia

- up to ¾"
- fleshy body enclosed in two clamped shells
- if alive, cannot be opened without harming it

Netspinner: Family Hydropsychidae

- up to ¾"
- 6 hooked legs on upper 1/3 of body
- 2 hooks at back end
- white tufts of gills on end

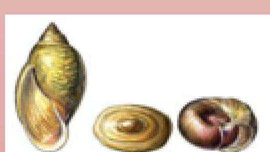
Midge: Family Chironomidae

- up to ¼"
- distinct head
- worm-like body
- 2 "legs" on each end

Group 4: **Very Tolerant** (Thrives in pollution)

Lunged Snail: Class Gastropoda

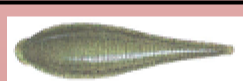
- up to ¾"
- no operculum (thin cover plate)



- shell opens to left with helix pointed up

Aquatic Worm: Class Oligochaeta

- ¼" – 2"
- wormlike body
- can be very tiny



Leech: Order Hirudinea

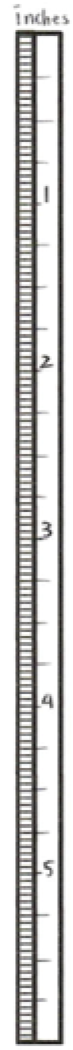
- ¼" -2"
- segmented body
- suction cups on both ends

Flat Worm: Family Planaridae

- up to ¼"
- soft body
- may have distinct head with eye spots

Black Fly: Family Simuliidae

- up to ¼"
- sucker on end
- end of body wider (bowling pin shape)



Illustrations from: Voshell, J.R. Jr. 2001. Guide to the Common Freshwater Invertebrates of North America. MacDonald and Woodward Publishing Co.

Puget Sound Stream Benthos – Managed by King County.
Example Benthic Index of Biotic Integrity Scores

	Total Taxa	Mayfly Species	Stonefly Species	Caddisfly Species	Tolerant Species %	Dominant Species %	Overall Rating
Des Moines Creek (2015)	30	2	2	3	31.2%	66.4%	Poor (14)
Cedar River (2013)	65	14	4	6	0.6%	27.0%	Good (75)

* Samples collected by WA Department of Ecology.

Des Moines Creek Watershed: 5.8 sq. mi of urban area.
Cedar River Watershed: 184 sq. mi. with about 2/3 of watershed protected as source of Seattle water supply.

Talking Points:

- Urban versus protected, forested watershed.
- Urban watershed has lower diversity of species and much higher percentage of tolerant macroinvertebrates.
- Why do you think we find more species diversity and less tolerant macroinvertebrates in the forested watershed?