Water Quality-Ins & Outs

GRADES: All grades (but feel free to pick and choose what you want to cover, especially with little ones!)

TIME FRAME: 2 hours

SETTING: Indoors, streamside outdoors for the stream assessment

MATERIALS:

- pH scale handouts
- Clean and "dirty" water to demonstrate turbidity
- Water-resistant paper; wax paper works great! (optional)
- Spray bottle (optional)
- Clear cups, water, coffee, and creamer for turbidity model (optional)

LEARNING OBJECTIVES:

- Students will identify and be prepared to analyze the chemical parameters that help us draw conclusions about water quality
- Students will identify the reasons why these chemical parameters may change naturally, or due to human activity
- Students will understand the relationship between the chemical parameters and the types of macroinvertebrates that may be found in a habitat

Overview:

The purpose of this document is to use as a general guide for turning a stream assessment into a full lesson. This includes how to introduce the water quality parameters, what can affect these parameters, and specific questions to help guide the discussion. For more information on the stream tests themselves, please see the field methods documents on The Watershed Institute's website under "Education Programs" and "StreamWatch Schools." You do not have to use this to be part of StreamWatch Schools. It is a reference to provide some ideas and pointers. Feel free to use as much or as little as you'd like. "Text in quotes" indicates something you might want to say to get your students thinking.

NJ Science Standards:

K-ESS-3 Communicate solutions that will reduce the impact of humans on land, water, air, and/or other living things in the local environment

3-LS4-3 Construct an argument with evidence that in a particular habitat some organisms can survive well, some survive less well, and some cannot survive at all.
5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.

MS-LS2-4 Construct an argument supported by empirical evidence that changes to physical or biological components of an ecosystem affect populations

Before the Stream Assessment:

Engage:

Start by asking the students about some things that scientists might look for to decide if water quality is good or bad. "How can we tell if a stream is clean or not?" One of the first answers you'll probably get is "pollution" or "litter."

"How does pollution get into the water? Do you think bodies of water tend be more polluted or less polluted than land?"

Introduce the concept of a watershed. A watershed is an area of land where all the surface water flows and drains into the same body of water. When there's a lot of precipitation, some of the water will infiltrate into the ground, but a lot of the water will not. The water that does not sink into the ground will flow over the land and eventually into a larger body of water. We call this water "run-off." Runoff can carry pollutants with it as it flows over the land. For example, when there's a big rainstorm in the Millstone River watershed, all the water in that area will either sink into the ground or eventually make its way into the Millstone River. As it flows, it will carry pollutants with it toward the river. Watersheds are influenced by geographic features like hills and mountains, not by any political boundaries.

Watershed Model-Runoff Demonstration

Salts, nitrates, and phosphates can all find their way into a stream due to runoff. Runoff can also increase turbidity. This activity is great to help them visualize how this happens (Even if you don't want to get into nitrates and phosphates, this is still GREAT for younger students because it shows how pollution can find its way to the water).

- Procedure
  - Give each student a piece of water-resistant paper (wax paper, parchment paper, etc.)
  - Have the students crumble the paper into a ball.
  - Have them open up the crumbled-up ball, but don't flatten it back out all the way. The idea here is we still want to see some "mountains" and "valleys" on the paper.
  - Go around with a spray bottle and spray each student's paper. They will notice how a lot of the water will pool together on different parts of the paper.
  - "Did all the water stay in the same spot or did it move around and collect? Where did it collect?" Explain that this happens in nature too. After it rains, the water doesn't stay in the same place. Most of it will flow to lower ground, where it might enter a river or a lake. And as the water flows to that place, it can carry things with it. This is one way pollution can end up in a stream.

Nitrates and Phosphates:

There are different kinds of pollution that can affect our waterways. A piece of physical pollution, like a candy wrapper, is often easy to spot and remove from the water. Chemical pollution is typically not so simple. Nitrates and phosphates are just two examples of chemical pollution that often make their way into our waterways.

- "Does anyone have any ideas on where these chemicals may come from?"
  - You may choose to give hints like "think of something that a lot of people put on their lawns." The students may land on fertilizers as an answer. This is the main source of nitrates and phosphates that we tend to talk about, but there are other sources, like wastewater and pet waste.
- As rainwater washes over the grass, it carries the fertilizers with it, and eventually it flows to a body of water.
- It's important to mention that nitrates and phosphates are natural, and they are supposed to be in the environment in small amounts. But, when these substances become more abundant due to human activity, that's when it can become a problem.
- For the purposes of the StreamWatch Schools program, we want to see nitrate levels below 2ppm (parts per million) and phosphate levels as close to 0 as possible.

Salinity:

Salinity refers to the salt levels in the water. “Salt” in the science world is not just table salt; it includes a variety of compounds. But the main one we call out in this program is road salt.

- “We’re going to talk about one more thing that finds its way into the water because of runoff. But this thing does not wash off the grass usually. Instead, it comes from the roads and gets carried into the water. Does anyone have any ideas on what that may be?”
    - Let the students think for a bit, then give them the hint that it’s something that we do when it’s snowy/icy.
- “When that salt gets into a freshwater habitat, do you think that could cause some issues?”
- We want to see salinity levels as close to 0 ppt (parts per thousand) as possible.

Turbidity:

When you ask students how we can tell whether the water is clean and healthy, often the first response will be to just look at it. If it looks muddy and murky, that can be an indicator that the water is polluted. The scientific term for water clarity is turbidity. Really cloudy, murky water has high turbidity, while clear water has low turbidity. This cloudiness comes from the suspended particles in the water, which can consist of soil, clay, decaying organic material, algae blooms, and sediment from the stream floor that gets stirred up by storms, animals, and recreational activity.

- A rise in turbidity is often connected to runoff and erosion. Stormwater increases erosion, which leads to more suspended particles in the stream. Human activities like agriculture, construction, and recreational activity can amplify this by disturbing loose soil, making it easier for it to be washed away.

It's important to keep in mind the difference between turbidity and natural color variation. For example, a stream may be brown in color, but still clear. The turbidity would still be considered low.

Turbidity Model

Get three clear cups. One cup should be filled with just clear water. A second should be filled most of the way with water, and then a bit of black coffee. This second cup should still be translucent. The third cup should be filled most of the way with water, and then a bit of coffee with creamer in it. This third cup should be opaque. The idea here is to demonstrate turbidity versus color. The cup with just water and black coffee has a different color than the clear water, but because you can see through it, we would still consider it to have low turbidity. The third cup with water, coffee, and creamer, would be considered highly turbid because it has low clarity.

From there, ask the students which one they think a fish would want to live in.

- "If you were a fish or something else living in the water, why would it be bad if the water is very murky?"
  - Can't see, can't see prey, can't see predators approaching, sediment can get in the gills, etc.
- "Do you think murky water is a bad thing for every animal?"
  - Not every animal. If the animal doesn't mind the murkiness, it can also help them hide from predators

This is a good time to explain that the standards are very different for what is "clean" when we're talking about stream water compared to drinking water. Stream water can still be considered clean and healthy, even if it doesn't look crystal clear. "If we decide that the stream water is clean for animals to live in, does that mean we should drink it?"

Dissolved Oxygen

Often, when asked how we can tell if the water is clean and healthy, students will only name things that we don't want in the water. Ask if anyone can name something that we *do* want in the water. What are some things that animals in the water need? Guide them toward answering with oxygen.

Air bubbles are not technically "dissolved," but it can be helpful to mention air bubbles, especially with younger students, since it's something they may be familiar with. It can convey the idea that oxygen and other gases mix with water.

- "How do you think oxygen gets in the water?"
  - If they don't have an answer you can start with *"Well, how does oxygen get in the air?"*
  - Oxygen dissolves in the water directly from the atmosphere, or through aquatic plants
- "Do you think we want there to be a lot of oxygen in the water or just a little?"
  - We want lots of oxygen. It helps animals live and grow.
- Depending on grade level, you may choose to talk about eutrophication.
- Eutrophication sequence:
  - Excess nutrients (like nitrates and phosphates) enter the water, often due to runoff.
  - This promotes the growth of excess algae which can lead to a harmful algal bloom.
  - The algae die and become food for microorganisms. Microorganism populations drastically increase.
  - The microorganisms deplete oxygen in the water through respiration.

pH:

If your students are already familiar with pH:

- "How about pH? What is the pH of water supposed to be?"
    - Pure water has a pH of 7. However, surface waters, like streams, lakes, and the ocean, are not pure H_2O. The rocks and sediment mixed in with the water usually make them slightly basic (between 7 and 8.5).

- "If the pH of the water is 3, what might happen to the animals living there?"
    - Most life will die in those conditions

If your students are not familiar with pH, but you want to introduce them to the concept:

- "pH is a measure of how acidic something is (introduce a pH scale)."
- If the pH is really low, that means it's a really strong acid. "Tell me anything you know about acid."
    - Someone will probably answer that acid can burn you
- "If the water is really acidic, do you think animals would be able to survive in that?"
- "So we don't want the water to be acidic. That means we don't want the pH to be close to 0. Do you think we want it to be all the way up to 14?"
    - Some students will probably say yes, some may say no. Explain that when pH is really high, it's the opposite of a strong acid, it's something called a strong base. To give a real-world example, you can say that many household cleaning products are bases, such as bleach. We use them for cleaning, but they can really hurt us if we don't use them properly.

- From there, you can explain that the pH of the water should be pretty close to the middle of the scale. “Think Goldilocks; it can’t be too low or too high, it has to be just right.”
- You may choose to discuss acid rain.
  - The fumes that we put in the air with our vehicles and factories cause rain to be more acidic than it normally would be.
- Generally, a pH of 6.5-8.5 is considered a good range for your stream.

Macroinvertebrates:

Discussion on sensitive vs. tolerant macroinvertebrates can happen before or during the actual stream assessment. Just make sure to explain that sensitive macroinvertebrates can be a great indicator of good water quality.

Sometimes with younger students, it can help to tell a story. Here’s one that works well:

I love to keep my bedroom super clean. I don’t want there to be any dust or mess at all. In fact, I won’t even sleep in my room if it’s too messy. Last week I came home one night, and I saw that my brother had completely messed up my room. There was trash everywhere, food rotting, and I was disgusted. So, I decided I didn’t want to sleep in my room until my brother cleaned it back up. I slept in a different room that night. But the fly that was in our house came into my room and it smelled all that food on the floor and saw all the mess and decided that my room was a good place to stay for a while. The next day, my brother thankfully cleaned up all the mess and so I went back into my room. I was thinking that because all the mess was gone that the fly would stay away, but I was wrong. The fly didn’t care if my room was messy or not. The fly was still happy to spend time in my room even when it was super clean. It was frustrating, but I was happy that at least my room was clean.”

- “In this story, can you tell me who was more sensitive, me or the fly?”

- I was more sensitive. The fly didn't care if my room was clean or not. Explain that if I'm more *sensitive*, then the fly was more *tolerant.*

- "Macroinvertebrates are the same way. Some of them are like me and need the water to be super clean and high quality or else they'll choose to go somewhere else. So, when we find those macros, we know the water quality is probably pretty good. These macros are considered sensitive or intolerant. Other macroinvertebrates are like the fly and they don't really care either way. Those macros are considered tolerant.

After the Stream Assessment

Potential discussion questions:

- "Does the water quality look good or bad, and why?"
- "Would any of the data we've collected indicate poor water quality?"
  - "What would 'good' data look like for those parameters? Why?"
- "What are some things we can do as a community to make the water quality better?"
  - Pick up litter, pick up after our pets, only salt our roads when we really need to (or find other alternatives), use less fertilizer or different kinds of fertilizers
- "Does the quality of our stream affect the quality of other streams close by? Why?"
  - Yes! All waterways are connected in one way or another. Pollution from upstream sources will find its way downstream.
- "Does the quality of other streams affect the quality of our stream? Why?"
- "What are some ways that we can reduce stormwater runoff?"
  - Planting native plants reduces erosion and the plants drink up excess stormwater.
    - Rain Garden
    - Green Roof
    - Bioswale
  - Rain barrels-water can then be used to water plants

- Pervious surfaces, as opposed to impervious, help promote infiltration instead of the water flowing over the land