Cacapon Institute's Potomac Highlands Watershed School
Virtual Stream Sampling Lesson for Middle School Students

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Overview

Cacapon Institute's ***Potomac Highlands Watershed School*** offers free online interactive activities at www.cacaponinstitute.org. This lesson utilizes three activities in the **Benthic Macroinvertebrate Portal**: **Sedimentation Blues, Introduction to Stream Sampling,** and **Virtual Stream Sampler**. The activities cover fundamentals of stream health then simulate scientific sampling through virtual representations of an actual stream. These activities will not only cover core biology, chemistry, and environmental science concepts, but will help prepare students for outdoor hands-on projects like trips to a stream for sampling and planting trees to reduce pollution.

Goals

- Students will understand the chemistry and biological concepts surrounding stream and water quality.
- Students will be able to explain how sedimentation and other pollutants impact life in a stream.
- Students will be able to understand what makes a stream and surrounding ecosystem healthy.
- Students will understand what benthic macroinvertebrates are and why they are important indicators to stream health and overall ecosystems.
- Students will understand dichotomous keys and how to sample a stream as effective scientists.
- Students will understand how to become stewards of their watershed and why it is important.

Duration

1.5 hours for complete stream sampling activity and review. One hour for fast track lesson. (see notes in lesson plan)

Preparation

Set up the projector and computer, or smart board to display the activity.

Navigate to the activity from www.cacaponinstitute.org

It may be useful to preload all activities before each class and keep them minimized

Important: If you have an extra ten minutes to devote to this lesson, consider starting with the **"What is a BMI"** activity; it will provide a very good grounding in key biological concepts on diversity, morphology, and development.

Sedimentation Blues Activity

This activity provides grounding in key concepts about how pollution impacts life in streams.

1. Start the Sedimentation Blues activity:
    a. Go to www.cacaponinstitute.org
    b. Navigate to the eSchool by clicking the 'eSchool' tab on the top of the homepage or the Potomac Highlands Watershed School logo at the right of the page.
    c. Click on the **Middle School** door.
    d. Click on the **BMI poster** lying on the desk to the right of the magnifying glass.
    e. In the Benthic Macroinvertebrate Portal, click on the Sedimentation Blues activity.
    f. If the activity is not the optimal size on the screen, maximize the window in your browser, then hold down the control key and press the + or – keys to adjust the zoom.
        1. *(Note: you can also hold control and use the mouse wheel)*
2. Choose a student to control the activity. Tell him or her to hover over the different benthic macroinvertebrates, click blue text and press the continue button when instructed.
3. Read the second slide
    a. Ask the students what they think a benthic macroinvertebrate is.
        1. *Note: There is a separate activity in the BMI portal – "What is a BMI" - dedicated to this question that can be completed if time allows. It provides a range of information about insects and other BMIs that may be useful to a biology section on diversity, morphology, and development. Otherwise, verbally ask what a benthic macroinvertebrate is.*
        ii. Break down the question:
            1. What is an invertebrate?
            2. What does it mean to be macro?
                a. *Hint: opposite of micro* (big enough to see with your naked eye)
            3. What does it mean to be benthic?
                a. Hint: where it lives (lives on the bottom of lakes, rivers, or streams)
        iii. Click on the blue text to show the answer to what a benthic macroinvertebrate is.
    b. Ask what the students think it means to be an indicator of stream health
4. Read the next slide and briefly explain habitat needs of different animals
5. On the next slide, explain that there are many different types of water pollution.
    a. Ask the Students:
        i. What is pollution?
        ii. What are some examples of different types of water pollution that they can think of?
    b. Explain that one of the main types of pollution to understand that most people don't think of is sediment pollution. Explain what sediment is (basically soil and rocks moved by water)
    c. Explain that soil is very valuable on the land but can be detrimental to the stream.
6. On the next slide, ask what it means to be tolerant of pollution vs. sensitive to pollution.
7. In the following three slides, have the students make observations of what is happening as the sedimentation continues to increase (the water level is rising, the BMIs disappear starting with the most sensitive creatures, the habitat between the rocks is filling in)
    a. By a show of hands see who in the class likes to go fishing.

b. Ask the kids what they use for bait.
    i. Explain how many kinds of bait are actually BMIs and many lures are modeled after BMIs.
8. As the next slide plays and the fish swims by and thinks, “dinner?” explain the importance of BMIs to the food chain.
9. On the next slide, explain how sedimentation makes streams more prone to flooding because it fills in the stream channel. Try to link the flooding slide to recent flood or heavy storm events in your area.
10. On the slide after the flood, the water is cloudy and grasses can barely be seen in the background.
    a. This slide is a good time to introduce another major type of pollution: nutrient pollution.
        i. Explain that most people think nutrients are beneficial, rather than pollution.
            1. Ask where we get our nutrients. (food)
            2. Ask some of the students what their favorite foods are.
                i. (Note: this is a way to engage some of the students that have not been as involved so far in the activity)
            3. Ask where plants get their nutrients (soil)
            4. Ask what farmers put on their soil to give it even more nutrients (manure/ fertilizer)
        ii. Explain nutrient pollution.
            1. If a cow comes by, poops on the ground and the nutrients go into the plants to help them grow, and we eat the plants, then that is great. However, if some of that fertilizer gets into the water, it makes algae grow.
                a. Explain what algae is and how if there is too much of it, it can sometimes cover entire surface of water bodies.
        iii. Explain how algae and sediment can block sunlight from getting to plants growing underwater.
                a. Ask why plants need sunlight (to grow, photosynthesis)
                b. Ask what plants give off in photosynthesis (oxygen)
            2. Explain as the algae dies, microscopic bacteria eat/decompose the algae. Explain that these types of microbes use up a lot of the oxygen in the water thereby stealing oxygen away from things that need it.
            3. Ask what fish and BMIs breathe (oxygen in the water. Without it they will actually start to “drown")
11. Continue on to the final slides
    a. Explain how riparian buffers can mitigate many of these problems.
        i. Ask if anyone knows what a buffer is.
            1. Click on the blue text for the answer
        ii. Explain that riparian buffers intercept nutrients and make the plants on land grow instead of the algae in the water grow.
        iii. Explain how riparian buffers reduce sediment pollution.

Introduction to Stream Sampling Activity

This activity provides an overview of all the key concepts students will need to understand when they do the final Virtual Stream Sampler activity, and when they take what they have learned out to sample their local stream.

1. Start the online activity:
    a. In the Benthic Macroinvertebrate portal, click on the **Introduction to Stream Sampling** activity.
    b. If the activity is not an optimal size on the screen, maximize the window, then hold down control and press the + or – key to adjust the zoom. (You can also hold control and use the mouse wheel.)
    c. Choose one student to control the activity. Tell him or her to click the blue arrow when instructed to.
2. Explain that the students are going to be doing what scientists all over the world do to figure out how healthy are streams and the entire watershed and ecosystem around them.
3. Read the slides to the class until you reach the dissolved oxygen slide.
    a. On this slide ask the students why they think dissolved oxygen is important. (Fish and other underwater creatures need oxygen to breath.)
4. Next, the second bullet will appear on the slide listing what healthy mountain streams have.
    a. Ask the students what they think pH is.
    b. Ask why measuring pH is important.
5. The next slide shows a pH meter; this is a good opportunity to give a very brief lesson on pH.
6. Next, the third bullet will appear on the slide listing what healthy mountain streams have.
    a. Explain that most fish and creatures in streams like cold water. Before going to the next slide, make the analogy of fish like cold water for the same reason we like cold soda
        i. Ask why we like cold soda, and why warm soda is nasty. (Cold soda has more bubbles/warm soda gets flat.)
        ii. Explain that cold liquid holds more gas. Just as cold soda can hold more bubbles, cold water can hold more gas
        iii. Ask why cold water is important in streams (can hold more oxygen)
    b. Explain that riparian buffers can keep the streams shaded and cool
    c. Ask the students what happens to asphalt and blacktop in the sun (gets very hot)
        i. Explain that if there is a lot of asphalt and blacktop (impervious surface) in the watershed, there might be a lot of warm water flowing into the stream.
7. Read the temperature range slide.
8. Read the alkalinity slide (alkalinity and conductivity may be too high level for younger students to understand in detail)
9. Continue through the slides
    1. ***Note: After the varying rock slide with the stonefly on the couch, the remainder of the Introduction to Stream Sampling slides explore concepts covered in the Sedimentation Blues activities in more detail. If you are running short on time and are unable to***

allocate at least 50 % of the session to the Virtual Stream Sampler, you may want skip the rest of this presentation and go directly onto the Virtual Stream Sampler.

10. Review sedimentation concepts on the following slides.
11. On the organic debris slide, explain that some organic debris is an essential source of nutrients for aquatic ecosystems; however this is not to be confused with the nutrient pollution from fertilizer or sewage.
12. *The EPT, dominance, and biotic index calculations are too high level for most middle school students. To save time here, simply explain that higher diversity of BMIs, especially ones that are sensitive to pollution, is better.*
13. On the algae slide, explain that algae effects the PH and makes rocks slippery as well as reduces the amount of oxygen in the water.

Review concepts of alga and oxygen reduction discussed at the end of the last activity

Virtual Stream Sampler Activity

Now it's time to take your students out to sample a virtual stream, and reinforce everything they learned in Sedimentation Blues and Introduction to Stream Sampling.

1. Start the online activity:
    - **a.** On the BMI portal, click on **Virtual Stream Sampler**
    - **b.** Click on one of the streams in the window.
    - c. The Virtual Stream Sampler activity will load. If the activity is not the optimal size on the screen, maximize the window, then hold down control and press the + or – key to adjust the zoom. (You can also hold control and use the mouse wheel.)
    - d. Explain that the stream they selected is a virtual representation of a real stream, and the activity uses real data collected by environmental scientists.
    - e. Have a different student control each of the sections of the stream sampling. Switch which student controls the computer after each BMI is identified and after each section is completed. The students can be chosen by who answers one of the following review questions correctly:
        i. What is a benthic macroinvertebrate?
        ii. What do benthic macroinvertebrates tell us about the stream?
        iii. What is a riparian buffer and why is it important?
        iv. What is something you can do to help your local stream?
        v. What is something that a farmer can do to keep local streams clean?
        vi. What are the two major types of pollution that we are most concerned about in the Chesapeake Bay Watershed?
        vii. What happens to fish in a stream with high levels of sediment?
        viii. What other issues happen when a stream has too much sediment?
        ix. What is the best way to prevent sedimentation in a stream?
        x. Name the BMIs that we have identified so far.
    - f. Students should work as a team and discuss their thoughts and ideas with the student controlling the activity. However, the controller has the final say on what activity to choose.
2. Explain the three sections of the activity and lead the class through the activities
    - **a.** **<u>BMI Identification:</u>** Click on the beetle logo
        - **i.** Click on the net on the top right corner to dip the net.
        - **ii.** Click and drag the leaves out of the net until a student finds a BMI they want to identify.
        - **iii.** Drag the desired BMI into the tray at the bottom right corner
            1. When the window opens with the BMI and a list of questions, click the '?' for more information on how to proceed.
                - ***a.*** *Note: because the identification is scored, you will be unable to exit the identification window until the BMI has been successfully identified.*
        - **iv.** Explain what a dichotomous key is and why it is important.
            1. Explain that a dichotomous key gives you two choices, and if you examine the unknown creature and choose the correct answer, you can get closer and closer to identifying what the creature is. **Note**: make sure the students understand they can click on the BMI in every frame of the Key to get information that will help them answer the key question.
                - **a.** If students are having trouble grasping the concept, relate dichotomous key relate it to the popular game '20 Questions .' In 20 Questions, players take turns asking a question which can be answered with a simple "Yes" or "No."

v. Explain that many of these benthic macroinvertebrates are actually the immature versions of insects that we see flying outside of the water all the time. Many of them spend almost their entire lives underwater. (Note: this information is also provided in the "What is a BMI" activity.)
    1. Explain that a nymph is an immature version of an insect that will go through incomplete metamorphosis. They will not go into the pupae phase. Nymphs may look somewhat like the adult.
    2. Explain that larvae, like a caterpillar, will go through a pupae phase. They look much less like the adult phase.
vi. Have a different student control the activity for each BMI. The students should be working as a team, but the student controlling the activity should make final decisions and selections.
    1. After each identification is completed, note how sensitive to pollution the BMI was, and what it tells us about the stream.
vii. Depth options
    1. For younger students, they may need your help to lead them through the activity and read the text on the screen.
    2. If you are short on time, only identify one or two benthic macroinvertebrates before going on to the other sections.
    3. If time allows, you may also use this key to introduce biological terms such as arthropod, insect, exoskeleton, herbivore, etc.
        a. Key Vocabulary can be found in the "What is a BMI" activity" in the BMI Portal.
        b. The dichotomous key is also available as a standalone activity "What is it?" that is widely used to teach core biological concepts.
    4. You may want to give some background information on each benthic macroinvertebrate. This information is available within the activity when you go complete an identification using the key. The final frame provides some key information, and if you click on the BMI even more specific information pops up.

b. **Habitat Assessment:** Click on the second tool
    i. Explain quantitative versus qualitative data.
        1. This section gathers qualitative data and the students should use their best judgment.
    ii. Chose a student to control the computer for this assessment.
        1. Explain that clicking throughout the stream will gain different hints from the Mayfly nymph.
    iii. Remind the students what they learned about embeddedness in the **Sedimentation Blues** and **Introduction to Stream Sampling** activities It is measure of how deeply buried the larger sediment (gravel, cobble, and boulders) are in fine sediment like sand and silt. An excellent upland stream will have almost no fine sediment filling the spaces between the larger rocks (gravel, cobble, and boulders) in the riffles. This provides much more habitat for the animals that live on the bottom of the stream. A poor upland stream will have rocks that are almost completely covered.
    iv. Explain the difference between brown and green algae, how green algae forms multicellular colonies that may be matted or hairy, while brown algae is the single cellar algae that coats the rock surface.
    v. When complete, select 'confirm answers' on the bottom of the screen.

c. **<u>Water Quality</u>:** Students will have already learned about each of the kinds of water quality measurements they will collect in this section when they went through the **Introduction to Stream Sampling**. This will provide a good opportunity to cement those lessons. Click on the thermometer logo
    i. Explain quantitative versus quantitative data
        1. This section gathers qualitative data. In this section students will be able to collect exact readings with numerical results.
    ii. Chose a student to control the computer for this assessment.
        1. Click on the logos next to each question to take a measurement
    iii. Water quality measurements
        1. Temperature
            a. Ask what the thermometer reads
                i. Examine if the question asks for Celsius or Fahrenheit.
                ii. Make sure the answer is in Celsius.
                iii. Ask if the students remember why temperature is important in a stream.
        2. pH
            a. Grab and drag the pH stick to match it up with the chart.
        3. Oxygen
            a. Explain that different animals need different concentrations of oxygen to survive. Explain that some animals such as trout need a lot of oxygen.
        4. Nitrogen
            a. Explain that nitrogen is one of the main types of nutrient pollution.
            b. Ask what could happen if there is too much nitrogen in the water.
                i. Note: Students with weak decimal math skills often get this question wrong. You can use this question as an opportunity to review decimal and math skills.
        5. Conductivity
            a. Low, medium or high?
                i. Note: Conductivity may be a concept too advanced for most middle school students to fully understand. Here are some general facts about conductivity:
                    1. Conductivity measures how well the water will carry an electrical charge.
                    2. Conductivity tells us how much minerals, chemicals, and/or ions are in the water that may carry an electric charge if electrified.
                    3. Sudden fluctuations of conductivity between extremes should be noted and may indicate a problem.
        6. Alkalinity
            a. Low, medium or high?
                i. If alkalinity is too low, the stream could be very vulnerable to acid rain.
d. When completed, click the green checkmark on the bottom right of the activity to generate a report.
    i. The score at the bottom of the report will only be significant if all parts of the activity is completed
        1. If desired, the score can be printed out and used for a grade.
    ii. Review the summary page.

1. Ask the students how healthy they believe the stream is.
2. Ask what people around Dumpling Run are doing to keep the stream so healthy.

3. Review major concepts of the lesson

Teacher Follow-Up

- After looking at illustrations of BMIs all day, your students might want to see actual pictures. Have them click on the "**A Closer Look**" icon to see some real BMIs and learn something about how they live.
- When the students finish the dragonfly identification, show them the following video on YouTube if available in class. The YouTube Video entitled 'Great Dragonfly larva on hunt' is from the BBC DVD, "Life in the Undergrowth" *(fun fact: the makers of movie 'Alien' got inspiration from dragonfly nymphs according to Biology Professor Shannon McCauley of California Polytechnic State University.)*
- Remind students the eSchool is free and available on any computer, at home or in the library. Encourage students to visit the eSchool again to try again or 'have fun' with CI's other hands-on activities.
- Use the BMI portal to prepare students for real stream monitoring and sampling on field trips to real streams.
- Use the eSchool to prepare students for hands-on restoration projects at their school.