



Stream Chemistry Monitoring: Students Investigating & Conserving Their Streams Presentation 2

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This presentation can be used as a stand-alone presentation or as part of ICPRB's Water Ways Stream Ecology and Assessment series for high school students. The presentation introduces the topic of water chemistry, which can be supplemented by the hands-on water chemistry activity provided on ICPRB's website. Using the two together makes it easier for students to understand and remember water chemistry information, which can be challenging. Teachers might want to omit or change some of the slides, if the presentation is too complex for their students. We endeavored to provide enough background in the notes for teachers to select the most important points to their students.

Stream Health Checkup

- Doctors determine health by checking our “vitals” — our hearts, ears, temperature, and weight.
- What aspects of these streams give us clues to their “health?”



If students have seen the initial Water Ways presentation (or Watershed Connections and Score Four presentations on ICPRB’s website), they could have some good guesses about signs of stream health. This slide is meant to get students talking and engaged. They do not have enough information for definitive answers. Following are possible observations.

- The stream on the left appears in good shape, as it seems to have a natural shape and trees on each bank. The water is clear and breaks over the rocks, providing oxygen.
- The middle picture shows algae covering the rocks on the bottom of the stream. This is a sign that the stream has too many nutrients. The student might notice that the green color doesn’t look right.
- The photo on the right shows a stream that is very muddy and has bare tree roots, both signs of erosion on the site and from upstream.

Healthy Streams Have...

Chemical properties that:

- Support fish, frogs, salamanders, and plants.
- Are safe swimming, wading, and fishing.



In this lesson you will be learn how to do water chemistry testing and how to understand your results.



Water Chemistry Tests

You will learn to do tests that tell you if the following properties are suitable for aquatic life:

- pH
- Dissolved Oxygen
- Nutrients – nitrogen & Phosphates
- Temperature
- Turbidity



These are some of the chemical tests performed by water scientists. Have your students heard of any of them?

pH – what it means

pH is measured on a scale of 0 to 14.

- 7 is neutral.
- <7 is acidic.
- >7 is basic or alkaline.

Fish need water with a pH between 5.5 and 8.5.

- Acidic waters harm fish and other aquatic species.



pH 0

2

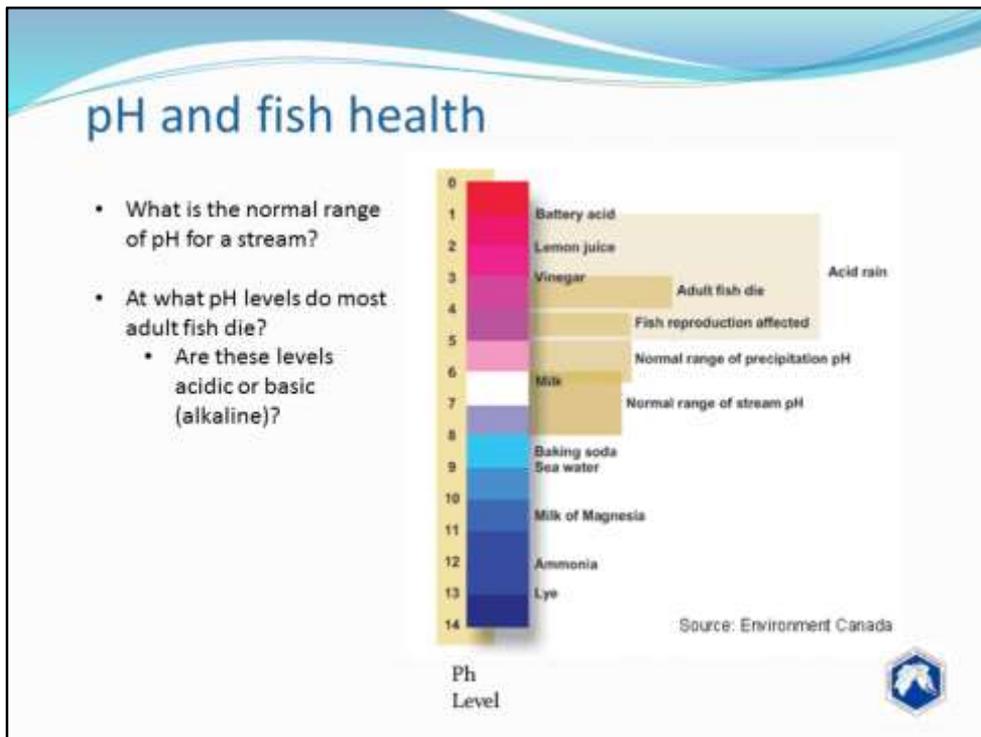
7

9

14

Take time to look at the picture graph on the bottom of this slide, so that students understand what pH level is appropriate for aquatic life, as well as how different the pH values are in terms of acidity and baseness.

Questions to engage students? Do they think aquatic life could survive in a stream in a stream that is acidic as battery acids or even lemons? Could such acidic water be used for a source of drinking water? Would it be safe – or even desirable – to wade in?



A pH less than 5 is considered harmful to most stream biota, especially fish. When the pH of stream water is too low, gill function, egg development and larval survival are affected.

More Background for teachers:

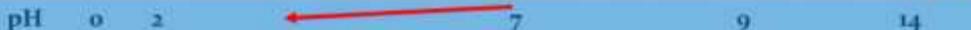
Different species of fish and other aquatic life have different levels of toleration for acidity. See the EPA pictorial chart depicting common species and their corresponding levels of tolerance to pH: <https://www.epa.gov/acidrain/effects-acid-rain>.

“Below a pH of 5, fish populations begin to disappear, the bottom is covered with undecayed material, and mosses may dominate nearshore areas. Below a pH of 4.5, the water is essentially devoid of fish.” <http://www.lenntech.com/aquatic/acids-alkalis.htm#ixzz4opU8kn5O>

Low pH levels also encourages the solubility of heavy metals. As the level of hydrogen ions increases, metal cations such as aluminum, lead, copper and cadmium are released into the water instead of being absorbed into the sediment. As the concentrations of heavy metals increase, their toxicity also increases. Aluminum can limit growth and reproduction while increasing mortality rates at concentrations as low as 0.1-0.3 mg/L. <http://www.fondriest.com/environmental-measurements/parameters/water-quality/ph/>

Human factors that increase stream acidity

The exhaust from coal-powered power plants and vehicles reacts with the air, making "acid rain."

Acid rain is the most important and most widespread source of acidity in Maryland streams, **affecting nearly one-fifth of the state's stream miles**, primarily in Western Maryland and Southern Maryland (western shore). Source: *From the Mountains to the Sea: The State of Maryland's Freshwater Streams*.

Reacts to form sulphuric acid and nitric acid.

Acid rain is caused by a chemical reaction that begins when compounds like **sulfur dioxide** and **nitrogen oxides** are released into the air. These substances can rise very high into the atmosphere, where they **mix and react** with water, oxygen, and other chemicals, forming sulfuric acid and nitric acid, respectively.

Human activities are the greatest causes of acid rain. Most gases that lead to acid rain are by-products of burning fossil fuels and electric power generation. Erupting volcanoes also release chemicals that lead to acid deposition.

For teachers:

Carbon dioxide (CO_2) from power plants, cars, and burning wood also reacts to form carbonic **acid**, H_2CO_3 . The hydrogen ions from carbonic **acid** give natural **rain** water a slightly **acid** pH value of 5.6. The acids formed by oxides of nitrogen and sulphur are far more corrosive (reactive).

Other human actions that alter pH

- Fertilizers increase acidity (lowers pH).
- Drainage from coal mines increases acidity.



Acid Mine Drainage kills the life in a stream.



Acid enters streams from four main sources: acid rain, abandoned coal mines, fertilizers, and decomposing leaves and other natural organic material.

Additional information

Carbon dioxide also affects the pH of waters. The evidence of this is most pronounced in estuaries and oceans.

We have not focused on the **natural influences** of pH in this presentation. Following is more information.

- So-called **black water systems**, formed naturally from decomposition of organic materials, tend to have root-beer colored water. The life in these systems are adapted to slightly acidic water.
- **Limestone** in chip or rock form is an alkaline and it will **neutralize** low pH **acid**. The **Calcium Carbonate** - CaCO_3 – in limestone reacts with strong acids to form water, carbon dioxide and calcium salts. The salts usually precipitate into a sludge. Limestone is used to counteract Acid Mine Drainage, successfully restoring stream ecosystems.
- **Volcanic ash** slightly lowers water acidity.

Dissolved Oxygen:
oxygen that is dissolved in water

Aquatic animals breathe oxygen through their gills and skin.

Sources of oxygen in the water:

- Aquatic plants produce oxygen.
- Choppy water and waves capture oxygen from the air.



Photos: Top: IWLA; Side: ICPRB

Fish need oxygen too, but since they don't have lungs, they take oxygen from the water through their gills. The oxygen in the water available to fish is called dissolved oxygen (oxygen that is dissolved in the water).

Unlike air, which is normally about 21% oxygen, water contains only a *tiny fraction of a percentage of dissolved oxygen*. In water it usually is expressed in milligrams per liter (mg/L), parts per million (ppm), or percent of saturation. At sea level, typical DO concentrations in fresh water range from 7.56 mg/L (or 7.56 parts oxygen in 1,000,000 parts water) at 30 degrees Celsius to 14.62 mg/L at zero degrees Celsius. (So you can see that water temperature is a big factor in how much DO is in water.)



<http://water.usgs.gov/edu/qa-chemical-fishkills.html>

Most fish do well when the dissolved oxygen is five parts per million (ppm) (= 5/1,000,000) or higher.

When the dissolved oxygen is less than five ppm they become uncomfortable.

Most fish will begin to suffocate and die when the dissolved oxygen is two ppm or lower.

<https://www.fws.gov/nc-es/edout/albefitfish2.html>

White suckers: <http://www.troutnut.com/underwater-pictures/of-fish>

Factors that Reduce Dissolved Oxygen

- Too much algae in the water.
 - After algae dies, it decomposes. This uses oxygen in the water.
- High water temperature:
 - Warm water holds less oxygen than cool water.
- Cloudy and muddy water
 - Less or no light reaches underwater plants, so they do not produce oxygen through photosynthesis.



Algae: simple nonflowering plants, including seaweeds and many single-celled forms that live in and on the water.



Algae also uses dissolved oxygen at night for respiration.

Photo: ICPRB

Warm water holds less dissolved oxygen than cold water, so summer is the time when fish can have a hard time getting enough oxygen, because other organisms also use oxygen.

For example in the summer *during the day, the algae and plants produce oxygen through photosynthesis, but at night photosynthesis stops. The algae and plants keep respiring, a process that uses oxygen. **If there is an ALGAE BLOOM** – too much algae – the amount of DO in the water will drop so low that fish suffocate.*

Also, when the algae and submerged plants die, they are decomposed by bacteria. The bacteria also use dissolved oxygen.

These factors can result in insufficient amounts of dissolved oxygen available for fish and other aquatic life.

“Fish kills” can occur as a result from natural conditions or from excess nitrogen and phosphorus polluting the water. Nutrients come from many sources: fertilizers, automobiles, sewage, manure, and others. An excess of nutrients tends to speed up the growth of algae and diminish the availability of dissolved oxygen.

Nitrogen and Phosphates

Nitrogen and phosphorus are two *nutrients* needed by plants for growth.

- But too much = pollution, because:
 - Excess nutrients cause too much algae to grow.
 - When the algae decomposes, it uses the oxygen in the water.



Nutrient: a substance that provides nourishment essential for growth and the maintenance of life.



This cycle of algae blooms and low oxygen is widespread throughout the United States. It is called eutrophication.

Photo: ICPRB

Sources of Excess Nutrients

<p>Nitrogen:</p> <ul style="list-style-type: none"> • Farm fertilizers and manure • Fertilizers from lawns • Dog and other pet waste • Air pollution from gas-burning vehicles. 	<p>Phosphorus:</p> <ul style="list-style-type: none"> • Farm fertilizers and manure • Fertilizers from lawns • Dog and other pet waste • Some washing detergents • Industrial wastes • Old wastewater treatment plants.
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Which of these pollutants can you reduce?







What do the students notice about the sources of excess nitrogen and phosphorus? Some of the sources are the same – fertilizers and dog waste are big sources of excess nutrients in water.

The biggest sources of excess nutrients in the Chesapeake Bay watershed are farms; however, the practices of urban residents also contribute greatly to pollution. Which sources of nitrogen and phosphorus on these lists are things that individuals can address by changes in their daily lives?

Photos

Fertilizing: *Wall Street Daily*

Dog photo: <https://za.pinterest.com/pin/575053446143133583/?lp=true>

Car Washing: EPA

Water Temperature: big affects

Temperature affects both water chemistry and aquatic life.

- Cold water holds more oxygen than warm water.
- Aquatic lifeforms are more stressed at higher temperatures. This makes them more susceptible to diseases.
- Harmful types of algae and bacteria multiply faster in warmer waters.



Warmer waters means less oxygen and increased animal metabolism increases. These stressors lower their resistance to disease. At the same time, some pathogens may respond to the warmer waters by multiplying faster.

Human Actions That Raise Water Temperature

- Industries and power plants that release warm water or industrial waste into rivers.
- Stormwater runoff that is heated by hot pavement.
- The loss of trees along waterways.
- Climate change.



Photo: Roger Winstead

Turbidity — how far can you see?

Turbidity is the measure of the cloudiness or murkiness of water.

- The cloudier the water, the greater the turbidity.
- The Effects: Sunlight cannot penetrate through the water to the plants on the bottom.
 - How would this affect the plants?
 - What other chemical property would be affected?



Algae growth



Turbidity reduced the amount of dissolved oxygen in the water because of eutrophication and plant death. Additionally, darker waters absorb more heat, so turbidity can increase the temperature of the water, also lowering oxygen levels.

Human Activities and Turbidity:

Turbidity is increased by:

- Soil from crop fields and construction.
- Runoff containing fertilizer (increases algae).
- Erosion from river banks and bare soil.



Water Chemistry Activity & Lab

Student Teams

- Nitrogen/nitrate -- takes about 15 min.
- Phosphorus -- takes about 10
- Dissolved Oxygen -- takes about 10
- pH and temperature
- Turbidity

Suggested Team Jobs

- Reader
- Writer/Recorder
- Timer
- Test-Tube Filler and Mixer
- Test-tube washer -- everybody
- Group reporter(s)



These are suggestions for using the activity cards and data sheet, along with water chemistry tests.

Only do alkalinity with more advanced classes. It is a harder concept to grasp.

Team Report to the Class

- Tell about your chemical or water property.
- Tell and show possible sources of pollution near your stream.
- Show the chart with your results.
- Give your results and thoughts about the results.



Water Chemistry Resources

HIGH SCHOOL TEACHERS:

Detailed description of condition, pollutants, and stressors of Maryland streams:

From the Mountains to the Sea: The State of Maryland's Freshwater Streams, D. Boward, P. Kazyak, S. Strako, et. al.

Maryland data sheets for chemical water monitoring:

[Explore and Restore Maryland Streams](#), Maryland Department of Natural Resources *Biological Assessment of Stream Health*.

- [Overall Student Data Sheets for All Stream Activities](#).
- [Coastal Overall Student Data Sheet](#) (for streams in the coastal plain geographic province)

Water chemistry results for Maryland streams, MD Department of Natural Resources:

[Maryland Stream Health Map](#) – view data collected on a stream near your school, using [interactive maps](#) and charts of the results. <http://dnr2.maryland.gov/streams/Pages/streamhealth/default.aspx>

K- MIDDLE SCHOOL TEACHERS

- **The Audobon Naturalist Society Green Kids:** complete lesson plans and power points for grades 4-5, covering stream habitat, monitoring procedures, and equipment. See [GreenKids Stream Lesson Plans](#) [<http://ansbookshop.org/index.php/nature-programs/schools-teachers/greenkids-school-partnerships#lessons>]
- **Creek Freak Program, Izaak Walton League of America** – Comprehensive teacher and student lessons for hands-on extensive inquiries of stream ecosystems. Grades 5-8.

[Interstate Commission on the Potomac River Basin](https://www.potomacriver.org), <https://www.potomacriver.org>

