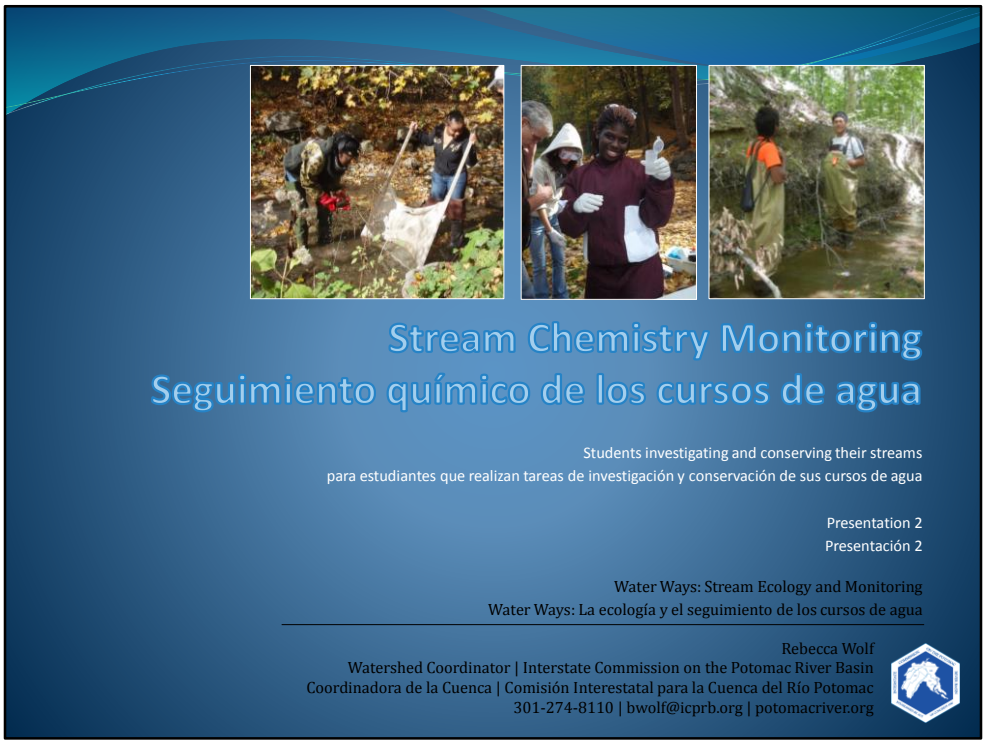
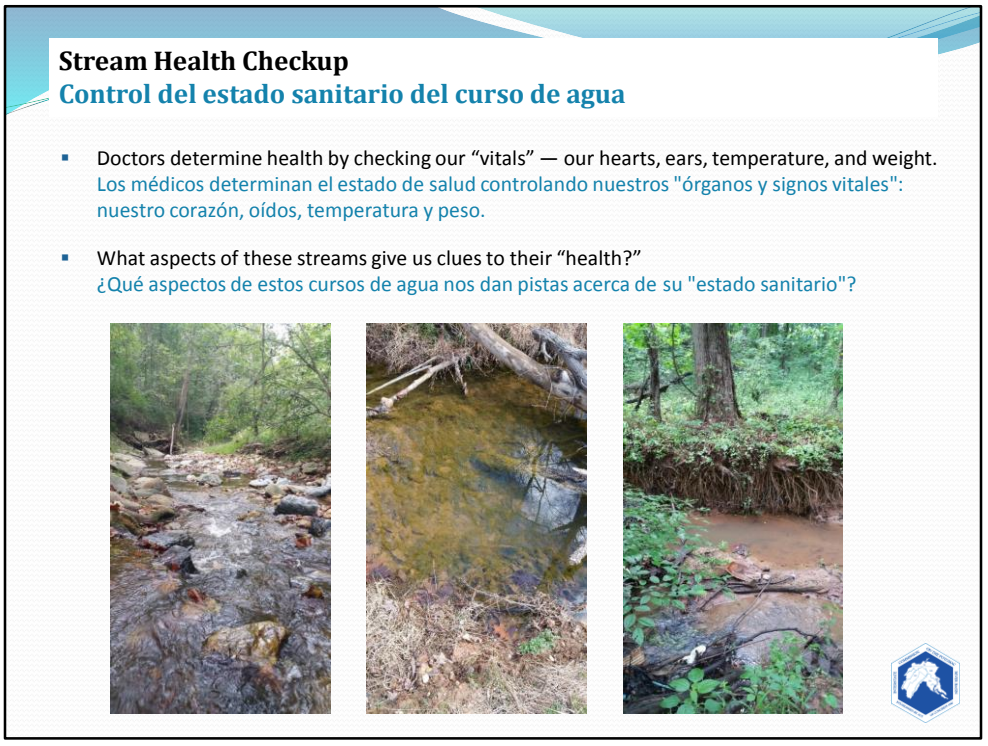


Interstate Commission on the Potomac River Basin – Water Ways: Stream Ecology and Monitoring
https://www.potomacriver.org/water_ways

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.



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…
Los cursos de agua en buen estado tienen…

Chemical properties that:
Propiedades químicas que:

- Support fish, frogs, salamanders, and plants.
  Son aptas para peces, ranas, salamandras y plantas.
- Are safe swimming, wading, and fishing.
  Son seguras para nadar, vadear y pescar.

In this lesson you will be learn how to do water chemistry testing and how to understand your results.
En esta lección aprenderás cómo hacer pruebas químicas del agua y cómo comprender tus resultados.

Water Chemistry Tests
Pruebas químicas del agua

You will learn to do tests that tell you if the following properties are suitable for aquatic life:
Aprenderás a hacer pruebas que te dirán si las siguientes propiedades son adecuadas para la vida acuática:

- pH
  pH
- Dissolved Oxygen
  Oxígeno disuelto
- Nutrients – Nitrogen and Phosphates
  Nutrientes: nitrógeno y fosfatos
- Temperature
  Temperatura
- Turbidity
  Turbiedad

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

pH – What It Means

pH: su significado

pH is measured on a scale of 0 to 14.
El pH se mide en una escala de 0 a 14.

- 7 is neutral.
  7 es neutro.
- <7 is acidic.
  < 7 es ácido.
- >7 is basic or alkaline.
  > 7 es básico o alcalino.

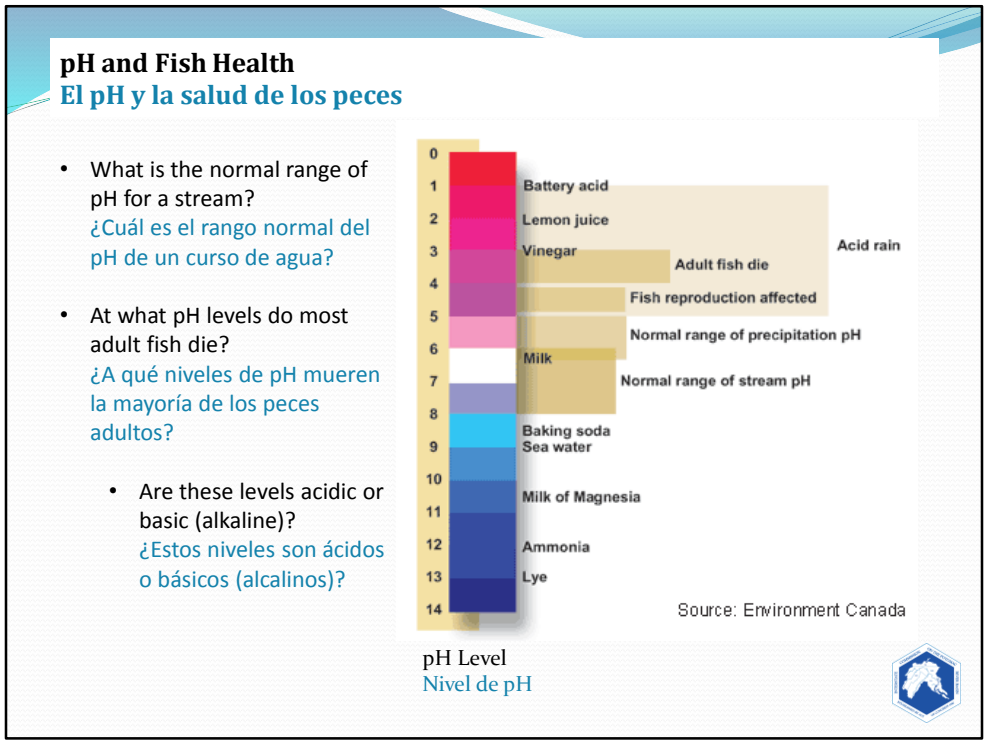
Fish need water with a pH between 5.5 and 8.5.
Los peces necesitan que el agua tenga un pH entre 5,5 y 8,5.

- Acidic waters harm fish and other aquatic species.
  El agua ácida es nociva para los peces y otras especies acuáticas.



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?

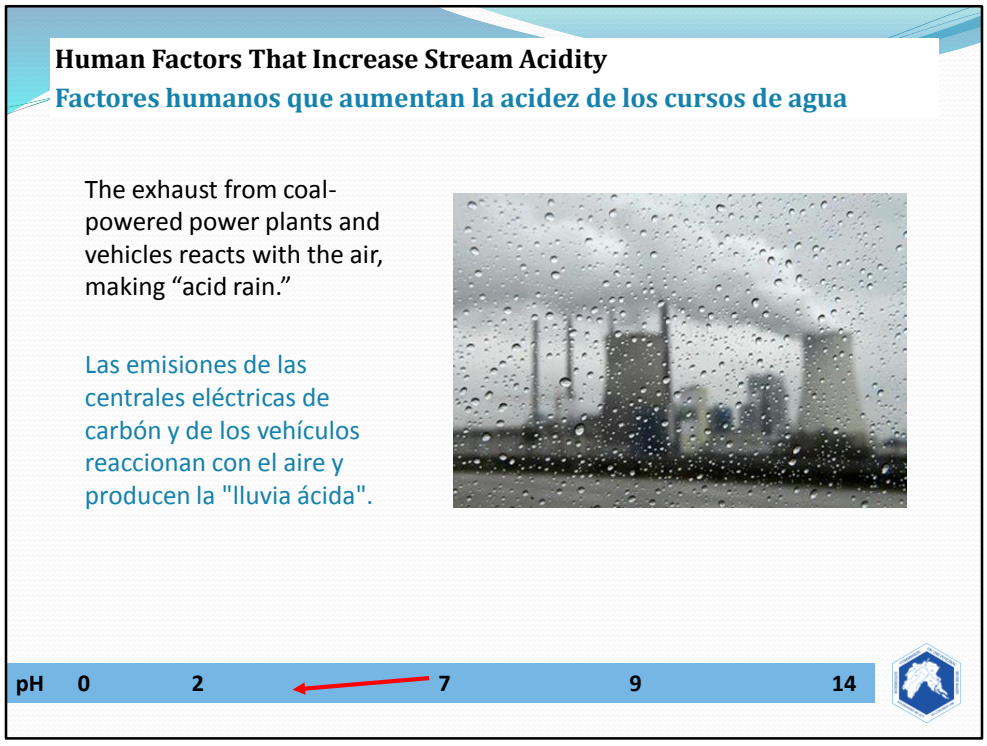


A pH less than 5 is considered harmful to most stream biota, especially fish. When the pH of stream water is too low, gill function, egg development and larval survival are affected.

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/



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, foring 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 ($C0^{2)}$ from power plants, cars, and burning wood also reacts to form carbonic **acid**, H2CO3. 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
Otras acciones humanas que alteran el pH

- Fertilizers increase acidity (lowers pH).
  Los fertilizantes aumentan la acidez (disminuyen el pH).
- Drainage from coal mines increases acidity.
  El drenaje de las minas de carbón aumenta la acidez.

Acid Mine Drainage kills the life in a stream.
El drenaje ácido procedente de las minas extermina la vida en un curso de agua.

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.

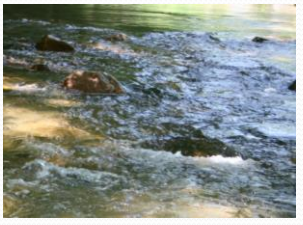
- So-called **black water systems**, formed naturally from decomposition of organic materials, tend to have root-beer colored water. The life in these systems are adapted to slightly acidic water.
- **Limestone** in chip or rock form is an alkaline and it will **neutralize** low pH **acid**. The **Calcium Carbonate** - CaCO3 – 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
Oxígeno disuelto: oxígeno que está disuelto en el agua

Aquatic animals breathe oxygen through their gills and skin.
Los animales acuáticos respiran oxígeno a través de sus branquias y de la piel.

Sources of oxygen in the water:
Fuentes de oxígeno en el agua:

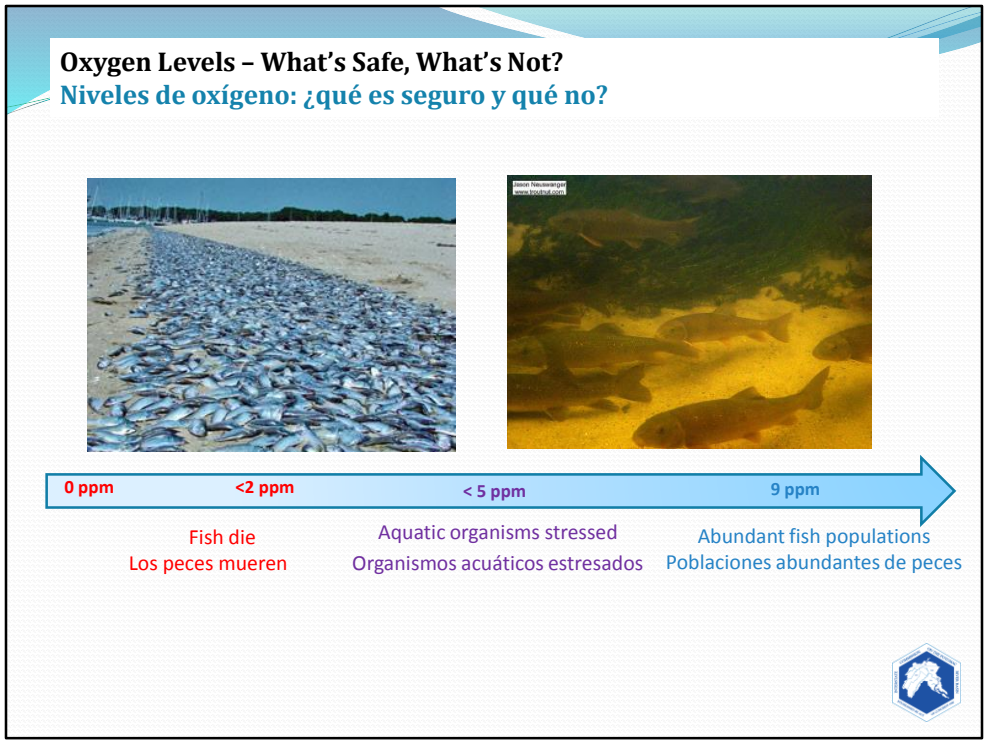
- Aquatic plants produce oxygen.
  Las plantas acuáticas producen oxígeno.
- Choppy water and waves capture oxygen from the air.
  El agua agitada y las olas captan oxígeno del aire.



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
Factores que reducen el oxígeno disuelto

- Too much algae in the water
  Demasiadas algas en el agua
  - After algae dies, it decomposes. This uses oxygen in the water.
    Luego de que las algas mueren, se descomponen. Esto consume oxígeno en el agua.
- High water temperature
  Temperatura elevada del agua
  - Warm water holds less oxygen than cool water.
    El agua tibia retiene menos oxígeno que el agua fría.
- Cloudy and muddy water
  Agua turbia y con lodo
  - Less or no light reaches underwater plants, so they do not produce oxygen through photosynthesis.
    Llega menos luz o ninguna a las plantas submarinas, por lo que estas no producen oxígeno mediante la fotosíntesis.

Algae: simple nonflowering plants, including seaweeds and many single-celled forms that live in and on the water.
Algas: plantas simples que no florecen, incluidas las algas marinas y muchas formas unicelulares que viven dentro del agua y sobre su superficie.

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 d*uring 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
Nitrógeno y fosfatos

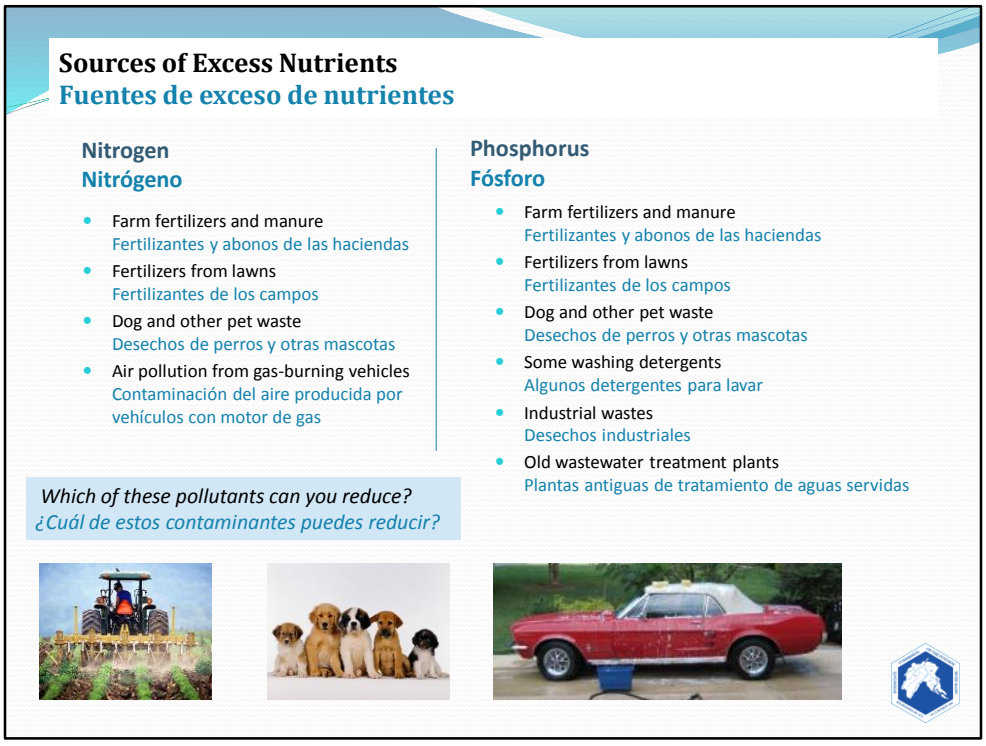
Nitrogen and phosphorus are two *nutrients* needed by plants for growth.
El nitrógeno y el fósforo son dos *nutrientes* que las plantas necesitan para crecer.

But too much = pollution, because:
Pero demasiado de ellos producen contaminación porque:

- Excess nutrients cause too much algae to grow.
  El exceso de nutrientes ocasiona el crecimiento de demasiadas algas.
- When the algae decomposes, it uses the oxygen in the water.
  Cuando las algas se descomponen, consumen el oxígeno del agua.

Nutrient: a substance that provides nourishment essential for growth and the maintenance of life.
Nutriente: sustancia que proporciona la nutrición esencial para el crecimiento y el mantenimiento de la vida.

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



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
Temperatura del agua: grandes perjuicios

Temperature affects both water chemistry and aquatic life.
La temperatura afecta tanto la química del agua como la vida acuática.

- Cold water holds more oxygen than warm water.
  El agua fría retiene más oxígeno que el agua tibia.
- Aquatic lifeforms are more stressed at higher temperatures. This makes them more susceptible to diseases.
  Las formas de vida acuática sufren mayor estrés con temperaturas más elevadas. Esto las hace propensas a enfermedades.
- Harmful types of algae and bacteria multiply faster in warmer waters.
  Los tipos nocivos de algas y bacterias se multiplican más rápido en aguas más cálidas.

Warmer waters means less oxygen and increased animal metabolism increases. These stressers 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
Acciones humanas que aumentan la temperatura del agua

- Industries and power plants that release warm water or industrial waste into rivers.
  Industrias y centrales eléctricas que vierten agua tibia o desechos industriales a los ríos.
- Stormwater runoff that is heated by hot pavement.
  Escorrentía pluvial que se calienta con el calor delpavimento.
- The loss of trees along waterways.
  Pérdida de árboles en las riberas de los cursos de agua.
- Climate change.
  Cambio climático.

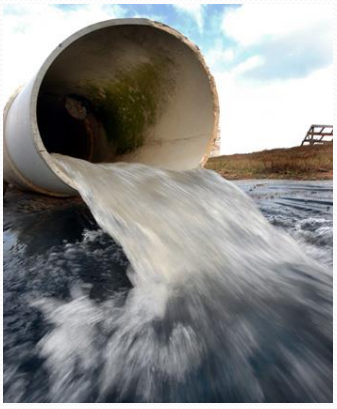


Photo: Roger Winstead

Turbididty – How Far Can You See?
Turbiedad: ¿hasta qué profundidad puedes ver?

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

La turbiedad es la medida que se utiliza para la falta de transparencia u opacidad en el agua.

- The cloudier the water, the greater the turbidity.
  Cuanto más borrosa se vea el agua, mayor será la turbiedad.
- The Effects: Sunlight cannot penetrate through the water to the plants on the bottom.
  Los efectos: la luz solar no puede penetrar en el agua para llegar a las plantas que se encuentran en el fondo.
  - How would this affect the plants?
    ¿De qué forma afectaría esto a las plantas?
  - What other chemical property would be affected?
    ¿Qué otras propiedades químicas se verían afectadas?

Algae growth
Crecimiento de algas

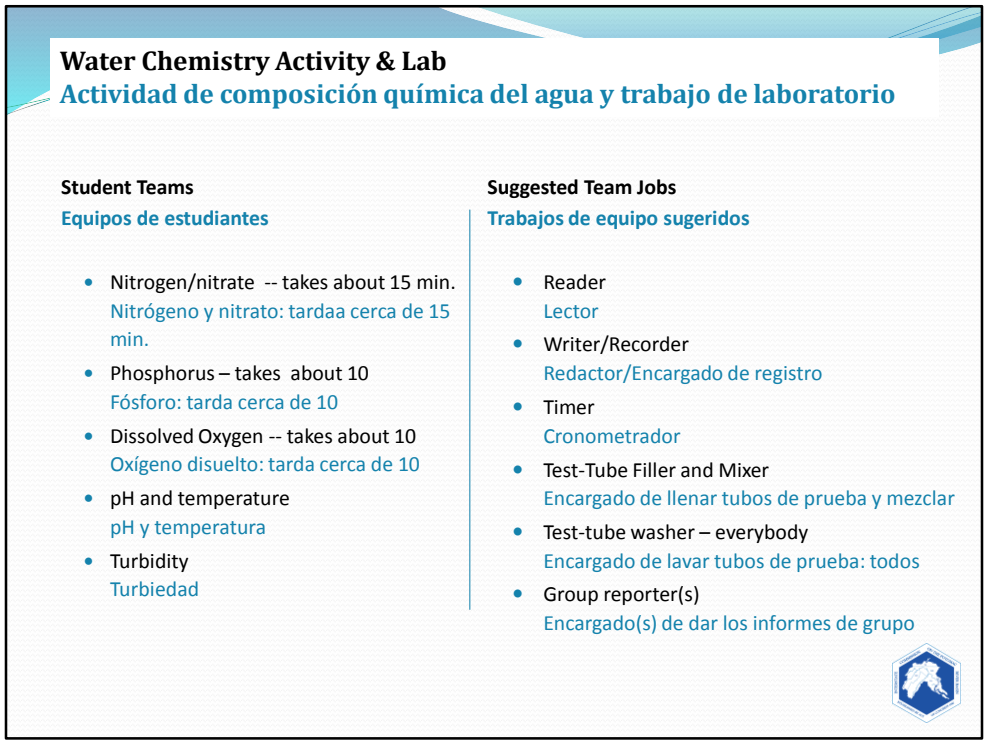
Turbidity reduced the amount of dissolved oxygen in the water because of eutrophication and plant death. Additionally, darker waters absorb more heat, so turbidity can increase the temperature of the water, also lowering oxygen levels.

Human Activities and Turbidity
Actividades humanas y turbiedad

Turbidity is increased by:

La turbiedad aumenta con:

- Soil from crop fields and construction.
  La tierra procedente de los campos de cultivo y la construcción.
- Runoff containing fertilizer (increases algae).
  La escorrentía que contiene fertilizantes (aumentan las algas).
- Erosion from river banks and bare soil.
  La erosión de las riberas de los ríos y el suelo pelado.



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
Informe de grupo para la clase

- Tell about your chemical or water property.
  Habla acerca de las propiedades químicas o del agua.
- Tell and show possible sources of pollution near your stream.
  Indica y muestra posibles fuentes de contaminación cerca de tu curso de agua.
- Show the chart with your results.
  Muestra la tabla con tus resultados.
- Give your results and thoughts about the results.
  Comparte tus resultados y lo que piensas sobre estos.

Water Chemistry Resources
Recursos de composición química del agua

HIGH SCHOOL TEACHERS:
DOCENTES DE ENSEÑANZA SECUNDARIA:

- Detailed description of condition, pollutants, and stressors of Maryland streams:
  Descripción detallada de las condiciones, contaminantes y factores de estrés de los cursos de agua de Maryland:
  - *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:
  Hojas de datos de Maryland para el seguimiento de la composición química del agua:
  - Explore and Restore Maryland Streams, Maryland Department of Natural Resources *Biological Assessment of Stream Health.*
    Programa Explore and Restore Maryland Streams, *Biological Assessment of Stream Health*, Departamento de Recursos Naturales de Maryland.

    http://dnr.maryland.gov/education/Pages/Biological_Assessment.aspx
    - Overall Student Data Sheets for All Stream Activities.
      Hojas de datos en general del estudiante para todas las actividades relativas a cursos de agua

      http://dnr.maryland.gov/education/Documents/StudentDataSheet.pdf
    - Coastal Overall Student Data Sheet (for streams in the coastal plain geographic province)
      Hoja de datos costeros en general del estudiante (para cursos de agua en la planicie costera de la provincia geográfica)

      http://dnr.maryland.gov/education/Documents/StudentDataSheet_Coastal.pdf

Water Chemistry Resources
Recursos de composición química del agua

- Water chemistry results for Maryland streams , MD Department of Natural Resources:
  Resultados de la composición química del agua de los cursos de agua de Maryland, Departamento de Recursos Naturales de Maryland:

  - Maryland Stream Health Map – view data collected on a stream near your school, using interactive maps and charts of the results.
    Mapa del estado sanitario de los cursos de agua de Maryland : consulta datos recabados en un curso de agua cerca de tu escuela empleando los mapas interactivos y los cuadros con los resultados.

    http://dnr.maryland.gov/streams/Pages/streamhealth/default.aspx

K-MIDDLE SCHOOL TEACHERS
DOCENTES DE PREESCOLAR HASTA NIVEL INTERMEDIO DE ENSEÑANZA SECUNDARIA:

- **The Audobon Naturalist Society Green Kids**: complete lesson plans and power points for grades 4-5, covering stream habitat, monitoring procedures, and equipment.

  Programa GreenKids de la organización Audobon Naturalist Society: planificaciones completas de clases y presentaciones para 4.º y 5.º grado que abarquen el hábitat de los cursos de agua, los procedimientos de seguimiento y los equipos.

  http://ansbookshop.org/index.php/nature-programs/schools-teachers/greenkids-school-partnerships#lessons

- **Creek Freak Program, Izaac Walton League of America** – Comprehensive teacher and student lessons for hands-on extensive inquiries of stream ecosystems. Grades 5-8.

  Programa Creek Freak de la organización Izaac Walton League of America : lecciones completas dirigidas a estudiantes y docentes para prácticas de investigaciones exhaustivas de los ecosistemas de los cursos de agua. 5.º y 8.º grado.

FIND MORE RESOURCES ON OUR WEBSITE: ***Interstate Commission on the Potomac River Basin***
ENCUENTRA MÁS RECURSOS EN NUESTRO SITIO WEB: ***Comisión Interestatal para la Cuenca del Río Potomac***
https://www.potomacriver.org