Acid Mine Drainage and Dissolved Oxygen

Students will analyze how sulfites and related chemical compounds affect the availability of oxygen in waterways exposed to acid mine drainage.

Lab Summary

Dissolved Oxygen Sensor
(PS-2108)

Students will measure the concentration of dissolved oxygen in an aqueous environment, both before and after the addition of two different pollutants common to acid mine drainage, sodium sulfite and sodium nitrate. Students will analyze how sulfites and related chemical compounds affect the availability of oxygen in waterways exposed to acid mine drainage.

The term "acid mine drainage" refers to water draining or being discharged from abandoned mining sites or from waste soils called mine tailings. This water is acidic due to high concentrations of sulfuric acid, produced as a result of chemical reactions that occur when sulfide minerals contact oxidants, usually oxygen, in a wet or humid environment. Water chemistry field measurements of pH, hardness, dissolved oxygen, temperature, and conductivity can be used to detect environmental damage resulting from a variety of reactions that occur following mining activity.

Chemical pollutants including sulfites, sulfates, nitrates, ammonia, and heavy metals produce direct chemical demands on oxygen in the water due to the oxidation-reduction reactions that result. Dissolved oxygen levels lower than 3 parts per million are stressful to most aquatic organisms, and dramatic events like fish kills can result when there is excessive demand on dissolved oxygen in an ecosystem.

Pyrite or "foolås gold" (iron disulfide, FeS_2) is one of the most common minerals found in the waste rock of mines, and even long after the mine is abandoned the amount of pyrite in the vicinity directly correlates to the level of acidity and the concentration of heavy metal pollutants in mine drainage. Additionally, as pyrite degrades chemically, iron (III) hydroxide precipitates, forming "yellow boy", which stains rocks, turns affected waters orange or red, and covers the stream bed with a slimy coating. The presence of limestone (calcium carbonate, $CaCO_3$) can further complicate the ecosystem through carbonate buffering. All of these chemical interactions, as well as the various resident populations of aquatic organisms, affect the overall health of an ecosystem. It is an ironic situation since oxygen is obviously needed to support organisms that respire aerobically, yet the very presence of oxygen where pyrite concentrations are high can begin the cascade of chemical reactions that ultimately pollute the region.

Hypothesize: What kinds of redox reactions might be expected when sulfite ions or nitrate ions encounter dissolved oxygen? Predict how the concentration of dissolved oxygen will be affected by the addition of these ions to a sample of aerated water.

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Downloads

- Acid Mine Drainage and Dissolved Oxygen - PASPORT (32 KB, .zip)
  Includes experiment setup, procedures and Datastudio file
- Acid Mine Drainage and Dissolved Oxygen - ScienceWorkshop (32 KB, .zip)
  Includes experiment setup, procedures and Datastudio file

Here's What You Need

U.S. Educator prices shown.

Probeware (PASPORT Systems)

Xplorer GLX (PS-2002) **- $349** Buy Now

The Xplorer GLX is a data collection, graphing, and analysis tool designed for science students and educators.
Learn more

PASPORT Dissolved Oxygen Sensor (PS-2108) **- $225** Buy Now

Provides real-time, aqueous oxygen concentration measurements. For use with PASPORT Interfaces.

Learn more

Probeware (ScienceWorkshop Systems)

750 Interface, USB (CI-7650) **- $679**

Buy Now

The 750 Interface allows students to measure force, temperature, pressure, angular velocity, acceleration, current, and magnetic field with a built-in function generator and oscilloscope mode.
Learn more

Dissolved Oxygen Sensor (CI-6542) **- $269**

Buy Now

Provides real-time, aqueous dissolved oxygen concentration measurements.
Learn more

Other Materials

- **Distilled or deionized water**
- **1 mL each of 2-M sodium sulfite solution and 2-M sodium nitrate solution**
- **Clamps and lab stand as needed to suspend sensor in solution**
- **Lab glassware: two 600-mL beakers, large and small graduated cylinder (or pipette), stirring rod**
- **Wash bottles for rinsing sensors**
- **Optional: magnetic stir bar setup**

Additional equipment:

- **2-M sodium sulfite solution (25.2 g Na_2SO_3 / 100 mL)**
- **2-M sodium nitrate solution (17 g $NaNO_3$ / 100 mL)**
- **large bottle or aquarium pump to aerate water**

Note: To saturate deionized water with air, fill a clean container one-third full with deionized water, seal it, and shake vigorously for 10 seconds. Alternatively, bubble air through the deionized water for 15 minutes using an aquarium pump.