Dissolved oxygen

"And the boiling voice of the waters . . ."
— Thomas Hardy

Oxygen is as essential to life in water as it is to life on land. Oxygen availability determines whether an aquatic organism will survive and affects its growth and development. The amount of oxygen found in water is called the **dissolved oxygen concentration (DO)** and is measured in milligrams per liter of water (mg/l) or an equivalent unit, parts per million of oxygen to water (ppm).

DO levels are affected by:

- Altitude
- Water agitation
- Water temperature
- Types and numbers of plants
- Light penetration
- Amounts of dissolved or suspended solids

As water low in oxygen comes into contact with air, it absorbs oxygen from the atmosphere. The turbulence of running water and the mixing of air and water in waterfalls and rapids add significant amounts of oxygen to water.

Effects of temperature on DO

Temperature directly affects the amount of oxygen in water—the colder the water, the more oxygen it can hold. Bodies of water with little shading can experience a drop in DO during periods of warm weather.

Thermal pollution, the discharge of warm water used to cool power plants or industrial processes, can reduce DO levels. The area immediately downstream from the entry of warm water can be altered drastically. Thermal pollution generally occurs in larger streams. However, dilution will temper these effects as warm water mixes with colder water downstream.

Temperature alterations are occasionally used to increase fish productivity, such as at a hatchery.

At higher altitude (elevation), the dissolved oxygen saturation point is lower than under the same conditions at lower altitude. Shown below are maximum amounts, or saturation levels, of dissolved oxygen (in ppm) in fresh water at sea level for different temperatures:

DO ppm	5	6	7	8	9	10	11	12	13	14	15
Temp°F	117	92	90	77	68	59	50	45	39	36	32

When aeration is high, DO levels can temporarily be higher than the saturation level. This extra oxygen is not stored in the water.

Temperature directly affects the amount of oxygen in water.

Photosynthesis, oxidation and decomposition

Oxygen can also be added to water as a result of plant photosynthesis. During the day, plants can produce oxygen faster than it can be used by aquatic animals. This surplus is temporarily available throughout the night for plant and animal respiration. Depending on individual

stream conditions, high daytime DO levels and low nighttime DO levels can occur.

Photosynthesis can be inhibited by sediments. Suspended sediments make water look murky or cloudy and block or reflect much of the sunlight that would otherwise be available for photosynthesis. Sediments can also settle onto the leaves of plants, further blocking their efficiency as oxygen producers.

The chemical oxidation and decomposition of dissolved, suspended and deposited sediments remove oxygen from the water. The amount of oxygen needed for these processes is called **biochemical oxygen demand (BOD)** and is oxygen that is unavailable for aquatic life. If the quantity of these sediments is large, remaining oxygen can be insufficient to support many forms of aquatic life.

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Most DO problems in Oregon streams occur when temperatures are at their highest and streamflows at their lowest. Salmon and trout are especially at risk during this time. Fry are often limited to small spawning streams during these "pinch periods" and DO is critical to their development. While a juvenile **salmonid** can withstand 1-2 ppm of DO for short periods, its growth rate drops sharply below 5 ppm, especially if the temperature is high.

Fish die-offs in shallow, warm ponds are a fairly common occurrence during the summer. During a long period of warm sunshine, algae grow profusely. A summer storm can result in several days of cloudy weather. The reduced sunlight can cause a massive die-off of the algal bloom. As dead algae decompose, available oxygen is depleted. The amount of DO drops to lethal levels, causing a subsequent die-off of fish and other aquatic organisms.

Maintaining productive DO levels

To maintain productive DO levels in a stream, shade should be provided to keep water temperatures cool. The presence of instream structures ensures mixing of water and air. Materials that can increase BOD, such as manure from feedlots or untreated municipal waste, should not be introduced.

Extensions

1. "Water canaries," *Aquatic Project WILD*, pp. 35-39.
2. "The Glass Menagerie," *Aquatic Project WILD*, pp. 121-124.
3. "Deadly Waters," *Aquatic Project WILD*, pp. 137-141.

Bibliography

Brown, George W., *Forestry and Water Quality*, 2nd ed., Corvallis: Oregon State University Bookstores, Inc., 1985.

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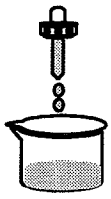


Dissolved Oxygen Testing

Dissolved oxygen is essential for the survival of aquatic plant and animal life. Measurements should be in the 8 to 15 mg/liter range for most game fish.

Method:

1. Follow the directions on the Hach dissolved oxygen test kit.

2. You will want to the student to take the sample 6" away from the stream bank and 2 1/2 " below the surface. As they fill the dissolved oxygen bottle, allow the streamwater to overflow the bottle to make sure there are no air bubbles in it.

3. Have students record findings in the dissolved oxygen data record on page *49*. Encourage them to look at the water quality chart on page *50*. Notice that some fish cannot live in the lower classifications of water quality.

Ask them to make some conclusions about the health of the stream and why the oxygen level is high or low.

Background: Meanders

- Natural meanders in the stream are important to create habitat and to control flow.
- Stream flow is influenced by human activities such as, removal of vegetation, which adds massive increases of water to a stream, along with sediment and excessive nutrients.

Kits available from Hach Company World Headquarters P.O. Box 389 Loveland, CO 80539. 1-800-227-4224.

Stream water contains a variety of naturally occurring and human created substances. Some of these are crucial to support life. However, they can cause water quality problems when too abundant.

Nutrients

- Nutrients like nitrogen and phosphorous are required by all organisms for basic processes of life. It occurs naturally in streams but is added in the form of fertilizers and detergents.
- Increased amounts of nutrients cause over growth of algae. This can clog waterways and use up dissolved oxygen depriving other organisms of the limited oxygen in the water.

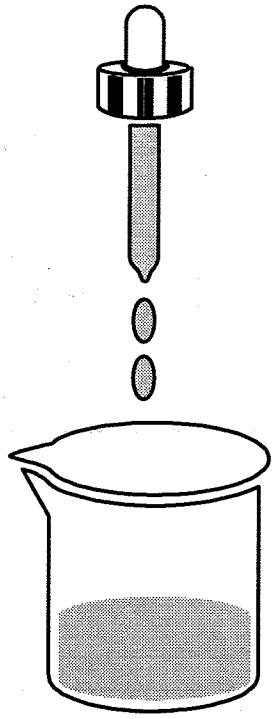
Sediment

- Sediment is carried by runoff from unstable stream banks, construction sites, logging sites, plowed fields, and residential areas.
- Sediment deposits on stream bottoms and fills gravel spaces, causing the stream bottom to become embedded and preventing fish from making redds to spawn.
- Fish gills become clogged with sediment, interfering with oxygen exchange.

Runoff

- Runoff into to streams in healthy watershed is absorbed and filtered of excessive nutrient, sediment and even some toxic substances by vegetation in riparian and wetland areas.
- Clearing land for agricultural, residential development, commercial or industrial use, or forest products, removes this vital filtration system.
- Every time it rains, our farms, logging trails, roads, parking lots, and lawns send pesticides, fertilizer, oil, dissolved metals, heavy metals (lead, cadmium, zinc, mercury) and oxygen robbing nutrients into our streams.

Dissolved Oxygen Testing



Testing for Dissolved Oxygen Concentration

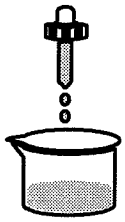
Method:

1. Follow the directions on the Hach dissolved oxygen test kit.

2. You will want to take the sample 6" away from the stream bank and 2 1/2" below the surface. As you fill the dissolved oxygen bottle, allow the stream water to overflow the bottle to make sure there are no air bubbles in it.

3. Record finding on dissolved oxygen data record.

Compare your findings to the standards sheet and make some conclusions about the health of the stream.



Dissolved Oxygen Fact Sheet

State Standards

Class AA (Extraordinary)	Exceed 9.5 mg/l
Class A (Excellent)	Exceed 8.0 mg/l
Class D (Good)	Exceed 6.5 mg/l
Class C (Fair)	Exceed 4.0 mg/l

Source: WAC 173-201A-030)

Data Record

Date: _____ Observers: _____

mg/l	Time	Which class does this fall in?

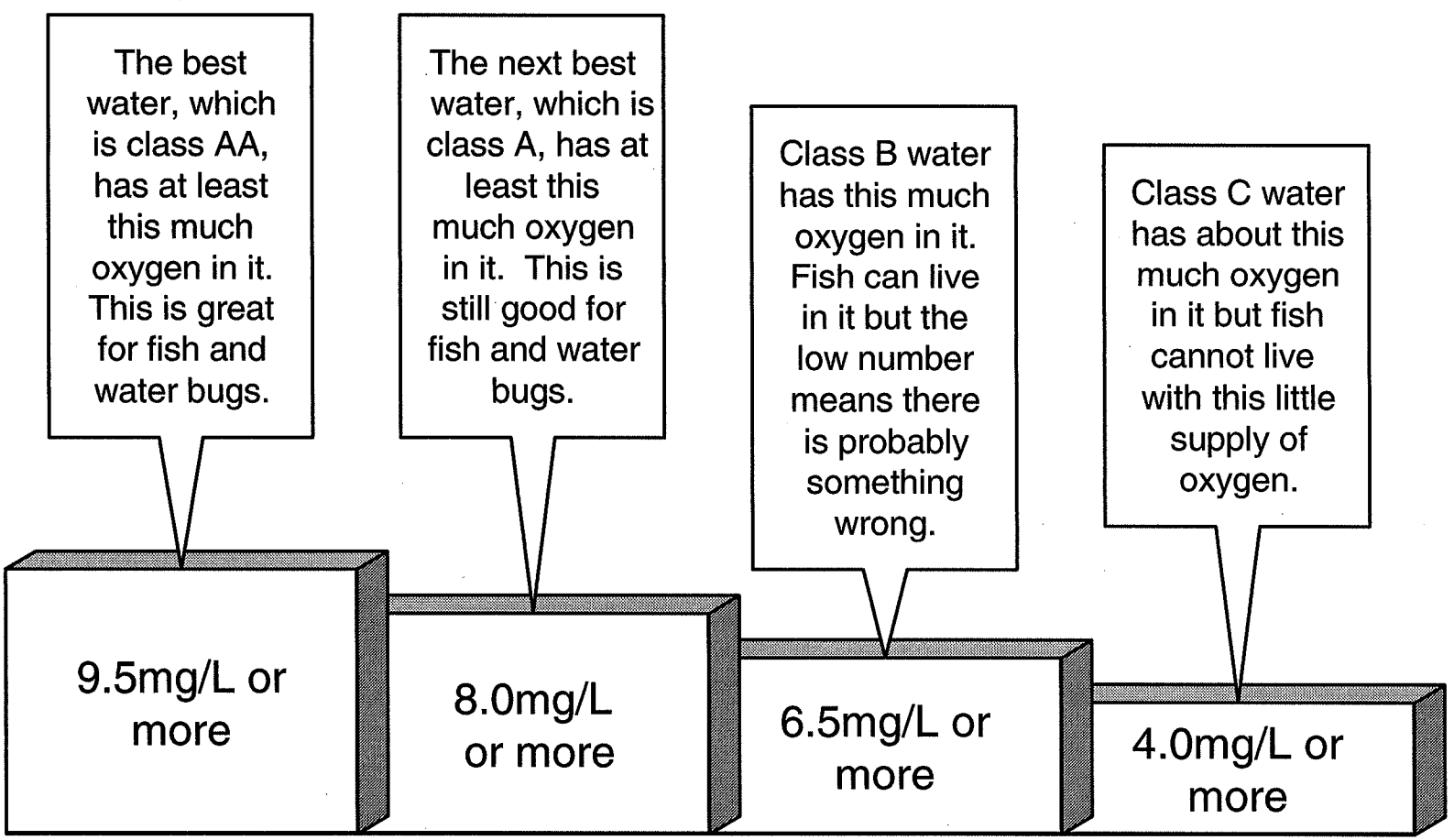
Reminder: In an actual monitoring situation, there would be several samples taken at a minimum of two sites. An average would be calculated of the samples at each site.

FACTORS THAT AFFECT DISSOLVED OXYGEN CONCENTRATIONS

- Since dissolved oxygen concentrations are directly affected by water temperature, (the warmer the water, the lower the amount of oxygen present), then all factors that affect water temperature affect dissolved oxygen con-concentrations. (Such as over-grazing, and warm water releases from industrial power plants.)

- Overgrowth of streamside vegetation will deplete water of the small amount of oxygen present for other aquatic life. This overgrowth can be stimulated by nitrate rich livestock waste and other fertilizer applied to crops.

Dissolved Oxygen Level Breakdown



This chart shows the breakdown of water quality classes by dissolved oxygen content. As you can see, fish and other creatures that live in the water need lots of oxygen to live, just like we do (Source: WAC 173-201A).