Louisiana Universities Marine Consortium

Parameter Information and Procedures for Dissolved Oxygen

Prepared for Coastal Roots Teachers
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Dissolved Oxygen

With some exceptions, estuarine plants and animals require oxygen to survive. Access to plentiful oxygen is usually not a factor on land where oxygen concentration in air does not change from about 21%. However, oxygen concentration in aquatic habitats varies in space and time. For example, cold water can hold more dissolved oxygen than warm water. Areas with plentiful plant life may have higher concentrations of oxygen because of photosynthesis. However, under some conditions too many plants can lead to low oxygen conditions (hypoxia) as the plants die and decompose. We will be using a technique called a Winkler titration to measure the concentration of dissolved oxygen in our study sites. Dissolved oxygen will be reported in milligrams per liter (mg/L).

Related Issues

Non-point source pollution: Pollution of all types is a threat to coastal areas throughout the world. Non-point source pollution cannot be traced to any one place or person (a point source), making it difficult to track and eliminate. Examples of non-point source pollution include nutrient contamination from agriculture; petroleum contamination from boats, refineries, and small leaks; and harmful chemicals that enter the water as runoff from highways, parking lots, and industrial sites through storm drains. In south Louisiana, non-point source pollution can be especially troublesome because we are downstream from many agricultural fields and industrial sites. In order to preserve our way of life, and preserve our natural environment, we must monitor water quality to prevent these pollutants from doing severe damage.

Hypoxia: Most living organisms require oxygen to thrive. On land, the concentration of oxygen in the air seldom varies from 21% (21 parts of oxygen in every 100 parts of air). In water, however, the oxygen concentration varies in time and space. In fact, under some conditions oxygen can become severely depleted. Hypoxia occurs when oxygen concentrations dip below 2 milligrams per liter (mg/L), and anoxia occurs when oxygen concentrations reach 0 mg/L. Hypoxia is a common problem in our bayous and along the Louisiana coast. "The Dead Zone" is a large area on the Louisiana coast that regularly experiences hypoxia and cannot support marine life. Hypoxia can also occur in our bayous and bays resulting in fish kills and other problems for wildlife. Hypoxia can result from many different processes. In the bayous, a combination of high temperatures, slow moving water, and (in some cases) pollution can cause hypoxia. In the Gulf of Mexico, hypoxia results from the decay of small plants (called phytoplankton) that thrive in the nutrients transported by the Mississippi River. We monitor the concentration of oxygen and nutrients in the water to understand when hypoxia will occur and the effects it has on our environment.

Quality Control

The techniques you use to process your sample are just as important as carefully following instructions for achieving reproducibility. Therefore, as in all things, practice makes perfect. Each student will have the opportunity to practice using every piece of equipment.

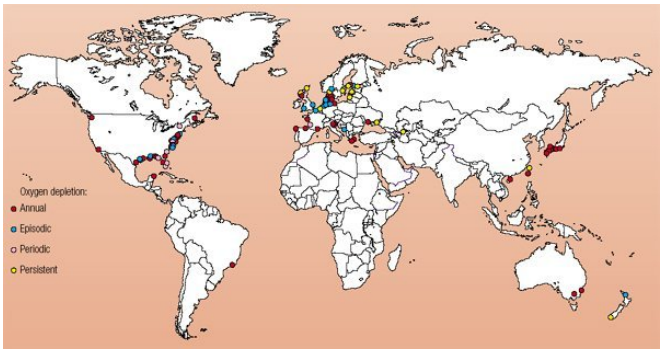
Contamination: Many of our methods and techniques are designed specifically to avoid contamination of our samples and chemicals. For example, rinsing the sample containers thoroughly before collecting a sample is critical to avoid contaminating the sample with residues from previous samples. Just as important is the proper handling of chemicals to ensure that the reagents don't become contaminated with sample water or with other reagents. This is important for two reasons. First, the methods we use are based on having pure chemical reagents. If our reagents are contaminated, our data are not useful and will not be reproducible by us or anyone else. Second, reagents are expensive and we need to preserve them for future samples. It is possible to ruin a whole bottle of reagent with a single drop of contaminant. Following these simple steps should eliminate the majority of contamination problems.

1) Open only one reagent at a time, and immediately recap the bottles with the same cap when done.

2) Never touch the tip of a dropper bottle or pipette to the sample or the sample container.

3) Rinse and dry sample containers thoroughly after use.

What Is Hypoxia?



Hypoxia is a phenomenon that occurs in both freshwater and saltwater aquatic systems where the dissolved oxygen concentration drops below a certain point and begins to adversely affect respiring organisms. Generally speaking, the dissolved oxygen concentration during an episode of hypoxia is below 2 mg/L. Anoxia occurs when dissolved oxygen levels drop to zero.

Low dissolved O_2 concentrations have been recorded in inland freshwater ponds as well as coastal areas around the world. According to the United Nations Environment Program, in 2003 there were 146 instances of coastal hypoxia worldwide. These areas are shown on the map one the next page. As the map indicates, hypoxia can occur with varying frequency. Most of these cases happen on an annual basis, usually in the warmer months of the year.

What Causes Hypoxia?

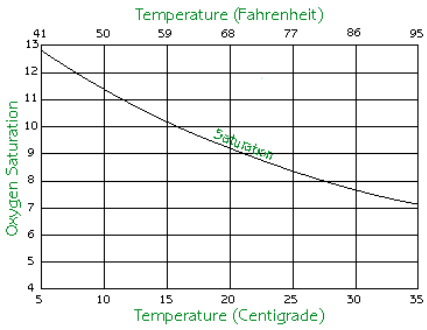
There are many factors that contribute to an area of hypoxia. Temperature, salinity, vegetation, and bacteria are just a few of these.

Before these factors are discussed, an understanding of how the oxygen gets into the water is needed. Water holds much less life-giving oxygen than air. Therefore, oxygen levels are extremely important when dealing with aquatic systems. Because oxygen is a byproduct of photosynthesis, plants and algae are the major source of oxygen in aquatic habitats. Another way oxygen gets into the water is through the air-water interface. Since there is more oxygen in the air than the water, the oxygen has a natural tendency to diffuse from air into water. This process is enhanced by windy conditions, especially during storms. Actively mixing the water to maximize air-to-water contact also helps to add oxygen. This is done, for example, by adding splashing fountains in ponds.

Now that we have established how oxygen can get into the water, let's look at how environmental factors can alter dissolved oxygen concentrations.

Temperature

Temperature has a very important effect to dissolved oxygen. As the temperature of the water goes up, the water loses the ability to hold the dissolved oxygen and the concentration goes down. When the water cools, it regains the ability to hold higher amounts of oxygen. The chart below simplifies this rule.



Knowing this relationship, one can deduce that hypoxia tends to occur in the warmer months of the year, namely during the summer.

Salinity

Salinity (the amount of dissolved salts in the water) has very interesting affect on the amount of oxygen in the water. First, there is an inverse relationship between the amount of salt versus the amount of dissolved oxygen in the water. 5 grams of salt in 1000 grams of water (5 ppt) will decrease the oxygen saturation levels about 1 mg/l.

Salinity also has another property that helps to create hypoxic zones. Salt water is more dense than fresh water. This causes two layers of water to form a lighter layer of fresh water on the top of a heavier layer of salt water on the bottom. This prevents adequate mixing of the water column and does not allow oxygenated water to get to the lower depths. Therefore the heavier, saltier layer at the bottom may become oxygen-depleted.

Most ponds and lakes are fresh water and are free from these salinity considerations.

Vegetation

Vegetation adds oxygen to the water. Plants undergo photosynthesis and release oxygen, so all aquatic plants play an integral role in maintaining healthy levels of oxygen. Also remember that phytoplankton use photosynthesis, too, and add oxygen to the water. Even though most phytoplankton is microscopic, these organisms are extremely important.

Bacteria

Bacteria can have a devastating effect on the amount of dissolved oxygen. Bacteria feed on this decaying material as it sinks to the bottom. These bacteria respire and use oxygen just like fish. So with billions and billions of bacteria respiring, the dissolved oxygen level may dramatically drop to dangerous levels. Bacteria play an integral role in the hypoxia zone that occurs each summer off of the coast of Louisiana.

Why Is Hypoxia Bad?

Zones of low oxygen cause devastating effects on the fauna that depend on oxygen. Some animals like fish and crabs can move to a more-suitable location. Animals like bivalves (clams and oysters) can not always escape the deadly effects of hypoxia. These animals often perish in such conditions.

In closed systems like ponds, the animals may have no way out of a low oxygen zone. Some species in deep water situations may not be able to move from the lower layers of the water where the low oxygen areas tend to occur. This is because of the temperature or pressure needs of the organism. These animals are effectively trapped in this location and may die.

Fish Kills

In some cases, hypoxia may cause a fish kill. When hypoxia takes occurs in an entire pond or in a vast area of open ocean, the animals can not escape and many of them die. Seeing dead, floating fish and other animals can indicate fish kills. The observer may also notice stressed fish at the water surface gulping for life-saving oxygen. These fish often perish as well. Bacteria will begin to decompose the fish and cause an even lower dissolved oxygen value. Eventually the fish will decompose or will be eaten by scavengers and the oxygen will slowly return to a more acceptable level. Unfortunately a fish kill may lead to an unbalanced fish population and other environmental problems.

References:
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