Name

STUDENT INFORMATION

7.1

What Is Biochemical Oxygen Demand?

In Lesson 6, you learned that many factors determine the amount of dissolved oxygen in a river or stream. For instance, oxygen gas can become dissolved in water through the natural process of splashing and wave action. Photosynthesis of aquatic plants produces more dissolved oxygen.

Even as such processes are adding oxygen to a waterway, organic matter is removing it. **Organic matter** means anything that is or was alive. The microorganisms in a river or stream feed on the organic matter, and the process by which they break down that organic matter reduces the supply of dissolved oxygen gas in the water.

All rivers and streams naturally contain some organic matter produced by aquatic organisms. Water flowing from swamps and bogs adds organic matter to water, as do falling leaves. Human sources include farms, food-processing plants, paper mills, untreated sewage, and grass clippings. When a river or stream receives excess organic matter, its populations of microorganisms that feed on such matter may increase rapidly, consuming greater amounts of dissolved oxygen.

Chemicals in rivers and streams may also react to deplete dissolved oxygen. Chemical waste from industries and homes often end up in rivers and streams. People dump paint, motor oil, fertilizer, and insecticide into drains and sewers that lead to streams and rivers. Whatever the sources, excess organic and chemical matter can overload a river or stream, so that the stream no longer has a healthy level of dissolved oxygen. **Biochemical oxygen demand** (BOD) is the requirement (demand) for oxygen that matter, organic and chemical, places on water. BOD is a measurement of how much stress is being placed on the dissolved-oxygen system of a waterway. The lower the stress, the more oxygen is available for aquatic organisms such as fish and shellfish.

How Is BOD Measured?

To find the BOD of a river or stream, first measure the amount of dissolved oxygen in the water, as you did in Lesson 6. Then collect another sample of the water and allow it to sit undisturbed in a lightproof compartment at 20°C for five days. At the end of the fifth day, analyze the sample again for dissolved oxygen. If the sample contains organic or chemical matter that has required oxygen, the sample will contain less dissolved oxygen than it did five days earlier. The difference between the initial level and the final level of dissolved oxygen is a measure of BOD. If the difference is zero, then there is no biochemical oxygen demand; the water contains no organic or chemical matter that requires oxygen. If the difference is large, then the water has a large amount of organic or chemical matter, or both.

As with dissolved oxygen, BOD is measured in mg/L. The smaller the BOD number, the better the water quality. A BOD value of 1 mg/L is excellent, and the water is considered "pure." A value of 2 mg/L is good, and a value of 3 or 4 mg/L is fair. Water is considered poor if it has a BOD of 5 mg/L or more.

Example: Assume your water sample contained 22 mg/L of dissolved oxygen when you were at the field site five days ago. At the end of five days, you find that 20 mg/L of dissolved oxygen remains. What created the 2 mg/L difference? (The container was covered.) The water must contain matter that used the 2 mg/L. The BOD is, therefore, 2 mg/L, which is good.

This type of method is a **bioassay.** This means that it does not measure the amount of matter directly; rather, it measures the effect of matter.

If you obtain a difference in dissolved oxygen over the five-day period, you do not know whether the demand comes from organic matter or chemical matter. Some tests can determine which type of source is placing the demand; for most rivers, however, the demand comes primarily from organic matter.

Why Place the Sample in a Lightproof Compartment?

When you collect and store a sample for a BOD analysis, you must protect it from exposure to light. A water sample from a river or stream may contain microscopic plant life. Plants, when exposed to sunlight, produce oxygen gas by photosynthesis. If your sample did have plant life and received exposure to sunlight, then it would produce oxygen by photosynthesis, which would add to the amount of oxygen in the sample. When you did your reading after five days, you would not have a valid measurement of the BOD. To insure that no oxygen gas is added, you will wrap your the stoppered sample and place it in a lightproof compartment.

Why 20°C? Why Five Days?

In order to live, microorganisms need an warm environment. Twenty degrees Celsius is a temperature that provides such an environment. Maintaining the sample temperature close to 20°C helps keep the microorganisms alive throughout the five-day period.

Incubating a water sample for five days as part of BOD testing has become a standard procedure, and here are two interesting tales about why this waiting period developed. One tale states that when BOD measurements were first initiated many years ago, investigators allowed samples to sit for five days simply because that was how long it took for the water from their area to flow to the sea. The second states that scientists' methods were not sensitive enough to obtain a noticeable difference in dissolved oxygen in a shorter waiting period. Whether the tales are true or false, the procedure must allow time for organic matter to use oxygen gas in order that a difference can be obtained. A scientist using an extremely sensitive method can obtain a valid result in less time. Remember, you are finding a difference in the amount of dissolved oxygen. You might be interested in finding BOD for different time periods.

Why Do Rivers and Streams Need a Nice BOD?

If the BOD number is low, a large amount of oxygen remains dissolved in the water. In this case, the small amount of organic matter will decompose into products, such as carbon dioxide, that are not harmful to aquatic life or humans (unless the products are in large amounts). Aquatic life has sufficient dissolved oxygen to flourish.

A high BOD number indicates that a large amount of organic matter is present in the water. In this case, all or nearly all of the dissolved oxygen will soon be depleted, and aquatic life that needs dissolved oxygen, such as fish, will die.

The only remaining organisms will be those that can grow in the absence of dissolved oxygen or at very low levels of dissolved oxygen. The decomposition of these microorganisms produces harmful products such as alcohol and formaldehyde. Some such products are foul smelling and may pollute the air. Even small amounts can give a water supply a very bad taste and odor.

How Can the BOD of a River or Stream Be Improved?

Human actions can improve the BOD of a river or stream by reducing or eliminating the dumping of organic waste into waterways. For instance, in order to keep BOD low, industries and sewage plants often partially decompose their waste before releasing it into waterways. Other plants may artificially aerate the water by bubbling oxygen through it or by increasing the flow rate. Reducing thermal pollution will reduce microorganisms in the waterway, which will, in turn, reduce BOD.

Questions

1. Why is the BOD test considered a bioassay?
2. The dissolved oxygen test in Lesson 6 had to be performed immediately after you collected the water sample. Why must you wait for five days to complete the same test for your BOD analysis?
3. Which is more desirable, a high or low BOD? Explain your answer.
4. What natural and human factors can cause BOD value to be high?
5. Suggest ways to improve the BOD of a river or stream.