A method for determining the dissolved-oxygen concentration near the mud-water interface

Cal R. Fremling

Winona State University

Follow this and additional works at: https://openriver.winona.edu/calfremlingpapers

Recommended Citation
https://openriver.winona.edu/calfremlingpapers/14

This Book is brought to you for free and open access by the Cal Fremling Archive at OpenRiver. It has been accepted for inclusion in Cal Fremling Papers by an authorized administrator of OpenRiver. For more information, please contact klarson@winona.edu.
A Method for Determining the Dissolved-Oxygen Concentration Near the Mud-Water Interface

Most benthic invertebrates depend upon the water near the mud-water interface for oxygen. Because bottoms which are rich in organic material often have a high biochemical oxygen demand, the dissolved-oxygen content of the water near the mud-water interface is undoubtedly a limiting factor for bottom fauna in many aquatic habitats. Conventional mechanical samplers fail to sample this thin stratum because either they sample too far above the bottom or they fill with mud.

The following technique is a simple, inexpensive, yet accurate method for sampling the dissolved-oxygen concentration near the mud-water interface.

A 4x5-in. (ca. 10.2 x 22.8 cm) polyethylene bag (0.002 in., ca. 0.05 mm thick) is filled with 1 liter of tap water. Glass marbles are added for ballast and the bag is pulled downward into a container of water until the air in the bag is completely displaced. The neck of the bag is then tied, and several of the marbles are fastened with rubber bands inside three corners of the bag. Thus weighted, the bag will conform to the lake bottom.

Polyethylene is permeable to oxygen, and as soon as the bag enters the water, oxygen begins to diffuse from the regions of higher to regions of lower concentration. Diffusion will continue until the partial pressure of dissolved oxygen is the same within the bag and in the ambient water. In fresh water, the concentrations of dissolved oxygen in the bag and in the ambient water will be equal when the partial pressures are equal. This is not true in saline waters, however, and an appropriate correction would be necessary in the latter case.

In deep water, the bag on the bottom is connected by a short line to an anchor marked by a buoy. In shallow waters, the bag can be positioned by wading. The flexibility of the bag allows it to be placed in almost any niche.

After the prescribed time, the bag is raised and immediately held over a large funnel which rests in a standard 300-ml dissolved-oxygen sample bottle. The stem of the funnel is extended to the bottom of the bottle by rubber tubing. The bag is held over the funnel, the extreme tip of one corner is cut off with scissors, and the bag is quickly lowered into the funnel. The weight of the water in the bag makes an airtight seal between the bag and the sides of the funnel. The first water to enter the bottle is undoubtedly oxygenated, but the liter of water in the bag is sufficient to flush the bottle adequately. The sample is then treated according to the standard Winkler method (Winkler 1888).

Fig. 1 shows results which were obtained by this method in laboratory experiments. In the first tests, the bags were filled with water previously saturated with oxygen. The sealed bags were then placed in a large vessel of water from which the oxygen had been removed either by adding
sugar to it or by bubbling nitrogen through it. The bags were removed from the deoxygenated water at various times and the dissolved oxygen content of the water in each was determined. The entire experiment was conducted at temperatures which were held between 19°C and 21°C.

In the second experiment, bags of water were placed in an iced solution of soured milk and water until the dissolved-oxygen content in them was reduced to 0.4 ppm. The bags were then removed to a second container which contained ice water through which air had been rapidly bubbled until the dissolved-oxygen content of the water was 12.6 ppm. As before, the bags were removed at intervals and the dissolved-oxygen content of each bag was determined.

It is evident from Fig. 1 that: 1) polyethylene film is permeable to oxygen; 2) the rate of oxygen diffusion is a logarithmic function; and 3) when equilibrium is almost reached the curve becomes asymptotic. At summer water temperatures, equilibrium is reached in about 30 hr. At 2°C, however, equilibrium is not approached until 48 hr. The rate of diffusion would be faster if larger, thinner bags and less water were used, but the bags used are durable and easily obtainable.

Field tests with the bags have yielded interesting data and the results of three field trials in diverse habitats are included as examples. In all 30-hr field tests, bag measurements and measurements with mechanical samplers were within 0.2 ppm of each other except at the lake and river bottoms where a Kemmerer sampler and overflow-type sewage samplers failed to obtain clean samples.

In Rainy Lake, Minnesota (an oligotrophic lake which had no thermocline when tested), the bag readings on 18 August 1962, were 8.8 ppm at the surface, 8.7 ppm 2 ft (0.6 m) from the bottom, and 8.5 ppm on the muddy lake bottom which was inhabited by mayfly (Hexagenia limbata and Ephemera simulans) nymphs.

In Rainy River, Minnesota, extensive sampling by standard methods failed to show a dissolved-oxygen concentration of less than 5.8 ppm during the summer of 1962. Although the river has a large volume of flow, there are extensive wood fiber deposits from an upstream paper mill. Bag readings on the surface of these submerged deposits gave readings between 4.0 and 5.0 ppm, while conventional readings taken as close to the bottom as possible with a mechanical sampler ranged from 5.9 to 7.4 ppm.

In a stagnant, 4-ft (1.2 m) deep bay of Rainy River, bag samples taken at the 2-ft (0.6 m) depth showed dissolved-oxygen concentrations ranging from 6.5 to 6.9 ppm, while bag samples on the silty bottom gave readings from 1.4 to 3.5 ppm.

The field observations indicate a marked drop in the dissolved-oxygen concentration at the mud-water interface in certain aquatic habitats and that mechanical samplers usually fail to detect it.

Calvin R. Fremling
and
John J. Evans
Winona State College, Winona, Minnesota
and
Ontario Water Resources Commission, Toronto

REFERENCE