Activity

ESTIMATION OF PRIMARY PRODUCTIVITY AND RESPIRATION IN A POND

Light and Dark Bottle Method

INTRODUCTION:

In aquatic ecosystems, producers and primary consumers are largely microscopic plankton suspended in the water. By measuring the rates of oxygen production and of oxygen consumption in a known volume of water, estimates of the rate of gross photosynthetic productivity, net productivity, and respiration rate can be calculated.

Using the Light and Dark Bottle Method, samples of water are placed in two bottles of the same volume. One bottle is left clear, and the other bottle is covered to exclude light. The initial **O_2** concentrations are measured, then the two bottles are returned to the light conditions from which they were taken for 24 hours. After 24 hours, the bottles are retrieved, and the final **O_2** concentrations are measured.

MATERIALS:

Two clear bottles of identical volume with lids or stoppers: one left clear and the other covered to exclude light, paint, tape, aluminum foil, or black plastic may be used.

Other sets of bottles may be used to measure at different depths.

Electronic DO meter or test kit.

PROCEDURE:

Pre-lab preparation (in the field)

This procedure can be done while on the SOS field trip although there is no DO meter on the boat so you would need to provide one or bring a test kit. If not done while on the SOS trip choose a pond or lake convenient for multiple trips to study. After deciding how many test sample pairs you will be doing, and at what depths, construct the apparatus to suspend the test bottles. The bottles need to be held in place at depth. A weight at the bottom of the line or lines will help to hold the bottles steady.

Pre-lab preparation (in the lab)

Prepare your sample bottles. Each pair of bottles should consist of one clear, and one covered to keep light out. The bottles need to be of identical volume, and should be labeled for the intended depth. Construct all attachments for the bottles before you head to the field.

In the field

1. Take water samples just below the surface by directly holding the sample bottle in the water. Use a third bottle to collect some water as before to top-off the sample bottles, if necessary, after O_2 readings are taken.

Collect water from the same source for a water bath to store the samples.

2. Measure the O_2 concentration of each bottle according to the instructions for your meter or test kit. This should be the same as the samples are identical initially. If water is lost in the measurement, replace from the third bottle of sample that is identical to the sample pair. Record the date and time, and the initial O_2 concentration as **mg / L** (this is also parts per million **ppm**), in the **DATA TABLE** .

*If you are doing more than one depth, repeat this procedure for the other sample pairs. Collect the samples according to the instructions for your particular sample collection apparatus.

3. Allow respiration and photosynthesis to proceed for **24 hours** .

4. Retrieve the sample bottles and measure the O_2 concentrations of each bottle. Record the concentrations, along with the date and time, in the appropriate place on the **DATA TABLE** .

DATA TABLE: Oxygen concentration data.

Samples	Initial Collection date / time	Depth collected (M)	Initial O_2 Concentration (mg / L)	Second Collection date / time	Final O_2 Concentration (mg / L)
#1 Light	☐	☐	☐	☐	☐
#1 Dark	☐	☐	☐	☐	☐
#2 Light	☐	☐	☐	☐	☐
#2 Dark	☐	☐	☐	☐	☐
#3 Light	☐	☐	☐	☐	☐

#3 Dark	☐	☐	☐	☐	☐

CALCULATIONS:

5. Calculate the respiration rate (**R**) in terms of oxygen consumption as follows:

$$R = \frac{C_O - C_D}{\Delta t}$$

where C_O is the initial concentration of O_2 (in mg/L), C_D is the final O_2 concentration in the **dark** bottle (in mg/L), and Δt is the period of time over which respiration took place. If Δt is measured in days, as in the procedure given, then **R** will be mg O_2 /liter/day; if Δt were in hours, then **R** would be mg O_2 /liter/hr.

Respiration rate = _____ mg O_2 /L/day

6. Calculate the gross photosynthetic productivity of oxygen (P_G) in mg O_2 /liter/day, as follows:

$$P_G = \frac{C_L - C_D}{\Delta t}$$

where C_L is the final concentration of oxygen in the **light** bottle.

Gross photosynthetic productivity = _____ mg O_2 /L/day

7. The net productivity of oxygen (P_N), expressed in mg O_2 /liter/day, is calculated as:

$$P_N = P_G - R$$

Net productivity = _____ mg O_2 /L/day

Extended Calculations

It is sometimes desirable to express respiration and production in cubic meters of water, rather than liters. Since one cubic meter is 1000 liters, any of the results above may simply be multiplied by 1000 to obtain

values in cubic meters.

Using the balanced chemical equations for photosynthesis and cellular respiration, you can calculate values for carbon dioxide (**CO_2**) fixed or respired.

Additional Comments:

If you calculated gross PP or net PP using the DO concentration difference your units should be in mg/L/unit of time (i.e., hour, day, and minutes). It is often desirable to convert to cubic meters instead of Liters, which is just a factor of 1000. The next step (and one that makes the results more understandable) is converting the DO into the amount of carbon dioxide that is fixed or respired. To do this, you need to use the equations for photosynthesis. Then your results show how much photosynthesis occurred in carbon units.

If DO doesn't change much before and after, it doesn't necessarily mean that there isn't much photosynthesis occurring-- it means that respiration is being balance by photosynthesis. Again, if you covert to carbon units it will make more sense from a PP perspective. It often is most effective to examine the change over some gradient (i.e., multiple depths, ponds of different productivity). It is also best to do it over at least 12 hours.

- Megan Brown, PhD. Professor of Biology

Source: Stephen Fuller, Kansas City Missouri Central School District