 

O_2 in the H_2O:

Determination of Diel Changes in Dissolved Oxygen Concentrations in Pond Water

Grade Level:	**Subject Area**:	**Time**:
8-12	Aquaculture, Biology, Mathematics	This experiment will take about one hour to collect water samples, and one hour to set up buckets and air stones. The conduct of the project will take about one hour to explain the procedures and let the students take the dissolved oxygen concentrations in the various buckets. Students and the teacher will have to measure the dissolved oxygen concentrations in all the buckets every three or four hours for at least 24 hours. Each time it will take about 15 to read 8 dissolved oxygen concentrations. Charting the various dissolved oxygen concentrations will take the students about one hour total. Clean up will be easy and will only require dumping out of the buckets and rinsing them out.

Student Performance Standards (Sunshine State Standards):

03.01 Employ scientific measurement skills (SC.912.E.7.8; SC.912.L.14.4; SC912.S.3.1, 9; MA. 912. A. 1.5; MA.912.S.4.2; MA.912.S.5.1, 3; MA.912.S.5.2, 3, 4, 5).

03.02 Demonstrate safe and effective use of common laboratory equipment (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.14.6SC.912.L.16.10; SC.912.L.17.12, 14, 15, 16; MA.912.A.2.1, 2)

11.07 Determine why aquatic crops may be more productive than terrestrial crops (LA.910.1.6.1, 2, 3, 4, 5; SC.7.L.10.2, 3; SC.7.L.11.2, SC.912.L.14.7).

11.10 List and describe the major factors in the growth of aquatic fauna and flora (LA.910.1.6.1, 2, 3, 4, 5; SC.7.L.17.1, 2, 3)

13.01 Identify and describe the qualities water should possess for use in aquaculture (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.17.In.a).

13.02 Explain how changes in water affect aquatic life (LA.910.1.6.1, 2, 3, 4, 5; SC.912.L.17.2, 3, 7, 10)

14.01 Identify factors to consider in determining whether to grow an aquaculture species (LA.910.1.6.1, 2, 3, 4, 5; MA.912.G.2.5; MA.912.G8.3, 6; SC.7.L.17.3)

16.04 Identify water quality problems (SC.7.E.6.6).

16.05 Determine quality of water and practice recommended solutions where needed (SC.912.L.17.9, 11, 12; MA.912.G.2.7; MA.912.A.10.2).

Objectives:
1. Students will be able to measure the dissolved oxygen concentration of simulated ponds exposed to different conditions during a 24-hour period.
2. Students will be able to explain the effects of sunlight, algae populations, and aeration on the diel changes in dissolved oxygen.

Abstract:

This activity will help students will understand the diel (involving a 24-hour period that usually includes a day and the adjoining night) changes in dissolved oxygen concentrations which occur in ponds due to the effects of photosynthesis, the effects of dense concentrations of algae and plants on dissolved oxygen, and how aquaculture ponds maintain consistent concentrations of dissolved oxygen throughout a 24-hour cycle. This activity has direct application to aquaculture, management of all water bodies, and demonstrating the effects of photosynthesis for botany or other courses.

Interest Approach:

Ask students the meaning of the word diel. Give them a few minutes to discuss with classmates. Lead into a discussion of what happens in a 24-hour period within a pond and the importance of oxygen concentrations.

Student Materials:
1. Pencil
2. Paper
3. Handouts

Teacher Materials:

Material	*Store*	*Estimated Cost*
Colormetric test kit OR Dissolved oxygen meter	Aquatic Ecosystems/Aquatic Ecosystems	$11 and up/$280 and up
Aquarium air pump with tubing	PetsMart, Carolina Biological	$10 and up
Airstone	PetsMart, Carolina Biological	$4 and up
Buckets (8-5 gallon)	WalMart, Lowe's	$5 and up

Pond water and phytoplankton OR macrophyte plants	NA	Free
Clear water free of algae and phytoplankton	NA	Free
Publication: Hargreaves, J.A. and C.S. Tucker. 2002. "Measuring Dissolved Oxygen Concentration in Aquaculture." *Southern Regional Aquaculture Center* Publication Number 4601.	Available as a PDF at scholar.google.com	NA

Student Instructions:

1. See Teacher Instructions and determine amount of student involvement based upon grade and experience level.

Teacher Instructions:

Preparations:

1. Fill eight 5-gallon plastic buckets with water from two sources.
   a. Four buckets will be filled with water with high concentrations of phytoplankton. Should be collected from a local water body (pond, canal, etc.)
   b. The other four buckets will be filled with clear water with little or no phytoplankton. Should be collected from another local water body with clear water or little to no green coloration.
   c. The buckets containing live aquatic macrophyte plants should contain the same clear water as the second set of buckets except a handful of live aquatic macrophyte plants can be added which can be collected from a local water body. The macrophyte plant should be kept alive and are easily pulled with roots in tact.
   d. The high phytoplankton aerated buckets should contain the same high phytoplankton water except a ceramic airstone should be added to each bucket with air bubbling.
2. One bucket of each treatment should be placed in full sunlight and the other in complete shade or in a dark room.
3. Bucket treatments.
   a. Placed in full sunlight
      i. Bucket 1: high phytoplankton
      ii. Bucket 2: no phytoplankton
      iii. Bucket 3: high phytoplankton aerated
      iv. Bucket 4: no phytoplankton with macrophyte plants added
   b. Placed in dark room or outdoor in complete shade.

i. Bucket 5: high phytoplankton
ii. Bucket 6: no phytoplankton
iii. Bucket 7: high phytoplankton aerated
iv. Bucket 8: no phytoplankton with macrophyte plants added

Activity:

1. Measure the dissolved oxygen concentrations of each bucket every three or four hours for 24 hours.

NOTE: The dissolved oxygen will have to be monitored during the night. If this is not possible then measure it as late at night as possible and again as early as possible in the morning. The lowest dissolved oxygen will occur just before sunrise so this is an important time for a measurement to be taken.

2. Chart the dissolved oxygen concentration to see a daily diel cycle of dissolved oxygen exposed to each condition.
   a. The y-axis will be dissolved oxygen.
   b. The x-axis will be time of day.
3. Discuss the results and how they could apply to aquaculture ponds.
4. Discuss what each of these conditions may mean for fish living in each simulated pond condition.

Post work/Clean-up:

1. Dispose of water and plants.
2. Clean out buckets and store materials for use next year.

Anticipated Results:

1. Shaded vs. sun exposure – shaded algae will have a lower afternoon dissolved oxygen concentration than algae in full sunlight. Shaded algae will have a lower dissolved oxygen concentration at night.
2. High phytoplankton algae vs. low phytoplankton water – low phytoplankton water will have a lower dissolved oxygen concentration in the afternoon. At night the dissolved oxygen will decrease the most in the high phytoplankton water.
3. Aerated vs. not aerated – aeration will minimize the peak and valley of dissolved oxygen concentration making it more linear. The dissolved oxygen concentration at night will remain higher than buckets not being aerated.

Support Materials:

1. Publication: Hargreaves, J.A. and C.S. Tucker. 2002. "Measuring Dissolved Oxygen Concentration in Aquaculture." *Southern Regional Aquaculture Center* Publication Number 4601.

Explanation of Concepts:

A pond's dissolved oxygen concentration is dependent on aeration provided and photosynthesis. The more algae in a pond, the more oxygen are produced by photosynthesis during the day. The highest oxygen concentration will occur at the peak of sunlight = the peak of oxygen generation by photosynthesis. The more algae present in a pond, the greater the amount of photosynthesis is occurring. On an overcast day, simulated by shaded or dark buckets, the amount of photosynthesis occurring will decrease because of less sunlight present to drive photosynthesis and oxygen generation. At night the lowest dissolved oxygen concentration will occur at the longest period since sunlight was present. The dark phase of photosynthesis will not produce oxygen and oxygen is consumed to produce sugar via the respiration phase of photosynthesis. It should not matter if the alga is phytoplankton or a rooted plant; both use photosynthesis to grow by the same process. The only difference may occur if the macrophyte plant collected is damaged so photosynthesis does not occur because the plant is dying.

These same processes occur in every pond and water body. In aquaculture ponds there is typically a high density of fish or shrimp stocked and these organisms consume significant amounts of oxygen, this is most pronounced at night just before the sun rises. This is the time in pond aquaculture that die offs can occur and the entire population of fish in the pond can suffocate. The addition of aeration is necessary for high-density pond aquaculture. The effects of this are modeled by adding an airstone to the bucket. The aeration in the bucket will decrease the peak and increase the valley in the diel cycle of high-density phytoplankton ponds. Aeration may not greatly affect the cycle of low phytoplankton water but will likely increase the concentrations at each time period.

Support Materials

Proper management of ponds is critical for the success of any pond based aquaculture production system. The water quality will have to be maintained 24/7, especially dissolved oxygen, and filamentous algae and weeds should be prevented, and a healthy phytoplankton population should be maintained.

Water quality is the most important part of any aquaculture operation. Dissolved oxygen is the most critical water quality parameter to maintain. Maintenance of DO in a pond is not as simple as in a recirculating system. In a pond, the majority of oxygen is produced by the plant material in the pond as a byproduct of photosynthesis. This occurs during the day light hours. At night the oxygen is consumed and converted into carbon dioxide. Therefore, aeration is critical for ponds during the dark cycle of a day or the living organisms in the pond will not get adequate oxygen. This is exacerbated when the density of the organisms present in the pond is high. When densities are low, the natural oxygen concentration of the water may be adequate to maintain all organisms in the pond system. This is the main difference between extensive and semi-intensive production systems. In a extensive system the density of living organisms being cultured equals the natural productivity of the pond and the natural dissolved oxygen concentration, while in a semi-intensive system the density of organisms is greater than can be supported by the natural dissolved oxygen concentrations, therefore mechanical aeration is required.

An aquaculture pond should be free of macroalgae and have a healthy population of phytoplankton (microalgae) in the pond giving it a green or brown color. If the water is clear, and you can see more than two feet deep, there is a strong likelihood that unwanted macroalgae will grow and proliferate in the pond. This can cause the bottom of the pond and water column to become filled with plant materials. This makes it very difficult to culture fish or crustaceans in the pond. Microalgae is desired in an aquaculture pond. Microalgae are tiny algae cells suspended in the water which utilize nutrients and are the primary producers in the pond. Primary producers capture energy from the sun and convert it into sugars (carbohydrates) and oxygen through photosynthesis. Macrophytes or filamentous algae can occur in ponds. The problems with these are that they consume the same nutrients as the desired phytoplankton, and if macrophytes get established they are difficult to control and eliminate from the pond. The best method to control growth of unwanted macrophytes is through managing a healthy phytoplankton population.

Diel cycles of dissolved oxygen and carbon dioxide in pond water are shown below.

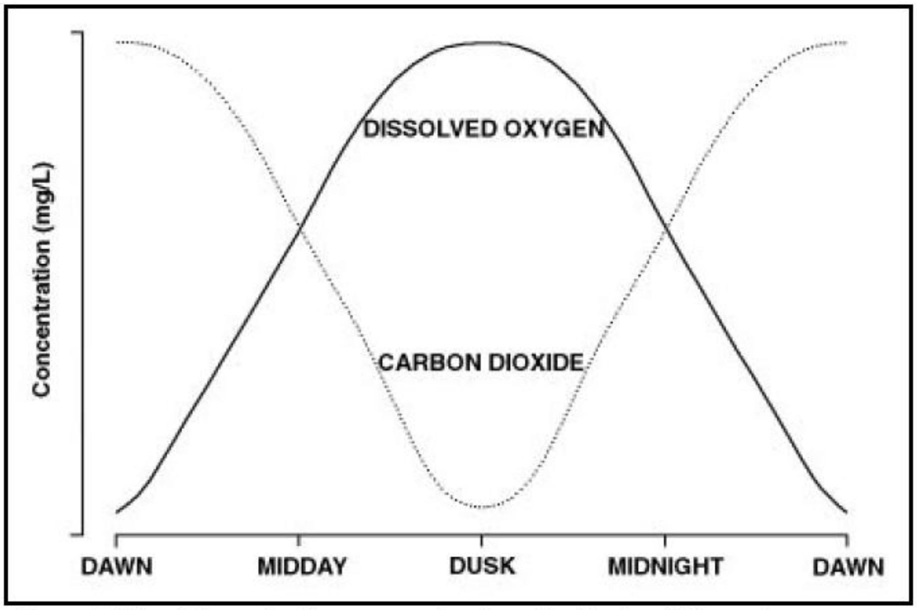

Figure 1. The daily cycle of oxygen and carbon dioxide in a fish pond.

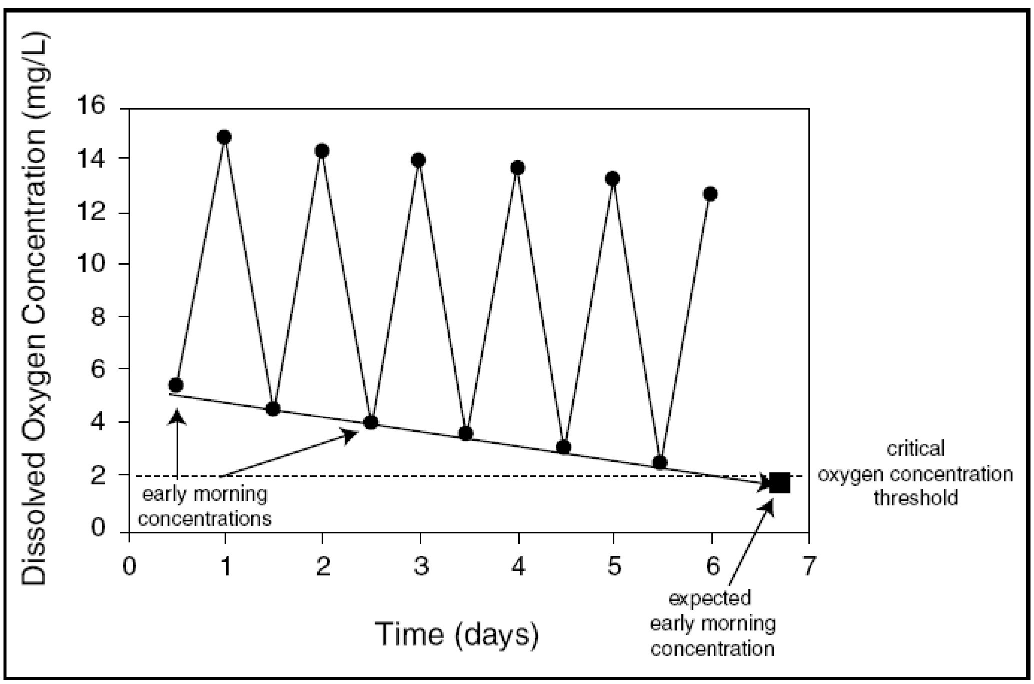

Figure 4. The trend in the dissolved oxygen concentration in a fish pond over several days can help to predict the need for emergency aeration.