BIODEGRADABLE MATERIALS AND THEIR EFFECT ON DISSOLVED OXYGEN LEVELS

TEACHER LAB TEMPLATE

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Correlation to Topic Outline in Course Description

I.B. The Cycling of Matter

III.A. Renewable and Nonrenewable Resources -- Water

IV. Environmental Quality

Correlation to National Standard

• TEACHING STANDARD A:

Teachers of science plan an inquiry-based science program for their students.

• TEACHING STANDARD E:

Teachers of science develop communities of science learners that reflect the intellectual rigor of scientific inquiry and the attitudes and social values conducive to science learning.

• CONTENT STANDARD A:

As a result of activities in grades 9-12, all students should develop abilities necessary to do scientific inquiry and understandings about scientific inquiry.

• CONTENT STANDARD B: As a result of their activities in grades 9-12, all students should develop an understanding of chemical reactions, conservation of energy and increase in disorder, interactions of energy and matter.

• CONTENT STANDARD F: As a result of activities in grades 9-12, all students should develop understanding of natural resources, environmental quality, natural and human-induced hazards.

Group Size

Since this is a relatively simple lab, group size can vary from two to four students.

Lab Length

This exercise requires one period to introduce the activity and plan the experiment, and one period to set up and conduct the experiment. Depending on the assessment, follow-up may take one or two periods. You can reduce time required by giving more direction in the procedure and using a simple assessment.

Preparation and Prep Time

30 minutes

Safety Measures

One of the advantages of this simple lab is that it is relatively safe and easy. You should, however, remind students that methylene blue is harmful if swallowed, and may be harmful if it is inhaled and/or comes in contact with skin. It may cause severe eye irritation.

Teaching Tips

- I usually use this activity to introduce the unit on water pollution and to teach serial dilution technique. It can be used either as an introduction or as a reinforcing activity, but it should be linked to an in-depth discussion of water pollution by common forms of biodegradable waste such as sewage. Oxygen sag curves, eutrophication, and BOD (Biological Oxygen Demand) should be included in the discussion.
- Milk works very well as a biodegradable material. You can also use cream, 10 percent sugar sucrose solution, clear juices like apple or white grape, etc. It's important that the color of the biodegradable solution does not obscure the methylene blue color change. It's important to point out that these materials, while biodegradable, are usually not the culprits in water pollution. Sewage, agricultural runoff, and industrial effluent are usually the problem, but they are not easily handled safely in a classroom situation. The students need to keep in mind that this activity works better as an analogy rather than as a re-creation of a common real-life situation.
- You can purchase methylene blue from any science products supplier. Methylene blue is clear in the absence of oxygen and blue in the presence of oxygen. The time for color change will vary depending on the concentration of biodegradable material, but I always tell students to watch the tubes -- it may be quick if you use a concentrated solution.
- You can purchase any commercial yeast packets from a supermarket. Don't hydrate the yeast until just before the lab. I usually use a 1:10 dilution -- 1 ml of dry yeast to 10 ml of tap water.

- You'll need to adjust the volume required depending on the number of lab groups. Again, remind students that yeast are usually not the principal decomposers of biodegradable waste but are easily handled safely in a classroom setting.
- It's important to use test tube racks that allow you to see the contents of the test tubes so that you don't have to disturb the tubes to observe the color change. Any movement of the tubes will affect the dissolved oxygen levels as air is mixed into the solution.
- It's easiest to have the methylene blue in dropper bottles.
- I usually have the students produce a formal lab report as an assessment.

Suggestions for further study:

- The effect of varying the decomposer concentration
- The effect of using different decomposers
- The effect of different biodegradable materials
- Quantification of the effects with Vernier dissolved oxygen probes

On the following pages is a simple procedure that works well if you want to give more direction.

Procedure

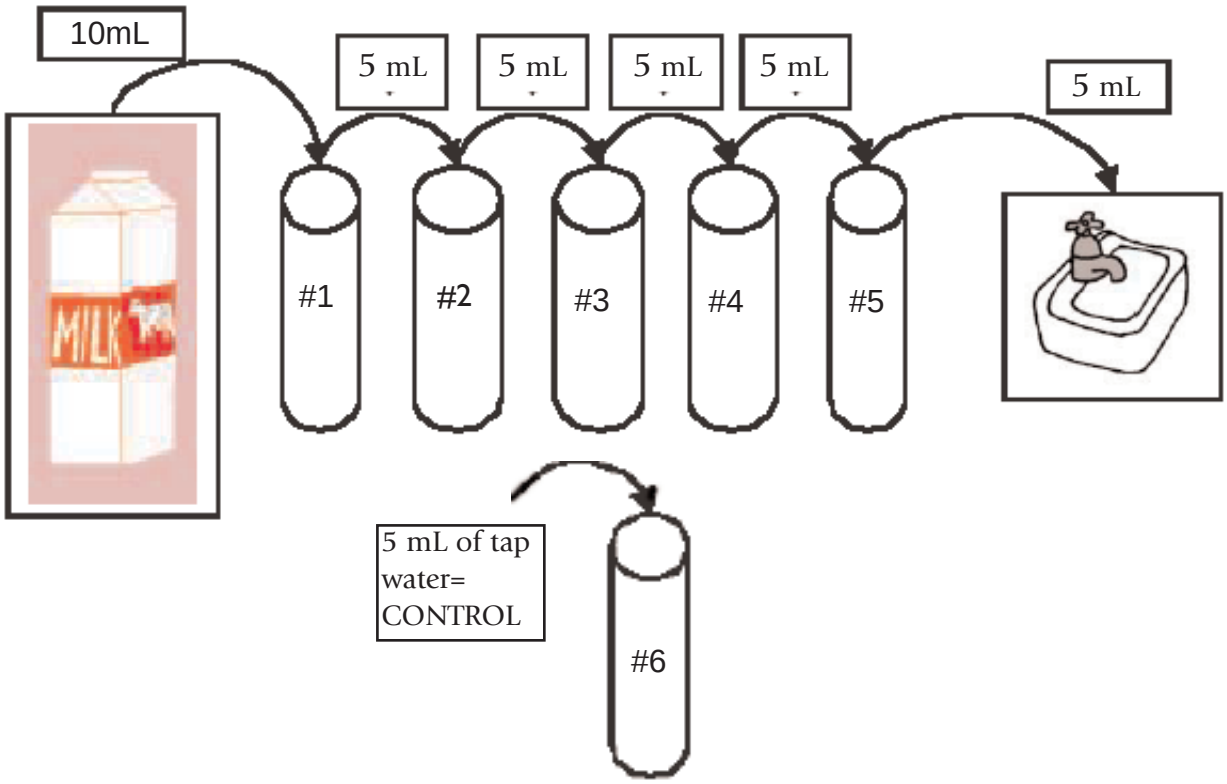
1. Label the test tubes #1 through #6. Place them in the test tube rack.

2. Using a graduated cylinder, add 5 ml of tap water to tubes #2 through #6.

3. Add 10 ml of milk to tube #1.

Steps 4 through 7 are an example of a simple serial dilution. Refer to Diagram 1 as you follow the procedure.

Diagram 1



4. Using a graduated cylinder, remove 5 ml of milk from tube #1 and place it in tube #2. Mix the contents well.

5. Remove 5 ml from tube #2 and place it in tube #3. Mix the contents well.

6. Remove 5 ml from tube #3 and place it in tube #4. Mix the contents well.

7. Remove 5 ml from tube #4 and place it in tube #5. Mix the contents well, and then discard 5 ml of the solution.

8. Add 3 drops of methylene blue to each tube. Be careful to hold the dropper bottle upright so that the drops are uniform. Mix each tube well.

9. The contents of each tube should now be as below:

Test Tube #	ml Milk and/or H_20	Methylene Blue	% Milk	Dilution
1	5	3 drops	100%	1:1
2	5	3 drops	50%	1:2
3	5	3 drops	25%	1:4
4	5	3 drops	12.5%	1:8
5	5	3 drops	6.25%	1:16
6	5	3 drops	0%	--

10. Noting the time, quickly add 1 ml of yeast mixture to each test tube. Invert each test tube four times and place in the test tube rack.

11. Carefully observe each tube and record the time at which the color change from blue to white is complete (no more color change).

12. When the color has changed from blue to white in each test tube, record the exact time at which the change is complete. The surface of each test tube will remain blue.

Test Tube #	Mixing Start Time (A)	Time of Color Change to White (B)	Total Time for Color Change (B-A)
1			
2			
3			
4			
5			
6			

13. BEFORE YOU CLEAN UP, SHAKE ONE OF THE TEST TUBES THAT HAS TURNED WHITE. Record your observations.

Analysis

1. What is the gas taken in by the microorganisms?

   O_2.

2. What is the gas given off by the microorganisms?

   CO_2.

3. Where do microorganisms living in water get the oxygen that they use in decomposition?

   Free O_2 that is dissolved in the water (NOT from the oxygen in the water molecules -- common misconception!).

4. Where do the green plants living in water get the carbon dioxide that they need?

   From carbon dioxide gas given off from cellular respiration of aquatic organisms.

5. What happened in the tube you shook after it had turned white (step 13)? Why?

   Turned blue again. Shaking reintroduced oxygen into solution.

6. Why is the oxygen in this experiment used up?

   Yeast consumes oxygen for cellular respiration as it uses the organic compounds in the milk for energy.

7. Which part of your experiment represents the decomposers?

   Yeast.

8. Which part of your experiment represents the sewage dumped into the water?

   Milk.

9. In which test tube did you have the most "sewage"?

   Test tube #1.

10. Graph your results using Excel. What are the labels for your axes?

    X-axis -- independent variable -- milk concentration.

    Y-axis -- dependent variable -- length of time for color change

    If you start with a 0 percent milk concentration on the *X*-axis, you should see a curve that has a positive slope. In other words, as you increase the milk concentration, the length of time for the color change should increase.

11. What does this graph tell you about the relationship between the biodegradable waste in water and the amount of dissolved oxygen in the water?

As the concentration of biodegradable material increases, the amount of dissolved oxygen will decrease.

12. What would be the effects of dumping a great deal of raw sewage into a river in regard to the dissolved oxygen in the same river?

Decreases dissolved oxygen.

13. Write a conclusion as to what you learned by performing this lab. Be sure to include the following:

- Was the hypothesis supported or refuted? Why or why not?
- What were the sources of error in this experiment?

Possible Assessments (in alphabetical order)

Concept/thinking maps

Critical thinking questions (with answers)

Formal lab report creation

Good class discussion

Group poster presentation

Oral presentations

Other creative ways of showing that students understand the results

PowerPoint presentation