A KBS K-12 Partnership Activity

"The Marvels of Mud"

its not ALL about carbon ☺

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OVERVIEW

Mud, or sediment, is an active part of aquatic ecosystems. Sediment varies widely within and among ecosystems in its biotic and abiotic characteristics. In many ecosystems sediment can release excess phosphorus (a common aquatic pollutant) into the water column causing internal eutrophication.

OBJECTIVES

At the conclusion of the lesson, students will be able to:

- Observe and describe abiotic and biotic characteristics of sediment
- Recognize that the sediment and water in a lake carry phosphorus, which is necessary for life, but can have negative ecosystem effects at high levels
- Describe the difference between experimental control and treatment groups
- Use observations to support conclusions

LENGTH OF LESSON

One 45 min time frame (or longer with walk time added)
About one week later, another 45 min to 60 min, which can be split into two days, if necessary

NOTE: Prior to the first day of the lesson, decide if the samples will be collected with a class "field trip" to a pond/stream (which will increase the time needed by the necessary travel time) or if the teacher will bring in pond water and pond mud samples, which will require a "field trip" for just the teacher ☺

GRADE LEVELS

This activity is appropriate for 6th grade where the subject of interactions between abiotic and biotic components of an ecosystem is introduced and high school biology in the context of biogeochemical cycles; the lesson can be modified to focus on earth materials for earlier grade levels

STANDARDS COVERED

MI High School Content Expectations
B1.1D Identify patterns in data and relate them to theoretical models.
B1.1E Describe a reason for a given conclusion using evidence from an investigation.
B 2.2B Recognize the six most common elements in organic molecules (C, H, N, O, P, S).
B3.3b Describe environmental processes (e.g. the carbon and nitrogen cycles) and their role in processing matter crucial for sustaining life.
MI Grade Level Content Expectations
S.IP.06.13 Use tools and equipment (spring scales, stop watches, meter sticks and tapes, models, hand lens, thermometer, models, sieves, microscopes) appropriate to scientific investigations.
L.EC.06.31 Identify the living (biotic) and nonliving (abiotic)

components of an ecosystem.
L.EC.06.32 Identify the factors in an ecosystem that influence changes in population size.

MATERIALS

Use one set of jars for the whole class
2-3 quart jars with lids
Mud from a pond (enough for about 1/3 of each of the jars)
Water from a pond--algae WILL be there (enough to fill the other 2/3 of each of the jars)

For each pair of students:
Compound microscope
Microscope slides
rulers

Optional
Dissolved oxygen meter
Dissecting microscope
Thermometer
Conductivity meter
Water quality kits for measuring nutrients

BACKGROUND

When studying aquatic ecosystems, people often think about the water and things that live in the water. However, the mud at the bottom of lakes and wetlands, or **sediment**, is an active part of these ecosystems. A wide diversity of organisms, both macroscopic and microscopic, live in sediments. Sediments can often be a source of nutrients, especially nitrogen and phosphorus, to the water column. Nutrients released from sediments are part of an ecosystem's **internal load** (as opposed to the external load, which consists of nutrients that come from outside the ecosystems.) Most commonly, sediments release large amounts of phosphorus as phosphate (PO_4^{3-}), sometimes causing excessive algal growth, harmful algal blooms (growth by algae that produce toxins), and even fish kills (as dead algae fall to the bottom of an ecosystem, fuel bacterial decomposition, and consume oxygen). These negative effects caused by sediment release of phosphorus are called **internal eutrophication.**

ACTIVITIES OF THE SESSION

First Day:
Hand out the student paper
• Brainstorming Questions

As the class is walking to the pond, or as the teacher shows them pictures of a pond and the pond sediment and pond water collected previously, have the students consider the questions, **"What does the pond water have in it? What does the pond sediment (or the soil that makes up the pond's floor) have in it?"** As you facilitate their brainstorming, you may want/need to encourage them to think on smaller scales (microscopic and atomic/molecular).

Lead the class in a discussion about how the abiotic and biotic components of the pond could interact. Use what the students have said to link the nutrient content of the sediment and water to the activity of living things in

the water. For example, nutrients released from the sediment can enhance growth of algae in the water.

• Hypothesis Generating and Experimental Set Up

1. Set up the jars:
    a. three with nothing but pond water in it (control group)
    b. another three jars with 1/3 pond sediment and 2/3 water in it (treatment)
    c. if possible a third set of jars with a different pond's sediment set up like "b"
2. Lead students through the process of developing a hypothesis with the guiding questions: **What differences do you expect to see in the treatment group and control group in about a week? Why do you think those differences might occur?** Possible hypothesis: There will be a greater number of algae in jar with sediment and pond water compared to the jar with only pond water.

<u>Second Day:</u>

Check the jars after one week. If you do not see obvious responses, check them again after two weeks as it may take some time for visible algal growth to occur.

• Data Collection

1. **Qualitative Observations:** appearance of the water and sediment, look for evidence of algae growth—cloudy water and green "slime" on the sediment; any bubbles coming from the sediment, smell, layers in sediment evidenced by color difference or texture changes; macroscopic organisms in either sediment or water; bacterial growth (slime). Use the "Field Guide to Mud" table (under "Resources in this document) and PowerPoint slides to help explain your qualitative observations
2. **Quantitative Observations:** use a microscope to count the algal cells in the water in each jar; if available, test the water in each jar with any available nutrient water testing kit (nitrogen and/or phosphorus), depth of water and sediment over time, water temperature, conductivity and dissolved oxygen, pH

• Data Analysis and Conclusions (if needed, this may be done on the next class day)

1. lead students back to their hypothesis and model for them how the results may or may not support their prediction. Emphasize the use of actual observations in their answers. Ex: The hypothesis "There will be a greater number of algae in jar with sediment and pond water compared to the jar with only pond water" was supported. There were 100 algal cells counted in the jar with sediment but only 30 algal cells in the jar containing only water.
2. Discuss with the students their reasoning on why the results turned out the way they did. If the results didn't support the expected (we WOULD expect more algae to grow with the sediment, since the mineral nutrients available in the water limits the population size of algae) then lead students in a discussion of possible sources of error, such as variables not kept constant between the two jars—original water's algae count, etc.

RESOURCES

A Field Guide to Mud (for supporting photographs, see PowerPoint file)

If you observe…	**It probably is…**
An *orange solid* on the surface or in other areas of the sediment	*Oxidized iron* (Fe^{3+}) in the sediment. This is the same thing as rust, and can bind large amounts of phosphate (PO_4^{3-})
A *jet black* layer in the sediment	*Iron sulfide* (FeS). When sulfide binds to iron, it effectively "steals" phosphate binding sites and can cause some phosphate to enter the water column.
That the sediment is *brown and mucky*	High in *organic matter*, or decomposed plant material.
Bubbles coming out of the sediment	*Carbon dioxide* and *methane* being produced by microbial metabolism.
That the sediment *smells like rotten eggs*	*Sulfur gas* coming out of the sediment, which a product of decomposition or microbial use of sulfate (SO_4^{2-}).
Green growth in the water or on the surface of the sediment	Filamentous or single-celled *algae* using nutrients that are being released from the sediment for growth.
Stained water (tea-colored)	*Dissolved organic carbon* (plant material that has been decomposed and broken up into to dissolved molecules). The darker the water is, the harder the molecules that are staining the water are to decompose.

EXTENSIONS & MODIFICATIONS

One way to modify this lesson is in the way you lead the discussion with students. Novice students will require help recognizing the mere existence of microscopic and atomic-scale components and may be able to only recognize that those factors are involved in some invisible processes within the algal cells. As students progress in their reasoning skills, the specific names of the matter involved and underlying processes as well as explaining how they work together can be expected.

Other ways you could use this basic set of materials to **do guided inquiry lessons with different treatments**:

- Try the treatment "shaken vs. non shaken" to mimic a sediment re-suspension event (wind, current, bioturbation by fish or other animals)
- Another treatment could be "dark vs. light" to display what happens with and without the possibility of photosynthesis.
- Vary the temperatures that the jars are kept at to show seasonal differences in metabolic rates
- Oxygen (use an aquarium bubbler) vs. no oxygen to display the differences in activity at the top and bottom layers of a lake
- Water from different places or sediment from different places to describe how varied aquatic ecosystems can be
- Dry vs. wet (keep one flooded, let one dry out) to show changes in ephemeral aquatic ecosystems

The Marvels of Mud

its not <u>all</u> about carbon ☺ *name:*

<u>Brainstorming</u>

1. What makes up the pond water?

2. What makes up the sediment at the bottom of the pond?

3. Describe some possible interactions that could occur between the things in the pond water and the sediment at the bottom of the pond.

<u>Experimental Set Up:</u>

Draw and label the set up as it was done in class

What part of the set up is the control group? _____

What part of the set up is the treatment group? _____

What differences do you expect to see in the treatment group and control group in about a week?

Why do you think those differences might occur?

Hypothesis statement: _____

_____

Data Collection

Qualitative Observations	Quantitative Observations

Conclusions

Was your hypothesis supported by the data?

_____

_____

_____

Explain what observations led you to this conclusion.

_____

_____

_____

Describe the science behind what happened in the jars.

_____

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