Laboratory Measures of Filtration by Freshwater Mussels

Grade: 9-12

Activity overview:

Turbidity is a measure of the relative clarity of water. The greater the turbidity, the murkier the water. Turbidity increases as a result of suspended solids in the water that reduce the transmission of light.

Turbidity can be measured using a simple device called a Secchi disk. This disk is divided into black and white quadrants. In this laboratory activity, miniature Secchi disks were used to measure water turbidity to determine if the mussels were filtering the water and reducing water turbidity.

Freshwater mussels live in the substrate of many freshwater streams and rivers, quietly filtering large volumes of water for most of their long lives. As they filter the water, they extract nutrients and other suspended particles, changing the properties of the water around them.

View a video of mussels filtering water: https://www.sciencelearn.org.nz/videos/732-mussels-filtering-water

In this experiment, changes in water clarity as a result of the freshwater mussels feeding behavior is examined. Freshwater mussels were used in 9.5 L (2.5 gallon) aquaria. Yeast was used as the turbidity-producing agent. Miniature Secchi disks were used to measure changes in turbidity.

Objectives:

Analyze the results obtained from the experimental activity on filtration by freshwater mussels. Determine if the mussels are filtering the water and reducing water turbidity.

Standard connection

State

9.1.1.1 A Way of Knowing
9.1.1.2 Inquiry
9.1.3.4 Knowledge and understanding (data)

9-12 1. The Nature of Science and Engineering 3. Interactions Among Science, Technology, Engineering, Mathematics, and Society 4. Science, technology, engineering, and mathematics rely on each other to enhance knowledge and understanding. 9.1.3.4.4 Relate the reliability of data to consistency of results, identify sources of error, and suggest ways to improve the data collection and analysis. For example: Use statistical analysis or error analysis to make judgments about the validity of results.

NGSS

HS-LS2-2. Use mathematical representations to support and revise explanations based on evidence about factors affecting biodiversity and populations in ecosystems of different scales.

Materials Used in Experiment

Freshwater mussels, Housing for the mussels--aquaria or plastic containers, water from the mussels natural environment or dechlorinated tap water, sand, aquarium pumps and a single air stone for each aquarium, yeast, large glass stirring rod, miniature Secchi disks.

Students will need graph paper and student sheet to complete activity.

Procedure

In this experiment, there are four experiment set-ups:

- Experimental 1: 9.5 L (2.5 gallons) water from the mussels' natural environment or dechlorinated tap water, 5 cm of sand, aquarium pump and a single air stone, yeast suspension (one gram of baker's yeast dissolved in 250 mL of pond water), and three freshwater mussels.
- Experimental 2: 9.5 L (2.5 gallons) water from the mussels' natural environment or dechlorinated tap water, 5 cm of sand, aquarium pump and a single air stone, yeast suspension (one gram of baker's yeast dissolved in 250 mL of pond water), and three freshwater mussels.
- Control 1: 9.5 L (2.5 gallons) water from the mussels' natural environment or dechlorinated tap water, 5 cm of sand, aquarium pump and a single air stone, yeast suspension (one gram of baker's yeast dissolved in 250 mL of pond water), and NO MUSSELS.

- Control 2: 9.5 L (2.5 gallons) water from the mussels' natural environment or dechlorinated tap water, 5 cm of sand, aquarium pump and a single air stone, NO YEAST, and three freshwater mussels.

Before taking a turbidity reading, all aquaria were stirred for 30 seconds with a stir rod, being careful not to disturb the substrate or the mussels if present. The turbidity of the water was then measured with the mini-Secchi disks. Turbidity measurements were taken every 15 minutes thereafter in each aquarium, C1, C2, E1, E2, for a period of 90 minutes using the same stirring procedure prior to conducting the experiment.

At the conclusion of the experiment, mussels were immediately removed from the aquaria and placed into fresh water.

Results:

Time (minutes)	E-1 (cm)	E-2 (cm)	Experimental Average (cm)	C-1 (cm)	C-2 (cm)
0	3.4	3.4	3.4	3.7	18.1
15	3.5	3.4	3.5	3.7	18.1
30	4.0	4.6	4.3	3.8	18.0
45	4.1	4.7	4.4	3.7	18.0
60	4.4	4.8	4.6	4.0	18.1
75	4.7	4.9	4.8	4.0	18.0
90	4.9	5.0	5.0	4.1	18.0

Table 1. Representative Secchi disc transparency measures in cm reported over time. Experimental aquaria (E-1 and E-2) had three mussels each plus yeast, Control 1 (C-1) had only yeast added and control 2 (C-2) had only 3 mussels added.

Assessment:
Have students graph the data from the Secchi disk transparency measures over time. After the graphs are made, ask students to make comparisons of data that had been collected and to draw conclusions about the experiment. Students should be able to offer possible reasons for why the experimental results occurred.

Discussion/Conclusion:
This laboratory exercise collected the data on the filtration behavior of freshwater mussels. Yeast was used as the turbidity-producing agent because mussels can filter single celled organisms effectively. Filter feeding can result in a significant reduction in turbidity.

Extension:
Students are asked to mathematically determine percent change in Secchi disk transparency measures over time. Students would then graph their data.

Analysis:

1. What affects water turbidity?
   Soil erosion, waste discharge, urban runoff, abundant bottom feeders such as carp that stir up bottom sediments, algal growth.

2. Describe the control aquarium C1.
   Received yeast but did not contain mussels.

3. Why do you think that this was the set up for the control aquarium C1?
   Allows to measure if the yeast settles out of the water, making the water less turbid, or if the yeast replicate in the tanks, making the water more turbid.

4. Describe the control tank C2. Contained mussels but did not have any yeast.

5. Why do you think that this was the set up for the control aquarium C2? Because mussels are filtering the water and potentially expelling waste products.

6. One of the controls is a negative control, meaning that no response is expected. Which one of the controls, C1 or C2 do you think is a negative control and why?
   C2 --no yeast to filter.

7. Did water clarity, due to filter feeding, increase within a 90 minute period? Explain using data in Table 1.
   In this study, the experimental aquaria, E1 and E2, had a mean Secchi disk transparency measure of 3.5 cm immediately following the addition of the yeast

suspension, and a Secchi disk transparency measure of 5.0 cm after 90 minutes. Thus, due to filter feeding, water clarity increased within a 90 minute period.

8. Explain what happened to control 1 within a 90 minute period using data recorded in Table 1.
   At zero minutes, the yeast only control, C1, had a Secchi disk transparency measures of 3.7 cm. After 90 minutes it had increased to 4.1 cm.

9. What might this data suggest? This data might suggest that yeast numbers may change slightly even if mussels are not present.

10. What would you hypothesize as a cause for the change in water clarity even if mussels are not present? (Yeast settled out of solution, the conditions killed the yeast, other aquatic invertebrates were in the original pond water feeding on the yeast.

11. Explain what happened to control 2 within a 90 minute period using data recorded in Table 1.
    The mussel only control, C2, remained relatively constant. The Secchi disk transparency measure was 18 cm throughout the 90 minutes.

12. Based on the data given, can you predict water clarity after 3 hours?
    Students will have to extrapolate from the graph. A possible answer would be 6.2 cm for the experimental average.

13. If you had to perform this experiment, what would you do differently to make it better?
    Measure the volume of water, measure the mussels size, use algal cells instead of yeast.

14. Can you come up with any sources of error for this experiment?
    Not reading the Secchi disk measurements accurately, not keeping accurate account of the time, not measuring yeast accurately.

Lesson Resources
https://www.sciencelearn.org.nz/videos/732-mussels-filtering-water

Reference:
HOBACK, W.W., KOUPAL, K.D., SHAFFER, J.J., SMITH, M.J., AND DEPARTMENT of BIOLOGY, UNIVERSITY of NEBRASKA at KEARNEY. Laboratory measures of Filtration by Freshwater Mussels: An Activity to Introduce Biology Students to an Increasingly Threatened Group of Organisms. (Nebraska Game and Parks Commission, Kearney, Nebraska).