WATER QUALITY

Freshwater plankton biodiversity investigation

Focus questions	Can human impact affect freshwater plankton biodiversity? How can Simpson's Index of Diversity help to determine the species richness of freshwater systems?
Learning target	Students will be able to understand and explain the importance of biodiversity in freshwater plankton communities and calculate Simpson's index of Diversity to determine how human impact can alter the biodiversity in a freshwater ecosystem.
Vocabulary	Biodiversity, plankton, phytoplankton, zooplankton, stability, Simpson's Index of Diversity, species richness, species evenness, relative abundance

HSLS-2: Ecosystems: Interactions, Energy, and Dynamics

Performance expectation HS-LS2-2	**Classroom connection:** Students explore the impacts of human activity on freshwater plankton ecosystems by calculating Simpson's Index of Diversity.

Science and engineering practices

Using Mathematics and Computational Thinking	**Classroom connection:** Students use mathematical and/or computational representations (e.g., trends, averages, graphs, spreadsheets) to determine the biodiversity of a given area.

Disciplinary core ideas

LS2.C: Ecosystem Dynamics, Functioning, and Resilience	**Classroom connection:** Students will investigate the human impacts of agricultural production, wastewater treatment, and lawn care on freshwater plankton ecosystems.

Cross-cutting concepts

Scale, Proportion, and Quantity	**Classroom connection:** Students will measure and compare the volume of freshwater to the biodiversity index of each sample to determine the ecological impact on the freshwater system.

Background

This activity focuses on using mathematics and computational thinking to determine the human impact on freshwater plankton ecosystems.

Freshwater plankton are microscopic organisms that live suspended in the top layers of a **Lentic** (standing water) **system** such as a lake or pond. Plankton are divided into two main groups: phytoplankton and zooplankton. **Phytoplankton** are microscopic autotrophs such as algae and bacteria that produce their own food via photosynthesis. **Zooplankton** are microscopic animals that either feed on phytoplankton or one another within the same community. These microscopic organisms play a critical role in the food web of a freshwater community. In almost every habitat of a freshwater ecosystem, billions of these organisms can be found, occupying large expanses of water and multiplying at an exponential rate under the right conditions.

Biodiversity is important because the more diverse the different roles (producers, consumers, and decomposers) found within the ecosystem, the more the ecosystem can maintain **stability**. The greater the biodiversity in an ecosystem, the more healthy and stable the ecosystem is. The healthier an ecosystem is, the longer the ecosystem can exist in nature.

Students will use **Simpson's Index of Diversity** to determine the level of biodiversity present in freshwater plankton ecosystems. Simpson's Index of Diversity is a measure of diversity that incorporates information about species richness, as well as the relative abundance (**species evenness)** of each species in the community. **Species richness** is the number of species per sample, whereas **relative abundance** compares the number of organisms of a species with the total number of organisms found in the sample. As species richness and evenness increase, then ecosystem diversity will increase. The Simpson's Index of Diversity value (D) ranges between 0 and 1. In Simpson's Index of Diversity, 1 represents infinite diversity and 0, no diversity.

$$D = 1 - \frac{\sum n(n-1)}{N(N-1)}$$

Simpson's Index of Diversity

n = the total number of organisms of a particular species

N = the total number of organisms of all species

Prior knowledge

In order to successfully complete this activity, students should know or have completed lessons relating to species classification, biodiversity, and ecological succession. Students should be able to complete algebraic equations as well as have a background of working with dissecting microscopes and/or foldscopes.

Materials

- Dissecting microscopes and/or foldscopes
- Freshwater plankton samples
- Guide to Identification of Freshwater Microorganisms: **msnucleus.org/watersheds/mission/plankton.pdf**
- Plankton collection tubes and/or nets
    - Tubes: 50–80 micron screen mesh, 1 2" PVC pipe cut to 12" long and 1 2" coupler
    - Nets: nylon stocking, heavy wire, small jar, duct tape, heavy string, key ring

Teacher preparation

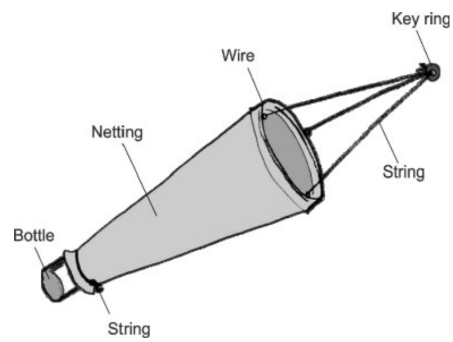
This activity will require 3–4 classroom periods or 120–160 minutes.

- Create plankton nets or tubes if not already assembled.
- Data collection: Go to a freshwater ecosystem and collect plankton using the student nets.
- Data collection: Observe and identify plankton.
- Analysis: Calculate Simpson's Index of Diversity.

- Determine where students can collect plankton samples in a local pond or other standing water system such as a local lake system.
- Provide students with freshwater plankton keys or ID books for identification of plankton.
- Create plankton collection nets or tubes following the instructions found below.

Procedure

Plankton net instructions*



1. Collect the following materials for your plankton net: nylon stocking, key ring, string, small bottle, duct tape, heavy wire.
2. As you construct your plankton net, you may want to refer to the diagram.
3. Bend the wire into a circle and wrap the ends around one another. Use duct tape to secure the wrapped ends and cover the sharp points.
4. Roll the largest opening of the stocking several times around the wire ring. Sew the stocking to the wire using the heavy thread and needle. Use duct tape to cover and protect the stocking.
5. Cut off the foot of the stocking and discard that piece. Now open the narrow foot end of the remaining stocking and insert the mouth of a small bottle. Wrap a piece of heavy string around the outside of the stocking and bottle mouth and tie the string tight to secure the stocking to the top of the bottle. Use duct tape to reinforce the connection between the bottle and string.
6. Cut three pieces of string, each about 50 cm long. These will become the "bridle" to tow your net. Tie the strings at equal intervals around the wire opening to the net. Tie the three loose ends of string to a key ring. This is the bridle ring. Your plankton net is now complete and ready.

Plankton tube instructions*

1. Collect the following materials for your plankton tube: 1, 12-inch long piece of 2 inch PVC pipe; a 2-inch PVC coupler; and 1, 4-inch × 4-inch piece of 50–80 micron screen mesh.
2. Place the screen mesh between the 12-inch PVC pipe and the PVC coupler and carefully slide the coupler over the screen mesh to secure it in place.

Differentiation

Other ways to connect with students with various needs:

- **Local Community:** Contact your local watershed advisory group and/or Soil and Water Conservation District and ask to volunteer to help learn more about local water quality within your community.
- **Students with special needs (language/reading/auditory/visual):**
  - Plankton Parade: `youtu.be/DjdJuY7ezp0`
  - Freshwater plankton under a microscope: Algae, Daphnia and Copepods: `youtu.be/FIogjkakLPo`
  - Calculating Simpson's Index: `youtu.be/8dYSvo8EqFE`
- **Extra support:** See above videos.
- **Extensions:** Students might compare water quality data from different freshwater ecosystems or the same ecosystem within different times of the calendar year to see how the diversity rates vary.

* Source: `coast.noaa.gov/data/estuaries/pdf/catching-plankton-resources.pdf`

Student handout

Conclusion

Based on your findings from the lab, what conclusions can you draw? Write a conclusion to show your interpretation of the data and how it relates to the concepts studied in this lab.

1. What was your purpose? Did your procedure and findings relate to your original purpose? Does there seem to be a relationship between the sample locations and the biodiversity calculated? If so, what is that relationship?

The purpose of this experiment was to calculate Simpson's Index of Diversity for various freshwater ecosystems. Students should describe the procedures that were used to calculate the Simpson's Index of Diversity of their samples and relate these back to the investigation's purpose outlining any possible relationships to the sample locations and diversity found there.

2. What did you hypothesize? Did your experiment support your hypothesis?

Answers will vary.

3. Explain your results. Why do you think you got the results you did? (Use your researched resources if necessary, but remember to cite information used.)

Answers will vary but should tie in the calculated values to either support or refute their hypothesis.

4. Identify at least two things that happened during the lab that could have introduced errors or affected the results—not simply human error! Be sure that you explain how/why you feel these caused errors in the experiment.

Answers will vary.

5. Were there any limitations to your experiment? In other words, were there matters that you feel may have affected the accuracy of your results but were out of your control? If so, describe them.

Answers will vary.

6. What improvements could be made to the procedures for this lab to reduce the errors and or limitations identified? Make sure that the improvements are specific and feasible!

Answers will vary but must relate to the answers for question 5 above.

Assessments

Rubric for assessment

Skill	Developing	Satisfactory	Exemplary
Uses mathematical and/or computational representations of species diversity to support explanations.	Simpson's Index of Diversity is calculated, but not correctly used.	Simpson's Index of Diversity is calculated and correctly used throughout the investigation.	Simpson's Index of Diversity is calculated and used to determine which human actions are most advantageous to ecosystem health.
Uses the concept of orders of magnitude to understand how a sample relates to a larger ecosystem.	Sample size is measured by volume and mass.	Sample size is discussed as a scaled proportion of the calculated ecosystem biodiversity.	Sample size area is scaled to the total area of the freshwater ecosystem. Sample size is identified as a representative of an ecosystem and grouped with classroom data samples to determine the biodiversity of the larger system.
Determine and explain the sample ecosystem resilience due to human impact.	Understand what ecosystem resilience is.	Understand what ecosystem resilience is and identify sample resilience based on data.	Explain ecosystem resilience as it relates to classroom data samples and human impact on freshwater ecosystems.

Rubric for self-assessment

Skill	Yes	No	Unsure
I understand that differences in agricultural production practices, wastewater treatment plants, and private lawn application can impact freshwater ecosystems.			
I understand what biodiversity is and can apply the concept to the ecological impact on human action.			
I used mathematical thinking to provide evidence to answer the question: How can human actions impact freshwater biodiversity?			
I understand how to scale the Simpson's Index of Diversity of my sample to that of the entire ecosystem.			
I can determine the freshwater ecosystem resilience for each sample.			