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?
Vocabulary	Biodiversity, plankton, phytoplankton, zooplankton, stability, Simpson's Index of Diversity, species richness, species evenness, relative abundance

A healthy freshwater ecosystem demonstrates high biodiversity with millions of **plankton** (microscopic organisms) that live in the upper layers of the freshwater ecosystem. 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. Human impact on freshwater ecosystems due to construction, agricultural production, wastewater treatment, and lawn care can impact plankton biodiversity and change species richness within the ecosystem.

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

Simpson's Index of Diversity
n = the total number of organisms of a particular species
N = the total number of organisms of all species

Simpson's Index of Diversity is a tool used to measure the level of **biodiversity** present in each freshwater sample. It measures both the **species richness** (number of species per sample) and the **species evenness or relative abundance** (compares the number of organisms of a species with the

Example: Sample Calculation

Species	Number (n)	n(n–1)
A	2	2
B	8	56
C	1	0
D	1	0
E	3	6
Total	**N = 15**	**∑ n(n–1) = 64**

$$D = 1 - \frac{(\ 64\ )}{(\ 15\ (14)\ )}$$

Simpson's Index of Diversity = 0.7

total number of organisms found in the sample) in a community. A community dominated by one or two species is considered to be less diverse than one in which several species have a similar abundance. 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.

What freshwater ecosystem will your group investigate? **Lentic** (standing water systems like ponds or lakes) freshwater systems have higher populations of plankton due to the structure and movement of the water system. Choose a freshwater ecosystem that is local to your area if possible. Human impact may be greatest in areas with high construction rates and/or conventional tillage practices in food production. Loose sediment can block the light many phytoplankton need for photosynthesis, decreasing their ability to reproduce and provide stability to the food web. Conversely, if nutrient inputs are high due to agricultural production, wastewater treatment and lawn care, increases in certain phytoplankton populations can impact the stability of the ecosystem as well.

It is important to measure the volume of your freshwater sample in order to compare the Simpson's Index of Diversity of your sample to the entire ecosystem.

If the lake or pond is rectangular in shape, multiply the lake's length, width, and average depth. Then multiply this amount by 7.48 to calculate total gallons of water in the pond. To convert to liters, multiply by the gallons by 3.78.

Example: length = 10 ft., width = 15 ft., depth = 11 ft.

10 ft. × 15 ft. × 11 ft. = 1,650 ft.^{3}

1,650 ft.^{3} × 7.48 gal/ft.^{3} = 12,342 gallons

12,342 gallons × 3.78 liter/gallon = 46,653 L

Questions to research for this investigation with your group:

1. How can the following human actions impact freshwater ecosystems?
    - Construction
    - Agricultural production
    - Lawn care
    - Wastewater treatment
2. What role do plankton play in a freshwater ecosystem?
3. What other factors other than human impact can alter freshwater plankton populations?

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

Procedure

1. Research how the following human actions impact freshwater ecosystems
   - Construction
   - Agricultural production
   - Lawn care
   - Wastewater treatment
2. Write a hypothesis to predict the Simpson's Index of Diversity values of a disturbed freshwater ecosystem and an undisturbed freshwater ecosystem.
3. Go to the freshwater system that you will be conducting your investigation of and if possible, measure the length, width, and depth of the pond or lake. If this is not possible, contact the local owner or authorities to determine this information for later use.
4. Collect your freshwater sample by either the **a** (plankton net) or **b** (plankton tube) method below.
   a. Tying a length of strong string to your key ring and dragging your **plankton net** through the water if possible.
      - Usually, scientists tow a plankton net behind a boat. If you do not have access to a boat, what are some other ways you can drag your net through the water?
      - Rinse the inside of the hose with water so that the plankton on the inside of the net are washed down into the collection bottle. Gently untie the string connecting the bottle to the net.
   b. Collecting water from the freshwater system and pouring it through the **plankton tube** to be collected on the screen. You can pour multiple samples through the tube for collection.
      - Gently separate the PVC pipe from the PVC coupler to remove the screen and rinse the screen over a beaker to remove the plankton.
5. Observe your plankton by transferring a few drops of the sample with a pipet to be viewed under a dissection microscope or a foldscope. The plankton should be moving around in and out of your viewing area!
6. Use the identification charts to help you with your species identification and record them in your data table. If you cannot determine their identity, count the number and name them Species A, B, etc.
7. Collect data following the steps below.
   a. Determine the species abundance and species diversity of your sample locations. How do these samples compare to the entire ecosystem? What is the diversity index of the ecosystem?

      Draft the data tables needed to display raw data collection that is measured for each trial. You may want to use another piece of paper for this and the following requirements below. Here is an example.

Species	**Number (n)**	**n(n–1)**	**Observations**
Total	**N =**	**∑ n(n–1) =**	

b. Determine the differences in the Simpson's Diversity Index values from one location to another. Show your work.
c. Create a data table to demonstrate the calculated D values from other student groups to determine the mean for each location.
d. Graph your data. You many want to use another piece of paper. Be sure to include a scaled interpretation of the volume of the ecosystem that the sample was taken from. *Remember, the x-axis is the horizontal axis and always is the independent variable. The y-axis is the vertical axis and is the dependent variable.*

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?

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

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.)

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.

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.

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!

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.			