

SNC1D/1P Sustainable Ecosystems/ Sustainable Ecosystems and Human Activity

Teacher Demo: Toxic Path: Bioaccumulation

Topics	Timing
bioaccumulation biomagnification food web toxins	preparation: 10 min demonstration: 15 min

Specific Expectations

SNC1D

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions

B3.5 identify various factors related to human activity that have an impact on ecosystems (e.g., the introduction of invasive species; shoreline development; industrial emissions that result in acid rain), and explain how these factors affect the equilibrium and survival of ecosystems (e.g., invasive species push out native species and upset the equilibrium in an ecosystem; shoreline development affects the types of terrestrial and aquatic life that can live near lake shores or river banks; acid rain changes the pH of water, which affects the type of aquatic life that can survive in a lake)

SNC1P

A1.10 draw conclusions based on inquiry results and research findings, and justify their conclusions

B3.5 identify some factors related to human activity that have an impact on ecosystems (e.g., the use of fertilizers and pesticides; altered shorelines; organic and conventional farming; urban sprawl), and explain how these factors affect the equilibrium and survival of populations in terrestrial and aquatic ecosystems (e.g., fertilizers change the fertility of soil, affecting what types of plants can grow in it; pesticides leach into water systems, affecting water quality and aquatic life; shoreline development affects the types of aquatic life and terrestrial vegetation that can live by lake shores or river banks; urban sprawl wipes out fields and woods, destroying wildlife habitats)

Introduction

Humans have had a huge effect on the environment by producing and releasing pollutants. Pollution leads to a variety of issues. Some of the better-known pollutants include greenhouse gases, which are the main cause of global warming; acid-producing air pollutants that result in acid rain; and persistent toxic chemicals, which can result in the death of the top predators in ecosystems.

In 1962, Rachel Carson published the book *Silent Spring*, in which she warned of the dangers of overusing pesticides and the potential environmental problems caused by the industrial

revolution. Less than a decade later the impacts of these chemicals became apparent as some top predatory bird populations began to decline due to the toxins reducing the success rate of eggs hatching.

Toxins have an impact on all living things but the impact is most clearly seen on top predators because the toxin's concentration is magnified through a food chain. For example, a pesticide may be sprayed on a marsh to control mosquitoes. Although the mosquito populations are kept under control, small traces of the pesticide accumulate in aquatic microorganisms such as phytoplankton (microscopic photosynthetic organisms that are the foundation of the aquatic food web). Insect larvae then feed on large quantities of the microorganisms and the concentration of toxins increases in the tissues of the larvae. Since many of these toxins are fat soluble, they get absorbed by the body tissues instead of remaining dissolved in water and passed through the excretory system. This process continues as the insects are eaten by small fish, which are then consumed by larger fish and then top predators such as gulls, falcons, and ospreys. In the top predators very high toxin levels affect the animals' functioning, causing death or limiting their ability to reproduce (Fig.1).

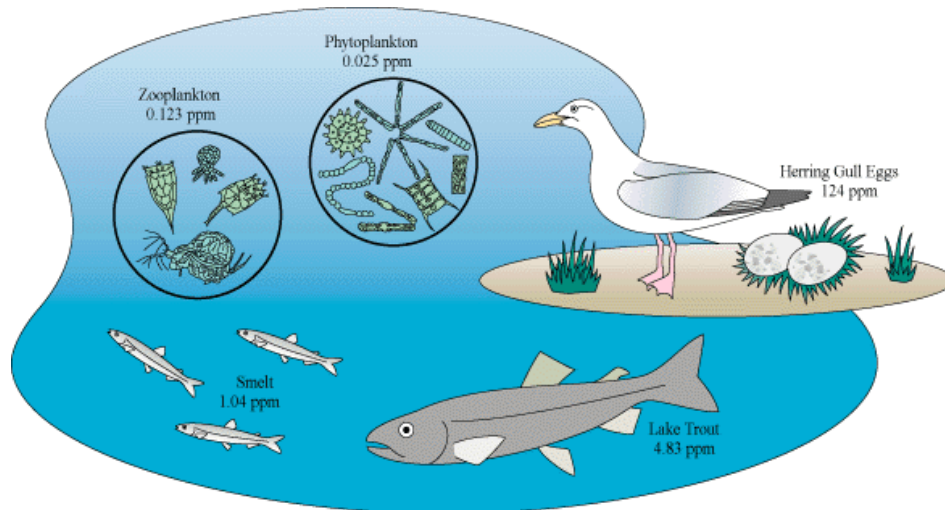


Image courtesy of EPA (Environmental Protection Agency)

Fig.1 The concentration of a toxin is magnified from 0.025 ppm (parts per million) in phytoplankton to 124 ppm in the eggs of a herring gull.

In this demo, containers represent organisms in a food chain and beads represent a water-borne toxin to which the organisms are exposed.

Materials

bag of coloured plastic beads, beans, or peas (100 mL)	50 mL beaker
10 small test tubes	100 mL beaker
3 medium test tubes	tape
large test tube	marker

Safety Considerations

- None

Procedure

1. **Predict/Explain**

Ask students, “How do the quantities of toxins in small organisms (primary consumers) compare to the quantities in larger predatory animals in an ecosystem?” Have students explain their prediction.

2. **Observe**

Work with students to construct a food chain (on the board) with 5 trophic levels. A trophic level is the feeding level of an organism. Example:

microorganisms → insects → small fish → large fish → falcon

3. Use the tape and marker to label the small test tubes with the first organism in the food chain; medium test tubes with the second organism; large test tube with the third organism; 50 mL beaker with the fourth organism; and the 100 mL beaker with the fifth organism.
4. To set the scene, tell students a story about a wetland ecosystem where mosquitoes breed and have the potential to spread a disease (such as West Nile Virus). To control the mosquito populations and to limit the spread of disease a pesticide will be sprayed on the ecosystem.
5. Place the 10 small test tubes in a test-tube rack standing on a tray. Sprinkle the beads (to simulate the pesticide spraying) until approximately 0.5 mL of beads has fallen into each test tube. As you sprinkle the beads explain to students what is happening: “The small test tubes represent the microorganisms. Pesticide is sprayed on the ecosystem and some of it is absorbed by the microorganisms.”
6. The medium-sized test tubes represent the second organism in the food chain developed by the class (e.g., the insects). Continue the story: “The insects eat 3 microorganisms.” Add the contents of 3 small test tubes to one of the medium-sized test tubes. Repeat for each of the other two medium-sized test tubes. Set aside the remaining small test tube (of the original ten) and tell students it will be used later.
7. The large test tube represents the third organism in the food chain (e.g., a small fish). The small fish eats three insects. Add the beads from the 3 medium-sized test tubes to the large test tube.
8. To one of the medium-sized test tubes (insects) add approximately 1.5 mL of beads and set aside to facilitate comparison of the amount of toxins in each organism at the end of the demonstration.
9. The 50 mL beaker represents the fourth organism (e.g., large fish). The large fish eats 3 small fish. Place a mark on the large test tube at the level of the beads, and then transfer the beads from the large test tube to the 50 mL beaker. Again, add beads up to the line in the large test tube and add to the 50 mL beaker. Repeat this action for a third time. Finally, add beads up to the line in the large test tube and set it aside for comparison later.
10. The top predator (e.g., falcon) is represented by a 100 mL beaker. The falcon eats 2 large fish. Mark the level of the beads in the 50 mL beaker and then add them to the 100 mL (falcon) beaker. Refill the 50 mL beaker with beads up to the mark, and feed them to the falcon. Finally, refill the large fish beaker (50 mL) with beads up to the mark again, and set it aside.
11. Compare the contents of the 5 “organisms” (Fig.2).

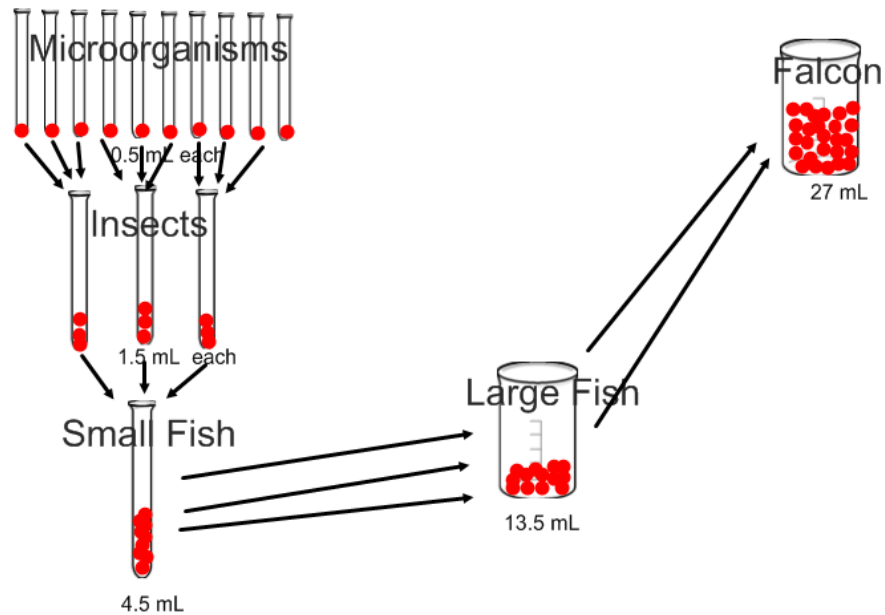


Fig.2 Flowchart showing the volume of beads (toxins) in each “organism” after it has fed on organisms at lower levels in the food chain

12. Explain

“Will all organisms at various levels in the food chain have the same toxin concentrations as all the other organisms at the same level?” Ask students to explain their answers to this question.

Disposal

Store beads and glassware for later use.

What happens?

The number of beads (amount of pesticide) in the containers (organisms) increases at successive levels in the food chain.

How does it work?

In the initial spraying of the pesticide a few beads accumulate in the small test tubes. This represents a low concentration of toxins at the beginning of the food chain. The toxins are accumulated at each new trophic level. This is represented in the demo by more beads in the bodies of higher predators. The reason is that the predators eat many contaminated organisms from below their trophic level in the food chain.

Teaching Suggestions/Hints

- As you work through the demo, emphasize to the students that the beads and glassware represent the pesticide and the organisms. As the beads are added and moved through the food chain repeatedly use the term “pesticide or toxin.” Similarly, use the names of the organisms from the food chain when using the glassware. For example, when holding the large test tube, “the small fish” is eaten by “large fish” (small beaker).

2. This demo illustrates the magnification of toxin levels through a food chain. These values will not be the same for every microorganism, insect, fish etc. To better simulate the ecosystem the beads could be randomly sprayed over the test tubes (there will be varying numbers in each). The insects could then randomly eat 3 microorganisms and so on. Over many trials the accumulation of toxins in the top predator will vary a bit with some being deadly. For example, if there are 50 beads the reproductive success is affected and if there are more than 100 the predator dies.

Next Steps

Discuss local problems with pollution and their potential impacts on aquatic or terrestrial ecosystems. Students could research how the government is responding to these pollution issues.

Additional Resources

1. NOAA: Biomagnification interactive model - <http://oceanexplorer.noaa.gov/edu/learning/player/lesson13/1131a1.html>
2. Environment Canada: Methylmercury in the Food Chain - <http://www.ec.gc.ca/mercure-mercury/default.asp?lang=en&n=d721ac1f-1>