SCIENCE NORTH SCIENCE NORD

SUDBURY, ONTARIO, CANADA

Bioaccumulation and Magnification **SNC1D Sustainable Ecosystems**

Lesson Plan

Assessment	FOR learning
Cross-curricular	Math

Big Ideas

- Ecosystems are dynamic and have the ability to respond to change, within limits, while maintaining their ecological balance
- People have the responsibility to regulate their impact on the sustainability of ecosystems in order to preserve them for future generation

Overall Expectation

- **B2.** investigate factors related to human activity that affect terrestrial and aquatic ecosystems, and explain how they affect the sustainability of these ecosystems;
- **B3.** Demonstrate an understanding of the dynamic nature of ecosystems, particularly in terms of ecological balance and the impact of human activity on the sustainability of terrestrial and aquatic ecosystems.

Specific Expectations

- **B2.1** use appropriate terminology related to sustainable ecosystems, including, but not limited to: *bioaccumulation, biosphere, diversity, ecosystem, equilibrium, sustainability, sustainable use, protection,* and *watershed* [C]
- **B3.5** identify various factors related to human activity that have an impact on ecosystems, and explain how these factors affect the equilibrium and survival of ecosystems

Learning Goals

- Understand how low level pollution can cause drastic health problems up the food chain, including for humans.
- Understand how bioaccumulation and magnification work.
- Gain an understanding of the complexity and interconnectedness of a food web.

Description

In this activity, students create a food web to model bioaccumulation as it occurs in a variety of scenarios.

Materials

- A handful of skewers (to start, extras should be available)
- Life form cards (supplied in lesson materials)
- Beads or poker chips etc. (any marker that can be handed out in relatively large quantities)
- Two stopwatches or timers (a timer on a cell phone will work just fine)

Safety Notes

N/A

Introduction

Opening Discussion – The Food Web

If you have not already discussed food webs, an introduction lesson is advised. Here's a review you can do with your students:

- **What is a food chain?** A food chain is how lifeforms are connected through consumption – humans eat cows, cows eat grass, grass feeds on soil, etc.
- Can you give some examples of a food chain?
- A **food web** is more complex because we look at all relationships between life forms in an ecosystem rather than just one chain. For example: grass gets eaten by grass hoppers, which get eaten by chickens and robins. Humans eat chickens. Hawks eat robins. Etc.)
- Understanding how the food web in an ecosystem works is crucial to understanding the ecosystem itself, but also how different events will affect the entire ecosystem (like a drought etc.). It goes well beyond just knowing who eats who.
- The activity being done today helps show how parts of the ecosystem are connected and that pollution can affect all parts of a food web.

Introductory Video

You may choose to play a video or part of a video to introduce the ideas of **bioaccumulation and biomagnification**. You could also let the students do the activity first and discover what happens to pollution in the food web and then watch these videos at the end as a consolidation activity.

- One suggestion is to watch this video to the 1:50 mark. This gives a good introduction. You can then resume and finish the video after the activity.
- https://youtu.be/dj0U9-ZvWZs - "What are you TOXIN about" by MindFuel Canada.

Action

This activity works well in a small group so students can discuss their approach and results together. A group of two or three students would work well, but it can also be done as individually. While it is possible to provide students with the required information, it is recommended that you let them research and explore the connections in the food web. Once the food web is laid out they can look at how toxins would move through the food web.

Action

Modeling Bioaccumulation

First, let's see how life forms absorb toxins in the environment. **Let us assume the toxin is found in water and it is taken up by algae**. Algae (and other life forms) can also rid themselves of some toxins. Let's investigate what happens by following the three scenarios on the activity instructions handout:

- For our modeling we will use beads (or a similar marker). One marker is one toxin "particle"
- Let us say that our algae can rid themselves of one toxin every 5 seconds.
- **Scenario one: Low pollution of the water**.
    - The algae absorb a toxin every 10 seconds.
- **Scenario two: intermediate water pollution.**
    - The algae absorb a toxin every 5 seconds.
- **Scenario three: high water pollution.**
    - The algae absorb a toxin every 3 seconds.
    - Play this scenario for a few turns to see how things develop.

- One student adds toxins at the right time intervals by placing them on the algae card. Another student removes ONE toxin at the right intervals (if there is at least one present) for each scenario. **Use timers to make sure each student uses the correct time interval.**

What happens? Discuss.

- **Scenario one**: the algae can handle the low level pollution – **no buildup.**
- **Scenario two: balance.** As long as nothing changes there is no buildup of toxins. This is a critical level, and if you were a regulator you might aim for this level of "acceptable" pollution that does not affect the environment (see why doing these kinds of models is so important in the real world too? This can be a complicated computer model of the ecosystem – rather than this simple model – but our activity gives us the correct basic idea).
- **Scenario three: toxins build up.** The algae cannot keep up with the toxins it absorbs. Over time the algae accumulates more and more of the toxin. This is called **bioaccumulation**. How might this affect life forms that consume the algae?

Setting up a Food Web

Students now lay out an example of a food web using the **supplied life form cards and the instructions** for the activity.

- Lay out all the life form cards (provided, or write your own life forms onto pieces of paper if you researched a different food web)
- Use skewers to make connections between life forms (pointing arrows from the producers to the consumers). Discuss with your team where the connections should be.
- Remind students of the terms "**producers**" and "**consumers**". Consumers eat the producers. A consumer can then become the producer for a higher level consumer…

It's up to the teacher to decide if the student food webs need to be corrected for accurate connections. The learning goal for this activity is to understand the concept of a food web rather than ensuring every connection is correct.

Modeling Biomagnification (or Bioamplification)

If time permits, there are other scenarios that can be completed. That said, the basic approach is always the same:

- Place one or several markers on each of the lowest level life forms (**primary producers**)
- **Follow the food web and add as many toxin markers to each life form as there were in total on the lower trophic level**. For example, if an otter consumes a crayfish (2 toxin markers) and a trout (3 toxin markers), the otter would have a total of 5 toxin markers. Progress along the web until you reach the end of each branch. (see images in the activity instructions handout for details)
- This first scenario is a simplified model. Students can complete the activity a second time and apply that in reality, each **higher level consumer eats MANY lower level producers**. In this scenario, you can add two or three toxin markers to the consumer for every one marker that it gets from a lower level producer. This demonstrates amplification in the biomagnification process.

What happens? Discuss.

- In these scenarios, toxins ARE building up in the lowest level life forms. So there is already bioaccumulation.
- As you move up the food chain, the toxins become increasingly concentrated. This is called **biomagnification (or bioamplification).**
- Are humans affected by this? YES. Very much so! Humans are high level consumers which is why we have to be careful about what we consume. Certain sea foods are known for being contaminated with heavy metals.
- In this way, even a low level of toxin pollution can become a really serious problem for the higher order consumers. Bears, wolves, eagles, AND humans are especially vulnerable.

Consolidation/Extension(s):

Discussion:

- Note how different animals and plants in the food web have very unique positions compared to other ones.
    - What is a plant or animal that many other life forms depend on directly or indirectly? (All the producers, e.g. algae, are good examples)
    - Is there a plant or animal that is connected to almost every other plant or animal in that ecosystem (many arrows pointing toward or away from it)? (e.g. frog)
    - What is a life form that depends highly on the success of other life forms? (top predators)
- Now discuss how toxins move up the food chain and how different life forms are affected.
    - At lower trophic levels, low amounts of toxins do not have as large an impact

- Toxins can accumulate very fast for top predators.
- What does this mean for humans? – The ecosystem in our example is one in which students may not consume meat from. Yet the same principles apply with other food chains in which humans are a part of. For example, cows in pastures, vegetables from gardens, fish from the sea, etc.
- What can we learn from this model? – Limiting pollution is extremely important; pollution builds up through food chains/webs.

- Now that you have done this exercise can you explain why birds of prey were particularly affected by spraying of DDT? (see associated video below)

Consolidate with videos:

- Finish the video you started (https://youtu.be/dj0U9-ZvWZs - "What are you TOXIN about" by MindFuel Canada).
- Look at a specific example: e.g. mercury intake for humans: https://youtu.be/Q1ZA8ZrK3U4
- Biomagnification and DDT example: https://www.youtube.com/watch?v=TZk6vcmLcKw