

2-Liter Bottle Ecosystem

Adapted from: National Research Council. 1996. *National science education standards*. Washington, DC: National Academy Press

Grade Level: High School

Duration: 2 or 3 class weeks, depending on how long the ecosystems survive

Setting: Classroom

Summary: Students will explore designs and build an “ecosystems” using 2-liter bottles that will educate them on cycles involved in the ecosystem.

Objectives: Students will develop an understanding of miniecosystems and how energy is cycled.

Vocabulary: Ecosystem, nitrogen cycle, sustainability, photosynthesis, carrying capacity, limiting factor, nitrogen cycle, water cycle

Materials (Included in Module):

Duct tape, scissors, paper for designs, soil test kits

Additional Materials (NOT Included in Module):

2-Liter bottles and any other material will be collected during the project.

ACADEMIC STANDARDS (ENVIRONMENT AND ECOLOGY)

7th Grade

- 4.3.7.C Explain biological diversity
- Explain the complex, interactive relationship among members of an ecosystem
 - Explain how diversity affects ecological integrity of the natural resources
- 4.6.7.A Explain the flows of energy and matter from organism to organism within an ecosystem
- Demonstrate the dependency of living components in the ecosystem on the nonliving components
 - Understanding limiting factors and predict their effects on an organism
- 4.7.7.A Describe diversity of plants and animals in ecosystems
- Select an ecosystem and describe different plants and animals that live there

10th Grade

- 4.6.10.A Explain the biotic and abiotic components of an ecosystem and their interaction
- Evaluate the efficiency of energy flow in a food chain
 - Explain the concept of carrying capacity in an ecosystem
- 4.7.10.A Explain the significance of diversity in ecosystems
- Identify a species and explain how its adaptations are related to its niche in the environment

12th Grade

- 4.6.12.A Analyze the interdependence of an ecosystem
- Analyze the relationships among components of an ecosystem.
 - Explain limiting factors and their influence on carrying capacity
- 4.7.12.A Analyze biological diversity as it pertains to the stability of an ecosystem
- Examine and explain how a specialized interaction between species may affect the survival of both species

BACKGROUND:

Aquaponics explores the **symbiotic** relationship between plants and animals within a closed system. Water is circulated between the constituent parts of these systems—aquariums and growing trays—thereby filtering

Sustainability - Aquaponics

nitrites that are toxic to fish but integral to plant growth. Most systems require little to no inputs and all waste is fed back into the process; solid fish waste and unused plant matter are composted to grow worms as fish food. As such, aquaponics embodies **sustainability**.

There are many different approaches to aquaponics, but the Allegheny College arrangement is a **closed-system**. Water from the fish tank is pumped through the growing bed to filter it and remove fish waste. Bacteria play a crucial part in the health of the aquaponics system, as they remove fish waste (ammonia) from the water, converting it to nitrites and later to nitrates. Nitrate-rich water is introduced to the hydroponically grown plants (plants grown without soil). These plants are placed in beds that sit on tubs filled with water. The plants' bare roots hang through holes in the beds and dangle in the nutrient-rich water. The roots of the plants absorb nitrates, which act as a nutritious plant food. Although the nitrates are the primary fertilizer for plant growth, their accumulation would eventually kill the fish in the system. Thus the symbiosis between plants and fish revolves around production and consumption of nitrogen, and is the same relationship found in every ecosystem around the world.

Plants grown using aquaponics are more likely to be organically grown, which means they are healthier for you. Pesticides and other chemicals cannot be used in aquaponics because they will harm the fish, disrupting the whole system. Additionally, plants grown in aquaponic systems have no threat of carrying soil-related diseases. When indoors, or with the assistance of a greenhouse, aquaponics can grow crops year round – especially useful in Northwest Pennsylvania. Aquaponics can encourage community development and local economic growth. On a larger scale, it is a project the community can care about together, and allows for more food to be grown and sold—or shared—locally. Creating a personal aquaponics system is easy and inexpensive, and can be done on a large or small scale. With a 50 gallon fish tank, you can have one in your own home.

OVERVIEW:

Students explore designs and then build miniecosystems using 2-Liter bottles and the 5E Model which encourages thinking about cycles and connectedness in aquaponics and ecosystems in general.

PROCEDURE:

Divide the students into groups of three or four. Present the challenge of building a miniecosystem that can last for 2 weeks. Hand out instruction sheet and criteria for the 2-Liter bottle ecosystem to each group, and go through it with them. Discuss aquaponics and ecosystems. Then, allow the students to work on designing a model for this based on what they have learned about ecosystems. Help in the process of creating the bottle ecosystems. Travel with students to a pond or creek one day to collect their organisms once the format of the miniecosystems' designs has been completed. Use soil test kits to find the initial phosphorus and nitrogen levels in the soil before sealing them. Have students observe their miniecosystems for the next class days to follow.

DISCUSSION:

Before they start, pose the following questions:

1. What will be the oxygen and carbon dioxide sources of the miniecosystem?

Sustainability - Aquaponics

2. What will be the food the organisms have in the miniecosystem?
3. How will plants and animals get water?

Also, share past models and examples of other bottle miniecosystems to give the students ideas.

After they have finished discuss each stage of the miniecosystem that the students were able to complete in their bottles. During the bacteria stage, discuss the **nitrogen cycle**. Explain how all waste has otherwise unusable nitrogen locked inside ammonia.

EVALUATION:

Students should be evaluated based on how they participate in the project and discussions. Also, the students should be evaluated on how successful their miniecosystems are.

EXTENSIONS AND MODIFICATIONS:

After building and observing their ecosystems, students can discuss and infer on how different cycles are incorporated into the ecosystem. Pose the following questions:

1. Where do plants get energy from?
2. How is water cycled from the water habitat to the air?
3. How is water cycled from the terrestrial habitat to the air?
4. In what direction does energy flow in the miniecosystem?
5. What happens to the animals after they die?
6. How are all organisms in a habitat interconnected?

NOTES (PLEASE WRITE ANY SUGGESTIONS YOU HAVE FOR TEACHERS USING THIS ACTIVITY IN THE FUTURE):