Lesson to Grow

Exploring the Nitrogen Cycle through Aquaponics

Description:

Students investigate the growing of food through an aquaponics system and the symbiotic relationship between plants and fish.

Grade Level: 6-8

Essential Skills:
5, 6

NGSS:
MS-LS2-1

CCSS:
6.RI.1, 6.RI.4, 6.SL.2, 7.W.1, 7.W.6, 6-8.R.H.5, 6-8.R.ST.3

Time: 1 Week +

Materials:
- Aquaponics System which can either be purchased or made
- *What do plants need to grow? worksheet**
- *Nitrogen Cycle Collage**
- *Tracking changes worksheet**

** Worksheets provided in unit materials*

AITC Library Resources:

Videos:
Live, Local, Organic Virtual Field Trip

Books:
Science with Plants
Growing Food
Careers in Agriculture Packets

More Lessons:
Hungry Plants
Propagation & Regeneration in Plants

Background:

As the global population grows, simultaneously the amount of available farmland decreases. The challenge of feeding more individuals on less land becomes very real and relevant. Aquaponics presents one possible solution as it incorporates both plants and animals into one system and leaves little waste. There are two basic ideas coming together for aquaponics—growing plants without soil and raising fish. This differs from hydroponics which does not include fish. In an aquaponics system, fish are fed and then excrete solid waste that is converted to ammonia by bacteria in the system. Ammonia is toxic to fish and a build up in the tank may cause the fish to die. Beneficial nitrifying bacteria convert the ammonia to less toxic nitrate, which is readily absorbed by the plants growing in the grow tray. By cycling the ammonia and nitrate filled water to the plants, the plants remove these forms of the nitrogen from the water, and use them to grow. The water then filters down through the grow tray and returns to the tank, giving the fish fresh clean water to live in. Both the needs of the plants and fish work together in an aquaponics system, providing larger world applications of how this industry will only grow in the future. Aquaponics is one sustainable method of food production. Aquaponics systems are environmentally responsible with low water usage and relatively low power usage.

Directions:

Part I: Introduction to Aquaponics

1. Ask your students to imagine a farm. What things are on the farm? *Animals, plants, tractors/equipment, land.* Record responses on the board.
2. If we have no land to grow food, where do we grow it? *With a growing population, we have less land for growing food.*
3. What are some other ways we can grow food?
4. Provide students a couple minutes to research what it looks like to farm without using land. What methods exist? *Vertical Farming, Aeroponics, Hydroponics Aquaponics...*
5. Introduce the concept of aquaponics and ask students to define it.

The art of growing plants in nutrient-rich water—those nutrients are provided by the fish. This method uses less water and land than traditional agriculture. This is a benefit because farmland is limited. Often the fish provide a protein source as well, which relieves pressure on ocean fisheries. Once established, a symbiotic relationship is developed and the only input is food for the fish!

5. Introduce students to aquaponics production by watching this tour of an aquaponics operation: bit.ly/3xpOiUm
6. After watching the video, discuss the following questions with students:
    a) What purpose do the fish serve?
    b) Which species of fish do they use?
    c) Does water move around? Why or why not?

Part II: Looking Deeper at Water & Nitrogen Cycle Working Together

Plant needs

1. Explain to students no matter the size of the system there are needs to consider for every living creature. *In this section, we will look at the needs of plants. All plants are critical for sustaining life in humans and animals. This covers everything from fruits, nuts, leafy greens and herbs that we may grow in our aquaponics system.*
2. Provide each student with a copy of the *What Do Plants Need to Grow?* worksheet. Instruct students to cut out the plant needs cards. Then, have students place the cards in the chart on the *What Do Plants Need to Grow?* worksheet to describe which of the plant's needs the card is describing.
3. After, discuss the following questions:
    a) How does the aquaponics system meet the needs of plants?
    b) What, if any, adjustments need to be made to grow plants without soil?
    c) Are there any needs that are not provided by the naturally occurring aquaponics system?
    d) How does the care of plants change in an aquaponics system compared to growing plants in soil?

Nitrogen Cycle Collage

1. Explain to students that nitrogen also plays a significant role in plant's growth and development, being an essential macronutrient needed by all plants to grow. In this activity, students will use pictures to help represent key components of the Nitrogen Cycle.
2. Provide students with a copy of the *Creating a Nitrogen Cycle Collage* worksheet and instruct them to read the background information on the worksheet. As a class, begin by discussing each part of the nitrogen cycle. Then, have students create a collage using photos they collect from the Internet or magazines that represent each term listed on their worksheet in the nitrogen cycle.
3. After the diagrams are complete, discuss the following questions:
    a) How do plants and animals get nitrogen?
    b) What is the difference between nitrites and nitrates? How would you explain this to someone unfamiliar?

Testing Nitrogen Levels

Day 1

1) As you initially set up the system, use test strips to measure the levels of ammonia (NH_3), nitrite (NO_2) and nitrate (NO3) in the tank and record the amounts in the Aquaponics Daily Log Table worksheet.
2)Add fish to the system. It's recommended to start with just one beta fish but you can experiment with this or try one round with beta and another with goldfish. Once the initial cycle is stable, add more fish incrementally until you have an adequate bioload (generalized term for the amount of life existing in an aquarium) for the system.

Information on Bioload:
If the bioload is creating more waste than your system can handle, then the Nitrogen Cycle is out of balance, leading to problems in your aquarium. The bioload in your aquarium is too high when ammonia and nitrites are being produced faster than the bacteria in your filter can convert them to nitrates.

Fortunately, this is easy to test since ammonia and nitrite levels should be 0 ppm. Any indications of ammonia or nitrites –after your tank has cycled– could indicate the bioload is too large for your aquarium. If this is the case, you have two options:

a) Get a larger filter or
b) Decrease the size or quantity of fish

Measure NH_3, NO_2, NO_3, and pH levels of the water that the fish came in, record the data in the table on the worksheet.

For more information on setting up the *Back to the Roots Water Garden,* visit this video: https://youtu.e/3c1cbBwill8

Day 2 +

1)Measure NH_3, NO_2, NO_3, and pH levels of the Back to the Roots aquarium water and record on your table.
2) Repeat the four tests 2-3 times a week for the next three or four weeks. Make sure to run the tests at the same time daily, before the fish are fed. The initial cycle will be completed when ammonia (NH_3) and nitrite (NO_2) levels are both at zero.
3)Record results using the worksheet provided in this lesson or have students create a spreadsheet.
4) After several days of data have been collected, have the students graph the results.

After testing is complete and you and your students feel comfortable with the system, use it to grow some herbs, leafy greens or sprouts.

Activity Page

What Do Plants Need to Grow?

Name_____

Directions: Place the cards in the correct row based on the label at the top of each card. Then, arrange the cards in each row based on which plant needs it's describing: water, air, nutrients or light.

Water	Air	Nutrients	Light

Resource Page

Plant Needs Cards

Directions: Cut out each of the cards below and attach them to the *What do Plants Need to Grow* worksheet.

Rarely Seen	Comprised of the elements $O + CO_2 + N$ Vapors and other gases	Comprised of the elements $H + O$	Often come from the breakdown of organic matter.
Over 70 percent of the earth is covered by _____.	Comes in 3 forms.	Holes in plant matter allow this to enter.	Used to irrigate farmland or plants in your aquaponic system.
Your body inhales _____ and exhales CO_2.	Vitamins for plants.	Helps to make vision possible.	Found in soil.
Used with CO_2 and H_2O to perform Photosynthesis.	Capture this energy to make food.	Also referred to as fertilizer.	Energy

Activity Page

Creating a Nitrogen Cycle Collage

Name_____

Background

We are similar to plants in needing nitrogen (N) in order to survive. The air has a significant amount of nitrogen (approximately 75%) in the form of N_2. The problem with N_2 is most life forms can't use nitrogen in that form. Plants get their nitrogen in a fixed form such as nitrate ions, ammonia, or urea. Animals (and humans) get their nitrogen from plants or animals that have eaten plants. Through their roots, plants can take up some forms of nitrogen such as ammonia-nitrogen, but most plants get nitrogen that has been further processed by nitrifying bacteria.

Instructions

1. Nitrogen is a key component in plant growth. In this activity, you will use the key components of the Nitrogen Cycle to create a picture and diagram of the Nitrogen Cycle as it relates to aquaponics. Assemble a collage of images to represent the following vocabulary:

- Ammonia (NH_3)
- Decompose
- Fish
- Plants
- Nitrites (NO_2)
- Nitrates NO_3)
- Light
- Water

After creating your collage, answer the following questions.

1) How do plants and animals get nitrogen?

2) What is the difference between nitrites and nitrates?

Aquaponics System Daily Log

Directions: Use a testing kit and record the daily levels of your aquaponics system. Make sure to test at the same time each day, before the fish are fed for consistent results.

Name_____

Date ____	Time Taken	Ammonia Level	Nitrite Level	Nitrate Level	pH Level
Day 1					

Resource Page

Understanding the Nitrogen Cycle

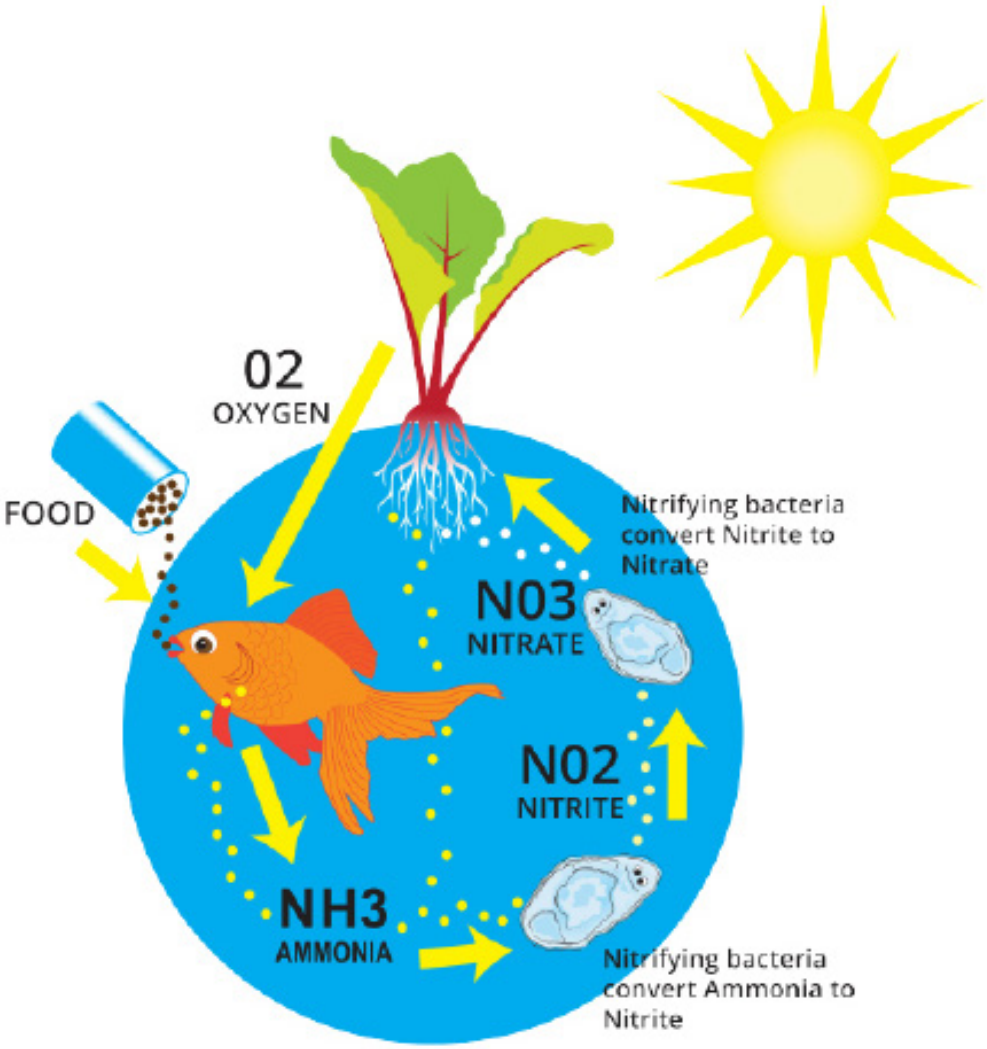

Image Source: leaffin.com/cycle-new-aquaponics-system/