Bioreactors to Improve Water Quality

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Session Goals:

1. Provide visitors to learn about the water pollution caused by agricultural activities
2. Provide visitors to observe bioreactors to clean up water
3. Provide visitors with an opportunity observe bacteria colonies on agar plates

Activities

Activity #1 – What is the nitrogen pollution?

Desired Learning outcomes:
1. Learn what is the N pollution, what causes this, where it occurs, why this is a problem, and how we can mitigate this problem.
2. Recognize how agriculture (and gardening) impact N pollution.

Materials:
1. Poster #1
2. Poster board
3. Large easel (from Market Science)

Lesson:
- Present poster #1 showing the overview of the N pollution. Show a lot of pictures (and cartoons) to attract people's attention.

Activity #2 – Miniature woodchip bioreactor

Desired Learning outcomes:
1. Learn the ongoing research effort to remove nitrate from agricultural runoff water.

Materials:
1. Miniature, table-top woodchip bioreactor
2. Blue water (10L, pH 8)
3. Water (2L, pH 5)
4. Bucket
5. Poster #2
6. Small easel (from Market Science)
7. Brochure for the research project

Lesson:
- Operate miniature woodchip bioreactor and explain how this can remove nitrate from water.

- Explain how it works using a small poster #2.
- Those who are interested in this topic can grab brochure.

Activity #3 – Observe woodchips collected from real-world woodchip bioreactors

Desired Learning outcomes:
1. Observe what is attaching on the surface of the woodchips collected from the field bioreactors

Materials:
1. Woodchips collected from woodchip bioreactors in the fields
2. Woodchips before filling to the woodchip bioreactors
3. Petri dish
4. Water
5. Dissecting microscope (from Market Science)

Lesson:
- Show degraded woodchips under dissecting microscope
- Kids should be excited if they observe something move. Ask them to draw what they observed.

Activity #4 – Power of microbes!

Desired Learning outcomes:
1. Recognize the diversity of microbes

Materials:
1. Bacteria grown on agar plates
2. Dissecting microscope
3. Slideshow presentation showing photos of bacteria cells (observed under 1000X)
4. Giant bacteria plush

Lesson:
- Show shapes of various bacteria isolated from woodchip bioreactors
- Explain how these bacteria look like under microscope

Pre-session trivia:

1. Excess nutrients can cause overgrowth of _____ in rivers, lakes, and oceans. (Level 1)
→ Answer: ALGAE. An increase in abundant plant growth, such as algae, depletes oxygen in the water environment and can cause fish die-offs. Excessive nutrient pollution in water systems is known as eutrophication.

2. Which of the following is considered as the largest source of nitrogen pollution in water? (Level 1)
   a. Agriculture
   b. Geese and other birds
   c. Stormwater
   d. Wastewater
   e. Home gardening
   → Answer: a. Fertilizers and livestock are the largest sources of nitrogen-based contaminants, like nitrogen oxides and ammonia. Nitrogen pollution contributes to the greenhouse effect and can be detrimental to aquatic life.

3. Bioreactors use the power of microbes to produce chemicals and to remove pollutants such as nitrate from water. Which of the following industry uses this technology the most (per volume basis)? (Level 2)
   a. Food and beverages
   b. Pharmaceuticals
   c. Petrochemicals (including bioethanol and biodiesel production)
   d. Wastewater treatment
   → Answer: d. In many places around the world, advancing bioreactor technology has been successfully applied to remove a number of pollutants during wastewater treatment processes.

4. A woodchip bioreactor is used to remove nitrate from water. What is the function of woodchips in this process? (Level 3)
   a. Woodchips are porous and function as filtration
   b. Woodchips serve as home and food for microbes
   c. No function, but a great way to recycle trees
   → b. Woodchips serve as home and food for microbes that naturally convert and remove pollutant nitrogen from the environment.

5. Some microbes reduce nitrate to N_2 gas. These microbes are called denitrifiers. We benefit from their activity with clean up water, but what is the benefit to the microbes that complete this process? (Level 4)
   a. Nitrate can be used as food by microbes
   b. N_2 gas can be used as food by microbes
   c. Nitrate is used in microbe respiration
   → c. Microbes breathe in nitrate and breath out N_2 gas, just like we breathe in oxygen and breathe out carbon dioxide. They can generate energy by this nitrate-respiration.

6. Which of the following most inhibit the activity of nitrate-removing microbes? (Level 5)
   a. Herbicides
   b. Pesticides
   c. Oxygen gas (O_2)
   d. Nitrogen gas (N_2)
   e. Light

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→ Answer: c. Nitrate-removing microbes grow in environments void of oxygen. These environments are known as anoxic environments. As denitrifying microbes respire, they use nitrate as a terminal electron acceptor. In aerobic, or oxygen-containing environments, oxygen is more energetically favored in respiration.

Recommended citation for this lesson plan:

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