Contributors

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Intended Audience

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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</thead>
<tbody>
<tr>
<td>K-4</td>
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<tr>
<td>5-8</td>
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</tr>
<tr>
<td>9-12</td>
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</table>

Activity Characteristics

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
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<tbody>
<tr>
<td>Classroom Setting</td>
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</tr>
<tr>
<td>Requires special equipment</td>
<td></td>
</tr>
<tr>
<td>Uses hands-on manipulatives</td>
<td>X</td>
</tr>
<tr>
<td>Requires mathematical skills</td>
<td></td>
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<tr>
<td>Can be performed individually</td>
<td>X</td>
</tr>
<tr>
<td>Requires group work</td>
<td></td>
</tr>
<tr>
<td>Requires more than one (45 min class) period</td>
<td>XXX</td>
</tr>
<tr>
<td>Appropriate for special needs student</td>
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</table>
Introduction

Description

Students add biotic and abiotic factors to a recycled soda bottle to create a closed ecosystem that they will later pollute and observe.

Abstract

In this activity, students construct an “ecosystem in a bottle” while identifying the biotic and abiotic factors and recognizing that, like Earth, their ecosystem is a closed system. After construction, the ecosystem is left in sunlight to grow for 2-3 weeks, then students make preliminary observations of their growing ecosystem, choose a pollutant to add, make predictions about the affects the pollutant will have, and finally make observations and conclusions about the affects 2-3 weeks later.

Core Themes Addressed

<table>
<thead>
<tr>
<th>Microbial Cell Biology</th>
<th></th>
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<tbody>
<tr>
<td>Microbial Genetics</td>
<td></td>
</tr>
<tr>
<td>Microorganisms and Humans</td>
<td>X</td>
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<tr>
<td>Microorganisms and the Environment</td>
<td>X</td>
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<tr>
<td>Microbial Evolution and Diversity</td>
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</tr>
<tr>
<td>Other -specify</td>
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</tbody>
</table>

Keywords

Biome, pollution, human impact, biotic and abiotic factors, closed system

Learning Objectives

At completion of this activity, learner will

1. Define biotic and abiotic factors and describe their interrelatedness within an ecosystem.
2. Explain what is meant by the term “closed system” as used to define their ecosystem and the Earth.
3. Analyze the effects of certain pollutants on ecosystems.
4. Propose ways to reduce pollution of ecosystems.
National Science Education Standards Addressed

Standard A: Science as Inquiry
- Abilities necessary to do scientific inquiry
- Understandings about scientific inquiry

Standard C: Life Science
- Interdependence of organisms
- Matter, energy, and organization in living systems

Standard D: Earth and space science
- Energy in the Earth system
- Geochemical cycles

Standard F: Science in personal and social perspectives
- Natural resources
- Environmental quality
- Natural and human induced hazards
Teacher Handout

Ecosystem in a Bottle

Student Prior Knowledge

Students should have a basic knowledge of what an ecosystem is and its necessary components. Students should be introduced to the different types of ecosystems found on Earth.

Teacher Background Information

This activity does not require any specific background knowledge.

Class Time

This activity will require a minimum of 3-4 class periods (example one 45 minute class period)

Teacher Preparation Time

This lesson will require approximately 30 minutes of preparation time for Day 1.

Day 1: Making the ecosystem in a bottle.

1. 2-liter soda bottles (1 per group) should be cut around the neck beforehand as this step can be time consuming and potentially hazardous for students.
2. It helps if appropriate amounts of potting soil and aquarium gravel are pre measured into zip top bags for students to pour into their bottles.
3. A watering can should be filled and the seeds to plant and any other biotic factors intended for use should be displayed in an organized fashion.

Day 2 (at least 2 weeks later ~20 minutes prep time):

Different pollutant mixtures should be laid out and labeled

Day 3 (at least 2 more weeks later):

No prep required other than having the rulers, etc ready for observations
Safety Precautions

Inform the students that the cut edges of the bottle are sharp enough to cut them. For day 2, several of the pollutants should be handled with care. Day 2 should take place in the lab and students should wear safety goggles and lab aprons and be told to not allow any of the pollutants to get onto their hands. Gloves, if available, would be a good idea.

Materials and Equipment

1. One empty 2-liter soda bottle per group
2. A roll of masking tape (enough to seal the necks of all the bottles)
3. Aquarium gravel (enough to place about one inch in the bottom of each bottle—about 1 cup per bottle).
4. Potting soil (or dirt) – enough for about 3 inches in the bottom of each bottle.
5. Sproutable bean seeds
6. Grass seed
7. Unsharpened wooden pencils—1 per group (for “digging” planting holes).
8. Plastic forks for plowing the soil back over the seeds
9. Watering cans with sprinkle spout
10. Any other seeds you would like to plant

Methods

Day 1: Building the ecosystem

1. Each group gets one 2-liter soda bottle that has been pre-cut by the teacher around the neck (cap required)

2. Each group adds aquarium gravel (about an inch) in the bottom of the bottle for drainage and then about 3 inches of potting soil (or any kind of dirt) on top of the gravel.

3. Use a fork to make little divots in the soil and add grass seed and any other selected plant seeds to the soil and gently rake dirt over this with the fork. (Tip: Seeds placed near the edge of the container will allow the roots to be visible through the bottle once the plants sprout.)

4. Other biotic factors (like snails or insects) or other abiotic factors (rocks) can be added based on teacher preference or student ideas.

5. Water the ecosystem until the soil is very damp. Too much water will cause mold to grow, but too little water will create drought conditions. It may be a good idea to have the different groups choose an amount of water they would like to add, measure it, and record it so that the ideal amount of water can be determined by comparison.
6. Turn the top part of the bottle upside down and seal with masking tape. You do not need to water the ecosystem anymore because it will actually rain inside the bottle once it is placed in the sunshine.

7. Place ecosystems in a sunny window and wait at least two weeks, but not more than a month to do "Day 2." You may have students take observations on them more often, however.

**Day 2: Pollution of the Ecosystem**

1. Emphasize to students the importance of good observations. Make sure they understand that the only way they will be able to accurately determine the effects of the pollutants is if they have detailed observations to compare their results to on the next day of the activity.

2. Pre-mix all of your pollutants and have them in labeled beakers on the front lab bench. You can use anything that you see fit, but suggestions include: weak bleach solution to simulate drained swimming pool water, very concentrated fertilizer solution, motor oil mixed with water, muddy water to simulate erosion (can add weed killer for more dramatic effects), weed killer solution, paint mixed with water, any household cleaner mixed with water, dish soap mixed with water, etc. The point of the activity is to highlight the effects of non-point source pollution, so anything that households may be dumping into the environment is good- just be sure to relate to the students where this pollutant would come from in the "real world."

2. Have students follow the lab sheet. Each group should choose a different pollutant so that comparisons can be made. The teacher should have his or her own ecosystem that receives no pollutants and thus serves as a control. BE SURE THAT STUDENTS MEASURE AMOUNT OF POLLUTANT ADDED. Tell students that they can add as much or as little of their pollutant as they want, but that they MUST MEASURE and RECORD how much they added so that comparisons can be made between classes.

**Day 3: Observe the Effects of the Pollutants and Draw Conclusions**

1. Have students take detailed measurements and observations of the components of their ecosystem and determine the ways in which each parameter has changed.

**Tips/Suggestions**

1. Go over proper scientific measuring techniques ahead of time.
2. "Round up" weed killer kills plants by "growing them to death." Therefore, a very small dose will actually act as a fertilizer and most likely make the ecosystem appear healthier.
References

This activity was modified from http://members.relia.net/thedane/ecosystem.html
Last accessed: April 23, 2013

Answers to Student Handouts

Many of the answers to the student sheets will vary as they are measurements, predictions, and observations. On day one, a lecture is included to introduce biomes and ecosystems and the lab sheet has fill-in-the-blank notes corresponding to the accompanying PowerPoint presentation and the blanks are completed below.

BIOMES

A ________BIOME_________ is a large region characterized by a specific type of climate and certain types of plants and animal communities. ______________ CLIMATE _________ includes both temperature and precipitation. There are nine different biomes we are going to discuss today. These biomes include: tropical rain forest, ______TEMPERATE_________ rain forest, temperate deciduous forest, taiga, ______SAVANNA_______, temperate grassland, chaparral, ______DESER T_________ and tundra.

The ______TROPICAL_______ rainforest has a humid & warm climate and typically receives 200-450 cm of rain per year. Areas of temperate rainforest are located in areas of North America, New Zealand, and Australia. The ______TEMPERATE_______ deciduous forest is characterized by the trees that drop their leaves each year. The ______TAIGA_______ biome has long winters, lasting 6-10 months. The ______SAVANNA_______ biome has a tropical climate and is dominated by grasses, shrubs, and small trees. The chaparral is characterized by little or no rain and low-lying evergreen shrubs. Desert regions accumulate little or no rain. The ______TUNDRA_______ biome has a permanent layer of frozen soil known as permafrost.

ECOSYSTEMS

Within each biome, there are multiple ecosystems. Ecosystems are smaller than biomes. An ecosystem is made up of a community of organisms and their ______ENVIRONMENT_____. An ecosystem contains both ______BIOTIC_______ (living) and abiotic (non living) components. Within an ecosystem, each organism has its own special role in the nutrient cycle (_______FOOD CHAIN______) and has specific effects on the environment itself and on the other organisms present in the system. This special role is called an organism’s ______NICHE______. An ecosystem is usually what scientists call a ______CLOSED_______ system. This means that everything that is taken out of the system will have an effect, and everything that is added to the system will have an effect. Ecosystems are a careful balancing act, and even ______SMALL_______ changes can be really bad.
Introduction

In this 3 day activity that will span over approximately 6 weeks, students will construct their own closed ecosystem in a bottle, pollute it, and document the affects of the pollutant through thorough observations taken before and after contamination.

Student Background Knowledge

This activity requires very little background knowledge as the student learns and explores throughout the activity. A grasp of the vocabulary below and an introduction to the pollutants offered in the second day is sufficient.

Vocabulary

Biome: A large region characterized by a specific type of climate and certain types of plants and animal communities.

Ecosystem: An ecosystem is made up of a community of organisms and their environment.

Abiotic factor: non-living components of an ecosystem like water, nitrogen, sunlight, and soil.

Biotic factor: living (or once living) components of an ecosystem like plants, animals, and bacteria.

Safety Considerations

The cut edges of the bottle are sharp enough to cut them. For day 2, several of the pollutants should be handled with care. Day 2 should take place in the lab and students should wear safety goggles and lab aprons and be told to not allow any of the pollutants to get onto their hands. Gloves, if available, would be a good idea.
Materials Checklist

| 1 per group | Empty 2-liter soda bottle, including cap, cut around the neck (about 4 inches below the cap, where the curvature ends) |
| 1 cup       | Aquarium gravel                                          |
| 2 cups      | Potting soil (or other dirt)                             |
| 6           | Bean seeds                                               |
| 1 teaspoon  | Grass seed                                               |
| 1 per group | Unsharpened, wooden pencils                              |
| 3 total     | Watering cans with sprinkle sprout                       |
| varies      | Other seeds, worms, insects, rocks, (anything else you would like to add). |

Procedure

Day 1: Building the ecosystem

1. Each group gets one 2-liter soda bottle that has been pre-cut by the teacher around the neck approximately 4 inches from the cap. (cap required)

2. Each group adds aquarium gravel (about an inch) in the bottom of the bottle for drainage and then about 3 inches of potting soil (or any kind of dirt) on top of the gravel.

3. Use a fork to make little divots in the soil and add grass seed and any other selected plant seeds to the soil and gently rake over with the fork. (tip: Seeds placed near the edge of the container will allow the roots to be visible through the bottle once the plants sprout.)

4. other biotic factors (like snails or insects) or other abiotic factors (rocks) can be added based on teacher preference or student ideas.

5. Water the ecosystem until the soil is very damp. Too much water will cause mold to grow, but too little water will create drought conditions. It may be a good idea to have the different groups choose an amount of water they would like to add, measure it, and record it so that the ideal amount of water can be determined by comparison.

6. Turn the top part of the bottle upside down and seal with masking tape. You do not need to water the ecosystem anymore because it will actually rain inside the bottle once it is placed in the sunshine.

7. Place ecosystems in a sunny window and wait at least two weeks, but not more than a month to do "Day 2."
Day 2: Pollution of the Ecosystem

1. When you first get your ecosystem, open it up (without damaging the bottle) and take careful and detailed observations by filling in the table and questions on your worksheet. The only way you will be able to accurately determine the effects of the pollutants is if you have detailed observations from before the ecosystem was polluted to compare to your observations after the ecosystem was polluted on the next day of the activity. It is important that you take your time and do a great job on this step.

2. As a group, choose which pollutant you will be adding to your ecosystem and how much. Write down everything you do and answer all worksheet questions.

3. BE SURE TO MEASURE AMOUNT OF POLLUTANT ADDED. You may add as much or as little of their pollutant as you want, but you MUST MEASURE and RECORD how much you add so that comparisons can be made between classes.

Day 3: Observe the Effects of the Pollutants and Draw Conclusions

1. Take detailed measurements and observations of the components of your ecosystem and determine the ways in which each parameter has changed.
Day 1: Constructing the Ecosystem in a Bottle

Student Worksheet

Name:_________________________ Date: Sept. 28, 2012
Period:_____________________

Environmental Science: Biomes and Ecosystems

Lecture:

BIOMES

A ____________________ is a large region characterized by a specific type of climate and certain types of plants and animal communities. _______________________ includes both temperature and precipitation. There are nine different biomes we are going to discuss today. These biomes include: tropical rain forest, ______________ rain forest, temperate deciduous forest, taiga, _______________, temperate grassland, chaparral, _____________ and tundra.

The ________________ rainforest has a humid & warm climate and typically receives 200-450 cm of rain per year. Areas of temperate rainforest are located in areas of North America, New Zealand, and Australia. The ________________ deciduous forest is characterized by the trees that drop their leaves each year. The ________________ biome has long winters, lasting 6-10 months. The _________________ biome has a tropical climate and is dominated by grasses, shrubs, and small trees. The chaparral is characterized by little or no rain and low-lying evergreen shrubs. Desert regions accumulate little or no rain. The _________________ biome has a permanent layer of frozen soil known as permafrost.

ECOSYSTEMS

Within each biome, there are multiple ecosystems. Ecosystems are smaller and ________________ than biomes. An ecosystem is made up of a community of organisms and their ___________________. An ecosystem contains both _________ (living) and abiotic (non living) components. Within an ecosystem, each organism has its own special role in the nutrient cycle (______________) and has specific affects on the environment itself and on the other organisms present in the system. This special role is called an organism's _____________. An ecosystem is usually what scientists call a ______________ system. This means that
everything that is taken out of the system will have an effect, and everything that is added to the system will have an effect. Ecosystems are a careful balancing act, and even _____________ changes can be really bad.

LAB: Building an Ecosystem in a bottle

Follow Ms. Perry through each step. We will be observing our ecosystems for the rest of the year.

Questions:
1. List the biotic factors we put in the bottle.

2. List the abiotic factors we put in the bottle.

3. True or False: There are many ecosystems in each biome.

4. True or False: There are many biomes in each ecosystem.
Student Worksheet

Day 2: Observations and pollution of the Ecosystem in a Bottle

Name: ______________________________ Date: Nov. 16, 2012 Period:______

Environmental Science: Human Impact: Ecosystem Pollution Experiments

Today's activity will take place in a science laboratory and all laboratory rules must be followed.

1) Safety goggles and lab aprons must be worn at all times.

2) No horseplay.

3) Follow all directions exactly as they are given.

First, you will record observations on the "ecosystem in a bottle" your group put together earlier in the year.

Examine your group's ecosystem and fill in the chart below:

Part I: Pre-pollution Ecosystem Observation:

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Detailed observation:</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of living plant species present</td>
<td></td>
</tr>
<tr>
<td>Question</td>
<td>Answer</td>
</tr>
<tr>
<td>------------------------------------------------------------------------</td>
<td>--------</td>
</tr>
<tr>
<td>Height of the tallest vegetation (in centimeters)</td>
<td></td>
</tr>
<tr>
<td>Total # of living herb stalks present (count all the shoots that are NOT grass)</td>
<td></td>
</tr>
<tr>
<td>Percent Ground Cover</td>
<td></td>
</tr>
<tr>
<td>(Looking in from the top, about how much of the soil is covered up with living vegetation)</td>
<td></td>
</tr>
<tr>
<td>About what percentage of the vegetation is already dead?</td>
<td></td>
</tr>
<tr>
<td>Is mold present?</td>
<td></td>
</tr>
<tr>
<td>(If yes, what affect is it having on the vegetation in your ecosystem?)</td>
<td></td>
</tr>
<tr>
<td>How tall (in centimeters) is MOST of the vegetation in the ecosystem?</td>
<td></td>
</tr>
<tr>
<td>What type of herb did your group plant?</td>
<td></td>
</tr>
</tbody>
</table>
Part II: Predictions and Pollution

Next, your group will decide what type of pollutant will be added to your ecosystem and make predictions about what will happen. We will observe the ecosystems again two weeks from today.

1. My group chose to pollute our ecosystem with ____________________________________________.

2. This pollutant enters real ecosystems by:
  ____________________________________________________________
  ____________________________________________________________
  ____________________________________________________________

3. Write at least 3 full sentences about what your group predicts will happen to your ecosystem as a result of the pollutant you are about to add. Include WHY you think these things will happen.
4. Amount of pollutant added:

Student Handout

**Day 3:** Observing affects of pollutants on the ecosystem and drawing conclusions

Name: ______________________________ Date: Nov. 16, 2012  Period: _______

**Environmental Science: Human Impact: Ecosystem Pollution**

**Experiments Part 2: Effects!**

Today you will see what effect (if any) the pollution you added to your ecosystem had on the organisms in your ecosystem. Examine your group's ecosystem and fill in the chart below:

**My group’s ecosystem was polluted with:** __________________________

**Amount:** _______________________

**Post pollution Ecosystem Observation:**

<table>
<thead>
<tr>
<th>Characteristic</th>
<th>Detailed Observation</th>
<th>More or less than before?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of living plant species present</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Height of the tallest vegetation (in centimeters)</td>
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### Questions:

1. Was your ecosystem positively or negatively affected by the pollution you added? Write at least 3 sentences about what happened/changed.
2. What effect do you think the pollutant you added would have on a real ecosystem? (at least 2 sentences)

3. How can you or people you know prevent this pollutant from entering our environment? (complete sentence)

4. How could you clean this pollutant out of your ecosystem?