Air Pollution-Detecting Gardens

3rd Grade

Standards
GPS S3L2
NGSS 3.LS4.C
GPS CCM if applicable

Time

Supplies
For the class:
- Milkweed seeds or plants

For each pair of students:
- small paper cups
- sharpened pencil
- petroleum jelly
- oregano or other spices
- balloons
- camera
- magnifying lens

Garden Connection
Students will grow milkweed in the garden to serve as a bio-indicator of ozone pollution and to provide food for monarch butterfly larvae.

STEM Connection
Students will make models of air pollution reduction devices, designed to capture particle pollutants.

Overview
Students will plant milkweed to create an ozone-monitoring garden in spring or fall, for the following year's class. At the beginning of the school year (late summer) students will monitor the milkweed planted by the previous year's class or observe other ozone–sensitive plants in the schoolyard to determine whether ozone levels got high enough to damage leaves. Students will also explore ways in which some pollutants can be reduced by making models of cyclone hoppers and electrostatic precipitators, which collect particle pollution before it escapes from smokestacks. Ground-level ozone cannot be mitigated this way, so students will brainstorm ways to reduce ozone by changing things people do. Students will contribute to a citizen science project by providing data from the study of their ozone-monitoring garden.

Essential Question
How can we tell if our air is polluted? And if so, what can we do about it?

Engaging Students
Students will watch a video about monarch butterflies, habitat loss and how monitoring sensitive bio-indicator plants can protect us from air pollution.

Exploration
Students will plant an ozone-detecting garden and conduct field investigations with bio-indicator plants like milkweed.

Explanation
Students will be able to explain how bio-indicators plants are the early warning system for pollution.

Environmental Stewardship
Students will contribute data to the national citizen science project: Hands On the Land.

Evaluation
A rubric is provided to assess student performance and understanding.

Extension
Students may conduct an indoor air pollution mitigation project.

Standards

Georgia Performance Standards in Science

S3L2. Students will recognize the effects of pollution and humans on the environment.
a. Explain the effects of pollution (such as littering) to the habitats of plants and animals.
b. Identify ways to protect the environment.
• Conservation of resources
• Recycling of materials

Next Generation Science Standards

3.LS4.C: Adaptation
For any particular environment, some kinds of organisms survive well, some survive less well, and some cannot survive at all. (3-LS4-3)

Teacher Preparation

Ground-level ozone is highest in summer when heat contributes to the formation of this pollutant. Therefore late summer or early fall (before frost) are the best times to find ozone leaf damage on sensitive plants (so-called bio-indicators), after ozone levels have been highest. Milkweed seeds can be planted in fall or spring and will grow throughout the summer until first frost.

Fall-planted seeds will experience freeze damage that helps them germinate in spring. Spring-planted seeds may need to be scarified with sandpaper in order to grow. If milkweed seeds were not previously planted in time for this activity, mature milkweed plants may be available from native plant societies, nurseries, or master gardener plant sales. Plant milkweed species that are native to your area. See Monarch Watch's list of native milkweed species: http://monarchwatch.org/bring-back-the-monarchs/milkweeds-by-state/.

If neither milkweed seeds nor plants are available, the class may select another sensitive species to monitor in fall, based on what plants are found in the garden or schoolyard. Among suitable species are choke cherry, black cherry, tulip tree, sycamore, dogbane, coneflower, flowering dogwood, and blackberry. For more information, refer to Using Sensitive Plants as Bio Indicators of Ground Level Ozone Air Pollution.

One misconception students may have is related to confusion between stratospheric (upper level) and tropospheric (ground level) ozone. It should be clarified that ozone in the stratosphere has the positive effect of blocking harmful ultraviolet (UV) rays from the sun. And ozone does not naturally occur at harmful levels in the troposphere (at ground level). However, on hot sunny days ozone can be formed near ground-level when nitrogen oxides from combustion engines and fumes from fossil fuels mixed. (More can be found about this topic at the Wisconsin Environmental Education web site).

PROCEDURES FOR LESSON ACTIVITIES

Day 1

Engagement (30 min)

Show the class this slide presentation about how they can become air pollution scientists, doing real science in the schoolyard by monitoring sensitive plants for signs of pollution. Focus on how students can distinguish ozone damage from other types of leaf damage, such as the chewing of monarch caterpillars.

Day 2

Exploration (45 – 60 minutes)

Planting an Ozone Detecting Garden

Allow students to research, plan, and plant an ozone-detecting garden for next year's class. (Milkweed will

attract monarch butterflies, in addition to providing bio-indicators for an ozone-detecting garden). Milkweed can be planted in fall or spring for the following school year. Prepare for collecting data outside by practicing estimation of extent of ozone damage on a leaf with this interactive online tutorial until student earns certificate of accuracy.

Day 3: 45 – 60 minutes

Field Investigation of Bio-Indicator Plants

Students should observe mature milkweed plants in late summer or early fall, or use an alternative bio-indicator plant that is also sensitive to ozone. (See Teacher Preparation section for details). Divide the class into teams of two. Each team will need a clipboard, pencil, and the Field Study Report form included with this lesson. Students will identify a bio-indicator plants and look for signs of leaf damage caused by ozone. After the field work, display team reports with corresponding photos and pressed leaves, so students can compare their results and get an overall picture of the health of milkweed plants in the ecosystem.

Day 4: 20 minutes

Encourage students to reflect on their research and field work to consider these questions: Does the condition of milkweed plants indicate that our air is polluted? *(answer will vary depending on location and season)* How do we know? *(ozone data map from research and milkweed monitoring results)* What are the first effects of ozone pollution on an ecosystem? *(sensitive plants may show damage before other components of ecosystem)* What effects cascade from the damage done to plants? *(scarcity of a plant limits the population of animals that depend on that plant for food and affects every other organism connected in a food web, in some way)* How could animals be affected by ozone pollution? *(indirectly, as a result of damage to plants on which they depend, and directly, in terms of their own respiratory health)* What are some ways that plants respond to pollution in an ecosystem? *(pollution-tolerant species may out-compete the pollution-sensitive species and become dominant in the area)* What are some ways that animals may respond to pollution in an ecosystem? *(migration, change in diet, increased competition for limited resources, starvation/decline in population)*

Day 5: 20 minutes

Making Models to Demonstrate Electrostatic Precipitators and Cyclone Hoppers

Students should work in pairs to make models of electrostatic precipitators by rubbing balloons against hair (to generate static electricity) and then collecting dried oregano, representing particle pollutants, by holding the balloons above the ground herb. Next, students can make models of cyclone hoppers by each applying petroleum jelly to the inside of a small paper cup (to represent a smokestack equipped with a cyclone hopper), sticking a sharpened pencil into the bottom of the cup as a handle, sprinkling oregano (particle pollutants) into the bottom of the cup, and spinning the cup to collect pollutants on the sides by centrifugal force. (For more information on these learning activities, check out this lesson from the Teach Engineering web site: Pollution Solutions). Ozone is invisible and cannot be collected and removed as easily as particle pollution, so it is important to prevent it from being formed in the first place. Ask students to brainstorm ideas for reducing ozone formation. (Ideas can be found at the Wisconsin Partners for Clean Air web site).

Explanation 20 minutes

Ask students to explain what they know about air pollution and its effects on plants, animals and ecosystems and highlight the following points, as they are made by students.

- Air pollution is a type of environmental change that affects entire ecosystems.
- Ground-level ozone is formed when pollutants from vehicle tailpipes react with vapors and fumes in the air on hot, sunny days. (It does not form on days without sun and heat).
- Ozone pollution hurts certain plants, including milkweed and many others.

- Ozone-damaged plants are an indicator that pollution levels are also high enough to affect humans, animals, and ecosystems.
- All organisms in an ecosystem are inter-connected.
- Air pollution can change an ecosystem by forcing organisms to adapt or die.
- If a plant cannot adapt quickly enough, it will die and be replaced by more pollution-tolerant species.
- Changes in the types of plants in a community will result in changes in the types of animals in the community, because plants provide shelter and food for the animals.
- If there are too few healthy milkweed plants and too many hungry monarch larvae (who only eat milkweed), the populations of both species will decline.
- Ozone pollution levels can be lowered by reducing vehicles' tailpipe emissions (i.e. more fuel-efficient vehicles, fewer miles driven, more carpooling, bus and bike riding, less time letting engines idle, etc.); reducing power plant emissions (by conserving energy and thus reducing demand for coal-fired electricity, cleaning smokestack emissions, etc.); and reducing release of vapors from volatile organic compounds (by patronizing "green" dry cleaners, fueling cars in the dark when gas fumes are less likely to evaporate, using low VOC paints, etc.).

  Students should be able to argue from evidence whether ozone pollution is detected by their sensitive plants, whether that means there is or is not any air pollution in their area, and how air pollution can be prevented as well as partially mitigated.

Environmental Stewardship

Contribute data from your school's ozone monitoring project to a national database, as part of an important citizen science research project. The Hands on the Land web site provides the protocol and details for data submission.

Evaluation

A rubric is provided to assess student competency in conducting the field investigation; understanding of the concept of plants as bio-indicators of air pollution; and ability to articulate human impacts on the environment and how they can be mitigated. In addition, students should be able to explain that plants which are bio-indicators of pollution are more pollution-sensitive than other species. If their environment becomes polluted, they are less likely to survive than more pollution-tolerant species. Over time, pollution could have the effect of changing the both the plants and the animals that live in an ecosystem, because the shift to more pollution-tolerant plants will provide habitat and food for different animals.

Extension

Grow plants in containers in the classroom, to mitigate the effects of airborne toxins. Indoor air pollution can harm human health just as outdoor air pollution can. Ask students to assess the classroom to see which building materials and furnishings could be releasing airborne toxins, according to the NASA Clean Air Study. Then select plants that have the ability to remove toxins from the air as they respire (breathe), and grow those species in pots near the best light.

Additional Resources:

Using Sensitive Plants as Bio Indicators of Ground Level Ozone Air Pollution
http://www.handsontheland.org/monitoring/projects/ozone/implementation_guide.pdf

Bio-indicator Monitoring slide show
http://dnr.wi.gov/org/caer/ce/eek/earth/field/biomon.htm

Sources of indoor airborne toxins and plants that can remove them from the air
http://www.denverplants.com/foliage/html/CleanAir3.htm

Directions for planting an ozone garden
http://aura.gsfc.nasa.gov/outreach/garden_getinvolved.html

Distinguishing ozone damage from other types of leaf damage
http://dnr.wi.gov/org/caer/ce/eek/earth/field/milkweed/slideshowindex.htm

Who eats milkweed?
http://www.monarchwatch.org/milkweed/damage.html

Interactive online training to estimate percentage ozone damage of a leaf
http://www.nature.nps.gov/air/edu/O3Training/index.cfm

How to submit a leaf damage photo to NASA for analysis
http://aura.gsfc.nasa.gov/outreach/garden_getinvolved.html

Ozone Bio-indicator Field Study Report

Identify plant species being studied: _____

Describe location where plant was found or planted: _____

Position of leaf on plant: Row ____ (# of row, counting down from top) of ____ (list total # leaf rows)

Observations

Describe general condition, coloring, damage to leaf:	Draw or trace leaf here (or indicate that drawing is on back, if leaf too large for this space). Show any damage, stippling, discoloration, holes, etc. using colored pencils.
_____ _____ Any black or purple dots? □yes □no Any dots on veins?* □yes □no Any dots under leaf?* □yes □no Any leaf yellowing (chlorosis)? □yes □no Is leaf wilted? □yes □no Is leaf dead (necrosis)? □yes □no Was leaf collected? (Attach.) □yes □no Was leaf photographed? □yes □no photo ref # , if any:	

Data

Approximately what percentage of the leaf is affected by ozone stippling, if any? _____

Conclusions

Has ozone air pollution affected this community of organisms (ecosystem)? □yes □no

What evidence supports your conclusion?

_____

Predictions

Predict how increased ozone levels might affect this ecosystem in the future.

_____

Predict what would happen to other plants and animals if milkweed became scarce or disappeared.

_____

_____

Assessment Air Pollution-Detecting Garden

Student Name(s): _____ **Date:** _____

Level of Mastery / Benchmark or Performance Measure	 **EMERGING** **Not yet proficient** **1 point**	 **COMPETENT** **Partially proficient** **4 points**	 **PROFICIENT** **Mastered task** **5 points**	**TOTAL POINTS**
Argumentation from Evidence	Student can name one impact of air pollution on an ecosystem	Student can name two impacts of air pollution on an ecosystem	Student can name three impacts of air pollution on an ecosystem	
Mastery of Field Study Techniques Needed to Accurately Collect Data	Student did not earn certificate of accuracy for estimating leaf damage through online tutorial	Student earned certificate of accuracy for estimating leaf damage through online tutorial	Student earned certificate of accuracy for estimating leaf damage through online tutorial	
Models of Air Pollution Mitigation Equipment	Students made a model of an electrostatic precipitator and cyclone hopper but could not explain how they worked and their limitations	Students made a model of an electrostatic precipitator and cyclone hopper and could explain how one model worked and its limitations	Students made a model of an electrostatic precipitator and cyclone hopper and could explain how both models worked and their limitations	
Plant an Ozone-Monitoring Garden	Made an effort to design garden but did not take field research into account	Designed a garden but your plan not selected	Design and build the garden	
Ozone Bio-Indicator Field Study Report	Students collected part of required data.	Students observed and collected all required data.	Students observed, collected data and reported it.	