Let It Rain: The Benefits of Rain Gardens

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INTRODUCTION

This lesson introduces students to the concept of rain gardens and why they are beneficial in cleaning up polluted waterways. Students will learn how and why rain gardens are created and then use their knowledge to build a model rain garden as part of a group.

LESSON OVERVIEW

Grade Level & Subject: Grades 9-12; Science

Length: 2 class periods: Class one: Introduction to rain gardens and preparation for lab
Class two: Rain Garden Lab

Objectives:
After completing this lesson, students will be able to:

- Explain what a rain garden is and why it is beneficial
- Understand how pollutants get into our waterways from storm water runoff
- Build a model rain garden

National Standards Addressed:
This lesson addresses the following National Education Standards[1]

- **Content Standard: NS.9-12.1 SCIENCE AS INQUIRY**
  As a result of activities in grades 9-12, all students should develop understanding of
  - Abilities necessary to do scientific inquiry
  - Understandings about scientific inquiry
- **Content Standard: NS.9-12.4 EARTH AND SPACE SCIENCE**
  As a result of activities in grades 9-12, all students should develop understanding of
  - Energy in the earth system
  - Geochemical cycles
  - Origin and evolution of the earth system
  - Origin and evolution of the universe
- **Content Standard: NS.9-12.6 PERSONAL AND SOCIAL PERSPECTIVES**
  As a result of activities in grades 9-12, all students should develop understanding of
  - Personal and community health
  - Population growth
  - Natural resources

[1] http://www.education-world.com/standards/

- Environmental quality
- Natural and human-induced hazards
- Science and technology in local, national, and global challenges

Materials Needed:
Class #1:

- Reproducible #1- **Rain Garden Diagrams**
- Reproducible #2- **Notes for Teacher**

Class #2

- Reproducible #3- **Rain Garden Lab**
- Materials for Model:
  - Sand
  - Gravel
  - Topsoil
  - Clay
  - Representation of trees/plants (small sticks, plastic, etc.)
  - Transparencies (or equivalent) to make sidewalks, blacktop areas, etc.
  - Baking pan or equivalent sized tub for each lab group
- Pitcher of water
- Optional: Prize for winning team (candy, a few extra credit points, etc)
- Reproducible #4- **Rain Garden Lab Teacher's Copy**

Assessment: Students will be assessed through the following activities:

- Reproducible #4- **Rain Garden Lab**
- Participation in group work and completion of rain garden model

LESSON BACKGROUND

Relevant Vocabulary:

- **Rain garden:** Gardens built with elements such as saucer-shaped depressions in the ground that are strategically placed to help catch and purify rainwater as it is absorbed back into the watershed.
- **Pollution:** Unnatural or harmful substances.
- **Filtration:** The process of removing matter from a liquid by means of porous media (materials with holes, various-sized).
- **Watershed:** Also known as catchment basins, these areas of land are defined by the flow patterns of rainwater or melting snow and ice; a geographic area where all water, sediments, and dissolved materials drain to a common outlet (stream, river system, reservoir, underground aquifer, or other body of water).
- **Permeability:** Describes how porous a material is and its capability for allowing water to pass through. Soils that allow water to flow through are more permeable than other soils that do not.
- **Porosity:** The volume of openings to the total volume of a material.
- **"Universal Solvent":** Another name for water - an excellent solvent (capable of dissolving other substances resulting in a solution) - because water can dissolve more substances within it

then any other liquid.

- **Bioremediation:** Process that uses microorganisms, fungi, green plants or their enzymes to return the natural environment altered by contaminants to its original condition.
- **Standing water:** Water that is not absorbed into the soil and sits on top of the landscape. It can be dangerous because it attracts breeding mosquitoes and bacteria.

Information:
Water is called the "universal solvent" because of all the substances that can be easily dissolved into it. As rainwater runs across impermeable surfaces such as pavement it picks up any dissolvable substance along the way. The runoff then carries this contaminated water into the soil and on to local waterways. It is the soil's job to filter the contaminants out, but if this is not done properly then the pollution follows as well. This can lead to contamination in local lakes, rives, ponds, etc. which are used for drinking water and recreational activities, as well as being a home for local wildlife. In some cases, the soil does not filter water at all, and this causes standing water that attracts mosquitoes and other pests, as well as bacteria and disease-causing vectors.

Government studies have shown that 70% of the pollution in local waterways is carried there by runoff from rainwater during a storm.[2] Rain gardens help with water filtration by catching rainwater and reducing runoff. They consist of permeable depressions in the ground that catch and absorb the rainwater, purifying it before it heads to local waterways. Rain gardens that are designed correctly also include local plants that can help filter the runoff and absorb harmful chemicals. It is through these processes that rain gardens bring purified water back into the local watershed.

Resources:
Information and tools for rain gardens:
http://www.kidsgardening.com/Dig/DigDetail.taf?ID=2140&Type=Art
Basics on rain gardens and how to build one:
http://www.raingardens.org/Index.php
More information on rain gardens:
http://www.chesapeakeecologycenter.org/chapter5.htm
Rain gardens:
www.raingardens.org

LESSON STEPS

Warm-up: *Thinking About Water*

1. Begin this lesson by discussing with your class the importance of water in our lives and the special properties that it has. Ask questions such as:
    a) Why is water called the "universal solvent"? (*Water is the liquid that can dissolve the most amount of substances due to its unique chemical makeup: 2 positive hydrogen molecules and one negative oxygen molecule*)[3]
    b) How might this relate to water pollution? *(Water dissolves and absorbs nearly every substance in comes into contact with, including chemicals, toxins and other forms of pollution. These*

[2] DC Schoolyard Greening. *Rain Gardens*. Retrived March 4, 2009 from http://www.dcschoolyardgreening.org/ gettingstarted/raingardens_about.htm

and other materials are carried with the water wherever it flows.)

c) What other special properties does water have? (*Neutral pH, found naturally as a liquid, solid and gas, high specific heat index, high surface tension, etc.*) [3]

d) What do we use water for? Where does our water come from and where does it go? (*Water is used in everything, from drinking water to agriculture and producing energy. Water comes from the local watershed such as lakes, rivers, and groundwater, as well as rain, snowmelt, and other forms of precipitation. Those of us in the US with running water get it from water treatment plants. Our water often returns to these sources, but also drains into gutters, ditches, sidewalks, rivers, streams, the ground, etc.*)

Activity One: *Introduction to Rain Gardens*

1. Pass out a copy of **Reproducible #1- Rain Garden Diagram** to each student, or project it up on the board to save paper.

2. Go through the diagram with students, explaining what a rain garden is and what it is used for. Use **Reproducible #2- Notes for Teacher** to make sure you are covering everything.

Activity Two: *Brainstorming Rain Gardens*

1. When you have finished introducing rain gardens, have students break into lab groups to discuss what they have learned. Pass out **Reproducible #3- Rain Garden Lab** and show them the materials they will use in the lab. Give them time as a group to look over the lab and start brainstorming ways that they will create their rain garden.

2. Homework Assignment (optional): Students should do additional research on rain gardens at home that night to help them move faster the next day. Mention that there will be a prize for whichever lab group creates the best rain garden.

Activity Three: *Lab - Designing a Rain Garden*

1. Set out supplies at each table or lab station, or have students collect all the materials they will need for their group (*clay, sand, gravel, etc.*).

2. Have students follow the directions in **Reproducible #3- Rain Garden Lab** to build and design their own model rain garden.

3. Walk around the room and encourage students to try a variety of different designs and to record what worked and what did not. Ask them to explain which design they think is the best and why.

4. When they are finished, have the students put their rain gardens on display at the front of the room. Take a pitcher of water and slowly pour some over each model, having students observe and record what happens for each model.

5. To conclude, go through each model with the class and discuss the strengths and weaknesses of each. What worked well? What didn't? Have students decide which model they thought

[3] "Water Science for Schools" United States Geological Survey. Retrieved March 12, 2009 from http://ga.water.usgs.gov/edu/waterproperties.html

was the best (based upon how water flowed in each rain garden). Optional: reward the winning lab group with a prize.

Wrap Up: ***Journal and Discussion***

1. Have students take a few minutes to write down what they learned from this lesson. Have them sketch the elements of the model rain gardens that were most effective. Also ask them to write down any questions that they still want answered about rain gardens. When they are finished, lead a discussion based upon what they wrote, and answer any questions that they still have. Connect rain gardens to the bigger picture of the water cycle and how doing something small in your backyard can make a big difference.

Extension: ***Take it Outside, Build a Rain Garden!***

Now that your class understands how rain gardens work have them build one at school! Groups of students can research different aspects, such as the best place to build, the type of soil needed, and the type of plants that would work best considering native species and bioremediation. Check out the following website for detailed instructions on creating a rain garden: www.raingardens.org

CONCLUSION

Rain gardens are a simple and natural way to filter and purify storm water before it enters local watersheds. By studying how rain gardens use soils and local plants to naturally remove contaminants from the water, students learn how making small changes to their landscape can help the world water supply as a whole. Students will also gain a better understanding of water's properties, the water cycle and the natural processes surrounding it.

Rainwater that runs off roofs, pavement, lawns, etc. can pick up pollutants along the way due to water's "universal solvent"

Outside the garden, rainwater hits the ground and runs off into nearby storm water drains that carry the water to local watersheds

Local plants with deep roots are used to absorb the most amount of water. They also require less maintenance

How shallow or deep the depression is will depend on how permeable the soil is. Better draining soils require a deeper depression and low drainage soils require a shallower depression

Rain garden soil should consists of 50-60% sand, 20-30% topsoil (no clay), and 20-30% compost

Picture: http://www.southviewdesign.com/images/RainGarden.jpg
Information: *Rain Gardens of West Michigan*. http://www.raingardens.org/Index.php

Teacher Notes for Let it Rain: the Benefits of Rain Gardens[4]

I. What is a Rain Garden?

a) Rain gardens are built as saucer shaped depressions in the ground that are strategically placed to help catch and purify rainwater as it is absorbed back into the watershed. They usually consist of native plants with deep roots that require little care and are adapted to the local climate. These roots hold soil in place to prevent erosion and absorb water into the plants. This water is filtered and used by the plants.

II. Why are rain gardens important?

a) Rain gardens help to filter storm water, which can be very high in pollutants. According to the EPA, 70% of all water pollution occurs through runoff from storm water. The ability of rain gardens to filter storm water depends on the porosity of the materials in the soil.

b) Porosity is the volume of openings to the total volume of a material. In the case of soil, porosity depends upon the size of the grains making up the material, which in turn affects the amount of space in the material. Materials with smaller grains and less space will catch contaminants and allow the water to filter through, while those with bigger grains and more space may not be as successful in filtering out pollution.
    a. For example, sandy soils have tiny grains and will filter water better because the small spaces only allow the water through.
    b. Materials such as gravel however, consist of bigger grains of material, meaning that the water flows through fast but does not always filter out contaminants. Clay is an example of a material that has very low porosity, and although it will catch the contaminants, it will also take awhile for the water to filter through.

c) Depending on the particle size, density and porosity of the soil (ex. varying mixtures of soil, clay, sand, gravel, etc.) and the amount of rainfall in the area, water will filter through the rain garden more or less quickly. Smaller particles have more surface area and will filter water more thoroughly, but will also take longer to do so. Increasing particle size in areas with heavy rainfall will reduce the likelihood of standing water. Standing water is not absorbed into the soil and sits on top of the landscape. It can be dangerous because it attracts breeding mosquitoes and bacteria.

d) Using certain plants in rain gardens can also contribute to purifying the water and soil through bioremediation. Bioremediation is a process that uses microorganisms, fungi, green plants or their enzymes to return the natural environment altered by contaminants to its original condition. Certain plants naturally reduce toxins in the soil, and by planting these in the rain garden they will remove unsafe chemicals from the soil and prevent contaminants from being dissolved in the rainwater that filters through. An example of this is sunflowers, which eliminate lead toxins in the soil.

III. How does storm water affect the local watershed?

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[4] Notes were created from the information at http://www.raingardens.org/FAQ.php. *Rain gardens of West Michigan*. Retrieved March 16, 2009.

a) Water is the "universal solvent" because it is able to absorb the most amounts of substances compared to other liquids. This means that basically anything water runs over it will be able to pick up. As rainwater falls onto our pavement, roofs, and lawns instead of being absorbed right back into the soil, it picks up pollutants that it carries into local storm drains. These pollutants are detrimental to human and wildlife health, and can also negatively impact local ecosystems.
b) Local waterways are usually replenished by a slow release of groundwater into rivers and streams. In contrast, storm water moves much more quickly into the watershed, causing erosion and flooding. Storm water is also usually warmer then the water in the local streams and rivers that it enters, causing problems for aquatic species whose survival depends upon a certain water temperature. Warmer water also means less oxygen that can be held in it, making it harder for aquatic species to survive. Rain gardens slow down the process so water that enters storm drains is cooler and moves more slowly.

IV. Where should rain gardens be built?

a) Rain gardens can be built anywhere, but they will be most successful in a place where rainwater regularly flows. Low areas where storm water ends up flowing into the local watershed or forming standing water are a great place to start. Following the natural flow of the rainwater across the landscape is the best way to determine which place to put a rain garden.
b) Soil type is very important in rain gardens because it needs to be able to absorb the water slowly enough to purify it, while still being fast enough to prevent standing water. The type of soil in a rain garden will determine how much water it is able to absorb. For instance, clay soil is very dense and does not absorb water very well, while sand, gravel, and topsoil will be more permeable. The perfect soil for a rain garden consists of 50-60% sand, 20-30% topsoil (no clay), and 20-30% compost.[5]
c) Depending upon the level of rainfall and the type of soil used, the depression in the rain garden will either need to be deeper or shallower. If the soil has poor drainage qualities, then the depression should be shallower so less standing water occurs. However, a deeper depression will be needed for soils that quickly retain water.

V. Looking at the Big Picture

a) Water that falls as raindrops and flows into local waterways is a part of the water cycle that carries water to all different places around the world. Installing a rain garden not only helps local ecosystems, but in a small way also helps the world's water supply to become cleaner.

[5] "Evaluate the Soil," *Rain gardens of West Michig*an Retrieved March 16, 2009 from http://www.raingardens.org/Evaluate_the_Soil.php.

Name_____
Date_____
Hour_____

Rain Garden Lab

Introduction: Rain gardens help to filter and purify rainwater so that it does not carry pollutants with it into the watershed. In this lab, you will create your own rain garden model by using different soil types and additional materials. The point is to create a working rain garden by using all of the materials given to you. At the end of the lab, all groups will pour water over their rain garden model to see whose works the best.

Materials:

- Sand
- Gravel
- Topsoil
- Clay
- Representation of trees/plants (small sticks, plastic, etc.)
- Transparencies (or equivalent) to make sidewalks, blacktop areas, etc.
- Baking pan or equivalent sized tub for each lab group

Instructions:

1. Start by assembling all the materials on your desk and looking them over to familiarize yourself with them. Place about a handful of each of the four soil materials separately in the pan. Pour a small amount of water over each and observe their permeability. Does the water soak through the soil? Does it happen quickly or slowly? Do you think that this material would make a good soil for a rain garden? Why or Why not?

   Gravel:

   Clay:

   Topsoil:

   Sand:

2. Using the different types of soil and your baking pan create a model of a rain garden and the surrounding landscape. Think about how to layer or mix the materials. Create elevation such as hills, valleys, and any other landscape feature that you think would affect rain gardens. Don't forget to add in your sidewalks, footpaths and trees! Think about what you learned yesterday in the introduction to rain gardens and apply it to your models.

   When you have completed your rain garden, draw a cross-section, or side view and explain why your group designed your garden this way.

3. Once every group is done, watch as your teacher pours water over each model. Record your observations in the chart below and then answer the questions

Model Name or #	Observations

Did your model work the way that you thought it would? What would you change on your model if you could?

Which model did you think worked the best? Why do you think that?

What model did you think was the least effective? Why?

Did your model have many impervious surfaces such as sidewalks or footpaths? How did this affect the water absorption or runoff? How could you improve the permeability of these areas?

The model plants and trees might not have had a significant effect on the model, but what role do they play in relationship to a real rain garden?

What type of plants should you use in a rain garden? How are these helpful in reducing water pollution?

If the water is not filtered into the soil at all it forms standing water. What are some problems with standing water?

Which type of soil do you think would be the best at filtering out pollution? Why?

Overall, what soils did you find to be most helpful in the rain garden? Did you try to mix the soils? If so, did that help? If not, do you think it would help?

Would it have made a difference to layer the soil materials in a different order? Why or why not?

Did the elevation have much to do with the rate of water runoff?

Name_____
Date_____
Hour_____

Rain Garden Lab- TEACHER'S COPY

Introduction: Rain gardens help to filter and purify rainwater so that it does not carry pollutants with it into the watershed. In this lab, you will create your own rain garden model by using different soil types and additional materials. The point is to create a working rain garden by using all of the materials given to you. At the end of the lab, all groups will pour water over their rain garden model to see whose works the best.

Materials:

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- Baking pan or equivalent sized tub for each lab group

Instructions:

1. Start by assembling all the materials on your desk and looking them over to familiarize yourself with them. Place about a handful of each of the four soil materials separately in the pan. Pour some water over each and observe their permeability. Does the water soak through the soil? Does it happen fast or slow? Do you think that this material would make a good soil for a rain garden? Why or Why not?
   Answers will depend upon student observations. In general, clay should be slower then gravel, and topsoil and sand will be in between.

   Gravel:

   Clay:

   Topsoil:

Sand:

2. Using the different types of soil and your baking pan create a model of a rain garden and the surrounding landscape. Think about how to layer or mix the materials. Create elevation such as hills, valleys, and any other landscape feature that you think would affect rain gardens. Don't forget to add in your sidewalks, footpaths and trees! Think about what you learned yesterday in the introduction to rain gardens and apply it to your models.

   When you have completed your rain garden, draw a cross-section, or side view and explain why your group designed your garden this way.

   Answers and drawings will vary by group.

3. Once every group is done, watch as your teacher pours water over each model. Record your observations in the chart below and then answer the questions

Model #	Observations

Did your model work the way that you thought it would? What would you change on your model if you could?

Answers will vary. Might include something like: I would change the way I layered the soil, or I would add in a higher elevation.

Which model did you think worked the best? Why do you think that?

Answers will vary.

What model did you think was the least effective? Why?

Answers will vary.

Did your model have many impervious surfaces such as sidewalks or footpaths? How did this affect the water absorption or runoff? How could you improve the permeability of these areas?

Impervious surfaces will cause runoff that can add pollution to the water. The natural flow of water will be disturbed and it will have to be absorbed elsewhere. Changing the material that the area is made of, or reducing the amount of area it covers, could help improve permeability.

The model plants and trees might not have had a significant effect on the model, but what role do they play in relationship to a real rain garden?

Plants and trees will absorb water in their roots. They can also filter out contaminants through the process of bioremediation.

What type of plants should you use in a rain garden? How are these helpful in reducing water pollution?

You should use plants that have long roots in a rain garden so they help to absorb the water. Plants that take in toxins, such as sunflowers that absorb lead, are also helpful to filter the water. Native plants should be used so that they involve little care and are more likely to survive.

If the water is not filtered into the soil at all it forms standing water. What are some problems with standing water?
Standing water can be dangerous because it attracts pests such as mosquitoes, and can harvest many forms of bacteria.

Which type of soil do you think would be the best at filtering out pollution? Why?

Sand and topsoil generally work the best because they have a small enough porosity to catch and filter pollution in the water, but they are still permeable enough to allow the water to flow through.

Overall, what soils did you find to be most helpful in the rain garden? Did you try to mix the soils? If so, did that help? If not, do you think it would help?

Answers may vary.

Would it have made a difference to layer the soil materials in a different order? Why or why not?

Answers may vary.

Did the elevation have much to do with the rate of water runoff?

Yes- a higher elevation means that water will runoff more quickly because there is a steeper slope.