Go with the Flow!

lesson packet

Purple Plow

Uncovering STEM Solutions

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What is runoff?

Lesson Length: 1 hour

National Learning Standards:

Elementary School: NGSS.5-ESS3-1. NGSS.5-ESS3.C, CCSS.ELA-LITERACY.RI.5.9

Middle School: NGSS.MS-ESS2-2, NGSS.MS-ESS2-4, CCSS.ELA-LITERACY.W.5.7

High School: NGSS.HS-ESS3-4, NGSS.HS-ESS3-6, CCSS.ELA-LITERACY.SL.9-10.4

Learning Objectives:

1. Students will define and investigate runoff.
2. Students will gain knowledge of pollution and other materials found in runoff and how we all contribute to it.

Key Terms:

Runoff, permeability, water cycle, vegetation, pollution, infiltration, precipitation, impervious

Background Information:

Runoff is a natural part of the water cycle. It is the water that flows over the land as surface water instead of being absorbed as groundwater or evaporating. Runoff is part of precipitation, snow melt, or irrigation water that appears in rivers, streams, drains, or sewers. It then flows to major bodies of water, picking up pollutants such as trash, oil, and fertilizers as it moves.
You can learn more runoff basics here: https://youtu.be/aWsnTtT0Uws

Materials:

- Poster board
- Construction paper
- Crayons, markers, colored pencils
- Computer with internet access

Introduction (Anticipatory set): (10 minutes)

1. Introduce the concept of runoff to the class and connect it to the Purple Plow Challenge.
    a. Who remembers what our challenge question is? What do you know about the water cycle and runoff?
    b. Today we will explore some basic terms and facts about runoff.
2. Dive deeper into terms and basics through a short explanation and discussion.
    a. "Runoff is a natural part of our water cycle. Some of the water from precipitation, snow melt or irrigation will be soaked into the ground as ground water. But what aabout the water that isn't soaked into the ground? Where does it go? Today we are going to discuss runoff on impervious surfaces and the things we can find in our runoff."
    b. "Impervious surfaces such as roofs, roads, sidewalk, parking lots, and industrial areas like airports and distribution centers are covered with impervious material such as asphalt. The runoff from these areas can't be soaked into the ground. The water picks up pollutants from that surface and carries it to nearby sewers, rivers, and streams. This is causing our water ways to become more and more polluted. Even pervious surfaces like grasses and farmland will have runoff when the amount of rainfall is happening faster than the ground can take it in. Fertilizers and other chemicals are then picked up in the runoff and carried to local streams and rivers."
3. Write the following phrases on the board:
    a. What is runoff?
        (a) Runoff is a natural part of the water cycle.
        (b) It is the water that from precipitation, snow melt and irrigation that isn't soaked into the ground.
        (c) Pollutants from impervious surfaces such as roofs, driveways and sidewalks are in the runoff.
    b. Where does it come from and where is it going?
        (a) Runoff comes from precipitation, snow melt, and irrigation.
        (b) Runoff collects the pollutants it flows over such as fertilizers, trash, oil, and other chemicals as it flows to nearby sewers, streams, rivers, lakes and oceans.

c. What's happening once it gets there?

(a) The polluted runoff mixes in with our ocean waters and effects the quality of the water and the habitat of the animals living in the water.

Input and Modeling: (5 minutes)

4. Divide students into groups of three to four.
5. Distribute materials to make a poster.
6. Assign each group to draw the "runoff cycle" in an urban or rural setting. Tell students that their posters should share important information in a creative and eye-catching manner.

Independent Practice: (30 minutes)

7. Allow students time to research, explore, plan, and create their posters.

Wrap-Up (Review, Assess, Challenge): (15 minutes)

8. Allow students to share their posters and discuss runoff in both urban and rural settings. Display the posters for others to see after groups have shared with the class.

Where's My Runoff Running Off To?

Lesson Length: Approximately 120 minutes or two, 1-hour class periods

National Learning Standards:

Elementary School: NGSS.5-ESS2-1, NGSS.5-ESS3-1, CCSS.ELA-LITERACY.W.5.2

Middle School: NGSS.MS-ESS2.C.1, CCSS.ELA-LITERACY.RST.6-8.1, CCSS.ELA-LITERACY.WHST.6-8.7

High School: NGSS.HS-ESS3-4, NGSS.HS-ESS3-6, CCSS.ELA-LITERACY.SL.9-10.4

Learning Objectives:

1. Students will define a watershed and/or drainage basin.
2. Students will explain a watershed and/or drainage basin's connection to the ocean.
3. Students will create a map of a major watershed and/or drainage basin.

Key Terms:

Drainage basin, watershed, tributary, estuary, water cycle, runoff

Background Information:

When precipitation collects and drains to a common outlet, we call this a drainage basin or watershed. Every lake, stream, river, etc. has a watershed. These ecosystems are important "because the streamflow and the water quality of a river are affected by things, human-induced or not, happening in the land area "above" the river-outflow point," according to the U.S. Geological Society.

Materials:

- Computers with access to internet
- PowerPoint, Google Slides, etc.
- Large construction paper or poster board
- Markers, crayons, colored pencils, etc.

Introduction (Anticipatory set): (5 minutes)

1. Project a map of your location on an interactive whiteboard or point to your location on a map. Explain that the water where you live is connected to the ocean.
2. Introduce the term "watershed." Ask students what they think the word means. Then explain that a watershed is an area of land that drains all streams and rivers to a common outlet.
3. Explain that due to the water cycle, all water is connected to the oceans. For example, "When precipitation falls over the land surface, it follows various routes in its subsequent paths. Some of it evaporates, returning to the atmosphere; some seeps into the ground as soil moisture or groundwater; and some runs off into rivers and streams. Almost all of the water eventually flows into the oceans, where the cycle continues."[1]

Input and Modeling: (5 minutes)

4. Put students into groups of two or three.
5. Explain that each group will choose a location on Earth and create a map that shows that location's watershed.
6. Share the following links with the class and explain that each team should create a two to three slide presentation that defines the concept of a watershed/drainage basin to accompany their map.
   a. https://www.nationalgeographic.org/encyclopedia/watershed/
   b. https://www.usgs.gov/special-topic/water-science-school/science/watersheds-and-drainage-basins?qt-science_center_objects=0#qt-science_center_objects
   c. https://oceanservice.noaa.gov/facts/watershed.html

Independent Practice: (50 minutes)

7. Allow for students to discuss, research, and take notes as well as create their map and summary presentations

Wrap-Up (Review, Assess, Challenge): (60 minutes)

8. Each team shares their short presentation and their chosen watershed.

References:

[1] https://earthobservatory.nasa.gov/features/Water/page2.php

How Runoff affects water quality and the rise of hypoxic zones

Lesson Length: 1 hour

National Learning Standards:

Elementary School: NGSS.5-ESS3-1.C, CCSS.ELA-LITERACY.W.5.7, CCSS.ELA-LITERACY.W.5.7

Middle School: NGSS.MS-ESS3-3, NGSS.MS-ESS3-4, CCSS.ELA-LITERACY.W.5.7

High School: NGSS.HS-ESS3-4, NGSS.HS-ESS3-6, CCSS.ELA-LITERACY.SL.9-10.4

Learning Objectives:

1. Students will discover and identify hypoxic zones worldwide.
2. Students will research water quality as it relates to underwater life quality.
3. Students will begin to synthesis all the contributions to polluted runoff and what has already been done to protect our water.

Key Terms:

Hypoxic zones, dead zones, eutrophication, water quality, nitrogen, phosphorus, algae blooms

Background Information:

Hypoxia is a term used to describe the depletion of oxygen. It is an environmental phenomenon in which oxygen levels decrease to a point in which the aquatic environment can no longer support aquatic organisms. Hypoxic zones are occurring all over the world in our lakes and oceans. Human activity is the largest reason we are dealing with this issue.

Materials:

- Computers with access to internet
- Materials for note taking

Introduction (Anticipatory set): (10 minutes)

1. Remember that in our previous lesson we discovered that all water is connected to the oceans through the water cycle, and that water reaches various locations through rivers and tributaries; sharing a common outlet called a watershed or drainage basin.
2. "Today we will explore how runoff is effecting water quality all over the world and the rise of hypoxic zones." Write the following categories on the board and ask students to identify practices that contribute to polluted runoff:
    a. Home practices: (lawn fertilizer, oil, grease, pet waste, etc.)
    b. Agricultural practices: (fertilizers, pesticides, manure, etc.)
    c. Industry practices: (heavy metals from roofs and other materials, thermal pollution from dark impervious surfaces, etc.)
3. "As these materials make their way to our lakes and oceans, they are causing a rise in nitrogen and phosphorus. The rise in these nutrients increase production of things like seaweed and algae blooms. As the algae blooms grow it results in less sunlight penetrating the water and a lack of oxygen for the animals that live there."
4. "Today you will work in groups to research the world's largest dead zones in each continent and what is happening to the animals that live there. Discuss with your group the potential causes of the polluted runoff and if anything has been done to improve the water quality there."

Input and Modeling: (5 minutes)

5. Put students into 7 groups.
6. Assign a continent to each group.
7. Each group will research hypoxic zones for that continent, noting the largest hypoxic zone for the area and prepare to present their findings to the class. You might choose to share the following links to get students started:
    a. https://oceanservice.noaa.gov/facts/deadzone.html
    b. https://www.scientificamerican.com/article/ocean-dead-zones/
    c. https://www.nationalgeographic.com/environment/oceans/dead-zones/
    d. https://www.vims.edu/research/topics/dead_zones/index.php

Independent Practice: (30 minutes)

8. Allow for students to discuss, research and take note of the largest hypoxic zones in the world and reasons why.

Wrap-Up (Review, Assess, Challenge): (15 minutes)

9. Discuss and begin drawing conclusions through comparisons of hypoxic zones as to why they are so large in certain parts of the world. Begin discussions on what has already been done in those areas to protect the quality of the water.

References:

https://www3.epa.gov/npdes/pubs/nps_urban-facts_final.pdf

https://www.usgs.gov/special-topic/water-science-school/science/runoff-surface-and-overland-water-runoff?qt-science_center_objects=0#qt-science_center_objects

https://copperriver.org/programs/dont-run-off-salmon/how-does-stormwater-run-off-affect-rural-communities/

Solutions already in place.

Lesson Length: 1 hour

National Learning Standards:

Elementary School: NGSS.5-ESS3-1, NGSS.5-ESS3-1.C, CCSS.ELA-LITERACY.RI.5.9

Middle School: NGSS.MS-ESS3-3, NGSS.MS-ESS3-4, CCSS.ELA-LITERACY.W.5.7

High School: NGSS.HS-ESS3-4, NGSS.HS-ESS3-6, CCSS.ELA-LITERACY.SL.9-10.4

Learning Objectives:

1. Students will learn about solutions for runoff issues.
2. Students will be able to explain how humans use ideas from science and engineering to protect, control, and make use of natural resources.
3. Students will research the impact humans have on an environment.

Key Terms:

Permeability, impervious, vegetation, runoff, erosion

Background Information:

We know that runoff is naturally occurring, but we can have more control over what is in the runoff. Protecting clean drinking water, lakes, and oceans from an overabundance of nutrients like phosphorus and nitrogen is a problem we should all be thinking about solving. There are steps we all can be taking. This lesson explores what has already been done to protect the quality of our water and what can still be done.

Materials:

- Computers with internet access
- Note taking materials
- Activity sheet

Introduction (Anticipatory set): (10 minutes)

1. "Today, we will begin to research the solutions that are already in place for issues like hypoxic zones because of polluted runoff." Write the following on the board in three columns:
    a. What do we know is being done already to help control runoff issues?
    b. What questions do we need answered?
    c. What are some solutions currently being used to address the problem?
2. Ask students to answer the question, "What do we know is being done to help control runoff issues?" Record student answers.
3. Ask the students to generate questions they need or want answered about addressing runoff issues and record their responses in the second column under the question, "What questions do we need answered?"

Input and Modeling: (5 minutes)

4. Break students into small groups.
5. Explain to the students that they will use their time to explore the solutions scientists and engineers are already using to address runoff issues. Use the following links to get them started:
    a. https://www.nationalgeographic.org/encyclopedia/runoff/
    b. https://www.epa.gov/nutrientpollution/sources-and-solutions-stormwater
    c. https://www.cbf.org/issues/polluted-runoff/solutions/
    d. https://www.rivernetwork.org/our-work/clean-water/best-practices/managing-urban-runoff/
6. Students should be prepared to present their solutions to the class.

Independent Practice: (30 minutes)

7. Students begin to research, analyze, and record ideas to share with the class.

Wrap-Up (Review, Assess, Challenge): (15 minutes)

8. Students present the solutions they learned about for the prevention or reduction of polluted runoff and discuss these solutions with the class.

9. Record student responses in the last column under the question, "What are some solutions currently being used to address the problem?" Connect students' responses to the current Purple Plow Challenge, and use these responses as a way to start brainstorming new and innovative solutions which the students might pursue in completing the design challenge.

References:

https://www.nationalgeographic.org/encyclopedia/runoff/
https://www.epa.gov/nutrientpollution/sources-and-solutions-stormwater
https://www.cbf.org/issues/polluted-runoff/solutions/
https://www.rivernetwork.org/our-work/clean-water/best-practices/managing-urban-runoff/

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