Lesson Name: What’s in our Stormwater?

Grade Level Connection(s)

NGSS Standards: 4-PS4-3: “General and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.”

FOSS CA Edition: W.4.7: Conduct short research projects that build knowledge through investigation of different aspects of a topic.

*Note to teachers: Detailed standards connections can be found at the end of this lesson plan.

Teaser/Overview

When water falls from the sky, it’s gotta go somewhere! When rain hits the Earth, it becomes known as stormwater runoff. In cities and other urbanized areas, stormwater flows over structures like building roofs, streets, sidewalks, and parking lots, picking up various contaminants (trash, dog poop, salts, chemicals, etc.) along its path to the nearest river, lake, or ocean. As scientists, engineers, and city planners, we must strive to protect these water bodies from an influx of human-related contaminants in order to protect the health and well-being of wildlife and our fellow humans.

Students will be designing a stormwater filtration system. The goal is to make the water as clean as possible, and to make the water flow rate as high as possible.

Lesson Objectives

Students will:
- Understand how stormwater runoff can negatively affect the water cycle
- Explore how different types of filter media (e.g., gravel, sand, activated carbon) impact flow rates and water quality by building small columns of a single type of media and running “dirty” water through them
- Design and construct a multi-layer geo-media filtration system in a small column, optimizing for flow rate and effluent water quality
Vocabulary Words

- Stormwater
- Contaminant
- Filter media
- Activated carbon
- Flow rate

Materials

Scientist Volunteers will bring:

Media types
- Gravel
- Sand
- Charcoal (similar to “activated carbon”)
- Dixie cup (to hand out the media = 3 per team)

Stormwater contaminants
- Brown sprinkles (poop / litter)
- Pepper (suspended solids, dirt -- for turbidity)
- Oil (fats, oils, greases)
- Food dye (chemicals)

In each team bucket
- 1 clear plastic cup
- 1 small plastic tray
- 1 Odwalla bottle (measuring bottle; labeled with “Line 1” and “Line 2”)
- Coffee filters (5 per team)
- Funnels (to pour water into columns = 1 per team)
- Filter column set up materials
  - 3 Odwalla bottles (see photo)
  - Netting to support media
  - Rubber bands (maybe?)

Classroom Set-Up

Students should be arranged into groups of (4).

Before class:
- Pour gravels, sand, activated carbon into a red solo cup, one per team
● Fill up a large see-through pitcher with clear drinking water

### 1. Introduction (10 minutes)

**Role Model Introduction:**

*Who are we as a group?*
- ReNUWIt! We use science and engineering to make our water resources cleaner and more sustainable. Can anybody tell us what sustainability means?

*Role model introduction (30-60s per person)*
- Who are we?
- What “grade” are we?
- What hobbies do we have?
- What did we want to be when we grew up, when we were their age?
- What kinds of science projects, etc did we do in elementary school?
- What most interests us about our research?

**Topic Introduction:**

One primary engineering method to protect water bodies from contaminated storm flows is **stormwater capture and treatment**. City planners are now starting to think about ways to reduce the amount of stormwater runoff that spills onto streets and floods basements, and more importantly, ways to treat stormwater runoff before it pollutes our rivers and lakes. They do this in a couple of ways (show slide with “best management practices). By building these large stormwater basins, or spaces where stormwater runoff is directed off of the street and into these structures. They can be large like this one (point to picture) or small like these systems built in shopping mall parking lots (point to other pictures).

There are some natural processes that can help remove contaminants in these basins...but a large amount of the contaminants will not be removed or broken down before the collected stormwater makes contact with our rivers and lakes. That’s why we at Berkeley are designing new materials that can be added to these systems to increase contaminant removal in stormwater!

We can create layers of these materials to help filter contaminants as the stormwater flows through the soil so that we don’t pollute our rivers, lakes and oceans with the incoming stormwater.

Through a combination of designing, constructing, and testing of small-scale filtration columns, students will explore from an engineer’s perspective how different types of filter media will impact the performance of a simulated stormwater filtration system.

### Classroom Visit
Important ideas:

- Water will flow faster through gravel or sand than through activated carbon, but sand and gravel will remove less contaminants than activated carbon.
- Filters “capture” particulate contaminants easily, even with materials like gravel.
- Dissolved contaminants won’t be removed by simple materials like sand - activated carbon should remove them!

2. Learning Experience (35 minutes)

Contamination of Stormwater (start PowerPoint; demonstration activity)

- Hold up the pitcher of clear drinking water. Ask the whole class:
  - Where did this water come from?
    - Tip: Students may give answers about the water’s immediate source (e.g., the faucet, the water fountain, a bottle)--ask probing questions and encourage them to think about the fact that the water originally came from a body of water such as a lake, river, or reservoir. The source may be nearby or even hundreds of miles away!
  - How do we know this water is safe to drink?
    - Possible Answers: It’s clear, tastes good, smells good. Nothing floating in it. Scientists test the water!
  - Have you ever seen water that you wouldn’t drink? Where did you see it, and what made you not want to drink it?
  - When it rains, water flows across the surface of the Earth. What are some possible contaminants the water?
    - Possible Answers: Trash, chemicals from factories, motor oil and salts from roads, fertilizers and animal waste from farms or dog poop on streets, animal waste in the mountains, soil
  - Where does the stormwater eventually go? How might these contaminants hurt wildlife there?
  - Let’s create our dirty stormwater! Add and say out loud:
    - Brown sprinkles (poop / litter)
    - Pepper (suspended solids, dirt -- for turbidity)
    - Oil (fats, oils, greases)
    - Food dye (chemicals)

Stormwater Treatment (continue PowerPoint)

- Overview of Today’s Activity: you will be designing a stormwater filtration system. Your goal is to make the water as clean as possible, and to make the water flow rate as high as possible.
- SHOW PICTURES OF
  - A bioswale
• A stormwater filtration system
  ○ Captures water that flows over the Earth’s surface, and
  ○ Filters the water through the ground, to
  ○ Clean the water of its contaminants!
• Stormwater filtration systems can be made of many types of materials.

Construction of Three Single-Media Columns (hands-on activity)

• Distribute a cup of each filter material. Ask the whole class:
  ○ How well will the gravel clean our water as compared to the sand?
  ○ How fast will water flow through the gravel as compared to the sand?
• Single Media Column Tests: Distribute team buckets (see Materials). Students will test out each single-media condition one-at-a-time. For each of the three media types, students will:
  ○ Use an Odwalla bottle as the “soil column”
  ○ Pour material from their media cup into their soil column.
  ○ Collect stormwater from the leaders using the Odwalla measuring bottle. Leaders will fill up to Line 1.
  ○ Will set up the column according to the experimental diagram.
  ○ Pour stormwater into each column, recording the:
    ■ Volume they got out
    ■ How fast was water coming out of column?
    ■ “Dirty-ness” of the water when it exits the column, qualitatively
• When students finish each of the 3 first test conditions, they will bring their worksheet up to a leader and talk about their findings.
• Design and construct an optimal three-layer filter column. Using any combination of the three media types, students will:
  ○ Draw out the layers of their optimal column and give two reasons why they built it that way.
  ○ Construct their column
  ○ Collect stormwater from the leaders using the Odwalla measuring bottle. Leaders will fill up to Line 2.
  ○ Pour stormwater into each column, recording the:
    ■ Volume they got out
    ■ How fast was water coming out of column?
    ■ “Dirty-ness” of the water when it exits the column, qualitatively

3. Wrap Up: Review and Discuss the Learning Experience (10 minutes)

Questions to ask the whole class
• What filter material had the highest flow rate?
• What filter material made the cleanest water?
  How did you optimize your filter to maximize your filter’s flow rate and how well it cleaned the stormwater?
4. Connections & Close (5 minutes)

Connections to the real world around students:
- Would you like to see stormwater filter systems in your community?
- Talk about the other uses of stormwater
  - Water crops
  - Water our lawns and golf courses and parks
  - Drinking water!! Especially for cities where it does not rain a lot and they need to find alternative sources of water

Close:
Wrap up as a role model by leaving a few minutes for students to ask questions about science, about being a scientist, and about becoming a scientist. Then, thanks and goodbye!

Follow Up: After the Presentation

Teachers who wish to extend the impact of this lesson may find the following CRS web pages useful:

- [http://www.crscience.org/educators/helpfulreports](http://www.crscience.org/educators/helpfulreports)
- [http://www.crscience.org/educators/treasuretrove](http://www.crscience.org/educators/treasuretrove)

Standards Connections

- Science and Engineering Practices
  - 4-PS4-3: “General and compare multiple solutions to a problem based on how well they meet the criteria and constraints of the design solution.”
- Disciplinary Core Ideas:
  - ETS1.C: Optimizing the design solution
    - “Different solutions need to be tested in order to determine which of them best solves the problem, given the criteria and constraints. (secondary to 4-PS4-3)”
- Crosscutting Concepts
  - 4-PS4-3: “Knowledge of relevant scientific concepts and research findings is important in engineering.”
- CA Common Core State Standards Connections:
  - W.4.7: Conduct short research projects that build knowledge through investigation of different aspects of a topic.