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| **Lesson Title : Surface Water Pollution** | **Unit #: 1** | **Lesson #:**  **1** | **Activity #:**  **2** |
| **Activity Title: Natural and Urban Water Cycles** |

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| **Estimated Lesson Duration:** | **7-8 class periods (47 minutes each)** |
| **Estimated Activity Duration:** | **3-4 class periods (47 minutes each)** |

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| **Setting:** | **Science classroom** |

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| **Activity Objectives:** |

* To compare and contrast the natural and urban water cycles
* To understand the impact of run-off pollution
* Investigate how different types of ground cover impacts run-off pollution

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| **Activity Guiding Questions:** |

Essential Questions To Address In This Activity:

* How does the natural water cycle system change from a rural environment to an urban environment and why?
* How is storm water pollution occur?
* Where does storm water/run-off go if it is not absorbed into the soil/ground?
* How do plants act like groundcover?

| **Next Generation Science Standards (NGSS)** | |
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| **Science and Engineering Practices (Check all that apply)** | **Crosscutting Concepts (Check all that apply)** |
| ☐ Asking questions (for science) and defining problems (for engineering) | ☐ Patterns |
| ☐ Developing and using models | ☒ Cause and effect |
| ☒ Planning and carrying out investigations | ☒ Scale, proportion, and quantity |
| ☒ Analyzing and interpreting data | ☒ Systems and system models |
| ☐ Using mathematics and computational thinking | ☒ Energy and matter: Flows, cycles, and conservation |
| ☒ Constructing explanations (for science) and designing solutions (for engineering) | ☒ Structure and function. |
| ☒ Engaging in argument from evidence | ☐ Stability and change. |
| ☐ Obtaining, evaluating, and communicating information |  |

| **Ohio’s New Learning Standards for Science (ONLS)** |
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| **Expectations for Learning - Cognitive Demands (Check all that apply)** |
| ☒ Designing Technological/Engineering Solutions Using Science concepts **(T)** |
| ☐ Demonstrating Science Knowledge **(D)** |
| ☐ Interpreting and Communicating Science Concepts **(C)** |
| ☒ Recalling Accurate Science **(R)** |

| **Common Core State Standards -- Mathematics (CCSS)** | |
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| **Standards for Mathematical Practice (Check all that apply)** | |
| ☐ Make sense of problems and persevere in solving them | ☐ Useappropriate tools strategically |
| ☐ Reason abstractly and quantitatively | ☐ Attendto precision |
| ☐ Construct viable arguments and critique the reasoning of others | ☐ Look for and make use of structure |
| ☐ Model with mathematics | ☐ Look for and express regularity in repeated reasoning |

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| **Unit Academic Standards (NGSS, ONLS and/or CCSS):** |

NGSS

**MS-ETS1-3. Analyze data from tests to determine similarities and differences among several design solutions to identify the best** **characteristics of each that can be combined into a new solution to better meet the criteria for success.**

**MS-ETS1-4. Develop a model to generate data for iterative testing and modification of a proposed object, tool, or process such that an** **optimal design can be achieved.**

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| **Materials**: (Link Handouts, Power Points, Resources, Websites, Supplies) |

**This activity was derived from a lesson from** [**www.TeachEngineering.org**](http://www.TeachEngineering.org) **at the following link:** [**https://www.teachengineering.org/view\_activity.php?url=collection/usf\_/activities/usf\_stormwater/usf\_stormwater\_lesson02\_activity2.xml**](https://www.teachengineering.org/view_activity.php?url=collection/usf_/activities/usf_stormwater/usf_stormwater_lesson02_activity2.xml)

You will need a computer, projector, and internet access for this activity.

Day One/Two Materials:

* Natural and Urban “Stormwater” Water Cycles Handout (one per student)
* Natural and Urban “Stormwater” Water Cycles PowerPoint Presentation

Day Three Materials:

Materials List

Each group needs:

* 12-inch biodegradable coir hanging basket or planter
* 5-gallon bucket, to catch draining water
* stopwatch
* measuring cup, volumetric cylinder or some other graduated plastic container, for measuring water volume
* [Does Media Matter? Worksheet](https://www.teachengineering.org/collection/usf_/activities/usf_stormwater/usf_stormwater_lesson02_activity2_worksheet_v3_tedl_dwc.pdf), one per student

To share with the entire class:

* 50-lb. bag construction/playground sand
* 50-lb. bag soil compost
* 50-lb. bag 3/8-inch limestone or pea gravel
* 2-cu. ft. bag sustainably harvested hardwood mulch, such as Melaleuca or eucalyptus
* (4) 5-gallon plastic buckets
* access to water and sink/drain

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| **Teacher Advance Preparation:** |

Day One/Two Preparations:

* Copies of Natural and Urban “Stormwater” Water Cycles Handout (one per student)
* Natural and Urban “Stormwater” Water Cycles PowerPoint Presentation

Day Three Preparations:

**Before the Activity**

* You may want to perform this activity in a science classroom or outdoors if weather permits.
* Gather materials and make copies of the [Does Media Matter? Worksheet](https://www.teachengineering.org/collection/usf_/activities/usf_stormwater/usf_stormwater_lesson02_activity2_worksheet_v3_tedl_dwc.pdf), one per student.
* Prepare four 5-gallon buckets by placing a different media type into each bucket: sand, soil, gravel, mulch. Fill each bucket with 4 liters of material.
* Have handy a measuring cup or volumetric cylinder for measuring water volume.
* Have stopwatches ready.
* Note that students will need their completed worksheets, coir baskets and media mixes for subsequent activities in this unit.

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| **Activity Procedures:** |

Day One/Two:

* 1. Students will activate prior knowledge during the Natural and Urban “Storm water” Water Cycles Activity. During this activity students will receive a fill in the blank note-sheet about Earth’s water systems and will be asked to make predictions about the water cycle. Then go through the powerpoint slides to discover the correct answers.

Day Three:

**With the Students**

1. Divide the class into groups of two or three students each, depending on the class size and availability of resources. Hand out the worksheets.
2. Present the Introduction/Motivation content to students, covering the following main points:

* Introduce students to the definition of media. In the context of this activity and the unit as a whole, media is defined as a combination of organic and/or inorganic earth materials. Describe the properties of inorganic vs. organic materials. Have students record the definition of media on the worksheet.
* Ask students if they know where water goes once it enters the ground and if they can define the terms used to describe the movement of water. Direct them to record their answers after the worksheet question: "What do we call the movement of water INTO media layers and define percolation?"
* Familiarize students with the different soil properties and have students record on their worksheets the definitions for the following properties: permeability, capillary action, porosity, percolation, storage capacity and field capacity.

1. As a class, calculate the storage capacity of each of the media within the prepared 5-gallon buckets by pouring water into the media layer until the water level reaches the top surface of the material. Keep track of the volume of water being poured into each bucket by first accounting for the water with a measuring cup or volumetric cylinder. This is the storage capacity, have students record these measurements in the worksheet table for each material type.
2. Let each group select a media type that it wishes to investigate (make sure at least one group tests each material type) and place the same volume of media as used in step 3 into its planter/basket. Ask students if they think more, less or the same volume of water will drain from the media in the planter/basket and why. Have groups each place a 5-gallon bucket under the planter/basket and then pour the same volume of water that was added to the 5-gallon bucket in step 3 (that is, the known storage capacity). Measure and record on the worksheets the amount of water that drains from the planter/basket graduated containers to get an accurate measurement of the drained volume of water.
3. Have students subtract the storage capacity (obtained in step 3) from the volume of water drained from the planter/basket (obtained in step 4) to obtain the field capacity, filling in the worksheet table. Also record comparative observations amongst the media types.
4. Continuing on, have groups make sure the media is fully saturated by filling their planters/baskets with water to the top of the media surface. Then have students determine the infiltration rate of the media in their planters/baskets. To determine the infiltration rate, add a known volume of water (such as 1 or 2 liters) and record the time it takes for the water to drain through the planter/basket, making sure to collect, measure and record the volume of water that leaves the planter/basket as well. The volume of water drained from the planter/basket divided by the time it takes for the water to drain is the infiltration rate (ml/sec). Note: It is likely that water will continue to drip from the media after the bulk of the water has passed through. So, make a judgment call to record the time it takes for the bulk of the water to pass through the media.
5. Have groups present the data that they collected on their selected media types. As data is presented on media types other than what each group investigated, have them fill in the data from other groups into their worksheet tables, so that everyone has infiltration rates and observations on all media types.
6. Next, challenge teams to use what they learned from the group presentations to create their own media mix combinations to best meet the design requirements. Inform them of the design objectives: Create a media layer that promotes infiltration, maximizes below-ground water storage and provides an environment for healthy plants and microbial communities. Make and test a media mix amount that has a total volume of between 2-3 liters. Direct students to first brainstorm as a group and then decide on their designs, recording on their worksheets the types of media and volumes or ratio of each material added.
7. Have each group determine the infiltration rate of its media mix combination (ml/sec) by running three experiments on the same media mix, each with different water quantities. Each experiment includes three identical trials, from which average infiltration rates can be calculated. On their worksheets, have students record the measured water volumes and infiltration times, and then calculate the infiltration rates.
8. Have students plot the volume of water vs. time. The slopes of the lines are the infiltration rates.
9. Conclude by leading a class discussion to share, compare and review student results and solutions, as described in the Assessment section. Collect and review the worksheets.
10. Go back to the brainstorming activity of the essential questions. Allow students to add on or edit their questions based on what they’ve learned from this activity.

**Formative Assessments:** Link the items in the Activities that will be used as formative assessments.

-Day one: students will assess their own prior knowledge during the warm-up activity

-Day two: Worksheet for media and infiltration rates data (collect and review)

**Summative Assessments:** These are optional; there may be summative assessments at the end of a set of Activities or only at the end of the entire Unit.

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| **Differentiation:** Describe how you modified parts of the Lesson to support the needs of different learners.  Refer to Activity Template for details. |

Day one: guided note sheet for all learners, along with a powerpoint for visual and auditory learners. Students with special needs will get a copy of the powerpoint slides to cut and paste into their science notebooks.

Day two: students work in cooperative learning groups on activity/activity worksheet. Kinesthetic learners will benefit from the hands-on activity.

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| **Reflection:** Reflect upon the successes and shortcomings of the lesson. |

Successes:

Students enjoyed the media infiltration lab. All students were engaged and enjoyed sharing the workload in the cooperative learning groups. By giving each student a job in their group, the work was split evenly and everyone understood the importance of their role throughout the lab.

Shortcomings:

The students did not like the prediction part of the urban vs natural water cycle notes. They seemed dis-engaged and not very interested in “testing their knowledge”. They had the “give me the answers!” attitude. Perhaps I could turn the notes into a more engaging activity, like using Kahoot or an online practice assessment through the Discovery Tech-book. However, most students showed that they knew the basics of the natural water cycle (especially the stages) through this activity.

Students have very little knowledge of the lab’s vocabulary, I wish I would have spent more time with the vocabulary. Students also do not know how to properly measure liquids using graduated cylinders or measuring cups. This was obvious from circling the groups and observing their work during the activity.