Enviroscape Watershed Model

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Lesson Overview: Through an Enviroscape model demonstration, students will learn how point and non-point source pollution moves through a watershed and what management strategies can be implemented to prevent or minimize negative effects on water resources.

Objectives: Students will be able to:

1. Define watershed and name the watershed in which they live.
2. Differentiate between point and non-point source pollution.
3. Identify and differentiate between a storm drain and sewer.
4. Name three best management practices (BMPs) that prevent or reduce non-point source pollution.

This lesson meets the following Michigan Department of Education standards:

Next Generation Science Standards (NGSS):

- ✓ K-2-ETS1-1 Ask questions, make observations, and gather information about a situation people want to change to define a simple problem that can be solved through the development of a new or improved object or tool.
- ✓ 2-ESS2-1 Compare multiple solutions designed to slow or prevent wind or water from changing the shape of the land.
- ✓ 3-ESS3-1 Make a claim about the merit of a design solution that reduces the impacts of a weather-related hazard.
- ✓ 3-5-ETS1-2 Generate and compare multiple possible solutions to a problem based on how well each is likely to meet the criteria and constraints of the problem.
- ✓ 3-5-ETS1-3 Plan and carry out fair tests in which variables are controlled and failure points are considered to identify aspects of a model or prototype that can be improved.
- ✓ 4-ESS2-1 Make observations and/or measurements to provide evidence of the effects of weathering or the rate of erosion by water, ice, wind, or vegetation.
- ✓ 4-ESS3-2 Generate and compare multiple solutions to reduce the impacts of natural Earth processes on humans.
- ✓ 5-ESS3-1 Obtain and combine information about ways individual communities use science ideas to protect the Earth's resources and environment.
- ✓ MS-ESS2-4 Develop a model to describe the cycling of water through Earth's systems driven by energy from the sun and the force of gravity.
- ✓ MS-ESS3-3 Apply scientific principles to design a method for monitoring and minimizing a human impact on the environment.
- ✓ 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.

Recommended Grade(s): 2nd, 3rd, 4th, 5th, 6th, 7th, 8th

Recommended Subject(s): Science **Duration:** Prep time: 15 min, Activity: 30-60 min

Materials Required: Enviroscape model and accessories (available through Eaton Conservation District), Kool-aid drink mix in red and green, coffee grounds, unsweetened instant tea, soy sauce, sprinkles, water, spray bottles, sponges cut into tiny strips, clay, felt,

Suggested Vocabulary for Students: human impact, investigation, model, observations, pollution, community, conservation, stormwater, groundwater, watershed or drainage basin, surface water, run-off, contaminants, sewer, combined sewers, combined sewer overflows, point source pollution, non-point source pollution, fertilizer, pesticide, bacteria, soil, thermal pollution, best management practices (BMPs), rain garden, algal bloom

Background Information for Educator: What happens to rain or snow after it falls? Some gets evaporated back into the atmosphere but of course, there are many other paths upon which precipitation can travel. To track these paths, it is helpful to learn about the watershed concept, and how water moves both over and through land.

A watershed, also called a drainage basin, is the land area that drains to a common body of water. The outer-most boundaries of the watershed have the highest elevation. In this analogy, water drains from high to low elevation and drains, and all of this water drains into the same body of water, similar to the way water drains in a bathtub. For example, all of the water that falls on your property may run into the Grand River, which flows into Lake Michigan that is connected to the St. Lawrence Seaway that runs into the Atlantic Ocean; water is always flowing into another water body!

Water enters a watershed in several different ways. One method is via infiltration. When rain falls hits the ground and is absorbed like a sponge. It is naturally filtered as it travels through layers of soil and rock until it becomes part of the groundwater supply and is eventually discharges into surface water such as a lake, stream, or river, and continues to flow until it reaches the ocean. Another way water enters a watershed is through surface water run-off, or what is also referred to as stormwater. When water hits an impervious surface that it cannot pass through, it flows across these sidewalks, roads, and parking lots to permeable areas or directly into the nearest stream or lake. Along the way, stormwater picks up sediment, heavy metals, nutrients, and toxins from the roads and treated lawns it runs over. All of these materials are different types of pollution, or substances, which can cause damage to the environment.

Water also enters a watershed through the collection of stormwater and wastewater in some large, developing cities where there is a significant amount of impervious surfaces. At first, combined sewers were used in these areas in which both wastewater from homes and businesses, and stormwater from storm drains were both collected and piped together to the waste-water treatment plant. As these areas continued to develop and the amount of impervious surfaces also grew, so too did the amount of stormwater. During a heavy rain event, this increase in stormwater, combined with the amount of wastewater being carried to the wastewater treatment plant, causes combined sewer overflows (CSOs) to occur which leads to the discharge of raw or partially treated sewage into surface waters before it was able to be treated. This in turn can cause a multitude of other problems. Now, many of these areas are switching to separate sewers in which wastewater is kept separate from stormwater, though combined sewers still exist in some areas due to the huge expense to make the necessary upgrades. The wastewater from homes and businesses still flows to the waste-water treatment plant while the stormwater is piped directly into the nearest stream, lake or river. From here, it flows all the way to the ocean.

Pollution is commonly divided into two types: point source and nonpoint source pollution. Point source pollution is contamination whose source can be pinpointed to a single thing, person, or property.

Industrial pollution and CSOs are considered point source pollution because their source can be traced back to their exact source of origin. On the other hand, nonpoint source pollution results from sources whose exact origin cannot be easily determined. For example, fertilizer may be washed away in stormwater which may drain into surface water, but its source cannot be identified easily usually because it may have been washed into the water after a storm event. Some examples of nonpoint source pollution are: excess fertilizers and pesticides from lawns and fields can wash off or infiltrate into the ground; bacteria from raw waste, either animal or human, can increase the spread of disease and make waters unsafe to drink and used for other purposes; bare soil can wash into streams cause habitat destruction and over time, makes the stream shallower and warmer as a result; thermal pollution in the form of sun-scorched paved surfaces such as concrete and asphalt which transfers some of this heat to the water that falls onto it, similar to the way water in which a radiator cools down the engine of a car.

There are some simple things that people can do to reduce or prevent stormwater pollution. These things, called best management practices (BMPs), are ways of reducing or preventing the impacts of pollution that can harm the environment. There are small things that you can do yourself in and around your home or school. You can also encourage your neighbors to do their part. Installing a rain garden is an example of a best management practice that reduces or prevents the effects of stormwater. A rain garden is a perennial garden consisting of native plants which catches stormwater, holding this water in place long enough to allow the plants and soil to filter out pollutants, and allow it to filter into the ground, thus recharging groundwater.

Lesson Procedure:

Introduction:

- ~ What is a model? Explain that the Enviroscape is a model that helps us visualize what happens to water in a watershed. Define watershed. Give them an analogy of a watershed as a large bathtub with hills, houses, roads and cities; any water poured into a bathtub flows toward the drain.
- ~ Ask the students to guess where all the water in your city goes. Name the watershed that you live in. Optional: Map out the course of water from your school/city to the ocean.
- ~ Ask the students what happens to rain that falls in the forest (of course many things could happen, but the answer you are looking for is absorption into the ground).
- ~ Ask the students whether water can be absorbed into pavement, roads, and roofs like it is absorbed into the ground (no). Define impervious. What happens to that water since it cannot be absorbed into the ground? Explain the difference between the sewer and a storm drain. The water goes to the storm drains and empties out untreated water into the nearest lake, river, or stream.
- ~ Have the students give their definitions of pollution. Tell the students that there are two types of pollution you will be talking about: point-source pollution and non-point source pollution. You can 'point' at where point source pollution is coming from, but you do not know exactly where non-point source pollution originates from. Give some brief examples of each.
- ~ Ask students "What did you eat for breakfast?" Connect what they ate for breakfast to the need for water to grow plants, and for animals and people to drink.
- ~ Brainstorm about how we depend on water; plants need water to grow, animals eat the plants, and people eat the animals and plants. Ask student "What is one way you use water?"
- ~ "Does anyone know how old this water is?" (Hold up water spray bottle.) The water from the shower you took this morning may have fallen as rain in the Amazon rainforest last year or could have been a drink for a dinosaur 100 million years ago.
- ~ Show students the water cycle diagram. There is no "new" water. The water on Earth moves constantly through a process called the water cycle. Review the cycle if necessary.

Activity: Part 1 – Unprotected Watershed

- ~ If we pretend this model (EnviroScape) is Michigan, we can demonstrate how the water cycle works. Have the students identify objects they see on the model. What is the purpose of all of the items? Are they all important? Which surfaces are permeable vs impermeable? Where do they think we might find pollution in this model of a community? What about in our community?
- ~ Have 3 students demonstrate rainfall by spraying the model with water. For younger grades, involve the other students by having them pat their knees to make a sound like a thunderstorm.
    - Example of thunderstorm: https://www.youtube.com/watch?v=ttBqXR-Eygk
- ~ Observe the water collecting on the model. The water collects in rivers, lakes, ponds, the great lakes and the ocean. Feel free to name all these after local bodies of water (and the farm, factory, subdivision, etc.) to help make it seem more realistic.
    - *Tip: Drain the lake before you begin. Make sure there isn't too much standing water on the model!
- ~ Show students where the factory is located in the model. Tell them that this factory is a bad factory and is dumping pollutants into our stream. (Emphasize that not all factories are bad. Many follow proper procedures and work to protect the water.)
    - Have a student pour soy sauce into the factory.
    - Ask the students whether this is point source or non-point source pollution (point).
- ~ Who here has a dog? Benny (any name) next door has a dog too and when he takes his dog for a walk he never cleans up its poop. Have a student sprinkle the unsweetened instant tea near the dog. There are lots of dogs in this neighborhood so make sure to sprinkle a lot.
    - Farmer Rob lets his cows wade right into the river near the farm. What do you think they do there? Make sure to add some unsweetened instant tea to the farm area and the river.
    - James likes to walk down to the Bay to feed the ducks and geese. With so many geese concentrated in one area, comes more animal waste. Add some more tea to the Bay.
    - Ask the students why they wash their hands after going to the bathroom (to get rid of germs). Well those germs are in animal waste too. When animal waste gets into the water, harmful germs also get in the water. *E. coli* is a bacterium that lives in intestines/digestive tract. It's presence in water tells us that some type of waste is washing into the water, and this can make people very sick.
    - Is animal waste a source of point source or non-point source pollution (usually non-point).
- ~ Move to the residential area / golf course. Who has a lawn at home? Mrs. Pots has a lawn too and she thinks the more fertilizer she uses the, greener her grass will be. But really, a little goes a long way. Tell them what fertilizer is, and how it works. Explain that although fertilizers are great for the health of lawns, it can be harmful to aquatic ecosystems. It can wash into our waterways if people use too much, apply it at the wrong time, or don't apply it properly. Have a student sprinkle green Kool-Aid on lawn areas.
    - For older students – Discuss an algal bloom. Ask the students to guess what happens to the plants underneath the water when there is a blanket of algae on top. Touch on photosynthesis and respiration.
    - Again, while a little is okay, the golf course and the farmer use too much fertilizer to grow the grass and crops. Make sure to sprinkle your green Kool-aid fertilizers on the golf course and farm.
    - Ask the students whether fertilizer is point source or non-point source pollution (non-point).
- ~ So if fertilizers help the plants and grass grow, does that means they'll look more appetizing to the bugs and other pests? Who has a garden at home? Mrs. Pots has a flower garden and she uses too many pesticides to get rid of the insects that eat her flowers.
    - Have a student sprinkle some of the red Kool-Aid pesticides on the lawns near the houses.
    - The golf course and the Farmer Rob also use too many pesticides too. Make sure to sprinkle red Kool-Aid pesticides there as well.
    - Ask the students whether pesticides are point or non-point source pollution (non-point).

~ Do you have a septic tank? Some houses are connected to sewers, and others have septic systems buried in their yards. Mr. Smith forgot to pump out his septic system and it overflowed.
    - Have a student squirt some soy sauce on the lawn of a house.
    - Is sewer leakage point or non-point source pollution? (point)
~ Can anyone guess why we shouldn't litter? Tommy always throws his candy wrappers and soda bottles on the ground. Have a student spread rainbow sprinkles on the street.
    - The people driving by in their cars throw their trash right out the window. Have the student throw the sprinkles in the ditch near the road. How can litter harm the environment?
    - Is litter point or non-point source pollution? (Non-point)
~ Cars contain harmful chemicals (oil, antifreeze, etc.) that can leak onto the street if the cars are not taken care of. These fluids can get washed into waterways as it becomes part of stormwater. Have a student drip soy sauce behind cars.
    - Point source or non-point source ? (non-point)
    - Does anyone help their family wash their car? Mr. Clean washes his car in the street and all the soap suds and dirt from the car go right into the storm drain.
        - Have a student pump the soap onto the car.
    - Mrs. Johnson also changes her own oil in her car. She is not very environmentally friendly and she dumps the extra oil directly down the storm drain.
        - Have a student squirt some soy sauce into the storm drain and observe that it leads directly to the water body.
~ In order to make all the new houses in town, the builders needed wood, so they cut down the forest. When the forest is cut down, the trees are gone, leaving the ground bare. Once the trees are gone, the bare soil is open to the rain. Soil that washes into water can also be a source of pollution. When you build a sand castle, what happens when you pour a bucket of water on top of it? It collapses and the sand washes away. At the construction site, all the grass and vegetation has been stripped away. What do you think will happen to the soil now?
    - How is soil harmful to the stream?
        - Destruction of habitat. Imagine you are a crayfish. You are chilling out on the clean gravel river bottom, catching food, enjoying the simple life. It starts raining, but you aren't worried, it rains all of the time. Then, all of a sudden, the water gets cloudy with dirt; you can't see anything and your nice neat gravel bed you just cleaned out is buried in soil.
        - For older students – Soil erosion can cause lake and streams to fill in prematurely. This can cause water temperature to rise and dissolved oxygen levels to decrease.
    - Sprinkle coffee grounds over the construction site.
    - Point or non-point? (non-point)
    - The farm area also exhibits erosion near the Bay. Sprinkle coffee grounds there.
~ Now it rains. Let 3 students take turns spraying the model with a spray bottle and let the pollution collect in the lake. You can have the remaining students make a thunderstorm by patting their knees.
    - *Tip: in order to get the pollution to drain off the enviroscape, you will probably need a lot of water. You may have to drain the lake once so you don't overflow (unless you want to talk about flood events, but you'll end up with a sticky mess.)
~ Ask the students whether they would want to swim in the dirty lake. Drain the lake and tell the students that you will be starting over and this time you will be focusing on ways to reduce the amount of pollution entering the lake.
~ Emphasize that the things we use in this activity are colored for greater visibility. In real life, however, most of these pollutants are invisible as they are added into the water.

Activity: Part 2 – Adding Protection to the Watershed

- ~ Go through each component of the model again, but this time ask the students what they can do to prevent as much pollution. Let them brain storm and add "fixes" to the model before letting it rain again. The following are suggestions, but let the students brainstorm it. If they can't find a fix, add new pollutants to the model. If they can, leave the left over pollution from the first round, and add the solution as well.
- ~ Factory – soy sauce down the pipe
  - Point or non-point? (Point)
  - What can you do if you see someone polluting?
  - (There is not really a "fix" on the model for this, but it's a good talking point!)
- ~ Fertilizer (green Kool-Aid) and Pesticides (red Kool-Aid) on lawns, golf course, ag field
  - Point or non-point? (non)
  - Use fertilizer correctly. Fertilizer can be washed off lawns if it is over-applied. Some people might think that a little fertilizer is good for grass so a lot of fertilizer must be great, but in reality, the grass can only absorb so much fertilizer and the rest is washed away.
  - Do not fertilize/pesticide areas of lawn directly adjacent to waterways. This is called a buffer zone, and helps to keep fertilizer and pesticides from entering these sensitive aquatic environments. Add a sponge filter strip along the edge of the farm field.
  - Plant rain gardens and vegetation. Explain rain garden. Plants with deep root systems are used in sunken rain gardens to help trap and filter large amounts of stormwater, thus keeping the contaminated water from running into the storm drains. Uses sponges to represent vegetation or rain gardens. Put some sponges in the residential area.
- ~ Animal waste – unsweetened instant tea
  - Point or non-point? (non)
  - Look at the farm. What is so special about cow waste? Cow waste is a natural fertilizer. So the farmer decides that he will scoop up the cow manure and use it on his field. Sprinkle tea on farm field but not in the cow pasture or on the road.
  - The farmer also builds a retaining wall (clay) to keep fertilizer, crops, and top soil from washing away into the lake. Put trees/rain garden in front of wall.
  - He might also build a fence or plant trees along river bank to keep cows from going directly into the river.
  - What about animal waste in the neighborhood? What can you do to prevent animal waste from washing into the streams?
    - Pick up your own animal's waste then properly dispose of it by throwing away, burying, or flushing it. Ask neighbors to dispose of their animal waste properly.
- ~ Litter - sprinkles
  - Point or non-point? (non)
  - Don't litter. Ask others not to litter. Pick up litter.
- ~ Car leakage – soy sauce
  - Point or non-point? (non)
  - Get vehicles tuned-up regularly to be sure there are no fluid leaks. People go to the doctor regularly to make sure everything is all right, so too should cars.
  - Add vegetated areas adjacent to roadways.
- ~ Soil erosion – coffee grounds
  - Point or non-point? (non)
  - Construct silt fences at construction site to prevent soil erosion.
  - Build on already developed land instead of undeveloped land.
- ~ Sewer system leaks – soy sauce
  - Point or non-point? (non)
  - Schedule regular maintenenace and get it pumped at the recommended time frame.
- ~ Now it rains. Spray the model with a spray bottle and let the drink mixes collect in the lake.

~ Ask the students whether they would want to swim in the first dirty lake, or the second preventative lake?

Wrap up:

~ Discuss all the sources of pollution in your watershed. What were the major sources of pollution? Minor sources?
~ Can you prevent all types of pollution? Why or why not?
~ What can you do to minimize the amount of pollution to your local watershed in your community?

Assessment Options:

~ Review the definition for watershed.
~ Have students name the watershed in which they live.
~ Ask students what they can do to prevent pollution in their neighborhood.

Adaptations/Extension/Enhancements:

~ Research and explore other watersheds that are directly adjacent to the watershed in which you live. What kinds of potential pollution sources can you identify? What could you do to prevent pollution in nearby watersheds from being carried to yours?
~ See if your class can tour your local waste water treatment plant.

Additional Resources:

~ MWSP website: www.miwaterstewardship.org
~ Map of Michigan watersheds: https://www.michigan.gov/documents/deq/lwm-mi-watersheds_202767_7.pdf
~ Clean Water Action: https://www.cleanwateraction.org/states/michigan
~ EPA Clean Water Act of 1972: https://www.epa.gov/laws-regulations/history-clean-water-act
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Our MWSP logo represents the two hands of Michigan - both the upper and lower peninsulas - and caring for our water resources and water quality. The green hand symbolizes all vegetation and crops in our state and the tan hand symbolizes soils. The lighter blue water signifies the vast surface water throughout the state and the darker blue water denotes groundwater.