Environmental Stewardship

Lesson 9: Good to the last drop! Modeling Leachate using Coffee

Grade Level 9-12
Time Required 50 minutes for planning and construction. Models will be observed on a weekly basis for a month.

Background

Leachate is produced when liquid (usually water) percolates through waste materials in a landfill. These materials contain various types of contaminants including heavy metals, high concentrations of nitrogenous wastes like ammonia, and various forms of inorganic and organic matter that leads to a high Chemical Oxygen Demand (COD) and/or high Biological Demand (BOD). Generally speaking, COD and BOD reflect the amount of oxygen necessary to convert the waste materials to a less toxic form, either chemically, or by the microbes that are present in a landfill.

There are many factors that affect the characteristics of leachate, and consequently, the actions that need to be taken to change the composition of the leachate so that it is less toxic. In this lab, we will investigate factors that influence the composition of leachate, using coffee grounds and water to construct our model.

Objectives

The purpose of this lesson is to help students understand the factors that affect leachate production. They will use coffee grounds and water, modifying conditions that affect the concentration of the coffee "leachate" produced. They will use this model and apply their observations to the real-world issue of leachate production.

Engineering Connections: Environmental Engineering, Chemical Engineering, Civil Engineering

Landfills may leak over time and the leachate released can affect the composition of groundwater. This lab models the production of leachate.

I Can:

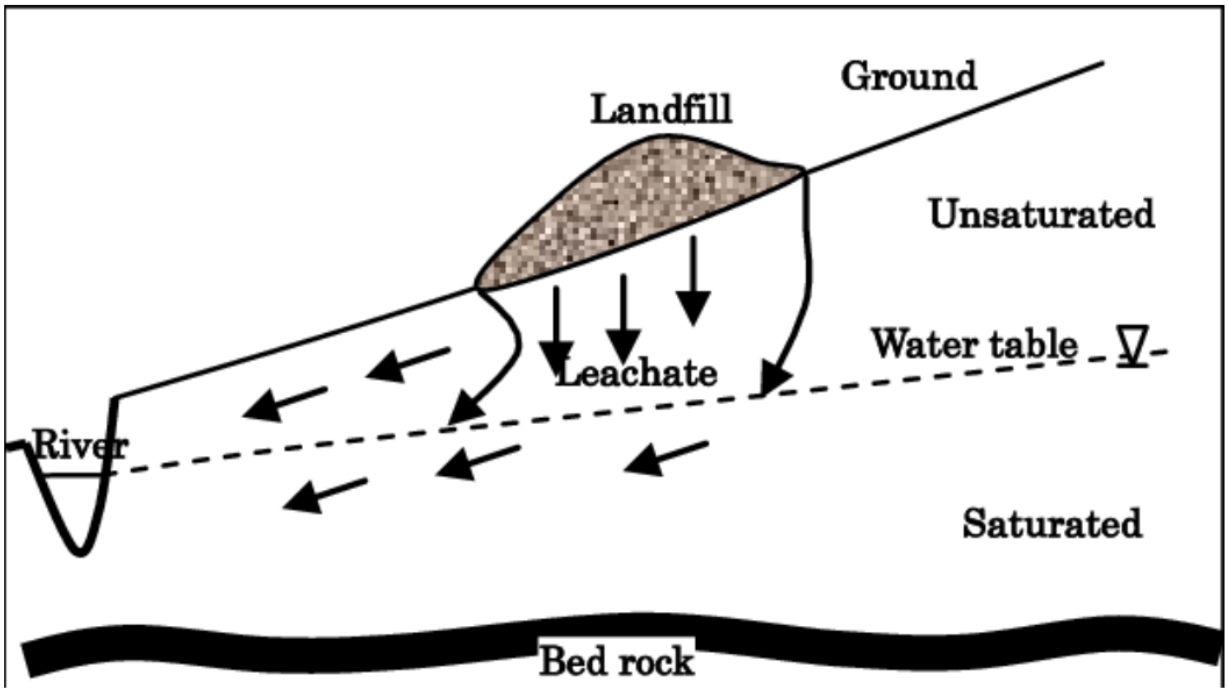
- **Define and correctly use related functional vocabulary: solubility, solvent, solute, concentration, surface area.**
- **Explain how different environmental factors influence the composition of leachate.**
- **Use a reference to evaluate concentration of a solution.**
- **Describe how certain areas may have greater issues with leachate based on climate conditions.**

HS-LS2-7 Ecosystems: Interactions, Energy, and Dynamics
Design, evaluate, and refine a solution for reducing the impacts of human activities on the environment and biodiversity.*
HS-ESS3-4 Earth and Human Activity
Evaluate or refine a technological solution that reduces impacts of human activities on natural systems.*
HS-ETS1-1 Engineering Design
Analyze a major global challenge to specify qualitative and quantitative criteria and constraints for solutions that account for societal needs and wants.

Keywords
solubility, solvent, solute, concentration, surface area, leachate

Pre-Lab: Complete required vocabulary: Using the resource preferred by your teacher, complete the following table with the correct scientific definition.

Term	Definition
Physical properties	
Chemical properties	
Solubility	
Concentration	
Dissolving	
Surface area	
Landfill	
Leachate	
Solvent	
Solute	



Schematic diagram of groundwater contamination by landfill leachate

https://www.researchgate.net/figure/Schematic-diagram-of-groundwater-contamination-by-landfill-leachate_fig1_261288075

Lab – Constructing a model for the production of Leachate

Materials needed: Pour-over Coffee filter, coffee filters, coffee grinder, coffee beans and grounds, Beakers of various volumes, tongs, hot plate, thermometer, balance, weigh boats, test tubes for side-by-side color comparison OR a colorimeter (If a colorimeter cannot be purchased, there are many sites that can provide instructions for constructing them. Students could even construct the colorimeters on a separate day, prior to lab. There are also several free apps available that do RBG color values that could be used)

Part 1 – Investigating the effect of precipitation volumes on the concentration of leachate

In different parts of the country, the quantity and composition of the leachate produced is greatly affected by the amount of precipitation that is common in that area of the country. In this part of the lab, you will vary the volume of water that you use to observe the effect on your coffee "leachate". Before proceeding, talk to your lab partners and form a prediction about how you think your leachate will look and how much is produced.

Prediction: If different volumes of water at the same temperature are added to the same mass of coffee grounds, the appearance of the coffee "leachate" will vary in the following ways:

_____

_____

_____

Procedure:

1. **Obtain a 250 ml beaker and place 200 ml of water in the beaker.**
2. **Set beaker filled with 200 ml water on the hotplate on low to medium temperature and warm the water gently on a hot plate.**
3. **When bubbles just begin to rise, remove the beaker carefully using tongs or 'hot gloves'.**
4. **Set up 2 of the pour-over filter apparatus (see diagram). Add 20 g of coffee to each filter.**
5. **Pour 125 ml of the warmed water into a graduated cylinder and pour over one of the coffee ground samples.**
6. **Pour 25 ml of the warmed water into a graduated cylinder and pour over the other coffee ground samples.**
7. **Allow the water to run through the grounds till all the water runs through**
8. **Compare the color of your 'leachate' in each of the collection beakers using a colorimeter. As an alternative, a side-by-side comparison can be done in test tubes.**

Record your observations for Part I:

Temperature of Water	**Volume of water used**	**Relative color, or color value from colorimeter** (Color observations – Describe color and rank. Rank solutions 1-5 lightest = 1 darkest = 5)

Part 1 Questions:

1. **Was your prediction correct? Were you surprised by the result? How does the color intensity reflect the concentration of the solution?**

2. **The different volumes you used represent the influence of precipitation differences on Leachate. Write a 2-3 sentence statement that reflects how precipitation levels may affect the characterists of leachate that passes out of a landfill.**

Part 2 – Investigating the effect of particle size on the concentration of leachate

Particle size of the materials in a landfill can affect the permeability factor in the landfill and influence the rate at which water moves through the landfill. In turn, this can also affect the composition of leachate. In this part of the lab, you will vary particle sizes to observe the effect on your coffee "leachate". Before proceeding, talk to your lab partners and form a prediction about how you think your leachate will look and how much is produced.

Prediction: If different particle sizes of coffee and water at the same temperature are added to the same mass of coffee grounds, the appearance of the coffee "leachate" will vary in the following ways:

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_____

Procedure:

1. **Obtain a 250 ml beaker and place 200 ml of water in the beaker.**
2. **Set beaker filled with 200 ml water on the hotplate on low to medium temperature and warm the water gently on a hot plate.**
3. **When bubbles just begin to rise, remove the beaker carefully using tongs or 'hot gloves'.**
4. **Set up two of the 'pour-over' apparatus.**
5. **Obtain a 20 g. sample of coarsely ground coffee and a 20 g. sample of very finely ground coffee. Add the two 20 g. samples of coffee to each filter.**
6. **Measure and record water temperature.**
7. **Carefully measure 75 ml. of the warmed water and pour over the first sample. Repeat this process for the second sample.**
8. **Allow the water to run through the grounds till all the water runs through**
9. **Compare the color of your 'leachate' in each of the collection beakers using a colorimeter. As an alternative, a side-by-side comparison can be done in test tubes.**

Record your observations for Part 2:

Temperature of Water	**Particle size**	**Relative color, or color value from colorimeter** (Color observations – Describe color and rank. Rank solutions 1-5 lightest = 1 darkest = 5)

Part 2 Questions:

1. **Was your prediction correct? Were you surprised by the result? How did the particle size affect the concentration of the two solutions?**

2. **Write a 2-3 sentence statement that reflects how particle sizes may affect the characteristics of leachate that passes out of a landfill.**

Part 3 – Investigating the effect of temperature on the concentration of leachate

Temperature of the water moving through a landfill can affect the concentration of the leachate in the landfill. In this part of the lab, you will vary temperature to observe the effect on your coffee "leachate". Before proceeding, talk to your lab partners and form a prediction about how you think your leachate will look and how much is produced.

Prediction: If different temperatures of water are added to the same mass of two samples of the same size coffee grounds, the appearance of the coffee "leachate" will vary in the following ways:

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Procedure:

1. **Obtain a 250 ml beaker and place 150 ml of water in the beaker.**
2. **Set beaker filled with 150 ml water on the hotplate on low to medium temperature and warm the water gently on a hot plate.**
3. **When bubbles just begin to rise, remove the beaker carefully using tongs or 'hot gloves'.**
4. **Pour 100 ml of the hot water into a graduated cylinder.**
5. **Obtain 100 ml of ice water in another graduated cylinder.**
6. **Set up 2 of the pour-over filter apparatus (see diagram). Add 20 g of coffee to each filter.**
7. **Pour the warmed water over one of the coffee ground samples and the cold water over the other.**
8. **Allow the water to run through the grounds till all the water runs through**
9. **Compare the color of your 'leachate' in each of the collection beakers using a colorimeter, or an app for color comparison. As an alternative, a side-by-side comparison can be done in test tubes.**

10. **Record your observations for Part 2:**

Temperature of Water	**Relative color, or color value from colorimeter** (Color observations – Describe color and rank. Rank solutions 1-5 lightest = 1 darkest = 5)

Post lab questions

1. **Which of the factors (Temperature, particle size, volume of solvent) had the greatest effect on the how much coffee dissolved and the strength of the "leachate" formed? Why does that factor have the greatest influence?**

2. **This lab was intended to model the environmental factors that might affect the production and composition of leachate. Focusing on water volume (analogous to precipitation) and temperature (analogous to climate influences), can you suggest the type of climate where production of leachate might be a bigger issue?**

3. **What are some things that can be done to reduce the risk of contamination of groundwater from leachate? Think about all the contributing factors and brainstorm interventions that could be helpful.**

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