Introduction to Environmental Engineering: A Water Filtration Experiment
Lesson Outline

General Lesson Information

Title: Introduction to Environmental Engineering: A Water Filtration Experiment

Overview/Annotation- *A short summary or description of the lesson including activities and science concepts.*
This lesson plan introduces students to the concept of environmental engineering, it's importance in protecting our air, land, and water, what techniques are used to clean our water, and provides a hands-on activity where students will be able to build and test their very own water filters.

Setting or format (outdoors, in groups, lab, etc.): In groups in standard classroom or lab

Intended group size (if groups are used): Groups of 3-4 students

Intended grade level(s):
Science - 5th, 6th, 7th

Approximate Time of Lesson (*Ideally break down into 20-50 minute periods*):
Four 50 minute periods

Researcher Biography

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https://www.youtube.com/@trainthetrainers5857/videos

Brief Description of Research Interests:
Through our program "Train the Trainers," we aim to educate local teachers and students in the Tuscaloosa/Northport area about the importance of Environmental Engineering to bring awareness to its concepts and provide opportunities for K-12 students to engage with S.T.E.M. concepts at this critical learning period. We create videos, lesson plans, and activities to allow students to connect and learn about our water quality and filtration research at an approachable and engaging level.

Associated Standards and Objectives

Content Standards- *List Alabama Course of Study Standards that connect to lesson*
5th: SC15.5.16 - Collect and organize scientific ideas that individuals and communities can use to protect Earth's natural resources and its environment (e.g., terracing land to prevent soil erosion, utilizing no-till farming to improve soil fertility, regulating emissions from factories and automobiles to reduce air pollution, recycling to reduce overuse of landfill areas).

SC15.5.17 - Design solutions, test, and revise a process for cleaning a polluted environment (e.g., simulating an oil spill in the ocean or a flood in a city and creating a solution for containment and/or cleanup).*

6th: SC15.6.16 - Implement scientific principles to design processes for monitoring and minimizing human impact on the environment (e.g., water usage, including withdrawal of water from streams and aquifers or construction of dams and levees; land usage, including urban development, agriculture, or removal of wetlands; pollution of air, water, and land).*

SC15.5.15 - Analyze evidence (e.g., databases on human populations, rates of consumption of food and other natural resources) to explain how changes in human population, per capita consumption of natural resources, and other human activities (e.g., land use, resource development, water and air pollution, urbanization) affect Earth's systems.

7th: SC15.7.9 - Engage in argument to defend the effectiveness of a design solution that maintains biodiversity and ecosystem services (e.g., using scientific, economic, and social considerations regarding purifying water, recycling nutrients, preventing soil erosion).

Primary Learning Objectives- *Sentences beginning with "Students will be able to…" that describe what students will do in the lesson that relates to how students will be assessed.*
See attached lesson plan below.

Additional Learning Objectives- *Any learning outcomes that are not directly related to the content standards but may relate to other local or national standards*
See attached lesson plan below.

Preparation Information

Total Duration- *How many minutes will the lesson last?*
Four 50 minute periods – 200 minutes of instruction/activities

Materials and Resources- *List of materials teacher will need to gather or prepare for lesson*
PowerPoint – see attachments below
Printed Worksheets – see attachments below
Pencils
Plastic Water Bottles – one per group

Coffee Filters
Cotton Balls
Rice
Sand
Activated Carbon
Measuring Cups
Sharpies – to label the filters
5 Gallon Bucket or Large Container to hold "Swamp Water"
Little Plastic Cups to distribute "Swamp Water"
"Swamp Water" ingredients – water, dirt, white vinegar, dish soap

Technology Resources Needed- *What technology will teacher and students need for the lesson?*
Smart board/projector for the attached PowerPoint and online stopwatch to track the filtration time.

Background and Preparation- *Description of information (science content, use of materials, etc.) teacher and/or students will need to know prior to this lesson; list steps for any preparation prior to the lesson*
Review the resources provided and become familiar with the different types of engineering and how environmental engineers aim to protect human health and our environment. Review information about the water treatment process and what facilities are located nearby to your school.

1. **Print out the worksheets that are attached below.**
2. **Prepare the "Swamp Water" ahead of time**
   - 1-2 gallons of water
   - 1 gallon of dirt
   - 1 to 2 cups of vinegar
   - ¼ to ½ cups of dish soap
3. **Prepare the water bottles ahead of time**
   - Cut a standard 16.9 fl oz water bottle in half (dumping the water into the "Swamp Water" bucket or using recycled bottles from the classroom/home), remove the cap and dispose, and flip the top of the water bottle upside down so the spout will pour into the bottom of the bottle to catch the filtered water.
4. **Prior to the building/testing of the filters (day 3 and 4):**
   - Set up materials table with the measuring cups for the rice, sand and activated carbon and have the cotton balls and coffee filters available for the students to select from for their designs.

Procedures and Activities

Step-by-step description of lesson that would allow another teacher to successfully complete the lesson (suggest possible reflection or comprehension questions along with examples of correct answers or common misconceptions)
See attached lesson plan and PowerPoint below.

Engagement (sparking interest, introducing phenomenon, engage students' everyday experiences)
See attached lesson plan below.

Main activity (suggest possible reflection or comprehension questions along with examples of correct answers or common misconceptions)
See attached lesson plan below.

Wrap up and Reflection (wrap up activity, reflecting on learning, informal assessments of student learning)
See attached lesson plan below.

Final product/Summative evaluation (e.g. quiz, presentation, essay, etc., may occur during a later class period)
See attached lesson plan below.

Attachments- *Any materials for the lesson such as video links, worksheets, etc., listed here*

SciREN Introduction to Environmental Engineering – A Water Filtration Experiment – Lesson Plans

SciREN Introduction to Environmental Engineering – A Water Filtration Experiment – PowerPoint

SciREN Introduction to Environmental Engineering – A Water Filtration Experiment – Worksheet

SciREN Introduction to Environmental Engineering – A Water Filtration Experiment – Honors Worksheet

Day 1: Introduction to Water Filtration

Objective:

- Understand why water filtration is important.
- Learn about different types of contaminants in water.
- Discuss how natural and man-made filtration systems work.

Materials:

- 5-gallon bucket of dirty water (prepared with dirt, white vinegar, and dish soap).
- Dixie cups.
- Paper towels.
- Portable turbidimeter (to measure water clarity).
- Whiteboard and markers.

Lesson Plan:

1. **Engage (10 min):** **fun short video** [https://www.youtube.com/watch?v=H1ae2dIVsIw]
    - Show students a cup of clean water and a cup of dirty water from the bucket.
    - Ask: "Would you drink this water? Why or why not?"
    - Discuss sources of water pollution and real-world impacts.
2. **Explain (15 min):**
    - Introduce **three main types of water contaminants**:
        - **Physical** (dirt, sand, particles)
        - **Chemical** (vinegar simulates acidic contamination, dish soap represents industrial waste)
        - **Biological** (bacteria- which we won't include for safety reasons).
    - Explain how natural water cycles filter water (soil, rocks, plants).
3. **Explore (20 min):**
    - Give each group a sample of dirty water in a cup.
    - Use paper towels to attempt a basic physical filtration.
    - Introduce the **turbidimeter** to measure how clear the water is before and after filtration.
    - Discuss how effective the paper towel was and brainstorm better filtration methods.
4. **Wrap-up (5 min):**
    - Ask students to list what they think makes a good filter material.

Day 2: Engineering a Water Filter

Objective:

- Learn about the materials used in water filtration.
- Design a water filter (before building).

Materials:

- Whiteboard & markers.
- Example of a simple filtration system (diagram or model).
- Materials used in HYPOTHETICAL design today: cut-in-half water bottles, cotton balls, rice, sand, activated carbon, coffee filters, and electrical tape. (will be used tomorrow)

Lesson Plan:

1. **Review (5 min):**
    - Discuss students' knowledge on filter materials.
    - Connect this to how modern water treatment plants work.
2. **Explain (15 min):**
    - Explain how each material in their water filter works:
        - **Cotton Balls** – Trap large debris.
        - **Rice** – Helps remove finer sediments.
        - **Sand** – Removes smaller dirt particles.
        - **Activated Carbon** – Absorbs chemicals and odors.
        - **Coffee Filters** – Acts as an initial coarse filter.
        - **Electrical Tape** – Helps secure filter layers.
    - Show a **diagram of a layered filter** to illustrate proper assembly.
3. **Explore (25 min):**
    - In groups, students sketch their water filter designs. [draw in white board]
    - After a nice design is made have students draw and label design on paper to bring to class tomorrow]
    - Each group selects a material order and explains why they chose that order.
4. **Wrap-up (5 min):**
    - Have students predict which material will be most effective.

Day 3: Building and Testing the Filters

Objective:

- Construct water filters and test them.
- Compare results and discuss improvements.

Materials:

- Each group's sketched design.
- Materials from Day 2 (cotton, rice, sand, carbon, etc.).
- 5-gallon bucket of dirty water.
- Measuring cups & graduated cylinders.
- Portable turbidimeter.

Lesson Plan:

1. **Review (5 min):**
    - Quick discussion: What is the expected outcome for each filter?
    - Explain the process of testing filtered water (observing clarity, measuring with a turbidimeter).
2. **Build (20 min):**
    - Groups assemble their filters based on their designs.
    - Secure layers with electrical tape.
3. **Test (20 min):**
    - Pour dirty water into filters.
    - Collect filtered water in a graduated cylinder.
    - Measure turbidity using the turbidimeter/ visuals. [worksheet]
    - Record results and compare between groups.
4. **Wrap-up (5 min):**
    - Quick reflection: What worked? What didn't?
    - Consider: Write one improvement for the filter.

Day 4: Improving and Finalizing Filters

Objective:

- Analyze filter effectiveness.
- Modify designs for better results.
- Discuss real-world applications.

Materials:

- Existing water filters from Day 3.
- Additional materials for adjustments.
- Measuring cups, graduated cylinders, turbidimeter.
- Paper towels for cleanup.

Lesson Plan:

1. **Review & Discuss (10 min):**
    - Have each group share their results.
    - Which filters worked best? Why?
    - Compare water clarity results with the turbidimeter.
2. **Improve (20 min):**
    - Groups make modifications based on test results.
    - Add/rearrange materials, change layer thickness, etc.
3. **Final Test (15 min):**
    - Retest improved filters.
    - Compare data with previous results.
4. **Wrap-up & Reflection (5 min):**
    - Discuss what students learned.
    - Connect to real-world filtration (e.g., clean water access globally).
    - Consider: Write a short reflection on how science and engineering worked together in this project.

Water Purification Challenge

You are working for a water treatment plant and have been asked to design a new water filtration system for a community with a polluted water supply. The most important requirements are that the system should (a) produce CLEAN WATER and (b) work FAST enough that the system can be used to supply water for the whole community.

Purpose: design a filter to purify water.

You will evaluate your design based on (1) the time it takes to filter $\frac{1}{2}$ cup (approximately 1 Dixie cup full) of dirty water and (2) the turbidity, or cleanliness, of the filtered water.

Below are the **materials** available to use, you may use up to 3 items in your filter.

In the table, write an X next to each item you will use and sketch your filter setup on a blank sheet of paper.

Materials	What we will use
2 cotton balls	
1 tablespoon of rice	
1 tablespoon of sand	
1 teaspoon of carbon/alum	
1 extra coffee filter	

Designing your filtration system

(1) **Decide** which 3 materials you will use in the filter.

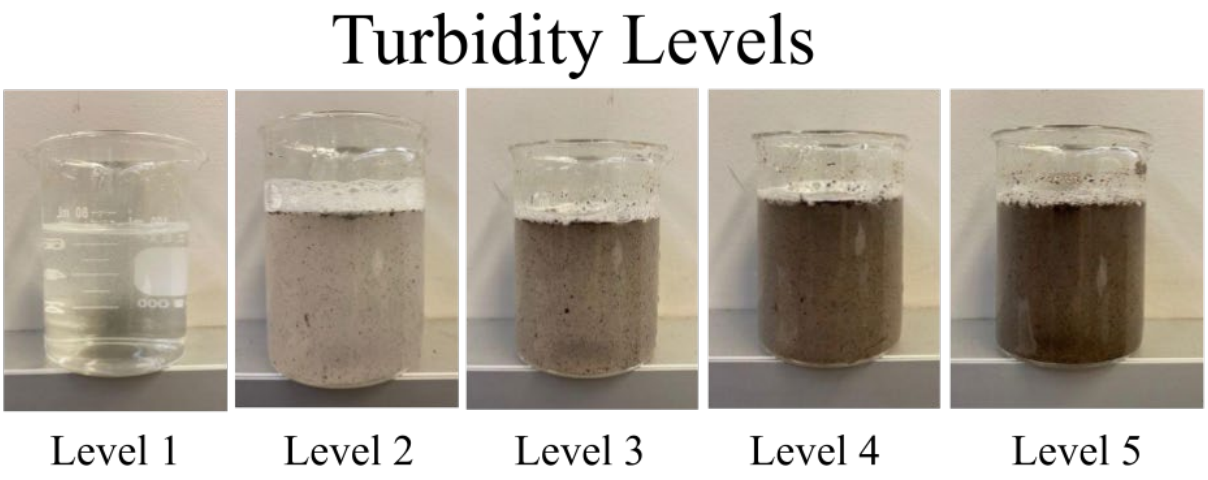
(2) **Draw** your filter design and label the materials in your drawing.

(3) **WHEN ASKED, send** one partner to obtain your materials and polluted water.

(4) **Build** your filtration system using the materials in your design.

(5) **WHEN INSTRUCTED, filter** the water, and **record** the time in minutes needed to collect $\frac{1}{2}$ cup of purified water.

(6) **Compare** the cleanliness of your filtered water to the images below.



(7) **Determine** your cleanliness level and **record** it on the below.

Level: _____

(8) **Record** how long it took to filter 20mL of water below.

Time: _____

Evaluate Your Design

In the space below, write 1-2 paragraphs reflecting on the process of making a water filter. Was your filter successful? What did you enjoy? What did you find difficult? How could you have made your filter better? Which part of your filter do you think was most effective in cleaning water?

Team members _____

Water Purification

The **purpose** of the experiment is to design a filter to purify water.

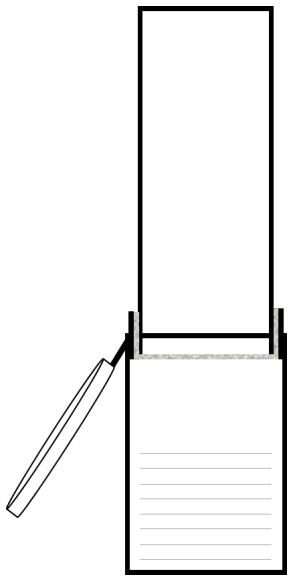
You will **evaluate** your design based on (1) the cost of the filter, (2) the time it takes to filter 3 ounces (1 dixie cup) of dirty water, and (3) the purity of the filtered water.

Here are the **materials** available to build your filter and their costs. In the table, write how much of each you will use and calculate the cost for each material and the total cost to build your filter. Maximum 75¢

Material	Price	How much we will use	Cost
1 cotton ball	2¢	×	= ¢
1 tablespoon of rice	3¢	×	= ¢
1 tablespoon of sand	5¢	×	= ¢
1 teaspoon of carbon	10¢	× **(2 max)**	= ¢
1 coffee filter	25¢	× **(1 max)**	= ¢
TOTAL COST TO BUILD OUR FILTER (maximum is 75¢) →			= ¢

Our Filter Design

Draw and label



Our Data

Cost to build our filter

_____ ¢

Time to filter 3 ounces of the dirty water

_____ minutes

Turbidity of filtered water

_____ (scale of 1-5)

TURN OVER THE SHEET TO DETERMINE YOUR FILTRATION SCORE!

Score Your Design

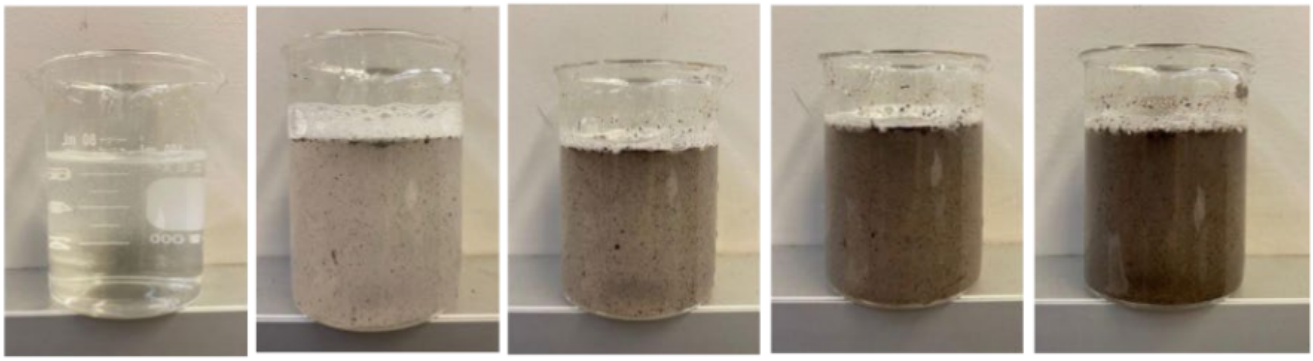
Enter values from your data page into the table and calculate scores for each row.

Variable	Value	Multiplication factor	Score
Cost to build our filter (¢)		× 10	= (A)
Time to filter 3 ounces of dirty water (minutes)		× 20	= (B)
Turbidity of filtered water (scale of 1-5)		× 10	= (C)

TOTAL SCORE = 1000 – (A) – (B) – (C)

Our Score _____

Turbidity Scale



Level 1 Level 2 Level 3 Level 4 Level 5

Challenge

You are working for Stone Clean Water Engineering Company and have been asked to design a new water filtration system for a community with a polluted water supply.

The community gives you a list of three requirements:

(1) The system should be CHEAP

(2) The system should work FAST

(3) The water should be POTABLE

You have 5 materials to put in your filtration system: cotton balls, rice, sand, carbon, coffee filter. You can use them in any order and different amounts, but you can spend a maximum of 75¢ for your filter system.

Designing your filtration system

(1) **Write** down how much of each material you will use in the table.

(2) **Use your math skills to calculate** the cost to build your filter with these materials, and **write** down the cost in the data box.

(3) **Draw** your filter design and label the materials in your drawing.

(4) **WHEN ASKED, send** one partner to obtain your materials and polluted swamp water.

(5) **Build** your filtration system using the materials in your design.

(6) **WHEN INSTRUCTED, filter** the water, and **record** the time in minutes needed to collect 3 ounces (oz) of purified water.

(7) **Record** the turbidity of your filtered water in the data box.

(8) **Calculate** your score and **record** it on the back of the sheet.

Evaluate Your Design

In the space below, write 1-2 paragraphs reflecting on the process of making a water filter. Was your filter successful? Which part of your filter do you think was most effective in cleaning water? What changes would you make if you had another design iteration? Why is it important for engineers to consider cost in their design process? How are water filters used to benefit people and our environment?