EXPERIMENT 3

THE SCIENCE OF CLEANING WATER

Cleaning Up Cosmetic Wastewater with Filtration

BACKGROUND

Cosmetic wastewater contains various contaminants, including surfactants, oils, dyes, preservatives, fragrances and microplastics. These pollutants can persist in aquatic environments, disrupting ecosystems, harming wildlife, and even entering human water supplies. Many of these compounds are resistant to natural degradation and can bioaccumulate in aquatic organisms.

As more personal care products are used daily and washed down the drain, understanding how to treat and clean this wastewater becomes essential. Filtration is one of the foundational steps in water treatment, helping remove suspended solids and improve water clarity and quality.

Filtration is a mechanical or physical process that separates solids from liquids by passing the mixture through a porous medium. In environmental water treatment, gravity filtration and vacuum filtration are commonly used to remove suspended particles. **Gravity filtration** relies on the natural force of gravity to move water through the filter, while **vacuum filtration** uses suction to accelerate the process, often resulting in more efficient and thorough removal of fine particles.

The **Urban Wastewater Treatment Directive (UWWTD)** is a key piece of EU legislation that regulates how municipalities treat wastewater. A recent revision of the directive aims to address emerging pollutants, such as pharmaceuticals and cosmetic residues, which were not previously covered (check the G-book$_2$ for details).

In this experiment, students will explore how filtration methods—such as gravity and vacuum filtration—can reduce contaminants found in cosmetic wastewater, helping to improve water quality and support environmental protection.

AIM OF THE EXPERIMENT

To determine the effectiveness of filtration in removing solid contaminants from cosmetic wastewater and analyse changes in pH and turbidity that cosmetics cause in water.

LEARNING OBJECTIVES

By the end of this experiment, students will be able to:

General Learning Objectives

- Identify and explain the role of filtration in water treatment.
- Understand how different cosmetic products (rinse-off vs. leave-on) behave in water treatment.

Specific Learning Objectives

- Compare gravity vs. vacuum filtration in removing cosmetic effluent chemicals.
- Measure pH and turbidity to observe changes in water quality.
- Use a sedimentation funnel to determine the total solid particles (TSP) before and after filtration.

TIME

90 min

MATERIALS NEEDED

Chemicals

- [ ] 3 rinse-off products: e.g., shampoo, face wash & liquid soap
- [ ] 3 leave-on products: e.g., foundation, lotion & sunscreen.

Equipment:

Gravity Filtration System:

- [ ] Plastic bottle
- [ ] Filtration layers: gravel, coarse sand, fine sand, activated charcoal, cotton or filter paper

Vacuum Filtration System:

- [ ] Lab vacuum pump (manual or electric)
- [ ] Büchner funnel and flask
- [ ] Filter paper (0.45 µm)
- [ ] Rubber tubing

Sedimentation & Analysis Tools:

- [ ] Sedimentation funnel (e.g., Imhoff cone or any conical sedimentation funnel)
- [ ] Graduated cylinder (100 mL or larger)
- [ ] Beakers (for sample preparation & collecting samples before & after filtration)
- [ ] pH paper or pH meter
- [ ] Turbidity meter (or visual clarity assessment)

SAFETY PRECAUTIONS

Before conducting this experiment, ensure you have read and understood the **General Safety Precautions** section of this handbook.

⚠️ There are no additional safety precautions specific to this experiment.

EXPERIMENT SETUP

Step 1 → Prepare the Work Area

- Ensure your workspace is clean and free from distractions.
- Set out all necessary materials.
- Wear your safety gear.

Step 2 → Prepare the Experiment

Prepare the cosmetic wastewater samples:

- Label two beakers: *"Rinse-off products"* and *"Leave-on products"*.
- Prepare 2 samples of cosmetic wastewaters:
  - Mix shampoo, face wash, and soap in approx. 500 mL of tap water (rinsed-off sample).
  - Mix lotion, foundation, and sunscreen in approx. 500 mL of tap water (leave-on sample).
- Stir both samples thoroughly to simulate wastewater.

Assemble the gravity filtration system with the following layers:

- Cut the bottle into funnel shape.
- Place cotton or filter paper at the bottom (first barrier).
- Add layers in this order (from bottom to top):
  - activated charcoal (removes chemicals, odours)
  - fine sand (traps small particles)
  - coarse sand (removes medium particles)
  - gravel (supports upper layers and prevents clogging)

Assemble the vacuum filtration system:

- Place filter paper (0.45 µm or similar) in a Büchner funnel.
- Attach the funnel to a vacuum flask.
- Connect the flask to a manual or electric lab vacuum pump using rubber tubing.
- Check for airtight seals.

Step 3 → Conduct the Experiment

Initial Testing:

- Measure and record the initial pH and turbidity of both samples using a pH meter/paper and a turbidity meter (or visual scale).
- Measure Total Solid Particles (TSP) using a sedimentation funnel or graduated cylinder (let solids settle and record volume).

Filtration Process:

- Divide each sample into two subsamples.
- Pour one subsample through the gravity filtration system; collect filtered water in clean beakers.
- Repeat the process using the vacuum filtration setup with new filter paper using another subsample.

Post-Filtration Testing:

- Measure and record pH and turbidity again for each filtered sample.
- Measure TSP after filtration using the sedimentation funnel or similar method.

Step 4 → Monitor and Record Data

Enter your results into the provided data spreadsheets.

RESULTS

Fill both spreadsheets below with obtained measurements **before** and **after** filtration.

pH & Turbidity Data

Sample Type	*Initial pH*	*Gravity Filtered pH*	*Vacuum Filtered pH*	*Initial Turbidity*	*Gravity Turbidity*	*Vacuum Turbidity*
Rinse-off						
Leave-on						

Total Solid Particles (TSP) Data

Sample Type	*TSP Before Filtration (mL)*	*TSP After Gravity Filtration (mL)*	*TSP* **After** *Vacuum Filtration (mL)*
Rinse-off			
Leave-on			

If available, include **Before & After photos** of water samples and provide a simple note next to them:

MY NOTES

ANSWER KEY QUESTIONS

Answer the questions either orally or in writing. Emphasize collaboration and critical thinking throughout the process!

1. What are the main differences between rinse-off and leave-on cosmetic products?

2. Which filtration method removed more solid particles—gravity or vacuum?

3. Was leave-on cosmetic wastewater harder to filter than rinsed-off products? Why?

4. How did the pH and turbidity change after filtration?

5. Why is it important to monitor water quality when treating wastewater?

Let's think critically:

6. How does this experiment relate to real-world wastewater treatment?

7. Why might vacuum filtration be more effective or efficient than gravity filtration in real wastewater treatment plants?

8. Some cosmetic ingredients are not visible (e.g., microplastics, preservatives). What challenges do these pose for water treatment systems?

9. If this experiment were scaled up to industrial levels, what environmental or economic factors should be considered?

10. Should cosmetic companies be responsible for reducing the environmental impact of their products? Why or why not?

FOR EDUCATORS

Additional Activities / Extensions (Optional):

- **Compare ingredient solubility:** Test how water-soluble vs. insoluble cosmetic ingredients behave in filtration.
- **Try alternate materials:** Replace or remove components (e.g., use cotton balls instead of sand) and observe filtration differences.

Adapting the Experiment for Secondary School Students:

- **Simplify data focus:** Have students record only pH changes using pH stripes before and after filtration.
- **Design investigations:** Let students modify one variable (e.g., filter thickness or contaminant type) and analyse its effect.

Adapting the Experiment for Primary School Students:

Simplify the experiment:

- **Visual-based observation:** Ask questions like “Is the water cleaner?” or “What changed?” instead of using tools.
- **Keep it simple and creative:** Use basic filters (e.g., cotton and gravel) and let students draw or name their water-cleaning invention.

General safety precautions

The following general safety precautions apply to all experiments in this handbook.

Please review them carefully before conducting any lab work. Some experiments may also have additional specific precautions listed within their respective tutorials.

⚠️ **Follow Instructions:** Always listen to your teacher/educator/assistant and follow the lab instructions carefully. If you're unsure about any step, ask for clarification before proceeding.

⚠️ **Know Safety Equipment:** Familiarize yourself with the location and proper use of safety equipment like eyewash stations and fire extinguishers.

⚠️ **Be Careful with Glassware:** Exercise caution when handling and washing glassware to avoid breakage and injury.

⚠️ **Safety Gear:** Always wear a lab coat, safety goggles, and gloves. Ensure you have closed-toe shoes and tie back long hair.

⚠️ **Handle Chemicals Safely:** Handle chemicals and equipment with care. Never taste or sniff chemicals. Always label containers or tubes.

⚠️ **Check Pictograms:** Before using any chemical, review the safety pictograms on the label to understand the hazards associated with it.

⚠️ **Handle Solvents Carefully:** Use solvents in a fume hood to avoid inhaling fumes and ensure proper ventilation.

⚠️ **Dispose of Waste Properly:** Follow proper procedures for disposing of chemical and biological waste. Do not pour chemicals down the drain unless instructed.

⚠️ **Report Accidents:** Immediately inform your teacher/educator/assistant of any accidents, spills, or injuries, no matter how minor they seem.