Filtering the Future: Low-Cost Microplastic Removal for Desert Communities

Introduction

Microplastics, defined as plastic fragments less than 5 millimeters in size, have become a widespread environmental issue affecting oceans, rivers, and even drinking-water systems. These particles commonly originate from synthetic fibers, cosmetic products, degraded plastic waste, and industrial runoff. Once present in water, microplastics persist for long periods of time because of their resistance to natural decomposition. The presence of microplastics has been linked to negative impacts on aquatic ecosystems, soil quality, and, potentially, human health through contamination of water sources.

Communities in desert regions, like San Luis, Arizona, face unique environmental challenges related to water quality. The area experiences limited natural filtration due to dry soil conditions, frequent dust, and agricultural runoff that may transport contaminants into local water systems. Because San Luis borders a major agricultural region and a busy port of entry, understanding simple and accessible water‑filtering methods is meaningful both academically and locally. While advanced filtration technologies exist, many households rely on basic filtration materials such as cotton, paper filters, or sand for general water clarification, not purification. This experiment explores whether low‑cost materials commonly found at home can effectively remove microplastics from water.

Research Question

Which household filter material, coffee filters, cotton, or a combination of sand plus a coffee filter, removes the highest percentage of microplastic particles from water?

Hypothesis

If thicker and more absorbent materials, such as cotton, are used, then they will remove more microplastic particles than thinner materials like coffee filters or sand‑plus‑coffee‑filter

combinations. This prediction was based on the structure of cotton fibers and previous research suggesting that dense materials trap more suspended particles.

This experiment is relevant for environmental science because it demonstrates how particle removal works, how filtration efficiency varies, and how common household materials can mimic the basic principles of sedimentation and mechanical filtration. It also introduces students to water-quality measurements using lux levels, which indicate how much light passes through water before and after filtration.

Methodology

Materials

All trials used the same setup and measurements for consistency. The materials included:

- Water (200 mL per trial)
- Glitter (1/8 teaspoon per trial, used as a microplastic substitute)
- Coffee filters
- Cotton balls (7 per trial)
- Clean sand (1 teaspoon per sand-layer trial)
- Funnels
- Measuring cup
- Measuring spoons
- Light meter to record lux levels
- Stopwatch or timer
- Cups for contaminated water and filtered water
- Notebook for recording data

These materials were chosen because they are inexpensive, accessible, and able to demonstrate particle removal using visible, measurable differences.

Experimental Procedure

The experiment contained three filter types, each tested in three separate trials, totaling nine trials. Every trial began with 200 mL of water mixed with 1/8 teaspoon of glitter, stirred until the glitter was evenly suspended.

Step-by-step procedure:

1. Measure 200 mL of water and pour it into a clear cup.
2. Add 1/8 teaspoon of glitter to simulate microplastic particles.
3. Stir until the glitter is fully mixed.
4. Measure and record the lux before filtering using a light meter positioned at a fixed distance.
5. Place a funnel on top of an empty cup.
6. Insert the filter material:
7. Coffee filter only,
8. Cotton (7 cotton balls pressed into the funnel),
9. Coffee filter lined with 1 teaspoon of sand.
10. Slowly pour the contaminated glitter water into the funnel.
11. Start the timer to measure filtration time.
12. Allow the water to filter completely without forcing or squeezing the material.
13. Measure the remaining water volume after filtration to assess water loss.
14. Measure and record the lux after filtering using the same setup as before.
15. Repeat steps 1–11 for each trial and each filter type.

The lux difference between before and after filtration was used to calculate the percent removed, representing the improvement in water clarity, which indicates microplastic particle reduction.

Results and Analysis

The results showed three distinct performance levels across filter types. Cotton filters removed the highest percentage of microplastics, followed by coffee filters, while the sand-plus-coffee-filter combination was the least effective. Lux measurements reflect how much light passed through the water sample. Higher lux after filtering indicates clearer water.

Coffee Filter Trials

Trial	Lux Before	Lux After	Time	% Removed
1	11.600	28,900	2:12.33	59.56%

2	12,900	29,530	2:04.70	56.32%
3	10,400	30,900	2:17.26	66.34%

Average removal: 60.74%

The coffee filter produced moderate filtration efficiency. It allowed most of the water to pass through, had consistent times, and trapped a noticeable amount of glitter, but not as effectively as cotton.

Cotton Trials

Trial	Lux Before	Lux After	Time	Water Left	% Removed
1	10,880	35,000	1:03	125 mL	69.14%
2	11,100	34,300	1:00.43	125 mL	67.74%
3	10,000	35,300	1:23.09	125 mL	71.67%

Average removal: 69.48%

Cotton removed the highest amount of microplastics, producing the clearest water of all filter types. However, the cotton also absorbed a significant amount of the water; each trial lost 37.5% of the original water volume. This shows that cotton filters trap particles well but also trap water within the fibers.

Coffee Filter + Sand Trials

Trial	Lux Before	Lux After	Time	% Removed
1	10,300	18,900	2:53.21	45.50%
2	10,900	22,000	2:59.01	53.18%
3	10,250	23,100	2:48.90	55.63%

Average removal: 51.44%

The combination of sand and a coffee filter resulted in the lowest filtration effectiveness. Although sand is commonly used in large-scale filtration systems, the 1-teaspoon layer used was too shallow to mimic real sand filtration, which typically requires several centimeters of depth.

Data Interpretation

The cotton filter outperformed all other types, which supports the hypothesis. Its fibrous structure creates a dense network that traps glitter particles effectively. The higher lux values after filtration confirm increased clarity of the water.

Coffee filters demonstrated a fair balance of precision, consistency, and water retention, making them a practical option for visible particle removal but not as strong as cotton.

The sand filter struggled due to inadequate sand depth. Water likely formed channels through the sand instead of passing uniformly, reducing contact time between particles and filtering material.

A graph of percent removal would show:

Cotton > Coffee Filter > Sand + Coffee Filter

These clear trends support the conclusion that absorbent, fibrous materials remove more microplastics than thin or granular ones.

Conclusion

The experiment successfully determined which household material best removes microplastic particles from water. Cotton filters produced the highest average removal at 69.48%, confirming the hypothesis that denser, more absorbent materials capture more microplastics. Coffee filters removed 60.74%, showing moderate effectiveness. The sand-plus-coffee-filter combination removed only 51.44%, performing below expectations due to the sand layer being too thin.

The results were consistent across trials and demonstrated clear patterns supported by environmental science principles. The data shows that while cotton is the most effective, it comes with a trade-off: a significant loss of water volume. Coffee filters offer a practical middle ground, while sand requires a deeper layer to function as intended.

This experiment demonstrates how simple materials can help visualize water-quality issues, particularly for communities like San Luis, Arizona, where environmental awareness is important. Although none of the filters tested make water safe to drink, they help model how filtration works and how pollution impacts clarity and cleanliness.

Evaluation

Strengths of the Experiment

- All measurements were kept constant across trials
- Multiple trials ensured reliability
- Lux readings gave measurable, numerical evidence
- The methods were simple and repeatable

Limitations

- Glitter does not behave exactly like real microplastics
- The sand layer was too thin to replicate real sand filtration
- The cotton filter absorbed water, affecting volume consistency
- Lux readings measure clarity, not particle count, so percentage removed is an approximation

Future Improvements

- Use deeper sand layers
- Add gravel and layered filtration systems
- Test more materials (charcoal, sponges, fabric types)
- Use a digital microscope to count particles more accurately
- Increase the number of trials for better statistical confidence

Citations

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