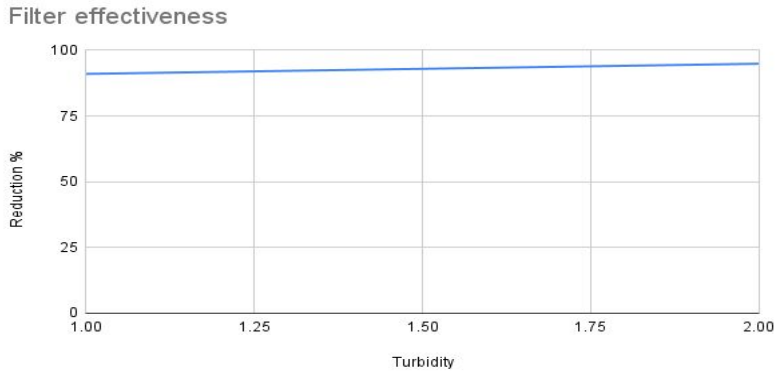
Water filtration system

Engineering Problem & Objectives

Access to clean is a global and local problem, especially in areas affected by environmental runoff, natural disasters, and limited infrastructure. Many filtration systems are expensive and not portable. The goal of this project was to design a simple cost-effective water filtration system capable of improving water clarity.

Data Analysis & Results



Project Design

The filtration system was design as a multi stage filter in order to remove particles of different seize, Water passed through several materials in a sequence.

- Coffee filter
- Cotton balls
- Fine sand
- Gravel
- Activated charcoal

Each layer was chosen to target different particle sizes and continents. The system relies heavily on gravity flow, requiring no electricity, making it portable and low-cost.

Interpretation & Conclusions

The results support the hypothesis that a low cost-multi-stage filtration system can significantly improve water quality. The decrease in absorbance shows that suspend particles were removed during filtration

While the system is limited, does not sterilize water completely or remove dissolved chemicals, it effectively reduces turbidity and visible contamination. This type of system could be useful in germeiencies and in communities without access to advanced water treatment.

Future improvements include adding biological or a chemical purification stage such as UV sterilization or chlorination

Variables & Control

Independent variable

- I used two groups, Trial 1 is Dirty Bucket water and Trial 2 is Fish Tank water.

Dependent variable

- OD600- Absorbance / Optical density

Controlled Variables

- Same Volume of water tested
- Same Cuvette time
- Same filtration model
- Same wavelength setting (OD600)
- Zero using distilled water
- Same measurement procedure

Control group

- Unfiltered contaminated water

Experimental Group

- Filtered water samples

Introduction

The purpose of this science fair project is to measure how effective a low-cost water filter is in eliminating bacteria and purifying dirty water samples from a fish tank using activated charcoal and should activated charcoal be used in water filtration systems widely. Access to clean water is a privilege that not all countries have specifically sub-saharan africa, rural areas like these dont have access to new and improved often expensive water filtration systems. With this experiment I'm hoping to introduce an low-cost effective water filter while following the question; Should activated charcoal be used in water filter systems widely ?

The study introduces the design and testing of a low cost, dispenser type household water filtration system made from locally available materials requiring no expensive technology . Laboratory results showed that the system significantly improved physician, chemical, and microbiological water quality producing water that met drinking standards. The author concludes that this filtration system is an affordable and sustainable solution for communities that may not have access to clean drinking water.

The article introduces a low cost effective filter system that eliminates common pathogenic bacteria The study demonstrates that the ceramic filter pores effectively absorb and remove contaminants, suggesting that it may be a practical option that can be used to improve water quality in resource limited areas. The results support the potential of a simple low cost effective water filtration system.

The article reviews the use for low cost materials coated with silver nanoparticles as antibacterial filters to remove E.Coli from drinking water, Results suggest support the authors claim and it showed that the silver -enhanced materials can reduce E.Coli in water. Highlighting their potential effectiveness in improving water quality.

A filter made by materials that are affordable are proven to be effective in making water filtration systems more affordable in settings with limited resources. Highlighting the potential for my experiment to improve the water quality in fish tanks, by removing contaminants with activated charcoal. As the authors have had successful results in improving water quality. Thus, my experiment proves to have significant potential overall.

Question

Question
Should activated charcoal be used in water filter systems widely?

Hypothesis
Activated charcoal should not be independently used in water filtration systems as it's not effective at eliminating bacteria alone and will show a inconsistent decrease in the amount of bacterial colonies.
If I increase the amount of activated charcoal then the turbidity and the number of associated bacteria particles will decrease, however free planktonic bacterial counts measured by CFU/mL will show an inconsistent decrease.

Methods

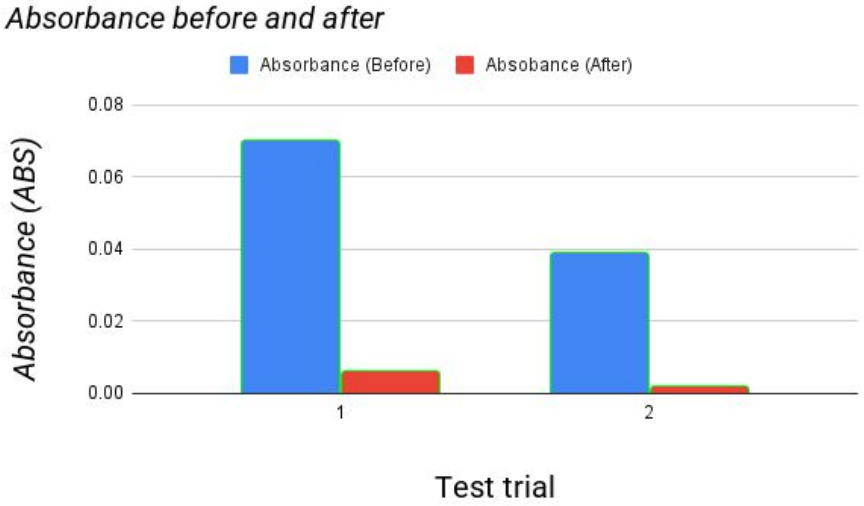
1) Collect 1.5 L of dirty bacteria water sample from the ag fish tanks
2) Bacteria must be collected in the sample
3) Make sure you have the following listed materials
   - Cotton/Coffee filter
   - 2 L plastic bottle(1) per filter (cut to form funnel +reservoir)
   - Cotton balls
   - Sand (fine)
   - Gravel (Coarse)
   - Activated Charcoal
   - Scissors, tape, rubber bands
4) Cut a 2 L bottle one third form the top and invert the top to from an funnel into the bottom reservoir, Secure with tape/rubber band
5) Add a small cotton plug at the neck to prevent loss media
6) Layer materials
   - Cotton
   - Activated charcoal
   - Fine sand
   - Coarse sand / small gravel
   - Larger gravel

Test trials	1	2
Absorbance (Before)	0.07	0.039
Absobance (After)	0.006	0.002
Reduction %	91	94.87

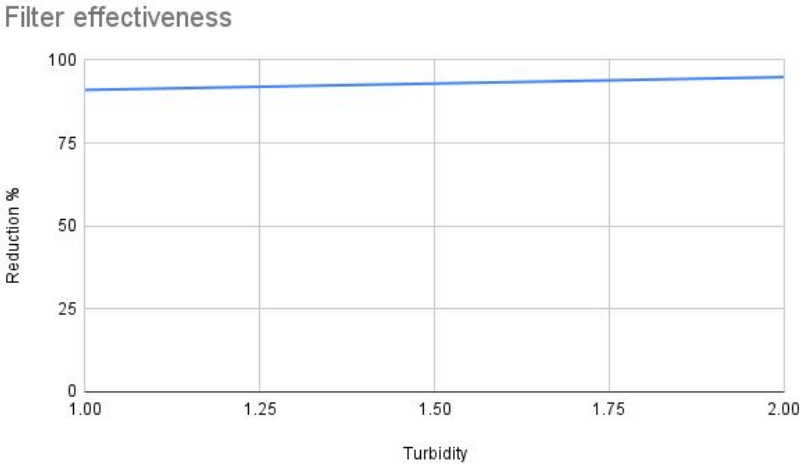
9) Pour 500 mL of water through the filter into a clean labeled collection bottle, record filtration time and observations.
10) Keep unfiltered 500 mL control sample aside
11) For each filtration and control, measure turbidity and temperature
12) For each trial record data
   - Prepare two sterile sample bottles 100-200 mL each
13) Calculate percentage reduction in bact`eria P = Control CFU/mL - Filtered CFU /mL / Control CFU/mL x 100– Report CFU or presence of bacteria (Membrane filtration for total coliforms /E .Coil
14) Place used filter media in biohazard
15) Run an blank control to check for contamination from assembly
   - If filter clogs., prefilter source water through coarse sleeve and note modification
   - Record times between collection and lab to help interpret the microbial counts

Results

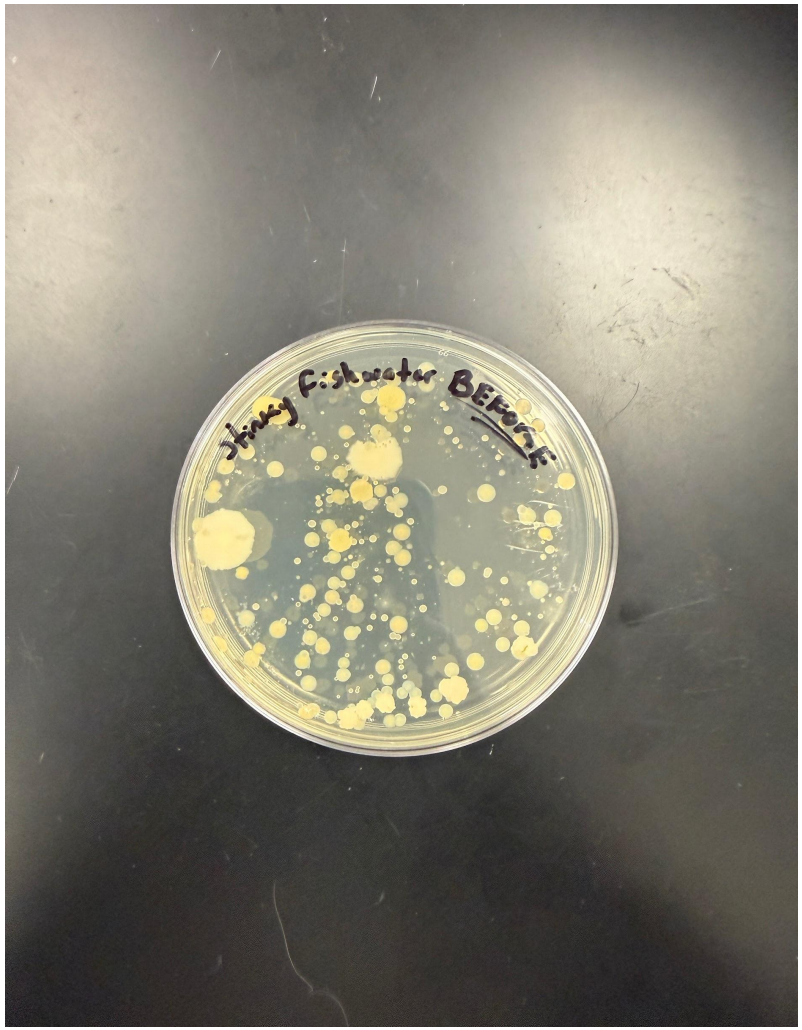
- According to the bar chart, my filtration system showed a significant reduction in absorbance (abs),
- As more particles (dirt, bacteria, suspended solids)->more blocked light -> higher absorbance.
- Less particles -> more light passes through ->lower absorbance.

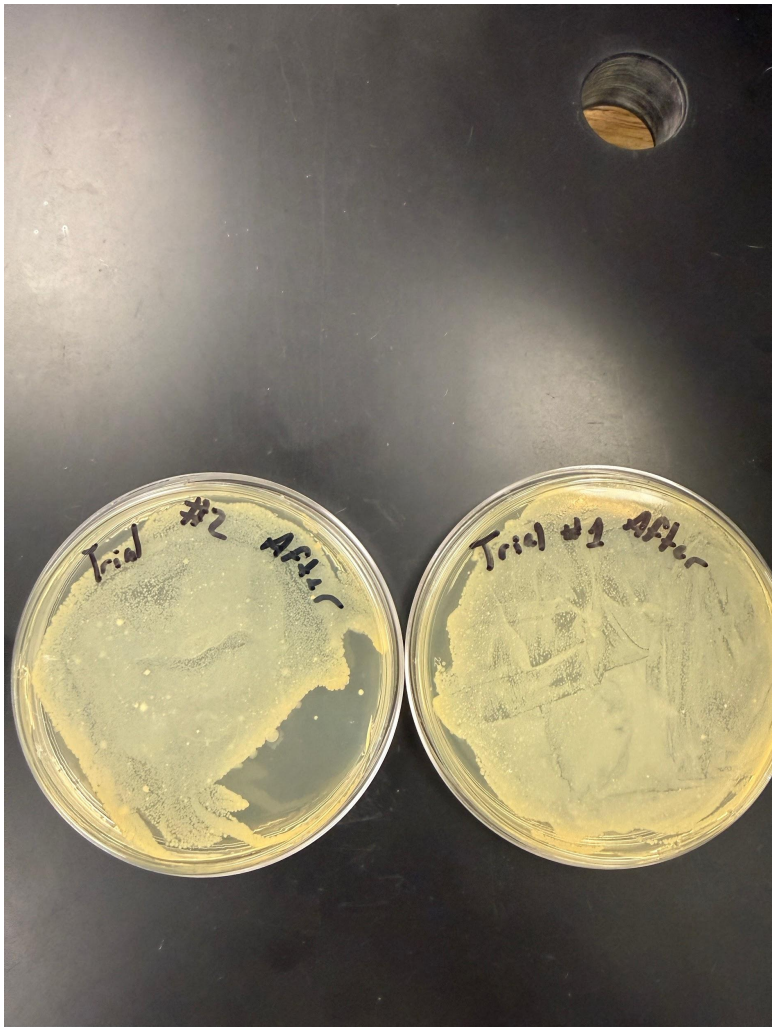


- %reduction = how much the filter improved the water expressed as a percentage
- It compares dirty it was before vs how clean after
- Formula used; %reduction = (1 -abs after/abs before) x 100/
- My results show that my filter effectively removed ~95% of the turbidity, In the stinky fish water compared to regular dirty water in a bucket.



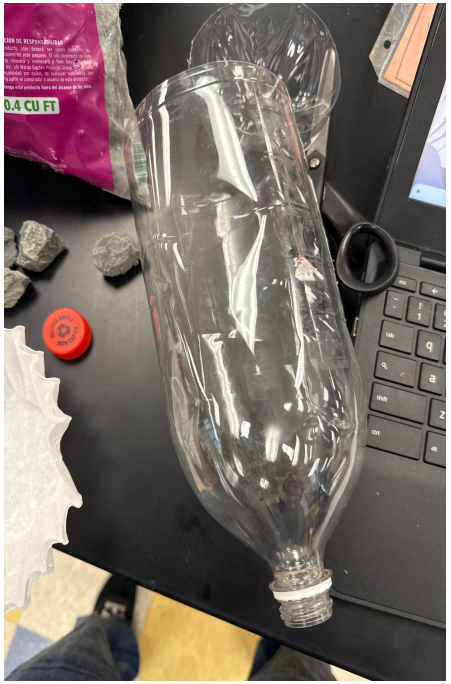
Bacteria Colonies





Design of water filtration

Design



Discussion

The filtration system produced a large decrease in absorbance , indicating that suspended particles were successfully removed from the dirty water. The absorbance measures how much light is blocked by particles, the lower readings after filtration show that the water had significantly decreased amount of particles blocking the light.The approximately 95%reduction in turbidity demonstrates that the multi-stage design was effective.

The materials used for the filter layers each contributed to the performance of the system. The coarse material(Gravel)) removed larger debris, while the sand and final layers captured smaller particles. This supports the engineering concept that sequential filtration stages improve removal efficiency compared to a single filter system. There were several limitations in my experiment.The spectrophotometer measures turbidity but does not detect dissolved chemicals, bacteria, or viruses. therefore , although the filtered water appeared clear and had lower absorbance measurements, it cannot be assumed safe for drinking as shown in the bacterial count results (before & after).In addition, variations in water flow rate and packing of the filter layers may have affected the measurements. Overall, my results supported the hypothesis that a simple low cost filtration system can sigifncatl improve water quality by reducing suspended particles, but additional treatment such as UV sterilization or chemical disinfection would be required for safe drinkable water.

Implications for Future Research

The system itself could be useful as a pretreatment method in emergency situations, outdoor environments, or areas without access to advanced water treatment infrastructure. By removing suspended solids, the filtration step would allow later purification methods such as boiling, chlorination, or UV treatment to work more effectively. future research could improve the system by testing additional filtration materials, such as finer activated carbon, ceramic filters, or membrane filters. Flow rate optimization and layer thickness could also be studied to maximize filtration efficiency while maintaining reasonable filtration speed. Additional studies could evaluate long-term performance, including how quickly the filter becomes clogged and how often it must be replaced or cleaned. Scaling the design into a portable or larger community-level system could also be explored.

References

Materials from University of Arizona

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