Comparing efficiency of water cleaning methods

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Abstract

The physical removal of particle contaminants from turbid water reduces bacteria and heavy metals and ensures greater safety in drinking water. Water filtration systems are utilized worldwide; however environmental research has yet to fully compare the efficiencies of three major methods to remove solid contaminants from water: gravitational (simple), vacuum and centrifuge. This study evaluated filtration efficiency based on the mean percent of contaminants filtered out, the mean volume of clean water produced, and the duration of filtration. The turbid water was manually created in the lab and each filtration method was tested five times. There was a significant difference between the three methods tested for each variable. Centrifugal filtration filtered out the most contaminants (94.87 ± 1.96%) but vacuum filtration produced the most water (95.8 ± 0.76 %) in the shortest time interval (27 ± 2.92 seconds). Gravitational filtration was shown to be the least effective in all three variables tested. This work demonstrates that centrifugation most efficiently removes contaminants while vacuum filtration produces clean water the fastest. However, considering the expense of electricity and filtration facilities required for centrifugal and vacuum systems, gravitational filtration is the most economically feasible and sustainable method to treat substantial quantities of water because it is easily operated and requires no electricity. The results of this project can contribute to future studies on methods of filtration. By providing data to evaluate water filtration efficiencies, this study furthers the sixth United Nations Sustainable Development Goal of clean water and sanitation.

Introduction

- Unsafe drinking water contributes to the global burden of disease that results from enteric illness and diarrheal diseases; it has been classified as a UN Sustainable Development Goal
- The efficient removal of physical particle contaminants from turbid water is crucial to ensuring the safety of its consumers post-filtration
- The objective of this study was to determine the most effective filtration method of physical water treatment between three specific methods: **centrifuge, vacuum,** and **gravitational (simple)**
- Efficiency was evaluated based on three variables: the mean percent of contaminants filtered out, the mean percent of filtered water produced, and the mean duration of the filtration

Materials and Methods

- 120 mL of turbid water was manually created in the lab for each trial by mixing 20 cm^3 of contaminants (Ace Potting Soil, course sand, and Stoney River Premium Aquarium Sand) and tap water
  - Reduced to 90 mL for centrifuge trials to accommodate capacity limit
- 5 trials were run for each filtration method
- Gravitational and vacuum trials: the turbid water was filtered through Grade 3 filter paper into a Büchner funnel
- Centrifuge trial: one sample of turbid water was distributed amongst six tubes and rotated for 30 seconds while another for 60
- The mass and volume were taken before and after each filtration and the time was recorded by video
- The contaminants were heated in an incubator at 36.0°C post-filtration until dry before the mass was taken
- One-way ANOVA Independent Test performed to test for significant difference between the three variables

Results

- No significant difference between the mean percent of contaminants filtered out for the 30-second and 60-second interval tests for centrifugal filtration
- Significant difference between the mean percentage of contaminants filtered out for each method
- Significant difference between the mean percent of initial water filtered out using each method
- Significant difference between the mean time of filtration for each method

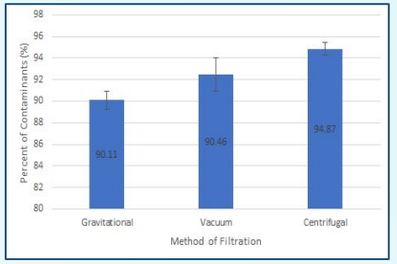

Fig. 1. The percent of the total initial amount of contaminants filtered out by each filtration method. The labels represent means and error bars represent standard error.

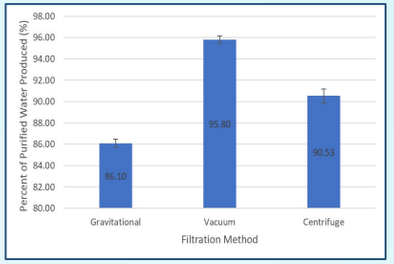

Fig. 2. The percent of the total initial amount of turbid water produced by each filtration method. Error bars represent standard error and labels represent mean.

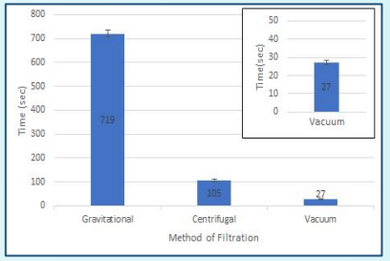

Fig. 3. The average time required to filter using each filtration method. Labels represent mean and error bars represent standard error. The smaller chart shows the vacuum filtration time more precisely.

Discussion

- Centrifugal filtration removed the highest percent of contaminants, but vacuum filtration produced the greatest volume of filtered water in the shortest time
- Centrifuge could filter only 90 mL of water at a time and large-capacity centrifuges cost thousands of dollars; only recommend for small amounts of water
- Vacuum filtration is the most recommended in order to produce the most water in the shortest time
- Centrifugal and vacuum methods both require substantial amounts of electricity while gravitational does not, therefore gravitational might not be the most effective, but it is the most sustainable filtration method
- Suggestions for future experiments include more methods of filtration such as reverse osmosis and cross-flow filtration and larger-scale filtrations
  - multiple methods of filtration can be paired together and tested for efficiency

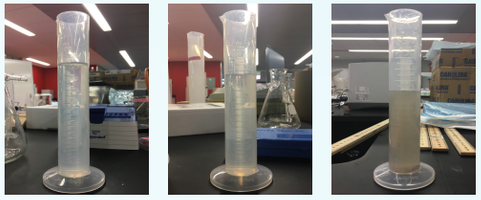

Fig. 4. Example purified samples from each filtration method. Left: from vacuum filtration. Center: gravitational. Right: centrifugal. From left to right, water turbidity increases.

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