Evaluating the Effectiveness of Different Filtration Methods in Removing Ibuprofen and Acetaminophen from Polluted Freshwater Sources

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Abstract

The purpose of this study was to evaluate the effectiveness of 3 filtration methods — activated carbon, membrane, and sand filtration. The experimentation process showed that the most efficient filtration technique to potentially incorporate into a real-world scenario, was activated carbon filtration. pH & absorbance level changes were the highest for this type, proving its peak effectiveness. Further, by using a combo of a literature review and an experimentation process, the most cost-effective and policy-friendly filtration was determined as being activated carbon filtration – though it does have a higher cost than the other two methods.

Introduction

Pharmaceutical pollution in freshwater is a growing concern, both environmentally and public-health wise. Various studies have shown that the EPA & WHO have shown that active ingredients, such as ibuprofen and acetaminophen are being more and more frequently detected in freshwater (such as lakes and rivers). These substances have been known to disrupt aquatic ecosystems, reproductive health in wildlife, and antibiotic resistance in humans (Hughes, 2023; Rzymski et al., 2017). After reviewing guidelines and reports from the EPA, WHO, & EU, it was found that many contaminants lack regulations and existing wastewater treatments aren't satisfactory in removing pharmaceuticals. To explore this further, I decided to experimentally compare sand, activated carbon, and membrane filtration methods. This study's aim is to find the most effective, whist low-cost filtration solution (out of the three) that could help mitigate this contamination issue.

Methodology

For experimentation:

- Procedure:
  1. Freshwater site will be chosen and sample collected
  2. Setup the three methods of filtration
     - Sand filtration: Cut out a 1-liter plastic bottle using a box cutter and layer on 2 additional bottles to create different levels. In each of the levels add 200g of sand from coarse to fine. Poke holes on each cap (using a paper clip) at every level.
     - Activated Carbon filtration: Do the same setup technique as above, but instead layer with 200g of activated carbon.
     - Membrane filtration: Use a general water filter that contains a membrane, like a water-pitcher.
  3. Running the experiment
     - Add 200mg of ibuprofen and 500mg of acetaminophen to 16oz of lake water.
     - Pour this unfiltered water sample into the top of the bottle and watch as it goes through the layers and filters out the bottom.
     - Once this is complete, note any changed in color, clarity, pH, and run these through a light spectrophotometer.

Results

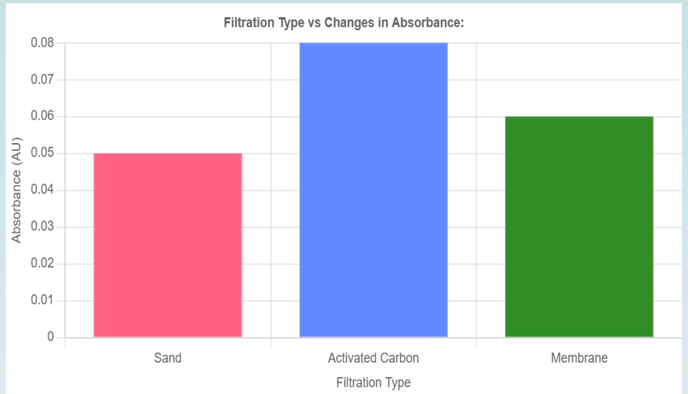

Fig. 1: Activated Carbon showed the greatest reduction in absorbance (AU) levels – It was 20% more effective than membrane filtration and 40% more effective than sand filtration.

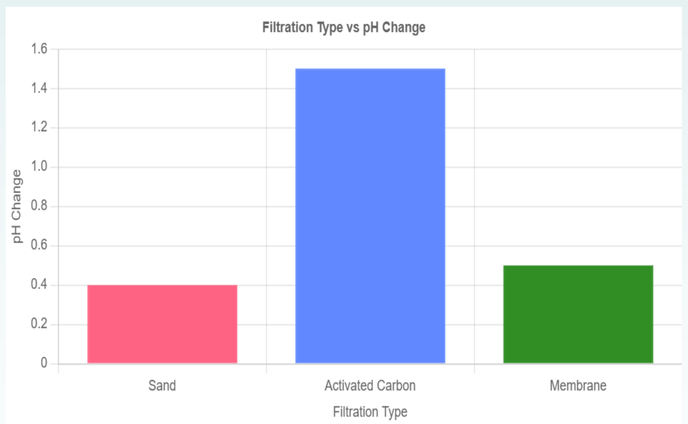

Fig. 2: Again, Activated Carbon showed the greatest change in pH. All samples started at a pH of around 6. Sand filtration changed the least, then membrane, then activated carbon (at around 70-90% higher).

Conclusion

In conclusion, pharmaceutical contaminants in water can be significantly reduced by various methods. However, due to the restrains presented by economical disparities and policy impacts, it is seen that activated carbon filtration is the most effective yet sustainable solution. Among the filtration methods studied, activated carbon filtration consistently demonstrated the highest removal efficiency, effectively eliminating up to 90% of pharmaceutical contaminants in some cases. Experimental trials supported these findings, with carbon filters outperforming other methods in improving water clarity, pH balance, and reducing contaminant levels. Although certain economic and implementation challenges exist, the results indicate that activated carbon filtration is the most effective and sustainable solution currently available for addressing pharmaceutical pollution in freshwater sources.

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