#NoFilter? Evaluating Portable Water Filters for Removal of Inorganic Contaminants

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Introduction

Portable consumer water filtration systems are primarily marketed for bacterial removal, but their efficacy in reducing metal contaminants remains largely untested. Given Montana's history of metal contamination in water systems due to acid mine drainage, this study evaluates the effectiveness of different portable filtration technologies—including hollow fiber microfiltration, hollow fiber ultrafiltration, and activated carbon with ion exchange resin—in removing inorganic metal contaminants from water.

Figure 1.
Carbon Activated Filter.

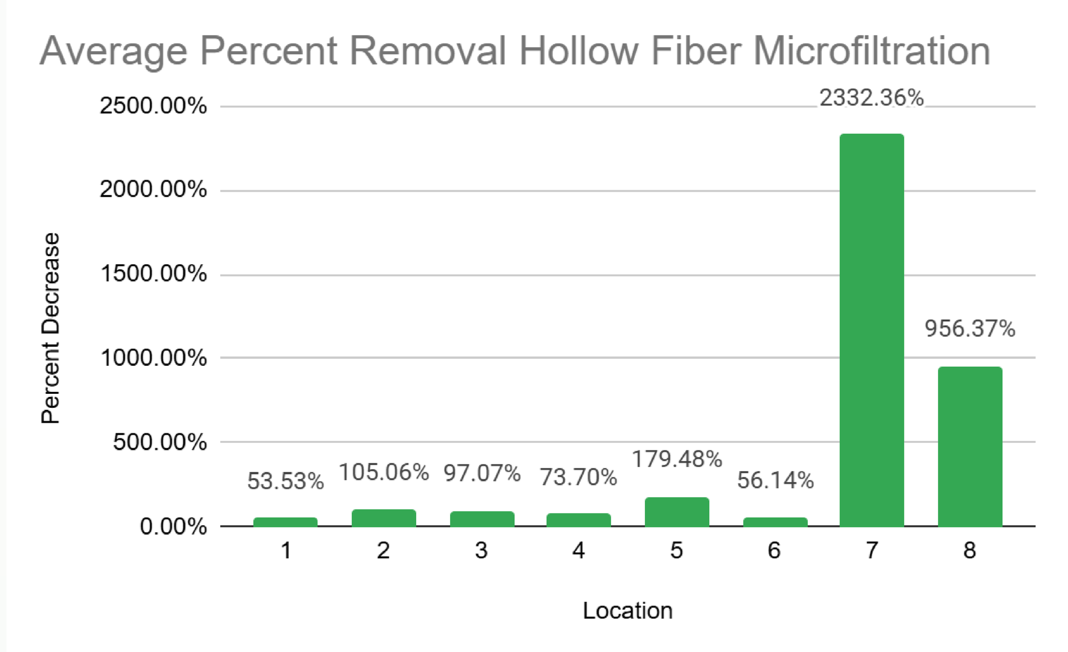
Figure 2.
Hollow Fiber Microfiltration.

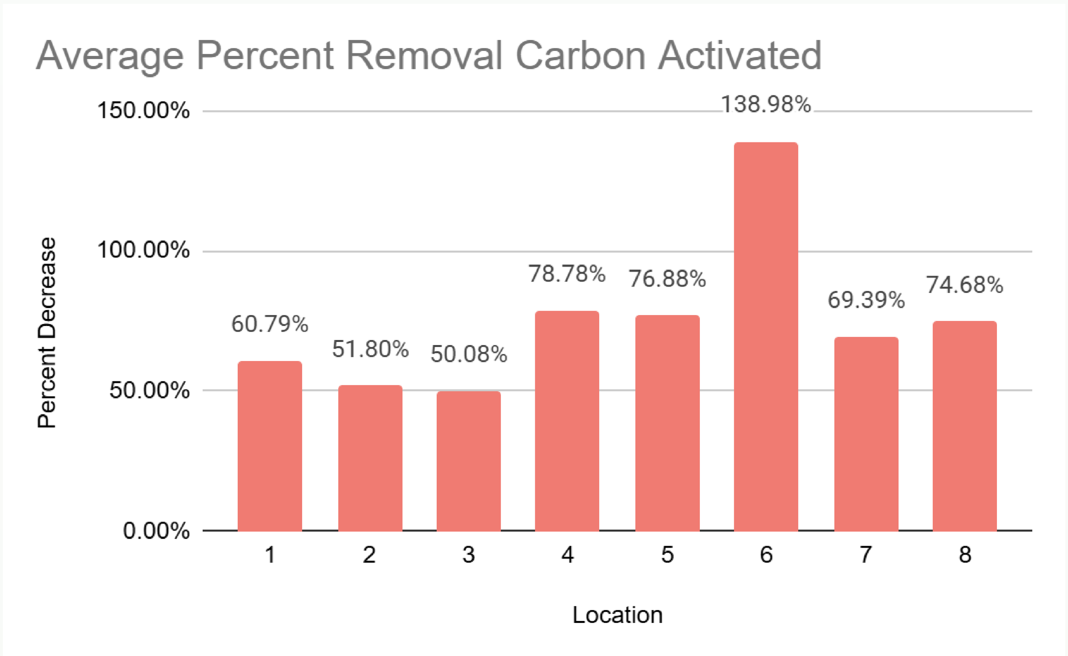
Figure 3.
Hollow Fiber Ultrafiltration.

Methods

Surface water samples were collected from sources impacted by acid mine drainage and preserved with nitric acid (pH < 2), denoted "Natural Water". In addition, lab-prepared deionized water solutions were spiked with known concentrations of metals, denoted "Controlled Amounts". Four consumer-grade filters were tested: hollow fiber microfiltration, hollow fiber ultrafiltration, and an activated carbon filter with ion exchange resin. Reverse osmosis was initially investigated but excluded due to excess volume requirement. Samples were filtered according to manufacturer instructions. Metal concentrations before and after filtration were quantified using ICP-OES (Inductively Coupled Plasma Optical Emission Spectroscopy). Bacterial growth tests were also performed on nutrient agar to assess microbial reduction.

Natural Water Results





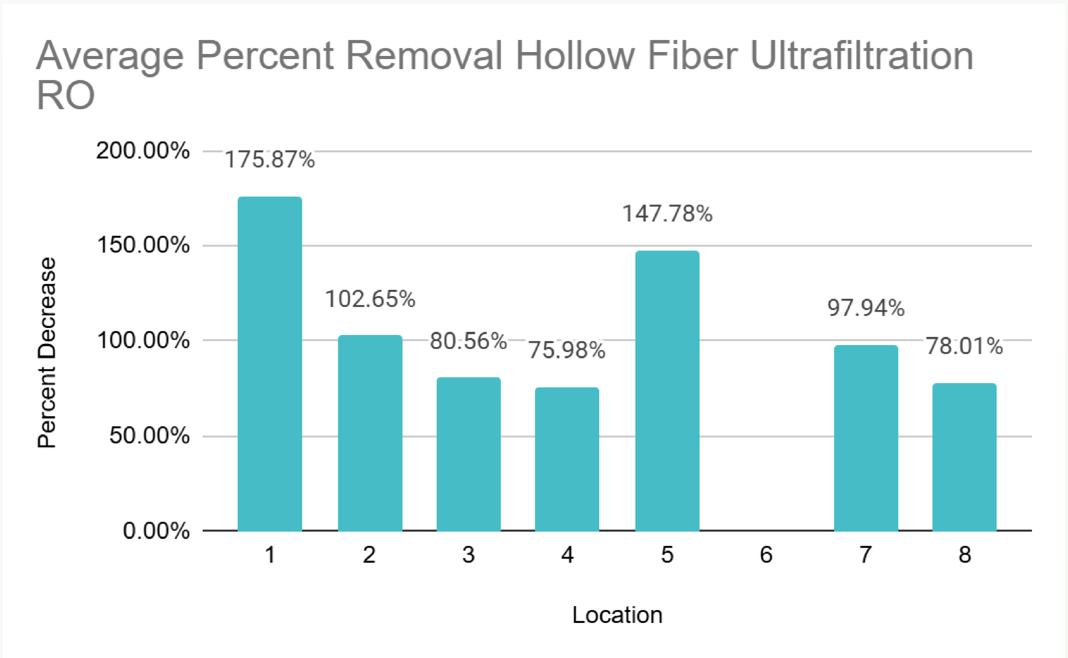


Figure 4-6. Graphs of the percent decrease for each location. Graphs are separated by filter type. *Indicates that there wasn't enough sample water to perform filtration.

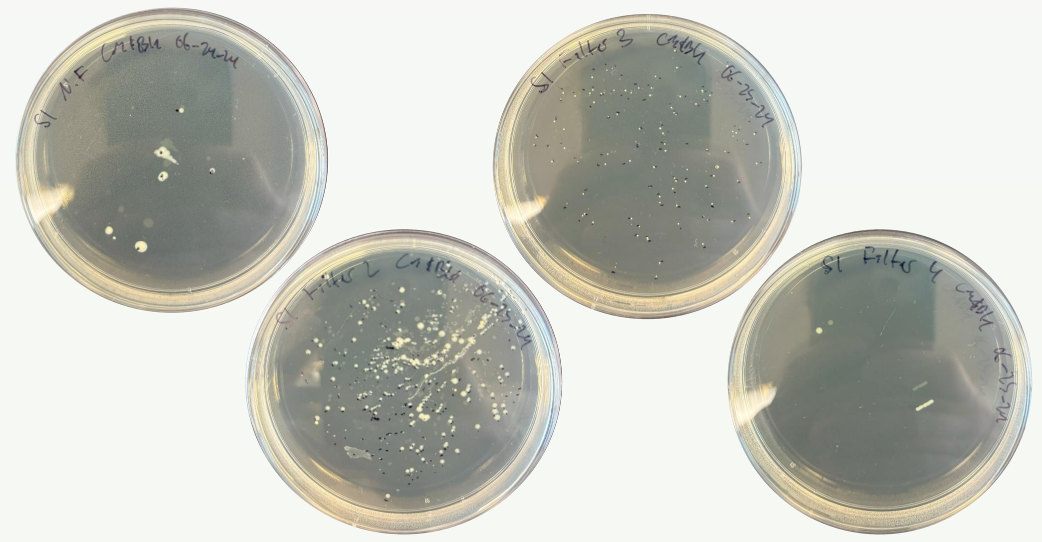
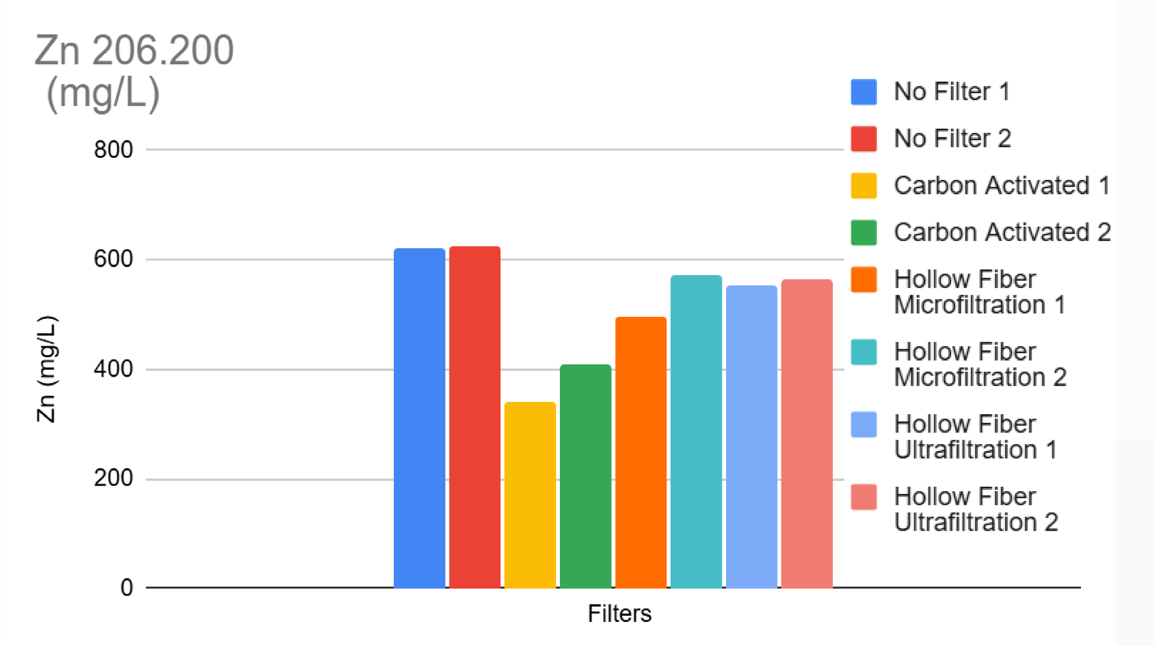
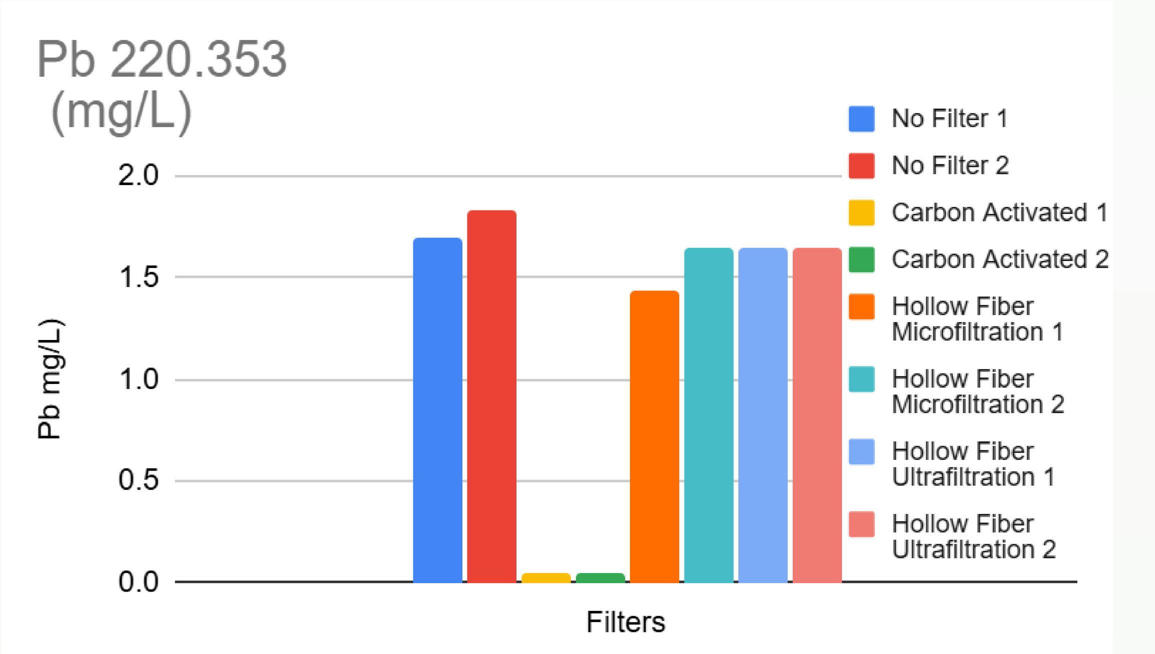


Figure 7. Bacterial Growth of samples from Location 1, before and after filtration.

Controlled Amounts Results





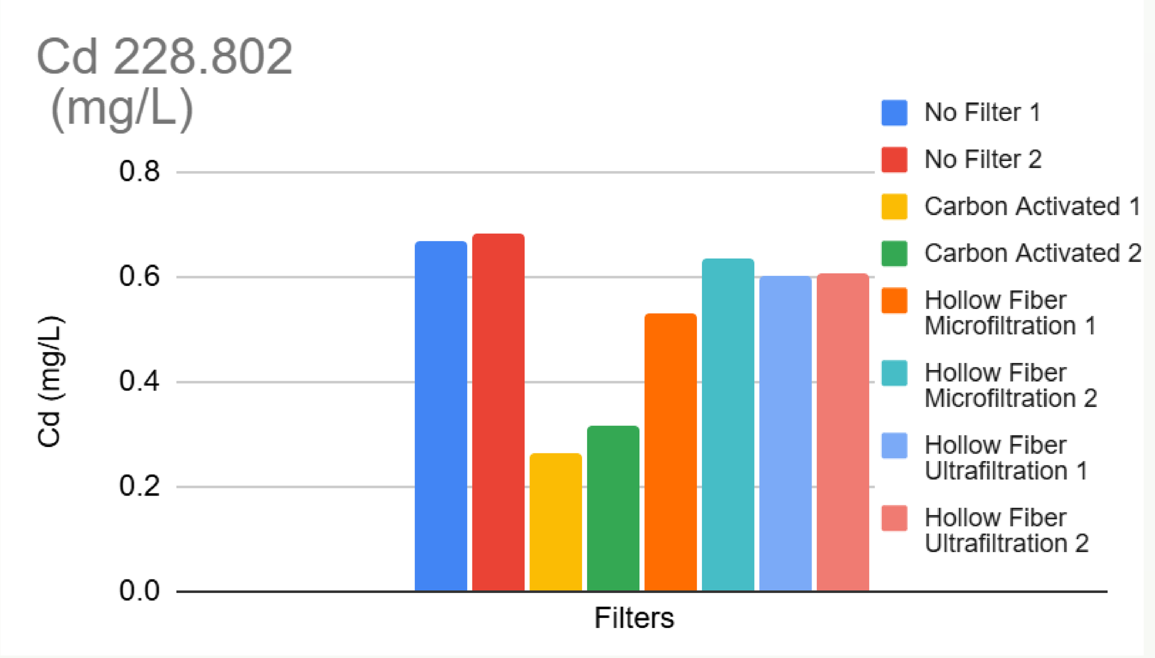


Figure 8-10. Concentrations of select metals before and after filtration of controlled amounts samples.

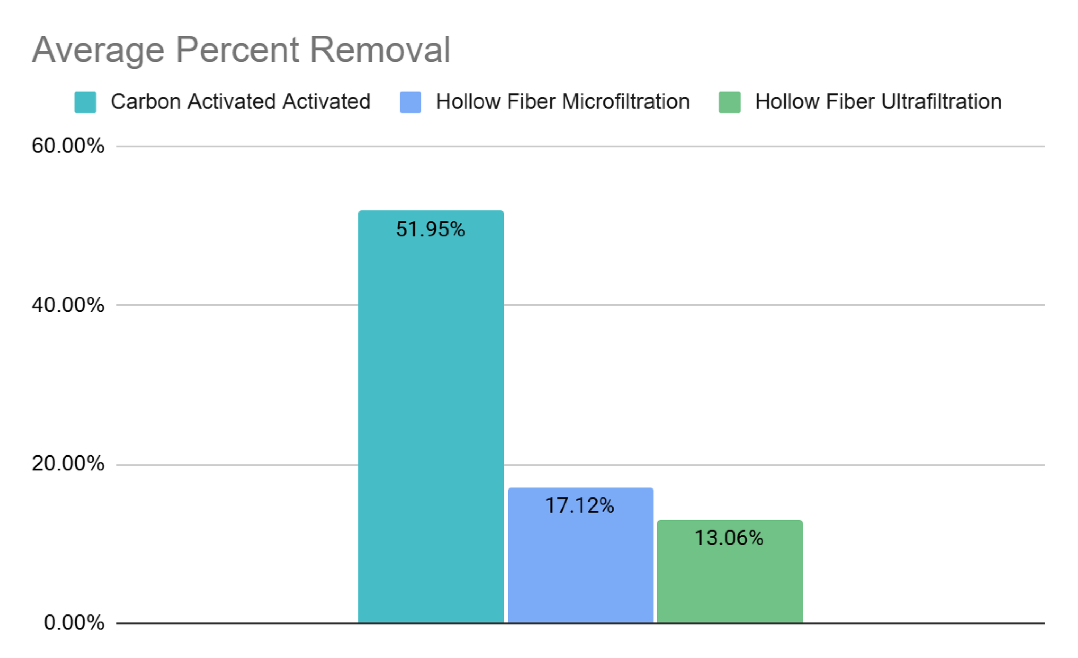


Figure 11. Average percent removal of metal concentration (for all metals analyzed) for each type of filter.

Controlled Amounts Results

	No Filter	Carbon Activated 1	Carbon Activated 2	Hollow Fiber Microfiltration 1	Hollow Fiber Microfiltration 2	Hollow Fiber Ultrafiltration 1	Hollow Fiber Ultrafiltration 2
As (mg/L)	1.53	1.05	1.18	1.15	1.40	1.41	1.38
Al (mg/L)	5.56	0.11	0.11	2.87	3.38	3.85	3.88
Be (mg/L)	0.52	0.40	0.43	0.39	0.47	0.48	0.46
Cr (mg/L)	8.38	4.50	5.08	6.88	7.85	7.54	7.59
Cu (mg/L)	107.34	13.29	16.60	86.35	98.08	96.04	97.10
Fe (mg/L)	24.40	9.14	10.52	18.71	21.66	21.83	21.99
Mn (mg/L)	0.05	0.08	0.09	0.04	0.04	0.10	0.10
Pb (mg/L)	1.83	0.04	0.05	1.44	1.65	1.65	1.65
Se (mg/L)	7.69	4.11	4.72	5.85	7.03	6.75	6.82
Cd (mg/L)	0.68	0.27	0.32	0.53	0.63	0.60	0.61
Zn (mg/L)	625.53	342.08	407.82	494.09	570.70	553.10	563.03
Sb (mg/L)	0.75	0.63	0.62	0.67	0.70	0.65	0.67
Ba (mg/L)	169.15	27.04	32.38	129.12	128.70	124.61	125.59
Na (mg/L)	93.28	87.05	88.01	86.15	86.18	83.95	84.71
Ca (mg/L)	0.016	1.49	1.42	0.15	0.15	2.19	2.18

Figure 12. Heat map of the average concentration for all metals analyzed for each filter. Green represents lowest concentration; red represents the highest concentration.

Conclusions

This study demonstrates that not all portable water filters are equally effective at removing inorganic contaminants. The activated carbon filter with ion exchange resin consistently removed a significantly higher percentage of metal ions. Notably, lead levels in controlled samples were reduced by over 80% with the activated carbon filter, while hollow fiber filters showed minimal impact. However, hollow fiber filters showed better performance in reducing bacterial growth on nutrient agar, indicating stronger microbial removal.

While many filters are marketed primarily for pathogen protection, these findings highlight that their ability to remove heavy metals varies widely. For areas impacted by historic mining and metal contamination, such as in Montana, understanding both microbial and metal contaminant removal is essential for making informed and effective water treatment choices.

References

1. Musselman, R. Sampling Procedure for Lake or Stream Surface Water Chemistry; 2012. https://www.fs.usda.gov/rm/pubs/rmrs_rn049.pdf.
2. US EPA. Drinking Water Regulations and Contaminants. US EPA. https://www.epa.gov/sdwa/drinking-water-regulations-and-contaminants (accessed 2024-06-10).