Analyzing Heavy Metal Removal in Two Point-Of-Use Water Systems

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1 INTRODUCTION

- ➢Having access to clean drinking water is a fundamental human need. Yet, for over 2 billion people in impoverished or rural regions of the world, this access remains limited. Many efforts exist to improve access, but fundamental limitations still exist like overall cost, on-site repairs, user operating knowledge, and understanding of local contaminants.
- ➢Heavy metal contamination of surface and groundwater is a serious global concern and developing effective heavy metal removal technology is required. Therefore, Metals in our water supply may occur naturally or may be the result of contamination.
- ➢Today, many developing countries are challenged to reduce heavy metal exposure owing to limited economic capacity to adopt modern heavy metal removal methods.
- ➢As an intervention to address the safe drinking water demand, the World Health Organization suggests point-of-use (POU), household water treatment which draws on applicable low-cost technology
- ➢This study was conducted after a previous study showed that Haitian water contain some heavy metals such Iron, Copper, Arsenic, Lead and Fluoride in which their concentrations are higher than the EPA maximum contaminant level for drinking water (MCL).
- ➢For this study we tested two POU, GOW and BSF, water filters mainly used in remote areas to determine their effectiveness in removing heavy metals from drinking water.

Hypothesis:

My hypothesis is that this research will demonstrate high chemical removal efficiency by using Gift Of water system or Biosand water filter as Point-Of-Use water treatment.

2 METHODS AND MATERIALS

Tap Water from UF → pH, Turbidity, Fluoride , Free and total Chloride were measured → 10 ml of samples taken for ICP-MS analysis

Tap water divided into 3 samples of 20 L each of identical consistency and spike each of chemical spiking solution

↓

Take 100 mL samples from each bucket and filter

↓

pH, Turbidity, Fluoride , Free and total Chloride were measured in each sample

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10 ml of samples taken for ICP-MS analysis → Statistical analysis (t-test) of the results

Cartridge filled with GAC.

String-wound filter

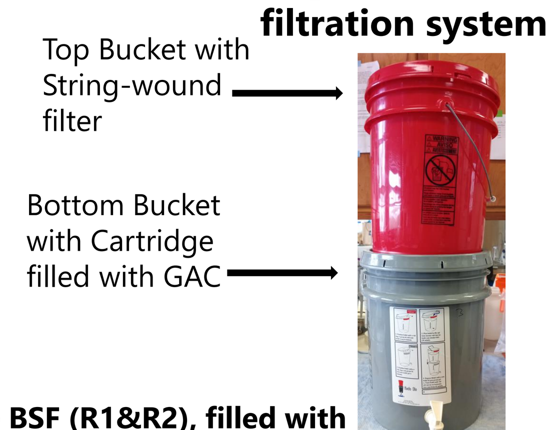


Figure 1: GOW filtration system

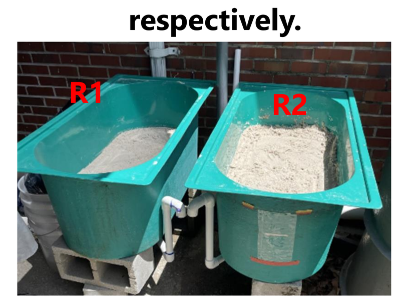


Figure 2: The BSF (R1&R2), filled with 13.5 cm and 18.75 cm fine sand, respectively.

To get sufficient data:

- ✓The tap water from University of Florida was spiked to assess whether the two (2) POU systems can remove these pollutants to levels below the acceptable drinking water standard.
- ✓The spiking concentrations of the following heavy metals Lead (Pb), Fluoride (F), Copper (Cu), Arsenic (As), and Iron (Fe) were set at 30 % over the MCL to determine the removal efficiency of each of them from the systems..

3 OBSERVATIONS AND RESULTS

Gift Of Water (GOW) System

Table 1: Average observed concentrations of interested chemicals from GOW system.

Sample	Fe (µg/L)	Cu (µg/L)	As (µg/L)	Pb (µg/L)	F (mg/L)
	Average ± SD				
Tap Water	16.5 ± 14.1	14.1 ± 2.4	0.11 ± 0.02	1.45 ± 1.73	0.74± 0.13
Prefiltration	500 ± 444	1358 ± 568	5.87 ± 5.14	3.54 ± 3.30	4.85 ± 2.25
Filtration	9.20 ± 6.36	130.27 ± 63.3	1.23 ± 0.14	0.06 ± 0.04	5.73 ± 0.11

Figure 3: Variations of chemical concentrations at run 1

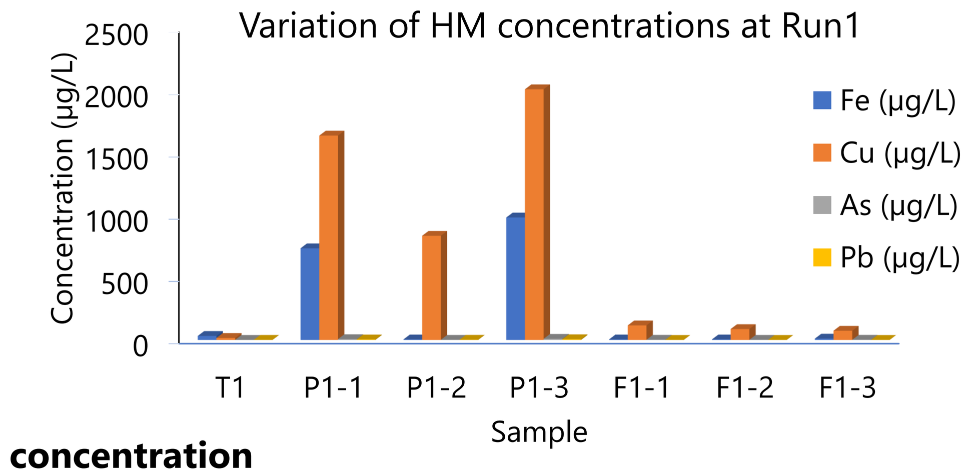
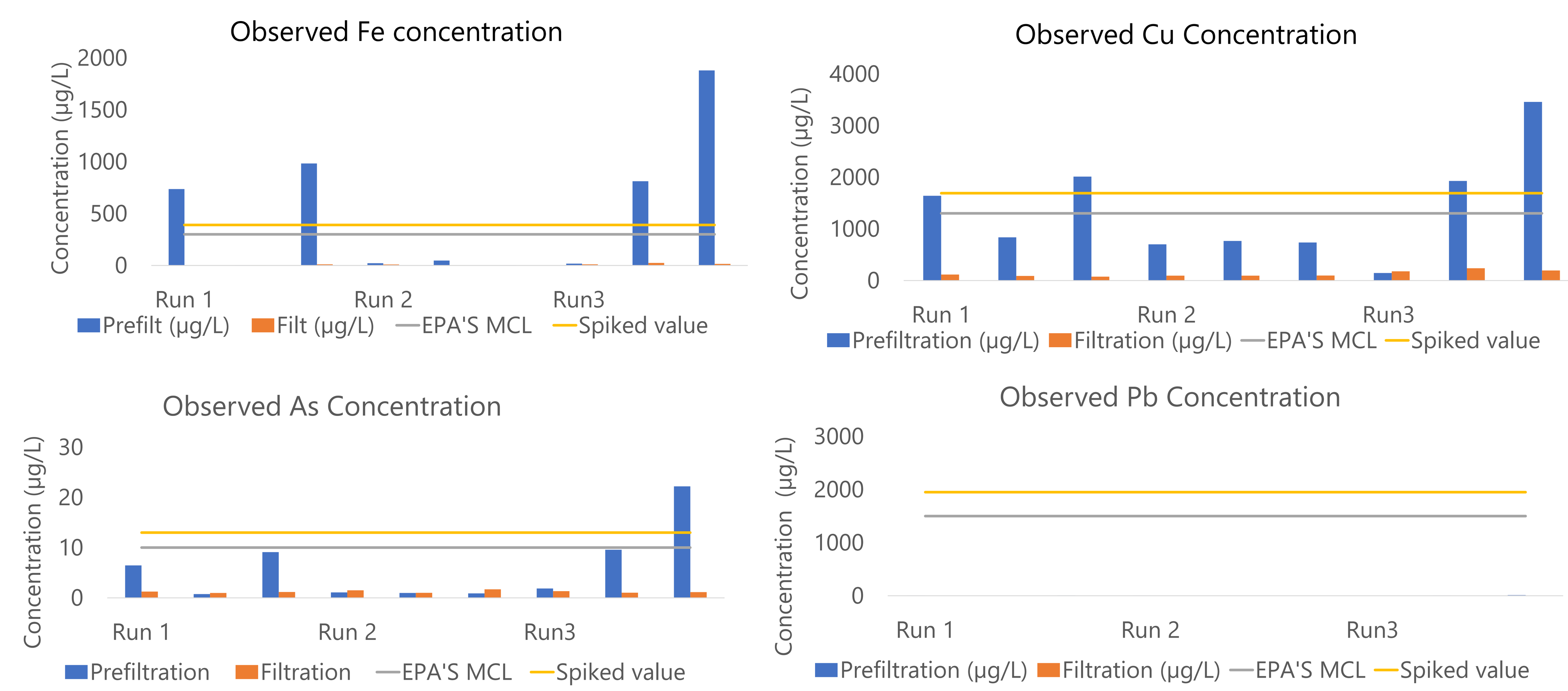


Figure 4: Chemical of interest final concentration



Biosand Water Filter (BSF)

Figure 5: Variation of the concentrations in filter 2 over the 12 days

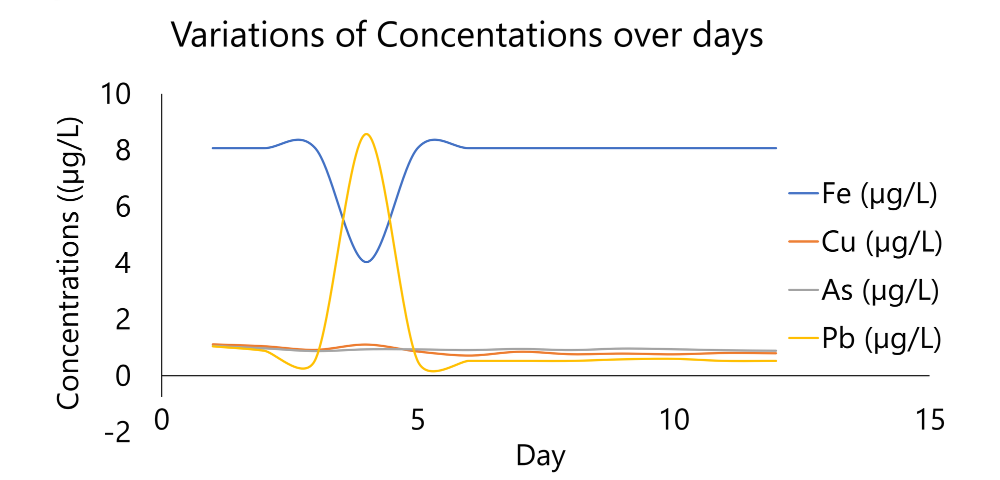


Figure 6: % recovery of chemicals concentration from day 5 in R1

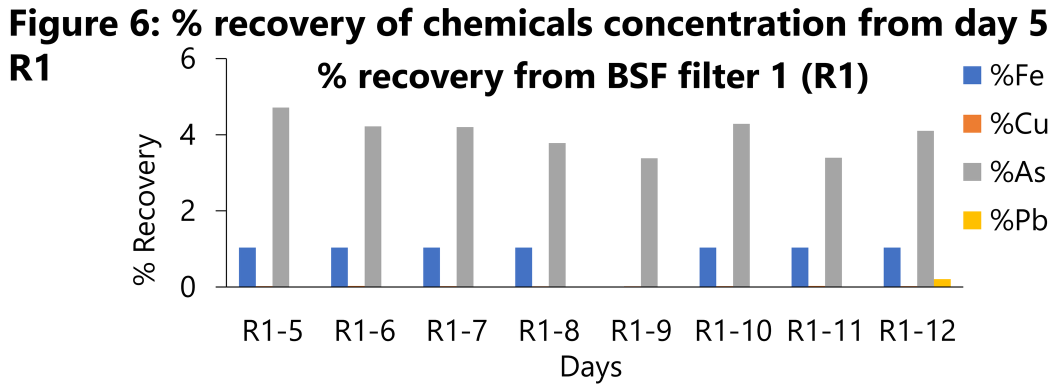
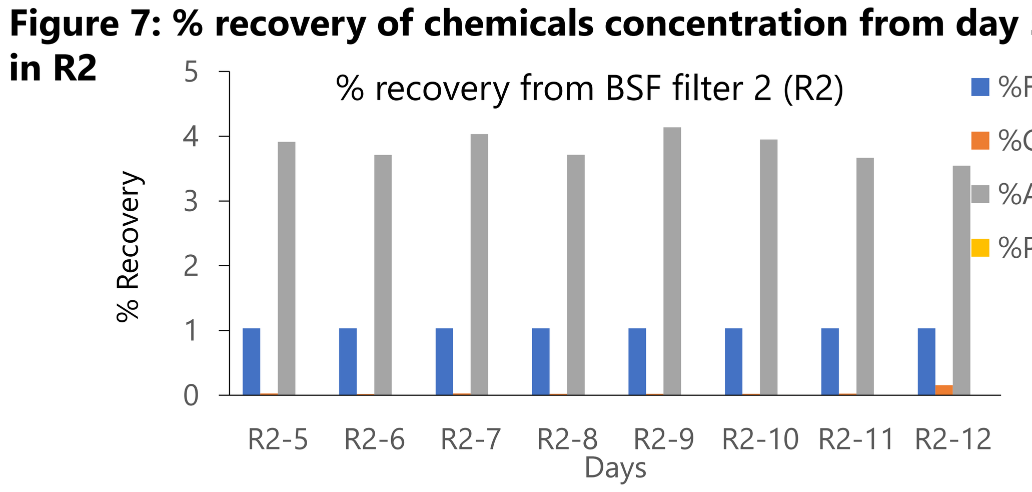


Figure 7: % recovery of chemicals concentration from day 5 in R2



4 DISCUSSION AND CONCLUSIONS

GOW

Table 2: Percentage (%) removal of each chemical by filter over the 3 runs

	Run	%Fe	%Cu	%As	%Pb	%F
	Average metal removal rate (%)					
Filter 1	R1	99.5	92.9	80.7	97.6	7.4
	R2	0.0	89.6	-32.1	96.2	-6.4
	R3	98.9	96.3	87.1	98.6	27.0
Filter 2	R1	53.7	86.6	-40.1	72.5	-12.3
	R2	91.3	87.7	-3.8	100.0	5.5
	R3	70.3	86.9	-92.7	100.0	1.8
Filter 3	R1	34.0	-22.3	28.6	-12.5	-236.4
	R2	97.0	87.6	89.2	98.2	-307.4
	R3	99.3	94.4	94.9	99.6	-50.3
Total Average		**71.54**	**77.74**	**23.53**	**83.35**	**-63.44**

Table 3: Statistical analysis between the prefiltration and filtration concentrations samples

Metal	*n*	*Mean ± SD*	*t-stat.*	*t-crit.*	*P-value*	*Conclusion*
Fe	9	499.95 ± 656.53 9.20 ± 7.14	2.24	2.12	0.04	Ho rejected ***good***
Cu	9	1358.02 ± 1010.30 130.27 ± 58.09	3.64	2.12	0.00	Ho rejected ***good***
As	9	5.87 ± 7.12 1.23 ± 0.24	1.95	2.12	0.07	Ho retained
Pb	9	3.54 ± 4.66 0.06 ± 0.04	2.24	2.12	0.04	Ho rejected ***good***
F	9	4.86 ± 2.18 5.74 ± 0.18	1.21	2.12	0.24	Ho retained

- ➢We found that GOW filters are not so efficiency in removal of arsenic and fluoride.
- ➢We found that the concentration levels of the contaminants were within the permissible limits of US EPA and WHO guidelines .

BSF

- ✓We conclude that the reduced concentration in our samples is because the filter was working and not because of other hydraulic properties like dilution or advection/dispersion.
- ✓Was it because of dilution? No - because we can calculate the diluted sample concentration, and it was still 2 orders of magnitude higher than what was collected in the sample.
- ✓Was it because of advection/dispersion? No - because we replaced all the water in the filter ~3x over the course of 12 days.

5 REFERENCES

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2)Muhammad, N. (1998). Removal of heavy metals by slow sand filtration.

3)Phillips, J. A., &Smidt, S. J. (2020). Modeling improved performance of reduced-height biosand water filter designs. Water.

4)WHO. (2008). Guidelines for drinking-water quality third edition incorporating the first and second addenda volume 1 recommendations Geneva 2008 .

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