

# The Effects of Adding Iron Oxide to a Ceramic Point-of-Use Potable Water Filter to Aid in the Reduction of Arsenic in Drinking Water



Melissa A. Griffin, Stephen McDonough, Nicholas C. Charassri, Ishan Desai ‡, Dr. Bryan Boulanger ‡  
 \*Eastfield College, DCCCD, Mesquite, TX ‡Texas A&M University, College Station, TX



## Abstract

Currently, silver-infused ceramic point-of-use filters are 99.9% effective in removing bacteria. The ceramic point-of-use filters are made from local clays, sawdust, colloidal silver, and fired in a kiln, making filters very cost effective to provide clean water to indigenous parts of the world. Unfortunately the filters are ineffective for filtering heavy metals, particularly Arsenic. The purpose of this study was to determine if adding Red Iron Oxide, a metal oxide, to a ceramic point-of-use filter would aid in the reduction of arsenic levels in drinking water. Four filters were made and then two liters of distilled water were run through each filter. Next, an Arsenic solution was prepared by with 50ppb of Arsenite,  $As_3^+$ , and 50 ppb of Arsenate,  $As_5^+$ . One pre filtration sample was taken and two post filtration samples were taken and then analyzed for arsenic using the Atomic Absorption Spectrophotometer. Results show some reduction in the amount of arsenic in the filters coated with red iron oxide but they are not significantly less than the control. Further testing needs to be completed using the filters made to a uniform, full-size to eliminate any variables which may have affected filtration.

## Introduction

Arsenic is a naturally occurring element in the earth's crust and is released into the environment by erosion of mineral deposits. Arsenic can also be released into the environment from human activities as a result of wood treatment, mining, and widespread use of Arsenic in pesticides.

Arsenic is a carcinogen and long term exposure to arsenic in drinking water has been shown to cause kidney, bladder, skin and lung cancer. It can also cause changes in skin such as hyper-pigmentation and hyperkeratosis. Long term exposure symptoms are often delayed, not occurring until a continual exposure for over a period of 10 years. In contrast, acute exposure has very different symptoms. In acute poisoning, the person deteriorates rapidly with typical shock symptoms: the pulse is weak, the skin cold, damp, and pale [1]. Unfortunately the signs and symptoms of arsenic poisoning appear to differ between individuals, populations, and geographical areas.

This study will test whether adding red iron oxide to ceramic filters will reduce the amount of arsenic in the filtered drinking water. When iron oxidizes, it loses electrons. This loss of electrons makes the iron very attractive to other hard metals. It is this attraction that makes the addition of iron to the sediment filter so important. Harmful hard metals such as arsenic bond to the negatively charged iron, and the water exiting the system is free of hard metals [2]. Expectantly, the addition of red iron oxide to the filters will aid in the reduction of arsenic from drinking water.



Figure 1: Set up of ceramic filters



Figure 2: Atomic Absorption Spectrophotometer

## Methods

Four filters were prepared using local clay from Lake Ray Hubbard. Lake Ray Hubbard is a freshwater lake located in Dallas, Kaufman, Collin, and Rockwall County, Texas. The clay was treated with the help of Eastfield College's Art Department. Next, the clay was mixed with a combustible material, sawdust, in a ratio of one to one, then molded into filters. Filter number 1 was used as a control. Filter number 2 was painted on the inside with red iron oxide, red iron oxide was painted on both the inside and outside of the filter number 3, and red iron oxide in powder form was mixed with the clay and sawdust prior to firing of filter number 4. All filters were fired in the kiln at 1500°F to create pores by burning out the combustible material to increase the surface area for the Arsenic to adhere.

After the filters were fired in the kiln, they were positioned on ring stands. (Figure 1) Then two liters of distilled water were run through each filter, and a sample was collected from each. An Arsenic solution was prepared by with 50ppb of Arsenite,  $As_3^+$ , and 50 ppb of Arsenate,  $As_5^+$ . One pre filtration sample was taken and two post filtration samples were taken and shipped to a Texas A&M University Environmental Engineering Lab for analysis using an Atomic Absorption Spectrophotometer. (Figure 2)

## Literature Cited

1. Emsley, John. 2005. The Elements of Murder. (Oxford Press), 96.
2. McCallister, Skye. May 2005. Analysis and Comparison of Sustainable Water Filters.

## Acknowledgments

I would like to thank my mentor, Dr. Bryan Boulanger, for his advice and guidance. Many thanks to: Ishan Desai for his time and assistance in the field and with lab work; Mr. Jeff Hughes for providing support in the field; Mr. Michael Bruce with the Eastfield College Art Department for his help with making the filters; and Dr. Carl Knight and Dr. Jennifer Baggett for their guidance, proofreading, and support. Eastfield College Project Pathways Summer Institute is supported by the National Science Foundation Science Talent Expansion Program Grant # DUE-0525536, the Dallas County Community College District, the National Park Service, and the Big Thicket Association.

## Results

The testing for arsenic with the use of the Atomic Absorption Spectrophotometer indicated that that the applied solution of arsenic was at a concentration of 85  $\mu\text{g/L}$ . The analytical detection limit for arsenic is 0.6  $\mu\text{g/L}$ . Samples below this limit are reported as below detection limit. Samples showing no signal are reported as non-detectable. The background concentrations ranged from non-detectable to 7.9  $\mu\text{g/L}$  therefore it is considered negligible for this study. Filter 1 had a primary filtrate concentration of 80  $\mu\text{g/L}$ , and filtrate 2 had a concentration of 84  $\mu\text{g/L}$  of arsenic. Filter 2 had a primary filtrate concentration of 82  $\mu\text{g/L}$ , and filtrate 2 had a concentration of 76  $\mu\text{g/L}$  of arsenic. Filter 3 had a primary filtrate concentration of 68  $\mu\text{g/L}$ , and filtrate 2 had a concentration of 86  $\mu\text{g/L}$  of arsenic. Filter 4 had a primary filtrate concentration of 96  $\mu\text{g/L}$ , and filtrate 2 had a concentration of 86  $\mu\text{g/L}$  of arsenic. [Figure 3] Since the filters were relatively slow in filtering, samples were often collected 24 hours after being put into the filter; therefore evaporation must be accounted for. Figure 4 shows the amount of water in milliliters collected post-filtration. On average, 400ml of water was passed through each filter. Although, the amount of water collected post filtration on filter number 3 was significantly less than the other filters in both the background filtrate and filtrate 1 the amount of water filtered seems to increase to a rate similar to the other filters on filtrate 2.

Results of Arsenic Concentrations in Filtrates

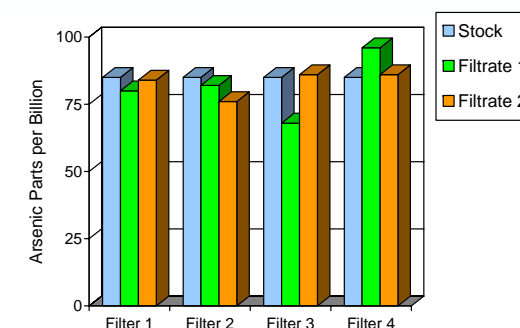


Figure 3: Graph of concentration of Arsenic in parts per billion (ppb).

Amount of Water Collected Post-Filtration

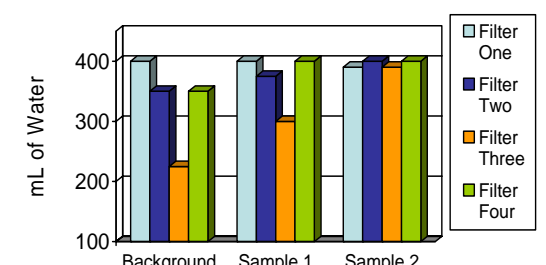


Figure 4: Amount of Water Post-Filtration

## Discussion

Based on the data, there seems to be little filtration of arsenic occurring. Results may be due to the structure of the filters. Filter one was slightly thinner than the other filters. Filter two was thick and had a large crack on the bottom of the filter. Filter three was of medium thickness with a few small cracks. Filter four was thick and had a large crack on the side. In the future results would be best if filters were made to a uniform full size with the use of a press. Filters 2 and 3, which contain red iron oxide coatings, seem to have the most effect on reducing the concentration of arsenic in the filtrate. Although, statistically the amount they filter is relatively small. The structure of the filters has had an effect on the filtration of arsenic, since results show some improvement; therefore additional testing is needed to determine the exact effect red iron oxide has in filtering arsenic. If filters were made to a uniform full size mold, there would be less variables and more water could be run through them, making any results would be more accurate.