The Impact of Metallic Biocide and User Compliance on the Effectiveness of Biological Sand Filtration

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Abstract

The purpose of this experiment was to determine the impact of milled copper and pause time on the effectiveness of biological sand filtration in order to provide enhanced water filtration systems to marginalized communities around the world. Testing entailed the creation of 4 biological sand filters (BSFs), two built according to traditional BSF guidelines, and the other two were modified to contain copper. Each filter was watered with 20 liters at a time with water samples taken from the Ocmulgee River in Macon, Georgia. To test the effectiveness of user compliance, one set of filters were fed daily while the other set were fed once every three days. One filter from each set had copper mixed into the filter bed of fine sand.

Background

Clean drinking water is often not readily available in many third world countries. As a result, there is a need to develop novel ways to provide water purification systems in people's homes. One form of water treatment is slow sand filtration, which includes biological sand filtration. Biological Sand Filters (BSFs) are a form of slow sand filtration designed to serve as point-of-use treatment units in a home. BSFs are becoming a more common form of water treatment around the world, and when operated under the right conditions, studies in laboratories have shown BSFs to be highly effective including up to 2-4 log removal of pathogenic organisms. BSFs are simple to make, from locally available materials, including layers of gravel, coarse and fine sand. A biolayer develops due to biological activity in the filter, and encourages better filtration. Aqua Clara recommends that copper be added to BSFs as a biocide. The use of a biocide can help remove biological contaminants, specifically coliforms from a water source.

Filter Setup

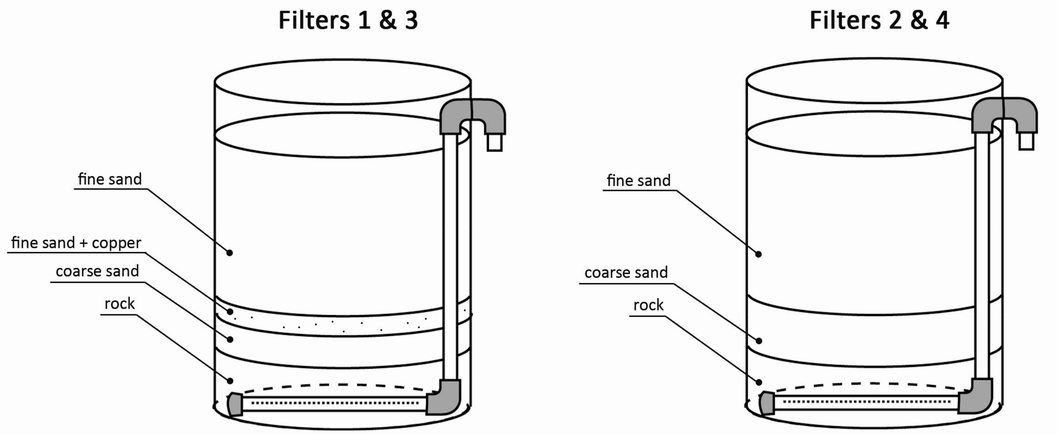

Figure One. Setup of Filters With and Without the Copper Layer.

Influent and Effluent Coliform Concentrations

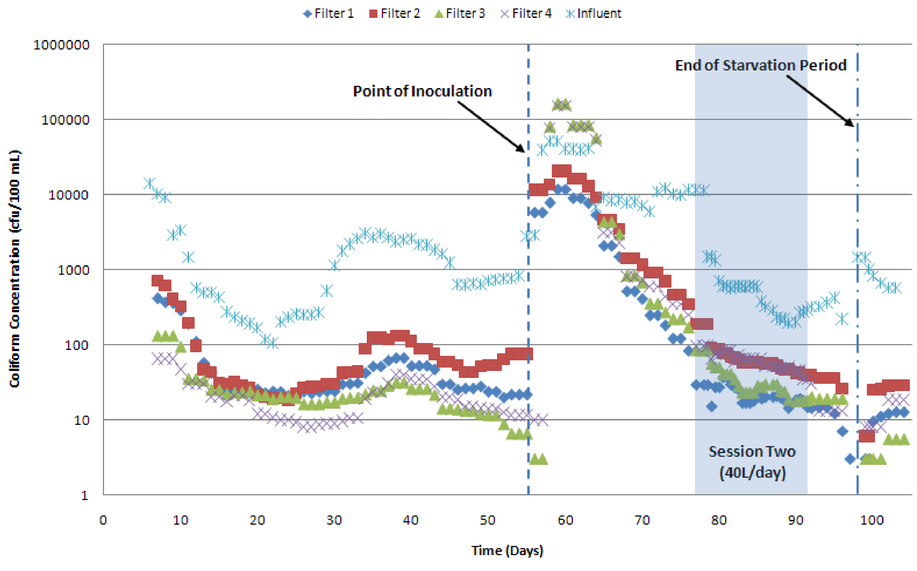

Figure Two. Effluent Coliform Concentrations with respect to Influent Coliform Concentrations.

Note: Seven Day Moving Average Applied to this Data.

Methodology

Figure One shows the composition of all four filters. For session One, filters were watered with only 20L per day. Inoculation occurred when we added a broth to increase coliform growth. Session 2 was marked by 40L watering a day, and filters were starved during session 3. all watering schemes mimicked possible methods of filter use in the field. In order to measure the effectiveness of the copper and the pause time, solids, coliforms, turbidity, pH, temperature and chemical oxygen demand (COD) were measured. Copper concentrations were also tested, and it was found that all copper levels in the effluent were below toxicity levels, including the EPA's maximum contaminant level goal of 1.3 mg/L. All filters were effective, often removing over 99.5% of coliforms from the source water. In order to determine if any of the filters performed significantly better than the others, a set of paired t-tests with α=0.5 were employed.

Discussion

Tests results determined that when a filter was watered daily, the addition of copper had a significant positive impact on its coliform removal efficiency, but the difference was not significant if the filter was watered irregularly. (There was a significant difference between the values for Filter 1 (M= 150.1, SD=480.9) and Filter 2 (M=322.5, SD=1077); $t(54)= 1.674$, $p = 0.05$, while there was no significant difference between the coliform concentrations for Filter 3 (M= 306.5, SD=1259) and Filter 4 (M=257.9, SD=929.2); $t(32)= 1.6938$, $p = 0.05$). Unequal flowrates are a possible reason for why copper did not have an impact when the filter was watered irregularly. A longer residence time and slower flowrate is preferred for the removal of contaminants in the water. Figure Two shows the coliform concentrations in the effluent peaks of each filter in correlation to the influent peak coliform concentration. Inoculation occurred when we added a broth to increase coliform growth. Filter One recovered the most quickly from Inoculation, during part of Session One. The starvation period was Session Three, when the filters were not watered at all.

Acknowledgements

I need to give a big thanks to Beth Hyde for allowing me to help her with her graduate research and for guiding me through the completion of my abstract and my poster.