Comparison of Silver Impregnated and Conventional Spigots in Ceramic Water Filters Devices

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INTRODUCTION

Ceramic filters water filtres (CWF) are a promising point-of-use water treatment technology in the developing world that can be made with local materials and labor. Currently CWFs are manufactured by pressing and firing a mixture of clay and a combustible material such as flour, rice husks, or sawdust prior to treatment with AgNPs. The filter is formed using a filter press, air-dried, and fired in a flat-top kiln, increasing the temperature gradually to about 900 ˚C during an 8-h period. This forms the ceramic material and combusts the sawdust, flour, or rice husk in the filters, making it porous and permeable to water. After firing, the filters are cooled and impregnated with a silver solution (either AgNPs or silver nitrate) by either painting with, or dipping in (Rayner, 2009). After painting with the antibacterial solution the ceramic component is commonly placed in a five gallons bucket. The contaminated water is placed inside the ceramic component from where it percolated through the porous matrix of the ceramic removing pathogenic microorganism (Oyanedel-Craver, 2008; Bielefeldt et al., 2009). The clean water drip into the plastic bucket where is stored and can be accessed through the spigot located at the bottom of the plastic receptacle. The CWF are capable to remove between 3 to 4 log of the microbial load in the influent water, however is has been observed that re-growth can happen after several month of usage (Kallman et al., 2012). The spigot has been identified as a potential sources of re-contamination of the purified water (Cohen, 2011).

OBJECTIVE

The objective of this study is to compare the potential benefits of the use of silver impregnated spigots in comparison with conventional non-impregnated spigots in ceramic water filters devices.

MATERIALS

- 8 buckets (5 gallons each)
- 33 125ml bottles
- Gloves
- Goggles
- Sink and running water to test (tap water from URI)
- 2 mL of M-FC with rosolic acid (purple color – one packet is 2 mL)
- Petri dish
- Tweezers (sterilize with alcohol before use)
- Alcohol (to sterilize instruments)
- Membrane (to grow bacteria on – circular paper)
- Funnel/filtration unit
- Incubator
- Autoclave

The figure to the right represents "Batch 2". In other words, the four buckets without impregnated silver spigots were place around a laboratory sink to allow tap water to be circulated through each bucket to replicate standard conditions in which bacteria (namely the bacteria of analysis, which is E. coli) can grow. "Batch 2" was compared to "Batch 1", which were the buckets with the impregnated silver spigots. Theoretically, Batch 1 should reduce the amount of growth of E. coli more significantly the Batch 2 (1).

Figure A: Front view of "Batch 2" around laboratory sink

PROCEDURE

Eight buckets with spigots built into the bottom were washed, labeled, sterilized and filled to begin experimentation. Each batch consisted of 4 buckets individually filled with 10 liters of tap water. The reason why eight buckets were chosen was because half of them had the silver impregnated spigots (Batch 1) and the other half had the conventional spigots (Batch 2). Every evening all 8 buckets (2 batches of buckets) were filled with 10 liters of water around 5:00 pm and left overnight. The following morning, all 8 buckets were emptied around 9:00am to 10:00am, by opening the spigots and allowing water to flow through. The buckets were separately covered with foil to prevent airborne bacteria to be deposited in the water inside the buckets. The process was repeated on a daily basis. Once a week, a bacteria analysis was conducted to figure out how much bacteria growth had taking place. Bacterial analysis was conducted in the following way:

- 125 mL samples of water was taken from each bucket
    - Two 125 mL samples from inside each bucket
    - Two 125 mL samples from outlet stream of each bucket
    - One 125 mL sample directly from sink
- 2 mL of M-FC with rosolic acid was added to a petri dish and set it aside (done so for each sample).
- Membrane was applied to the top of filtration system.
- Magnetic funnel was placed at top of filtration system and membrane.
- The sink was turned to turn on filtration system.
- 125mL of sample was poured into filtration system.
- When previous step was completed, membrane was taken (with sterilized tweezers) and placed on top of purple M-FC in petri dish that was set aside beforehand.
- Disk was covered and taped on table to prevent bubbles.
- Each funnel was boiled in water before reuse for 5 minutes.
- Dish was placed in an incubator at 44.1C.
- Dishes were labeled and bacteria were left to grow to grow overnight.
- 1 dot = 1 colony = 1 colony forming unit (CFU).
- Each dot was counted to know how much bacteria were present in that particular sample.
- Process was repeated for each of the 33 samples.
- Once bacteria were counted, petri dishes were thrown away and put all bottles were put in Autoclave apparatus for 1 hour, to disinfect reusable sample bottles.

FIGURE SAMPLES

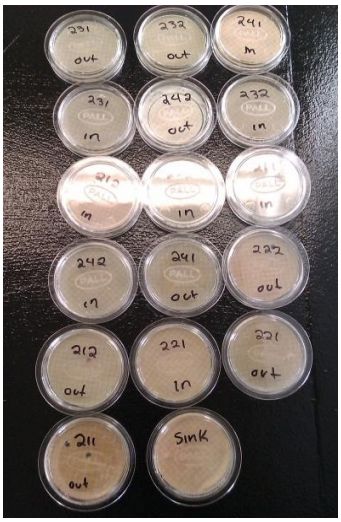

Figure 1: test results of bacterial analysis

Figure 2: Batch 2, Bucket 2, sample 1

Figure 3: results example of an "unknown"

The figures presented above represent results that were found on Dec 2, 2011. At the beginning of experimentation, an "unknown" organism was found going in a couple of petri dishes (example of one petri dish in Figure 1). After observing major characteristics of the organism with the professor and graduate researchers, the organism was concluded to be fungi. A fungus commonly grows in warm climates during long periods of time. So, it was not unexpected to find such consequences after longer periods of incubation. Figure 3 represents a complete set of collected bacteria growth data for Batch 2. Included are two samples of water within each bucket, two samples of water from the outlet stream of the spigots and a "sink" sample which represents the outlet stream of water from the laboratory sink. Each blue dot in each petri dish represents a colony forming unit (CFU) which is equivalent to the number of bacteria present. Figure 2 represents sample one the first bucket of Batch 2. There are 2 CFU's present in this sample. Data for all of the CFU values for each experiment can be found in the Appendix.

DATA

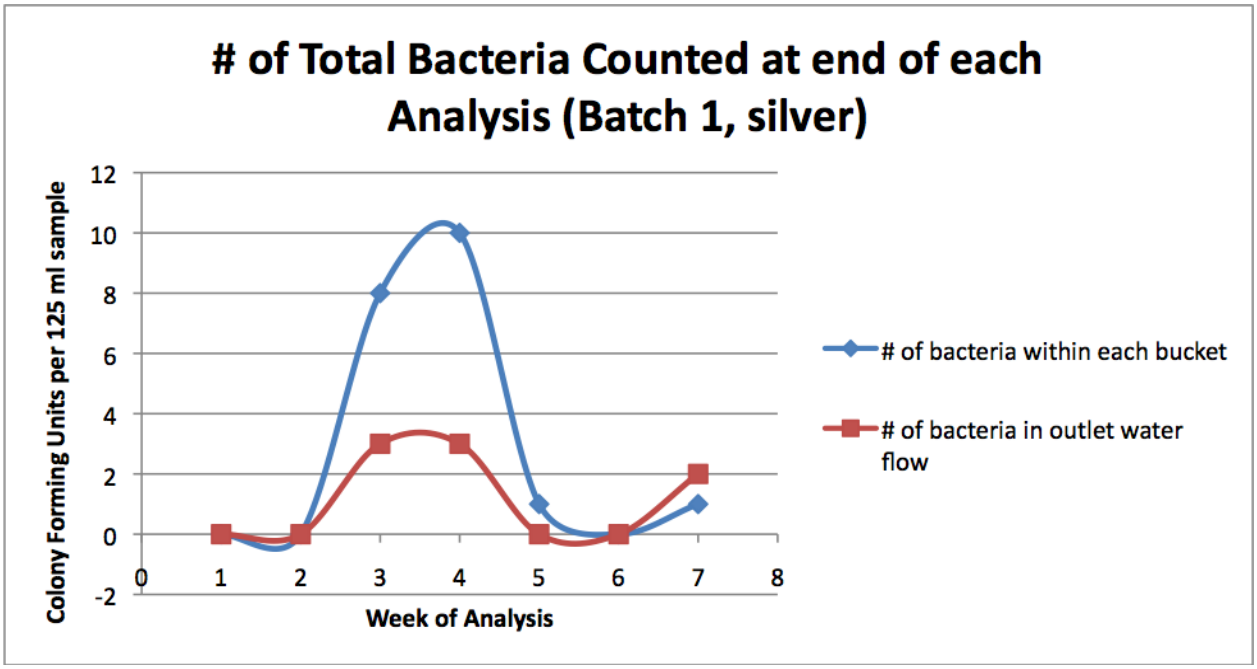

Figure 4*- Number of total bacteria counted at end of each analysis (Batch 1): The blue line represents the amount of bacteria that the bucket reproduced. The red line represents the amount of bacteria that get out using filter.*

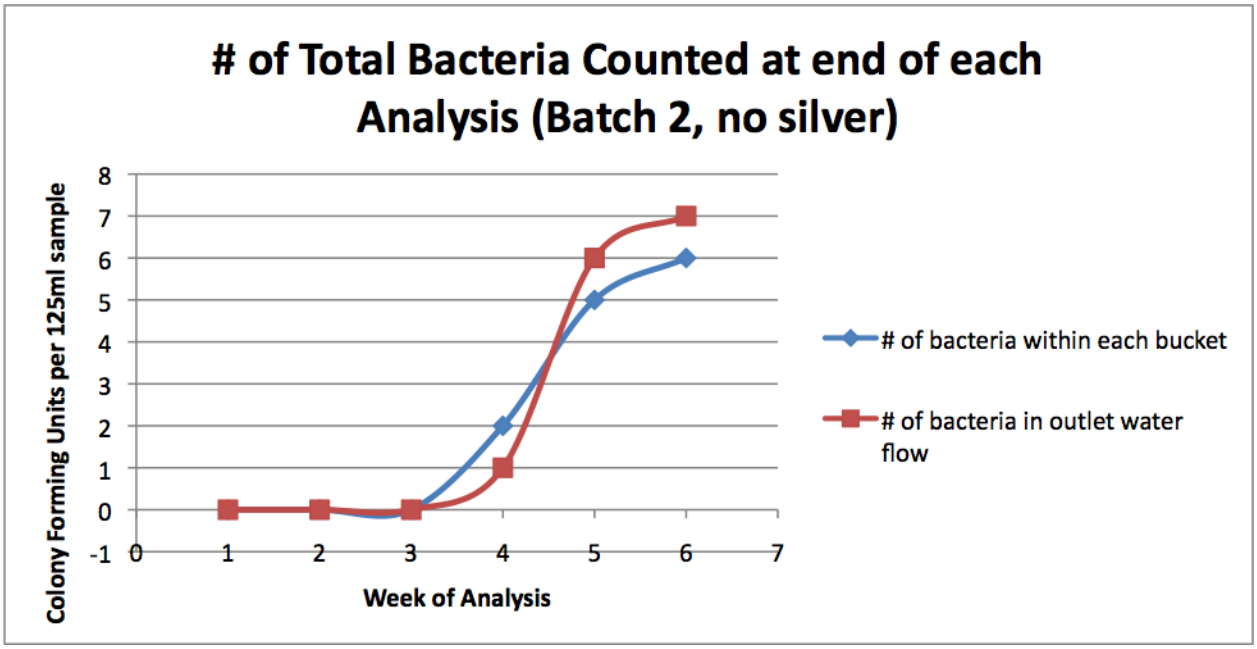

Figure 5*- Number of total bacteria counted at end of each analysis (Batch 2): The blue line represents the amount of bacteria that the bucket reproduced. The red line represents the amount of bacteria that get out using filter.*

RESULTS

No bacteria growth was found within the "sink" sample, which is the sample taken direct from the laboratory sink. This sample served as a standard for water that was original filled in each batch every day. It was important that no bacteria growth occurred in the sink sample, so that experimental results would not be altered. Bacteria began to grow around week three within a few of the other samples. An Ag+ test was also done on all samples to find any presence of silver and was concluded to be negative, since all the wavelength values were negative. This means the no water was present in the outlet stream of any of the spigots. Based on the Figures 4, there seemed to be more bacteria growth inside the buckets of Batch 1(silver) than outside the buckets of Batch 1. Based on the Figure 5, there seemed to be more bacteria growth outside the buckets of Batch 2 (no silver) than inside the buckets of Batch 2. This means that it seems that the spigots containing silver may have prevented bacteria growth, since the material was only present in buckets of Batch 1.

CONCLUSION

The spigot impregnated spigots seemed to reduce amount of bacteria in the outlet stream of water much more sufficiently than the non-impregnated spigots. Unfortunately, more time would be required to achieve consistent growth in almost all samples, so that conclusions could be established with regards to which bucket produced the least amount of growth. Error could have been introduced throughout the testing by experimental error in procedure, which may have prevented faster bacteria growth. The one recommendation as a change to the procedure was increasing the number of samples taking from within and outside of the bucket to three samples instead of two. That may also have produced a wider variation in results.

REFERENCES

- CDC, Center for Disease Control and Prevention; "Best Practice Recommendations for Local Manufacturing of Ceramic Pot Filters for Household Treatment", June 2011, First edition
- Cohen, B. (2011). Personal communication, September 3rd.
- Bielefeldt, A. R., Kowalski, K., Summers, S. (2009). Bacterial treatment effectiveness of point-of-use ceramic water filters. Wat. Res., 43, 3559-3565
- Kallman, E., Oyanedel-Craver, V.A., Smith, J.A. (2011) Ceramic filters impregnated with silver nanoparticles for Point-of-use water treatment in Rural Guatemala. J. Environ. Eng. 137, 407-416.
- Oyanedel-Craver, V. A., & Smith, J. A. (2008). Sustainable Colloidal-Silver-Impregnated ceramic filter for Point-of-Use water treatment. Environ. Sci. Technol., 42, 927-933.
- Rayner, J. (2009). Current practices in manufacturing of ceramic pot filters for water treatment. Master of Science Thesis. Loughborough University.