The Effect of Sawdust Size on Ceramic Filters and Their Efficiency in Water Filtration

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Abstract

In the developing countries, the lack of access to clean water is a significant problem. It is of great importance to find a method of purifying water using available resources. One solution is to use a filter that could be easily made using traditional methods and abundant materials such as clay and sawdust. An experiment was designed to test flow rate of water with regard to porosity size in the filter using clay and sawdust obtained from local sources. The sawdust was manually sieved into separate portions of varying size. The sawdust was mixed into the clay with a 1:1 ratio by volume to simulate standard methods to be used in developing countries. The clay was formed into circular disks and then fired to burn the sawdust from the clay and create pores in the disks. The fastest filtration corresponded to the largest range in sawdust particle size.

Background

In developing countries, millions of people are living without clean water. Contaminated water can cause a variety of waterborne diseases. Ceramic water filters have been developed to help eliminate the particles from the water. Ceramic water filters are made with clay, sawdust, and water. They are fired so the sawdust burns and leaves behind a porous clay pot. The turbid water is poured into the filter, leaving one to three liters of clean drinking water every hour. The removal of particles from the water will also reduce the amount of bacteria and parasites. Cleaner water will increase the quality of life for everyone drinking it.

Materials and Methods

Filter Production Procedure

1. Sieve sawdust to appropriate sizes
2. Measure ~200 mL clay (note mass)
3. Measure ~200 mL sawdust of appropriate size (note mass)
4. Calculate 44% of the combined mass of sawdust and clay for the necessary amount of dH_2O
5. Mix and knead clay, sawdust and dH_2O until a uniform consistency is achieved (see left photo below)
6. Repeat steps 7-12 to make four filters
7. Place circular mold on top of parafilm (measure parafilm's mass)
8. Cover mold with plastic (to prevent clay from sticking from the rolling device)
9. Place clay into mold, roll out excess clay from mold with rolling device (glass jar)
10. Remove plastic from the top of the mold
11. Weigh formed clay/sawdust/dH_2O disc. Record mass.
12. Mark formed disks (see right photo below)
13. Let dry for 2 hours
14. Place plastic tray over disks (to prevent cupping)
15. Allow to dry overnight
16. Heat in oven for 1 hour at 100º C
17. Heat for 3 hours at 890º C

Filter Testing Procedure (see photo at left)

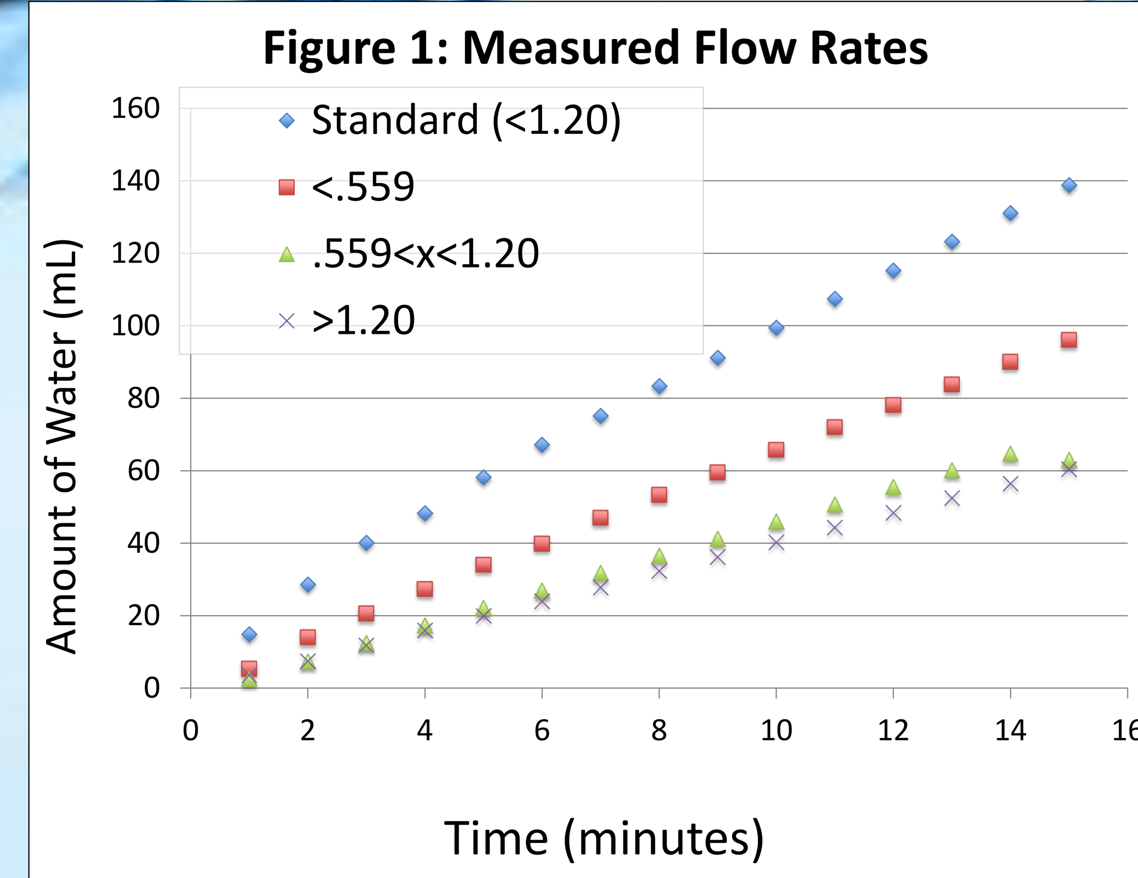
1. Dismantle testing apparatus
2. Apply petroleum jelly generously to areas of the testing apparatus that will make contact with the filter to ensure a good seal. Take care not to apply excess amounts of petroleum jelly as this may interfere with filtration
3. Gently insert filter into testing apparatus
4. Assemble testing apparatus
5. Attach testing apparatus to ring and ring stand
6. Place balance beneath testing apparatus
7. Place waste tub on balance and tare tub
8. Pour 1.4 L H_2O into testing apparatus and start timer
9. Record mass every minute for 15 minutes
10. Repeat test for all four disks

Results and Discussion

Flow Rates and Hydraulic Conductivity

Typical plots of volume collected over time are shown in Figure 1 for four sawdust size classes. The flow rates were used to calculate hydraulic conductivity values. Hydraulic conductivities are shown in Figure 2.

The largest hydraulic conductivity corresponds to the "standard" sawdust particle size, which also corresponds to the largest range of sawdust particle size. The smallest hydraulic conductivity corresponds to the sawdust particle size greater than 1.20 mm. The results show that the widest range of particle size is the most efficient.

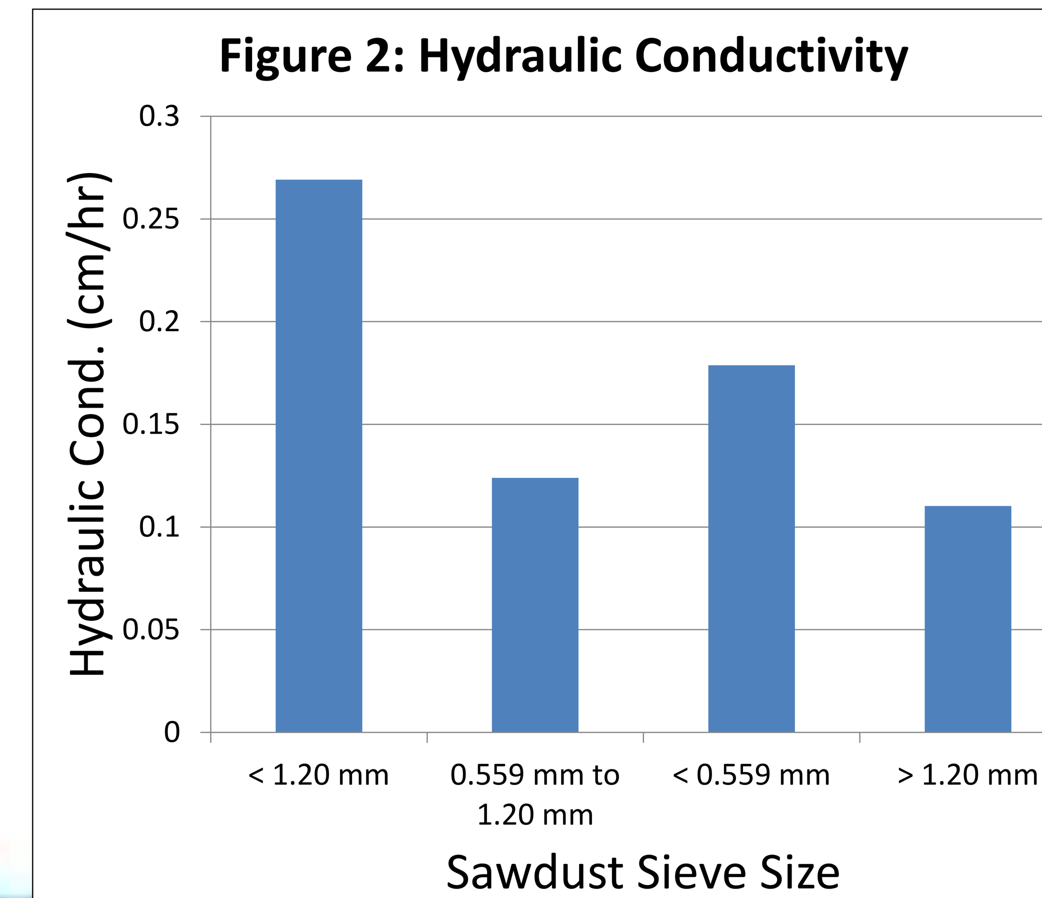


Darcy's Law

The governing equation for the flow of water through a porous filter is Darcy's Law: $Q/A = K(\Delta h)/L$. We measured the flow (Q). The cross-sectional area (A) was fixed, as was the disk thickness (L) and height of the water column during testing (Δh). This allowed us to calculate the hydraulic conductivity (K).

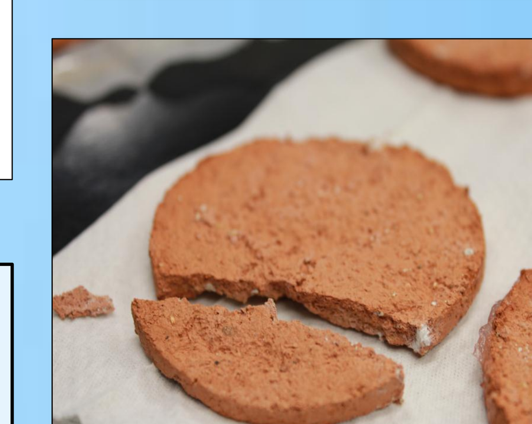
Literature Cited

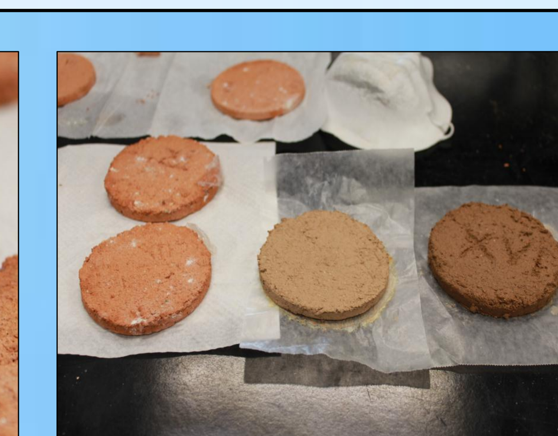
"Potters for Peace Ceramic Water Filter." *Potters for Peace Ceramic Water Filter*. N.p., n.d. Web. 5 Mar. 2013.
Chan*Pizza and Other Stuff*. 2012. Gizmodo, Australia. Web. 27 Mar 2013. http://www.gizmodo.com.au/2012/06/this-is-how-much-water, Casey. *This is How Much Water It Takes To Make Jeans, Burgers,* -it-takes-to-make-jeans-burgers-pizza-and-other-stuff/.



Broken Disks

Many of the disks created to be tested were flawed or broke. Disks 1, 5, 9, and 13 were visibly cracked and were untestable; disks 4 and 7 were flawed in some way and their filtration rates were outliers that most likely resulted from cracks or measurement error. Disk 15 was created too thick and broke when testing was attempted. As the clay was mixed and the disks were made by hand, some variance is expected.





Conclusions and Future Work

The fastest filtration corresponded to the largest range in sawdust particle size, while the smaller sawdust particle sizes correspond to slower filtration. The most efficient size is the most easily reproducible in the field.

Further testing should be performed to determine the effect of sawdust particle size on filtration rate of turbid water as the particles filtered out of the turbid water – what the ceramic water filters would be used to filter in the field – may have an effect on the filtration rate.