The
“Water Dominator”
Water Purification System

Created by The BAMF’s:
Nate Kenyon
Garret Hilton
David Ramirez
Kyle Brewer

GEEN 1400
May 7, 2006
Professor Robyn Sandekian

Abstract

Our engineering projects class decided to take the theme of appropriate technology. This means, simply, that we had to design a project that could be put to use in areas where access to technological materials is limited, and the standard of living is much lower than what we are accustomed to living in. Our group, the BAMF's, opted to make a water filter for use in rural Africa because that is the most important thing that these villages need. The filter we designed used layers of materials that these villages have easy access to, so that they do not have to spend money and do not need teams of people to help put this system together. Overall, our designing of this filtration system went very well, and was an excellent learning experience.

Challenge Statement

Clean water in rural Africa is expensive and hard to obtain. Villages in Africa are forced to drink water which is contaminated with bacteria, E. coli, sediments, and nitrates. Our group decided to build a water filter that would give the rural communities a safe source of water, at an affordable cost.

Design Requirements

Functional

- Removes all E. coli
- Cleanses the water of nitrates
- Eradicates bacteria
- Removes sediments

Qualitative

- User friendly
- Easy to clean and maintain
- Made of materials easily accessible and available in rural Africa
- Must be durable
- Usable indoors/outdoors

Quantitative

- Takes up no more than 16 cubic feet of space
- Costs less than $8 American
- Produce at least 60 gallons of water per day

Final Design

The “Water Dominator” is a simple yet functional water purification system. Our team did a great job of manufacturing the design into something that does not take a team of engineers to replicate. Furthermore, the “Water Dominator” was built with a very limited budget in mind, so it is easy to produce and cheap. The “Water Dominator” is a basic sand filter on top of a charcoal filter; the sand filter does most of the sifting while the charcoal filter catches the remaining undesirable matter. The simplicity of the “Water Dominator” is really the brilliance of the system.

As our team was researching the methodology of sand filters we realized sand filters are simple and effective as long as they are built and maintained correctly. The sand filter works because there are several different layers of sand, all with varying coarsenesses that prevent sediments from passing through. Our sand filter is three levels of fine sand, coarse sand, and gravel. The fine sand, which is on top of the filter, does most of the sifting; it catches sediments and most other undesirable matter. The coarse sand, the middle layer, does a similar operation, but also prevents the fine sand from falling through the bottom of the filter. The last layer of the sand filter is the gravel. The gravel is the last level of filtration, but the main function of the gravel to keep the sand in place. After the water passes through the sand filter it than falls into the second filter, the charcoal filter.

The charcoal filter was an idea that our team implemented after we had already designed the sand filter. The charcoal filter, like the sand filter, is easy to produce and maintain. The charcoal filter is set up so that when the water passes through it is filtered by the millions of bonding points created by the carbon in the charcoal. These bonding points are invisible to the naked eye, but catch most viruses/bacteria that the sand filter may have missed. Not only does the charcoal filter get rid of the harmful bacteria, but it also filters out the bad taste. After the dirty water passes through the “Water Dominator” it is safer to drink, tasteless, and virtual transparent.

The “Water Dominator” is a two-filter process that stacks a sand filter on top of a charcoal filter. The “Water Dominator” does an incredible job of eradicating most contaminates in the water, as well as making the water visually appeasing and tasteless. It is easy to produce, maintain, and can be replicated for next to nothing. The materials are readily available to most of the world, because they consist of sand, wood for making charcoal, gravel, a few optional screens, and three five gallon buckets. The table our team decided to build was only added to make the “Water Dominator” even more user friendly.

Parts List

• Charcoal	Our Cost:	$17.25
	African Cost:	Natural from burnt wood
• Fine sand	Our Cost:	$14.84
	African Cost:	Natural
• Coarse sand	Our Cost:	Donated by Robyn Sandekian
	African Cost:	Natural
• Three buckets	Our Cost:	$5.19
	African Cost:	Donated by relief organizations
• Gravel	Our Cost:	$4.95
	African Cost:	Natural
• Screens	Our Cost:	$2.22
	African Cost:	Donated by relief organizations
• Wood	Our Cost:	$16.03
	African Cost:	Natural

Project Evaluation

Our project met all the functional, qualitative, and quantitative design requirements. We tested our project for the removal of E. coli; it removed 3 colonies/ml to 0 colonies/ml. In the nitrate removal test it reduced the nitrates from up to 30mg/L to 0.5mg/L (the US legal limit for nitrates is 10mg/L). However the nitrate tests are inconclusive because the initial level of nitrates before being filtered is uncertain. We rant the test 4 times with the same water getting different initial nitrate readings from 0-30mg/L. Our final nitrate readings were constantly 0.5mg/L. The turbidity test, which tests for the number of sediments in the water, showed that we reduced the FAU (formazin attenuation unit) count from 206 to 9.

Our filter is 5/4ft by 5/4ft by 3 ft = 4.69 cubic feet which is considerably less then the maximum size of 16 cubic feet. Our filter was required to produce at least 50 gallons of water per day. Our filter produces 6 gallons of water an hour or 144 gallons per day. Our water cost to the user requirement was $8 American. Our cost to the consumer, was $5.19 the price for 3 buckets. The sand, charcoal, gravel, and wood would not be a cost to the consumer. This is because the sand, gravel, and wood are all naturally available to the communities. The charcoal that we used in our filter is all natural charcoal, in other words is just burnt wood. Burnt wood in rural Africa is free or can be recycled from their fire wood. The screens we used cost $2.22, but can be replaced with an old cotton shirt. So the total cost to the consumer would be between $5.19-$7.41 depending on if he bought screens. The costs we used however were the price you pay in America. In Africa consumer goods like buckets are cheaper.

Our project is user friendly, because it's easy to put together, and maintain. The only maintenance is replacing the top inch or so of sand every week. The materials are readily available to Africa. Since it only takes up 4.69 cubic feet it can be used indoors or outdoors.

Recommendations

Though our project worked much better than we had expected, there are still some areas where we would like to improve. As of now, we can only filter around eleven cups of water at a time. We would like to add a water storage unit at the top of the first bucket, so that the "Water Dominator" can filter more water at a time. Another enhancement we would like to make on our project is to add more sand to the top layer in order to improve turbidity. Though it did reduce the amount of sediments in the water by a very large amount, it did not completely eliminate them, so there is room for improvement. Otherwise, the "Water Dominator" did nearly perfect considering that it is free to Africans.

User's Guide

Because not everyone in the world has an engineering background, it is critical to have a user-friendly guide to give them. What this consists of is how to build, maintain, and utilize their very own "water dominator." The good thing about our project is that although a lot of engineering went into the design and concept of it, the device itself is simple to make and employ. So, the manual itself will not be intimidating to the user, because it is very straightforward and the set-up is easy. You would not need to send a team of skilled professionals or engineers to help in the construction. All one needs to do is follow these simple step-by-step instructions.

1. Gather three plastic buckets (at least 5-gallon sized).
2. Take two of them down to a place where you would find sand, and fill one up with very fine sand, and fill the other up with coarse sand.
3. Once back at your home, put the gathered sand, separated, in a storage place.
4. Place two buckets, upside down, one a level surface.
5. Make small sized holes, evenly dispersed in a circle, starting about half and inch from the edge of the bucket, and filling up the whole bottom face (as shown in Figure 1)
    - These hole dimensions are more of a guideline than a must. All you need to try to remember is that you don't want too many holes, or holes that are close together, because that would make the bottom of the bucket weak.
6. Repeat on the bottom of the second bucket
7. Take your third bucket and go find and collect pebbles or small gravel and fill your bucket up with them.
8. On the bottom of one empty bucket with holes, place 2 screens, cut out in exact circular size as the bottom of the bucket. (See Figure 2)
9. In the other bucket with holes in it, fill it about 2 inches deep with the gravel.
10. Next, pour about 3 inches of coarse sand on top of the pebbles.
11. Pour 4 inches of fine sand on top of that.
12. Take your bucket to someplace where it can be elevated off the ground, and nothing will get in the way of the holes on the bucket
    - A good idea is a table with a circular hole cut in it as shown in Figure 3

13. Fill up the sand bucket to the top with water.
14. Let the water run all the way through. See Figure 4
15. Repeat two more times.
    - What this does is clean the sand and gravel. Your water will most likely come out brown or just dirty the first two times, and this is because it is just washing off the dirt that was on the sand and gravel.
16. What you need to get now is a nice collection of burnt wood (enough to fill up one of the buckets about ¾ full). So, either use the charcoal that you cooked with, or gather up some pieces of wood and burn them till they become completely black and charred.
17. Break the charcoal up into equal parts of three different sizes—fine, medium, and large chunks.
18. To make fine charcoal, either hammer the bits of burnt wood into a powder or small chunks, or crush them in another, similar way.
19. For medium charcoal, again hammer the wood, but do not make it into a fine powder; leave it in medium sized chunks (about 2-4 inches long)
20. For the large charcoal, only break up the wood if necessary to make it around 5-7 inches long.
21. On the bottom of the other empty bucket with holes, place two screens on the bottom, just like you did in step #8
22. On top of the screens, place about ¼ the size of the bucket of large charcoal.
23. Place about a ¼ the size of the bucket of medium sized charcoal on top of the large charcoal.
24. On top of the medium charcoal, fill about ¼ the size of the bucket with the fine charcoal.
    - So you will have about ¼ of the bucket visible on the top
25. You are now going to place the sand bucket right on top of the charcoal bucket.
26. Find something(s) to place in between the buckets in order for there to be at least a 4-inch space between the bottom of the sand bucket and the beginning of the find sand layer.
    - We suggest six wedges of wood placed evenly around the outside of the sand bucket (See Figure 5 for example of the wedge and finished product if confused about wedge placement)
27. Place the two bucket system on top of the elevated platform you put just the sand bucket on before in order to clean it out.
28. Run water through the bucket system about 3-4 times.
    - This is going to clean the entire system out now. The water will be dirty about the first 2 times
29. Run water through again, and this time rinse out the third bucket with the now clean water.
30. Fill it with water again, this time placing the clean bucket beneath the system in order to capture the water that comes out.
31. You now have your very own “WATER DOMINATOR!”
32. Enjoy the water that comes out of it from now on—it tastes delicious, and is significantly healthier than the water you were using before!

Maintenance

The only thing you have to do to maintain your “Water Dominator” is scoop off about two inches of the fine sand on top of the system about once a week. This is to just get rid of all the initial dirt, debris, bacteria, and just gunk that gets trapped right on the top. Then just replace it with a new layer of fine sand. ***REMEMBER***, you need to run water through the system once without capturing the water after each time you replace a layer in order to clean out any dirt that was in the new fine sand you just put on top. Other than that, the rest of the materials in your machine are extremely long lasting and will not need to be maintained or replaced! Congratulations on your new, easy to use, easy to manage “Water Dominator.” May all your water needs be bettered by your new system! ENJOY!!

Finished Product


qualité
calidad

Figure 4


WARNING
AVISO
Children can fall into bucket and drown.
Keep children away from bucket with even a small amount of liquid.
Los niños pueden caerse en este cubo y ahogarse.
No deje que los niños se acerquen al cubo aunque solo contenga una pequeña cantidad de líquido.