Cheap and Portable Solution to Water Pollution Using UV Radiation and Activated Carbon

Anshuman Mohanty

DuPont Manual High School

Abstract

The purpose of this science fair project is to learn the best method for water purification that has to be cheap and portable. First step is to collect 1 gallon of water from the lake. Then pull out 5 strips from the test kit and dip them into the water for 2 seconds then put each of them in 5 bags and keep them in a dark place under 86 degrees for 48 hours. The next day have all 15 bottles with the lake water underneath the UV light for 2, 4, 6 hours for the UV experiment. Then make a filter to do the Activated Carbon part of the experiment, which all you need is a bottle with the bottom cut off then stuff a 1 or 2 layer of cotton and last is to pour the Activated Carbon in. Then dip the number of strips needs into the bottles/cups just as we did for the lake water. The data shows the AC filter purified the bacteria level to 89 CFU/ml which is a huge improvement from the control. So the AC filter had an average of 89 CFU/ml which was the least among all IV levels. The research hypothesis was correct in the end because the Activated Carbon purified the water the best in all of the IV levels. The data also showed that t-test values were significant among all IV levels. So the t-test and the null hypothesis were all supported by the data.

Keywords: purpose, UV experiment, Activated Carbon part, data, hypothesis

Introduction

What do humans need to survive? Humans need food, air, clean water, and shelter. The lack of clean drinking water has been a big problem for people over the past few decades. The problem is that for people in third-world countries, clean drinking water is scarce. The main reason for this is there aren't many places in Africa to find sources of water since Africa is hot and dry throughout the year except for places by a river. On top of that many of them are polluted. Specifically talking about ponds and lakes. To even get drinkable water from a river they must travel a long distance. For the people in poverty, they can't afford any kind of purification system or a bottle of water. This is mainly happening in the desert parts of Africa and parts of Asia. Around 2.5 billion people worldwide don't have access to clean water which is roughly 35% of the population. (Slaymaker and Bain, 2017). Each year 3-4 million people die due to water-related diseases because they don't have access to clean drinking water. Diseases that people may get from contaminated water are Cholera, dysentery, Hepatitis A, diarrhea, typhoid, and Polio. (CDC WASH Research).

The goal of the project is to determine which method of water purification is the cheapest and portable for people who lack a source of clean drinking water. In this experiment, we hope to learn about the best method for water purification which would go along with the topic "Cheap and Portable". We also hope to accomplish results that people can use when they can't afford a purification system. My question for the experiment is: Which method of water purification is the cheapest and portable for people who lack a source of clean drinking water? The control in this experiment would be the 0-hour purification or no purification. The hypothesis is if Activated Carbon would filter out the raw materials in the dirty water then it should result in

better purification because UV would only kill the bacteria but not the heavy metals which the Activated Carbon can do.

There are many cheap solutions to this idea, but for this experiment, the solutions that would be selected should be easy for people to gain access to. For example, everyone has the sun as their source of radiation and you get Activated Carbon which is the same thing as charcoal from burnt wood. The experiment will be using Activated Carbon and UV irradiation to purify contaminated water. So how does Activated Carbon work? Well, when you put the Powdered Activated Carbon (PAC), in a filter it will filter out a given substance. As the liquid gets into contact with activated carbon, the intermolecular forces draw molecules into millions of pores and pockets on the surface of activated carbon. (CB Tech Activated Carbon Research, 2018). So basically it just absorbs the raw materials which should also make the water clean.

The experiment will be testing the UV radiation at different levels of time. For the experiment, we will test the purification by putting in 5 bottles for 2hrs, another 5 for 4hrs, and the last 5 for 6hrs. The independent variables are the methods of purification and the levels are the time of purification. The dependent variable is the levels of bacteria left after the purification. Take a one-gallon jar and collect the water from the lake. After bringing the jars back open the kit and pull out 5 strips and dip them into the water for 2 seconds then put each of them in 5 bags and keep them in a dark place under 86 degrees for 48 hours. Make sure there is no air when zipping the bag. Then the next day in the noon right about 12 PM has all 15 bottles with the lake water underneath the UV light. This is the UV purification part of the experiment. 5 bottles will be under the light for 2 hours, the other set of 5 will be for 4 hours and the last set will be for 6 hours. When the time period is done do the same thing we did for getting the bacteria level for the lake. Get a stip dip into the water for 2 seconds, put it in the bag and seal it, then place it in a

dark place under 86 degrees for 48 hours. The other part of the experiment which is using Activated Carbon to purify the water can be done at any time in the day. For this part, we need to have 5 cups with the lake water in them. Size doesn't matter. In order to purify the water, we must make a filter. To make the filter we need to cut the bottom of the plastic bottle so we can put the coffee filter at the bottom and a piece of cloth on top of that to hold the Activated Carbon. Make sure to also poke a hole through the bottle cap so the water can flow through. You need another 5 cups for each time the lake water runs through the filter. Give it some time for it to run through, remember the slower it drips the more clean the water will be. After this procedure is done, then begin testing the bacteria levels which will be the same procedure as the one we did for the UV part. When the results come in, record them, and analyze the data. To record the result the water test kit gives a scale to see the level of bacteria in the water sample. When results are recorded then compare them to each other.

Methodology Paper:

The UV portion of the test must be done during the day. Take a one-gallon jar and collect the water from the lake. After bringing the jars back open the kit and pull out 5 strips and dip them into the water for 2 seconds then put each of them in 5 bags and keep them in a dark place under 86 degrees for 48 hours. Make sure there is no air when zipping the bag. Then the next day in the noon right about 12 PM has all 15 bottles with the lake water underneath the UV light. This is the UV purification part of the experiment. 5 bottles will be under the light for 2 hours, the other set of 5 will be for 4 hours and the last set will be for 6 hours. When the time period is

done do the same thing we did for getting the bacteria level for the lake. Get a stip dip into the water for 2 seconds, put it in the bag and seal it, then place it in a dark place under 86 degrees for 48 hours. The other part of the experiment which is using Activated Carbon to purify the water can be done at any time in the day. For this part, it required to have 5 cups with lake water in them. Size doesn't matter. In order to purify the water, a filter is to be constructed by cutting the bottom of a 1liter plastic bottle. Then an inch layer of cotton is inserted after that roughly half a liter of Activated Carbon is added to finish the filter. Make sure to also poke a hole through the bottle cap so the water can flow through. You need another 5 cups for each time the lake water runs through the filter. Give it some time for it to run through, remember the slower it drips the more clean the water will be. After this procedure is done, then begin testing the bacteria levels which will be the same procedure as the one we did for the UV part. The same testing procedure and test strips will be utilized as with the UV-treated water. To record the result the water test kit gives a scale to see the level of bacteria in the water sample. When results are recorded then compare them to each other.

Data and Results

Figure 1

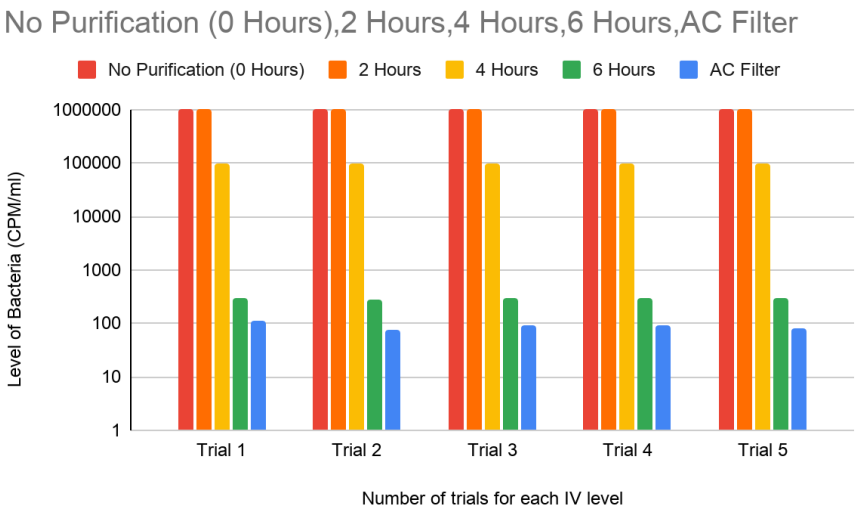


Figure 2

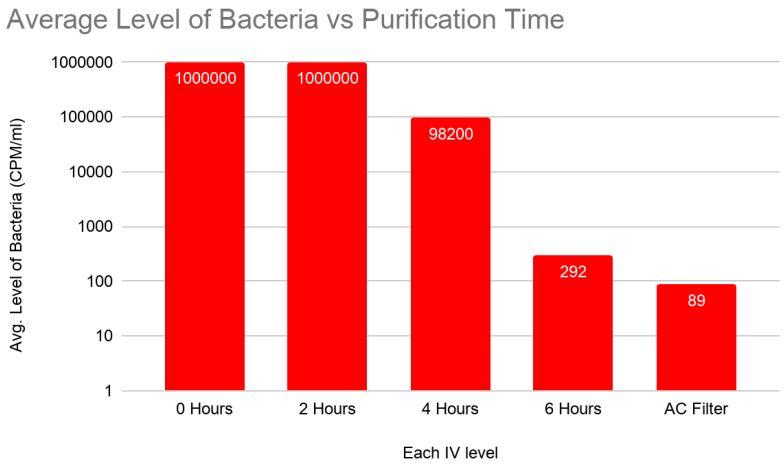
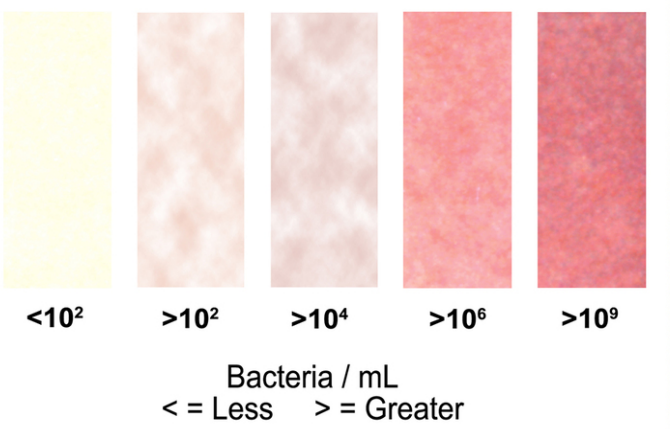


Figure 3: Scale used to measure the level of bacteria.



In figure 1, it shows how the amount of time for purification affects the number of bacteria left. Figure 2 shows how each method did in the experiment and the average bacteria level for each IV level. As you can see the graphs compare UV light purification to Activated Carbon filter purification. The data shows that Activated carbon did a better job in purifying the lake water than the UV light. Figure 3 is the scale that was used to measure the bacteria level in the water.

Table 1: Bacteria level measure at the end of each time period, including filter

Bacteria level(CPM/ml)	Control (0 Hours)	2 Hours	4 Hours	6 Hours	AC Filter
Trial 1	1000000	1000000	99000	300	110
Trial 2	1000000	1000000	98000	280	75
Trial 3	1000000	1000000	98000	300	90
Trial 4	1000000	1000000	97500	290	90
Trial 5	1000000	1000000	98500	290	80

The table above shows the level of bacteria left from each trial. The 2 hours purification had no improvement from the control. As shown in the table, the 4 hours had a significant change in bacteria levels, from 1000000 CPM/ml it reduced it to an average of 98200. Resulting in the 6 hours of purification to reduce to an average of 292 CPM/ml. What the data shows us that the AC filter purified the bacteria level to 89 CPM/ml which is a huge improvement from the control which was 1000000 CFU/ml. So the AC filter had an average of 89 CPM/ml which is less than the average of 6 hours of purification.

Table 2: Effect of purification time and method on bacteria level

Time / Method	0	2	4	6	AC Filter
Mean	1000000	1000000	98200	292	89
Variance	0	0	325000	70	180
Standard Deviation	0	0	570	8	13
1 SD (68% Band)	1000000 - 1000000	1000000 - 1000000	97630 - 98770	284 - 300	76 - 102
2 SD (95% Band	1000000 - 1000000	1000000 - 1000000	97060 - 99340	276 - 308	63 - 115
3 SD (99% Band)	1000000 - 1000000	1000000 - 1000000	96490 - 99910	268 - 316	50 - 128
Result of test			$t = 3537.1506$, $p < 0.00001$	$t = 267183.2016$, $p < 0.00001$	$t = 166651.8333$, $p < 0.00001$

For all df = 8 alpha = 0.05			Significant	Significant	Significant

The table t for all the t-test was 1.869. The null hypothesis for the 4 hours and the control was the mean level of bacteria of 4 hours will be the same as 0 hours. The alternative hypothesis was the mean level of bacteria of 4 hours will be less than 0 hours. There was a significant effect for the 4 hours purification, $t(8) = 3537.1506$, $p < 0.00001$ with the 4 hours purification ($M = 98200$, $SD = 570$) greater than the 0 hour purification ($M=1000000$, $SD = 0$). The calculated t is greater than the t in the table so, the null hypothesis is rejected and the alternative hypothesis is not rejected and the research hypothesis is supported. The null hypothesis for the 6 hours and the control was the mean level of bacteria of 6 hours will be the same as 0 hours. The alternative hypothesis was the mean level of bacteria of 6 hours will be less than 0 hours. There was a significant effect for the 6 hours purification, $t(8) = 267183.2016$, $p < 0.00001$ with the 6 hours purification ($M = 292$, $SD = 8$) greater than the 0 hour purification ($M=1000000$, $SD = 0$). The calculated t is greater than the t in the table so, the null hypothesis is rejected and the alternative hypothesis is not rejected and the research hypothesis is supported. The null hypothesis for the AC filter and the control was the mean level of bacteria of the AC filter will be the same as 0 hours. The alternative hypothesis was The mean level of bacteria of AC Filter hours will be less than 0 hours. There was a significant effect for the AC filter purification, $t(8) = 166651.8333$, $p < 0.00001$ with the AC filter purification ($M = 89$, $SD = 13$) greater than the 0 hour purification ($M=1000000$, $SD = 0$). The calculated t is greater than the t in the table so, the null hypothesis is rejected and the alternative hypothesis is not rejected and the research hypothesis is supported.

Conclusion

The purpose of this science fair project is to learn the best method for water purification that has to be cheap and portable. The goal of the project is to determine which method of water purification is the cheapest and portable for people who lack a source of clean drinking water. The goal is maintained by selecting purification methods that can be made then eliminate the ones that aren't cheap and portable. The project's findings should be used to guide an understanding of which time period is best for water purification and the best method for water purification that is cheap and portable.

The project was successful in achieving the goal of determining the best method from the methods that were evaluated for water purification that is cheap and portable. The results of this project allow us to better understand how Activated Carbon works and a solution to the problem of people not being able to afford purification systems. The final results showed there was no improvement in bacteria levels until the 4 hours of purification. It means that the 4 hours did a better job in killing the amount of bacteria compared to the control. The 6 hours and the Activated Carbon filter had done far better of killing the bacteria. So in the end the Activated Carbon killed the most bacteria proving it purifies better than UV light in this experiment. Now the UV could have purified it better but since the experiment was conducted during winter when it's cold outside so it was conducted at room temperature. But that's where we have Activated Carbon which can be used during the colder seasons which isn't hard to make. It is the same as charcoal which comes when you burn coal and you need to ground it so it can purify the water better.

The final results supported the research hypothesis because the Activated Carbon purification reduced the bacteria level to an average of 89 CPM/ml which killed the most bacteria in all of the IV levels. The data also showed that t-test values were significant among all IV levels. So the t-test and the null hypothesis were all supported by the data. To explain why the data is like this is because Activated Carbon absorbs the heavy metals in the water which UV light can't do, ultimately purifying the water more. The UV light would have done much better in the experiment but since it was not the sun that was being used and it was winter it didn't kill as much bacteria. It is a scientific fact that heat kills most bacterias and viruses like Salmonella. Salmonella is an infectious bacteria that can be found in water if not clean which can cause people to have diarrhea and abdominal pain. But there is another thing that the experiment supports is Activated Carbon would perform better in the colder seasons compared to UV radiation and in the hotter seasons, it should be about the same. The reasoning for there to be no reduction in bacteria levels in the 2-hour purification period is since there is no heat it takes longer for the UV light to kill the bacteria so 2 hours wasn't enough. If the experiment were to be done again one recommendation would be to use a more discrete measurement than the scale because you can't measure the exact amount of bacteria just from looking at the scale. Another recommendation would be to perform the experiment in summer when it is hot to prove UV radiation could have done much better in this experiment.

Appendix

- https://docs.google.com/spreadsheets/d/1_Ro2gXiS510dvyjN7hXHyt8Dv1sAJikuA-PbK-Xd2_Q/edit#gid=1928290587

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