Innovation Park Water

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Research Paper and Notebook

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Abstract

Innovation Park Water focuses on making water purification more efficient and quicker by using an immersion water heater to heat the water instead of thermal energy from direct sunlight. It was hypothesized that by incorporating an immersion water heater, the time needed to purify water will decrease. The quantitative analysis involved testing the first chamber individually, then testing the device as a whole. Data was collected, using a timer, on the length of time it took for the water to heat until it started vaporizing, and a TDS water purity tester was used to determine the purity of the water before and after the process. The results of the experiment showed that it takes about five minutes to heat the water to a sufficient temperature for vaporizing, and the water purity went from 248 ppm, which is in the range for tap water, to 80 ppm, the value for mountain springs, which is much more pure than tap water. This data was only collected from the last trial because all other trials did not produce a sufficient enough water to be tested. The design was altered multiple times to produce an effective project. The angle of the top of the first chamber was changed so all the vapor would be directed to the coil and the coil was stretched out to ensure that it was curving down at all points. By the end of the last trial, the adhesive for the first chamber became too weak to continue testing.

Introduction and Background

Less than one percent of the available water on Earth is drinkable and there has been a big effort to convert some of the saltwater into freshwater. Most modern technology for desalination takes a lot of energy and the burning of fossil fuels; 130 million tons of oil a year is needed to produce 13 million m^3/day of desalinated water and the energy necessary is still growing (Kalogirou). Underdeveloped countries do not possess the resources to burn that much oil to provide enough fresh water to a village or town, limiting not only the location of where a village can be, but the number of people able to live in one village and still live healthy. The average American uses between 300 to 500 liters of water a day, whereas someone in Africa uses between 20 and 50 liters, and someone in Asia, a little under 100 liters (Food). Since most of the freshwater in underdeveloped countries is spent on agriculture, using desalination provides a medium for the amount of drinking water necessary for healthy living, and necessary irrigation to provide food. The devices already invented are either too costly, reaching almost $10,000, or take too long to provide drinkable water as some mechanisms take up to eight hours to fully produce drinkable water. Innovation Park Water provides another source of fresh, drinkable water by using the concepts of evaporation and condensation to take abundant saltwater and change some of it to safe water for other people to use. To improve what already exists, an immersion water heater will be used to heat the water and act as an additional thermal energy source. The additional energy source will allow the water to boil at a quicker rate, combating the time necessary for purification using direct sunlight while also using cheaper methods to lower the cost of desalination in the hopes of creating a device that can be applied in underdeveloped countries.

Question

In order to successfully complete Innovation Park Water, research on how a chamber system can be used to conduct distillation, how to link solar energy and distillation to create a quicker process, and how to construct a solar distillation machine from scratch must be conducted. The goal of this experiment is to find a more efficient and cheaper way to purify water. In order to accomplish this goal, a water purification system must be created. The plan is to use the process of distillation to separate the contaminants and the water, so how can the chambers be constructed and the components of the device designed so they work effectively with each other? The purity of the water will be investigated using a TDS water purity tester. Regulations on safe water drinking, the salinity of saltwater and freshwater, and the PPM of tap water contaminants must be investigated to ensure the water after going through the device meets regulation standards for healthy drinking water. This experiment targets people in third world world countries who are impacted daily by the effects of unclean water and people living near contaminated water. Research on how other water purification devices and plants work will help the construction of Innovation Park Water as the objective is to significantly improve the smaller, more easily accessible devices already available to the public that are not realistic to people in underdeveloped countries.

Hypothesis

If a water purification device includes an immersion water heater, then the amount of time needed to conduct purification will decrease and improve safe water storage.

The null hypothesis is that the immersion water heater will not decrease the time needed for purification of the water.

The test can be applied to water purification efforts in developing countries that lack the natural resources, money, or time, to purify water using traditional boiling methods, or water purification using fossil fuels.

Materials and Methods

The variables being measured in the experiment are the length of time required to completely purify a jug of salt water and the purity of the water. The first chamber was tested individually to ensure it heats the water to a sufficient temperature to make it vaporize, then the whole device was tested. A thermometer was used to measure the temperature the water was heated to in a given amount of time to ensure that it was heating at an acceptable rate. A timer was used to record how long the water was heating. Both chambers were then tested together . The next stage of testing was to measure how long the water distiller took to purify the water. A timer was used to record how long it took for the vapor to condense and pass through the coil. The second stage of testing consisted of determining the purity of the water. The purity of the water was measured before it was purified and after it went through the process. A TDS water purity tester measured the cleanliness of the water. Values ranging from 0 to 50 ppm represents ideal drinking water, going through the process of reverse osmosis and deionization. Values ranging from 50 to 100 represents water passing through carbon filters or mountain spring water. Values ranging from 200 to 300 represents average tap water. These value ranges were used to determine where the water lied on the purity spectrum before and after the purification process. The goal was to create a distillation system that can purify enough water for people to live off of in an adequate amount of time.

Data/ Results and Analysis

Type of water	Before purification (PPM)	After purification (PPM)	Time taken to purify one cup (minutes)
Tap water	248	80	58

Table 1: This table shows the change in water purity before entering the purification device and after exiting the second chamber. The ppm shows that the water is purer, containing less chemicals than when it enter the first chamber. The time allows the efficiency to be tested and compared to other devices to see if this design creates significant changes.

The device together was tested and the values of the water purity are shown in Table 1. The initial value is within the range for the purity of tap water, which is what was used. The final value is the value for natural spring water, which is more pure than household tap water. This proved that the idea of boiling water and condensing the vapor is successful in purifying water. It took 5 minutes for the water to boil, and averaged about an hour to get a cup of water. This was slower than anticipated because most other water purifier designs that do not incorporate water heaters purify roughly one cup of water per hour (Service). The goal was to limit the time, but the time was not limited as much as initially planned. The slow time taken to purify a cup of water can be dedicated to the design placement of the condenser coil and the shape and curve of the coil used in Innovation Park Water's design.

Conclusion

The hypothesis was not completely supported by the project in action but the theory was proved to be correct. After taking the condensation from the first chamber, the ppm of the tap water tested went down by almost 70%, making it the same quality as spring water. The time taken to purify the water was too long, as the table shows one cup per hour, matching the rate of common water purifies with similar prices.

The first few trials were not successful because the amount of water that passed through the device was insufficient. The water got stuck at an incline in the coil and the water vapor was collecting at the top of the first chamber instead of using the opening to the condenser coil as an outlet. At this stage, the device is not ready to be applied to third world countries, but could be modified to make a cheaper alternative to purifying large amounts of contaminated water. Not all types of water were tested as the device began breaking down before further testing could occur, but the results taken before the device broke down was enough to prove the concept.

If testing and modifications were to continue, the first change to the design would be to get a new condenser coil that is better made for water purification as opposed to focusing on price. The coil in the device was not effective because there was a hole in the coil allowing water vapor to escape and the coil was bent so water got trapped in the middle of the coil. Inserting a coil with a different shape, specifically one that wraps in a tighter spiral would allow better water flow. The second change would be that the second chamber would be placed above the first chamber as opposed to next to it, allowing more vapor to pass through the coil, instead of condensing on the top of the first chamber. Lastly, the adhesive would be changed to provide a stronger bond for the frame of the first chamber.

References

Bunce, K. T., Daly, M. J., Humphray, J. M., & Stables, R. (1981). H2-receptor antagonists protect against aspirin-induced gastric lesions in the rat. *Agents and Actions*, *11*(1–2), 167–170.

Chaouchi, Béchir. (2007). Desalination of Brackish Water By Means of a Parabolic Solar Concentrator. *Desalination*. Retrieved September 26, 2017 from https://www.sciencedirect.com/science/article/pii/S0011916407004778.

Food and Agriculture Organizations of the United Nations. (n.d.). Water and People Whose Right Is It? Retrieved December 18, 2017, from http://www.fao.org/docrep/005/Y4555E/Y4555E00.HTM

Kalogirou, S. (1997). Survey of Solar Desalination Systems and System Selection. *Fuel and Energy Abstracts*. Retrieved September 20, 2017, from http://www.sciencedirect.com/science/article/pii/S0360544296001004.

Safe Water System. (2014, May 01). Retrieved September 13, 2017, from https://www.cdc.gov/safewater/index.html.

Service, R. F., Mervis, J., Vogel, G., & Wadman, M. (2017, December 09). Sunlight-powered purifier could clean water for the impoverished. Retrieved May 15, 2018, from http://www.sciencemag.org/news/2017/02/sunlight-powered-purifier-could-clean-water-impoverished

Sobsey, M. D., Stauber, C. E., Casanova, L. M., Brown, J. M., & Elliott, M. A. (2008). Point of Use Household Drinking Water Filtration: A Practical, Effective Solution for Providing

Sustained Access to Safe Drinking Water in the Developing World. *Environmental Science & Technology*, *42*(12), 4261–426. Retrieved September 13, 2017, from https://doi.org/10.1021/es702746n.