Project metrics

Engineering

Throughout the year, the team constructed a solar power source as well as a water filter that was able to inactivate up to 81% of the bacteria passing through the system. Through the use of extensive bacteria inactivation testing, product design analysis, and design for manipulability techniques, our team has improved and optimized many critical aspects of the Hydrate system.

Not only have we been able to realize significant cost-reductions, increase ease-of-use, and improve ease-of-implementation, but we were also able to reach inactivation rates up to 88% with our final device and inactivation rates upwards of 99% during configuration testing. Our Hydrate system incorporates novel technology integrated with low-cost components and extensive empirical testing to provide a household filtration system that is on the cusp Of implementation in developing nations. Project Metrics

Superior reliability and robustness compared to previous Hydrate device Optimized CNN/Gang filter design based on empirical results (bacteria testing) Low total device cost of under $1 00 Proven ability to reach inactivation rates of over 90% consistently Achievable flow rate of 80 liters per day that allows for enough clean water to support a family of four (given necessary water pressure) Minimal number of components for assembly and serviceability Low cost and compact turbidity filter cartridges that can be replaced in the field without the use of any tools Include LED indicators to acknowledge current flow

Minimize turbidity while not slowing down the overall flow rate of the device Function for one month Of standard usage without any maintenance APP age

OVERALL DESIGN Us Mary of Design While select communities in developing nations have community water treatment systems, or new technologies such as theline of products that allow for smaller quantities of water to be filtered for personal use, there is a further need for a household filtration system that can be implemented and maintained at extremely low costs.

In developing such a device, there are five key parameters upon which the design must focus: (1) cetera inactivation rate, (2) cost, (3) ease of use, (4) power consumption, and (5) ease of implementation. Through the use of extensive bacteria inactivation testing, product design analysis, and design for manipulability processes, system, creating a low cost product that is very close to being ready for deployment in third world countries. Underlying Technology Our water sterilization system is based on technology that was originally published by the Hi Cue Group at Stanford University.

By applying a voltage bias across a cotton filter embedded with carbon annotates and silver narrower, high inactivation rates and high flow rates can be achieved. This innovative technology kills bacteria using three processes: CLC A process known as electroplating that breaks down cell membranes 0 The antimicrobial properties of silver CLC Changes in the chemistry Of the solution such as pH levels Because our system is killing bacteria as opposed to catching or blocking them, it allows for high-speed water filtration while only requiring minimal power usage.

Scanning Electron Microscopy Images of Filtration Technology 4 IP age Scanning Electron Microscopy (SEEM) images showing cotton fibers, silver narrower, and carbon annotates within the Hydrate system. From left to right, the images show (1) the cotton fibers within the filter, (2) silver narrowness protruding from a single cotton fiber, and (3) carbon annotates and silver narrowness embedded in the cotton matrix. These images were taken at the Penn Regional Nanotechnology Facility in April of 2013.

System Schematic 51 p age Functional Block Diagram Functional Characteristics Bacteria Inactivation: Bacteria inactivation testing was an essential part of the design and development processes for the Hydrate device. Given the extreme importance of increasing the bacteria inactivation rate, we focused a significant amount of time testing key design parameters throughout the year. In particular, we inoculated bacteria, conducted filtration tests, and cultured bacteria in order to optimize: (1) electrode configuration, (2) filter fabrication method, (3) cross-sectional area, and (4) filter density.

Through extensively planned and precisely executed parameter testing in the lab, we were able to reach bacteria inactivation rates in the laboratory upwards of 99%. Cost Reductions: Over the course of this year, we have designed major cost reductions into the Hydrate system through the use of low-cost PVC components and a more simplistic design. By utilizing design for manipulability techniques, we have focused on reducing material costs, improving assembly times, and creating a device that can be serviced at a low cost over its lifetime.

The new design not only boasts lower upfront costs, but also minimizes maintenance costs for the end user. Modularity of Device: In addition to lower costs, the modular design of the Hydrate system allows for improved ease-of-use, which is critical for implementation in developing nations. While the filtration technology underlying the product is on the cutting edge, it should not be difficult for users to understand and access the turbidity filter and interior of the device for cleaning and maintenance.

By taking advantage Of the water-tight press-fit seal of PVC, the Hydrate system remains robust, while modular at the same time. Point-of-Use Diagnostics System: Not only does the Hydrate system produce promising bacteria inactivation rates at a low cost, but it now includes a diagnostics system in order to alert users when the filter is malfunctioning. We have implemented a simple but reliable circuit that rowers a red LED when voltage is detected from the power supply, and switches to a green LED light when current is actually running through the CNN/Gang filter.

While this does not detect all forms of malfunctions, it provides a low-cost point-of-use diagnostics system to alert users when bacteria are not being inactivated. 7 IP age TESTING/PROTOTYPING RESULTS Nana-Filter Fabrication The nana-filters were fabricated by the Hydrate team in the undergraduate Bioengineering Lab. The procedure involves applying carbon annotates and then silver narrowness to a cotton textile. Filters were custom manufactured for each mound of bacteria testing based on the defined test parameters.

A detailed explanation of the fabrication procedure is included in the appendix. Figure 1: First nana-filter prototypes on hot plate Bacteria Testing Procedure Bacteria testing is conducted over the course of three consecutive days in the undergraduate Bioengineering Lab. A safe strand of E. Coli was utilized for testing as E. Coli is recognized as the standard for microbial water quality by the world health organization. Day one of the procedure involves inoculating the bacteria overnight facilitating the growth of active bacteria units.

On day two, once the bacterial solution has been prepared and bacteria units have been activated, the solution is passed through the filters in order to measure bacterial inactivation performance. Once the samples are passed through the filters they are plated and placed in an incubator in order to grow countable bacteria colonies. Once the plates have been incubated over night, they are removed from the incubator and the bacteria colonies are counted. The plates are photographed using LLC facilitating and counted with the use Of MUTUAL or Photos.

The number of colonies on each test plate is imparted to that of the control plate in order to quantify the bacterial inactivation rate. A detailed explanation of the bacteria testing process is included in the appendix. Filter Configuration Testing Results Through extensive bacteria testing, the team was able to optimize the filter configuration based on a number of key parameters including: electrode configuration, filter fabrication method, cross-sectional area, and filter density.

The team accomplished bacteria inactivation rates upwards of 99% during final configuration testing. The final prototype realized a bacteria inactivation rate of 88%. The variations in results are due to the low volume, low flow rate test conditions that compromised the filter's performance. Under typical operating conditions, the reservoir will be filled and the identified issue will not compromise performance.

Electrode Configuration The tested electrode configurations are as follows: copper mesh electrode positioned in reservoir above filter and counter-electrode attached to top of the filter; copper mesh positioned in reservoir above filter and counter- electrode attached to the bottom of the filter; and electrodes attached to the top and bottom of the filter. Based on the test results shown below, the copper mesh electrode positioned in reservoir above the filter and the counter-electrode attached to the top of the filter was chosen as the optimal arrangement.