WRS

Water Recovery Systems

UV Water Purification Device

University of Colorado Boulder

Engineering for Social Innovation

Background and Motivation

Problem

Water purification is an important safety measure for people across the globe. However, access to clean water is an issue for multiple regions and affects people worldwide. Water Recovery Systems has the goal of making water purification more widely available to consumers who travel to these regions with the hopes of being able to partner with aid organizations to provide clean water to underprivileged regions where clean water is not readily available.

Solution

The goal is to create a product that effectively purifies water to the safety standards determined to prevent sicknesses caused from consuming contaminated water. Purification will focus on removing pathogens such as Giardia lamblia and Cryptosporidium parvum, with an aim of 99.9 percent removal. The design will use ultra-violet radiation to remove said pathogens from the water as the user drinks. This assembly will be connected to a Nalgene bottle cap which houses the batteries and system controls. Additionally, to make the water safer and the UV purification more effective, the product will contain a mechanical filter to remove small particulates. To preserve the lifespan of a charge, the circuit will be completely off when the straw is flat against the cap, as this is the resting position that users are familiar with. Materials have been chosen to ensure that the product is both durable and safe for the consumer. Electronics will follow strict water and dust-proofing guidelines of 58 IP to keep them protected. The UV LEDs will be encapsulated to provide enough transmissibility to provide the required dosage to the water, while also preventing the user from being exposed to an unsafe amount of UV radiation. The product will also contain indicator lights that inform the user of the battery to ensure that they are aware of when UV purification is occurring to prevent consumption of unpurified water.

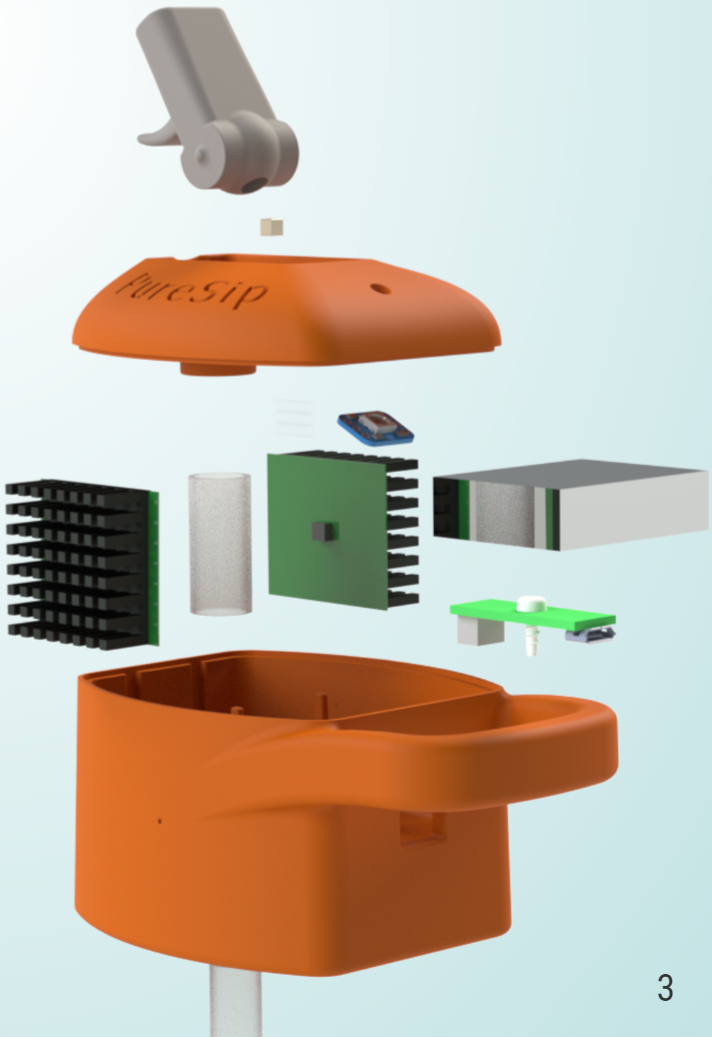
Design Overview

Key Features

To ensure functionality of our final product the drafts and features are optimized for injection molding. Additionally, ultrasonic welding will be used to enhance the products lifetime by increasing its durability. The handle and mouthpiece are designed to maximize user comfort and ease of use. Our product is controlled by circuitry that is built into the cap. The circuit is controlled by reed switches activated by flipping up the mouthpiece, into the drinking position. This will activate the UV LEDs which will purify the water in the straw as the user drinks. In the case the user leaves the mouthpiece up, the circuit turns off at low battery or after being on for 2 minutes. We will also use an indicator LED that informs the user of the battery level.

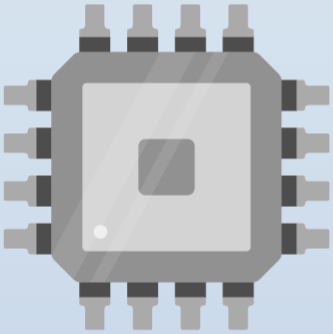
Design Justification

To optimize the design we performed user testing. This included testing various people, drinking from different size straws to determine ideal drinking flow rates. This allowed the team to ensure that the water would have enough time to be purified at the fastest drinking rates. On the other hand, we used the slowest drinking rate to determine the low end of how much water could be purified within one charge of the battery.



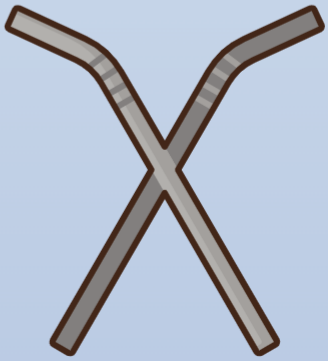
Manufacturing

A few parts are designed with injection molding in mind. Three separate parts in total will be made this way, each using a polypropylene impact copolymer or HDPE plastic as the resin for injection molding. The goal of using one of these plastics for injection molding is to have an FDA compliant material that is also strong and meets our durability and reliability requirements.



The main body of the lid is one of the injection molded parts. It is the main housing for the circuitry, the UV filter, and the threaded interface between a wide mouth bottle and our lid. Another injection molded part is the cap for the lid which fits over the opening in the top of the main body. After electronics are assembled by hand and secured into the main body, the lid is sonic welded to the top which will ensure a near seamless and waterproof seal for the entire electronics enclosure. Finally, the mouthpiece will need to be injection molded as well, with the magnet used for the reed switch placed and glued into a groove on the side of the mouthpiece.

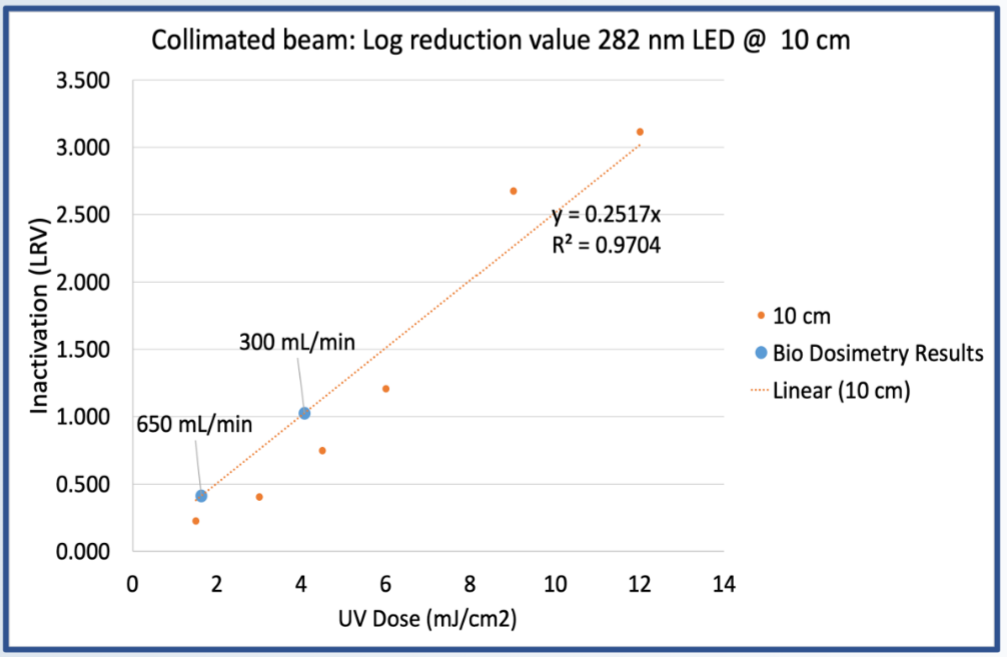
The UV permissible FEP plastic tubing used for the straw portion within the lid is a standard stock size and easily fitted into the main body of the lid when the circuitry is being placed. The straw portion that extends into the bottle is a non-FEP, BPA free, plastic straw.



Testing

- **Preparation Testing**
  - Drinking flow rates
  - Test 3D prints
- **Circuit Setup and LED Spec Verification**
  - FEP tube transmissibility
  - Collimated beam inactivation
  - Indicator LED color changing
- **Subassembly Testing**
  - Bio dosimetry
  - Battery life
- **Final Prototype**
  - Enclosure durability and sealing
  - User experience

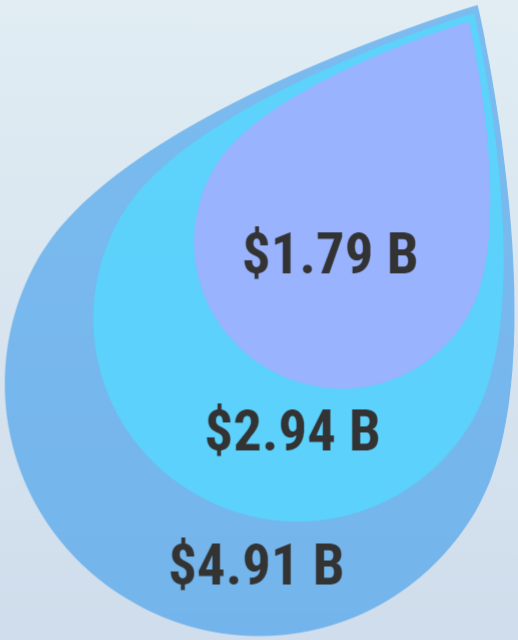
The Linden Research Group shared their procedure for testing flow-through UV purification products, which involved characterization of the isolated UV LED and its spectrum, irradiance pattern, and inactivation curve. The team then performed bio dosimetry testing by pumping E.coli K12 cell solution through the product at a range of flow rates to simulate use conditions before using the inactivation rate constant from the inactivation curve and the Log Reduction Value from the flow-through experiment to calculate the UV dose received by the solution at each flow rate.



Business Opportunity

Market Size

This product lies within various markets but will be most successful in the travel sector. The total addressable market for those who are travelling outside the United States per year is 4.91 billion USD [X]. The serviceable available market, made up of those travelling outside the US, specifically going to countries with low quality water sources, is 2.94 billion USD [X]. Refining the market down, the serviceable obtainable market is valued at 1.79 billion USD [X]. The serviceable obtainable market is made up of those travelling outside the US to countries with low quality water sources and who specifically want to travel sustainably. By combining travelers and sustainability, the large market shows that there is clear potential for Water Recovery Systems to be competitive in the UV water purification industry.



Competition

Water Recovery Systems is making competitive strides in the portable UV water purification industry. With PureSip's unique straw design, there is little competition that purifies with UV as quick and efficiently. PureSip is also adaptable to various wide-mouth water bottles, so only the top attachment needs to be purchased. The current market competition either takes longer to purify—1-3 minutes—or the customer must buy a whole new water bottle. Water Recovery System's solution is unique to the market and has a clear competitive advantage at a similar price point.

Company Traction

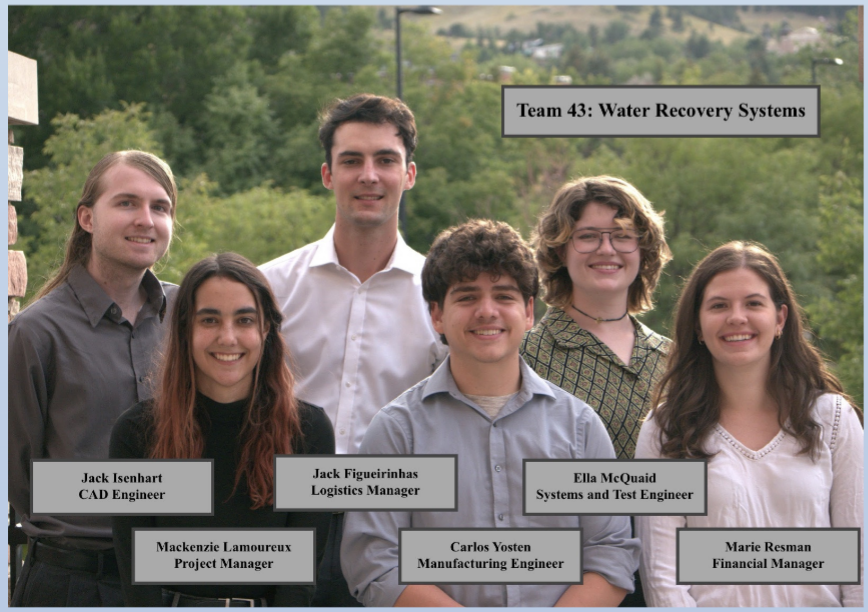
Water Recovery Systems received third place in the 2023 New Venture Challenge Climate competition and was a semifinalist in the main round of New Venture Challenge. Combined with expert guidance from the Liden Research Lab, interest from industry professionals, and GetSeed funding from CU Boulder, Water Recovery Systems is set to expand and generate profits.

Conclusion

In order to ensure the quality of our product we have conducted extensive testing. We are predicting that the cap will be able to kill 99.9 percent of germs by the final iteration. Additionally, the battery life has been tested and determined that it meets the design requirements that were set at the beginning of the project. While meeting these requirements, the prototype is fully functional, however, by using 3D printing instead of injection molding, the prototype is not currently food safe.

Given more time, there are some improvements we think could add to the product's functionality and use. We hope to add a charcoal filter at the bottom of the straw that allows for mechanical filtration to improve the taste of the water by removing large particulates. We also think it would be beneficial to add solar charging capabilities to enhance the products usage in areas where electricity is limited.

Team



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