

# Researching Reusable Water Bottle Cleaning Techniques to Provide Sustainable and Safe Access to Clean Water for the Homeless Population in the Phoenix Area

Patrick Farley- Electrical Engineering, Faculty Mentor: Dr. Steven Trimble, Clean Water Research Team

## Background

This project began when Mary Contreras of Women of Valley of the Sun United Way, a philanthropic social services organization, launched a single use water bottle drive that donated over 400,000 water bottles to the City of Phoenix homeless shelters in 2021. In search of a more sustainable option, Mary Contreras reached out to Dr. Trimble to mentor a reusable water bottle project of GCSP students. This exploratory research supports the overall project effort.

## Problem Statement

Research current industrial and residential cleaning methods to find a sustainable and effective cleaning method for reusable water bottles.

## Necessary Criteria

- must be cost-effective.
- must limit human contact with the reusable water bottle.
- must both sanitize and remove contaminants.

## References

Rogener, F. et al. "Modeling of Impurity Concentrations in the Cleaning Zones of Bottle Washing Machines in the Treatment of Alkaline Cleaning Solutions and Rinsing Water." *Chemical Engineering & Technology*, vol. 25, no. 1, WILEY-VCH Verlag, 2002, pp. 41-47. [https://doi.org/10.1002/1521-4125\(200201\)25:1<41::AID-CEAT41>3.0.CO;2-D](https://doi.org/10.1002/1521-4125(200201)25:1<41::AID-CEAT41>3.0.CO;2-D)

Sun, Xiadi, et al. "The Cleanliness of Reusable Water Bottles: How Contamination Levels Are Affected by Bottle Usage and Cleaning Behaviors of Bottle Owners." *Food Protection Trends*, Vol. 37, No. 6, Pp. 352-402, Nov. 2017.

Red Cross. "Food and Water in an Emergency - American Red Cross." *Food and Water in an Emergency - Red Cross*. FEMA, May 2008. <https://www.industrydocuments.ucsf.edu/docs/9F0F>

Husain, Qasim, et al. "Lightening in a Bottle: Comparison of Ultraviolet Light to Traditional Sterilization in Saline Irrigation Bottles." *International Forum of Allergy & Rhinology*, vol. 10, no. 1, Wiley Subscription Services, Inc. 2020, pp. 53-58. <https://doi.org/10.1002/for.22457>

"Care and Cleaning of Water Bottles." [https://www.healthyschools.org/Files/Care\\_and\\_Cleaning\\_of\\_Water\\_Bottles.pdf](https://www.healthyschools.org/Files/Care_and_Cleaning_of_Water_Bottles.pdf)

"Making Water Safe in an Emergency." *Centers for Disease Control and Prevention, Centers for Disease Control and Prevention*, 27 Jan. 2022. <https://www.cdc.gov/healthywater/emergency/making-water-safe.html>

"Small Business Safety and Health Handbook." <https://www.osha.gov/sites/default/files/publications/small-business.pdf>

"Community Drinking Water Systems." *Centers for Disease Control and Prevention, Centers for Disease Control and Prevention*, 11 Jan. 2022. <https://www.cdc.gov/healthywater/emergency/drinking-community-water-systems.html>

"Drinking Water Distribution System Tools and Resources." *EPA, Environmental Protection Agency*. <https://www.epa.gov/drinkingwater/distribution-system-tools-and-resources>. [Accessed: 12-Apr-2022]

"Small Business Safety and Health Handbook." *27-Apr-2021*. [Online]. Available: <https://www.osha.gov/sites/default/files/publications/small-business.pdf>. [Accessed: 12-Apr-2022]

"Drinking Water Distribution System Tools and Resources." *EPA, Environmental Protection Agency*. <https://www.epa.gov/drinkingwater/distribution-system-tools-and-resources>. [Accessed: 11-Apr-2022]

L. A. Sotgiu and T. R. Chien. "Water Sterilization Using Power UV LEDs." *2021 18th International Conference on Electrical and Electronics Engineering (ICEEL)*, 2021, pp. 49-53. doi: 10.1109/ICEEL52422.2021.9415965.

F. Zakariyah Ramdani, B. Anggo Seroaji, A. Nurdi, W. Maharni, R. Aprilia and M. Rudi Adhyanman. "A Study of Conveyor System with UV Light for Vegetable and Fruit Sterilization for Farmer." *2021 International Conference on Computer Science, Information Technology, and Electrical Engineering (ICOMITEE)*, 2021, pp. 197-201. doi: 10.1109/ICOMITEE53461.2021.9655009.

J. De la Rosa, G. Koshimizu, N. Kobayashi, and O. Smith. "A Stride Towards the Elimination of Consumer Water: Development of a Reusable Cold Machine." *Worcester Polytechnic Institute, Worcester*, 07-Apr-2022.

T. Taziri, M. M. Fouad, Z. M. F. Adiliah and N. Nasser. "UV-CDS: An Energy Efficient Scheduling of UV's for Premises Sterilization." in *IEEE Transactions on Green Communications and Networking*, vol. 5, no. 3, pp. 1191-1201, Sept. 2021. doi: 10.1109/TCGN.2021.3074536.

Center for Devices and Radiological Health. "UV lights and lamps: Ultraviolet-C radiation, disinfection, and Corona." *U.S. Food and Drug Administration*. [Online]. Available: <https://www.fda.gov/medical-devices/coronavirus-covid-19-and-medical-devices/uv-lights-and-lamps-ultraviolet-c-radiation-disinfection-and-coronavirus>. [Accessed: 11-Apr-2022]

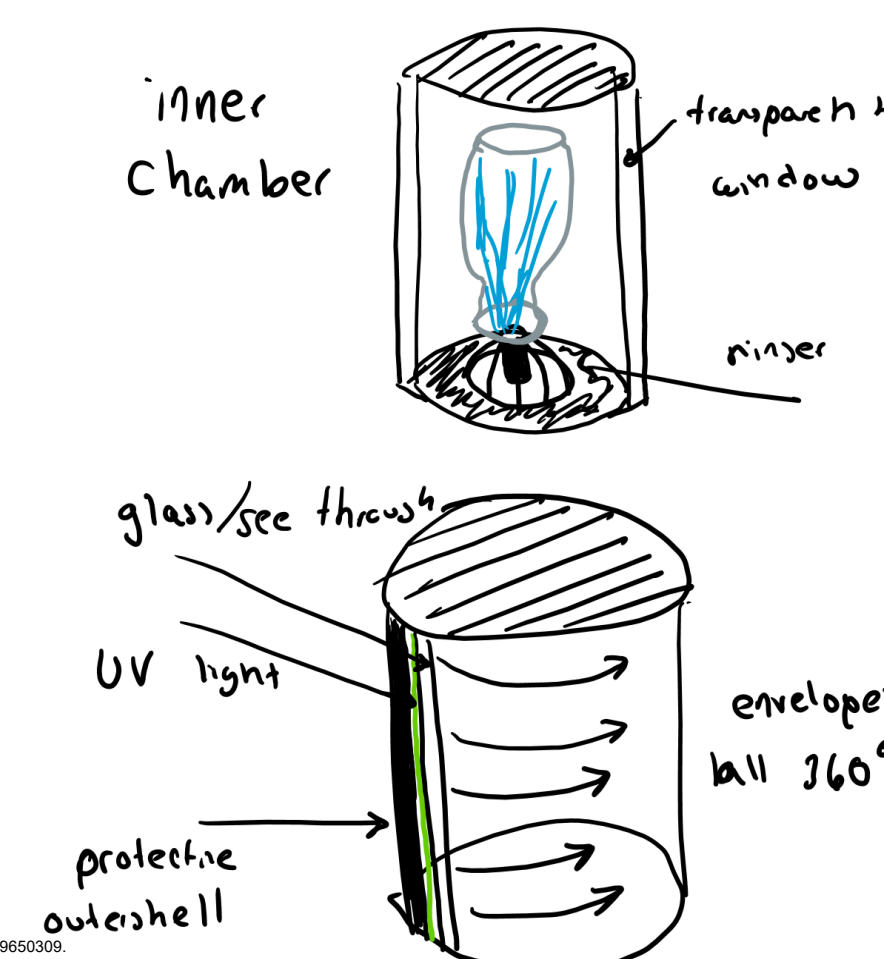
"Does ultraviolet (UV) light kill the coronavirus?" *National Academies.org*. 22-Apr-2020. [Online]. Available: <https://www.nationalacademies.org/organized-science/covid-19/does-ultraviolet-light-kill-the-coronavirus/>. [Accessed: 11-Apr-2022]

## Abstract

The GCSP Clean Water Research Team seeks to find a sustainable solution to water accessibility for the homeless population of Phoenix while also preventing the spread of Covid-19. The portion of the project completed by this researcher was to use the engineering process to explore and find a cleaning process/ mechanism that fits the necessary criteria of the stakeholders. Necessary criteria included low cost for mass production, effectiveness of cleaning process, sustainability, durability, and lack of human contact.

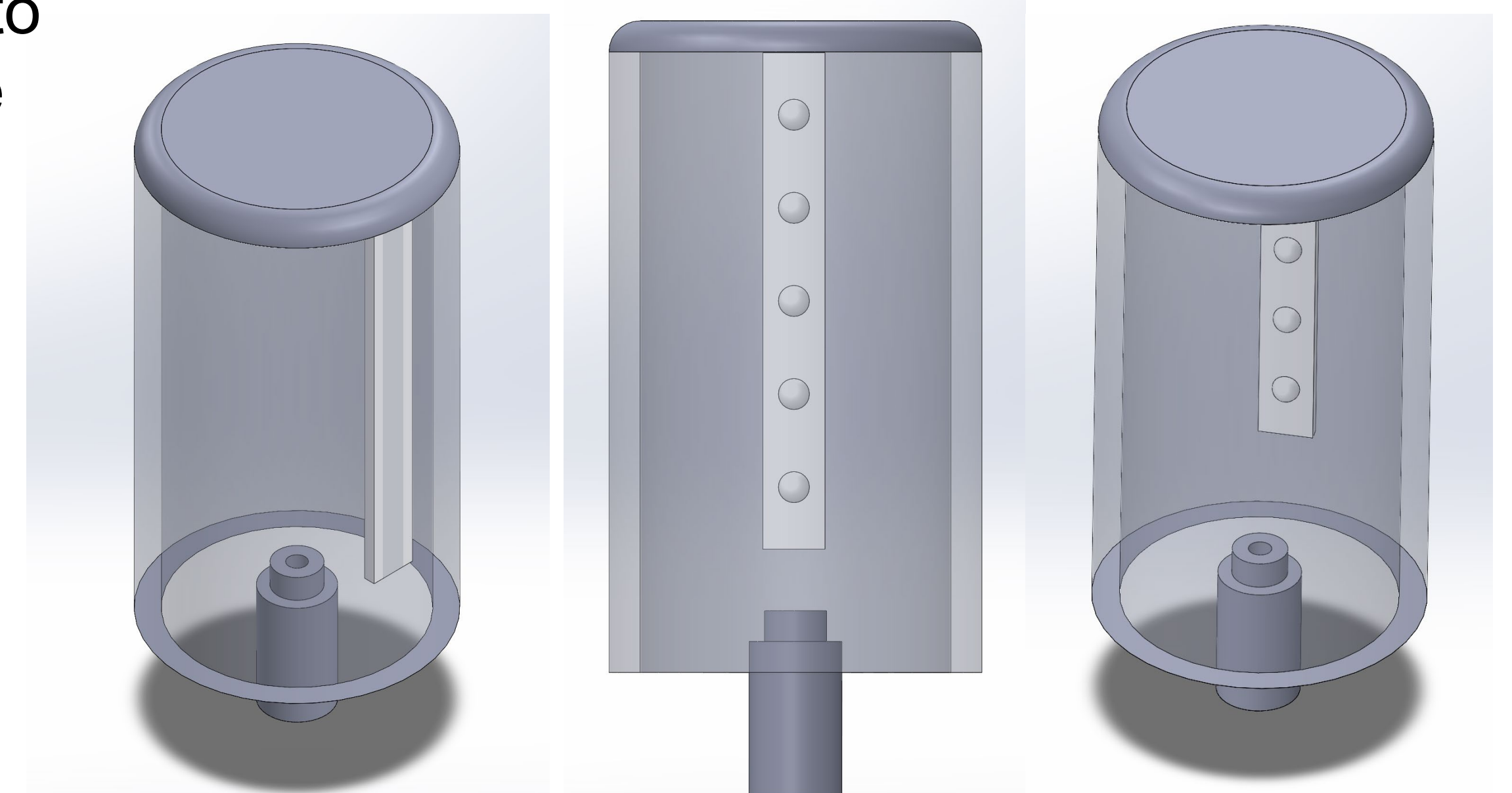
## Possible Solution

A cleaning chamber combining UV-C light outer layer, surrounding a "Starbucks" rinser. The UV-C provides sanitation against Covid-19 and other diseases, while the rinser expels a precise amount of water and soap to disinfect and clean the inside of the bottle.



## Future Progress

More research needs to be done into FDA guidelines and establish contact with prominent Phoenix homeless shelters while still exploring more options for the project's future.



# Grand Challenges Scholars Program

**ASU** Ira A. Fulton Schools of  
**Engineering**  
Arizona State University