Challenge link:
https://irc.community.wazoku.com/challenge/4e5d116dd6a84286b43349fbd22c71b5

4. Problem & Opportunity – Please highlight the innovation in your approach to the problem, its point of difference, and the specific advantages/benefits this brings (500 words)

The Seeker (the International Rescue Committee, IRC) is looking for existing technologies or innovative designs and concepts to increase compliance with hand hygiene in healthcare environments. Specifically, the IRC is looking for solutions that enable the practice of hand hygiene in the absence of infrastructure like a fresh water supply and a functional supply chain for consumables.

Traditional hand wash stations require a fresh water supply and antibacterial soap, both of which may be a challenge to obtain in developing regions of the world. Alcohol-based hand sanitizers may also be difficult to obtain, especially with challenged supply chains. Ultraviolet (UV) light can be used to kill germs and requires no consumables, but using UV light on healthcare workers' hands several times per day risks skin damage and would increase the risk of skin cancer.

For this reason, the Solver recommends using ozonated water to disinfect healthcare workers' hands. Six seconds of exposure to ozonated water containing 0.5ppm of ozone will destroy 99.99% of pathogens on hands[1]. Furthermore, unlike harsh chemicals or alcohol-based hand sanitizers, ozonated water is gentle on skin and pleasant to use[2]. It can help to repair irritated or wounded skin and helps make hands feel softer. These positive benefits will ***increase compliance*** with hand hygiene in healthcare environments. Another key attribute of this Solution is that it continuously recirculates the ozonated water. This feature provides several benefits:

1) Low water use
2) The water doesn't need to be purified or sanitized in advance; the ozone generator sanitizes it *in situ*
3) Low power. Since the water is recirculated, the ozone generator can be small, low power and low cost

5. Solution Overview – Please describe the features of your solution and how they address the SOLUTION REQUIREMENTS (add supporting data, diagrams, etc. as attachments below) (500 words).

The proposed solution is shown in the process & instrumentation diagram (P&ID) of Figure 1. A pump drives water through a filter and venturi injector. The venturi injector pulls ozone from a 0.055 g/hr ozone generator and mixes it with the water. The ozonated water then flows continuously into a hand wash sink where healthcare workers can sanitize their hands. The water is collected in a 10-gallon storage tank and reused. Because the water is continuously flowing through a filter and ozone is continuously added, the water develops a high level of ozone (0.7 ppm) and can be reused, thus reducing the need to add fresh water.

Figure 2 (see spreadsheet) shows that the steady state concentration of ozone reaches 0.7ppm, sufficient to kill 99.99% of pathogens during a 6-second sanitation. The equation for the steady-state concentration of ozone C_O3 [ppm] is:

C_O3=mdot_O3/ln(0.5^(-1/t_half))

where mdot_O3 is the production rate of ozone in [ppm/min] (dependent on the volume of water) and t_half is the half-life of ozone in water.

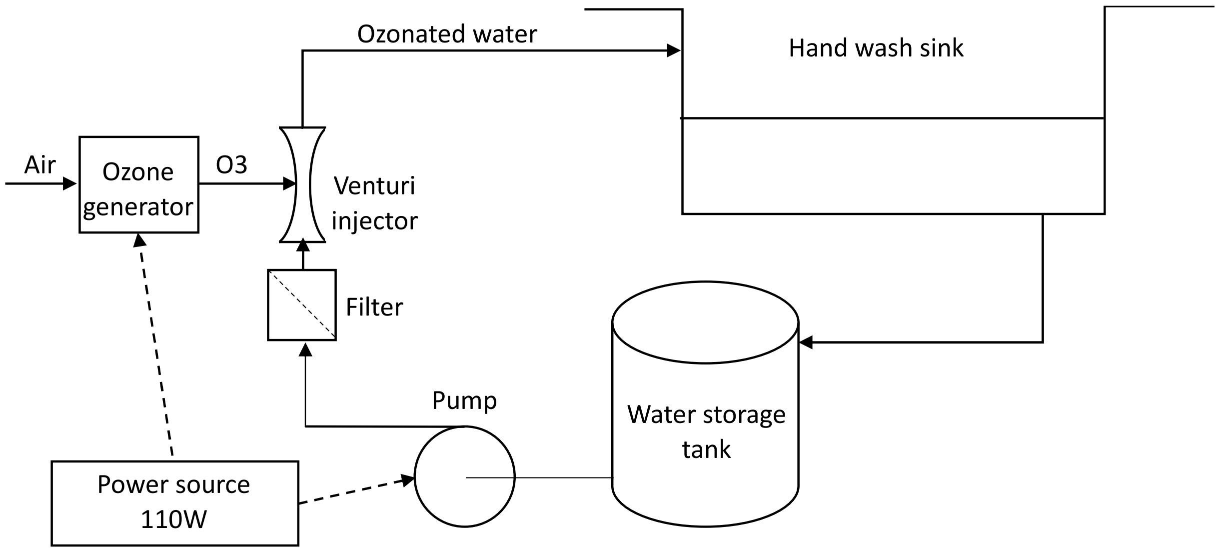

Figure 1. P&ID of the proposed hand sanitization station

t_half	20	min				
mdot_O3	0.055	g/hr	0.00092	g/min	0.02424	ppm/min
Q_water	10	gal				
m_water	83.3	lb	37818.2	g		
C_O3	0.70	ppm				

Figure 2. The system provides a concentration of 0.7ppm ozone, enough to kill 99.99% of pathogens.

Both the pump (100W) and the ozone generator (10W) require electrical power provided by the grid or microgrid (if available) or by a dedicated solar station[3] as shown in Figure 3.

Figure 3. A solar station could provide power if a grid/microgrid is not available.

The key components in this system are shown in the Bill of Materials (BOM) in Table 1 (see spreadsheet).

Component	Cost	Link
Ozone generator	$66.00	https://www.amazon.com/HCD-55-Ozonator-Hi-Output-Generator-Gallons/dp/B0CKFBYTG2/ref=asc_df_B0CKFBYTG2/
Pump	$297.88	https://www.mcmaster.com/9930K41/
Filter	$39.86	https://www.amazon.com/dp/B0C2ZNTR6Z/
Venturi injector	$27.03	https://www.mcmaster.com/3704N111/
Sink	$119.99	https://www.amazon.com/Commercial-Stainless-Gooseneck-Washing-Restaurant/dp/B07V6Q5H59/
Storage tank	$89.99	https://www.amazon.com/Gallon-Fresh-Gray-Water/dp/B07KGJRRGV/
Pipes	$50.00	estimate
Structure	$50.00	estimate
Total	$740.75	

Table 1. BOM of the proposed hand sanitization station.

The proposed solution meets all of the Seeker's requirements:

- **Effectiveness** – The proposed Solution will kill 99.99% of pathogens within 6 seconds of hand sanitation. Because ozonated water is nonirritating to the hands, healthcare workers will be motivated to sanitize their hands at the 5 WHO-recommended moments.
- **Value for money** – As shown above, the proposed Solution will cost approximately $750 to construct. It should have a lifetime of 5 years. The sanitizer will have an amortized cost of $1.50 per healthcare worker per year based on a 100-person hospital. It uses approximately 110W to power the pump and ozone generator. The total energy use is 964 kWh per year. Assuming $0.50 per kWh from a grid/microgrid, the energy cost is $4.82 per healthcare worker per year, making the total cost $6.32 per healthcare worker per

year. If a grid is unavailable, the cost of the solar panels, wind turbine, or generator could be amortized over its lifetime.

- **Accessibility** – This Solution is applicable to environments with limited water and other resources, and it has no supply chain concerns. Although it requires 10 gallons of water, this supplied water need not be pure – the filter and ozone will disinfect the water *in situ*.
- **Convenience** – This Solution will be convenient and easy to use. The water will be continuously running so that healthcare workers can easily sanitize.
- **Behavioral elements** – This Solution will soften and heal hands, unlike irritating antibacterial soap or alcohol-based hand sanitizers. Healthcare workers will enjoy using it, increasing adherence.

6. Experience - Expertise, use cases and skills you or your organization have in relation to your proposed solution. The IRC may wish to partner at the conclusion of the Challenge; please include a statement describing your expertise and indicating your interest in volunteering towards realizing your prototype solution (up to 500 words).

I am a U.S.-based mechanical engineer and engineering manager with experience in several industries including inkjet printing, aerospace/defense, semiconductor capital equipment, and redox flow batteries for grid-level energy storage. I have more than 10 U.S. Patents and have brought several innovative products to market. I love solving difficult problems and have a passion for making the world a better place! I believe my solution can help make medical care safer, particularly in developing regions. As I am currently employed full time in a different industry, I am not interested in partnering with the Seeker on this Solution but would be interested in occasional consulting.

7. Solution Risks – Please describe any risks you see with your solution and how you would plan for this (500 words)

One risk is that one of the proposed hand sanitization stations is not sufficient to support 100 healthcare workers, especially since the healthcare workers are expected to enjoy using this station and will use it frequently. If that is the case, 2 or more sanitization stations can be provided and still meet the cost target, as the cost for each is $6.32 per healthcare worker per year based on 100 healthcare workers.

A second risk is that the water will evaporate over time. This will not affect the effectiveness of the solution, as it will only increase the concentration of ozone in the water. Additional water can be added as needed, or the water can be replaced periodically. The water does not need to be clean as the ozone will sanitize it.

8. Timeline, capability and costs - describe what you think is required to deliver the solution, estimated time and cost – please note the cost constraints of 25 USD per healthcare worker per year for already existing technologies/solutions and the cost constraint of 66 USD per healthcare worker per year for novel solutions, technologies, or concepts/designs. (up to 500 words).

As shown above, the cost to construct the proposed hand sanitization station is <$750 USD. At $6.32 USD per healthcare worker per year, it easily meets the cost constraint of $66 USD per healthcare worker per year.

Furthermore, since it primarily uses off-the-shelf components, it can be easily prototyped within a few weeks, including material lead time. This will allow it to be tested for functionality, and if needed the design can be further refined.

9. References

1. https://www.oxidationtech.com/blog/how-much-ozone-do-i-need-to-destroy-bacteria-and-viruses
2. https://greensciencesolutions.com/study-finds-aqueous-ozone-is-soft-on-skin/
3. https://us.oukitel.com/products/oukitel-p2001-200w-portable-solar-panel

10. How did you find this Challenge? – please indicate what drew you to this Challenge, including any relevant advertising or marketing that you followed to this Challenge.

As mentioned above, I love solving difficult problems! For that reason, I have entered over 40 challenges on Wazoku and have won 5 so far. I regularly check Wazoku for new challenges. This challenge caught my attention because I am interested in improving health in developing countries. The need for improved hand hygiene seems very obvious, and I thought that I had a simple and cost-effective solution that could help.