



BACKGROUND

- Waterborne illnesses cause over 50% of deaths in Haiti.¹
- Captured water must be sterilized. Common methods are chemical (e.g., bleach), thermal (e.g., pasteurization), or radiation (e.g., solar disinfection).
- Sunlight is abundant in Haiti.
- Continuous-flow systems are more efficient than large batch systems for heating water.
- Water can be heated to 70°C for 7 min.

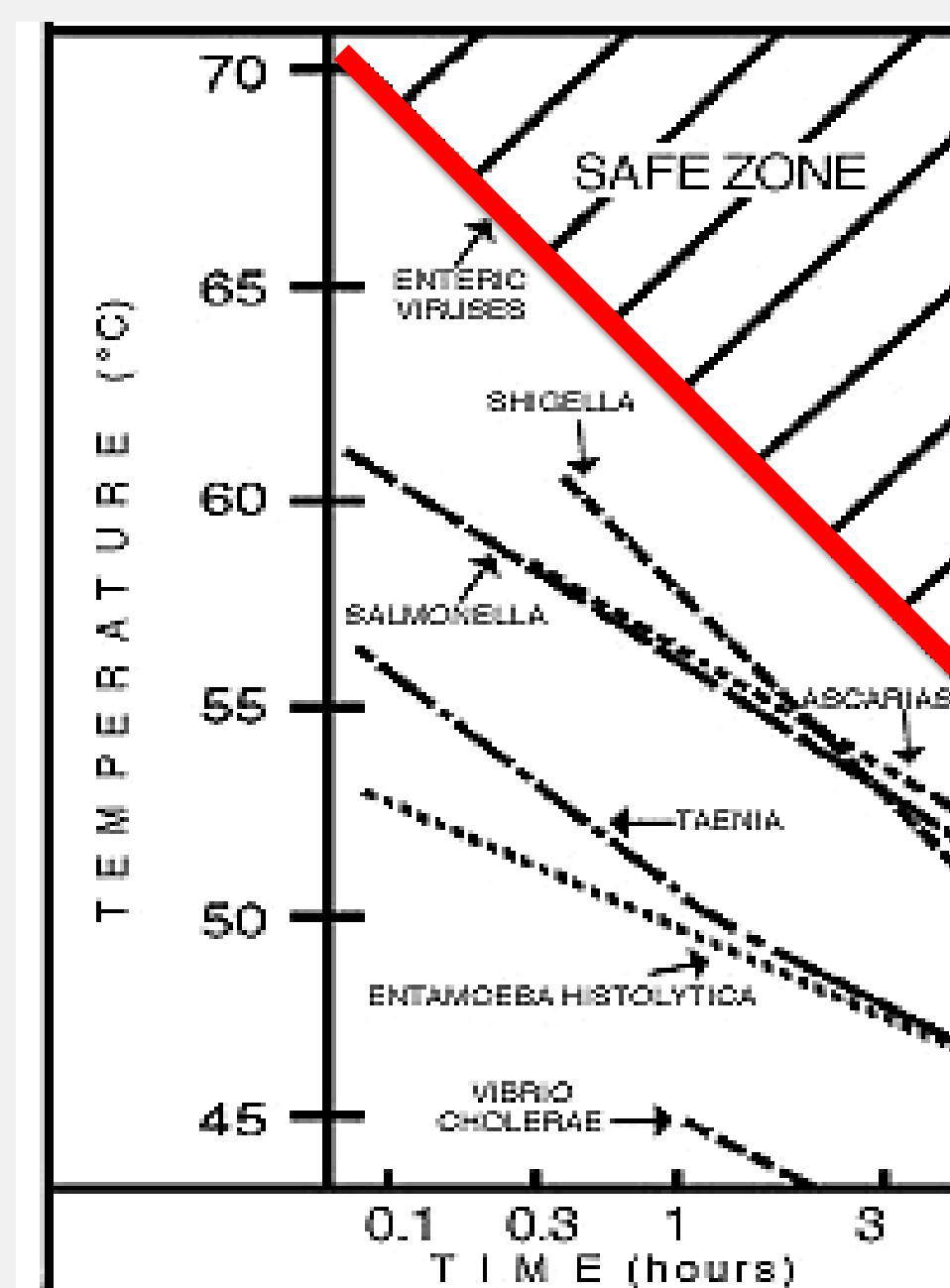


Fig. 1. Water temperature vs. residence time needed for pasteurization.²

OBJECTIVE

Use UV radiation to treat 150 L H₂O per day.

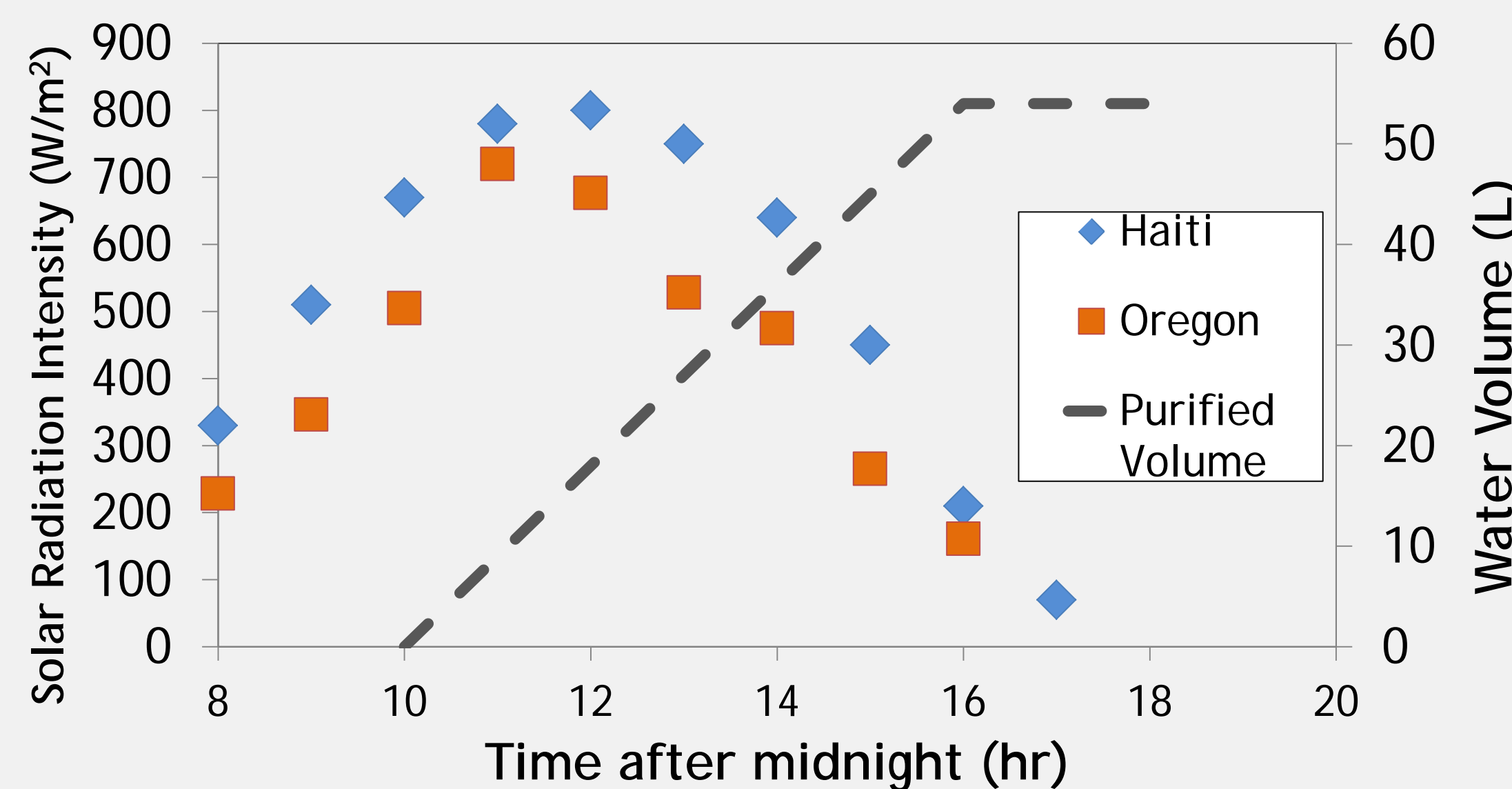


Fig. 2. Average daily solar irradiance (W/m²-K) for Haiti³ (lat. 19°) and Oregon^{3,4} (lat. 45.5°) determined by scaling average daily irradiance at lat. 40.5°. Cumulative purified water volume represents predicted daily yield at a water flowrate of 150 $\frac{mL}{min}$, assuming operation at peak hours (10:00-16:00).

SOLAR WATER STERILIZATION

Developing an innovative and inexpensive water pasteurization device for Haiti

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THE DEVICE

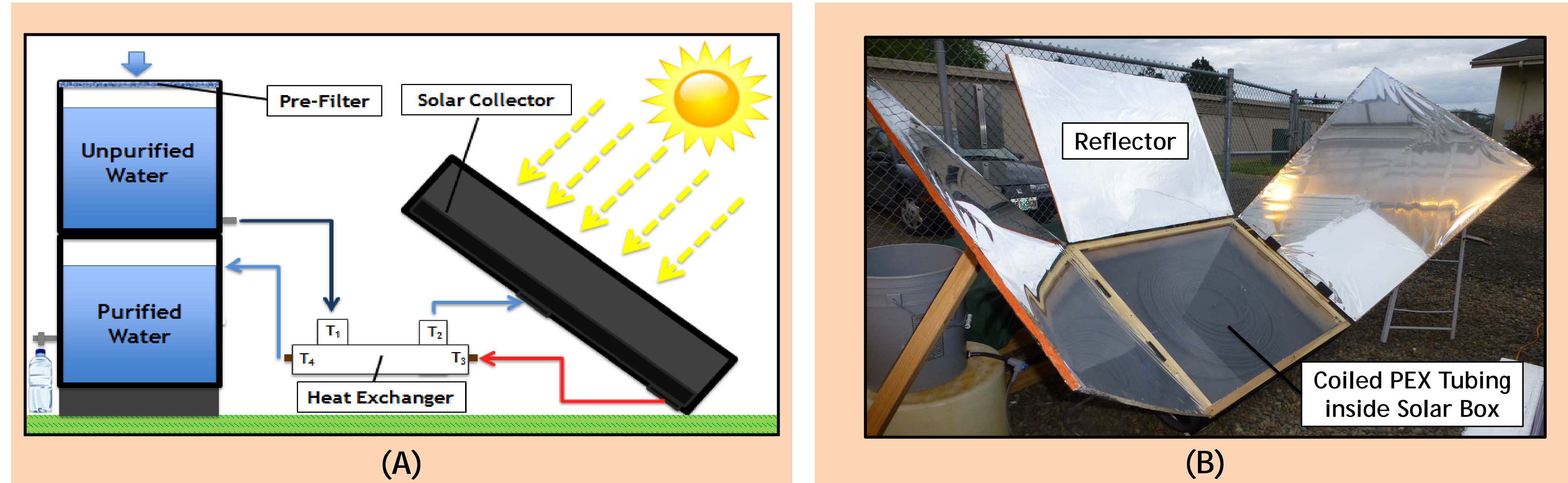


Fig. 3. (A) Device Schematic. Water flows from a cold reservoir, is preheated by the heat exchanger (HX), is heated in the solar box, re-enters the HX to pre-heat inlet water, and collects in a reservoir. (B) Prototype. The 3'x4' solar box has 3 reflectors to maximize UV reflection into the box. Water flows through 100 ft of PEX tubing mounted on a 3'x4' steel plate and is sealed with a solar window (clear plastic sheet) to prevent heat loss.

Table 1. Material list for the solar device & HX, along with purchased costs & projected unit cost after bulk production.

	Material	Dimensions	Quantity	Cost (USD)	Bulk Cost (USD)	Haiti Alternatives	Cost
Solar Collector	Plywood	4' x 8'	2	14	7	Available lumber, pallets	Prototype Cost
	2" x 6" Lumber	8'	2	7	3.5	Available lumber, pallets	
	PEX Tubing	100'	1	28	14	Garden hoses	
	Steel Plate	3' x 4'	1	22	11	Tin cans, available scrap	Bulk Production Cost
	0.5" x 1" Lumber	8'	2	1.2	0.6	Available lumber, pallets	
	Clear window plastic	3' x 4'	1	4	2	Saran Wrap, window panes, available clear plastic	
Heat Exchanger	Reflective Mylar	3' x 4'	3	3.5	1.8	Space blankets, aluminum foil	Prototype Cost
	PVC Pipe	1" x 3'	1	1	0.5	Available scrap	
	PVC T connection	1"	2	0.25	0.2	Available scrap	
	Threaded PVC	1"	2	1.2	0.6	Available scrap	Bulk Production Cost
	Copper Pipe	3'	1	5	2.5	Available scrap	
	Brass Fittings	3/8"	4	3	1.5	Available scrap	
	PE Tubing	3/8"	1	4	2	Available scrap	Bulk Production Cost
							\$12.5

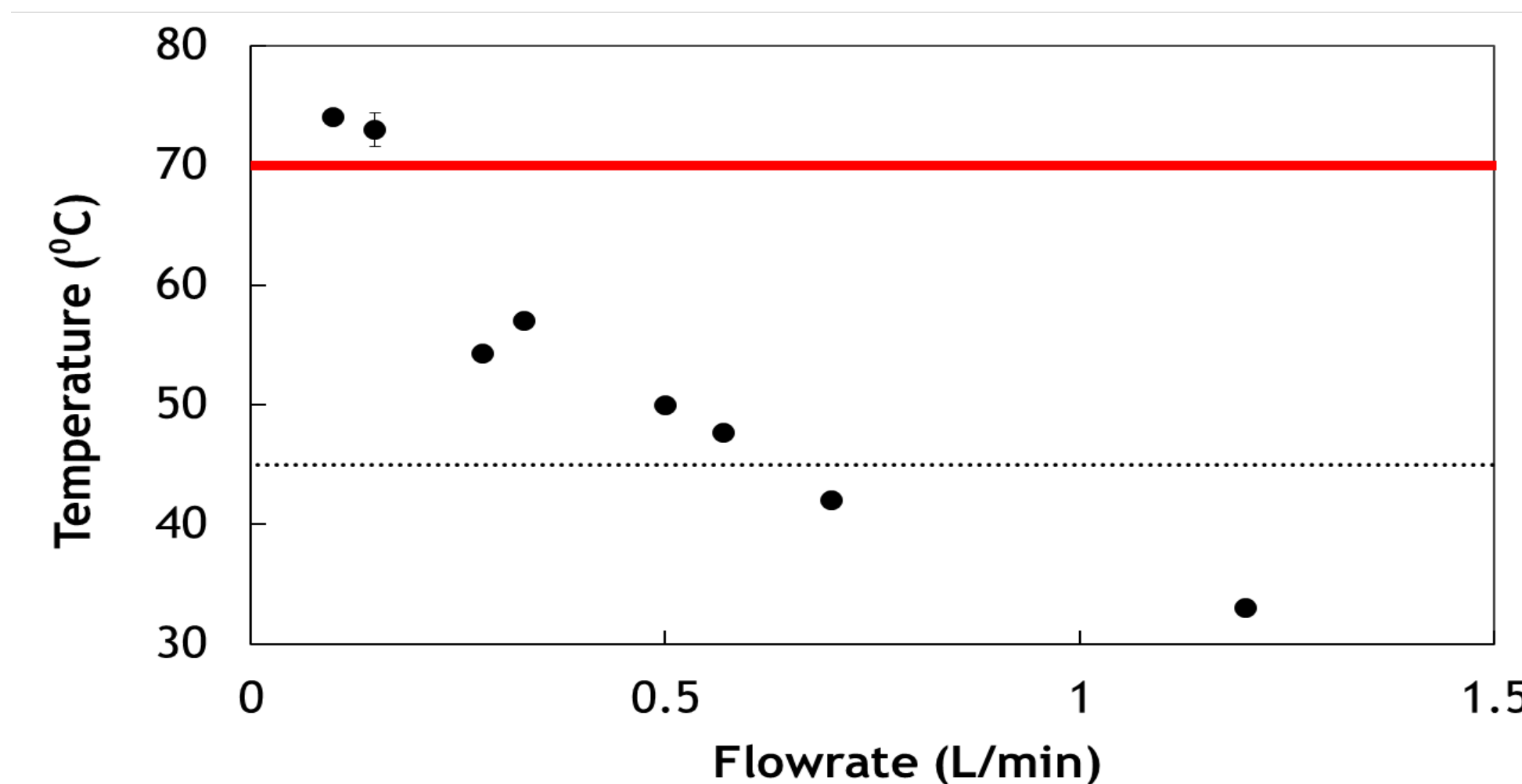


Fig. 4. Steady state water temperature (°C) exiting the solar collector vs. water flowrate (mL/min). The red line denotes target pasteurization temperature (70°C) and dotted line is the target temperature (45 °C) for solar disinfection in PET bottles. Error bars show standard deviation.

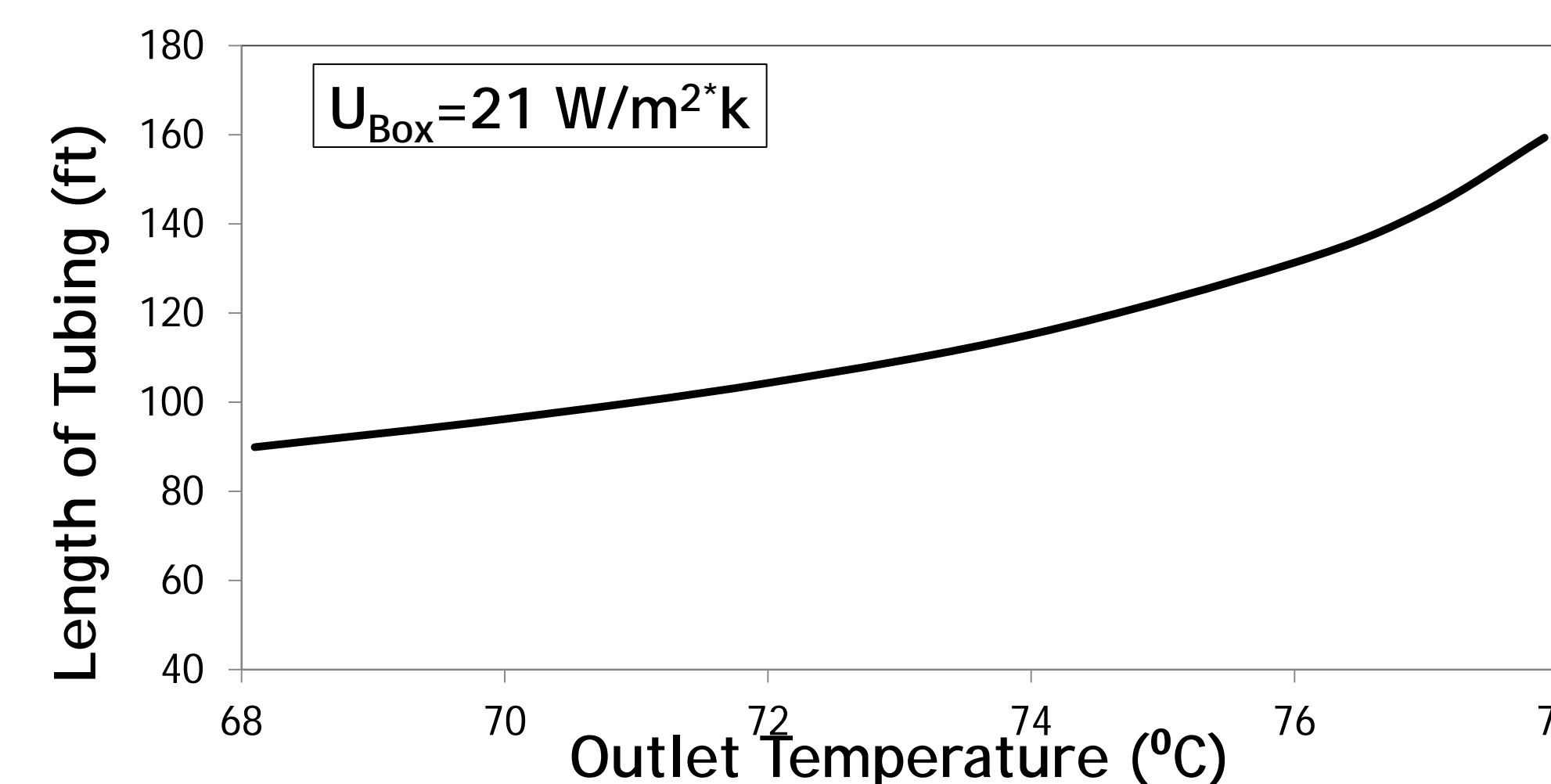


Fig. 5. Length of PEX tubing (ft) needed for water to reach desired outlet temp (°C). The overall heat transfer rate of the box (U_{Box}) was found by $Q = mCp\Delta T = U_{Box}A\Delta T_{lm}$, and length was found by area (A).

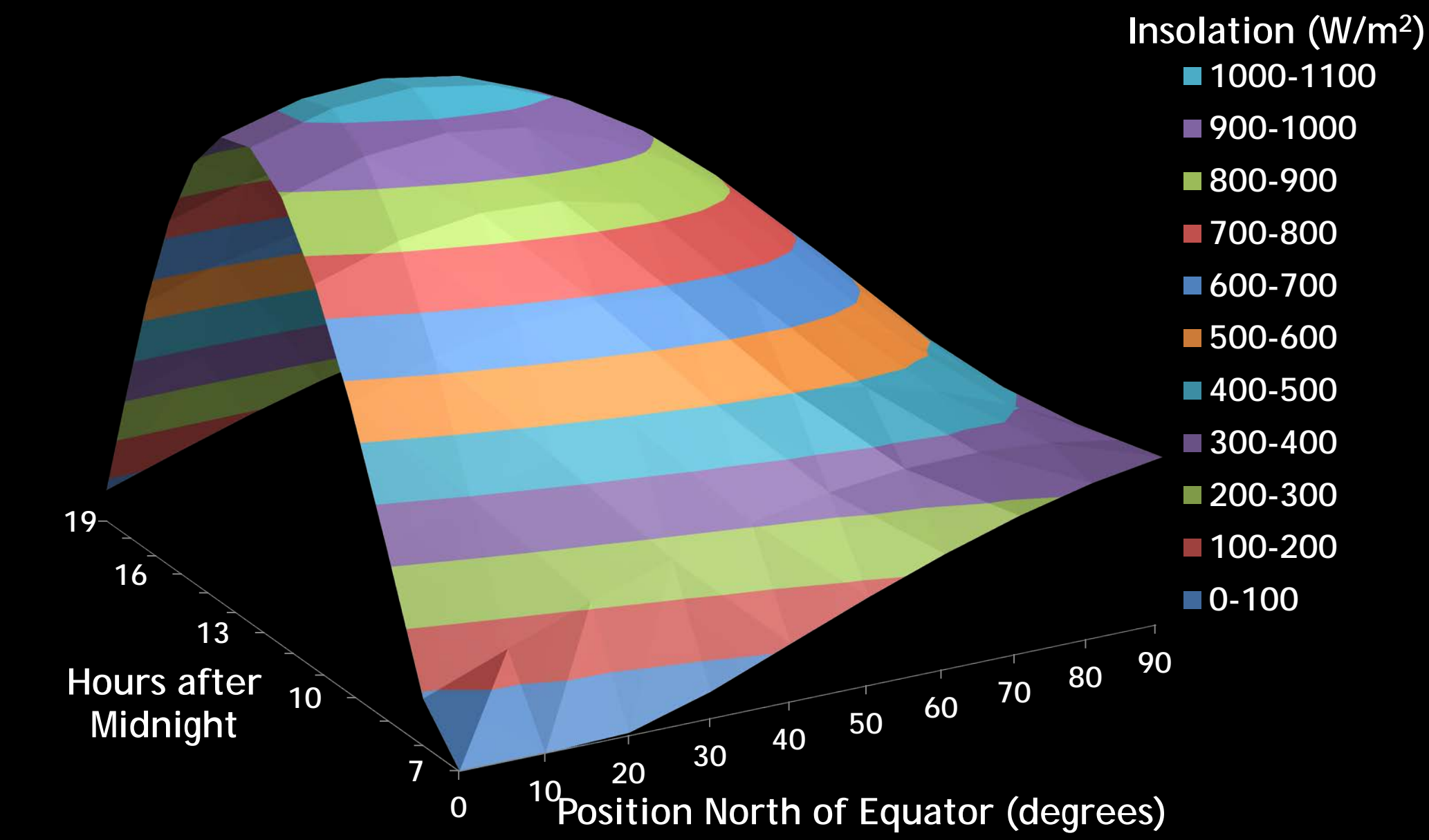


Fig. 6. Three dimensional plot showing the change in Solar Insolation (W/m²) with respect to the position in degrees north from the equator. All data was calculated using the Bird Simplified Clear Sky Solar Insolation Model for June 1st.⁷

FUTURE WORK & CONSIDERATIONS

- Synergistic Heating (device = preheater)
H₂O in PET bottles: 32°C for 5 hr.⁶
Water Pasteurization Indicator (WAPI)

- Adaptation to Haitian Culture
- Increase HX & PEX tubing length to improve performance and purify 150 L/day.
- Publish plan in *Journal of Humanitarian Engineering*. If design is accepted, the complex components (e.g., HX) could be built domestically in bulk and shipped to Haiti.

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