**Introduction**

Access to clean water is an increasing problem in developing countries and developed countries as pollution increases.

**Major Contaminants of focus:**
- Bacteria
- Lead
- Fluoride
- Chloride

The goal of the filter is to provide a portable filter with changeable components at a small enough size to fit under the sink of an average kitchen household. The model focused on maximizing the purity of the water by testing the components ability to remove extreme concentrations contaminants from water.

**Impact, Sustainability, and Factors**

**Impact**
- Compact water treatment product
- Able to remove contaminants of varying size
- Minimal maintenance costs

**Sustainability**
- Heat pump reduces biofouling of membranes for subsequent filters
- The system is a zero waste model
- Requires minimal energy input

**Factors Affecting Decisions**
- Environmental: low power use
- Global: availability to developing countries
- Economic: affordable solution worth the price

**Process Description**

The water filtration system removes contaminants in decreasing order of size through a four step process consisting of a heat pump system, a UV germicidal irradiation system, reverse osmosis system, and an ion exchange system. The entire process is contained within a 24"x10"x7.46" box able to fit inside a standard kitchen cabinet.

**Model Description**

Our group was unable to do experiments because we could not get all the equipment we needed. Instead, we designed a high level MATLAB model.

- **Heat Pump**
  - The heat pump code uses established literature values that the heat pump kills 99% of contaminants.

- **UV Irradiation**
  - We found the dose of radiation for the UV bulb.
  - Then we found the survival of the bacteria based on the dose.

- **Reverse Osmosis**
  - For the reverse osmosis code, we found the flux of each contaminant and used that perform a mass balance.

- **Ion Exchange**
  - For ion exchange, we used established literature equations to determine how particles bound to the resin.

**Optimization**

Each unit operation was optimized based on the lowest operating cost and the effectiveness of impurities being removed.

- **Heat Pump**
  - Determined the optimal diameter size to output water at 3 gal/min to the sequential filters without dramatically increasing pressure drop. This was found to be 0.118 inches.

- **UV Irradiation**
  - Determined the optimal height of the UV tank, while keeping flow rate constant.
  - Was found to be 8.5 inches.

- **Reverse Osmosis**
  - Determined the optimal diameter of the filter while keeping length, change in pressure, and the friction factor constant.
  - Was found to be 1.14 inches.

- **Ion Exchange**
  - Determined ideal resin bead size, which was found to be 0.1 cm.

**Economic Results**

Cost analysis of each unit process was simulated by code calculated to be an annual cost of $11,412.18. The heat pump optimized the cost as a function of the piping diameter to increase the internal pressure and minimize energy costs. The initial cost of the stainless steel heat pump is steep. The heat pump code analysis of each unit process was simulated by code calculated to be an annual cost of $11,412.18. The heat pump optimized the cost as a function of the piping diameter to increase the internal pressure and minimize energy costs. The initial cost of the stainless steel heat pump is steep. The heat pump cost analysis based on operating, equipment, and total cost vs estimated cost of operation.

**Conclusion**

The filtration system is a zero waste model outputting highly purified water (pharmaceutical grade). The initial outflowing stream from the heat pump maintains the purity of that resembling tap water. For areas in which are not exposed to high levels of specific toxins, the filtration system can be reduced by omitting select components depending on need.

Optimum output was found to be 3 gal/min for economic cost of $11,412.18 per year and water purity of 99.99%. The service life of the filters was estimated to be 10 years. The output of contaminants in the water after passing through all of the filters was approximately zero on orders of 10^-7 cm^3 for ions and 10^-9 cm^3 for bacteria.

**Technical Advisor:**
- Dr. Martin Okos

**Instructors:**
- Dr. Martin Okos

**Acknowledgements:**
- Alyssa Christoffer