Task 7: Clean Energy Water Disinfection for Small Rural Communities

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SUMMARY

Background

Unsafe drinking water in developing countries often harbors water-borne diseases which account for 3.6 million deaths each year.

Objective

Design a disinfection system to help alleviate the need for safe drinking water in rural, third-world areas by meeting the World Health Organization's (WHO) standards for bacterial contamination.

Figure 1: Unsanitary drinking water in developing countries

Criteria

The system must:

- Harness clean energy to disinfect water
- Be a mobile unit
- Be cost effective based on initial capital cost and operating cost per gallon of water disinfected
- Be applicable to rural, third-world settings
- Be capable of meeting a flow of 3,000 gallons per day
- Be easy for ordinary citizens in third-world environments to implement, operate, and maintain

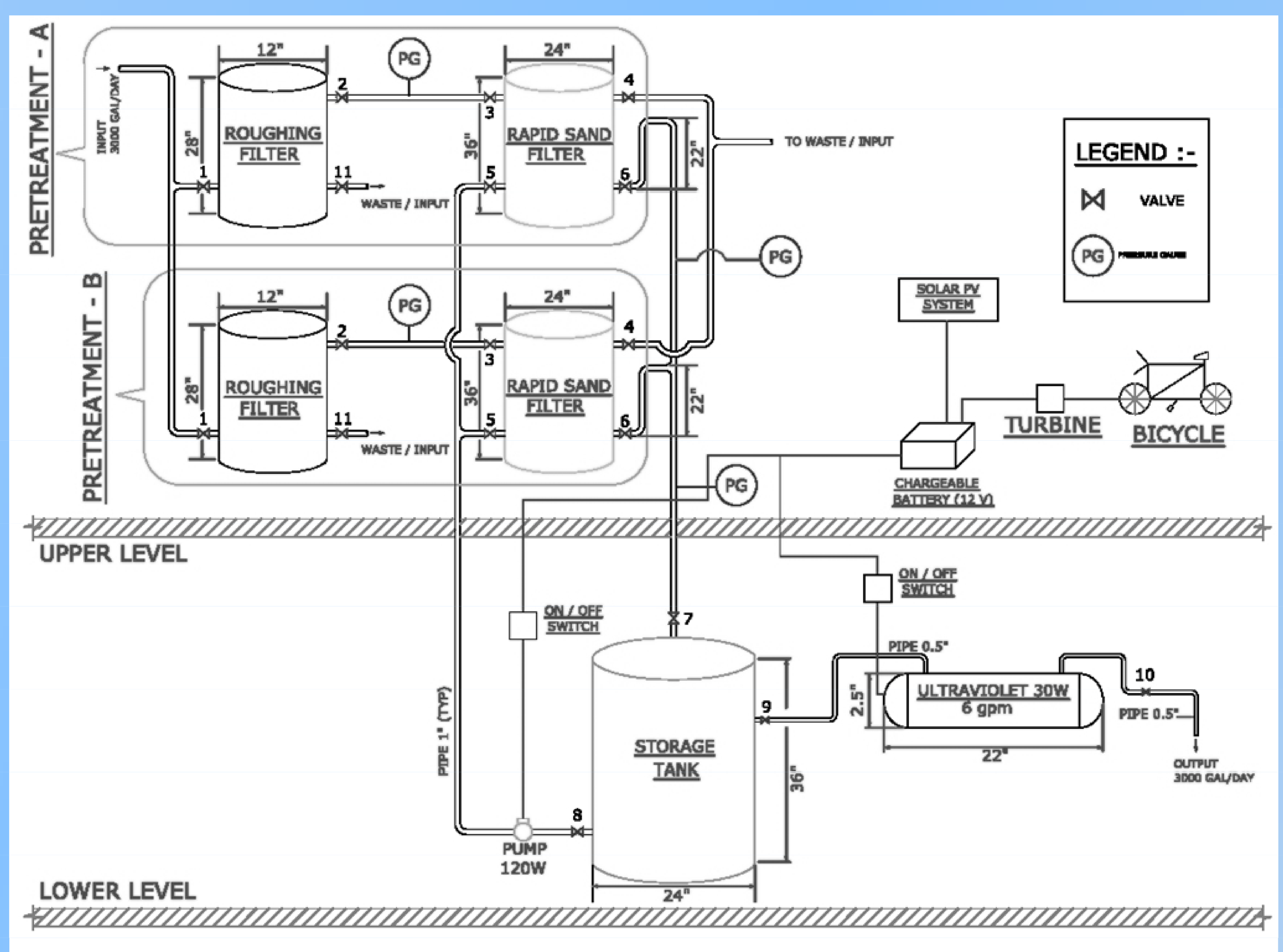

Figure 2: Full scale design schematic

DESIGN

Design Solution

The final disinfection system, seen in Figure 2, uses three stages of treatment. A roughing filter and rapid sand filter are first used to reduce solids and then a disinfection stage is used to deactivate bacteria with ultraviolet (UV) radiation.

Pretreatment

As illustrated in Figure 3, the influent water enters a roughing filter and then flows upward and into a rapid sand filter. Two identical pretreatment series will operate in parallel to ensure continuous operation.

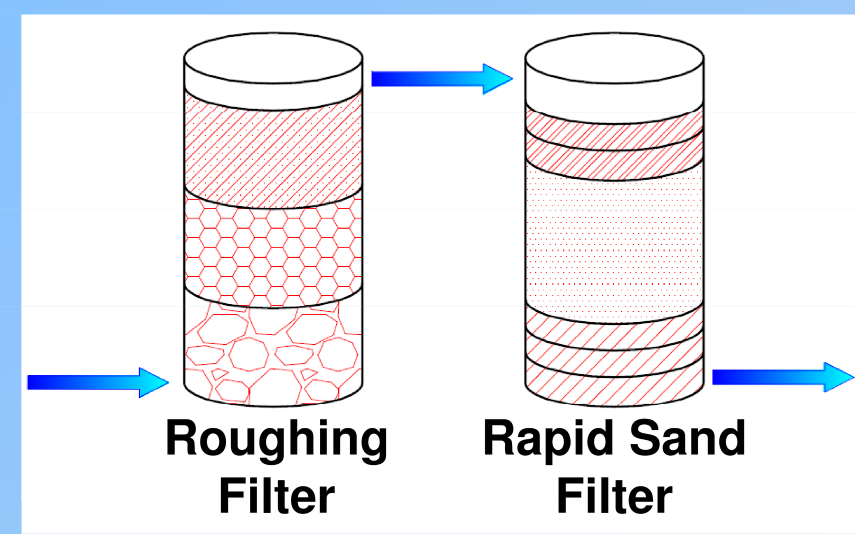

Figure 3: Pretreatment process flow schematic

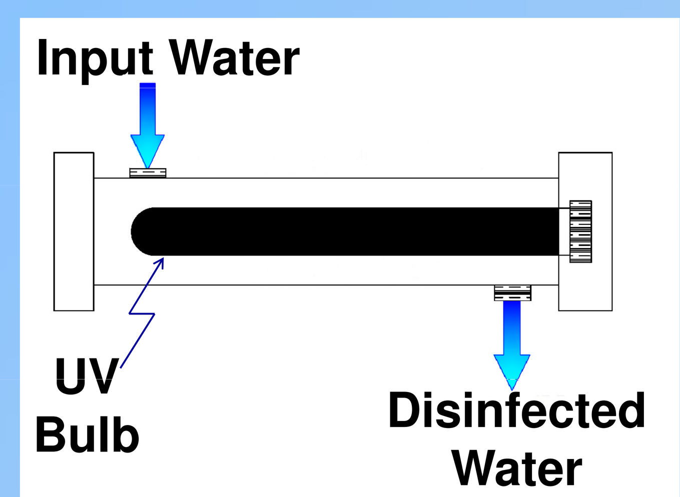

Figure 4: Ultraviolet disinfection system

Disinfection

The water then flows into a UV disinfection device similar to the one shown in Figure 4. The UV radiation is used to deactivate all microorganisms in the water.

Power

The electricity needed to power a backwashing pump and the UV system is provided via portable solar panels which will charge a 12-volt battery. In addition, a bicycle will be available to power the system in emergency situations or when solar panels are not feasible, as seen in Figure 5.

Figure 5: Electrical power schematic

RESULTS

Turbidity Removal

The reduction in turbidity was tested after the roughing filter and the rapid sand filter. As seen in Figure 6, each filter removed about 40% for a total of more than 85% reduction in turbidity.

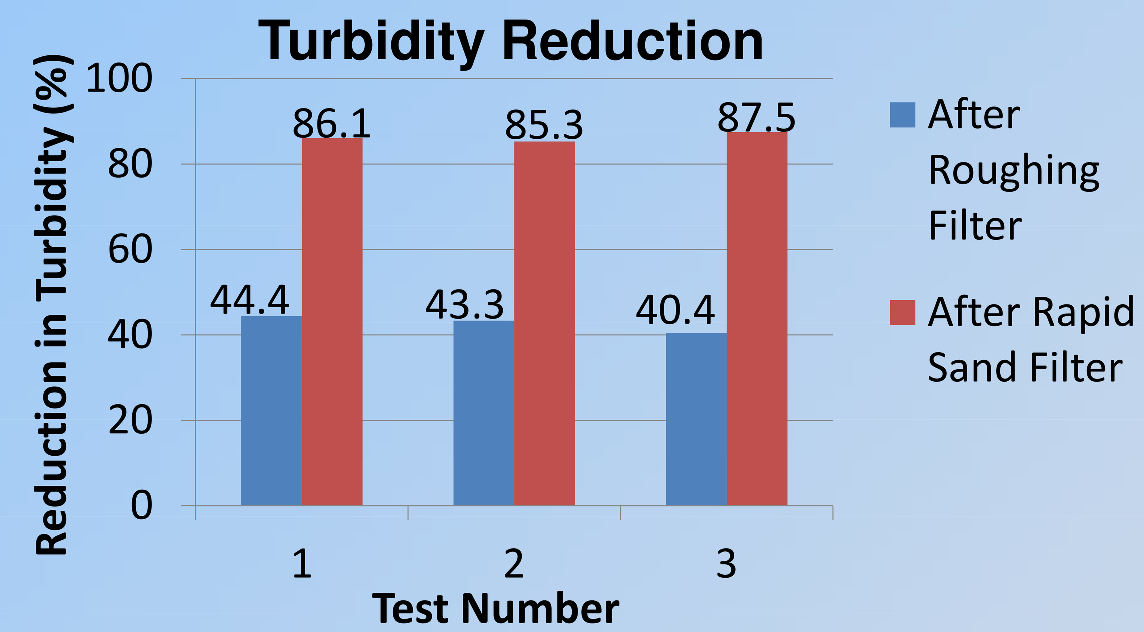

Figure 6: Percent turbidity reduction after pretreatment

Bacteria Removal

The plate and count method was used to test for the presence of bacteria in the output water. The bacteria plates, seen in Figure 7, indicate that the system successfully removed all bacteria from the influent water.

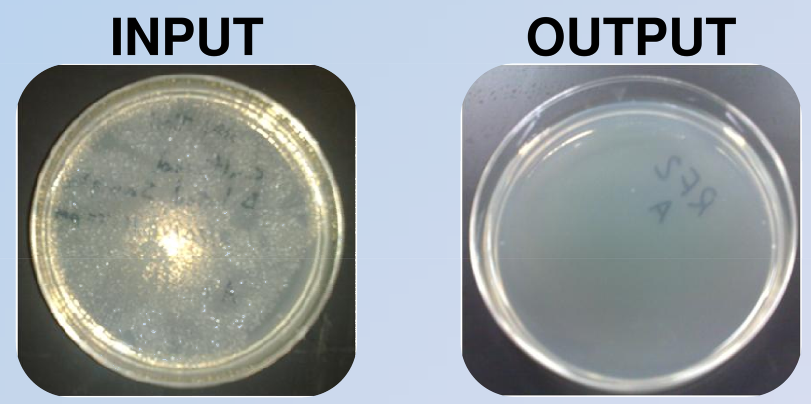

Figure 7: Influent and effluent bacteria plates

Cost Estimate

The initial cost for the system will be $2,251 including all necessary materials for construction. Table 1 shows the cost per day due to operation and maintenance costs after 6 years to be only $1.39.

Table 1: Full scale operation and maintenance costs

Materials	Replacement Frequency	Unit Price	1 Year Cost	3 Year Cost	6 Year Cost
Initial Cost	-	$2,251	$2,251	$2,251	$2,251
UV Lamp	2 Years	$61	-	$61	$122
Battery 12v	3 Years	$200	-	$200	$400
Other	1 Year	$45	$45	$135	$270
		Cost per Day of Operation	$6.29	$2.42	$1.39