Water Filter Project

- Safe and readily available water is important for public health, whether it is used for drinking, domestic use, food production or recreational purposes.
- Improved water supply and sanitation, and better management of water resources, can boost countries' economic growth and can contribute greatly to poverty reduction.

Water Filter Project

- In 2010, the UN General Assembly explicitly recognized the human right to water and sanitation.
- Everyone has the right to sufficient, continuous, safe, acceptable, physically accessible, and affordable water for personal and domestic use.

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- In 2017, 71% of the global population (5.3 billion people) used a safely managed drinking-water service – that is, one located on premises, available when needed, and free from contamination.
- 90% of the global population (6.8 billion people) used at least a basic service. A basic service is an improved drinking-water source within a round trip of 30 minutes to collect water.

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- 785 million people lack even a basic drinking-water service, including 144 million people who are dependent on surface water.
- Globally, at least 2 billion people use a drinking water source contaminated with feces.
- Contaminated water can transmit diseases such diarrhea, cholera, dysentery, typhoid, and polio. Contaminated drinking water is estimated to cause 485,000 diarrheal deaths each year.

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Water Filter Project

- By 2025, half of the world's population will be living in water-stressed areas.
- In least developed countries, 22% of health care facilities have no water service, 21% no sanitation service, and 22% no waste management service.

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Water Filter Project

- RDW, Inc. is inviting proposals for a small-scale personal water filtration system to be used in remote areas to provide clean drinking water.
- The contact person for this project is Ms. Doris Paanee, Senior Research Manager.

Water Filter Project

- The objective of this project is to design and construct, within given constraints, a granular-media filter that would treat as much water as possible (maximize volume) while removing as many suspended particles as possible (minimizing turbidity levels) for a given amount of time.

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- The amount of suspended particles will be measure by the turbidity of the influent water.
- Turbidity is defined as any finely divided, insoluble impurities, whatever their nature, that may be suspended in and mar the clarity of water.

Water Filter Project

- The types of filters used for the filtration of water are almost universally employ a granular filter medium, such as fine sand or anthracite, through which water is pulled through the filter by gravity.

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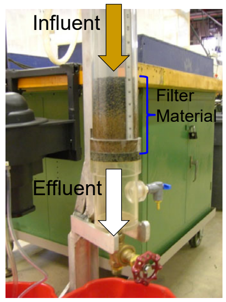
- A series of experimental granular filters will be evaluated over the next several weeks.
- From these preliminary experiments, each group will evaluate the effectiveness of the filters and use the results to design a water filter.

Water Filter Project

The design constraints are as follows:

- The filter materials are limited to anthracite and/or filter sand.
- The filter must be constructed in the 3.5 in. diameter tube provided.
- The height of the filter must be 8 in.
- The height of the influent above the top of the filter bed must be maintained at 6 inches ±½ in.



Water Filter Project

The design constraints are as follows:

- The influent water flowrate into the filter is restricted to the flowrate of the provided pump;
- The filter is to be tested for a period of 60 minutes; and
- Each filter must have a minimum filter efficiency 40,000 ml and a minimum %Turbidity (NTU) removal of 95%.

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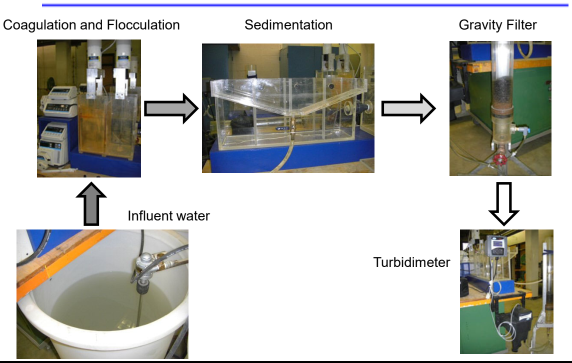
- The efficiency of the water filter will be evaluated on the volume and quality of the water treated by the filter and the reduction in turbidity of the influent during a 60-minute filter run.

Water Filter Project

- The prototype treatment system will consist of five sequential processes:
  - rapid mix – coagulation
  - flocculation
  - sedimentation
  - gravity filtration
  - turbidity measurement

Water Filter Project



Filter Efficiency Calculations

- The filter efficiency calculation is designed to compute the average turbidity (NTU) removed by a water filter run.
- There are two types of calculations:
  - Average flowrate over a time interval
  - Cumulative turbidity (NTU) removed

Filter Efficiency Calculations

Given the following data collected during a filter run where the initial turbidity (NTU) is 105:

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35		
10	800	28		
20	800	24		
30	650	15		
40	650	13		
50	500	15		
60	--	20		

Filter Efficiency Calculations

First, compute the average flowrate over each time interval.

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35		
10	800	28		
20	800	24		
30	650	15		
40	650	13		
50	500	15		
60	--	20		

Filter Efficiency Calculations

$$\textit{Incremental Volume} = \textit{Flowrate}_{i-1} \times \textit{Time}_i$$

At the end of the 10 minutes
The incremental volume is: $800\,{}^{\text{ml}}/_{\text{min}} \times 10 \text{ minutes} = 8{,}000\,\text{ml}$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	
10	800	28	8,000	
20	800	24	8,000	
30	650	15	8,000	
40	650	13	6,500	
50	500	15	6,500	
60	--	20	5,000	
			42,000	

Filter Efficiency Calculations

Next, compute the average turbidity for each time interval.

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	
10	800	28	8,000	
20	800	24	8,000	
30	650	15	8,000	
40	650	13	6,500	
50	500	15	6,500	
60	--	20	5,000	
			42,000	

Filter Efficiency Calculations

$$\textit{Average Turbidity}_i = \frac{\textit{Turbidity}_i + \textit{Turbidity}_{i-1}}{2} \times \frac{\textit{Incremental Volume}}{\textit{Total Volume}}$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	
10	800	28	8,000	
20	800	24	8,000	
30	650	15	8,000	
40	650	13	6,500	
50	500	15	6,500	
60	--	20	5,000	
			42,000	

Filter Efficiency Calculations

$$\text{Average Turbidity}_{10} = \frac{35 + 28}{2} \times \frac{8{,}000\,ml}{42{,}000\,ml} = 6.00 \text{ NTU}$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	--
10	800	28	8,000	6.00
20	800	24	8,000	
30	650	15	8,000	
40	650	13	6,500	
50	500	15	6,500	
60	--	20	5,000	
			42,000	

Filter Efficiency Calculations

$$\text{Average Turbidity}_{20} = \frac{28+24}{2} \times \frac{8{,}000\,ml}{42{,}000\,ml} = 4.95 \text{ NTU}$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	--
10	800	28	8,000	6.00
20	800	24	8,000	4.95
30	650	15	8,000	
40	650	13	6,500	
50	500	15	6,500	
60	--	20	5,000	
			42,000	

Filter Efficiency Calculations

The remaining incremental Average Turbidity values are:

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	--
10	800	28	8,000	6.00
20	800	24	8,000	4.95
30	650	15	8,000	3.71
40	650	13	6,500	2.17
50	500	15	6,500	2.17
60	--	20	5,000	2.08
			42,000	

Filter Efficiency Calculations

Average Turbidity is the sum the incremental values.

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	--
10	800	28	8,000	6.00
20	800	24	8,000	4.95
30	650	15	8,000	3.71
40	650	13	6,500	2.17
50	500	15	6,500	2.17
60	--	20	5,000	2.08
			42,000	21.08

Filter Efficiency Calculations

Lastly, compute the %Turbidity (NTU) removed and the filter efficiency.

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	--
10	800	28	8,000	6.00
20	800	24	8,000	4.95
30	650	15	8,000	3.71
40	650	13	6,500	2.17
50	500	15	6,500	2.17
60	--	20	5,000	2.08
			42,000	21.08

Filter Efficiency Calculations

$$\%\text{Turbidity Removed} = \frac{\text{Turbidity}_{\text{Initial}} - \text{Average Turbidity}}{\text{Turbidity}_{\text{Initial}}}$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	--
10	800	28	8,000	6.00
20	800	24	8,000	4.95
30	650	15	8,000	3.71
40	650	13	6,500	2.17
50	500	15	6,500	2.17
60	--	20	5,000	2.08
			42,000	21.08

Filter Efficiency Calculations

$$\%\text{Turbidity Removed} = \frac{105 - 21.1}{105} \times 100\% = 79.9\%$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	--
10	800	28	8,000	6.00
20	800	24	8,000	4.95
30	650	15	8,000	3.71
40	650	13	6,500	2.17
50	500	15	6,500	2.17
60	--	20	5,000	2.08
			42,000	21.08

Filter Efficiency Calculations

$$\text{Filter Efficiency} = \text{Volume (ml)} \times \text{\%Turbidity Removed}$$

$$\text{Filter Efficiency} = 42{,}000\,\text{ml} \times 79.9\% = \boxed{33{,}558\,\text{ml}}$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	800	35	--	--
10	800	28	8,000	6.00
20	800	24	8,000	4.95
30	650	15	8,000	3.71
40	650	13	6,500	2.17
50	500	15	6,500	2.17
60	--	20	5,000	2.08
			42,000	**21.08**

Water Filter Project

Any questions?