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 195:

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	200	35		
10	200	48		
20	200	54		
30	150	65		
40	150	83		
50	100	95		
60	--	120		

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	200	35		
10	200	48		
20	200	54		
30	150	65		
40	150	83		
50	100	95		
60	--	120		

Filter Efficiency Calculations

$$Incremental\ Volume = Flowrate_{i-1} \times Time_i$$

At the end of the 10 minutes
The incremental volume is: $200\,ml/\min \times 10\ \text{minutes} = 2{,}000\,ml$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	200	35	--	
10	200	48	2,000	
20	200	54	2,000	
30	150	65	2,000	
40	150	83	1,500	
50	100	95	1,500	
60	--	120	1,000	
			10,000	

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	200	35	--	
10	200	48	2,000	
20	200	54	2,000	
30	150	65	2,000	
40	150	83	1,500	
50	100	95	1,500	
60	--	120	1,000	
			10,000	

Filter Efficiency Calculations

$$Average\ Turbidity_i = \frac{NTU_i + NTU_{i-1}}{2} \times \frac{Incremental\ Volume}{Total\ Volume}$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	200	35	--	
10	200	48	2,000	
20	200	54	2,000	
30	150	65	2,000	
40	150	83	1,500	
50	100	95	1,500	
60	--	120	1,000	
			10,000	

Filter Efficiency Calculations

Average turbidity $NTU_{10} = \frac{35+48}{2} \times \frac{2{,}000ml}{10{,}000ml}$ = 8.3 NTU

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	200	35	--	--
10	200	48	2,000	8.3
20	200	54	2,000	
30	150	65	2,000	
40	150	83	1,500	
50	100	95	1,500	
60	--	120	1,000	
			10,000	

Filter Efficiency Calculations

Average turbidity $NTU_{20} = \frac{48+54}{2} \times \frac{2{,}000ml}{10{,}000ml}$ = 10.2 NTU

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	200	35	--	--
10	200	48	2,000	8.3
20	200	54	2,000	10.2
30	150	65	2,000	
40	150	83	1,500	
50	100	95	1,500	
60	--	120	1,000	
			10,000	

Filter Efficiency Calculations

- The remaining incremental Average Turbidity values are:

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	200	35	--	--
10	200	48	2,000	8.3
20	200	54	2,000	10.2
30	150	65	2,000	11.9
40	150	83	1,500	11.1
50	100	95	1,500	13.4
60	--	120	1,000	10.8
			10,000	

Filter Efficiency Calculations

- Average Turbidity is sum the incremental values

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	200	35	--	--
10	200	48	2,000	8.3
20	200	54	2,000	10.2
30	150	65	2,000	11.9
40	150	83	1,500	11.1
50	100	95	1,500	13.4
60	--	120	1,000	10.8
			10,000	65.6

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	200	35	--	--
10	200	48	2,000	8.3
20	200	54	2,000	10.2
30	150	65	2,000	11.9
40	150	83	1,500	11.1
50	100	95	1,500	13.4
60	--	120	1,000	10.8
			10,000	65.6

Filter Efficiency Calculations

$\%Turbidity(NTU)\,Removed = \frac{195-65.6}{195} \times 100\% = 66.4\%$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	200	35	--	--
10	200	48	2,000	8.3
20	200	54	2,000	10.2
30	150	65	2,000	11.9
40	150	83	1,500	11.1
50	100	95	1,500	13.4
60	--	120	1,000	10.8
			10,000	65.6

Filter Efficiency Calculations

$$Filter\ Efficiency = 10{,}000ml \times 66.4\% = \boxed{6{,}636ml}$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	200	35	--	--
10	200	48	2,000	8.3
20	200	54	2,000	10.2
30	150	65	2,000	11.9
40	150	83	1,500	11.1
50	100	95	1,500	13.4
60	--	120	1,000	10.8
			10,000	65.6

Group Problem

- Given the following data collected during a filter run where the initial turbidity (NTU) is 83:

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	750	4		
10	750	5		
20	750	5		
30	750	6		
40	750	8		
50	750	11		
60	--	10		

Group Problem

- Compute the incremental volume and the Average Turbidity

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	750	4	--	--
10	750	5	7,500	0.75
20	750	5	7,500	0.83
30	750	6	7,500	0.92
40	750	8	7,500	1.17
50	750	11	7,500	1.58
60	--	10	7.500	1.75
			45,000	7.0

Group Problem

$$\%Turbidity(NTU)\ Removed = \frac{83-7}{83} \times 100\% = 91.6\%$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	750	4	--	--
10	750	5	7,500	0.75
20	750	5	7,500	0.83
30	750	6	7,500	0.92
40	750	8	7,500	1.17
50	750	11	7,500	1.58
60	--	10	7.500	1.75
			45,000	7.0

Group Problem

$$Filter\ Efficiency = 45{,}000ml \times 91.6\% = \boxed{41{,}205ml}$$

Time (min)	Flowrate (ml/min)	Turbidity (NTU)	Volume (ml)	Average Turbidity (NTU)
0	750	4	--	--
10	750	5	7,500	0.75
20	750	5	7,500	0.83
30	750	6	7,500	0.92
40	750	8	7,500	1.17
50	750	11	7,500	1.58
60	--	10	7.500	1.75
			45,000	7.0

Filter Efficiency Calculations

Any Questions