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# Design of Trickling Filter using NRC Equations Formulas

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# List of 21 Design of Trickling Filter using NRC Equations Formulas

## Design of Trickling Filter using NRC Equations

### 1) Area given Hydraulic Loading

$$\text{fx } A = (1 + \alpha) \cdot \frac{W_w}{H \cdot 1440}$$

[Open Calculator !\[\]\(a870788d6ed9b8fd294b7654a8c8526b\_img.jpg\)](#)

$$\text{ex } 52.5\text{m}^2 = (1 + 1.5) \cdot \frac{1.4\text{m}^3/\text{s}}{4\text{m}^3/\text{d} \cdot 1440}$$

### 2) Hydraulic Loading to each Filter

$$\text{fx } H = (1 + \alpha) \cdot \frac{W_w}{A \cdot 1440}$$

[Open Calculator !\[\]\(c50c8b7b2cc2cf9ff925edec0ee94c0d\_img.jpg\)](#)

$$\text{ex } 4.2\text{m}^3/\text{d} = (1 + 1.5) \cdot \frac{1.4\text{m}^3/\text{s}}{50\text{m}^2 \cdot 1440}$$

## BOD Loading

### 3) BOD Loading for First Stage Filter

$$\text{fx } W' = Q_i \cdot W_w \cdot 8.34$$

[Open Calculator !\[\]\(f1c5da15572e3e09d343161be98f508d\_img.jpg\)](#)

$$\text{ex } 2.8\text{E}^{-5}\text{kg}/\text{d} = 0.002379\text{mg}/\text{L} \cdot 1.4\text{m}^3/\text{s} \cdot 8.34$$



#### 4) BOD Loading for First Stage Filter using BOD Loading for Second Filter Stage

$$\text{fx } W = \frac{W'}{1 - E_f}$$

[Open Calculator !\[\]\(cbe80b694ebd74fcfe136a095b608235\_img.jpg\)](#)

$$\text{ex } 3.428571\text{kg/d} = \frac{2.4\text{kg/d}}{1 - 0.3}$$

#### 5) BOD Loading for Second Stage Filter

$$\text{fx } W' = (1 - E_f) \cdot W$$

[Open Calculator !\[\]\(3e2231b1ad3ca8da8658228c00dd08e0\_img.jpg\)](#)

$$\text{ex } 2.45\text{kg/d} = (1 - 0.3) \cdot 3.5\text{kg/d}$$

#### 6) BOD Loading to Second Filter Stage given Efficiency of Second Filter Stage

**fx**
[Open Calculator !\[\]\(0d5ec72f61334709c3fc9450209b754f\_img.jpg\)](#)

$$W' = V_T \cdot F \cdot \left( \left( \frac{1 - E_f}{0.0561} \right) \cdot \left( \left( \frac{100}{E_2} \right) - 1 \right) \right)^2$$

$$\text{ex } 1.921506\text{kg/d} = 0.0035\text{m}^3 \cdot 0.4 \cdot \left( \left( \frac{1 - 0.3}{0.0561} \right) \cdot \left( \left( \frac{100}{99} \right) - 1 \right) \right)^2$$



## Efficiency of Filter

### 7) Efficiency of First Filter given BOD Loading for Second Filter

$$\text{fx } E = 1 - \left( \frac{W'}{W'} \right)$$

[Open Calculator !\[\]\(23d9fc146e83b5c3013cfa32c784f8d5\_img.jpg\)](#)

$$\text{ex } 0.825 = 1 - \left( \frac{0.42\text{kg/d}}{2.4\text{kg/d}} \right)$$

### 8) Efficiency of First Filter Stage

$$\text{fx } E_1 = \frac{100}{1 + \left( 0.0561 \cdot \sqrt{\frac{W'}{V_T \cdot F}} \right)}$$

[Open Calculator !\[\]\(aa53ad6fea213b8b2226d3077e30533a\_img.jpg\)](#)

$$\text{ex } 99.21598 = \frac{100}{1 + \left( 0.0561 \cdot \sqrt{\frac{2.4\text{kg/d}}{0.0035\text{m}^3 \cdot 0.4}} \right)}$$

### 9) Efficiency of First Filter Stage using Efficiency of Second Filter Stage

$$\text{fx } E = 1 + \left( \left( \frac{0.0561}{\frac{100}{E_2}} - 1 \right) \cdot \sqrt{\frac{W'}{V_T \cdot F}} \right)$$

[Open Calculator !\[\]\(626ce8ac21792b9405bfddfea8e0c96a\_img.jpg\)](#)

$$\text{ex } 0.866964 = 1 + \left( \left( \frac{0.0561}{\frac{100}{99}} - 1 \right) \cdot \sqrt{\frac{2.4\text{kg/d}}{0.0035\text{m}^3 \cdot 0.4}} \right)$$



## 10) Efficiency of Second Filter Stage

$$\text{fx } E_2 = \frac{100}{1 + \left( \left( \frac{0.0561}{1-E_1} \right) \cdot \sqrt{\frac{W'}{V_T \cdot F}} \right)}$$

[Open Calculator !\[\]\(e2376d476d06eb31946dc01a69a4403a\_img.jpg\)](#)

$$\text{ex } 100.008 = \frac{100}{1 + \left( \left( \frac{0.0561}{1-100} \right) \cdot \sqrt{\frac{2.4\text{kg/d}}{0.0035\text{m}^3 \cdot 0.4}} \right)}$$

## 11) Overall Efficiency of Two Stage Trickling Filter

$$\text{fx } E = \left( Q_{ie} - \frac{Q_o}{Q_{ie}} \right) \cdot 100$$

[Open Calculator !\[\]\(0b5e7e25e8775f7e7e80906ada4f0021\_img.jpg\)](#)

$$\text{ex } 2.390158 = \left( 24\text{mg/L} - \frac{0.002362\text{mg/L}}{24\text{mg/L}} \right) \cdot 100$$

## Influent and Effluent BOD


## 12) Effluent BOD given Overall Efficiency of Two-Stage Trickling Filter

$$\text{fx } Q_o = \left( 1 - \left( \frac{E}{100} \right) \right) \cdot Q_i$$

[Open Calculator !\[\]\(0fb13ad0bfa3d86868cdd3883e5665b3\_img.jpg\)](#)

$$\text{ex } 0.002322\text{mg/L} = \left( 1 - \left( \frac{2.39}{100} \right) \right) \cdot 0.002379\text{mg/L}$$




13) Influent BOD given BOD Loading for First Stage Filter 

$$\text{fx } Q_i = \frac{W'}{W_w \cdot 8.34}$$

[Open Calculator !\[\]\(d3fb9f94af8b26d1c844efa9a98805b0\_img.jpg\)](#)

$$\text{ex } 0.002379 \text{mg/L} = \frac{2.4 \text{kg/d}}{1.4 \text{m}^3/\text{s} \cdot 8.34}$$

14) Influent BOD given Overall Efficiency of Two-Stage Trickling Filter 

$$\text{fx } Q_i = \frac{100 \cdot Q_o}{100 - E}$$

[Open Calculator !\[\]\(e1d6102fe77919492c04879c8450f1f5\_img.jpg\)](#)

$$\text{ex } 0.00242 \text{mg/L} = \frac{100 \cdot 0.002362 \text{mg/L}}{100 - 2.39}$$

Recirculation Factor 15) Recirculation Factor 

$$\text{fx } F = \frac{1 + \alpha}{\left(1 + \frac{\alpha}{10}\right)^2}$$

[Open Calculator !\[\]\(104fbf564e2e5a8fbd84f31656d114c7\_img.jpg\)](#)

$$\text{ex } 1.890359 = \frac{1 + 1.5}{\left(1 + \frac{1.5}{10}\right)^2}$$



## Recirculation Ratio

### 16) Recirculation Ratio given Hydraulic Loading

$$fx \quad \alpha = \left( \frac{H \cdot A \cdot 1440}{W_w} \right) - 1$$

[Open Calculator !\[\]\(83f22ed94ec5517769dd76d702c6bfd8\_img.jpg\)](#)

$$ex \quad 1.380952 = \left( \frac{4m^3/d \cdot 50m^2 \cdot 1440}{1.4m^3/s} \right) - 1$$

### 17) Recirculation Ratio of Wastewater

$$fx \quad \alpha = \frac{Q_r}{W_w}$$

[Open Calculator !\[\]\(3cb60d42b10e53f9522bb0b392c1c4cd\_img.jpg\)](#)

$$ex \quad 1.785714 = \frac{2.5m^3/s}{1.4m^3/s}$$

## Volume of Filter

### 18) Volume of Filter Media given Efficiency of Second Filter Stage

$$fx \quad V_T = \left( \frac{W'}{F} \right) \cdot \frac{1}{\left( \left( \frac{1-E_1}{0.0561} \right) \cdot \left( \frac{100}{E_2} - 1 \right) \right)^2}$$

[Open Calculator !\[\]\(274fd520e03b61c1b9ffc861754cacdc\_img.jpg\)](#)

$$ex \quad 2.2E^{-7}m^3 = \left( \frac{2.4kg/d}{0.4} \right) \cdot \frac{1}{\left( \left( \frac{1-100}{0.0561} \right) \cdot \left( \frac{100}{99} - 1 \right) \right)^2}$$



## Wastewater Flow

### 19) Wastewater Flow given BOD Loading for First Stage

$$\text{fx } W_w = \frac{W'}{8.34 \cdot Q_i}$$

[Open Calculator !\[\]\(96cc62f861fdd6e50510c0224a756dff\_img.jpg\)](#)

$$\text{ex } 1.400029\text{m}^3/\text{s} = \frac{2.4\text{kg}/\text{d}}{8.34 \cdot 0.002379\text{mg}/\text{L}}$$

### 20) Wastewater Flow given Hydraulic Loading

$$\text{fx } W_w = H \cdot A \cdot \frac{1440}{1 + \alpha}$$

[Open Calculator !\[\]\(f95dab70c751fda7d824b8b03650f7aa\_img.jpg\)](#)

$$\text{ex } 1.333333\text{m}^3/\text{s} = 4\text{m}^3/\text{d} \cdot 50\text{m}^2 \cdot \frac{1440}{1 + 1.5}$$

### 21) Wastewater Flow given Recirculation Ratio

$$\text{fx } W_w = \frac{Q_r}{\alpha}$$

[Open Calculator !\[\]\(e9474ce1d70442456f8fe9c393ea149c\_img.jpg\)](#)

$$\text{ex } 1.666667\text{m}^3/\text{s} = \frac{2.5\text{m}^3/\text{s}}{1.5}$$










## Variables Used

- **A** Area (Square Meter)
- **E** Overall Efficiency
- **E<sub>1</sub>** Efficiency of First Filter Stage
- **E<sub>2</sub>** Efficiency of Second Filter Stage
- **E<sub>f</sub>** Efficiency of First Filter Stage BOD Loading
- **F** Recirculation Factor
- **H** Hydraulic Loading (Cubic Meter per Day)
- **Q<sub>i</sub>** Influent BOD (Milligram per Liter)
- **Q<sub>ie</sub>** Influent BOD Efficiency (Milligram per Liter)
- **Q<sub>o</sub>** Effluent BOD (Milligram per Liter)
- **Q<sub>r</sub>** Recirculation Flow (Cubic Meter per Second)
- **V<sub>T</sub>** Volume (Cubic Meter)
- **W** BOD Loading to Filter (Kilogram per Day)
- **W<sub>2</sub>** BOD Loading to the Second Stage Filter (Kilogram per Day)
- **W<sub>w</sub>** Waste Water Flow (Cubic Meter per Second)
- **W<sub>1</sub>** BOD Loading to Filter 2 (Kilogram per Day)
- **α** Recirculation Ratio



## Constants, Functions, Measurements used

- **Function:** **sqrt**, sqrt(Number)  
*A square root function is a function that takes a non-negative number as an input and returns the square root of the given input number.*
- **Measurement:** **Volume** in Cubic Meter ( $\text{m}^3$ )  
*Volume Unit Conversion* 
- **Measurement:** **Area** in Square Meter ( $\text{m}^2$ )  
*Area Unit Conversion* 
- **Measurement:** **Volumetric Flow Rate** in Cubic Meter per Second ( $\text{m}^3/\text{s}$ ), Cubic Meter per Day ( $\text{m}^3/\text{d}$ )  
*Volumetric Flow Rate Unit Conversion* 
- **Measurement:** **Mass Flow Rate** in Kilogram per Day ( $\text{kg}/\text{d}$ )  
*Mass Flow Rate Unit Conversion* 
- **Measurement:** **Density** in Milligram per Liter ( $\text{mg}/\text{L}$ )  
*Density Unit Conversion* 



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