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# Substrate Concentration Formulas

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# List of 11 Substrate Concentration Formulas

## Substrate Concentration

### Concentration of Solids

#### 1) Concentration of Sludge in Return Line given RAS Pumping Rate from Aeration Tank

Open Calculator

fx $$X_r = X \cdot \frac{Q_a + RAS}{RAS + (Q_w')}$$

ex $$32.78049\text{mg/L} = 1200\text{mg/L} \cdot \frac{1.2\text{m}^3/\text{d} + 10\text{m}^3/\text{d}}{10\text{m}^3/\text{d} + 400\text{m}^3/\text{d}}$$

#### 2) Concentration of Sludge in Return Line given Wasting Rate from Return Line

Open Calculator

fx $$X_r = \left(V \cdot \frac{X}{\theta_c \cdot (Q_w')}\right) - \left(Q_e \cdot \frac{X_e}{Q_w'}\right)$$

ex $$199.9999\text{mg/L} = \left(1000\text{m}^3 \cdot \frac{1200\text{mg/L}}{7\text{d} \cdot 400\text{m}^3/\text{d}}\right) - \left(1523.81\text{m}^3/\text{d} \cdot \frac{60\text{mg/L}}{400\text{m}^3/\text{d}}\right)$$

#### 3) Concentration of Solids in Effluent given Wasting Rate from Return Line

Open Calculator

fx $$X_e = \left(V \cdot \frac{X}{\theta_c \cdot Q_e}\right) - \left((Q_w') \cdot \frac{X_r}{Q_e}\right)$$

ex $$59.99998\text{mg/L} = \left(1000\text{m}^3 \cdot \frac{1200\text{mg/L}}{7\text{d} \cdot 1523.81\text{m}^3/\text{d}}\right) - \left(400\text{m}^3/\text{d} \cdot \frac{200\text{mg/L}}{1523.81\text{m}^3/\text{d}}\right)$$

# Effluent Substrate Concentration

## 4) Effluent Flow Rate given Wasting Rate from Return Line

Open Calculator

fx $$Q_e = \left(V \cdot \frac{X}{\theta_c \cdot X_e}\right) - \left((Q_w') \cdot \frac{X_r}{X_e}\right)$$

ex $$1523.81\text{m}^3/\text{d} = \left(1000\text{m}^3 \cdot \frac{1200\text{mg/L}}{7\text{d} \cdot 60\text{mg/L}}\right) - \left(400\text{m}^3/\text{d} \cdot \frac{200\text{mg/L}}{60\text{mg/L}}\right)$$

## 5) Effluent Substrate Concentration given Net Waste Activated Sludge

Open Calculator

fx $$S = S_o - \left(\frac{P_x}{Y_{obs} \cdot Q_a \cdot 8.34}\right)$$

ex $$24.9975\text{mg/L} = 25\text{mg/L} - \left(\frac{20\text{mg/d}}{0.8 \cdot 1.2\text{m}^3/\text{d} \cdot 8.34}\right)$$

## 6) Effluent Substrate Concentration given Theoretical Oxygen Requirement

Open Calculator

fx $$S = S_o - \left((O_2 + (1.42 \cdot P_x)) \cdot \left(\frac{f}{8.34 \cdot Q_a}\right)\right)$$

ex $$24.9979\text{mg/L} = 25\text{mg/L} - \left((2.5\text{mg/d} + (1.42 \cdot 20\text{mg/d})) \cdot \left(\frac{0.68}{8.34 \cdot 1.2\text{m}^3/\text{d}}\right)\right)$$

## 7) Effluent Substrate Concentration given Volume of Reactor

Open Calculator

fx $$S = S_o - \left(\frac{V \cdot X_a \cdot (1 + (k_d \cdot \theta_c))}{\theta_c \cdot Q_a \cdot Y}\right)$$

ex $$15.6994\text{mg/L} = 25\text{mg/L} - \left(\frac{1000\text{m}^3 \cdot 2500\text{mg/L} \cdot (1 + (0.050\text{d}^{-1} \cdot 7\text{d}))}{7\text{d} \cdot 1.2\text{m}^3/\text{d} \cdot 0.5}\right)$$

# Influent Substrate Concentration

## 8) Influent Substrate Concentration for Organic Loading using Hydraulic Retention Time

Open Calculator

fx $S_o = V_L \cdot \theta_s$

ex $9.84\text{mg/L} = 1.23\text{mg/L} \cdot 8\text{s}$

## 9) Influent Substrate Concentration given Net Waste Activated Sludge

Open Calculator

fx $S_o = \left(\frac{P_x}{8.34 \cdot Y_{obs} \cdot Q_a}\right) + S$

ex $15.0025\text{mg/L} = \left(\frac{20\text{mg/d}}{8.34 \cdot 0.8 \cdot 1.2\text{m}^3\text{/d}}\right) + 15\text{mg/L}$

## 10) Influent Substrate Concentration given Organic Loading

Open Calculator

fx $S_o = V_L \cdot \frac{V}{Q_i}$

ex $25.10204\text{mg/L} = 1.23\text{mg/L} \cdot \frac{1000\text{m}^3}{49\text{m}^3\text{/s}}$

## 11) Influent Substrate Concentration given Theoretical Oxygen Requirement

Open Calculator

fx $S_o = (O_2 + (1.42 \cdot P_x)) \cdot \left(\frac{f}{8.34 \cdot Q_a}\right) + S$

ex $15.0021\text{mg/L} = (2.5\text{mg/d} + (1.42 \cdot 20\text{mg/d})) \cdot \left(\frac{0.68}{8.34 \cdot 1.2\text{m}^3\text{/d}}\right) + 15\text{mg/L}$

## Variables Used

- **f** BOD Conversion Factor
- **$k_d$** Endogenous Decay Coefficient *(1 Per Day)*
- **$O_2$** Theoretical Oxygen Requirement *(Milligram per Day)*
- **$P_x$** Net Waste Activated Sludge *(Milligram per Day)*
- **$Q_a$** Average Daily Influent Flow Rate *(Cubic Meter per Day)*
- **$Q_e$** Effluent Flow Rate *(Cubic Meter per Day)*
- **$Q_i$** Influent Average Flow Rate *(Cubic Meter per Second)*
- **$Q_w'$** WAS Pumping Rate from Return Line *(Cubic Meter per Day)*
- **RAS** Return Activated Sludge *(Cubic Meter per Day)*
- **S** Effluent Substrate Concentration *(Milligram per Liter)*
- **$S_o$** Influent Substrate Concentration *(Milligram per Liter)*
- **V** Reactor Volume *(Cubic Meter)*
- **$V_L$** Organic Loading *(Milligram per Liter)*
- **X** MLSS *(Milligram per Liter)*
- **$X_a$** MLVSS *(Milligram per Liter)*
- **$X_e$** Solid Concentration in Effluent *(Milligram per Liter)*
- **$X_r$** Sludge Concentration in Return Line *(Milligram per Liter)*
- **Y** Maximum Yield Coefficient
- **$Y_{obs}$** Observed Cell Yield
- **$\theta_c$** Mean Cell Residence Time *(Day)*
- **$\theta_s$** Hydraulic Retention Time in Seconds *(Second)*

## Constants, Functions, Measurements used

- Measurement: **Time** in Day (d), Second (s)
  *Time Unit Conversion*
- Measurement: **Volume** in Cubic Meter ($m^3$)
  *Volume Unit Conversion*
- Measurement: **Volumetric Flow Rate** in Cubic Meter per Day ($m^3/d$), Cubic Meter per Second ($m^3/s$)
  *Volumetric Flow Rate Unit Conversion*
- Measurement: **Mass Flow Rate** in Milligram per Day (mg/d)
  *Mass Flow Rate Unit Conversion*
- Measurement: **Density** in Milligram per Liter (mg/L)
  *Density Unit Conversion*
- Measurement: **First Order Reaction Rate Constant** in 1 Per Day ($d^{-1}$)
  *First Order Reaction Rate Constant Unit Conversion*

## Check other formula lists

- **Substrate Concentration Formulas**

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