

# MATH FORMULAS FOR WASTEWATER, COLLECTIONS & PHYSICAL CHEMICAL EXAMS

<b>GENERAL</b>	
<b>Lbs</b> = mg/l x MGD x 8.34 (lbs/gal)	<b>Watts</b> = volts x amps = $\frac{\text{voltage}}{\text{ohms}}$
<b>Circumference of a circle</b> = $\pi \times \text{diameter}$ , <u>or</u> $2 \times \pi \times \text{radius}$ <i>where <math>\pi = 3.14</math></i>  <b>Area of a circle</b> = $\pi(r^2)$ <u>or</u> $0.785 \times (d^2)$ <i><math>r = \text{radius}</math> <math>d = \text{diameter}</math></i>	<b>Volume (ft<sup>3</sup>)</b> = length (ft) x width (ft) x depth (ft) <b>Volume of a tank</b> = cubic feet (ft <sup>3</sup> ) in the tank x 7.48 gals/ft <sup>3</sup> <b>Volume of a cylinder</b> = area of the circular base x height <b>Volume of a cone</b> = $1/3 \times (\text{volume of a cylinder})$  <b>Volume/Concentration Conversion:</b> mls x normality = mls x normality
<b>Area of a triangle</b> = $\frac{1}{2}$ base x height	<b>Geometric Mean</b> = antilog of $\frac{\text{sum of logs of sample results}}{\text{number of samples}}$
<b>Area of a rectangle</b> = length x width	<b>Slope</b> = Rise/Run <b>Percent Slope</b> = Rise/Run x 100%
<b>Temperature Conversions:</b> Centigrade = $\frac{\text{Fahrenheit} - 32}{1.8}$ , Fahrenheit = $\frac{9}{5}$ Centigrade + 32	

<b>PUMP / FLOW</b>	
<b>1 psi</b> = 2.31 feet of head	<b>Q = A x V</b> where Q = quantity of flow (in units of ft <sup>3</sup> /sec.) A = cross sectional area V = velocity
<b>Water horsepower (Water HP)</b> = $\frac{\text{gpm} \times \text{total head in ft}}{3960}$	
<b>Brake horsepower (Brake HP)</b> = $\frac{\text{flow in gpm} \times \text{total head in ft}}{3960 \times \text{pump efficiency}}$	<b>Velocity in ft/sec</b> = $\frac{\text{flow rate} - \text{in ft}^3/\text{sec}}{\text{cross-sectional area} - \text{in ft}^2}$
<b>Motor horsepower (Motor HP)</b> = $\frac{\text{gpm} \times \text{total head in ft}}{3960 \times \text{pump efficiency} \times \text{motor efficiency}}$	
<b>Pump electrical costs/year</b> = hp x 0.746 kW/hp x # of hours pump operates per day x cost (\$) per kW/hr x 365 day/yr	

<b>PROCESS CONTROL</b>	
<b>BOD<sub>5</sub> (mg/l, unseeded)</b> = $\frac{\text{Initial DO} - \text{DO after 5 days}}{p}$  <i>where <math>p = \frac{\text{mls of sample}}{300 (\text{mls in a BOD bottle})}</math></i>	<b>BOD<sub>5</sub> (mg/l, seeded)</b> = Seeded BOD mg/L = $\frac{(\text{Initial DO} - \text{DO after 5 days}) - ((\text{Initial seeded BOD} - \text{Seeded BOD after 5 days}) * f)}{p}$  <i>where <math>f = \frac{\text{mls of Seed in Sample}}{\text{mls of Seed in Seed Blank}}</math>      <math>p = \frac{\text{mls of sample}}{300 \text{ mls}}</math></i>
<b>Nitrogenous Oxygen Demand (NOD), mg/l</b> =	$\text{NH}_3, \text{mg/l} \times 4.6 \text{ mg/l O}_2 \text{ per mg/l NH}_3 \text{ converted to NO}_3$
<b>Ultimate Oxygen Demand (UOD), mg/l</b> =	$(1.5 \times \text{BOD, mg/l}) + (4.6 \times \text{NH}_3, \text{mg/l})$
<b>Chemical Oxygen Demand (COD), mg/l</b> = <i>*FAS = Ferrous Ammonium Sulfate</i>	$\frac{(\text{mls of FAS to titrate blank} - \text{mls of FAS to titrate sample}) \times \text{normality of FAS} \times 8000}{\text{mls of sample}}$

<b>Stream Concentration Formula</b> =	$\frac{\text{lbs/day discharged from plant} + \text{lbs/day upstream total flow}}{\text{MGD (plant flow} + \text{stream flow)} \times 8.34}$
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<b>Organic Loading, lbs/day/1000 ft<sup>3</sup></b> = $\frac{\text{BOD applied in lbs per day}}{\text{volume of media in 1000 ft}^3}$	<b>Hydraulic Loading, gpd/ft<sup>2</sup></b> = $\frac{\text{gal. per day (including recirculation flow)}}{\text{surface area in ft}^2}$	<b>Recirculation Ratio</b> = $\frac{\text{recirculation flow}}{\text{influent wastewater flow}}$
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<b>Pond population equivalent (in persons) =</b> $\frac{\text{flow in MGD} \times \text{BOD in mg/l} \times 8.34 \text{ lbs/gal}}{0.2 \text{ lbs BOD/day/person}}$	<b>Pond detention time (days) =</b> $\frac{\text{pond volume in acre} - \text{ft}}{\text{influent rate in ac} - \text{ft/day}}$	<b>Pond area (acres) =</b> $\frac{\text{avg width in feet} \times \text{avg length in feet}}{43560 \text{ ft}^2/\text{acre}}$
<b>Pond volume, acre feet (ac ft) =</b> $\text{area in acres (ac)} \times \text{depth in feet (ft)}$	<b>Pond organic loading, lbs BOD/day/acre =</b> $\frac{\text{BOD in mg/l} \times \text{MGD} \times 8.34}{\text{pond area in acres}}$	<b>Pond influent flow in ac-ft/day =</b> $\frac{\text{gals per day}}{7.48 \text{ gal/ft}^3 \times 43560 \text{ ft}^2/\text{acre}}$
<b>Pond hydraulic loading, inches/day =</b> $\frac{\text{depth of pond in inches}}{\text{detention time in days}}$		<b>Pond population loading =</b> $\frac{\text{population served in \# of persons}}{\text{pond area in acres}}$

<b>Detention Time (hours) =</b> $\frac{\text{tank volume in gallons} \times 24 \text{ hour/day}}{\text{flow in gallons per day}}$	<b>% Efficiency of Removal =</b> $\frac{\text{mg/l influent} - \text{mg/l effluent}}{\text{mg/l influent}} \times 100\%$
<b>Sludge Volume Index (SVI) =</b> $\frac{(\% \text{ settleable solids} \times 10,000)}{\text{MLSS in mg/l}}$	<b>% Settleable Solids =</b> $\frac{\text{mls of settled sludge after 30 min.}}{\text{vol. of settleometer}} \times 100$
<b>Weir overflow rate =</b> $\frac{\text{flow in GPD}}{\text{feet of weir}}$	<b>Surface loading (overflow) rate, gpd/ft<sup>2</sup> =</b> $\frac{\text{flow in GPD}}{\text{surface area in ft}^2}$
<b>Wasting rate (gpm) =</b> pumping rate, MGD x 694 gpm/MGD	<b>F/M (food to microorganism) ratio =</b> $\frac{\text{BOD (or COD) in mg/l} \times \text{MGD} \times 8.34}{\text{MLVSS in mg/l} \times \text{aeration basin vol. in MG} \times 8.34}$
<b>Mean cell residence time (MCRT) in days =</b> $\frac{\text{MLSS in mg/l} \times \text{MG (aer. tank + sec. clar. vol.)} \times 8.34}{(\text{Eff. SS in mg/l} \times \text{MGD} \times 8.34) + (\text{WAS in mg/l} \times \text{WAS MGD} \times 8.34)}$	<b>Sludge age (days) =</b> $\frac{\text{MLSS in mg/l} \times \text{aerator volume in MG} \times 8.34}{\text{Primary Eff. SS in mg/l} \times \text{MGD} \times 8.34}$
<b>Total Suspended Solids (TSS), mg/l =</b> $\frac{\text{dry solids in grams} \times 1000 \text{ mg/g} \times 1000 \text{ ml/l}}{\text{sample volume in mls}}$ <b>or</b> $\frac{\text{weight of solids in mg} \times 1000 \text{ mls/l}}{\text{sample volume in mls}}$	
<b>Total Solids (TS), mg/l =</b> $\frac{A-B \times 1000}{\text{sample volume in mL}}$	<b>where</b> <i>A = weight of dish + dried residue in milligrams</i> <i>B = weight of dish in milligrams</i>
<b>Volatile Solids (VS), mg/L =</b> $\frac{(A-B) \times 1000}{\text{sample volume in mL}}$	<b>where</b> <i>A = weight of residue + dish before ignition in milligrams</i> <i>B = weight of residue + dish after ignition in milligrams</i>
<b>Volatile Solids, percentage (%) =</b> $\frac{(A-C) \times 100}{A-B}$	<b>where</b> <i>A = weight of dish + dried residue in milligrams</i> <i>B = weight of dish in milligrams</i> <i>C = weight of residue + dish after ignition in milligrams</i>
<b>Dry solids to a digester, lbs/day =</b> $\text{sludge in gpd} \times 8.34 \times \frac{\% \text{ Total Solids}}{100}$	
<b>Volatile Solids to a digester, lbs/day =</b> $\text{sludge in gpd} \times 8.34 \times \frac{\% \text{ Total Solids}}{100} \times \frac{\% \text{ Vol. Solids}}{100}$	
<b>Volatile Solids Destroyed in a digester, lbs/day/ft<sup>3</sup> =</b> $\frac{\text{Volume of sludge in gal/day} \times \% \text{ solids} \times \% \text{ volatile} \times \% \text{ reduction} \times 8.34}{\text{Digester volume in ft}^3}$	
<b>% Volatile Solids Destroyed in a digester:</b> $\% \text{ reduction} = \frac{(\text{in}) - (\text{out})}{(\text{in}) - (\text{in} \times \text{out})} \times 100$	
<b>Return Activated Sludge (RAS) Rate calculated using settleability:</b> $\text{MGD} = \text{Secondary influent flow, MGD} \times \text{Return Sludge Rate Ratio}$ <b>where Return Sludge Rate Ratio =</b> $\frac{30 \text{ min. settled sludge volume in ml/l}}{\text{clear liquid volume in ml/l}}$	
<b>Total Waste Activated Sludge (WAS) in MGD =</b> current rate in MGD + additional rate in MGD	<b>Waste Activated Sludge (WAS) pumping rate =</b> $\frac{\text{Solids to be wasted in lbs/day}}{\text{WAS SS in mg/l} \times 8.34}$