MATH FORMULAS FOR WASTEWATER, COLLECTIONS & PHYSICAL CHEMICAL EXAMS

GENERAL

Lbs = mg/l x MGD x 8.34 (lbs/gal)

Watts = volts x amps $= \frac{\text{voltage}}{\text{ohms}}$

Circumference of a circle = π x diameter, or 2 x π x radius

where $\pi = 3.14$

Area of a circle = $\pi(r^2)$ **or** 0.785 x (d^2)

r = radius d = diameter

Volume (ft^3) = length (ft) x width (ft) x depth (ft)

Volume of a tank = cubic feet (ft^3) in the tank x 7.48 gals/ft^3

Volume of a cylinder = area of the circular base x height

Volume of a cone = 1/3 x (volume of a cylinder)

Volume/Concentration Conversion: mls x normality = mls x normality

Area of a triangle = $\frac{1}{2}$ base x height

Geometric Mean = antilog of $\frac{\text{sum of logs of sample results}}{\text{number of samples}}$

Area of a rectangle = length x width

Slope = Rise/Run **Percent Slope =** Rise/Run x 100%

Temperature Conversions: Centigrade $= \frac{\text{Fahrenheit} - 32}{1.8}$, Fahrenheit $= \frac{9}{5}$ Centigrade $+ 32$

PUMP / FLOW

1 psi = 2.31 feet of head

Water horsepower (Water HP) = $\frac{\text{gpm x total head in ft}}{3960}$

Brake horsepower (Brake HP) = $\frac{\text{flow in gpm x total head in ft}}{3960 \text{ x pump efficiency}}$

Motor horsepower (Motor HP) = $\frac{\text{gpm x total head in ft}}{3960 \text{ x pump efficiency x motor efficiency}}$

$Q = A \times V$ *where Q = quantity of flow (in units of ft^3/sec.)*
A = cross sectional area
V = velocity

Velocity in ft/sec = $\frac{\text{flow rate} - \text{in ft}^3/\text{sec}}{\text{cross-sectional area} - \text{in ft}^2}$

Pump electrical costs/year = hp x 0.746 kW/hp x # of hours pump operates per day x cost ($) per kW/hr x 365 day/yr

PROCESS CONTROL

BOD_5 (mg/l, unseeded) =

$\frac{\text{Initial DO} - \text{DO after 5 days}}{\text{p}}$

where $p = \frac{mls\ of\ sample}{300\ (mls\ in\ a\ BOD\ bottle)}$

BOD_5 (mg/l, seeded) = Seeded BOD mg/L =

$\frac{(\text{Initial DO} - \text{DO after 5 days}) - ((\text{Initial seeded BOD} - \text{Seeded BOD after 5 days}) * f)}{\text{p}}$

where $f = \frac{mls\ of\ Seed\ in\ Sample}{mls\ of\ Seed\ in\ Seed\ Blank}$ $\quad p = \frac{mls\ of\ sample}{300\ mls}$

Nitrogenous Oxygen Demand (NOD), mg/l = NH_3, mg/l x 4.6 mg/l O_2 per mg/l NH_3 converted to NO_3

Ultimate Oxygen Demand (UOD), mg/l = (1.5 x BOD, mg/l) + (4.6 x NH_3, mg/l)

Chemical Oxygen Demand (COD), mg/l =
**FAS = Ferrous Ammonium Sulfate*

$\frac{(\text{mls of FAS to titrate blank} - \text{mls of FAS to titrate sample}) \text{ x normality of FAS x } 8000}{\text{mls of sample}}$

Stream Concentration Formula =

$\frac{\text{lbs/day discharged from plant} + \text{lbs/day upstream total flow}}{\text{MGD (plant flow + stream flow) x } 8.34}$

Organic Loading, lbs/day/1000 ft^3 =

$\frac{\text{BOD applied in lbs per day}}{\text{volume of media in 1000 ft}^3}$

Hydraulic Loading, gpd/ft^2 =

$\frac{\text{gal. per day (including recirculation flow)}}{\text{surface area in ft}^2}$

Recirculation Ratio =

$\frac{\text{recirculation flow}}{\text{influent wastewater flow}}$

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Pond population equivalent (in persons) = $\frac{\text{flow in MGD x BOD in mg/l x 8.34 lbs/gal}}{\text{0.2 lbs BOD/day/person}}$	**Pond detention time (days) =** $\frac{\text{pond volume in acre} - \text{ft}}{\text{influent rate in ac} - \text{ft/day}}$	**Pond area (acres) =** $\frac{\text{avg width in feet x avg length in feet}}{43560\ \text{ft}^2/\text{acre}}$
Pond volume, acre feet (ac ft) = area in acres (ac) x depth in feet (ft)	**Pond organic loading, lbs BOD/day/acre =** $\frac{\text{BOD in mg/l x MGD x 8.34}}{\text{pond area in acres}}$	**Pond influent flow in ac-ft/day =** $\frac{\text{gals per day}}{7.48\ \text{gal/ft}^3 \text{ x } 43560\ \text{ft}^2/\text{acre}}$
Pond hydraulic loading, inches/day = $\frac{\text{depth of pond in inches}}{\text{detention time in days}}$		**Pond population loading =** $\frac{\text{population served in \# of persons}}{\text{pond area in acres}}$

Detention Time (hours) = $\frac{\text{tank volume in gallons x 24 hour/day}}{\text{flow in gallons per day}}$	**% Efficiency of Removal =** $\frac{\text{mg/l influent} - \text{mg/l effluent}}{\text{mg/l influent}} \text{ x } 100\%$
Sludge Volume Index (SVI) = $\frac{(\%\ \text{settleable solids x } 10{,}000)}{\text{MLSS in mg/l}}$	**% Settleable Solids =** $\frac{\text{mls of settled sludge after 30 min.}}{\text{vol. of settleometer}} \text{ x } 100$
Weir overflow rate = $\frac{\text{flow in GPD}}{\text{feet of weir}}$	**Surface loading (overflow) rate, gpd/ft² =** $\frac{\text{flow in GPD}}{\text{surface area in ft}^2}$
Wasting rate (gpm) = pumping rate, MGD x 694 gpm/MGD	**F/M (food to microorganism) ratio =** $\frac{\text{BOD (or COD)in mg/l x MGD x 8.34}}{\text{MLVSS in mg/l x aeration basin vol. in MG x 8.34}}$
Mean cell residence time (MCRT) in days = $\frac{\text{MLSS in mg/l x MG (aer. tank + sec. clar. vol.) x 8.34}}{\text{(Eff. SS in mg/l x MGD x 8.34) + (WAS in mg/l x WAS MGD x 8.34)}}$	**Sludge age (days) =** $\frac{\text{MLSS in mg/l x aerator volume in MG x 8.34}}{\text{Primary Eff. SS in mg/l x MGD x 8.34}}$

Total Suspended Solids (TSS), mg/l = $\frac{\text{dry solids in grams x 1000 mg/g x 1000 ml/l}}{\text{sample volume in mls}}$ **or** $\frac{\text{weight of solids in mg x 1000 mls/l}}{\text{sample volume in mls}}$

Total Solids (TS), mg/l = $\frac{A - B \text{ x } 1000}{\text{sample volume in mL}}$

where ***A*** *= weight of dish + dried residue in milligrams*
B *= weight of dish in milligrams*

Volatile Solids (VS), mg/L = $\frac{(A - B) \text{ x } 1000}{\text{sample volume in mL}}$

where ***A*** *= weight of residue + dish before ignition in milligrams*
B *= weight of residue + dish after ignition in milligrams*

Volatile Solids, percentage (%): $\frac{(A - C) \text{ x } 100}{A - B}$

where ***A*** *= weight of dish + dried residue in milligrams*
B *= weight of dish in milligrams*
C *= weight of residue + dish after ignition in milligrams*

Dry solids to a digester, lbs/day = $\text{sludge in gpd x } 8.34 \text{ x } \frac{\%\ \text{Total Solids}}{100}$

Volatile Solids to a digester, lbs/day = $\text{sludge in gpd x } 8.34 \text{ x } \frac{\%\ \text{Total Solids}}{100} \text{ x } \frac{\%\ \text{Vol.Solids}}{100}$

Volatile Solids Destroyed in a digester, lbs/day/ft³ = $\frac{\text{Volume of sludge in gal/day x \% solids x \% volatile x \% reduction x } 8.34}{\text{Digester volume in ft}^3}$

% Volatile Solids Destroyed in a digester: $\%\ \text{reduction} = \frac{(\text{in}) - (\text{out})}{(\text{in}) - (\text{in} * \text{out})} * 100$

Return Activated Sludge (RAS) Rate calculated using settleability: MGD = Secondary influent flow, MGD x Return Sludge Rate Ratio

where **Return Sludge Rate Ratio** $= \frac{\text{30 min.settled sludge volume in ml/l}}{\text{clear liquid volume in ml/l}}$

Total Waste Activated Sludge (WAS) in MGD = current rate in MGD + additional rate in MGD	**Waste Activated Sludge (WAS) pumping rate =** $\frac{\text{Solids to be wasted in lbs/day}}{\text{WAS SS in mg/l x } 8.34}$

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