Water Treatment & Distribution and Wastewater

Online Math Sessions

Contents

Week 1

1. Water Math - Week 3

Density

- Density is defined as the weight of a substance per a unit of its volume. For example, pounds per cubic foot or pounds per gallon.
- Here are a few key facts about density:
  - Density is measured in units of lb/ft3, lb/gal, or mg/L. Density of water = 62.4 lb/ft3 = 8.34 lb/gal.

Specific Gravity

- Specific gravity is the ratio of the density of a substance (liquid or solid) to the density water.
- It is the ratio of the weight of the substance of a certain volume to the weight of water of the same volume.
- Any substance with a density greater than that of water will have a specific gravity greater than 1.0. Any substance with a density less than that of water will have a specific gravity less than 1.0.
- Specific gravity examples:
  - Specific gravity of water = 1.0
  - Specific gravity of concrete = 2.5 (depending on ingredients)
  - Specific gravity of alum (liquid @ 60°F) = 1.33
  - Specific gravity of hydrogen peroxide (35%) = 1.132
- Specific gravity is used in two ways:
  1. To calculate the total weight of a % solution (either as a single gallon or a drum

volume).
Total Weight = Drum Vol X SG X 8.34

2. To calculate the "active ingredient" weight of a single gallon or a drum.
Active Ingredient Weight within Drum = Drum Volume X SG X 8.34 X % solution as a decimal. (i.e., Total Weight X % solution as a decimal)
NOTE: Both ways start with solving for the total weight (Drum Vol X SG X 8.34). When solving for "active ingredient" weight, you have to then multiply by % solution as a decimal.

Example: What is the weight of 5 gallons of a 40% ferric chloride solution given its specific gravity of 1.43?

$$(8.34 * 1.43)\ \ lbs/gal * 5\ \ gallons = \boxed{59.6\ \ lbs}$$

The weight of active ferric chloride in the drum will be 59.6*0.4=23.84 lbs (as ferric chloride is 40% strength)

Concentration

- Concentration is typically expressed as mg/l which is the weight of the constituent (mg) in 1 liter of water.
- As 1 liter of water weighs 1 million mg, a concentration of 1 mg/l implies 1 mg of constituent per 1 million mg of water or one part per million (ppm). Thus, mg/l and ppm are synonymous.
- Sometimes the constituent concentration is expressed in terms of percentage.

  Example: 12.5% chlorine concentration solution.

  100% would mean 1,000,000 mg/l or 1,000,000 ppm

  $\Longrightarrow$ 1% would be $\dfrac{1,000,000}{100}$mg/l = 10,000 mg/l or 10,000 ppm

  $\Longrightarrow$ 12.5% chlorine concentration is 125,000 mg/l or 125,000 ppm.

  $1\%\ \ concentration = 10,000\ \ ppm\ \ or\ \ \frac{mg}{l}$
  $0.1\%\ \ concentration = 1,000\ \ ppm\ \ or\ \ \frac{mg}{l}$
  $0.01\%\ \ concentration = 100\ \ ppm\ \ or\ \ \frac{mg}{l}$
  $10\%\ \ concentration = 100,000\ \ ppm\ \ or\ \ \frac{mg}{l}$
  $5\%\ \ concentration = 50,000\ \ ppm\ \ or\ \ \frac{mg}{l}$
  $12.5\%\ \ concentration = 125,000\ \ ppm\ \ or\ \ \frac{mg}{l}$

Above concepts are used for chemicals such as fluoride and hypochlorites - the strength of the product as used is commonly expressed as a percentage.

Example 1: A chlorine solution was made to have a 4% concentration. It is often desirable to determine this concentration in mg/L. This is relatively simple: the 4% is four percent of a million.

To find the concentration in mg/L when it is expressed in percent, do the following:

1. Change the percent to a decimal.

$$4\% \div 100 = 0.04$$

3. Multiply times a million.

$$0.04 \times 1,000,000 = 40,000\text{mg/L}$$

We get the million because a liter of water weighs $1,000,000$mg.1mg in 1 liter is 1 part in a million parts (ppm).$1\% = 10,000$mg/L.

Example 2: How much 65% calcium hypochlorite is required to obtain 7 pounds of pure chlorine?

65% implies that in every lb of calcium hypochlorite has 65% lbs of available chlorine.

Therefore, $\dfrac{\text{0.65 lbs available chlorine}}{\text{lb of calcium hypochlorite}}$ or conversely $\dfrac{\text{lb of calcium hypochlorite}}{\text{0.65 lbs available chlorine}}$

$$\implies \text{lbs calcium hypchlorite required} = \frac{\text{lb of calcium hypochlorite}}{\text{0.65 lbs } \cancel{\text{available chlorine}}} * \frac{\text{7 lb of } \cancel{\text{available chlorine}}}{}$$

$$= \boxed{\text{10.8 lbs of calcium hypochlorite with 65\%available chlorine is required}}$$

Pounds Formula

- Pounds formula:

$$lbs \ \textbf{or} \ \frac{lbs}{day} = Concentration\left(\frac{mg}{l}\right) * 8.34 * volume(MG) \ \textbf{or} \ Flow(MGD)$$

- So if the concentration of a particular constituent (in mg/liter) and the volume or flow of wastewater is given, one can calculate the amount of that constituent or using this formula.
  Important notes:
  1. The unit of the constituent loading rate will be in lbs per the unit of time the flow is expressed in. So if the flow is in MG per day the calculated loading rate will be in lbs/day. Likewise if the flow value used is in MG per minute, the calculated loading rate will be in lbs/min.
  2. If volume is used, the calculated value will be the mass of the constituent in that volume. If flow is used, the calculated value will be the mass of the constituent in that flow.
  3. For the Pound Formula to work, the volume or flow needs to be expressed in MG. Volume or flows in other units - gallons, ft^3 etc. needs to be converted to MG.
- The formula assumes that all of the material found in water (TSS, BOD, MLSS, Chlorine, etc.) weighs the same as water, that is, 8.34 pounds per gallon.
- In the Pounds Formula, there are three variables – lbs, concentration and volume, and one constant - 8.34. Knowing any of the two variables in the formula, one can calculate the third (unknown) variable by rearranging the equation.

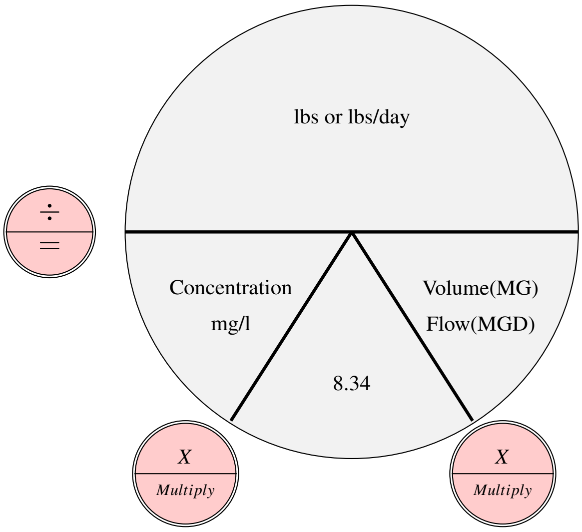


Figure 1.1: Davidson Pie

- Davidson Pie provides a pictorial reference for calculating any unknown variable. If for example, if Concentration is unknown, it can be calculated as follows:

$$Concentration\left(\frac{mg}{l}\right) = \frac{lbs \ \textbf{or} \ \frac{lbs}{day}}{8.34 * Volume(MG) \ \textbf{or} \ Flow(MGD)}$$

- Likewise, if Volume (or Flow) is the unknown variable. it can be calculated as:

$$Volume(MG) \ \ or \ \ Flow(MGD) = \frac{lbs \ \textbf{or} \ \frac{lbs}{day}}{Concentration\left(\frac{mg}{l}\right) * \ 8.34}$$

- Pounds formula is used for:
  - Calculating the quantity in pounds of a particular wastewater constituent entering or leaving a wastewater treatment process
  - Calculating the pounds of chemicals to be added

Forms of chlorine

- Due to safety issues related to the use of chlorine gas, **hypochlorites** are often used in lieu of chlorine
- Types of hypochlorites
  - Sodium hypochlorite ($NaOCl$) comes in a liquid form which contains up to 12.5% chlorine
  - Calcium hypochlorite ($Ca(OCl)_2$), also known as High-test Hypochlorite (HTH), is a solid which is mixed with water to form a hypochlorite solution. Calcium hypochlorite is 65-70% concentrated.

- Hypochlorites decompose in strength over time while in storage. Temperature, light, and physical energy can all break down hypochlorites before they are able to react with pathogens in water.

Chlorine dosing terms

- **Chlorine dose** - the amount of chlorine added to the system. It can be determined by adding the desired residual for the finished water to the chlorine demand of the untreated water. Dosage can be either milligrams per liter (mg/L) or pounds per day (lb/day).
- **Chlorine Demand** - the amount of chlorine consumed by iron, manganese, turbidity, algae, and microorganisms in the water. Because the reaction between chlorine and microorganisms is not instantaneous, demand is relative to time. For instance, the demand 5 minutes after applying chlorine will be less than the demand after 20 minutes.
- **Free chlorine** - free chlorine refers to all chlorine present in the water as $Cl_2(g)$, HOCl(aq) and $OCl^-(aq)$.
- **Combined residual** - is the result of combining free chlorine with nitrogen compounds. Combined residuals are also referred to as chloramines.
- **Total chlorine residual** - is the mathematical combination of free chlorine and combined residuals. Total residual can be determined directly with standard chlorine residual test kits. Residual, like demand, is based on time. The longer the time after dosage, the lower the residual will be, until all of the demand has been satisfied. Residual, like demand, is expressed in mg/L. The presence of a free residual usually provides a high degree of assurance that the disinfection of the water is complete.

$$\mathrm{ChlorineDose(mg/L)} = \mathrm{ChlorineDemand} + \mathrm{ChlorineResidual}$$

Example 1: If a 5 MGD flow is to be dosed with 25 mg/l of a certain chemical, calculate the lbs/day that chemical required.

Solution

Applying lbs formula:

$$\frac{lbs}{day} = 5MGD * 250\frac{mg}{l} * 8.34 = \boxed{1,042\frac{lbs}{day}}$$

Example 2: Calculate the lbs of chemical in 7,500 gallons of 4.5% active solution of that chemical.

Solution

Applying lbs formula:

$$lbschemical = \frac{7500}{1,000,000}MG * 4.5 * 10,000 * 8.34 = \boxed{2,815\ \ lbs\ \ chemical}$$

Note:

1) 7500 gallons was converted to MG by dividing by 1,000,000

$$7500\ \ gallons * \frac{1MG}{1,000,000\ \ gallon}$$

2) 4.5% was converted to mg/l by multiplying by 10,000 as 1%=10,000mg/l

Chemicals Related Math Problems

Chemical Dosing

- Use lbs formula to calculate the lbs of chemicals required
- Using the calculated lbs chemical required value, calculate the amount of that chemical at the concentration available

Example 1: If a 5 MGD flow is to be dosed with 25 mg/l of a certain chemical, calculate the lbs/day that chemical required.

Solution

Applying lbs formula:

$$\frac{lbs}{day} = 5MGD * 250\frac{mg}{l} * 8.34 = \boxed{1,042\frac{lbs}{day}}$$

Example 2: Calculate the lbs of chemical in 7,500 gallons of 4.5% active solution of that chemical.

Solution

Applying lbs formula:

$$lbschemical = \frac{7500}{1,000,000}MG * 4.5 * 10,000 * 8.34 = \boxed{2,815\ \ lbs\ \ chemical}$$

Chlorine dosing problems

Example 4: Determine the chlorinator setting (lb/day) required to treat a flow of 4MGD with a chlorine dose of 5mg/L.

Chlorine feed rate (lb/ day) $=$ Chlorine $(\mathrm{mg/L}) \times$ Flow (MGD) $\times\, 8.34 \mathrm{lb/gal}$

Chlorine feed rate (lb/ day) $= 5 \mathrm{mg/L} \times 4 \mathrm{MGD} \times 8.34 \mathrm{lb/gal}$

Chlorine feed rate (lb/ day) $= 167$lb/ day

Example 5: A pipeline that is 12 inches in diameter and 1400ft long is to be treated with a chlorine dose of 48mg/L. How many lb of chlorine will this require?

First determine the gallon volume of the pipeline:

Volume (gal) $= 0.785 \times \mathrm{D}^2 \times$ length (ft) $\times\, 7.48 \mathrm{gal/cuft}$

Volume (gal) $= 0.785 \times (1\mathrm{ft})^2 \times 1400\mathrm{ft} \times 7.48 \mathrm{gal/cuft}$ Volume (gal) $= 8221 \mathrm{gal}$

Next calculate the amount of chlorine required:

Chlorine feed rate (lb/ day) $=$ Chlorine (mg/L) x Flow (MGD) $\times 8.34 \mathrm{lb/gal}$

Chlorine feed rate (lb/ day) $= 48 \mathrm{mg/L} \times 0.008221 \mathrm{MGD} \times 8.34 \mathrm{lb/gal}$

Chlorine feed rate (lb/ day) $= 3.3$lb

Example 6: A water sample is tested and found to have a chlorine demand of 1.7mg/L. If the desired chlorine residual is 0.9mg/L, what is the desired chlorine dose (in mg/L)?

Chlorine Dose $(\mathrm{mg/L}) =$ Chlorine Demand $+$ Chlorine Residual

Chlorine Dose $(\mathrm{mg/L}) = 1.7 \mathrm{mg/L} + 0.9 \mathrm{mg/L}$

Chlorine Dose$(\mathrm{mg/L}) = 2.6 \mathrm{mg/L}$

Example 7:

The chlorine dosage for water is 2.7mg/L. If the chlorine residual after a 30-minute contact time is found to be 0.7mg/L, what is the chlorine demand (in mg/L)?

Chlorine Demand = Chlorine Dose − Chlorine Residual

Chlorine Demand = 2.7mg/L − 0.7mg/L

Chlorine Demand = 2.0mg/L

Example 8: How many gallons per day of bleach solution (SG 1.2)containing 12.5% available chlorine is required to disinfect a 10 MGD flow of water given the required chlorine dosage of 7 mg/l.

1. Calculate the lbs of chlorine required using the lbs formula:

$$=10MGD \; * \; 7\frac{mg}{l} \; * \; 8.34 \; = \; 583.8 \; lbs \;\; chlorine \;\; per \;\; day$$

2. Calculate the gallons of bleach which will provide the 583.8 lbs chlorine

   Applying the lbs formula - note that 8.34 * SG will give the actual lbs/gal of bleach. If SG is not provided, use only 8.34 lbs per gallon:

$$583.8\frac{lbs \;\; bleach}{day} \; = \; x\frac{gal}{day} \; * \; 8.34*1.2\frac{lbs \;\; bleach}{gal} \; * \; 0.0125\frac{lbs \;\; chlorine}{lb \;\; bleach}$$

$$\Longrightarrow x\frac{gal}{day} \; = \; \frac{583.8}{8.34*1.2*0.125} \; = \boxed{467\frac{gal}{day}}$$

The above problem can be solved directly using the formula below given in the SWRCB Water Treatment Exam Formula Sheet.

$$\text{GPD} = \frac{(\text{MGD})*(\text{ppm or mg/l})*8.34 \;\; \text{lbs/gal}}{\% \;\; \text{purity}*\text{Chemical} \;\; \text{Wt. (lbs/gal)}} \; \text{GPD} = \frac{10*7*8.34}{0.125*(1.2*8.34)} = \boxed{467\frac{\text{gal}}{\text{day}}}$$

Blending and Dilution Calculations

- Blending and dilution calculations apply to the following scenarios:
  - Blending involves mixing two streams - each with a different concentration of contaminant/chemical, to obtain a certain volume or flow containing the target concentration of contaminant/chemical. For example: *Finding the correct blend of two source water streams - one with 15 mg/L of iron and other containing 4 mg/L of iron to get a 100 gpm product water containing 8 mg/l of iron.* **OR**
    Calculating the actual combined TDS concentration obtained by mixing two known flows with known TDS concentrations.
  - Dilution involves makedown of a higher concentration of a chemical to a lower concentration using water as a dilutant. For example: *How much initial volume of a 4% polymer solution is needed to make 3500 gallons of polymer at 0.25% concentration?*

- These type of problems are solved using C*V relationship where:
  - C is the concentration expressed in ppm or mg/l or as % purity.
  - V is either the volume or flow.
  - The product - C*V - $\frac{\text{mass}}{\text{volume/flow}} * \text{volume/flow} = \text{mass}$
- For blended streams, the sum of the mass from each of the two source streams will equal to the mass in the target stream:
- Thus, **for blending calculations**, if:

  C_1 and V_1 is the concentration and volume respectively of the one of the sources streams and

  C_2 and V_2 is the concentration and volume respectively of the second source stream, and

  C_3 and and V_3 is the concentration and volume respectively of the target stream

  The sum of the mass from each of the two source streams will equal to the mass in the target stream:

  $\mathbf{C_1 * V_1 + C_2 * V_2 = C_3 * V_3.}$

  This equation can be manipulated algebraically to calculate anyone of the unknown values in the equation.

  Also, any of the three volume variables can be expressed as the sum or difference of the other two - , or $V_1 + V_2 = V_3$ or $V_1 = V_3 - V_2$ or $V_2 = V_T - V_1$
- **For dilution**, the mass of the target chemical will remain the same, as only water is added to the source (concentrated chemical).
- Thus, for dilution calculations, if:

  C_1 and V_1 is the concentration and volume respectively of the concentrated product used for the dilution, and

  C_2 and V_2 is the concentration and volume of the resultant product after dilution with water

  The mass of the target chemical in the volume of the concentrated product used for dilution will remain the same in the final diluted product:

  $\mathbf{C_1 * V_1 = C_2 * V_2.}$

Example Problem #1: Two wells are used to satisfy demand during the summer months. One well produces water that contains 22 mg/L of Arsenic. The other well produces water that contains 3 mg/L of Arsenic. If the total demand for water is 400 gpm and the target Arsenic concentration in the finished water is 8 mg/L, what is the highest pumping rate possible for the first well?

Solution:
$C_1 * V_1 + C_2 * V_2 = C_3 * V_3$

Thus $22 * V_{22} + 3 * V_3 = 8 * V_8$

$V_{22} + V_3 = V_8 = 400$ gpm

As we want to solve for V_{22}, we can express V_3 as: $V_3 = 400-V_{22}$

Thus, $22 * V_{22} + 3 * (400-V_{22}) = 8 * 400=3,200$

$22V_{22} + 1200-3V_{22} = 3,200$

$V_{22}(22-3) = 2,000$

$$V_{22} = \frac{2,000}{19} = \boxed{105.3 \ \ gpm}$$

Also, V_3=400-105.3=294.7

NOTE: If one does not want to utilize algebraic manipulation, one may memorize the following formula:

$$V_{1/2} = \frac{|C_3 - C_{2/1}| * V_3}{C_1 - C_2}$$

Applying the formula above to Example Problem #2:

$$V_{22} = \frac{|8-3| * 400}{22-3} = \boxed{105.3 \ \ gpm}$$

$$V_3 = \frac{|8-22| * 400}{22-3} = \boxed{294.7 \ \ gpm}$$

Example Problem #2: How many gallons of a 4% polymer solution is required to make a 3,500 gallon batch of 0.25% polymer solution.

Solution:

Here, we are adding water - which has zero percent of polymer concentration to the 4% polymer to make a 0.25% polymer solution.

$C_1 * V_1 = C_2 * V_2$

$C_{4\%} * V_{4\%} = C_{0.25\%} * V_{0.25\%}$

$4 * V_{4\%} = 0.25 * 3,500$

$$\implies V_{4\%} = \frac{0.25 \ * \ 3500}{4} = \boxed{219 \ \ \text{gal}}$$

Take 219 gallons of the 4% polymer and dilute to 3,500 gallons to give a 0.25% polymer solution.

Disinfection Math Problems

1. What is the concentration in mg/l of 4.5% solution of that substance.

   Solution:

$\boxed{45,000 mg/l}$

2. How much does each gallon of zinc orthophosphate weigh (pounds) if it has a specific gravity of 1.46?

   Solution:

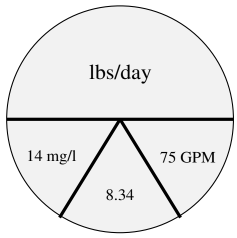
   $$8.34 \frac{lb}{gal} * 1.46 = \boxed{12.18 \frac{lb}{gal}}$$

3. How much does a 55 gallon drum of 25% caustic soda weigh (pounds) if the specific gravity is 1.28?

   Solution:

   $$8.34 \frac{lb}{\cancel{gal}} * 1.28 * 55 \cancel{gal} = \boxed{12.18 \frac{lb}{gal}}$$

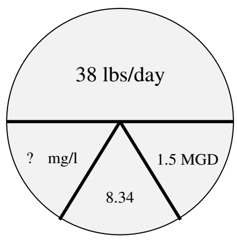
4. A water treatment plant operates at the rate of 75 gallons per minute. They dose soda ash at 14 mg/L. How many pounds of soda ash will they use in a day? Solution:



$$\frac{\text{lbs}}{\text{day}} = \text{Flow} \frac{\text{MG}}{\text{day}} * \text{Concentration} \frac{\text{mg}}{1} * 8.34$$

$$\frac{\text{lbs}}{\text{day}} = 75 \frac{\cancel{\text{gallons}}}{\cancel{\text{min}}} * 1440 \frac{\cancel{\text{min}}}{\text{day}} * \frac{\text{MG}}{1,000,000 \ \cancel{\text{gallons}}} * 14 \frac{\text{mg}}{1} * 8.34 = \boxed{12.6 \frac{lbs}{day}}$$

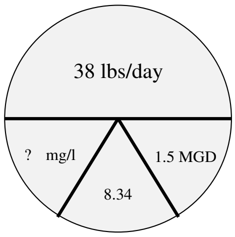
5. A water treatment plant is producing 1.5 million gallons per day of potable water, and uses 38 pounds of soda ash for pH adjustment. What is the dose of soda ash at that plant? Solution:



$$\frac{\text{lbs}}{\text{day}} = \text{Flow}\frac{\text{MG}}{\text{day}} * \text{Concentration}\frac{\text{mg}}{\text{l}} * 8.34 \quad \Longrightarrow \quad \text{Concentration}\frac{\text{mg}}{\text{l}} = \frac{\frac{\text{lbs}}{\text{day}}}{\text{Flow}\frac{\text{MG}}{\text{day}} * 8.34}$$

$$\text{Concentration}\frac{\text{mg}}{\text{l}} = \frac{38\frac{\text{lbs}}{\text{day}}}{1.5\frac{\text{MG}}{\text{day}} * 8.34} = \boxed{3\frac{\text{mg}}{\text{l}}}$$

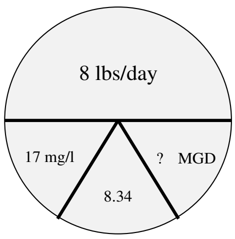
6. A water treatment plant produces 150,000 gallons of water every day. It uses an average of 2 pounds of permanganate for iron and manganese removal. What is the dose of the permanganate?
Solution:



$$\frac{\text{lbs}}{\text{day}} = \text{Flow}\frac{\text{MG}}{\text{day}} * \text{Concentration}\frac{\text{mg}}{\text{l}} * 8.34 \quad \Longrightarrow \quad \text{Concentration}\frac{\text{mg}}{\text{l}} = \frac{\frac{\text{lbs}}{\text{day}}}{\text{Flow}\frac{\text{MG}}{\text{day}} * 8.34}$$

$$\text{Concentration}\frac{\text{mg}}{\text{l}} = \frac{2\frac{\text{lbs}}{\text{day}}}{\left(150,000\frac{\cancel{\text{Gallons}}}{\text{day}} * \frac{\text{MG}}{1,000,000\ \cancel{\text{Gallons}}} * 8.34\right)} = \boxed{3\frac{\text{mg}}{\text{l}}}$$

7. A water treatment plant uses 8 pounds of chlorine daily and the dose is 17 mg/l. How many gallons are they producing?
Solution:



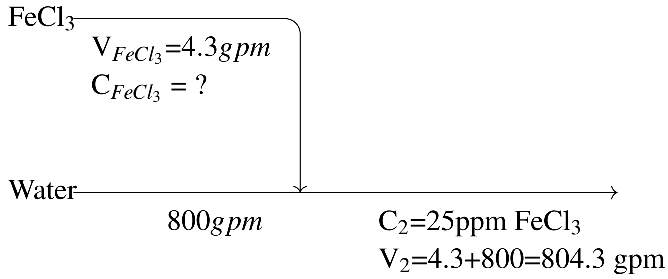
$$\frac{\text{lbs}}{\text{day}} = \text{Flow}\frac{\text{MG}}{\text{day}} * \text{Concentration}\frac{\text{mg}}{\text{l}} * 8.34$$

$$\Longrightarrow \text{Flow}\frac{\text{MG}}{day} = \frac{\frac{\text{lbs}}{\text{day}}}{\text{Concentration}\frac{\text{mg}}{\text{l}} * 8.34} = \frac{8\frac{\text{lbs}}{\text{day}}}{17\frac{\text{mg}}{\text{l}} * 8.34} = 0.056425\frac{\text{MG}}{day}$$

$$0.056425\frac{\text{MG}}{day} * \frac{1,000,000 \ \text{Gallons}}{\text{MG}} = \boxed{56,425 \ \text{Gallons}}$$

8. Ferric chloride is being added as a coagulant to the raw water entering a plant. Sampling shows that the concentration of ferric in the raw water is 25 ppm. A quick check of the chemical metering pump shows that it is operating at a flow rate of 4.3 gpm. If the flow through the water plant is 800 gpm, what is the concentration of raw chemical in the dosing tank?

   Solution:

   $C_1 * V_1 = C_2 * V_2$

   $C_{FeCl_3} * V_{FeCl_3} = C_2 * (V_{FeCl_3}+V_{Water})$

   $C_{FeCl_3} * 4.3 = 25 * (804.3)$

   $$C_{FeCl_3} = \frac{25*(804.3)}{4.3} = \boxed{4,676 \ \text{ppm or } 0.47\%}$$

9. A water plant is fed by two different wells. The first well produces water at a rate of 600 gpm and contains arsenic at 0.5 mg/L. The second well produces water at a rate of 350 gpm and contains arsenic at 12.5 mg/L. What is the arsenic concentration of the blended water?

   Solution:

   $C_1 * V_1 + C_2 * V_2 + = C_3 * V_3 = C_3 * (V_1 + V_2)$

   $C_{Well \ 1} * V_{Well \ 1} + C_{Well \ 2} * V_{Well \ 2} = C_{Blend} * V_{Blend} = C_{Blend} * (V_{Well \ 1} + V_{Well \ 2})$

   $$\Longrightarrow C_{Blend} = \frac{C_{Well \ 1} * V_{Well \ 1} + C_{Well \ 2} * V_{Well \ 2}}{V_{Well \ 1} + V_{Well \ 2}} = \frac{0.5*600 + 12.5*350}{600+350} = \boxed{4.9 \ \text{mg/l}}$$

10. An operator mixes 40 lb of lime in a 100-gal tank containing 80 gal of water. What is the percent of lime in the slurry?

    Total lbs: $40lbs \ \ lime + \left(80gal * \frac{8.34lbs}{gal}\right) \ water = 707.2lbs$

    $$\Longrightarrow 707.2lbs = 100\%, therefore \ \ 40lbs \ \ lime \ \ would \ \ be \frac{40*100}{707.2} = \boxed{5.66\%}$$

11. What is the chlorine demand if the chlorine dosage is 15 mg/l and the residual is 3 mg/l?

    Chlorine dosage = chlorine demand + chlorine residual
    $\Longrightarrow chlorine\ \ demand = chlorine\ \ dosage - chlorine\ \ residual = 15 - 3 = \boxed{12mg/l}$

12. Calculate how many pounds per day of chlorine should be used to maintain a dosage of 12 mg/l at a 5.0 MGD flow.

    $lbs/day = conc.(mg/l) * flow(MGD) * 8.34$

    $lbs/day = 12 * 5 * 8.34 = \boxed{500.4lbs/day}$

13. If 80 pounds of chlorine are applied each day to a flow of 1.5 MGD, what is the dosage in mg/l?

    Applying the pounds formula:
    $lbs/day = conc.(mg/l) * flow(MGD) * 8.34$
    $\Longrightarrow conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{80}{1.5*8.34} = \boxed{6.4mg/l}$

14. How many pounds per day of chlorine will be required to disinfect a secondary effluent flow of 1.68 MGD if the chlorine demand is found to be 8.5 mg/l and a residual of 3 mg/l is desired?

    Chlorine dosage = chlorine demand + chlorine residual

    $chlorine\ \ dosage = 8.5 + 3 = 11.5mg/l$
    $lbs/day = conc.(mg/l) * flow(MGD) * 8.34 = 1.68 * 11.5 * 8.34 = \boxed{161.2lbs/day}$

15. The chlorine demand is 4.8 mg/l and a chlorine residual is 0.75 mg/l is desired. For a flow of 2.8 MGD, how many pounds per day should the chlorinator be set to deliver.

    Chlorine dosage = chlorine demand + chlorine residual

    $chlorine\ \ dosage = 4.8 + 0.75 = 5.55mg/l$

    To calculate pounds per day, applying the pounds formula:

    $lbs/day = conc.(mg/l) * flow(MGD) * 8.34 = 2.8 * 5.55 * 8.34 = \boxed{129.6lbs/day}$

16. Chlorine is being fed at the rate of 75 pounds per day. Plant flow is 1.2 MGD. The chlorine residual is measured and found to be 2.6 mg/l Calculate chlorine demand.

    $Chlorine\ \ dosage(lbs/day) = conc.(mg/l) * flow(MGD) * 8.34$

    $\Longrightarrow chlorine\ \ dosage\ \ conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{75}{1.2*8.34} = 7.5mg/l$

    Chlorine dosage = chlorine demand + chlorine residual

    $\Longrightarrow chlorine\ \ demand = chlorine\ \ dosage - chlorine\ \ residual = 7.5 - 2.6 = \boxed{4.9mg/l}$

17. Experience has shown that a minimum dosage of 24 mg/l is necessary in order to disinfect

a wastewater effluent and leave a residual of 1.0 mg/l. How many pounds of chlorine must be fed at this dosage to a flow of 0.5 MGD?

$Chlorine\ \ dosage(lbs/day) = conc.(mg/l) * flow(MGD) * 8.34 = 24 * 0.5 * 8.34 = \boxed{100lbs/day}$

18. 25 lbs/day of chlorine is being applied to a wastewater effluent flow of 250,000 gpd. Calculate the chlorine dosage in mg/l.

$lbs/day = conc.(mg/l) * flow(MGD) * 8.34$
$\implies conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{25}{0.25*8.34} = \boxed{12mg/l}$

19. You wish to dose the influent channel at 5 mg/l chlorine to help control odors. The flow is 11.5 MGD. How many pounds of chlorine must be fed each day?
$lbs/day = conc.(mg/l) * flow(MGD) * 8.34 = 5 * 11.5 * 8.34 = \boxed{480lbs/day}$
20. Jar testing shows that the chlorine demand of an effluent is 12.5 mg/l. In order to assure disinfection, a residual of 1.0 mg/l is required. How many pounds of chlorine must be fed per 1MGD to assure disinfection?

$chlorine\ \ dosage = chlorine\ \ demand\ \ +\ \ chlorine\ \ residual$

$\implies chlorine\ \ dosage = (12.5\ \ +\ \ 1)mg/l = 13.5mg/l$

$lbs/day = 13.5(mg/l) * 1(MGD) * 8.34 = \boxed{112.6lbs/day}$
21. What is the chlorine dosage if the chlorinator is feeding 120 lbs/day and the average daily flow is 3.5 MGD? What is the chlorine demand if the residual is 1.3 mg/l?
a. $Chlorine\ \ dosage(lbs/day) = conc.(mg/l) * flow(MGD) * 8.34$

$\implies chlorine\ \ dosage\ \ conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{120}{3.5*8.34} = \boxed{4.1mg/l}$

b. Chlorine dosage = chlorine demand + chlorine residual

$\implies chlorine\ \ demand = chlorine\ \ dosage - chlorine\ \ residual = 4.1 - 1.3 = \boxed{2.8mg/l}$

22. Experience has shown that a minimum dosage of 24 mg/l is necessary in order to disinfect a wastewater effluent and leave a residual of 1.0 mg/l. How many pounds of chlorine must be fed at this dosage to a flow of 0.5 MGD?
$Chlorine\ \ dosage(lbs/day) = conc.(mg/l) * flow(MGD) * 8.34 = 24 * 0.5 * 8.34 = \boxed{100lbs/day}$

23. 25 lbs/day of chlorine is being applied to a wastewater effluent flow of 250,000 gpd. Calculate the chlorine dosage in mg/l.
$lbs/day = conc.(mg/l) * flow(MGD) * 8.34$
$\implies conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{25}{0.25*8.34} = \boxed{12mg/l}$

24. You wish to dose the influent channel at 5 mg/l chlorine to help control odors. The flow is 11.5 MGD. How many pounds of chlorine must be fed each day? Is it necessary to

maintain a chlorine residual to control odors?

$lbs/day = conc.(mg/l) * flow(MGD) * 8.34 = 5 * 11.5 * 8.34 = \boxed{480 lbs/day}$

25. Jar testing shows that the chlorine demand of an effluent is 12.5 mg/l. In order to assure disinfection, a residual of 1.0 mg/l is required. How many pounds of chlorine must be fed per 1MGD to assure disinfection?

$chlorine \;\; dosage = chlorine \;\; demand \;\; + \;\; chlorine \;\; residual$

$\implies chlorine \;\; dosage = (12.5 \;\; + \;\; 1) mg/l = 13.5 mg/l$

$lbs/day = 13.5(mg/l) * 1(MGD) * 8.34 = \boxed{112.6 lbs/day}$

26. What is the chlorine dosage if the chlorinator is feeding 120 lbs/day and the average daily flow is 3.5 MGD? What is the chlorine demand if the residual is 1.3 mg/l?

a. $Chlorine \;\; dosage(lbs/day) = conc.(mg/l) * flow(MGD) * 8.34$

$\implies chlorine \;\; dosage \;\; conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{120}{3.5*8.34} = \boxed{4.1 mg/l}$

b. Chlorine dosage = chlorine demand + chlorine residual

$\implies chlorine \;\; demand = chlorine \;\; dosage - chlorine \;\; residual = 4.1 - 1.3 = \boxed{2.8 mg/l}$

27. A 2.5 MGD secondary flow is disinfected by the application of 320 lbs of chlorine per day. This dose provides a chemical residual of 2.1 mg/l. There is a need to switch to the use of sodium hypochlorite which has a 12.5% available chlorine, SG of 1.2 and a cost of $0.60 per gallon. Chlorine costs $0.28/lb.
Calculate: 1) The chlorine demand, and 2) Cost difference ($ per day) between chlorine and sodium hypochlorite

Dosage = Demand + Residual

Dosage:

$$\frac{320 lbs \;\; chlorine}{day} = 2.5 MGD * 8.34 * x \frac{mg}{l}$$

$$x \frac{mg}{l} = \frac{320}{2.5 * 8.34} = 15.34 \frac{mg}{l}$$

Chlorine Demand = Dosage - Residual = 15.34 - 2.1 = $\boxed{13.24 \frac{mg}{l}}$

Cost per day to use chlorine: $\frac{\$320}{lb} * \frac{\$0.28}{lb} = \$89.60$

To calculate the hypochlorite we need to determine the gallons per day of bleach required.

$$320 \frac{lbs \;\; chlorine}{day} \;\; = \;\; x \frac{gal \;\; bleach}{day} \;\; * \;\; 8.34 * 1.2 \frac{lbs \;\; bleach}{per \;\; gal \;\; bleach} * \;\; 0.125 \frac{lbs \;\; chlorine}{lb \;\; bleach}$$

$$\rightarrow x\frac{gal\ \ bleach}{day} = \frac{320}{8.34*1.2*0.125} = 256\frac{gal\ \ bleach}{day}$$

$256\frac{gal\ \ bleach}{day} * \frac{\$0.60}{gal\ \ bleach} = \$153.48$ Cost difference \$153.48 - \$89.60 = $\boxed{\$63.88}$

28. The operator at a 1.5 MGD conventional activated sludge plant is considering using either HTH or sodium hypochlorite as an alternative to chlorine gas. Currently chlorine is being dosed at 15 mg/l in order to achieve a residual of 3.0 mg/l. Using the data provided below calculate the daily cost for chlorine, HTH, and sodium hypochlorite (NaOCl) (Sp.Gravity 1.21).

    Chlorine $\rightarrow$ 0.15 \$/lb

    HTH (70% available chlorine) $\rightarrow$ 0.25 \$/lb

    NaOCl (15% available chlorine) $\rightarrow$ 0.35 \$/gal

    lbs chlorine required:

    $$\frac{1.5MG}{day} * \frac{8.34lbs}{gallon} * \frac{15mg\ \ chlorine}{l} = \frac{188lbs\ \ chlorine}{day}$$

    Daily cost if chlorine is used:

    $$188lbs\ \ chlorine * \frac{\$0.15}{lb\ \ chlorine} = \boxed{\$28.20}$$

    Daily cost if HTH is used:

    $$188lbs\ \ chlorine * \frac{lb\ \ HTH}{0.7lb\ \ chlorine} * \frac{\$0.25}{lb\ \ chlorine} = \boxed{\$67.14}$$

    Daily cost if NaOCl is used:

    $$188lbs\ \ chlorine * \frac{lb\ \ NaOCl}{0.15lb\ \ chlorine} * \frac{gal\ \ NaOCl}{8.34*1.21lbs\ \ NaOCl} * \frac{\$0.35}{gal\ \ NaOCl} = \boxed{\$43.47}$$

29. A water storage tank is 30 feet in diameter and has a water depth of 18.5 feet. It is desired to super-chlorinate this tank with 30 ppm of chlorine, how many pounds of HTH will be required (HTH has 70% available chlorine)?

    Tank Volume:

    $$0.785*30^2*18.5ft^3*7.48\frac{gal}{ft^3} = 97,765gal$$

    lbs HTH required:

    $$\frac{30lbs\ \ chlorine}{1,000,000lbs\ \ water} * \frac{8.34lbs\ \ water}{gal\ \ water} * 97,765gal\ \ water * \frac{lb\ \ HTH}{0.70lb\ \ chlroine} = \boxed{35lbs\ \ HTH}$$

30. Polymer is being added at 0.2 mg/l in order to achieve a 98% capture efficiency for a belt press. The feed to the belt press is 75 gallons per minute, containing 2.5% solids. Given the polymer costs \$250 per gallon of 4.5% active polymer with a specific gravity of 1.08. What is the cost of polymer per dry ton of solids captured

    lbs polymer required:

$$75*1440\frac{gal\ \ sludge}{day}*8.34\frac{lbs\ \ sludge}{gal\ \ sludge}*\frac{0.2lbs\ \ polymer}{1,000,000lbs\ \ sludge}$$

$$=0.1801\frac{lbs\ \ polymer}{day}$$

gallons polymer solution required:

$$0.1801\frac{lbs\ \ polmyer}{day}=x\frac{gal\ \ polymer\ \ solution}{day}*\frac{8.34*1.08lbs\ \ polymer\ \ solution}{gal\ \ polymer\ \ solution}*0.045\frac{lbs\ \ polymer}{lb\ \ polymer\ \ solution}$$

$$=0.444\frac{gal\ \ polymer\ \ solution}{day}$$

Polymer cost:

$$\frac{\$250}{gallon\ \ polymer\ \ soultion}*\frac{0.444gal\ \ polymer\ \ soultion}{day}$$

$$=\frac{\$111}{day}$$

Dry tons of solids captured:

$$75*1440\frac{gal\ \ sludge}{day}*\frac{8.34*0.025\ \ lbs\ \ solids}{gal\ \ sludge}*\frac{0.98\ \ lbs\ \ solids\ \ captured}{lbs\ \ solids}*\frac{ton\ \ solids}{2000lbs\ \ solids}$$

$$=\frac{11tons\ \ dry\ \ solids}{day}$$

Polymer cost per dry ton of solids captured:

$$\frac{\$111perday}{11tons\ \ dry\ \ solids\ \ per\ \ day}=\boxed{\$10.09}$$

31. A 50 MGD flow is being treated with 20 mg/l ferric chloride. How many lbs of ferric chloride is required daily

    lbs ferric chloride required:

    $$\frac{50MG}{day}*\frac{8.34lbs}{gallon}*\frac{20mg\ \ ferric\ \ chloride}{l}=\boxed{\frac{8,340lbs\ \ ferric\ \ chloride}{day}}$$

32. If the ferric chloride solution used contains 40% dry ferric chloride with a specific gravity of 1.4, what is its required feed rate in GPM.

    Required $FeCl_3$ feed (gal/min) to feed 8,340 lbs ferric chloride:

    $$\frac{8,340lbs\ \ FeCl_3}{day}=\frac{xgal\ \ FeCl_3\ \ soltn.}{minute}*\frac{8.34*1.4lbs\ \ FeCl_3\ \ soltn}{gal\ \ FeCl_3\ \ soltn.}*\frac{0.4lbs\ \ FeCl_3}{lbs\ \ FeCl_3\ \ soltn.}*\frac{1440min}{day}$$

    $$\implies x=\frac{8,340}{8.34*1.4*0.4*1440}=\boxed{\frac{1.24gal}{min}}$$

33. What is the daily ferric chloride dosing cost if the ferric chloride cost is $580/dry ton ferric chloride.

    Daily ferric chloride dosing cost:

$$\frac{8,340lbs\ FeCl_3}{day} * \frac{ton}{2000lbs} * \frac{\$580}{ton\ FeCl_3} = \boxed{\frac{\$2,419}{day}}$$

34. A 0.5% (based on dry weight) solution of polymer is being fed to a secondary effluent prior to sand filtration. It is desired to dose this effluent at 2.5 mg/l. Assuming an effluent flow of 3000 gpm, at what rate (gpm) should the polymer feed pump be set?

    · **lbs polymer required:**

    $$\frac{3000gallons}{min} * \frac{8.34\ lbs\ effluent}{gallon} * \frac{2.5\ lbs\ polymer}{1,000,000lbs\ effluent} = \frac{0.0626lbs\ polymer}{min}$$

    Required pumping rate to feed 0.0626 lbs polymer minute:

    $$\frac{0.0626\ lbs\ polymer}{min} = \frac{x\ gallon\ polymer\ solution}{minute} * \frac{8.34\ lbs\ polymer\ solution}{gallon\ polymer\ solution} * \frac{0.005\ lbs\ polymer}{lbs\ polymer\ solution}$$

    $$\frac{x\ gallon\ polymersolution}{minute} = \frac{0.0626}{8.34*0.005} = \boxed{\frac{1.5\ gallon}{min}}$$

35. How many pounds of dry polymer should be added to how many gallons of water to make enough 2% polymer solution to dose a 10 MGD secondary effluent flow at 3.0 ppm of polymer?

    lbs polymer required:

    $$10MGD * \frac{8.34lbs\ effluent}{gallon} * \frac{3mg\ polymer}{l} = \frac{250.2lbs\ polymer}{day}$$

    Required pumping rate to feed 250.2 lbs polymer minute:

    $$\frac{250.2lbs\ polymer}{day} = \frac{xgallon\ polymer\ solution}{day} * \frac{8.34lbs\ polymer\ solution}{gallon\ polymer\ solution} * \frac{0.02lbs\ polymer}{lbs\ ploymer\ solution}$$

    $$\frac{xgallon\ polymer\ solution}{day} = \frac{250.2}{8.34*0.02} = \boxed{\frac{1500gallon}{day}}$$

    This can also be done as follows:

    $$\frac{250.2lbs\ polymer}{day} * \frac{lbs\ ploymer\ solution}{0.02lbs\ polymer} * \frac{gallon\ polymer\ solution}{8.34lbs\ polymer\ solution} = \boxed{\frac{1500gallon}{day}}$$

    So dissolve 250.2 lbs polymer in 1500 gallons

    Check: $\frac{250.2lbs\ polymer}{1500*8.34lbs\ polymer\ solution} = \frac{0.02lbs\ polymer}{lb\ polymer\ solution} = 2\%polymer$

36. A 0.35% solution of polymer is being fed to a secondary effluent prior to sand filtration. The polymer feed pump is set to pump 0.5 gpm to an effluent flow of 4200 gpm. What is the polymer dose rate in ppm?

    Pounds polymer pumped:

    $$\frac{0.5gal\ PS}{min} * \frac{8.34lbs\ PS}{gal\ PS} * \frac{0.0035lbs\ P}{lb\ PS} = \frac{0.0146lbs\ Polymer}{min}$$

Polymer dose rate:

$$\frac{lbs\ \ polymer}{10^6\ \ lbs\ \ effluent}(ppm\ \ or\ \ \frac{mg}{l}) = \frac{0.0146 lbs\ \ min}{\frac{8.34*4,200}{1,000,000}10^6\ \ lbs\ \ effluent} = \boxed{0.42 ppm\ \ polymer}$$

37. Liquid alum (49% alum, sp. gravity 1.32, \$1.85/gal)) is being used to remove phosphorus from a 600,000 gpd activated sludge effluent. Two hundred milligrams per liter (200 mg/l) of alum, $Al_2(S0_4)_3.14H_20$, is required to give adequate removal of the phosphorus in this effluent. Calculate the daily cost of liquid alum needed to remove phosphorus. [Formula Weights: Al =27, $Al_2(S0_4)_3.14H_20$ =594]

lbs alum required:

$$\frac{0.6MG}{day} * \frac{8.34 lbs}{gallon} * \frac{200 mg\ \ alum}{l} = \frac{1001 lbs\ \ alum}{day}$$

Required liquid alum feed (gal/day) to feed 1001 lbs alum:

$$\frac{1001 lbs\ \ alum}{day} = \frac{xgallon\ \ liquid\ \ alum}{minute} * \frac{8.34*1.32 lbs\ \ liquid\ \ alum}{gallon\ \ liquid\ \ alum} * \frac{0.49 lbs\ \ alum}{lbs\ \ liquid\ \ alum}$$

$$\implies x = \frac{1001}{8.34*1.32*0.49} = 186 gal$$

Daily cost of liquid alum to remove phosphorous:

$$\frac{186 gal}{day} * \frac{\$1.85}{gal} = \boxed{\frac{\$344.10}{day}}$$

38. A 1.5% polymer solution (based on dry weight) is to be fed at the rate of 3.5 pp to a secondary effluent flow of 4.0 MGD.
(a) Calculate the polymer pump feed rate (gallon per minute) necessary to dose this secondary effluent.
(b) How many gallons per day of polymer solution will be required for an average flow of 3470 gpm?

(a)

- **Polymer required:**

$$4*3.5*8.34 = \frac{116.8 lbs\ \ polymer}{day}$$

- **Feed rate ($\frac{gal}{min}$):**

$$\frac{116.8 lbs\ \ polymer}{day} * \frac{100 lbs\ \ polymer\ \ solution}{1.5 lbspolymer} * \frac{gal\ \ polymer\ \ solution}{8.34 lbs\ \ polymer\ \ solution} * \frac{day}{1440 min} = \boxed{0.65\frac{gal}{min}}$$

(b)

- **Polymer required:**

$$\left[\frac{3470 gal}{min} * \frac{MG}{1,000,000 gal} * \frac{1440 min}{day}\right] MGD*3.5*8.34 = \frac{145.9 lbs\ \ polymer}{day}$$

- **Feed rate ($\frac{gal}{min}$):**

$$\frac{145.9 lbs\ \ polymer}{day} * \frac{100 lbs\ \ polymer\ \ solution}{1.5 lbs polymer} * \frac{gal\ \ polymer\ \ solution}{8.34 lbs\ \ polymer\ \ solution} * \frac{day}{1440 min} = \boxed{0.81 \frac{gal}{min}}$$

39. Liquid alum (Sp. gravity 1.32, 49% Alum, $1.70 per gallon,) is being used to remove phosphorus from a 595,000 gal/day secondary. A dose of 14.0 mg/l of aluminum is required to give adequate removal of the phosphorus in this effluent. Calculate the daily cost of liquid alum. (Note: Dry alum contains 9.4% aluminum).

    Aluminum Required:

    $$0.595 * 14 * 8.34 = \frac{69.47 lbs\ \ aluminum}{day}$$

    Cost of alum ($\frac{\$}{day}$):

    $$\frac{69.47 lbs\ \ aluminum}{day} * \frac{100 lbs\ \ alum}{9.4 lbs\ \ aluminum} * \frac{100 lbs\ \ alum\ \ solution}{49 lbs\ \ alum} * \frac{gal\ \ alum\ \ solution}{(8.34 * 1.32) lbs\ \ alum\ \ solution} * \frac{\$1.70}{gal\ \ alum\ \ solution} = \boxed{\frac{\$232.91}{day}}$$

40. Polymer solution (0.5% weight to weight) is being fed at the rate of 0.83 gpm to a secondary effluent flow of 1950 gpm prior to sand filtration. Calculate the polymer dose in units of ppm.

    Polymer Dose - $\frac{lbs\ \ polymer}{10^6 lbs\ \ effluent}$ which is $\frac{mg}{l}$ or ppm:

    polymer solution(PS) & polymer(P)

    $$\frac{0.83 gal\ \ PS}{min} * \frac{8.34 lbs\ \ PS}{gal\ \ PS} * \frac{0.005 lbs\ \ P}{lbs\ \ PS} * \frac{min}{\frac{(8.34 * 1950)}{1,000,000} 10^6 lbs\ \ effluent} = \boxed{\frac{2.13 mg}{l}\ \ polymer}$$

41. A 4.5% (weight to weight basis) solution of polymer is being fed to a secondary effluent prior to sand filtration. It is desired to dose at 2.4 mg/l. Assuming an effluent flow of 6550 gpm, at what rate (gallons per minute) should the polymer feed pump be set?

    Polymer feed rate GPM:

    $$6550 * 8.34 * \frac{2.4}{10^6} \frac{lbs\ \ polymer}{min} * \frac{100 lbs\ \ polymer\ \ solution}{4.5 lbs polymer} * \frac{gal\ \ polymer\ \ solution}{8.34 lbs\ \ polymer\ \ solution} = \boxed{0.35 \frac{gal}{min}}$$

42. Polymer is being added at 0.3 mg/l in order to achieve a 92% capture efficiency for a belt press. The feed to the belt press is 100 gallons per minute, containing 2.5% solids. Given the polymer costs $460 per gallon of 4% active polymer with a specific gravity of 1.1. What is the cost of polymer per dry ton of solids captured

lbs polymer required:

$$100*1440\frac{gal\ \ sludge}{day}*8.34\frac{lbs\ \ sludge}{gal\ \ sludge}*\frac{0.3 lbs\ \ polymer}{1,000,000 lbs\ \ sludge}$$

$$=0.36\frac{lbs\ \ polymer}{day}$$

gallons polymer solution required:

$$0.36\frac{lbs\ \ polmyer}{day} = x\frac{gal\ \ polymer\ \ solution}{day} * \frac{8.34*1.1 lbs\ \ polymer\ \ solution}{gal\ \ polymer\ \ solution} * 0.04\frac{lbs\ \ polymer}{lb\ \ polymer\ \ solution}$$

$$=0.982\frac{gal\ \ polymer\ \ solution}{day}$$

Polymer cost:

$$\frac{\$460}{gallon\ \ polymer\ \ soultion}*\frac{0.982 gal\ \ polymer\ \ soultion}{day}$$

$$=\frac{\$451.26}{day}$$

Dry tons of solids captured:

$$100*1440\frac{gal\ \ sludge}{day}*\frac{8.34*0.025\ \ lbs\ \ solids}{gal\ \ sludge}*\frac{0.92\ \ lbs\ \ solids\ \ captured}{lbs\ \ solids}*\frac{ton\ \ solids}{2000 lbs\ \ solids}$$

$$=\frac{13.81 tons\ \ dry\ \ solids}{day}$$

Polymer cost per dry ton of solids captured:

$$\frac{\$451.26 perday}{13.81 tons\ \ dry\ \ solids\ \ per\ \ day}=\boxed{\$32.67}$$

43. A flow of 5 MGD is being treated with 9.8 mg/l aluminum using liquid alum of 48% strength and SG of 1.32. Alum has 19% aluminum. If the liquid alum costs $1.62 per gallon, what is the cost per day

Solution:

lbs aluminum required:

$$5MGD*8.34*9.8\frac{lbs\ \ aluminum}{day}=408.7\frac{lbs\ \ aluminum}{day}$$

Alum needed to meet this dosing need:

$$408.7\frac{lbs\ \ aluminum}{day} = x\frac{gal\ \ liquid\ \ alum}{day} * 8.34*1.32\frac{lbs\ \ liquid\ \ alum}{per\ \ gal\ \ liquid\ \ alum} * 0.48\frac{lbs\ \ alum}{lb\ \ liquid\ \ alum} * 0.19\frac{lbs\ \ aluminum}{lb\ \ alum}$$

$$\Longrightarrow x\frac{gal\ \ liquid\ \ alum}{day} = \frac{408.7}{8.34*1.32*0.48*0.19} = 407\frac{gal\ \ liquid\ \ alum}{day}$$

Cost per day=$407\frac{gal\ \ liquid\ \ alum}{day}*\frac{\$1.62}{gal\ \ liquid\ \ alum} = \boxed{\$659.45}$

44. Prior to sand filtration, a secondary effluent flow of 5 MGD is dosed with 0.75% strength polymer solution to achieve a dose of 1.5mg/l of polymer. a) What is the lbs of dry polymer per day necessary to treat this effluent, and b) What is the required GPM feed of the 0.75% polymer:

a) lbs of dry polymer required (lbs formula)=$5MGD*8.34*1.5 = \boxed{62.55\frac{lbs\ \ polymer}{day}}$

b) Flow rate of 0.75% strength polymer = $62.55\frac{lbs\ \ polymer}{day} = \frac{x\frac{gal}{min}*1440\frac{min}{day}}{1,000,000\frac{gal}{MG}}*8.34*$ 7500

$$\Longrightarrow x\frac{gal}{min} = \frac{62.55*1,000,000}{1440*8.34*7,500} = \boxed{0.7GPM}$$

45. If a chemical costs \$30 per ton, how much will it cost per year to treat a flow of 15 MGD if the average dose is 18 mg/l?

Tons of chemical required per year: (use lbs formula)

$$\left[15\ \ MGD*18\ \ \frac{mg}{l}\ \ *8.34\right]\frac{lbs}{day}*365\frac{days}{year}*\frac{ton}{2000lbs} = \frac{411\ \ tons}{year}$$

Chemical cost:

$$\frac{411\ \ tons}{year}*\frac{\$30}{ton} = \boxed{\$12,328\ \ per\ \ year}$$