SELECTED MATH PROBLEMS FOR SOLIDS HANDLING MATH

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Math Problem Solving Strategy

1. Read the question carefully and underline what they are asking you to find.
2. Write down the formula you need to solve the problem. Look in the front of the test booklet if necessary.
3. Fill in everything you know. Sometimes filling in what you know might require you to find something else first like area or volume.
4. Check your units! Make sure they are correct for the formula and agree with each other.
5. Convert units where needed.
6. Put the new units into the formula.
7. Solve.
8. Check the units of your answer. Are they what the question asked for?
9. Convert units if necessary.

THE RULES FOR BASIC ALGEBRA

1. For Unit Conversions
   a. Only tops and bottoms can cancel
   b. Everything on the top gets multiplied
   c. Everything on the bottom gets divided
2. You can rearrange any equation by following these simple rules:
   a. Do anything you want.
   b. Do the opposite.
   c. Do it to both sides.
3. Simplify any equation correctly by following the Order of Operations. Whenever you CAN do things in this order, you MUST do them in this order.
   a. **P**arenthesis, **P**owers or **E**xponents (x^2), **M**ultiply, **D**ivide, **A**dd, and **S**ubtract
   b. **PMDAS** or **PEMDAS**
   c. **P**olly **M**akes **D**onuts **A**fter **S**chool
   d. **P**lease **E**xcuse **M**y **D**ear **A**unt **S**ally

SOLIDS HANDLING MATH

1. The anaerobic digester must be maintained at 95 ^{o}F plus or minus 1 degree per day. What is this in degrees Centigrade?

2. MLSS is pumped to an anaerobic digester. The MLSS is 3,000 mg/L and contains 80% volatile solids. The digester contains 1.82% total solids. Biosolids removed from the digester are only 67% volatile. What was the percent volatile solids reduction through the digester?

3. Backwards – much harder! A digester is being fed with 78% volatile solids. The plant has historically had difficulty meeting the minimum 38% volatile solids reduction required by the 503 Regulations prior to land application. How low does the percent of volatile solids need to be in the digester in order to meet the minimum reduction rate?

4. A digester holds 0.45 MG. It is fed a mixture of primary and secondary sludge that is 5% total solids and the solids are 82% volatile. Find the loading rate to the digester in pounds of volatile solids per cubic foot per day when the feed rate is 2000 gpd.

5. Find the solids detention time for an aerobic digester that is 100 feet long by 40 feet wide by 12 feet deep. The digester is full and the solids concentration in the digester is 2% total solids. The digester is decanted daily at a rate of 2,000 gallons per day. The decant liquid contains 400 mg/L of total suspended solids on average. Solids are removed from the digester for ultimate disposal at a rate of 4000 gallons per day. WAS is added to the

digester at a rate of 7500 gallons per day and contain 6,200 mg/L of total suspended solids.

6. A WWTP produces 240 dry tons of biosolids per year. The biosolids are land applied to a quarter section (160 acres). Lab results indicate that the concentration of Cadmium in the biosolids is 22 mg/kg. What is the annual cadmium loading rate to the site? Express your answer as pounds of Cadmium per acre.

7. Calculate the volatile solids loading rate in pounds per day per cubic foot to a conical bottomed, cylindrical digester that receives 13,000 gpd of sludge that is 5% solids. Assume the solids are 75% volatile. The digester is 40 feet in diameter and has a side water depth of 25 feet. The cone is an additional 10 feet deep at its deepest point.

8. A belt filter press receives a feed sludge at 3% total solids and produces a cake that is 21% total solids. If the influent flow rate to the press is 50 gpm, how many cubic yards of finished cake will be produced if the press runs for 8 hours?

9. A belt filter press receives 8,250 gallons of WAS each day. The WAS concentration is 12,000 mg/L. If the press captures 98% of the incoming solids, how many pounds of solids will end up in the filtrate?

10. For the filter press in problem #9, if the average feed rate is 900 pounds per hour. How many hours will the press need to operate?

1. $$°C = \frac{°F - 32}{1.8}$$

$$°C = \frac{95 - 32}{1.8}$$

$$°C = \frac{63}{1.8}$$

$$°C = 35$$

2. $$\text{PERCENT VOLATILE SOLIDS REDUCTION} = \left[\frac{(In - Out)}{In - (In)(Out)}\right] * 100$$

$$\% VSR = \left[\frac{(0.8 - 0.67)}{0.8 - (0.8)(0.67)}\right] * 100$$

$$\% VSR = \left[\frac{0.13}{0.8 - (0.8)(0.67)}\right] * 100$$

$$\% VSR = \left[\frac{0.13}{0.8 - 0.536}\right] * 100$$

$$\% VSR = \left[\frac{0.13}{0.264}\right] * 100$$

$$\% VSR = 49.2$$

3. $$\%VSR = \left[\frac{(In - Out)}{In - (In * Out)}\right] * 100$$

$$\frac{\frac{38}{100} = \left[\frac{0.78 - Out}{0.78 - (0.78)(Out)}\right] * 100}{100}$$

DIVIDE BOTH SIDES BY 100

$$(0.78 - (0.78)(out))\, 0.38 = \left[\frac{0.78 - OUT}{0.78 - (0.78)(OUT)}\right](0.78 - (0.78)(OUT))$$

TOP + BOTTOM CANCEL

multiply — multiply again

$$0.38(0.78 - (0.78)(OUT)) = 0.78 - OUT$$

$$0.2964 - (0.2964)(OUT) = 0.78 - OUT$$

we now need to rearrange to get the "OUT"s together and the numbers together.

subtract 0.2964 from both sides

$$0.2964 - (0.2964)(OUT) - 0.2964 = 0.78 - OUT - 0.2964$$

$$-(0.2964)(OUT) = 0.4836 - OUT$$

add OUT to both sides

1 out

$$-0.2964\,OUT + OUT = 0.4836 - OUT + OUT$$

$$\frac{0.7036\,OUT}{0.7036} = \frac{0.4836}{0.7036}$$

$$OUT = 0.687$$

or

68.7 % volatile

Whew!

4. Loading Rate = $\frac{\text{lbs VS}}{\text{cubic ft}}$ two pieces to find.

$$5\% \left| \frac{10000 \text{ mg/L}}{1\%} \right| = 50000 \text{ mg/L}$$

$$\frac{2000 \text{ gal}}{d} \left| \frac{1 \text{ MG}}{1000000 \text{ gal}} \right| = 0.002 \text{ MG}$$

lbs VS = (mg/L)(MG)(8.34)(% volatile)

lbs VS = (50 000 mg/L)(0.002 MG)(8.34)(0.82)

lbs VS = 683.88

we have the first piece

$$0.45 \text{ MG} \left| \frac{1000\,000 \text{ gal}}{1 \text{ MG}} \right| \frac{1 \text{ cf}}{7.48 \text{ gal}} \right| = 60160.42 \text{ cf}$$

Plug + Chug

Loading Rate = $\frac{\text{lbs VS}}{\text{cf}}$

$= \frac{683.88 \text{ lb}}{60160.42 \text{ cf}}$

$= 0.01136 \text{ lb/cf}$

SUPER LIGHTLY LOADED.
TYPICAL WOULD BE 0.1 − 0.3 lbsVS/cf

5. SDT = $\dfrac{\text{SOLIDS IN DIGESTER}}{(\text{SOLIDS IN} - \text{SOLIDS OUT})/2}$

A. Find volume of digester and lbs inside it.

$V = L \times W \times H$

$V = (100\,ft)(40\,ft)(12\,ft)$

$V = 48000\ cf$

$48000\,cf \left| \dfrac{7.48\,gal}{1\,cf} \right| \dfrac{1\,MG}{1000000\,gal} \Big| = 0.35904\ MG$

$2\% \left| \dfrac{10.000\,mg/L}{1\%} \right| = 20,000\ mg/L$

lbs in digester $= (mg/L)(MGD)(8.34)$

$= (20,000\,mg/L)(0.35904\,mg)(8.34)$

$= 59,888$

lbs WAS being added $= (mg/L)(MGD)(8.34)$

lbs WAS $= (6200\,mg/L)(0.0075\,MGD)(8.34)$

lbs WAS $= 387.81$

lbs LEAVING $= (mg/L)(mgD)(8.34)$

lbs LEAVING $= (20,000\,mg/L)(0.004\,mgd)(8.34)$

lbs LEAVING $= 667.2$

same concentration leaving as inside the digester.

I am going to ignore solids in the decant.
Very small compared to everything else.

$$SDT = \frac{\text{lb in digester}}{(\text{incoming} - \text{outgoing})/2}$$

$$SDT = \frac{59888 \text{ lbs}}{(387.81 - 667.2)/2}$$

$$SDT = \frac{59888}{(-279.39)/2}$$

$$SDT = \frac{59888}{139.69}$$

SDT = 428 days

A VERY LONG TIME

20-40 DAYS IS TYPICAL

6. 240 tons | 2000 lbs / 1 ton | 1 metric ton / 2204.62 lbs | 1000 kg / 1 metric ton | = 217724 kg BIOSOLIDS

$$240 \text{ tons} \times \frac{2000 \text{ lbs}}{1 \text{ ton}} \times \frac{1 \text{ metric ton}}{2204.62 \text{ lbs}} \times \frac{1000 \text{ kg}}{1 \text{ metric ton}} = 217724 \text{ kg BIOSOLIDS}$$

Yes, it is a weird conversion. It messes up lots of folks on their biosolids reports.

$$217724 \text{ kg BIOSOLIDS} \times \frac{22 \text{ mg Cd}}{1 \text{ kg Bios.}} \times \frac{1 \text{ g}}{1000 \text{ mg}} \times \frac{1 \text{ kg}}{1000 \text{ g}} \times \frac{1 \text{ lb}}{2.2 \text{ kg}} = 2.177 \text{ lbs Cd}$$

THIS GETS ME FROM BIOSOLIDS TO CADMIUM

THIS PART CONVERTS MG OF CD TO POUNDS OF CADMIUM APPLIED

$$\text{LOADING RATE} = \frac{\text{lbs CD}}{\text{ACRES}}$$

$$= \frac{2.177 \text{ lbs Cd}}{160 \text{ acres}}$$

$$= 0.0136 \text{ lbs/acre}$$

7. Let's find the volume of the digester first.

$V = 0.785 d^2 h$

$V = (0.785)(40ft)(40ft)(25ft)$

$V = 31400$ cf *just the cylinder.

Now find volume of the cone.

$V = \frac{0.785 d^2 h}{3}$

$V = \frac{(0.785)(40ft)(40ft)(10ft)}{3}$

$V = 4186.7$ cf ← CONE VOLUME

31400 cf	cylinder
+ 4186.7 cf	cone
35586.7 cf	total volume

Now find pounds of volatile solids.

$5\% \left| \frac{10000 \text{ mg/L}}{1\%} \right| = 50,000 \text{ mg/L}$ $\quad$ $13,000 \text{gal} \left| \frac{1 \text{MG}}{1000000 \text{ gal}} \right| = 0.013 \text{ MG}$

lbs volatiles = (mg/L)(MGD)(8.34)(% volatile)

lbs volatiles = (50,000 mg/L)(0.013 mg)(8.34)(0.75)

lbs volatiles = 4065.75

LOADING = $\frac{\text{lbs volatiles}}{\text{cubic ft}}$

$= \frac{4065.75 \text{ lbs}}{35586.7 \text{ cf}}$

= 0.11 lbs VS/cf ← PERFECT!

TYPICAL IS 0.1 – 0.3

8. START BY FINDING TOTAL GALLONS SENT TO THE PRESS

$$\frac{8 \text{ hrs}}{} \left| \frac{60 \text{ min}}{1 \text{ hr}} \right| \frac{50 \text{ gal}}{1 \text{ min}} = 24{,}000 \text{ gallons}$$

$$\underbrace{C_1 V_1}_{\text{START}} = \underbrace{C_2 V_2}_{\text{END}}$$

*THIS IS CALLED THE NORMALITY EQUATION IN THE TEST BOOK

$$(3\%)(24{,}000 \text{ gal}) = (21\%)(V_2)$$

$$\frac{72{,}000}{21} = \frac{(21\%)(V_2)}{21}$$

$$3428.6 = V_2$$

gallons

$$\frac{3428.6 \text{ gallons}}{} \left| \frac{1 \text{ cf}}{7.48 \text{ gal}} \right| \frac{1 \text{ cy}}{27 \text{ cf}} = 16.98 \text{ cubic yards}$$

So . . . if my truck holds 5 cubic yards, I will need to make 4 trips to apply my biosolids.

9. TWO PERCENT OF THE TOTAL!

$$lbs = (mg/L)(MGD)(8.34)(percent)$$

$$lbs = (12000\ mg/L)(0.00825\ mgd)(8.34)(0.02)$$

$$lbs = 16.5$$

10. $$lbs = (mg/L)(MGD)(8.34)$$

$$lbs = (12000\ mg/L)(0.00825\ mgd)(8.34)$$

$$lbs = 825.66$$

NOT EVEN 1 HR

$$825.66\ lbs \left| \frac{1\ hr}{900\ lbs} \right| = 0.9174\ hours$$