Wastewater Treatment Math Study Guide

Kentucky Division of Compliance Assistance
Certification and Licensing Branch

This study guide is intended to help students become more familiar with the variety of math equations within the Wastewater Treatment manual and exam.

Below is a chart of where math can be found in the training manual.

Chapter	Name	Page	Concept
1	Certified Operator	PPT	Area/Volume/Conversions/Lbs Formula
2	KPDES Permitting	26	Lbs Formula
2	KPDES Permitting	27	BOD Measurement
2	KPDES Permitting	28	Percent Removal
3	Biology	48	F/M Ratio
3	Biology	50	Hydraulic/Surface Load Rate (Also see pg. 84)
3	Biology	50	Organic Load Rate, Activated Sludge
3	Biology	54	Sludge Age
3	Biology	54	MCRT
5	Physical and Biological Treatment	83	Pump Rate
5	Physical and Biological Treatment	83	Lbs Formula Conversion
5	Physical and Biological Treatment	83	Detention Time
5	Physical and Biological Treatment	84	Weir Overflow Rate
5	Physical and Biological Treatment	84	Hydraulic Load Rate (Also see pg. 50)
5	Physical and Biological Treatment	86	Organic Load Rate (Trickling Filter)
5	Physical and Biological Treatment	88	Organic Load Rate (RBC)
5	Physical and Biological Treatment	95	MLSS (from dish weights)
5	Physical and Biological Treatment	96	MLVSS (from dish weights)
5	Physical and Biological Treatment	96	Sludge Volume Index (SVI)
5	Physical and Biological Treatment	106	Solids Loading Rates
5	Physical and Biological Treatment	111	Ponds Organic Loading/Acre
5	Physical and Biological Treatment	111	Ponds Organic Pop Served/Acre
6	Digesters	126	SOUR (see Formula Sheet)
6	Digesters	130	Digester Loading (Volatile Solids)
7	Disinfection		Lbs Formula
8	Flow measurement	162	Conversions

Work through each problem introduced in each chapter and the math questions (if any) at the end of each chapter.

Class I & II

1. A town with a population of 4,500 people has a treatment pond with a surface area of 200 acres. What is the population loading in persons/acre?

A. 22.5 persons/acre
B. 45 persons/acre
C. 60 persons/acre
D. 75 persons/acre

2. The flow to three 800 feet long by 450 feet wide lagoons is 1.2 MGD. These lagoons serve a population of 1,250 people. What is the loading in persons/acre?

A. 16.6 persons/acre
B. 33 persons/acre
C. 50.4 persons/Acre
D. 65 persons/Acre

3. What is the organic loading for a facility that has a flow rate of 750,000 gallons per day and a BOD concentration of 125 mg/L? The area of the pond is 12.5 acres.

A. 31.25 lbs BOD/Day/Acre
B. 62.55 lbs BOD/Day/Acre
C. 72.6 BOD/Day/Acre
D. 89.4 BOD/Day/Acre

4. What is the organic loading for a facility that has a flow rate of 500 gpm, a BOD concentration of 62 mg/L, and the area of the pond is 490,500 ft ?

A. 5.6 lbs BOD/day/Acre
B. 11.2 BOD/day/Acre
C. 23.5 BOD/day/Acre
D. 33.1 lbs BOD/day/Acre

5. How many lbs of Total Suspended Solids (TSS) does a plant receive that has a flow rate of 72,000 gpd at a concentration of 210 mg/L?

A. 15.12 lbs
B. 126.1 lbs
C. 151.2 lbs
D. 277 lbs

6. The effluent flow from a wastewater treatment facility is 675,000 gallons per day. From the DMR, 92 pounds of BOD_5 were discharged daily. What is the BOD_5 concentration in the plant effluent?

A. 16.34 mg/L
B. 1.63 mg/L
C. 0.5 mg/L
D. 0.01 ppm

7. What is the capacity of a plant that was designed to handle 125 pounds of BOD with a BOD concentration of 42 mg/L?

A. 0.2 MGD
B. 3,570 gpd
C. 35,700 gpd
D. 357,000 gpd

8. The initial DO of a 25 ml sample was 9.6 mg/L and the final DO after 5 days of incubation at 20°C in a 300 ml sample bottle was 3.1 mg/L. What was the BOD in mg/L?

A. 37 mg/L
B. 78 mg/L
C. 115 mg/L
D. 152 mg/L

9. A plant with an average influent BOD of 215 mg/L produces an effluent BOD of 48 mg/L. What is the percent removal for this plant?

A. 22.3%
B. 77.7%
C. 85%
D. 93.2%

10. What is the food to microorganism ratio (F/M) of a plant with the following operational parameters? 2,450 pounds of MLVSS in the aeration tank of the plant. The average BOD concentration is 220 mg/L and the plant flow averages 0.9 MGD.

A. 0.40
B. 0.67
C. 1.2
D. 1.8

11. What is the food to microorganism ratio (F/M) of a plant with the following operational parameters? The aeration basin holds 1.2 MG and the MLVSS concentration in the basin is 350 mg/L. The average BOD concentration is 220 mg/L and the plant flow averages 750,000 gpd.

A. 0.39
B. 0.8
C. 1.1
D. 1.6

12. What is the weir overflow rate of a weir that is 70 feet long with a flow rate of 0.11 MGD?

A. 658 gpd/ft
B. 967 gpd/ft
C. 1240 gpd/ft
D. 1571 gpd/ft

Note: Weir length may be given in inches or as the size of the basin. The basin could be rectangular or circular. Flow rate may be given in gpm or gallons per day.

13. A basin measures 45 feet wide by 90 feet long and 15 feet deep services a treatment plant. An average flow of 0.2 MGD goes through the plant. What is the detention time in days?

A. 0.13 days
B. 0.76 days
C. 2.27 days
D. 3.4 days

There are two formulas on the sheet, one for days and one for hours. Use the appropriate one based on units of the answers.

14. What is the sludge age of a plant where an aeration basin contains 51,500 pounds of MLSS and the influent TSS is calculated at 1,960 pounds per day?

A. 20.2
B. 26.3
C. 35.5
D. 52.8

You may also be given flow, volume and concentration data to determine lbs.

15. A wastewater treatment plant is serving a population of 185,000. How much phosphorus would be removed from this plant on a daily basis assuming 100% conversion of the phosphorus?

A. 888 lbs
B. 3145 lbs
C. 3700 lbs
D. 8880 lbs

This question may ask for any population equivalents. Be aware of the units of the answers.

16. A 2.5 MGD extended aeration plant is at full capacity with an influent BOD of 235 mg/L. What is the organic loading on this facility in pounds BOD/1,000 ft^3?

A. 1.46 lbs BOD/1,000 ft^3
B. 7.3 lbs BOD/1,000 ft^3
C. 14.6 lbs BOD/1,000 ft^3
D. 21.7 lbs BOD/1,000 ft^3

17. Two drying beds measuring 45 feet wide by 80 feet long are filled with 18 inches of sludge from a digester in 2 hours and 45 minutes. What is the pump rate in gal/min?

A. 48.9 gpm
B. 244.8 gpm
C. 326.4 gpm
D. 489.6 gpm

18. What is the SOUR in mg/g VSS/hr at a facility where the MLVSS was measured at 1,760 mg/L. During the analysis the initial DO was 8.9 mg/L and 3 minutes later the DO is 5.2 mg/L.

A. 42.0 mg/g VSS/hr
B. 59.1 mg/g VSS/hr
C. 101.1 mg/g VSS/hr
D. 126.1 mg/g VSS/hr

19. To calculate a Sludge Volume Index, the thirty minute settled sludge volume was 295 ml and the MLSS is 3640 mg/L. What is the SVI?

A. 0.81
B. 8.1
C. 81
D. 810

20. What is the hydraulic loading rate on a clarifier that is 65 ft in diameter and 12 ft deep and receives a daily average flow of 890,000 gallons per day?

A. 268.3 lbs BOD/1000 ft^2
B. 1,610 lbs BOD/1000 ft^2
C. 2,683 lbs BOD/1000 ft^2
D. 3,220.1 lbs BOD/1000 ft^2

Answer Key

1. A
2. C
3. B
4. D
5. B
6. A
7. D
8. B
9. B
10. B
11. A
12. D
13. C
14. B
15. A
16. C
17. D
18. A
19. C
20. A

Class III & IV

Math questions for class III and class IV require a better understanding of the math in the manual and of the formulas on the formula sheet. The exams also introduce a different way of displaying the data needed to solve the problem (See question 21) for this change in question format. Questions will also require a greater skill level for what could be called "bank balance math", in that they are not associated with a specific formula on the formula sheet or covered specifically in the manual.

Class III and class IV exams will include questions that were covered for class I and class II exams. Be aware of the units for data in the question and the units of the answer. Don't forget the importance of conversions.

21. Given the following information, what is the cost of removal per 1,000 pounds of total suspended solids, assuming 100% removal?
Data:
Average flow = 4.9 MGD
TSS removed = 190 ppm
Operating costs = $68,250 per year

A. $24.08
B. $28.63
C. $32.98
D. $36.50

22. The flow to a plant is 1.75 MGD. The influent BOD_5 concentration is 275 mg/L. If the primary treatment process removes 25% of the incoming BOD_5 and the aerator F/M is 40 pounds of BOD_5 per 100 pounds MLVSS, how many pounds MLVSS should be maintained in the aeration basin?

A. 2,508.5 lbs
B. 7,525.5 lbs
C. 10,034 lbs
D. 7,525.5 lbs

Clue: Aerator F/M is 40 pounds of BOD_5 per 100 pounds MLVSS. BOD is food (F) and MLVSS is bacteria (M). Rearrange formula.

23. What is the weir overflow rate in gallons per day per foot of weir, if the flow is 165 gpm and the radius of the clarifier is 22 feet and 6 inches?

A. 3,262 gpd/ft of weir
B. 2,456 gpd/ft of weir
C. 1,963.5 gpd/ft of weir
D. 1,681.5 gpd/ft of weir

24. What is the detention time for two clarifiers that are 60 feet in diameter and 10 feet deep with a flow of 12.2 cubic feet per second?

A. 0.13 hours
B. 0.9 hours
C. 1.3 hours
D. 2.6 hours

There are many conversions in this problem. There are many ways to solve it too.

25. The desired sludge age for a particular extended aeration plant is 19 days. The daily flow is 1.95 MGD with an influent suspended solids concentration of 210 mg/L. If the 2.5 MG aeration basin has a MLSS concentration of 3,450 ppm, how many gallons will be wasted if the waste sludge flow is concentrated to 1.35%?

A. 62,550 gallons
B. 64,889 gallons
C. 71,932 gallons
D. 86,250 gallons

26. What is the mean cell residence time for a 2.6 MGD oxidation ditch with a flow of 1.5 MGD, a MLSS of 2,980 mg/L? The plant wastes sludge at a rate of 49,500 gal per day at 7,000 mg/L TSS and has an effluent TSS concentration of 12.5 mg/L.

A. 19 days
B. 21 days
C. 24 days
D. 28 days

27. Using the following data calculate the mean cell residence time (MCRT) for an activated sludge oxidation ditch.
DATA:
Oxidation Ditch = 1.7 MGD
MLVSS = 1,720
Flow = 1.2 MGD
Return sludge flow = 70%
Influent BOD5 = 285 mg/L
Effluent SS = 12.6 ppm
Waste sludge concentration = 1.12%
MLSS = 3,600 ppm
Sludge Flow = 65,300 gpd

A. 3.9 days
B. 6.9 days
C. 8.2 days
D. 12.3 days

Note the extra information given in the question. Be aware of information you do not need.

28. Calculate the mean cell residence time (MCRT), in days, for an oxidation ditch.
DATA:
Plant flow = 0.82 MGD
Waste sludge flow = 12,000 gpd
Aeration tank volume = 1.1 MG
Return sludge flow MLSS concentration = 9,000 mg/L of MLSS
Aeration MLSS = 2,900 mg/L
Plant discharge to stream = 18 mg/L of SS
Return sludge flow = 75%

A. 18.2 days
B. 25.9 days
C. 29.3 days
D. 31.5 days

29. Calculate the organic loading rate on a trickling filter in pounds of BOD_5 /1,000 sq.ft.

DATA:

Influent BOD_5 = 255 ppm

Filter diameter = 65 feet

Plant flow = 1.3 MGD

Filter depth = 7 feet

Plastic Media = 24 ft^2 per ft^3 volume

A. 2.59 gpd/ft^2

B. 3.89 gpd/ft^2

C. 4.96 gpd/ft^2

D. 6.32 gpd/ft^2

30. What is the organic loading rate in pounds of BOD_5 per day per 1,000 cubic feet for a trickling filter that is 120 feet in diameter and 7 feet deep? The primary effluent flow is 2,140 gpm and the BOD_5 is 190/mg/L?

A. 61.68 lbs BOD_5 /1,000 ft^3

B. 106.9 lbs BOD_5 /1,000 ft^3

C. 120.6 lbs BOD_5 /1,000 ft^3

D. 190.2 lbs BOD_5 /1,000 ft^3

31. A sample of sludge going to an aerated digester has a MLVSS of 1,960 mg/L. An analysis for Specific Oxygen Uptake Rate (SOUR) indicated the initial dissolved oxygen was 7.9 mg/L and 5 minutes later the dissolved oxygen was 5.2 mg/L. What is the SOUR in mg/g VSS/hr?

A. 13.9 mg/g VSS/hr

B. 15.8 mg/g VSS/hr

C. 16.5 mg/g VSS/hr

D. 24.2 mg/g VSS/hr

32. Given the following information regarding a treatment plant sample, calculate the mg/L of mixed liquor suspended solids (MLSS) in the aeration basin.
DATA:
Sample Size = 25 ml
Weight of dish (tare wt.) = 15.2153 g
Before burning, ash weight of sample and dish = 15.2456 g
After burning, ash weight of sample and dish = 15.2412 g

A. 176 mg/L
B. 572 mg/L
C. 1,036 mg/L
D. 1,212 mg/L

33. Calculate the sludge volume index from the following information.
DATA:
Mixed liquor suspended solids = 2,950 mg/L.
Five minute settleometer reading = 640 ml/L.
Thirty minute settleometer reading = 420 ml/L
Sixty minute settleometer reading = 330 ml/L

A. 111 ml/mg
B. 142 ml/mg
C. 217 ml/mg
D. 7023 ml/mg

34. A wastewater plant is receiving 2,500 pounds of total suspended solids each day. Industrial facilities contribute 15% and 85% is domestic and commercial. Calculate the population equivalent of the industrial contribution.

A. 1,875 people
B. 2,205 people
C. 2,500 people
D. 10,625 people

35. A rectangular dissolved air floatation unit is 15 feet long and 12 feet wide. What is the solids loading rate in pounds per hour per square foot if the unit receives 55 gpm of sludge from a clarifier with a solids content of 0.75%?

A. 0.72 lbs/hr/ft^2
B. 0.9 lbs/hr/ft^2
C. 1.0 lbs/hr/ft^2
D. 1.14 lbs/hr/ft^2

Note the units…

36. Calculate the solids loading rate on the final clarifier in pounds of suspended solids per day per square foot.
Clarifier diameter = 60 ft.
Plant Flow = 1.2 MGD
Side wall depth = 12 ft.
MLSS = 2,550 ppm
Return sludge flow = 80%

A. 8.7 lbs/day/ft^2
B. 16.3 lbs/day/ft^2
C. 24.0 lbs/day/ft^2
D. 31.6 lbs/day/ft^2

Note the units in the question!

37. Calculate the percent reduction of volatile solids.
DATA:
Raw VSS = 63%
Digested VSS = 49.5%

A. 35%
B. 42%
C. 51%
D. 63%

38. If the sludge entering a digester has a volatile solids content of 55.7% and the digester effluent sludge has a volatile solids content of 42.6%, calculate the percentage of volatile solids reduction.

A. 35%
B. 41%
C. 51%
D. 63%

39. Calculate the volatile solids loading in pounds of volatile suspended solids per cubic foot on an anaerobic digester if the waste sludge flow is 10,200 gallons per day. The total suspended solids is 2.1 percent, the volatile suspended solids is 62 percent of the total suspended solids and the digester volume is 65,000 gallons.

A. 0.08 lbs vss/ft^3
B. 0.13 lbs vss/ft^3
C. 0.21 lbs vss/ft^3
D. 0.55 lbs vss/ft^3

Answer Key

21. A
22. B
23. D
24. C
25. A
26. B
27. C
28. B
29. C
30. A
31. C
32. D
33. B
34. A
35. D
36. B
37. B
38. B
39. B

Class I & II Solved Equations

1. Formula used: *Population Served, Persons ÷ Pond Surface, Acres*
   4,500 People ÷ 200 acres = 22.5 persons/acre

2. First calculate surface area of lagoons in acres:
   3 x 800 ft x 450 ft = 1,080,000 ft^2 ÷ 43,560 ft^2/Acre = 24.79 acres
   1,250 Persons ÷ 24.79 acres = 50.4 persons/acre

3. Formula used: *pounds of BOD ÷ area in acres*
   First calculate pounds of BOD:
   125 mg/L x 8.34 x 0.75 MGD = 781.88 pounds/day
   Divide pounds of BOD by the surface area of pond in acres:
   781.88 pounds/12.5 acres = 62.55 lbs BOD/day/acre

4. Convert flow from gpm to MGD and surface area of pond from ft^2 into acres:
   500 gpm ÷ 694.5 gpm/MGD = 0.72 MGD
   490,500 ft^2 ÷ 43,560 ft^2/acre = 11.26 acres
   Calculate pounds of BOD:
   62 mg/L x 8.34 x 0.72 MGD = 372.30 lbs BOD/day
   Calculate organic loading:
   372.20 lbs BOD/day ÷ 11.26 acres = 33.06 or 33.1 lbs BOD/day/acre

5. Formula used: *pounds = mg/L x 8.34 x Flow, MGD*
   First convert:
   gallons/day to MGD – 72,000 gal ÷ 1,000,000 = 0.072 MGD
   Calculate pounds:
   210 mg/L x 8.34 X 0.072 MGD = 126.1 lbs

6. Formula used: *ppm(mg/L) = pounds ÷ (8.34 x Flow, MGD)*
   First convert flow from gallons/day to MGD:
   675,000 gallons/day ÷1,000,000 = 0.675 MGD
   Calculate concentration:
   Mg/L = 92 lbs ÷ (8.34 x 0.675 MGD) = 92 lbs ÷ 5.63 = 16.34 mg/L

7. Formula used: *Flow, MGD = pounds ÷ (Concentration (mg/L) x 8.34)*
   Calculate Flow, MGD:
   Flow, MGD = 125 lbs ÷ (42 mg/L x 8.34) = 125 lbs ÷ 350.28 = 0.357 MGD
   Convert to gallons/day:
   0.357 MGD x 1,000,000 = 357,000 gpd

8. Formula used:
   BOD, mg/L = ((Initial DO, mg/L – Final DO, mg/L) x Bottle vol, ml) ÷ Sample, ml
   Calculate BOD in mg/L:
   BOD, mg/L = ((9.6 mg/L – 3.1 mg/L) x 300 ml) ÷ 25 ml
   BOD, mg/L = (6.5 mg/L x 300 ml) ÷ 25 ml = 1,950 ÷ 25 = 78 mg/L

9. Formula used: *Percent Removal = ((Influent – Effluent) ÷ Influent) x 100*
   Calculate Percent Removal:
   Percent Removal = ((215 mg/L – 48 mg/L) ÷ 215 mg/L) x 100
   Percent Removal = (167 mg/L ÷ 215 mg/L) x 100 = 0.7767 x 100 = 77.7%

10. Formula used: *F/M = lbs BOD, in Influent ÷ lbs MLVSS, in aeration basin*
    First calculate lbs of BOD in the influent:
    220 mg/L x 8.34 x 0.9 MGD = 1,651.32 lbs BOD
    Calculate F/M ratio:
    F/M = 1,651.32 lbs, BOD ÷ 2,450 lbs, MLVSS = 0.67

11. Formula used: *F/M = lbs BOD, in Influent ÷ lbs MLVSS, in aeration basin*
    First convert daily flow from gallons/day to MGD:
    750,000 gpd ÷ 1,000,000 = 0.750 MGD
    Calculate lbs BOD in Influent:
    220 mg/L x 8.34 x 0.75 MGD = 1,376.1 lbs/day
    Calculate lbs MLVSS in the Aeration Basin:
    350 mg/l x 8.34 x 1.2 MG = 3,502.8 lbs MLVSS
    Calculate F/M ratio:
    1,376.1 lbs BOD in Influent ÷ 3,502.8 lbs MLVSS in basin = 0.39 F/M

12. Formula used: *Weir Overflow rate, GPD/ft = Flow, GPD ÷ Length of weir, ft*
    Convert flow in MGD to GPD:
    0.11 MGD x 1,000,000 = 110,000 gpd
    Calculate Weir Overflow Rata, GPD/ft:
    110,000 gpd ÷70 ft = 1,571.4 or 1,571 gpd/ft

13. Formula used: *Detention Time, Days = Volume, MG ÷ Flow, MGD*
    Calculate the volume of the tank in MG:
    Volume = 45 ft x 90 ft x 15 ft = 60,750 ft^3 x 7.48 gal/ft^3 = 454,410 gal ÷ 1,000,000 = 0.454 MG
    Calculate detention time:
    0.454 MG ÷ 0.2 MGD = 2.27 days

14. Formula used:
    Sludge Age = Lbs of MLSS in Aeration basin ÷ Lbs/day of TSS in Influent
    Calculate sludge age:
    Sludge Age = 51,500 lbs of MLSS ÷ 1,960 lbs of TSS/day in influent = 26.27 or 26.3 Days

15. Formula used: *Population x lbs of phosphorous a person contribute per day*
    Calculate lbs of phosphorous:
    185,000 x 0.0048 lbs of phosphorus / person / day = 888 lbs/day

16. First calculate the pounds of BOD the plant receives daily:
    Lbs BOD = 235 x 8.34 x 2.5 MGD = 4,899.75
    Find the number of ft^3 in the plant:
    2.5 MG x 1,000,000 = 2,500,000 gallons ÷ 7.48 gal/ft^3 = 334,224.6 ft^3
    Find the number of 1,000 ft^3 units:
    334,224.6 ft^3 ÷ 1000 = $334.22_{1000\ ft^3}$
    Find lbs BOD per 1000 ft^3:
    4,899.75 lbs BOD ÷ $334.22_{1000\ ft^3}$ = 14.66 lbs BOD / 1000 ft^3

17. Calculate the volume of sludge pumped in gallons:
    Convert inches to feet: 18/12=1.5 ft
    2 beds x 45 ft x 80 ft x 1.5 ft = 10,800 ft^3 x 7.48 gal/ft^3 = 80,784 gallons

    Calculate the time in minutes it took to fill the beds and divide gallon by minutes to get pump rate:
    2 hours = 2 x 60 min = 120 minutes + 45 minutes = 165 minutes
    80,784 ÷165 minutes = 489.6 gpm

18. First calculate the Oxygen Uptake Rate (OUR):
    $$OUR = \frac{(DO_1 - DO_2)}{(Time_2 - Time_1)} \times 60 = \frac{(8.9 - 5.2)}{3\ Min} \times 60 = \frac{3.7}{3} \times 60 = 1.233 \times 60 = 74$$

    Calculate SOUR:
    $$SOUR = \frac{OUR}{MLVSS\ mg/L} \times 1000 = \frac{74}{1{,}760} \times 1000 = 0.042 \times 1000 = 42.0\ mg/m\ VSS/hr$$

19. Formula used:
    Sludge volume index (SVI), mg/L) = (SSV30,ml/ L× 1,000 mg/g) ÷ (MLSS, mg/L)
    SVI = (295 ml/L x 1,000 mg/g) ÷ 3,640 mg/l = 295,000 ÷ 3640 = 81 mg/L

20. Formula used: *Hydraulic loading gpd/ft^2= Flow , gpd/ Surface area , ft^2*
    Calculate surface area of clarifiers:
    0.785 x 65 ft x 65 ft = 3,319.625 ft^2
    Divide flow, gpd by the surface area of the tank:
    Hydraulic Loading Rate = 890,000 gpd ÷ 3,319.625 ft^2= 268.3 gpd / ft^2

Class III & IV Solved Equations

21. Calculate how many 1000 lb units of TSS are removed per year:
    Lbs = 190 mg/L x 8.34 x 4.9 MGD = 7,764.54 lb/day x 365 day/yr = 2,834,057.1 lb/yr
    2,834,057.1 ÷ 1000 = 2,834.06 1,000 lb units
    Divide cost per year by number of 1,000 lb units:
    $68,250 ÷ 2,834.06 1000 lb units = $24.08 per 1000 pounds removed

22. First calculate lb of BOD received each day:
    BOD = 275 mg/L x 8.34 x 1.75 MGD = 4,013.6 lbs
    Calculate pounds not removed by the clarifier:
    4,013.6 lbs x 0.75 = 3,010.2 lbs make it to the aerator

    For every 40 lbs of BOD, 100 lbs of MLVSS is needed so calculate how many 40 lb units of BOD are present and multiplying that number by 100 to get lbs of MLVSS needed:
    3,010.2 ÷ 40 = 75.255 x 100 = 7,525.5 lbs of MLVSS are needed

23. Calculate the diameter of the tank and then calculate the circumference (length of weir):
    Diameter equal 2 x 22.5 ft = 45 ft
    Circumference = 45 ft x 3.14 = 141.3 ft
    Calculate flow in gallons per day:
    165 gpm x 1440 min/day = 237,600 gpd
    Divide gpd by the length of weir to get Weir Overflow Rate:
    237,600 ÷ 141.3 ft = 1,681.5 gpd/ft or weir

24. Formula used: *Detention Time (Hrs) = (tank vol,ft^3 × 7.48 gal/ft^3 × 24 hrs/day) ÷ (flow, gpd)*
    Calculate the tank size in ft^3 then in gallons and the flow in gpd:
    Tank, ft^3 = 2 x 0.785 x 60 x 60 ft x 10 = 56,520 ft^3 x 7.48 gal/ft^3 = 422,749.6 gal
    Flow, gpd = 12.2 ft^3/ sec x 448.8 gpm = 5475.36 gpm x 1440 min / day = 7,884,518.4 gpd

    Calculate detention time, hrs:
    Detention time, hrs = (422,769.6 gallon x 24 hr) ÷ 7,884,384.4 gpd = 10,146,470.4 ÷ 7,884,384.4 = 1.28 or 1.3 hrs

25. Calculate pounds of MLSS in the aeration basin:
    3,450 mg/L x 8.34 x 2.5 MG = 71,932.5 lbs MLSS
    Calculate the pounds of MLSS if sludge age was 19 days:
    210 mg/L x 8.34 x 1.95 = 3,415.23 x 19 days = 64,889.4 lbs MLSS at 19 day sludge age
    Calculate the number of pounds that would need to be wasted:
    71,932.5 – 64,889.4 = 7043.1 lbs wasted
    Calculate gallons to be wasted at 1.35% (13,500 mg/l) concentration:
    Flow = 7043.1 ÷ (13,500 mg/L x 8.34) = 7043.1 ÷ 112,590 = 0.06255 MGD
    0.06255 MGD x 1,000,000 = 62,550 gallons that need to be wasted

26. Formula used: $MCRT, Days = \frac{lbs\ of\ MLSS\ in\ aeration\ basin}{(lbs\ sludge\ wasted + lbs\ TSS\ lost\ over\ weir)}$

    Calculate the three pounds formulae needed:
    lbs MLSS = 2,980 mg/L x 8.34 x 2.6 MG = 64,618.32 lb MLSS
    lbs wasted = 7,000 mg/L x 8.34 x 0.0495 MG = 2,889.81 lbs wasted
    lbs TSS lost = 12.5 mg/l x 8.34 x 1.5 MGD = 156.38 lb TSS lost

    Now calculate the MCRT:
    MCRT, days = 64,618.32 lbs ÷ (2,889.81 lbs + 156.38 lbs)
    MCRT, days = 64,618.32 lbs ÷ 3,046.19 lbs = 21.2 or 21 days

27. Uses same formulae as #26. Just replace the numbers.
    Calculate the three pounds formulae needed:
    lbs MLSS = 3,600 mg/l x 8.34 x 1.7 MG = 51,040.8 lbs MLSS
    lbs wasted = 11,200 mg/l x 8.34 x 0.0653 MGD = 6,099.54 lbs wasted
    lbs TSS lost – 12.6 mg/L x 8.34 x 1.2 MGD = 126.1 lbs TSS lost

    Now calculate the MCRT:
    MCRT, days = 51,040.8 lbs ÷ (6,099.54 lbs + 126.1 lbs)
    MCRT, days = 51,040.8 lbs ÷ 6,225.64 lbs = 8.19 or 8.2 days

28. Uses the same formulae as # 26. Just replace the numbers.
    Calculate the three pounds formulae needed:
    lbs MLSS = 2,900 mg/l x 8.34 x 1.1 MG = 26,604.6 lbs MLSS
    lbs wasted = 9,000 mg/L x 8.34 x 0.012 MG = 900.72 lbs wasted
    lbs TSS lost = 18 mg/L x 8.34 x 0.82 MGD = 123.1 lbs TSS lost

    Now calculate the MCRT:
    MCRT, days = 26,604.6 lb ÷ (900.72 lb + 123.1 lb)
    MCRT, days = 26,604.6 lb ÷ 1,023.82 lb = 25.9 days

29. First calculate the lbs of BOD entering the system:
    lbs BOD = 255 ppm x 8.34 x 1.3 MGD = 2,764.71 lbs BOD
    Calculate the number of ft^2 of plastic media in the filter:
    Volume of filter, ft^3 = 0.785 x 65 x 65 x 7 = 23,216.38 ft^3
    Area of plastic media, ft^2 = 23,216.38 ft^3 x 24 ft^2/ft^3 = 557,193.12 ft^2
    # of 1000 ft^2 units = 557,193.12 ft^2 ÷ 1000 = 557.19 1000 ft^2 units
    Organic Loading, lb BOD/1000 ft^2 = 2,764.71 lbs BOD ÷ 557.19 1000 ft^2 units = 4.96

30. First calculate the pounds of BOD entering the filter after the Flow is converted to MGD:
    Flow, MGD = 2,140 gpm ÷ 694.5 gpm/MGD = 3.08 MGD
    lbs BOD = 190 mg/L x 8.34 x 3.08 MGD = 4,880.57 lbs
    Calculate the volume of the trickling filter in ft^3:
    Volume of filter, ft^3 = 0.785 120 x 120 x 7 = 79,128 ft^3
    Calculate the number of 1000 ft^3 units in the filter:
    # 1000 ft^3 units = 79,128 ft^3 ÷ 1,000 = 79.13 1000 ft^3 units
    Organic loading, lb BOD/1000 ft^3 units = 4,880.57 ÷ 79.13 = 61.68 lbs BOD / 1000 ft^3

31. This formula is the same as what's used in Class 1 & 2 #18:
    Calculate the Oxygen Uptake Rate (OUR):
    OUR = (7.9 mg/l – 5.2 mg/l) ÷ 5 min = 2.7 ÷ 5 = 0.54 x 60 = 32.4
    Calculate the Specific Oxygen Uptake Rate (SOUR):
    SOUR = (32.4 x 1000) ÷ 1,960 mg/l = 332,400 ÷ 1,960 = 16.53 or 16.5 mg/g VSS/hr

32. Formula used:
    MLSS Suspended solids, mg/L = ((W2-W1) / (ml sample) × 1,000 × 1,000)
    Where, W1 = Dish W2 = Dish & Dry Solids W3 = Dish & Ash
    Mg/L MLSS = (15.2456 g – 15.2153 g) ÷ 25 ml = 0.0303 ÷ 25 = 0.001212 = 0.001212 x 1000 x 1000 = 1,212 mg/L

33. Formula used:
Sludge volume index (SVI), mg/L = ((SSV30, mL × 1,000 mg/g)) ÷ (MLSS, mg/L))
SVI = (420 ml/L x 1,000 mg/g) ÷ 2,950 mg/L
SVI = 420,000 ÷ 2,950 = 142.37 or 142 ml/mg

34. Calculate the number of pounds contributed by Industry:
Industrial Contribution, lbs = 2500 lbs TSS x 0.15 (15%) = 375 lbs
Calculate the population equivalent of the industrial contribution:
Population Equivalent = 375 lbs ÷ 0.20 lbs/person = 1,875 people

35. Calculate the surface area of the tank:
15 ft x 12 ft = 180 ft^2
Convert flow from GPM to MGD – 55 gpm ÷ 694.5 gpm/MGD = 0.079 MGD
Calculate pounds of sludge per day:
7500 mg/L x 8.34 x 0.079 = 4,941.45 lbs/day
Calculate pounds of sludge per hour:
7,941.45 lbs/day ÷ 24 hr/day = 205.89 lbs/hr
Calculate sludge loading rate:
205.89 lbs/hr ÷ 180 ft^2 = 1.14 lbs/hr/ft^2

36. Calculate the surface area of the clarifier:
0.785 x 60 ft x 60 ft = 2,826 ft^2
Calculate the total flow to the clarifier:
1.2 MGD + (1.2 MGD x 0.80) = 1.2 MGD + 0.96 MGD = 2.16 MGD
Calculate pounds of sludge per day:
2,550 mg/L x 8.34 x 2.16 MGD = 45,936.72 lbs/day
Calculate sludge loading rate:
45,936.72 lbs/day ÷ 2,826 ft^2 = 16.26 or 16.3 lbs/day/ft^2

37. Formula used: *% VS reduction = (in - out) ÷ (in - (in × out)) × 100*
Convert % to decimal by dividing and use decimal in equation.
% Reduction (VS) = (0.63 – 0.495) ÷ ((0.63 – (0.63 x 0.495)) x 100
% Reduction (VS) = (0.135 ÷ (0.63 – 0.312)) x100 = (0.135 ÷ 0.318) x 100
% Reduction (VS) = 0.424 x 100 = 42.4 or 42%

38. Use the same Formula as last problem and same conversion of % to decimal.
    % Reduction (VS) = (0.557 – 0.426) ÷ ((0.557 – (0.557 x 0.426) x 100
    % Reduction (VS) = (0.0.131 ÷ (0.557 – 0.237)) x100 = (0.131 ÷ 0.32) x 100
    % Reduction (VS) = 0.409 x 100 = 40.9 or 41%

39. Formula used:
    Digester loading, lbs⁄day/ft^3 = (VS added, lbs⁄day) / (digester vol, ft^3))
    Calculate pounds of VS loaded:
    21,000 mg/l x 8.34 x 0.0102 MGD x 0.62 (62% VS) =1,107.59 lbs
    Calculate digester volume in ft^3 = 65,000 gal ÷ 7.48 ft3 / gal = 8,689.84 ft^3
    Calculate VS loading = 1,107.59 lbs VS ÷ 8,689.84 ft^3 = 0.127 or 0.13 lbs VSS/ft^3

Questions or Concerns?

The Kentucky Operator Certification Program provides training and issues certifications to ensure that individuals engaged in performing many of Kentucky's critical environmental activities are qualified and capable to perform their duties. DCA staff are available to provide on-site assistance and training.

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