Bassett Adult School
Career Training Center

Water Technology

Wastewater Treatment

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Contents

1. Constituents Properties and Analysis Assessmen

Constituents Properties and Analysis Assessment

1. Positive ORP indicates the presence of an _____ environment
2. _____ is the predominant microorganism responsible for biological wastewater treatment processes
3. MPN is a statistics based method to estimate the concentration of viable bacteria is wastewater and it stands for _____
4. Describe the three types of composite sampling and explain in your own words on how the sampling would be conducted for each of those methods
5. Alkalinity helps in _____control when organic acids are formed as a result of microbiological activity
6. Nitrogen in wastewater is typically present as _____ and _____
7. Volatile solids is determined by incinerating the solids at _____ deg. C in a _____
8. What would be the expected BOD concentration in the wastewater if per capita (person) generation is 0.15lb BOD per day per person and each person produces 80 gallons per day?
   (Hint: The answer is going to be in mg BOD/l. So multiply lb per day per person by the inverse of dallons per day - so that the unit is lbs per gallon and then convert that to mg/l)
9. Describe the three types of composite sampling and explain in your own words on how the sampling would be conducted for each of those methods
10. tBOD = ___BOD + ___BOD
11. BOD stands for
12. Alkalinity helps in Nderlinehspace1cm control when organic acids are formed as a result

of microbiological activity

13. Nitrogen in wastewater is typically present as _____ and _____
14. Volatile solids is determined by incinerating the solids at _____ [temp] deg. C in a _____ [equipment]
15. How does one estimate the wastewater sample size used for BOD testing
16. Explain how is the nBOD quantified
17. Explain why coliforms and enterococcus are used for wastewater bacteriological testing
18. What is MPN and why is it used.
19. Explain the steps involved in the MTF method
20. What is the difference between volatile solids (VS) and volatile suspended solids (VSS)
21. Solids that can be used as food by microorganisms
22. Test method for determining total ammonium and organic nitrogen content: ___
23. Inorganic solids are also called ___
24. Oxygen in an anoxic environment is present as _____
25. Conductivity is the measure of _____ solids
26. Negative ORP signifies _____ environment
27. Alkalinity helps in ___ control when organic acids are formed as a result of microbiological activity
28. An Imhoff cone is often used to measure the effectiveness of primary sedimentation.
    a. True
    *b. False
29. At a primarily domestic wastewater treatment plant, the influent wastewater BOD is always greater than its chemical oxygen demand.
    a. True
    *b. False
30. Dissolved oxygen in wastewater usually is referred to as combined oxygen.
    a. True
    *b. False
31. Domestic wastewater generally contains only about 0.1
    *a. True
    b. False
32. Grab or composite samples may be used interchangeable, whichever is most convenient and safest for all laboratory tests.
    a. True
    *b. False
33. Wastewater with a pH of 12.0 to 14.0 would be too "acidic" for biological treatment.
    *a. True
    b. False
34. Pre-aeration improves settleability in primary clarifier
    *a. True

b. False

35. Total solids are made up of dissolved and suspended solids both of which contain organic and inorganic matter

*a. True

b. False

36. pH value less than 7 indicates an alkaline or basic condition

a. True

*b. False

37. Conductivity is a very useful test for assessing sea water intrusion into sewer lines

*a. True

b. False

38. Sample obtained for wastewater bacteriological testing is typically a composite sample

a. True

*b. False

39. Samples collected for the analysis of COD, BOD, and pH should be acidified for preservation.

a. True

*b. False

40. The MPN test is used to measure pathogen concentrations in wastewater.

a. True

*b. False

41. The total solids in wastewater would be the combination of the fixed solids and the settleable solids.

a. True

*b. False

42. Wastewater with a pH of 2.0 to 4.0 would be too "basic" for biological treatment.

a. True

*b. False

43. Match the measurement units for each of the following:

44. The MPN test measures the number of pathogens in a wastewater sample

a. True

*b. False

45. The values of organic matter present in wastewater as measured by BOD and COD tests are typically almost identical

a. True

*b. False

46. In order to obtain valid results in coliform testing, the sample must be dechlorinated at the time of its collection.

*a. True

b. False

47. A flow of 100 gallons per capita per day is often used for estimating flow into a wastewater treatment plant.
    *a. True
    b. False
48. An Imhoff cone is used to measure settleable solids in units of mg/l.
    a. True
    *b. False
49. A standardized method exists for the measurement of floatable solids.
    a. True
    *b. False
50. In the test for coliform bacteria, samples are incubated for 5 days at 20 deg. C.
    a. True
    *b. False
51. Coliform group organisms are found only in wastewater.
    a. True
    *b. False
52. Where highly colored samples are involved, the determination of pH by use of a pH meter rather than by color-comparison is
    preferred.
    *a. True
    b. False
53. What comes into a treatment plant must go out. This is the basis of the solids balance concept.
    *a. True
    b. False
54. Receiving water measurements are used to determine the effect of the plant's waste discharge on the receiving waters; therefore, it is necessary to measure both stream and plant effluent characteristics.
    *a. True
    b. False
55. There are two types of samples that may be collected. One is called an integrated sample, and the other is referred to as a composite.
    a. True
    *b. False
56. Coliform testing is typically conducted on a grab sample
    *a. True
    b. False
57. Typical domestic wastewater BOD content is about 2000mg/l
    a. True
    *b. False

58. BOD is a measure of the organic content of wastewater
    *a. True
    b. False
59. ORP measurements can be used for controlling the disinfection process
    *a. True
    b. False
60. MPN is used for enumerating wastewater bacteria and it stands for Measured Pathogen Number
    a. True
    *b. False
61. For measuring dissolved oxygen in wastewater, it is advisable to use a composite sample
    *a. True
    b. False
62. A sample to be used for pH measurements should be preserved by the addition of an acid prior to its analysis in the laboratory
    a. True
    *b. False
63. BOD is a measure of the organic content of wastewater and it stands for Biological Oxidation Demand
    a. True
    *b. False
64. Conductivity is measured in the units of millivolts using an electrochemical probe
    a. True
    *b. False
65. Conductivity measurements provide an indirect way to measure total solids present in wastewater
    a. True
    *b. False
66. Typical wastewater TSS concentrations are in the 2,000-2,500 mg/l range
    a. True
    *b. False
67. A 24-hr flow proportioned sample may be collected for a fecal coliform test
    a. True
    *b. False
68. Wastewater with a pH of 12.0 to 14.0 would be too "acidic" for biological treatment.
    *a. True
    b. False
69. The laboratory measurement of volatile solids is a fair approximation of the organic content of the wastewater.
    *a. True

b. False

70. BOD5 and SS are both used to measure the strength of wastewater

*a. True

b. False

71. Pre-aeration improves settleability in primary clarifier

*a. True

b. False

72. pH value less than 7 indicates an alkaline or basic condition

a. True

*b. False

73. A BOD test is run on a secondary effluent. The data for this test are given below. Assuming that the average BOD test result for an "inhibitor" on this same secondary effluent was 22 mg/L (cBOD), calculate the oxygen demand caused by nitrification. What percentage of the total BOD is the nitrogenous oxygen demand? On April 04, 2009 Exam

$SampleVolume, ml$	50	75	$Blank$
$InitialDO, mg/l$	9.0	8.9	9.2
$FinalDO, mg/l$	3.5	1.2	9.0

- Solution:

$Difference, mg/l$	5.5	7.7	9.0
$tBOD, mg/l$	$5.5*300/50 = 33$	$7.7*300/75 = 30.8$	

Average: $\frac{(33+30.8)}{2} = 31.9\frac{mg}{l}$
$tBOD = cBOD + nBOD \implies 31.9 = 22 \ + \ nBOD \implies nBOD = 9.9$
$\%nBOD = 9.9/31.9*100 = \boxed{31\%}$

74. BOD tests are run on the final effluent from an activated sludge plant with and without the use of a "nitrification inhibitor". Three hundred milliliter bottles (300 ml) are used in these tests. The raw data for these tests are presented below. What is the average NITROGENOUS BOD (NBOD)? Exam on April 04, 2009
BOD Test without "inhibitor" (tBOD)

$SampleVolume, ml$	30	60	$Blank$
$InitialDO, mg/l$	9.0	8.7	9.1
$FinalDO, mg/l$	5.1	1.2	9.0

BOD Test with "inhibitor" added (cBOD)

$SampleVolume, ml$	30	60	$Blank$
$InitialDO, mg/l$	9.0	8.7	9.1
$FinalDO, mg/l$	6.5	3.5	9.0

- Solution:

$tBOD$			
$Diff., mg/l$	3.9	7.5	0.1
$tBOD, mg/l$	$3.9*300/30 = 39$	$7.5*300/60 = 37.5$	
$cBOD$			
$Diff., mg/l$	2.5	5.2	0.1
$tBOD, mg/l$	$2.5*300/30 = 25$	$5.2*300/60 = 26$	

Average:
tBOD: $\frac{(39+37.5)}{2} = 38.3\frac{mg}{l}$
cBOD: $\frac{(25+26)}{2} = 25.5\frac{mg}{l}$
$tBOD = cBOD + nBOD \implies 38.3 = 25.5 + nBOD \implies nBOD = \boxed{12.8\frac{mg}{l}}$

75. Calculate the TSS of the secondary effluent given the following:

Sample volume	41 ml
Tare weight of filter sample	1.4604 gm
Filter + dried residue	1.4722 gm

76. The technician quickly pours 41 ml of well mixed influent into the filter funnel. The tare weight of the filter is 1.4604 gm. After rinsing, drying, cooling, and weighing, the first dry weight is 1.4722 gm. The filter is returned to the oven and dried, cooled, and weighed. The second dry weight is 1.4700 gm. Calculate the TSS.
    - Solution
    $\frac{(1.4722-1.4604)gm \quad TSS}{41ml} * 1000\frac{mg}{gm} * \frac{1000ml}{l} = \boxed{288\frac{mg}{l}}$

77. BOD tests are run on the final effluent from an activated sludge plant with and without the use of a "nitrification inhibitor". Three hundred milliliter bottles (300 ml) are used in these tests. The raw data for these tests are presented below. What **percentage of the average total BOD is the average nBOD**? (10 points)

$SampleVolume, ml$	10	20	30	40	$Blank$
$InitialDO, mg/l$	9.0	8.9	8.8	9.1	9.1
$FinalDO, mg/l$	6.9	4.8	2.5	1.1	9.0

BOD Test with "inhibitor" added (cBOD)

$SampleVolume, ml$	10	20	30	40	$Blank$
$InitialDO, mg/l$	8.9	8.9	9.0	9.0	9.1
$FinalDO, mg/l$	7.5	6.2	5.0	3.3	9.0

Solution:

$tBODDiff., mg/l$	2.1	4.1	6.3	8
$tBOD, mg/l$	$2.1*300/10 = 63.0$	$4.1*300/20 = 61.5$	$6.3*300/30 = 63.0$	$8.0*300/40 = 60.0$
$cBODDiff., mg/l$	1.4	2.7	4.0	5.7
$cBOD, mg/l$	$[Discard - diff. < 2]$	$2.7*300/20 = 40.5$	$4.0*300/30 = 40$	$5.7*300/40 = 42.8$

$tBOD(avg) = 63 + 61.5 + 63 + 60 = 61.9$ $\quad$ $cBOD(avg) = 40.5 + 40 + 42.75 = 41.1$

nBOD = tBOD - cBOD $\Longrightarrow$ nBOD = 61.9-41.1=20.8 $\Longrightarrow$ nBOD(%)=20.8/61.9*100=$\boxed{33.6\%}$

78. BOD tests are run on the final effluent from an activated sludge plant with and without the use of a "nitrification inhibitor". Three hundred milliliter bottles (300 ml) are used in these tests. The raw data for these tests are presented below. What is the average NITROGENOUS BOD (NBOD)? Exam on April 04, 2009
BOD Test without "inhibitor" (tBOD)

$SampleVolume, ml$	30	60	$Blank$
$InitialDO, mg/l$	9.0	8.7	9.1
$FinalDO, mg/l$	5.1	1.2	9.0

BOD Test with "inhibitor" added (cBOD)

$SampleVolume, ml$	30	60	$Blank$
$InitialDO, mg/l$	9.0	8.7	9.1
$FinalDO, mg/l$	6.5	3.5	9.0

Solution:

$tBOD$			
$Diff., mg/l$	3.9	7.5	0.1
$tBOD, mg/l$	$3.9*300/30 = 39$	$7.5*300/60 = 37.5$	
$cBOD$			
$Diff., mg/l$	2.5	5.2	0.1
$tBOD, mg/l$	$2.5*300/30 = 25$	$5.2*300/60 = 26$	

Average:
tBOD: $\frac{(39+37.5)}{2} = 38.3\frac{mg}{l}$
cBOD: $\frac{(25+26)}{2} = 25.5\frac{mg}{l}$
$tBOD = cBOD + nBOD \implies 38.3 = 25.5 + nBOD \implies nBOD = \boxed{12.8\frac{mg}{l}}$

79. Calculate percent total solids and percent volatile solids of a sludge sample given the following data:

Weight of dish	=	104.55 gms
Weight of dish and wet sludge	=	199.95 gms
Weight of dish and dry sludge	=	108.34 gms
Weight of dish and ash	=	106.37 gms

(Answer: TS = 3.97%. VS = 52%)

Solution:

Weight of dish=104.55 gms

Weight of dish and wet sludge=199.95 gms

Weight of dish and ash = 106.37 gms

$$\Longrightarrow Weight\ \ of\ \ sludge = 199.95 - 104.55 = 95.40\ \ gms$$

$$\Longrightarrow Weight\ \ of\ \ dry\ \ sludge\ \ (solids) = 108.34 - 104.55 = 3.79\ \ gms$$

$$\Longrightarrow Weight\ \ of\ \ volatile\ \ solids = 108.34 - 106.37 = 1.97\ \ gms$$

$$Total\ \ solids(TS\%) = \frac{gms\ \ solids}{100\ \ gms\ \ sludge} = \frac{3.79}{95.40}\ \ \frac{gms\ \ solids}{\cancel{gms\ \ sludge}} * \frac{100\ \ \cancel{gms\ \ sludge}}{100\ \ gms\ \ sludge} = \boxed{3.97\%}$$

$$Total\ \ volatile\ \ solids(VS\%) = \frac{1.97}{3.79}\ \ \frac{gms\ \ volatile\ \ solids}{\cancel{gms\ \ total\ \ solids}} * \frac{100\ \ \cancel{gms\ \ total\ \ solids}}{100\ \ gms\ \ total\ \ solids} = \boxed{52.0\%}$$

80. What is percent volatile solids of a sludge sample given the following data:

Weight of dish	=	130.69 gms
Weight of dish and wet sludge	=	249.94 gms
Weight of dish and dry sludge	=	134.74 gms
Weight of dish and ash	=	132.05 gms

Solution:

Weight of dish=130.69 gms

Weight of dish and wet sludge=249.94 gms

Weight of dish and ash = 132.05 gms

$$\Longrightarrow Weight\ \ of\ \ sludge = 249.94 - 130.69 = 119.25\ \ gms$$

$$\Longrightarrow Weight\ \ of\ \ dry\ \ sludge\ \ (solids) = 134.74 - 130.69 = 4.05\ \ gms$$

$$\Longrightarrow Weight\ \ of\ \ volatile\ \ solids = 134.74 - 132.05 = 2.69\ \ gms$$

$$Total\ \ solids(TS\%) = \frac{gms\ \ solids}{100\ \ gms\ \ sludge} = \frac{4.05}{119.25}\ \ \frac{gms\ \ solids}{\cancel{gms\ \ sludge}} * \frac{100\ \ \cancel{gms\ \ sludge}}{100\ \ gms\ \ sludge} = \boxed{3.4\%}$$

$$Total\ \ volatile\ \ solids(VS\%) = \frac{2.69}{4.05}\ \ \frac{gms\ \ volatile\ \ solids}{\cancel{gms\ \ total\ \ solids}} * \frac{100\ \ \cancel{gms\ \ total\ \ solids}}{100\ \ gms\ \ total\ \ solids} = \boxed{66.4\%}$$

81. Products that are non-biodegradable will have _____ as compared with biodegradable products
    a. Same BOD
    *b. A lower BOD
    c. A higher BOD
    d. There is no relationship between BOD and biodegradability
82. Coliform bacteria are
    a. Algae
    b. Coagulant aids
    *c. Indicators
    d. Sequestering agents
83. What is percent volatile solids of a sludge sample given the following data:
    Weight of dish = 130.69 gms
    Weight of dish and wet sludge = 249.94 gms
    Weight of dish and dry sludge = 134.74 gms
    Weight of dish and ash = 132.05 gms
    *a. 38.3%
    b. 66.4%
    c. 42.6%
    d. 58.0%
84. What is percent volatile solids of a sludge sample given the following data:
    Weight of dish = 130.69 gms
    Weight of dish and wet sludge = 249.94 gms
    Weight of dish and dry sludge = 134.74 gms
    Weight of dish and ash = 132.05 gms
    *a. 38.3%
    b. 66.4%
    c. 42.6%
    d. 58.0%
85. A device called an Imhoff cone is commonly used to measure settleable solids in:
    a. %
    *b. mL/L
    c. mg/L
    d. ppm
    e. SVI units
86. An aerobic treatment process is one that requires the presence of:
    a. Ozone
    b. organic oxygen
    c. no oxygen
    d. combined oxygen

*e. dissolved oxygen

87. A pH probe:
    a. Can be used to measure ORP in chlorine disinfection.
    b. Is often used to measure hydrogen production in wet wells.
    c. Measures, in millivolts, the difference between oxidants like chlorine and reductants such as organic matter.
    *d. Measures hydrogen ion activity in wastewater.
    e. Sends a 4-20 mA signal directly to a chlorine controller.
88. Sludge solids in wastewater has an average specific gravity of 1.2; this means they are
    a. 12% heavier than water
    *b. 20% heavier than water
    c. 2% lighter than water
    d. 20% lighter than water
89. How should the pH electrode be stored when not in use:
    a. In a strong acid solution
    b. In a strong caustic solution
    c. In a safe place in a drawer
    *d. In distilled water
    e. In a detergent
90. In the normal Winkler test:
    a. A snow white precipitate forms in direct proportion to the nitrate concentration
    b. A brownish flocculant precipitate is evidence that D.O. is absent
    c. An endpoint is reached when a dark blue color changes to black
    d. The muffle furnace must be in excess of 500 deg. C before incubation
    *e. A snow white precipitate forms if DO is absent
91. Organisms in wastewater that are not harmful to humans but are indicators of diseases are:
    a. Pathogens
    b. Viruses
    *c. Coliform
    d. Bacteria
92. The typical range of suspended solids in domestic influent wastewater is:
    *a. 100-300 mg/L
    b. 400-600 mg/L
    c. 700-900 mg/L
    d. 1000-12000 mg/L
93. Which of the flowing statement(s) is/are true with regards to BOD
    i) BOD test results are suitable for quickly establishing process efficiencies
    ii) BOD value is always greater than the COD value of the same wastewater sample
    iii) BOD is expressed in mg/ L or in ppm
    iv) BOD is the measure of organic strength

v) BOD stands for biological oxygen demand

a. i) & ii)

b. i), ii) & iv)

c. i), iv) & v)

*d. iii) & iv)

e. iii), iv) & v)

94. An amperometric titrater is used to measure

a. Alkalinity

*b. Chlorine residual

c. Conductivity

d. COD.

95. Which of these pH readings indicates an acidic wastewater?

*a. 3

b. 7

c. 9

d. 12

96. Which of the following conditions will probably cause the greatest change in pH?

a. Buffering sample

*b. Exposing sample to atmosphere

c. Fixing sample

d. Refrigerating sample

97. Nderlinehspace1cm matter in wastewater, is normally composed of grit, sand and silt.

a. Colloidal

*b. Inorganic

c. Organic

d. Volatile

98. Which of the following characteristics would be least helpful to an operator assessing the organic loading on his plant?

a. solids concentration

b. BOD

c. COD

*d. pH

e. nitrogen content

99. Pathogens

*a. Are bacteria or virus that cause disease.

b. Are bacteria which do not occur in water.

c. Can obtain their food supply without help.

d. Are not harmful to man.

100. Regarding the total coliform test which one of the following statements is TRUE?

a. If less than 2 coliforms per 100 mL are found in a secondary effluent, we can be assured

that we have destroyed all viruses and coliforms.

b. Total coliforms are monitored in wastewater because they are generally considered to be disease causing organisms.

c. Sodium thiosulfate should be added drop-wise after collection of a coliform sample to destroy residual chlorine.

*d. The multiple tube fermentation method for measuring total coliforms is only a statistical estimate of the coliform organism concentration.

101. Results from the Multiple-Tube Fermentation Technique for members of the Total Coliform Group are expressed as

a. DPD.

b. MF.

c. MGD.

*d. MPN.

102. The advantage in the use of coliform organisms as an indicator lies in the following fact:

a. They are found everywhere and they grow in common bacterial media

b. They are found everywhere and are readily killed by chlorine

*c. They are predominant bacteria associated with intestinal discharges and grow on nutrient agar forming characteristic colonies

103. The purpose of adding sodium thiosulfate to a microbiological sample bottle is to

a. Extend the allowable holding time from 6 to 30 hours.

b. React with nitrates that interfere with the MPN test.

*c. Remove any chlorine residual present.

d. To ensure sterilization of sample bottle.

104. The solids in a raw wastewater sample may be classified in several different categories. However, one may say that all the solids in a wastewater sample may be expressed as the sum of:

a. The total of settleable solids + total dissolved solids.

*b. The total dissolved solids + total suspended solids.

c. The total of settleable solids + colloidal solids + total suspended solids

105. The term MPN is used in reference to:

a. The mass of phosphorus and nitrogen per unit of carbon

*b. The number of coliforms per unit volume of sample that is most likely to have caused the observed results in a multiple tube test

c. The number of fecal stetococci per unit volume of sample that is most likely to have caused the observed results in the multiple tube test

d. The result of membrane filter test

e. The standard plate count result

106. The volatile portion of suspended solids contained in normal domestic wastewater could be expected to be in the range of

a. Less than 10 b. 25-50*c. 70-80d. 90-100

107. What disease is not considered to be normally conveyed or transmitted by untreated wastewater?
    a. Amoebic dysentery.
    b. Hepatitis.
    *c. Malaria.
    d. Chlorea.
108. What test is not run on the influent?
    a. BOD.
    *b. Fecal coliform.
    c. Suspended solids.
    d. pH.
109. Which one of the following statements is TRUE regarding the standard BOD5 test?
    a. Some NPDES permits specify that only CBOD is to be reported on a wastewater plant's final effluent. The letters CBOD refer to complete BOD (i.e the TOTAL BOD).
    b. Phenylarsineoxide (PAD) is typically added to destroy nitrifying bacteria when running this test.
    c. Dechlorinated secondary effluents need not be seeded when set up for the BODs test.
    d. Nitrate ions interfere with this test
    *e. The BOD measured includes the nitrogenous BOD (nBOD).results due to the oxygen demand exerted by certain bacteria as they oxidize ammonia to nitrate ions.
110. A composite sample will provide a(an)
    a. Even color.
    b. High pH.
    c. Low solids sample.
    *d. Representative sample.
111. Flow proportionate composite samples are collected because:
    a. The waste characteristics are continually changing
    b. The flow is continually changing
    *c. The flow and waste characteristics are continually changing
    d. This requires less time than grab samples
    e. All of the above
112. Over a four-year period, the totalizing hour meter on an instrument air compressor had the following readings at the end of each year: 1st year - 9,763; 2nd year - 13,258; 3rd year - 20,071; and 4th year - 23,714 How many hours does the meter show the compressor ran during
    the third year?
    a. 349.5 hours
    b. 364.3 hours
    *c. 681.3 hours
    d. 830.2 hours

113. Grab sample is always collected for which of the following test
    a. BOD
    b. TSS
    *c. Coliform
    d. COD
    e. None of the above
114. Samples collected over several hours during the day and combined are known as:
    *a. Composite samples.
    b. Grab samples.
    c. Deep samples.
    d. Periodic samples.
115. Grab samples are considered to be representative of the
    a. Average daily condition at the sample location
    b. Average daily condition in the system
    c. System conditions for the two hours before and after the sample was taken
    *d. System condition at the time of the sample
116. Characteristics that should be measured immediately after the sample is collected are:
    a. Velocity and dissolved solids
    *b. Temperature, pH and DO
    c. TSS and BOD
    d. Hardness and alkalinity
117. A stilling well on the effluent side of a wastewater facility is:
    a. a chlorine injection concentrator
    b. an automatic sampler for coliform counts
    *c. a structure containing the float for a flow measuring device
    d. dry well side of a pump station
    e. a none of the above
118. The advantages of automatic sampling equipment are:
    a. elimination of human error inherent in manual sampl ing
    b. reduction of personnel requirements and cost
    c. allows for more frequent sampling
    d. collection of more representative samples
    *e. all of the above
119. In collecting a sample for a chlorine residual determination of the final effluent, the most suitable sampling point is:
    a. at the site of chlorine injection
    b. at the entrance to the chlorine contact chamber
    c. at the midpoint of the chlorine contact chamber
    d. at the exit side of the chlorinator
    *e. at the point of effluent discharge

120. The recommended minimum portion which should be collected for testing in sampling wastewater is: (Assume a grab sample)
    a. 10 ml
    b. 50 ml
    c. 10 0 ml
    d. 500 ml
    *e. 1,000 ml
121. A composite sample will give a(n)
    a. Even color
    b. High pH
    c. Instantaneous sample
    *d. Representative sample
122. Chlorine residual may be determined using the reagent
    *a. Diethyl-p-phenylenediamine (DPD)
    b. Ethylendiamine tetraacetic acid (EDTA)
    c. Polychlorinated biphenyls (PCB)
    d. Sodium thiosulfate (Na2S203)
123. BOD5 is the most common method to quantify the organic content in wastewater. Another method used is:
    a. Chemical oxygen demand
    b. Volatile solids analysis
    c. Total organic carbon
    *d. Any of the above
124. The laboratory test results on domestic raw sewage were: COD = 320 mg/1 BOD = 475 mg/1. The best interpretation would be:
    a. the raw wastewater had a high grease content
    b. the raw wastewater was septic
    *c. the laboratory results, as reported, were in error
    d. the sample was held too long before analysis
    e. the glass fiber filters used to run the test were contaminated
125. TKN is the measure of:
    a. Ammonia/Ammonium+Inorganic Nitrogen
    *b. Ammonia/Ammonium+Organic Nitrogen
    c. Nitrate+Nitrite+Organic Nitrogen
    d. Organic Nitrogen+Inorganic Nitrogen
126. Volatile solids concentration of sludge with 6
    *a. 42,000mg/l
    b. 70,000mg/l
    c. 42mg/l
    d. 700mg/l

127. Wastewater solids can be categorized as:
    a. Suspended+Fixed
    b. Dissolved+Volatile
    *c. Volatile+Fixed
    d. Volatile+Settleable
128. Non-settleable solids are composed of:
    a. Volatile +Dissolved
    b. Dissolved+Settleable
    c. Floatable + Suspended
    *d. Collodial + Floatable
129. Sludge with a specific gravity of 1.1 will weigh:
    a. 1.1lbs/gal
    b. 8.34lbs/gal
    *c. 9.17lbs/gal
    d. 7.58lbs/gal
130. A composite sample will provide a(an)
    a. Even color.
    b. High pH.
    c. Low solids sample.
    *d. Representative sample.
131. Bacteria which cause diseases in man are generally called:
    a. Mesophilic
    b. Facultative
    *c. Pathogenic
    d. Coliforms
132. How should the pH electrode be stored when not in use:
    a. In a strong acid solution
    b. In a strong caustic solution
    c. In a safe place in a drawer
    *d. In distilled water
    e. In a detergent
133. In the normal Winkler test:
    a. A snow white precipitate forms in direct proportion to the nitrate concentration
    b. A brownish flocculant precipitate is evidence that D.O. is absent
    c. An endpoint is reached when a dark blue color changes to black
    d. The muffle furnace must be in excess of 500 deg. C before incubation
    *e. A snow white precipitate forms if DO is absent
134. The typical range of suspended solids in domestic influent wastewater is:
    *a. 100-300 mg/L
    b. 400-600 mg/L

c. 700-900 mg/L

d. 1000-12000 mg/L

135. Which of the flowing statement(s) is/are true with regards to BOD

1) BOD test results are suitable for quickly establishing process efficiencies

2) BOD value is always greater than the COD value of the same wastewater sample

3) BOD is expressed in mg/ L or in ppm

4) BOD is the measure of organic strength

5) BOD stands for biological oxygen demand

a. 1) and 2)

b. 1), 2) & 4)

c. 1), 4) & 5)

*d. 3) & 4)

e. 3), 4) and 5)

136. Nderlinehspace1cm matter in wastewater, is normally composed of grit, sand and silt.

a. Colloidal

*b. Inorganic

c. Organic

d. Volatile

137. Pathogens

*a. Are bacteria or virus that cause disease.

b. Are bacteria which do not occur in water.

c. Can obtain their food supply without help.

d. Are not harmful to man.

138. Regarding the total coliform test which one of the following statements is TRUE?

a. If less than 2 coliforms per 100 mL are found in a secondary effluent, we can be assured that we have destroyed all viruses and coliforms.

b. Total coliforms are monitored in wastewater because they are generally considered to be disease causing organisms.

c. Sodium thiosulfate should be added drop-wise after collection of a coliform sample to destroy residual chlorine.

*d. The multiple tube fermentation method for measuring total coliforms is only a statistical estimate of the coliform organism concentration.

139. Results from the Multiple-Tube Fermentation Technique for members of the Total Coliform Group are expressed as

a. DPD.

b. MF.

c. MGD.

*d. MPN.

140. The advantage in the use of coliform organisms as an indicator lies in the following fact:

a. They are found everywhere and they grow in common bacterial media

b. They are found everywhere and are readily killed by chlorine

*c. They are predominant bacteria associated with intestinal discharges and grow on nutrient agar forming characteristic colonies

141. The purpose of adding sodium thiosulfate to a microbiological sample bottle is to

a. Extend the allowable holding time from 6 to 30 hours.

b. React with nitrates that interfere with the MPN test.

*c. Remove any chlorine residual present.

d. To ensure sterilization of sample bottle.

142. The term MPN is used in reference to:

a. The mass of phosphorus and nitrogen per unit of carbon

*b. The number of coliforms per unit volume of sample that is most likely to have caused the observed results in a multiple tube test

c. The number of fecal stetococci per unit volume of sample that is most likely to have caused the observed results in the multiple tube test

d. The result of membrane filter test

e. The standard plate count result

143. Describe total coliform & fecal coliform bacteria. What is the difference between the two? Describe the test procedures for both.

Response:

a *Describe total coliform & fecal coliform bacteria.*

- Coliform bacteria are a broad group of bacteria found in soil, water and other environments.
- Fecal coliform are coliforms which originate in the intestines of warm-blooded animals

b *What is the difference between the two?*

While total coliforms are found widely in different environments, fecal coliforms are typically found in the intestines of warm blooded animals and are indicators of fecal contamination.

c *Describe the test procedures for both.*

The Multiple Tube Fermentation method to estimate the quantity of both these microorganisms includes the following steps:

- Conducting a presumptive test by inoculating the sample in a set of 15 tubes containing Lauryl Tryptose Broth each containing an inverted Durham tube followed by incubation and observation of a positive result for each tube indicated by turbidity and presence of gas bubble.
- Conducting a confirmed test by innoculating each of the positive samples from the presumptive test into a tube containing BGB broth - for Total Coliform and EC Broth - for Fecal Coliform
- Conducting a completed test by streaking and incubating an agar plate with positives from the confirmed test followed by innoculating and incubating an

agar slant and nutrient broth with colonies from the agar plate.

144. What is ORP Response:

Oxidation is a chemical reaction in which electrons are gained by oxidizing agent and lost by the substance being oxidized. Electrons cause bonds to be broken in the organic matter thus destroying it.

Oxidation potential is the direct measure in millivolts of demand for chlorine; more chlorine increases oxidants potential more organic matter lowers oxidation potential.
Using ORP probe reduces amount of chlorine used for disinfection. Chlorine by-products are toxic cause problems in effluent toxicity test.

ORP (oxidation reduction potential) probes have been found to be effective in precisely

controlling chlorine disinfection as well as de-chlorination. An ORP probe measures directly the oxidation potential and compares (his measured potential to a set point (typically 540 mV). A 4-20 milliamp controller can be used to adjust the chlorine feed to use precisely the amount of chlorine needed for disinfection.

145. When chlorine is added to a wastewater effluent it is said to act as an oxidizing agent. Define oxidation. Explain how oxidation might be effective in disinfection of a wastewater effluent.

Response:

Oxidation is a chemical reaction in which electrons are gained by the oxidizing agent and lost by the substance being oxidized.
These lost electrons cause bonds to be broken in the organic matter (bacteria) and thus destroy it.

146. Define oxidation potential. Explain how (his potential changes in relationship to the addition of chlorine or the increase in organic material or bacteria in the wastewater.

Response:

Oxidation potential is a direct measure, in millivolts, of the potential for electron transfer to the oxidizing agent (chlorine).
More chlorine increases oxidation potential.
More organic material or bacteria lowers the oxidation potential.

147. One WWTP found that it was better able to meet its effluent toxicity limit when using an ORP probe. Identify and briefly explain one possible reason for this.

Response:

Using an ORP probe reduces significantly the amount of chlorine being used for disinfec-

tion.

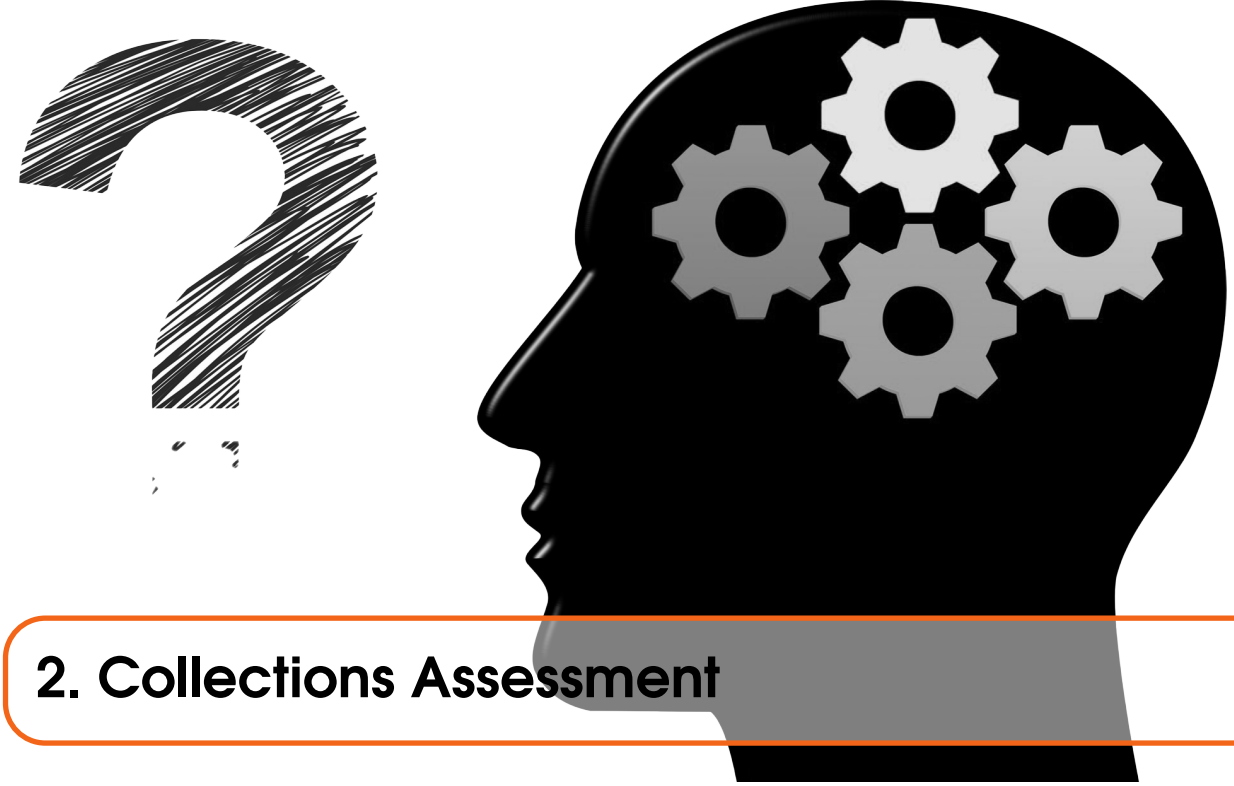
Chlorine by-products are often toxic and thus cause problems in the effluent toxicity test (bioassay test).

Reducing the chlorine used may make it easier to meet the toxicity limit.

148. An ORP probe must be place several minutes downstream of the point where chlorine is added in a chlorine contact tank. Why? Identify the data and conversion factor(s) necessary to calculate where an ORP probe is to be placed. Assume that at peak dry flow (he probe is to be placed 5 minutes downstream of the point where chlorine is added. Show the steps necessary to do this calculation.

    Response:

    Reactions with ammonia-nitrogen are not instantaneous. Thus, sometime between the point of addition of chlorine and the site of the ORP probe to allow these reactions to be complete. Data needed to calculate position of the probe: Peak Flow (MGD), the conversion factor = MGD = 1.547 cu. ft. / sec., the width of the chlorine contact chamber, the depth of the water in the chlorine contact chamber (so that the cross-sectional area of the flow can be calculated), 60 sec = 1 minute.
    1. Find the velocity of flow (ft/sec): Q at peak x 1.547 cu. ft./sec divided by cross-sectional area in ft2. 2. Convert velocity (ft/sec) to ft/min = ft/sec x 60 sec/min = ft/min 3. Multiply ft/min x 5 min to find ft.



2. Collections Assessment

Collections Assessment

1. Hydrogen sulfide gas in a moist atmosphere can result in corrosion of concrete structures
   *a. True
   b. False
2. As a rule of thumb, the velocity in a gravity sewer should be at least 2 cubic feet per second to ensure that the solids do not settle out in the sewer lines
   a. True
   *b. False
3. A combined sewer implies that it carries domestic and industrial wastes only
   a. True
   *b. False
4. Hydrogen sulfide gas in a moist atmosphere can result in corrosion of concrete structures
   *a. True
   b. False
5. Inflow is storm water entering into the sewer system
   *a. True
   b. False
6. A combined wastewater collection system handles only domestic waste and industrial waste.
   a. True
   *b. False
7. Fats, oils and grease accumulation in sewers can cause sewer overflows

*a. True

b. False

8. Storms could potentially cause sewer overflows in a Combined Sewer system

*a. True

b. False

9. Groundwater entering sewer collection pipes through cracks and defective pipe joints is termed as inflow

a. True

*b. False

10. A Combined sewer system is the one that brings the combined domestic and industrial wastewater flow to the treatment plant

a. True

*b. False

11. Infiltration is when groundwater enters the sewage collections systems

*a. True

b. False

12. Infiltration is when groundwater enters the sewage collections systems

*a. True

b. False

13. As a rule of thumb, the velocity in a gravity sewer should be at least 2 cubic feet per second to ensure that the solids do not settle out in the sewer lines

a. True

*b. False

14. A combined sewer implies that it carries domestic and industrial wastes only

a. True

*b. False

15. Hydrogen sulfide gas in a moist atmosphere can result in corrosion of concrete structures

*a. True

b. False

16. Inflow is storm water entering into the sewer system

*a. True

b. False

17. A lateral is the largest sewer line which brings the wastewater to the treatment plant

a. True

*b. False

18. Hydrogen sulfide gas in a moist atmosphere can result in corrosion of concrete structures

*a. True

b. False

19. As a rule of thumb, the velocity in a gravity sewer should be at least 2 cubic feet per second to ensure that the solids do not settle out in the sewer lines

a. True

*b. False

20. A combined sewer implies that it carries domestic and industrial wastes only

a. True

*b. False

21. Hydrogen sulfide gas in a moist atmosphere can result in corrosion of concrete structures

*a. True

b. False

22. Inflow is storm water entering into the sewer system

*a. True

b. False

23. A combined wastewater collection system handles only domestic waste and industrial waste.

a. True

*b. False

24. Fats, oils and grease accumulation in sewers can cause sewer overflows

*a. True

b. False

25. Storms could potentially cause sewer overflows in a Combined Sewer system

*a. True

b. False

26. Groundwater entering sewer collection pipes through cracks and defective pipe joints is termed as inflow

a. True

*b. False

27. A Combined sewer system is the one that brings the combined domestic and industrial wastewater flow to the treatment plant

a. True

*b. False

28. Infiltration is when groundwater enters the sewage collections systems

*a. True

b. False

29. Define Infiltration and Inflow. Discuss the impact of inflow and infiltration on the wastewater treatment plant:

30. In wastewater collections what is a gravity system:

31. A sewer system designed to transport only wastewater from homes, industries, institutions and businesses is called:

a. Combined sewer

*b. Sanitary sewer

c. Service sewer

d. Building sewer

32. Velocity of sewers is usually expressed as:
    *a. Feet per second
    b. Gallon per minute
    c. MGD
    d. mg/l
    e. sq. ft
33. Which of the following statements is not true regarding a wastewater collection system:
    *a. A sewer is designed to allow the waste to flow at a rate of approximately 1 ft/sec.
    b. Grease can be serious problem in a collection system.
    c. Inflow and infiltration are frequently problems in older collection systems.
    d. High concentrations of hydrogen sulfide in a sewer can lead to corrosion of concrete.
    e. Scouring can be a problem if wastewater is flowing too fast.
34. Which of the following statements is not true regarding a wastewater collection system:
    *a. A sewer is designed to allow the waste to flow at a rate of approximately 1 ft/sec.
    b. Grease can be serious problem in a collection system.
    c. Inflow and infiltration are frequently problems in older collection systems.
    d. High concentrations of hydrogen sulfide in a sewer can lead to corrosion of concrete.
    e. Scouring can be a problem if wastewater is flowing too fast.
35. A sewer system designed to transport only wastewater from homes, industries, institutions and businesses is called:
    a. Combined sewer
    *b. Sanitary sewer
    c. Service sewer
    d. Building sewer
36. Velocity of sewers is usually expressed as:
    *a. Feet per second
    b. Gallon per minute
    c. MGD
    d. mg/l
    e. sq. ft
37. Velocity of flow in sewers is usually expressed in terms of
    *a. Feet per second
    b. Gallon per minute
    c. MGD
    d. Milligrams per liter
    e. Square feet
38. Velocity of flow in sewers is usually expressed in terms of
    *a. Feet per second
    b. Gallon per minute

c. MGD

d. Milligrams per liter

e. Square feet

39. Infiltration is caused by: *a. Cracked pipes b. Improper CCTV operation c. Poor ventilation d. All of the above
40. Define infiltration & inflow, compatible & non-compatible. List 4 major concerns. List 2 corrections.

3. Preliminary Treatment Assessment

Preliminary Treatment Assessment

1. A weir can be also be used for measuring flows
   *a. True
   b. False

2. The process of pre-aeration in no way influences the degree of settling in a primary clarifier

   a. True
   *b. False

3. Septic sludge has a low pH
   *a. True
   b. False

4. A Parshall flume measures the velocity of the influent flow
   a. True
   *b. False

5. A barminutor frequently operates automatically.
   *a. True
   b. False

6. A grit chamber with a faster flow velocity than recommended may allow appreciable or-

ganic matter to collect in the grit.
a. True
*b. False

7. A grit chamber with a slower flow velocity than recommended may allow appreciable organics to settle out with the grit.
*a. True
b. False

8. A Parshall Flume is a device used to divide the incoming flow for equal distribution to a plant having more than one primary clarifier.
a. True
*b. False

9. A Parshall flume measures the velocity of the influent flow
a. True
*b. False

10. A properly operated grit chamber will normally increase the solids loading to the primary clarifier
*a. True
b. False

11. A properly operating grit chamber should yield grit that is high in fixed solids (inorganic material) and low in volatile solids.
*a. True
b. False

12. At most treatment plants preliminary treatment is used to protect pumping equipment and to facilitate subsequent treatment processes.
*a. True
b. False

13. A Venturi meter measures the amount of electricity used and should be read when there is a high electrical demand.
a. True
*b. False

14. A weir can be used as a flow measuring device
*a. True
b. False

15. Hydrogen sulfide gas in a moist atmosphere can result in corrosion of concrete structures
    *a. True
    b. False

16. Inefficient grit removal would tend to cause a decrease in percent volatile solids in raw primary sludge
    *a. True
    b. False

17. pH value less than 7 indicates an alkaline or basic condition
    a. True
    *b. False

18. Poor grit removal would affect all of the following: pumps and other mechanical equipment, anaerobic digestion, percent volatile and percent total solids in the raw sludge.
    *a. True
    b. False

19. Pre-aeration improves settleability in primary clarifier
    *a. True
    b. False

20. Pre-aeration of raw wastewater may cause better solids separation and removals in the primary clarifier.
    *a. True
    b. False

21. Presence of hydrogen sulfide cannot always be detected by its characteristic odor
    *a. True
    b. False

22. In a typical treatment facility, it is necessary to have flow meters on the influent and effluent to detect the loss in plant flow.
    a. True
    *b. False

23. A Venturi meter is a reliable device for measuring flows of either treated or untreated wastewater.
    *a. True
    b. False

24. A flow measurement device such as a constant differential meter, or the more common

name, rotameter, is used for the measurement of liquids or gases.
*a. True
b. False

25. It is often necessary to pre-chlorinate wastewater to prevent odors. When this is done, it is not necessary to satisfy a chlorine demand or expect a chlorine residual.
*a. True
b. False

26. Inefficient grit removal would tend to cause an increase in the percent volatile solids in raw sludge.
a. True
*b. False

27. Grit is composed mostly of inorganic material and organic material that is not easily biodegradable
*a. True
b. False

28. A weir can be also be used for measuring flows
*a. True
b. False

29. Nderlinehspace1cm is used for controlling the flow velocity in a horizontal grit channel
Correct Answer(s):
a. True
b. False

30. Septic sludge has a low pH
*a. True
b. False

31. Barminutors and comminutors are devices which cut up or shred material which is normally found in raw wastewater.
*a. True
b. False

32. Barmunitor and comminutor are devices used for cutting up or shredding material normally present in raw wastewater
*a. True
b. False

33. Coliform testing is typically conducted on a grab sample
    a. True
    *b. False

34. Comminutors cut up or shred large objects normally found In raw wastewater and remove them from the wastewater flow.
    a. True
    *b. False

35. Conductivity is a very useful test for assessing sea water intrusion into sewer lines
    *a. True
    b. False

36. Fresh wastewater is characterized by a blackish color, foul and unpleasant odors with floating materials and suspended solids.
    a. True
    *b. False

37. Hydrogen sulfide in addition to creating an odor nuisance can be an explosion hazard when mixed with air in certain concentrations.
    *a. True
    b. False

38. Inflow is storm water entering into the sewer system
    *a. True
    b. False

39. Percent efficiency of total solids or BOD removal is calculated using the following formula: (In-Out*100)/(In-(In*Out))
    a. True
    *b. False

40. Poor grit removal would affect anaerobic digester operation
    *a. True
    b. False

41. Pre-chlorination is frequently used to disinfect raw wastewater.
    a. True
    *b. False
    @Prechlorination is primarily for reducing septicity

42. Solids removed from preliminary treatment are typically treated in an anaerobic digester

a. True
*b. False

43. The function of a comminutor is to shred rags, paper, wood, and other large wastewater solids and remove the from the flow.
a. True
*b. False

44. The laboratory measurement of volatile solids is a fair approximation of the organic content of the wastewater.
*a. True
b. False

45. The size and nature of solids in the wastewater is of no significant concern to the wastewater treatment plant operator.
a. True
*b. False

46. The velocity of wastewater flowing through a long channel type of grit chamber may be controlled by a proportional weir.
*a. True
b. False

47. Total solids are made up of dissolved and suspended solids both of which contain organic and inorganic matter
*a. True
b. False

48. Typical domestic wastewater BOD content is about 2000mg/l
a. True
*b. False

49. Wastewater with a pH of 12.0 to 14.0 would be too "acidic" for biological treatment
a. True
*b. False

50. _____ matter in wastewater, is normally composed of grit, sand and silt.
a. Colloidal
*b. Inorganic
c. Organic
d. Volatile

51. _____ is used for controlling the flow velocity in a horizontal grit channel
    a. Magmeter
    *b. Proportional weir
    c. Parshall flume
    d. V-notch weir

52. A _____ is used in the wastewater treatment plant to remove debris such as large rocks, branches, pieces of lumber, leaves, paper, tree roots, etc. from the influent.
    a. Comminutor
    *b. Bar Screen
    c. Belt filter
    d. Grit chamber

53. A pH probe:
    a. Can be used to measure ORP in chlorine disinfection.
    b. Is often used to measure hydrogen production in wet wells.
    c. Measures, in millivolts, the difference between oxidants like chlorine and reductants such as organic matter.
    *d. Measures hydrogen ion activity in wastewater.
    e. Sends a 4-20 mA signal directly to a chlorine controller.

54. A sewer system designed to transport only wastewater from homes, industries, institutions and businesses is called:
    a. Combined sewer
    *b. Sanitary sewer
    c. Service sewer
    d. Building sewer

55. Carryover of grit from the grit chamber may indicate the need to:
    *a. Increase rate of settled grit removal from the grit chamber..
    b. Decrease the operational depth of the channel.
    c. Increase the flow to the primary clarifier.
    d. Increase the air input to an aerated grit chamber.

56. Characteristics that should be measured immediately after the sample is collected are:
    a. Velocity and dissolved solids
    *b. Temperature, pH and DO
    c. TSS and BOD
    d. Hardness and alkalinity

57. Flow proportionate composite samples are collected because:
    a. The waste characteristics are continually changing

b. The flow is continually changing
*c. The flow and waste characteristics are continually changing
d. This requires less time than grab samples
e. All of the above

58. Grab samples are considered to be representative of the
a. Average daily condition at the sample location
b. Average daily condition in the system
c. System conditions for the two hours before and after the sample was taken
*d. System condition at the time of the sample

59. Grit is composed mostly of which of the following substances?
a. Grease
b. Colloidal solids
c. Rubber goods
*d. Inorganics
e. Plastics

60. Organisms in wastewater that are not harmful to humans but are indicators of diseases are:
a. Pathogens
b. Viruses
*c. Coliform
d. Bacteria

61. Which of the following pollutants would be removed to the extent in an efficiently operating grit chamber?
a. Egg shells
b. Seeds
c. Oils and grease
*d. Sand
e. Fixed solids

62. Proportional weirs usually are located at:
a. Immediately after the barscreens
b. Primary clarifiers
c. Aerobic digester scum boxes
*d. Grit chambers
e. Inside the Parshall flume

63. Which of the following process units is not usually considered to be a preliminary treatment unit?
a. Grit chamber

b. Bar screen
c. Comminutor
d. Bar rack
*e. A meniscus

64. Which of the following would be included in the pretreatment unit?
a. preaeration
b. grit removal
c. screening
d. comminutor
*e. all of the above

65. As grit accumulates in a recetangular channel or chamber, the velocity of the influent wastewater:
*a. increases
b. decreases
c. remains constant
d. behaves independent of inflow
e. none of the above

66. Grit usually contains some organic matter which decomposes and creates odors. To facilitate disposal without nuisance, the organic matter is removed by washing methods. Commonly used is:
a. aeration
b. elutriation
c. vacuum filtration
d. wet oxidation
*e. none of the above

67. The flow through rate for grit channels is usually:
a. 20 seconds to 1.0 minute
b. 2 feet per second
*c. 1 foot per second
d. 30 days, depending on temperature
e. none of the above

68. Given the following data, what is the most likely cause of the mechanically cleaned bar-screen problem?
DATA: Normal dry weather flow
Motor running but unit not operating
Drive chain excessively tight

Water differential across screen above 6 inches
Controls on automatic.
Pin sheared or automatic clutch tripped.
a. Bubble tube malfunction
b. Flow too high
*c. Rocks lodged in screen
d. Suction channel level too high

69. In which of the following types of wastewater would settling occur most rapidly?
*a. Cold wastewater
b. Old (stale) wastewater
c. Septic wastewater
d. Strong wastewater

70. Given the following data, whatis the most likely cause of
the grit separator problem?
DATA: ·Lower than normal flow of water and grit from apex
High separation chamber pressure
*a. Grit pump suction clogged.
b. Partial obstruction near apex
c. Stick lodged in separation chamber
d. Vortex finder worn

71. What is the most likely cause of an aerated grit chamber problem if the grit pump is in automatic mode and running, the suction valve is wide open, the pressure on discharge line is low and erratic, and less than normal water and grit are discharging from discharge line?
a. Discharge check valve partially plugged.
b. Grit classifier partially plugged.
*c. Grit pump suction line partially plugged.
d. Malfunctioning air supply to grit chamber causing pump to get air bound.

72. Usually, preliminary treatment includes removal of most of the:
a. Pathogenic bacteria.
b. Biodegradable organics.
c. Settleable solids.
d. Dissolved solids.
*e. Grit.

73. A spray nozzle on the mechanically cleaned screen has become plugged. To ensure your safety, prior to entering the screen housing to repair the nozzle, you should
a. Leave note on breaker panel of repair being made

b. Request assistance for repair •
*c. Turn off and lock motor control
d. Turn off local control switch

74. An aerobic treatment process is one that requires the presence of:
a. Ozone
b. organic oxygen
c. no oxygen
d. combined oxygen
*e. dissolved oxygen

75. Which of the following should not normally be a significant part of grit
a. Sand.
b. Rocks
c. Eggshells.
*d. Fecal Matter.

76. Samples collected over several hours during the day and combined are known as:
*a. Composite samples.
b. Grab samples.
c. Deep samples.
d. Periodic samples.

77. Which of the following is not a characteristic of hydrogen sulfide?
a. Foul odors
*b. Lighter than air
c. Toxic
d. Corrosiveness
e. Explosiveness

78. The following device is used to measure the flow of wastewater:
a. Comminutor.
b. Comparator.
*c. Parshall flume.
d. Sluice gate.

79. A device called an Imhoff cone is commonly used to measure settleable solids in:
a. Percent
*b. mL/L
c. mg/L
d. ppm
e. SVI units

80. The proper operation of an aerated grit removal process will:
    a. Cause material with a specific gravity of greater than 1.0 to settle.
    b. Cause sand and other non-organics to settle and keep organic material in suspension.
    c. Help to freshen stale or septic wastewater.
    *d. b and c

81. Velocity of sewers is usually expressed as:
    *a. Feet per second
    b. Gallon per minute
    c. MGD
    d. mg/l
    e. sq. ft

82. Which of the following statements is not true regarding a wastewater collection system:
    *a. A sewer is designed to allow the waste to flow at a rate of approximately 1 ft/sec.
    b. Grease can be serious problem in a collection system.
    c. Inflow and infiltration are frequently problems in older collection systems.
    d. High concentrations of hydrogen sulfide in a sewer can lead to corrosion of concrete.
    e. Scouring can be a problem if wastewater is flowing too fast.

83. In order for the grit to settle in a non-aerated grit chamber, the average velocity should be kept near:
    *a. 1 ft/sec .
    b. 2 ft/sec.
    c. 5 ft/sec.
    d. 1 ft/min.
    e. 2 ft/min.

4. Primary Treatment Assessment

Primary Treatment Assessment

1. An Imhoff cone is often used to measure the effectiveness of primary sedimentation.
   a. True
   *b. False
2. An inadequate detention time in a primary clarifier would result in increased solids pumping to digesters
   a. True
   *b. False
3. A well-operated primary clarifier, will remove between 90 and 95 percent of the influent settleable solids.
   *a. True
   b. False
4. Baffles ahead of outlet weirs in primary tanks serve as a physical barrier to inhibit the loss of floating solids and grease.
   *a. True
   b. False
5. Baffles upstream of outlet weirs in primary tanks serve as a physical barrier to inhibit the loss of floating solids and grease.
   *a. True
   b. False
6. Detention time is the time required to fill a tank at a given flow.
   *a. True

b. False

7. Gas bubbles rising to the surface in a primary clarifier are normally an indication that the sludge in the unit is undergoing proper settling
   a. True
   *b. False
8. Hydraulic loading to a clarifier is expressed as gallons/day.
   a. True
   *b. False
9. It is common for primary clarifiers to remove 80-85% of the BODand90-95% of the TSS.
   a. True
   *b. False
10. Operators may use sludge blanket levels in primary clarifiers to adjust sludge pumping rates.
    *a. True
    b. False
11. The weir overflow rate of a primary clarifier is expressed as gal/day/ft2 (gallons per day per square feet)
    a. True
    *b. False
12. Primary treatment is a process which allows substances that will settle or float to be separated from the wastewater being treated.
    *a. True
    b. False
13. A well operating primary clarifier will generally remove nearly all of the influent suspened solids.
    a. True
    *b. False
14. Sludges from primary clarifiers are usual ly more dense than sludges from secondary clarifiers.
    *a. True
    b. False
15. The generally accepted range of BOD removal in a well operating primary clarifier would be 40 - 60% .
    a. True
    *b. False
16. Wooden flights in a rectangular clarifier usually are equipped with wearing shoes.
    *a. True
    b. False
17. The typical percentage of BOD which should be removed in primary clarifiers is in the range of about 90%-99%

a. True

*b. False

18. If the collector mechanism on a circular clarifier stalls, it would be advisable to reverse the motor and back up the collector.

a. True

*b. False

19. Raw sludge drawn from a primary sedimentation tank normally would contain 1,000 mg/l - 3,000 mg/1 of settleable solids.

a. True

*b. False

20. When pumping primary clarifier scum to a holding tank, there should be no additional problems in cold weather.

a. True

*b. False

21. If a shear pin for a particular installation is constantly bending, it would be proper and advisable to replace it with a pin of greater shear strength.

a. True

*b. False

22. Septic sludge generally has a low pH.

*a. True

b. False

23. Short circuiting in a primary clarifier occurs mainly because of the effluent weirs being plugged or not level

*a. True

b. False

24. Wear shoes are found in circular clarifiers

a. True

*b. False

25. Hydraulic loading is the number of gallons flowing each day through one cubic foot volume of the clarifier

a. True

*b. False

26. Clarifier detention time is the time required to fill the clarifier at a given flow rate

*a. True

b. False

27. Main objective of primary treatment is to remove organics present in wastewater

a. True

*b. False

28. Raw sludge pumped from a primary clarifier generally contains about 3% to 6% total solids.

*a. True

b. False

29. The main function of launders in a rectangular sedimentation tank is to prevent scum and other floatables from leaving with the primary effluent.

*a. True

b. False

30. The solids in primary sludge contain both volatile and fixed parts.

*a. True

b. False

31. Uneven weirs (heights) may result In short circuiting in a primary clarifier

*a. True

b. False

32. “V” -notch weirs attached to a primary effluent launder measure the flow rate.

*a. True

b. False

33. A well-operated primary clarifier, will remove between 90 and 95 percent of the influent settleable solids.

*a. True

b. False

34. A well operating primary clarifier will generally remove nearly all of the influent settleable solids.

*a. True

b. False

35. In a well-designed, efficiently operated wastewater treatment facility, most of the colloidal and dissolved matter in wastewater will be removed in the primary clarifiers

a. True

*b. False

36. In some primary clarifiers water or aIr sprays may be used to push scum toward the scum removal point.

*a. True

b. False

37. The main purpose of primary treatment is to remove the materials that might damage downstream equipment and/or the pumps.

a. True

*b. False

38. The volume of sludge to be removed from a primary settling tank maybe estimated by measuring the primary influent and effluent settleable solids and wastewater flow.

*a. True

b. False

39. A device called an Imhoff cone is commonly used to measure settleable solids in:

a. Percent
*b. mL/L
c. mg/L
d. ppm
e. SVI units

40. An efficient primary clarifier is expected to remove what percent of the influent settleable solids?
a. 2 to 6 %
b. 20 to 40 %
c. 40 to 50 %
d. 60 to 75 %
*e. 90 % or better

41. A primary clarifier does not have adequate detention time. Which of the following would result?
a. Decreased organic leading on secondary unit
b. Overloading of collector or flight drive motor
c. Increased solids pumped to digester
*d. Low BOD removal
e. Reduced suspended solids in aeration tank.

42. If the sludge depth in a secondary sedimentation tank is too high, what will happen?
a. Decreased turbidity in effluent.
b. Return activated sludge will have lower oxygen demand
c. Settleable solids from aeration tank will increase
*d. Sludge may become septic

43. Odors associated with septic sludge are usually caused by
a. A neutral pH
b. Inorganic matter
c. Short retention time in collection system
d. Active aerobic bacteria
*e. Active anaerobic bacteria

44. The main objectives of primary sedimentation are to remove:
a. Finely divided particles and dissolved organics
b. TDS and colloidal solids
c. BOD, COD, and SS
*d. Settleable solids and floatables
e. Detritus and volatile organics

45. The withdrawal of sludge from a primary clarifier should be slow in order to:
a. conserve electricity
*b. prevent pulling too much water with the sludge
c. keep the BOD stabilized

d. not disturb the bacteria in the clarifier

e. protect the pump

46. The withdrawal of sludge from a clarifier should be slow in order to:

a. protect the pump.

b. conserve electricity.

*c. prevent the pulling of too much water with the sludge.

d. not disturb the bacteria in the digester.

e. avoid breaking the water seal in the digester.

47. Which of the following terms refers to a hydraulic condition, typically indicated by billowing solids flowing over the effluent weir, where a portion of the flow through a clarifier experiences a much shorter detention time than the rest of the wastewater in the tank?

a. surging

*b. shortcircuiting

c. overload

d. dispersion

48. When wastewater enters a rectangular clarifier, it is often evenly dispersed across the entire width of the tank by means of:

*a. a baffle.

b. a proportional weir.

c. a submerged launder.

d. a dome diffuser.

e. a hydraulic pump.

49. Rectangular primary clarifiers have wooden or plastic flights, which are equipped with:

a. shear pins.

b. friction skirts.

*c. wear shoes.

d. grease nipples.

e. sludge hinges.

50. The main function of an inlet baffle in a settling tank is to:

*a. Reduce velocity and disperse the flow

b. Increase velocity to prevent excessive settling near the inlet

c. Remove scum from the wastewater

d. Protect the scrapping mechanism from damage by excessive velocities.

51. If short circuiting occurs in a clarifier, the operator should

*a. Identify the cause

b. Change fuses.

c. Increase the sludge drawoff

d. Restart the pump.

52. The expected range of BOD removal in a well operated primary clarifier is:

a. 10 to 20%

*b. 25 to 40%

c. 40 to 60%

d. 60 to 80%

53. A treatment plant process using sedimentation after screening and grit removal and before aerobic treatment is known as:

a. preliminary treatment.

*b. primary treatment.

c. secondary treatment.

d. RBC treatment.

e. advanced wastewater treatment.

54. Sludge gasification in a primary clarifier may be the result of:

a. hydraulic overloading

b. low influent BOD concentrations

*c. infrequent pumping of sludge

d. too short of detention time

55. The withdrawal of sludge from a primary clarifier should be slow in order to:

a. conserve electricity

*b. prevent pulling too much water with the sludge

c. keep the BOD stabilized

d. not disturb the bacteria in the clarifier

e. protect the pump

56. Primary sedimentation will remove most of the:

a. BOD and suspended solids.

b. settleable solids and suspended solids.

c. grit and raw sludge.

*d. floatable and settleable solids.

e. suspended solids and pathogens.

57. The time it takes for a unit volume of wastewater to pass entirely through a primary clarifier is called:

*a. detention time

b. hydraulic loading rate

c. overflow time

d. weir loading rate

58. Primary treatment units are designed to remove settleable solids from the wastewater stream by:

a. biological treatment

b. chemical addition

c. biofiltration

*d. gravity sedimentation

e. comminuting devices

59. Which one of the following factors would have least influence on the settleability of solids in a clarifier:
    a. detention time
    b. flow velocity
    c. short-circuiting
    d. temperature
    *e. soluble BOD
60. The least acceptable method of handling scum and skimmings from a primary clarifier is:
    a. burning
    b. burial
    c. pumping to a digester
    *d. discharging into the effluent
    e. hauling to a sanitary landfill
61. Given the following data, what is the most likely cause of the primary sedimentation tank problem? DATA: Raw sludge pumps run 10 minutes in each hour Raw sludge has 3% total solids at start of pumping cycle, 2% total solids at end. No sludge accumulation on tank floor Slight sludge accumulation in sludge hopper
    a. Raw sludge pumping duration too short
    *b. Raw sludge pumping duration too long
    c. Raw sludge total solids too high
    d. Sludge collectors running too long
62. Raw sludge pumping cycles that are too short will
    *a. Cause wastestream going to secondary treatment to turn dark.
    b. Decrease return and waste sludge suspended solids.
    c. Increase amount of grit in raw sludge.
    d. Increase rags in raw sludge.
63. Raw sludge should be removed from a primary settling tank at any plant
    a. At least hourly.
    b. Not more often than once a week.
    *c. At least once a day.
    d. Whenever sludge rises to the surface.

64. You are the operations supervisor at a modern 27 MGD (average dry weather flow) conventional activated sludge wastewater treatment plant. During a recent plant expansion, four (4) new primary sedimentation tanks (160 ft. long x 25 ft. wide x 12 ft. deep) were built. These tanks have been tested and are ready for service. These new tanks are to be put on line while six old sedimentation tanks are to be taken out of service so that they may be inspected and repaired. The primary influent channel and other mechanical equipment (e.g. pumps, collector mechanisms, flights, etc.) will also be inspected and repaired. It is estimated that the total down time will be one month or more. Because of the design of the primary influent channel, all six of the old sedimentation tanks must be taken out of service at one time.

    The table below summarizes the calculated surface loading rates and detention times with the original and when only four tanks are on line.

FLOW CONDITION	*SURFACE LOADING*	*DETENTION TIME*
Ave. Daily Flow	1688 gpd/ft^2	1.3 *hours*
Peak Flow	2531 gpd/ft^2	0.85 *hours*

    Note: Peak flow is 1.5 times the average daily flow.

    Write a memo to your shift supervisors in which you identify and briefly discuss FIVE (5) significant concerns in regard to a plan of action (POA) for removal and inspection of the old sedimentation tanks. State all assumptions.

Response:

Assessing the clarifier surface loading rate for the new clarifiers:

Surface area of new tanks= $160ft * 25ft = 4,000ft^2/tank = 16,000ft^2$ total surface area - four new clarifiers

Clarifier surface loading - average dry flow condition:

$$\left(\frac{gpd}{ft^2}\right) = \frac{Clarifier\ \ influent\ \ flow(gpd)}{Clarifier\ \ surface\ \ area(ft^2)} \implies \frac{27*10^6 gpd}{16{,}000ft^2} = 1{,}688\ \ \frac{gpd}{ft^2}$$

Assessing the clarifier detention time for the new clarifiers:

Volume of new tanks= $160ft * 25ft * 12ft = 48,000ft^3/tank = 288,000ft^3$ total volume - four new clarifiers

Clarifier detention time - average dry flow condition:

$$(hrs) = \frac{Clarifier\ \ volume(ft^3)}{flow(\frac{ft^3}{hr})} \implies \frac{288{,}000ft^3}{27*10^6 \frac{gal}{day} * \frac{day}{24hrs} * \frac{ft^3}{7.48gal}} = 1.91\ \ hrs$$

Both, detention time & the surface loading rate of the new clarifiers is comparable to the existing ones - so no concern from that perspective.

i Ensure the effluent weirs in the new clarifiers are level to ensure there is no short circuiting

ii Ensure that the new clarifier mechanical equipment and its associated control systems are tested to ensure reliable operations prior to the switch.

iii For the inspection/repair of the old tanks, ensure lockout-tagout and proper confined entry procedures are followed

65. Chemical enhanced primary treatment (CEPT) is used at a number of conventional activated sludge planes. CEPT, also called advanced primary treatment, typically involves the application of liquid ferric chloride and an anion polymer ahead of the primary sedimentation tank. Although the long-term addition of chemicals to a wastewater flow can be costly, the benefits of CEPT may outweigh its cost.

    Answer the fol- lowing question about advanced primary treatment:

    (a) Identify two operational considerations in order optimize CEPT.
    (b) Identify and explain two ways in which CEPT could result in energy saving in a convention activated sludge plant that uses cogeneration
    (c) Identify two additional benefits to anaerobic digester operations that may result from the addition of ferric chloride. Briefly explain how ferric chloride is able to yield these benefits.

    Response:

    a *Identify two operational considerations in order optimize CEPT.*
        - Optimal ferric chloride and polymer dosage
        - Adequate mixing time and energy for ensuring proper coagulation by ferric chloride
        - Ensure the polymer is gently folded into the coagulated wastewater just prior to entering the clarifier.

    b *Identify and explain two ways in which CEPT could result in energy saving in a convention activated sludge plant that uses cogeneration.*
        - By increasing BOD removal in the primary clarifier, the influent BOD loading to the secondary treatment is lower reducing the oxygen requirements thus resulting in energy savings.
        - The organic material in the sludge feed to the digester has a higher proportion of primary sludge which is more easily digestable thus producing more digester gas for cogeneration.

    c *Identify two additional benefits to anaerobic digester operations that may result from the addition of ferric chloride. Briefly explain how ferric chloride is able to yield these benefits.*
        - The residual ferric chloride in the primary sludge feed allows for the control of H_2S concentration in the digester gas
        - Ferric chloride also helps in minimizing struvite forming potential in the digester due to its ability to remove phosphate, one of the key elements of struvite.

66. Recently your activated sludge plant has acquired a two 2-meter belt press to dewater anaerobically digester sludge.
    (a) List four (4) factors, other than belt speed, which generally affect the belt press performance.
    (b) The belt press is running. You observe what one of your operator's calls washout. Define "washout."
    (c) Identify two possible cause of washout.
    (d) It has been said that the "the ideal belt speed is the slowest the operator can maintain without causing washout." Explain why this is so.

    Response:

    a *List four (4) factors, other than belt speed, which generally affect the belt press performance.*
        - Primary sludge dewaters better than secondary sludge. Digested sludge with a higher proportion of primary will produce drier (higher solids content) dewatered biosolids.
        - Optimal dosage and adequate mixing of polymer with the sludge.
        - Cleanliness of the belts.
        - Adequate and even hydraulic pressure to ensure water is squeezed out from the sludge.

    b *Identify two possible cause of washout.*
        - Inadequate polymer dosing.
        - Hydraulic overloading.
        - Blinded gravity zone belt.
        - Slow belt speed

    c *It has been said that the "the ideal belt speed is the slowest the operator can maintain without causing washout." Explain why this is so.*

    As the belt speed is slowed, the water from the sludge will have more time to drain producing a drier cake. However, due to the slow belt speed, solids will build up on the belt preventing the water from draining. Washout occurs when the belt speed is slowed to a point when there is so much standing water that it flows over the sides of the belt.

5. Trickling Filters Assessment

Trickling Filters Assessment

1. Compared to activated sludge, trickling filters are sturdy work units not easily up set by shock loads.
   *a. True
   b. False
2. Ponding on the surface of trickling filters is almost always caused by plugging of the underdrains immediately below the point of ponding
   a. True
   *b. False
3. Zoogleal mass sheared of from the trickling filter media and carried out as part of the effluent flow is termed as sloughing
   *a. True
   b. False
4. For multiple trickling filter operation, the parallel mode is more suitable than the series mode for treating influent wastewater with a high BOD content
   a. True
   *b. False
5. Synthetic /pre-manufactured media used in the biofilter has the advantage of providing a greater surface area per volume upon which the zoologeal film may grow while providing ample void space for the free circulation of air.
   *a. True
   b. False

6. Of the two forms of secondary treatment: trickling filters and conventional activated sludge, trickling filters are more likely to produce a clearer effluent.
   a. True
   *b. False
7. A trickling filter reduces the strength of wastewater applied to it by the filtering and straining action of the stones or support media.
   a. True
   *b. False
8. A trickling filter provides higher BOD removal in cold weather than in hot weather.
   a. True
   *b. False
9. The biological growth on trickling filter media is composed principally of aerobic forms of bacteria, fungi, algae, protozoa, worms and the larvae of insects.
   a. True
   *b. False
10. The spaces between the filter media in a trickling filter need to remain open to permit free flow of air throughout the bed.
    *a. True
    b. False
11. The flooding of filter media with wastewater is sometimes effective in killing filter flies.
    *a. True
    b. False
12. Sandstone, because of its ability to provide excellent ventilation usually is used for media in trickling filters.
    a. True
    *b. False
13. When a trickling filter is referred to as a "roughing filter", it means the operational life of the filter is at an end, and a major overhaul is eminent.
    a. True
    *b. False
14. The hydraulic loading applied. to a trickling filter is the total volume of liquid, including recirculation.
    *a. True
    b. False
15. The main function of a launder in a secondary clarifier is to prevent scum and other floatables from leaving with the effluent flow
    a. True
    *b. False
16. The trickling filter recirculation ratio is calculated as Qi/Qr where Qi is the influent flow and Qr is the recirculated flow.

a. True

*b. False

17. The advantage of trickling filter over the activated sludge lies in its BOD removal efficiency

a. True

*b. False

18. Recirculation helps prevent excessive sloughing

a. True

*b. False

19. Series operation of trickling filter is the preferred mode during very low temperature conditions during winter

a. True

*b. False

20. A good reason to run a trickling filter in the series mode of operation is:

a. During cold weather to prevent ice formation

b. When the influent BOD loading is low

*c. When the influent BOD loading is high

d. When the weather is warm

21. A good reason to run a trickling filter in the parallel mode of operation is:

a. When the weather is warm

b. When the BOD loading is high

*c. When the BOD loading is low

d. To prevent filter flies

22. A pan test should be done monthly on a trickling filter to:

a. Check oil quality in the distributor bearing

*b. Check sewage distribution on filter

c. To check flow rates through the media

d. All the above

e. None of the above

23. A problem associated with trickling filters is

a. Bulking

b. Protozoans

*c. Ponding

d. Liquefaction

24. A trickling filter or activated sludge process causes nitrification. which is

a. Conversion of nitrogen to nitrate

b. Conversion of nitrogen to ammonia

c. Conversion of nitrate to nitrogen

*d. Conversion of ammonia to nitrate and nitrite nitrogen

25. If a trickling filter has been operating with a hydraulic loading (including some recircu-

lation) of 10 to 12 MGD and organic loading of about 80 pounds of BOD per 1,000 cu. ft./day the treatment efficiency will usually increase if the recirculation is increased. This might be attributed to:

a. The increased recirculation wears down the soluble BOD to finer particles

*b. The increased flow more completely wets and contacts all of the slime surfaces in the filter so the food to effective microorganism ration is less as in an activated sludge process

c. The grazing population of warm and other organisms in the filter is flushed out before they consume the slime bacteria

d. The increased flow more completely fills the under drains so cold updrafts are eliminated

e. The statement is just poppycock put out by power companies to get us to use more electricity to run pumps

26. Most common trickling filter operational control method is:
    a. Sloughing control
    *b. Recirculation
    c. Sludge removal
    d. Distributor arm speed
27. The media in trickling filters is placed
    a. On a rubber tile floor.
    *b. On a system of tile or columnar underdrains.
    c. Directly in a concrete slab.
    d. Directly in the ground
28. Sloughing from a trickling filter refers to
    a. A process whereby wastewater is recirculated over the filter.
    b. Bypassing of the filter.
    c. The breaking of the filter stone as a result of weathering and the sluicing of small stone particles to the final settling tank.
    *d. The periodic discharge of large quantities of slime growth with the filter effluent.
29. The primary organisms responsible for treating wastewater in the trickling filter process are:
    a. Anaerobic bacteria
    b. Anoxic bacteria
    c. Facultative bacteria
    *d. Aerobic bacteria
30. The primary organisms responsible for treating wastewater in the trickling filter process are:
    a. Anaerobic bacteria
    b. Anoxic bacteria
    c. Facultative bacteria
    *d. Aerobic bacteria

31. Ponding of a trickling filter means
    a. Flooding the filter.
    b. Hosing the growth from the rocks with a high pressure hose.
    *c. Blockage in the media that s prevents water to flow through.
    d. Running the trickling filter effluent to a wastewater pond.
32. Which of the following would be a cause for trickling filter ponding:
    a. Increased recirculation
    b. Filter flies
    c. Zoogleal mass
    *d. An excessive organic loading without a corresponding high recirculation rate
33. A good reason to run a trickling filter in the series mode of operation is:
    a. During cold weather to prevent ice formation
    b. When the influent BOD loading is low
    *c. When the influent BOD loading is high
    d. When the weather is warm
34. A good reason to run a trickling filter in the parallel mode of operation is:
    a. When the weather is warm
    b. When the BOD loading is high
    *c. When the BOD loading is low
    d. To prevent filter flies
35. A problem associated with trickling filters is
    a. Bulking
    b. Protozoans
    *c. Ponding
    d. Liquefaction
36. A trickling filter or activated sludge process causes nitrification. which is
    a. Conversion of nitrogen to nitrate
    b. Conversion of nitrogen to ammonia
    c. Conversion of nitrate to nitrogen
    *d. Conversion of ammonia to nitrate and nitrite nitrogen
37. Which test best measures the efficiency of a trickling filter?
    a. Total solids.
    b. pH
    *c. BOD
    d. Temperature
    e. Sludge age
38. What are sloughings?
    a. Troughs.
    b. Slop.
    *c. Zoogleal mass washed off trickling filter media.

d. Waste-activated sludge.

e. Grit.

39. Most common trickling filter operational control method is:

a. Sloughing control

*b. Recirculation

c. Sludge removal

d. Distributor arm speed

40. Most common trickling filter operational control method is:

a. Sloughing control

*b. Recirculation

c. Sludge removal

d. Distributor arm speed

41. The rotating biological contactors operate based upon the same principles as:

a. Aerated lagoons

b. Activated sludge systems

*c. Trickling filters

d. Extended aeration

42. A two-stage trickling filtration system means:

a. one filter used with recirculation returning from filter effluent to filter influent at 100b. one filter used with recirculation from secondary clarifier effluent to trickling filter influent

*c. two filters used in series, either directly or with a clarifier in between

d. two filters used in parallel

e. one filter used with no primary clarification

43. Regardless of shape, one acre-foot of media in a trickling filter is equal to:

a. 33,000 cu. ft.

*b. 43,560 cu. ft.

c. 55,560 cu. ft.

d. 77,840 cu. ft.

e. none of the above

44. The presence of a "rotten egg" odor in the area of a trickling filter generally would indicate which of the following:

a. the presence of the psychoda fly

b. the clogging of the distributor arm orifices

*c. anaerobic conditions within the filter

d. too much recirculation

e. too high a DO in the: wastewater being applied to the filter

45. Analysis of a wastewater effluent from a standard rate trickling filter shows the following:

Nitrite= 8 mg/L

Ammonia= 2 mg/L

Nitrate= 2 mg/L

What do these results indicate?

*a. Plant is operating properly

b. Final end product, nitrite, is too low

c. Final end product, nitrate, is too low

d. DO was insufficient to allow complete aerobic oxidation of the nitrate to nitrite

46. Given the data below, what is the most likely cause of the trickling filter problem? –
DATA: Normal dry weather plant flow rate
Sweep arms operating at normal rate
Water not passing through as rapidly as normal
Increased odor level
Increased chlorine demand in final effluenTrue
Final effluent turbid.

*a. Filter media plugged with dead microorganisms

b. Low solids load to filter

c. seal in sweep arms worn

d. Spray nozzles partially plugged.

47. The rock/media in most trickling filters is placed

a. Directly in the ground.

b. Directly in a concrete slab.

*c. On a system of tile underdrains

d. On a rubber tile floor

48. The primary organisms responsible for treating wastewater in the trickling filter process are:

a. Anaerobic bacteria

b. Anoxic bacteria

c. Facultative bacteria

*d. Aerobic bacteria

49. Trickling filters usually consist of a bed of stone which performs its function in sewage by:

a. Mechanical filtration of organic solids

b. Mechanical filtration of inorganic solids

c. Provides aeration

*d. Supports a growth of organisms which feed upon the sewage and reduce BOD

e. None of the above

50. What are sloughings?

a. Troughs.

b. Slop.

*c. Zoogleal mass washed off trickling filter media.

d. Waste-activated sludge.

e. Grit.

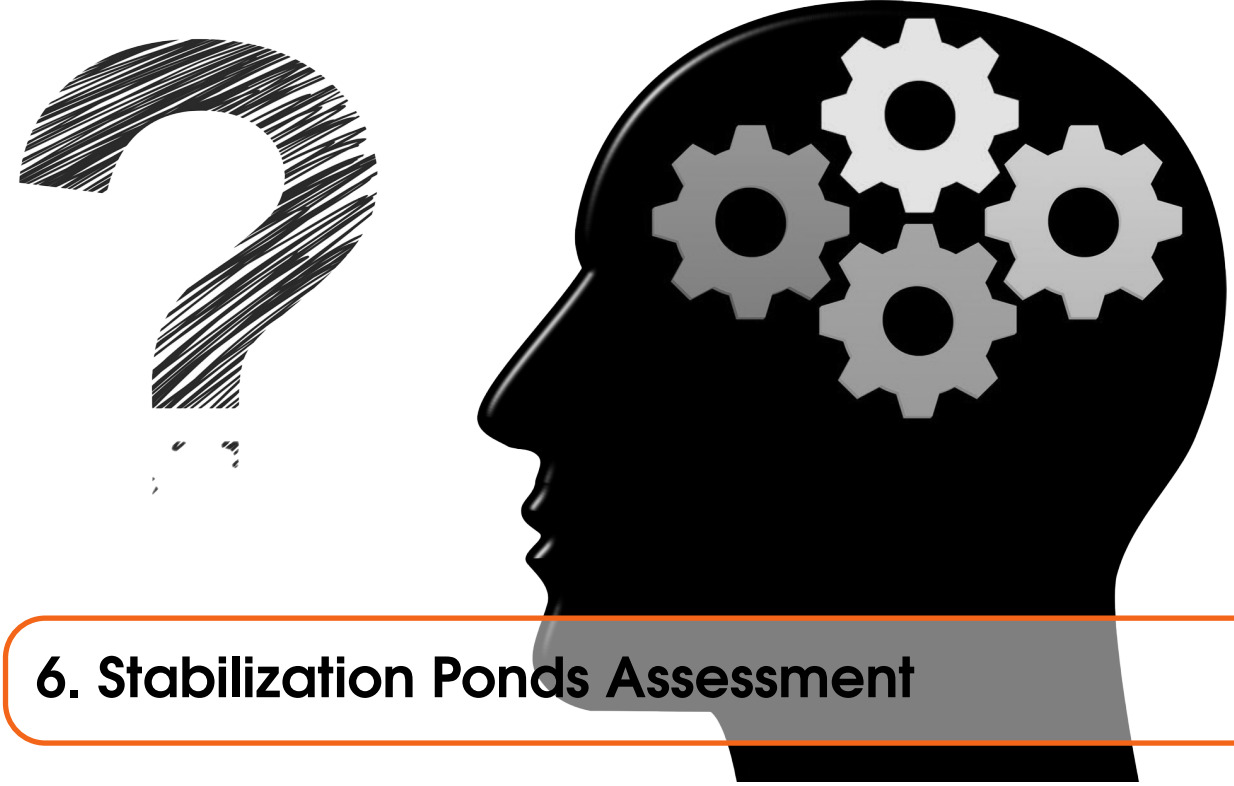
51. Which of the following is not a benefit of recirculation in the trickling filter process?

a. Dilutes high strength or toxic wastes.

b. Helps prevent septic conditions in trickling filter

*c. Helps prevent excessive sloughing

d. Helps control odors, ponding and filter flies



6. Stabilization Ponds Assessment

Stabilization Ponds Assessment

1. Organic loading to a stabilization pond is always calculated by knowing the pounds of BOD applied per 1.000 cubic feet of pond volume per day.
   a. True
   *b. False
2. An abundance of aquatic plant growth in and around the edge of a facultative pond provides more surface area for biologic activity and increases treatment capacity.
   a. True
   *b. False
3. Facultative ponds are anaerobic on the bottom and aerobic near the surface.
   *a. True
   b. False
4. The best time of the year to initiate operation of a new facultative pond is during the coldest months of the year.
   a. True
   *b. False
5. Ponds that contain an aerobic top layer and an anaerobic bottom layer are called facultative ponds.
   *a. True
   b. False
6. In a facultative pond, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.

a. True

*b. False

7. It is recommended to start up a pond in the coldest months of the year in order to avoid odor problems and to take advantage of the increased solubility of oxygen in cold water.

a. True

*b. False

8. A one acre wastewater treatment pond operated at a depth of 3 feet holds approximately 1 million gallons.

*a. True

b. False

9. Algae is primarily responsible for the effective working of an anaerobic pond

a. True

*b. False

10. Tertiary (polishing) ponds typically receive raw (untreated wastewater) as the feed stream

a. True

*b. False

11. Facultative ponds are anaerobic on the bottom and aerobic near the surface.

*a. True

b. False

12. In a facultative pond, a drop in the pH will normally be accompanied by a rise in the dissolved oxygen.

*a. True

b. False

13. Algae is primarily responsible for the effective working of an anaerobic pond

a. True

*b. False

14. Algae produce oxygen in a facultative pond.

*a. True

b.False

15. A one acre wastewater treatment pond operated at a depth of 3 feet holds approximately 1 million gallons.

*a. True

b. False

16. In a facultative pond, aerobic bacteria produce oxygen that is consumed by algae.

a. True

*b. False

17. In a facultative pond, the pH falls when carbon dioxide produced by the aerobic bacteria is consumed by the algae

a. True

*b. False

18. In a facultative pond, the algae utilizes the oxygen given off as a by-product of bacterial respiration
    a. True
    *b. False
19. In a facultative pond, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.
    a. True
    *b. False
20. In a facultative pond, a drop in the pH will normally be accompanied by a rise in the dissolved oxygen.
    *a. True
    b. False
21. In a facultative pond, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.
    a. True
    *b. False
22. In a facultative wastewater treatment pond that Is operating normally, a rise In DO will be accompanied by a drop in pH.
    a. True
    *b. False
23. It is recommended to start up a pond in the coldest months of the year in order to avoid odor problems and to take advantage of the increased solubility of oxygen in cold water.
    a. True
    *b. False
24. Operational depth of a wastewater pond is not used for calculating its organic loading
    *a. True
    b. False
25. Ponds that contain an aerobic top layer and an anaerobic bottom layer are called facultative ponds.
    *a. True
    b. False
26. In a facultative pond, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.
    a. True
    *b. False
27. It is recommended to start up a pond in the coldest months of the year in order to avoid odor problems and to take advantage of the increased solubility of oxygen in cold water.
    a. True
    *b. False
28. A one acre wastewater treatment pond operated at a depth of 3 feet holds approximately 1

million gallons.

*a. True

b. False

29. Algae is primarily responsible for the effective working of an anaerobic pond

a. True

*b. False

30. Tertiary (polishing) ponds typically receive raw (untreated wastewater) as the feed stream

a. True

*b. False

31. The best time of the year to initiate operation of a new facultative pond is during the coldest months of the year.

a. True

*b. False

32. Ponds that contain an aerobic top layer and an anaerobic bottom layer are called facultative ponds.

*a. True

b. False

33. In a facultative pond, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.

a. True

*b. False

34. It is recommended to start up a pond in the coldest months of the year in order to avoid odor problems and to take advantage of the increased solubility of oxygen in cold water.

a. True

*b. False

35. A one acre wastewater treatment pond operated at a depth of 3 feet holds approximately 1 million gallons.

*a. True

b. False

36. A wastewater pond may have a detention time of 30 to 120 days.

*a. True

b. False

37. Sludge deposits are usually in evidence at the effluent end of a waste treatment pond rather than the influent end.

a. True

*b. False

38. It is good practice to start waste treatment ponds during winter because of the lower level of biological activity.

a. True

*b. False

39. Anaerobic ponds require higher. minimum temperatures than aerobic ponds to achieve satisfactory treatment,
    *a. True
    b. False
40. The formula for calculating percent BOD removal in pond systems is: BOD removal,
    *a. True
    b. False
41. The organic loading on a wastewater lagoon is higher than on a polishing pond.
    *a. True
    b. False
42. Algae produce oxygen in a facultative pond.
    *a. True
    b. False
43. A disadvantage of excessive scum on an oxidation pond is that it will interfere with photosynthesis.
    *a. True
    b. False
44. Ranges of treatment efficiencies that can be expected from ponds vary more than most other treatment processes.
    *a. True
    b. False
45. At night, algae in a facultative pond consume oxygen.
    *a. True
    b. False
46. In wastewater treatment ponds, DO levels very rarely exceed 15 mg/l at the pond surface.
    a. True
    *b. False
47. Organic loading to a wastewater treatment pond is expressed in units of pounds of VSS per acre per day.
    a. True
    *b. False
48. Tertiary (polishing) ponds typically receive raw (untreated wastewater) as the feed stream
    a. True
    *b. False
49. Ponds that contain an aerobic top layer and an anaerobic bottom layer are called facultative ponds.
    *a. True
    b. False
50. Ponds that contain an aerobic top layer and an anaerobic bottom layer are called facultative ponds.

*a. True

b. False

51. In a facultative pond, a drop in the pH will normally be accompanied by a rise in the dissolved oxygen.

*a. True

b. False

52. Algae is primarily responsible for the effective working of an anaerobic pond

a. True

*b. False

53. Algae is primarily responsible for the effective working of an anaerobic pond

a. True

*b. False

54. Algae produce oxygen in a facultative pond.

*a. True

b.False

55. A one acre wastewater treatment pond operated at a depth of 3 feet holds approximately 1 million gallons.

*a. True

b. False

56. In a facultative pond, aerobic bacteria produce oxygen that is consumed by algae.

a. True

*b. False

57. In a facultative pond, the pH falls when carbon dioxide produced by the aerobic bacteria is consumed by the algae

a. True

*b. False

58. In a facultative pond, the algae utilizes the oxygen given off as a by-product of bacterial respiration

a. True

*b. False

59. In a facultative pond, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.

a. True

*b. False

60. In a facultative pond, a drop in the pH will normally be accompanied by a rise in the dissolved oxygen.

*a. True

b. False

61. In a facultative pond, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.

a. True

*b. False

62. In a facultative pond, a drop in the pH will normally be accompanied by a rise in the dissolved oxygen.

a. True

*b. False

63. In a facultative wastewater treatment pond that Is operating normally, a rise In DO will be accompanied by a drop in pH.

a. True

*b. False

64. It is recommended to start up a pond in the coldest months of the year in order to avoid odor problems and to take advantage of the increased solubility of oxygen in cold water.

a. True

*b. False

65. It is recommended to start up a pond in the coldest months of the year in order to avoid odor problems and to take advantage of the increased solubility of oxygen in cold water.

a. True

*b. False

66. Operational depth of a wastewater pond is not used for calculating its organic loading

*a. True

b. False

67. The best time of the year to initiate operation of a new facultative pond is during the coldest months of the year.

a. True

*b. False

68. Ponds that contain an aerobic top layer and an anaerobic bottom layer are called facultative ponds.

*a. True

b. False

69. In a facultative pond, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.

a. True

*b. False

70. It is recommended to start up a pond in the coldest months of the year in order to avoid odor problems and to take advantage of the increased solubility of oxygen in cold water.

a. True

*b. False

71. A one acre wastewater treatment pond operated at a depth of 3 feet holds approximately 1 million gallons.

*a. True

b. False

72. Algae is primarily responsible for the effective working of an anaerobic pond
    a. True
    *b. False
73. Tertiary (polishing) ponds typically receive raw (untreated wastewater) as the feed stream
    a. True
    *b. False
74. Ponds that contain an aerobic top layer and an anaerobic bottom layer are called facultative ponds.
    *a. True
    b. False
75. Ponds that contain an aerobic top layer and an anaerobic bottom layer are called facultative ponds.
    *a. True
    b. False
76. In a facultative pond, a drop in the pH will normally be accompanied by a rise in the dissolved oxygen.
    *a. True
    b. False
77. Ranges of treatment efficiencies that can be expected from ponds vary more than most other treatment processes.
    *a. True
    b. False
78. Tertiary (polishing) ponds typically receive raw (untreated wastewater) as the feed stream
    a. True
    *b. False
79. The best time of the year to initiate operation of a new facultative pond is during the coldest months of the year.
    a. True
    *b. False
80. The color of the algae at the surface of a facultative pond can be an indication of its operational condition.
    *a. True
    b. False
81. The flow to a wastewater treatment pond may be expressed in units of acre -feet.
    a. True
    *b. False
82. Usually facultative ponds are mixed with mechanical aerators at night and on cloudy days to disperse food and bacteria evenly.
    a. True

*b. False

83. Wastewater treatment ponds that receive untreated raw wastewater are called stabilization ponds.
    *a. True
    b. False
84. When a facultative pond develops a green appearance, it should be treated with copper sulfate to kill off the algae.
    a. True
    *b. False
85. When operating ponds in series, the accumulation of solids in the first pond may become a problem after long periods of use.
    *a. True
    b. False
86. Organic loading to a stabilization pond is always calculated by knowing the pounds of BOD applied per 1.000 cubic feet of pond volume per day.
    a. True
    *b. False
87. An abundance of aquatic plant growth in and around the edge of a facultative pond provides more surface area for biologic activity and increases treatment capacity.
    a. True
    *b. False
88. Facultative ponds are anaerobic on the bottom and aerobic near the surface.
    *a. True
    b. False
89. The best time of the year to initiate operation of a new facultative pond is during the coldest months of the year.
    a. True
    *b. False
90. Ponds that contain an aerobic top layer and an anaerobic bottom layer are called facultative ponds.
    *a. True
    b. False
91. In a facultative pond, the bottom layer of the pond will generally contain more dissolved oxygen than the surface layer.
    a. True
    *b. False
92. It is recommended to start up a pond in the coldest months of the year in order to avoid odor problems and to take advantage of the increased solubility of oxygen in cold water.
    a. True
    *b. False

93. A one acre wastewater treatment pond operated at a depth of 3 feet holds approximately 1 million gallons.
    *a. True
    b. False
94. Algae is primarily responsible for the effective working of an anaerobic pond
    a. True
    *b. False
95. Tertiary (polishing) ponds typically receive raw (untreated wastewater) as the feed stream
    a. True
    *b. False
96. In a facultative pond, a drop in the pH will normally be accompanied by a rise in the dissolved oxygen.
    *a. True
    b. False
97. One short-term corrective measure for an overloaded facultative pond might be to add:
    a. copper sulfate .
    b. sodium sulfide.
    c. ammonium sulfide .
    *d. sodium nitrate.
    e. potassium chloride.
98. Photosynthesis is an essential part of the biological activity associated with:
    a. Activated sludge
    b. Trickling filters
    c. Oxidation ditches
    d. Aerobic digesters
    *e. Sewage lagoons
99. During the process of algal photosynthesis:
    a. Chlorophyll converts sunlight into energy for growth.
    b. Algae produces oxygen
    c. Algae converts CO2, NH3, and PO4, into additional algae cells
    *d. All of the above
100. pH of the facultative pond will be the highest
    *a. during daytime when the consumption of CO2 is the highest
    b. during daytime when the consumption of CO2 is the lowest
    c. during nighttime when the production of CO2 is highest
    d. during nighttime when the production of CO2 is lowest
101. A lagoon operator collects a sample of effluent at 2:15 pm. on a sunny July day and tests it. for dissolved oxygen. The dissolved oxygen is 22 mg/1 and the pH is 9.2. The lagoon has a green color. Effluent suspended solids have been running at 75 mg/1. The operator should

a. Do nothing. The conditions described are normal.

*b. Apply algaecide to the lagoon to kill the algae.

c. Drawdown the lagoon to eliminate excess DO.

d. Isolate cell.

102. Algae in a stabilization pond is most likely to:

a. consume oxygen during daylight hours.

b. decrease effluent TSS during the day.

*c. change the pH throughout the day.

d. increase oxygen at night.

e. None of the above.

103. Algae in a stabilization pond is most likely to:

a. consume oxygen during daylight hours.

b. decrease effluent TSS during the day.

*c. change the pH throughout the day.

d. increase oxygen at night.

e. None of the above.

104. An operator cannot maintain adequate water levels in one of the ponds. What will cause this to happen?

a. The pond is hydraulically overloaded.

*b. The pond seal leaks.

c. The flow control structure leaks.

d. The flow control structure does not split the flow evenly.

105. A properly designed and operated wastewater stabilization pond will remove _____ percent BOD.

a. 40%-60%.

b. 60%-70%.

c. 70%-80%.

*d. 80%-90%.

106. At night algae in a conventional lagoon will:

*a. Cease to produce oxygen

b. Consume oxygen

c. Produce less oxygen

d. Increase the pH of the lagoon contents

107. At what time of day is the dissolved oxygen content highest in a lagoon?

a. 3 a.m.

b. 7 a.m.

c. 9 a.m.

*d. 3 p.m.

108. Cattails growing in lagoon will

*a. Cause short circuiting in affected lagoon.

b. Eliminate mosquito larvae.

c. Increase the diurnal pH fluctuations.

d. Increase toxic blue-green algae concentrations in the effluent.

109. Dike vegetation should be controlled by

*a. Mowing periodically.

b. Burning in the spring and fall.

c. Allowing the cattle to graze on the dikes.

d. Any of the above would be acceptable.

110. Due to diurnal differences in operation, a lagoon system is likely to experience the lowest dissolved oxygen readings

a. At any time since diurnal differences have no bearing on DO values

b. During the time when the sun is out and it is the hottest

*c. During night, just before dawn

d. When BOD loading is the lowest

111. During the process of algal photosynthesis:

a. Chlorophyll converts sunlight into energy for growth.

b. Algae produces oxygen

c. Algae converts CO2, NH3, and PO4, into additional algae cells

*d. All of the above

112. Given the following data, what is the most likely cause of the aerated pond problem? — DATA: Turbulence over center part of pond. Solids floating to surface on edge of pond. DO in center portion= 1.4 mg/L.

a. Hydraulic flow too slow through pond.

*b. Inadequate aeration on edges on pond.

c. Sludge scraper not operating.

d. Toxic materials in pond.

113. Hydraulic loading to a facultative pond equals:

a. Volume (MG) divided by Flow (MGD)

*b. Depth (inches) divided by Detention Time (days)

c. Volume (acre-feet) divided by Flow (acre-inches/day)

d. Flow (gallons/day) divided by Area (acres)

e. Area (acres) divided by Flow (acre-inches/day)

114. In a properly operating facultative pond, algae live on carbon dioxide and nutrients during the day, and at night produce carbon dioxide. This has what effect on the pH?

*a. pH increases during the day, and decreases at night

b. pH decreases during the day, and increases at night

c. pH stays the same no matter what time of day

d. Carbon dioxide has no effect on pH

115. It is important to completely mix and aerate the following type of pond:

*a. aerobic.

b. facultative.

c. anaerobic.

d. All of the above.

e. None of the above.

116. One short-term corrective measure for an overloaded facultative pond might be to add:

a. copper sulfate .

b. sodium sulfide.

c. ammonium sulfide .

*d. sodium nitrate.

e. potassium chloride.

117. pH of the facultative pond will be the highest

*a. during daytime when the consumption of CO2 is the highest

b. during daytime when the consumption of CO2 is the lowest

c. during nighttime when the production of CO2 is highest

d. during nighttime when the production of CO2 is lowest

118. Photosynthesis is an essential part of the biological activity associated with:

a. Activated sludge

b. Trickling filters

c. Oxidation ditches

d. Aerobic digesters

*e. Sewage lagoons

119. Due to diurnal differences in operation, a facultative pond is likely to experience the lowest dissolved oxygen readings

a. At any time since diurnal differences have no bearing on DO values

b. During the time when the sun is out and it is the hottest

*c. During night, just before dawn

d. When BOD loading is the lowest

120. Due to diurnal differences in operation, a facultative pond is likely to experience the lowest dissolved oxygen readings

a. At any time since diurnal differences have no bearing on DO values

b. During the time when the sun is out and it is the hottest

*c. During night, just before dawn

d. When BOD loading is the lowest

121. The main function of algae in a facultative wastewater treatment pond is to:

a. produce carbon dioxide, which is then used by the facultative bacteria.

b. use up nutrients such as nitrogen and phosphorus.

*c. produce oxygen during daylight hours.

d. serve as a food source for essential protozoa

e. break down complex organics in the wastewater.

122. Which of the following microorganisms are involved in the stabilization of wastewater in a

facultative wastewater treatment pond?

a. Aerobic bacteria

b. Anaerobic

c. Facultative bacteria

*d. All of the above

e. (a) and (c) only

123. Which of the following terms is usually not associated with wastewater treatment ponds?

*a. Filamentous bacteria

b. Symbiotic relationship

c. Photosynthesis

d. Sewage lagoon

e. Inches/day

124. Which of the following statements is not true regarding a facultative wastewater treatment pond?

a. When starting a facultative pond, 1 foot of relatively clean water should be added to the pond prior to the addition of wastewater.

b. A facultative pond generally is operated at a detention time of 50 to 60 days or longer.

*c. DO concentrations of 10 to 15 mg/L or greater are frequently found in a facultative pond during the afternoon of a sunny day.

d. Organic loading to a pond is expressed as pounds of volatile suspended solids per acre per day.

e. A facultative pond has an anaerobic layer and an aerobic layer.

125. The main function of algae in a facultative wastewater treatment pond is to:

a. produce carbon dioxide, which is then used by the facultative bacteria.

b. use up nutrients such as nitrogen and phosphorus.

*c. produce oxygen during daylight hours.

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pond during the afternoon of a sunny day.

d. Organic loading to a pond is expressed as pounds of volatile suspended solids per acre per day.

e. A facultative pond has an anaerobic layer and an aerobic layer.

128. Which of the following would not be a routine operational or maintenance problem in the operation of pond:

a. weed control.

b. levee maintenance.

c. insect control.

*d. temperature control.

e. scum control.

129. Algae in a stabilization pond is most likely to:

a. consume oxygen during daylight hours.

b. decrease effluent TSS during the day.

*c. change the pH throughout the day.

d. increase oxygen at night.

e. None of the above.

130. At night algae in a conventional lagoon will:

*a. Cease to produce oxygen

b. Consume oxygen

c. Produce less oxygen

d. Increase the pH of the lagoon contents

131. Which of the following microorganisms are involved in the stabilization of wastewater in a facultative wastewater treatment pond?

a. Aerobic bacteria

b. Anaerobic

c. Facultative bacteria

*d. All of the above

e. (a) and (c) only

132. Which of the following is not a term used to refer to a conventional wastewater treatment lagoon?

a. Oxidation pond

b. Stabilization pond

c. Facultative lagoon

*d. Aerobic lagoon

133. The main function of algae in a facultative wastewater treatment pond is to:

a. produce carbon dioxide, which is then used by the facultative bacteria.

b. use up nutrients such as nitrogen and phosphorus.

*c. produce oxygen during daylight hours.

d. serve as a food source for essential protozoa.

e. break down complex organics in the wastewater.

134. Sodium nitrate is a chemical that may be used in the operation of a wastewater pond to restore normal conditions after a pond "turn over." Its function is:
*a. To provide a source of chemically combined oxygen for the facultative bacteria.
b. To kill off the unwanted blue-green algae.
c. To preserve the nitrogen balance in the pond.
d. To control the growth of weeds.
e. To neutralize chlorine residuals in the pond effluent.

135. It is important to completely mix and aerate the following type of pond:
*a. aerobic.
b. facultative.
c. anaerobic.
d. All of the above.
e. None of the above.

136. The laboratory tests most frequently used to monitor a facultative pond on a daily basis are:
a. pH, color, and BOD
*b. pH, BOD, and suspended solids
c. pH, DO, and temperature
d. DO, BOD, and SS
e. Microscopic examination, color, and DO

137. The effluent from a conventional lagoon should be withdrawn:
a. Off the surface
b. Near the bottom
*c. Six to eighteen inches below the surface
d. Intermittently

138. Algae in a stabilization pond is most likely to:
a. consume oxygen during daylight hours.
b. decrease effluent TSS during the day.
*c. change the pH throughout the day.
d. increase oxygen at night.
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d. Organic loading to a pond is expressed as pounds of volatile suspended solids per acre per day.

e. A facultative pond has an anaerobic layer and an aerobic layer.

141. One short-term corrective measure for an overloaded facultative pond might be to add:

a. copper sulfate .

b. sodium sulfide.

c. ammonium sulfide .

*d. sodium nitrate.

e. potassium chloride.

142. Photosynthesis is an essential part of the biological activity associated with:

a. Activated sludge

b. Trickling filters

c. Oxidation ditches

d. Aerobic digesters

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*a. during daytime when the consumption of CO2 is the highest

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a. Chlorophyll converts sunlight into energy for growth.

b. Algae produces oxygen

c. Algae converts CO2, NH3, and PO4, into additional algae cells

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a. Do nothing. The conditions described are normal.

*b. Apply algaecide to the lagoon to kill the algae.

c. Drawdown the lagoon to eliminate excess DO.

d. Isolate cell.

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a. consume oxygen during daylight hours.

b. decrease effluent TSS during the day.

*c. change the pH throughout the day.

d. increase oxygen at night.

e. None of the above.

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a. The pond is hydraulically overloaded.

*b. The pond seal leaks.

c. The flow control structure leaks.

d. The flow control structure does not split the flow evenly.

151. A properly designed and operated wastewater stabilization pond will remove what percent BOD.

a. 40%-60%.

b. 60%-70%.

c. 70%-80%.

*d. 80%-90%.

152. At night algae in a conventional lagoon will:

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b. Consume oxygen

c. Produce less oxygen

d. Increase the pH of the lagoon contents

153. At what time of day is the dissolved oxygen content highest in a lagoon?

a. 3 a.m.

b. 7 a.m.

c. 9 a.m.

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154. Cattails growing in lagoon will

*a. Cause short circuiting in affected lagoon.

b. Eliminate mosquito larvae.

c. Increase the diurnal pH fluctuations.

d. Increase toxic blue-green algae concentrations in the effluent.

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*a. Mowing periodically.

b. Burning in the spring and fall.

c. Allowing the cattle to graze on the dikes.

d. Any of the above would be acceptable.

156. Due to diurnal differences in operation, a lagoon system is likely to experience the lowest dissolved oxygen readings

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b. During the time when the sun is out and it is the hottest

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d. When BOD loading is the lowest

157. Given the following data, what is the most likely cause of the aerated pond problem? — DATA: Turbulence over center part of pond. Solids floating to surface on edge of pond. DO in center portion= 1.4 mg/L.

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*b. Inadequate aeration on edges on pond.

c. Sludge scraper not operating.

d. Toxic materials in pond.

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a. Volume (MG) divided by Flow (MGD)

*b. Depth (inches) divided by Detention Time (days)

c. Volume (acre-feet) divided by Flow (acre-inches/day)

d. Flow (gallons/day) divided by Area (acres)

e. Area (acres) divided by Flow (acre-inches/day)

159. In a properly operating facultative pond, algae live on carbon dioxide and nutrients during the day, and at night produce carbon dioxide. This has what effect on the pH?

*a. pH increases during the day, and decreases at night

b. pH decreases during the day, and increases at night

c. pH stays the same no matter what time of day

d. Carbon dioxide has no effect on pH

160. It is important to completely mix and aerate the following type of pond:

*a. aerobic.

b. facultative.

c. anaerobic.

d. All of the above.

e. None of the above.

161. Due to diurnal differences in operation, a facultative pond is likely to experience the lowest dissolved oxygen readings

a. At any time since diurnal differences have no bearing on DO values

b. During the time when the sun is out and it is the hottest

*c. During night, just before dawn

d. When BOD loading is the lowest

162. The main function of algae in a facultative wastewater treatment pond is to:

a. produce carbon dioxide, which is then used by the facultative bacteria.

b. use up nutrients such as nitrogen and phosphorus.

*c. produce oxygen during daylight hours.

d. serve as a food source for essential protozoa

e. break down complex organics in the wastewater.

163. Which of the following microorganisms are involved in the stabilization of wastewater in a facultative wastewater treatment pond?

a. Aerobic bacteria

b. Anaerobic

c. Facultative bacteria

*d. All of the above

e. (a) and (c) only

164. Which of the following statements is not true regarding a facultative wastewater treatment pond?

a. When starting a facultative pond, 1 foot of relatively clean water should be added to the pond prior to the addition of wastewater.

b. A facultative pond generally is operated at a detention time of 50 to 60 days or longer.

*c. DO concentrations of 10 to 15 mg/L or greater are frequently found in a facultative pond during the afternoon of a sunny day.

d. Organic loading to a pond is expressed as pounds of volatile suspended solids per acre per day.

e. A facultative pond has an anaerobic layer and an aerobic layer.

165. Which of the following would not be a routine operational or maintenance problem in the operation of pond:

a. weed control.

b. levee maintenance.

c. insect control.

*d. temperature control.

e. scum control.

166. Which of the following is not a term used to refer to a conventional wastewater treatment lagoon?
    a. Oxidation pond
    b. Stabilization pond
    c. Facultative lagoon
    *d. Aerobic lagoon
167. Sodium nitrate is a chemical that may be used in the operation of a wastewater pond to restore normal conditions after a pond "turn over." Its function is:
    *a. To provide a source of chemically combined oxygen for the facultative bacteria.
    b. To kill off the unwanted blue-green algae.
    c. To preserve the nitrogen balance in the pond.
    d. To control the growth of weeds.
    e. To neutralize chlorine residuals in the pond effluent.
168. The laboratory tests most frequently used to monitor a facultative pond on a daily basis are:
    a. pH, color, and BOD
    *b. pH, BOD, and suspended solids
    c. pH, DO, and temperature
    d. DO, BOD, and SS
    e. Microscopic examination, color, and DO
169. The effluent from a conventional lagoon should be withdrawn:
    a. Off the surface
    b. Near the bottom
    *c. Six to eighteen inches below the surface
    d. Intermittently
170. The facultative zone in a pond:
    a. provides no treatment.
    b. provides oxygen to the anaerobic zone.
    c. is a barrier to light penetration
    d. produces the bacteria for the anaerobic zone.
    *e. uses nitrate as an oxygen source for digestion.
171. Which of the following terms is usually not associated with wastewater treatment ponds?
    *a. Filamentous bacteria
    b. Symbiotic relationship
    c. Photosynthesis
    d. Sewage lagoon
    e. Inches/day
172. A lagoon operator collects a sample of effluent at 2:15 pm. on a sunny July day and tests it. for dissolved oxygen. The dissolved oxygen is 22 mg/1 and the pH is 9.2. The lagoon has a green color. Effluent suspended solids have been running at 75 mg/1. The operator

should

a. Do nothing. The conditions described are normal.

*b. Apply algaecide to the lagoon to kill the algae.

c. Drawdown the lagoon to eliminate excess DO.

d. Isolate cell.

173. Given the following data, what is the most likely cause of the aerated pond problem? — DATA: Turbulence over center part of pond. Solids floating to surface on edge of pond. DO in center portion= 1.4 mg/L.

a. Hydraulic flow too slow through pond.

*b. Inadequate aeration on edges on pond.

c. Sludge scraper not operating.

d. Toxic materials in pond.

174. Hydraulic loading to a facultative pond equals:

a. Volume (MG) divided by Flow (MGD)

*b. Depth (inches) divided by Detention Time (days)

c. Volume (acre-feet) divided by Flow (acre-inches/day)

d. Flow (gallons/day) divided by Area (acres)

e. Area (acres) divided by Flow (acre-inches/day)

175. Which of the following is not a term used to refer to a conventional wastewater treatment lagoon?

a. Oxidation pond

b. Stabilization pond

c. Facultative lagoon

*d. Aerobic lagoon

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a. pH, color, and BOD

*b. pH, BOD, and suspended solids

c. pH, DO, and temperature

d. DO, BOD, and SS

e. Microscopic examination, color, and DO

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a. Off the surface

b. Near the bottom

*c. Six to eighteen inches below the surface

d. Intermittently

179. Sodium nitrate is a chemical that may be used in the operation of a wastewater pond to restore normal conditions after a pond "turn over." Its function is:

*a. To provide a source of chemically combined oxygen for the facultative bacteria.

b. To kill off the unwanted blue-green algae.

c. To preserve the nitrogen balance in the pond.

d. To control the growth of weeds.

e. To neutralize chlorine residuals in the pond effluent.

180. The effluent from a conventional lagoon should be withdrawn:

a. Off the surface

b. Near the bottom

*c. Six to eighteen inches below the surface

d. Intermittently

181. The facultative zone in a pond:

a. provides no treatment.

b. provides oxygen to the anaerobic zone.

c. is a barrier to light penetration.

d. produces the bacteria for the anaerobic zone.

*e. uses nitrate as an oxygen source for digestion.

182. One short-term corrective measure for an overloaded facultative pond might be to add:

a. copper sulfate .

b. sodium sulfide.

c. ammonium sulfide .

*d. sodium nitrate.

e. potassium chloride.

183. During the process of algal photosynthesis:

a. Chlorophyll converts sunlight into energy for growth.

b. Algae produces oxygen

c. Algae converts CO2, NH3, and PO4, into additional algae cells

*d. All of the above

184. pH of the facultative pond will be the highest

*a. during daytime when the consumption of CO2 is the highest

b. during daytime when the consumption of CO2 is the lowest

c. during nighttime when the production of CO2 is highest

d. during nighttime when the production of CO2 is lowest

7. Activated Sludge Assessment

Activated Sludge Assessment

1. What is the activated sludge floc made of
2. What properties of activated sludge floc are key to the effectiveness of the activated sludge process
3. List the activated sludge process control parameters (names/description)
4. List the key design differences between a rectangular and circular primary clarifier
5. Why is it important to ensure having a "good" microbiological composition of the activated sludge process (5 points)
6. What is/are the main factor/s that control the microbial population
7. MLVSS represents the _____ fraction of the MLSS
8. Optimal range of SVI is between _____ to _____
9. Straggler floc is associated with [type1] sludge while pin-floc is associated with _____ sludge

   Bulking and foaming is due to_____ bacteria
10. Portion of the activated sludge floc settled in the clarifier that is returned to the front of the aeration basin to seed the incoming primary effluent is called [name]
11. Which one of the following statements is TRUE regarding the various modifications of the activated sludge process

    a. MCRT of 5 to 10 days is typical for extended aeration

    *b. Typical hydraulic detention times in the contact tank of the contact stabilization process need only be 0.5 to 1.0 hour.

    c. F to M ratios of 0.03 to .1 are appropriate for the step-aeration mode of the activated

sludge process

d. Pure oxygen activated sludge floc often has a large population of rotifers.

e. Step feed -aeration involves decreasing the air being fed along the length of the aeration tank.

12. What is the significance/importance of measuring OUR and SOUR and what are their respective units of measurement
    Correct Answer(s):
13. List the advantages and disadvantages of the constant RAS flow control
    Correct Answer(s):
14. Name and describe the two RAS control approaches
    Answer the following related to activated sludge floc:
15. What is the activated sludge floc made of (3 points)
16. Activated sludge is an anaerobic process
    a. True
    *b. False
17. Secondary treatment is mainly to remove the organic content of the wastewater
    *a. True
    b. False
18. The contents of an aeration tank utilized in activated sludge treatment is referred to as mixed liquor.
    *a. True
    b. False
19. In conventional activated sludge plants, six to eight hours of aeration detention time is used for acceptable plant operation.
    *a. True
    b. False
20. Bulking occurs in primary clarifiers and is associated with improper scum removal.
    a. True
    *b. False
21. Contact stabilization is a modification of the conventional activated sludge system.
    *a. True
    b. False
22. In secondary settling tanks, the sludge pumping considerations would be the same as in primary settling tanks.
    a. True
    *b. False
23. The main function of a launder in a secondary clarifier is to prevent scum and other floatables from leaving with the effluent flow
    a. T
    @Incorrect. Launder collects and conveys the effluent flow. Effluent baffles prevent scum

and other floatables from leaving with the effluent flow

*b. F

@Correct. Launder collects and conveys the effluent flow. Effluent baffles prevent scum and other floatables from leaving with the effluent flow

24. Excessive filamentous bacteria in activated sludge is typically controlled by bleach addition to RAS

    *a. True

    b. False

25. SVI is a measure of the sludge volume that needs to be wasted

    a. True

    *b. False

26. pH has little effect on the activated sludge plant

    a. True

    *b. False

27. Bulking is caused by excessive filamentous bacteria

    *a. True

    b. False

28. Extended aeration involves operating the activated sludge process at a high F: M ratio

    a. True

    *b. False

29. In conventional secondary wastewater treatment processes, aerobic decomposition of solids will occur.

    *a. True

    b. False

30. In the activated sludge process, the wastewater oxygen demand may be separated into two categories: carbonaceous and nitrogenous

    *a. True

    b. False

31. MCRT refers to the average number of days that a “cell” remains in an activated sludge system.

    *a. True

    b. False

32. In activated sludge treatment a young sludge age is marked by a low F:M ratio

    a. True

    *b. False

33. The "M" in the F:M ratio is the mass of mixed liquor suspended solids in the aeration basin

    a. True

    *b. False

34. The SVI test is used for establishing amount of sludge to be wasted

    a. True

*b. False

35. A WAS or RAS flow change of 25% in one day will have little impact on the activated sludge treatment process
    a. True
    *b. False
36. Rotifers are the dominant microorganisms in a young activated sludge
    a. True
    *b. False
37. The F in the F to M ratio refers to the pounds of mixed liquor volatile suspended solids under aeration in an activated sludge plant.
    a. True
    *b. False
38. The use of F:M ratio for controlling the activated sludge process implies the need for higher mass of microorganisms to treat a stream with a higher BOD
    *a. True
    b. False
39. The white billowing foam commonly seen during the startup of the activated sludge plant is caused by low F:M ratio
    a. True
    *b. False
40. When an activated sludge plant is first started, one should expect to see foaming
    *a. True
    b. False
41. MLVSS represents the _____ fraction of the MLSS
42. Optimal range of SVI is between _____ _____
43. Straggler floc is associated with [_____ sludge while pin-floc is associated with _____ sludge
44. Bulking and foaming is due to _____ bacteria
45. Portion of the activated sludge floc settled in the clarifier that is returned to the front of the aeration basin to seed the incoming primary effluent is called [name]
46. The basic objective in the activated sludge process is to maintain balanced conditions in the aeration basin, this balance is called:
    a. Endogenous respiration
    *b. Food/microorganism ratio
    c. Equilibrium status
    d. Mass balance ratio
47. In the activated sludge treatment process, there are several control methods. One method is to maintain a BOD:MLVSS ratio. This is commonly referred to as:
    a. MCRT.
    b. SA.

c. SA:SDI.

*d. F:M.

e. TS:SRT

48. In calculating the detention time in an aeration tank, which one factor would not be considered?

a. tank volume

b. RAS flow

c. plant flow

*d. MLSS concentration

e. none of the above

49. The BOD loading rate divided by the quantity of microorganisms present in the biological reactors (aeration tanks) is known as:

a. organic loading

b. toxicity

c. hydraulic loading

*d. food to microorganism ration F:M

50. An activated sludge process that has a desired F/M ratio of 0.05 and a sludge age of 30 days is what type of activated sludge process modification?

*a. Extended aeration

b. Conventional

c. Complete mix

d. Oxidation ditch

51. Two major operational difficulties which sometimes occur in activated sludge secondary clarifiers are:

*a. Low D.O. and algae growth

b. Short circuiting and scum accumulation

c. Rising sludge and bulking sludge

d. Long detention time and short MCRT.

52. A thick, scummy, dark tan foam on the surface of an activated sludge aeration tank is an indication of:

*a. Aeration tank is underloaded (high MLSS.

b. Aeration tank is overloaded (low MLSS.

c. Excess grease in raw wastewater

d. Excess phosphates (detergents. in raw wastewater

53. A good quality of activated sludge is shown by:

a. Black color and very small particle size

b. Finely dispersed milky white particles

c. A chocolate brown MLSS that does not settle well in the jar test

d. A sludge that settles in one minute in the jar test

*e. A chocolate color which settles out in 20-30 minutes with a D.O. of 2.0

54. An aerobic treatment process is one that requires the presence of:
    a. Ozone
    b. organic oxygen
    c. no oxygen
    d. combined oxygen
    *e. dissolved oxygen
55. An increasing F/M ratio and decreasing MCRT indicates
    *a. Excessive solids wasting causing a decrease in solids inventory
    b. Inadequate solids wasting causing an increase in the solids inventory
    c. Decreased hydraulic load increasing the sludge detention time
    d. Operation is normal
56. A rapid and significant increase in filamentous organisms in the mixed liquor may be expected to:
    a. Result in a far better effluent because of the great amount of surface area for absorption
    b. Plug up the return sludge pumps because the filaments hang upon valves and gaskets in the sludge line
    c. Lead to much denser return sludge because the filaments would tend to strain the dispersed cells of ordinary organisms out of the effluent
    *d. Cause bulking of the sludge solids to the point that some solids might be swept out along with an otherwise clear liquid phase and result in turbid, poor quality effluent
    e. Lead to a much lower F/M ratio because the filaments are so totally insoluble.
57. In the activated sludge treatment process, there are many control methods. One method is to maintain a constant BODs:MLVSS ratio. sludge treatment process. This is commonly referred to as:
    a. MCRT
    b. SA
    c. SA: SDI
    *d. F:M
    e. TS:SRT
58. The SVI of activated sludge is defined as:
    a. the volume of settled mixed liquor after 30 minutes or settling·
    b. the weight in grams of 200 ml of settled activated sludge
    *c. the volume in ml of 1 gram of activated sludge after 30 minutes of settling
    d. the total volume of MLSS in the aeration tank
    e. the volume of settled sludge in the secondary clarifier
59. The amount of air required in the operation of an activated sludge aeration tank is independent of the:
    a. temperature
    b. flow
    c. detention time

d. organic loading

*e. none of the above

60. The successful operation of an activated sludge plant requires the maintenance of proper solids concentration in the system. One major limiting factor is:

a. mixed liquor tank volume

b. effluent flow

*c. air supply

d. chlorine demand

e. none of the above

61. The main difference between primary and secondary clarifiers is the:

a. overall dimensions

b. type of outlet weirs

*c. density of sludge

d. detention period

e. flow distribution

62. Given the data below, what is the most likely cause of the extended aeration facility problem?

DATA: DO level high

Blower normal

Wastewater characteristics normal

Drop pipe air control valves open

Surface turbulence high

a. Air relief valve stuck shut

*b. Blower speed too fast

c. Blower speed too slow

d. Drop pipe air control valves not open far enough

63. What test is used to determine the organic matter found in the mixed liquor?

a. COD

b. MLSS

*c. MLVSS

d. TOC

64. Fixed porous plate diffusers can be cleaned by scrubbing with

a. Detergent

b. A strong acid solution

*c. A strong chlorine solution

d. A weak sodium hydroxide solution

65. A 30 minute settleability test MLSS sample should be collected:

a. At the primary clarifier effluent

b. In the return sludge line

c. Where the return sludge mixes with the aeration basin contents

d. At the aeration basin influent

*e. At the aeration basin outlet

66. A consulting engineer has recommended addition of a roughing filter and intermediate clarifier between your primary clarifier and aeration basin to better handle increasing industrial loads. This addition would:

a. Be the best form of flow equalization available

b. Remove most of the fixed dissolved solids

c. Reduce drastically the fine dissolved matter

d. Cost a lot and do nothing

*e. Reduce the organic load on the aeration basin

67. An activated sludge process that has a desired F/M ratio of 0.05 and a sludge age of 30 days is what type of activated sludge process modification?

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68. Two major operational difficulties which sometimes occur in activated sludge secondary clarifiers are:

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70. Possible techniques for controlling filamentous organisms in an activated sludge process include:

*a. Dosage of return sludge with a disinfectant such as chlorine or hypochlorite

b. Lower DO levels in aeration bans so filamentous organisms cannot breathe or respire

c. Lower F/M level to starve filamentous organisms

d. Stop wasting to allow activated sludge bugs to gain control

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    c. Lead to much denser return sludge because the filaments would tend to strain the dispersed cells of ordinary organisms out of the effluent
    *d. Cause bulking of the sludge solids to the point that some solids might be swept out along with an otherwise clear liquid phase and result in turbid, poor quality effluent
    e. Lead to a much lower F/M ratio because the filaments are so totally insoluble.
76. During severe cold weather operation of an activated sludge plant biological activity and clarifier sludge settling is reduced. White of the following might help?
    *a. Increase the MLSS
    b. Decrease the MLSS
    c. Increase the D.0.
    d. Decrease the D.0.
    e. Add ammonia
77. Excess white foam in an aeration basin can be corrected by
    a. Decreasing the aeration rate
    b. Decreasing detention time
    *c. Increasing the MLSS
    d. Decreasing the MLSS
    e. Increasing aeration rate

78. Given the following data, what is the most likely cause of the activated sludge problem?
    DATA: The aeration tanks in an activated sludge plant have maintained a stable white foam with a brownish tint less than one inch thick. ·
    BOD removals have been at their normal high efficiency.
    Settling of the activated sludge in the secondary clarifiers has been good - as is normal.
    Air supplied to the system has been a normal 30,000 cfm, with a consistent DO of 2.5 mg/L.
    MLSS has been maintained at 2,500 mg/L - normal.
    Gradually during your shift the DO has risen to 5.0 mg/L.
    a. A toxic substance has affected the activated sludge.
    b. BOD loading on the aeration system has increased.
    c. Increased BOD loading has caused a corresponding increase in activated sludge activity.
    *d. No change.
79. Given the following data, what is the most likely cause of the secondary sedimentation tank problem?
    DATA: Sludge depth in tank too high.
    Tank effluent turbid.
    Tank effluent requiring above normal chlorine dosage. Sweeparms in tank bottom operating.
    Return activated sludge flow to aeration tank low.
    Controls on return activated sludge pump on automatic.
    Control sensors for return sludge operating normally.
    a. Accuracy of sludge depth measurement.
    b. Return activated sludge pump worn, needing repair.
    *c. Speed of sweeparms travel.
    d. Sweep arm overload tripped.
80. How many gallons of paint will be required to paint the walls of a 40 ft long x 65 ft wide x 20 ft high tank if the paint coverage is 150 sq. ft per gallon. Note: We are painting walls only. Disregard the floor and roof areas.
    *a. 28 gallons
    b. 63 gallons
    c. 35 gallons
    d. 56 gallons
81. If there is an insufficient supply of air or oxygen being introduced into the aeration tank of an extended aeration plant, the liquid in the tank will likely
    a. Contain a very fine light brown floc.
    b. Contain very small air bubbles.
    *c. Have a black or blackish appearance and an offensive odor.
    d. Have a dishwater appearance and a greasy odor.
82. If the return sludge pump does not function the effect on other unit processes will be to:

a. Tum the aeration basin influent dark

b. Increase chlorine residual

*c. Increase effluent suspended solids

d. All the above

e. None of the above.

83. If the sludge depth in a secondary sedimentation tank is too high, what will happen?

a. Decreased turbidity in effluent.

b. Return activated sludge will have lower oxygen demand.

c. Settleable solids from aeration tank will increase.

*d. Sludge may become septic.

84. If you must waste sludge from an activated sludge plant the maximum rate is:

*a. 20 % per day

b. 40 % per day

c. 60 % per day

d. 75% per day

e. 100 % perday

85. In an activated sludge system, what is perhaps the most important parameter affecting biological activity?

a. pH.

b. Alkalinity.

*c. Dissolved oxygen.

d. Temperature.

86. Mean cell residence time (MCRT. represents the theoretical time that a microorganism stays in the activated sludge system. The typical values for most activated sludge processes are:

a. 3 - 30 days

*b. 3 - 15 days

c. 5 - 15 days

d. 5 - 20 days

87. Nocardia is associated with a particular type of brown, viscous scum or foam on the surface of the activated sludge aeration tank. One operational strategy that has been somewhat successful in reducing the severity of this foam is:

a. to increase the plant's MCRT.

*b. to decrease the plant's mixed liquor concentration.

c. to operate at an F:M ratio of less than 0.025.

d. to spray the foam with fine mist water sprays.

e. to increase the luxury DO concentration at the end of the aeration tank.

88. One limitation in using constant mixed liquor volatile suspended solids (MLVSS) or mixed liquor total suspended solids (MLTSS) as the control methodology for activated sludge treatment is

*a. In practice it is not possible to operate at a constant MLTSS or MLVSS.

b. It is based on consistency of raw waste load which seldom exists.

c. Most facilities don't have the lab equipment necessary to determine MLVSS.

d. None of the above.

89. Define Nocardia & problems associated with it. List 5 methods of controlling Nocardia.
Response:

a *Define Nocardia & problems associated with it.*

- Nocardia is a type of filamentous organism which on overgrowth in the mixed liquor is the cause of foaming during aeration in the activated sludge process. Nocardia proliferation is associated with the following three causes in combination: (1) high grease and oil; (2) longer sludge age; and (3) low oxygen conditions or septicity.
  Nocardia develops a persistent, viscous brown foam scum. If not skimmed properly, this can cause an increase in both suspended solids and BOD and cause scum spill over on to the catwalks and make them sticky and slimy. Additionally, Nocardia from the secondary sludge could cause digester foaming.

b *List 5 methods of controlling Nocardia.*

i. Reduce sludge age by increasing wasting rate. This would also effectively reduce MLSS concentration in the aeration tank and increase F:M.
ii. Mechanically skim and remove the foam.
iii. Enforce industrial waste control program and manage the collections cleaning procedures to minimize the amount of grease and oil in the influent wastewater.
iv. Chlorinate the RAS stream or the mixed liquor return or by spraying directly into the aeration tank.
v. Use of mannich polymer to enhance settling and removal of the Nocardia filaments

90. Clearly show how SOUR & OUR are different. List two possible causes for a sudden 40% decrease in OUR during the last 12 hours of operation. What lab test might confirm or refute the two causes of this sudden decrease in OUR. Response:
    a *Clearly show how SOUR & OUR are different.*
        - Oxygen Uptake Rate (OUR) involves measurement of the amount of oxygen used up by the microorganisms in the mixed liquor using a DO probe and is expressed in unit time of mg/L-hr (ppm O_2 consumed per hour). By knowing the OUR, we can establish the activity of the microorganisms in the aeration tank and know if they are consuming the oxygen provided for removing organic matter. For conventional activated sludge process the typical OUR values range from 10 to 30 mg/L-hr

          Specific Oxygen Uptake Rate (SOUR) provides the OUR information based on the concentration of microorganisms present. SOUR is obtained by dividing OUR with MLVSS.

          The value is indicated and measured in terms of unit of $\frac{\frac{mg}{l-hr}O_2}{\frac{mg}{l}MLVSS} * 1000\frac{mg}{gm}$.

          Optimal range of SOUR is usually between 8 to 20.

    b *List two possible causes for a sudden 40% decrease in OUR during the last 12 hours of operation.*
        i. Presence of toxic substance in the mixed liquor inhibiting the normal biological activity in the aeration basin
        ii. Excessive loss of biomass due to inadvertent wasting

    c *What lab test might confirm or refute the two causes of this sudden decrease in OUR.*
        i. Run a MLSS test to see if adequate biomass is present
        ii. Run a COD test to ensure adequate amount of organics (food) is present
        (If there is sufficient biomass and food present, the only reason why the OUR would have declined would be because of toxic substance entering the system)

91. The control and calculation of RAS flow rates are important considerations in the Operation of activated sludge wastewater treatment plants. Most commonly the operator Either sets the return rate (Qr) at a constant flow or as a constant percentage of flow.
    (a) Identify two effects that each of these approaches will have on plant operations.
    Assume that a normal diurnal variation in both wastewater flow and strength.
    (b) The so-called "solids balance approach" (shown below) may be used to Mathematically estimate Qr. What two assumptions are made in deriving this formula?
    [Qr + Q] x MLSS Conc. = Qr x RAS Conc.
    (c) Using the information given below and the "solids balance" equation, calculate SVI and Qr comment on these values:
    Q. . . . . ..2.0 MGD
    MLSS. . . . . 2350 mg/L
    RAS. . . . . .7350 mg/L

SV30. . . . . 320 mLs/g

8. Nutrient Removal Assessment

Nutrient Removal Assessment

1. Nitrification is conversion of _____ to _____
2. Nitrosomonas are _____ (type) bacteria
   Correct Answer(s):
   a. Autotrophic
3. Denitrification requires _____ condition
   Correct Answer(s):
   a. anoxic
4. Presence of adequate quantity of _____ is critical for phosphorous removal
   Correct Answer(s):
   a. vfa
5. In nitrification, _____ parts of oxygen required per part of ammonium nitrogen
   Correct Answer(s):
   a. 4.57
6. In domestic water _____
   Correct Answer(s):
   a. 40
7. Nitrification is conversion of _____ to _____
8. In domestic water _____ % of nitrogen is present as ammonia/ammonium
   Correct Answer(s):
   a. 40
9. The approximate pH for good nitrification is closest to

a. 6.5

b. 7.0

*c. 8.5

d. 10.0

10. Which of the following biological processes can produce alkalinity?

a. Carbonaceous BOD removal

*b. Denitrification

c. Nitrification

d. Phosphorus removal by chemical addition with ferrous chloride

11. In a typical biological nitrification system, an oxygen demand of _____ parts oxygen per part of ammonia oxidized is exerted in the nitrification process.

a. 2.37

b. 5.47

c. 27

*d. 4.57

12. The biological nitrification process is carried out by bacteria that convert ammonia nitrogen to nitrate nitrogen. the two (2) specific groups of bacteria that perform this conversion are:

*a. Nitrosomonas and nitrobacter

b. Flagellates and swimming ciliates

c. Flagellates and crawling ciliates

d. Crawling ciliates and swimming ciliates

13. Biological denitrification requires _____ conditions.

a. Aerobic

*b. Anoxic

c. Anaerobic

d. Facultative

14. Denitrification is an activated sludge plant involves:

a. Oxidation of ammonia to nitrate.

b. High concentrations of D.O. in the mixed liquor as it settle in the secondary clarifier.

c. Biological oxidation of nitrate to nitric oxide.

*d. Biological reduction of nitrate to nitrogen gas.

e. Poor compaction of mixed liquor as it settles in the secondary clarifier.

15. In a nitrifying activated sludge plant, it is important to maintain adequate D.O. in the mixed liquor as it settles in the final clarifier to prevent:

a. Death of organisms in the floc that “eat” organic materials.

*b. Denitrification.

c. Bulking.

d. Growth of filamentous organisms.

e. Death of filamentous organisms.

16. Nitrification in activated sludge does not involve:
    a. The oxidation of ammonia to nitrite.
    *b. Removal of oxygen from nitrate to form nitrogen gas.
    c. The biological oxidation of nitrite to nitrate.
    d. Higher concentration of D.O. in the aeration basin.
    e. Control of alkalinity to stabilize pH.
17. Limits on the concentration total NH3 - N are frequently placed on secondary effluents discharged into sensitive receiving waters. An important consideration in the setting of these limits by the RWQCB would be:
    a. The concentration of algal cells in the receiving water.
    *b. The pH & temperature of the receiving water.
    c. The salinity of the receiving water.
    d. The population of nitrosomonas bacteria in the final effluent.
    e. The concentration of copper ions in the final effluent because these ions form a non-toxic complex with the ammonia nitrogen.
18. Many NPDES permits limit the amount of ammonia nitrogen that can be discharged into a stream because:
    a. Ammonia exerts an oxygen demand in the stream
    b. Ammonia can be toxic to aquatic life
    c. Ammonia reacts with chlorine which can interfere with disinfection
    *d. Any of these
19. Possible techniques for controlling filamentous organisms in an activated sludge process include:
    *a. Dosage of return sludge with a disinfectant such as chlorine or hypochlorite
    b. Lower DO levels in aeration bans so filamentous organisms cannot breathe or respire
    c. Lower F/M level to starve filamentous organisms
    d. Stop wasting to allow activated sludge bugs to gain control
20. Nitrogen and phosphorous are biologically significant in waste water because:
    a. Nitrogen is reduced to pure nitrogen gas when phosphorous is present as a catalyst and this leads to nitrogen super saturation and rapid fish kills.
    b. Nitrogen in the form of nitrates will reduce sodium thiosulfate and thus cause low results in the D.O. test while phosphates will oxidize the iodine to iodide and cause high results.
    *c. Nitrogen and phosphorous are essential nutrients that can enable aquatic plant growth to become troublesome.
    d. Nitrogen pentaphosphate is toxic to the organisms that metabolize.
21. What are the bacteria that remove ammonia in the activated sludge process
    a. Filamentous bacteria
    *b. Nitrosomonas
    c. Stalked ciliates

d. E. Coli

22. The loading on a nitrification system consists of ammonia plus organic nitrogen and is typically referred to as total nitrogen.
    a. True
    *b. False
23. Chlorine is being applied at a constant dose rate of 24 mg/L to a partially nitrified activated sludge effluent having a pH of 6.8 and a temperature of 67 deg. F. Ammonia nitrogen is found to range from 2 to 3 mg/L in this effluent. Disinfection in this effluent might be difficult because:
    a. A temperature of 70 deg. F or higher is necessary in order to achieve effective disinfection.
    b. Chloramines are present most of the time.
    c. The chlorine dose rate is too low.
    d. The pH of this effluent will limit the effectiveness of free chlorine.
    *e. The ratio of chlorine to ammonia nitrogen may make it difficult at times to maintain adequate chlorine residual.
24. During breakpoint chlorination:
    a. A ratio of 5 parts of chlorine to 1 part of ammonia nitrogen is adequate to reach the breakpoint.
    b. Ammonia nitrogen is reduced to nitrogen dioxide.
    *c. As the breakpoint is approached, additional chlorine causes the chlorine residual to decrease.
    d. Significant concentrations of dichloramine remain after the breakpoint is passed.
25. In the breakpoint chlorination method of ammonia nitrogen removal, parts of chlorine are required for each part of ammonia removed.
    a. 3.0
    b. 6.7
    *c. 7.6
    d. 2.0

26. The correct statement regarding the effect of nitrogen in chlorine disinfection is:
    a. The reaction of ammonia with chlorine increases pH.
    b. The reaction of ammonia with chlorine decreases pH.
    c. The reaction of nitrite with free chlorine produces chloride.
    *d. The reaction of ammonia with free chlorine produces chloramines.
    e. The reaction of nitrate with free chlorine produces nitrogen gas.
27. You are the superintendent of a 100,000 gpd conventional activated sludge plant which discharges into a shallow bay. Your NPDES permit currently sets a discharge limit of 5 mg/L for total ammonia-nitrogen in your effluent. However, the Regional Water Quality Control Board at the request of the Department of Fish and Game will soon revise your plant's discharge requirements and have even lower total ammonia limits so that certain species of fish may be re-introduced into the bay. The proposed maximum total ammonia-nitrogen concentration limit for November through March 15th - 2.0 mg/L and 1.0 mg/L for the period March 16th through October 31st Answer the following questions:
    1. Limits on the concentration total NH_3 - N are frequently placed on secondary effluents discharged into sensitive receiving waters. An important consideration in the setting of these limits by the RWQCB would be:
        a The concentration of algal cells in the receiving water.
        b The pH & temperature of the receiving water.
        c The salinity of the receiving water.
        d The population of nitrosomonas bacteria in the final effluent.
        e The concentration of copper ions in the final effluent because these ions form a non-toxic complex with the ammonia nitrogen.
    2. Many NPDES permits limit the amount of ammonia nitrogen that can be discharged into a stream because:
        a Ammonia exerts an oxygen demand in the stream
        b Ammonia can be toxic to aquatic life
        c Ammonia reacts with chlorine which can interfere with disinfection
        d Any of these
    3. Impacts of new ammonia-nitrogen limits on plant operations would include:
        a Process change to remove ammonia further: nitrification – denitrification
        b Increased MCRT, higher activated sludge power demands and Lower sludge yields
        c Potential impacts to disinfection strategy related to breakpoint chlorination
        d Options [a] and [b]
        e Options [a], [b] and [c]

28. You are the operations supervisor of a wastewater treatment plant that consists of the following unit processes: primary clarifiers, activated sludge aeration tanks, secondary clarifiers, a DAF thickener used to thicken WAS, and anaerobic digesters. Anaerobic digester gas is used, when it is available in sufficient amounts, to fuel engines that drive blowers supplying air to the activated sludge aeration tanks. Waste heat from these engines is sufficient to heat the digesters. When a sufficient amount of gas is not available, then electric motors are used to drive blowers. The regional water quality control board will soon impose a limit of 1.0 mg/L on the discharge of ammonia-nitrogen. In order to meet this limit, your plant will be modified to achieve complete nitrification.
    Answer the following questions:
    1. Demand Charge is measured in:
        a). $/kWh
        b). $/Hp
        c). $/kW
        d). $/day
    2. Most significant impact on energy consumption related to changes in mode of operation in order to meet the new permit requirement will be due to:
        a). Increased digester gas production
        b). Additional sampling and testing requirements
        c). Associated with meeting higher F:M requirements for nitrification
        d). Higher aeration air requirements
    3. Which of the following is true for Demand Charges:
        a). Applies to residential customers also.
        b). Based upon how much electricity used and the rate at which it is consumed
        c). It is calculated based on 15-minute interval data
        d). Options a) and c)
        e). Options b) and c)
        f). Options a), b) and c)
    4. Digester gas production is expected to:
        a). Increase.
        b). Decrease
        c). Remain the same
    5. More power will need to be purchased because of:
        a). Increased power demands related to denitrification
        b). Meet power demand associated with higher F:M ratio requirements
        c). Additional sludge pumping to digesters
        d). Additional RAS pumping requirement

29. Part A: You are the chief plant operator at a 3 MGD conventional activated sludge plant that discharges into a nearby creek. Currently you operate this plant at an MCRT of between 4 to 5 days. Your plant's maximum daily total coliform limit is 23 MPN/100 ml. Chlorine disinfection to achieve a total chlorine residual of 5 mg/L followed by dechlorination with sulfur dioxide had been used to meet your effluent total cofifom, limit. Recently, at the request of the state department of fish and game, the RWQCB revised your plant's NPDES pemiit in order to make the creek more habitable for certain species of fish. Your plant will now be required to meet a final effluent total ammonia-nitrogen (N-NH_3) limit of 2 mg/L during the winter months (November 1- March 1) and 1 mg/L during the rest of the year. Your plant's total coliform limit was not revised.
    Answer the following questions:
    (a) Define total ammonia-nitrogen?
    (b) Why are such low limits necessary? Why are there different limits in winter and summer?
    (c) Identify and briefly discuss three significant impacts that these new limits will have on plant operations

    Part B: Prior to this revision of your NPDES permit, your plant rarely had a problem meeting its total colifom, limit. Within days of meeting the revised ammonia-nitrogen limit, you've experienced frequent violations of your total coliform limit. Plant records show that maintaining a total chlorine residual of 5 mg/L has been difficult even though more chlorine has been used. Likewise, chlorine use has increased significantly. You've also noticed that at times the effluent in the chlorine contact chamber is "crystal clear" almost like a swimming pool. Plant records show no significant changes in plant flow or influent characteristics (i.e. BOD, TSS, pH, etc.).
    (a) How do these observations help explain why you are having total colifom, violations?
    (b) Identify and briefly discuss one step you might take to prevent these coliform violations.

    Response:

    Part A:

    a *Define total ammonia-nitrogen*
        - Total ammonia nitrogen is the total amount of nitrogen in the forms of NH_3 and NH_4^+ in the wastewater.

    b *Why are such low limits necessary? Why are there different limits in winter and summer?*
        - Presence of nitrogen in wastewater effluent will promote plant & algae growth causing eutrophication (oxygen depletion) of the water body in which the effluent is discharge impacting aquatic life
        - Additionally, ammonia-nitrogen is toxic to aquatic life
        - Toxicity of ammonia is affected by temperature, fish breeding times and suscep-

tibility of juvenile fishes to ammonia– thus the different limits during winter and summer

c *Identify and briefly discuss three significant impacts that these new limits will have on plant operations*

- Process changes to remove ammonia further through implementation of nitrification – denitrification as part of the activated sludge process
- Potential impact to the disinfection process required to meet the coliform limit - breakpoint chlorination

  Associated impacts include:
  - Increase MCRT – increased RAS pumping
  - Lower sludge yields – less biosolids
  - Additional oxygen requirements – more energy consumption – higher power costs
  - Potential need for alkalinity and cBOD supplements for facilitating nitrification/denitrification
  - Less digester gas production

Part B:

a *How do these observations help explain why you are having total colifom, violations?*

- Potential impact of nitrite accumulation on chlorine disinfection
- 5 ppm of chlorine used up for each part of nitrite present
- Chlorine being consumed by nitrite and is not available for disinfection

b *Identify and briefly discuss one step you might take to prevent these coliform violations.*

- Measure nitrite levels at the effluent end of the activated sludge reactors
- Increase DO for the nitrification step to facilitate the oxidation of nitrite to nitrate

30. Define nitrification. Name four factors that effect nitrification and discuss ranges, requirements and what lab tests are used.

    Response:

    Response:

    a *Define nitrification*

    - In wastewater treatment, nitrification is used for the removal of ammonia nitrogen - the predominant form of nitrogen in wastewater. Nitrification involves a two step biological process where in the first step ammonia NH_3 is biologically oxidized by ammonia oxidizing bacteria such as nitrosomonas to nitrite (NO_2), followed by the oxidation of NO_2 to nitrate (NO_3) by ntirite oxidizing bacteria such as nitrobacter.

    b *Name four factors that effect nitrification and discuss ranges, requirements and what lab tests are used.*

    i. Dissolved oxygen

    4.5 parts of O_2 are needed for every part of $NH_4{}^+N$ (nBOD) to be degraded. In order for nitrification to occur, dissolved oxygen levels of 1.0 to 4.0 mg/L are usually maintained in the aeration tanks. Maximum nitrification occurs at DO levels of about 3.0 mg/L. Dissolved oxygen (DO)is measured using a DO probe.

    ii. Alkalinity and pH

    Presence of adequate alkalinity in the mixed liquor is critical as the nitrification process consumes alkalinity. Alkalinity provides a buffer for pH change. If the alkalinity is reduced beyond certain levels, further formation of acidic metabolic byproducts of bacterial activity may lead the pH to decline inhibiting bacterial activity. **7.14 parts of alkalinity are required for each part of ammonia removed.** Nitrification rates are rapidly depressed as the pH is reduced below 7.0. pH levels of 7.5 to 8.5 are considered optimal. An alkalinity of 60 mg/L in the secondary treatment reactor is generally required to ensure adequate buffering. Alkalinity is measured in the laboratory by titrating the sample with an acid until a specific pH is reached. Alkalinity is reported as mg/l of calcium carbonate.

    iii. MCRT, F/M, or Sludge Age

    For nitrification to occur the activated sludge treatment process needs to be operated at higher MCRT/sludge age (low F:M) as the reproductive rates of nitrfiers is low. An MCRT of greater than 8 days is typically considered essential for nitrification to occur.

    iv. Wastewater temperature

    Nitrification is inhibited at lower wastewater temperatures in wastewater treatment plants. To achieve the same level of nitrification, longer detention time may be needed in the winter versus the summer months since the activity drops significantly. Lower temperature effects on Nitrification may be partially mitigated by increasing MLVSS and MCRT. The optimal temperature range for

nitrification is between 60° to 95° degrees F. Below 40° nitrification will probably not occur.

v. Inhibition to nitrification by toxic compounds

Many compounds can be toxic to nitrifiers- Nitrosomonas and Nitrobacter. These include unionized ammonia, heavy metals, solvents and cyanide.

31. What is meant by un-ionized ammonia and total ammonia nitrogen? Why is it important to set a low limit on un-ionized ammonia-nitrogen?
    Response:

    a *What is meant by un-ionized ammonia and total ammonia nitrogen?*
    Ammonia is the predominant form of nitrogen in wastewater. Ammonia (NH_3) can exist as ammonia itself which is the unionized form or it could change to its ionized form - ammonium (NH_4^+) by absorbing a proton (H^+). Total ammonia nitrogen is the sum of the concentrations of the unionized ammonia and the ammonium ions present. These two forms of nitrogen can rapidly change from one to the other depending on pH and temperature.

    b *Why is it important to set a low limit on un-ionized ammonia-nitrogen?*

        i. Nitrogen in any of its forms, if present in wastewater effluent discharge, promote growth of plant and algal matter in the receiving waters causing destruction of the normal aquatic life mainly due to oxygen depletion - eutrophication. Ammonia is sought by nitrifying bacteria and is converted to nitrate at the expense of the oxygen present in the water body.
        ii. Additionally, ammonia specially in its unionized form is particularly toxic to aquatic life

32. Define and explain importance of:
    (a) Breakpoint chlorination
    (b) Chlorine demand
    (c) Chlorine residual
    (d) Chloromines
    (e) Rotometer

    Response:

    a *Breakpoint chlorination*

    When disinfecting with chlorine, as chlorine is added to wastewater, the presence of inorganic and organic substances including ammonia in the wastewater, will exert a demand for chlorine as chlorine is a strong oxidizing agent. This consumption of chlorine does not allow the chlorine to be present as free chlorine - the strongest form of chlorine disinfectant. Breakpoint chlorination is the point where the demand for chlorine has been fully satisfied and any further addition of chlorine will show a proportional increase in free chlorine residual.

    b *Chlorine demand*

    The amount of chlorine used up as part of the reaction of chlorine with the inorganic and organic substances present in wastewater is referred to as the chlorine demand.

    c *Chlorine residual*

    Chlorine residual is the sum of free chlorine and combined chlorine and it represents the amount of chlorine available for disinfection.

    d *Chloramines*

    Chloramines which include monochloramine, dichloramine and trichloramine are products of the reaction of chlorine with ammonia.

    e *Rotometer*

    Rotometer is a flow measurement device most commonly used for measuring the flow of chlorine gas for disinfection.

9. Biosolids Regulations Assessment

Biosolids Regulations Assessment

1. Grit and screenings from the preliminary treatment are also considered as biosolids
   *a. True
   b. False
2. A true statement regarding the term “biosolids” is:
   a. The term is mandated for user by public law 92-500.
   b. The term was developed by US EPA to define all biologically toxic precipitates.
   *c. The term is recommended by WEF for “a primarily organic solids product, produced by wastewater treatment processes, that can be beneficially recycled”.
   d. The term is used by the California Water Resources Control Board to include “all insoluble matter derived from living aquatic organisms.
3. When you spread sludge on agricultural land, the annual application rate of cadmium in the sludge should be less than 2 lbs/acre/year If your sludge contains 30 mg cadmium per kilogram of solids and your plant produces 950,000 lbs per year of dry solids, how many acres do you need?
   a. 3 acres
   *b. 14 acres
   c. 19 acres
   d. 27 acres

4. Essay type question:

   (a) Define vector and pathogens.
   (b) Class A & B landfill requirements: what you need to do to get your anaerobic digester to produce class B sludge to prepare for landfill.
   (c) What unit processes can produce class A & B sludge?

   Response:

   a *Define vector and pathogens.*

   - Pathogens are disease causing organisms such as bacteria, viruses and parasites
   - Vectors are organisms such as rodents and insects that can carry disease by carrying and transferring pathogens

   b *Class A & B landfill requirements: what you need to do to get your anaerobic digester to produce class B sludge to prepare for landfill.*
   For the digested sludge to qualify as Class B sludge it needs to meet the following related to 40 CFR Part 503:

   - Meet the Minimum Concentration Standards of the Pollution Concentration Standards
   - Meet the digestion sludge detention time-temperature requirements
   - Meet the Vector Reduction Standards

   c *What unit processes can produce class A & B sludge?*
   For Class A sludge:

   i. Composting
   ii. Heat drying
   iii. Heat treatment
   iv. Thermophillic aerobic digestion
   v. Beta ray irradiation
   vi. Gamma ray radiation
   vii. Pasteurization

For Class B sludge:

i. Aerobic digestion
ii. Air drying
iii. Anaerobic digestion
iv. Composting
v. Lime stabilization

10. Solids Thickening Assessment

Solids Thickening Assessment

1. In a gravity thickener the depth of the sludge is kept minimal (<six inches) to avoid solids going over the effluent weir
   a. True
   *b. False
2. Sludge thickening is primarily conducted to reduce costs associated with biosolids hauling
   a. True
   *b. False
3. Gravity thickener is commonly used for sludge dewatering
   a. True
   *b. False
4. Sludge thickening is primarily conducted to reduce costs associated with biosolids hauling
   a. True
   *b. False
5. A DAF thickener has effluent solids of 55 mg/L and float solids of 2.0%. Solids loading and polymer dosing is in the normal range. This data likely indicates:
   a. This unit is operating normally
   b. Too low air to solids ratio
   c. Float blanket too thick
   *d. Flight speed too fast
   e. Flight speed too slow
6. An air flotation thickener will produce a thin float if:

*a. Flight speed too high and skimmer wiper not adjusted properly

b. Excessive air/solids ratio and polymer dosages too low

c. High dissolved oxygen and flight speed too low

d. Polymer dosages too high and unit overloaded

7. An increase in the pool depth of a scroll-type centrifuge:

a. would not affect the moisture content of the cake.

b. would produce a drier cake

*c. would produce a wetter cake, but produce a greater solids recovery.

d. would not affect either solids recovery, nor cake moisture content.

e. would require an increase in the cationic polymer dosage.

8. A sludge thickened from 1% to 4% solids will be reduced in volume by how much?

a. no more than 4% of original volume

b. approximately 17% of original volume

c. approximately 25% of original volume

d. more information is needed

9. Gravity thickeners, compared to DAFs, are best suited to:

*a. Thickening primary sludge.

b. Thickening waste activated sludge.

c. Controlling sulfide odors.

d. Removing filamentous bacteria.

e. Provide highest concentration sludge.

10. Which of the following is not the main reason for thickening sludge

a. Improved digester performance due to a lower volume of sludge

b. Cost savings in the construction of new digestion facilities

c. Reduction in anaerobic digestion heating requirements since less water has to be heated

*d. Reduce costs of biosolids hauling

11. What zone is not involved in a belt filter press?

a. Gravity

b. Low pressure (wedge)

c. High pressure

*d. Twilight

12. The float blanket in a DAF unit appears well flocculated and concentrated. Too low a flight speed would likely result in:

a. Using excessive amounts of air.

b. Float solids that are too thick.

c. Too low an air-to-solids ratio.

*d. Poor thickener underflow quality.

e. De-flocculation of float solids.

13. The least critical operational control of a dissolved air flotation thickener in producing an adequately thickened sludge is the:

a. Flight speed.

b. Air to solids ratio.

c. Polymer dosage.

*d. Recycle ratio.

e. Pre-thickened WAS concentration.

14. The operational control of a dissolved air flotation thickener most critical for producing an adequately thickened float solids is the:

a. Fight speed.

*b. Air to solids ratio.

c. Polymer dosage.

d. Recycle ratio.

e. Concentration of WAS being thickened.

15. To increase solids recovery on a dual belt, belt press, the operator should:

a. Increase the differential belt speed.

b. Increase belt speed.

c. Increase sludge feed rate.

*d. Decrease sludge feed rate.

e. Increase polymer feed.

16. Too high a flight speed in a DAF will likely result in:

a. Using excessive amounts of air.

b. Excessive underflow volume.

*c. Thin float solids.

d. Too high an air to solids ratio.

e. Too low an air to solids ratio.

17. Which one of the following statements is TRUE in regard to DAF thickeners?

*a. The air to solids ratio in a DAF unit is typically 0.03 to 0.05.

b. The speed of the so-called "flights" has very little effect on the concentration of the float solids.

c. Adjustments in the air to solids ratio in a DAF unit will affect the float solids but not the unit's effluent suspended solids.

d. Anionic polymers are typically used to condition the WAS feed to a DAF unit.

18. Which one of the following process units is usually classified as a sludge thickening device as opposed to a dewatering device:

*a. DAF unit.

b. Sludge drying bed.

c. Vacuum filter press.

d. Belt press.

e. All of the above are thickeners, not dewatering devices.

19. Which one the following statements is TRUE in regard to gravity thickeners?

a. Longer solids detention times are desired during summer operation of these units.

b. The sludge-volume-ratio (SVR) or sludge detention time is defined as the volume of the sludge blanket divided by the daily volume of sludge withdrawn from the thickener.

c. SVRs should be in range of 5 to 10 hours.

d. A likely cause of a gravity thickener producing a poor quality effluent is too low of a sludge blanket.

20. A DAF thickener has effluent solids of 55 mg/L and float solids of 2.0%. Solids loading and polymer dosing is in the normal range. This data likely indicates:

    a. This unit is operating normally

    b. Too low air to solids ratio

    c. Float blanket too thick

    *d. Flight speed too fast

    e. Flight speed too slow

21. An increase in the pool depth of a scroll-type centrifuge:

    a. would not affect the moisture content of the cake.

    b. would produce a drier cake

    *c. would produce a wetter cake, but produce a greater solids recovery.

    d. would not affect either solids recovery, nor cake moisture content.

    e. would require an increase in the cationic polymer dosage.

22. A sludge thickened from 1% to 4% solids will be reduced in volume by how much?

    a. no more than 4% of original volume

    b. approximately 17% of original volume

    c. approximately 25% of original volume

    d. more information is needed

23. Gravity thickeners, compared to DAFTs, are best suited to:

    *a. Thickening primary sludge

    b. Thickening waste activated sludge

    c. Controlling sulfide odors

    d. Removing filamentous bacteria

    e. Provide highest concentration sludge

24. Identify the incorrect statement regarding gravity thickeners.

    a. Gravity thickeners are similar in design to primary clarifiers.

    *b. The sludge blanket depth and the rate of sludge withdrawal are used to calculate the sludge detention time.

    c. The purpose of pickets in a sludge thickener is to gently stir settling sludge particles to release gases that may prevent the sludge particles from compacting.

    d. Mixtures of primary and waste activated sludge are never thickened in a gravity thickener due to the possibilility of de-nitrification.

    e. Solids loading (pounds per day per square foot) is an important guideline for a gravity thickener.

25. On a routine check of a DAFT unit the operator finds suspended solids of 450 mg/L in the

effluent. The float blanket appears well flocculated and concentrated. The operator should:

a. increase the flight speed

b. do nothing, the unit is operating normally

c. reduce the air to solids ratio

*d. increase the air to solids ratio

e. check unit operating pressure

26. Gravity-thickened primary sludge will contain solids within which of the following concentration ranges?

a. 1,000 - 8,000 mg/l

b. 10,000 – 40,000 mg/l

c. 40,000 - 80,000 mg/l

d. 100,000 - 400,000 mg/l

*e. none of the above

11. Solids Stabilization Digestion Assessment

Solids Stabilization Digestion Assessment

1. A change in the-pH-of digesting sludge in anaerobic digester is the best early warning indicator of potential digester upset.
   a. True
   *b. False
2. A good maintenance program should be established for all flame arresters to ensure they are all set at the recommended "pop-off' pressures.
   *a. True
   b. False
3. A healthy anaerobic digester should have a carbon dioxide concentration of more than 40%.
   a. True
   *b. False
4. A high rate anaerobic digester is always heated and mixed.
   *a. True b.False
5. Anaerobically digested sludge produces gas as a by-product. The gas produced is of little or no value.
   a. True
   *b. False
6. Digester gas containing 60% methane by volume will likely explode when exposed to a spark or flame.
   a. True

*b. False

7. Digester gas containing 60% methane by volume will likely explode when exposed to a spark or flame
   *a. True
   b. False
8. In an anaerobic digester, the [1] is destroyed producing [2]. The digester gas production is typically in the range of [3] cubic feet of digester gas per lb of volatile matter destroyed.
9. Gas production in an anaerobic digester results from the destruction of fixed solids
   a. True
   *b. False
10. A well operating digester will have a CO2 concentration of greater than 60%
    a. True
    *b. False
11. Volatile solids removal efficiency of a digester is most commonly monitored utilizing the BOD test
    a. True
    *b. False
12. Volatile solids removal efficiency of a digester is most commonly monitored utilizing the BOD test
    a. True
    *b. False
13. The range of volatile material in raw sludge may be as high as 60% - 80% while digested sludge normally will be below 20%.
    a. True
    *b. False
14. Foaming in digesters is often due to rapid acid digestion is caused by adding too much raw sludge during too short a time period.
    *a. True
    b. False
15. Aerobic digestion produces methane gas that provides energy for other operations.
    a. True
    *b. False
16. A good maintenance program should be established for all flame arresters to ensure they are all set at the recommended "pop-off" pressures.
    a. True
    *b. False
17. A flame arrester in the gas line between a waste gas burner and an anaerobic digester contains plates which should periodically be inspected and cleaned.
    *a. True
    b. False

18. The methane forming bacteria in an anaerobic digester reproduce more rapidly than the acid forming bacteria.
    a. True
    *b. False
19. The main function of a secondary digester in normal operation is to provide a storage space for seed sludge.
    a. True
    *b. False
20. Supernatant liquor is withdrawn from the lowest possible level in an anaerobic digester.
    a. True
    *b. False
21. The pH of digested sludge in a healthy anaerobic digester will be near 7.0
    *a. True
    b. False
22. Volatile solids reduction is a measure of the effectiveness of an anaerobic digester.
    *a. True
    b. False
23. A properly operated anaerobic, digester functions best within a pH range of 5.4 to 5.8.
    a. True
    *b. False
24. In computing anaerobic digester loadings, it is necessary to take into account the solids lost in the supernatant system.
    a. True
    *b. False
25. In conventional secondary wastewater treatment processes, aerobic decomposition of solids will occur.
    *a. True
    b. False
26. Aerobic digesters are operated under the principle of extended aeration from the activated sludge process.
    *a. True
    b. False
27. After pumping raw sludge to a digester, it is necessary to seal both ends of the line to prevent back siphonage.
    a. True
    *b. False
28. Propeller mixers are located mainly on floating covers of anaerobic digesters rather than on fixed covers.
    a. True
    *b. False

29. A gallon of water weighs 8.34 pounds. A gallon of digested sludge, due to its high volatile content, will weigh much less.
    a. True
    *b. False
30. The range of volatile material in raw sludge may be as high as 60% - 80% while digested sludge normally will be below 20%.
    a. True
    *b. False
31. Foaming in digesters is often due to rapid acid digestion is caused by adding too much raw sludge during too short a time period.
    *a. True
    b. False
32. Aerobic digestion produces methane gas that provides energy for other operations.
    a. True
    *b. False
33. A good maintenance program should be established for all flame arresters to ensure they are all set at the recommended "pop-off" pressures.
    a. True
    *b. False
34. A flame arrester in the gas line between a waste gas burner and an anaerobic digester contains plates which should periodically be inspected and cleaned.
    *a. True
    b. False
35. The methane forming bacteria in an anaerobic digester reproduce more rapidly than the acid forming bacteria.
    a. True
    *b. False
36. The main function of a secondary digester in normal operation is to provide a storage space for seed sludge.
    a. True
    *b. False
37. Supernatant liquor is withdrawn from the lowest possible level in an anaerobic digester.
    a. True
    *b. False
38. The pH of digested sludge in a healthy anaerobic digester will be near 7.0
    *a. True
    b. False
39. Volatile solids reduction is a measure of the effectiveness of an anaerobic digester.
    *a. True
    b. False

40. A properly operated anaerobic, digester functions best within a pH range of 5.4 to 5.8.
    a. True
    *b. False
41. In computing anaerobic digester loadings, it is necessary to take into account the solids lost in the supernatant system.
    a. True
    *b. False
42. In conventional secondary wastewater treatment processes, aerobic decomposition of solids will occur.
    *a. True
    b. False
43. Aerobic digesters are operated under the principle of extended aeration from the activated sludge process.
    *a. True
    b. False
44. After pumping raw sludge to a digester, it is necessary to seal both ends of the line to prevent back siphonage.
    a. True
    *b. False
45. A gallon of water weighs 8.34 pounds. A gallon of digested sludge, due to its high volatile content, will weigh much less.
    a. True
    *b. False
46. Gas production in an anaerobic digester results from the destruction of fixed solids in the raw sludge.
    a. True
    *b. False
47. "High rate" and Low rate" when used in referring to an anaerobic digester may refer to the rate of volatile solids loading.
    *a. True
    b. False
48. In computing anaerobic digester loadings, it is necessary to take into account the solids lost in the supernatant system.
    a. True
    *b. False
49. Increased concentrations of volatile acids and decreased alkalinity are the first measurable changes that take place when the process of anaerobic digestion is becoming upset.
    *a. True
    b. False
50. A change in the-pH-of digesting sludge in anaerobic digester is the best early warning

indicator of potential digester upset.

a. True

*b. False

51. A good maintenance program should be established for all flame arrestors to ensure they are all set at the recommended "pop-off' pressures.

*a. True

b. False

52. A healthy anaerobic digester should have a carbon dioxide concentration of more than 40%.

a. True

*b. False

53. A high rate anaerobic digester is always heated and mixed.

*a. True

b. False

54. Anaerobically digested sludge produces gas as a by-product. The gas produced is of little or no value.

a. True

*b. False

55. Digester gas containing 60% methane by volume will likely explode when exposed to a spark or flame.

a. True

*b. False

56. Volatile solids removal efficiency of a digester is most commonly monitored utilizing the BOD test

a. True

*b. False

57. Gas production in an anaerobic digester results from the destruction of fixed solids in the raw sludge.

a. True

*b. False

58. "High rate" and "Low rate" when used in referring to an anaerobic digester may refer to the rate of volatile solids loading.

*a. True

b. False

59. In computing anaerobic digester loadings, it is necessary to take into account the solids lost in the supernatant system.

a. True

*b. False

60. Increased concentrations of volatile acids and decreased alkalinity are the first measurable changes that take place when the process of anaerobic digestion is becoming upset.

*a. True

b. False

61. In a two-stage anaerobic digestion system, it is in the secondary tank where most of the volatile solids destruction occurs

a. True

*b. False

62. The lower explosive limit for methane is 40%

a. True

*b. False

63. Volatile solids removal efficiency of a digester is most commonly monitored utilizing the BOD test

a. True

*b. False

64. Sludge digestion is a process by which principally the inorganic matter in sludge is gasified and/or converted to a more stable form by the biological process.

a. True

*b. False

65. The determination of the pH on the anaerobic digester is one of the best early warning systems of digester upset.

a. True

*b. False

66. The gas produced as part of the anaerobic digestion is of little or no value

a. True

*b. False

67. The main function of a secondary digester in normal operation is to provide a storage space for seed sludge.

a. True

*b. False

68. The pH of digested sludge in a healthy anaerobic digester will be near 7.0.

*a. True

b. False

69. Volatile solids reduction is a measure of the effectiveness of an anaerobic digester.

*a. True

b. False

70. Volatile solids removal efficiency of a digester is most commonly monitored utilizing the BOD test

a. True

*b. False

71. Identify the incorrect statement regarding anaerobic digestion.

a. An anaerobic digester with pH of 7.05, an alkalinity of 2,900 mg/l and a volatile acid

concentration of 250 mg/l is probably operating normally.

*b. Sodium bicarbonate may be used in place of lime to neutralize a sour anaerobic digester.

c. When adding lime to a sour anaerobic digester, it is important to add an excess of this chemical to act as a reservoir of alkalinity.

d. Ferrous sulfate may be added to an anaerobic digester to reduce hydrogen sulfide concentration where air quality is of concern.

e. Gas production from anaerobic digester may be expressed as cubic feet of gas produced per pound of volatile matter added per day.

72. One action that may be taken to improve the health of an anaerobic digester that is going sour would be to:

a. Add small doses of lime daily to maintain the digester pH above 7.0.

*b. Add ferrous sulfate to reduce the concentration of hydrogen sulfide in the digester.

c. Add seed sludge from a healthy primary digester.

d. Pump raw sludge to this digester more frequently so that this sludge has a higher pH.

e. Increase the temperature of the digester to favor a population increase of the methane formers.

73. Identify the incorrect statement regarding operation of an anaerobic digester.

*a. A healthy anaerobic digester would generally have volatile acids in the range of 50 mg/l to 300 mg/l.

b. The best strategy for pumping raw sludge to an anaerobic digester is to pump it once or twice a day so that the thickest possible raw sludge may be pumped.

c. An anaerobic digester operating at an alkalinity of 3200 mg/l should be able to tolerate a volatile acid concentration of 250 mg/l.

d. The change in pH is not a reliable indicator of the changing characteristics of the digesting sludge because the alkalinity in an anaerobic digester acts as a buffer.

e. The higher the volatile solid content of the primary sludge being fed to the digester, the higher is the expected volatile reduction.

74. Identify the true statement about anaerobic digesters:

a. Carbon dioxide and methane in digester gas should be 65% and 35%, respectively.

*b. Increasing carbon dioxide readings indicate possible organic overload.

c. Decreasing mixing will always improve recovery of a sour digester.

d. Increasing the frequency and decreasing the amount of sludge pumping will not improve digester performance.

e. Reducing the ratio of primary to waste activated sludge will improve gas production.

75. All of the following are normal operating guidelines for a healthy anaerobic digester except for:

a. A mesophilic digester operating at 93°F to 98°F.

b. Methane gas in the range of approximately 62% to 70%.

c. Carbon dioxide gas in the range of 30% to 38%.

*d. Organic loading to a high rate digester of 0.15 to 0.2 pounds (Lb) volatile Solids per day per ft3 of digester capacity.

e. Bicarbonate alkalinity in the range of 1500 to 1800.

76. When adding anhydrous ammonia to a sour primary anaerobic digester, the [redacted] is an important consideration because if it is too high, digester "poisoning" may result:

a. Concentration of hydrogen sulfide in digester gas.

*b. pH in digesting sludge.

c. Concentration of free copper ions in digesting sludge

d. Ferrous and ferric ion concentration in digesting sludge.

e. Dissolved sulfide concentration.

77. Which one of the following parameter ranges is most appropriate for a healthy anaerobic digester?

a. Volatile solid reduction in the range of 60 to 70%.

b. Digester gas production of 7 to 10 ft3 of gas produced per day per pound of volatile solids destroyed.

*c. Alkalinity in the range of 2500 to 3500 mg/L.

d. Hydrogen sulfide in range of 1% to 2% by volume.

e. Volatile acids in range of 500 to 750 mg/L.

78. Identify the incorrect statement regarding operation of an anaerobic digester.

a. A healthy anaerobic digester would generally have volatile acids in the range of 50 mg/l to 300 mg/l.

*b. The best strategy for pumping raw sludge to an anaerobic digester is to pump it once or twice a day so that the thickest possible raw sludge may be pumped.

c. An anaerobic digester operating at an alkalinity of 3200 mg/l should be able to tolerate a volatile acid concentration of 250 mg/l.

d. The change in pH is not a reliable indicator of the changing characteristics of the digesting sludge because the alkalinity in an anaerobic digester acts as a buffer.

e. The higher the volatile solid content of the primary sludge being fed to the digester, the higher is the expected volatile reduction.

79. Lab data from your 100,000 gallon primary anaerobic digester, which receives primary sludge only, is shown below. Using this data :

$Date$	pH	$Alkalinity(mg/L)$	$Vol.Acids(mg/L)$	$CO_2(\%)$
9/02	7.10	3,200	280	35.5
9/09	7.00	3,020	320	36.0
9/16	6.90	2,800	400	37.7
9/17	6.85	2,720	450	38.2

Date	*RawSludge(TS%)*	*Raw Sludge(VS%)*	*Digested Sludge(VS%)*
9/02	5.4	65.5	56.0
9/09	5.0	66.7	53.8
9/16	4.9	65.9	54.2

(a) Calculate the average volatile solids reduction. Compare your calculated value to generally accepted ranges for a healthy anaerobic digester. Comment.

(b) Compare the other data to expected ranges.

(c) Is this digester experiencing an operational problem ? If so, what is the problem. Name three steps that may be taken to mitigate the problem.

(d) Should slake lime be added ? Why or why not ?

80. As part of an ongoing training program at your wastewater plant you are assigned the task of preparing a lecture for OITs on the subject of "buffer" in an anaerobic digester. Answer the following questions in preparation for your presentation.

a. What is "buffer" and why is it important in an anaerobic digester?

b. What lab test is used to measure "buffer" in an anaerobic digester? Explain how this test is run

c. Most of the buffer in an anaerobic digester is due to the presence of

12. Dewatering Assessment

Dewatering Assessment

1. What can be a problem with a belt filter press?
   a. Washing out
   b. Polymer overdosing
   c. Blinding
   *d. All of the above
2. Which one of the following statements is TRUE in regard to the operation of a belt filter press:
   a. Unlike a gravity belt, cationic polymers need not be used to condition the feed sludge to this unit.
   b. When dewatering a mixture of WAS and primary sludge, which has been anaerobically digested, the operator can expect to produce a sludge cake with 22% TS to 25%.
   *c. The best belt speed for this unit is the slowest speed the belt can be operated at, without causing "washout."
   d. Colloidal solids are likely to cause plugging of belt pores and thus cause "belt binding."
3. What can be used to evaluate the efficiency of a belt filter press?
   a. Vacuum required in inches of mercury
   b. % volatile solids in cake
   c. Sludge feed rate in gpd
   *d. Filter yield in lbs/hr/sq ft
   e. Gph of filtrate removal.
4. An increase in the pool depth of a scroll-type centrifuge:

a. would not affect the moisture content of the cake.

b. would produce a drier cake

*c. would produce a wetter cake, but produce a greater solids recovery.

d. would not affect either solids recovery, nor cake moisture content.

e. would require an increase in the cationic polymer dosage.

5. What can be used to evaluate the efficiency of a belt filter press?

   a. Vacuum required in inches of mercury

   b. % volatile solids in cake

   c. Sludge feed rate in gpd

   *d. Filter yield in lbs/hr/sq ft

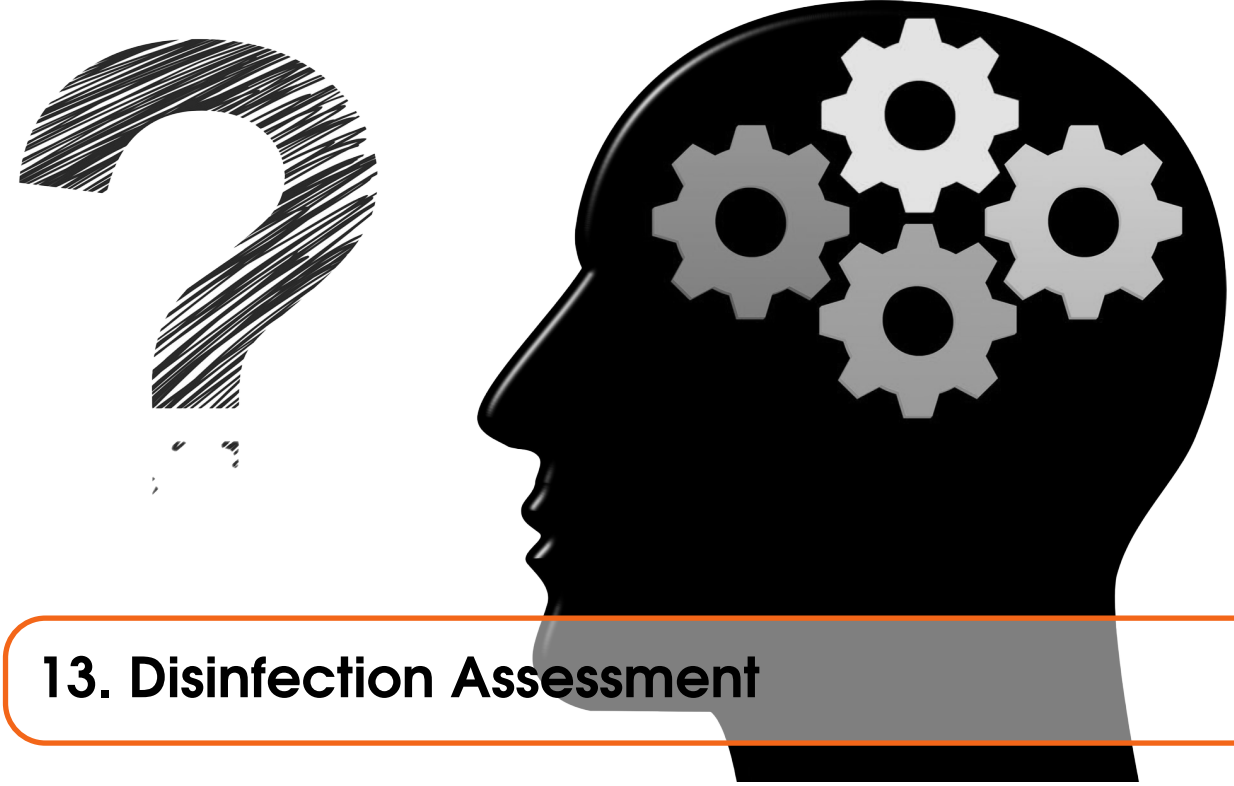
   e. gallons-per-hour of filtrate removal.

6. You are assigned to supervise the operation ofa belt filter press. Anerobically digested sludge - a mixture of primary and secondary sludge is being dewatered. Lab records show that this belt press routinely produces a sludge cake having a total solids concentration of 16.5%. No other lab tests are run on the belt press. Answer the following questions:

   a. Are you satisfied with the dryness of the cake? Why or why not? Explain your answer.

   b. List three (3) variables you could adjust to optimize the BFP. Explain how these adjustments affect the optimization of this unit.

   c. List two (2) other lab tests that must be performed in order to better monitor the operation,of the BFP



13. Disinfection Assessment

Disinfection Assessment

1. All 100- and 150-pound chlorine cylinders should be restrained or safety-chained to sturdy supports even when empty. Except when actually being moved to or from storage.
   *a. True
   b. False
2.
3. Chlorine demand is a good indicator of effective disinfection
   a. True
   *b. False
4. Chlorine demand is a good indicator of effective disinfection
   a. True
   *b. False
5. Chlorine demand is defined as the amount of chlorine remaining in the waste water at the end of a specific contact period.
   a. True
   *b. False
6. Chlorine disinfection is more effective at higher pH
   a. True
   *b. False
7. Chlorine dosage is the difference between the amount of chlorine added to wastewater and the amount of residual chlorine remaining after a given contact time.
   a. True

*b. False

8. Chlorine feed rate and chlorine residual are both usually expressed in units of ppm.
   *a. True
   b. False
9. Chlorine is used to sterilize wastewater in order to insure protection of public health.
   a. True
   *b. False
10. Chlorine demand is a good indicator of effective disinfection
    a. True
    *b. False
11. Vents in a chlorine storage room are located at the ground level as chlorine is lighter than air
    a. True
    *b. False
12. Chlorine demand is defined as the amount of chlorine remaining in the waste water at the end of a specific contact period.
    a. True
    *b. False
13. Chlorine dosage is the difference between the amount of chlorine added to wastewater and the amount of residual chlorine remaining after a given contact time.
    a. True
    *b. False
14. Hypochlorite solution is a more effective disinfectant than gas chlorine and is much less expensive.
    a. True
    *b. False
15. All 100- and 150-pound chlorine cylinders should be restrained or safety-chained to sturdy supports even when empty. Except when actually being moved to or from storage.
    *a. True
    b. False
16. Vents in a chlorine storage room are located at the ground level as chlorine is lighter than air
    a. True
    *b. False
17. Chlorine demand is defined as the amount of chlorine remaining in the waste water at the end of a specific contact period.
    a. True
    *b. False
18. Chlorine dosage is the difference between the amount of chlorine added to wastewater and the amount of residual chlorine remaining after a given contact time.

a. True

*b. False

19. Hypochlorite solution is a more effective disinfectant than gas chlorine and is much less expensive.

a. True

*b. False

20. All 100- and 150-pound chlorine cylinders should be restrained or safety-chained to sturdy supports even when empty. Except when actually being moved to or from storage.

*a. True

b. False

21. Chlorine dosage is the difference between the amount of chlorine added to wastewater and the amount of residual chlorine remaining after a given contact time.

a. True

*b. False

22. Before any new or repaired chlorine piping system is placed into operation, it should be pressure tested with water to detect any possible leaks before chlorine gas or liquid is used.

a. True

*b. False

23. To produce a savings in chlorination cost and power consumption, chlorine feed rates for odor control should be determined at low flow conditions.

*a. True

b. False

24. Chlorine is used to sterilize wastewater in order to insure protection of public health.

a. True

*b. False

25. The purpose of disinfection with chlorine is to destroy pathogenic organisms.

*a. True

b. False

26. Oxidation pond effluents are easily disinfected with chlorine because of the large amount of algae present

a. True

*b. False

27. The chlorine demand of wastewater equals the chlorine dosage plus the residual.

a. True

*b. False

28. Post chlorination is employed primarily for odor control and BOD reduction.

a. True

*b. False

29. The safety plugs on a one-ton chlorine tank are designed to soften or melt at temperatures in excess of 158°F.

*a. True

b. False

30. When moving a chlorine cylinder a short distance, for example 10 feet, it is not necessary to replace the protective cap.

a. True

*b. False

31. A leaking chlorine cylinder cannot be transported.

*a. True

b. False

32. Canister-type gas masks are not recommended for use when working ·on chlorine leaks, because they do not supply oxygen to the wearer.

*a. True

b. False

33. Canister-type gas masks may be used to attend chlorine gas leaks at concentrations in the range of two to five percent.

a. True

*b. False

34. Hypochlorite solution is a more effective disinfectant than gas chlorine and is much less expensive.

a. True

*b. False

35. Objective of the disinfection process is to sterilize the wastewater

a. True

*b. False

36. Caution needs to be exercised when handling chlorine due to its explosive properties

a. True

*b. False

37. It is important that the (PPE) including self-contained breathing apparatus, for handling leaks from chlorine cylinders is located inside the chlorine storage building to ensure easy access

a. True

*b. False

38. Ammonia solution is used for finding leaks in chlorine cylinders

*a. True

b. False

39. Sodium hypochlorite is more effective and less expensive than chlorine gas

a. True

*b. False

40. Sodium hypochlorite is more effective and less expensive than chlorine gas

a. True

*b. False

41. Vents in a chlorine storage room are located at the ground level as chlorine is lighter than air

    a. True

    *b. False

42. All 100- and 150-pound chlorine cylinders should be restrained or safety-chained to sturdy supports even when empty. Except when actually being moved to or from storage.

    *a. True

    b. False

43. Chlorine demand is a good indicator of effective disinfection

    a. True

    *b. False

44. Chlorine demand is a good indicator of effective disinfection

    a. True

    *b. False

45. Chlorine demand is defined as the amount of chlorine remaining in the waste water at the end of a specific contact period.

    a. True

    *b. False

46. Chlorine disinfection is more effective at higher pH

    a. True

    *b. False

47. Chlorine dosage is the difference between the amount of chlorine added to wastewater and the amount of residual chlorine remaining after a given contact time.

    a. True

    *b. False

48. Chlorine feed rate and chlorine residual are both usually expressed in units of ppm.

    *a. True

    b. False

49. Chlorine is used to sterilize wastewater in order to insure protection of public health.

    a. True

    *b. False

50. Vents in a chlorine storage room are located at the ground level as chlorine is lighter than air

    a. True

    *b. False

51. Vents in a chlorine storage room are located at the ground level as chlorine is lighter than air

    a. True

    *b. False

52. Chlorine dosage is the difference between the amount of chlorine added to wastewater and the amount of residual chlorine remaining after a given contact time.
    a. True
    *b. False
53. Hypochlorite solution is a more effective disinfectant than gas chlorine and is much less expensive.
    a. True
    *b. False
54. All 100- and 150-pound chlorine cylinders should be restrained or safety-chained to sturdy supports even when empty. Except when actually being moved to or from storage.
    *a. True
    b. False
55. Hypochlorite solution is a more effective disinfectant than gas chlorine and is much less expensive.
    a. True
    *b. False
56. Sodium hypochlorite is more effective and less expensive than chlorine gas
    a. True
    *b. False
57. The chlorine dose rate plus the chlorine residual equals the chlorine demand.
    a. True
    *b. False
58. Vents in a chlorine storage room are located at the ground level as chlorine is lighter than air
    a. True
    *b. False
59. Chlorine demand is defined as the amount of chlorine remaining in the waste water at the end of a specific contact period.
    a. True
    *b. False
60. Chlorine dosage is the difference between the amount of chlorine added to wastewater and the amount of residual chlorine remaining after a given contact time.
    a. True
    *b. False
61. Hypochlorite solution is a more effective disinfectant than gas chlorine and is much less expensive.
    a. True
    *b. False
62. All 100- and 150-pound chlorine cylinders should be restrained or safety-chained to sturdy supports even when empty. Except when actually being moved to or from storage.

*a. True

b. False

63. Chlorine demand is a good indicator of effective disinfection

a. True

*b. False

64. A chlorine cylinder valve is thought to be leaking. If ammonia vapor is passed over the valve, the presence of a leak is indicated by

a. A hissing noise.

*b. A white cloud.

c. An odor of hydrogen sulfide.

d. Red smoke

65. A chlorine residual is often maintained in a plant effluent:

a. to keep the chlorinator working.

b. for control of fluctuation of wastewater flow.

c. for testing purposes.

*d. to protect the bacteriological quality of the receiving water.

e. None of the above.

66. Acids should never be added to chlorine solutions as they

*a. Cause chlorine gas to be released.

b. Corrode or "eat away" the solution tank.

c. Decrease the disinfecting properties of chlorine.

d. Result in the formation of a chloride precipitate. „

67. An amperometric titrater is used to measure

a. Alkalinity.

*b. Chlorine residual.

c. Conductivity.

d. COD.

68. An operator should never enter a room containing a high concentration of chlorine gas without

a. Staying low on the floor.

b. Holding breath and have help standing by.

*c. Having self-contained air or oxygen supply and help standing by.

d. Covering nose and mouth with a wet handkerchief.

69. As water temperatures decrease, the disinfecting action of chlorine

*a. Decreases.

b. Increases.

c. Remains the same.

70. At a wastewater treatment plant. The amount of chlorine used in a day from a cylinder or tank that is in service is normally determined by:

a. knowing both the pressure and temperature of the cylinder pressure gauges.

b. rotameter readings.

*c. weighing of the cylinder or tank

d. the chlorine residual test .

e. None of the above.

71. At what level should the exhaust be drawn off in a chlorination room?

a. At chest height.

b. At least two feet above the height of the chlorine cylinder.

c. Near the ceiling.

*d. Near the floor.

72. Chloramines are

*a. Combined chlorine.

b. Enzymes.

c. Found in polluted air.

d. Free chlorine.

73. Chlorine gas

a. Is lighter than air.

*b. Is heavier than air.

c. Is pink in color.

d. Will liquify at 70 degrees F.

74. Chlorine gas is

a. Colorless.

*b. Heavier than air.

c. Non-toxic.

d. Odorless.

75. Chlorine is:

a. Colorless

b. Explosive

*c. Toxic

d. All of the above

76. Chlorine is being applied at a constant dose rate of 24 mg/L to a partially nitrified activated sludge effluent having a pH of 6.8 and a temperature of 67F. Ammonia-nitrogen is found to range from 2 to 3 mg/L in this effluent. Disinfection in this effluent might be difficult because:

a. a temperature of 70' F or higher is necessary in order to achieve effective disinfection.

b. chloramines are present most of the time.

c. the chlorine dose rate is too low.

d. the pH of this effluent will limit the effectiveness of free chlorine.

*e. the ratio of chlorine to ammonia-nitrogen may make it difficult at times to maintain adequate chlorine residual.

77. 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.

*a. 4.9 mg/L

b. 5.7 mg/L

c. 7.5 mg/L

d. 8.3 mg/L

78. Chlorine is used to

*a. Disinfect.

b. Prevent corrosion.

c. Raise the pH.

d. Stabilize organics.

79. Chlorine residual may be determined using the reagent

*a. Diethyl-p-phenylenediamine (DPD).

b. Ethylendiamine tetraacetic acid (EDTA).

c. Polychlorinated biphenyls (PCB).

d. Sodium thiosulfate (Na2S203)

80. "Chlorine residual" refers to:

a. the amount of chlorine remaining in the ton cylinder after use.

b. the amount of chlorine consumed during disinfection.

*c. the chlorine remaining after disinfection.

d. the chlorine that displays no disinfection power.

e. the residue left after the evaporation of chlorine gas.

81. The effectiveness of chlorine disinfection is measured by:

a. the chlorine demand

b. the chlorine dosage

c. the total chlorine residual

*d. the coliform concentration of the effluent

82. The amount of chlorine used per day from a 1 ton chlorine cylinder is normally determined by:

a. Pressure gauges.

b. Rotometers.

*c. Weighings.

d. Chlorine residuals.

e. Ammonia equivalents.

83. One liter of liquid chlorine can evaporate and produce how many liters of chlorine gas?

a. 100

b. 250

*c. 460

d. 490

84. Which of the following discharges would in general, require the lowest chlorine dosage to ensure adequate disinfection?

a. Primary plant effluent
b. Activated sludge plant effluent
c. Trickling filter plant effluent
*d. Sand filter effluent
e. Stabilization pond effluent

85. Which of the following are factors that may influence the effectiveness of chlorine?
a. Chlorine dose rate
b. Contact time
c. Suspended solids concentration of the wastewater being disinfected.
*d. Only (a) and (b)
e. (a), (b), and (c)

86. The fundamental purpose of disinfection is to:
a. Destroy fecal coliform bacteria
b. Destroy all bacteria
*c. Destroy pathogenic organisms
d. Protect downstream users from waterborne diseases

87. In the application of chlorine for disinfection, which of the following is not normally an operational consideration?
a. Mixing
b. Contact time
*c. DO
d. pH
e. None of the above

88. "Chlorine residual" refers to:
a. the amount of chlorine remaining in the ton cylinder after use.
b. the amount of chlorine consumed during disinfection.
*c. the chlorine remaining after disinfection.
d. the chlorine that displays no disinfection power.
e. the residue left after the evaporation of chlorine gas.

89. In the application of chlorine for disinfection, which of the following is not normally an operational consideration?
a. Mixing
b. Contact time
*c. DO
d. pH
e. None of the above

90. A chlorine residual is often maintained in a plant effluent:
a. to keep the chlorinator working.
b. for control of fluctuation of wastewater flow.
c. for testing purposes.

*d. to protect the bacteriological quality of the receiving water.

e. None of the above.

91. At a wastewater treatment plant. The amount of chlorine used in a day from a cylinder or tank that is in service is normally determined by:

a. knowing both the pressure and temperature of the cylinder pressure gauges.

b. rotameter readings.

*c. weighing of the cylinder or tank

d. the chlorine residual test .

e. None of the above.

92. The fundamental purpose of disinfection is to:

a. Destroy fecal coliform bacteria

b. Destroy all bacteria

*c. Destroy pathogenic organisms

d. Protect downstream users from waterborne diseases

93. One liter of liquid chlorine can evaporate and produce how many liters of chlorine gas?

a. 100

b. 250

*c. 460

d. 490

94. Identify the incorrect statement regarding disinfection.

a. When chlorine is added to water it forms acids, which tend to lower the pH of the wastewater effluent

b. HTH is a dry form of calcium hypochlorite

c. Appropriate doses of chlorine may be used to control odors, control filamentous bulking in activated sludge mixed liquor, or reduce BOD5 of wastewater

*d. Hypochlorite's are sometimes used in place of chlorine because they are more effective and less costly

95. Hypochlorite solution is used in effluent disinfection because:

a. Chlorine residual determination is more stable and accurate in hypochlorite

b. Hypochlorite residuals are more resistant to nitrite interference

*c. Chlorine gas is more hazardous to store and handle

d. Hypochlorite solution is easier and less costly to ship than gas chlorine

e. Chlorine causes too many problems with disinfection efficiency

96. Chlorine is:

a. Colorless

b. Explosive

*c. Toxic

d. All of the above

97. The effectiveness of chlorine disinfection is measured by:

a. the chlorine demand

b. the chlorine dosage

c. the total chlorine residual

*d. the coliform concentration of the effluent

98. The amount of chlorine used per day from a 1 ton chlorine cylinder is normally determined by:

a. Pressure gauges.

b. Rotometers.

*c. Weighings.

d. Chlorine residuals.

e. Ammonia equivalents.

99. Which of the following discharges would in general, require the lowest chlorine dosage to ensure adequate disinfection?

a. Primary plant effluent

b. Activated sludge plant effluent

c. Trickling filter plant effluent

*d. Sand filter effluent

e. Stabilization pond effluent

100. Which of the following are factors that may influence the effectiveness of chlorine?

a. Chlorine dose rate

b. Contact time

c. Suspended solids concentration of the wastewater being disinfected.

*d. Only (a) and (b)

e. (a), (b), and (c)

101. The fundamental purpose of disinfection is to:

a. Destroy fecal coliform bacteria

b. Destroy all bacteria

*c. Destroy pathogenic organisms

d. Protect downstream users from waterborne diseases

102. In the application of chlorine for disinfection, which of the following is not normally an operational consideration?

a. Mixing

b. Contact time

*c. DO

d. pH

e. None of the above

103. "Chlorine residual" refers to:

a. the amount of chlorine remaining in the ton cylinder after use.

b. the amount of chlorine consumed during disinfection.

*c. the chlorine remaining after disinfection.

d. the chlorine that displays no disinfection power.

e. the residue left after the evaporation of chlorine gas.

104. In the application of chlorine for disinfection, which of the following is not normally an operational consideration?
    a. Mixing
    b. Contact time
    *c. DO
    d. pH
    e. None of the above

105. A chlorine residual is often maintained in a plant effluent:
    a. to keep the chlorinator working.
    b. for control of fluctuation of wastewater flow.
    c. for testing purposes.
    *d. to protect the bacteriological quality of the receiving water.
    e. None of the above.

106. At a wastewater treatment plant. The amount of chlorine used in a day from a cylinder or tank that is in service is normally determined by:
    a. knowing both the pressure and temperature of the cylinder pressure gauges.
    b. rotameter readings.
    *c. weighing of the cylinder or tank
    d. the chlorine residual test .
    e. None of the above.

107. The fundamental purpose of disinfection is to:
    a. Destroy fecal coliform bacteria
    b. Destroy all bacteria
    *c. Destroy pathogenic organisms
    d. Protect downstream users from waterborne diseases

108. One liter of liquid chlorine can evaporate and produce how many liters of chlorine gas?
    a. 100
    b. 250
    *c. 460
    d. 490

109. Identify the incorrect statement regarding disinfection.
    a. When chlorine is added to water it forms acids, which tend to lower the pH of the wastewater effluent
    b. HTH is a dry form of calcium hypochlorite
    c. Appropriate doses of chlorine may be used to control odors, control filamentous bulking in activated sludge mixed liquor, or reduce BOD5 of wastewater
    *d. Hypochlorite's are sometimes used in place of chlorine because they are more effective and less costly

110. Hypochlorite solution is used in effluent disinfection because:

a. Chlorine residual determination is more stable and accurate in hypochlorite

b. Hypochlorite residuals are more resistant to nitrite interference

*c. Chlorine gas is more hazardous to store and handle

d. Hypochlorite solution is easier and less costly to ship than gas chlorine

e. Chlorine causes too many problems with disinfection efficiency

111. Chlorine is:

a. Colorless

b. Explosive

*c. Toxic

d. All of the above

112. The difference between the amount of chlorine added and the amount of chlorine remaining after the contact period is referred to as:

*a. the chlorine demand

b. free chlorine residual

c. total chlorine residual

d. combined chlorine residual

e. free available chlorine

113. The ultimate measure of the effectiveness of chlorination in disinfection is:

a. the measurement of chlorine dosage

b. meeting the chlorine demand of the wastewater

c. the establishment of a chlorine demand

*d. effective reduction of the coliform count

e. none of the above

114. A chlorine cylinder valve is thought to be leaking. If ammonia vapor is passed over the valve, the presence of a leak is indicated by

a. A hissing noise.

*b. A white cloud.

c. An odor of hydrogen sulfide.

d. Red smoke

115. A chlorine residual is often maintained in a plant effluent:

a. to keep the chlorinator working.

b. for control of fluctuation of wastewater flow.

c. for testing purposes.

*d. to protect the bacteriological quality of the receiving water.

e. None of the above.

116. Acids should never be added to chlorine solutions as they

*a. Cause chlorine gas to be released.

b. Corrode or "eat away" the solution tank.

c. Decrease the disinfecting properties of chlorine.

d. Result in the formation of a chloride precipitate. „

117. An amperometric titrater is used to measure
    a. Alkalinity.
    *b. Chlorine residual.
    c. Conductivity.
    d. COD.
118. An operator should never enter a room containing a high concentration of chlorine gas without
    a. Staying low on the floor.
    b. Holding breath and have help standing by.
    *c. Having self-contained air or oxygen supply and help standing by.
    d. Covering nose and mouth with a wet handkerchief.
119. As water temperatures decrease, the disinfecting action of chlorine
    *a. Decreases.
    b. Increases.
    c. Remains the same.
120. At a wastewater treatment plant. The amount of chlorine used in a day from a cylinder or tank that is in service is normally determined by:
    a. knowing both the pressure and temperature of the cylinder pressure gauges.
    b. rotameter readings.
    *c. weighing of the cylinder or tank
    d. the chlorine residual test .
    e. None of the above.
121. At what level should the exhaust be drawn off in a chlorination room?
    a. At chest height.
    b. At least two feet above the height of the chlorine cylinder.
    c. Near the ceiling.
    *d. Near the floor.
122. Chloramines are
    *a. Combined chlorine.
    b. Enzymes.
    c. Found in polluted air.
    d. Free chlorine.
123. Chlorine gas
    a. Is lighter than air.
    *b. Is heavier than air.
    c. Is pink in color.
    d. Will liquify at 70 degrees F.
124. Chlorine gas is
    a. Colorless.
    *b. Heavier than air.

c. Non-toxic.

d. Odorless.

125. Chlorine is:

a. Colorless

b. Explosive

*c. Toxic

d. All of the above

126. Chlorine is being applied at a constant dose rate of 24 mg/L to a partially nitrified activated sludge effluent having a pH of 6.8 and a temperature of 67F. Ammonia-nitrogen is found to range from 2 to 3 mg/L in this effluent. Disinfection in this effluent might be difficult because:

a. a temperature of 70' F or higher is necessary in order to achieve effective disinfection.

b. chloramines are present most of the time.

c. the chlorine dose rate is too low.

d. the pH of this effluent will limit the effectiveness of free chlorine.

*e. the ratio of chlorine to ammonia-nitrogen may make it difficult at times to maintain adequate chlorine residual.

127. 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.

*a. 4.9 mg/L

b. 5.7 mg/L

c. 7.5 mg/L

d. 8.3 mg/L

128. Chlorine is used to

*a. Disinfect.

b. Prevent corrosion.

c. Raise the pH.

d. Stabilize organics.

129. Chlorine residual may be determined using the reagent

*a. Diethyl-p-phenylenediamine (DPD).

b. Ethylendiamine tetraacetic acid (EDTA).

c. Polychlorinated biphenyls (PCB).

d. Sodium thiosulfate (Na2S203)

130. "Chlorine residual" refers to:

a. the amount of chlorine remaining in the ton cylinder after use.

b. the amount of chlorine consumed during disinfection.

*c. the chlorine remaining after disinfection.

d. the chlorine that displays no disinfection power.

e. the residue left after the evaporation of chlorine gas.

131. The effectiveness of chlorine disinfection is measured by:

a. the chlorine demand
b. the chlorine dosage
c. the total chlorine residual
*d. the coliform concentration of the effluent

132. The amount of chlorine used per day from a 1 ton chlorine cylinder is normally determined by:
a. Pressure gauges.
b. Rotometers.
*c. Weighings.
d. Chlorine residuals.
e. Ammonia equivalents.

133. Which of the following discharges would in general, require the lowest chlorine dosage to ensure adequate disinfection?
a. Primary plant effluent
b. Activated sludge plant effluent
c. Trickling filter plant effluent
*d. Sand filter effluent
e. Stabilization pond effluent

134. Which of the following are factors that may influence the effectiveness of chlorine?
a. Chlorine dose rate
b. Contact time
c. Suspended solids concentration of the wastewater being disinfected.
*d. Only (a) and (b)
e. (a), (b), and (c)

135. The fundamental purpose of disinfection is to:
a. Destroy fecal coliform bacteria
b. Destroy all bacteria
*c. Destroy pathogenic organisms
d. Protect downstream users from waterborne diseases

136. In the application of chlorine for disinfection, which of the following is not normally an operational consideration?
a. Mixing
b. Contact time
*c. DO
d. pH
e. None of the above

137. "Chlorine residual" refers to:
a. the amount of chlorine remaining in the ton cylinder after use.
b. the amount of chlorine consumed during disinfection.
*c. the chlorine remaining after disinfection.

d. the chlorine that displays no disinfection power.

e. the residue left after the evaporation of chlorine gas.

138. In the application of chlorine for disinfection, which of the following is not normally an operational consideration?

a. Mixing

b. Contact time

*c. DO

d. pH

e. None of the above

139. A chlorine residual is often maintained in a plant effluent:

a. to keep the chlorinator working.

b. for control of fluctuation of wastewater flow.

c. for testing purposes.

*d. to protect the bacteriological quality of the receiving water.

e. None of the above.

140. At a wastewater treatment plant. The amount of chlorine used in a day from a cylinder or tank that is in service is normally determined by:

a. knowing both the pressure and temperature of the cylinder pressure gauges.

b. rotameter readings.

*c. weighing of the cylinder or tank

d. the chlorine residual test .

e. None of the above.

141. The fundamental purpose of disinfection is to:

a. Destroy fecal coliform bacteria

b. Destroy all bacteria

*c. Destroy pathogenic organisms

d. Protect downstream users from waterborne diseases

142. One liter of liquid chlorine can evaporate and produce how many liters of chlorine gas?

a. 100

b. 250

*c. 460

d. 490

143. Identify the incorrect statement regarding disinfection.

a. When chlorine is added to water it forms acids, which tend to lower the pH of the wastewater effluent

b. HTH is a dry form of calcium hypochlorite

c. Appropriate doses of chlorine may be used to control odors, control filamentous bulking in activated sludge mixed liquor, or reduce BOD5 of wastewater

*d. Hypochlorite's are sometimes used in place of chlorine because they are more effective and less costly

144. Hypochlorite solution is used in effluent disinfection because:
    a. Chlorine residual determination is more stable and accurate in hypochlorite
    b. Hypochlorite residuals are more resistant to nitrite interference
    *c. Chlorine gas is more hazardous to store and handle
    d. Hypochlorite solution is easier and less costly to ship than gas chlorine
    e. Chlorine causes too many problems with disinfection efficiency
145. Chlorine is:
    a. Colorless
    b. Explosive
    *c. Toxic
    d. All of the above
146. Exhaust from a chlorinator room should be taken from
    a. Anywhere–the location is not important.
    *b. At floor level.
    c. Close to the entrance.
    d. In the ceiling.
147. How many pounds of chlorine gas is necessary to treat 4,000,000 gallons of wastewater at a dosage of 2 mg/L?
    a. 61 lbs.
    b. 65 lbs.
    *c. 67 lbs.
    d. 69 lbs.
148. How much chlorine is needed to provide 10 mg/L dosage for a flow of 2 MGD?
    a. 75 lbs.
    b. 83 lbs.
    c. 130 lbs.
    *d. 167 lbs.
149. Hypochlorite solution is used in effluent disinfection because:
    a. Chlorine residual determination is more stable and accurate in hypochlorite
    b. Hypochlorite residuals are more resistant to nitrite interference
    *c. Chlorine gas is more hazardous to store and handle
    d. Hypochlorite solution is easier and less costly to ship than gas chlorine
    e. Chlorine causes too many problems with disinfection efficiency
150. Identify the incorrect statement regarding disinfection.
    a. When chlorine is added to water it forms acids, which tend to lower the pH of the wastewater effluent
    b. HTH is a dry form of calcium hypochlorite
    c. Appropriate doses of chlorine may be used to control odors, control filamentous bulking in activated sludge mixed liquor, or reduce BOD5 of wastewater
    *d. Hypochlorite's are sometimes used in place of chlorine because they are more effective

and less costly

151. If a chlorinator is connected to the bottom valve of a half full one-ton cylinder, the chlorinator is withdrawing
    a. Chlorine gas.
    *b. Liquid chlorine.
    c. Liquid or gas chlorine, depending upon temperature.
    d. Nothing, since there is only one connection.
152. If you encounter a liquid chlorine leak in a one-ton cylinder, what action will immediately help to reduce the effect of the leak?
    a. Spray it with water.
    b. Apply ice. to leaking area.
    c. Spray it with ammonia solution.
    *d. Rotate cylinder so leak is in uppermost position.
153. In the application of chlorine for disinfection, which of the following is not normally an operational consideration?
    a. Mixing
    b. Contact time
    *c. DO
    d. pH
    e. None of the above
154. One liter of liquid chlorine can evaporate and produce how many liters of chlorine gas?
    a. 100
    b. 250
    *c. 460
    d. 490
155. The amount of chlorine used per day from a 1 ton chlorine cylinder is normally determined by:
    a. Pressure gauges.
    b. Rotometers.
    *c. Weighings.
    d. Chlorine residuals.
    e. Ammonia equivalents.
156. The amperometric titration method is used to measure:
    a. Alkalinity.
    *b. Chlorine residual.
    c. pH.
    d. Total hardness.
157. The fundamental purpose of disinfection is to:
    a. Destroy fecal coliform bacteria
    b. Destroy all bacteria

*c. Destroy pathogenic organisms

d. Protect downstream users from waterborne diseases

158. The measure of the effectiveness of chlorine in disinfection is:

a. The chlorine demand.

b. The chlorine dosage.

*c. The chlorine residual.

d. The amount of chloramine formed.

e. The final effluent coliform concentration.

159. When replacing piping in your chlorinator, be sure to

a. Replace with steel lines only.

b. Replace with CIP only.

*c. Replace with corrosion resistant piping only.

d. No special reqirement.

160. Which of the following discharges would, in general, require the lowest chlorine dosage to ensure adequate disinfection?

a. Primary plant effluent

b. Activated sludge plant effluent

c. Trickling filter plant effluent

*d. Sand filter effluent

e. Stabilization pond effluent

161. Which of the following are factors that may influence the effectiveness of chlorine?

a. Chlorine dose rate

b. Contact time

c. Suspended solids concentration of the wastewater being disinfected.

*d. Only (a) and (b)

e. (a), (b), and (c)

162. Which of the following are safe procedures for handling chlorine cylinders?

a. Keep cylinders close to direct heat to prevent freezing. -

*b. Protective cap should always be in place when moving a cylinder.

c. Roll cylinders in a horizontal position.

d. Store cylinders on their sides.

163. Which of the following discharges would in general, require the lowest chlorine dosage to ensure adequate disinfection?

a. Primary plant effluent

b. Activated sludge plant effluent

c. Trickling filter plant effluent

*d. Sand filter effluent

e. Stabilization pond effluent

14. Odor Control Assessment

Odor Control Assessment

1. Three systems used for vapor phase odor control in wastewater treatment
2. Explain how bioxide works to control H2S odor
3. Why do we need to control H2S in wastewater/wastewater treatment
4. Explain how bioxide (sodium nitrate) works in controlling odors
5. In your own words how is a biofilter different from a carbon scrubber
6. Why is the control of hydrogen sulfide important in wastewater treatment
7. Explain how bioxide works to control H2S odor
8. Why do we need to control H2S in wastewater/wastewater treatment
9. What are the characteristics of hydrogen sulfide
10. Explain how bioxide (sodium nitrate) works in controlling odors
11. In your own words how is a biofilter different from a carbon scrubber
12. Why is the control of hydrogen sulfide important in wastewater treatment
13. Three systems used for vapor phase odor control in wastewater treatment
14. Hydrogen sulfide removal from the foul air can be accomplished by scrubbing with an alkaline solution

    *a. True

    b. False
15. Odor control of hydrogen sulfide can be accomplished by the use of which of the following agents?

    a. hydrogen peroxide

    b. chlorine

c. ozone

*d. all of the above

e. none of the above

16. Ferric chloride helps in odor control by:

a. Oxidizing the odor constituents

b. Destruction of microorganisms responsible for odors

*c. Precipitating hydrogen sulfide

d. Raising the pH of the wastewater

17. Use of caustic soda in odor scrubbers is used for controlling:

*a. Hydrogen sulfide

b. Ammonia

c. Fouling

d. Organic compounds

18. Caustic soda is used in odor scrubbers for controlling:

*a. Hydrogen sulfide

b. Ammonia

c. Fouling

d. Organic compounds

19. Hydrogen sulfide control in the collection systems by caustic soda dosing is accomplished by:

*a. pH control

b. Chemical reaction

c. Oxidation

d. Biological control

20. High sulfide concentrations (either gaseous or dissolved) often cause problems in a wastewater treatment plant's influent structure. Pre-chlorination of a plant influent is routinely practiced to control sulfides and odors. At your plant the piping that supplies chlorine for pre-chlorination needs replacing. It is developing cracks and is corroded. Rather than replace this piping immediately, you are directed by your supervisor to identify alternate means of controlling these influent sulfides. Do the following:

(a) Identify THREE alternative methods of controlling sulfides.

(b) Briefly explain how each of these methods identified in (1) is able to control sulfides (e.g chlorine destroys sulfides by chemical oxidization of these sulfides.

(c) From the three alternative methods of controlling sulfides select the one you feel is the best substitute for chlorine gas and briefly state why you think it is best.

Response:

a *Identify THREE alternative methods of controlling sulfides.*

- pH control – Caustic/magnesium hydroxide addition in the collection system.
- Foul air treatment using chemical scrubbers – capture and treat the foul air
- Chemical precipitation using iron salts

b *Briefly explain how each of these methods identified in (1) is able to control sulfides (e.g chlorine destroys sulfides by chemical oxidization of these sulfides.*

- pH control: Keeps the H_2S in the liquid phase. Caustic would also help in controlling/removing the slime layer which is responsible for odor/H_2S generation.
- Foul air treatment using chemical or biological scrubbers – capture and treat the foul air – for chemical scrubbers - methods used could be using an oxidizing agent (peroxide or beach) or alkaline pH (using caustic) recirculation water.
- Chemical precipitation using iron salts – iron salts chemically remove the hydrogen sulfide by forming iron sulfide precipitate.

c *From the three alternative methods of controlling sulfides select the one you feel is the best substitute for chlorine gas and briefly state why you think it is best.*

- Process changes to remove ammonia further through implementation of nitrification – denitrification as part of the activated sludge process
- Iron sulfide – good control over anticipated sulfide levels in the plant

21. Why is H_2S control important? Describe the methods for controlling odor in both, in the sewer collection systems and in the plant.

Response:

a *Why is H_2S control important?*

- safety
- preventing public nuisance, and
- corrosion prevention.

b *Describe the methods for controlling odor in both, in the sewer collection systems and in the plant.*

In sewer collection system:

i. pH adjustment by dosing with alkaline chemicals such as caustic soda or magnesium hydroxide
ii. By injecting oxygen or air to prevent the formation of H_2S
iii. By dosing with a iron salt to precipitate the H_2S
iv. By adding sodium nitrate (Bioxide) to facilitate biodegradation of H_2S

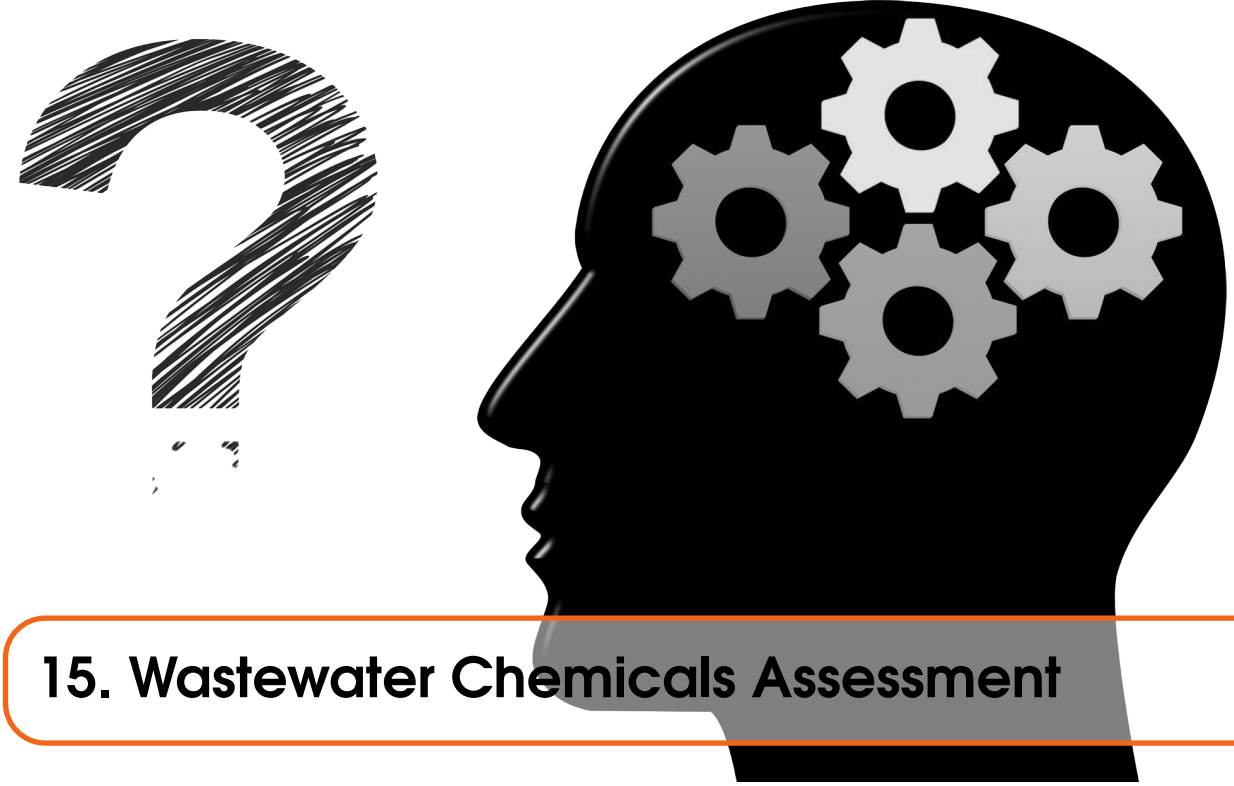
In the plant:

By capturing and treating the foul air using the following methods:

i. Packed tower chemical scrubber using one of the following:
   - Oxidizing chemicals such as hydrogen peroxide or bleach
   - Chemicals like caustic soda which increase the pH of the recirculation water
ii. Use of biological removal based systems such as:
   - Biofilter
   - Biotrickling filter
iii. Use of adsorbtive material such as activated carbon

22. What is UV radiation disinfection? Discuss maintenance and operational issues. Advantages and disadvantages. What is the dosage measured in and what does the equation

(MW-sec/cm2) mean?



15. Wastewater Chemicals Assessment

Wastewater Chemicals Assessment

1. What is mannich polymer and what are its drawbacks.
2. Chemical requirements for the conditioning of sludge are normally based upon laboratory-scale "jar tests" which determine the volume of chemical solution required for floc formation.
   *a. True
   b. False
3. Cationic polymers are high-molecular-weight organic compounds carrying a negative charge
   a. True
   *b. False
4. Anionic polymer is used for:
   a. Thickening solids in a gravity thickener
   b. Flocculating solids for dewatering
   c. For odor control
   *d. For enhancing solids and BOD removal in the primaries
5. Alum is frequently used along with an anionic polymer when dewatering anaerobically digested sludge using a belt press.
   a. Cationic polymers are high molecular weight organic compounds carrying a negative charge.
   b. A dry polymer is always a better choice for application in centrifuges than any liquid polymer solution.

*c. Because of its viscosity, a Mannich polymer may be difficult to pump.

d. All liquid polymer solutions are harmless and need not require the examination of their MSDS.

6. Either alum; ferric chloride; or lime may be used to remove solids from a secondary effluent. Which one of, the following statements is TRUE regarding these chemicals:

a. Typical dose rates for alum when it is applied for the removal of phosphorus from a secondary effluent are 1 to 10 mg/L.

b. Hydrated lime needs to be "slaked" prior to use.

*c. The safety precautions for handling liquid ferric chloride are the same as those for handling an acid.

d. All of these chemicals raise the pH of the wastewater to which they are applied.

7. Ferric chloride helps in odor control by:

a. Oxidizing the odor constituents

b. Destruction of microorganisms responsible for odors

*c. Precipitating hydrogen sulfide

d. Raising the pH of the wastewater

8. Flocculation is best accomplished by

a. Decreasing alkalinity.

*b. Gentle agitation.

c. Increased sunlight.

9. Sodium hydroxide, (caustic soda) when used in wastewater:

Is typically applied at 1 - 10 mg/l when used to precipitate phosphorus in primary sedimentation systems.

a. Should be treated as an acid with regard to safe handling.

b. Should be immediately diluted to 10% upon receiving.

*c. Raises the pH of the wastewater to which it is added.

d. Is added to filtered effluent to improve de-chlorination with sulfur dioxide.

10. Either alum; ferric chloride; or lime may be used to remove solids from a secondary effluent. Which one of, the following statements is TRUE regarding these chemicals:

a. Typical dose rates for alum when it is applied for the removal of phosphorus from a secondary effluent are 1 to 10 mg/L.

b. Hydrated lime needs to be "slaked" prior to use.

*c. The safety precautions for handling liquid ferric chloride are the same as those for handling an acid.

d. All of these chemicals raise the pH of the wastewater to which they are applied.

11. Flocculation is best accomplished by

a. Decreasing alkalinity.

*b. Gentle agitation.

c. Increased sunlight.

d. Rapid mixing

12. Flocculation is best accomplished by:
    a. Decreasing alkalinity
    *b. Gentle agitation
    c. Increased sunlight.
13. If a chemical costs S30 per ton, how much will it cost per year to treat a flow of 1.5 MGD if the average dose is 18 mg/L?
    a. $803.
    b. $110.
    *c. $233.
    d. $506.
    Identify the correct statement regarding polymers.
14. Sodium hydroxide, (caustic soda) when used in wastewater:
    Is typically applied at 1 - 10 mg/l when used to precipitate phosphorus in primary sedimentation systems.
    a. Should be treated as an acid with regard to safe handling.
    b. Should be immediately diluted to 10% upon receiving.
    *c. Raises the pH of the wastewater to which it is added.
    d. Is added to filtered effluent to improve de-chlorination with sulfur dioxide.
15. Which one of the following statement is TRUE regarding polymers?
    a. Alum is frequently used along with an anionic polymer when dewatering anaerobically digested sludge using a belt press.
    b. Cationic polymers are high-molecular-weight organic compound carrying a negative charge.
    c. A dry polymer is always a better choice for application in centrifuges than any liquid polymer solution.
    *d. Because of its high pH, Mannich polymers may cause scale formation.
    e. All. liquid polymer solutions are harmless and need not require the examination of its MSDS sheet.
16. Which one of the following statement is TRUE regarding polymers?
    a. Cationic polymers are high molecular weight organic compound carrying a negative charge.
    b. A dry polymer is always a better choice for application in centrifuges than any liquid polymer solution.
    *c. Because of its high pH, Mannich polymers may cause scale formation.
    d. All liquid polymer solutions are harmless and need not require the examination of its MSDS sheet.
    e. Alum is frequently used along with an anionic polymer when dewatering anaerobically digested sludge using a belt press.

16. Pumping Assessment

Pumping Assessment

1. A 240 volt motor runs an average of 8 hours a day. If the electric meter registered 6,450 kilowatt hours for a 31-day month, what is the motor horsepower? [35 Hp]
2. A pump is equipped with a pressure gauge in the discharge pipe that reads 100 psi. The total discharge head in feet would be?

   $100 psi * \frac{2.31 ft \ \ water}{psi} = \boxed{231 ft \ \ water}$

3. 900 GPM pump is pumped against a 12 ft head. What is the water Hp water Hp = flow *

   head

   $900 GPM * 12 ft * \frac{Hp}{3{,}960 GPM - ft} = \boxed{2.7 Hp}$
4. A 50 ft^3/sec flow is pumped against a head of 8 feet. What is the water Hp

   water Hp = flow * head

   $\frac{5}{0} ft^3 sec * 8 ft * \frac{7.48 gal}{ft^3} * \frac{60 sec}{min} * \frac{Hp}{3{,}960 GPM - ft} = \boxed{45.4 Hp}$
5. 1 MGD is pumped against a 14' head. What is the water Hp? The pump mechanical efficiency is 85%. What is the brake horsepower?

   water Hp = flow * head

   $\frac{1{,}000{,}000 gal}{day} * \frac{day}{1440 min} * 14 ft * \frac{Hp}{3{,}960 GPM - ft} = \boxed{Water \ \ Hp = 2.46 Hp}$

   pump Hp = brake Hp * pump efficiency

   $brake \ \ Hp = \frac{2.46}{0.85} = \boxed{Brake \ \ Hp = 2.89 Hp}$

6. A flow of 2.5 MGD is being lifted 10 feet and then pumped up another 120 feet to a storage reservoir. Calculate the pump output power required to lift this water. Ignore friction losses.

   water Hp = flow * head

   $\frac{2{,}500{,}000gal}{day} * \frac{day}{1440min} * (120+10)ft * \frac{Hp}{3{,}960GPM-ft} = \boxed{Water\ \ Hp = 57Hp}$

7. A pump is pumping 400 gpm. The suction pressure gauge indicates a pressure of 5 ft and the pump discharge pressure gauge indicates a pressure of 100 ft. If the pump brake horse power is 12 hp, what is the pump efficiency

water Hp = flow * head

$400gpm * (100-5)ft * \frac{Hp}{3{,}960gpm-ft} = \boxed{9.6Hp}$

pump efficiency - $\eta_p = \frac{9.6Hp}{12Hp} * 100 = \boxed{79\%}$

8. A flow of 200 gpm is pumped against a total head of 4.0 feet. · The pump is 78% efficient and the motor' is 90% efficient. Calculate the input Hp.

water Hp = flow * head

$200GPM * 4ft * \frac{Hp}{3{,}960GPM-ft} = 0.2Hp$

water Hp=brake Hp*pump efficiency, and

brake Hp=input Hp*motor efficiency

Therefore, water Hp=input Hp*motor efficiency*pump efficiency

input Hp=$\frac{water\ \ Hp}{motor\ \ efficiency * pump\ \ efficiency} = \frac{0.2}{0.9*0.78} = \boxed{0.28Hp}$

9. 500,000 gpd of secondary· effluent is pumped to a storage pond for reuse as golf course irrigation water. The water is lifted 12 feet in the plant, and then pumped up another 75 feet to the storage pond. Friction losses are assumed to be 10% of the static head. Assuming the pump efficiency of 70% and a motor efficiency of 92% and an electrical cost of $0.0725 per KWh, calculate the daily cost of pumping this water.

   Solution:
   water Hp = flow * head

   $$\frac{500{,}000gal}{day} * \frac{day}{1440min} * (87ft - static\ \ head + 87 * 0.1ft - friction\ \ head) * \frac{Hp}{3{,}960GPM - ft}$$
   $$= 8.39 - water\ \ Hp$$

   input Hp=$\frac{water\ \ Hp}{motor\ \ efficiency * pump\ \ efficiency} = \frac{8.39}{0.92 * 0.70} = \boxed{13Hp}$

   Electrical cost=$13Hp * \frac{0.746kW}{Hp} * \frac{24hrs}{day} * \frac{\$0.0725}{kWh} = \boxed{\frac{\$16.87}{day}}$

10. A pump motor (93% efficient) generates an output of 130 HP and runs 75% of the time. Electricity costs an average of 8.455 cents per kilowatt-hour. What is the monthly cost of operating this pump in $ per month?

    $$\frac{130Hp}{0.93} * \frac{0.746kW}{Hp} * \frac{24hrs}{day} * \frac{30days}{month} * 0.75 * \frac{\$0.08455}{kWh} = \boxed{\frac{\$4{,}761}{month}}$$

11. A wet well is 8 ft x 8 ft x 16.5 ft deep and receives a continuous flow of 310,000 gpd. A 500 gpm pump draws down 12 feet of water each pumping cycle. The motor that drives the pump draws 52.5 Hp when it pumps. The cost of electricity is $0.0755 per kilowatt - hour. Calculate
(a) the time it takes to pump down the wet well, and
(b) The daily electrical energy cost for this pump.

Solution:
$@\frac{310{,}000gal}{day} * \frac{day}{1440min} = \frac{215.3gal}{min}$

Volume of wetwell that will be pumped down with the 500 gpm pump and a 215.3 gpm flow to the wetwell:
$\frac{500gal}{min} - \frac{215.3gal}{min} = \frac{284.7gal}{min}$

Minutes required to pump down the wetwell :
$8 * 8 * 12ft^3 * \frac{7.48gal}{ft^3} * \frac{min}{284.7gal} = \boxed{20.2min}$

Time to fill wetwell with pump off @215.3gal/min influent flow:
$8 * 8 * 12ft^3 * \frac{7.48gal}{ft^3} * \frac{min}{215.3gal} = 26.7min$

# of cycles per day:
$\frac{cycle}{(20.2+26.7)min} * \frac{1440min}{day} = \frac{30.7cycles}{day}$

# of hrs pump operational:
$\frac{20.2min}{cycle} * \frac{30.7cycles}{day} * \frac{hrs}{60min} = \frac{10.33hours}{day}$

Daily electrical cost:
$52.5Hp * \frac{0.746kW}{Hp} * \frac{10.33hrs}{day} * \frac{\$0.0755}{kWh} = \boxed{\frac{\$30.54}{day}}$

12. A 6-year old pump motor is to be replaced at a net cost of $15,800. The new motor, just like the old one, would run 65% of the time. Both existing and replacement motors would operate at 125 output Hp. The existing motor efficiency is 86% while the replacement motor would be guaranteed at 94% efficiency. Electricity currently averages $0.088 per kWh.
    (a) Calculate the energy cost savings per year (to the nearest dollar) if the existing motor is replaced with the new motor (neglect any consideration of impact upon demand charges or interest on capital).
    (b) What is payback period to the nearest tenth of a year. Energy cost savings per year:

    Input Hp for old motor: $\frac{125}{0.86} = 145.35Hp$
    Input Hp for old motor: $\frac{125}{0.94} = 132.98Hp$
    Energy cost savings:
    $(145.35-132.98)Hp * \frac{0.746kW}{Hp} * \frac{(365*24*0.65)hrs}{yr} * \frac{\$0.088}{kWh} = \boxed{\frac{\$4,623.94}{yr}}$

    Calculate payback:
    $\$15,800 * \frac{yr}{\$4,623.94} = \boxed{3.4yr}$
13. A 8 ft diameter cylindrical wetwell receives an average incoming flow if 135 gpm and is pumped down with a pump that delivers 450 gpm again a total dynamic head of 120 ft. The pump is controlled using two floats; a stop float located at 2.5 ft and a start float located at 16 ft. If the pump motor is rated at 88% and the pump at 77%, what is the monthly (30 days/month) for running this pump if power costs are $0.11/Kwh? (Ans: $356/month)

    Volume of wetwell that will be pumped down with the 450 gpm pump and a 135 gpm flow to the wetwell:
    $\frac{450gal}{min} - \frac{135gal}{min} = \frac{315gal}{min}$

    Minutes required to pump down the wetwell :
    $0.785 * 8^2 * (16-2.5)ft^3 * \frac{7.48gal}{ft^3} * \frac{min}{315gal} = \boxed{16.1min}$

    Time to fill wetwell with pump off @135gal/min influent flow:
    $[0.785 * 8^2 * (16-2.5)]ft^3 * \frac{7.48gal}{ft^3} * \frac{min}{135gal} = 37.6min$

    # of cycles per day:
    $\frac{cycle}{(16.1+37.6)min} * \frac{1440min}{day} = \frac{26.8cycles}{day}$

    # of hrs pump operational:
    $\frac{16.1min}{cycle} * \frac{26.8cycles}{day} * \frac{hrs}{60min} = \frac{7.19hours}{day}$

    Daily electrical cost:
    $\frac{450gpm*120ft}{0.88*0.77} * \frac{Hp}{3,960gpm-ft} * \frac{0.746kW}{Hp} * \frac{7.19hrs}{day} * \frac{30days}{month} * \frac{\$0.11}{kWh} = \boxed{\frac{\$356}{day}}$

14. A pump operating at 80% effieciency generates an water Hp of 60 HP and runs 75% of the time. Assuming the pump motor is 90% efficent and electricity costs an average of $0.0821 per kilowatt-hour. The monthly (30 days) cost of operating this pump is:

$$\frac{60Hp}{0.90*0.80} * \frac{0.746kW}{Hp} * \frac{24hrs}{day} * \frac{30days}{month} * 0.75 * \frac{\$0.0821}{kWh} = \boxed{\frac{\$2,756}{month}} - Correct\ \ Answer$$

$$\frac{60Hp}{0.8} * \frac{0.746kW}{Hp} * \frac{24hrs}{day} * \frac{30days}{month} * 0.75 * \frac{\$0.0821}{kWh} = \boxed{\frac{\$2,480}{month}}$$

$$\frac{60Hp}{0.90} * \frac{0.746kW}{Hp} * \frac{24hrs}{day} * \frac{30days}{month} * 0.75 * \frac{\$0.0821}{kWh} = \boxed{\frac{\$2,205}{month}}$$

$$\frac{60Hp}{0.90*0.80} * \frac{0.746kW}{Hp} * \frac{24hrs}{day} * \frac{30days}{month} * \frac{\$0.0821}{kWh} = \boxed{\frac{\$3,675}{month}}$$

15. A 8 ft diameter cylindrical wetwell receives an average incoming flow if 135 gpm and is pumped down with a pump that delivers 450 gpm again a total dynamic head of 120 ft. The pump is controlled using two floats; a stop float located at 2.5 ft and a start float located at 16 ft. If the pump motor is rated at 88% and the pump at 77%, what is the monthly (30 days/month) for running this pump if power costs are $0.11/Kwh? (Ans: $356/month)
16. A 8 ft diameter cylindrical wetwell receives an average incoming flow if 135 gpm and is pumped down with a pump that delivers 450 gpm again a total dynamic head of 120 ft. The pump is controlled using two floats; a stop float located at 2.5 ft and a start float located at 16 ft. If the pump motor is rated at 88% and the pump at 77%, what is the monthly (30 days/month) for running this pump if power costs are $0.11/Kwh? (Ans: $356/month)
17. If a wasting pump has a fixed pump rate of 250 GPM, and your calculation indicates you must waste 126,000 gallons, what hourly cycle rate do you set the timer?
    a. Turn pump on 21 minutes every day
    b. Turn pump on 504 minutes every hour
    c. Turn pump on 42 minutes every day
    d. Turn pump on 21 minutes every hour

    Solution:

$$\frac{min}{hr} = \frac{126{,}000\ \ gal}{day} * \frac{day}{24\ \ hrs} * \frac{min}{250\ \ gal} = \boxed{\frac{21\ \ min}{hr}}$$

18. How long will it take to pump down 25 feet of water in a 110 ft diameter cylindrical tank when using a 1420 gpm pump.
    a. 26 hours and 56 minutes
    *b. 26 hours and 33 minutes
    c. 2 hours and 47 minutes
    d. 12 hours and 36 minutes
19. A positive displacement pump should be started up with the discharge valve closed in order to avoid any problems with "air lock".
    a. True
    *b. False

20. Brake horse power is the input power to the motor
    a. True
    *b. False
21. Cost of electrical usage for pumps is based upon kilowatt per hour
    a. True
    *b. False
22. A centrifugal pump can be used to pump sludge.
    *a. True
    b. False
23. Variable speed sludge pumps may be used to keep the density of the sludge nearly constant.
    *a. True
    b. False
24. The keeping of records of plant operation and maintenance, even when a portion of the plant is temporarily out of balance, is an integral part of good operation.
    *a. True
    b. False
25. A positive displacement pump could be damaged if it is started with the discharge valve closed.
    *a. True
    b. False
26. The common unit of power or rate of doing work is horsepower. This· is equal to 746 ft. lbs/min.
    *a. True
    b. False
27. Total dynamic head is the sum of the suction head and the discharge head minus the friction head
    a. True
    *b. False
28. Water power is the output power of the pump
    *a. True
    b. False
29. A positive displacement pump should be started up with the discharge valve closed in order to avoid any problems with "air lock".
    a. True
    *b. False
30. Brake horse power is the input power to the motor
    a. True
    *b. False
31. Cost of electrical usage for pumps is based upon kilowatt per hour

a. True

*b. False

32. The common unit of power or rate of doing work is horsepower. This· is equal to 746 ft. lbs/min.

*a. True

b. False

33. Total dynamic head is the sum of the suction head and the discharge head minus the friction head

a. True

*b. False

34. Water power is the output power of the pump

*a. True

b. False

35. What is the vertical distance between the elevation of the free water surface at the suction and that of the free water surface at the discharge of a pump called?

a. Discharge head.

b. Dynamic head.

c. Velocity head.

*d. Static head.

36. If a wasting pump has a fixed pump rate of 250 GPM, and your calculation indicates you must waste 126,000 gallons, what hourly cycle rate do you set the timer?

a. Turn pump on 21 minutes every day

b. Turn pump on 504 minutes every hour

c. Turn pump on 42 minutes every day

*d. Turn pump on 21 minutes every hour

37. A positive displacement pump is connected to a 25' wide x 125' long x 12' side water depth aerobic digester. How long will it take to empty the contents of the digester if the pump rate is 225 gallons per minute?

a. 15.3 hours

b. 2.8 hours

*c. 20.8 hours

d. 15.6 hours

38. A centrifuge is fed sludge with a concentration of 3.4% solids. If the sludge feed rate is set at 50 gallons per minute, what is the centrifuge loading rate in pounds per hour?

a. 763 lbs/hour

*b. 850 lbs/hour

c. 735 lbs/hour

d. 960 lbs/hour

39. Calculate the surface loading rate for a treatment plant with 4 clarifiers each with a 100 foot diameter. The plant has an influent flow of 35 MGD.

a. 279 gal/sq ft
b. 950 gal/sq ft
c. 4,459 gal/sq ft
*d. 1,115 gal/sq ft

40. Calculate the flow velocity in feet/minute if 7.5 MGD of flow passes through a channel that is 3' wide x 4' deep, and the depth of flow is 15 inches.
*a. 186 ft/min
b. 58 ft/min
c. 202 ft/min
d. 46.5 ft/min

41. Determine the pounds per day of primary solids removed at a plant with a flow rate of 1.5 MGD and the following data:
Clear Waters Fall 2013
Influent TSS = 250 mg/L
Primary Effluent TSS = 150 mg/L,
Final Effluent TSS = 12 mg/L
a. 1,101 lbs/day
*b. 1,251 lbs/day
c. 982 lbs/day
d. 2,977 lbs/day

42. A sewage pump is located above the wet well which is 8 feet deep and the pump is pumping to an above ground clarifier with 12 feet depth of water. The pump manufacturer has given you the pump characteristics curve which shows Total Dynamic Head vs. flow rates. If the operating wet well water depth is 6 feet, what is the total dynamic head in order to determine pumping rate from the chart? Assume the top of the wet well and the bottom of the clarifier are at the same elevation.
a. 12 feet
b. 20 feet
*c. 14 feet
d. 10 feet

43. A sewage pump is located above the 8-foot diameter wet well which is 8 feet deep and the pump is pumping to an above ground clarifier. The flow meter on the pump is not operating and you want to calculate the pumping rate by measuring the drop in wet well water level during when inflow to wet well is minimal? If the drop in water level in one minute is 2 feet, what is the approximate pumping rate in gallons per minute?
a. 250 GPM
b. 375 GPM
c. 500 GPM
*d. 750 GPM

44. The head against which a pump must operate:

a. Is the sum of the static head and the head due to friction loss.
b. Must always be above the shut-off head.
c. Is the static head.
d. Is the friction head.

45. What term describes the condition that exists when the source of the water supply is below the centerline of the pump?
a. Pressure head
b. Velocity head
c. Suction lift
d. Total discharge head

46. A pump operating at 80% efficiency generates an water Hp of 60 HP and runs 75% of the time. Assuming the pump motor is 90% efficent and electricity costs an average of $0.0821 per kWh. The monthly (30 days) cost of operating this pump is:
*a. $2,756
b. $2,480
c. $2,205
d. $3,675

17. Constituents Properties and Analysis Assessme

Constituents Properties and Analysis Assessment

1. Hazardous conditions in a manhole, wetwell or other similar type of structure may not be always be detected by the presence of odor because:
   a. some toxic gases have no detectable odor
   b. the environment may be oxygen deficient
   c. some gases may deaden the sense of smelll
   d. not all explosive gases have detectable odor
   *e. all of the above
2. An operator should not enter an enclosed structure if the percentage of oxygen in the air is less than:
   *a. 19.5%
   b. 23.5%
   c. 27.2%
   d. 32.5%
3. Digester gas containing 60
   a. True
   *b. False
4. Prior to working in a drained anaerobic digester, confined space entry permits must be prepared.
   *a. True
   b. False
5. Hydrogen sulfide gives off an odor similar to

a. Ammonia.
b. Chlorine gas
*c. Rotten eggs
d. Decayed wood.

6. Which of the following is not a characteristic of hydrogen sulfide?
a. Foul odors
*b. Lighter than air
c. Toxic
d. Corrosiveness
e. Explosiveness
7. If you come upon a co-worker who is not breathing, you should immediately
a. Apply cold compresses to the worker's forehead
b. Check for bleeding
*c. Call for help
d. Start CPR
8. What is the first, immediate, action you should take if concentrated acid is spilled on the floor?
a. Pour sodium nitrate and wash with warm water
b. Run to a shower and wash yourself thoroughly
*c. Sound the alarm
d. Wash with water and neutralize with sodium bicarbonate (baking soda)
9. Key steps in a safety program would not include
a. Controlling work habits
*b. Injury records for the operator
c. Locating hazards
d. Medical insurance for all employees
10. Three waterborne diseases are
a. Mumps, measles, colds
b. Scarlet fever, pneumonia, hay fever
*c. Typhoid fever, dysentery, cholera.
d. TB, diptheria, chickenpox
11. Improper handling, storing or preparing solutions of chemicals can cause
a. Burns
b. Explosions
c. Loss of eye sight
*d. All of the above
12. What disease is not considered to be normally conveyed or transmitted by untreated wastewater?
a. Amoebic dysentery
b. Hepatitis

*c. Malaria.

d. Chlorea.

13. Pathogens

*a. Are bacteria or virus that cause disease

b. Are bacteria which do not occur in water

c. Can obtain their food supply without help

d. Are not harmful to man

14. Employee hazards include

a. Noxious or toxic gases or vapors

b. Oxygen deficiency

c. Physical injuries

*d. All of the above

15. What is the proper slope of a ladder?

*a. Every 4 feet up the ladder is 1 foot out from the wall.

b. Every 5 feet up the ladder is 1 foot out from the wall.

c. Every 6 feet up the ladder is 1 foot out from the wall.

d. Every 7 feet up the ladder is 1 foot out from the wall.

16. What is the safe oxygen level for entering a confined space? a. 14 to 16 ppm.

b. 17 to 19 ppm.

*c. 20 to 22 ppm.

d. 23 to 25 ppm.

17. Cluttered work areas can cause accidents. Keep work areas clean. When you are finished with tools, put them:

a. On the table.

b. Under the table.

c. On your supervisor's desk.

*d. In the tool cabinet.

18. What type of tools are recommended to perform maintenance on an anaerobic digester?

*a. Brass.

b. Stainless steel.

c. Carbon steel.

d. None of the above.

19. Before entering a permit-required confined space, you must:

a. Check the atmosphere with a calibrated gas detector.

b. Make notification that personnel are entering the space.

c. Lock out and tag out all equipment.

*d. All of the above.

20. When working on a chemical feed pump, what of the following is not required?

a. Nitrile gloves.

b. Safety glasses.

*c. Leather work gloves.

d. Full face shield.

21. When making a sulfuric acid dilution, the appropriate method is:

a. Add the water to the acid.

*b. Add the acid to the water.

c. Add both at the same time.

d. None of the above.

22. When aluminum sulfate mixes with water, a very _____ combination occurs.

a. Noxious. *b. Slippery. c. Colorful. d. Tacky.

23. Operators working with any form of lime are exposed to a number of hazards. Goggles, approved respiratory protection, emergency eyewash and deluge shower are necessary safety precautions. What else may be kept on hand to help flush eyes in case of severe exposure?

a. Inert absorbent materials.

b. A mild solution of acetic acid.

*c. A mild solution of boric acid.

d. None of the above.

24. A mixture of 85%-95% atmospheric air in combination of 5%-15% methane creates which of the following?

*a. An explosive condition

b. Struvite

c. Excess pressure

d. Increased BTU

25. The first step the maintenance staff should take in properly locking and tagging out a piece of equipment is to _____.

*a. Alert the operator on duty. b. Turn the equipment off at the motor control center (MCC).

c. Pull the switch on the electrical panel to "OFF."

d. Fill out the tags.

26. When working in an area with two or more floor coverings, be sure that they are always _____.

a. Overlapping one another.

*b. Secured together.

c. Separated from one another.

d. At the entrances and exits only.

27. When manually lifting any object, be sure to _____.

a. Hold it at arm's length.

b. Keep your back bent and hold it low.

*c. Keep it close to your body and use leg strength.

d. Keep your knees locked and bend at the waist.

28. Oxygen deficiency becomes a concern when the oxygen level in a confined space is less

than _____.

*a. 19.5%.

b. 22.5%.

c. 25.5%.

d. 28.5%.

29. Which of the following provides safety information for potentially hazardous or toxic materials?

a. EPA.

b. OSHA.

c. CFR.

*d. SDS.

30. The threshold limit value concentration for chlorine vapor is _____. a. 0.1 ppm.

b. 0.3 ppm.

*c. 0.5 ppm.

d. 1.0 ppm.

31. When working in confined spaces where flammable gases may be present, use only tools made of _____. a. Stainless steel.

b. Lead.

c. Iron.

*d. Beryllium.

32. Presence of hydrogen sulfide cannot always be detected by its characteristic odor

*a. True

b. False

33. The quantities and dosing requirements for a particular wastewater chemical can be found in the SDS

a. True

*b. False

34. Hydrogen sulfide in addition to creating an odor nuisance can be an explosion hazard when mixed with air in certain concentrations.

*a. True

b. False

35. The lower explosive limit for methane is 40%

a. True

*b. False

36. What is the proper slope of a ladder?

(a) Every 4 feet up the ladder is 1 foot out from the wall.

(b) Every 5 feet up the ladder is 1 foot out from the wall. c. Every 6 feet up the ladder is 1 foot out from the wall. d. Every 7 feet up the ladder is 1 foot out from the wall.

Hydrogen sulfide at 130 ppm smells most like:

(a) Degreaser.

(b) Rotten eggs.

(c) Bleach.

(d) Nothing.

37. What is the safe oxygen level for entering a confined space?

(a) 14 to 16 ppm.

(b) 17 to 19 ppm.

(c) 20 to 22 ppm.

(d) 23 to 25 ppm.

38. Cluttered work areas can cause accidents. Keep work areas clean. When you are finished with tools, put them:

(a) On the table.

(b) Under the table.

(c) On your supervisor's desk.

(d) In the tool cabinet.

39. What type of tools are recommended to perform maintenance on an anaerobic digester?

(a) Brass.

(b) Stainless steel.

(c) Carbon steel.

(d) None of the above.

40. Before entering a permit-required confined space, you must:

(a) Check the atmosphere with a calibrated gas detector.

(b) Make notification that personnel are entering the space.

(c) Lock out and tag out all equipment.

(d) All of the above.

41. When working on a chemical feed pump, what of the following is not required?

(a) Nitrile gloves.

(b) Safety glasses.

(c) Leather work gloves.

(d) Full face shield.

42. When making a sulfuric acid dilution, the appropriate method is:

(a) Add the water to the acid.

(b) Add the acid to the water.

(c) Add both at the same time.

(d) None of the above.

43. When aluminum sulfate mixes with water, a very _____ combination occurs.

(a) Noxious.

(b) Slippery.

(c) Colorful.

(d) Tacky.

44. Operators working with any form of lime are exposed to a number of hazards. Goggles,

approved respiratory protection, emergency eyewash and deluge shower are necessary safety precautions. What else may be kept on hand to help flush eyes in case of severe exposure?

(a) Inert absorbent materials.
(b) A mild solution of acetic acid.
(c) A mild solution of boric acid.
(d) None of the above.
(e) What safety hazard is created by a polymer spill?
    i. explosive condition
    ii. fire
    iii. slippery surface
    iv. toxic gas
    v. skin burns
(f) When is it safe to enter a manhole?
    i. after a hazardous condition has been identified
    ii. after ventilation equipment has been turned on
    iii. when wearing an SCBA and having a back-up standing by
    iv. when no hazardous condition exists

18. Math Assessment

Practice Problems - Fractions

1. Convert $22\frac{1}{4}$ into a fraction
2. Express 10ft, 6in into fraction
3. Express 10ft, 6in into decimal

Practice Problems - Decimals and Powers of Ten

1. Write the equivalent of 10,000,000 as a power of ten
2. Find the product of $3.4564 * 10^{2}$
3. Find the product of $534.567 * 10^{-2}$
4. Find the value of $\frac{165.93}{10^{-2}}$
5. Find the value of $0.023 * 10^{4}$

Solutions:

1. 10^{7}
2. 345.64
3. 5.34567
4. 16,593
5. 230

Practice Problems - Rounding and Significant Digits

Round the following to the nearest hundredths (the second place after the decimal).

A. 2.4568

B. 27.2534

C. 128.2111

D. 364.8762

E. 354.777777

F. 34.666666

G. 67.33333

Solution:

A. 2.46

B. 27.25

C. 128.21

D. 364.88

E. 354.78

F. 34.67

G. 67.33

Round the following to the nearest tenths (the first place after the decimal).

A. 2.4568

B. 27.2534

C. 128.2111

D. 364.8762

E. 354.777777

F. 34.666666

G. 67.33333 Solution:

A. 2.5

B. 27.3

C. 128.2

D. 364.9

E. 354.8

F. 34.7

G. 67.3

Round the following answers off to the most significant digit.

	Problem	Accurate Answer
A.	$25.1 + 26.43 = 51.53$	
B.	$128.456 - 121.4 = 7.056$	
C.	$85 - 7.92432 = 77.07568$	
D.	$8.564 + 5 = 13.564$	

	Problem	Accurate Answer
A.	$26.34 \times 124.34567 = 3,275.26495$	
B.	$23.58 \times 34.251 = 807.63858$	
C.	$12,453/13.9 = 895.8992805755$	
D.	$12,457.92 \times 3 = 37,373.76$	

Practice Problems - Averages

1. Find the average of the following set of numbers:
   0.2

   0.2

   0.1

   0.3

   0.2

   0.4

   0.6

   0.1

   0.3
2. The chemical used for each day during a week is given below. Based on these data, what was the average lb/day chemical used during the week?

Monday	92 lb/day
Tuesday	93 lb/day
Wednesday	98 lb/day
Thursday	93 lb/day
Friday	89 lb/day
Saturday	93 lb/day
Sunday	97 lb/day

3. The average chemical use at a plant is 77 lb/day. If the chemical inventory is 2800 lbs, how many days supply is this?
4. A well pumped for 45 days. The beginning meter reading was 7,456,400 and 45 days later the same meter was 15,154,400. What was the average flow in gallons per day?

Practice Problems - Percentage

1. 25% of the chlorine in a 30 -gallon vat has been used. How many gallons are remaining in the vat?
2. The annual public works budget is $\$147,450$. If 75% of the budget should be spent by the end of September, how many dollars are to be spent? How many dollars will be remain-

ing?

3. A 75 pound container of calcium hypochlorite has a purity of 67%. What is the total weight of the calcium hypochlorite?
4. 3/4 is the same as what percentage?
5. A 2% chlorine solution is what concentration in mg/L ?
6. A water plant produces 84,000 gallons per day. 7,560 gallons are used to backwash the filter. What percentage of water is used to backwash?
7. The average day winter demand of a community is 14,500 gallons. If the summer demand is estimated to be 72% greater than the winter, what is the estimated summer demand? Demand - When related to use, the amount of water used in a period of time. The term is in reference to the "demand" put onto the system to meet the need of customers.
8. The master meter for a system shows a monthly total of 700,000 gallons. Of the total water, 600,000 gallons were used for billing. Another 30,000 gallons were used for flushing. On top of that, 15,000 gallons were used in a fire episode and an estimated 20,000 gallons were lost to a main break that was repaired that same day. What is the total unaccounted for water loss percentage for the month?
9. Your water system takes 75 coliform tests per month. This month there were 6 positive samples. What is the percentage of samples which tested positive?

$$Time = \frac{Total\ \ volume\ \ to\ \ be\ \ pumped}{Pump\ \ flow\ \ rate}$$

$$\Longrightarrow \frac{(0.785 * 110^2 * 25)\cancel{ft^3} * \frac{7.48\cancel{gal}}{\cancel{ft^3}}}{\frac{1420\cancel{gal}}{min}} = \boxed{1,251\ \ min}$$

Practice Problems - Ratio and Proportion

1. It takes 6 gallons of chlorine solution to obtain a proper residual when the flow is 45,000 gpd. How many gallons will it take when the flow is 62,000 gpd?
2. A motor is rated at 41 amps average draw per leg at 30Hp. What is the actual Hp when the draw is 36 amps? C.
3. If it takes 2 operators 4.5 days to clean an aeration basin, how long will it take three operators to do the same job?
4. It takes 3 hours to clean 400 feet of collection system using a sewer ball. How long will it take to clean 250 feet?
5. It takes 14 cups of HTH to make a 12% solution, and each cup holds 300 grams. How many cups will it take to make a 5% solution?
6. A bike travelling at 5 miles/hr completes a journey in 40 minutes. How long would the same journey take if the speed was increased to 8 miles/hr?

Solution

1. The gallons chlorine and flow are directly related.

   Thus,
   $$\frac{6}{45,000} = \frac{X}{62,000} \implies X = \frac{6*62,000}{45,000} = 8.3\text{gallons}$$

2. The amp draw and Hp are directly related.

   This
   $$\frac{30}{41} = \frac{X}{36} \implies X = \frac{30*36}{41} = 26.3\text{Hp}$$

3. The number of operators and the days to clean are inversely related.

   Thus,
   $$2*4.5 = 3*X \implies X = \frac{2*4.5}{3} = 3\text{days}$$

4. The hours to clean and the length of system cleaned are directly proportional.

   Thus,
   $$\frac{3}{400} = \frac{X}{250} \implies X = \frac{3*250}{400} = 1.9\text{hours}$$

5. The cups of HTH and percentage HTH solution are directly proportional.

   Thus,
   $$\frac{14}{12} = \frac{X}{5} \implies X = \frac{14*5}{12} = 5.8\text{cups}$$

6. The bike speed and time to complete the journey are inversely related.

   Thus,
   $$5*40 = 8*X \implies X = \frac{5*40}{8} = 25\text{min}$$

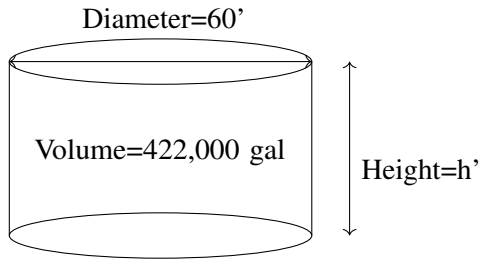
Practice Problems - Area and Volume

1. A 60-foot diameter tank contains 422,000 gallons of water. Calculate the height of water in the storage tank.
2. What is the volume of water in ft^3, of a sedimentation basin that is 22 feet long, and 15 feet wide, and filled to 10 feet?
3. What is the volume in ft^3 of an elevated clear well that is 17.5 feet in diameter, and filled to 14 feet?
4. What is the area of the top of a storage tank that is 75 feet in diameter?
5. What is the area of a wall 175ft. in length and 20ft. wide?
6. You are tasked with filling an area with rock near some of your equipment. 1 Bag of rock covers 250 square feet. The area that needs rock cover is 400 feet in length and 30 feet wide. How many bags do you need to purchase?
7. A circular clearwell is 150 feet in diameter and 40 feet tall. The Clearwell has an overflow at 35 feet. What is the maximum amount of water the clearwell can hold in Million gallons rounded to the nearest hundredth?

8. A sedimentation basin is 400 feet length, 50 feet in width, and 15 feet deep. What is the volume expressed in cubic feet?
9. A clearwell holds $314,000 ft^3$ of water. It is 100ft in diameter. What is the height of the clearwell?
10. A treatment plant operator must fill a clearwell with $10,000 ft^3$ of water in 90 minutes. What is the rate of flow expressed in GPM?
11. A water tank has a capacity of 6MG. It is currently half full. It will take 6 hours to fill. What is the flow rate of the pump?
12. A clearwell with the capacity of 2.5MG is being filled after a maintenance period. The flow rate is 2,500 GPM. The operator begins filling at 7 AM. At what time will the clearwell be full?
13. A chemical feed pump with a 6-inch bore and a 6-inch stroke pumps 60 cycles per minute. Find the pumping rate in gpm.
14. Determine the flow capacity of a pump in gpm if the pump lowers the water level in a 6 -foot square wet well by 8 inches in 5 minutes.
15. How much paint will it take for a single coat of the top and sidewalls of the storage tank that is 100-feet in diameter and 30-feet tall, if one gallon of paint covers 200 square feet?
    a. 86 gallons
    b. 96 gallons
    c. 106 gallons
    d. 116 gallons
    e. 126 gallons
16. Under like conditions, how much more water would an 8-inch pipe carry than a 4-inch pipe?
    a. 2 times
    b. 3 times
    c. 4 times
    d. not enough information given

Solution:

1. Volume = Surface area * height $\implies$ height $= \dfrac{\text{Volume}}{\text{Surface area}}$



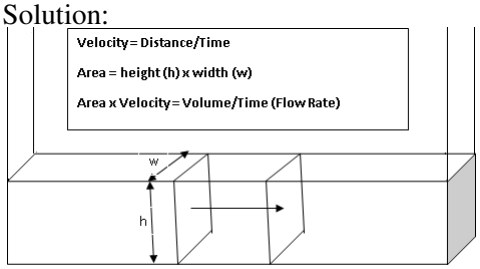
$$\implies \text{height} = \frac{422,000 \ \cancel{gal} * \frac{ft^3}{7.48 \ \cancel{gal}}}{0.785 * 60^2 \ \cancel{ft^2}} = \boxed{101 \ ft}$$

Practice Problems - Flow and Velocity

1. A rectangular channel 3 ft. wide contains water 2 ft. deep flowing at a velocity of 1.5 fps. What is the flow rate in cfs?
2. Flow in an 8-inch pipe is 500 gpm. What is the average velocity in ft/sec? (Assume pipe is flowing full)
3. A pipeline is 18" in diameter and flowing at a velocity of 125 ft. per minute. What is the flow in gallons per minute?
4. The velocity in a pipeline is 2 ft./sec. and the flow is 3,000 gpm. What is the diameter of the pipe in inches?
5. Find the flow in a 4-inch pipe when the velocity is 1.5 feet per second.
6. A 42-inch diameter pipe transfers 35 cubic feet of water per second. Find the velocity in ft/sec.
7. A plastic float is dropped into a channel and is found to travel 10 feet in 4.2 seconds. The channel is 2.4 feet wide and 1.8 feet deep. Calculate the flow rate of water in cfs.
8. The flow velocity of a 6-inch diameter pipe is twice that of a 12-inch diameter pipe if both are carrying 50 gpm of water. True or false?
9. What should the flow meter read in gpm if a 4-inch diameter main is to be flushed at a velocity of 4.6 fps?
10. The velocity through a channel is 4.18 fps. If the channel is 4 feet wide by 2 feet deep by 10 feet long, what is the flow rate in gpm?
11. What is the average flow velocity in ft/sec for a 12-inch diameter main carrying a daily flow of 2.5mgd ?

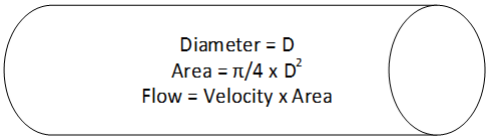
Solution:

1. Solution:



$$Q = V * A \implies Q = 1.5\frac{ft}{sec} * (3*2)ft^2 = \boxed{9\frac{ft^3}{sec}}$$

2. Solution:



$$Q = V * A$$

$$\Longrightarrow V = \frac{Q}{A} \Longrightarrow V\left(\frac{ft}{s}\right) = \frac{\frac{500 \cancel{gallon}}{\cancel{min}} * \frac{\cancel{ft^3}^{ft} * \frac{min}{60 sec}}{7.48 \cancel{gal}}}{0.785 * \left(\frac{8}{12}\right)^2 \cancel{ft^2}} = \boxed{3.2 ft/s}$$

3. Solution:

   The diameter of the pipe is 4 inches. Therefore, the radius is 2 inches. Convert the 2 inches to feet.

   $$\frac{2}{12} = 0.6667\text{ft}$$
   $$\text{A} = \pi \times \text{r}^2$$
   $$\text{A} = \pi \times (0.167\text{ft})^2$$
   $$\text{A} = \pi \times 0.028\text{ft}^2$$
   $$\text{A} = 0.09\text{ft}^2$$
   $$\text{Q} = \text{V} \times \text{A}$$
   $$\text{Q} = 1.5\text{ft/sec} \times 0.09\text{ft}^2$$
   $$\text{Q} = 0.14\text{ft/3sec(cfs)}$$

Practice Problems - Unit Conversions

Convert the following:

1. Convert 1000 ft^3 to cu. yards
2. Convert 10 gallons/min to ft^3/hr
3. Convert 100,000 ft^3 to acre-ft.
4. Find the flow in gpm when the total flow for the day is 65,000 gpd.
5. Find the flow in gpm when the flow is 1.3cfs.
6. Find the flow in gpm when the flow is 0.25cfs.
7. The flow rate through a filter is 4.25 MGD. What is this flow rate expressed as gpm?
8. After calibrating a chemical feed pump, you've determined that the maximum feed rate is 178 mL/ minute. If this pump ran continuously, how many gallons will it pump in a full day?
9. A plant produces 2,000 cubic foot of water per hour. How many gallons of water is produced in an 8-hour shift?

Solution

1. Solution:
   $1000 \cancel{ft^3} * \frac{cu.yards}{27 \cancel{ft^3}} = 37 cu.yards$
2. Solution:

$$\frac{10\ \cancel{\text{gallons}}}{\cancel{\text{min}}} * \frac{\text{ft}^3}{7.48\cancel{\text{gallons}}} * \frac{60\cancel{\text{min}}}{\text{hr}} = \frac{80.2\ \text{ft}^3}{\text{hr}}$$

3. Solution:

$$100,000\cancel{ft^3} * \frac{acre-ft}{43,560\cancel{ft^2-ft}} = 2.3acre-ft$$

Note: From the conversion table: acre = 43,560 ft^2
Thus, acre-ft = 43,560 ft^2-ft or 43,560 ft^3

4. Solution:

$$\frac{65,000\text{gpd}}{1,440\ \text{min/day}} = 45\text{gpm}$$

5. Solution:
$1.3\frac{\text{cfs}}{1}\text{x}\frac{448\text{gpm}}{1\text{cfs}} = 582\text{gpm}$

6. Solution:

$$0.25\frac{\text{cfs}}{1} \times \frac{448\text{gpm}}{1\text{cfs}} = 112\text{gpm}$$

7. Solution:

$$Flowrate, gpm = \frac{Flow\ \ rate,\ \ gpd}{1440\ \ min/day}$$

Note: We are assuming that the filter operated uniformly over that 24 hour period.

$$Flowrate, gpm = \frac{4.25\ \frac{\cancel{MG}}{\cancel{day}} * 1,000,000\ \frac{gal}{\cancel{MG}}}{1440\frac{min}{\cancel{day}}} = \boxed{2,951\ \ gpm}$$

8. Solution:

$$\frac{2000\ \cancel{\text{ft}^3}}{\cancel{hr}} * \frac{7.48\ \ \text{gallons}}{\cancel{\text{ft}^3}} * \frac{60\ \cancel{\text{hr}}}{\text{shift}} = \boxed{\frac{119,680\ \ \text{gallons}}{\text{shift}}}$$

Practice Problems - Concentration

1. What is the concentration in mg/l of 4.5% solution of that substance.
2. How many lbs of salt is needed to make 5 gallons of a 2,500mg/l solution

Solution

1. 45,000 mg/l
2. Applying pounds formula: lbs salt = $\frac{5}{1,000,000} * 2,500 * 8.34 = \boxed{0.14lbs}$

Practice Problems - Density and Specific Gravity

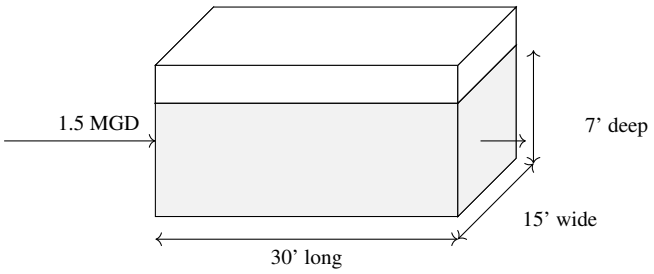
1. What is the specific gravity of a 1 ft^3 concrete block which weighs 145 lbs?
2. What is the specific gravity of a chlorine solution if 1 (one) gallon weighs 10.2lbs?
3. How much does each gallon of zinc orthophosphate weigh (pounds) if it has a specific gravity of 1.46?
4. How much does a 55 gallon drum of 25% caustic soda weigh (pounds) if the specific gravity is 1.28?

Practice Problems - Detention Time

1. A flocculation basin is 7 ft deep, 15 ft wide, and 30 ft long. If the flow through the basin is 1.35 MGD, what is the detention time in minutes?
2. A tank has a diameter of 60 feet with an overflow depth at 44 feet. The current water level is 16 feet. Water is flowing into the tank at a rate of 250 gallons per minute. At this rate, how many days will it take to fill the tank to the overflow?
3. How long will it take to fill a 50 gallon hypochlorite tank if the flow is 5gpm ?
4. Find the detention time in a 45,000 gallon reservoir if the flow rate is 85gpm.
5. If the fuel consumption to the boiler is 35 gallons per day. How many days will the 500 gallon tank last.
6. The sedimentation basin in a water plant contains 5,775 gallons. What is the detention time if the flow is 175gpm.

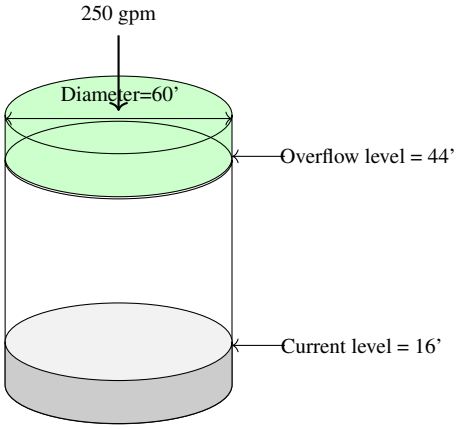
Solution

1. Solution:



$$\text{DT} = \frac{(30*15*7)\text{ft}^3 * 7.48\frac{gal}{ft^3}}{1,350,000\frac{\text{gal}}{day} * \frac{\text{day}}{1440\text{min}}} = 25\text{min}$$

2. Solution:



$$\text{Fill time} = \frac{Volume}{Flow} = \frac{0.785 * 60^2 * (44-16) ft^3 * \frac{7.48 gallons}{ft^3}}{250 \frac{gallons}{min} * \frac{1440\ min}{day}} = 1.6\ days$$

3. Solution:

$$\text{DT} = \frac{50\text{gal}}{5\text{gal/min}} = 10 \text{ min}$$

4. Solution:

$$\text{DT} = \frac{45,000\text{gal}}{85\text{gal/min}} = 529 \text{ min} \quad \text{or} \ \frac{529 \text{ min}}{60 \text{ min/hr}} = 8.8\text{hrs}$$

5. Solution:

$$\text{DT} = \frac{500 \text{ gal}}{35\text{gal/ day}} = 14.3 \text{ days}$$

6. Solution:

$$\text{DT} = \frac{5,775\text{gal}}{175\text{gal/min}} = 33 \text{ min}$$

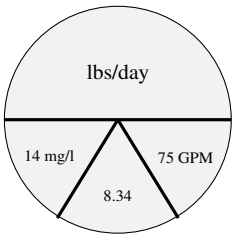
Practice Problems - Pounds Formula

1. 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?
2. 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?
3. 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?
4. A water treatment plant uses 8 pounds of chlorine daily and the dose is 17 mg/l. How many gallons are they producing?

5. 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?
6. A treatment plant has a maximum output of 30MGD and doses ferric chloride at 75 mg/L. How many pounds of Ferric Chloride does the plant use in a day?
7. A treatment plant uses 750 pounds of alum a day as it treats 15MGD. What was the dose rate?
8. A treatment plant operates at 1,500 gallons a minute and uses 500 pounds of alum a day. What is the alum dose?

Solution:

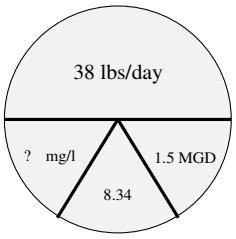
1. Solution:



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

$$\frac{\text{lbs}}{\text{day}} = 75\frac{\cancel{\text{gallons}}}{\cancel{\text{min}}} * 1440\frac{\cancel{\text{min}}}{\text{day}} * \frac{\text{MG}}{1,000,000\ \cancel{\text{gallons}}} * 250\frac{\text{mg}}{\text{l}} * 8.34 = \boxed{225\frac{lbs}{day}}$$

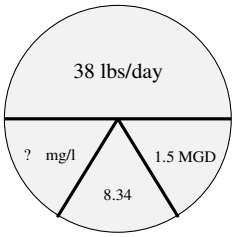
2. Solution:



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

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

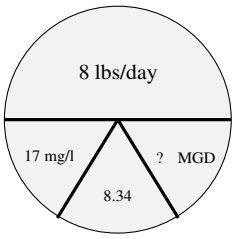
3. Solution:



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

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

4. Solution:



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

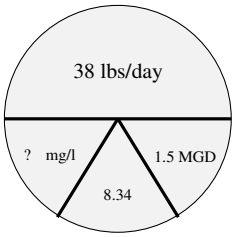
$$\implies \text{Flow}\frac{\text{MG}}{day} = \frac{\frac{\text{lbs}}{\text{day}}}{\text{Concentration}\frac{\text{mg}}{\text{l}} * 8.34} = \frac{8\frac{\text{lbs}}{\text{day}}}{17\frac{\text{mg}}{\text{l}} * 8.34} = 0.056425\frac{\text{MG}}{day}$$

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

5. Solution:

$$\text{lbs} = \text{Volume(MG)} * \text{Concentration}\frac{\text{mg}}{\text{l}} * 8.34$$

$$\implies \text{Concentration}\frac{\text{mg}}{\text{l}} = \frac{\text{lbs}}{\text{Volume(MG)} * 8.34} = \frac{40\ \text{lbs}}{80\ \text{gallons} * \frac{\text{MG}}{1{,}000{,}000\ \cancel{\text{gallons}}} * 8.34}$$



Practice Problems - Temperature Conversion

1. Convert 22°C into degree Fahrenheit.
2. Convert 56°C into degree Celsius.

Preliminary Treatment

1. On an average a 12.5 yd. load of grit is hauled to the landfill once every 20 days. Plant flow averages 12.5 MGD. Calculate the rate of grit collection in ft3/MG.
   Correct Answer(s):
   a. 1.4

2. A grit channel is 2 feet 4 inches wide. When wastewater is flowing 8 inches deep in this channel, the velocity is found to be 1.6 ft per second. Calculate flow in MGD.
   a. 1.55 MGD
   *b. 1.60 MGD
   c. 1.90 MGD
   d. 2.50 MGD

3. A grit channel is 2 feet 4 inches wide. When wastewater is flowing 8 inches deep in this channel, the velocity is found to be 1.6 ft per second. Calculate flow in MGD.
   a. 1.55 MGD
   *b. 1.60 MGD
   c. 1.90 MGD
   d. 2.50 MGD

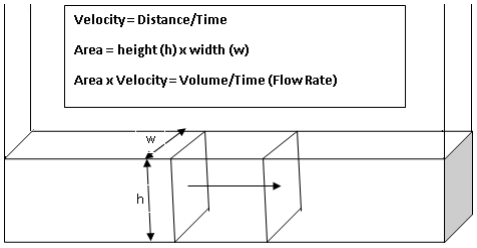
4. At a wastewater treatment plant which receives a flow rate of 650,000 gallons per day, a total of 50 cubic feet of grit was removed for the month. Calculate the rate of grit removal assuming 30 days in a month.
   Solution:
   $$GritRemoval\,\frac{ft^3}{MG} = 50\frac{ft^3}{\cancel{month}} * \frac{\cancel{month}}{30\cancel{days}} * \frac{\cancel{day}}{650{,}000\cancel{gal}} * 1{,}000{,}000\frac{\cancel{gal}}{MG} = \boxed{2.6\frac{ft^3}{MG}}$$

5. On an average a 12.5 yd. load of grit is hauled to the landfill once every 20 days. Plant flow averages 12.5 MGD. Calculate the rate of grit collection in ft^3/MG.
   Solution:
   $GritRemoval\left(\frac{ft^3}{MG}\right) = \frac{12.5\cancel{yd^3}}{20\cancel{days}} * \frac{27ft^3}{\cancel{yd^3}} * \frac{\cancel{day}}{12.5MG} = \boxed{1.4\frac{ft^3}{MG}}$

6. On an average, 2 inches of grit is collected and removed every day in a 2.2 feet wide, 205 feet long grit channel. Knowing the average flow through that grit channel is 10 MGD calculate the rate of grit collection in ft^3/MG
   Solution:
   Grit volume accumulated: $\frac{2}{12}ft * (2.2 * 205)ft^2 = \frac{75.16ft^3}{day}$ Grit Collection: $\frac{\frac{75.16ft^3}{\cancel{day}}}{\frac{10MG}{\cancel{day}}} =$
   $\boxed{7.5\frac{ft^3}{MG}}$

7. What is the grit production rate (cu. ft/MG) if 46 cu. ft of grit is removed every five days and the daily plant flow averages 2 MGD.
   a. 12 cu. ft/MG
   b. 23 cu. ft/MG
   *c. 4.6 cu. ft/MG
   d. 9.2 cu. ft/MG
   Solution:
   $Grit\ \ Production\ \ Rate\left(\frac{ft^3}{MG}\right) = \frac{46\cancel{ft^3}}{5\ \cancel{days}} * \frac{\cancel{day}}{2MG} = \boxed{4.6\frac{ft^3}{MG}}$

8. A grit chamber is 2 feet 4 inches wide. When wastewater is flowing 8 inches deep in this channel, the flow velocity is found to be 1.6 ft per second. Calculate flow in MGD.
   Solution:



   $Q = V * A$
   $Q = 1.6\frac{ft}{s} * \left(\frac{28}{12} * \frac{8}{12}\right)ft^2 = 2.49\frac{ft^3}{s}$
   $Q = 2.49\frac{\cancel{ft^3}}{\cancel{s}} * \frac{(1440 * 60)\cancel{s}}{day} * 7.48\frac{\cancel{gal}}{\cancel{ft^3}}\frac{MG}{\cancel{gal}} = \boxed{1.61MGD}$

9. A steel bin is used to collect the daily accumulation of grit for disposal in a land fill. The bin is 8 ft long, 5.25 ft. wide, and 6 feet deep. When the bin is three-quarters full it is hauled away. This occurs on the average every 10 days. Average flow to the plant is

3.75 MGD. What is the rate of grit collection in units of cubic feet per MG of flow?
Correct Answer(s):
a. 4.9

10. A flow controlled grit chamber has two channels which are each 2.5 feet wide, and 20 feet long. Only one of these channels is currently in service and it receiving a flow of 4.5 MGD. The wastewater is flowing 1.5 feet deep in this channel. Calculate the velocity of this flow. Should we put the other channel in service?
    Correct Answer(s):

11. Calculate the flow, in gpd, that would pass through a grit chamber 2 feet wide, at a depth of 6 inches, with a velocity of 1 ft /sec.
    Correct Answer(s):
    a. 646272.0

Primary Treatment

1. A clarifier has a TSS removal efficiency of 50%. If the influent TSS concentration is 220 mg/l, how many lbs/day of TSS are removed if the flow is 10 MGD. Also, how many cu. ft of sludge is pumped if the sludge has a TS concentration of 5%.
   $lbs\ \ solids\ \ removed = (220 * 0.50) mg/l * 10 MGD * 8.34 = 9,174 lbs\ \ solids\ \ per\ \ day$

   $$\frac{ft^3\ \ sludge}{day} = \frac{9,174\ \ \cancel{lbs\ \ solids}}{day} * \frac{1\ \ \cancel{lb\ \ sludge}}{0.05\ \ \cancel{lbs\ \ solids}} * \frac{\cancel{gal\ \ sludge}}{8.34 \cancel{lb\ \ sludge}} * \frac{ft^3\ \ sludge}{7.48\ \ \cancel{gal}} = \boxed{2,941 \frac{ft^3\ \ sludge}{day}}$$

2. A community has a total flow of 15 MGD which is passed through a primary treatment plant which removes 60% of the TSS and 35% of the BOD. The average strength of the influent is 400 mg/l TSS and 275 mg/l BOD. If the total solids of the raw sludge is 5%, how many cu. ft of sludge is pumped daily? $lbs\ \ solids\ \ removed = (400 * 0.60) mg/l * 15 MGD * 8.34 = 30,024 lbs\ \ solids\ \ per\ \ day$

   $$\frac{ft^3\ \ sludge}{day} = \frac{30,924\ \ \cancel{lbs\ \ solids}}{day} * \frac{1\ \ \cancel{lb\ \ sludge}}{0.05\ \ \cancel{lbs\ \ solids}} * \frac{\cancel{gal\ \ sludge}}{8.34 \cancel{lb\ \ sludge}} * \frac{ft^3\ \ sludge}{7.48\ \ \cancel{gal}} = \boxed{9,626 \frac{ft^3\ \ sludge}{day}}$$

3. How many lbs of solids are removed daily by a primary clarifier treating a 6 MGD flow if the average influent TSS concentration is 300 mg/l and the clarifier TSS removal efficiency is 67%?
   As the removal efficiency is 67%, 0.67 * 300 mg/l = 201 mg/l solids are removed.
   The total lbs removed can be calculated using the lbs formula.
   $\frac{lbs\ \ solids}{day} = 6 MGD * 201 \frac{mg\ \ SS}{l} * 8.34 = \boxed{10,058 \frac{lbs\ \ solids}{day}}$
4. Calculate the primary clarifier influent solids concentration if its outlet concentration is 60 mg/l and the known clarifier removal efficiency is 75%?

$\frac{Actual\ \ inlet\ \ (X)}{Actual\ \ outlet} = \frac{100}{100-Removal\ \ efficiency}$

$\frac{Actual\ \ inlet\ \ (X)}{60} = \frac{100}{100-75} = 4$

$\Longrightarrow Actual\ \ inlet\ \ (X) = 4*60 = \boxed{240mg/l}$

5. A circular clarifier receives a flow of 11 MGD. If the clarifier is 90 ft. in diameter and is 12 ft. deep, what is: a) the hydraulic/surface loading rate, b) weir overflow rate, and c) clarifier detention time in hours?

   Solution:

   a) Hydraulic/surface loading rate:

   $Clarifier\ \ hydraulic\ \ loading\ \ \left(\frac{gpd}{ft^2}\right) == \frac{\frac{11\cancel{MG}}{day}*\frac{10^6 gal}{\cancel{MG}}}{0.785*90^2 ft^2} = \boxed{1,730gpd/ft^2}$

   b) Weir overflow rate:

   $Weir\ \ overflow\ \ rate\left(\frac{gpd}{ft}\right) = \frac{\frac{11\cancel{MG}}{day}*\frac{10^6 gal}{\cancel{MG}}}{3.14*90ft} = \boxed{38,924gpd/ft}$

   c) Clarifier detention time:

   $Clarifier\ \ detention\ \ time\ \ (hr) = \frac{Clarifier\ \ volume(cu.ft\ \ or\ \ gal)}{Influent\ \ flow\ \ (cu.ft\ \ or\ \ gal)/hr)}$

   $Clarifier\ \ detention\ \ time\ \ (hr) = \frac{(0.785*90^2*15)\cancel{ft^3}}{\frac{11\cancel{MG}}{\cancel{day}}*\frac{10^6\cancel{gal}}{\cancel{MG}}*\frac{\cancel{ft^3}}{7.48\cancel{gal}}*\frac{\cancel{day}}{24hrs}} = \boxed{2hrs}$

6. A clarifier has a TSS removal efficiency of 50%. If the influent TSS concentration is 220 mg/l, how many lbs/day of TSS are removed if the flow is 10 MGD. Also, how many cu. ft of sludge is pumped if the sludge has a TS concentration of 5%.

   Solution:

   $lbs\ \ solids\ \ removed = (220*0.50)mg/l*10MGD*8.34 = 9,174lbs\ \ solids\ \ per\ \ day$

   $\frac{ft^3\ \ sludge}{day} = \frac{9,174\ \ \cancel{lbs\ \ solids}}{day}*\frac{1\ \ \cancel{lb\ \ sludge}}{0.05\ \ \cancel{lbs\ \ solids}}*\frac{\cancel{gal\ \ sludge}}{8.34\cancel{lb\ \ sludge}}*\frac{ft^3\ \ sludge}{7.48\ \ \cancel{gal}} = \boxed{2,941\frac{ft^3\ \ sludge}{day}}$

7. If a clarifier has a capacity of 0.25 MG, what is the detention time in hours if it receives a flow of 3 MGD

   Solution:

   $Clarifier\ \ detention\ \ time\ \ (hr) = \frac{Clarifier\ \ volume(MG)}{Influent\ \ flow\ \ (MG/hr)}$

   $Clarifier\ \ detention\ \ time\ \ (hr) = \frac{0.25\cancel{MG}}{\frac{3\cancel{MG}}{\cancel{day}}*\frac{\cancel{day}}{24hrs}} = \boxed{2hrs}$

8. If a clarifier has a capacity of 0.25 MG, what is the detention time in hours if it receives a flow of 3 MGD

   Solution:

   $Clarifier\ \ detention\ \ time\ \ (hr) = \frac{Clarifier\ \ volume(MG)}{Influent\ \ flow\ \ (MG/hr)}$

   $Clarifier\ \ detention\ \ time\ \ (hr) = \frac{0.25\cancel{MG}}{\frac{3\cancel{MG}}{\cancel{day}}*\frac{\cancel{day}}{24hrs}} = \boxed{2hrs}$

9. At a 2.5 MGD wastewater treatment plant the primary clarifier has a detention time of 2 hours. How many gallons does this clarifier hold?

   Solution:

$$Clarifier\ \ detention\ \ time\ \ (hr) = \frac{Clarifier\ \ volume(gal)}{Influent\ \ \ flow\ \ (gal/hr)}$$

$$\Longrightarrow Clarifier\ \ volume(gal) = Clarifier\ \ detention\ \ time\ \ (hr) * Influent\ \ flow\ \ (gal/hr)$$

$$\Longrightarrow Clarifier\ \ volume(gal) = \Big(2\ \ hrs\Big) * \Big(2.5 * 10^6\ \ \tfrac{gal}{day} * \tfrac{day}{24\ \ hrs}\Big) = \boxed{208,333\ \ gals}$$

10. What is the surface loading rate (gal/(day-sq.ft) of a 15 MGD flow in a 105 ft diameter primary sedimentation tank operating at water depth of 20 ft.

    Solution:

    $$Clarifier\ \ hydraulic\ \ loading\ \ \Big(\frac{gpd}{ft^2}\Big) = \frac{\frac{15\cancel{MG}}{day} * \frac{10^6 gal}{\cancel{MG}}}{0.785 * 105^2 ft^2} = \boxed{1,733 gpd/ft^2}$$

11. If a 90 ft diameter primary clarifier operating at water depth of 20 ft is treating a 12MGD flow, calculate the surface loading rate (gal/(day-sq.ft).

    Solution:

    $$Clarifier\ \ hydraulic\ \ loading\ \ \Big(\frac{gpd}{ft^2}\Big) = \frac{\frac{12\cancel{MG}}{day} * \frac{10^6 gal}{\cancel{MG}}}{0.785 * 90^2 ft^2} = \boxed{1,887 gpd/ft^2}$$

12. What is the weir overflow rate (gpd/ft) when treating a 15 MGD flow in a 105 ft diameter primary sedimentation tank operating at water depth of 20 ft.

    Solution:

    $$Clarifier\ \ detention\ \ time\ \ (hr) = \frac{(0.785 * 105^2 * 20)\cancel{ft^3}}{\frac{15\cancel{MG}}{\cancel{day}} * \frac{10^6 \cancel{gal}}{\cancel{MG}} * \frac{\cancel{ft^3}}{7.48\cancel{gal}} * \frac{\cancel{day}}{24hrs}} = \boxed{2.1hrs}$$

13. A circular clarifier receives a flow of 3.2 MGD. If the diameter is 70 ft, what is the weir overflow rate?

    Solution:

    $$Weir\ \ overflow\ \ rate\Big(\frac{gpd}{ft}\Big) = \frac{\frac{3.2\cancel{MG}}{day} * \frac{10^6 gal}{\cancel{MG}}}{3.14 * 70 ft} = \boxed{14,559 gpd/ft}$$

14. How many lbs/day of solids are removed in a clarifier treating a 6 MGD flow if the average inlet concentration is 320 mg/l and its average outlet concentration is 80 mg/l

    Solution:

    Applying pounds formula:

    $$\tfrac{lbs\ \ solids\ \ removed}{day} = 6MGD * (320 - 80)\tfrac{mg}{l} * 8.34 = \boxed{120,096 \frac{lbs\ \ solids}{day}}$$

15. At a 2.5 MGD wastewater treatment plant the primary clarifier has a detention time of 2 hours. How many gallons does this clarifier hold?
16. What is the detention time (hrs) in a 105' diameter primary sedimentation tank operating at water depth of 20' when treating a 15 MGD flow (Ans: 2.1)
17. What is the surface loading rate (gal/(day-sq.ft) of a 15 MGD flow in a 105 ft diameter primary sedimentation tank operating at water depth of 20 ft. (Ans: 1,733)

18. What is the weir overflow rate (gpd/ft) when treating a 15 MGD flow in a 105 ft diameter primary sedimentation tank operating at water depth of 20 ft. (Ans: 45,496)
19. A circular clarifier receives a flow of 3.2 MGD. If the diameter is 70 ft, what is the weir overflow rate? (Ans: 14,559)
20. A clarifier has an influent suspended solids concentration of 420 mg/l. If the suspended solids efficiency is 62%, how many mg/l suspended solids are removed? (Ans: 260)
21. Given the following for a primary sedimentation tank:
    TSS removal efficiency = 63%
    Effluent TSS concentration = 95 mg/l
    Calculate the influent TSS concentration (mg/l)
    (Ans: 257)
22. What is the clarifier influent TSS if its outlet concentration is 60 mg/l and the known clarifier removal efficiency is 75%?
    *a. 240 mg/l
    b. 300 mg/l
    c. 80 mg/l
    d. 120 mg/l
23. What is the clarifier removal efficiency if the inlet and outlet concentrations are 300 mg/l and 60 mg/l respectively?
    a. 20%
    b. 30%
    *c. 80%
    d. 72%
24. A rectangular sedimentation tank is 85 feet long, 35 feet wide, and 14 feet deep including 3 feet of freeboard. Flow to this tank is 2.3 MGD. Calculate the surface loading to this tank in gpd per ft2.
    a. 318 gpd/ft2
    *b. 773 gpd/ft2
    c. 845 gpd/ft2
    d. 1932 gpd/ft2
25. What is the detention time in a 40 ft diameter primary clarifier operating with a 12 ft water depth, when treating a 1.5 MGD flow?
    a. 0.24 hours
    b. 0.60 hours
    *c. 1.8 hours
    d. 2.3 hours
    e. 11.0 hours
26. How many lbs/day of solids are removed in a clarifier treating a 6 MGD flow if the average inlet concentration is 320 mg/l and its average outlet concentration is 80 mg/l
    a. 16,000 lbs/day

*b. 1,210 lbs/day
c. 4,000 lbs/day
d. 9,000 lbs/day

27. At a 5 MGD wastewater flow, a primary clarifier has a detention time of 1 hour. How many gallons does this clarifier hold?
    a. 104,000 gallons
    *b. 208,000 gallons
    c. 250,000 gallons
    d. 500,000 gallons
    e. 5,000,000 gallons
28. Percent efficiency of total solids or BOD removal is calculated using the following formula: (In-Out*100)/(In-(In*Out))
    a. True
    *b. False
29. The only function of flights in a rectangular sedimentation tank is to push the settled sludge towards the hopper
    a. True
    *b. False
30. A settling basin has a length of 60 ft., width of 20 ft., and depth of 12 ft. At a flow rate of 60 mgd, what is the retention time of this basin?
    a. 15 minutes.
    b. 30 minutes.
    *c. 1.1 hours.
    d. 2.3 hours.
31. Calculate the detention time for a sedimentation tank that is 48 feet wide, 210 feet long and 9 feet deep with a flow of 5 MGD.
    *a. 3.25 hours.
    b. 3.63 hours.
    c. 5.65 hours.
    d. 5.82 hours.
32. Calculate the weir loading for a sedimentation tank that has an outlet weir 480 ft. long and a flow of 5 MGD.
    a. 9220 gpd/ft.
    b. 9600 gpd/ft.
    c. 9920 gpd/ft.
    *d. 10,420 gpd/ft.
33. If a primary clarifier consistently operates at 30 % efficiency and produces an effluent which averages 140 mg/l BOD, what is the influent BOD?
    a. 100 mg/l
    b. 125 mg/l

c. 175 mg/l

*d. 200 mg/l

e. 225 mg/l

34. At a 2.5 MGD wastewater treatment plant the primary clarifier has a detention time of 2 hours. How many gallons does this clarifier hold?

a. 104,000 gallons

*b. 208,000 gallons

c. 250,000 gallons

d. 500,000 gallons

e. 5,000,000 gallons

35. A 3.1 MGD flow with a 190 mg/l TSS concentration is treated in a primary clarifier which averages 55% removal efficiency. Calculate the pounds/day TSS in the primary effluent.

a. 2445 lbs/day

*b. 2211 lbs/day

c. 3800 lbs/day

d. 4200 lbs/day

36. A 75 ft long, 25 ft wide and 10 ft deep sedimentation basin receives a flow of 1.6 MGD. What is the detention time in hours.

a. 7 hrs

b. 1.7 hrs

*c. 2.1 hrs

d. 4 hrs

37. A sludge pump is set to pump 5 minutes each hour. It pumps at the rate of 35 gpm. How many gallons of sludge are pumped each day?

a. 120 gpd

b. 175 gpd

c. 840 gpd

*d. 4200 gpd

38. A primary clarifier has an influent suspended solids concentration of 250 mg/l. If the suspended solids removal efficiency is 60%, what is the primary effluent suspended solids concentration

a. 10 mg/l

*b. 100 mg/l

c. 50 mg/l

d. 150 mg/L

39. A treatment plant receives a flow of 3.5 MGD. If the clarifier is 100 ft. long, 30 ft. wide, and 15 ft. deep, what is the surface loading rate?

a. 78 gal/ft/day

b. 700 gal/ft/day

*c. 1,170 gal/ft/day

d. 1,500 gal/ft/day

e. 4,500 gal/ft /day

40. A settling basin has a length of 60 ft, width of 20 ft, and depth of 12 ft At a flow rate of 60 MGD, what is the detention time of this basin?

    a. 15 minutes

    b. 30 minutes

    *c. 1.1 hours

    d. 2.3 hours

41. If a clarifier has a capacity of 0.25 MG, what is the detention time in hours if it receives a flow of 3 MGD

    a. 1.8 hrs

    *b. 2.0 hrs

    c. 2.25 hrs

    d. 2.50 hrs

    e. 3.00

Solution:

$$Clarifier\ \ detention\ \ time\ \ (hr) = \frac{Clarifier\ \ volume(gal)}{Influent\ \ \ flow\ \ (gal/hr)}$$

$$\Longrightarrow Clarifier\ \ volume(gal) = Clarifier\ \ detention\ \ time\ \ (hr) * Influent\ \ \ flow\ \ (gal/hr)$$

$$\Longrightarrow Clarifier\ \ volume(gal) = 2hrs * 2,500,000 \frac{gal}{day} * \frac{day}{24\ \ hrs} = \boxed{208,333gal}$$

Trickling Filter

1. The influent to a trickling filter plant is 200 mg/l and the effluent BOD is 20 mg/l. What is the BOD removal efficiency (
2. The flow to a trickling filter is 1.33 MGD. If the primary effluent has a BOD concentration of231 mg/land the trickling filter effluent has a BOD concentration of 83 mg/l, how many pounds of BOD are removed? (Ans: 1642 lbs/day)
3. A 80-ft diameter trickling filter with a media depth of 7 ft receives a flow of 2,180,000 gpd. If the BOD concentration of the primary effluent is 139 mg/l, what is the organic loading on the trickling filter in lbs BOD/day/1000 cu ft? (Ans: 72 lbs/day-1000 ft3)
4. A standard-rate filter, 90 ft in diameter, treats a primary effluent flow of 540,000 gpd. If the recirculated flow to the trickling filter is 120,000 gpd, what is the hydraulic loading rate on the filter in gpd/sq ft? (Ans: 104)
5. A 90 feet diameter trickling filter treats a 540,000 gpd primary effluent flow. If the recirculated flow to the trickling filter is 120,000 gpd, what is the hydraulic loading on the trickling filter in gpd/ft2.

    *a. 104 gpd/ft2

    b. 2 gpd/ft2

c. 3 gpd/ft2
d. 4 gpd/ft2

6. A trickling filter plant operating at a recirculation ratio of 1 receives a raw wastewater flow of 2 MGD. This means that the flow being applied to the filter would be:
*a. 4mgd.
b. 1mgd
c. 3mgd
d. 2mgd
e. 6mgd
7. What is the hydraulic loading of a trickling filter with a 100-foot diameter, if it receives a flow of 4.0 MGD?
a. 480 GPD/ft2
*b. 510 GPD/ft2
c. 540 GPD/ft2
d. 570 GPD/ft2
e. 600 GPD/ft2
8. A 12 MGD primary clarifier effluent flow is fed to a trickling filter. If the total flow to the trickling filter including the recirculated flow is 17 MGD, what is the recirculation ratio? (Ans: 0.42)
9. A trickling filter 100 ft. in diameter and 6 ft. deep receives a flow of 0.5 mgd with a BOD of 150 mg/l. What is the BOD loading in pounds per day per 1000 cubic feet of filter media?
a. 11.9.
*b. 13.3.
c. 26.8.
d. 133.
10. Calculate the organic load in lbs of BOD/day/1000 cu. ft. for a trickling filter 50 ft in diameter and eight (8) ft deep. Given a flow of 250,000 gpd, and a 150 mg/l BOD concentration of the primary effluent feed to the trickling filter.
a. 2 lbs/day/1000 cu. ft.
b. 5 lbs/day/1000 cu. ft.
*c. 20 lbs/day/1000 cu. ft.
d. 50 Ibs/day/1000 cu. ft.
11. Calculate the pounds of BOD per day entering the trickling filter.
DATA: Raw wastewater flow is 1.5 MGD.
Raw wastewater BOD is 150 mg/l.
There is a 30*a. 1600 lbs/day
b. 880 lbs/day
c. 870 lbs/day
d. 560 lbs/day

12. A trickling filter wastewater treatment plant receives a flow 1.95 MGD. Calculate the organic loading to this plant if it has a 135 ft diameter trickling filter with a 5 foot media depth and has a primary effluent BOD concentration of 110 mg/l.
    a. 0.5 lbs BOD/1,000 ft³/day.
    b. 2.7 lbs BOD/1,000 ft³/day.
    *c. 25 lbs BOD/1,000 ft³/day.
    d. 39 lbs BOD/1,000 ft³/day.
    e. 44 lbs BOD/1,000 ft³/day.
13. At a 2.1 MGD wastewater treatment plant the influent suspended solids concentration to the primary clarifier is 240 mg/l. The primary sludge contains 3.2gallons of primary sludge should be pumped per day?
    a. 63,000 gal/day ·
    b. 32,200 gal/day
    c. 8,200 gal/day
    *d. 7,550 gal/day
14. Calculate the pounds of BOD per day entering the trickling filter
    DATA:
    Raw wastewater flow is 15 MGD
    Raw wastewater BOD is 150 mg/l
    There is a 30
    a. 560 lbs/day
    b. 870 1 bs/ day
    c. 880 1 bs /day
    *d. 1600 lbs/day
15. Calculate the organic load in lbs of BOD/day/1000 cu ft for a trickling filter 50 ft in diameter and 8 feet deep, a BOD design loading of 50 lbs/day/1000 cu ft, a flow of 250,000 gpd, and a primary effluent BOD to filter of 150 mg/l
    a. 2 lbs/day/1000 cu ft
    b. 5 lbs/day/1000 cu ft
    *c. 20 lbs/day/1000 cu ft
    d. 50 lbs/day/1000 cu ft
16. What is the trickling filter hydraulic loading if the influent flow is 3 MGD and the recirculation rate is 4:1?
    a. 3 mgd
    b. 6mgd
    c. 9mgd
    d. 12mgd
    *e. 15 mgd
    f. None of the above
17. Calculate the organic load in lbs of BOD/day/1000 cu. ft. for a trickling filter 50 ft in diam-

eter and eight (8) ft deep. Given a flow of 250,000 gpd, and a 150 mg/l BOD concentration of the primary effluent feed to the trickling filter.

a. 2 lbs/day/1000 cu. ft.

b. 5 lbs/day/1000 cu. ft.

*c. 20 lbs/day/1000 cu. ft.

d. 50 Ibs/day/1000 cu. ft.

18. The desired trickling filter recirculation ratio is 1.4. If the primary effluent flow is 4.4 MGD what is the trickling filter effluent flow that needs to be recirculated. (Ans: 6.2)

Stabilization Ponds

1. A 40 acre pond receives a 0.6 MGD flow. If the pond is operated at a depth of 4ft, what is the detention time (days) of this pond. (Ans: 87)
2. The flow to a pond is 750 gpm. The pond width is 200 ft and length is 450 ft. If the BOD in the pond influent is 240mg/l, what is the organic loading to this pond in lbs-BOD/day/acre? (Ans: 1046)
3. Calculate the depth the liquid level must be lowered in the fall below the normal 3-foot depth to prepare for winter and provide 180 day storage. DATA: Wastewater stabilization ponds total area of 13.8 acres (600,000 sq. ft.) Average winter wastewater flow to the ponds is 100,000 gpd. Maximum liquid storage depth is 5 feet. (Assume no loss of liquid by percolation or evaporation and that the ponds will fill to the maximum storage level of 5 feet.)

   a. 0.1 ft.

   b. 1.0 ft.

   *c. 2.0 ft.

   d. 4.0 ft.
4. Compute the lagoon's detention time (days) DATA: Surface area= 6.0 acres Average depth= 3.0 feet Average evaporation exceeds precipitation by 0.4 in/day Average daily flow (influent)= 0.25 MGD 1 acre (area)= 43,560 sq ft 1 cu ft contains 7.5 gal

   a. 24

   *b. 32

   c. 37

   d. None of the above
5. A pond is 600 ft. long and 150 ft. wide. If the pond is 6 ft. deep, what is the volume in acre ft? (Ans: 13.9)
6. A wastewater pond has a detention time of 30 days and is operated at a pond depth of 4 ft. What is the hydraulic loading on the pond?

   a. 7.5 in/day

   *b. 1.6 in/day

c. 0.63 in/day

d. 0.41 in.day

e. 013 in/day

7. The volume of an aerated pond is 700,000 cubic feet. Flow to the pond averages .050 MGD. How many days detention time does the pond provide?

   a. 10.5 days.

   b. 14 days.

   *c. 105 days.

   d. 140 days.

8. Assume a community of 1,100 people has a lagoon. The flow averages 80,000 gallons per day. The flow is

   a. 14 gallons per capita.

   *b. 72 gallons per capita.

   c. 80 gallons per capita.

   d. 140 gallons per capita.

9. What is the organic loading on a lagoon (lbs./day/acre) if the influent BOD averages 164 mg/l and the flow averages 0.67 MGD. The lagoon has two (2) identical square cells with each side of 800 ft.

   a. 29 lbs./ac.

   b. 23 lbs./ac.

   *c. 31 lbs./ac.

   d. 52 lbs./ac.

10. A stabilization pond is 1100 ft. long, 600 ft wide, and is operated at a depth of 5 ft. It receives a flow of 500,000 gpd and which has an influent BOD of 185mg/l. Using this information do the following:

    (a) Convert the flow to the pond in units of acre-ft/day **(Ans. 1.53 acre-ft/day)**

    (b) Find the area of this pond in units of acres. **(Ans. 540,000 ft3 and 13.9 acre-ft)(Ans. 15.2 acres)**

    (c) Find the volume of pond in units of acre-feet. **(Ans. 75.8 acre-ft)**

    (d) Calculate the pond detention time in days. **(Ans. 44.9)**

    (e) Calculate the hydraulic loading to the pond in units of inches per day. **(Ans. 1.2 in/day)**

    (f) Calculate the organic loading to the pond (lbs of BOD/day/acre) **(Ans. 50.8 lbs BOD/day-acre)**

    Solution:

    (a) $\frac{500,000gal}{day} * \frac{ft^3}{7.48gal} * \frac{acre-ft}{43,560ft^3} = \boxed{1.53\frac{acre-ft}{day}}$

    (b) $(1,100*600)ft^2 * \frac{acres}{43,560ft^2} = \boxed{15.2acres}$

    (c) $(1,100*600*5)ft^3 * \frac{acres-ft}{43,560ft^3} = \boxed{75.8acre-ft}$

(d) $DT = \frac{volume}{flow} = (1,100*600*5)ft^3 * \frac{1}{500,000\frac{gal}{day}} \frac{7.48gal}{ft^3} = \boxed{49.4days}$

(e) $Pond\ hydraulic\ loading\ rate\left[\frac{in}{day}\right] = \frac{Pond\ depth\ (in)}{Pond\ detention\ time\ \frac{Volume}{Flow}} = \frac{5*12in}{49.4} = \boxed{1.2\frac{in}{day}}$

(f) $Organic\ loading = \frac{lbs\ BOD\ per\ day}{area\ (acres)}$

$\Longrightarrow \frac{0.5MGD\ *\ 185mg/l\ *\ 8.34}{1,100*600ft^2} * \frac{43,560ft^2}{acre} = \boxed{\frac{50.9lbs\ BOD}{day-acre}}$

11. What is the surface area of a pond that is 4 feet deep, if it holds 30 million gallons?

Solution:

$Pond\ Volume = Surface\ Area * Depth \Longrightarrow 30MG = Surface\ Area * 4ft$

$\Longrightarrow Surface\ Area\ (acres) = \frac{30MG * 3.069\frac{acre-ft}{MG}}{4ft} = \boxed{23\ acre}$

12. The influent flow to a pond is 10,000 gallons/hour with a suspended solids concentration of 142mg/l in the raw wastewater. How many lbs of suspended solids are sent to the pond daily?

Solution:

$\frac{lbsSS}{day} = 10000\frac{gal}{hr} * \frac{24hrs}{day} * \frac{MG}{1000000gal} * 142\frac{mg}{l} * 8.34 = \boxed{284\frac{lbs\ SS}{day}}$

13. A pond is 260 ft. long and 80 ft. wide. What is the area of this pond in acres?

Solution:

$(260*80)ft^2 * \frac{acre}{43,560ft^2} = \boxed{0.48acre}$

14. A pond has a volume of 1,800,000 ft^3. If the flow to the pond is 425 gpm, what is the pond detention time in days?

Solution:

$DT = \frac{volume}{flow} = 1,800,000ft^3 * \frac{1}{425\frac{gal}{min}} * \frac{day}{1440min} * \frac{7.48gal}{ft^3} = \boxed{22days}$

15. Find pond hydraulic loading in inches/day when the depth of the pond is 6 ft. and the detention time is 30 days.

Solution:

$Hydraulic\ Loading\ (HL) = \frac{flow}{area}$

$Detention\ time\ (DT) = \frac{vol}{flow} \Longrightarrow flow = \frac{vol}{DT}$

Substituting for flow in the HL formula above:

$HL = \frac{\frac{vol}{DT}}{area}\ or\ \frac{vol}{area*DT} \Longrightarrow \boxed{HL = \frac{pond\ depth}{DT}}\ as\ \frac{vol}{area} = pond\ depth$

$Pond\ hydraulic\ loading\ rate = \frac{Pond\ depth\ (in)}{Pond\ detention\ time\ \frac{Volume}{Flow}} = \frac{6*12\ inches}{30\ days} = \boxed{\frac{2.4in}{day}}$

16. The flow to a pond is 7.2MGD. If the pond diameter is 350 ft and the BOD in the pond influent is 170mg/l, what is the organic loading to this pond in lbs BOD/day/acre?
    Solution:
    $$Organic\ \ loading = \frac{lbs\ \ BOD\ \ per\ \ day}{area\ \ (acres)} = \frac{7.2MGD\ *\ 170mg/l\ *\ 8.34}{0.785*350^2 ft^2} * \frac{43,560 ft^2}{acre} = \boxed{\frac{4,624 lbs\ \ BOD}{day - acre}}$$
17. The flow to a pond is 750,000 gpd. If the pond diameter is 100 ft and the BOD in the pond influent is 300 mg/l, what is the organic loading to this pond in lbs BOD/day/acre? **(Ans. 10,412 lbs BOD/day-acre)**
    Solution:
    $$Organic\ \ loading = \frac{lbs\ \ BOD\ \ per\ \ day}{area\ \ (acres)} = \frac{0.75MGD\ *\ 300mg/l\ *\ 8.34}{0.785*100^2 ft^2} * \frac{43,560 ft^2}{acre} = \boxed{\frac{10,413 lbs\ \ BOD}{day - acre}}$$
18. A 40 acre wastewater treatment pond receives a flow of 0.6 MGD. If the pond is operated at a depth of 4ft. What is the detention time of this pond?
    Solution:
    $$Pond\ \ detention\ \ time = \frac{Volume}{Flow} = \frac{(40*4) acre - ft}{0.6*10^6 \frac{gal}{day} * \frac{ft^3}{7.48 gal} * \frac{acre - ft}{43,560 ft^3}} = \boxed{87\ \ days}$$
19. A 2.5 acre stabilization pond is operated at a depth of five (5) ft. What is the pond detention time if the flow to the pond is 18,000 cu. ft/day?
    Solution:
    $$Pond\ \ detention\ \ time = \frac{Volume}{Flow} = \frac{(2.5*5) acre - ft}{18,000 \frac{ft^3}{day} * \frac{acre - ft}{43,560 ft^3}} = \boxed{30\ \ days}$$
20. The influent to a pond is 1,200 gpm with a BOD concentration of 180mglL in the raw wastewater. How many lbs/day of BOD are sent to the pond daily? **(Ans. 2,600 lbs BOD/-day)**
21. The influent flow to a pond is 10,000 gallons/hour with a suspended solids concentration of 142mg/l in the raw wastewater. How many lbs of suspended solids are sent to the pond daily? **(Ans. 284 lbs SS/day)**
22. A pond is 260 ft. long and 80 ft. wide. What is the area of this pond in ft2 and acres? **(Ans. 20,800 ft2)**
23. A pond has a volume of 1,800,000 ft3. If the flow to the pond is 425 gpm, what is the pond detention time in days? **(Ans. 22 days)**
24. Find pond detention time in days given the following:
    - Flow to pond = 250 gpm
    - Pond length = 125 ft .
    - Pond width = 40ft.
    - Pond depth = 7ft.

    (Ans. 0.7 days)
25. Find hydraulic loading in inches/day for a pond given the following:

- Pond depth = 12ft.
- Pond volume = 1,400,000ft3
- Pond flow = 1,000,000gal/day

Solution:

$$Pond\ hydraulic\ loading\ rate\ \left[\frac{in}{day}\right] = \frac{Flow}{Area} \Longrightarrow \frac{1{,}000{,}000\frac{gal}{day} * \frac{ft^3}{7.48gal}}{\frac{1{,}400{,}000ft^3}{12ft}} * 12\frac{in}{ft} =$$

$$\boxed{13.8\frac{in}{day}}$$

Note: The area of the pond was found by dividing the volume ($1{,}000{,}000ft^3$) by the pond depth (12ft)

26. The flow to a pond is 7.2MGD. If the pond diameter is 350 ft and the BOD in the pond influent is 170mg/l, what is the organic loading to this pond in lbs BOD/day/acre? **(Ans. 0.3 lbs BOD/day-acre)**
27. The flow to a pond is 200,000 gph. The pond width is 650 ft and the length is 300 ft. If the BOD in the pond influent is 265mg/l, what is the organic loading to this pond in lbs BOD/day/acre? **(Ans. 2,370 lbs BOD/day-acre)**
28. The influent flow to a pond is 600 gpm with a BOD concentration of 150mg/l in the raw wastewater. How many lbs of BOD are sent to the pond daily? **(Ans. 1081 lbs BOD/day)**
29. The influent flow to a pond is 50,000 gallons/hour with a suspended solids concentration of 125mg/l in the raw wastewater. How many lbs of suspended solids are sent to the pond daily? **(Ans. 1,251 lbs TSS/day)**
30. The flow to a pond is 60 gpm with a COD concentration of 240mg/l in the pond influent. How many lbs/day of COD are sent to the pond daily? **(Ans. 173 lbs COD/day)**
31. A pond is 100 ft. long and 210 ft wide. What is the area of this pond in ft2 and acres?**(Ans. 21,000 ft2 and 0.48 acres)**
32. A pond has a diameter of 80ft. What is the area of this pond in ft2 and acres? **(Ans. 5,024 ft2 and 0.12 acres)**
33. A pond is 450 ft. long and 450 ft. wide. If the pond is 3 ft. deep, what is the volume in ft3 and acre ft? **(Ans. 607,500 ft3 and 13.9 acre-ft)**
34. A pond has a diameter of 230 ft. and is 6 ft. deep. What is the volume in ft3 and acre ft of this pond? **(Ans. 249,159 ft3 and 5.7 acre-ft)**
35. A pond has a diameter of 50 ft. and is 8 ft deep. What is the volume of this pond in ft3 and acre ft? **(Ans. 15,700 ft3 and 0.36 acre-ft)**
36. A pond has a volume of 2,800,000 ft3. If the flow to the pond is 500 gpm, what is the detention time in days? **(Ans. 29 days)**
37. A 75 acre facultative pond is operated at a depth of 5.5 feet. Flow to this pond averages 2.2 MGD. The influent pond BOD averages,195 mg/l. Calculate the following:

    (a) The detention time **(Ans. 61 days)**

(b) The hydraulic loading **(Ans. 1.08 in/day)**

(c) The organic loading **(Ans. 47 lbs BOD/day-acre)**

38. How deep must a 60 acre facultative pond be operated in order to have a detention time of 45 days. Flow to the pond is 2.0 MGD. **(Ans. 4.6 ft)**
39. Find pond detention time in days.
    - Flow to pond = 300,000 gpm
    - Pond width = 450 ft.
    - Pond length = 500 ft.
    - Pond depth = 5 ft.

    (Ans. 28 days)
40. A 75 acre pond receives an influent flow of 5 MGD. If the operating level of the pond is to be raised from 4.0 ft to 5.5 ft, how long will it take for the pond level to rise to the new discharge level **(Ans. 7.3 days)**
41. Find the pond detention time in days if the flow to the pond is 600 gpd, and the pond is 450ft wide, 500 ft long and operating at a depth of 5 ft.
42. The flow to a pond is 500 gpm with a COD concentration of 240mg/l in the pond influent. How many lbs/day of COD are present to the pond daily?
43. The flow to a pond is 864,000 gal/day. The suspended solids concentration in the pond influent is 380mg/l. How many lbs/ day of suspended solids are sent to the pond daily?
44. A 5 acre stabilization pond is operated at a depth of five (5) ft. What is the pond detention time if the flow to the pond is 30,000 cu. ft/day?

    Solution:

    $$Pond\ \ detention\ \ time = \frac{Volume}{Flow} = \frac{(5*5)acre-ft}{30{,}000\frac{ft^3}{day} * \frac{acre-ft}{43{,}560 ft^3}} = \boxed{36.3\ \ days}$$
45. What is the hydraulic loading rate (in/day) on a 20 acre pond if it receives a flow of 3.3 acre-ft/day.

    a. 1 in/day

    b. 12 in/day

    c. 0.165 in/day

    *d. 2 in/day
46. It is found that at a wastewater treatment pond system 35 days are required to bring the pond system to its operations depth of 3.5 feet. Assuming that the pond system was empty when the filling of the pond was initiated and that a constant incoming flow rate fills the pond, what would be the hydraulic loading on this pond system ?

    a. 0.47 inches/day

    *b. 1.2 inches/day

    c. 2.1 inches/day

    d. 3.5 inches/day

    e. 10.0 inches/day

Activated Sludge

1. The aeration tank of a conventional activated sludge plant contains 9300 lbs of MLSS. Lab tests show that the MLSS are 79% volatile solids. The primary effluent contains 2900 lbs of BOD. Calculate the F to M ratio for this wastewater treatment plant. (Ans: 0.4)
2. How many lbs of solids are in a 400,000 gallon aeration tank if the suspended solids concentration is 1200 mg/l? (Ans: 4003.0)
3. Operational data is given below for a conventional activated sludge treatment plant:
   Influent flow: 2.5 mgd
   Influent BOD: 220 mg/l
   Influent TSS: 240 mg/l
   Primary BOD removal efficiency: 30%
   RAS SS: 8,500 mg/l
   RAS VSS: 6,630 mg/l
   RAS flow: 160%
   Aeration tank volume: 1.8 MG
   Secondary clarifier volume: 0.8 MG
   MLSS: 3,600 mg/l
   MLVSS: 2,800 mg/l
   WAS flow: 35,000 gpd
   AS Effluent TSS: 25 mg/l
   AS Effluent BOD: 19 mg/l
   Settleability results: 60 min= 300 ml/L
   Settleability results: 30 min= 320 ml/L
   1) Calculate the MCRT (8 points)
   2) Calculate the F/M Ratio (8 points)
   3) Calculate the SVI (8 points)
   4) Calculate the aeration basin detention time
4. Calculate the F to M ratio given the following.
   Plant flow- 0.8 MGD
   Aerator vol- 200,000 gal.
   Clarifier Volume-175,000 gal
   Primary eff BOD- 120 mg/l
   MLVSS conc. -1950 mg/l
   (Ans: 0.25)
5. Quantify the amount (lbs) of MLVSS in the two (2) aeration tanks if each tank is 40 ft. long, 15 ft. wide and operating at a water depth of 12 ft. The MLSS is 2500 mg/l and is found to be 69% volatile. (Ans: 1728 lbs)
6. The aeration tank of a conventional activated sludge plant contains 12,000 lbs of MLSS. Lab tests show that the MLSS are 79% volatile solids. The primary effluent contains 3800

lbs of BOD. Calculate the F to M ratio for this wastewater treatment plant. (Ans: 0.4)

7. An activated sludge plant with the following parameters treats 5 MGD flow.
   Aeration tank volume: 0.25 MG
   Clarifier volume: 0.15 MG
   MLSS: 3000 mg/l
   RAS concentration: 6500 mg/l
   Secondary effluent TSS: 16 mg/l
   MCRT: 6 days
   1. Calculate the lbs MLSS in the aeration system (Aeration tank + Clarifier)
   2. Calculate the lbs TSS/day in the final effluent - 5 points
   3. At the given MCRT, calculate the WAS solids removed from the system (lbs/day)
   4. Using the given value of WAS concentration, calculate the gallons per day of WAS
8. In an aeration tank, the MLSS is 2500 mg/l and recorded 30-minute settling test for a 1-litre MLSS samples indicates 230 ml of settled solids. What is the sludge volume index? (Ans: 92)
9. An activated sludge process treating a 3 MGD flow has a 1 MG volume aeration basin and a 0.25 MG volume final clarifier. The MLSS is 2000 mg/l and contains 82% volatile solids. If the secondary effluent suspended solids concentration is 20mg/l and the WAS concentration is 7500 mg/l and is wasted at a rate of 0.06 MGD. Calculate the MCRT. (Ans: 4.9)
10. The desired F/M ratio at a particular activated sludge plant is 0.5 lbs BOD/lb MLVSS. If the 3 MGD primary effluent flow has a BOD of 165 mg/l, how many lbs of MLVSS should be maintained in the aeration tank. (Ans: 8,257)
11. Operational data is given below for a conventional activated sludge treatment plant:
    Influent flow: 0.500 mgd
    RAS SS: 12600 mg/l
    RAS VSS: 9450 mg/l
    Influent BOD: 199 mg/l
    Influent TSS: 221 mg/l RAS flow: 160%
    Aeration tank volume: 350,000 gal WAS flow: 6433 gpd
    Secondary clarifier volume: 150,000 gal
    MLSS: 4200 mg/l Effluent TSS: 45 mg/l
    MLVSS: 3150 mg/l Effluent VSS: 36 mg/l
    Settleability results: 30 min= 360 ml/L Effluent BOD: 20 mg/l
    Settleability results: 60 min= 330 ml/L
    Calculate the MCRT
    Answer: 21 days
    Calculate the F/M Ratio
    Answer: 0.09
    Calculate the aeration tank detention time

Answer: 6.5 hrs

Calculate the SVI

Answer: 88 mL/g

12. Calculate the F to M ratio given the following.
    Plant flow- 0.8 MGD
    Aerator vol- 200,000 gal.
    Clarifier Volume-175,000 gal
    Primary eff BOD- 120 mg/l
    MLVSS conc. -1950 mg/l
    (Ans: 0.25)
13. An operator ran a 30 minute settling test on a mixed liquor sample using a 1000 ml graduated cylinder. The mixed liquor settled to 22% of the cylinder volume. The lab determined that the MLSS concentration was 3380 mg/l. What was the Sludge Volume Index for the mixed liquor?
    Correct Answer: 65.0
14. The desired F/M ratio is .35lbs BOD/day/lb MLVSS. If 2,100 lbs of BOD enter the aerator daily, how many lbs of MLVSS should be maintained in the aeration tank?
    a. 3430 lbs
    b. 420 lbs
    *c. 6000 lbs
    d. 735 lbs
15. A sludge settleability test shows a reading 220 ml after 30 minutes of settling in a one liter graduated cylinder. Lab testing on this mixed liquor shows a MLSS concentration of 1850 mg/l and a MLVSS concentration of 1440 mg/l. Calculate SVI for this mixed liquor sample.
    *a. 119
    b. 108
    c. 153
    d. 138
16. Given the following data, calculate the mean cell residence time (MCRT) .
    DATA: Influent flow = 3.5 MGD. MLSS = 2850 mg/l. Waste sludge flow = 0.08 MGD. Total secondary system volume = 2.0 MG. Waste activated sludge suspended solids conc -6000mg/l. Final effluent suspended solids = 25 mg/l.
    a. 6 days.
    b. 8 days.
    *c. 10 days.
    d. 12 days.
17. What is the Sludge Volume Index given the following: MLSS = 2800 mg/l; MLVSS 240 mg/l; Settled Volume after 30 minutes = 250 ml/L
    a. 0.09 ml/g

*b. 89 ml/g

c. 0.11 ml/g

d. 113 ml/g

18. Given the following data, calculate the suspended solids required to maintain a food to microorganism (F/M) ratio of 0.3

    DATA:

    Daily flow = 10 MGD.

    Average primary effluent BOD = 150mg/l

    Aeration tank capacity = 200,000 gal

    a. 2100 mg/l

    *b. 2500 mg/l

    c. 3300 mg/l

    d. 4200 mg/l

19. Given the following data, calculate the mean cell residence time (MCRT)

    DATA:

    Influent flow= 35 MGD

    MLSS = 2850 mg/l

    Waste sludge flow = 0.08 MGD

    Total secondary system volume= 20 MG

    Waste activated sludge suspended solids conc. = 6000 mg/l

    Final effluent suspended solids = 25 mg/l

    a. 6 days

    b. 8 days

    *c. 10 days

    d. 12 days

20. Calculate the waste sludge pumping rate if you want to waste 2,000 pounds per day with a concentration of return sludge at 5000 mg/l

    a. 29 gpm

    *b. 33 gpm

    c. 35 gpm

    d. 37 gpm

21. Calculate the return activated sludge (RAS) concentration

    DATA:

    SVI = 140

    SSV(30) = 350

    Influent flow = 25 MGD

    MLSS concentration = 2500 mg/l

    a. 8,300 mg /L

    *b. 7,100 mg /L

    c. 4,150 mg/l

d. 2,800 mg/l

22. Calculate the return activated sludge (RAS) concentration.
    DATA:
    SVI = 140 SSV = 350 30
    Influent flow= 2.5 MGD
    MLSS concentration= 2500 mg/l.
    a. 8300 mg /l.
    *b. 7100 mg/l.
    c. 4150 mg/l.
    d. 2800 mg/l.
23. Given the following data, calculate the mean cell residence time (MCRT):
    DATA: Influent flow= 3.5 MGD.
    MLSS = 2850 mg/l.
    Waste sludge flow= 0.08 MGD.
    Total secondary system volume= 2.0 MG.
    Waste activated sludge suspended solids conc.: 6000 mg/l.
    Final effluent suspended solids= 25 mg/l.
    a. 6 days.
    *b. 8 days.
    c. 10 days.
    d. 12 days.
24. Calculate the return activated sludge (RAS) concentration.
    DATA:
    SVI = 140 SSV = 350 30
    Influent flow= 2.5 MGD
    MLSS concentration= 2500 mg/l.
    a. 8300 mg /l.
    *b. 7100 mg/l.
    c. 4150 mg/l.
    d. 2800 mg/l.
25. Calculate the return activated sludge (RAS) concentration.
    DATA:
    SVI = 140 SSV = 350 30
    Influent flow= 2.5 MGD
    MLSS concentration= 2500 mg/l.
    a. 8300 mg /l.
    *b. 7100 mg/l.
    c. 4150 mg/l.
    d. 2800 mg/l.
26. Given the following data, calculate the mean cell residence time (MCRT) .

DATA: Influent flow = 3.5 MGD. MLSS = 2850 mg/l. Waste sludge flow = 0.08 MGD. Total secondary system volume = 2.0 MG. Waste activated sludge suspended solids conc -6000mg/l. Final effluent suspended solids = 25 mg/l.

a. 6 days.

b. 8 days.

*c. 10 days.

d. 12 days.

27. At an activated sludge wastewater treatment plant receiving 3.25 MGD, the final effluent suspended solids concentration averages 21.2 mg/l. What would the calculated MCRT value be when the aeration basin carries 2,050 mg/l MLSS and wastes 0.0550 MGD. The waste activated sludge has a concentration of 7,980 mg/l. The aeration tank has a volume of 1.00 MG and the secondary clarifier has an operational volume of 0.250 MG.
Solution:

$$MCRT(days) = \frac{MLSS\ in\ aeration\ tank\ (lbs) + MLSS\ in\ clarifier\ (lbs)}{SS\ effluent\ (lbs/day) + SS\ WAS\ (lbs/day)}$$

$$MLSS\ in\ aeration\ tank\ (lbs) = 1 * 2050 * 8.34 = 17,097 lbs$$

$$MLSS\ in\ clarifier\ (lbs) = 0.25 * 2050 * 8.34 = 4,274.3 lbs$$

$$SS\ effluent\ (lbs/day) = 3.25 MGD * 21.2 mg/l * 8.34 = 574.6 lbs/day$$

$$SS\ WAS\ (lbs/day) = 0.055 MGD * 7,980 mg/l * 8.34 = 3,660.4 lbs/day$$

Plugging in the values calculated above: $MCRT(days) = \frac{17,097.6 + 4,274.3}{574.6 + 3,660.4} = 4.8 =$ $\boxed{5\ days}$

28. Calculate the MCRT of an activated sludge plant given the following information.
Plant flow- 4.25 MGD
WAS conc-7980 mg/l
Waste flow- 0.055 MGD
RAS conc.- 7980 mg/l
Aeration tank vol-1MG
Clarifier vol- 0.25 MG
Final eff TSS conc. - 21.2 mg/l
MLSS conc.- 2050 mg/l

Solution:

$$MCRT(days) = \frac{MLSS\ in\ aeration\ tank\ (lbs) + MLSS\ in\ clarifier\ (lbs)}{SS\ effluent\ (lbs/day) + SS\ WAS\ (lbs/day)}$$

$$MLSS\ in\ aeration\ tank\ (lbs) = 1 * 2050 * 8.34 = 17097 lbs$$

$$MLSS\ in\ clarifier\ (lbs) = 0.25 * 2050 * 8.34 = 4274.3 lbs$$

$SS\ \ effluent\ \ (lbs/day) = 4.25MGD * 21.2mg/l * 8.34 = 751.4lbs/day$

$SS\ \ WAS\ \ (lbs/day) = 0.055MGD * 7980mg/l * 8.34 = 3660.4lbs/day$

Plugging in the values calculated above: $MCRT(days) = \frac{17097.6 + 4274.3}{751.4 + 3660.4} = 4.8 =$ $\boxed{5days}$

29. Calculate the MCRT given the following.

    Plant flow - 1.8 MGD

    MLSS conc - 2800 mg/l

    WAS flow - 0.04 MGD

    MLVSS conc. - 2190 mg/l

    Aerator vol - 0.3 MG

    Reactor vol. - 0.2 MG

    RAS conc. - 8150 mg/l

    Effluent SS conc.-18 mg/l

    Solution:

    $$MCRT(days) = \frac{MLSS\ in\ aeration\ tank\ (lbs) + MLSS\ in\ clarifier\ (lbs)}{SS\ effluent\ (lbs/day) + SS\ WAS\ (lbs/day)}$$

    $$MLSS\ in\ aeration\ tank\ (lbs) = 0.3 * 2800 * 8.34 = 7005.6lbs$$

    $$MLSS\ in\ clarifier\ (lbs) = 0.2 * 2800 * 8.34 = 4670.4lbs$$

    $$SS\ effluent\ (lbs/day) = 1.8MGD * 18mg/l * 8.34 = 270.2lbs/day$$

    $$SS\ WAS\ (lbs/day) = 0.04MGD * 8150mg/l * 8.34 = 2718.8lbs/day$$

    Plugging in the values calculated above: $MCRT(days) = \frac{7005.6 + 4670.4}{270.2 + 2718.8} = 3.9 = \boxed{4days}$

30. In an aeration tank, the MLSS is 2650 mg/l and recorded 30-minute settling test indicates 221 ml/L. What is the sludge volume index?

    Solution:
    SVI (ml/g)= $\frac{Settled\ \ sludge\ \ volume\ \ in\ \ ml/l\ \ after\ \ 30\ \ min}{MLSS\ \ mg/l} * 1000\frac{mg}{g}$

    SVI=$\frac{221ml/l}{2650mg/l} * 1000\frac{mg}{g} = \boxed{83ml/g}$

31. The desired F/M ratio is .35 lbs BOD/day/lb MLVSS. If 2,100 lbs of BOD enter the aerator daily, how many lbs of MLVSS should be maintained in the aeration tank?

    Solution:
    $F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$

    $\Longrightarrow 0.35 = \frac{2100}{x} \Longrightarrow x = \boxed{6000lbs\ \ MLVSS}$

32. A sludge settleability test shows a reading 220 ml after 30 minutes of settling in a one liter graduated cylinder. Lab testing on this mixed liquor shows a MLSS concentration of 1850 mg/l and a MLVSS concentration of 1440 mg/l. Calculate SVI for this mixed liquor sample.

    *a. 119
    b. 108
    c. 153
    d. 138

    Solution:
    SVI (ml/g)= $\frac{Settled\ \ sludge\ \ volume\ \ in\ \ ml/l\ \ after\ \ 30\ \ min}{MLSS\ \ mg/l} * 1000\frac{mg}{g}$

    SVI=$\frac{220ml/l}{1,850mg/l} * 1000\frac{mg}{g} = \boxed{119ml/g}$

33. Calculate F/M ratio based on the following data:
    Secondary influent BOD - 156 mg/l
    Four (4) aeration basins - 30 ft x 70 ft x 10 ft. deep
    Influent flow - 0.65 MGD
    MLSS - 3600 mg/l
    MLSS average % volatile - 72%
    Solution:

    $F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$

    $F:M = \frac{156 * 0.65 * 8.34}{3600 * 0.72 * 4 * (30 * 70 * 10)ft^3 * \frac{7.48gal}{ft^3} * \frac{MG}{1000000gal} * 8.34} = \boxed{0.06}$

34. An activated sludge plant operates well at an F:M ratio of between 0.23 and 0.28. Calculate the minimum MLSS concentration, given the following:
    Q = 0.4 MGD
    Primary influent BOD = 250 mg/l
    Primary effluent BOD = 128 mg/l
    Aeration tank vol. = 350,000 gallons
    Clarifier vol = 250,000 gallons
    MLSS has 80% volatile solids
    Solution:

$$F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$$

$$\implies F:M \propto \frac{1}{MLSS\ \ concentration} \implies \text{F:M is inversely proportional to MLSS}$$

    So to have minimum MLSS conc. F:M needs to be the maximum of the range provided

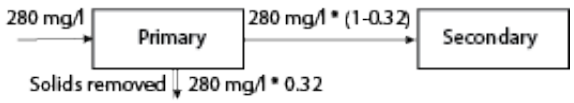
    If the MLSS concentration = x: $\implies F:M = 0.28 = \frac{0.4*128*8.34}{0.35*x*0.8} \implies x = \boxed{5446 mg/l\ \ MLSS}$

35. Given that an activated sludge plant with an influent flow of 1.2 MGD is operated at an MCRT of 6 days and the parameters below, calculate the WAS flow rate (wasting rate) in gallon per day.

Two aeration tanks – 0.5 MG each	Two final clarifiers – 0.25 MG each
Final effluent $= 20\frac{mg}{l}$	WAS = 7500 ppm
MLSS =3600$\frac{mg}{L}$	MLSS volatile solids content = 80%

36. Your plant currently is running at an MCRT of 5 days. You want to adjust things so that the plant is operating at an MCRT of 9 days. What is the new volume in gallons you should waste everyday to achieve this? Given the following information: Aeration tank volume of 750,000 gal. MLSS of 2400 mg/l. Plant effluent SS of 7 mg/l, and a WAS concentration of 6500 mg/l. Influent flow 1.0 MGD. [Ans. 29,292 gallons]
37. Your engineer is upgrading your pond by providing surface aerators. She suggests you need two 7-1/2 horsepower surface aerators with an oxygen transfer rate of 1.6 pounds of oxygen per horsepower per hour. Assume only 80% of the oxygen transfer will reduce the BOD 1:1. What is the minimum number of hours these time-clocked aerators will run to remove 85% of the influent BOD, which averages 295 pounds a day? [Ans. 13.1 hrs]

38. Given the following information calculate MCRT for your WWTP. The plant is an extended aeration system with an aeration tank that has a volume of 66800 cu. ft. The MLSS is 1950 mg/l. The flow to the WWTP is 1.5 MGD and your effluent TSS is 9 mg/l. The WAS is 7000 mg/l and you waste 11990 gallons each day. [Ans. 10 days]
39. Given a system that has 25,000 pounds of MLSS in it and the desired quantity is 23,500 pounds of MLSS, how many gallons of sludge must be wasted if the RAS and WAS concentration is 7,200 mg/l?[Ans. 24,980 gallons]
40. Your aeration tank is 80 feet long, 40 feet wide and has 10.5 feet of mixed liquor depth. The MLVSS in the aeration tank is 1,850 mg/l. You are experiencing biological bulking and have read 2 pounds of chlorine per 1,000 pounds of MLVSS should control this form of bulking. How many pounds of chlorine are added to the RAS portion of the RAS/WAS splitter box to achieve this process control strategy?[Ans. 7.8 lbs Cl2]
41. An extended aeration plant is as follows: 0.28 MGD of 210 mg/l influent BOD, aeration basin volume 0.32 MG. The MLVSS is 4,450 mg/l (81% volatile) and the RAS is 9,200 mg/l. (a) What is the F/M? [Ans. 0.051 F:M] (b) How many pounds of suspended solids must be wasted to obtain an F/M of .06? [1785.6 lbs MLSS] (c) What is the new MLVSS in mg/l? [Ans. 3781 mg/l MLSS]
42. Plant data: WAS Rate – 9 gpm Flow – 1.5 MGD MLSS – 2,350 mg/l Influent BOD – 210 mg/l RAS/WAS – 5,875 mg/l Influent TSS – 186 mg/l 30 min. Settling test – 320 ml/L Primary effluent BOD – 143 mg/l MLSS is 85% volatile solution Primary effluent TSS – 86 mg/l Effluent BOD – 18 mg/l Aeration basins (2) Total Volume 468,750 gal Effluent TSS – 13 mg/l a). Calculate the F/M ratio: [Ans. 0.23] b). Calculate the sludge age: [Ans. 8.54days] c). Calculate MCRT: [Ans. 11.5 days] d). Calculate the SVI: [Ans. 136]
43. The 1.5 MGD influent to a treatment plant has an average BOD of 280 mg/l. 32% of this BOD is removed in the primary sedimentation tank. The primary effluent flows into an aeration tank containing 7000 lbs of MLSS with 79 % volatile matter. Calculate this plant's F to M ratio.



Influent BOD concentration to the AS basin: $280\frac{mg}{l} * (1-0.32) = 190.4\frac{mg}{l}$

$$\frac{F}{M} = \frac{1.5MGD * 190.4\frac{mg}{l} * 8.34}{7000 * 0.79} = \boxed{0.43\frac{F}{M}}$$

44. Given that an activated sludge plant with an influent flow of 1.2 MGD is operated at an MCRT of 6 days and the parameters below, calculate the WAS flow rate (wasting rate) in gallon per day.

Two aeration tanks – 0.5 MG each	Two final clarifiers – 0.25 MG each
Final effluent $= 20\frac{mg}{l}$	WAS – 7500 ppm
MLSS –$3600\frac{mg}{L}$	MLSS volatile solids content = 80%

MCRT$= \dfrac{lbsMLSS(system)}{\frac{lbs}{day}EffluentSS + \frac{lbs}{day}WASSS}$

lbs MLSS (system)$= (2*0.5+2*0.25)MG*3600\frac{mg}{L}*8.34 = 45036lbs$

$\frac{lbs}{day}EffluentSS = 1.2MG*20\frac{mg}{L}*8.34 = 200.2lbs$

MCRT: $6days = \dfrac{45036}{200.2\frac{lbs}{day} + \frac{lbs}{day}WASSS}$

$\frac{lbs}{day}WASSS = \frac{45036}{6} - 200.2 = 7306\frac{lbs}{day}$

$7306\frac{lbs}{day} = WASFlow(MGD)*7500*8.34 \implies WASFlow(MGD) = \frac{7306}{7500*8.34} =$

$0.116MGD = \boxed{116,000\frac{gal}{day}}$

45. Calculate the MCRT of an activated sludge plant given the following information.

Plant flow- 4.25 MGD

WAS conc-7980 mg/l

Waste flow- 0.055 MGD

RAS conc.- 7980 mg/l

Aeration tank vol-1MG

Clarifier vol- 0.25 MG

Final eff TSS conc. - 21.2 mg/l

MLSS conc.- 2050 mg/l

Solution:

$$MCRT(days) = \frac{MLSS\ in\ aeration\ tank\ (lbs) + MLSS\ in\ clarifier\ (lbs)}{SS\ effluent\ (lbs/day) + SS\ WAS\ (lbs/day)}$$

$$MLSS\ in\ aeration\ tank\ (lbs) = 1*2050*8.34 = 17097lbs$$

$$MLSS\ in\ clarifier\ (lbs) = 0.25*2050*8.34 = 4274.3lbs$$

$$SS\ effluent\ (lbs/day) = 4.25MGD*21.2mg/l*8.34 = 751.4lbs/day$$

$$SS\ WAS\ (lbs/day) = 0.055MGD*7980mg/l*8.34 = 3660.4lbs/day$$

Plugging in the values calculated above: $MCRT(days) = \dfrac{17097.6+4274.3}{751.4+3660.4} = 4.8 =$

$\boxed{5days}$

46. Calculate the MCRT given the following.

    Plant flow - 1.8 MGD

    MLSS conc - 2800 mg/l

    WAS flow - 0.04 MGD

    MLVSS conc. - 2190 mg/l

    Aerator vol - 0.3 MG

    Reactor vol. - 0.2 MG

    RAS conc. - 8150 mg/l

    Effluent SS conc.-18 mg/l

    Solution:

    $$MCRT(days) = \frac{MLSS\ \ in\ \ aeration\ \ tank\ \ (lbs) + MLSS\ \ in\ \ clarifier\ \ (lbs)}{SS\ \ effluent\ \ (lbs/day) + SS\ \ WAS\ \ (lbs/day)}$$

    $$MLSS\ \ in\ \ aeration\ \ tank\ \ (lbs) = 0.3 * 2800 * 8.34 = 7005.6lbs$$

    $$MLSS\ \ in\ \ clarifier\ \ (lbs) = 0.2 * 2800 * 8.34 = 4670.4lbs$$

    $$SS\ \ effluent\ \ (lbs/day) = 1.8MGD * 18mg/l * 8.34 = 270.2lbs/day$$

    $$SS\ \ WAS\ \ (lbs/day) = 0.04MGD * 8150mg/l * 8.34 = 2718.8lbs/day$$

    Plugging in the values calculated above: $MCRT(days) = \frac{7005.6 + 4670.4}{270.2 + 2718.8} = 3.9 = \boxed{4days}$

47. In an aeration tank, the MLSS is 2650 mg/l and recorded 30-minute settling test indicates 221 ml/L. What is the sludge volume index?

    Solution:
    SVI (ml/g)= $\frac{Settled\ \ sludge\ \ volume\ \ in\ \ ml/l\ \ after\ \ 30\ \ min}{MLSS\ \ mg/l} * 1000\frac{mg}{g}$

    SVI=$\frac{221ml/l}{2650mg/l} * 1000\frac{mg}{g} = \boxed{83ml/g}$

48. The desired F/M ratio is .35 lbs BOD/day/lb MLVSS. If 2,100 lbs of BOD enter the aerator daily, how many lbs of MLVSS should be maintained in the aeration tank?

    Solution:
    $F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$

    $\Longrightarrow 0.35 = \frac{2100}{x} \Longrightarrow x = \boxed{130,100lbs\ \ MLVSS}$

49. Calculate F/M ratio based on the following data:

    Secondary influent BOD - 156 mg/l

    Four (4) aeration basins - 30 ft x 70 ft x 10 ft. deep

    Influent flow - 0.65 MGD

    MLSS - 3600 mg/l

    MLSS average % volatile - 72%

    Solution:

    $F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$

    $F:M = \frac{156 * 0.65 * 8.34}{3600 * 0.72 * 4 * (30 * 70 * 10)ft^3 * \frac{7.48gal}{ft^3} * \frac{MG}{1000000gal} * 8.34} = \boxed{0.06}$

50. An activated sludge plant operates well at an F:M ratio of between 0.23 and 0.28. Calculate the minimum MLSS concentration, given the following:
    Q = 0.4 MGD
    Primary influent BOD = 250 mg/l
    Primary effluent BOD = 128 mg/l
    Aeration tank vol. = 350,000 gallons
    Clarifier vol = 250,000 gallons
    MLSS has 80% volatile solids
    Solution:

$$F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$$

$$\Longrightarrow F:M \propto \frac{1}{MLSS\ \ concentration} \Longrightarrow \text{F:M is inversely proportional to MLSS}$$

    So to have minimum MLSS conc. F:M needs to be the maximum of the range provided

    If the MLSS concentration = x: $\Longrightarrow F:M = 0.28 = \frac{0.4*128*8.34}{0.35*x*0.8} \Longrightarrow x = \boxed{5446mg/l\ \ MLSS}$

51. 5. Given that an activated sludge plant with an influent flow of 1 MGD is operated at an MCRT of 6 days and the parameters below, calculate the WAS flow rate (wasting rate) in gallon per day. (10 points)

Two aeration tanks – 0.45 MG each	Two final clarifiers – 0.2 MG each
Final effluent $= 16\frac{mg}{l}$	WAS = 6500 ppm
MLSS =$3000\frac{mg}{L}$	MLSS volatile solids content = 85%

    Solution:

$$\text{MCRT} = \frac{lbsMLSS(system)}{\frac{lbs}{day}EffluentSS + \frac{lbs}{day}WASSS}$$

$$\text{lbs MLSS (system)} = (2*0.45+2*0.2)MG*3000\frac{mg}{L}*8.34 = 32,526lbs$$

$$\frac{lbs}{day}EffluentSS = 1MG*16\frac{mg}{L}*8.34 = 133.4lbs$$

$$\text{MCRT: } 6days = \frac{32,526}{133.4\frac{lbs}{day} + \frac{lbs}{day}WASSS}$$

$$\frac{lbs}{day}WASSS = \frac{32,526}{6} - 133.4 = 5,288\frac{lbs}{day}$$

$$5,288\frac{lbs}{day} = WASFlow(MGD) * 6500 * 8.34$$

$$\implies WASFlow(MGD) = \frac{5,288}{6,500 * 8.34} = 0.097546MGD = \boxed{97,546\frac{gal}{day}}$$

52. Operational data is given below for a conventional activated sludge treatment plant:

Influent flow: 2.5 mgd

Influent BOD: 220 mg/l

Influent TSS: 240 mg/l

Primary BOD removal efficiency: 30%

Aeration tank volume: 1.8 MG

Secondary clarifier volume: 0.8 MG

MLSS: 3,600 mg/l

MLVSS: 2,800 mg/l

RAS SS: 8,500 mg/l

RAS VSS: 6,630 mg/l

RAS flow: 100%

WAS flow: 35,000 gpd

AS Effluent TSS: 25 mg/l

AS Effluent BOD: 19 mg/l

Settleability results: 60 min= 300 ml/L

Settleability results: 30 min= 320 ml/L

(a) Calculate the MCRT

(b) Calculate the F/M Ratio

(c) Calculate the SVI

Solution:

(a) $$MCRT(days) = \frac{MLSS\ in\ aeration\ tank\ (lbs) + MLSS\ in\ clarifier\ (lbs)}{SS\ effluent\ (lbs/day) + SS\ WAS\ (lbs/day)}$$

$$MLSS\ in\ aeration\ tank\ (lbs) = 1.8 * 3,600 * 8.34 = 54,043lbs$$

$$MLSS\ in\ clarifier\ (lbs) = 0.8 * 3,600 * 8.34 = 24,019lbs$$

$$SS\ effluent\ (lbs/day) = 2.5MGD * 25mg/l * 8.34 = 521lbs/day$$

$$SS\ WAS\ (lbs/day) = \frac{35,000}{1,000,000}MGD * 8,500mg/l * 8.34 = 2,481lbs/day$$

$$MCRT(days) = \frac{54,043 + 24,019}{521 + 2,481} = \boxed{26\ days}$$

(b) $$F:M = \frac{(lbs/day)\ primary\ effluent\ BOD\ entering\ the\ aeration\ tank}{(lbs)\ MLVSS\ in\ the\ aeration\ tank}$$

$$F:M = \frac{220 * (1 - 0.3) * 2.5 * 8.34}{1.8 * 2,800 * 8.34} = \boxed{0.08}$$

(c) SVI (ml/g)= $\frac{Settled\ \ sludge\ \ volume\ \ in\ \ ml/l\ \ after\ \ 30\ \ min}{MLSS\ \ mg/l} * 1000\frac{mg}{g}$

SVI=$\frac{320ml/l}{3,600mg/l} * 1000\frac{mg}{g} = \boxed{89ml/g}$

53. What is the Sludge Volume Index given the following:
MLSS = 2800 mg/l; MLVSS 2400 mg/l; Settled Volume after 30 minutes = 250 ml/L

Solution:
SVI (ml/g)= $\frac{Settled\ \ sludge\ \ volume\ \ in\ \ ml/l\ \ after\ \ 30\ \ min}{MLSS\ \ mg/l} * 1000\frac{mg}{g}$

SVI=$\frac{250ml/l}{2800mg/l} * 1000\frac{mg}{g} = \boxed{89ml/g}$

54. Plant Influent Flow: 3.5 MGD
Plant Influent BOD: 276 mg/l
Primary Treatment BOD Removal: 36%
Desired F/M: 0.3
Find lbs of MLVSS that should be maintained in the activated sludge treatment process. (Answer: 17,187 lbs)

55. Given that an activated sludge plant with an influent flow of 1 MGD is operated at an MCRT of 6 days and the parameters below, calculate the WAS flow rate (wasting rate) in gallon per day

Two aeration tanks – 0.45 MG each	Two final clarifiers – 0.2 MG each
Final effluent = $16\frac{mg}{l}$	WAS = 6500 ppm
MLSS =$3000\frac{mg}{L}$	MLSS volatile solids content = 85%

(Answer: 97,546 gal/day)

56. The aeration tank of a conventional activated sludge plant contains 9300 Ibs of MLSS. Lab tests show that the MLSS are 79% volatile solids. The primary effluent contains 2900 Ibs of BOD. Calculate the F to M ratio for this wastewater treatment plant. (Answer: 0.4)
57. How many lbs of solids are in a 400,000 gallon aeration tank if the suspended solids concentration is 1200 mg/l? (Answer: 4003 lbs)
58. An activated sludge wastewater treatment plant treats an average flow of 3.25 MGD. The aeration tank has a volume of 1.0 MG and a MLSS concentration of 2100 mg/l. The final clarifier has an operating volume of 0.25 MG. Effluent suspended solids concentration averages 21.2 mg/l. The WAS concentration is 8100 mg/l and is wasted at the rate of 0.055 MGD. Calculate the MCRT.
59. What is the F/M ratio on an aeration tank if 1,500 pounds of BOD are added per day and 5000 pounds of volatile solids are under aeration?
60. In an aeration tank, the MLSS is 2500 mg/l and recorded 30-minute settling test indicates 230 ml. What is the sludge volume index?
61. An activated sludge aeration tank receives a primary effluent flow of 2.61 MGD with a

BOD concentration of 195 mg/l. The mixed liquor volatile suspended solids concentration is 2560 mg/l and the aeration tank volume is 470,000 gallons. What is the current F/M ratio?

62. Calculate the MCRT given the following. Plant flow- 2.8 MGD
    MLSS conc.- 2800 mg/l
    WAS flow- 0.07 MGD
    MLVSS conc.- 2190mg/l
    Aerator volume - 0.38MG
    RAS SS concentration - 6800 mg/l
    Clarifier volume - 0.19 MG
    Final effluent TSS - 18 mg/l
63. If in a conventional activated sludge treatment plant the aeration tank contains 7000 lbs of MLSS and the final clarifier contains 2500 lbs of MLSS. If 1300 lbs of solids are wasted each day and 120 lbs of solids leave in the final effluent, Calculate the MCRT.
64. The aeration tank of a conventional activated sludge plant contains 9300 Ibs of MLSS. Lab tests show that the MLSS are 79% volatile solids. The primary effluent contains twenty-nine hundred pounds (2900 Ibs) of BOD. Calculate the F to M ratio for this wastewater treatment plant.
65. A conventional activated sludge plant receives an average flow of 2.5 MGD. The influent BOD averages 230 and the primary effluent BOD average 160 mg/I. The 0.6 MG aeration tank has a MLSS cone. of 2800 mg/l and a MLVSS cone. of 21 50 mg/l. Calculated the F to M ratio for this plant.
66. A convention activated sludge plant receives an average influent flow of 800,000 gpd. The influent BOD averages 200 mg/l and on the average 32% of this BOD is removed in the primary sedimentation tank. The mixed liquor tank contains 3250 Ibs of MLSS. These solids contain 77% volatile matter. Calculate this plant's F to M ratio.
67. In an conventional activated sludge plant calculations show that the aeration tank contains 6500 Ibs of MLSS and the final clarifier contains 2500 Ibs of MLSS. Twelve hundred and fifty pounds (1250 Ibs) of solids is wasted each day and 100 Ibs/day of solids leave in the final effluent. Calculate the MCRT for this plant.
68. A activated sludge plant has a total of 25,000 pounds of solids in the system (i.e. aerator + final clarifier) and has an average effluent flow of 3.75 MGD. The effluent suspended solids concentration averages 22 mg/l. The WAS has a concentration of 7500 mg/l and is being wasted at 0.05 MGD. Calculate the MCRT.
69. An activated sludge wastewater treatment plant discharges an average flow of 3.25· MGD. The mixed liquor tank has a volume of 1.0 MG and a MLSS concentration of 2100 mg/l. The final clarifier has an operating volume of 0.25 MG. Effluent suspended solids concentration averages 21.2 mg/l. The WAS concentration is 8100 j mg/l and is wasted at the rate of 0.055 MGD. Calculate the MCRT.
70. In an conventional activated sludge plant show that the aeration tank contains 6500 Ibs of

MLSS and the final clarifier contains 2500 lbs of MLSS. 1250 Ibs of solids is wasted each day and 100 Ibs/day of solids leave in the final effluent. Calculate the MCRT for this plant. Answer: 7 days

71. An activated sludge plant has a total of 25,000 pounds of solids in the system (aerator + final Clarifier) and has an average effluent flow of 3.75 MGD. The effluent suspended solids concentration averages 22 mg/l. The WAS has a concentration 'of 7500 .mg/l and is being wasted at 0.05 MGD. Calculate the MCRT. Answer: 7 days
72. An activated sludge wastewater treatment plant discharges an average flow of 3.25 MGD. The mixed liquor tank has a volume of 1.0 MG and a MLSS concentration of 2100 mg/l. The final clarifier has an operating volume of 0.25 MG. Effluent suspended solids concentration averages 21.2 mg/l and the WAS concentration is 8100 mg/l and is wasted at the rate of 0.055 MGD. Calculate the MCRT. Answer: 5.1 days
73. A conventional activated sludge plant receives an average flow of 2.5 MGD. The influent BOD averages 230 and the primary effluent BOD averages 160mg/l The 0.6 MG aeration tank has a MLSS conc. of 2800 mg/l and a MLVSS conc. of 2150mg/l. Calculate the F to M ratio for this plant. Answer: 0.31
74. A conventional activated sludge plant receives an influent flow of 800,000 gpd. The influent BOD averages 200 mg/l and on the average 32% of this BOD is removed in the primary sedimentation tank. The mixed liquor tank contains 3250 Ibs of MLSS. These solids contain 77% volatile matter. Calculate this plant's F to M ratio. Answer: 0.36
75. Calculate the MCRT given the following. Plant flow- 1.8 MGD
    MLSS conc.- 2800 mg/l
    WAS flow- 0.04 MGD
    MLVSS conc.- 2190mg/l
    Aerator vol- 0.3MG
    RAS conc.- 8150 mg/l
    Clarifier vol- 0.lMG
    Final eff TSS- 26 mg/l
    Answer: 3 days
76. Calculate the F to M ratio given the following Information. Plant flow- 3.7 MGD
    Primary eff TSS- 120mg/l
    Aerator Vol - 0.85 MG
    MLSS conc.- 3200 mg/l
    Clarifier Vol - 0.25 MG
    MLVSS conc.- 2550 mg/l
    Primary effluent BOD-120 mg/l
    Answer: 0.2
77. Calculate the F to M ratio given the following. Plant flow- 0.8 MGD Aerator vol- 200,000 gal. Clarifier Volume-175,000 gal Primary eff BOD- 120 mg/l MLVSS cone. -1950 mg/l
    Answer: 0.25

$$F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$$

$$F:M = \frac{120*0.8*8.34}{1950*0.2*8.34} = \boxed{0.25}$$

78. Calculate the MCRT of an activated sludge plant given the following information. Plant flow- 4.25 MGD
WAS conc-7980 mg/l
Waste flow- 0.055 MGD
RAS conc.- 7980 mg/l
Aeration tank vol-1MG
Clarifier vol- 0.25 MG
Final eff TSS conc. - 21.2 mg/l
MLSS conc.- 2050 mg/l

$$MCRT(days) = \frac{MLSS\ \ in\ \ aeration\ \ tank\ \ (lbs) + MLSS\ \ in\ \ clarifier\ \ (lbs)}{SS\ \ effluent\ \ (lbs/day) + SS\ \ WAS\ \ (lbs/day)}$$

$$MLSS\ \ in\ \ aeration\ \ tank\ \ (lbs) = 1*2050*8.34 = 17097lbs$$

$$MLSS\ \ in\ \ clarifier\ \ (lbs) = 0.25*2050*8.34 = 4274.3lbs$$

$$SS\ \ effluent\ \ (lbs/day) = 4.25MGD*21.2mg/l*8.34 = 751.4lbs/day$$

$$SS\ \ WAS\ \ (lbs/day) = 0.055MGD*7980mg/l*8.34 = 3660.4lbs/day$$

Plugging in the values calculated above: $MCRT(days) = \frac{17097.6+4274.3}{751.4+3660.4} = 4.8 =$ $\boxed{5days}$

79. Calculate the MCRT given the following.
Plant flow - 1.8 MGD
MLSS conc - 2800 mg/l
WAS flow - 0.04 MGD
MLVSS conc. - 2190 mg/l
Aerator vol - 0.3 MG
Reactor vol. - 0.2 MG
RAS conc. - 8150 mg/l
Effluent SS conc.-18 mg/l
Solution:

$$MCRT(days) = \frac{MLSS\ \ in\ \ aeration\ \ tank\ \ (lbs) + MLSS\ \ in\ \ clarifier\ \ (lbs)}{SS\ \ effluent\ \ (lbs/day) + SS\ \ WAS\ \ (lbs/day)}$$

$$MLSS\ \ in\ \ aeration\ \ tank\ \ (lbs) = 0.3*2800*8.34 = 7005.6lbs$$

$$MLSS\ \ in\ \ clarifier\ \ (lbs) = 0.2*2800*8.34 = 4670.4lbs$$

$$SS\ \ effluent\ \ (lbs/day) = 1.8MGD*18mg/l*8.34 = 270.2lbs/day$$

$SS\ \ WAS\ \ (lbs/day) = 0.04MGD * 8150mg/l * 8.34 = 2718.8lbs/day$

Plugging in the values calculated above: $MCRT\,(days) = \dfrac{7005.6 + 4670.4}{270.2 + 2718.8} = 3.9 = \boxed{4days}$

80. The desired F/M ratio is .35 lbs BOD/day/lb MLVSS. If 2,100 lbs of BOD enter the aerator daily, how many lbs of MLVSS should be maintained in the aeration tank?
Solution:
$$F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$$
$$\implies 0.35 = \frac{2100}{x} \implies x = \boxed{6000lbs\ \ MLVSS}$$

81. Calculate F/M ratio based on the following data:
Secondary influent BOD - 156 mg/l
Four (4) aeration basins - 30 ft x 70 ft x 10 ft. deep
Influent flow - 0.65 MGD
MLSS - 3600 mg/l
MLSS average % volatile - 72%
Solution:
$$F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$$
$$F:M = \frac{156 * 0.65 * 8.34}{3600 * 0.72 * 4 * (30 * 70 * 10)ft^3 * \dfrac{7.48gal}{ft^3} * \dfrac{MG}{1000000gal} * 8.34} = \boxed{0.06}$$

82. An activated sludge plant operates well at an F:M ratio of between 0.23 and 0.28. Calculate the minimum MLSS concentration, given the following: Q = 0.4 MGD Primary influent BOD = 250 mg/l Primary effluent BOD = 128 mg/l Aeration tank vol. = 350,000 gallons Clarifier vol = 250,000 gallons MLSS has 80% volatile solids Solution:
$$F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$$
$$\implies F:M \propto \frac{1}{MLSS\ \ concentration}$$
So to have minimum MLSS conc. F:M needs to be the maximum of the range provided
If the MLSS concentration = x: $\implies F:M = 0.28 = \dfrac{0.4 * 128 * 8.34}{0.35 * x * 0.8} \implies x = \boxed{5446mg/l\ \ MLSS}$

83. If the target MCRT for an activated sludge plant with the following parameters is 8 days, what is the required wasting rate (in gallons per day)? (8 points)
Aeration Tank Volume = 1.5 MG
Clarifier Volume = 1.2 MG
MLSS Concentration = 2500 mg/l
MLSS Volatile Solids = 79%
WAS SS = 5100 mg/l
Secondary Effluent SS = 12 mg/l

Plant flow = 15 MGD

$$MCRT = \frac{(Total\ \ MLSS\ \ lbs\ \ in\ \ the\ \ aeration\ \ system(aeration\ \ tank\ \ +\ \ clarifier))}{(Total\ \ amount\ \ in\ \ \frac{lbs}{day}\ \ of\ \ SS\ \ leaving\ \ the\ \ system(effluent + WAS))}$$

$$MCRT = \frac{(MLSS_{\text{aeration tank}}(lbs)\ \ +\ \ MLSS_{\text{clarifier}}\ \ (lbs))}{(SS_{\text{effluent}}(lbs/day) + SS_{\text{WAS}}(lbs/day))}$$

$$\implies 8days = \frac{(1.5+1.2)MG*8.34*2500\frac{mg}{l}}{(15MGD*12\frac{mg}{l}*8.34)(lbs/day\ \ SS_{\text{effluent}} + (xMGD\ \ WAS*5100\frac{mg}{l}*8.34)(lbs/day\ \ SS_{\text{WAS}})}$$

$$(15*12*8.34(lbs/day)SS_{\text{effluent}} + xMGD\ \ WAS*5100*8.34)(lbs/day)SS_{\text{WAS}} = \frac{(1.5+1.2)MG*8.34*2500}{8}$$

$$xMGD\ \ WAS*5100*8.34(lbs/day)SS_{\text{WAS}} = \frac{(1.5+1.2)MG*8.34*2500}{8} - (15*12*$$
$$8.34(lbs/day)SS_{\text{effluent}}$$

$$42,534x = 5535.7 \implies x = \frac{5535.7}{42,534} = 0.1301MGD = \boxed{130,100\frac{gal}{day}}$$

84. Given the following: Plant Influent Flow: 3.5 MGD

Plant Influent BOD: 276 mg/l

Primary Treatment BOD Removal: 36%

Desired F/M: 0.3

Find lbs of MLVSS that should be maintained in the activated sludge treatment process.

(7 points) $F:M = \frac{lbs\ \ Influent\ \ BOD}{lbs\ \ MLVSS} \implies 0.3 = \frac{276*(1-0.36)*3.5*8.34}{lbsMLVSS} \implies$

$lbs\ \ MLVSS = \boxed{17,187lbs}$

5. Given that an activated sludge plant with an influent flow of 1 MGD is operated at an MCRT of 6 days and the parameters below, calculate the WAS flow rate (wasting rate) in gallon per day. (10 points)

Two aeration tanks – 0.45 MG each	Two final clarifiers – 0.2 MG each
Final effluent $= 16\frac{mg}{l}$	WAS = 6500 ppm
MLSS =$3000\frac{mg}{L}$	MLSS volatile solids content = 85%

Solution:

MCRT= $\frac{lbsMLSS(system)}{\frac{lbs}{day}EffluentSS + \frac{lbs}{day}WASSS}$

lbs MLSS (system)= $(2*0.45+2*0.2)MG*3000\frac{mg}{L}*8.34 = 32,526lbs$

$\frac{lbs}{day}EffluentSS = 1MG*16\frac{mg}{L}*8.34 = 133.4lbs$

$$\text{MCRT: } 6days = \frac{32,526}{133.4\frac{lbs}{day} + \frac{lbs}{day}WASSS}$$

$$\frac{lbs}{day}WASSS = \frac{32,526}{6} - 133.4 = 5,288\frac{lbs}{day}$$

$$5,288\frac{lbs}{day} = WASFlow(MGD) * 6500 * 8.34$$

$$\implies WASFlow(MGD) = \frac{5,288}{6,500 * 8.34} = 0.097546MGD = \boxed{97,546\frac{gal}{day}}$$

85. The desired F/M ratio is 0.35. If 2,100 lbs of BOD enter the aerator daily and the volume of the mixed liquor in the aeration tank is 375,000 gallons , what should be the target MLVSS concentration?

    Solution:

    $F:M = \frac{(lbs/day)\ \ primary\ \ effluent\ \ BOD\ \ entering\ \ the\ \ aeration\ \ tank}{(lbs)\ \ MLVSS\ \ in\ \ the\ \ aeration\ \ tank}$

    $\implies 0.35 = \frac{2100}{x} \implies x = \boxed{6000lbs\ \ MLVSS}$

    $\implies 6,000lbs\ \ MLVSS = 8.34 * \frac{375,000}{1,000,000}MG * x\frac{mg\ \ MLVSS}{L}$

    $\implies x\frac{mg\ \ MLVSS}{L} = \frac{6000}{8.34*0.375} = \boxed{1,900\frac{mg\ \ MLVSS}{L}}$

Solids Treatment Math Problems

1. Calculate the volatile solids reduction in an anaerobic digester given the following information: Raw sludge feed to digester: 73.7 % VS and digested sludge: 57.2 %VS

    *a. 52.3%

    b. 64%

    c. 16.5%

    d. 42%

    Solution:

    The VS reduction of the digester is provided by the Van Kleeck equation

    $Digester\ \ VS\ \ reduction(\%) = \frac{VS_{in} - VS_{out}}{VS_{in} - VS_{in} * VS_{out}} * 100$

    $Digester\ \ VS\ \ reduction(\%) = \frac{0.737 - 0.572}{0.737 - 0.737 * 0.572} * 100 = \boxed{52.3\%}$

2. 42,000 gallons of 6% sludge containing 67% volatile matter is pumped to the digester. The digester reduces the volatile matter by 52%. What volume of sludge in gallons containing 5% solids remains after digestion? [Ans: 32,841 gal]

3. An anaerobic digester is 37' in diameter and 27' deep with a 5,000 gallon daily sludge flow. The sludge is 6% solids and 66% volatile solids. What is the volatile solids loading in pounds per cubic foot per day? [0.057 lbs VS/ft3-day]
4. An Imhoff cone result is 5.5 ml/l. Approximately how many gallons of primary sludge will need to be pumped if the flow is 0.7 MGD? [3,850 gallons]
5. A sludge digester equipped with a floating cover is 31 ft. inside diameter. The corbels are 16 feet above the floor and the top of the wall is 20 feet above the floor. The digester currently has a sludge depth of 16.5 ft. How many gallons of sludge are needed to displace the cover 1 foot? [5,643 galllons]
6. 10,000 gallons/day of sludge is pumped to an anaerobic digester/day at 4% solids (70% VS). If 50% of the VS is destroyed, how many lbs of VS is destroyed per day?
   Solution:
   $\frac{10{,}000\ \ Gal}{day} * \frac{8.34\ \ lbs\ \ sludge}{Gal} \frac{0.04*0.7\ \ lbs\ \ VS\ \ feed}{lb\ \ sludge} * \frac{0.5\ \ lbs\ \ VS\ \ destroyed}{lbs\ \ VS\ \ feed} = \boxed{\frac{1{,}168 lbs\ \ VS\ \ destroyed}{day}}$
7. Two sludges are blended together as follows: 15,000 gal. primary sludge at 4.1% solids. 28,000 gal. secondary sludge at 1.3% solids. What is the combined solids concentration? [Ans. 2.28%] If the primary sludge is 68% VS and the secondary sludge is 63% VS, how many pounds of VS are in the combined sludge? [Ans. 5400.3 lbs VS]
8. 12,000 gallons of 1.8% sludge is pumped to a thickener, and is thickened to 3800 gallons of 4.9% solids. The supernatant is returned back to the head of the STP for treatment. What is the volume in gallons and solids concentration in ppm of the supernatant?[Ans. 24,980 gallons]
9. How many pounds of solids are pumped to a digester each day if the digester receives 10,000 gpd of sludge at 5% solids concentration?
   Solution:
   $\frac{lbs\ \ TS}{day} = \frac{10{,}000 gal\ \ sludge}{day} * \frac{(8.34 * 0.05 lbsTS)}{gal\ \ sludge} = 4{,}170 \frac{lbs\ \ TS}{day}$
10. Calculate the % VS reduction in a digester given the volatile solids content of the influent sludge to the digester is 70% and the volatile solids content of the sludge leaving the digester is 52.5%
    Solution: $Digester\ \ VS\ \ reduction(\%) = \frac{0.7 - 0.525}{0.7 - 0.7 * 0.525} * 100 = \boxed{53\%}$
11. If an anaerobic digester receives sludge with VS of 80% and discharges digested sludge with a 60% VS. Its VS reduction is:
    a. 20%
    b. 25%
    c. 63%
    d. 89%

    Solution:

    $Digester\ \ VS\ \ reduction(\%) = \frac{0.8 - 0.6}{0.8 - 0.8 * 0.6} * 100 = \boxed{63\%}$
12. Calculate the VS loading to the digester in lbs/day if 10,000 gallons of sludge containing

5% TS with and average VS content of 78%

Solution:

Digester VS loading (lbs/day)

$$= \frac{10{,}000\ \ gallons\ \ sludge}{day} * \frac{8.34 lbs\ \ sludge}{gal} * \frac{0.05 * 0.78 lbsVS}{lb\ \ sludge} = \boxed{3{,}253 lbs\ \ sludge\ \ per\ \ day}$$

13. Primary sludge containing five percent (5%) solids is pumped to a digester continuously at a rate of 25 gpm. How many pounds of volatile solids are added to the digester each day if the volatile solids content is 73% of the total solids?

a. 1,310 lbs/day

b. 1,800 lbs/day

c. 9,830 lbs/day

d. 10,960 lbs/day

e. 15,010 lbs/day

Solution:

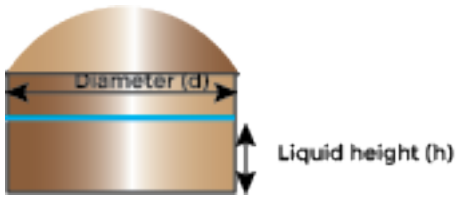
Digester VS loading (lbs/day)

$$= \frac{25 * 1{,}440\ \ gallons\ \ sludge}{day} * \frac{8.34 lbs\ \ sludge}{gal} * \frac{0.05 * 0.73 lbsVS}{lb\ \ sludge} = \boxed{10{,}960\ \ lbs\ \ sludge\ \ per\ \ day}$$

14. An anaerobic digester is 37' in diameter and 27' deep with a 5,000 gallon daily sludge flow. The sludge is 6% solids and 66% volatile solids. What is the volatile solids loading in pounds per cubic foot per day?

Solution:

$$Digester\ \ volatile\ \ solids\ \ loading\ \ rate = \frac{Digester\ \ Loading \frac{lbs\ \ VS}{day}}{Digester\ \ volume(V) ft^3}$$



$$= \frac{5000 \frac{gal\ \ sludge}{day} * (8.34 * 0.06 * 0.66) \frac{lbsVS}{gal\ \ sludge}}{(\frac{\pi}{4} * 37^2 * 27) ft^3} = \boxed{0.057 \frac{lbs\ \ VS}{day - ft^3}}$$

15. How much gas is produced in the above digester in ft^3/day if the digested sludge contains 2.5% total solids of which 59% is volatile solids and the gas production rate is 14 ft^3/lb VS destroyed?

Solution:

$$Digester\ \ VS\ \ reduction(\%) = \frac{0.70 - .59}{0.70 - 0.70 * 0.59} * 100 = 38.3\%$$

$$\frac{lbs\ \ VS\ \ reduction}{day} = \frac{3153 lbs\ \ VS\ \ feed * 0.383\ \ VS\ \ reduction}{day} = 1{,}208 \frac{lbs\ \ VS\ \ reduction}{day}$$

$$\frac{ft^3 gas\ \ produced}{day} = 1208\frac{lbs\ \ VS\ \ reduced}{day} * \frac{14 ft^3\ \ gas\ \ produced}{lb\ \ VS\ \ reduced} = 16{,}912\frac{ft^3\ \ digester\ \ gas\ \ produced}{day}$$

16. The sludge feed to a digester is 80,000 gal/day. The sludge contains 4.5% total solids with 75% volatile solids. If 50% of VS are reduced in the digester:

    (a) Find lbs VS destroyed per 1000 gal of digester capacity per day if the digester radius is 55 ft with an operating sludge level of 25 ft.(5 points)

    Solution:
    Digester Volume: $(\pi * 55^2 * 25) ft^3 * 7.48\frac{gal}{ft^3} = 1{,}776{,}220 gallons = 1{,}776.2\ \ (1000\ \ gallons)$

    $$\frac{lbs\ \ VS\ \ reduction}{day} = \frac{80{,}000 gal * 8.34\frac{lbs}{gal} * (0.045 * 0.75)\frac{lbsVS}{lb} * 0.5\frac{lbs\ \ VS\ \ reduction}{lb\ \ VS}}{day}$$

    $$= 11{,}259\frac{lbs\ \ VS\ \ reduction}{day}$$

    $$\frac{lbs\ \ VS\ \ reduction}{1000\ \ digester\ \ capacity} = \frac{11{,}259\frac{lbs\ \ VS\ \ reduction}{day}}{1{,}776.2\ \ (1000\ \ gallons)} = \boxed{6.3\frac{lbs\ \ VS\ \ reduction}{1000 gallons\ \ digester\ \ volume}}$$

    (b) What is the digester gas production in Btu/day? Assume 14 cu. ft digester gas per lb of VS destroyed and a 650 Btu/cu. ft heating value for the digester gas produced (5 points)

    Solution:
    $$\frac{ft^3 gas\ \ produced}{day} = 11{,}259\frac{lbs\ \ VS\ \ reduced}{day} * \frac{14 ft^3\ \ gas\ \ produced}{lb\ \ VS\ \ reduced} = 157{,}626\frac{ft^3\ \ digester\ \ gas\ \ produced}{day}$$

    $$\frac{BTU\ \ produced}{day} = 157{,}626\frac{ft^3\ \ gas\ \ produced}{day} * \frac{650 BTU\ \ gas\ \ produced}{ft^3 gas} = \boxed{102{,}456{,}900\frac{BTU\ \ produced}{day}}$$

17. The volatile acids concentration of sludge in an anaerobic digester is 195 mg/l. If the maximum volatile acids:alkalinity ratio is 0.087, what should the alkalinity be in mg/l?
    Solution:
    Volatile acid:Alkalinity=0.087=$\frac{195}{x} \implies x = \frac{195}{0.087} = \boxed{2{,}241\frac{mg}{l}}$

18. 10,000 gallons of sludge is pumped to an anaerobic digester/day at 4% solids (70% VS). 50% of the VS are destroyed, creating 15 ft^3 of gas per lbs. of VS destroyed. How much gas is produced each day?

$$\frac{lbs\ \ VS\ \ reduction}{day} = \frac{10,000gal * 8.34\frac{lbs}{gal} * (0.04 * 0.7)\frac{lbsVS}{lb} * \frac{0.5lbs\ \ VS\ \ reduction}{lb\ \ VS}}{day} = 1,168\frac{lbs\ \ VS\ \ reduction}{day}$$

$$\frac{ft^3 gas\ \ produced}{day} = 1,168\frac{lbs\ \ VS\ \ reduced}{day} * \frac{15ft^3\ \ gas\ \ produced}{lb\ \ VS\ \ reduced} = 17,520\frac{ft^3\ \ digester\ \ gas\ \ produced}{day}$$

19. Given a sludge flow of 5,500 gpd with 6.5% solids containing 72% VS to a digester with a VS destruction of 48% If the digester is digester is 40 ft. diameter with a sludge level of 25 ft, find lbs. VS destroyed per 1000 gal of digester capacity per day. What is the digester gas production in Btu/day if the % VS reduction in the digester is 58% and the digester raw sludge feed is 6000 cu. Ft/day containing 4.5% total solids with a 64% VS content? Assume 13.5 cu. ft digester gas per lb of VS destroyed and a 650 Btu/cu. ft heating value for the digester gas produced

Digester Volume: $(\frac{\pi}{4} * 40^2 * 25)ft^3 * 7.48\frac{gal}{ft^3} = 940,086gallons = 940\ \ (1000\ \ gallons)$

$$\frac{lbs\ \ VS\ \ reduction}{day} = \frac{5,500gal * 8.34\frac{lbs}{gal} * (0.065 * 0.72)\frac{lbsVS}{lb} * \frac{0.48lbs\ \ VS\ \ reduction}{lb\ \ VS}}{day} = 1,030\frac{lbs\ \ VS\ \ reduction}{day}$$

$$\frac{lbs\ \ VS\ \ reduction}{1000\ \ digester\ \ capacity} = \frac{1,030\frac{lbs\ \ VS\ \ reduction}{day}}{940\ \ (1000\ \ gallons)} = 1.1\frac{lbs\ \ VS\ \ reduction}{1000gallons\ \ digester\ \ volume}$$

$$\frac{ft^3 gas\ \ produced}{day} = 1,030\frac{lbs\ \ VS\ \ reduced}{day} * \frac{13.5ft^3\ \ gas\ \ produced}{lb\ \ VS\ \ reduced} = 13,905\frac{ft^3\ \ digester\ \ gas\ \ produced}{day}$$

$$\frac{BTU\ \ produced}{day} = 13,905\frac{ft^3\ \ gas\ \ produced}{day} * \frac{650BTU\ \ gas\ \ produced}{ft^3 gas} = 9,038,250\frac{BTU\ \ produced}{day}$$

20. Two sludges are blended together as follows: 60,000 gal per day. primary sludge at 4.5% solids and 28,000 gal secondary sludge at 5% solids.

    (a) What is the combined solids concentration? (3 points)
    $\frac{60,000 * 4.5 + 28,000 * 5}{88,000} = \boxed{4.66\%}$

    (b) How many lbs of solids (per day) are in the combined sludge (3 points)
    $88,000gal * 8.34 * 0.0466 = \boxed{34,200lbs}$

(c) If the primary sludge is 68% VS and the secondary sludge is 83% VS, how many pounds of VS are in the combined sludge? (3 points)

$$60,000gal * \frac{8.34 * 0.045 * 0.68 lbs\ \ VS}{gal} + 28,000gal * \frac{8.34 * 0.05 * 0.83 lbs\ \ VS}{gal} =$$

$$\boxed{25,003 lbs\ \ VS}$$

(d) What is the digester feed VS%? (3 points)

$$\frac{25,003 lbs\ \ VS}{34,200 lbs TS} = \boxed{73.1\%}$$

(e) If the digester is 120' diameter with a liquid height of 20', what is the VS loading in lbs VS/ft3-day (3 points)

$$\frac{25,003 lbs\ \ VS}{0.785 * 120^2 * 20} = \boxed{\frac{0.11 lbs\ \ VS}{day - ft^3}}$$

(f) If the digested sludge has 52% VS, calculate the digester VS reduction percent (3 points)

$$Digester\ \ VS\ \ reduction(\%) = \frac{0.731 - .52}{0.731 - 0.731 * 0.52} * 100 = \boxed{60.1\%}$$

(g) What is the gas production (ft^3/day) if the digester produces 14 ft^3 gas/lb VS destroyed (3 points)

25,003*0.601$\frac{lbs\ \ VS destroyed}{}$ $* \frac{14 ft^3\ \ gas\ \ produced}{lb\ \ VS\ \ destroyed} = \boxed{210,375 ft^3 gas}$

(h) How many belt presses are needed to keep up with the digested sludge flow if the belt presses can be operated at a maximum flow of 50 GPM (3 points)

$$88{,}000 \frac{gal\ \ sludge}{day} * \frac{day}{1440 min} = 61 GPM$$

@50 GPM per press - $\boxed{2\ \ BFP\ \ required}$

(i) If the digested sludge feed to the belt filter presses is 2.6% and assuming the belt press feed solids capture is 90%. How many lbs of solids (dry) are produced by the BFP (4 points)

$$88,000\frac{gal}{day} * 8.34 * 0.026\frac{lbs\ \ solids\ \ feed}{day} * 0.9\frac{lbs\ \ solids\ \ captured}{lbs\ \ solids\ \ feed} = \boxed{17,174 lbs\ \ solids\ \ per\ \ day}$$

(j) If the BFP produces a 20% cake, how many wet tons cake produced per day (4 points)

$$\frac{17,174 lbs\ \ solids\ \ produced}{day} * \frac{100 lbs\ \ cake}{20 lbs\ \ solids\ \ produced} * \frac{tons}{2,000 lbs} = \boxed{\frac{42.9 tons}{day}}$$

(k) If the cake density is 68 lbs/cu. ft, how much time will it take to fill a 30 cu. yd bin (3 points)

(Ans. 15.4 hours) $\frac{(42.9 * 2000) lbs\ \ cake}{day} * \frac{day}{1440 min} = \frac{59.583}{lbs\ \ cake} min$

$$\frac{59.583}{lbs\ \ cake} min * \frac{ft^3}{68 lbs\ \ cake} = \frac{0.876 ft^3}{min}$$

$$30 yd^3 * \frac{27 ft^3}{yd^3} * \frac{min}{0.876 ft^3} * \frac{hrs}{60 min} = \boxed{15.4 hrs}$$

(l) What will be the cost of hauling dewatered cake per day @ $65 per ton cake (2 points)

$$42.9\frac{tons}{day} * \frac{\$65}{ton} = \boxed{\frac{\$2,789}{day}}$$

21. Calculate the VS loading to the digester in lbs/day if 25,000 gallons of sludge containing 4.5% TS with and average VS content of 76% is fed to the digester
22. Calculate the organic loading rate to two 320,000 gallon anaerobic digesters given: Primary sludge feed rate of 25,000 gallons with 6.2% TS containing 73% solids and SG of 1.03. Secondary sludge feed rate of 30,500 gallons with 3.8% TS containing 77% solids (7 points) (Answer: 0.2lbs VS/day-ft3)
23. Calculate the organic loading rate to two 320,000 gallon anaerobic digesters given:
    Primary sludge feed rate of 25,000 gallons with 3.8% TS containing 73% solids and SG of 1.03.
    Secondary sludge feed rate of 30,500 gallons with 3.8% TS containing 77% solids
    (Answer: 0.2 $\frac{lbs\ \ VS}{day - ft^3}$)

24. 325 GPM of WAS with 7,000 mg/l TSS is thickened in a DAFT. Assuming an air:solids ratio of 0.05 lb of air for each lb of feed solids, The SCFM (standard cubic feed per minute) air required to thicken the WAS given 1 SCFM = 0.075 lb is:
(Answer: 12.6 $SCFM$)
Solution:
Correct Answer:

$$0.05 = \frac{lb\ \ air}{lb\ \ solids} = \frac{\frac{0.075\ \ lbs\ \ air}{SCF} * x\ \ SCFM}{(\frac{325}{1,000,000} MG\ \ per\ \ min * 7000 * 8.34)\ \ lbs\ \ solids}$$

$$\Longrightarrow x\ \ SCFM = \frac{0.05 * 325 * 7000 * 8.34}{0.075 * 1,000,000} = \boxed{12.6\ \ SCFM} - Correct\ \ answer$$

Incorrect Answer #1:
12,600SCFM

Incorrect Answer #2:
0.126SCFM

Incorrect Answer #3:
1.26SCFM

25. 30,000 gpd of 4.5% sludge is dewatered in a centrifuge yielding 24.5 yd^3/day of 25% cake with a density of 65 lb per ft^3. Calculate the percentage solids recovery.
(Answer: 95.5%)

26. Estimate the amount of heat value of the gas produced from an anaerobic digester in $\frac{BTU}{day}$ given the following:

Raw sludge pumping schedule	12 min/hr
Sludge pumping rate	68 GPM
Raw sludge %TS	5.2%
Raw sludge %VS	72.5%
Gas production	$\frac{12 ft^3}{lb\ \ VS\ \ destroyed\ \ -\ \ day}$
Percent CO_2	34%
Other gases	1%
Pure methane net heat value	932 $\frac{BTU}{ft^3}$

(Answer: 23,146,220 $\frac{BTU}{day}$)

27. 12,000 ft^3 of anaerobically digested sludge containing 2.8% TS is dewatered in a centrifuge. The centrifuge yields 37 yd^3 of 26% of dewatered cake with a density of 73 lb/ft^3. Calculate the solids capture rate.
Solution:

$$lbs\ \ TS\ \ feed\ \ to\ \ centrifuge = 12{,}000 ft^3\ \ sludge * 7.48 \frac{gal}{ft^3} * \frac{(8.34 * 0.028 lbs\ \ TS)}{gal\ \ sludge} = 20{,}960 lbs\ \ TS$$

$$lbs\ \ TS\ \ feed\ \ from\ \ centrifuge = 37 yd^3\ \ sludge * 27 \frac{ft^3}{yd^3} * \frac{(73 lbs * 0.26\ \ TS)}{ft^3\ \ sludge} = 18{,}961 lbs\ \ TS$$

$$solids\ \ capture\ \ rate = \frac{18{,}961 lbs\ \ solids\ \ produced\ \ by\ \ centrifuge}{20{,}960 lbs\ \ solids\ \ fed\ \ from\ \ digester} * 100 = \boxed{90.4\% solids\ \ capture}$$

28. At a 60 GPM of 2.8% feed a belt press which has a 90% solids capture rate produces a 20% cake at 68 lbs/ft^3. How long would it take to fill a 3 yd^3 bin

Solution:

Approach:

- First calculate the amount of cake solids produced in terms of weight per time.
- From the weight of the cake produced calculate the volume time, and finally
- using the calculated value of the volume of the cake produced per time, calculate the time required to fill the bin

$$\frac{cake\ \ TS\ \ produced - lbs}{min} = \frac{60 gallons\ \ sludge}{min} * \frac{8.34 lbs\ \ sludge\ \ feed}{galllon} * \frac{0.028 lbs\ \ TS}{lb\ \ sludge} * 0.9$$

$$= \frac{12.61 lbs\ \ TS}{min}$$

$$\frac{ft^3\ \ cake\ \ produced}{min} = \frac{12.61 lbs\ \ TS}{min} * \frac{100 lbs\ \ cake}{20 lbs\ \ TS} * \frac{ft^3\ \ cake}{68 lbs\ \ cake} = \frac{0.927 ft^3 cake}{min}$$

$$\frac{ft^3\ \ cake\ \ produced}{min} = \frac{12.61 lbs\ \ TS}{min} * \frac{100 lbs\ \ cake}{20 lbs\ \ TS} * \frac{ft^3\ \ cake}{68 lbs\ \ cake} = \frac{0.927 ft^3 cake}{min}$$

$$Time\ \ required\ \ to\ \ fill\ \ the\ \ bin = \frac{min}{0.927 ft^3} * 3 yd^3 * \frac{27 ft^3}{yd^3} = \boxed{75 min}$$

29. Calculate the annual cost savings for an improvement of cake solids from 20% to 21% if 400 wet tons (@ 20% cake) are produced each day and the average cake hauling and disposal cost is $65 per wet ton.

$$Total\ (dry)\ solids\ produced\ per\ day = \frac{400\ wet\ tons}{day} * \frac{20 tons\ solids}{100 wet\ tons} = 80 tons\ solids$$

$$Tons\ wet\ cake\ @21\%\ solids = \frac{80\ tons\ solids}{day} * \frac{100 wet\ tons}{21 tons\ solids}$$

$$= \frac{380 tons\ wet\ solids}{day}$$

$$Net\ savings\ (\$/yr) = (400-380)\frac{wet\ tons}{day} * 365 * \frac{days}{yr} * \frac{\$65}{wet\ ton} = \boxed{\$474,500\ per\ year}$$

NOTE: General formula for future reference: So if the cake dryness goes up from 20% to 26% and currently a utility is spending $1,000,000 per year for biosolids hauling and disposal, their net savings will be: (26-20)/26*1,000,000 = $230,769. Conversely say if the dewatering cake solids drops to 18%, the net impact will be: (18-20)/18*1,000,000 = $-111,111 (loss or extra cost).

30. Two sludges are blended together as follows: 60,000 gal per day. primary sludge at 4.5% solids and 28,000 gal secondary sludge at 5% solids.

    (a) What is the combined solids concentration? (3 points)
    $$\frac{60,000 * 4.5 + 28,000 * 5}{88,000} = \boxed{4.66\%}$$

    (b) How many lbs of solids (per day) are in the combined sludge (3 points)
    $$88,000 gal * 8.34 * 0.0466 = \boxed{34,200 lbs}$$

    (c) If the primary sludge is 68% VS and the secondary sludge is 83% VS, how many pounds of VS are in the combined sludge? (3 points)
    $$60,000 gal * \frac{8.34 * 0.045 * 0.68 lbs\ VS}{gal} + 28,000 gal * \frac{8.34 * 0.05 * 0.83 lbs\ VS}{gal} =$$
    $$\boxed{25,003 lbs\ VS}$$

    (d) What is the digester feed VS%? (3 points)
    $$\frac{25,003 lbs\ VS}{34,200 lbs TS} = \boxed{73.1\%}$$

    (e) If the digester is 120' diameter with a liquid height of 20', what is the VS loading in lbs VS/ft3-day (3 points)
    $$\frac{25,003 lbs\ VS}{0.785 * 120^2 * 20} = \boxed{\frac{0.11 lbs\ VS}{day - ft^3}}$$

    (f) If the digested sludge has 52% VS, calculate the digester VS reduction percent (3 points)
    $$Digester\ VS\ reduction(\%) = \frac{0.731 - .52}{0.731 - 0.731 * 0.52} * 100 = \boxed{60.1\%}$$

(g) What is the gas production (ft^3/day) if the digester produces 14 ft^3 gas/lb VS destroyed (3 points)

$25{,}003 * 0.601 \frac{lbs\ VS destroyed}{} * \frac{14 ft^3\ gas\ produced}{lb\ VS\ destroyed} = \boxed{210{,}375 ft^3 gas}$

(h) How many belt presses are needed to keep up with the digested sludge flow if the belt presses can be operated at a maximum flow of 50 GPM (3 points)

$88{,}000 \frac{gal\ sludge}{day} * \frac{day}{1440 min} = 61 GPM$

@50 GPM per press - $\boxed{2\ BFP\ required}$

(i) If the digested sludge feed to the belt filter presses is 2.6% and assuming the belt press feed solids capture is 90%. How many lbs of solids (dry) are produced by the BFP (4 points)

$88{,}000 \frac{gal}{day} * 8.34 * 0.026 \frac{lbs\ solids\ feed}{day} * 0.9 \frac{lbs\ solids\ captured}{lbs\ solids\ feed} = \boxed{17{,}174 lbs\ solids\ per\ day}$

(j) If the BFP produces a 20% cake, how many wet tons cake produced per day (4 points)

$\frac{17{,}174 lbs\ solids\ produced}{day} * \frac{100 lbs\ cake}{20 lbs\ solids\ produced} * \frac{tons}{2{,}000 lbs} = \boxed{\frac{42.9 tons}{day}}$

(k) If the cake density is 68 lbs/cu. ft, how much time will it take to fill a 30 cu. yd bin (3 points)

(Ans. 15.4 hours) $\frac{(42.9 * 2000) lbs\ cake}{day} * \frac{day}{1440 min} = \frac{59.583}{lbs\ cake} min$

$\frac{59.583}{lbs\ cake} min * \frac{ft^3}{68 lbs\ cake} = \frac{0.876 ft^3}{min}$

$30 yd^3 * \frac{27 ft^3}{yd^3} * \frac{min}{0.876 ft^3} * \frac{hrs}{60 min} = \boxed{15.4 hrs}$

(l) What will be the cost of hauling dewatered cake per day @ $65 per ton cake (2 points)

$42.9 \frac{tons}{day} * \frac{\$65}{ton} = \boxed{\frac{\$2{,}789}{day}}$

31. 12,000 ft^3 of anaerobically digested sludge containing 2.8% TS is dewatered in a centrifuge. The centrifuge yields 37 yd^3 of 26% of dewatered cake with a density of 73 lb/ft^3. Calculate the solids capture rate.

Solution:

$lbs\ TS\ feed\ to\ centrifuge = 12{,}000 ft^3\ sludge * 7.48 \frac{gal}{ft^3} * \frac{(8.34 * 0.028 lbs\ TS)}{gal\ sludge} = 20{,}976 lbs\ TS$

$lbs\ TS\ feed\ from\ centrifuge = 37 yd^3\ sludge * 27 \frac{ft^3}{yd^3} * \frac{(73 lbs * 0.26\ TS)}{ft^3\ sludge} = 18{,}961 lbs\ TS$

$solids\ capture\ rate = \frac{18{,}961 lbs\ solids\ produced\ by\ centrifuge}{20{,}976 lbs\ solids\ fed\ from\ digester} * 100 = \boxed{90.4\% solids\ capture}$

32. At a 60 GPM of 2.8% feed a belt press which has a 90% solids capture rate produces a

20% cake at 68 lbs/ft^3. How long would it take to fill a 3 yd^3 bin

Solution:

Approach:

- First calculate the amount of cake solids produced in terms of weight per time.
- From the weight of the cake produced calculate the volume time, and finally
- using the calculated value of the volume of the cake produced per time, calculate the time required to fill the bin

$$\frac{cake\ \ TS\ \ produced-lbs}{min} = \frac{60gallons\ \ sludge}{min} * \frac{8.34lbs\ \ sludge\ \ feed}{galllon} * \frac{0.028lbs\ \ TS}{lb\ \ sludge} * 0.9$$

$$= \frac{12.61lbs\ \ TS}{min}$$

$$\frac{ft^3\ \ cake\ \ produced}{min} = \frac{12.61lbs\ \ TS}{min} * \frac{100lbs\ \ cake}{20lbs\ \ TS} * \frac{ft^3\ \ cake}{68lbs\ \ cake} = \frac{0.927ft^3cake}{min}$$

$$\frac{ft^3\ \ cake\ \ produced}{min} = \frac{12.61lbs\ \ TS}{min} * \frac{100lbs\ \ cake}{20lbs\ \ TS} * \frac{ft^3\ \ cake}{68lbs\ \ cake} = \frac{0.927ft^3cake}{min}$$

$$Time\ \ required\ \ to\ \ fill\ \ the\ \ bin = \frac{min}{0.927ft^3} * 3yd^3 * \frac{27ft^3}{yd^3} = \boxed{75min}$$

33. Calculate the annual cost savings for an improvement of cake solids from 20% to 21% if 400 wet tons (@ 20% cake) are produced each day and the average cake hauling and disposal cost is $65 per wet ton.

Solution:

$$Total\ (dry)\ solids\ produced\ per\ day = \frac{400\ wet\ tons}{day} * \frac{20\ tons\ solids}{100\ wet\ tons} = 80\ tons\ solids$$

$$Tons\ wet\ cake\ @21\%\ solids = \frac{80\ tons\ solids}{day} * \frac{100\ wet\ tons}{21\ tons\ solids}$$

$$= \frac{380\ tons\ wet\ solids}{day}$$

$$Net\ savings\ (\$/yr) = (400-380)\frac{wet\ tons}{day} * 365 * \frac{days}{yr} * \frac{\$65}{wet\ ton} = \boxed{\$474,500\ per\ year}$$

NOTE: General formula for future reference: So if the cake dryness goes up from 20% to 26% and currently a utility is spending $1,000,000 per year for biosolids hauling and disposal, their net savings will be: $\frac{(26-20)}{20} * \$1,000,000 = \$300,000$

34. A belt press is used for dewatering 70 GPM digested sludge containing 3% TS, seven hours per day. At the end of the day it produces 24 yd^3 of 16% TS biosolids @ 65 lbs/ft^3 density. What is the percent belt press solids recovery?

Solution:

lbs solids feed to belt press: $\frac{70\ gal}{min} * \frac{8.34\ lbs}{gal} * \frac{0.03\ lbs\ solids}{lb\ feed\ sludge} * \frac{7*60\ min}{day} = \frac{7,356\ lbs\ solids}{day}$

lbs solids in belt press cake: $\frac{24\ yd^3\ cake}{day} * \frac{27\ ft^3}{yd^3} * \frac{65\ lbs\ cake}{ft^3} * \frac{0.16\ lbs\ solids}{lb\ cake} = \frac{6,739\ lbs\ solids}{day}$

belt press solids recovery: $\frac{6,739}{7,356} = \boxed{0.92\ or\ 92\%}$

35. Calculate the air required (SCFM) to meet a 0.04 lb air:lb feed solids ratio for a 100 GPM WAS flow with a solids content of 6500mg/l? Assume 0.08 lbs air/SCF air.

Solution:

$$0.04 = \frac{lb\ air}{lb\ solids} = \frac{\frac{0.08\ lbs\ air}{SCF} * x\ SCF\ per\ minute}{(\frac{100}{1,000,000} MG\ per\ min * 6500 mg/l * 8.34)\ lbs\ solids}$$

$$\Longrightarrow 0.04 = 0.0148\ *\ x\ SCF\ per\ minute \Longrightarrow x\ SCF\ per\ minute = \frac{0.04}{0.0148} = \boxed{2.7\ SCFM}$$

36. A treatment plant receives an influent flow of 30 MGD with a TSS concentration of 280 mg/l. The primary treatment removes 55% TS and the primary sludge is pumped to a 40 ft diameter gravity thickener. Calculate the average solids loading to the thickener in lbs TSS/day-ft^2

Solution:

Solids loading to gravity thickener= $\frac{(30\ MGD\ *\ 280 * 0.55\ mg/l\ * 8.34) lbs\ TSS\ per\ day}{0.785 * 40^2\ ft^2} =$

$\boxed{30.7\ \ lbsTSS/day - ft^2}$

37. Two, 110' diameter digesters with a cone depth of 15 ft and operating at a cylindrical liquid level of 28 ft is fed with a blend of primary and secondary sludge. The 85,000 gal/day primary sludge feed contains 5% solids with a 65% VS content. The secondary sludge flow is 33,000 gallons per day with a 5.5% solids and 86% VS content.

(a) What is the combined solids concentration?

Combined solids concentration:

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

$\implies C_3 = \frac{C_1 * V_1 + C_2 * V_2}{V3} = \frac{C_1 * V_1 + C_2 * V_2}{V_1 + V_2} = \frac{5 * 85,000 + 5.5 * 33,000}{88,000 + 33,000} =$

$\boxed{5.14\% \ TS \ content}$

(b) What is the digester VS loading rate ($lbs \ VS/ft^3$)

Digester VS loading = $\frac{lbs \ VS}{Digester \ volume}$

$$\implies \frac{8.34 * (Pri. \ Sldg \ gal/day * Pri.Sldg \ TS * \%VS + \ Sec. \ sludge \ gal/day * Sec. \ sludgeTS * \%VS)}{2 * \left[\frac{3.14 * D^2 * h_1}{12} + 0.785 * D^2 * h\right]}$$

$$\implies \frac{8.34 * (88,000 \ gal/day * 0.05 * 0.65 \ + \ 33,000 \ gal/day * 0.055 * 0.86)}{2 * \left[\frac{(3.14 * 110^2 * 15}{12} + 0.785 * 110^2 * 28\right]}$$

$= \boxed{0.059 \frac{lbs \ VS}{ft^3}}$

(c) If the digested sludge has 52% VS, calculate the digester VS reduction percent

Calculate VS% in: $= \frac{lbs \ VS}{lbs \ TS} * 100$

$$\implies \frac{8.34 * (Pri. \ Sldg \ gal/day * Pri.Sldg \ TS * \%VS + \ Sec. \ sludge \ gal/day * Sec. \ sludgeTS * \%VS)}{8.34 * (Pri. \ Sldg \ gal/day * Pri.Sldg \ TS + \ Sec. \ sludge \ gal/day * Sec. \ sludgeTS *)}$$

$$\implies \frac{8.34 * (88,000 \ gal/day * 0.05 * 0.65 \ + \ 33,000 \ gal/day * 0.055 * 0.86)}{8.34 * (88,000 \ gal/day * 0.05 \ + \ 33,000 \ gal/day * 0.055)} * 100$$

$= \frac{36,870 lbs \ VS}{51,833 \ lbs \ TS} * 100 = \boxed{71.1\% VS_{in}}$

$Digester \ VS \ reduction(\%) = \frac{0.71 - .52}{0.71 - 0.71 * 0.52} * 100 = \boxed{55.8\% \ VS \ reduction}$

(d) What is the gas production (ft^3/day) if the digester produces 14 ft^3 gas/lb VS destroyed

$36,870 \ lbs \ VS_{in} * 0.558 lbs \ VS \ destroyed * \frac{14 ft^3 \ gas \ produced}{lb \ VS \ destroyed} = \boxed{288,028 \ ft^3 \ gas \ produced}$

(e)

(f) How many belt presses are needed to keep up with the digested sludge flow if the belt presses can be operated at a maximum flow of 50 GPM

$121{,}000 \frac{gal \ sludge}{day} * \frac{day}{1440 min} = 84 GPM$

@50 GPM per press - $\boxed{2\ BFP\ required}$

(g) If the digested sludge feed to the belt filter presses is 2.6% and assuming the belt press feed solids capture is 90%. How many lbs of solids (dry) are produced by the BFP

$$121,000\frac{gal}{day} * 8.34 * 0.026\frac{lbs\ \ solids\ \ feed}{day} * 0.9\frac{lbs\ \ solids\ \ captured}{lbs\ \ solids\ \ feed} = \boxed{23,028 lbs\ \ solids\ \ per\ \ day}$$

(h) If the belt press produces a 20% cake at 68 lbs/ft^3. How long would it take to fill a 3 yd^3 bin?

$$lbs\ \ cake: 23,028\ \frac{lbs\ \ solids}{day} * \frac{lb\ \ cake}{0.2\ \ lb\ \ solids} = 115,140\ \frac{lbs\ \ cake}{day}$$

Volume of cake produced: $115,140\ \frac{lbs\ \ cake}{day} * \frac{ft^3}{68\ \ lbs\ \ cake} * \frac{yd^3}{27\ \ ft^3} * \frac{day}{24\ \ hrs} =$

$2.61\ \frac{yd^3\ \ cake}{hr}$

(i) Time to fill the 3 cu. yd bin: $3\ \ yd^3 * \frac{hr}{2.61 yd^3\ \ cake} = \boxed{1.15\ \ hrs}$

eak

38. Two sludges are blended together as follows: 60,000 gal. primary sludge at 4.5% solids and 28,000 gal. secondary sludge at 5% solids.

(a) What is the combined solids concentration?

(b) If the primary sludge is 68% VS and the secondary sludge is 83% VS, how many pounds of VS are in the combined sludge?

(c) If the digester is 120' diameter cylinder with a liquid height of 20', what is the VS loading in lbs VS/ft^3-day?

(d) If the digester VS reduction is 60%, what is the gas production (ft^3/day) if the digester produces 14 ft^3 gas/lb VS destroyed?

(e) How many belt presses are needed to keep up with the digested sludge flow if the belt presses are operated at a maximum flow of 50 GPM ?

(f) Knowing the digester VS reduction and the TS feed, calculate the solids (TS) concentration coming out of the digesters

(g) Assuming the belt press solids capture is 90%; if it produces a 20% cake which is 68 lbs/ft^3, in how many hours will it take to fill a 3 yd^3 bin with the cake?

Solution:

(a) What is the combined solids concentration?

Combined solids concentration: $C_1 * V_1 + C_2 * V_2 = C_3 * V_3$

$$\implies C_3 = \frac{C_1 * V_1 + C_2 * V_2}{V3} = \frac{C_1 * V_1 + C_2 * V_2}{V_1 + V_2} = \frac{4.5 * 60,000 + 5 * 28,000}{60,000 + 28,000} =$$

$\boxed{4.66\%}$

lbs TS from primary sludge: $(4.5 * 10,000)\frac{mg}{l} TS * \frac{60,000}{1,000,000} MGD * 8.34 =$

$22,518\ \ lbs\ \ TS$

lbs TS from secondary sludge: $(5 * 10,000)\frac{mg}{l} TS * \frac{28,000}{1,000,000} MGD * 8.34 =$

$11,676\ \ lbs\ \ TS$

Total TS = 22,518+11,676=34,194 lbs TS

$$TS\ \ conc.(mg/l) = \frac{34,194\ \ lbs\ \ TS}{8.34 * \frac{88,000}{1,000,000} MGD} = \boxed{46,591 \frac{mg}{l}\ \ or\ \ 4.66\%}$$

(b) If the primary sludge is 68% VS and the secondary sludge is 83% VS, how many pounds of VS are in the combined sludge?

lbs of VS in combined sludge: $C_{VS1} * V_1 + C_{VS2} * V_2 = C_{VS3} * V_3$

$$\implies C_{VS3} = \frac{C_{VS1} * V_1 + C_{VS2} * V_2}{V3} = \frac{C_{VS1} * V_1 + C_{VS1} * V_2}{V_1 + V_2}$$

$$\implies C_{VS3} = \frac{4.5 * 60,000 * 0.68 + 5 * 28,000 * 0.83}{60,000 + 28,000} = 3.406\%$$

$$lbs\ \ VS = 3.41 * 10,000 mg/l * \frac{88,000}{1,000,000} * 8.34 = \boxed{25,027\ \ lbs\ \ VS}$$

lbs VS from primary sludge: $(4.5 * 0.68 * 10,000) \frac{mg}{l} VS * \frac{60,000}{1,000,000} MGD * 8.34 =$ $15,312\ \ lbs\ \ VS$ lbs VS from secondary sludge: $(5 * 0.83 * 10,000) \frac{mg}{l} VS * \frac{28,000}{1,000,000} MGD *$ $8.34 = 9,691\ \ lbs\ \ VS$ Total VS = 15,312+9,691= $\boxed{25,003\ \ lbs\ \ VS}$

(c) If the digester is 120' diameter cylinder with a liquid height of 20', what is the VS loading in lbs VS/ft^3-day?

$$VS\ \ loading = \frac{lbs\ \ VS\ \ per-day}{Digester\ \ volume\ \ (ft^3)} = \frac{25,003\ \ lbs\ \ VS\ \ per-day}{0.785 * 120^2 * 20\ \ ft^3} = \boxed{\frac{0.11\ \ lbs\ \ VS}{day - ft^3}}$$

(d) If the digester VS reduction is 60%, what is the gas production (ft^3/day) if the digester produces 14 ft^3 gas/lb VS destroyed?

$$Digester\ \ gas\ \ production = lbs\ \ VS\ \ reduced * gas\ \ production\ \ rate(ft^3/lb\ \ lbs\ \ VS\ \ reduced$$

$$\implies 25,003 * 0.6\ \ lbs\ \ VSreduced * \frac{14\ \ ft^3\ \ gas}{lb\ \ VS\ \ destroyed} = \boxed{210,025\ \ ft^3\ \ gas\ \ per-day}$$

(e) How many belt presses are needed to keep up with the digested sludge flow if the belt presses are operated at a maximum flow of 50 GPM?

Flow to the belt press=Flow to the digesters as digesters are fixed volume tanks

$\implies$ flow in to the digester = flow out of the digesters - which will be the flow to the belt press

$$\implies \text{flow to the belt press = 88,000 gal} \implies 88,000 \frac{gal}{day} * \frac{day}{1440\ \ min} = 61 \frac{gal}{min}$$

$$\implies @50\ \ GPM\ \ belt\ \ press\ \ flow\ \ capacity\ \ need\ \ \boxed{2\ \ belt\ \ presses}$$

(f) Knowing the digester VS reduction and the TS feed, calculate the solids (TS) concentration coming out of the digesters

Approach: Calculate the lbs of VS destroyed in the digester and subtract that out of the lbs TS feed to the digester. This will be the mass of solids leaving the digester. The mass of solids divided by the volume of the feed (also the out) would be the TS concentration

$$\Longrightarrow \frac{34,194\ lbs\ TS\ feed - 25,003 * 0.6\ lbs\ VS\ reduced}{88,000\ gal * 8.34\ \frac{lbs}{gal} * \frac{10^6 lbs}{1,000,000 lbs}}$$

$$= 20,441 \frac{lbs\ solids}{10^6\ lbs}\ or\ 26,150\ ppm\ or\ \boxed{2.61\%}$$

(g) Assuming the belt press solids capture is 90%; if it produces a 20% cake which is 68 lbs/ft^3, in how many hours will it take to fill a 3 yd^3 bin with the cake?

Approach

i. Calculate the lbs of solids feed to the belt press.
ii. Based on the 90% capture rate, calculate the lbs of solids leaving the belt press.
iii. Knowing the cake is 20% solids, calculate the lbs of cake produced.
iv. Knowing the density of the cake (68 lbs/ft^3), calculate the volume of the cake produced.
v. Knowing the cake volume produced, calculate the time it will take to fill the 3 cu. yd bin

Calculations:

i. $(34,194\ lbs\ TS\ feed - 25,003 * 0.6\ lbs\ VS\ reduced)\ solids\ feed\ belt\ press = 19,192\ lbs\ TS\ solids\ feed$
ii. solids leaving belt press: 19,192*0.9=17,273 lbs
iii. $lbs\ cake: 17,273\ \frac{lbs\ solids}{day} * \frac{lb\ cake}{0.2\ lb\ solids} = 86,365\ \frac{lbs\ cake}{day}$
iv. Volume of cake produced: $86,365\ \frac{lbs\ cake}{day} * \frac{ft^3}{68\ lbs\ cake} * \frac{yd^3}{27\ ft^3} * \frac{day}{24\ hrs} = 1.96\ \frac{yd^3\ cake}{hr}$
v. Time to fill the 3 cu. yd bin: $3\ yd^3 * 1.96\ \frac{hr}{yd^3\ cake} = \boxed{1.53\ hrs}$

Question 1: A sludge thickened from 1% to 4% solids will be reduced in volume by how much?

Solution: Assume 1 lbs of solids are in the sludge.

Sludge weight for 1% solids = 100 lbs because, $1\% \Longrightarrow \frac{100\ lbs\ sludge}{1\ lb\ solids}$

Sludge weight for 4% solids = 25 lbs because, $4\% \Longrightarrow \frac{100\ lbs\ sludge}{4\ lb\ solids}\ or\ \frac{25\ lbs\ sludge}{1\ lb\ solids}$

Thus, sludge weight and volume of the 4% sludge will be 25% of the original 1% sludge

Alternatively, $C_{1(1\%)} * V_{1(1\%)} = C_{2(4\%)} * V_{2(4\%)} \Longrightarrow 0.01 V_{1(1\%)} = 0.04 V_{2(4\%)} \Longrightarrow V_{2(4\%)} = 0.25 V_{1(1\%)}$

Thus, volume of the 4% sludge will be 25% of the original 1% sludge.

39. If a belt filter press is used 14 hrs per day to dewater 90 GPM digester sludge feed with 2.7% solids, the daily lbs solids feed is:

    Solution:

    lbs solids feed to belt press:

    $$90\frac{gal}{min} * 8.34\frac{lbs}{gal} * 0.027\frac{lbs\ \ solids}{lb\ \ feed\ \ sludge} * (14 * 60)\frac{min}{day} = \boxed{17,024\frac{lbs\ \ solids}{day}}$$

40. A belt filter press is used 10 hrs per day to dewater 80 GPM digester sludge feed with 2.5% solids. The belt press produces 22% biosolids (bulk density - 70 lbs/ft^3) which is loaded into trucks for offsite disposal. Five truckloads of biosolids are produced every three days with each truckload averaging 13.3 yd^3 of material.

    (a) Calculate the lbs of solids feed to the belt press (5 points)

    (b) Calculate lbs cake hauled by the trucks over the three days (5 points)

    (c) Calculate the lbs solids in the cake hauled (given the solids % of biosolids) (5 points)

    (d) Calculate percent solids recovery (lbs solids produced per lbs feed solids) (5 points)

    Solution:

    (a) lbs solids feed to belt press:

    $$80\frac{gal}{min} * 8.34\frac{lbs}{gal} * 0.025\frac{lbs\ \ solids}{lb\ \ feed\ \ sludge} * (10 * 60)\frac{min}{day} = \boxed{10,008\frac{lbs\ \ solids}{day}}$$

    (b) lbs cake hauled by truck over three days:

    $$13.3\frac{yd^3\ \ sludge}{truck} * 5\frac{trucks}{three\ \ days} * 27\frac{ft^3}{yd^3} * 70\frac{lbs\ \ cake}{ft^3\ \ sludge} = \boxed{125,685\frac{lbs\ \ cake}{three\ \ days}}$$

    (c) lbs solids in the cake hauled:

    $$125,685\frac{lbs\ \ cake}{three\ \ days} * 0.22\frac{lbs\ \ solids}{lbs\ \ cake} = \boxed{27,651\frac{lbs\ \ solids}{three\ \ days}}$$

    (d) Percent solids recovery:

    $$= \frac{lbs\ \ solids\ \ in\ \ cake}{lbs\ \ solids\ \ fed\ \ to\ \ belt\ \ press} = \frac{27,651\frac{lbs\ \ solids}{three\ \ days}}{10,008 * 3\frac{lbs\ \ solids}{three\ \ days}} = \boxed{0.92\ \ or\ \ 92\%}$$

41. Lab data from your 100,000 gallon primary anaerobic digester, which receives primary sludge only, is shown below. Using this data :

    (a) Calculate the average volatile solids reduction. Compare your calculated value to generally accepted ranges for a healthy anaerobic digester. Comment.

    (b) Compare the other data to expected ranges.

    (c) Is this digester experiencing an operational problem ? If so, what is the problem. Name three steps that may be taken to mitigate the problem.

    (d) Should slake lime be added ? Why or why not ?

Data							
Date	pH	Alkalinity (mg/l)	Volatile acids (mg/l)	CO_2	Raw Sludge (TS%)	Raw Sludge (VS%)	Digested Sludge (VS%)
9/02	7.10	3,200	280	35.5	5.4	65.5	56
9/09	7.00	3,020	320	36.0	5.0	66.7	53.8
9/16	6.90	2,800	400	37.7	4.9	65.9	54.2
9/17	6.85	2,720	450	38.2			

42. Two sludges are blended together as follows: 8,000 cu. ft primary sludge at 4.90% solids and 23,000 gal. secondary sludge at 5.20% solids. What is the combined solids concentration?

    Solution:

    Correct Answer:

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

    $$\Longrightarrow C_3 = \frac{C_1 * V_1 + C_2 * V_2}{V3} = \frac{C_1 * V_1 + C_2 * V_2}{V_1 + V_2} = \frac{4.9 * 8,000 ft^3 * \frac{7.48 gal}{ft^3} + 5.2 * 23,000}{8000 * 7.48 + 23,000} =$$

    $\boxed{4.98\%}$ $-$ *Correct Answer*

    Incorrect Answer #1

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

    $$\Longrightarrow C_3 = \frac{C_1 * V_1 + C_2 * V_2}{V3} = \frac{C_1 * V_1 + C_2 * V_2}{V_1 + V_2} = \frac{4.9 * 8,000 ft^3 + 5.2 * 23,000}{8000 + 23,000} =$$

    $\boxed{5.12\%}$ $-$ *Incorrect Answer*#1

    Incorrect Answer #2

    6.23%

    Incorrect Answer #3

    3.84%

43. You have two 110 foot diameter primary clarifiers. The raw wastewater flow of 1.5 MGD is divided equally between the these two basins. Raw settled primary sludge is pumped continuously from both clarifiers for thickening in a single 40 foot diameter gravity thickener. The average suspended solids are 210 mg/l for the raw influent flow and 85 mg/l for the primary effluent. Calculate the average solids loading on the thickener in pounds/ft^2/day Ans. 1.25lbs/ft^2/day

44. A belt filter press is used 10 hrs per day to dewater 80 GPM digester sludge feed with 2.5% solids.

45. A belt filter press is used 10 hrs per day to dewater 80 GPM digester sludge feed with 2.5% solids. The belt press produces 22% biosolids (bulk density - 70lbs/cu. ft) which is loaded into trucks for offsite disposal. Five truckloads of biosolids are produced every three days with each truckload averaging 13.3 cu. yd of material.

    (a) Calculate the lbs of solids feed to the belt press (5 points)
    (b) Calculate lbs cake hauled by the trucks over the three days (5 points)
    (c) Calculate the lbs solids in the cake hauled (given the solids % of biosolids) (5 points)
    (d) Calculate percent solids recovery (lbs solids produced per lbs feed solids) (5 points)
    (e) Two sludges are blended together as follows: 8,000 cu. ft primary sludge at 4.90% solids and 23,000 gal. secondary sludge at 5.20% solids. What is the combined solids concentration?

        a. 3.84

        b. 6.23

c. 5.12

*d. 4.98

46. 325 GPM of WAS with 7,000 mg/l TSS is thickened in a DAFT. Assuming an air:solids ratio of 0.05 lb of air for each lb of feed solids, The SCFM (standard cubic feed per minute) air required to thicken the WAS given 1 SCFM = 0.075 lb is:
    *a. 12.6 SCFM
    b. 0.126 SCFM
    c. 12,600 SCFM
    d. 1.26 SCFM
47. When you spread sludge on agricultural land, the annual application rate of cadmium in the sludge should be less than 2 lbs/acre/year If your sludge contains 30 mg cadmium per kilogram of solids and your plant produces 950,000 lbs per year of dry solids, how many acres do you need?
    a. 3 acres
    *b. 14 acres
    c. 19 acres
    d. 27 acres
48. 42,000 gallons of 6% sludge containing 67% volatile matter is pumped to the digester. The digester reduces the volatile matter by 52%. What volume of sludge in gallons containing 5% solids remains after digestion? [Ans: 32,841 gal]
49. An Imhoff cone result is 5.5 ml/l. Approximately how many gallons of primary sludge will need to be pumped if the flow is 0.7 MGD? [3,850 gallons]
50. A sludge digester equipped with a floating cover is 31 ft. inside diameter. The corbels are 16 feet above the floor and the top of the wall is 20 feet above the floor. The digester currently has a sludge depth of 16.5 ft. How many gallons of sludge are needed to displace the cover 1 foot? [5,643 galllons]
51. 10,000 gallons of sludge is pumped to an anaerobic digester/day at 4% solids (70% VS). 50% of the VS are destroyed, creating 10 ft.3 of gas per lbs. of VS destroyed. How much gas is produced each day? [Ans. 11,676 cu. ft/day]
52. Two sludges are blended together as follows: 15,000 gal. primary sludge at 4.1% solids. 28,000 gal. secondary sludge at 1.3% solids. What is the combined solids concentration? [Ans. 2.28%] If the primary sludge is 68% VS and the secondary sludge is 63% VS, how many pounds of VS are in the combined sludge? [Ans. 5400.3 lbs VS]
53. 12,000 gallons of 1.8% sludge is pumped to a thickener, and is thickened to 3800 gallons of 4.9% solids. The supernatant is returned back to the head of the STP for treatment. What is the volume in gallons and solids concentration in ppm of the supernatant?[Ans. 24,980 gallons]
54. How many pounds of solids are pumped to a digester each day if the digester receives 10,000 gpd of sludge at 5% solids concentration?
    Solution:

$$\frac{lbs\ \ TS}{day} = \frac{10{,}000 gal\ \ sludge}{day} * \frac{(8.34 * 0.05 lbsTS)}{gal\ \ sludge} = 4{,}170 \frac{lbs\ \ TS}{day}$$

55. Calculate the % VS reduction in a digester given the volatile solids content of the influent sludge to the digester is 70% and the volatile solids content of the sludge leaving the digester is 52.5%

    Solution: $Digester\ \ VS\ \ reduction(\%) = \frac{0.7 - 0.525}{0.7 - 0.7 * 0.525} * 100 = \boxed{53\%}$

56. Calculate the VS loading to the digester in lbs/day if 10,000 gallons of sludge containing 5% TS with and average VS content of 78%

    Solution:

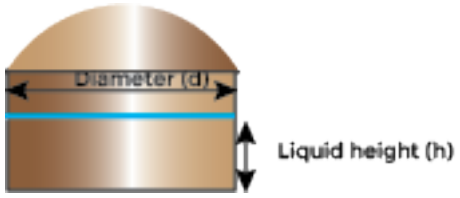
    Digester VS loading (lbs/day)

    $= \frac{10{,}000\ \ gallons\ \ sludge}{day} * \frac{8.34 lbs\ \ sludge}{gal} * \frac{0.05 * 0.78 lbsVS}{lb\ \ sludge} = \boxed{3{,}253 lbs\ \ sludge\ \ per\ \ day}$

57. The sludge feed to a digester is 12,000 ft^3/day. The sludge contains 4.5% total solids with 70% volatile solids. What is the digester loading in lbs VSS/day per ft^3 if the digester diameter is 100 ft and a working sludge level of 20 ft.

    Solution:

    $$Digester\ \ volatile\ \ solids\ \ loading\ \ Rate = \frac{Digester\ \ loading \frac{lbs\ \ VS}{day}}{Digester\ \ volume(V) ft^3}$$

    $$= \frac{12{,}000 \frac{ft^3\ \ sludge}{day} * 7.48 \frac{gal}{ft^3} * (8.34 * 0.045 * 0.70) \frac{lbsVS}{gal\ \ sludge}}{(\frac{\pi}{4} * 100^2 * 20) ft^3} = \boxed{0.15 \frac{lbs\ \ VS}{day - ft^3}}$$

58. How much gas is produced in the above digester in ft^3/day if the digested sludge contains 2.5% total solids of which 59% is volatile solids and the gas production rate is 14 ft^3/lb VS destroyed?

    Solution:

    $Digester\ \ VS\ \ reduction(\%) = \frac{0.70 - .59}{0.70 - 0.70 * 0.59} * 100 = 38.3\%$

    $$\frac{lbs\ \ VS\ \ reduction}{day} = \frac{3153 lbs\ \ VS\ \ feed * 0.383\ \ VS\ \ reduction}{day} = 1{,}208 \frac{lbs\ \ VS\ \ reduction}{day}$$

    $$\frac{ft^3 gas\ \ produced}{day} = 1208 \frac{lbs\ \ VS\ \ reduced}{day} * \frac{14 ft^3\ \ gas\ \ produced}{lb\ \ VS\ \ reduced} = 16{,}912 \frac{ft^3\ \ digester\ \ gas\ \ produced}{day}$$

59. The sludge feed to a digester is 80,000 gal/day. The sludge contains 4.5% total solids with 75% volatile solids. If 50% of VS are reduced in the digester:

    (a) Find lbs VS destroyed per 1000 gal of digester capacity per day if the digester radius is 55 ft with an operating sludge level of 25 ft.(5 points)

Solution:

Digester Volume: $(\pi * 55^2 * 25) ft^3 * 7.48 \frac{gal}{ft^3} = 1,776,220 gallons = 1,776.2 \ \ (1000 \ \ gallons)$

$$\frac{lbs \ \ VS \ \ reduction}{day} = \frac{80,000 gal * 8.34 \frac{lbs}{gal} * (0.045 * 0.75) \frac{lbsVS}{lb} * 0.5 \frac{lbs \ \ VS \ \ reduction}{lb \ \ VS}}{day}$$

$$= 11,259 \frac{lbs \ \ VS \ \ reduction}{day}$$

$$\frac{lbs \ \ VS \ \ reduction}{1000 \ \ digester \ \ capacity} = \frac{11,259 \frac{lbs \ \ VS \ \ reduction}{day}}{1,776.2 \ \ (1000 \ \ gallons)} = \boxed{6.3 \frac{lbs \ \ VS \ \ reduction}{1000 gallons \ \ digester \ \ volume}}$$

(b) What is the digester gas production in Btu/day? Assume 14 cu. ft digester gas per lb of VS destroyed and a 650 Btu/cu. ft heating value for the digester gas produced (5 points)

Solution:

$$\frac{ft^3 gas \ \ produced}{day} = 11,259 \frac{lbs \ \ VS \ \ reduced}{day} * \frac{14 ft^3 \ \ gas \ \ produced}{lb \ \ VS \ \ reduced} = 157,626 \frac{ft^3 \ \ digester \ \ gas \ \ produced}{day}$$

$$\frac{BTU \ \ produced}{day} = 157,626 \frac{ft^3 \ \ gas \ \ produced}{day} * \frac{650 BTU \ \ gas \ \ produced}{ft^3 gas} = \boxed{102,456,900 \frac{BTU \ \ produced}{day}}$$

60. Two sludges are blended together as follows: 15,000 gal. primary sludge at 4.1% solids. 28,000 gal. secondary sludge at 1.3% solids. What is the combined solids concentration? If the primary sludge is 68% VS and the secondary sludge is 63% VS, what is the VS concentration (%) in the combined sludge?

Solution:

Combined solids concentration: $C_1 * V_1 + C_2 * V_2 = C_3 * V_3$

$$\implies C_3 = \frac{C_1 * V_1 + C_2 * V_2}{V3} = \frac{C_1 * V_1 + C_2 * V_2}{V_1 + V_2} = \frac{4.1 * 15,000 + 1.3 * 28,000}{15,000 + 28,000} = \boxed{2.28\%}$$

Lbs of VS in combined sludge: $C_{VS1} * V_1 + C_{VS2} * V_2 = C_{VS3} * V_3$

$$\implies C_{VS3} = \frac{C_{VS1} * V_1 + C_{VS2} * V_2}{V3} = \frac{C_{VS1} * V_1 + C_{VS1} * V_2}{V_1 + V_2}$$

$$\implies C_{VS3} = \frac{4.1 * 15,000 * 0.68 + 1.3 * 28,000 * 0.63}{15,000 + 28,000} = \boxed{1.50\%}$$

61. 10,000 gallons of sludge is pumped to an anaerobic digester/day at 4% solids (70% VS). 50% of the VS are destroyed, creating 15 ft^3 of gas per lbs. of VS destroyed. How much gas is produced each day?

$$\frac{lbs\ \ VS\ \ reduction}{day} = \frac{10,000gal * 8.34\frac{lbs}{gal} * (0.04 * 0.7)\frac{lbsVS}{lb} * \frac{0.5lbs\ \ VS\ \ reduction}{lb\ \ VS}}{day} =$$

$$1,168\frac{lbs\ \ VS\ \ reduction}{day}$$

$$\frac{ft^3 gas\ \ produced}{day} = 1,168\frac{lbs\ \ VS\ \ reduced}{day} * \frac{15ft^3\ \ gas\ \ produced}{lb\ \ VS\ \ reduced} = 17,520\frac{ft^3\ \ digester\ \ gas\ \ produced}{day}$$

62. Two sludges are blended together as follows: 60,000 gal per day. primary sludge at 4.5% solids and 28,000 gal secondary sludge at 5% solids.

(a) What is the combined solids concentration? (3 points)

$$\frac{60,000 * 4.5 + 28,000 * 5}{88,000} = \boxed{4.66\%}$$

(b) How many lbs of solids (per day) are in the combined sludge (3 points)

$$88,000gal * 8.34 * 0.0466 = \boxed{34,200lbs}$$

(c) If the primary sludge is 68% VS and the secondary sludge is 83% VS, how many pounds of VS are in the combined sludge? (3 points)

$$60,000gal * \frac{8.34 * 0.045 * 0.68lbs\ \ VS}{gal} + 28,000gal * \frac{8.34 * 0.05 * 0.83lbs\ \ VS}{gal} =$$

$$\boxed{25,003lbs\ \ VS}$$

(d) What is the digester feed VS%? (3 points)

$$\frac{25,003lbs\ \ VS}{34,200lbsTS} = \boxed{73.1\%}$$

(e) If the digester is 120' diameter with a liquid height of 20', what is the VS loading in lbs VS/ft3-day (3 points)

$$\frac{25,003lbs\ \ VS}{0.785 * 120^2 * 20} = \boxed{\frac{0.11lbs\ \ VS}{day - ft^3}}$$

(f) If the digested sludge has 52% VS, calculate the digester VS reduction percent (3 points)

$$Digester\ \ VS\ \ reduction(\%) = \frac{0.731 - .52}{0.731 - 0.731 * 0.52} * 100 = \boxed{60.1\%}$$

(g) What is the gas production (ft^3/day) if the digester produces 14 ft^3 gas/lb VS destroyed (3 points)

$$25{,}003 * 0.601 \frac{lbs\ \ VS destroyed}{} * \frac{14 ft^3\ \ gas\ \ produced}{lb\ \ VS\ \ destroyed} = \boxed{210{,}375 ft^3 gas}$$

(h) How many belt presses are needed to keep up with the digested sludge flow if the belt presses can be operated at a maximum flow of 50 GPM (3 points)

$$88{,}000 \frac{gal\ \ sludge}{day} * \frac{day}{1440 min} = 61 GPM$$

@50 GPM per press - $\boxed{2\ \ BFP\ \ required}$

(i) If the digested sludge feed to the belt filter presses is 2.6% and assuming the belt press feed solids capture is 90%. How many lbs of solids (dry) are produced by the BFP (4 points)

$$88{,}000 \frac{gal}{day} * 8.34 * 0.026 \frac{lbs\ \ solids\ \ feed}{day} * 0.9 \frac{lbs\ \ solids\ \ captured}{lbs\ \ solids\ \ feed} = \boxed{17{,}174 lbs\ \ solids\ \ per\ \ day}$$

(j) If the BFP produces a 20% cake, how many wet tons cake produced per day (4 points)

$$\frac{17{,}174 lbs\ \ solids\ \ produced}{day} * \frac{100 lbs\ \ cake}{20 lbs\ \ solids\ \ produced} * \frac{tons}{2{,}000 lbs} = \boxed{\frac{42.9 tons}{day}}$$

(k) If the cake density is 68 lbs/cu. ft, how much time will it take to fill a 30 cu. yd bin (3 points)

(Ans. 15.4 hours) $$\frac{(42.9 * 2000) lbs\ \ cake}{day} * \frac{day}{1440 min} = \frac{59.583}{lbs\ \ cake} min$$

$$\frac{59.583}{lbs\ \ cake} min * \frac{ft^3}{68 lbs\ \ cake} = \frac{0.876 ft^3}{min}$$

$$30 yd^3 * \frac{27 ft^3}{yd^3} * \frac{min}{0.876 ft^3} * \frac{hrs}{60 min} = \boxed{15.4 hrs}$$

(l) What will be the cost of hauling dewatered cake per day @ $65 per ton cake (2 points)

$$42.9 \frac{tons}{day} * \frac{\$65}{ton} = \boxed{\frac{\$2,789}{day}}$$

63. Calculate the VS loading to the digester in lbs/day if 25,000 gallons of sludge containing 4.5% TS with and average VS content of 76% is fed to the digester

Solution:

$$\frac{25,000\ \ Gal}{day} * \frac{8.34\ \ lbs\ \ sludge}{Gal} * \frac{(0.045 * 0.76)\ \ lbs\ \ VS\ \ feed}{lb\ \ sludge} = \boxed{\frac{7,131\ \ lbs\ \ VS}{day}}$$

64. Calculate the organic loading rate to two 320,000 gallon anaerobic digesters given: Primary sludge feed rate of 25,000 gallons with 6.2% TS containing 73% solids and SG of 1.03. Secondary sludge feed rate of 30,500 gallons with 3.8% TS containing 77% solids (7 points) (Answer: 0.2lbs VS/day-ft3)
65. 10,000 gallons/day of sludge is pumped to an anaerobic digester/day at 4% solids (70% VS). If 50% of the VS is destroyed, how many lbs of VS is destroyed per day?

Solution:

$$\frac{10,000\ \ Gal}{day} * \frac{8.34\ \ lbs\ \ sludge}{Gal} \frac{0.04 * 0.7\ \ lbs\ \ VS\ \ feed}{lb\ \ sludge} * \frac{0.5\ \ lbs\ \ VS\ \ destroyed}{lbs\ \ VS\ \ feed} =$$

$$\boxed{\frac{1,168 lbs\ \ VS\ \ destroyed}{day}}$$

66. Two sludges are blended together as follows: 8,000 cu. ft primary sludge at 4.90% solids and 23,000 gal. secondary sludge at 5.20% solids. What is the combined solids concentration?

a. 3.84

b. 6.23

c. 5.12

*d. 4.98

67. Calculate the VS loading to the digester in lbs/day if 10,000 cu. ft of sludge containing 4.8% TS with and an average VS content of 82% (Ans: 24,554)
68. Calculate the VS loading to the digester in lbs/day if 25,000 gallons of sludge containing 4.5% TS with and average VS content of 76% is fed to the digester (Ans: 7,131)
69. Calculate the % VS reduction in a digester given the volatile solids content of the feed sludge to the digester is 76% and the volatile solids content of the sludge leaving the digester is 55% (Ans: 61.4)
70. If an anaerobic digester receives sludge with VS of 76% and discharges digested sludge

with a 56% VS. Its VS reduction is:

a. 36%

b. 48%

*c. 60%

d. 89%

71. Calculate the VS loading to the digester in lbs/day if 25,000 gallons of sludge containing 4.5% TS with and average VS content of 76% is fed to the digester
Correct Answer(s): a. 7131.0

72. Calculate the organic loading rate to two 320,000 gallon anaerobic digesters given: Primary sludge feed rate of 25,000 gallons with 6.2% TS containing 73% solids and SG of 1.03. Secondary sludge feed rate of 30,500 gallons with 3.8% TS containing 77% solids (7 points) (Answer: 0.2lbs VS/day-ft3)
Correct Answer(s):

73. Calculate the VS loading to the digester in lbs/day if 25,000 gallons of sludge containing 4.5% TS with and average VS content of 76% is fed to the digester

*a. 7,131 lbs/day

b. 17,432 lbs/day

c. 19,256 lbs/day

d. 26,244 lbs/day

74. What is the digester efficiency if the volatile solids concentration entering an anaerobic digester is 70% and the volatile solids concentration leaving the digester is 50%?

*a. 29%

b. 40%

c. 57%

d. 71%

75. You are operating a 1 MGD trickling filter plant with a single stage anaerobic digester You pump about 3,000 gpd of sludge to the fixed cover digester. The supernatant has a BOD of 950 mg/l The BOD loading coming from the supernatant in pounds per day is

a. 12

*b. 24

c. 36

d. 48

76. How many pounds of solids are pumped to a digester each day, if the digester receives 10,000 gpd of sludge at 5% density?

a. 417 lbs/day

b. 1,497 lbs/day

c. 2,337 lbs/day

d. 3,273 lbs/day

*e. 4,170 lbs/day

77. If a digester loading is 0.05 lbs VSS/ft3/Day, how large must the digester be if it receives

1,000 lbs. of suspended solids per day with a volatile percentage of 75%?

a. 3,750 cu.ft

b. 10,000 cu.ft

*c. 15,000 cu.ft

d. 26,666 cu.ft

e. 37,500 cu.ft

78. What is the digester efficiency if the volatile solids concentration entering an anaerobic digester is 70% and the volatile solids concentration leaving the digester is 50%?

*a. 29%

b. 40%

c. 57%

d. 71%

79. You are operating a 1 MGD trickling filter plant with a single stage anaerobic digester You pump about 3,000 gpd of sludge to the fixed cover digester. The supernatant has a BOD of 950 mg/l The BOD loading coming from the supernatant in pounds per day is

a. 12

*b. 24

c. 36

d. 48

80. How many pounds of solids are pumped to a digester each day, if the digester receives 10,000 gpd of sludge at 5% density?

a. 417 lbs/day

b. 1,497 lbs/day

c. 2,337 lbs/day

d. 3,273 lbs/day

*e. 4,170 lbs/day

81. If a digester loading is 0.05 lbs VSS/ft3/Day, how large must the digester be if it receives 1,000 lbs. of suspended solids per day with a volatile percentage of 75%?

a. 3,750 cu.ft

b. 10,000 cu.ft

*c. 15,000 cu.ft

d. 26,666 cu.ft

e. 37,500 cu.ft

Disinfection Math Problems

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

   Solution:

   Chlorine dosage = chlorine demand + chlorine residual

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

2. 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.
   Solution:
   $lbs/day = conc.(mg/l) * flow(MGD) * 8.34$
   $lbs/day = 12 * 5 * 8.34 = \boxed{500.4 lbs/day}$

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

   Solution:

   Applying the pounds formula:
   $lbs/day = conc.(mg/l) * flow(MGD) * 8.34$

   $\implies conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{80}{1.5*8.34} = \boxed{6.4 mg/l}$

4. 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

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

5. 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.
   Solution:
   Chlorine dosage = chlorine demand + chlorine residual

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

   To calculate pounds per day, applying the pounds formula:

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

6. 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.
   a. 4.9 mg/l
   b. 5.7 mg/l
   c. 7.5 mg/l
   d. 8.3 mg/l

   Solution:
   $Chlorine\ \ dosage(lbs/day) = conc.(mg/l) * flow(MGD) * 8.34$
   $\implies chlorine\ \ dosage\ \ conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{75}{1.2*8.34} = 7.5 mg/l$
   Chlorine dosage = chlorine demand + chlorine residual

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

7. 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?
   Prior to sand filtration, a secondary effluent flow of 5 MGD Solution:
   Prior to sand filtration, a secondary effluent flow of 5 MGD $Chlorine\ \ dosage(lbs/day) = conc.(mg/l) * flow(MGD) * 8.34 = 24 * 0.5 * 8.34 = \boxed{100lbs/day}$
8. 25 lbs/day of chlorine is being applied to a wastewater effluent flow of 250,000 gpd. Calculate the chlorine dosage in mg/l.
   Solution:
   $lbs/day = conc.(mg/l) * flow(MGD) * 8.34$
   $\Longrightarrow$ $conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{25}{0.25*8.34} = \boxed{12mg/l}$
9. 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?
   Solution:
   $lbs/day = conc.(mg/l) * flow(MGD) * 8.34 = 5 * 11.5 * 8.34 = \boxed{480lbs/day}$
   No. Chlorine residual is for disinfection only. Odor control would not require a residual
10. 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?
    Solution: $chlorine\ \ dosage = chlorine\ \ demand\ \ +\ \ chlorine\ \ residual$
    $\Longrightarrow$ $chlorine\ \ dosage = (12.5\ \ +\ \ 1)mg/l = 13.5mg/l$
    $lbs/day = 13.5(mg/l) * 1(MGD) * 8.34 = \boxed{112.6lbs/day}$
11. 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?
    Solution:
    a. $Chlorine\ \ dosage(lbs/day) = conc.(mg/l) * flow(MGD) * 8.34$
    $\Longrightarrow$ $chlorine\ \ dosage\ \ conc.(mg/l) = \frac{lbs/day}{flow(MGD)*8.34} = \frac{120}{3.5*8.34} = \boxed{4.1mg/l}$
    b. Chlorine dosage = chlorine demand + chlorine residual
    $\Longrightarrow$ $chlorine\ \ demand = chlorine\ \ dosage - chlorine\ \ residual = 4.1 - 1.3 = \boxed{2.8mg/l}$
12. 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?
    Solution:
    $Chlorine\ \ dosage(lbs/day) = conc.(mg/l) * flow(MGD) * 8.34 = 24 * 0.5 * 8.34 = \boxed{100lbs/day}$
13. 25 lbs/day of chlorine is being applied to a wastewater effluent flow of 250,000 gpd. Calculate the chlorine dosage in mg/l.

Solution:

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

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

14. 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?

    Solution:

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

    No. Chlorine residual is for disinfection only. Odor control would not require a residual

15. 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?

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

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

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

16. 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?

    Solution:

    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

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

17. 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:

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

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

    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 = $\boxed{\$63.88}$

18. Three hundred pounds (300 lbs) per day of chlorine (cost = \$0.32/lb) are being used to disinfect a secondary effluent flow of 6.5 MGD. Due to safety concerns, the substitution of sodium hypochlorite (12.5% available chlorine, 10.0 lbs/gal and a cost of \$0.55/gal) for the chlorine is being considered at this plant. What is the cost difference per day between the chlorine and sodium hypochlorite?

    (Ans:\$36/year)

19. 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

    SOLUTION

    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:

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

20. 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:
    $0.785 * 30^2 * 18.5 ft^3 * 7.48 \frac{gal}{ft^3} = 97,765 gal$

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

21. 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.
    *a. 130
    b. 116
    c. 112
    d. 18
    e. 16
22. 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.
    *a. 4.9 mg/l
    b. 5.7 mg/l
    c. 7.5 mg/l
    d. 8.3 mg/l
23. Assuming that a chlorine residual of 0.5 mg/l is being maintained and the chlorine demand is 19.5 mg/l, approximately how many pounds of chlorine per day will be required to treat a flow of 5.0 MGD?
    a. 21 lbs
    b. 792 lbs
    c. 813 lbs
    *d. 834 lbs
24. 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.
    *a. 4.9 mg/l
    b. 5.7 mg/l
    c. 7.5 mg/l
    d. 8.3 mg/l
25. If 25 Ibs/day of chlorine is being applied to a wastewater effluent flow of 250,000 gpd. Calculate the chlorine demand in mg/l if the chlorine residue is 1.2 mg/l.
    a. 2.5 mg/l
    *b. 10.8 mg/l

c. 15.1 mg/l

d. 6.3 mg/l

26. Calculate how many pounds per day of chlorine should be used to maintain a dosage of 12 mg/l at 6.0 MGD flow

a. 60 lbs/day

b. 450 lbs/day

c. 500 lbs/day

*d. 600 lbs/day

e. 6,700 lbs/day

27. 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.

*a. 4.9 mg/l

b. 5.7 mg/l

c. 7.5 mg/l

d. 8.3 mg/l

28. Chlorine is being fed at the rate of 200 pounds per day. Plant flow is 4 MGD. The chlorine residual is measured and found to be 3 mg/l Calculate chlorine demand.

a. 3 mg/l

*b. 2 mg/l

c. 16 mg/l

d. 9 mg/l

29. 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.

*a. 130

b. 116

c. 112

d. 18

e. 16

30. 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.

*a. 4.9 mg/l

b. 5.7 mg/l

c. 7.5 mg/l

d. 8.3 mg/l

31. Assuming that a chlorine residual of 0.5 mg/l is being maintained and the chlorine demand is 19.5 mg/l, approximately how many pounds of chlorine per day will be required to treat a flow of 5.0 MGD?

a. 21 lbs

b. 792 lbs

c. 813 lbs

*d. 834 lbs

32. 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.
    *a. 4.9 mg/l
    b. 5.7 mg/l
    c. 7.5 mg/l
    d. 8.3 mg/l
33. If 25 Ibs/day of chlorine is being applied to a wastewater effluent flow of 250,000 gpd. Calculate the chlorine demand in mg/l if the chlorine residue is 1.2 mg/l.
    a. 2.5 mg/l
    *b. 10.8 mg/l
    c. 15.1 mg/l
    d. 6.3 mg/l
34. Calculate how many pounds per day of chlorine should be used to maintain a dosage of 12 mg/l at 6.0 MGD flow
    a. 60 lbs/day
    b. 450 lbs/day
    c. 500 lbs/day
    *d. 600 lbs/day
    e. 6,700 lbs/day
35. What is the chlorine residual of a 2.5 MGD secondary effluent stream if its chlorine demand is 9 mg/l and is treated with 300 lbs/day chlorine? Ans: 5.4
36. How many lbs per day of chlorine is required to maintain a dosage of 12 mg/l for a 5 MGD flow? Ans: 500.4
37. What is the chlorine residual of a 2.5 MGD secondary effluent stream if its chlorine demand is 9 mg/l and is treated with 300 lbs/day chlorine? Ans: 5.4
38. How many lbs per day of chlorine is required to maintain a dosage of 12 mg/l for a 5 MGD flow? Ans: 500.4
39. What is the chlorine residual of a 2.5 MGD secondary effluent Ans: 5.4
40. How many lbs per day of chlorine is required to maintain a dosage of 12 mg/l for a 5 MGD flow? Ans: 500.4
41. 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? Ans: 100.0
42. 25 lbs/day of chlorine is being applied to a wastewater effluent ow of 250,000 gpd. Calculate the chlorine dosage in mg/l. Ans: 12.0
43. You wish to dose the in 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? Ans:480.0
44. 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? Ans: 112.6

45. What is the chlorine dosage if the chlorinator is feeding 120 lbs/day and the average daily flow is 3.5 MGD? Ans: 4.1
46. What is the chlorine residual of a 2.5 MGD secondary effluent stream if its chlorine demand is 9 mg/l and is treated with 300 lbs/day chlorine? Ans: 5.4
47. How many lbs per day of chlorine is required to maintain a dosage of 12 mg/l for a 5 MGD flow? Ans: 500.4
48. 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.
    *a. 4.9 mg/l
    b. 5.7 mg/l
    c. 7.5 mg/l
    d. 8.3 mg/l
49. 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.
    *a. 4.9 mg/l
    b. 5.7 mg/l
    c. 7.5 mg/l
    d. 8.3 mg/l
50. Chlorine is being fed at the rate of 200 pounds per day. Plant flow is 4 MGD. The chlorine residual is measured and found to be 3 mg/l Calculate chlorine demand.
    a. 3 mg/l
    *b. 2 mg/l
    c. 16 mg/l
    d. 9 mg/l
51. Chlorine is being fed at the rate of 200 pounds per day. Plant flow is 4 MGD. The chlorine residual is measured and found to be 3 mg/l Calculate chlorine demand.
    a. 3 mg/l
    *b. 2 mg/l
    c. 16 mg/l
    d. 9 mg/l
52. 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.
    *a. 130
    b. 116
    c. 112
    d. 18
    e. 16
53. 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.

*a. 4.9 mg/l

b. 5.7 mg/l

c. 7.5 mg/l

d. 8.3 mg/l

54. Assuming that a chlorine residual of 0.5 mg/l is being maintained and the chlorine demand is 19.5 mg/l, approximately how many pounds of chlorine per day will be required to treat a flow of 5.0 MGD?

a. 21 lbs

b. 792 lbs

c. 813 lbs

*d. 834 lbs

55. 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.

*a. 4.9 mg/l

b. 5.7 mg/l

c. 7.5 mg/l

d. 8.3 mg/l

56. If 25 Ibs/day of chlorine is being applied to a wastewater effluent flow of 250,000 gpd. Calculate the chlorine demand in mg/l if the chlorine residue is 1.2 mg/l.

a. 2.5 mg/l

*b. 10.8 mg/l

c. 15.1 mg/l

d. 6.3 mg/l

57. Calculate how many pounds per day of chlorine should be used to maintain a dosage of 12 mg/l at 6.0 MGD flow

a. 60 lbs/day

b. 450 lbs/day

c. 500 lbs/day

*d. 600 lbs/day

e. 6,700 lbs/day

58. How many pounds of chlorine will be used in one day if the flow is 700,000 gpd and a uniform dose of 12 mg/l is applied?

*a. 7 lbs

b. 15 lbs

c. 22 lbs

d. 26 lbs

59. Assuming that a chlorine residual of 0.5 mg/l is being maintained and the chlorine demand is 19.5 mg/l, approximately how many pounds of chlorine per day will be required to treat a flow of 50 MGD?

a. 21 lbs

b. 792 lbs

c. 813 lbs

*d. 834 lbs

60. How many pounds of chlorine gas is necessary to treat 4,000,000 gallons of wastewater at a dosage of 2 mg/l?

a. 61 lbs

b. 65 lbs

*c. 67 lbs

d. 69 lbs

61. If you need a chlorine residual of 1 mg/l , how many pounds of chlorine must be applied each day if the fl ow is 2.5 MGD and the chlorine demand is l5 mg/l?

a. 291 .pounds/day

b. 312 pounds/day

*c. 334 pounds/day

d. 419 pounds/day

e. 516 pounds/day

62. 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.

*a. 4.9 mg/l

b. 5.7 mg/l

c. 7.5 mg/l

d. 8.3 mg/l

63. Chlorine is being fed at the rate of 200 pounds per day. Plant flow is 4 MGD. The chlorine residual is measured and found to be 3 mg/l Calculate chlorine demand.

a. 3 mg/l

*b. 2 mg/l

c. 16 mg/l

d. 9 mg/l

64. 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.

*a. 130

b. 116

c. 112

d. 18

e. 16

65. 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.

*a. 4.9 mg/l

b. 5.7 mg/l

c. 7.5 mg/l

d. 8.3 mg/l

66. Assuming that a chlorine residual of 0.5 mg/l is being maintained and the chlorine demand is 19.5 mg/l, approximately how many pounds of chlorine per day will be required to treat a flow of 5.0 MGD?

a. 21 lbs

b. 792 lbs

c. 813 lbs

*d. 834 lbs

67. 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.

*a. 4.9 mg/l

b. 5.7 mg/l

c. 7.5 mg/l

d. 8.3 mg/l

68. If 25 Ibs/day of chlorine is being applied to a wastewater effluent flow of 250,000 gpd. Calculate the chlorine demand in mg/l if the chlorine residue is 1.2 mg/l.

a. 2.5 mg/l

*b. 10.8 mg/l

c. 15.1 mg/l

d. 6.3 mg/l

69. Calculate how many pounds per day of chlorine should be used to maintain a dosage of 12 mg/l at 6.0 MGD flow

a. 60 lbs/day

b. 450 lbs/day

c. 500 lbs/day

*d. 600 lbs/day

e. 6,700 lbs/day

Chemical Dosing Math Problems

1. 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

Solution:

lbs polymer required:

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

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

gallons polymer solution required:

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

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

Polymer cost:

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

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

Dry tons of solids captured:

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

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

Polymer cost per dry ton of solids captured:

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

2. 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:

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

3. 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 (7 points)

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

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

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

4. What is the daily ferric chloride dosing cost if the ferric chloride cost is \$580/dry ton ferric chloride (5 points)

Daily ferric chloride dosing cost:

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

5. 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:**

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

Required pumping rate to feed 0.0626 lbs polymer minute:

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

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

6. 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:

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

Required pumping rate to feed 250.2 lbs polymer minute:

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

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

This can also be done as follows:

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

So dissolve 250.2 lbs polymer in 1500 gallons

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

7. 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:

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

Polymer dose rate:

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

8. 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:

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

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

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

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

Daily cost of liquid alum to remove phosphorous:

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

9. 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:**
     $$4 * 3.5 * 8.34 = \frac{116.8lbs\ \ polymer}{day}$$
   - **Feed rate ($\frac{gal}{min}$):**
     $$\frac{116.8lbs\ \ polymer}{day} * \frac{100lbs\ \ polymer\ \ solution}{1.5lbspolymer} * \frac{gal\ \ polymer\ \ solution}{8.34lbs\ \ polymer\ \ solution} * \frac{day}{1440min} = \boxed{0.65\frac{gal}{min}}$$

   (b)

   - **Polymer required:**
     $$\left[\frac{3470gal}{min} * \frac{MG}{1,000,000gal} * \frac{1440min}{day}\right] MGD * 3.5 * 8.34 = \frac{145.9lbs\ \ polymer}{day}$$
   - **Feed rate ($\frac{gal}{min}$):**
     $$\frac{145.9lbs\ \ polymer}{day} * \frac{100lbs\ \ polymer\ \ solution}{1.5lbspolymer} * \frac{gal\ \ polymer\ \ solution}{8.34lbs\ \ polymer\ \ solution} * \frac{day}{1440min} = \boxed{0.81\frac{gal}{min}}$$

10. 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 ($\frac{\$}{day}$):

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

11. 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)

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

12. 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:

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

$$\boxed{0.35 \frac{gal}{min}}$$

13. 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

    Solution:

    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:

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

14. 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:

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

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

15. 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:

    Solution:

    Correct Answer:

    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

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

    Incorrect Answer 1:

    a) lbs of dry polymer required (lbs formula)=$5MGD*8.34*1.5*0.75 = \boxed{46.9\frac{lbs\ \ polymer}{day}}$

    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

    $\Longrightarrow x\frac{gal}{min} = \frac{46.9*1{,}000{,}000}{1440*8.34*7{,}500} = \boxed{0.5GPM} - Incorrect\ \ Answer\#1$

    Incorrect Answer #2:

    $\boxed{62.6GPM} - Incorrect\ \ Answer\#2$

    Incorrect Answer#3:

    $\boxed{12.6GPM} - Incorrect\ \ Answer\#3$

16. 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?

    Solution:

    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:

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

17. 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. What is the required GPM feed

of the 0.75

a. 12.6 GPM

b. 62.6 GPM

*c. 0.7 GPM

d. 0.5 GPM

Practice Problems - Pumping Power Requirements

1. If a pump is operating at 2,200 gpm and 60 feet of head, what is the water horsepower? If the pump efficiency is 71%, what is the brake horsepower?
2. The water horsepower of a pump is 10Hp and the brake horsepower output of the motor is 15.4Hp. What is the efficiency of the pump?
3. The water horsepower of a pump is 25Hp and the brake horsepower output of the motor is 48Hp. What is the efficiency of the pump?
4. The efficiency of a well pump is determined to be 75%. The efficiency of the motor is estimated at 94%. What is the efficiency of the well?
5. If a motor is 85% efficient and the output of the motor is determined to be 10 BHp, what is the electrical horsepower requirement of the motor?
6. The water horsepower of a well with a submersible pump has been calculated at 8.2 WHp. The Output of the electric motor is measured as 10.3BHp. What is the efficiency of the pump?
7. Water is being pumped from a reservoir to a storage tank on a hill. The elevation difference between water levels is 1200 feet. Find the pump size required to fill the tank at a rate of 120 gpm. Express your answer in horsepower.
8. A 25hp pump is used to dewater a lake. If the pump runs for 8 hours a day for 7 days a week, how much will it cost to run the pump for one week? Assume energy costs $0.07 per kilowatt hour.
9. A pump station is used to lift water 50 feet above the pump station to a storage tank. The pump rate is 500gpm. If the pump has an efficiency of 85% and the motor has an efficiency of 90%, find each of the following: Water Horsepower, Brake Horsepower, Motor Horsepower, and Wire-to-Water Efficiency.
10. Find the brake horsepower for a pump given the following information: Total Dynamic Head = 75 feet, Pump Rate = 150 gpm, Pump Efficiency = 90%, Motor Efficiency = 85%
11. Water is being pumped from a reservoir to a storage tank on a hill. The elevation difference between water levels is 1200 feet. Find the pump size required to fill the tank at a rate of 120 gpm. Express your answer in horsepower.

Solutions:

1. Solution:

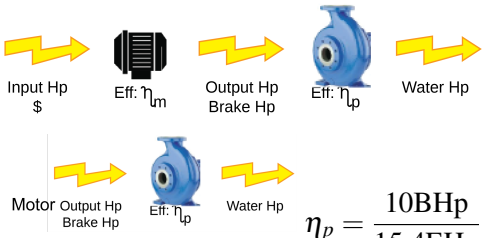
   water Hp = flow * head

$$2,200GPM * 60ft * \frac{Hp}{3,960GPM - ft} = \boxed{Water\ \ Hp = 33.3Hp}$$

pump Hp = brake Hp * pump efficiency

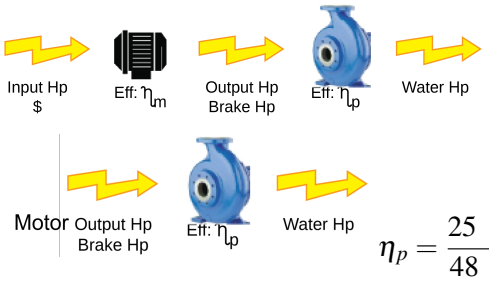
$$brake\ \ Hp = \frac{33.3}{0.71} = \boxed{Brake\ \ Hp = 47Hp}$$

2. Solution:



$$\eta_p = \frac{10\text{BHp}}{15.4\text{EHp}} \times 100 = \boxed{65\%}$$

3. Solution:

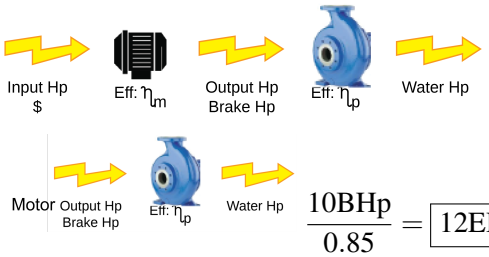


$$\eta_p = \frac{25\ \text{Water Hp}}{48\ \text{brake Hp}} \times 100 = \boxed{52\%}$$

4. Solution:

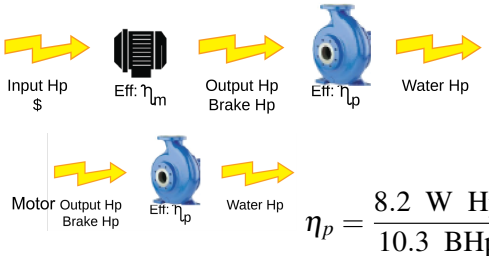
$$Well\ \ efficiency = \eta_m * \eta_p \implies 0.94 \times 0.75 = 0.705 \times 100 = \boxed{71\%}$$

5. Solution:



$$\frac{10\text{BHp}}{0.85} = \boxed{12\text{EHp or Input Hp}}$$

6. Solution:



$$\eta_p = \frac{8.2\ \text{W Hp}}{10.3\ \text{BHp}} \times 100 = \boxed{80\%}$$

7. Solution:

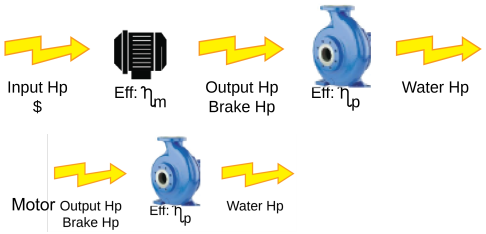
water Hp = flow * head

$$\text{Water Hp} = 120 \text{ gpm} * 1{,}200 \text{ ft} * \frac{\text{Hp}}{3{,}960 \text{ gpm} - \text{ft}} = \boxed{37 \text{ Hp}}$$

8. Solution:

$$25 \text{ Hp} \frac{0.746 \text{ kW}}{\text{Hp}} * \frac{8 \text{ hrs}}{\text{day}} * \frac{7 \text{ days}}{\text{month}} * \frac{\$0.07}{\text{kWh}} = \boxed{\frac{\$73.1}{\text{week}}}$$

9. Solution:



water Hp = flow * head

$$\text{Water Hp} = 500 \text{ gpm} * 50 \text{ ft} * \frac{\text{Hp}}{3{,}960 \text{ gpm} - \text{ft}} = \boxed{6.3 \text{ WHp}}$$

$$\text{Pump efficiency} = \frac{\text{water Hp}}{\text{brake Hp}} \implies \text{brake Hp} = \frac{\text{pump Hp}}{\text{Pump efficiency}}$$

$$\text{brake } Hp = \frac{6.3}{0.85} = \boxed{7.4 \text{ Hp}}$$

$$\text{Motor efficiency} = \frac{\text{brake Hp}}{\text{input Hp}} \implies \text{input Hp} = \frac{\text{brake Hp}}{\text{motor efficiency}} = \frac{7.4}{0.9} = \boxed{8.2 \text{ Hp}}$$

$$\text{Wire} - \text{to} - \text{water efficiency} = \eta_m * \eta_p \implies 0.9 \times 0.85 \times 100 = \boxed{77\%}$$

10. Solution:

water Hp = flow * head

$$150 \text{ GPM} * 75\text{ft} * \frac{Hp}{3{,}960 GPM - ft} = \boxed{Water \ Hp = 2.8Hp}$$

pump Hp = brake Hp * pump efficiency

$$brake \ Hp = \frac{2.8}{0.9} = \boxed{Brake \ Hp = 3.1Hp}$$