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Problem 9.-

a) COD suspended solids

Methanol

$$CH_3OH + \frac{3}{2}O_2 \rightarrow CO_2 + 2H_2O$$

COD = 300 mg O_2/L

Buthanol

$$C_4H_{10}O + 6O_2 \rightarrow 4CO_2 + 5H_2O$$

COD = 259.46 mg O_2/L

Total COD = 559.46 mg O_2/L

$$COD - O_2 \text{ consumption by methanol and buthanol} = COD_{SS}$$

COD_{SS} = 240.54 mg O_2/L

b) Diameter and depth of primary settling tank

$$V = t_{RH} \cdot Q = 252\ m^3$$

$$S = \frac{Q}{F_c} = 100.8\ m^2$$

$$H = \frac{V}{S} = 2.5\ m$$

$$d = 11.33\ m$$

c) Primary sludge production

$$300\ \frac{mg\ SS}{L} \cdot \frac{75\ mg\ SS_{removed}}{100\ mg\ SS} \frac{35 \cdot 3600 \cdot 24\ L}{day} \cdot \frac{365\ day}{year} = 2.48 \cdot 10^{11}\ \frac{mg\ SS}{year}$$

$$2.48 \cdot 10^{11}\ \frac{mg\ SS}{year} \cdot \frac{1\ kg}{10^6 mg} \cdot \frac{1\ m^3}{1100\ kg\ SS} \cdot \frac{100\ m^3 sludge}{2\ m^3 SS} = 11288.45\ \frac{m^3 sludge}{year}$$

d) Concentration of SS in the effluent

$$Q_{water\ sludge} = 300\ \frac{mg\ SS}{L} \cdot \frac{75\ mg\ SS_{removed}}{100\ mg\ SS} \cdot \frac{35\ L\ \cdot 3600\ s/h}{h} \cdot \frac{1\ m^3}{1100\ kg\ SS_{removed}} \cdot \frac{98\ m^3 water}{2\ m^3 SS} = 1.263\ \ m^3 water$$

$$Q_{out} = Q_{in} - Q_{water\ sludge} = 126 - 1.263 = 124.737\ \frac{m^3}{h}$$

$$\frac{126\ \frac{m^3}{h}}{124.737\ \frac{m^3}{h}} = 1.010124\ ;\ SS_{out} = \frac{75\ mg\ SS}{L} \cdot 1.010124 = \mathbf{75.76}\ \frac{\mathbf{mg\ SS}}{\mathbf{L}}$$

Problem 10.-

a) Sludge production

SS removal = 565 mg SS/L

Q = $2.88 \cdot 10^7$ L/day

27.12 tn sludge/day

b) BOD

$$CH_3 - (CH_2)_{14} - COOH + 23O_2 \rightarrow 16CO_2 + 16H_2O$$

COD = 287.5 mg O_2/L

c) Biological aerobic treatment

$$\%\ treated = \frac{287.5 - 25}{287.5} \cdot 100 = 91.3\%$$

d) Phosphates after precipitation

$$PO_4^{3-} + AlCl_3 \rightarrow AlPO_4(s) + 3Cl^-$$

$$AlPO_4(s) \leftrightarrow Al^{3+} + PO_4^{3-} + 3Cl^-$$

$$K_{ps} = [Al^{3+}][PO_4^{3-}] = s^2$$

$$s = 1.14 \cdot 10^{-10}\,\frac{\text{mol}}{\text{L}}$$

$$[PO_4^{3-}] = 1.08 \cdot 10^{-5}\,\frac{\text{mg}}{\text{L}}$$

$$[PO_4^{3-}] = 1.08 \cdot 10^{-5}\text{ppm}$$

This value is acceptable; it does not exceed the limit value.

Problem 11.-

a) Daily primary sludge production

$$6000\ \frac{\text{m}^3\text{wastewater}}{\text{day}} \cdot \frac{10^3\text{L}}{1\ \text{m}^3} \cdot \frac{210\ \text{mg SS}}{1\ \text{L}} \cdot \frac{1\ \text{kg}}{10^6\text{mg}} \cdot \frac{60\ \text{kg SS removed}}{100\ \text{kg SS}} = 11340\ \frac{\text{kg SS}_{\text{removed}}}{\text{day}}$$

$$378000\ \frac{\text{kg sludge}}{\text{day}}$$

$$378000\ \frac{\text{kg sludge}}{\text{day}} \cdot \frac{1\ \text{m}^3\ \text{sludge}}{1000\ \text{kg sludge}} = \mathbf{\frac{378\ m^3\ sludge}{day}}$$

b) Hydraulic load rate

$$\text{HLR} = \frac{\text{Q}}{\text{A}} = \frac{\frac{378\ \text{m}^3\ \text{sludge}}{\text{day}}}{63\ \text{m}^2} = 6\ \frac{\text{m}^3}{\text{m}^2 \cdot \text{day}}$$

c) Diameter and depth of the thickener

$$A = \pi\frac{\text{d}^2}{4} = 63\ \text{m}^2; \text{d} = 8.96\text{m}$$

$$\text{H} = \frac{\text{V}}{\text{A}} = \frac{\frac{\text{HRT}}{\text{Q}}}{\text{A}} = \frac{126\ \text{m}^3}{63\ \text{m}^2} = 2\ \text{m}$$

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Problem 12.-

a) Sludge production

15000 kg SS/day

525000 kg sludge/day

b) CO_2 emission

$$\frac{525000\ \text{kg sludge}}{\text{day}} \cdot \frac{60\ \text{kg sludge digested}}{100\ \text{kg sludge}} \cdot \frac{0.8\ \text{kg CO}_2}{100\ \text{kg sludge digested}} = 2520\ \frac{\text{kg CO}_2}{\text{day}}$$

$$2520\ \frac{\text{kg CO}_2}{\text{day}} \cdot \frac{1\ \text{kg CH}_4}{3\ \text{kg CO}_2} = 840\ \frac{\text{kg CH}_4}{\text{day}}$$

$$CH_4 + 2O_2 \rightarrow CO_2 + 2H_2O$$

$$840\ \frac{\text{kg CH}_4}{\text{day}} \cdot \frac{1\ \text{kmol CH}_4}{16\ \text{kg CH}_4} \cdot \frac{1\ \text{kmol CO}_2}{1\ \text{kmol CH}_4} \cdot \frac{44\ \text{kg CO}_2}{1\ \text{kmol CO}_2} = 2310\ \frac{\text{kg CO}_2}{\text{day}}$$

Total CO_2 emitted:

2520 + 2310 = 4830 kg CO_2/day

c) SS concentration

$$\frac{15000\ \text{kg SS}}{\text{day}} \cdot \frac{30\ \text{kg SS not removed}}{100\ \text{kg SS}} \cdot \frac{10^6\text{mg}}{1\ \text{kg}} \cdot \frac{1\ \text{day}}{49485\ \frac{\text{m}^3}{\text{day}}} \cdot \frac{1\ \text{m}^3}{10^3\text{L}} = 90.94\ \text{mg SS/L}$$