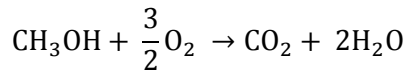




Problem 9.-

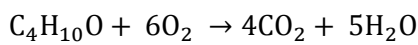
a) COD suspended solids

Methanol



$$\text{COD} = 300 \text{ mg O}_2/\text{L}$$

Buthanol



$$\text{COD} = 259.46 \text{ mg O}_2/\text{L}$$

$$\text{Total COD} = 559.46 \text{ mg O}_2/\text{L}$$

$$\text{COD} - \text{O}_2 \text{ consumption by methanol and buthanol} = \text{COD}_{\text{SS}}$$

$$\text{COD}_{\text{SS}} = 240.54 \text{ mg O}_2/\text{L}$$

b) Diameter and depth of primary settling tank

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

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

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

$$d = 11.33 \text{ m}$$

c) Primary sludge production

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

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

d) Concentration of SS in the effluent



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

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

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

Problem 10.-

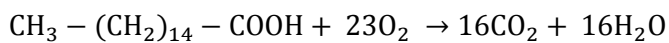
a) Sludge production

SS removal = 565 mg SS/L

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

27.12 tn sludge/day

b) BOD

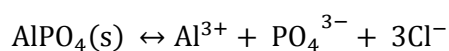
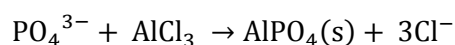


COD = 287.5 mg O₂/L

c) Biological aerobic treatment

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

d) Phosphates after precipitation



$$K_{\text{ps}} = [\text{Al}^{3+}][\text{PO}_4^{3-}] = s^2$$



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

$$[\text{PO}_4^{3-}] = 1.08 \cdot 10^{-5} \frac{\text{mg}}{\text{L}}$$

$$[\text{PO}_4^{3-}] = 1.08 \cdot 10^{-5} \text{ppm}$$

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

Problem 11.-

a) Daily primary sludge production

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

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

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

b) Hydraulic load rate

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

c) Diameter and depth of the thickener

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

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



Problem 12.-

a) Sludge production

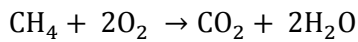
15000 kg SS/day

525000 kg sludge/day

b) CO₂ emission

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

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



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

Total CO₂ emitted:

$$2520 + 2310 = 4830 \text{ kg CO}_2/\text{day}$$

c) SS concentration

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