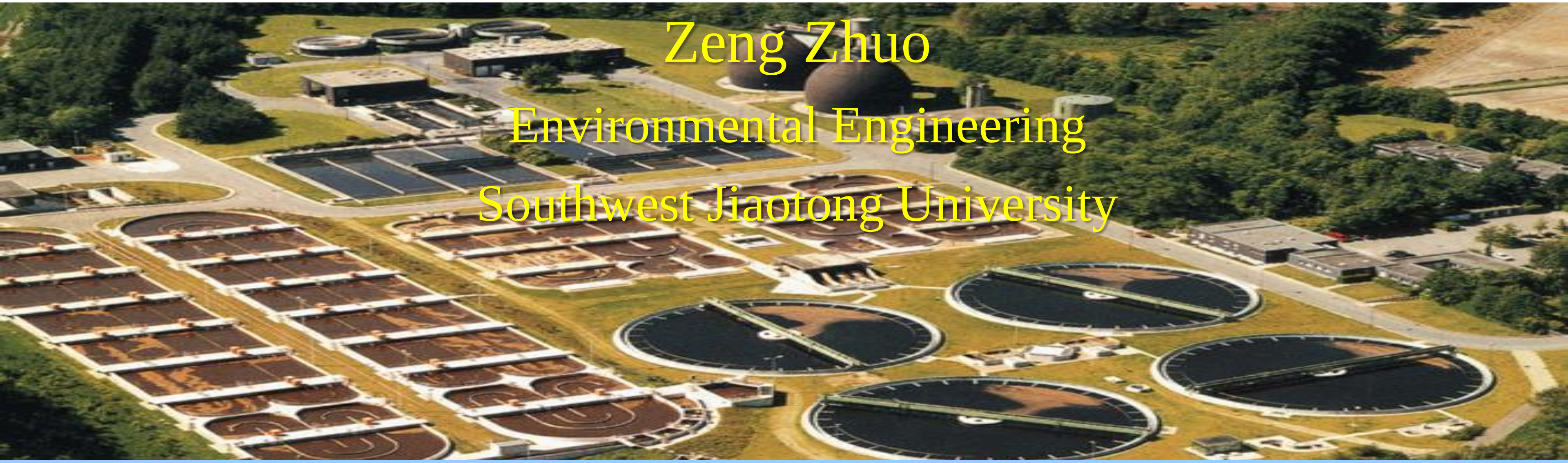
Chapter Six

Design of water treatment systems



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Homework

Problem 1, Page 325

1 Estimate the water demand for a city of 100,000 people. Assume the annual average consumption rate is 647 liters per capita per day (Lpcd) and use the flow ratios given in Table 6.4 for estimating the following flow rates:

a. Average daily demand (m^3/d).
b. Peak daily demand (m^3/d).
c. Peak hourly demand (m^3/d).
d. Fire demand (m^3/d).
e. Coincident demand (m^3/d).

Problem 2, Page 325

2 Using the information in Problem 6.1, determine the design capacities for the following:

a. Source (m^3/d).
b. Low-lift pumps (m^3/d).
c. Treatment plant (m^3/d).
d. High-service pumps (m^3/d).
e. Distribution system (m^3/d).

Problem 10 and 11, Page 326

10 Calculate the solubility of $Al(OH)_3$ in water at 25°C, given the K_{sp} is 1.0×10^{-31}.

11 Calculate the solubility of $MgCO_3$ in water at 25°C, given the K_{sp} is 4.0×10^{-5}.

Problem 16, Page 327

16 Four rectangular settling basins operating in parallel are to be sized for treating 37,850 m^3/d of water. Use a length : width ratio of 3 : 1 and assume a detention time of 3.0 hours. The effluent weir length in each basin is equal to three times the tank width. Determine the following:

a. The dimensions of each tank (m).
b. The weir loading rate [$m^3/(m \cdot d)$].

Homework

Problem 1, Page 325

Estimate the water demand for a city of 100,000 people. Assume the annual average consumption rate is 647 liters per capita per day (Lpcd) and use the flow ratios given in Table 6.4 for estimating the following flow rates:

a. Average daily demand (m^3/d).
b. Peak daily demand (m^3/d).
c. Peak hourly demand (m^3/d).
d. Fire demand (m^3/d).
e. Coincident demand (m^3/d).

a) Average daily demand = 100000 $\times$ 647 Lpcd = 6.47×10^7 L/d = $\mathbf{6.47 \times 10^4\ m^3/d}$

b) Peak daily demand = ratio $\times$ ADD = $1.5 \times 6.47 \times 10^4$ = $\mathbf{9.71 \times 10^4\ m^3/d}$

c) Peak hourly demand= ratio $\times$ ADD = $2.5 \times 6.47 \times 10^4$ = $\mathbf{1.62 \times 10^5\ m^3/d}$

d) Fire demand = $3.86 \times \sqrt{100} \times \left(1 - 0.01\sqrt{100}\right)$= 34.74 m^3/min= $\mathbf{5 \times 10^4\ m^3/d}$

e) Coincident demand=PDD + Fire demand= $9.71 \times 10^4 + 5 \times 10^4$ = $\mathbf{1.47 \times 10^5\ m^3/d}$

Homework

Problem 2, Page 325

2 Using the information in Problem 6.1, determine the design capacities for the following:

a. Source (m^3/d).
b. Low-lift pumps (m^3/d).
c. Treatment plant (m^3/d).
d. High-service pumps (m^3/d).
e. Distribution system (m^3/d).

a) The design capacity of source for water supply = **PDD= 9.71×10^4 m^3/d**
b) The design capacity of low-lift pumps = **(1+10%-33%)$\times$PDD = (1.07-1.29)$\times 10^5$ m^3/d**
c) The design capacity of treatment plant = **PDD = 9.71×10^4 m^3/d**
d) The design capacity of high-service pumps = **(1+10%-33%)$\times$PHD**= **(1.78-2.15)$\times 10^5$ m^3/d**
e) The design capacity of distribution system =**max(PHD, PDD+fire demand)=** max(**1.62×10^5 , 1.47×10^5) m^3/d = 1.62×10^5 m^3/d**

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Problem 10 and 11, Page 326

10 Calculate the solubility of $Al(OH)_3$ in water at 25°C, given the K_{sp} is 1.0×10^{-31}.

11 Calculate the solubility of $MgCO_3$ in water at 25°C, given the K_{sp} is 4.0×10^{-5}.

$Al(OH)_3 \rightarrow Al^{3+} + 3OH^-$

$$K_{sp} = [\mathrm{Al}^{3+}]\,[\mathrm{OH}^-]^3$$

Assume the concentration of Al^{3+} is x mol/L

The concentration of OH^- is $3x$ mol/L

$$K_{sp} = [\mathrm{Al}^{3+}][\mathrm{OH}^-]^3 = x \cdot (3x)^3 = 27x^4$$
$$= 1 \times 10^{-31}$$

$$x = 7.8 \times 10^{-9}\ \mathrm{mol/L}$$

$$\mathrm{Solubility} = 7.8 \times 10^{-9}\,\frac{\mathrm{mol}}{\mathrm{L}} \times 78\,\frac{\mathrm{g}}{\mathrm{mol}}$$
$$= 6.1 \times 10^{-7}\ \mathrm{g/L} = 6.1 \times 10^{-4}\ \mathrm{mg/L}$$

$MgCO_3 \rightarrow Mg^{2+} + CO_3^{2-}$

$$K_{sp} = [\mathrm{Mg}^{2+}][\mathrm{CO_3}^{2-}]$$

Assume the concentration of Mg^{2+} is x mol/L

The concentration of CO_3^{2-} is x mol/L

$$K_{sp} = [\mathrm{Mg}^{2+}][\mathrm{CO_3}^{2-}] = x \cdot x = x^2$$
$$= 4 \times 10^{-5}$$

$$x = 6.3 \times 10^{-3}\,\mathrm{mol/L}$$

$$\mathrm{Solubility} = 6.3 \times 10^{-3}\,\mathrm{mol/L} \times 84.3\,\frac{\mathrm{g}}{\mathrm{mol}}$$
$$= 0.53\,\mathrm{g/L} = 530\,\mathrm{mg/L}$$

Homework

Problem 16, Page 327

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a. The dimensions of each tank (m).

b. The weir loading rate [$m^3/(m \cdot d)$].

a) The dimensions of each tank (m)

$$\tau = \frac{V}{Q} \qquad V = \tau \cdot Q = 3\ \mathrm{h} \times \frac{37850\mathrm{m}^3/\mathrm{d}}{4 \times 24\ \mathrm{h/d}} = 1183\ \mathrm{m}^3$$

$$\frac{L}{W} = 3 \quad \frac{L}{H} = 15 \qquad V = L \cdot \frac{L}{3} \cdot \frac{L}{15} = 1183\ \mathrm{m}^3$$

$$L = 37.6\ \mathrm{m} \quad W = 12.5\ \mathrm{m} \quad H = 2.5\ \mathrm{m}$$

b) The weir loading rate ($m^3/(m \cdot d)$)

$$\text{Wire length} = 3W = 3 \times 12.5 = 37.5\ \mathrm{m}$$

$$q = \frac{Q}{\text{wire length}} = \frac{37850\mathrm{m}^3/\mathrm{d}}{4 \times 37.5\ \mathrm{m}} = 252.3\ \mathrm{m}^3/(\mathrm{m} \cdot \mathrm{d})$$

The end