APPENDIX C3. DESIGN OF A REVERSE OSMOSIS UNIT

Problem Formulation

It is desired to produce 1000 m3/24h of potable water (500 mg/l dissolved salts) from water containing 3000 mg/l of dissolved salts, mainly ammonium salts. Design a reverse osmosis unit for this job. A membrane is available that has shown ammonium chloride rejection of 0.95 at 45 atm. pressure. The permeability is 2.5 * 10^{-5} g / cm^2 / sec / atm.

Solution

$$\pi = \frac{2 * 3000}{58.5 * 10^3} 0.082 * 298 = 2.5 \text{ atm.}$$

$\varphi \approx 1$

To be conservative we use: $R' = \frac{Q_p}{Q_f} = 0.9$

Therefore the osmotic pressure of the concentrate is approximately 10π feed or 25 atm.

$Q_p = 1000 \text{ m}^3 / 24\text{h}$

$Q_f = 1110 \text{ m}^3 / 24\text{h}$

$Q_r = 111 \text{ m}^3 / 24\text{h}$

$$C_p = \frac{2C_{if}}{2 - R'}(1 - R_{av}) - \frac{2 * 3000}{2 - 0.9}(1 - 0.95) = 272 \text{ mg/l}$$

$$C_i = \frac{Q_r * C_p - Q_p * C_p}{Q_r} = \frac{1110 * 3000 - 1000 * 272}{111} = 27577 \text{ mg / l}$$

$$C_{ia} = \frac{Q_r * Q_i + Q_f * C_p}{Q_r + Q_f} = \frac{111 * 27577 + 1110 * 3000}{1222} = 5232 \text{ mg / l}$$

$$C_p = C_a (1 - R_{av}) = 5232 (1 - 0.95) = 262 \text{ mg / l}$$

$$F = 2.5 * 10^{-5} (45 - 2.5) = 1.06 * 10^{-3} \text{ g / cm}^2 \text{ / sec}$$

$$A = \frac{Q_p}{F} = \frac{1000}{1.06 * 10^{-3} * 10^{-6} * 10^4 * 3600 * 24} = 1092 \text{ m}^2$$

It is suggested that **1400 m2** be used to allow for compaction and fouling of membranes.