### Screening

- Coarse bar racks and fine traveling racks are employed at intake structure, on reservoirs and rivers.
- Coarse bar screen racks usually have clear spaces up to 3 inches (75mm) between the bars and are used to prevent the entry of large debris, such as logs, into the intake structure.

### Aeration

- Aeration may be used for gas stripping (degasification) to remove unwanted gases, such as carbon dioxide and hydrogen sulfide, and iron and manganese.
- Groundwaters, in particular, may require aeration to remove these contaminants.
- Usually, aeration is accomplished by cascades, multiple-tray aerators, spray nozzles, or diffused compressed air.
Aeration

- **A cascade** usually is a flight of three or four concrete or metal steps over which the water tumbles as a thin sheet.

- **Multiple-tray aerator** - Consists of a series of horizontal traps, each containing 8 to 12 inches of medium, the medium being ceramic balls 2 to 6 inches in diameter, slag, or stones.

- Some tray aerators have no medium and depend upon the perforated plates, slots, or screen trays.

Aeration

- **Aerial view of a lagoon showing mixing taking place by aerators just below the surface**

Aeration

- **Spray nozzles** are sometimes used for aeration; however, they require considerable pressure head.

Aeration

- **Model of natural surface flow patterns using velocity vectors (blue represents low velocity**

Aeration

- **Diffused compressed air tanks** - The air is supplied by diffusers that are placed along the bottom of one wall to give a spiral roll to the water.
**Aeration Model**

- The removal of carbon dioxide can be estimated as follows:
  \[
  \frac{C}{C_0} = e^{-kn}
  \]
  where:  
  - \( C \) is the effluent concentration, mg/l, 
  - \( C_0 \) is the influent concentration, mg/l, 
  - \( k \) is the rate constant, and 
  - \( n \) is the number of trays

- Typically, \( k \) is from 0.28 to 0.37 for carbon dioxide

**Carbon Dioxide Removal Problem**

- A groundwater containing 8 mg/l of carbon dioxide is to be degasified using a multiple-tray aerator with five trays. The design population is 5,000 persons, and the maximum demand is 150 gal/person-day. The \( k \) value is 0.33, and the hydraulic loading is 3 gpm/ft.².

- Determine:
  - The carbone dioxide content of the product water.
  - The size of the trays if the length-to-width ratio is 4:1 and the trays are made to 1 inch increments.

**The performance equation is:**

\[
\frac{C}{C_0} = e^{-kn}
\]

Therefore:

\[
C = C_0e^{-kn}
\]

- **Five aeration trays**
- **8 mg/l initial concentration**

\[
C = (8 \text{ mg/l})e^{-(5)(0.33)} = 1.54 \text{ mg/l}
\]

**The area is:**

\[
A = \left( \frac{520.8 \text{ gpm}}{3 \text{ gpm/ft}^2} \right) = 173.6 \text{ ft}^2
\]

- Since \( L = 4W \), therefore:
  - \( A = W(4W) = 173.6 \text{ ft}^2 \)
  - \( W = 6.59 \text{ ft. or 6 ft. 7.05 in. or 6 ft. 8.0 in.} \)
  - \( L = 4(6.59 \text{ ft}) = 26.35 \text{ ft. or 26 ft. 5 in.} \)

**The flow to the aerator is:**

\[
Q = \frac{5,000 \text{ persons} \times 150 \text{ gal/person-day}}{1,440 \text{ min/day}} = \frac{750,000 \text{ gal}}{\text{day}}
\]

\[
Q = \left[ \frac{750,000 \text{ gal}}{\text{day}} \right] \left[ \frac{1 \text{ day}}{440 \text{ min}} \right] = 520.8 \text{ gal/min}
\]

**A groundwater containing 20 mg/l of carbon dioxide is to be degasified using a series of ten multiple-tray aerators. Each aerator uses four trays. The aerators will be operated in parallel. For flexibility, any eight aerators will be operative at one time while two aerators are inoperative for cleaning and maintenance.**

- The design population is 50,000 persons, and the maximum demand is 150 gal/person-day. The \( k \) value is 0.31, and the hydraulic loading is 4 gpm/ft.².

- Determine:
  - The carbon dioxide content of the product water.
  - The size of the trays if the length-to-width ratio is 2:1 and the trays are made to 1 inch increments.
Carbon Dioxide Removal Problem

- The performance equation is: \( \frac{C}{C_0} = e^{-kn} \)
- Therefore:
  \[ C = C_0 e^{-kn} \]
  
  \[ C = 20 e^{-0.31} \]
  
  \[ C = 20(0.2894) = 5.79 \text{ mg/l} \]

- The flow to each aerator is:
  \[ Q = \frac{50,000 \text{ persons} \times 150 \text{ gal/person-day}}{1,440 \text{ min/day}} = 7.5 \times 10^4 \text{ gal/day} \]

- The number of aerators is:
  \[ Q = \left(\frac{7.5 \times 10^4 \text{ gal/day}}{1,440 \text{ min}}\right) = 5208.3 \text{ gal/min} \]

- The total flowrate is:
  \[ \frac{1}{5} = 651 \text{ gal/min} \]

Carbon Dioxide Removal Problem

- The area is:
  \[ A = \frac{651 \text{ gpm}}{4 \text{ gpm}} = 162.8 \text{ ft}^2 \]
- Since \( L = 2W \), therefore:
  \[ A = W(2W) = 162.8 \text{ ft}^2 \]
  
  \[ W = 9.02 \text{ ft. or } 9 \text{ ft. 0.25 in. or } 9 \text{ ft. 1 in.} \]
  
  \[ L = 2(9 \text{ ft. 1 in.) or } 18 \text{ ft. 2 in.} \]

Adsorption

- Activated carbon is a universal adsorbent since it adsorbs nearly all organic compounds causing taste, odor, or color problems, and numerous other dissolved substances.
- The particles have a large surface-area-to-volume ratio, and the surface area has slight positive and negative charges.
- This allows it to adsorb organic compounds having slightly polar charges, which nearly all organic compounds have.

Adsorption Model

- Adsorption equilibrium can be estimated as follows:
  \[ \frac{x}{m} = K (C_0)^{1/n} \]
  
  where: 
  \[ x \] is the mass of solute adsorbed,
  \[ m \] is mass of adsorbent,
  \[ C_0 \] is the equilibrium concentration of the solute (mass/volume), and
  \[ K \] and \[ n \] are experiential constants

Prechlorination

- Prechlorination may prevent odors and taste compounds from being produced by bacterial action in the settling basin sludge.
- Also, prechlorination may prevent algal growths on the filter media, which can cause tastes and odors.
The rate of disinfection by a chemical can be modeled by:

\[
\frac{dN}{dt} = kN
\]

where:
- \(\frac{dN}{dt}\) is the rate of cell destruction (number/time),
- \(k\) is the rate constant, and
- \(N\) is the number of living cells remaining at time \(t\).

The rate of disinfection by a chemical can be modeled by:

\[
\ln\left(\frac{N}{N_0}\right) = -kt
\]

where \(N_0\) is the number of living cells at \(t=0\).

The following is actual data for a virus exposed to an experimental disinfectant. Estimate the contact time required to obtain a reduction of the 1/10,000 of the original number of virus.

<table>
<thead>
<tr>
<th>Time, second</th>
<th>4</th>
<th>8</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N/N_0)</td>
<td>1/13</td>
<td>1/158</td>
<td>1/2000</td>
</tr>
</tbody>
</table>

Plot the data with \(-\ln(N/N_0)\) on the y axis and time on the x axis. The data for the plot are as follows:

<table>
<thead>
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<th>Time, second</th>
<th>4</th>
<th>8</th>
<th>12</th>
</tr>
</thead>
<tbody>
<tr>
<td>(N/N_0)</td>
<td>1/13</td>
<td>1/158</td>
<td>1/2000</td>
</tr>
<tr>
<td>(-\ln(N/N_0))</td>
<td>2.56</td>
<td>5.06</td>
<td>7.60</td>
</tr>
</tbody>
</table>

The data are plotted below:

The slope of the line is the disinfection constant:

\[
K = \frac{7.6}{12\text{ sec}} = 0.63 / \text{sec}
\]
Disinfection Problem

The time required for a reduction of $1/10,000$ is:

$$t = \frac{-\ln \left( \frac{N}{N_0} \right)}{k} = \frac{-\ln \left( \frac{1}{10,000} \right)}{0.634 \text{ / sec}} = 14.52 \text{ seconds}$$

$t = 14.52 \text{ seconds}$ or $15 \text{ seconds}$

Any Questions?