EWCE 331
Water Supply Engineering

Lecture 10

Instructor

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Lecture outline

Water Treatment Methods

Topics	References
• **Advanced water treatment for heavy metal removal** ✓ **Taste and Odor control** ✓ **Hardness removal – water softening**	**1. Water and Environmental Engineering** Authors: M. Habibur Rahman, Abdullah Al-Muyeed 1st ed., ITN-BUET **2. Environmental Engineering** Authors: Howard S. Peavy, Donald R. Rowe and George Tchobanoglous International Edition, McGraw Hill Companies **2. Water Supply and Sanitation** Authors: M. Feroz Ahmed, Md. Mujibur Rahman 1st ed., ITN-BUET

Control of Taste and Odor – **Aeration**

- Aeration is effective in removing tastes and odors that are caused by volatile materials.
- Volatile materials (e.g Methane and hydrogen sulfide) have low boiling point and will vaporize very easily.
- Many taste and odor problems in surface water could be caused by oils and by-products that algae produce.
- Since oils are much less volatile than gases, aeration is only partially effective and requires oil separation techniques to be applied.

Control of Taste and Odor – **Aeration**

Hydrogen Sulfide:

- A poisonous gas, having rotten-egg odor.

- H_2S occurs mainly in groundwater supplies, caused by the action of iron or sulphur reducing bacteria in the well.

- H_2S in a water supply will disagreeably alter the taste of coffee, tea, and ice.

- H_2S is corrosive to piping, tanks, water heaters, and copper alloys that it contacts.

Control of Taste and Odor – **Aeration**

Hydrogen Sulfide:

Operational problems:

- Disinfection of the water can become less effective because of the chlorine demand exerted by the hydrogen sulfide.

$$H_2S + Cl_2 + O^{2-} \rightarrow S + H_2O + 2Cl^-$$

$$H_2S + 4Cl_2 + 4\,H_2O \rightarrow H_2SO_4 + 8\,HCl$$

- There could be corrosion of the piping systems and the water tanks.

Control of Taste and Odor – **Aeration**

Removal of Hydrogen Sulfide:

• H_2S is physically removed by agitating the water via bubbling or cascading and then separating or stripping the hydrogen sulfide in a container.

$$H_2S + O_2 = \text{water } (H_2O) + \text{elemental sulfur}$$

• Aeration is most effective when H_2S concentration is lower than 2.0 mg/l.

• At higher concentrations, this method may not remove all of the offensive odor unless the air is used to oxidize H_2S chemically into solid sulfur, which is then filtered.

Removal of Hardness

- Hardness in water is principally caused by the solution in water of carbonate, bicarbonate and sulfate of calcium and magnesium.

- Sometimes iron and aluminium cause hardness to a lesser degree.

- The general methods used for water softening are:
  - ✓ Boiling
  - ✓ Lime process
  - ✓ Lime and soda-ash process
  - ✓Base-exchange process

Removal of Hardness

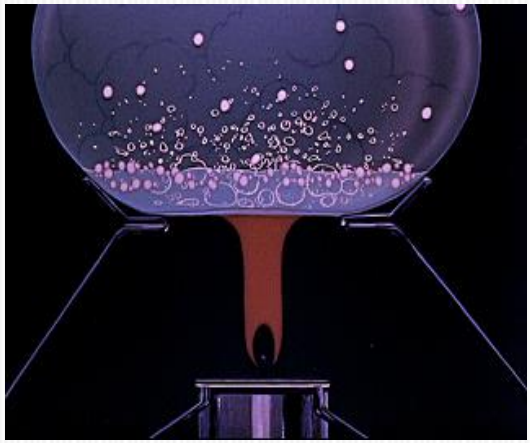
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Removal of Hardness – **Heating/ Boiling**

- Heating is only effective for removal of bicarbonate hardness.



- Heating of water breaks down the bicarbonate into carbonate, water and carbon dioxides.

$$\mathbf{Ca(HCO_3)_2 + Heat = CaCO_3 + H_2O + CO_2}$$

- $CaCO_3$ is insoluble and settles down.
- Excess CO_2 escapes from water.
- Similarly, hardness due to $Mg(HCO_3)_2$ can also be removed by simple heating.

Removal of Hardness – **Lime Process**

- Also known as Clark process, reduces only carbonate hardness.

- The principle involved is to neutralize with milk of lime, i.e $Ca(OH)_2$, forming normal carbonates which precipitate out when present in excess amounts.

$$\mathbf{Ca(HCO_3)_2 + Ca(OH)_2 = 2CaCO_3 + H_2O}$$

$$\mathbf{Mg(HCO_3)_2 + Ca(OH)_2 = CaCO_3 + MgCO_3 + H_2O}$$

- The precipitated carbonates are removed by sedimentation and filtration.

Removal of Hardness – **Lime & Soda Ash Process**

- Lime has no effect on sulfate of calcium and magnesium, which are responsible for causing most of the non-carbonate hardness found in natural waters.

- Non-carbonate hardness is removed by the addition od soda ash (Na_2CO_3).

$$CaSO_4 + Na_2CO_3 = CaCO_3 + Na_2SO_4$$

$$Ca(HCO_3)_2 + Na_2CO_3 = CaCO_3 + NaHCO_3$$

Removal of Hardness – **Lime & Soda Ash Process**

- Some of the insoluble materials formed here may remain in the water in a finely divided state.
- These may be found deposited on the filter sand or in the distribution pipelines at a later time.
- This difficulty may be overcome by treating the water with CO_2, process called recarbonation.

Removal of Hardness – **Base Exchange Process**

- Hard water is passed through a bed of zeolite sand (complex silicates of aluminium and sodium).
- The water exchanges its calcium and magnesium for sodium in the zeolite bed until the sodium becomes exhausted.
- The lost sodium from the bed is then restored by regenerating the zeolite with a solution of common salt (NaCl).
- The zeolite or base-exchange process of water softening is applicable only to clear water, since the presence of turbidit causes clogging of zeolite material.

Removal of Hardness – **Base Exchange Process**

- The chemical reactions are as follows:

$$\left.\begin{array}{l} CaSO_4 \\ MgSO_4 \\ CaCO_3 \\ MgCO_3 \\ CaCl_2 \\ Etc \end{array}\right\} + Na_2Al(SiO_3)_2 = \underset{\text{(zeolite)}}{\left.\begin{array}{l} Ca \\ \\ Mg \end{array}\right\}} Al(SiO_3)_2 + \left\{\begin{array}{l} Na_2CO_3 \\ Na_2SO_4 \\ 2NaCl \\ \text{etc.} \end{array}\right.$$

- **Regeneration:**

$$\left.\begin{array}{l} Ca \\ \\ Mg \end{array}\right\} Al(SiO_3)_2 + 2NaCl = \underset{\text{(regenerated zeolite)}}{Na_2Al(SiO_3)_2} + \left\{\begin{array}{l} CaCl_2 \\ \\ MgCl_2 \end{array}\right.$$