Water treatment

Water treatment

- Water treatment process overview
- Concepts and practices of each process
  - Coagulation and flocculation
  - Softening (removing hardness)
  - Sedimentation
  - Filtration
  - Disinfection
  - Sludge treatment and disposal

Water treatment

- Goal of municipal water treatment: to provide water that is both potable and palatable
  - potable: safe to drink; palatable: pleasant to drink

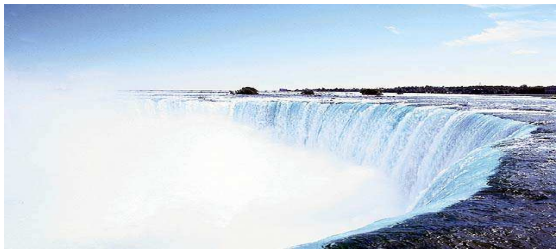
- Factors determining drinking water quality
  - Physical: color and turbidity, temperature, taste and odor
  - Chemical: toxic chemicals and chemicals that make water non-palatable
  - Microbiological: pathogens
  - Radiological: ex) uranium

Indicator for pathogens

- Indicator is needed for pathogens because it is not practical to analyze all different species
- Total coliforms
  - Most frequently used indicator for pathogens
  - Reasons for using total coliforms as an indicator:
    - Inhabit the intestinal tracks of humans and other mammals
    - Exist in large numbers in individuals
    - Survive in natural waters for relatively long without growth
    - Relatively easy to analyze

Sources of drinking water

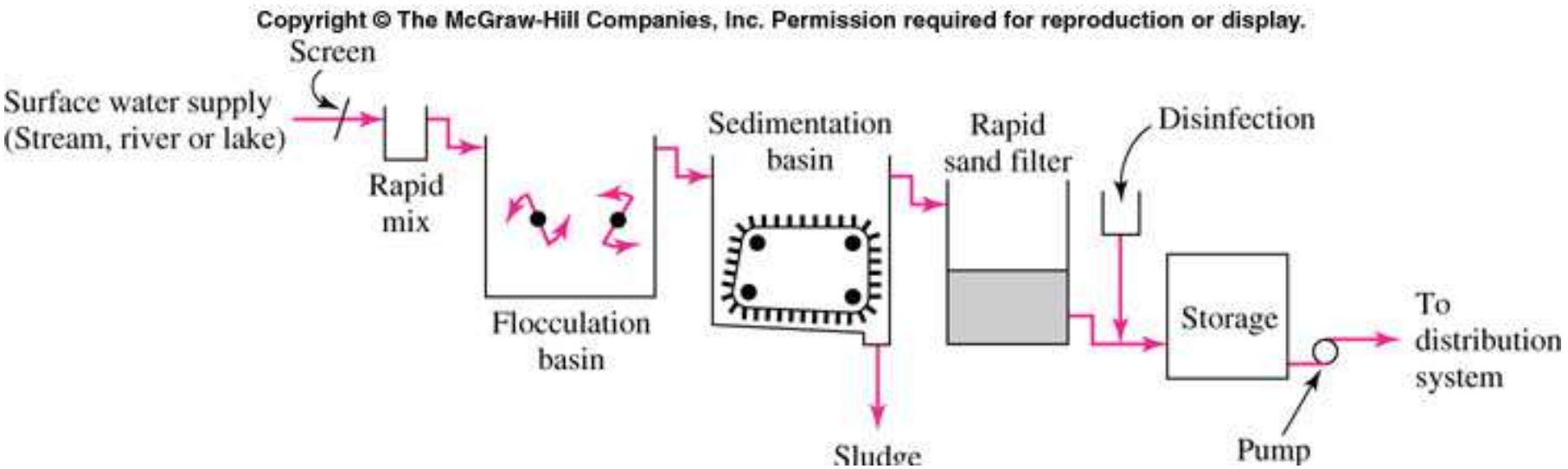
- Surface water
  - Variable composition
  - Low mineral content
  - Low hardness
  - High turbidity
  - Colored
  - DO present



- Groundwater
  - Constant composition
  - High mineral content
  - High hardness
  - High Fe, Mn
  - Low turbidity
  - Low color
  - Low DO

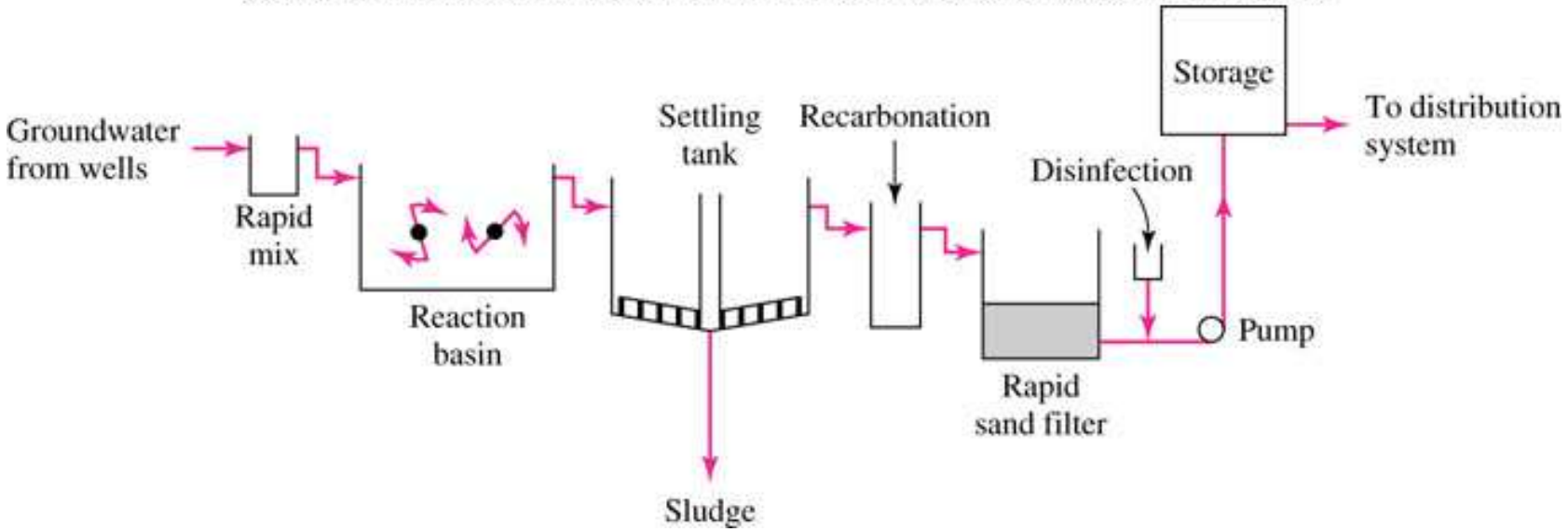
Water treatment systems

- Coagulation plant: conventional surface water treatment



Water treatment systems

- Water softening plant: for groundwater with high hardness



Particle removal in water

- In surface water treatment, remove particles first
- Concerns

  Particles..

  – Cause turbidity and color in water

  – Clog filters, foul membranes, reduce disinfection efficiency

  And some particles…

  – Are pathogenic (viruses, bacteria, cysts, …)

  – Harbor pathogens

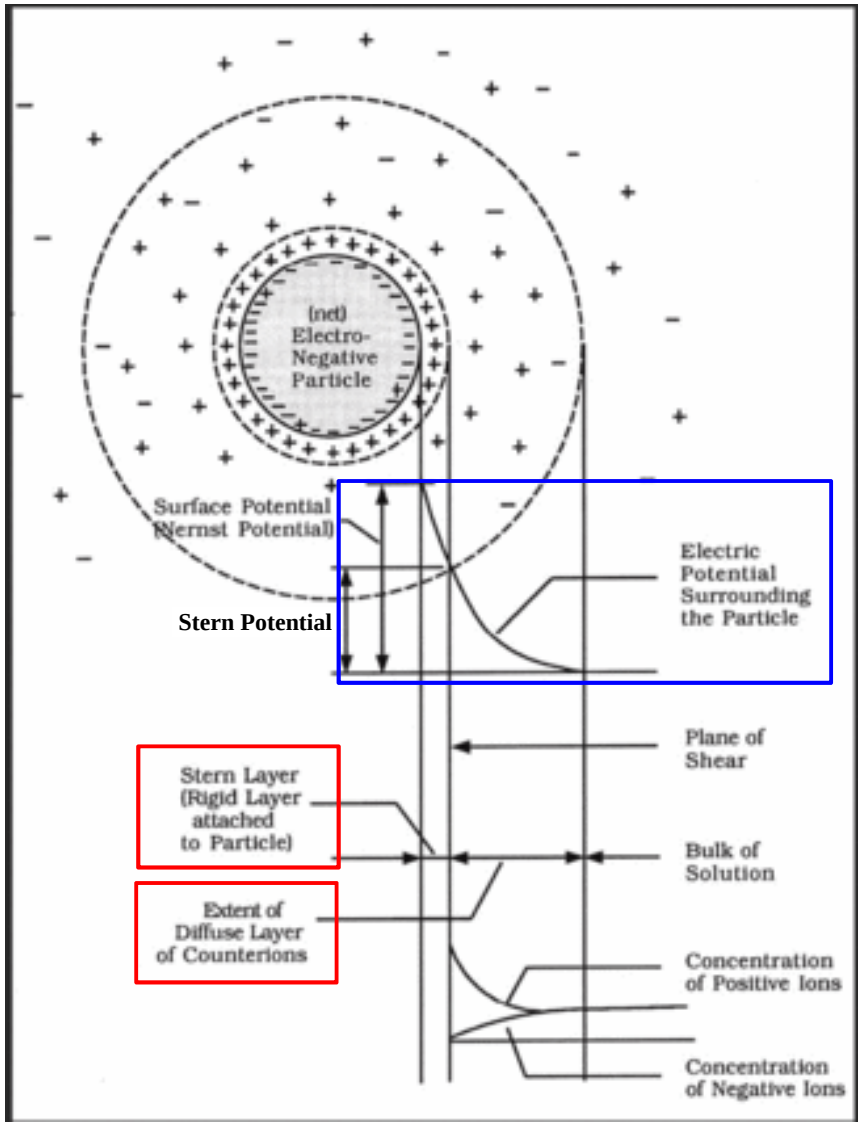
  – Have toxic substances

  – Are involved in disinfection byproduct formation

Colloids

- Small particles (0.001 to 1 µm)
- Usually negatively charged
- Stability of colloidal suspension
  - "Stable" colloidal suspension: particles are like-charged → → particles repel each other → particles do not stick together or settle down easily
  - Destabilization of colloidal suspension: neutralizing the particle charge so that the particles can stick together and settle down

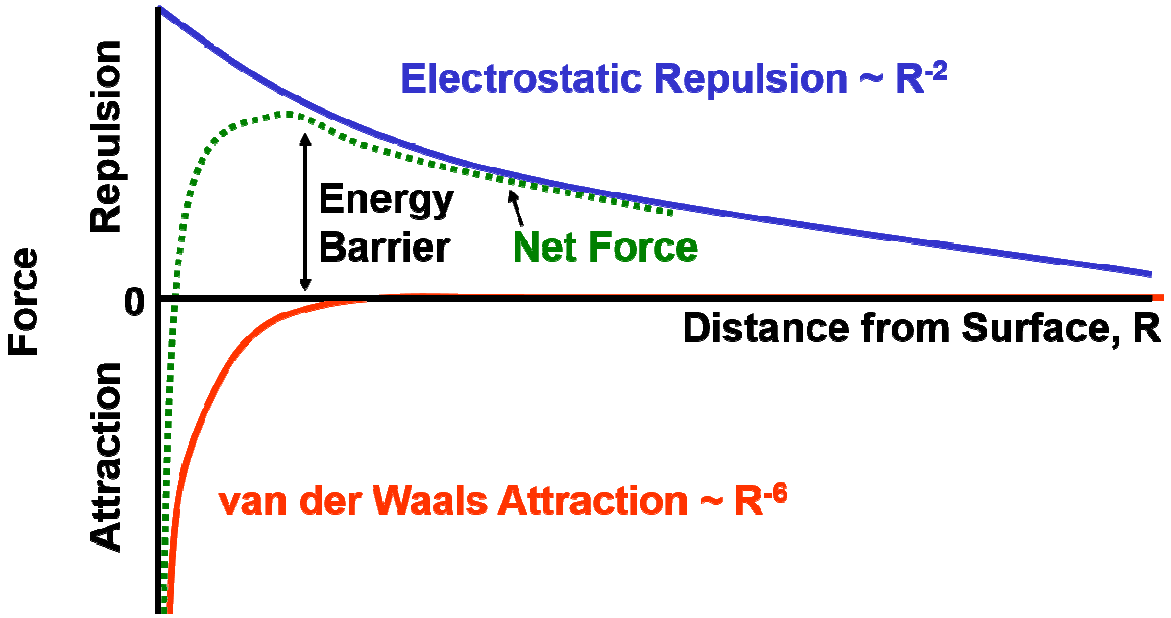
Colloids – electrical double layer



- Ion distribution near the charged colloid is different from the bulk liquid
- Stern layer: rigid layer, ions attached to particle
- Diffuse layer: ions are mobile

http://imk209.wikispaces.com

Colloids – electrical double layer

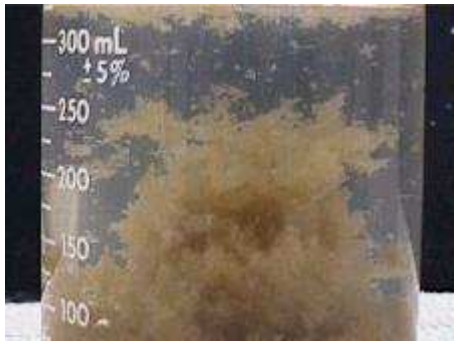


- Need “jumping” the energy barrier for particle adhesion
- Ways to reduce the energy barrier
  - Reduce the surface charge of the particle
  - Increase the ionic strength of the solution (compresses the electrical double layer)

Coagulation-flocculation

- Coagulation-flocculation process is used to remove colloidal particles from water
  - Coagulation: a **chemical** process; change the particle surface properties so that particles can stick together when they collide
  - Flocculation: a **physical** process; create conditions that allows particles to grow in size

- Result: formation of a “floc” (larger, settleable particles)



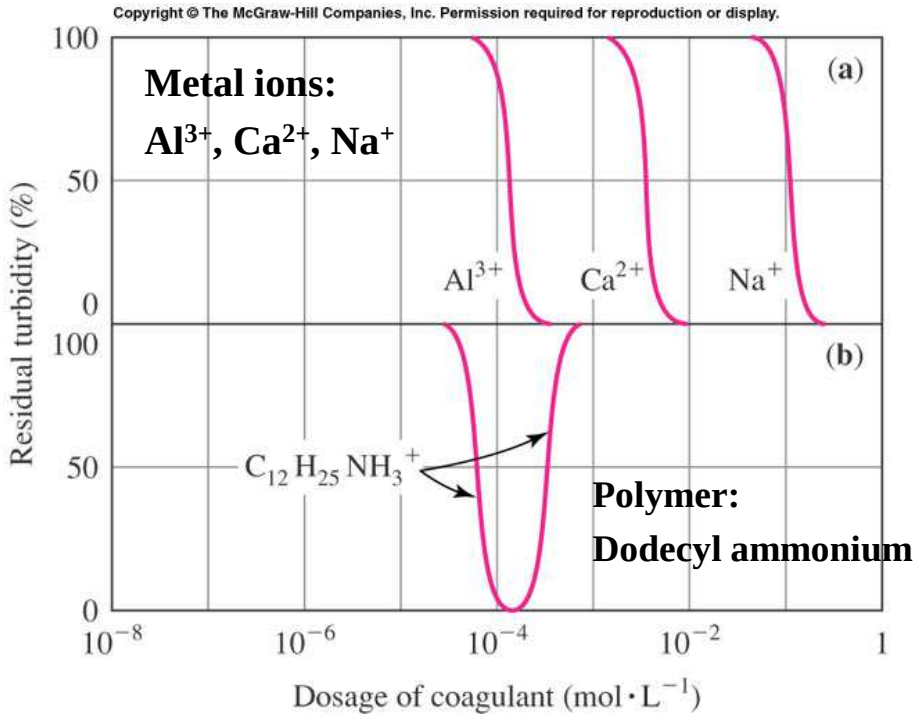
http://www.wrights-trainingsite.com/WT%20coagfloconb.html

Mechanisms of Coagulation-flocculation

- Charge neutralization
- Compression of the electric double layer
- Inter-particle bridging
- Enmeshment in a precipitate

Coagulation

- Goal: To alter the surface charge of the particles so that the particles can stick together to form an initial “floc”
- Coagulants: chemicals added to water for coagulation
- Metal salts or polymeric materials are used as coagulants



- Among metal ions, trivalent ions are most effective
- For some coagulants, charge reversal may occur if overdosed (-) → (+)

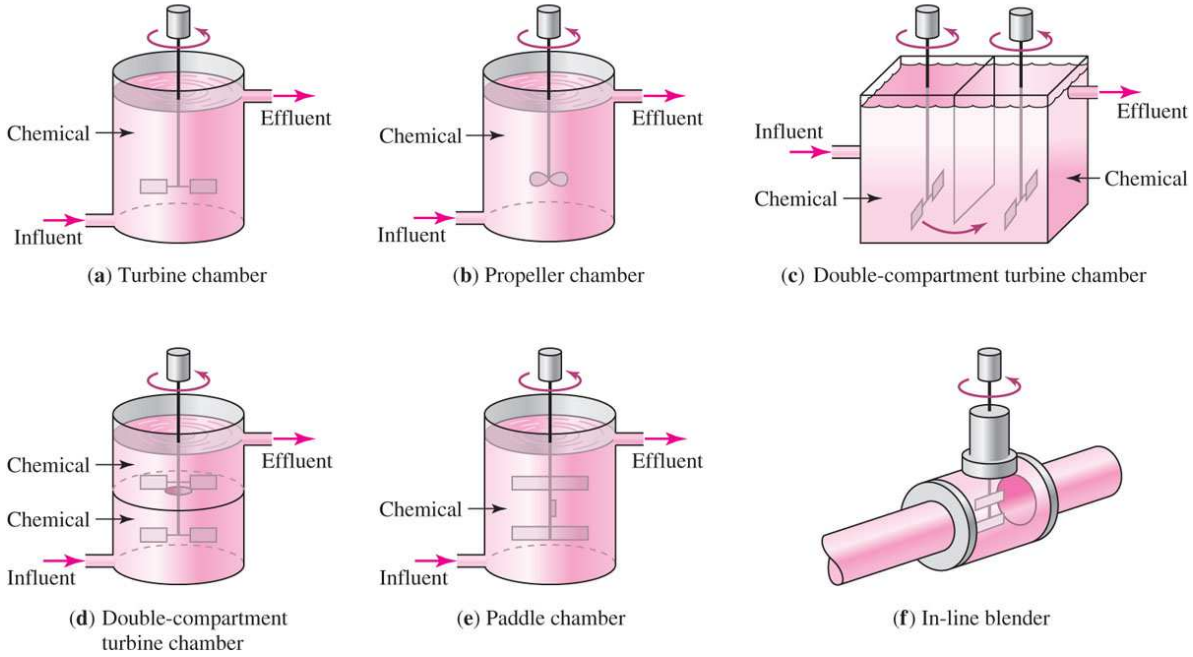
Coagulants

- Key properties
  - Trivalent cation (if a metal salt is to be used)
  - Nontoxic
  - Insoluble in neutral pH

- Commonly used coagulants
  - Al^{3+} or Fe^{3+} salts
  - Alum ($Al_2(SO_4)_3 \cdot 14H_2O$): most common
    - Alum dissolution: $Al_2(SO_4)_3 \cdot 14H_2O \leftrightarrow 2Al^{3+} + 3SO_4^{2-} + 14H_2O$
  - Ferric (Fe^{3+}) cations: $Fe_2(SO_4)_3 \cdot 7H_2O$, $FeCl_3 \cdot 7H_2O$

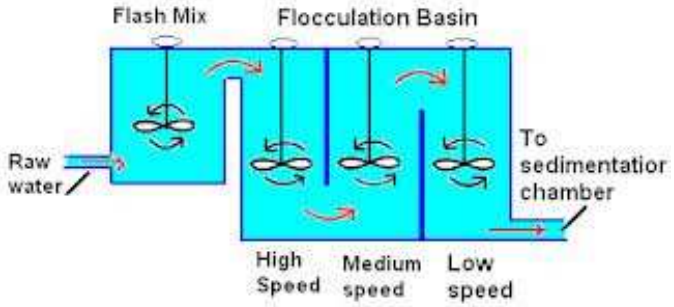
Rapid mix

- To blend chemicals (ex: coagulants, softening agents) with water
- Short retention time (10-30 s)

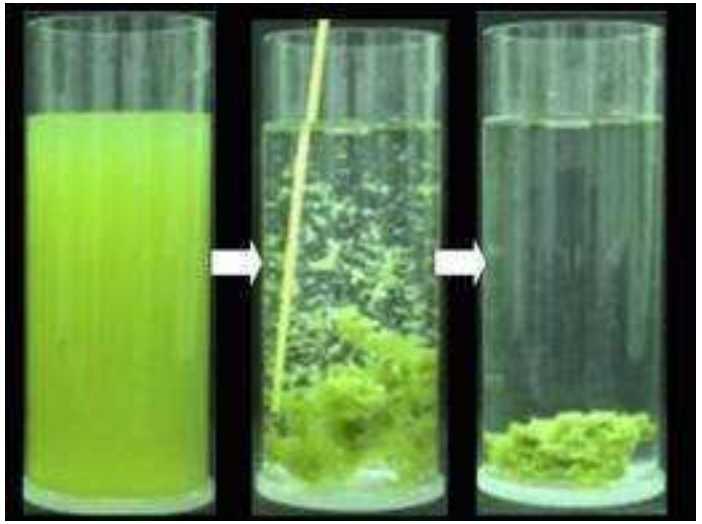


Flocculation

- Goal: allow particles to grow by gentle mixing so that they can easily settle
- Usually configured as a three step process
- Too little mixing → not enough energy for particles to stick together
- Too much mixing → particles break down



http://chemistry.tutorvista.com



http://www.tech-faq.com

Reading assignment

Textbook Ch 10 p. 453-470