

Drinking Water Treatment

Coagulation and Flocculation

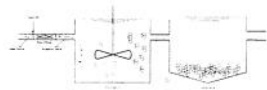
Simon Parsons

Aims and Objectives

- To understand why we coagulate and flocculate and what are the mechanisms
- Introduce chemicals and processes available
- Application/performance of the process
- Be aware of general conditions for flocculation

What is covered in this lecture?

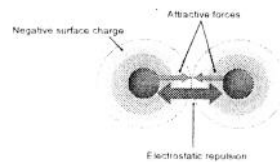
Flowsheet



Turbidity



Mechanism



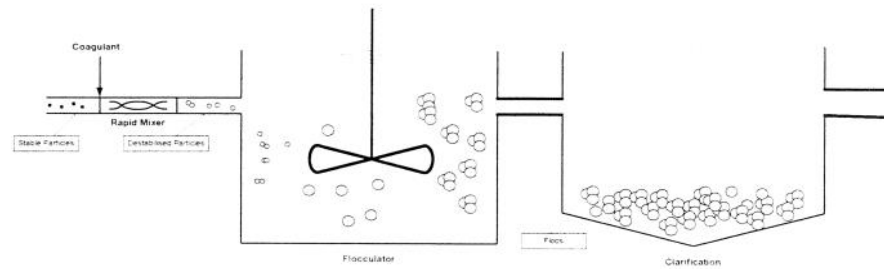
Zeta Potential



Terminology

- Coagulation - process whereby particles in water are destabilised by dosing certain additives (coagulants) to form aggregates
- Flocculation - is the process where destabilised particles and small aggregates are encouraged to collide with each other to form flocs.

Flowsheet



Why coagulate?

- Natural waters can contain:
 - Inorganic particles: clay, silt, mineral oxides
 - Organic particles: bacteria, viruses, algae, cysts
 - Dissolved organics: NOM
- Pollutants are pseudo stable in water:
 - Size
 - Electrical charge (- charge)
 - Hydrophobicity (hydrophilic particles are stable)
- If these properties left unchanged then pollutants remain in the water
- Also used for COD, SS and P removal from wastewaters

Coagulation-Flocculation

- The objective of the coagulation-flocculation process is to make larger particles out of smaller particles - WHY?
- Larger particles are easier to remove by sedimentation
- Larger particles are easier to remove by filtration

Settling Rates

Particle diameter			Type of particle	Settling time through 1 m of water	Specific area $m^2.m^{-3}$
mm	μm	$\text{\AA}$			
10	10^6	10^8	Gravel	1 second	6.10^2
1	10^3	10^7	Sand	10 seconds	6.10^3
10^{-1}	10^2	10^6	Fine sand	2 minutes	6.10^4
10^{-2}	10	10^5	Clay	2 hours	6.10^5
10^{-3}	1	10^4	Bacteria	8 days	6.10^6
10^{-4}	10^{-1}	10^3	Colloid	2 years	6.10^7
10^{-5}	10^{-2}	10^2	Colloid	20 years	6.10^8
10^{-6}	10^{-3}	10	Colloid	200 years	6.10^9

Floc Formation

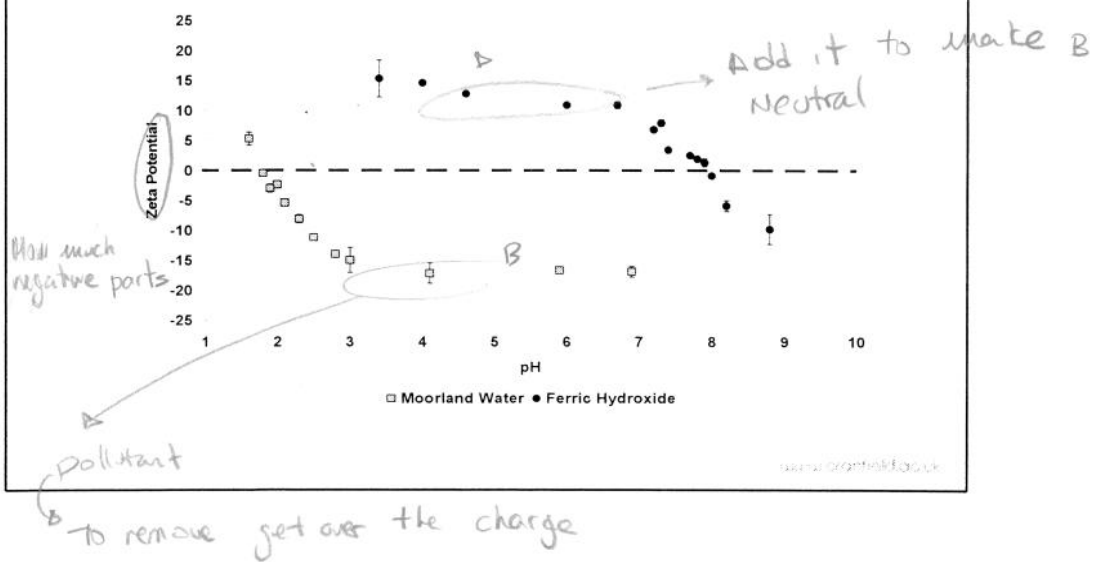
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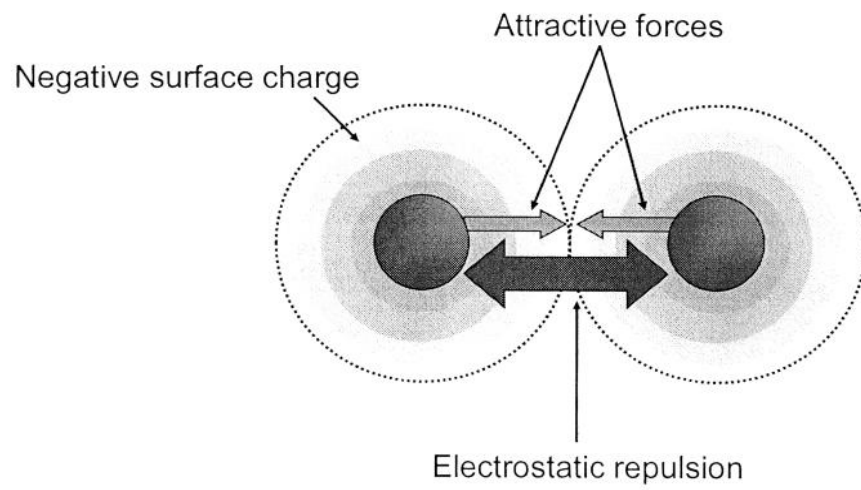
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Process Science

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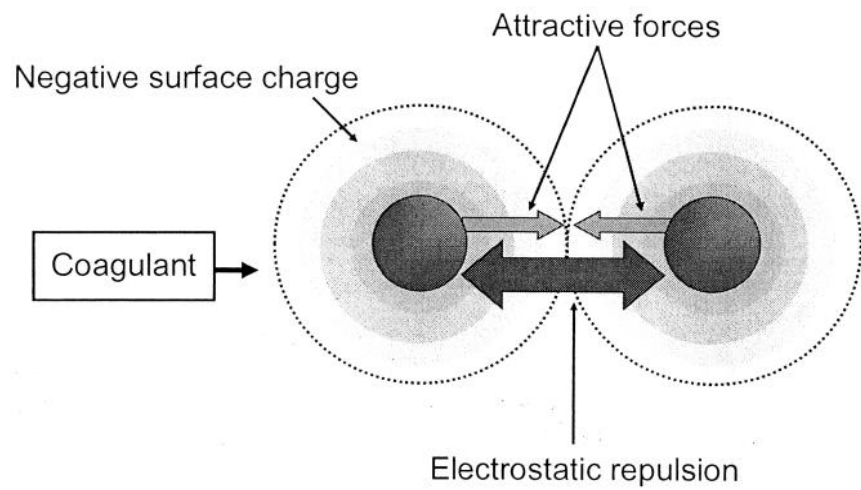


Mechanism

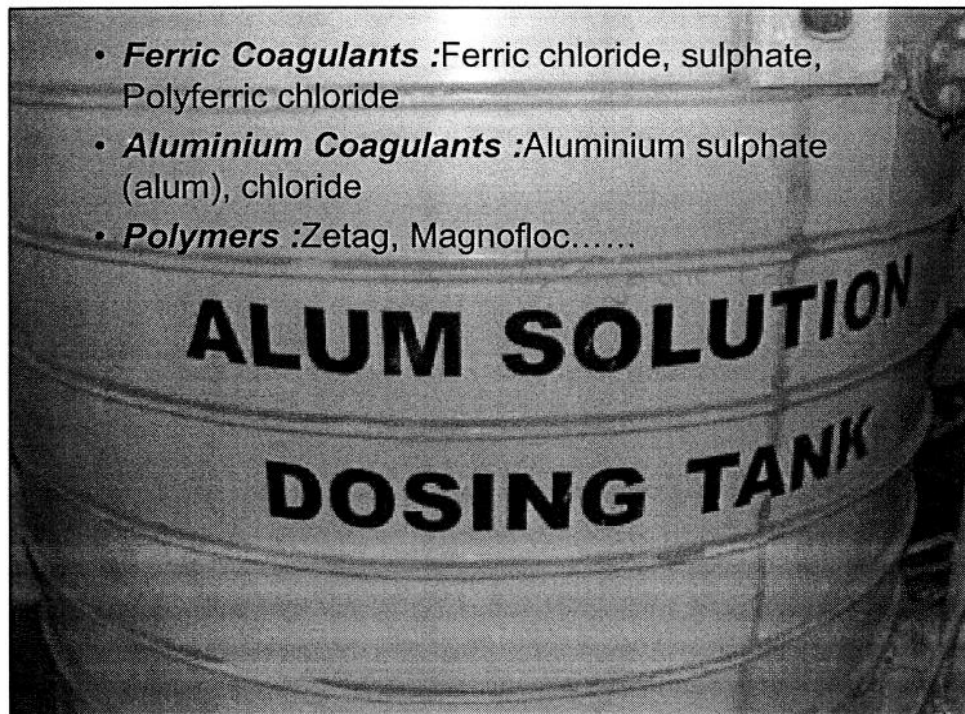


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Mechanism



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Mechanism

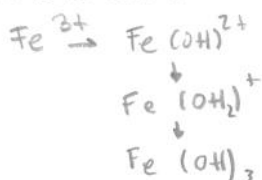
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Flocculation by hydrolysing metal salts can be summarised as:

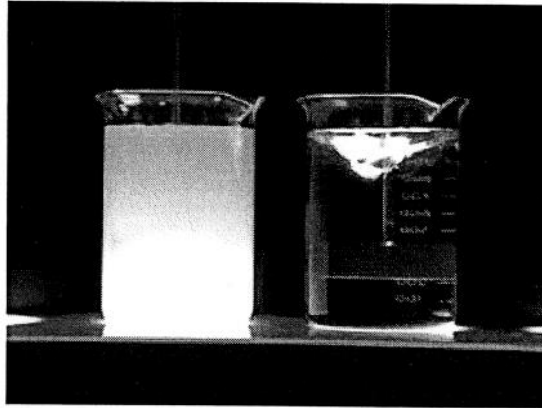
1. Chemical reaction $\Rightarrow$ hydrolysis products (< 1 sec).
2. Adsorption of some hydrolysis products on particles and formation of colloidal hydroxide precipitate (few seconds)
3. **Perikinetic** flocculation of precipitated hydroxide particles and some of the coated particles (< 1 minute).
4. **Orthokinetic** flocculation $\Rightarrow$ large flocs containing most of the original particles (several minutes).

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1- Chemical reaction



Rapid Mix

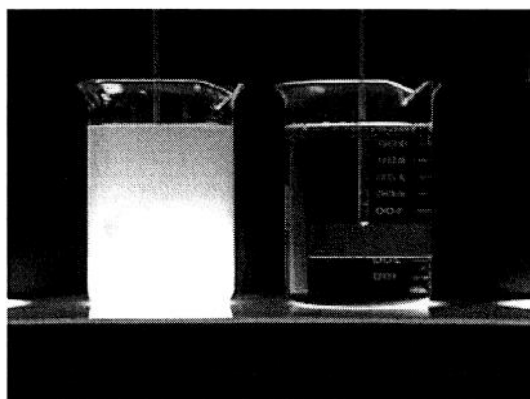


Flocculation

- The objective is to bring particles into contact so that they will collide, stick together, and grow to a size that will readily settle
- Must control G to promote mixing but avoid shearing
- Tapered Flocculation $\rightarrow$ 3 G zones
 - G decreases from beginning to end
 - Average G is the design value

Examples

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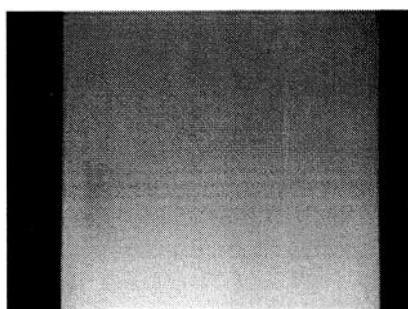
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COLOUR

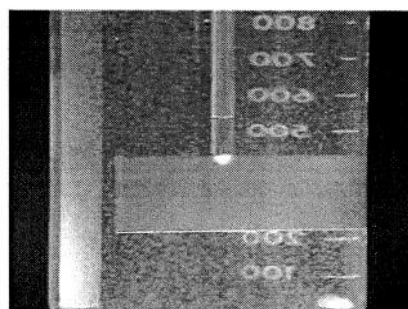
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Slow Mix

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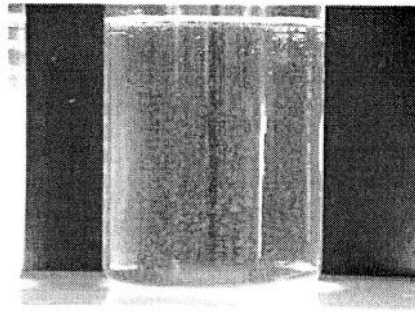
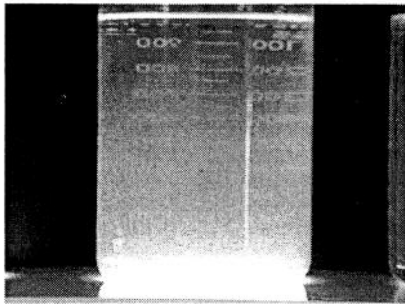


COLOUR

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Settlement

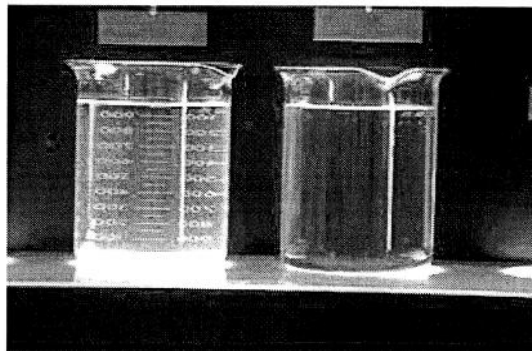
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Final Water

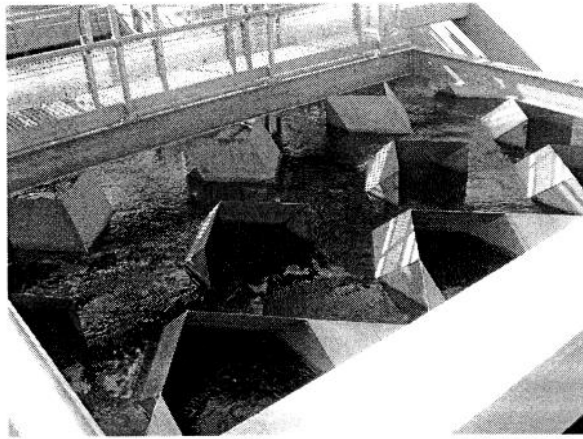
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Chemical dosing

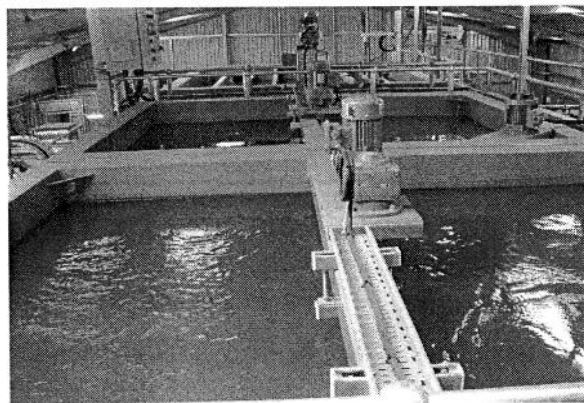
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Mechanical Flocculators

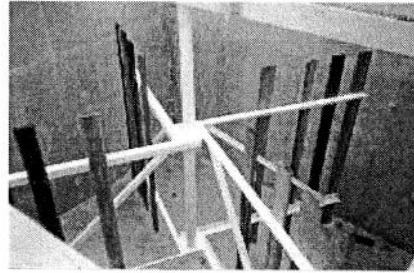
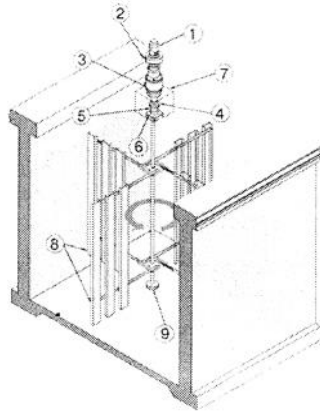
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Paddle Flocculators

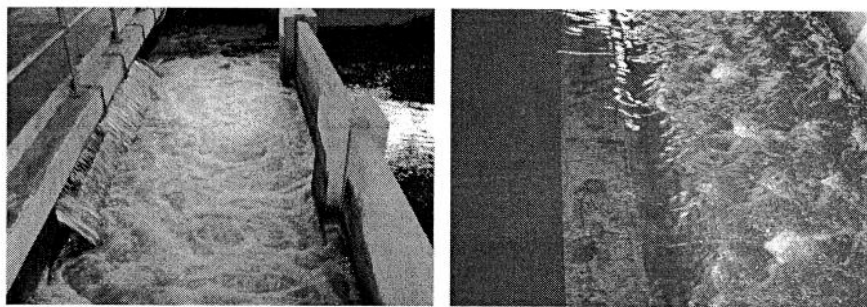
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Hydraulic Flocculation

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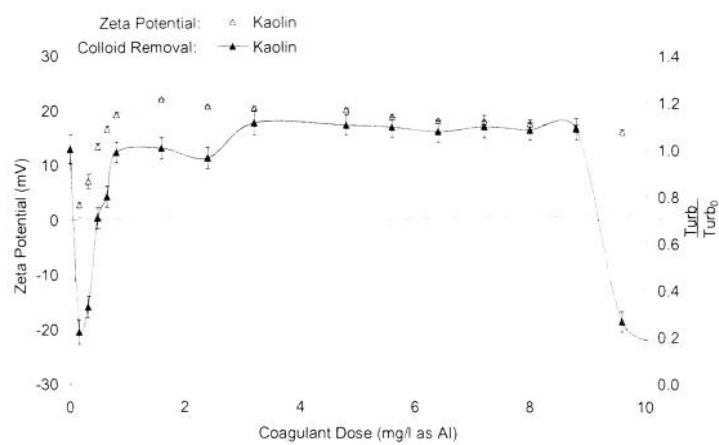
Applications

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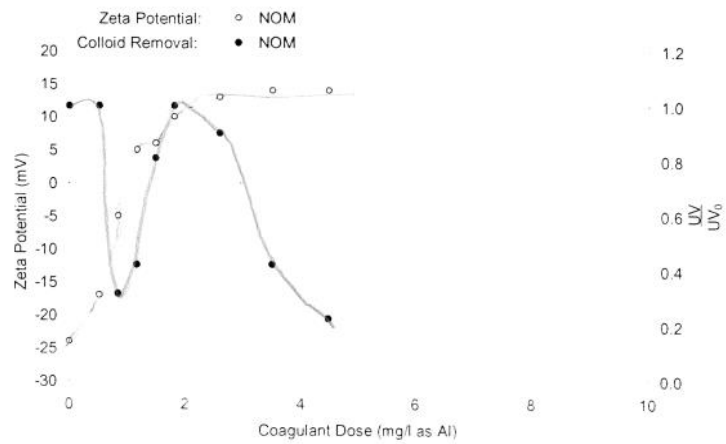
Turbidity: Really easy to remove

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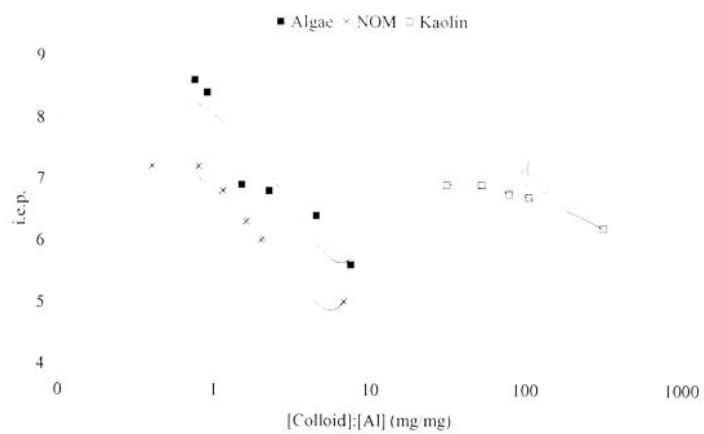


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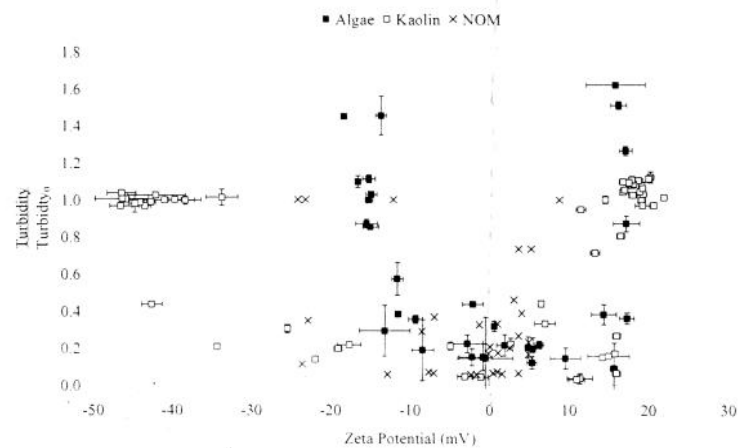
NOM (Not organic matter)



Comparison



Zeta Potential



Particles

- The coagulant demand of both organic particles is ~ 100 x that of turbidity particles
- Means that if organics are present they may control dose requirements
- Problem in 'flashy' rivers where particles and organics flushed in during rainstorms

Aims and Objectives

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