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MARCH 5, 2018
AALTO UNIVERSITY

Water treatment with Kemira

kemira

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Chemical water treatment

Examples of impurities in water and wastewater

Particles and dissolved compounds:

- Mineral particles, e.g. clay, sand
- Humic substances
- Bacteria, viruses, parasithes, helminth eggs
- Pesticides
- Nutrients
- Organic matter

Chemical treatment

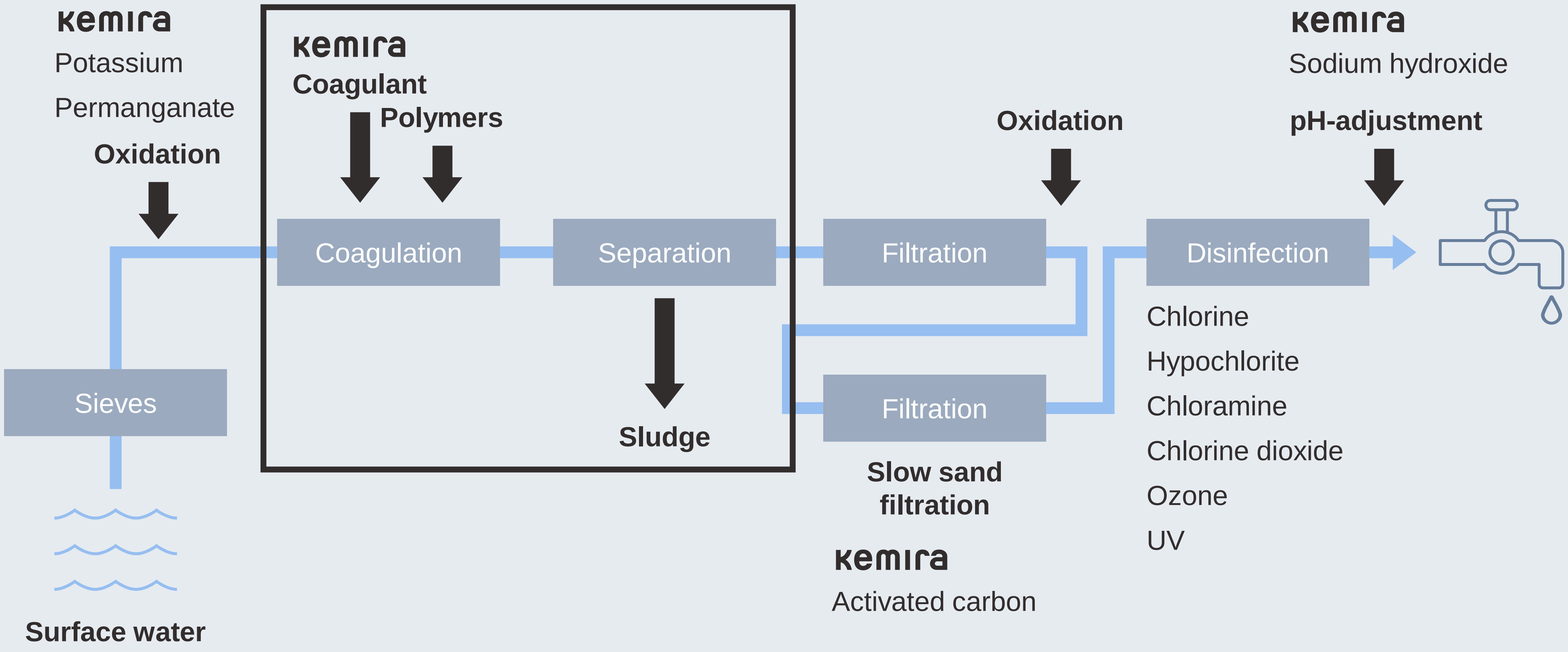
With the help of chemistry, impurities and unwanted compounds are removed from water and wastewater

We produce 150 liters of wastewater per person per day

1 kg of a coagulant treats our wastewater for three months

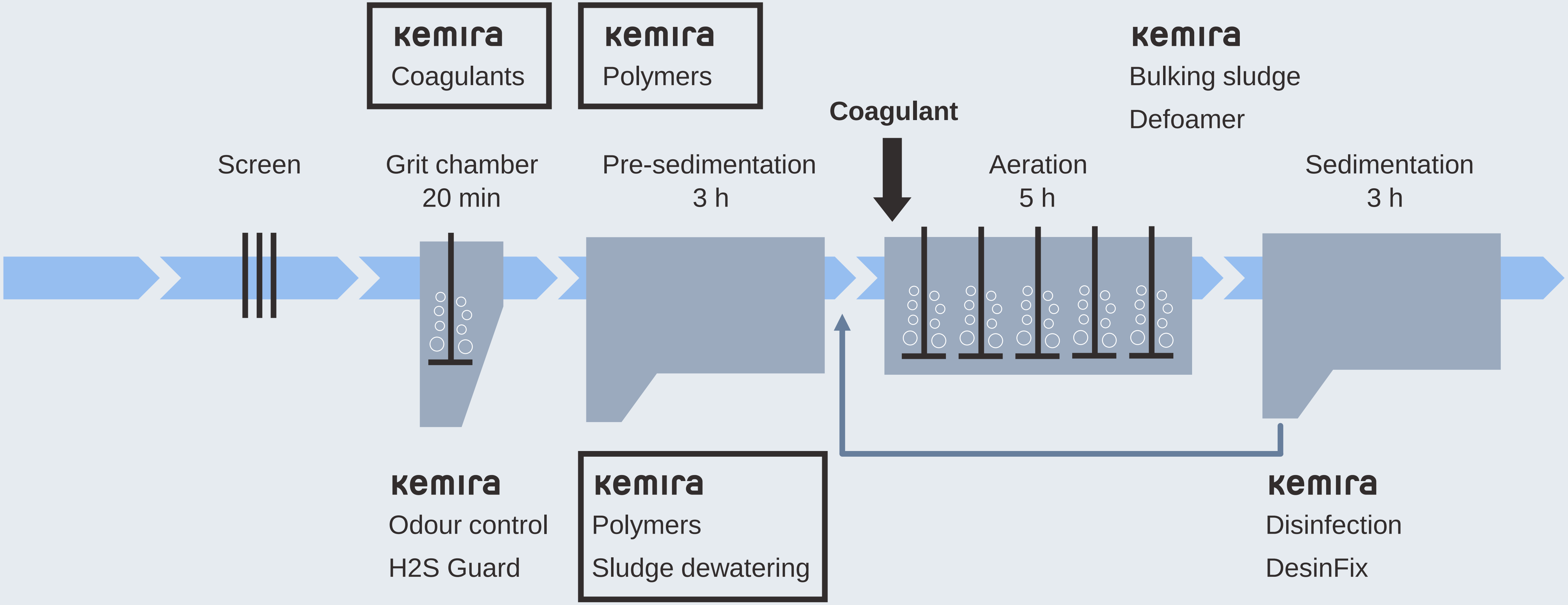
1 kg of a flocculant treats our wastewater for one year

Surface water treatment - chemicals support the process and the removal of impurities



Wastewater treatment – chemicals support the process and the removal of impurities

SIMULTANEOUS PRECIPITATION



Products

Kemira – Most important water treatment product

Coagulants

Flocculants

Inorganic coagulants in water and wastewater treatment

- Iron and aluminium salts
- Trade names
  - Kemira PIX
  - Kemira PAX
  - Kemira ALG/ALS/AVR
- Production in about 40 plants worldwide
- Production of approx. 3 million tons per year

Main inorganic coagulants in water and wastewater treatment

PIX	$FeCl_3$, $Fe_2(SO_4)_3$, $FeCl_2$, $FeSO_4$, $FeClSO_4$
	Ferric chloride and sulphate
	Ferrous chloride and sulphate
PAX	$Al(OH)_xCl_{3-x}$
	Polyaluminium chloride
PAS	$Al(OH)_x(SO_4)_{3-x}$
	Polyaluminium sulphate
ALG/ALS/AVR	$Al_2(SO_4)_3$
	Aluminium sulphate
	Aluminium iron sulphate

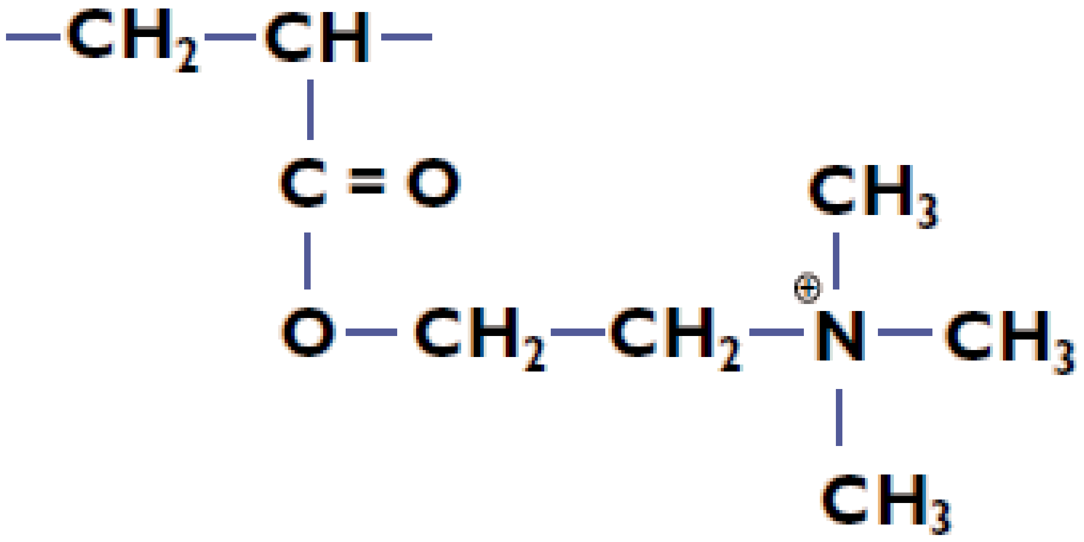
Organic products in water treatment

Flocculants - Superfloc

- Polymer Polyacrylamide (PAM)
- Cationic, non-ionic, anionic
- Very high molecular weight

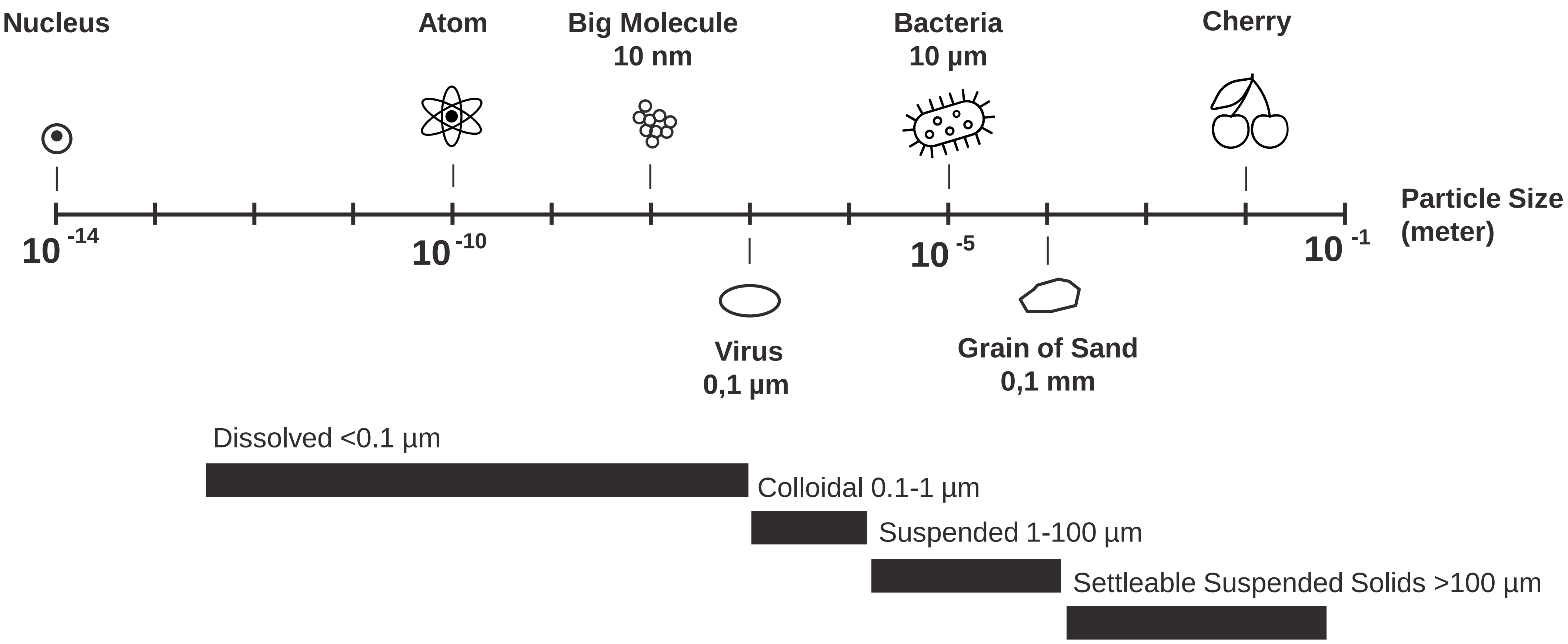
Organic coagulants - Superfloc

- Poly-DADMAC
- Polyamine
- Medium molecular weight



About particle size and density

Particle distribution

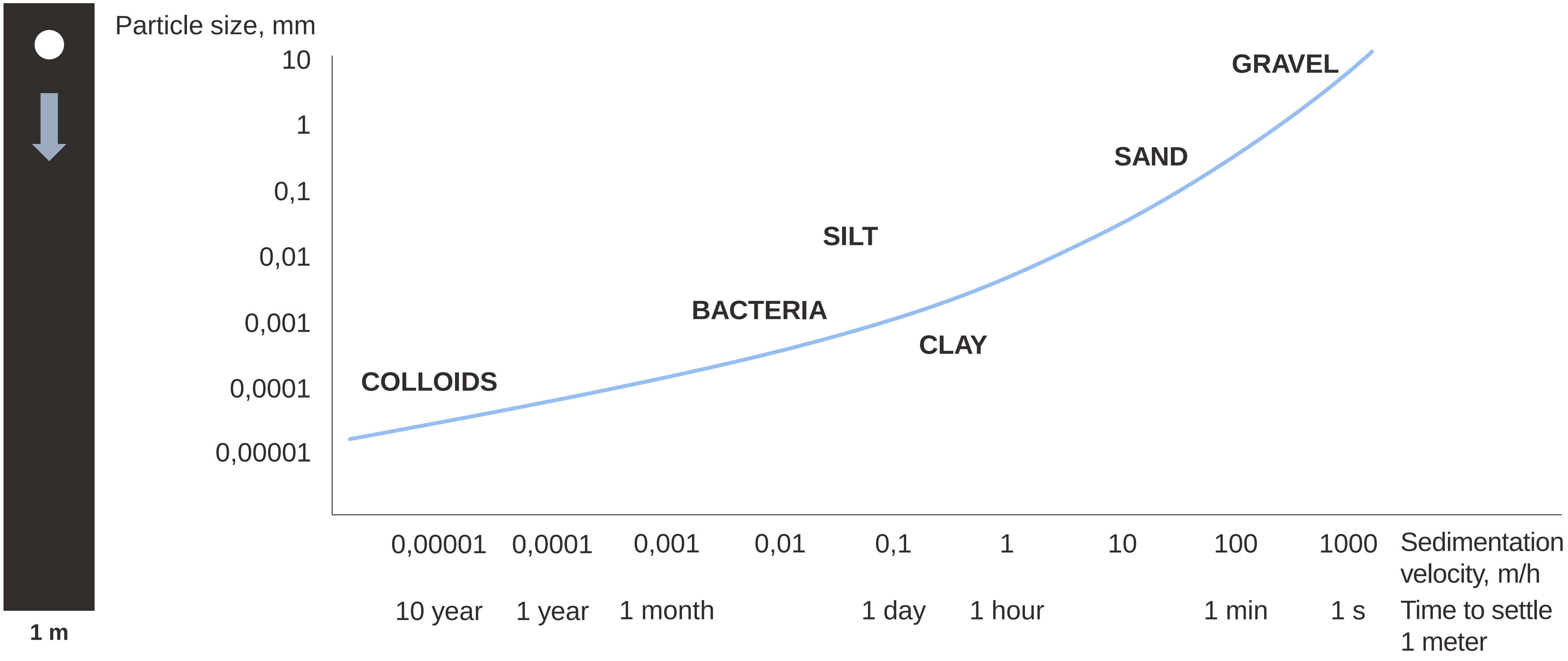


Influence of particle size and density on the sedimentation time

➤ **Table 7:2** Influence of particle diameter on the time required for particles to settle 1 m in stationary water at a temperature of 25°C, assuming that particle sedimentation follows Stokes' law and that particles have a density of 1,05, 1,10 and 2,65 g/cm^3 respectively. The table also shows the surface area of 1 cm^3 of particles of different sizes.

Particle diameter	Sedimentation time (1,05 g/cm^3)	Sedimentation time (1,10 g/cm^3)	Sedimentation time (2,65 g/cm^3)	Total particle area (m^2/cm^3)
1 mm	37 seconds	18 seconds	1 second	0,006
0,1 mm	1 hour	31 minutes	2 minutes	0,06
10 µm	4 days	2 days	3 hours	0,6
1 µm	1 year	0,6 year	13 days	6
0,1 µm	117 years	58 years	3,5 years	60

Sedimentation velocity for particles



Coagulation

Definitions

THE AIM OF CHEMICAL TREATMENT: TO CHANGE THE IMPURITIES IN WATER TO SUCH A FORM THAT THEY CAN EASILY BE SEPARATED

ONE DEFINITION:

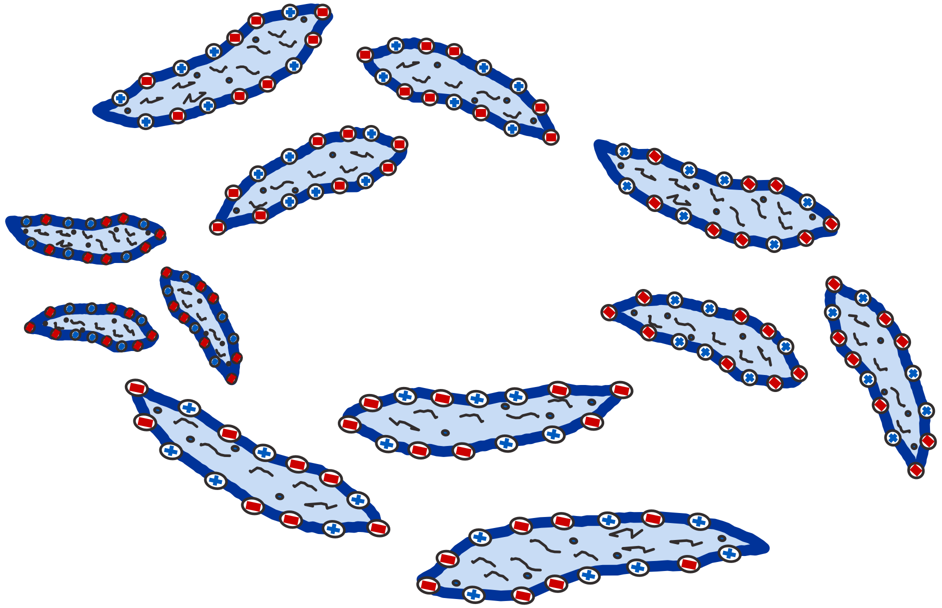
COAGULATION the process whereby charged particles are neutralized

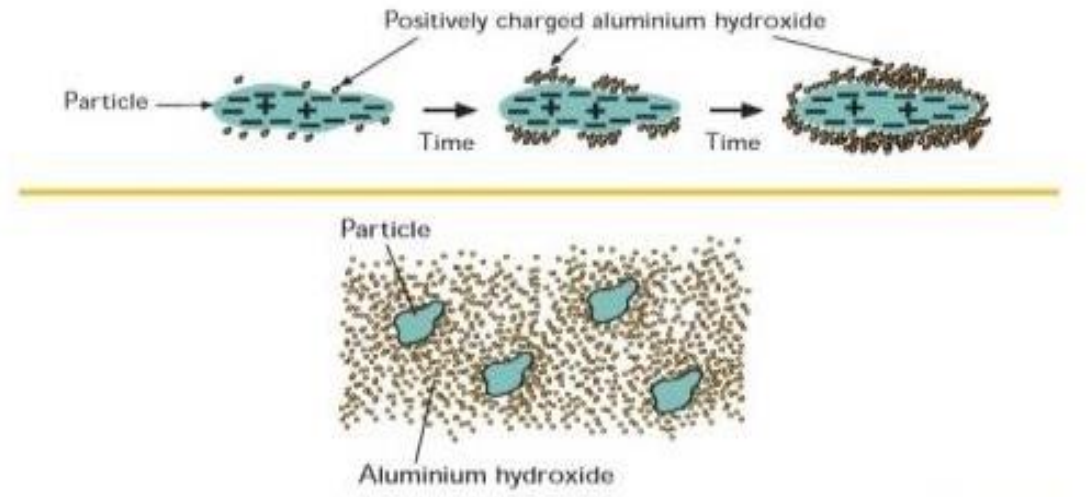
FLOCCULATION the process whereby neutralized particles join together (agglomerates) and form aggregates

ANOTHER DEFINITION:

FLOCCULATION the generic term covering all aggregation processes

Coagulation/Particle Destabilization



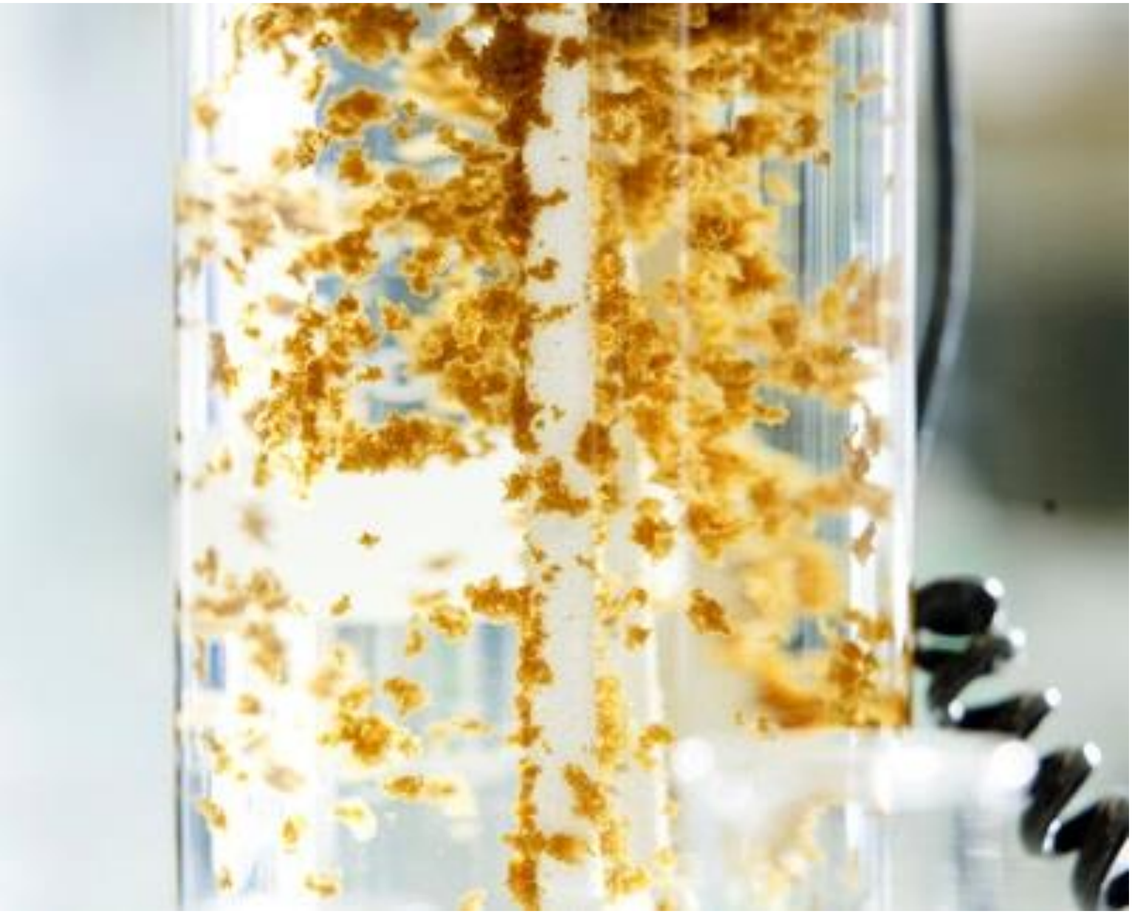


Charge neutralization

Patch coagulation

Sweep coagulation

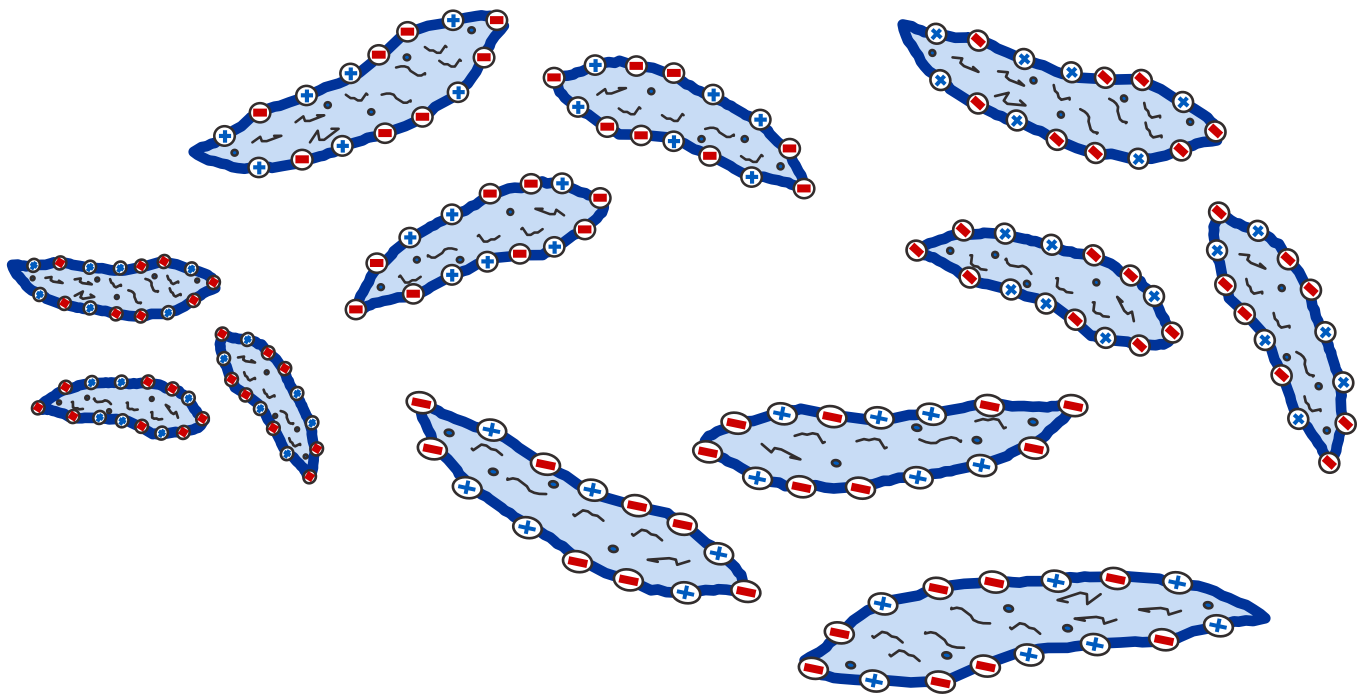
Charge neutralisation



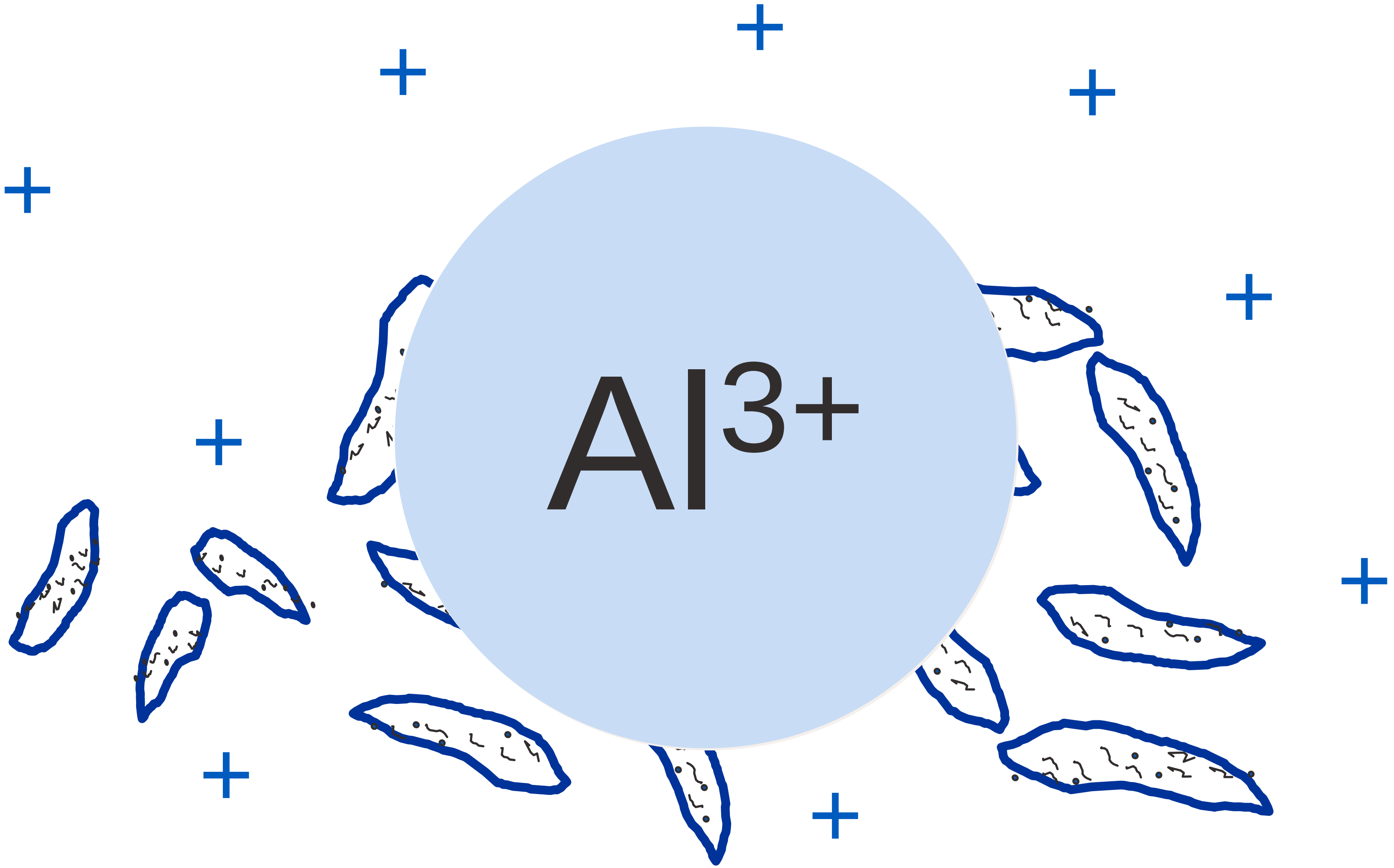
- Almost all particles in water have a negative charge and therefore repel each other
- When their surface charge is reduced, they can aggregate (van der Waals)
- The negative net charges are neutralized by addition of positive metal ions (Al^{3+} & Fe^{3+}) or other cationic compounds such as organic coagulants
- Extremely fast reaction < 0,1 second

Particles in water…

…HAVE NEGATIVE CHARGES AND REPEL EACH OTHER



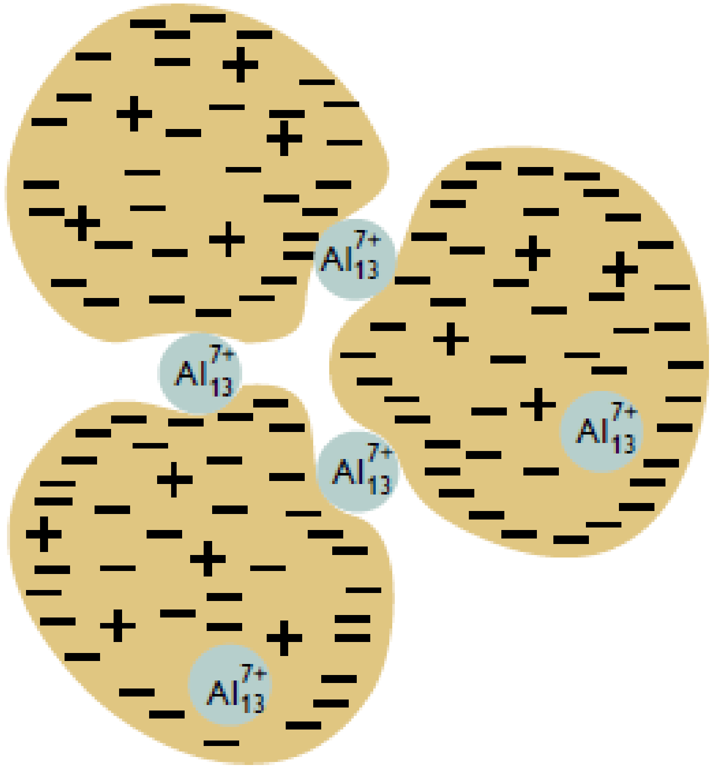
Charge neutralisation



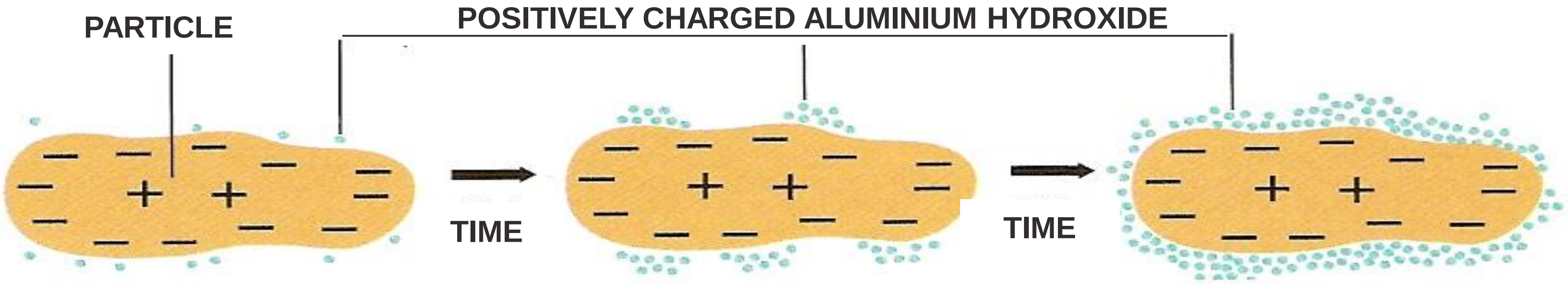
Patch coagulation

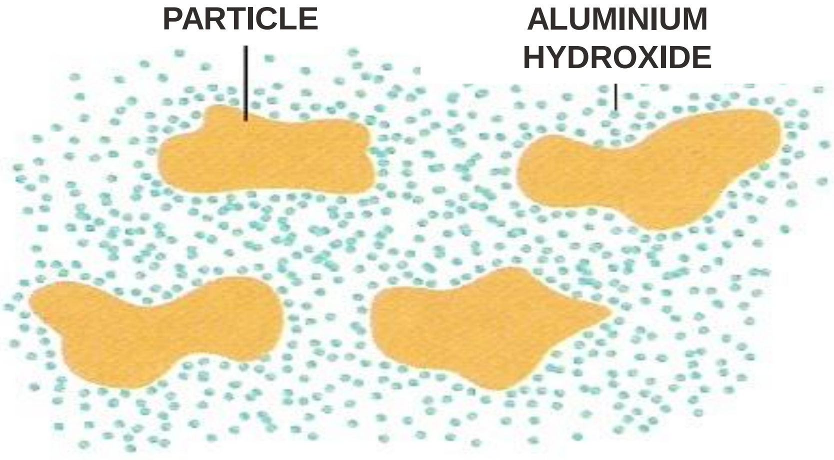
POLYMERS ADSORB ON TO PATCHES OF THE PARTICLES AND ACT AS A SORT OF GLUE THAT STICKS THE PARTICLES TOGETHER

Patch adsorption and cross-linking with Al_{13} ions



Sweep coagulation





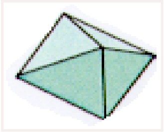
The contaminants become enmeshed in the hydroxides, start to sink and sweep even more with sinking

Fast reaction, 1 to 7 seconds

$$Al^{3+} + 3H_2O \rightarrow Al(OH)_3 + 3H^+$$
$$Fe^{3+} + 3H_2O \rightarrow Fe(OH)_3 + 3H^+$$

INSOLUBLE FLOCS

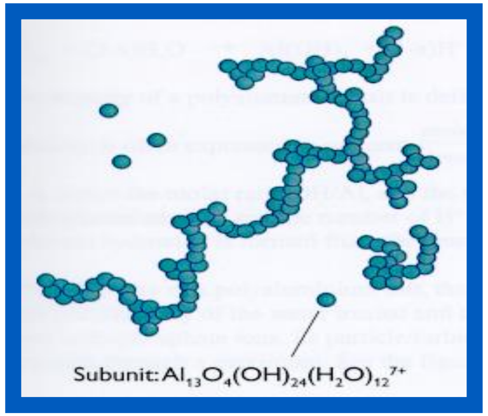
Aluminium(III) complexes

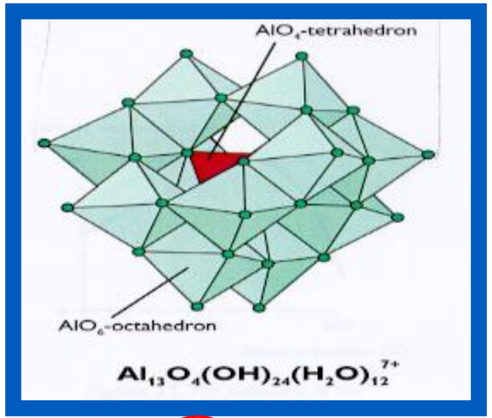


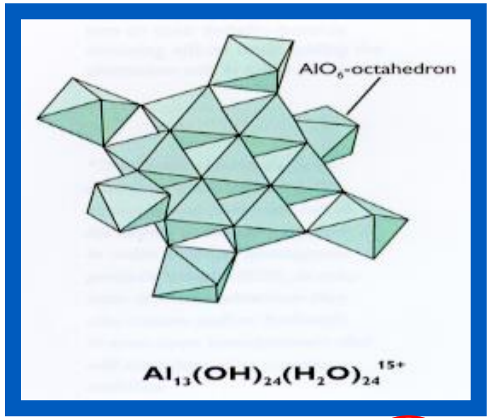
$Al(H_2O)_6^{3+}$

Al^{3+}

By varying the recipe, it is possible to change the properties of the coagulant







$Al_{13}O_4(OH)_{24}^{7+}$

$Al_{13}(OH)_{24}^{15+}$

Organic coagulants

- Similar function as inorganic coagulants but not as efficient on small particles
- Charge neutralisation
- Can be mixed with aluminium or iron coagulants
- Allows water to be treated at higher pH
- Note! No effect on soluble phosphates

Flocculation

Flocculation with polymers

Polymer can

- Neutralize the charge
- Bridge charged particles
- Cross-link the flocs after coagulant has been added

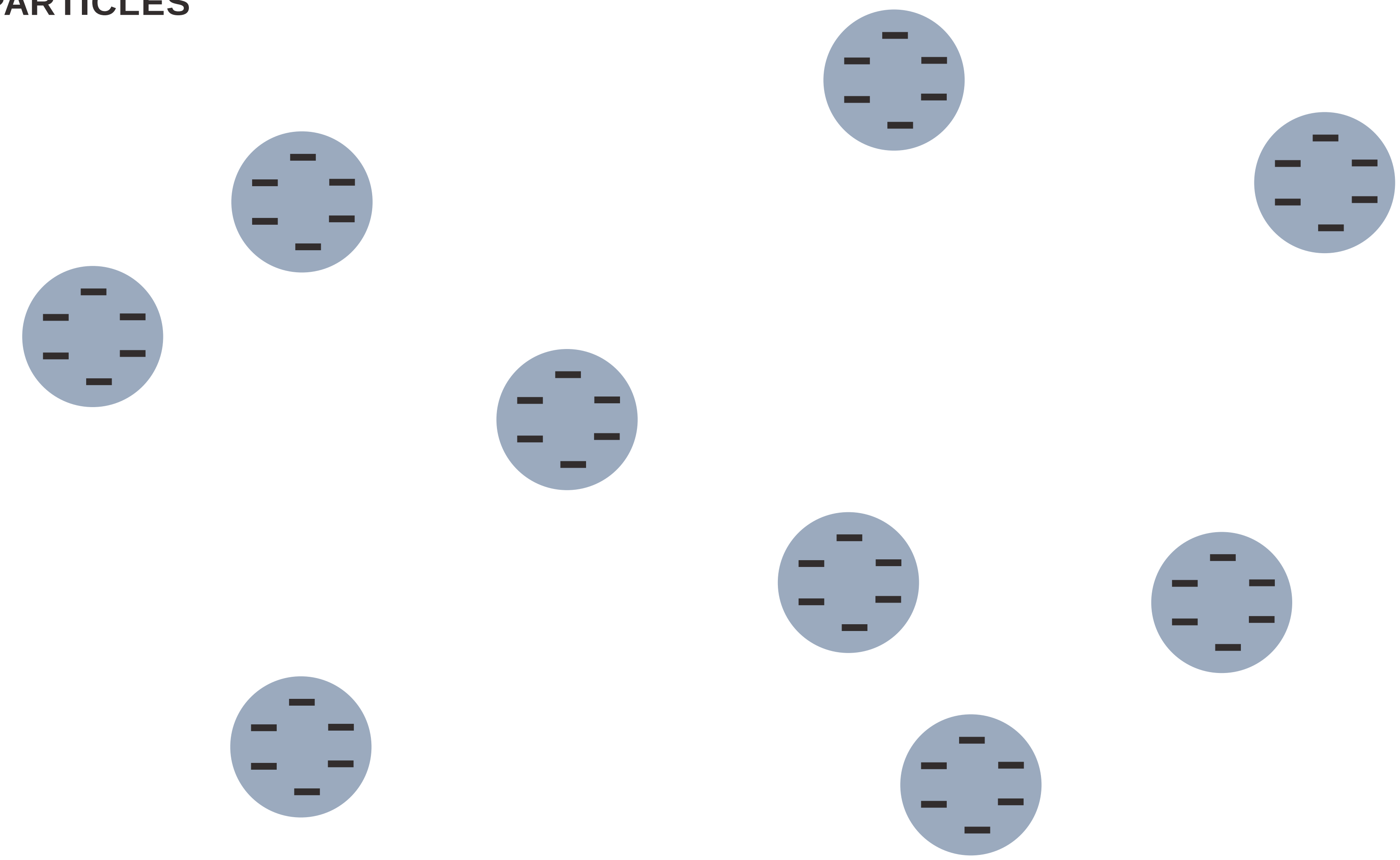
Polymers are like an adhesive tape or glue, joining the particles and smaller flocs together into larger, denser agglomerates

Denser – Stronger – Less water

Faster separation

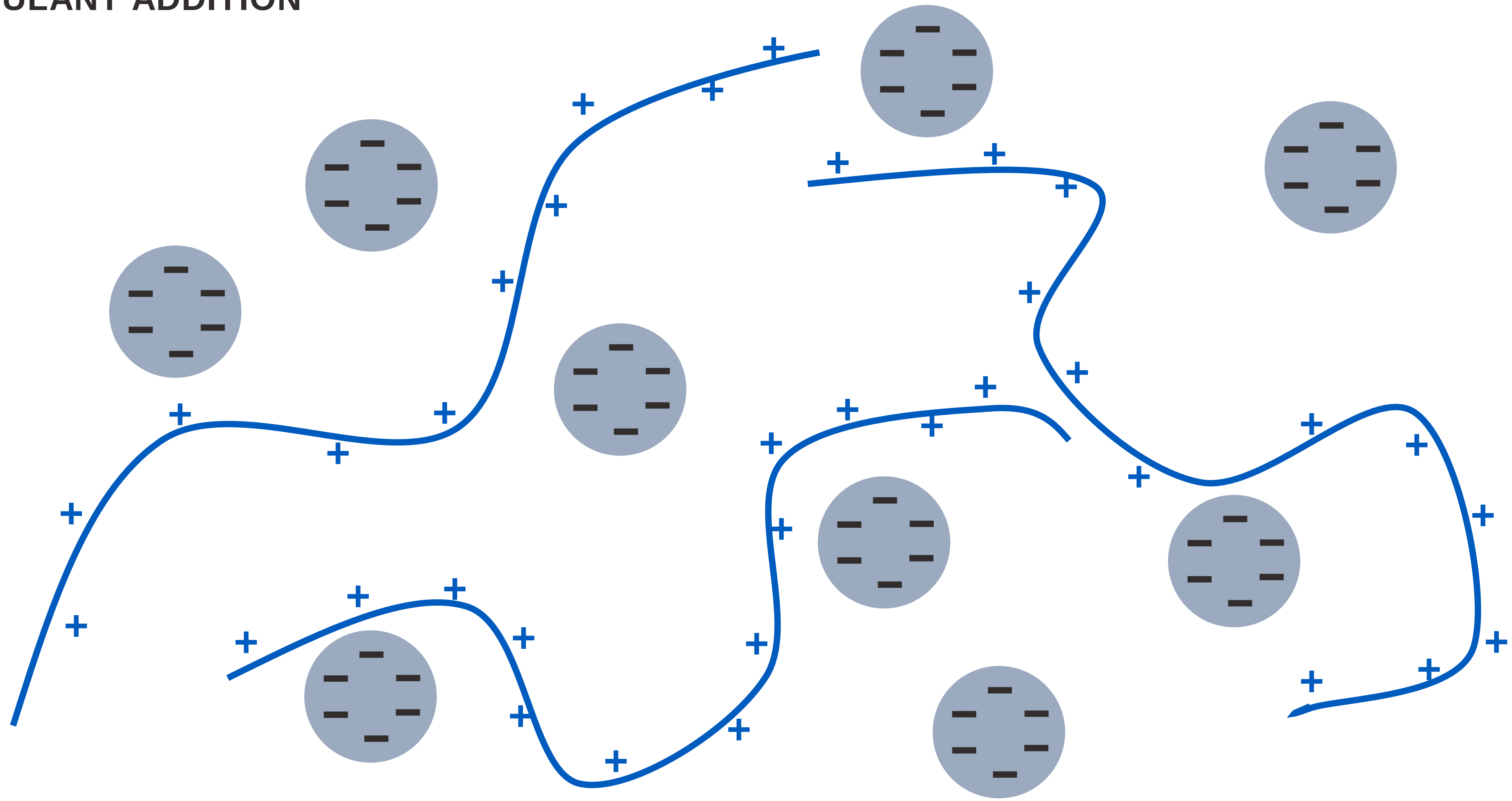
Flocculation

DISCRETE PARTICLES



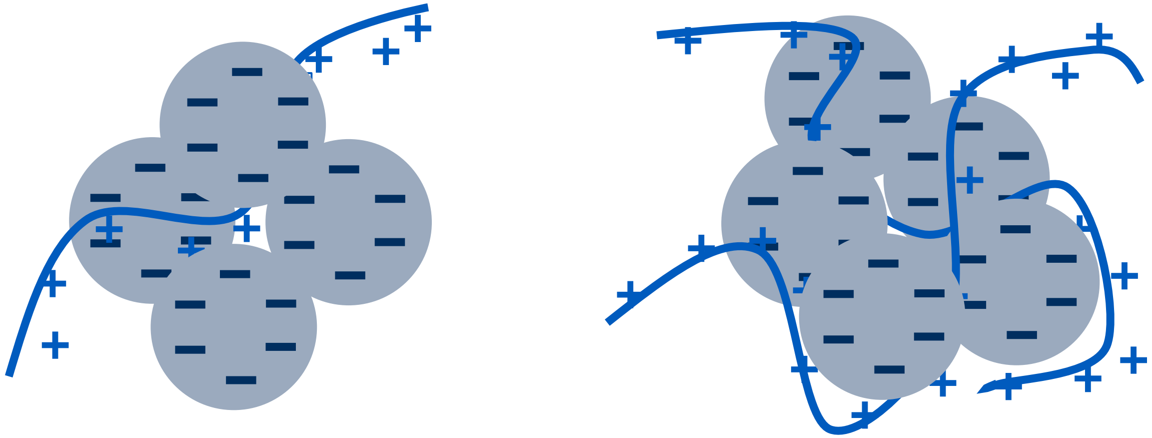
Flocculation

FLOCCULANT ADDITION



Flocculation

BIGGER FLOCS



Two typical applications of Polyacrylamides

- Sludge dewatering – water and wastewater treatment processes

- To support the coagulation process – water treatment plant and e.g. tertiary treatment at wastewater treatment plant

Polyacrylamides in sludge dewatering

Products having different molecular weights are used for different applications

- Centrifuge application requires a strong bridging action - PAM with a high molecular weight forms strong flocs that can tolerate the high shear rates and is used in these applications
- Some other application require less bridging action. A polymer with a lower molecular weight should be chosen for such cases.

Polyacrylamide supports the coagulation process

Improved water treatment

- Building stronger flocs
- Building flocs more rapidly
- Building heavier flocs

Replacing part of inorganic coagulant

- Reduced sludge production
- Reduced alkaline consumption

Using a polymer only is normally not enough

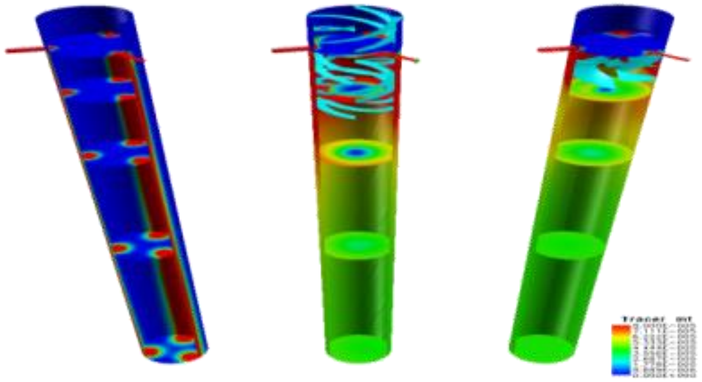
- The inorganic coagulant is the key component in water treatment – the flocculant supports

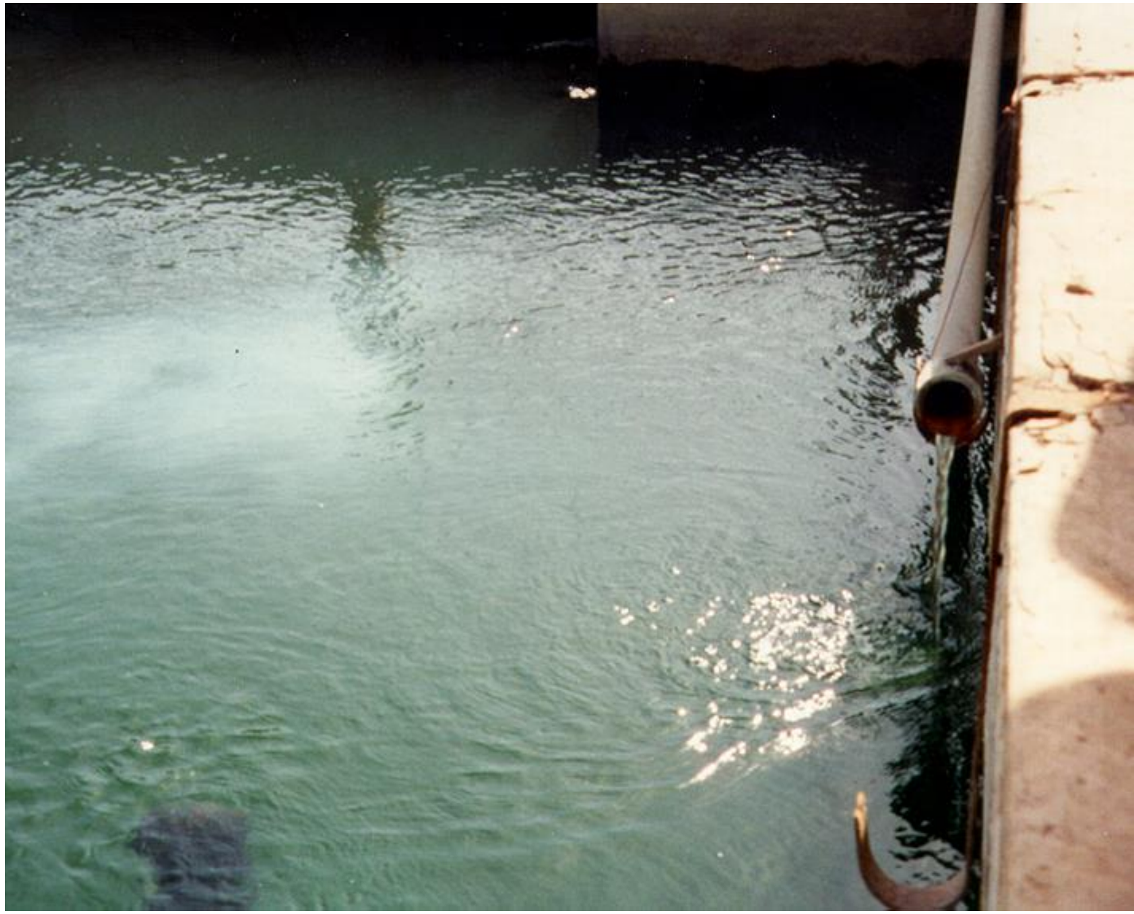
https://www.youtube.com/watch?v=TKAHZECfXok
https://www.youtube.com/watch?v=8Q9bWjxmT0o
kemira

Important factors for optimal results

Factors that influence coagulation

- pH
- Alkalinity
- Turbidity
- Colour
- Organic content
- Mixing energy
- Type of coagulant
- Temperature
- Order of addition
- Dose





Factors that influence coagulation

- pH
-
-
-
-
- Mixing energy
-
-
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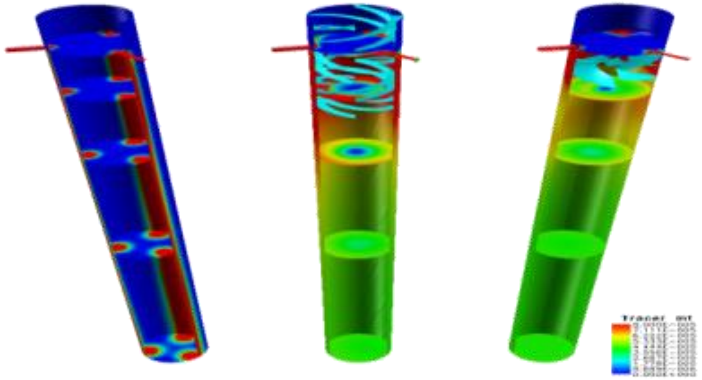
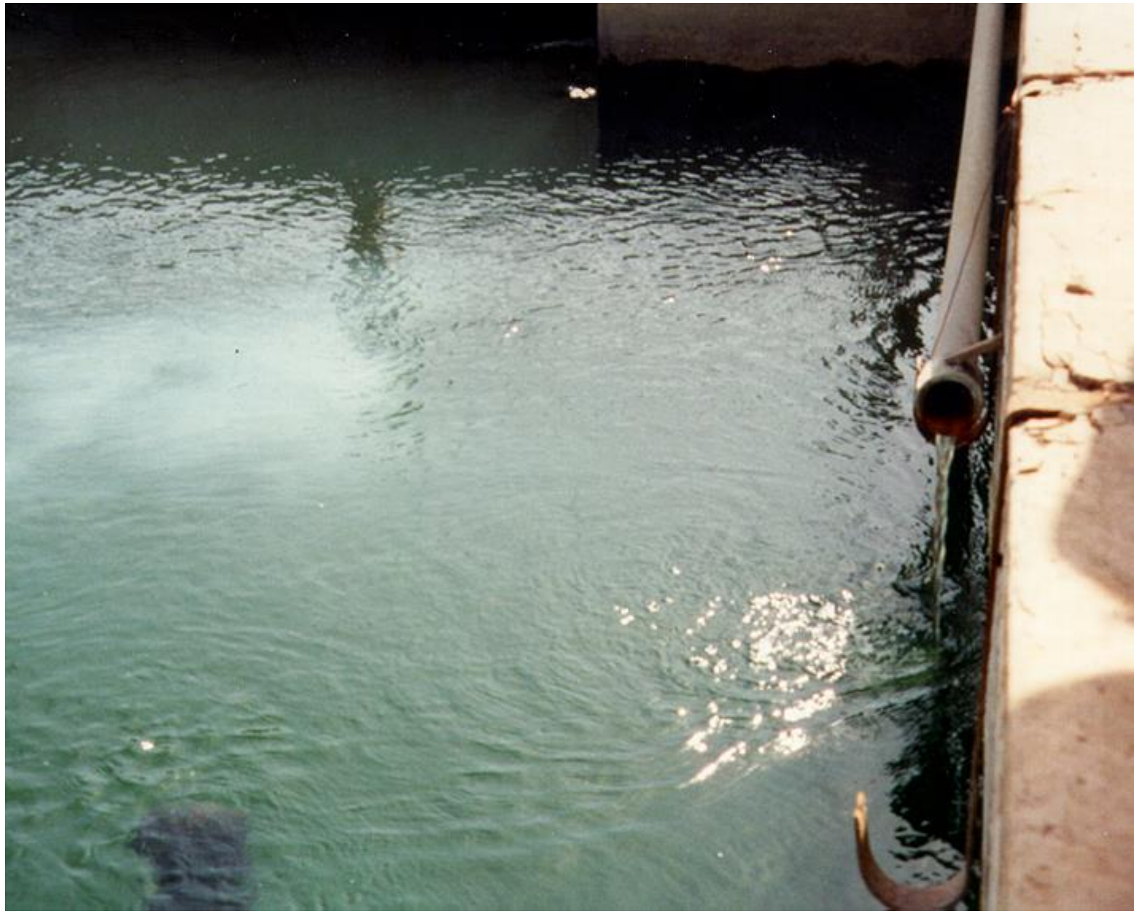
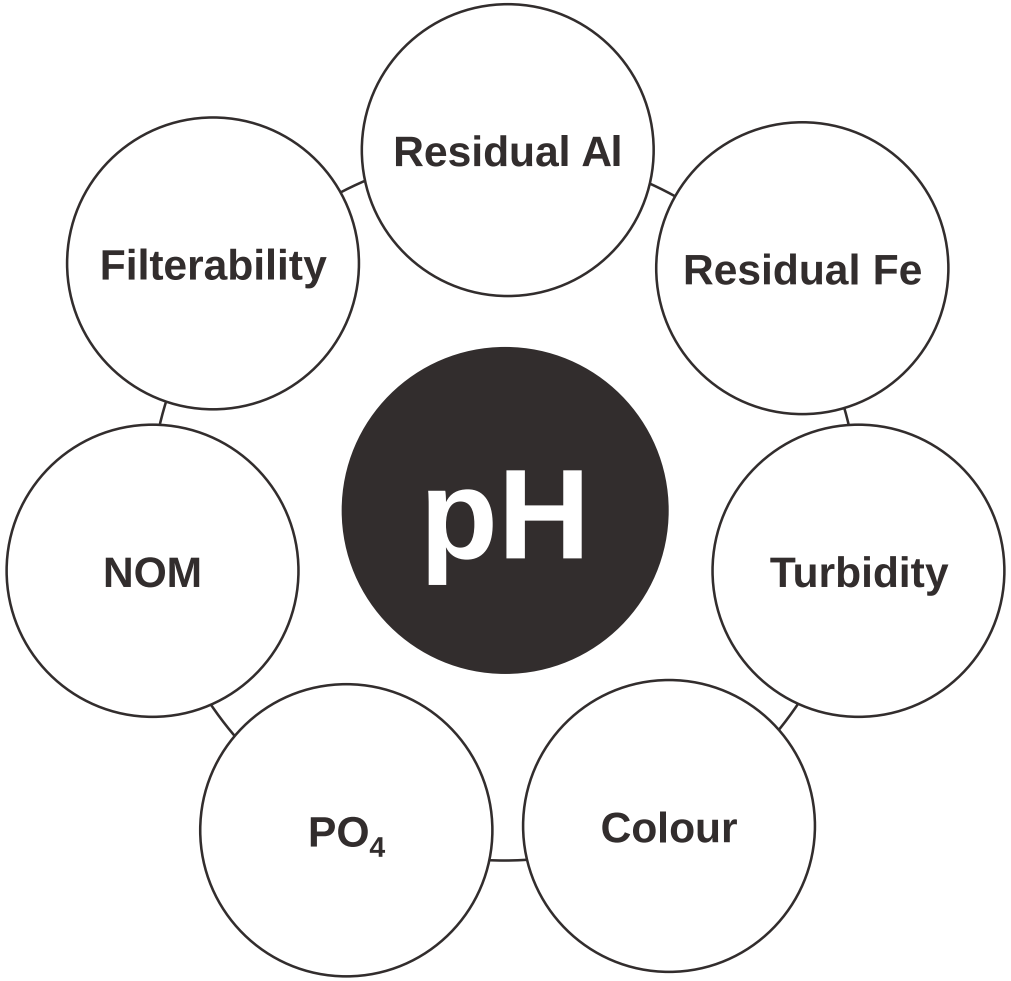


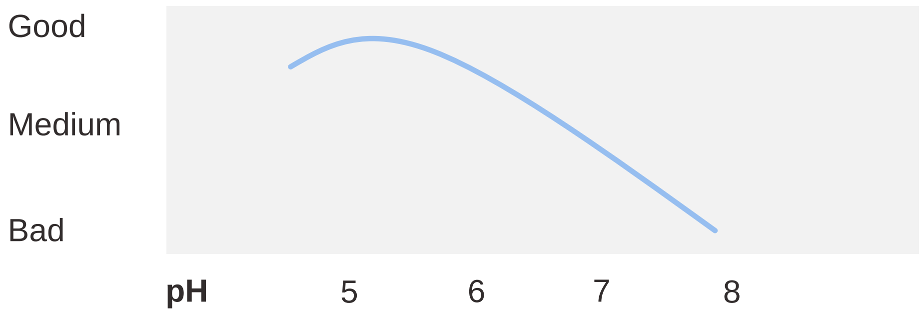


pH – one of the most important factor!

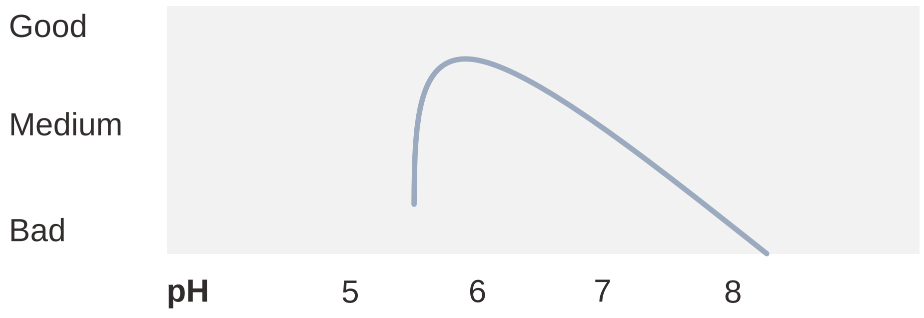


The coagulation window – Aluminium products

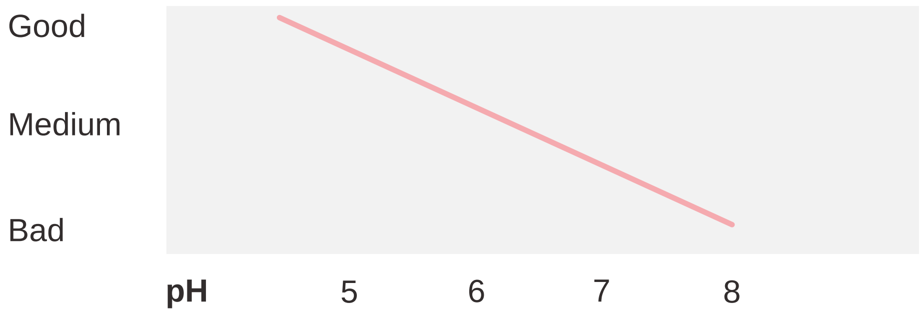
REDUCTION OF NOM



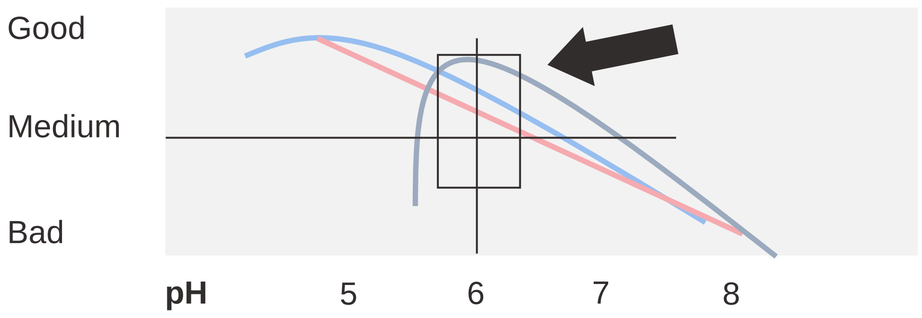
LOW RESIDUAL AL



REDUCTION OF COLOUR

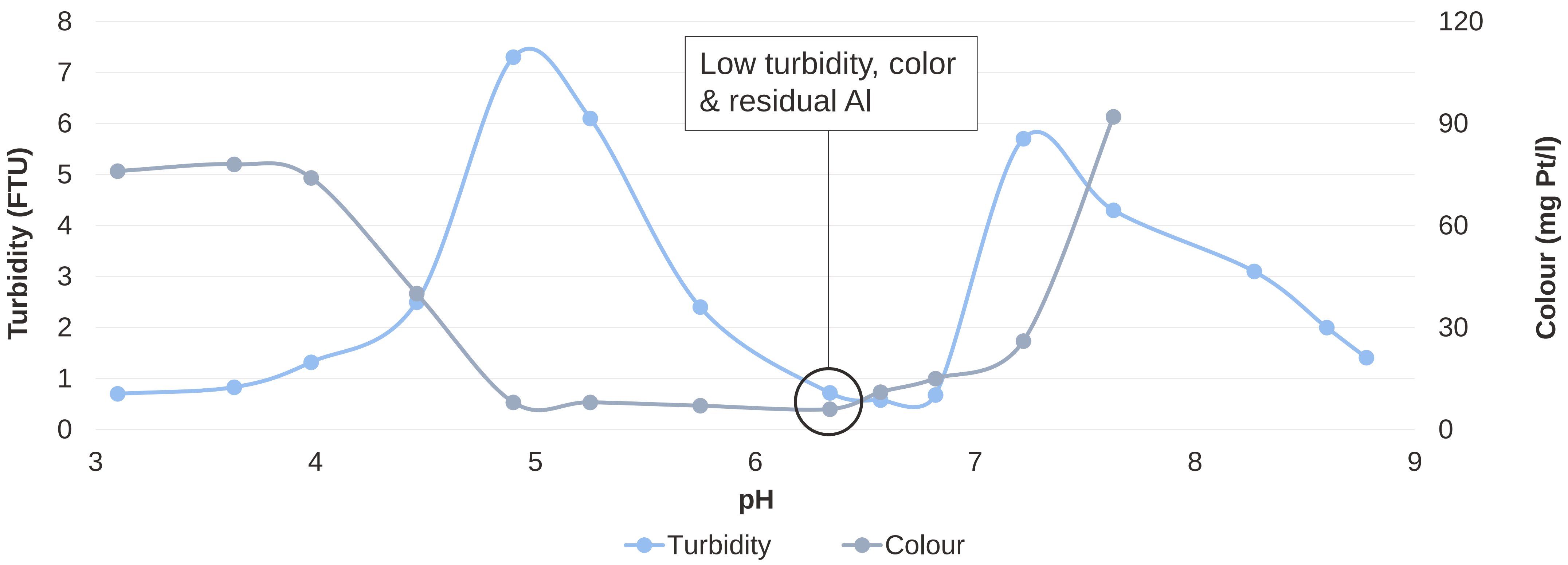


OPTIMUM WINDOW

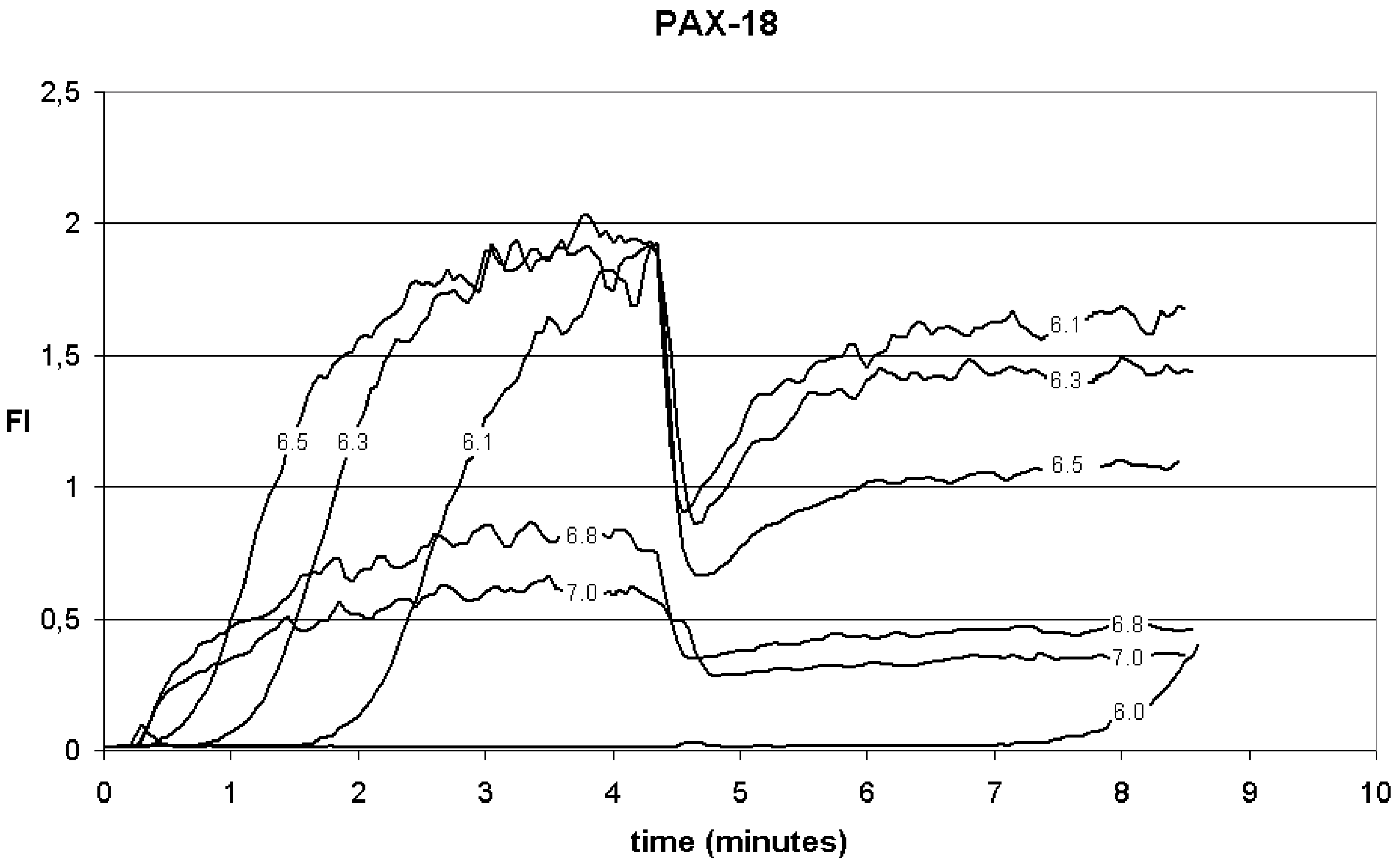


Example: Influence of pH on residual turbidity & color

INFLUENCE OF PH ON THE RESIDUAL TURBIDITY AND TRUE COLOUR OF WATER TREATED WITH 300 MMOL AL/L GIVEN AS ALUMINIUM SULPHATE



Influence of pH and flocculation time on the floc size

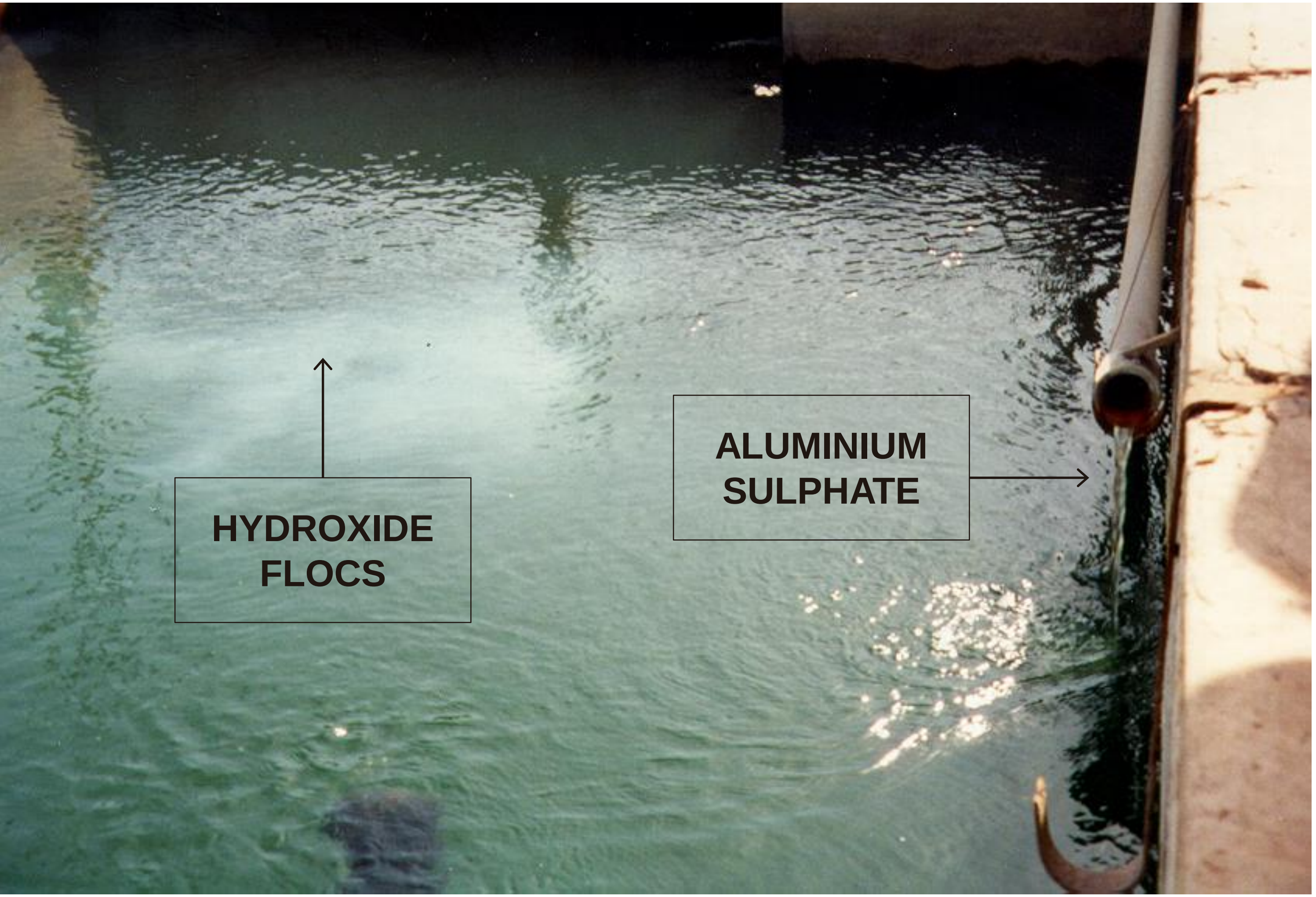


MIXING – a question about success or not…

Mixing assures thorough and fast distribution of the treatment chemicals in the water flow

Many treatment chemicals can be added just prior to or into the rapidly mixing device

- Inorganic and organic coagulants
- Polymers
- Chlorine
- Activated carbon
- Lime
- Other chemicals



The result of ineffective mixing

Ineffective mixing!

- Higher dose of coagulant needed
- More sludge is produced
- Increased treatment costs

Good mixing

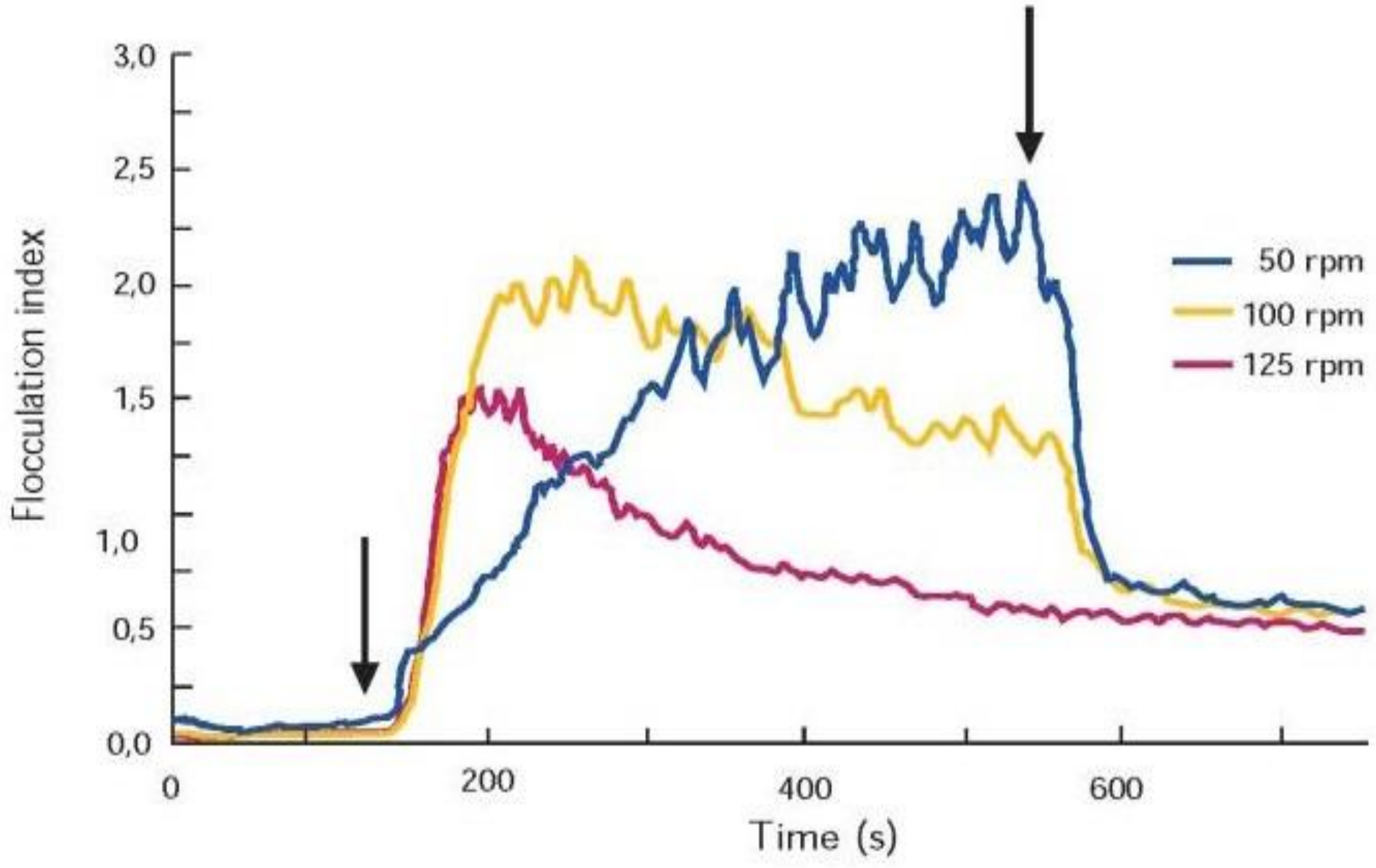
Fantastic mixing

Caroni Arena WTP – WASA, Trinidad, WI

Time and mixing efficiency versus floc size

INFLUENCE OF THE COAGULATION TIME AND PROPELLER SPEED ON THE FLOC SIZE

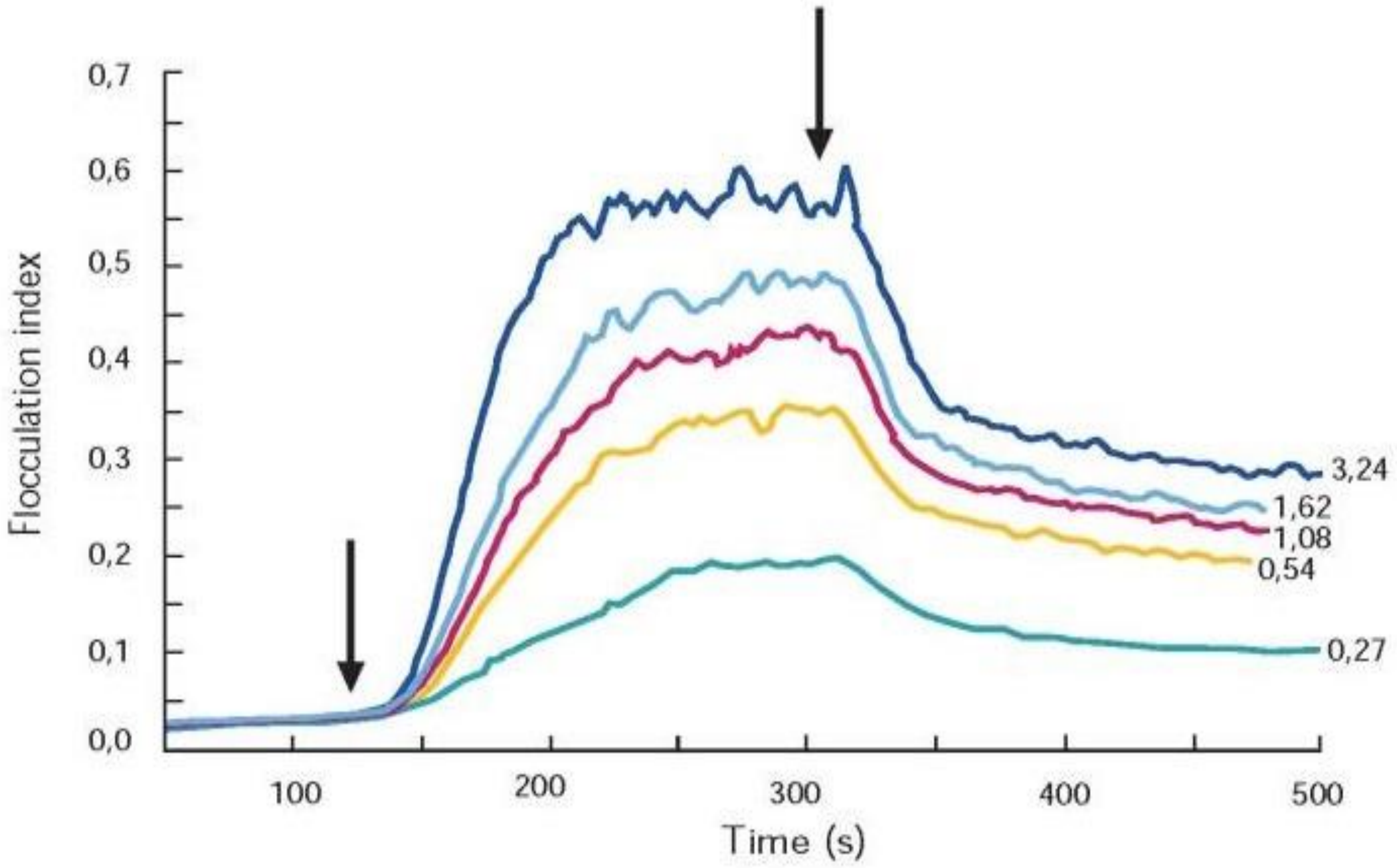
The first arrow indicates the time of addition of coagulant and the second one when the propeller speed was increased to 200 rpm.



Coagulation time and dose versus floc size

INFLUENCE OF THE COAGULATION TIME AND ALUMINIUM SULPHATE DOSE ON THE FLOC SIZE

The first arrow shows the time of addition of coagulant and the second one when the propeller speed was increased from 100 to 200 rpm.



Good coagulation needs proper mixing

Without mixing the coagulant can not react with impurities

After an initial rapid mixing, the mixing speed shall be more and more careful over time

Fast mixing or turbulent flow can destroy formed flocs

Destroyed flocs can be difficult to rebuild

Flocculant mixing to support coagulation

- Moderate and soft mixing is usually enough
- When supporting floc build up, polymer can even be dosed in flocculation chamber
- It is worthwhile to test different dosing points at the treatment plant!

Case stories

JEAN-CHRISTOPHE ADES
CASE STUDY: DRINKING WATER PLANT

Ajman desalination plant – improving operational efficiency

United Arab Emirates, 2016

Ajman desalination plant

- Plant is located in Ajman City in the United Arab Emirates
- Capacity of the plant was 4 600 m^3/d at the time of the trial
- Expanded to 9 600 m^3/d in Q2/2017
- Seawater comes from the Arabian Gulf
- Drinking water for local recidents and very high-quality water for bottling companies

Process

- Coagulant is dosed in the incoming pipe and mixed by a static mixer
- Two treatment lines after coagulant dosing
- Sedimentation chamber
- Filtration
- Several cartridge filters
- RO membranes

Incoming water

- Includes 42 000 mg/l of dissolved solids (high amount typical of sea water in the Arabian Gulf)
- 80 % particles < 5 µm, typically colloids (puts a lot of pressure on the membranes used in the desalination plant)
- pH 8,1
- Turbidity 4,2

Objectives

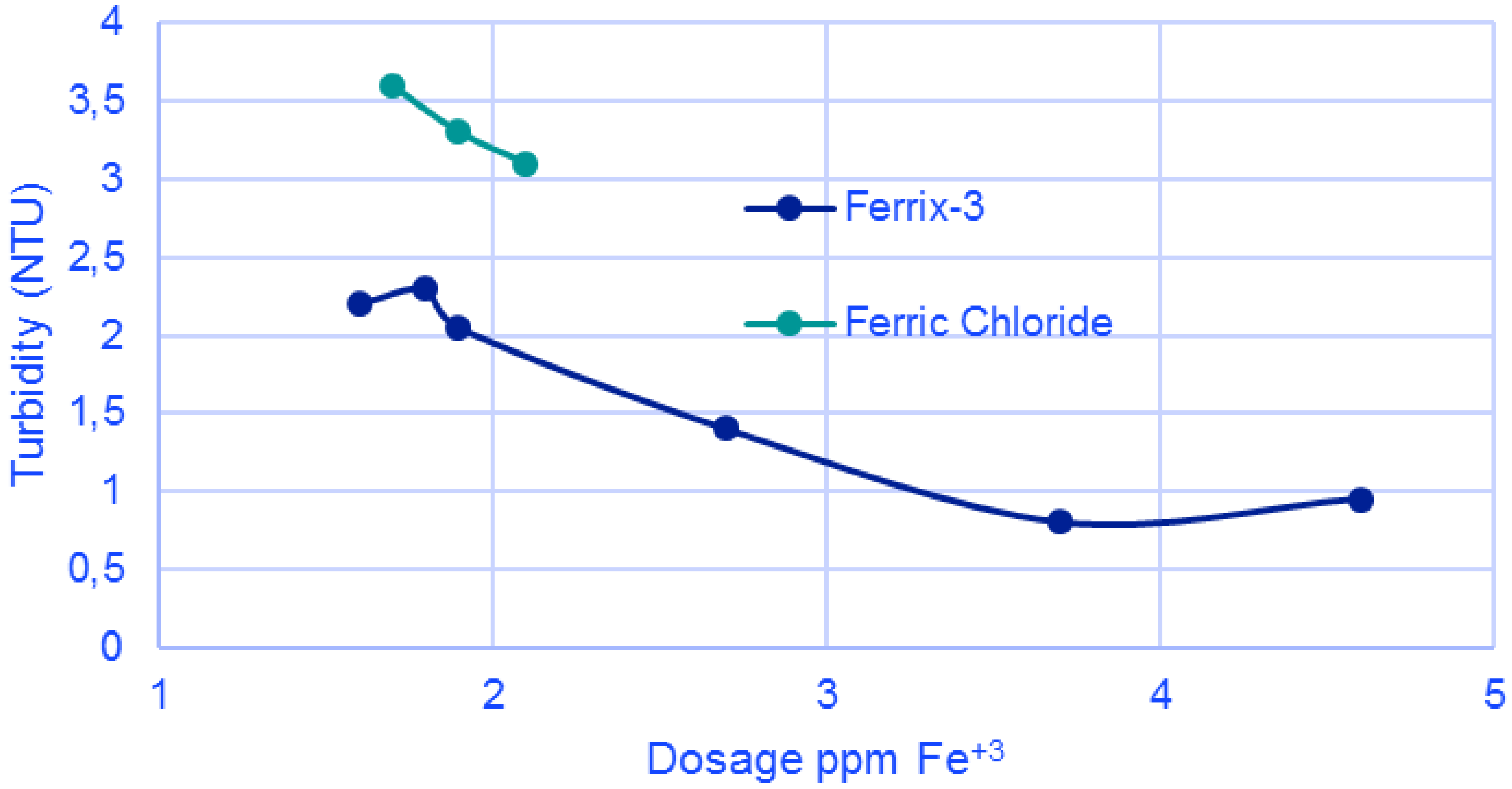
To investigate the possibilities to change Ferric Chloride to Ferix-3

Products

Earlier:	Ferric Chloride
Current:	Ferix-3 – high purity granular product
Future:	Kemira Superfloc® to support coagulation

Results

FERRIC CHLORIDE VS FERRIX-3 AS ACTIVE FE^{+3}



Advantages

Filters stay in shape twice as long as before

Lower maintenance cost

Silt Density Index (SDI) was brought down from more than 5 to 3.2 – 3.7

Reduction of SDI helps in controlling the fouling of RO membranes

This means

- less cleaning,
- less downtime,
- less need of RO membrane replacement

Compared to Ferric chloride, Ferix-3 brings

- less residual iron,
- is less corrosive,
- sand filter backwashing is less frequent

The plan is to introduce Kemira Superfloc® with Ferix-3 in an effort to bring SDI below 3

POLL - What happens in the coagulation?

ALL ARE CORRECT!

A	The largest coagulated particles sink to the bottom of the tank
B	Sinked particles are removed from disturbing the purification process onwards
C	The particles that are carried onwards are larger than without coagulant
D	The filter can catch them more easily
E	Generally smaller load of particles go to the filters
F	All this means efficiency in the separation processes

WIM SMET
CASE STUDY – DAIRY

Dairy – Performance optimization

Aalter, Belgium

Dairy in Aalter

- One of the largest dairy co-operatives in the world
- One of the top 5 dairy companies in the world
- Dairy in Aalter is one of its biggest plants
- Generates 4 000 m^3/d wastewater
- Wastewater is treated nearby at Veolia plant
- The treated water has better quality than the original water from the nearby chanal
- About 70 % of treated water is discharged to the canal, whereas 30 % is reused in the process

Objectives

- Optimization of performace was required
- Target was to improve grease removal, and a COD, PO_4, SS reduction on the DAF Unit
- New approach by changing the pH and switch from an anionic polymer to C-496HMW
- New opportunity on sludge dewatering (centrifuge) with E-5204

Advantages of the new treatment

- Waste Water Treatment – DAF Unit
- Actual treatment: PIX-111 and Superfloc A-137HMW
- New Treatment: Decrease pH to +/- pH 7 (H_2SO_4) + lower dosage of PIX-111 followed by Superfloc C-496HMW
- Results:
  - Lower PIX-111 dosage
  - Better efficiency (grease removal, COD,...) COD removal up to 90 %.
  - Higher throughput on the DAF. System is no longer overloaded
  - Lower sludge growth, so less sludge, less dewatering, less sludge disposal, lower overall costs

Poll – Why the flotation result was improved?

A	Because of better mixing
B	Adjusting pH to the optimum
C	Changing the flocculant
D	Adding salt

B AND C CORRECT!


Thank you.
kemira
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