Settling Aids in Wastewater Treatment

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Organic Polymers

Settling – clarifiers, may provide metals removal
Tertiary Filter Aids
Dewatering – gravity thickening, presses, centrifuges

Metal Salts

Dissolved Air Flotation, Magnetically Ballasted Clarifiers
Settling – clarifiers as well as some reuse water systems
Phosphorous Removal

Factors that Effect Settling

Temperature

Mass

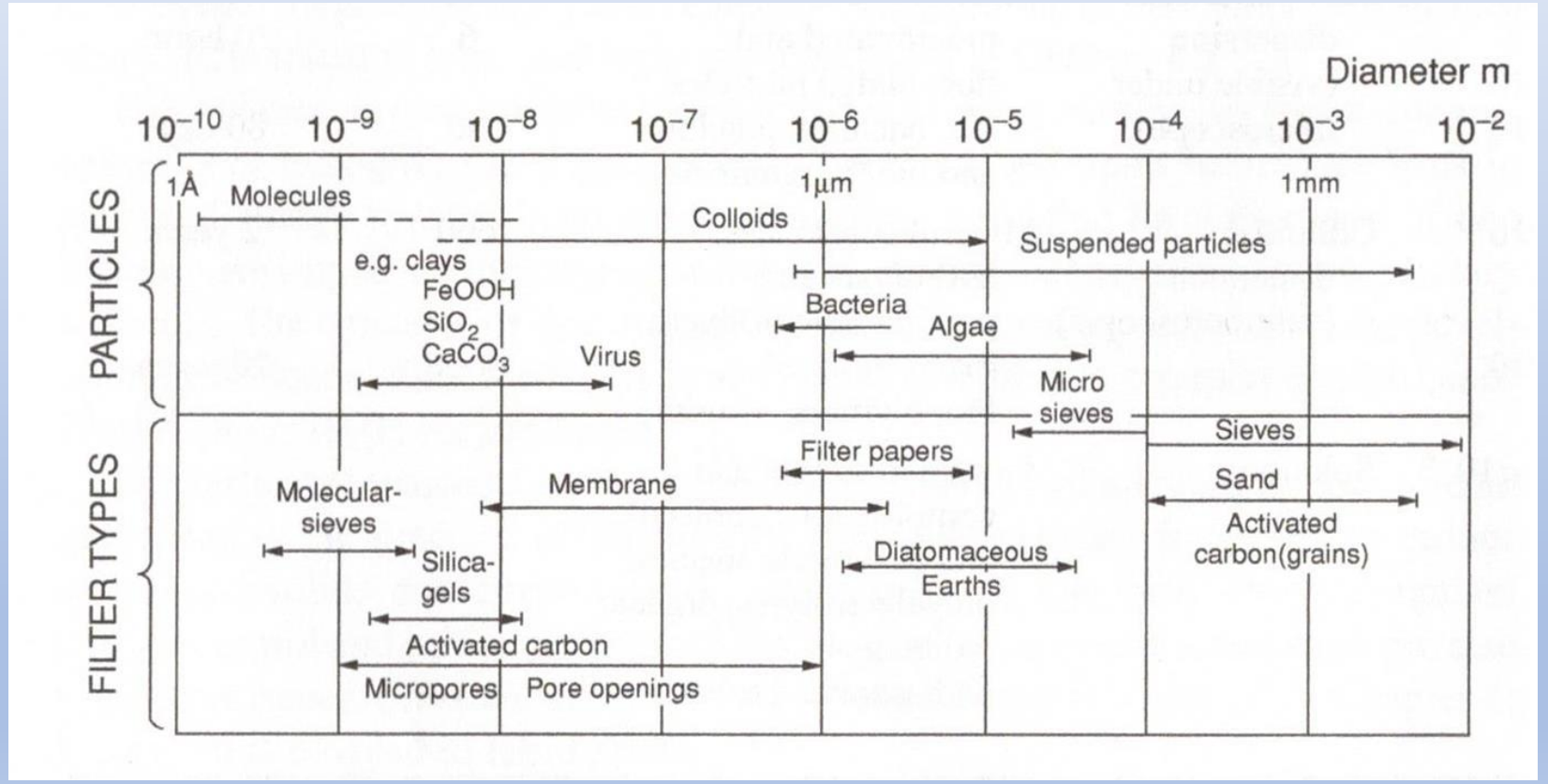
Surface Area – becomes very important with chemical addition

Surface Charge of Colloidal Particles

Settling Times

Course Dispersions	10 mm	0.1 – 13 Sec
Fine Particle Dispersion	10^{-2} mm	11 min – 80 days
Colloidal Dispersion	10^{-5} mm	2 – 20 years or more
Solution	< 10^{-6} mm	

Size Spectrum Chart



Colloids

Very Low Mass

High Surface Charge

Surface charge over rides the mass

What happens chemically

Polymer

- Charge Destabilization
- Bridging

Metal Salt

- Charge Destabilization
- Hydroxide Floc Formation & Enmeshment

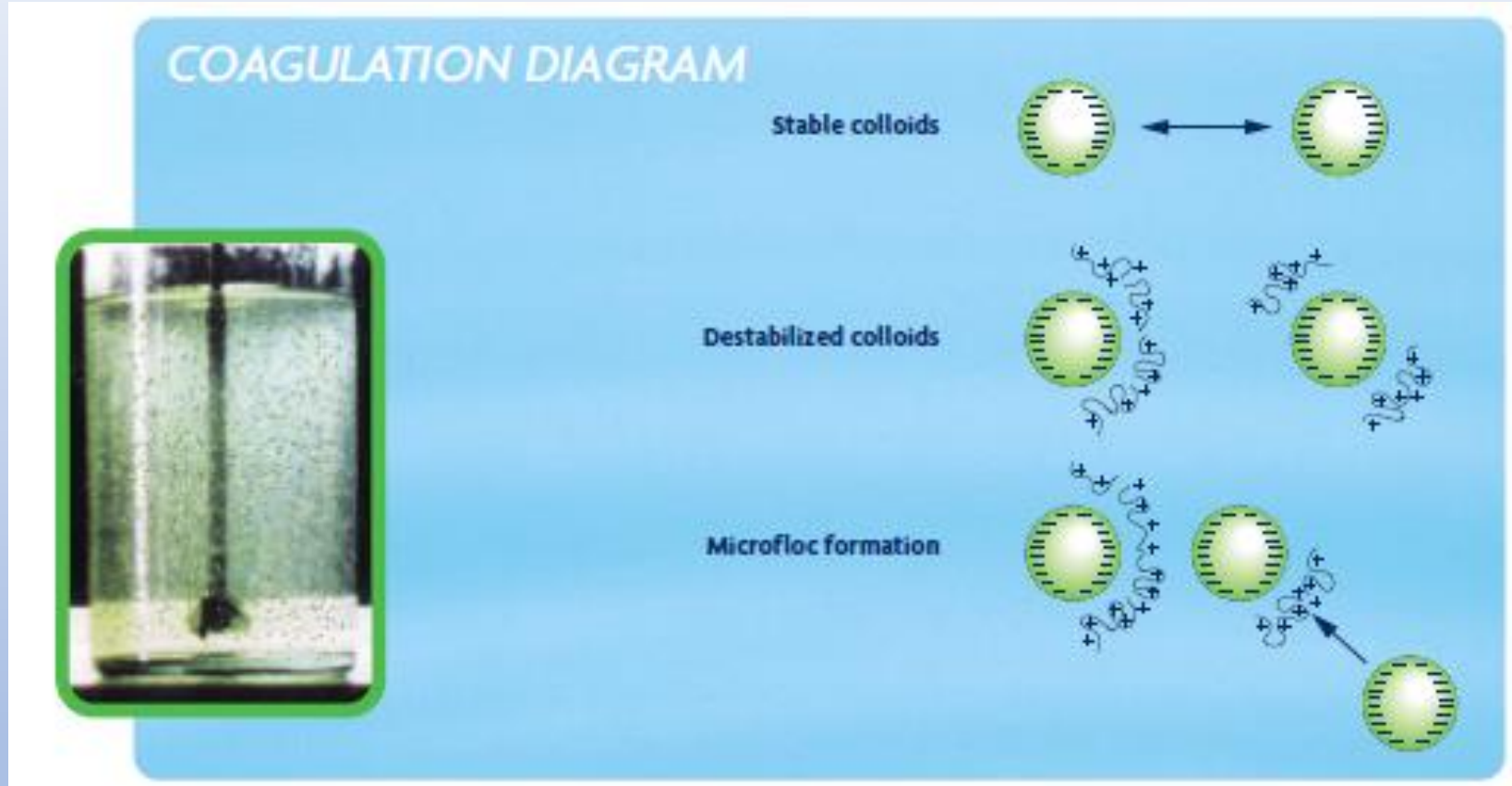
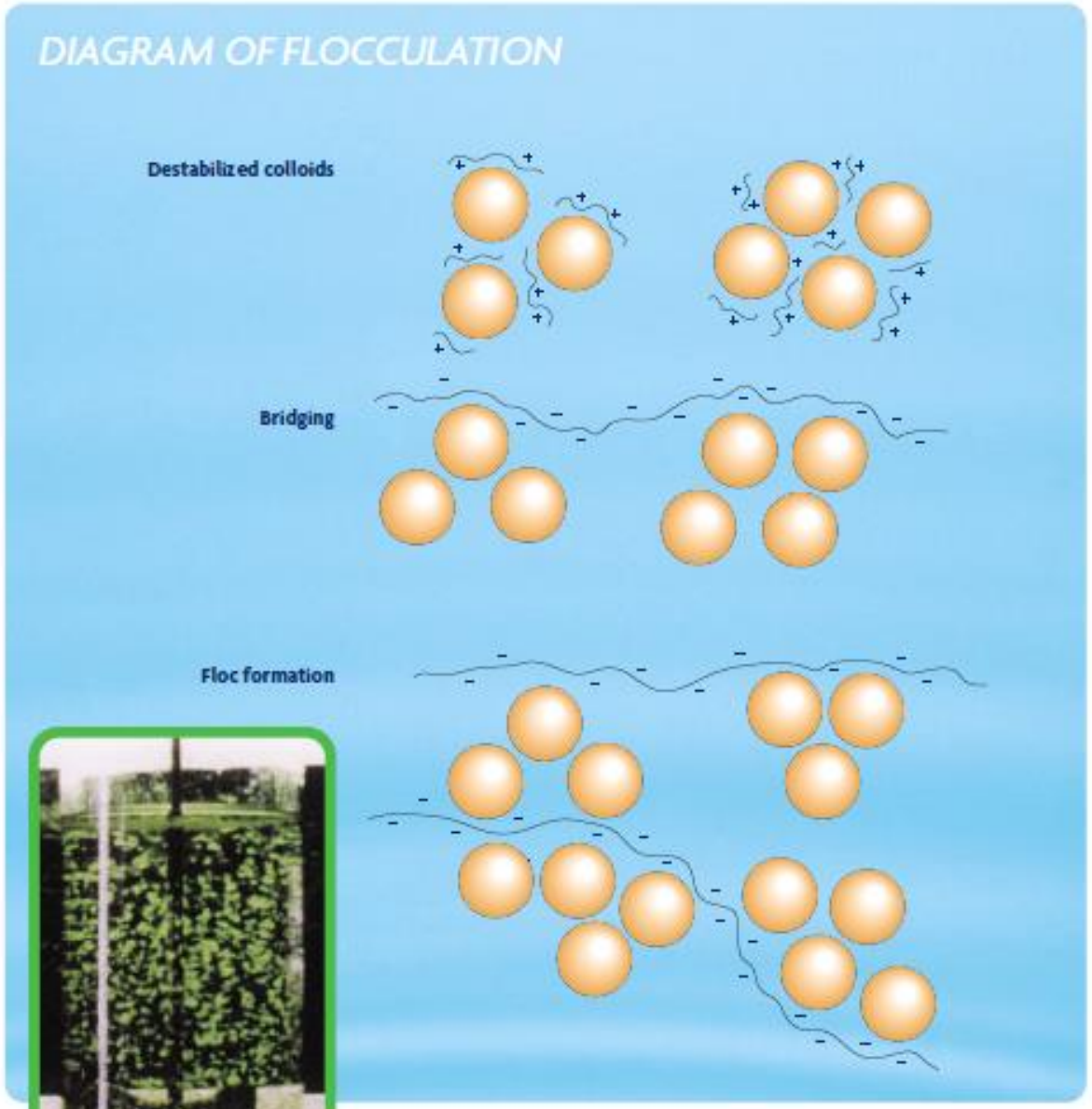

COAGULATION DIAGRAM
Stable colloids
Destabilized colloids
Microfloc formation

DIAGRAM OF FLOCCULATION



Organic Polymers

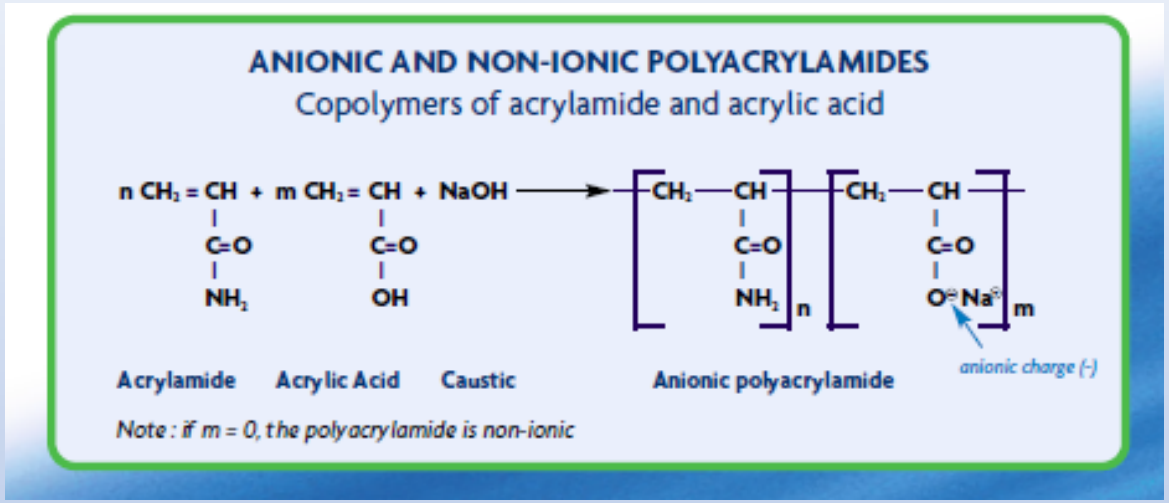
Characteristics of Polymers

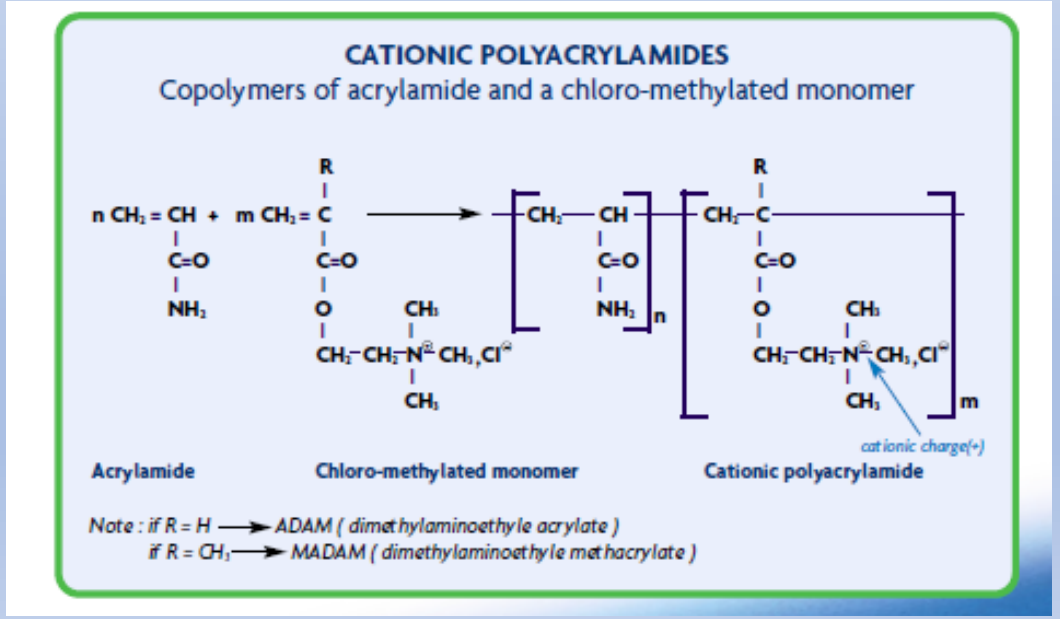
1. Molecular Weight
2. Charge type (positive or negative)
3. Charge % (0 – 100%)
4. Structure (linear, branched, cross-linked)

Forms of Polymer

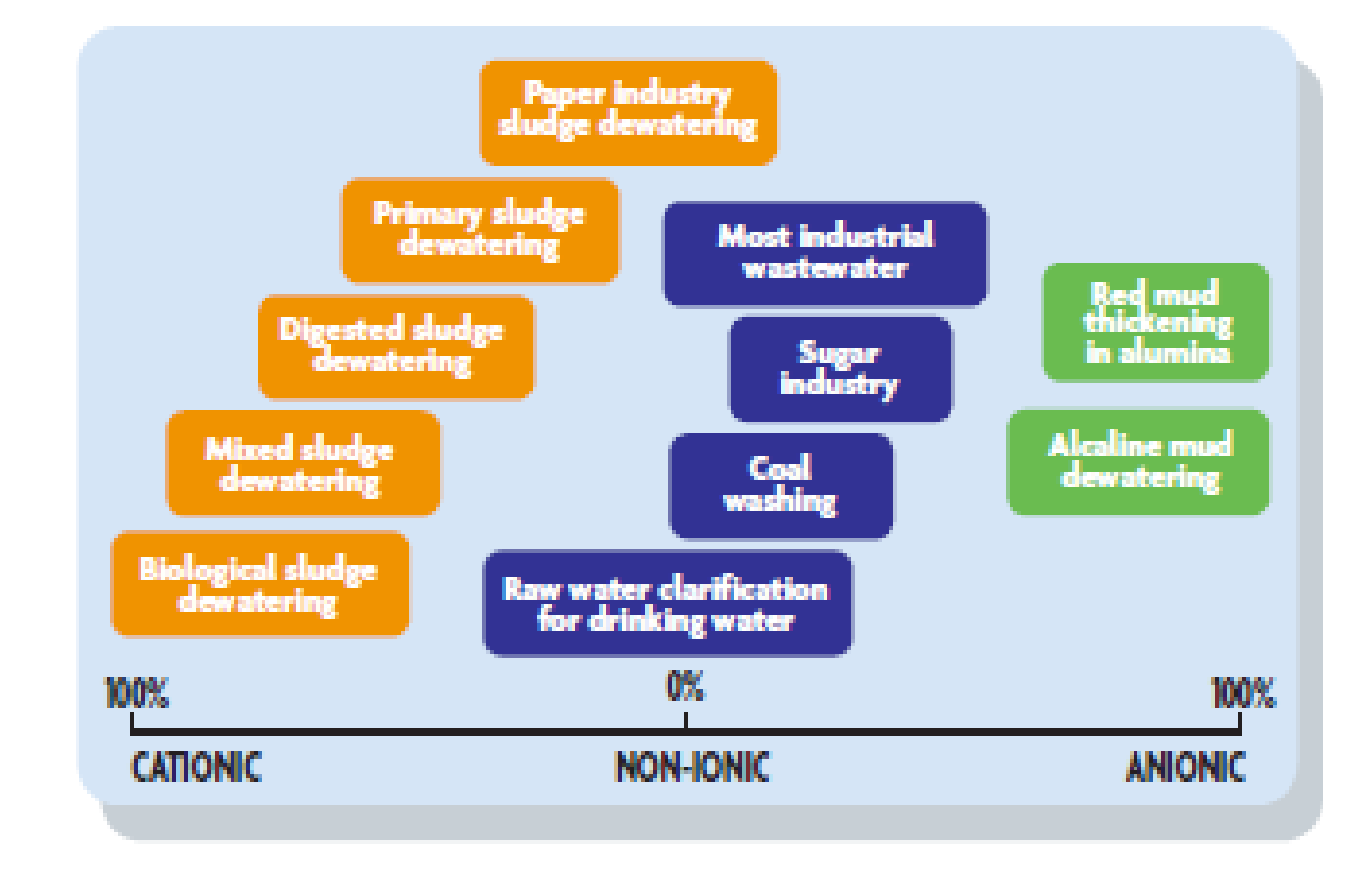
- Powders – require premixing
- Emulsions – can be used immediately but must be mixed energetically to separate polymer and emulsion.
- Water Based – can be added directly, 100% charge & short chain

Monomers

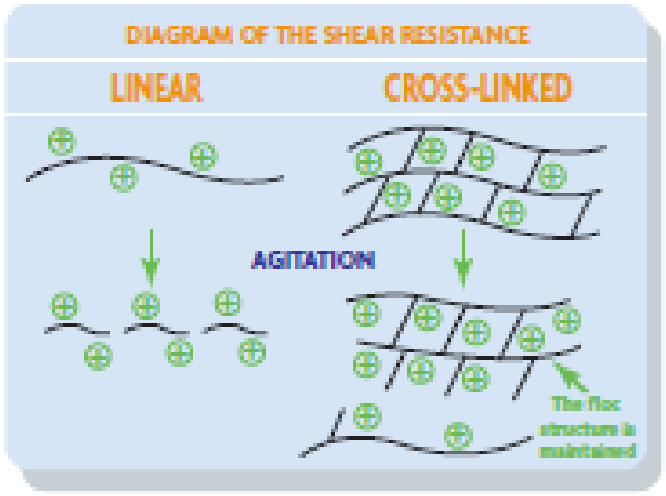

ANIONIC AND NON-IONIC POLYACRYLAMIDES
Copolymers of acrylamide and acrylic acid
n CH2 = CH + m CH2 = CH + NaOH
C=O
NH2
OH
n
m
anionic charge (-)
Acrylamide
Acrylic Acid
Caustic
Anionic polyacrylamide
Note : if m = 0, the polyacrylamide is non-ionic

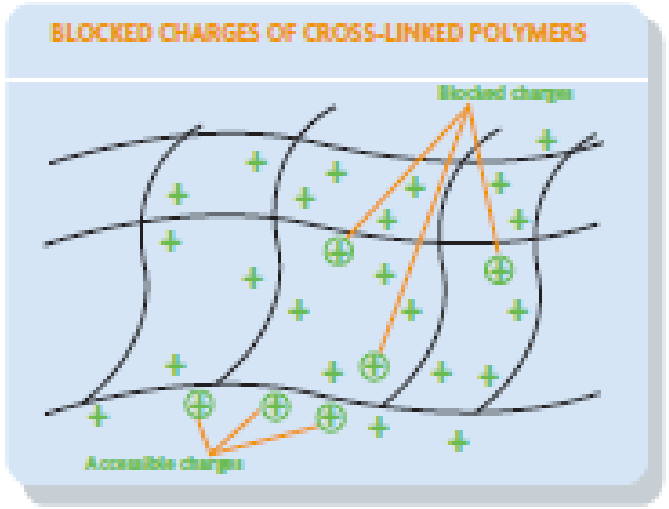

CATIONIC POLYACRYLAMIDES
Copolymers of acrylamide and a chloro-methylated monomer
n CH2 = CH + m CH2 = C
R
C=O
NH2
O
CH3
CH2–CH2–N⊕–CH3, Cl⊖
n
m
cationic charge(+)
Acrylamide
Chloro-methylated monomer
Cationic polyacrylamide
Note : if R = H → ADAM (dimethylaminoethyle acrylate)
if R = CH3 → MADAM (dimethylaminoethyle methacrylate)

Charge & Charge Strength



Polymer Structure





LINEAR OR CROSS-LINKED STRUCTURE ?

LINEAR	CROSS-LINKED
ADVANTAGES	
• Low dosage • Large range of MW	• Very strong flocs • Excellent drainage • Higher cake dryness
DRAWBACKS	
• Low strenght of the flocs • Possibility of overdosing	• High dosage


B-D

Metal Salts

Not seen is municipal WWTP's as often as organic polymers.

They are more often seen for phosphorous removal in WWTP's but they can be used as settling aids. We will talk more about phosphorous removal shortly.

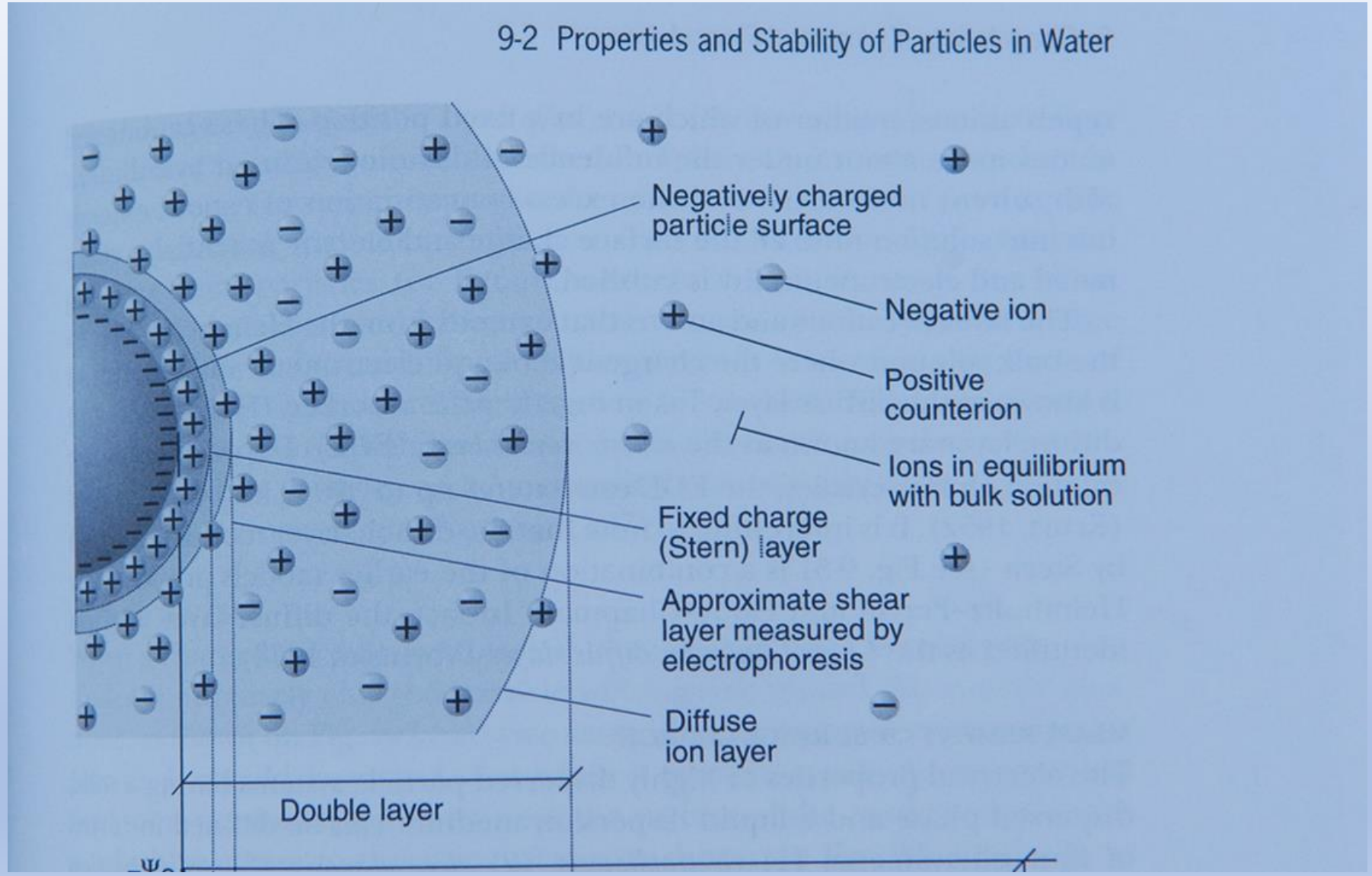
Normally used on the industrial wastewater side in D.A.F. units.

May be seen in some reuse systems, an example of which we will see latter.

Can be in the form of inorganic polymer, Poly Aluminum Chloride

Typical Metal Salts

- Ferric Sulfate & Ferric Chloride (up to 72% soln)
  - Consume the most alkalinity, binds organics tightly, D.A.F. units
- Aluminum Sulfate & Aluminum Chloride (Normally a 50% soln)
  - Consumes less alkalinity
- Sodium Aluminate (38% soln)
  - Increases the pH and does not use alkalinity
- Poly Aluminum Chloride – polymerized but behaves as a metal salt


Negatively charged particle surface
Negative ion
Positive counterion
Ions in equilibrium with bulk solution
Fixed charge (Stern) layer
Approximate shear layer measured by electrophoresis
Diffuse ion layer
Double layer

Hydroxide Flocs

- $Al^{3+} + 3HCO^{3-} \rightarrow Al(OH)_{3(s)} + 3CO_3$
- $Al^{3+} + OH^{-} \rightarrow Al(OH)_{3(s)}$
- $Fe^{3+} + 3HCO^{3-} \rightarrow Fe(OH)_{3(s)} + 3CO_3$
- $Fe^{3+} + OH^{-} \rightarrow Fe(OH)_{3(s)}$

Sodium Aluminate

$$NaAlO2 + CO_2 + 3H_2O \rightarrow 2Al(OH)_3 + Na_2CO_3$$

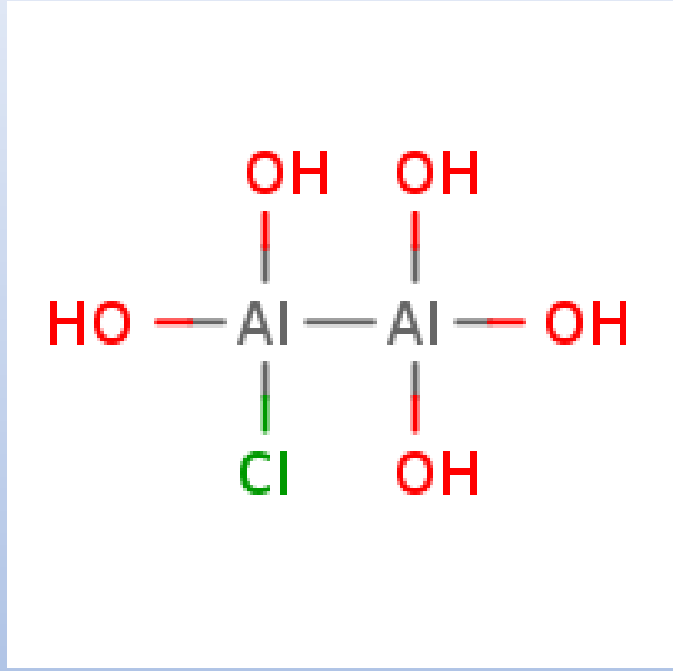
$$NaAlO_2 \rightarrow Na^+ + AlO^{2-}$$

$$AlO_2^- + H_3O^+ \rightarrow Al^{3+} + 3(OH^-)$$

Hydroxide Floc (Metal Salts)

Poly Aluminum Chloride

- Polymerized aluminum chloride
  - Inorganic polymer
- High charge density
  - Available as 8 – 23% as Al_2O_3
  - Aluminum Sulfate is 8%
- Contains its own caustic
  - Basicity varies by product
- May be preblended with organic polymers or iron salts



- Works well in cold water

- Less sludge production since less hydroxide floc is formed.
  - PACl units have higher charges so they destabilize colloids better.

Can be used simultaneously

Fine turbidity removal in addition to normal settling in clarifiers.

Phosphorous removal in addition to settling.

Tertiary reuse water systems that use coagulation & flocculation similar to traditional drinking water plants.

Short Chain 100% Charge

- Low molecular weight organic polymers are also used in the same way as metal salts
- Higher molecular weights are used to aid flocculation and improve settling characteristics of solids.
- Cheraw SC, Reuse Systems, Perdue, Seasonal Variation

Phosphorous Removal

- Phosphorous is precipitated out as a solid
- Aluminum based products are most effective
- Theoretically 0.87 lbs of aluminum removes 1 lbs of phosphorous; 1.80 lbs of iron would be required
- Optimum pH is 6.5

$$Al^{3+} + PO_4^{3-} \rightarrow Al(PO_4)s$$

- Alum uses 0.5 mg/L of alkalinity for each mg/L of aluminum
- PACl uses nearly 0 since it brings its own.
- Sodium aluminate will increase pH.

Reuse Water Applications

Reuse applications and tertiary treatment processes can resemble small water treatment plants.

These systems use the same steps as conventional surface water treatment plants.

Conventional Water Treatment Steps

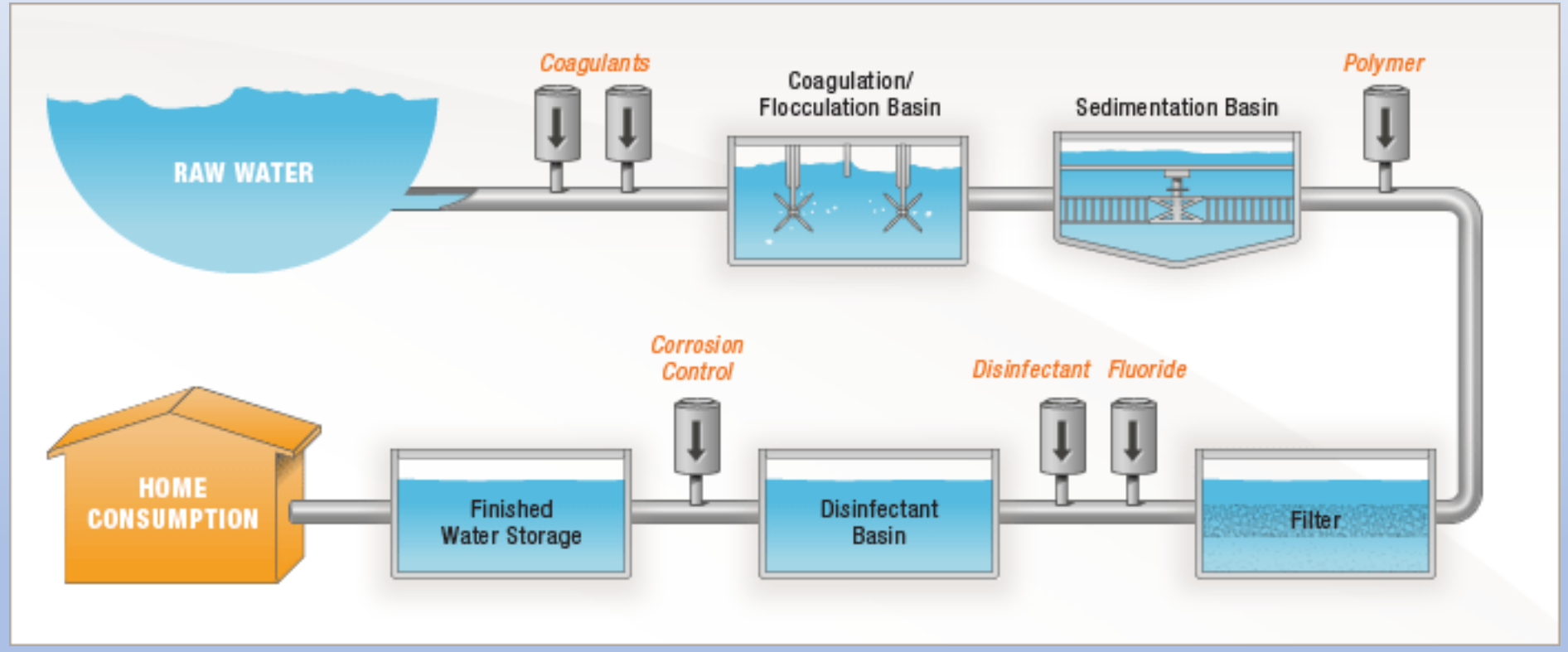
Coagulation Step – rapid mixing, two processes are taking place, metal salt or perhaps polyamine or DADMAC

In the initial coagulation step a metal salt combines with the alkalinity of the water to form hydroxide flocs. The process of charge destabilization also happens during this step.

Flocculation Step – slow mixing, may add organic polymer

Mixing energy is decreased and flocs are allowed to come together and create a larger floc that will settle better.

Typical Drinking Water Process

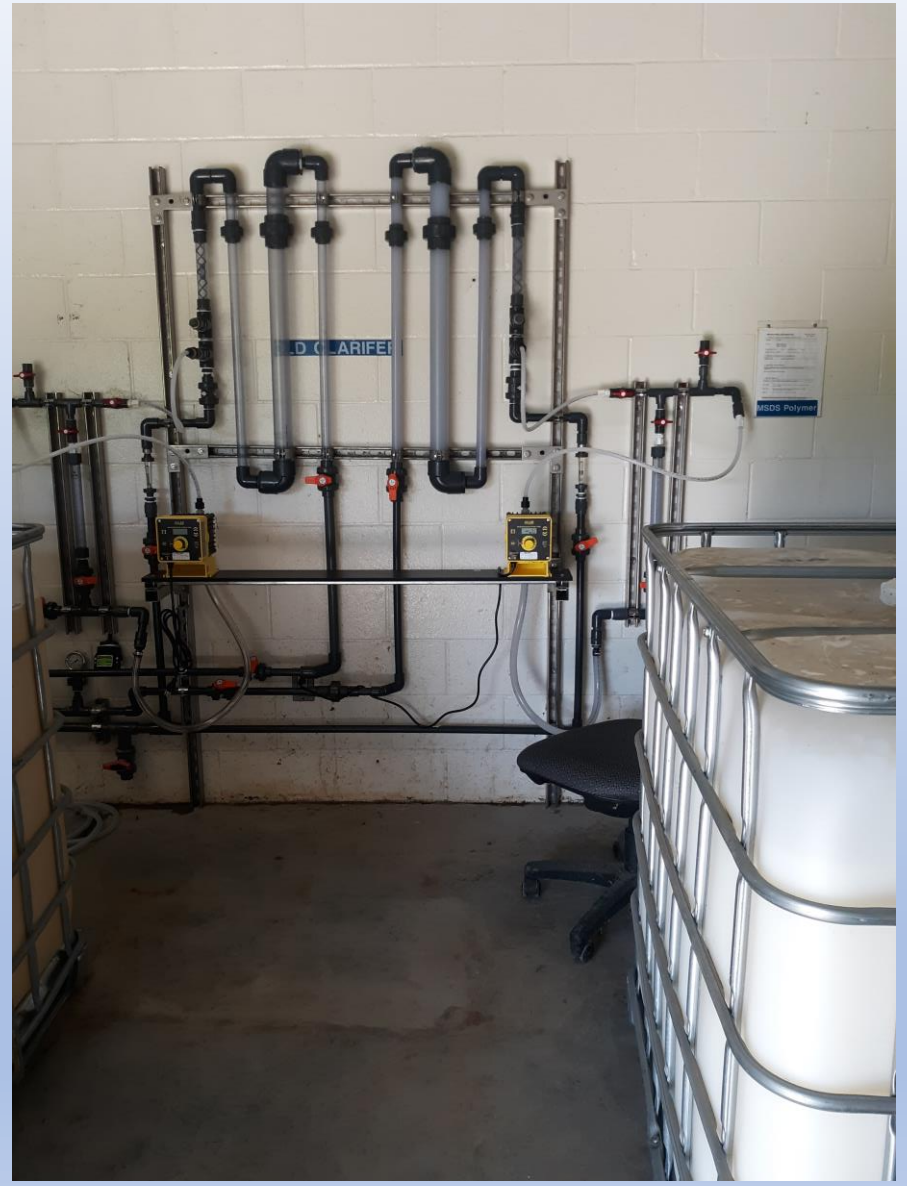



KAESER

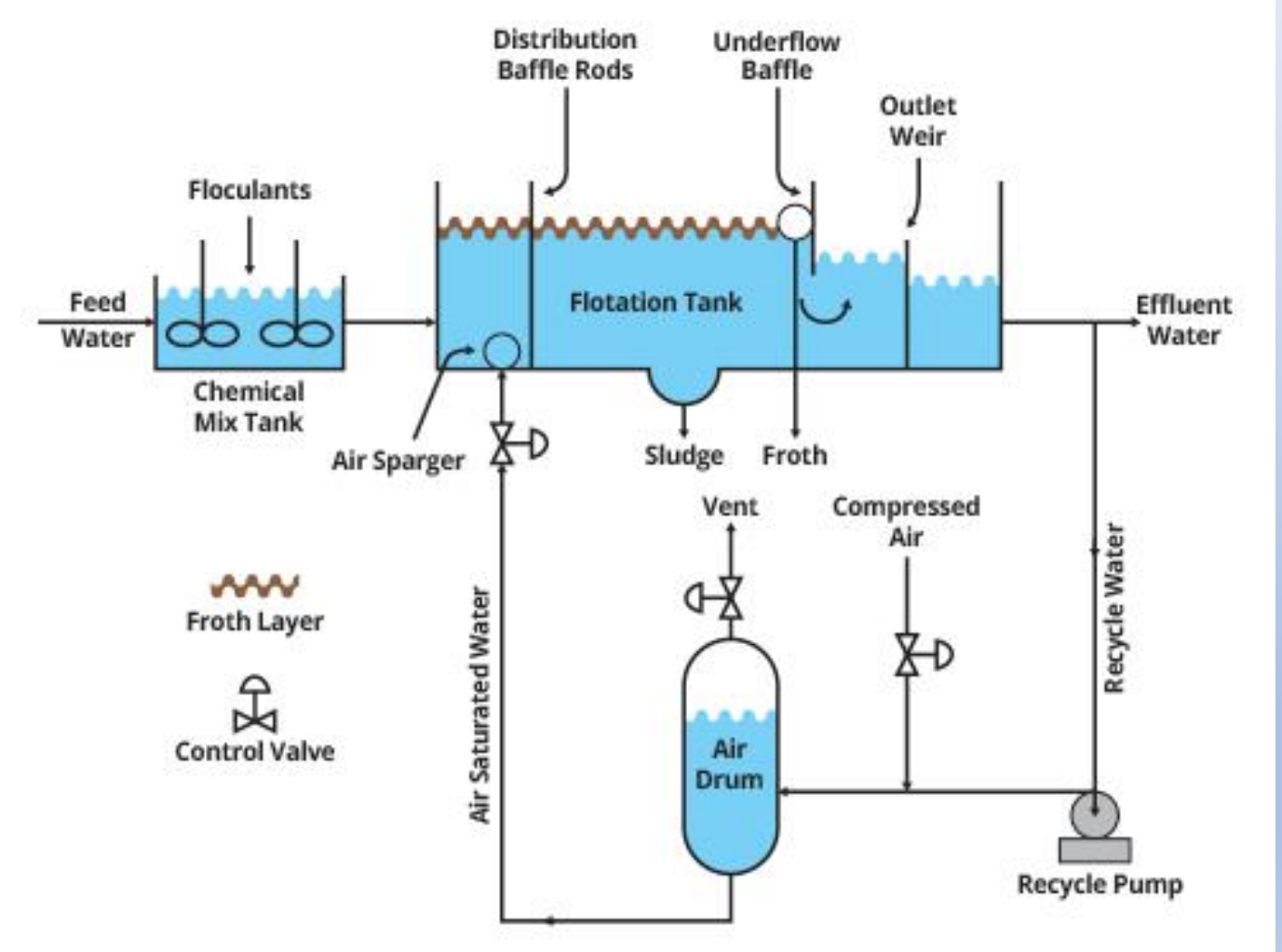

24 VOLTS


Acrison


LMI


MSDS Polymer

Dissolved Air Flotation Unit

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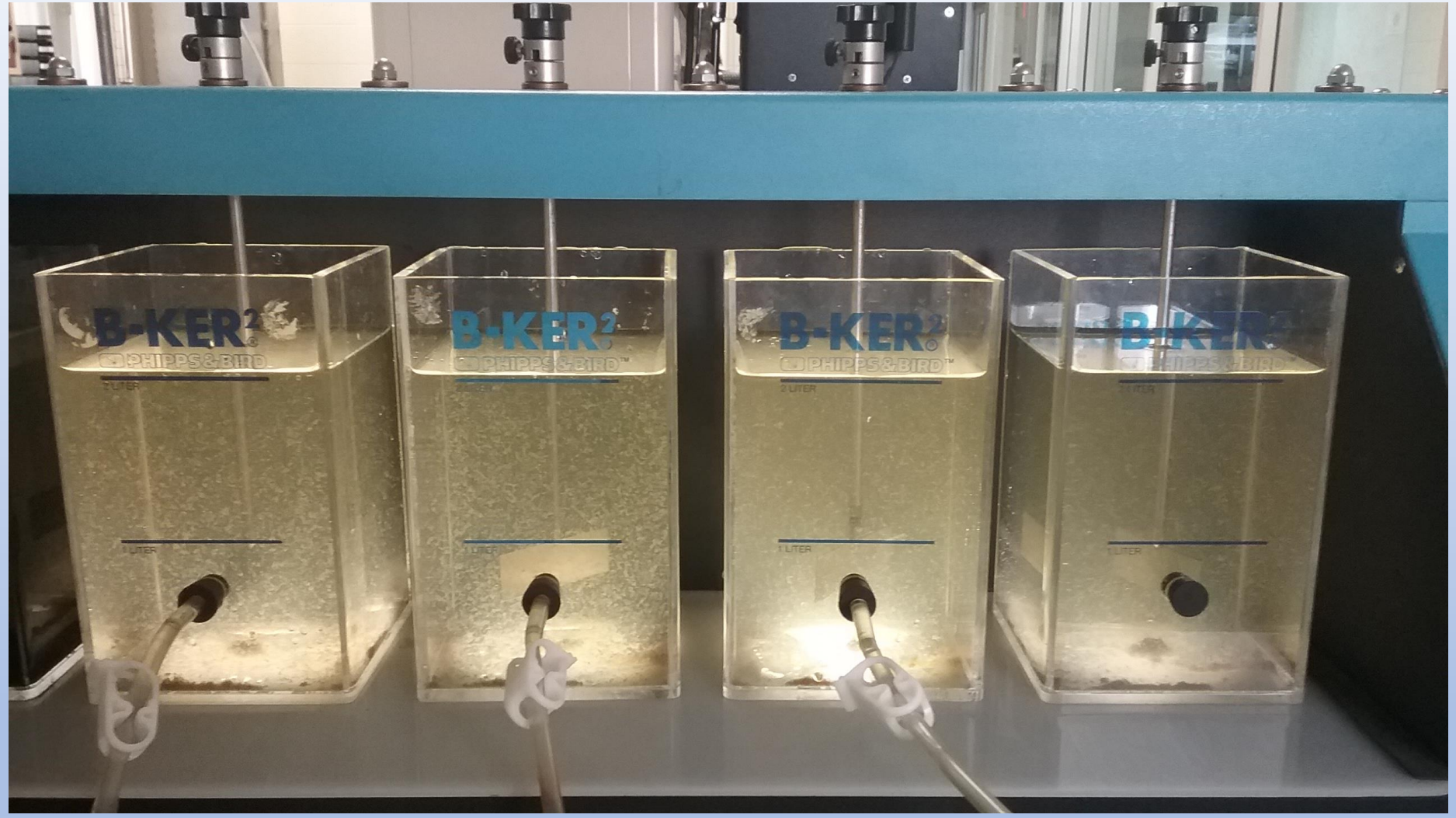
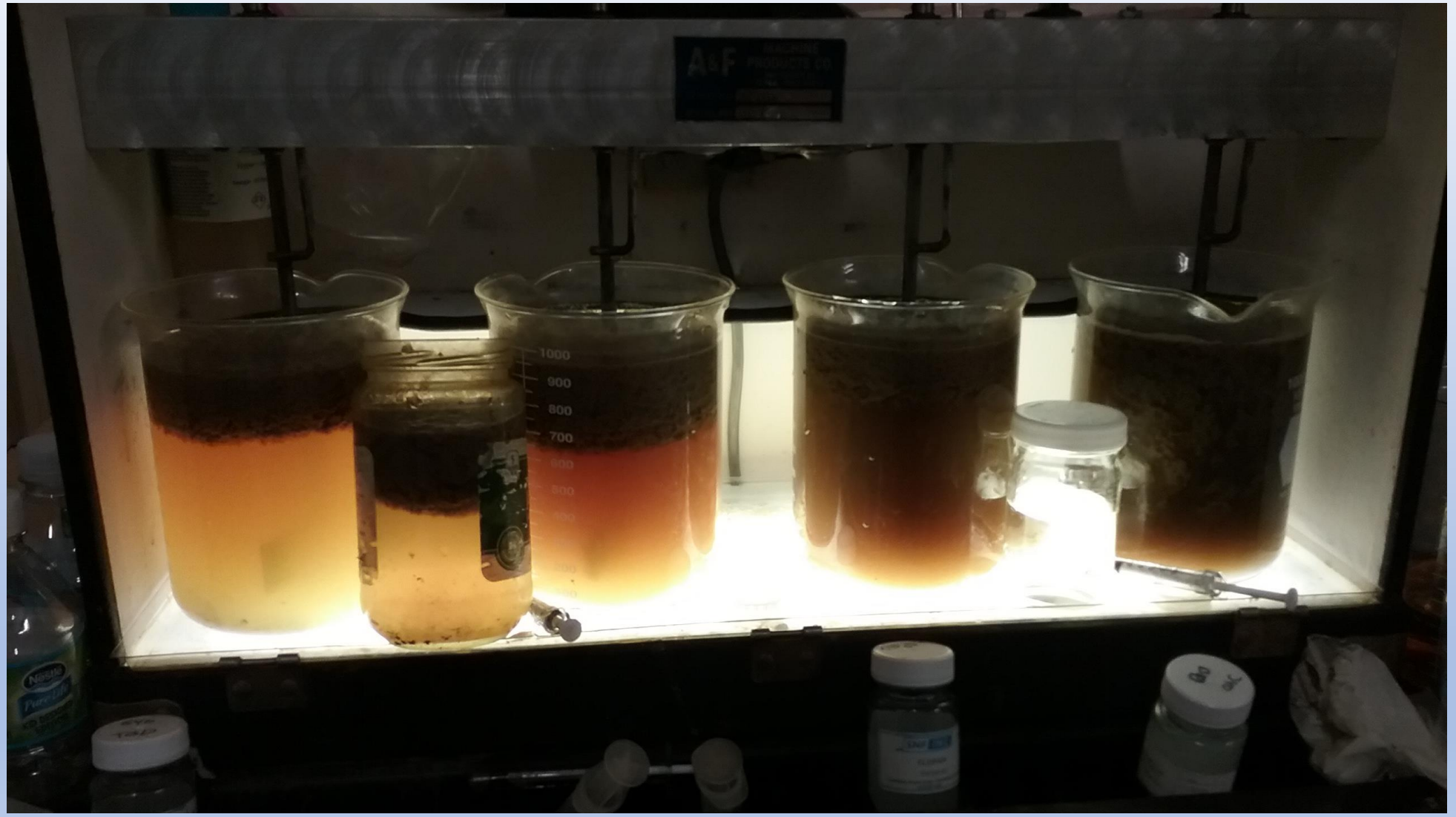
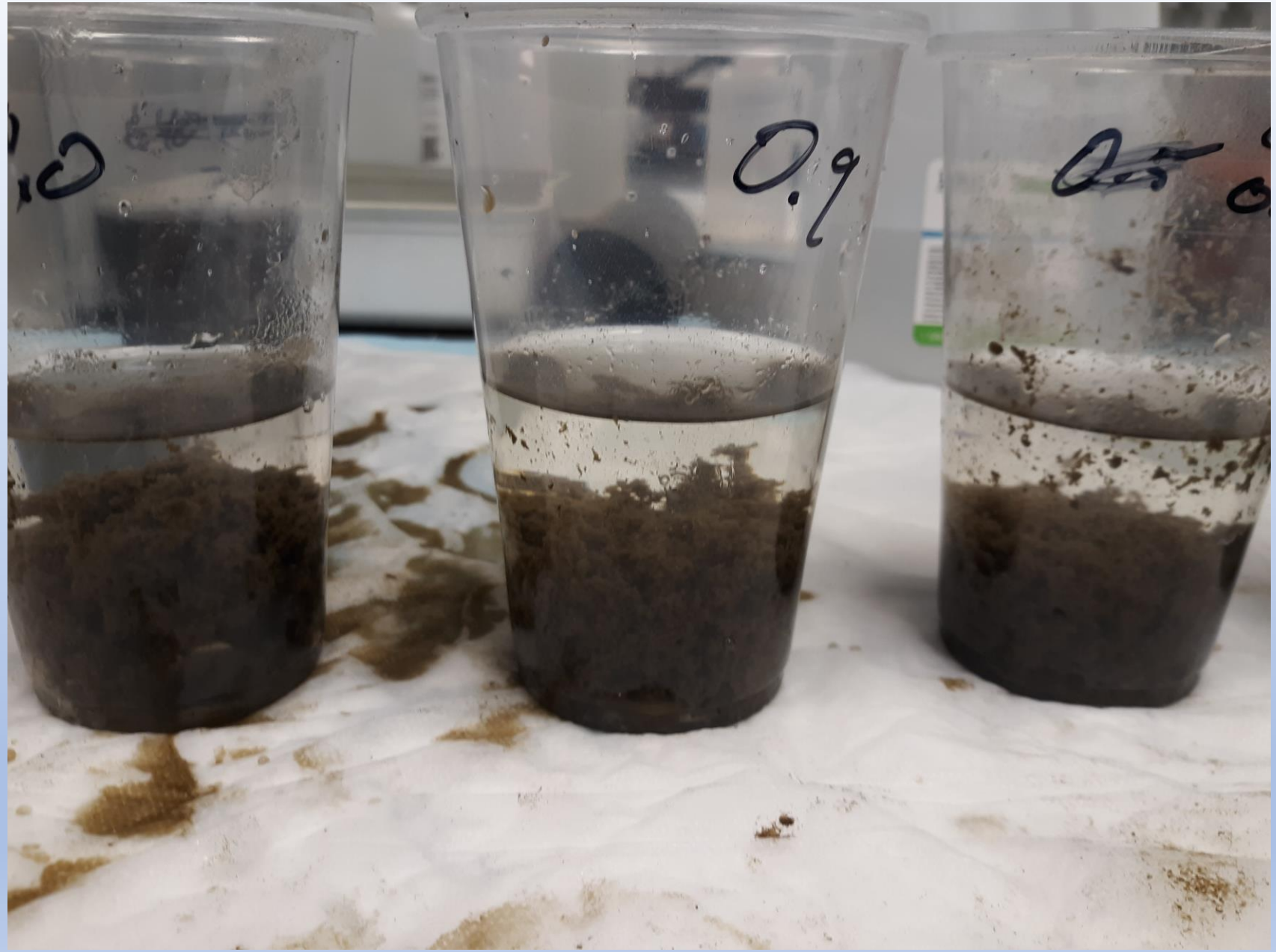
KAESER

Jar Testing


B-KER2
PHIPPS & BIRD
2 LITER
1 LITER
B-KER2
PHIPPS & BIRD
2 LITER
1 LITER
B-KER2
PHIPPS & BIRD
2 LITER
1 LITER
B-KER
PHIPPS & BIRD
2 LITER
1 LITER


1000
900
800
700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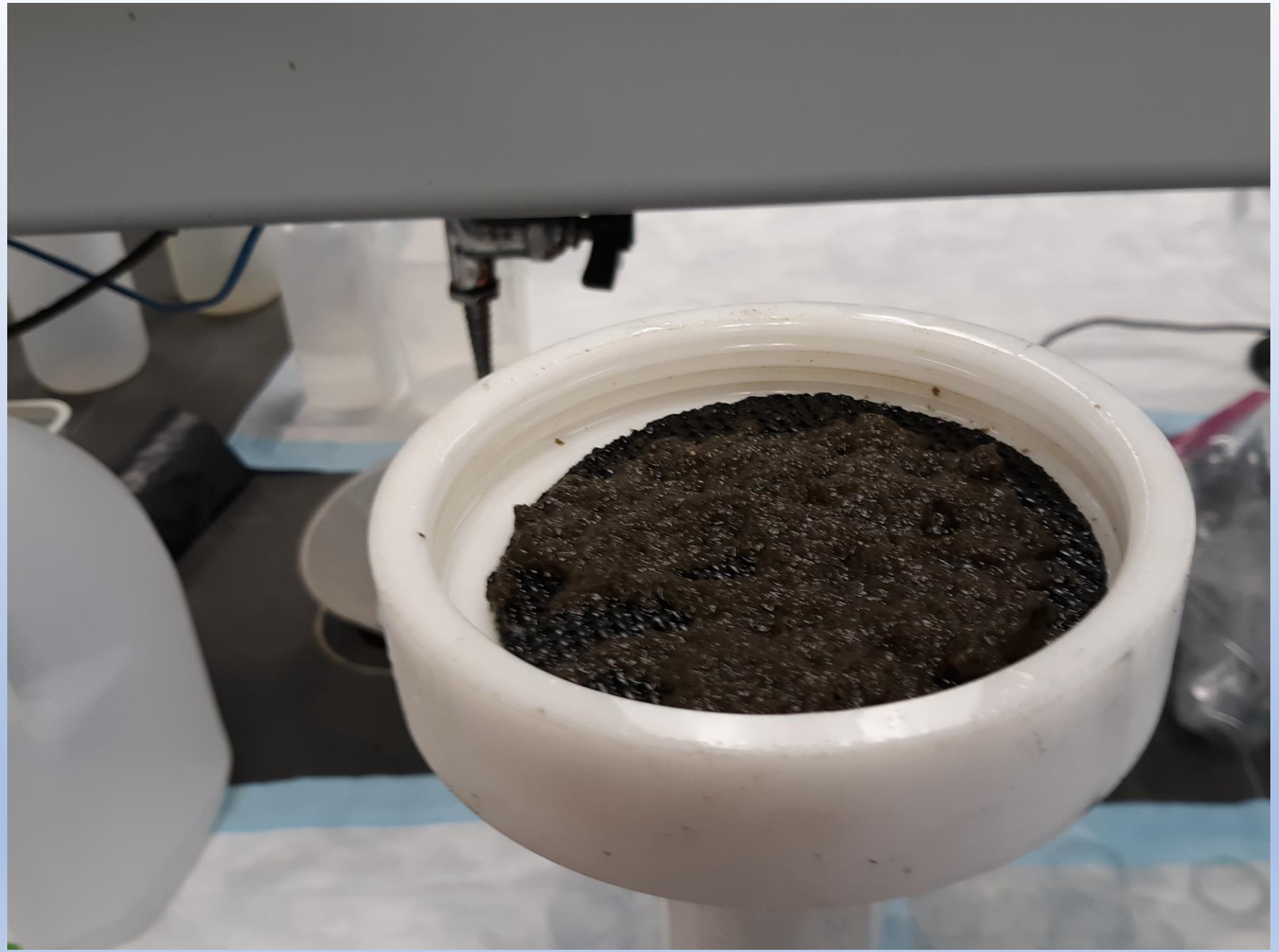
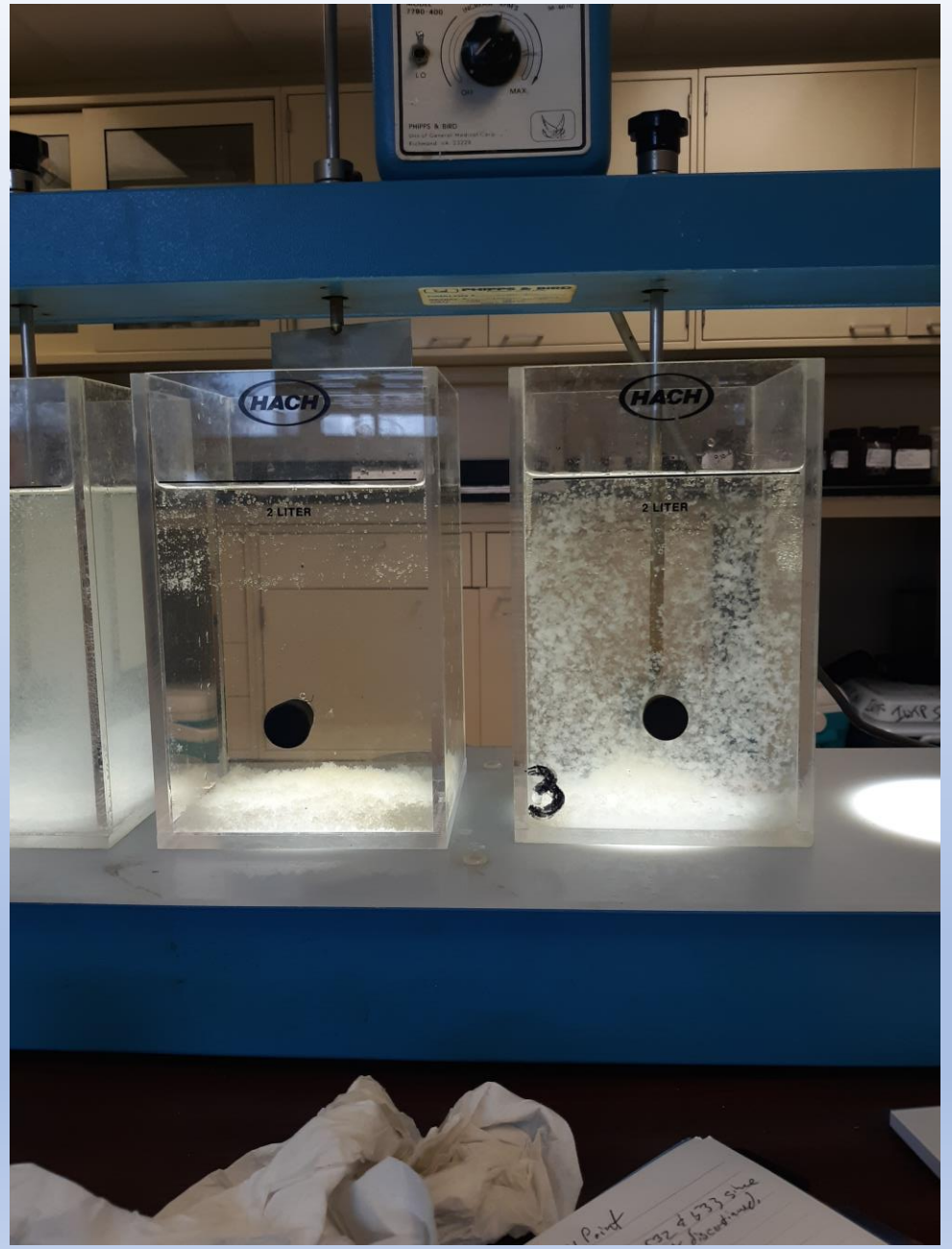


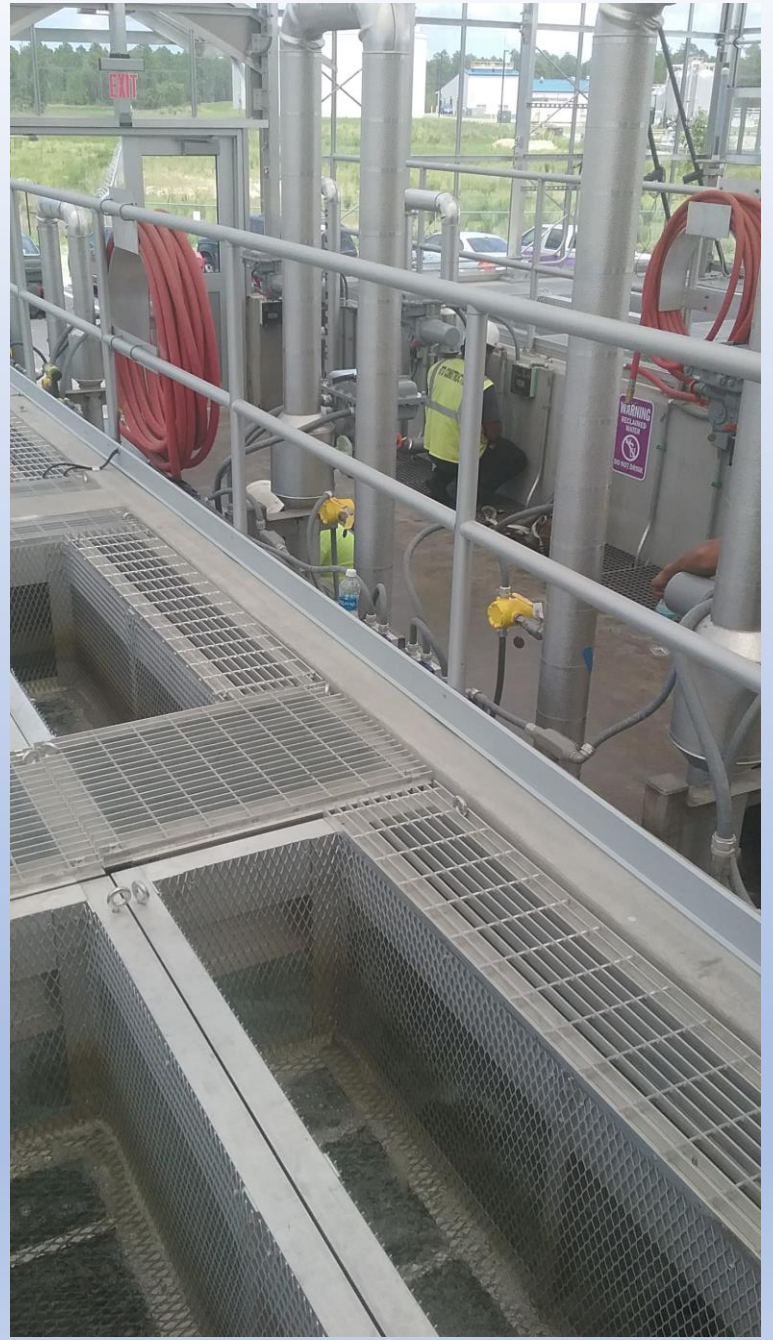

HACH
2 LITER
HACH
2 LITER
3


G2
SLUDGE


G2
Centrifuge
No. 2


POLYMER SYSTEM
NO. 1
Cake Lube
Pump No. 1
WARNING
HIGH VOLTAGE
SIEMENS


469


EXIT
WARNING