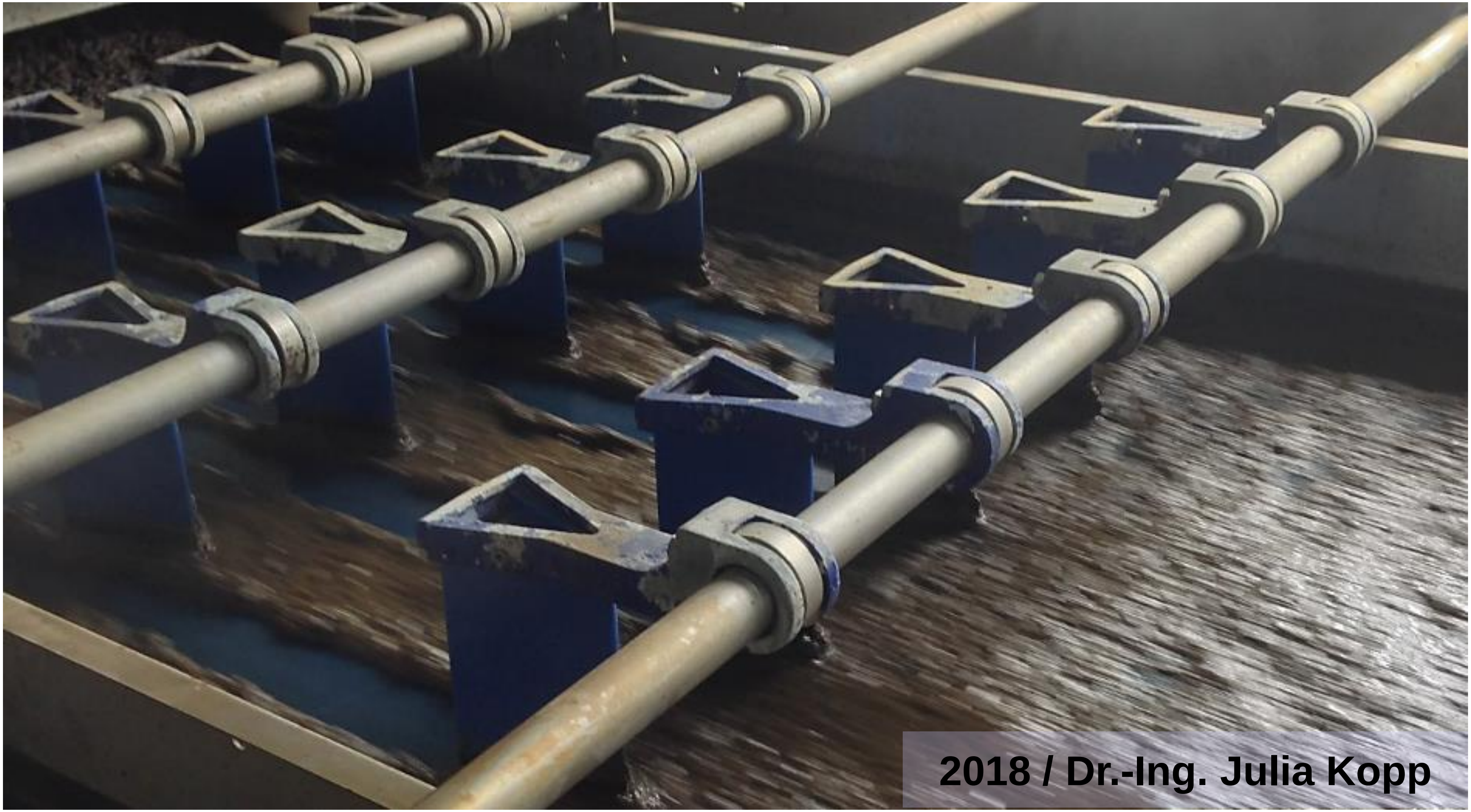
Dewatering / Thickening / Polymer

Interreg Baltic Sea Region

EUROPEAN UNION

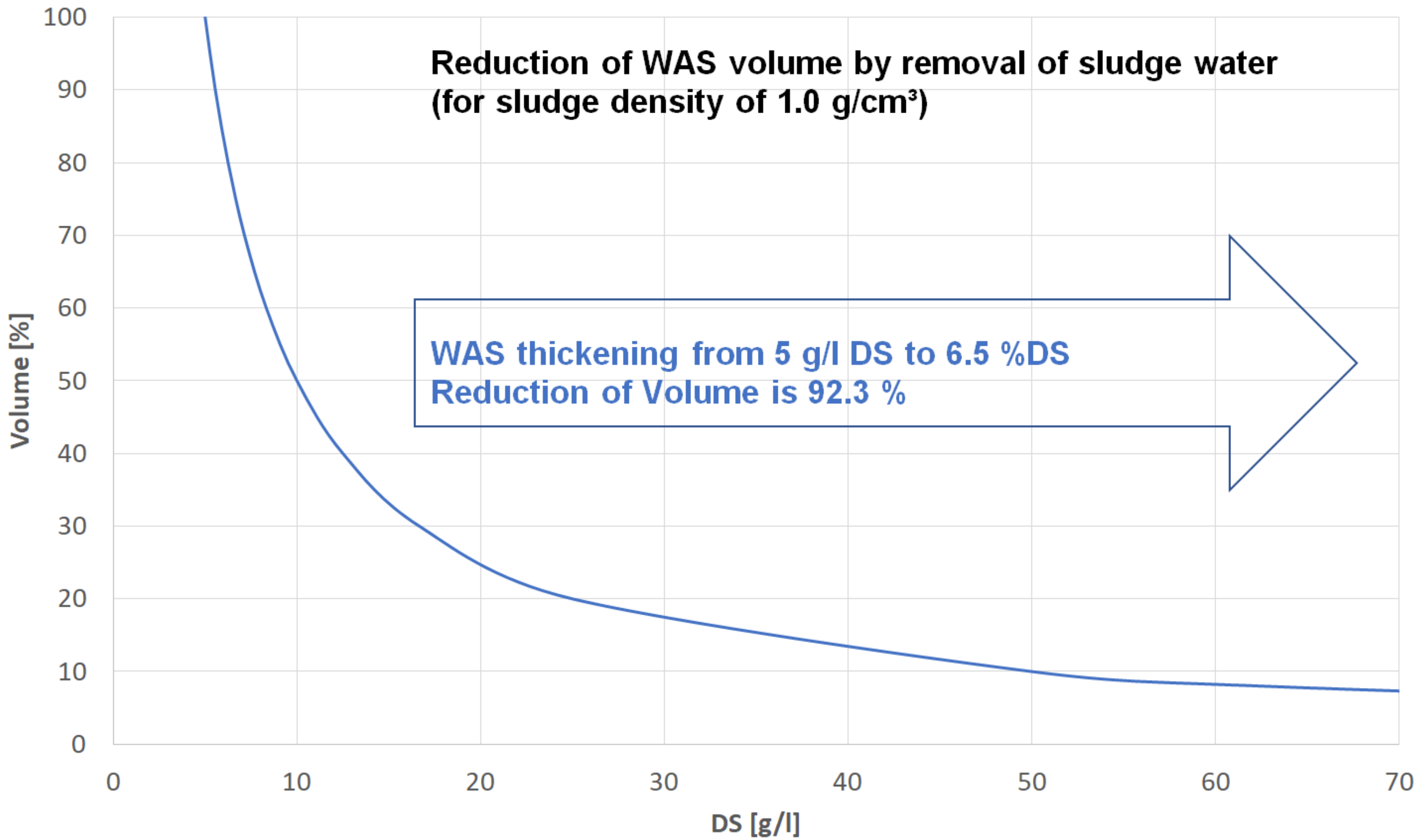
EUROPEAN REGIONAL DEVELOPMENT FUND

IWAMA Interactive Water Management



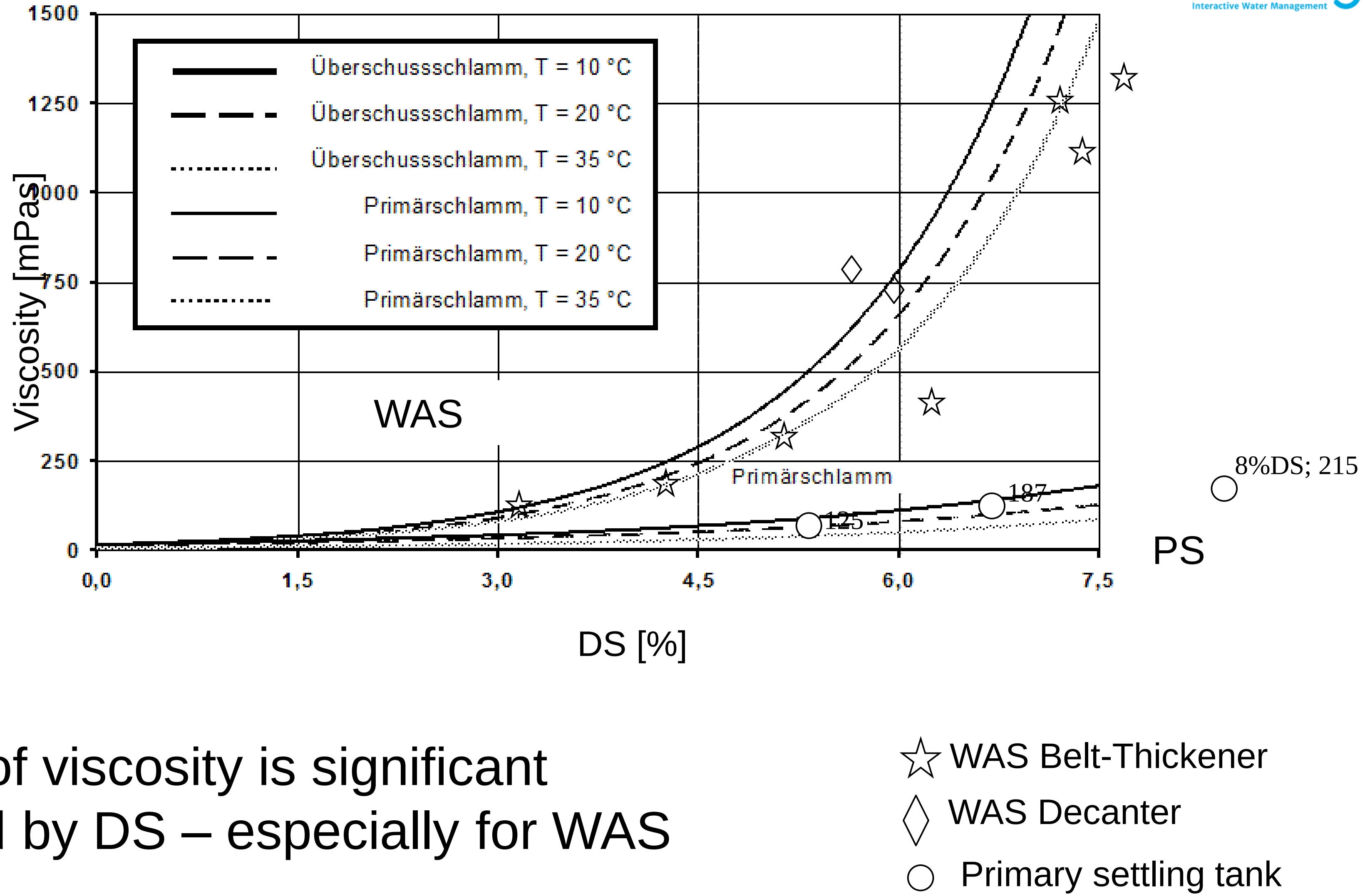
2018 / Dr.-Ing. Julia Kopp

Thickening = Volume Reduction



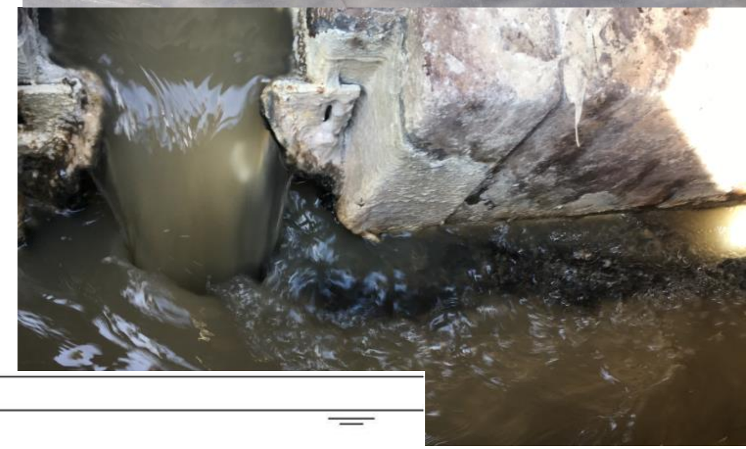
Limitation: pumping of sludge to digester

DS & Viscosity

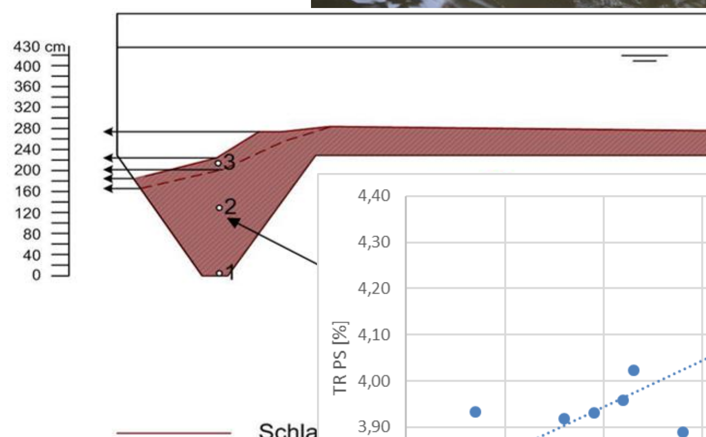


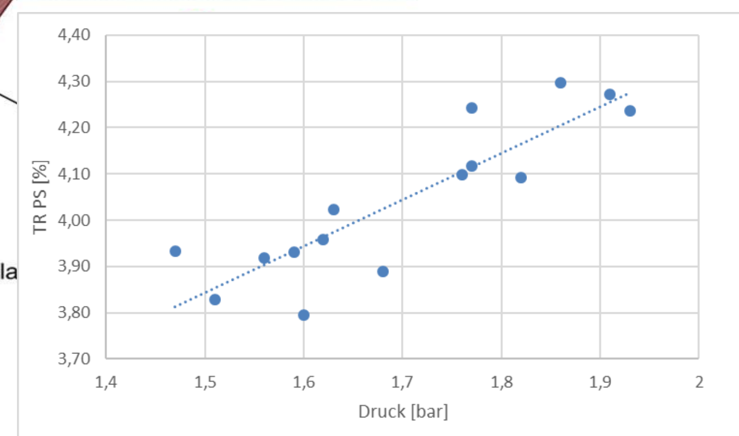
Increase of viscosity is significant influenced by DS – especially for WAS

Primary Sludge Thickening

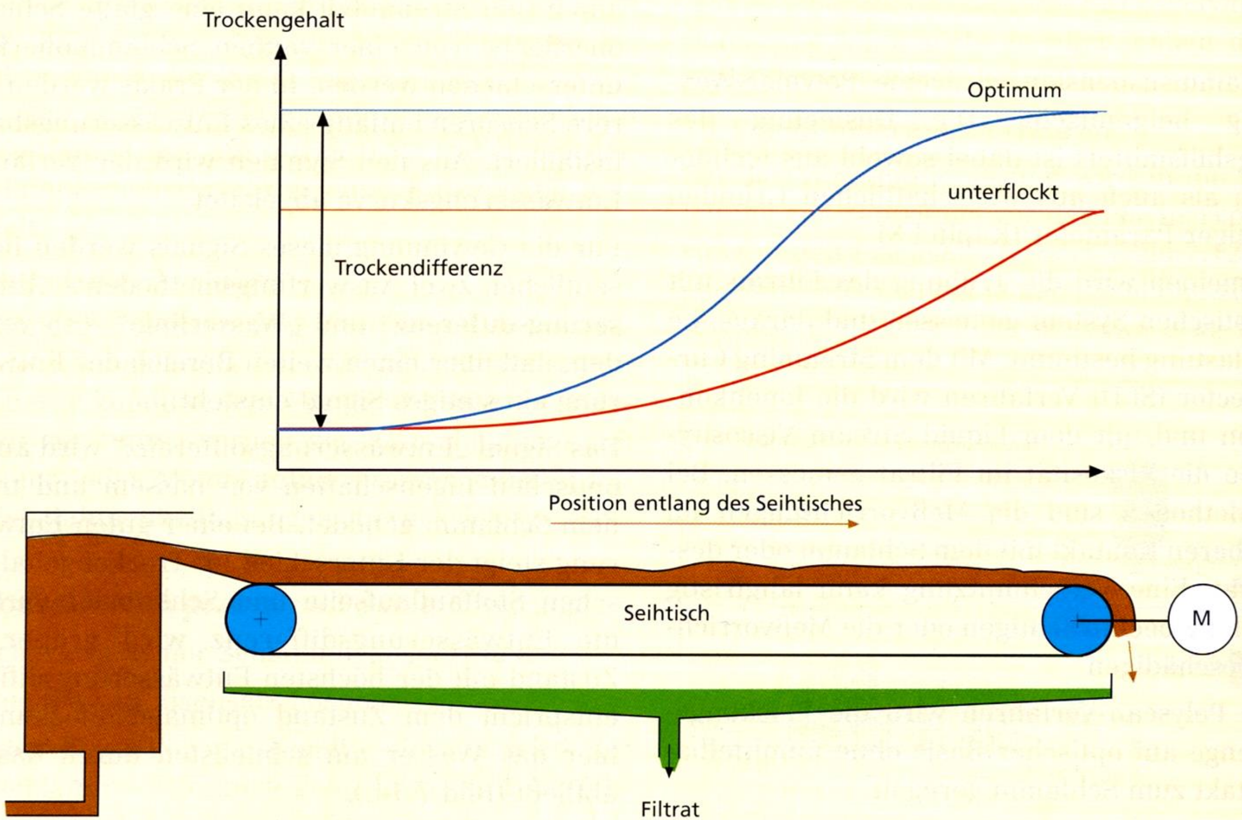


- Thickening of PS mostly in Settling-Tanks
- „milking“ of thick PS out of the clarifiers is recommended.
- Pressure of pumps correlate to DS of PS
- No Polymer-Addition is necessary
- Mistakes in mass balances are often related to sampling of PS
  DS of PS mostly too high
- Never!! use WAS to lubricate PS due to filamentous bacteria!!





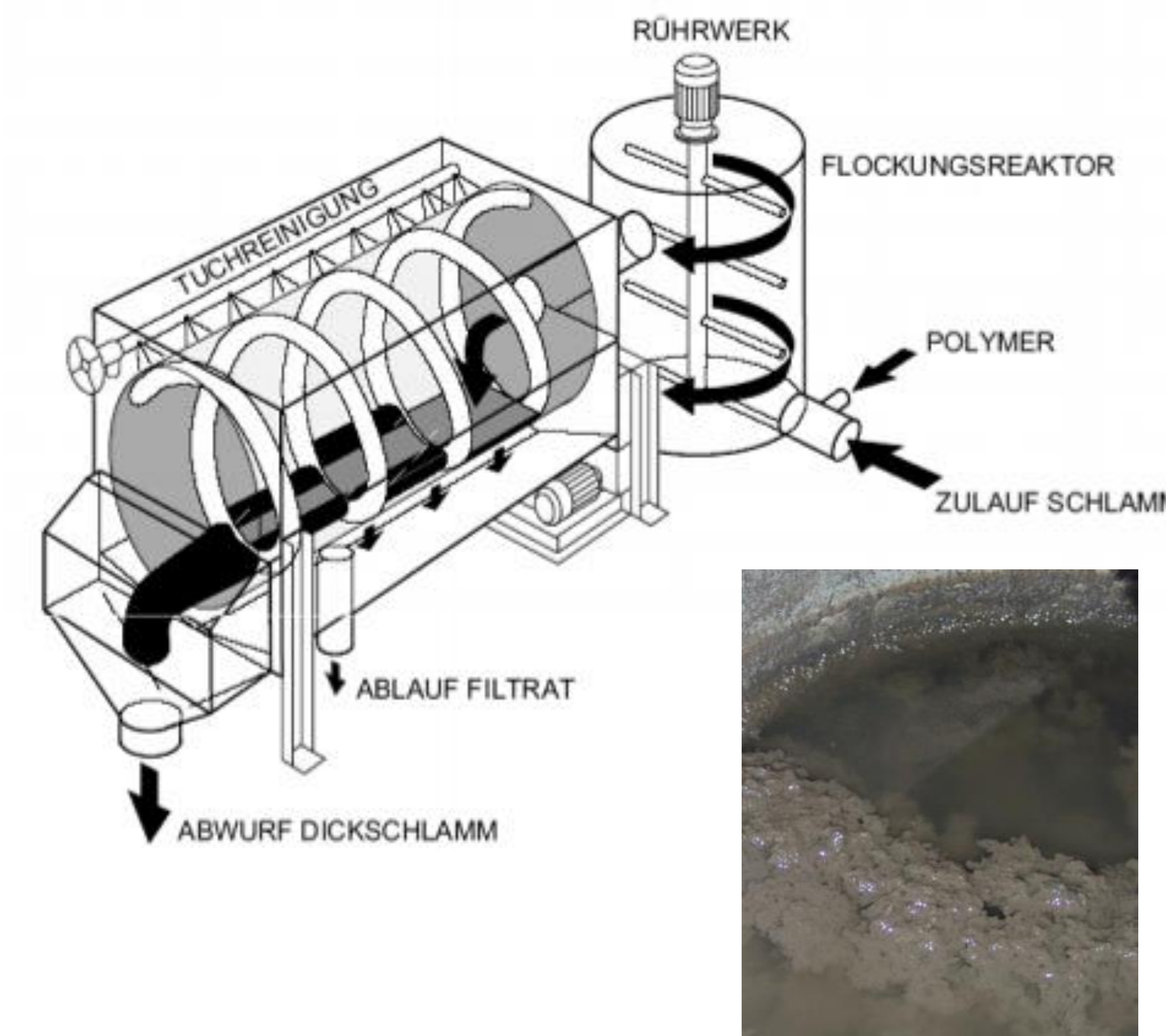
WAS Belt Thickener:

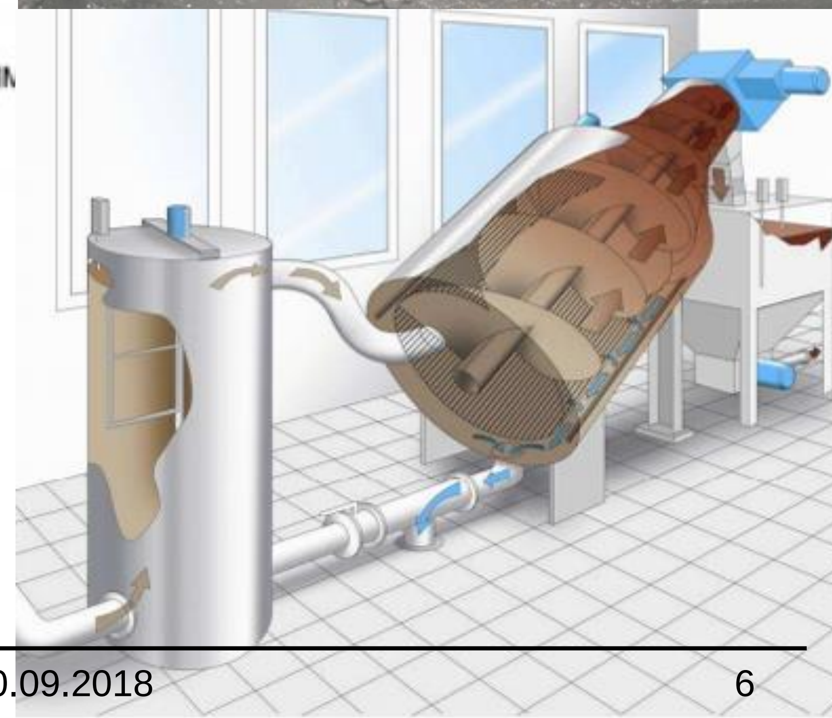


Thickener Sizes

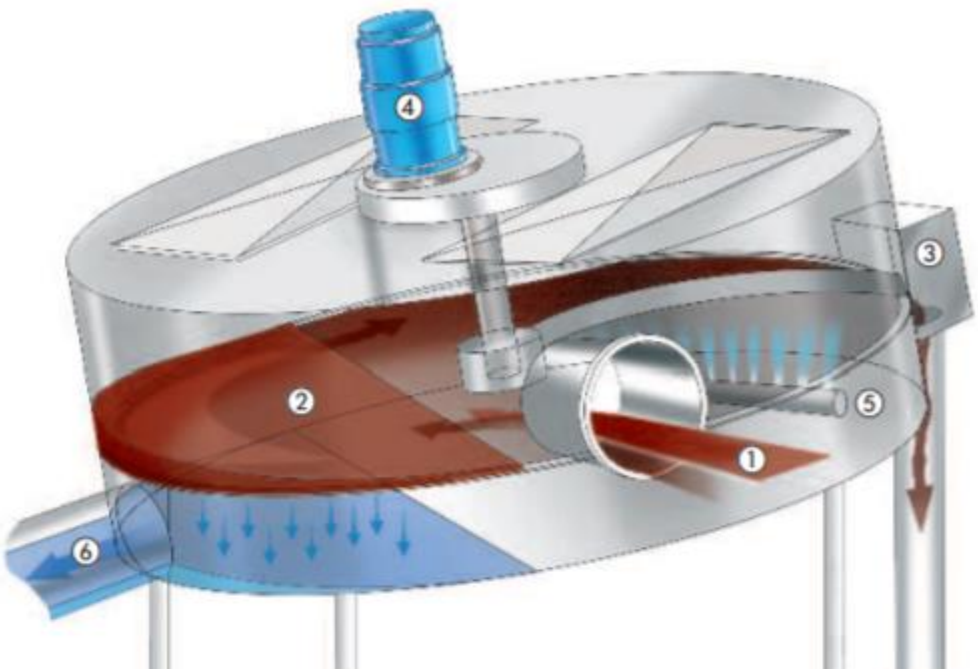
Size	Belt width [mm]	Throughput capacity [m³/h]
0.5	500	23
1.0	1000	45
1.5	1500	68
2.0	2000	90

Drum Thickener





Disc Thickeners:

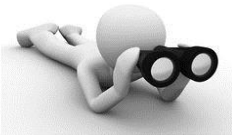


① *sludge inlet*
② *sludge liquor*
③ *sludge discharge*
④ *drive*
⑤ *spray bar*
⑥ *filtrate outlet*

Unit sizes

Size	Throughput capacity [m³/h]	Drive capacity [kW]
1	20	0.55
2	40	0.75

Flocculation of sludge

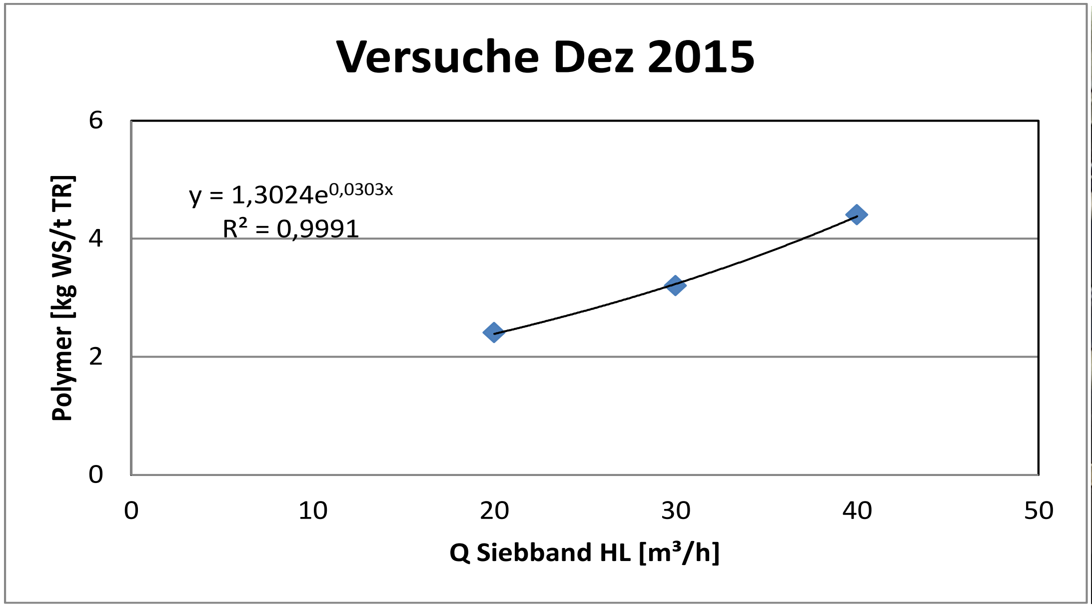


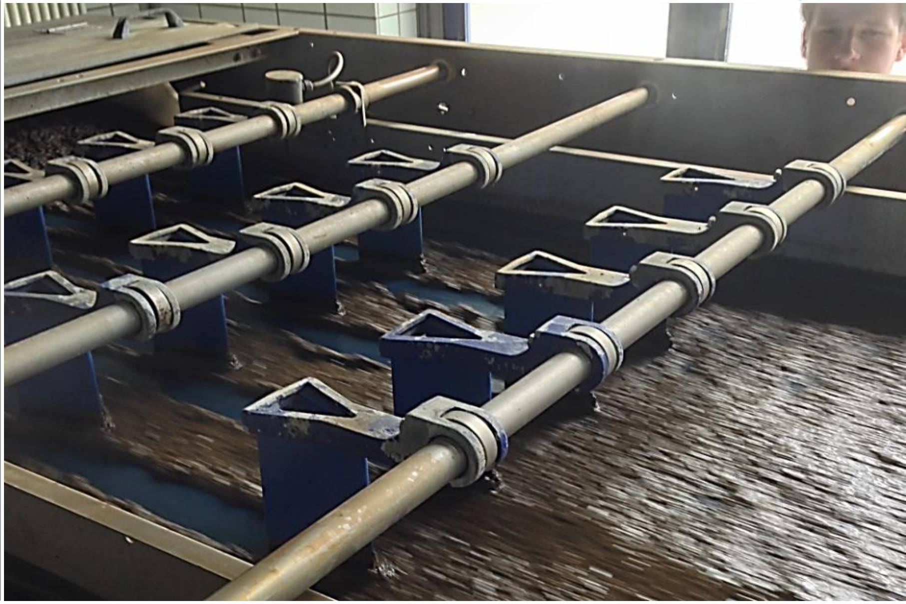
Increasing amount of poly – increase water release and floc size (WS = active substance) ***„floc watching“***

4 kgWS/tTR	6kgWS/tTR	8 kgWS/tTR	9kgWS/tTR

10 kgWS/tTR	11kgWS/tTR	overdose (16kgWS/tTR)

Influence on polymer demand





Test WAS Thickening DS ~ 6% + capture rate >95%

Polymer-demand

4,4 kg AS/t DS at 40 m³/h
3,2 kg AS/t DS at 30 m³/h -28%
2,4 kg AS/t DS bei 20 m³/h -45%

Polymer- demand is influenced by retention time on belt!!

polymer-demand of thickeners

see DWA M-381

Typical demand:

Centrifuge ~ 0-2 kgAS/MgDS

Belt ~ 2-4 kgAS/MgDS

Disc ~ 2-5 kgAS/MgDS

„old“ Drums ~ 4-8 kgAS/MgDS

Dewatering

Dewatering

Background:

- dewatering is a centerpiece in biosolids processing
- removal of water reduces volume of sludge
  to be hauled away & reused
- mechanical dewatering achieves 15-35%DS cake solids
- mechanical dewatering requires chemical conditioning
- mechanical dewatering devices: Centrifugation or Filtration
  (Belt Filterpress, Screw Press, Rotary Press, Bucher Press)

Process Quality:

- Dewatering (well maintained?; operation parameters re-checked?)
- Sludge Characteristics (did your sludge change?)
- Conditioning
  (matching polymer?; Mixing in the polymer at the right place?

Dewatering Parameters

Dewatering parameters are used to describe the dewatering characteristics of a sewage sludge and to detect causes for changes in the dewaterability.

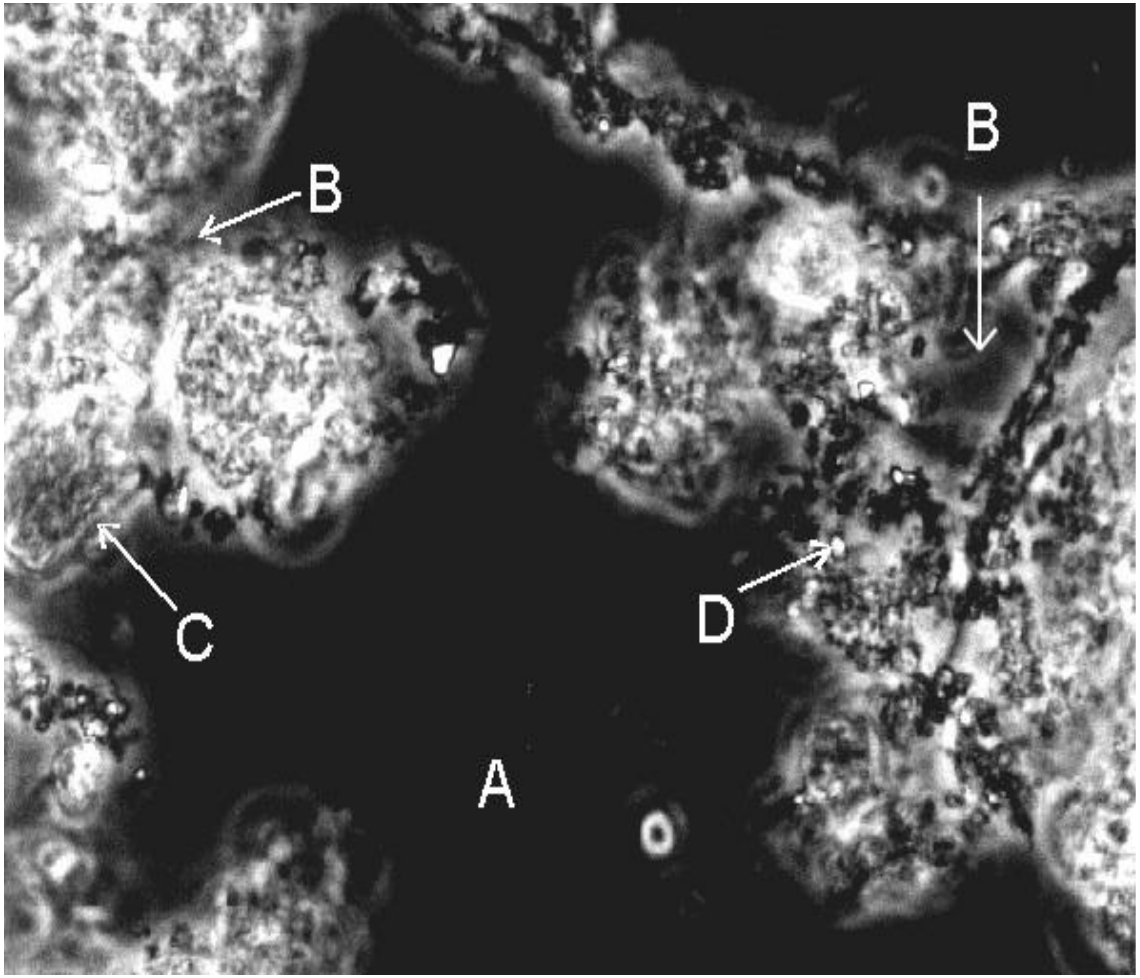
Dewatering parameters should be parameters, which:
- allow an objective comparison of the dewaterability of various sludges and
- if possible permit drawing of conclusions concerning the plant operation.

Dewatering parameters are classified as follows:

1) Basic parameters
2) Enhanced parameters
3) Conditioning parameters
4) Prognosis parameters

More information see DWA M-383, M-366 = technical guides for sludge dewatering,
DWA M-381 Thickening, M-350 Polymer-preparation

Water in Sludge Suspension



A: free water
= no binding

B: floc water
= capillary forces

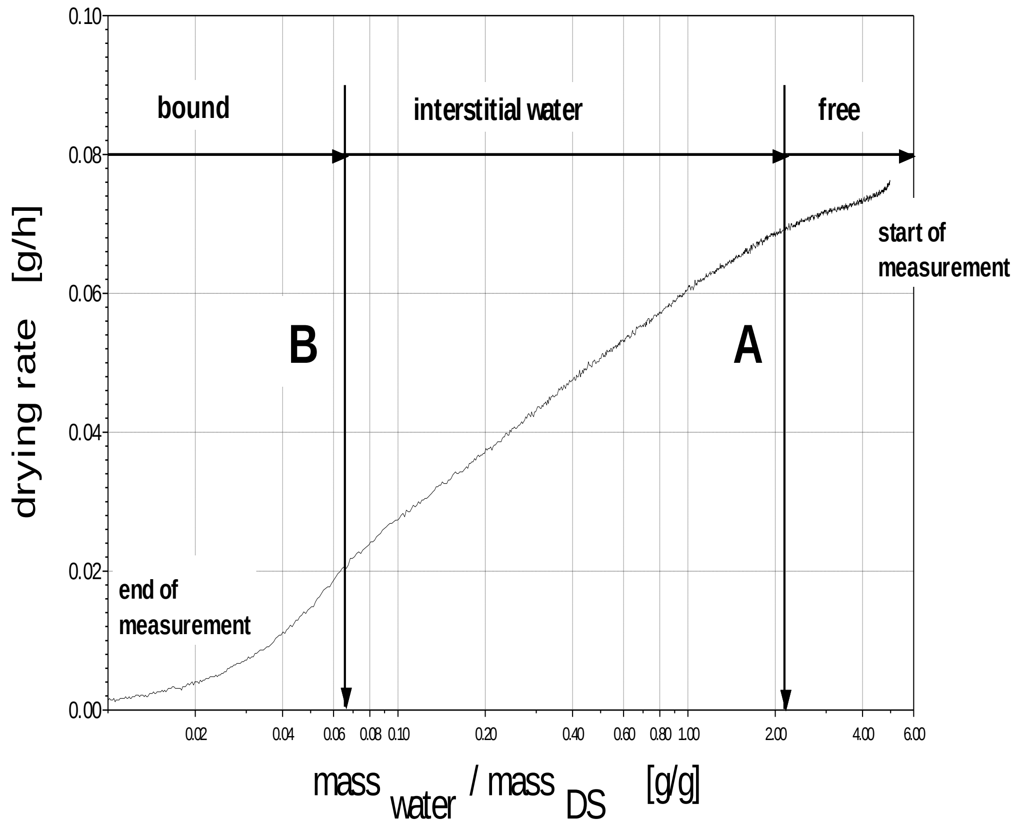
C: surface water
= adhesive forces

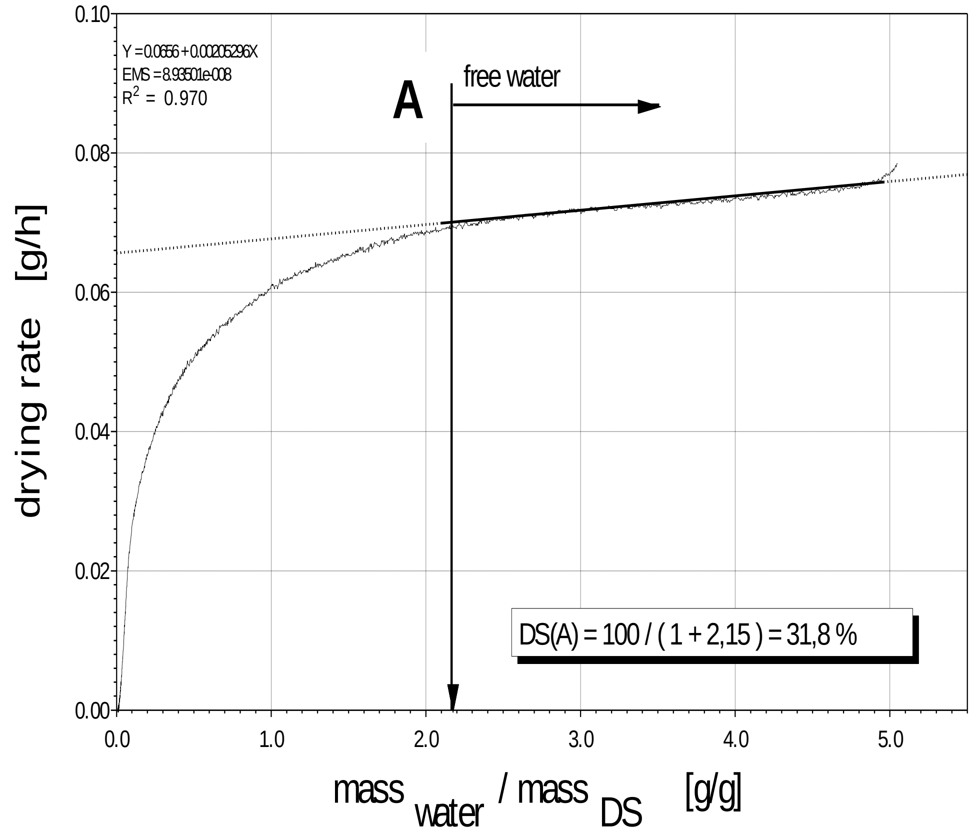
D: intracellular water

C+D: bound water

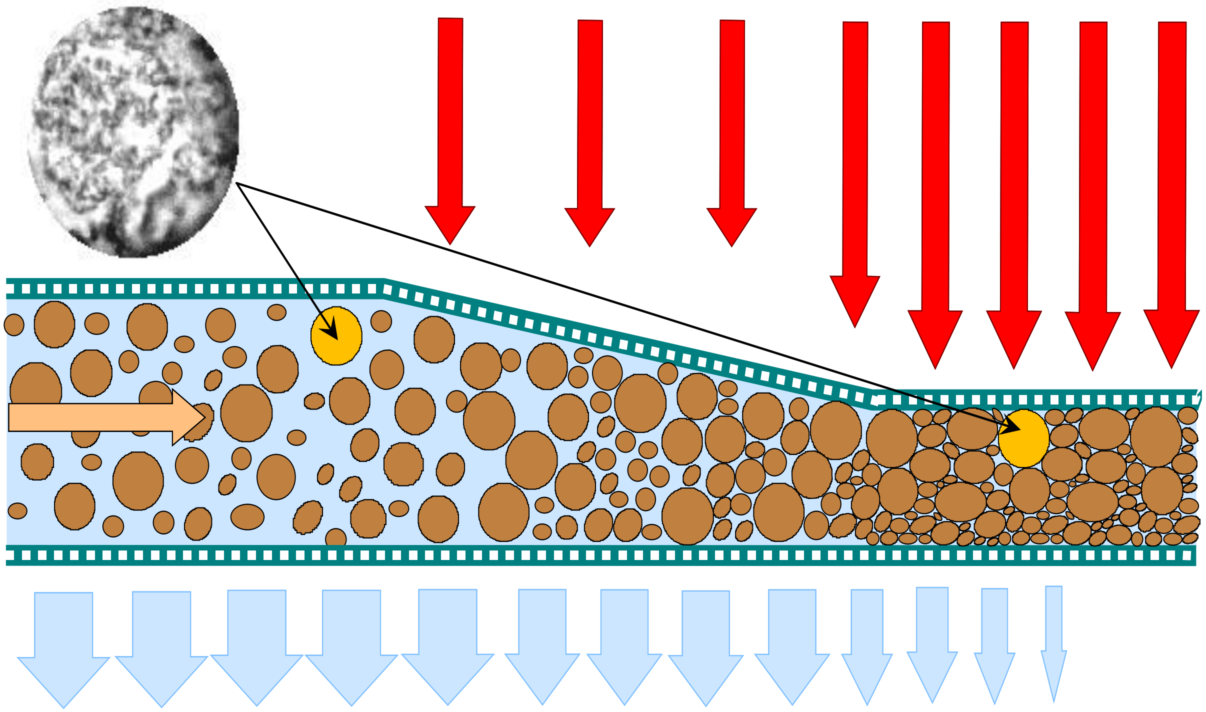
DS(A) - thermogravimetric measurements

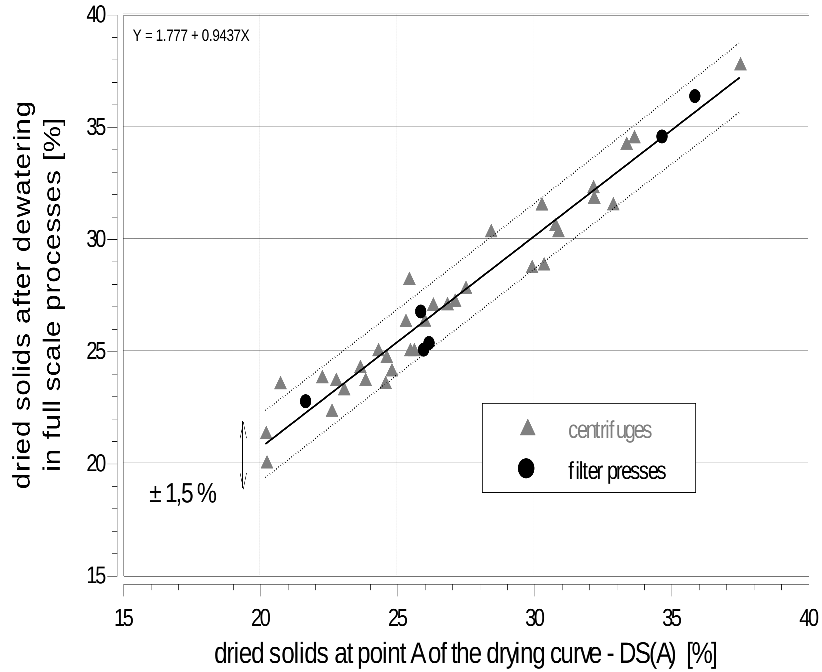
measurement of free water content





only the free water can be separated by dewatering





- Extensive experience on sludge dewatering (more than 800 sludges since 2001)
- Expertises are approved as guaranty values
- DS(A) is accepted by court in Europe

state of technology
= separation of free water

Decanter: **Drum > 300 mm**
acceleration > 3000 g → DS(A)

Decanter: "small" Drum < 300 mm
acceleration < 3000 g → DS(A) – 2% DS

Belt Filter Presses: → DS(A) – 2% DS

Screw Presses: → DS(A) – 2% DS

Chamber Filter Press: → DS(A)

Bucher Press: → DS(A) + 1% DS
+ 3 kg AS/t DS Polymer
according the shear force

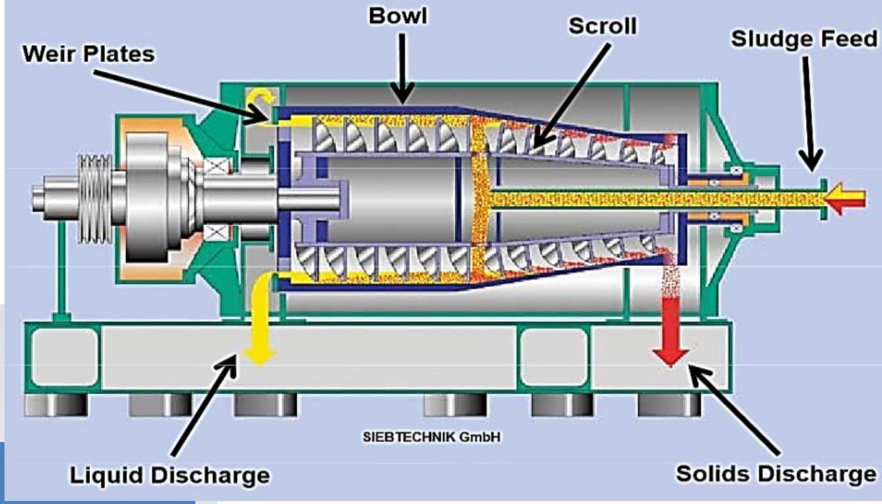
(AWEL, Kopp 2013)

Tabelle 4: Darstellung der Leistungsindikatoren der Klärschlammentwässerung

Input	Prozessschritt	Output	Kennzahl und Dimension	Zielwert für den „Stand der Technik"
Faulschlamm	Beschickung des Aggregates	TR-Fracht	[kgTR/h]	kontinuierliche Frachtbeschickung
	Polymer Aufbereitung	Stammlösung	Reifezeit [min] Lösungsviskosität	45 min nach Befüllen Verbrauch binnen 1-4 h 2-Kammer-Batchanlage und Kontrolle der Lösungsviskosität
	Schlammkonditionierung	Polymerprodukt Dosis	Labor- & Betriebsversuche [kgWS/tTR]	Flockenstruktur scherstabil / druckstabil bei effizienter Dosierung
	Entwässerung	Energieverbrauch	[kWh/tTR], [kWh/m³]	0,6-2,2 [kWh/m³] ** siehe Tabelle 3
	Entwässerung mit **Dekanter**	entw. Schlamm	[% TR]	Abtrennung des freien Wassers: Erreichen TR(A)* AG > 95 % für stabilen Betrieb erforderlich
	Entwässerung mit **Bandfilterpresse**	entw. Schlamm	[% TR]	Abtrennung des freien Wassers: TR(A)* – 2 % TR AG > 95 % für stabilen Betrieb erforderlich
	Entwässerung mit **Schneckenpresse**	entw. Schlamm	[% TR]	Abtrennung des freien Wassers: TR(A)* – 2 % TR AG > 95 % für stabilen Betrieb erforderlich
	Entwässerung mit **Schlauchfilterpresse**	entw. Schlamm	[% TR]	Abtrennung des freien Wassers: TR(A) + 1 % TR*** AG > 95 % für stabilen Betrieb erforderlich

* = oder anderer Prognosekennwerte (DWA M-383)
** = Energieverbrauch abhängig vom Aggregat siehe Tabelle 3
*** = aufgrund der hohen Scherkräfte bei der Entwässerung in der Schlauchfilterpresse ist der Bedarf an polymeren Flockungsmitteln erhöht

Centrifuges



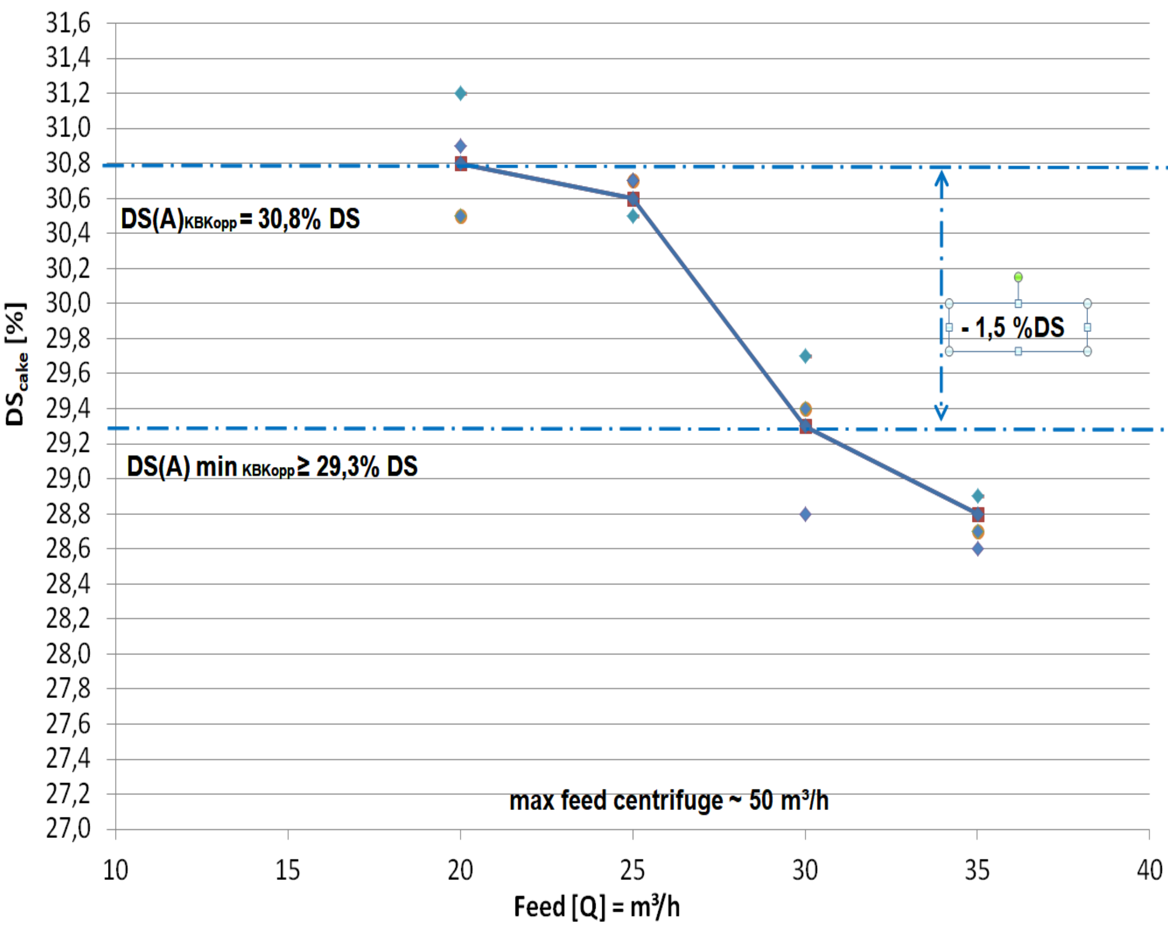
Operational Targets

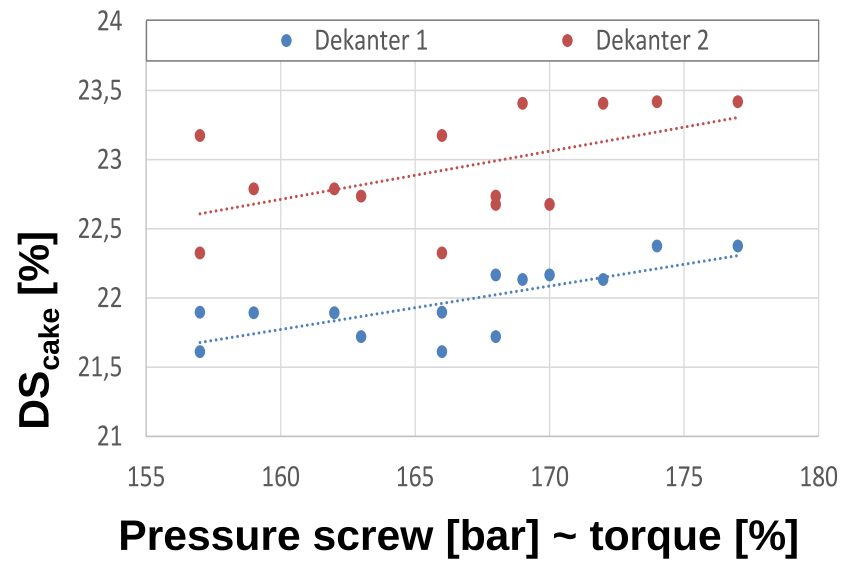
Criteria	Units	Importance
Cake dryness	%TS	Disposal costs Water equals weight and takes up volume
Centrate quality > 95%	%TS or TSS, mg/L	Impact on liquid treatment processes Re-treatment of solids (thickening, digestion and dewatering) Impact of inert solids on activated sludge mass calculations
Throughput	Pounds per hour	How centrifuges are sized and sold
Polymer dose	Active pounds per dry ton	Operating costs

optimal operation with DS online probe & constant polymer dosage per kg DS

Influence of load capacity of machine

optimal operation at ~ 60-70% of max rated value

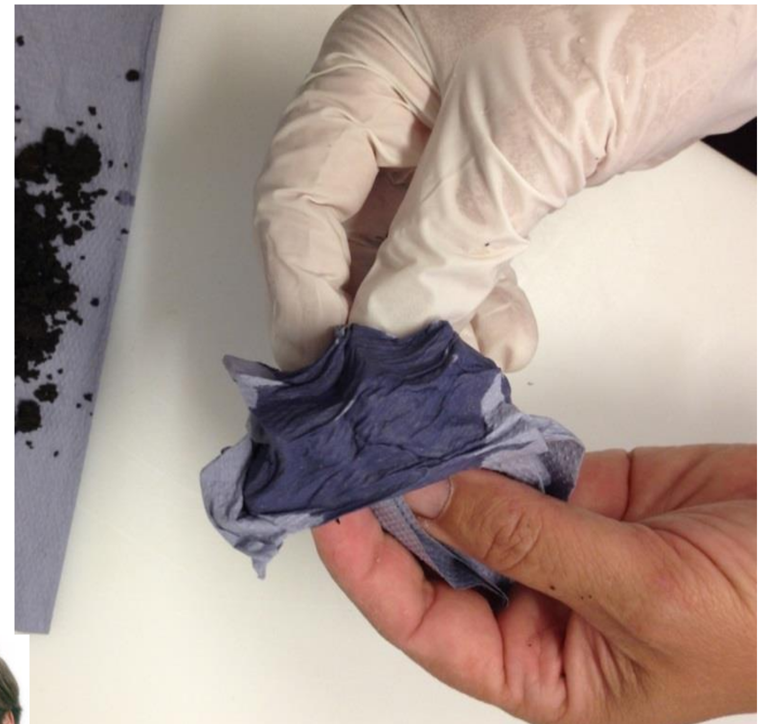




Longer solids retention time in centrifuge and high %torque or pressure [bar] increase DS(Cake)

Check the Cake

“tissue test” – just to get an idea …

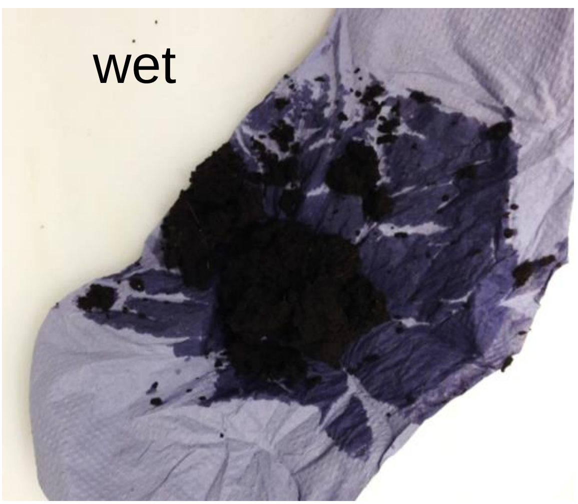


dry cake (?)

Looks crumbly

after pressing:

wet



Screw Presses

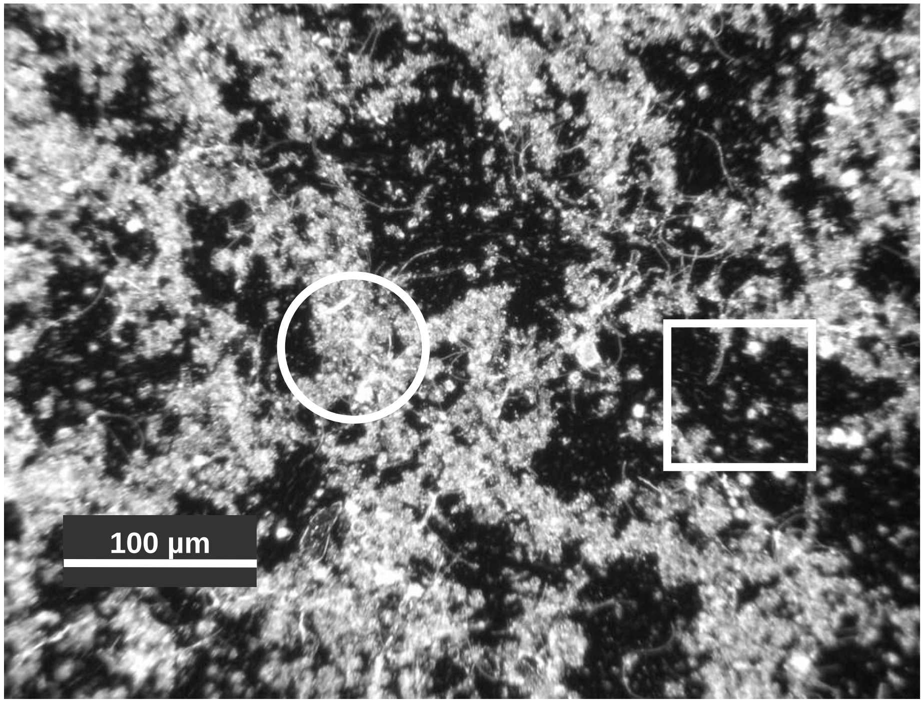
optimal operation
at ~ 50% of
max rated value

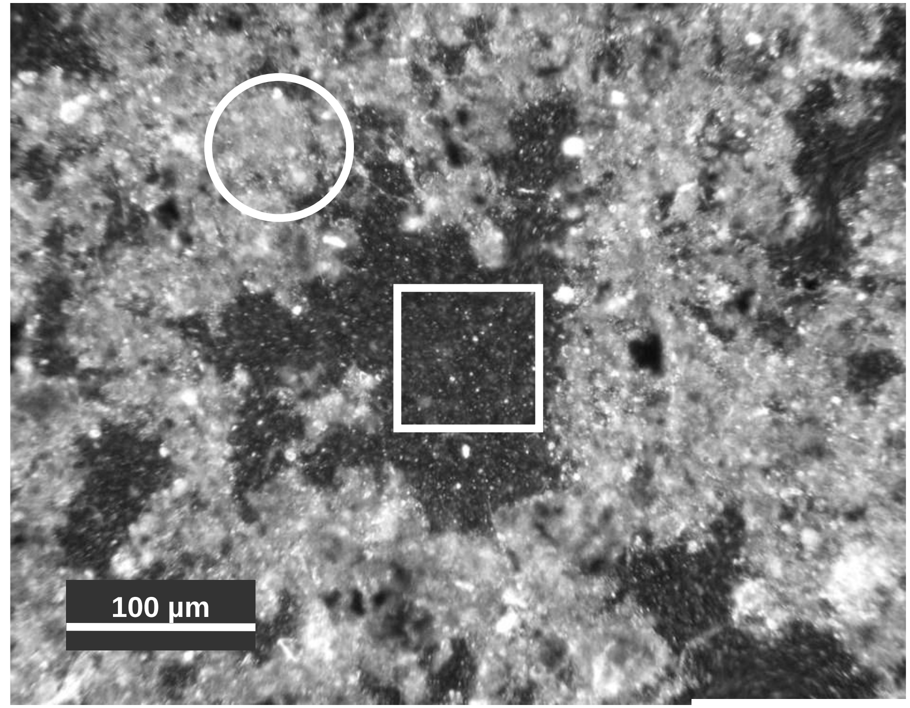
Tools for Optimization:

- Chemical Treatment:
  - Type
  - Dosage
- Operator Observations
- Equipment settings:
  - Flows
  - Screw Rpm
  - Cone Pressure
  - Feed Pressure
- Instrumentation:
  - Flows
  - Suspended Solids
  - Turbidity
  - Zeta potential
- Mechanical Condition of Equipment

(Kelly Brown CWEA Seminar 2012 Ohio)

Genesis ► Structure ► Dewaterability





DS_{cake} ~ 30% **DS_{cake} ~ 20%**

- The origin of the sludge:

Primary ⟶ Digested primary ⟶ Fresh mixed ⟶ Digested mixed ⟶ Biological

Low colloidal nature ⟶ High colloidal nature

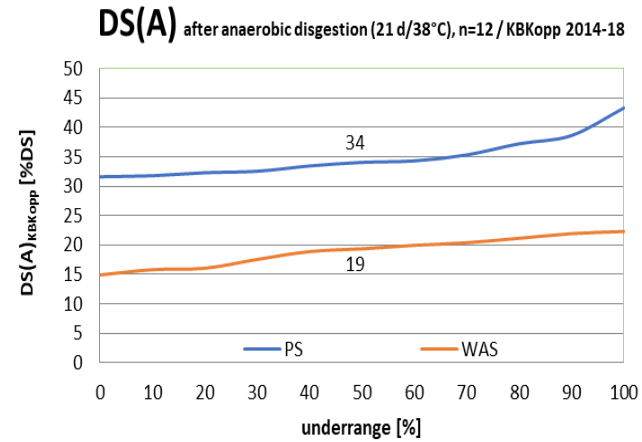
Influence on sludge dewatering

1) WAS/PS in raw sludge

Increase of WAS - dewaterability decrease

2) Phosphate

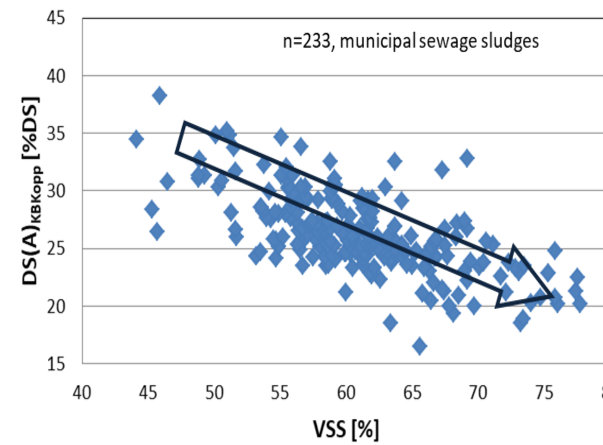
4%DS less DS_{Cake} with EBPR for PO_4P > 100 mg/l



3) VSS

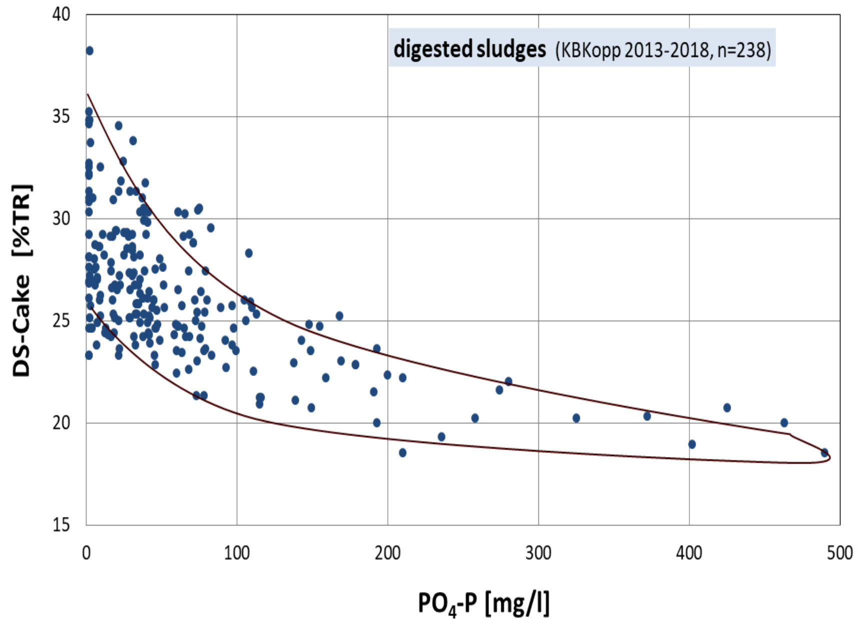
influence of VSS on dewaterability is minor to influence of WAS/PS and interaction EPS/PO_4P. VSS is no guarantee value!

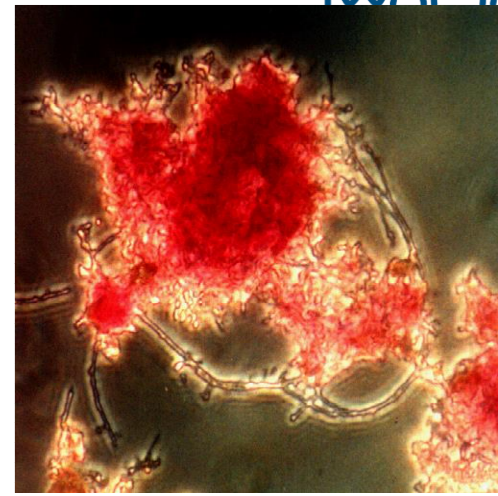
4) Further: sand, fiber/screen, Al^{3+}/SVI, Co-digestion / proteins

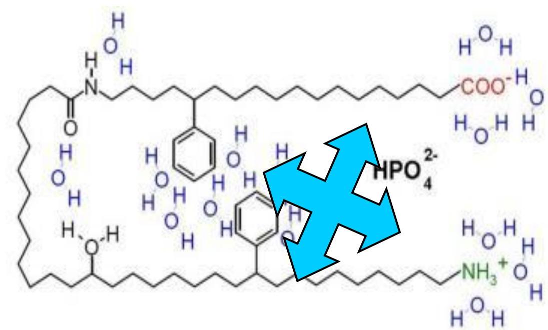


Enhanced Bio P Removal – statistic data analysis

- **EPS** = extracellular polymeric substances polysaccharides & proteins
- ~ 35% of excess sludge is EPS & water binding of EPS is influenced by pH and PO_4P
- Influence of EBPR is significant



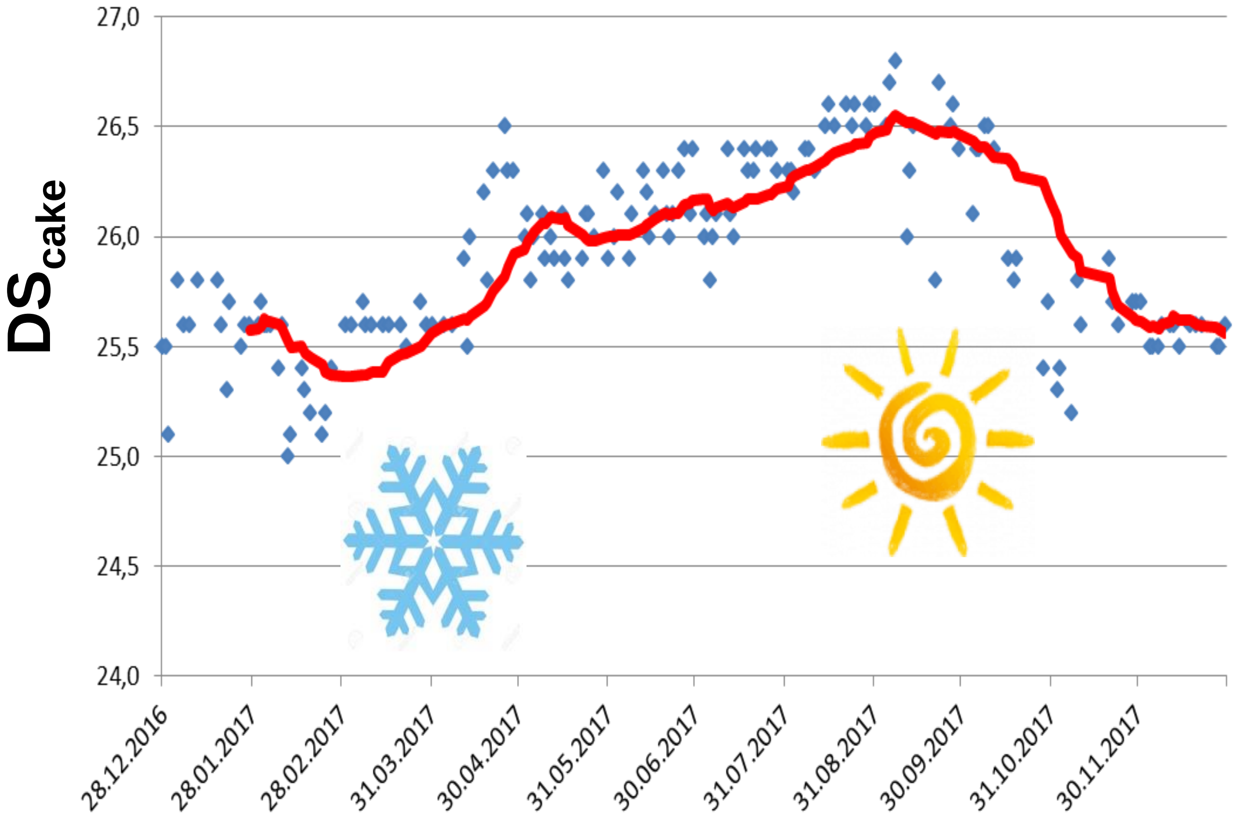




WWTP	Ø DS(A) [%]	Ø Poly [g AS/kgDS]	Ø Poly [lbs AS/tonDS]	digested sludges	n
P - Precipitation	29	10	22	2-30 mg/l PO_4P	91
enhanced biol. P Removal	25	13	29	> 100 mg/l PO_4P	145

all data without THP samples
after THP PO_4P and DS(A) are high,
water binding protein is changed

Saisonal changes in VSS and DS_{cake}

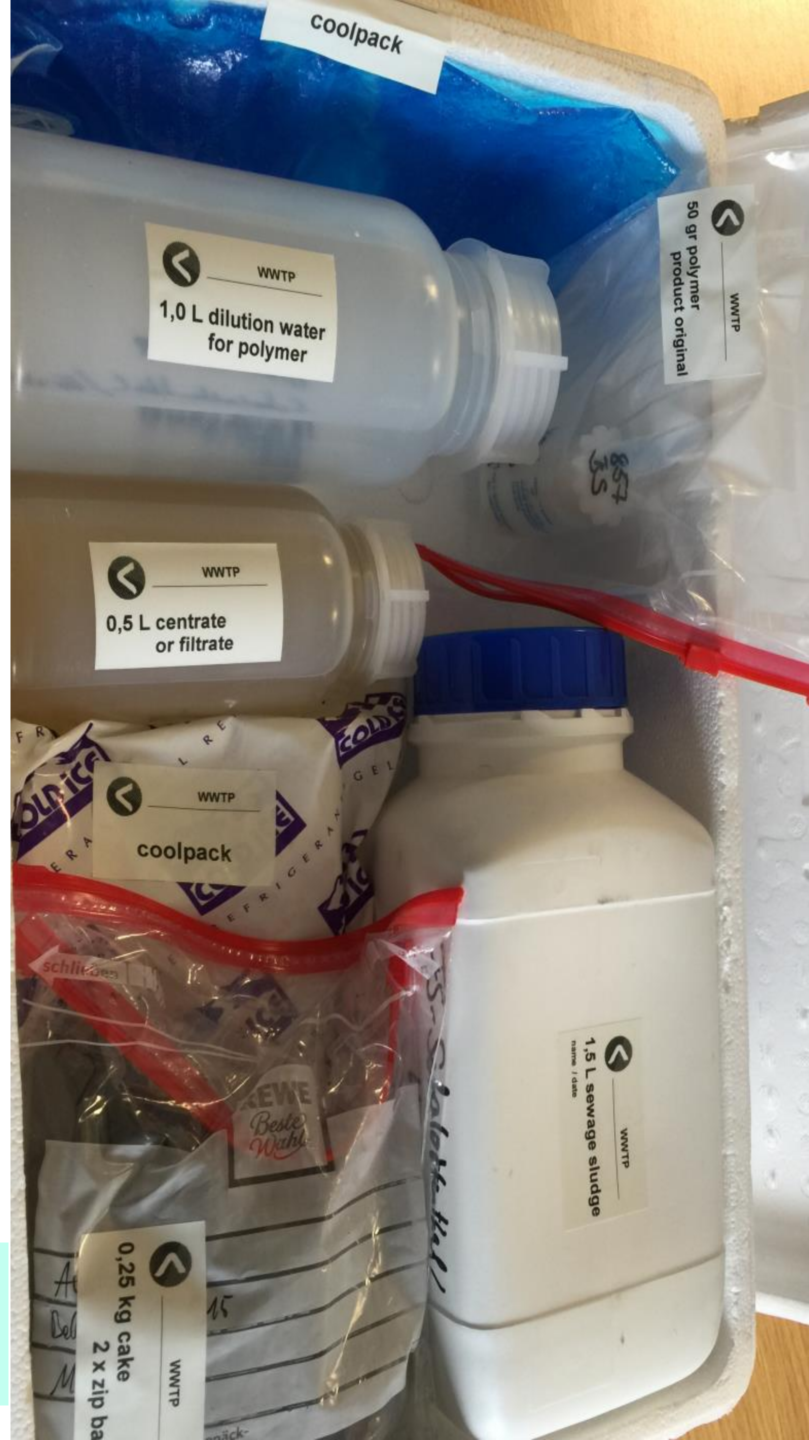


- due to lower temperatures sludge age and VSS is higher in wintertime
- DS reduce ~ 2%DS in wintertime
- to improve dewatering reduce of feed dewatering machine

DS(A) by KBKopp:

- Only free water can be separated by mechanical dewatering → **DS(A)**
- Accuracy of DS(A) measurement is ± 1,5%DS
- DS(A) is influenced by floc structure, EPS & biological P
  With increasing amount of excess sludge on raw sludge dewaterability decrease
- The proper selection and preparation of polymer is required to achieve good dewatering results. Providing shear stable flocs by conditioning is important.
- KBKopp is able to take a fingerprint of dewaterability for your sewage sludge!
- Expertises are approved as guaranty values in Europe.
- Cost: Ask for an offer! Time needed for analysis ~ 1 week
- **Toll**: **EORI Number KBKopp DE234338744403123 !!!**

We need: 1,5-2 l sludge, 0,5 l centrate, 1 l dilution water polymer
0,25 kg cake (in 2 x zip bag), 50 gr. Polymer orig. product!



Questions?

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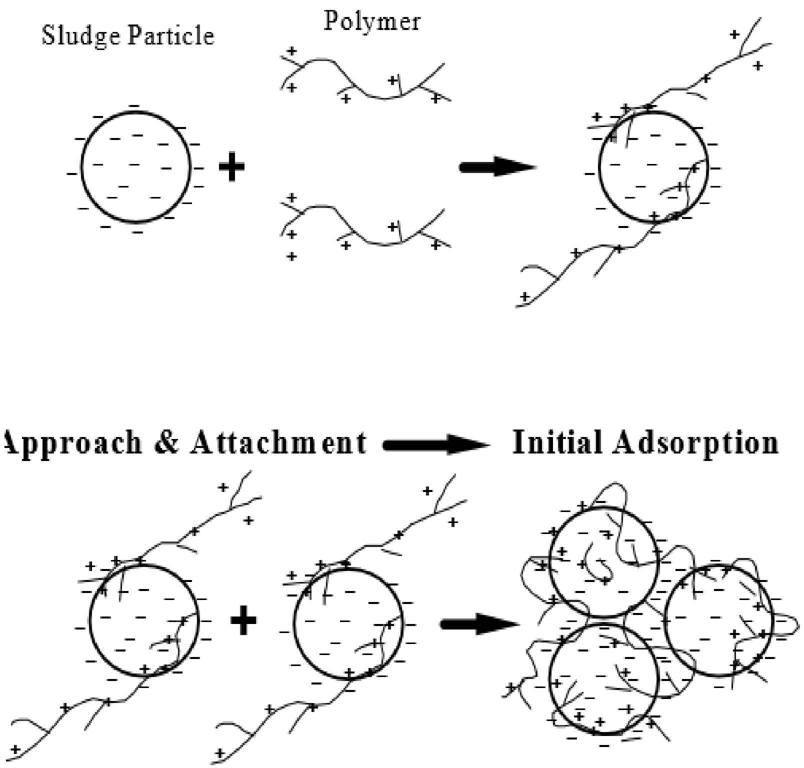
Sludge Conditioning



(Gregory, 1993).

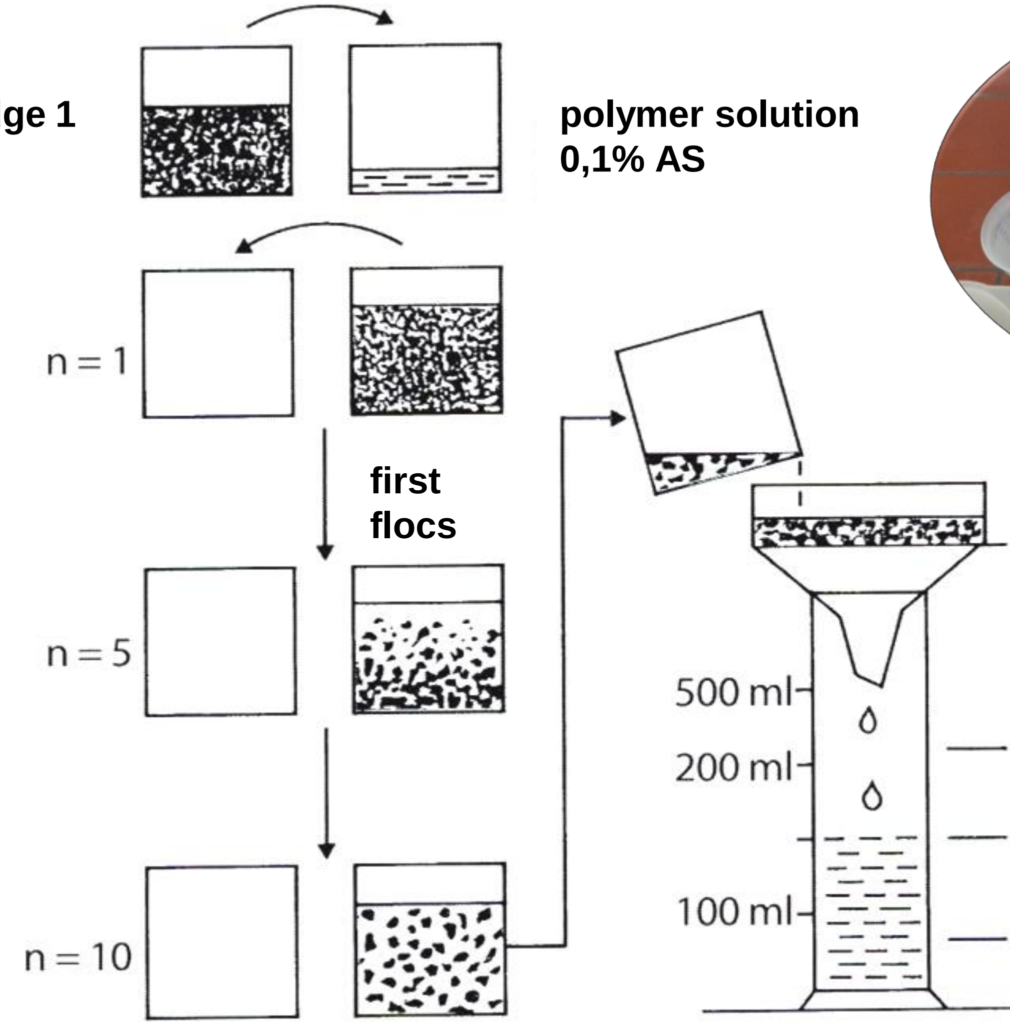
Sludge floc formation by the bridging mechanism.

flocculation increases release of free water!

Dripping Test *"quick & easy"*

sludge 1

polymer solution
0,1% AS



first
flocs

optimal flocs

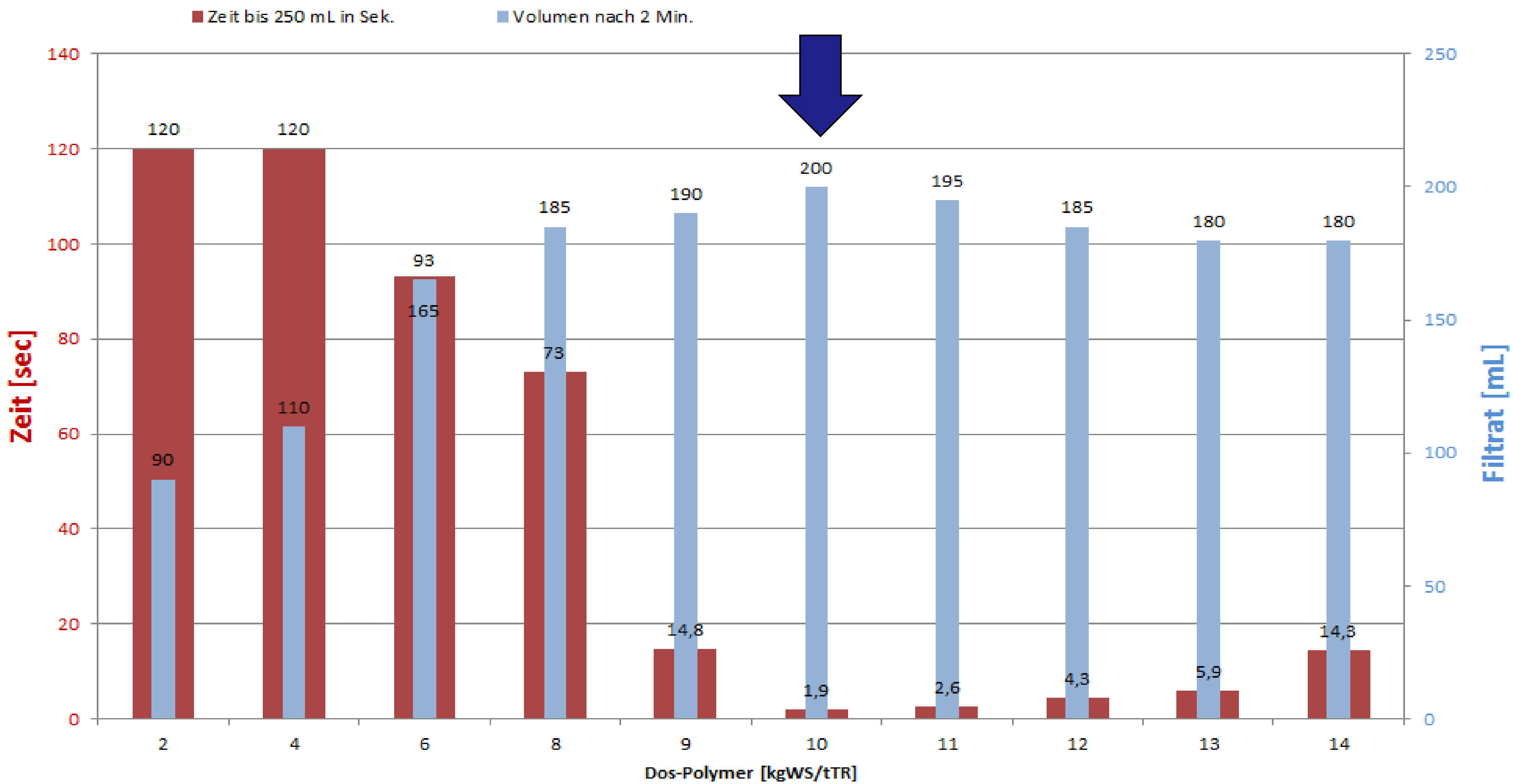
Sieve from beltpress

standing cylinder

time [sec] to get 150 ml

Filtrate

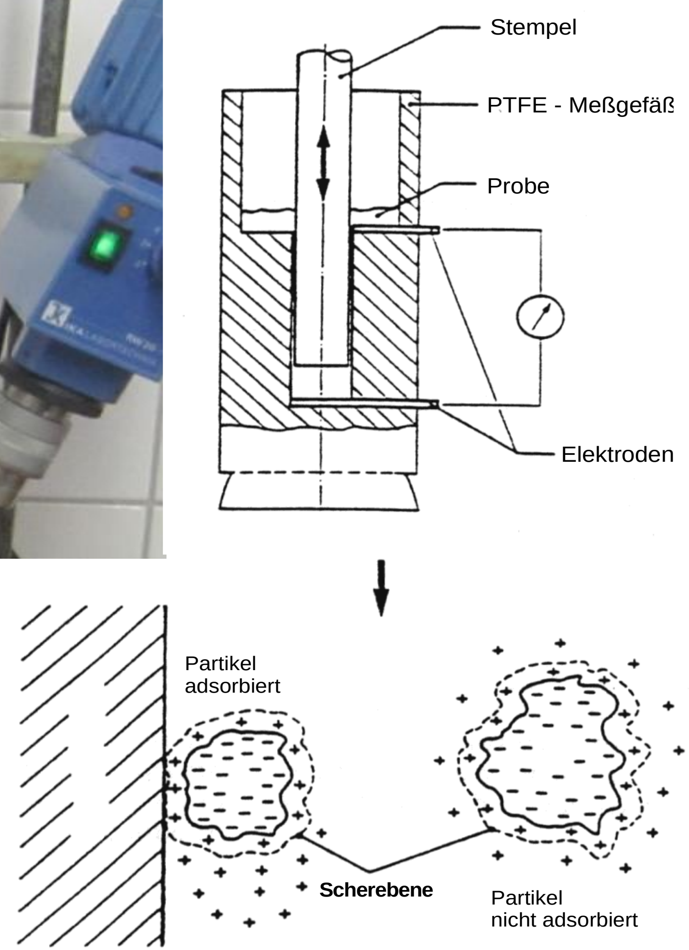
Example – Dripping Test for Dewatering



good = min time + max filtrate

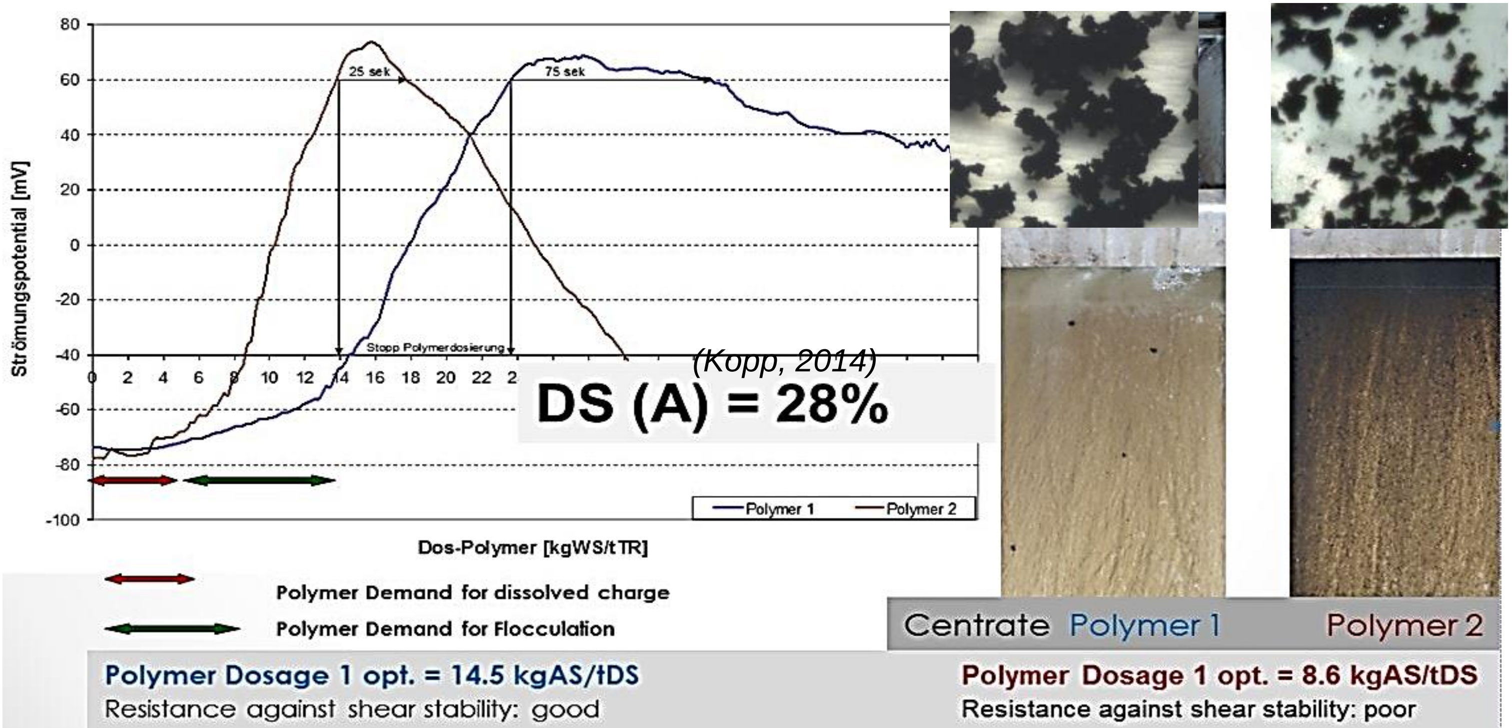
(Kopp, 2014)

streaming potential measurement



(Bley / Muetek)

requirement: optimal polymer conditioning



Polymer 1: shear-stabel

Polymer-demand 14,5 kg AS/t DS

Polymer-dosage 13 kg AS/ t DS

DS $_{dewatered}$ = 26,8% DS

Degree of separation =98,9 > 95%

DS(A) = 28%

Polymer 2: not suitable

Polymer-demand 8,6 kg AS/t DS

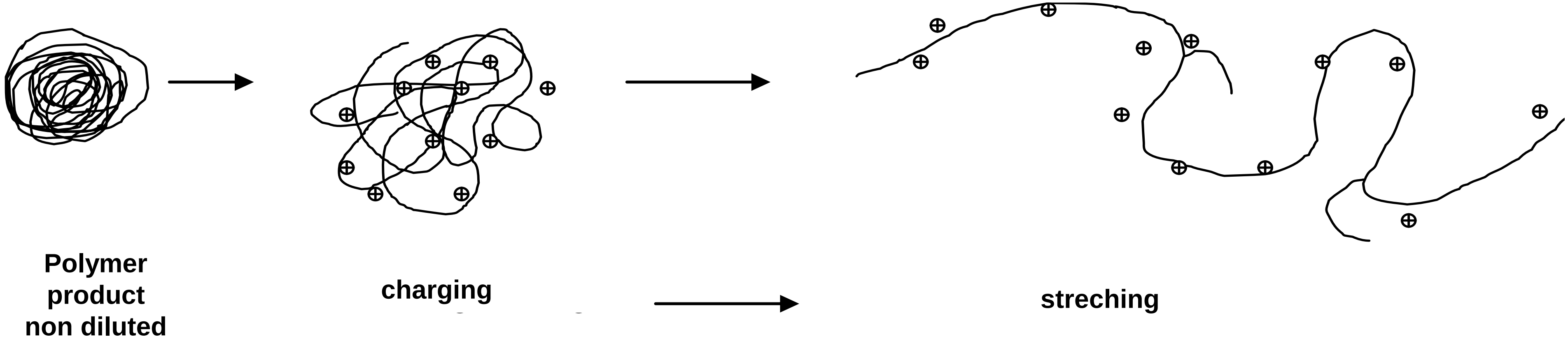
Polymer-dosage 12,5 kg AS/ t DS

DS $_{dewatered}$ = 24,3% DS

Degree of separation = 89,2 < 95%

DS(A) = 28%

Polymer Preparation



Optimal preparation is needed for an optimal dewatering

Maturing time: > 45 min

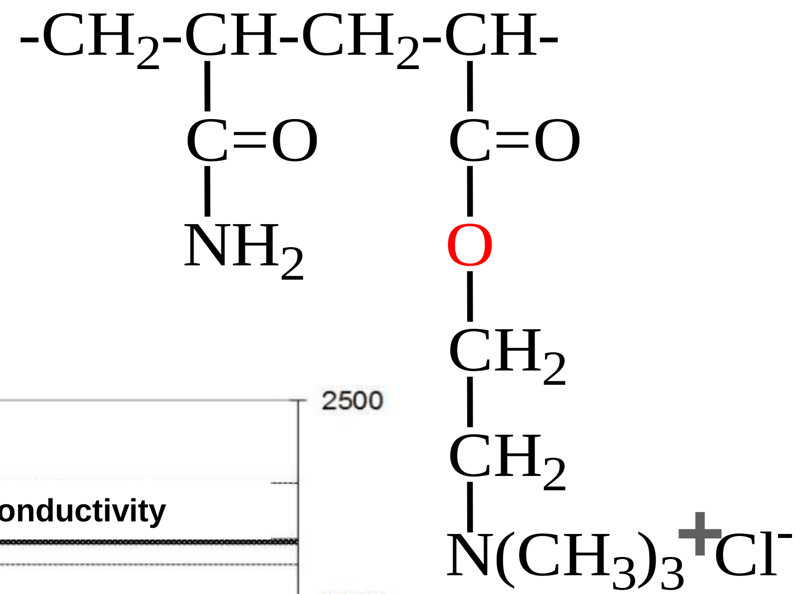
Dilution: 2 chamber system

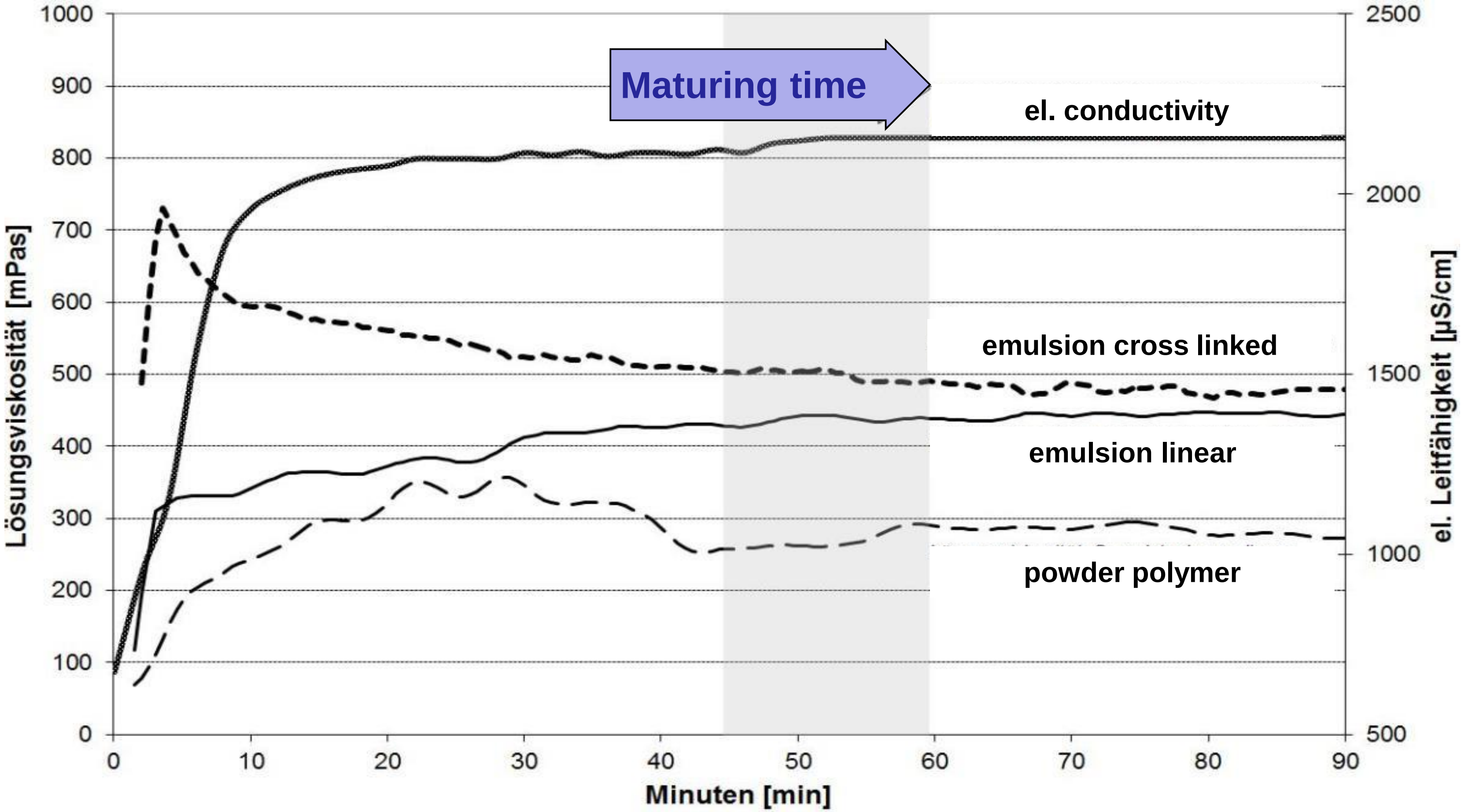
Dosing: within 4 hours after maturing

Control: DS of polymer solution

(DWA M-350 & Kopp 2014)

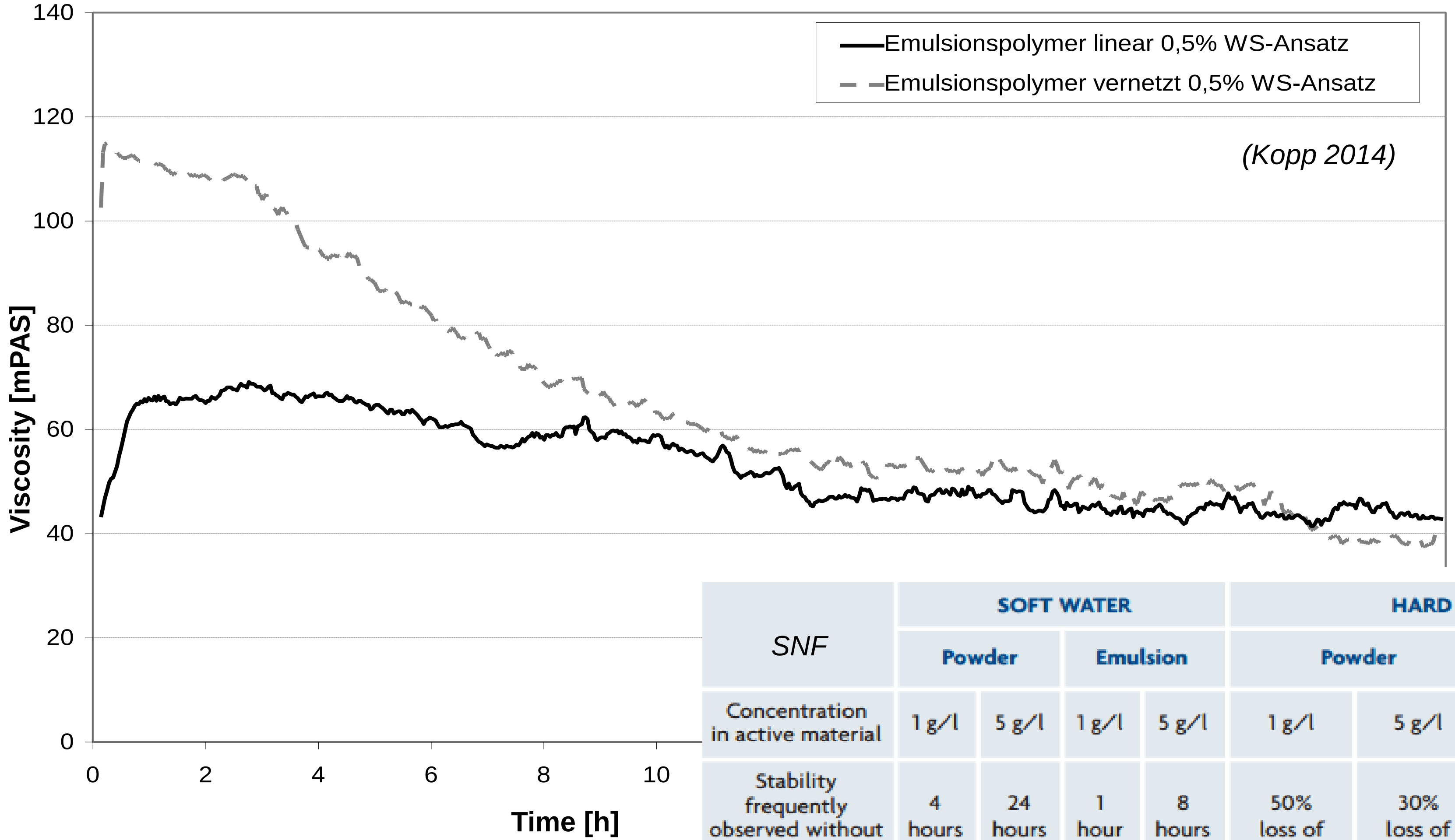
viscosity - maturing





(DWA M-350 & Kopp 2014)

Use of polymer-solution

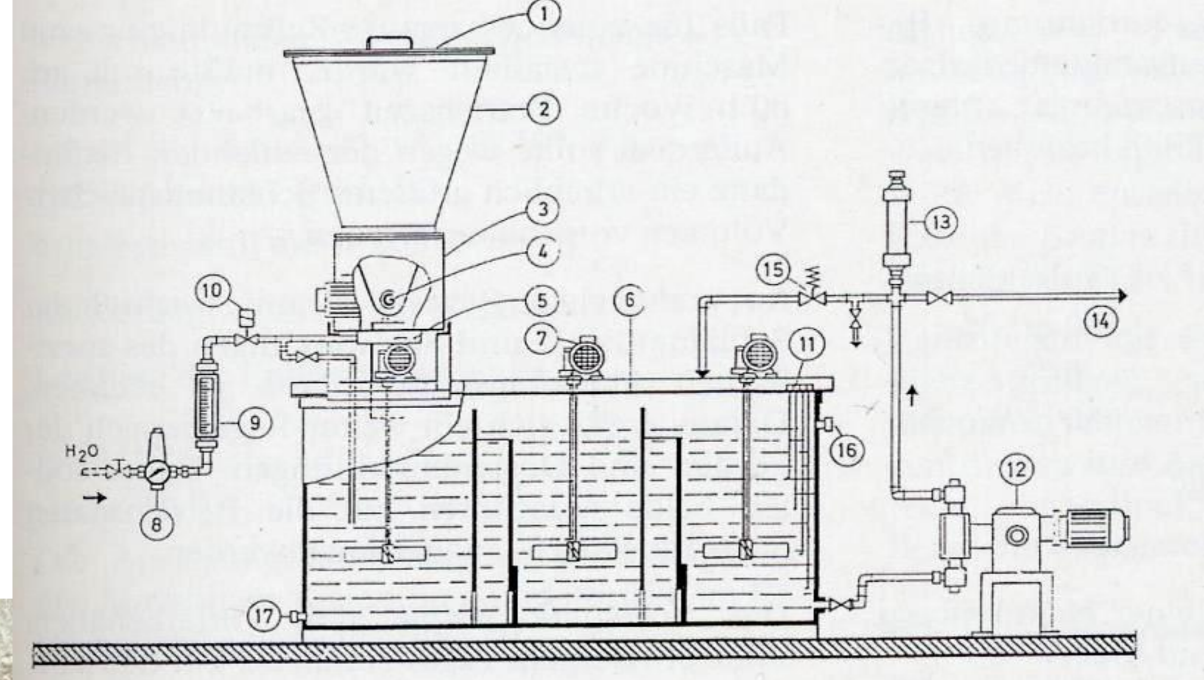


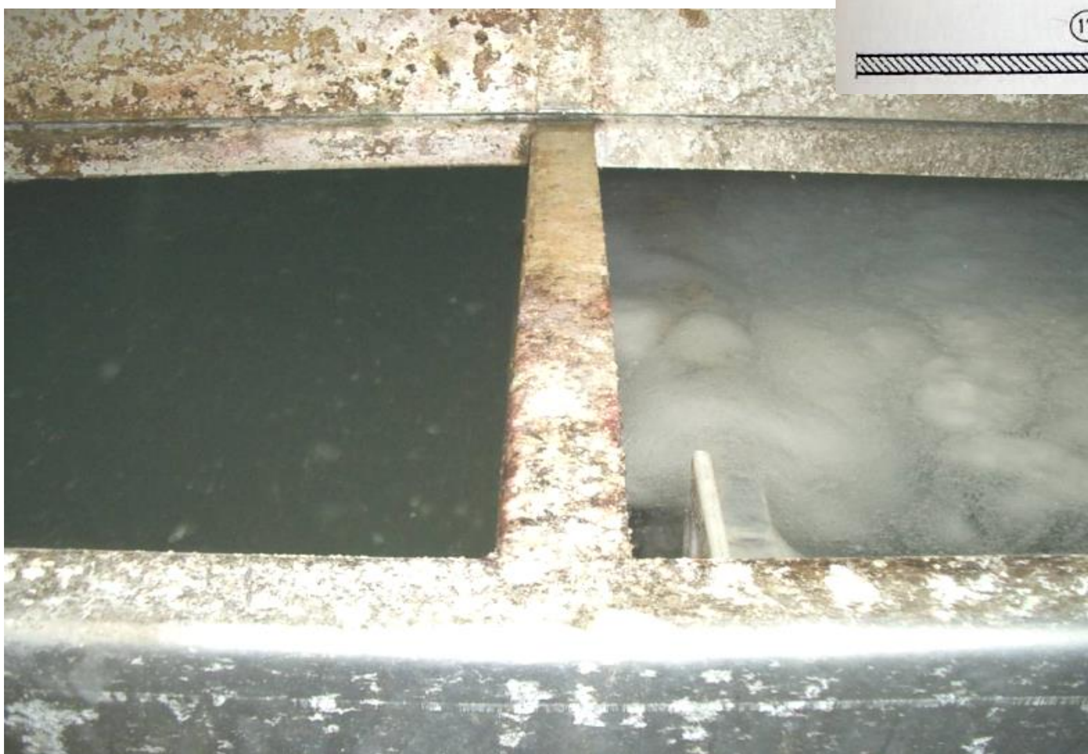
SNF	SOFT WATER				HARD WATER			
	Powder		Emulsion		Powder		Emulsion	
Concentration in active material	1 g/l	5 g/l	1 g/l	5 g/l	1 g/l	5 g/l	1 g/l	5 g/l
Stability frequently observed without modification of pH	4 hours	24 hours	1 hour	8 hours	50% loss of efficiency	30% loss of efficiency	10 minutes	30 minutes

Equipment

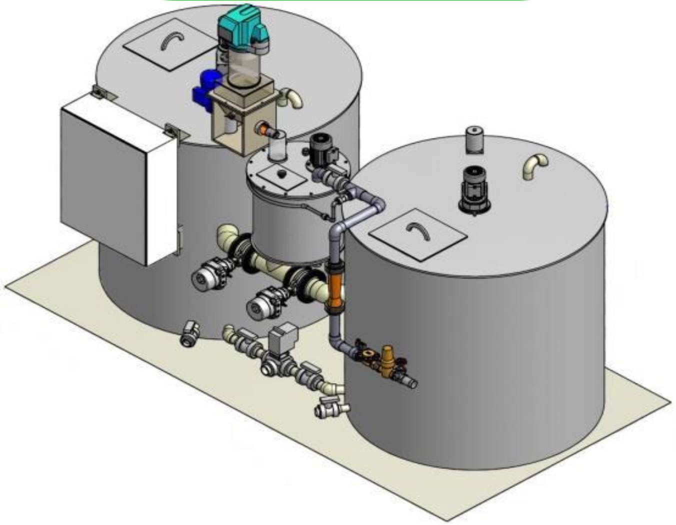
3-Chamber-Systems

don‘t use:



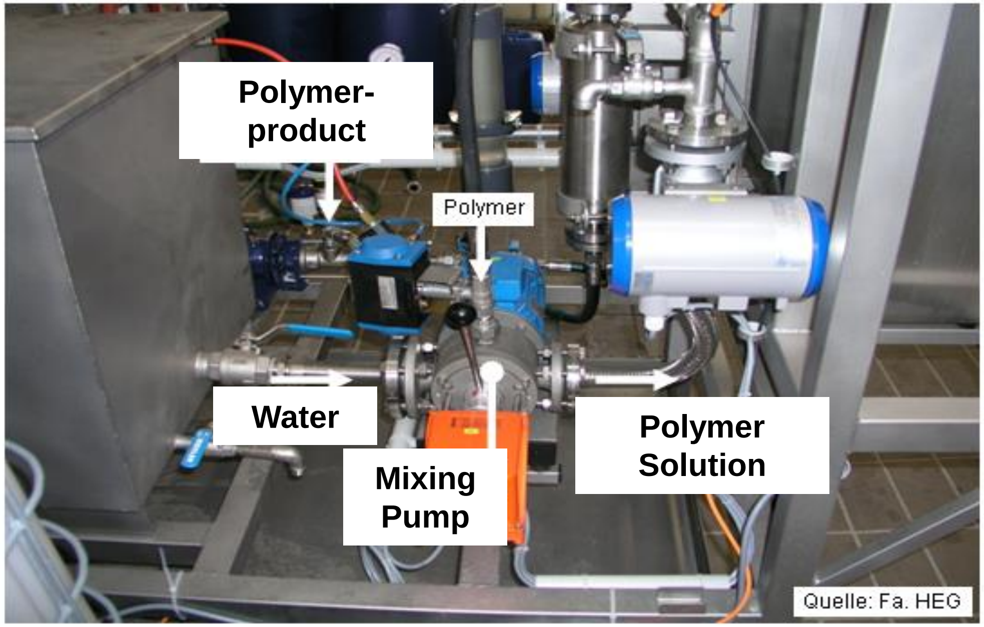


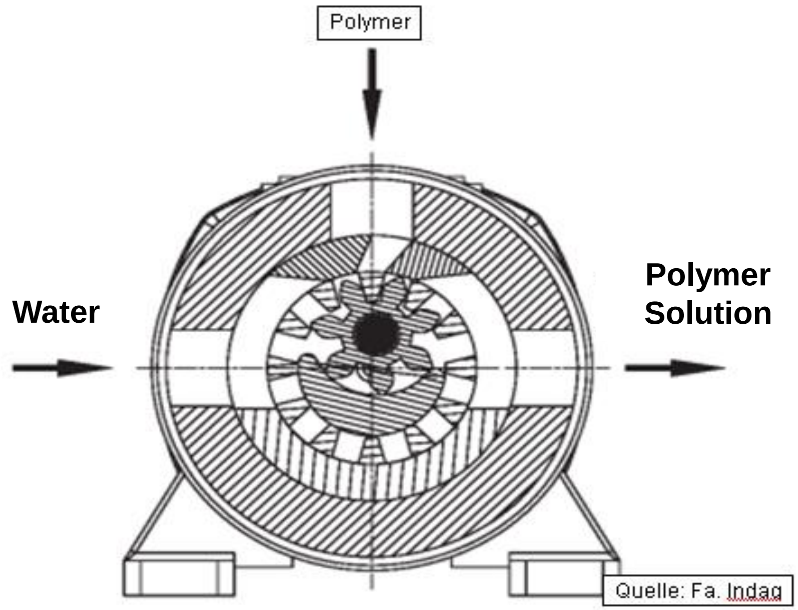
Recommendation:
2 - Chamber - System



First Contact Polymer - Water!
needs high turbulence

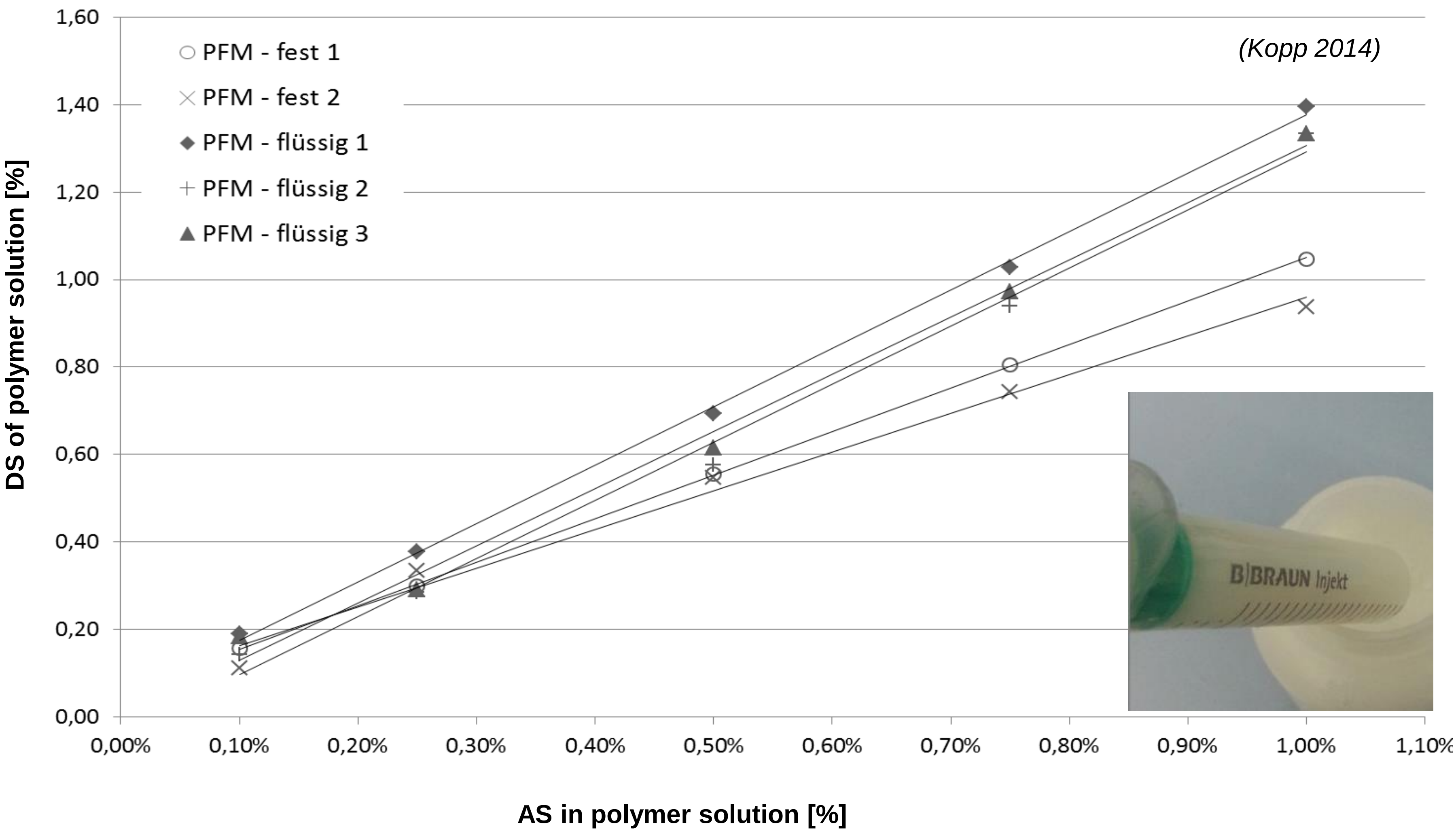
Polymer-Preparation Pumps





- Polymer-preparation-pumps work solely with liquid products
- Gear pump produces high mixing energy
- **+**: needs no further pumping
- **-** : maturing time is too short
- Connected maturing tank is recommended

Check: poly concentration



Summary

- The proper selection and preparation of polymer is required to achieve good dewatering results.
- The building of shear stable flocs by conditioning is important.
- The polymer-demand and the dewatering result depend strictly on quality of polymer preparation. Mostly the maturing time is disregarded.
- By measuring viscosity of the polymer solution the maturing time can be determined. The time of utilization depends on pH and polymer-concentration.
- **Maturing time of 45 minutes and using the solution during 4 hours are recommended.**
- **For polymer-preparation 2-Chamber-Batch-Systems are recommended.**
- Check concentration of polymer-solution frequently by measuring DS.
- Check polymer-consumption 4 times a year and document operational data carefully.

Questions: