Simulation of conductivity increase in closed papermaking circuits

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Effluent reuse for fresh water reduction

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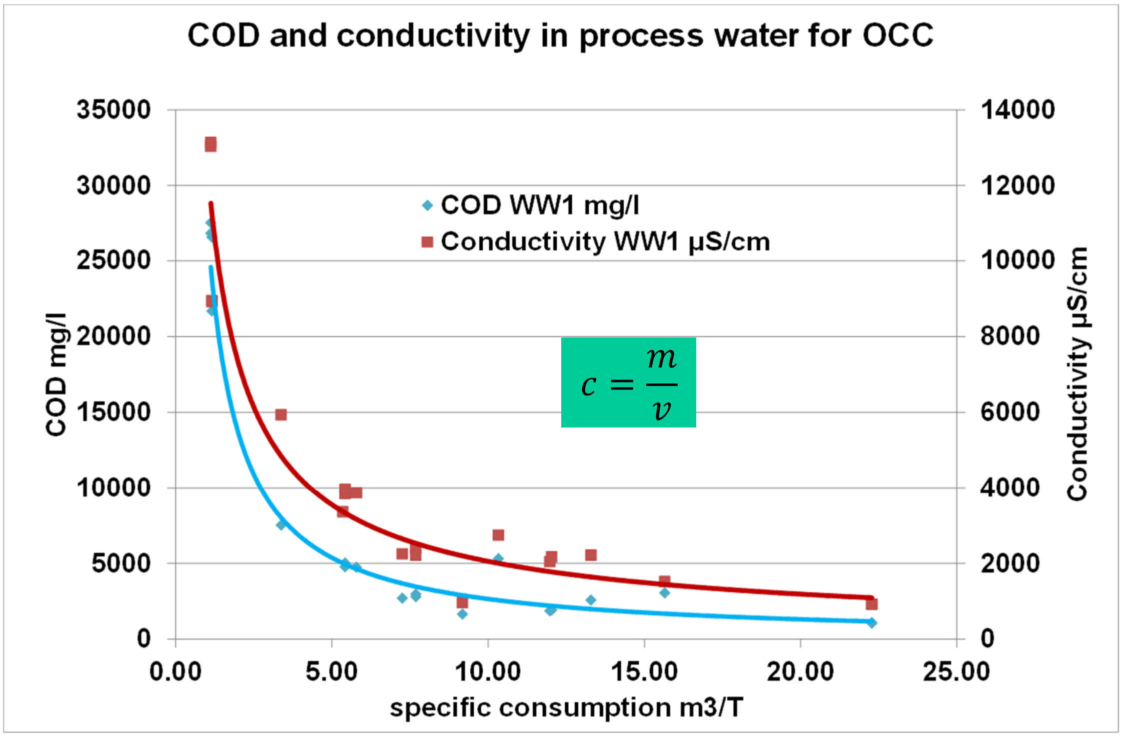
- Water circuits closure is still a hot topic due to environmental and regulation constraints and sustainable development papermaking group policy
- Reducing fresh water volume has environmental and techno-economical advantages:
  - Reduction of natural resources needs, energy consumption, effluent flow,
  - Fresh water and effluent treatment cost reduction,
  - More stable operating conditions.
- But…

Consequences of circuits closure



Consequences of circuits closure

Reduced water consumption

- Organics build-up
- Inorganics build-up
- Temperature increase
- Oxygen decrease
- Anaerobic activity

Salinity increase

- Chemicals inefficiency
  - retention aids
  - wet-ends additives
  - flocculants
- Mineral deposits
  - fabrics
  - pipes

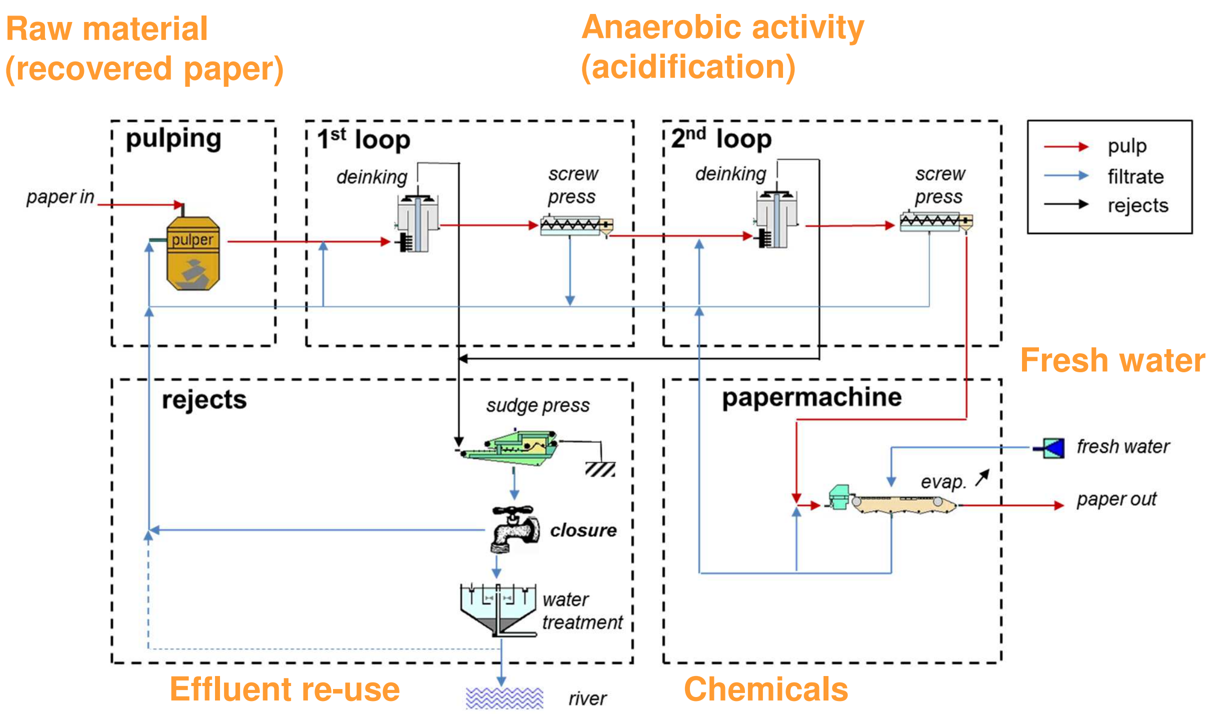
Mill Test case

- Mill producing 3.6 T/h of domestic sanitary paper
  - From deinked pulp (wood-free recovered paper)
  - using 6.8 m^3/T of fresh water

- Fresh water usage is already minimal
- But scarcity of local water resource (Spain) calls for further water usage reduction

- ➔proposed solution: recycling of bio-treated effluent
- Consequences on the process ?

Conductivity sources



Modelling objective

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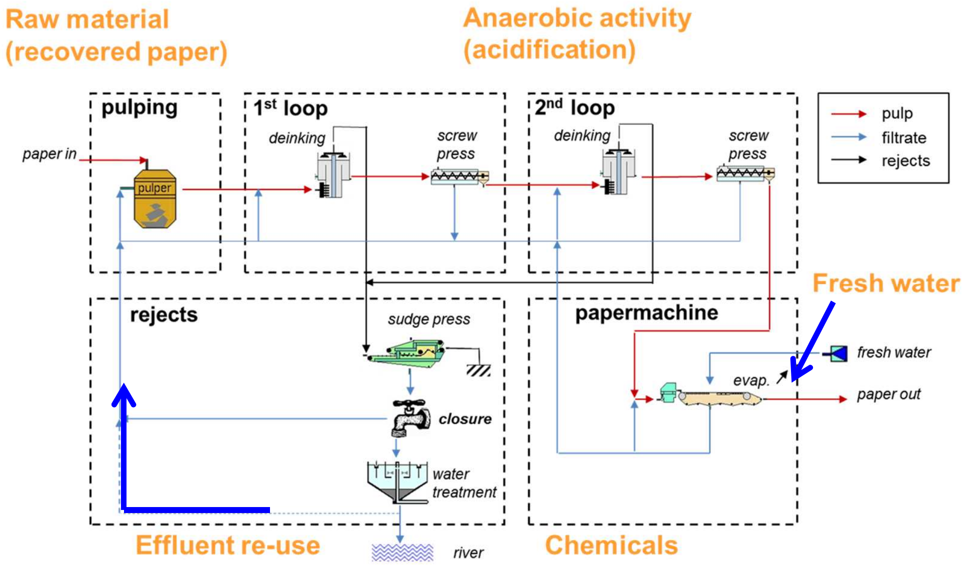
- To predict conductivity increase when closing the circuits



➔maximum acceptable closure level for paper production ?

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Modelling methods

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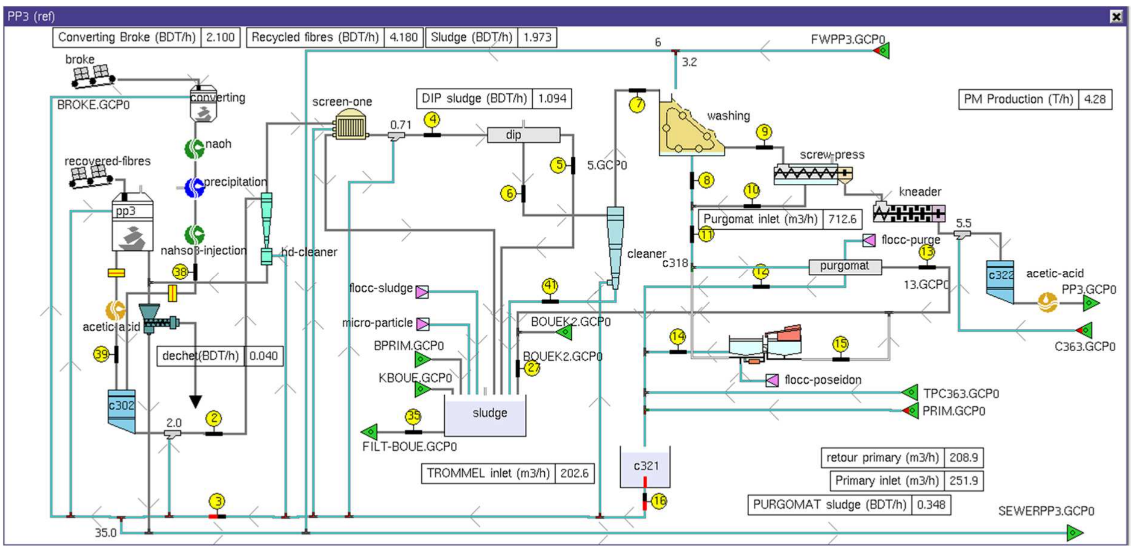
- Build a mass balance simulation of the mill (PS2000)



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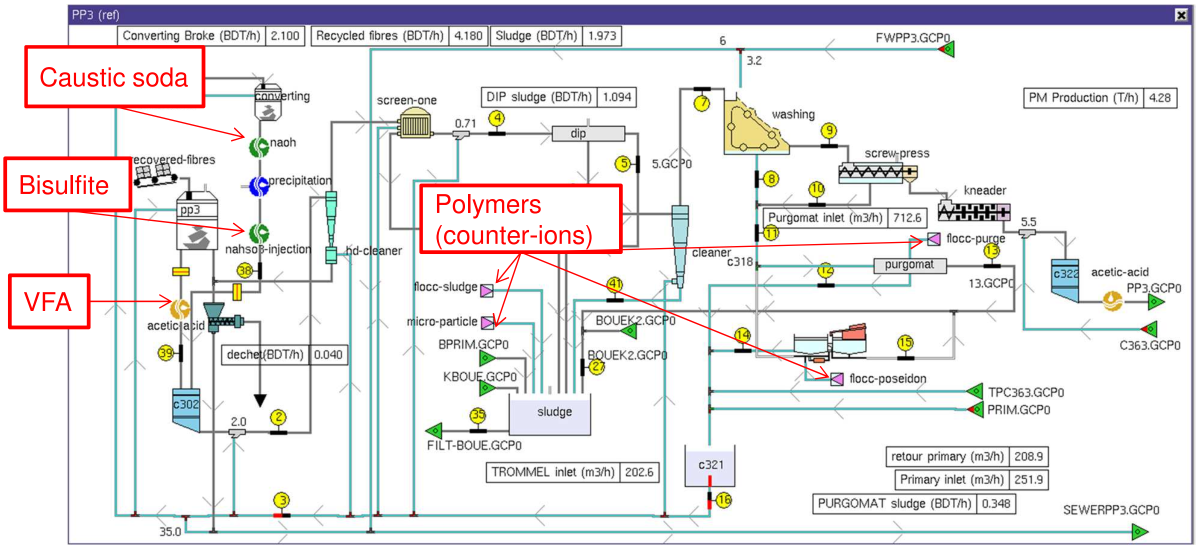
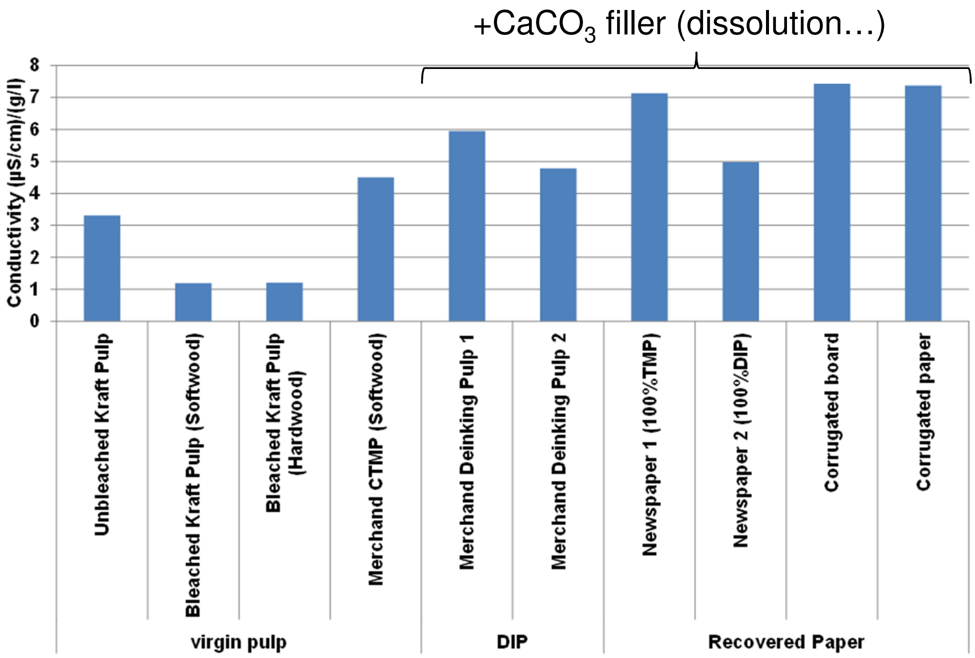
Modelling methods

- Implement ionic sources in the simulation



Conductivity sources: raw materials



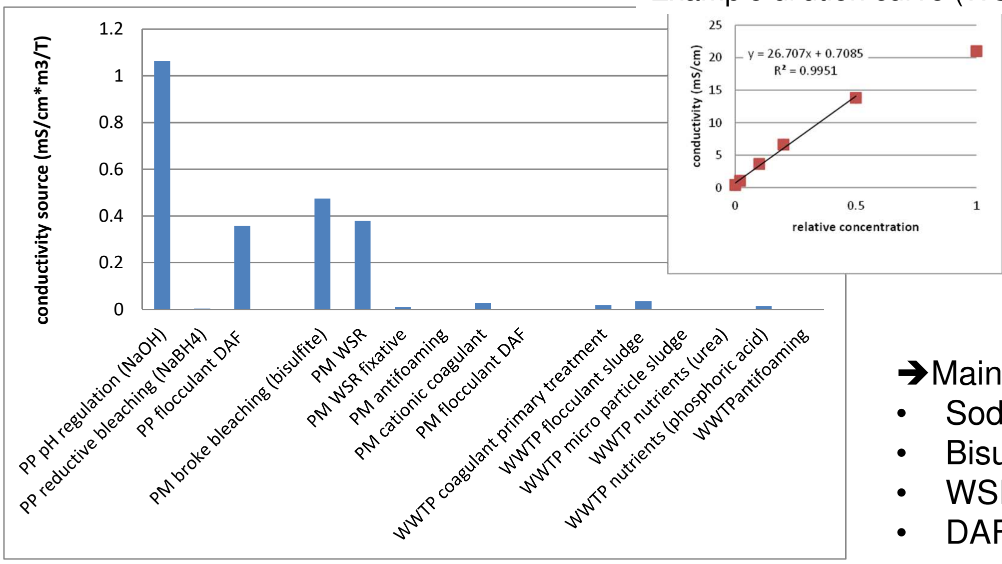
⇨ Contribution of raw materials to conductivity depends on their nature

⇨ Major ions: Na^{+}, Ca^{2+}, SO_4^{2-}, Cl^{-}

Conductivity sources: chemicals

- Tissue mill
  - Conductivity source = α(dilution curve)*dosage

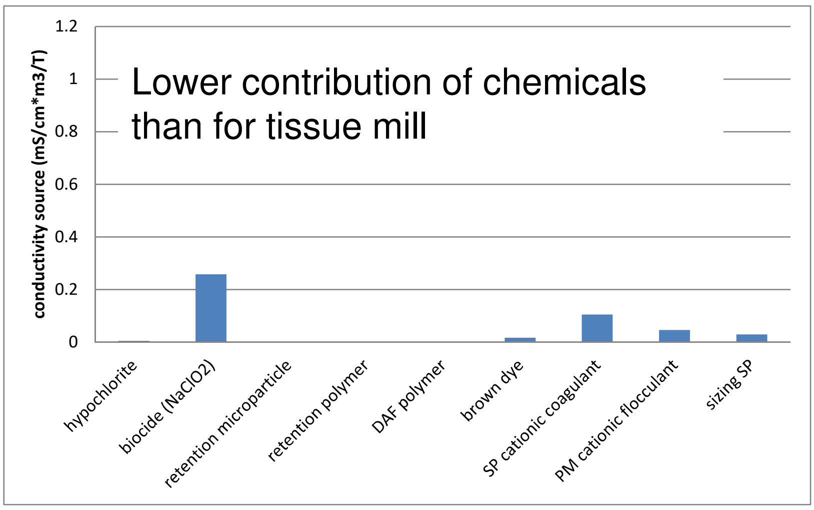
Example dilution curve (WSR)



➔Main effects
- Soda
- Bisulfite
- WSR
- DAF flocculants

Conductivity sources: chemicals

- Comparison with Corrugated board mill
  - Conductivity source = α(dilution curve)*dosage



➔Main effects
- Biocide
- Coagulant

Methods

- Resolve the balances and chemical equilibria

Chemical speciation (PHREEQC (Charlton & Parkhurst 2011)

	Species	Molality
	H+	2.73E-07
	OH-	1.07E-07
	H2O	5.55E+01
Acetate		**3.65E-02**
	Acetate-	3.18E-02
	Ca(Acetate)+	3.98E-03
	H(Acetate)	3.36E-04
	Mg(Acetate)+	2.27E-04
	Na(Acetate)	1.82E-04
C(-4)		**0.00E+00**
CH4		**0.00E+00**
C(4)		**4.35E-03**
	HCO3-	2.92E-03
	CO2	1.10E-03
	CaHCO3+	3.01E-04
	MgHCO3+	1.27E-05
	NaHCO3	1.22E-05
	CaCO3	8.39E-06
	CO3-2	1.32E-06
	MgCO3	2.16E-07
	NaCO3-	1.94E-07
Ca		**2.23E-02**
	Ca+2	1.67E-02
	Ca(Acetate)+	3.98E-03
	CaSO4	1.31E-03
	CaHCO3+	3.01E-04
	CaCO3	8.39E-06
	CaOH+	6.51E-09
	CaHSO4+	2.51E-09

	Species	Molality
Cl		**4.67E-03**
	Cl-	4.67E-03
H(0)		**7.16E-25**
	H2	3.58E-25
Mg		**1.11E-03**
	Mg+2	7.88E-04
	Mg(Acetate)+	2.27E-04
	MgSO4	8.65E-05
	MgHCO3+	1.27E-05
	MgCO3	2.16E-07
	MgOH+	1.55E-08
Na		**1.19E-02**
	Na+	1.16E-02
	Na(Acetate)	1.82E-04
	NaSO4-	5.25E-05
	NaHCO3	1.22E-05
	NaCO3-	1.94E-07
	NaOH	2.65E-10
O(0)		**0.00E+00**
	O2	0.00E+00
S(6)		**3.47E-03**
	SO4-2	2.03E-03
	CaSO4	1.31E-03
	MgSO4	8.65E-05
	NaSO4-	5.25E-05
	HSO4-	2.90E-08
	CaHSO4+	2.51E-09

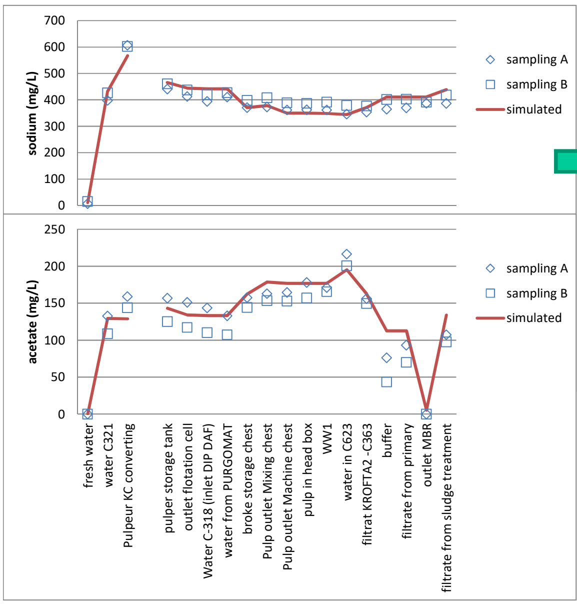
Specific conductance

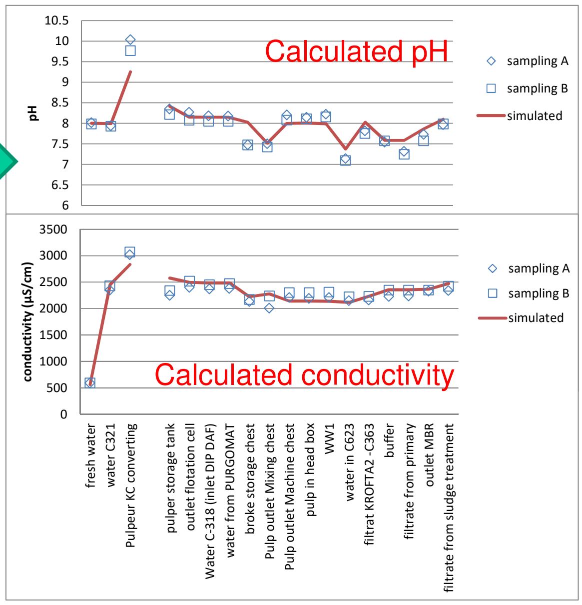
$$SC = \sum_i \Lambda_{0,i}\gamma_i m_i$$

Local conductivity back to process simulation

Methods: calibration of the simulation

- Adjustment of chemicals sources to match measured concentrations (soda, acetate…)
- Resolution of chemical equilibria (acid-base, dissolution, CO_2 stripping…)

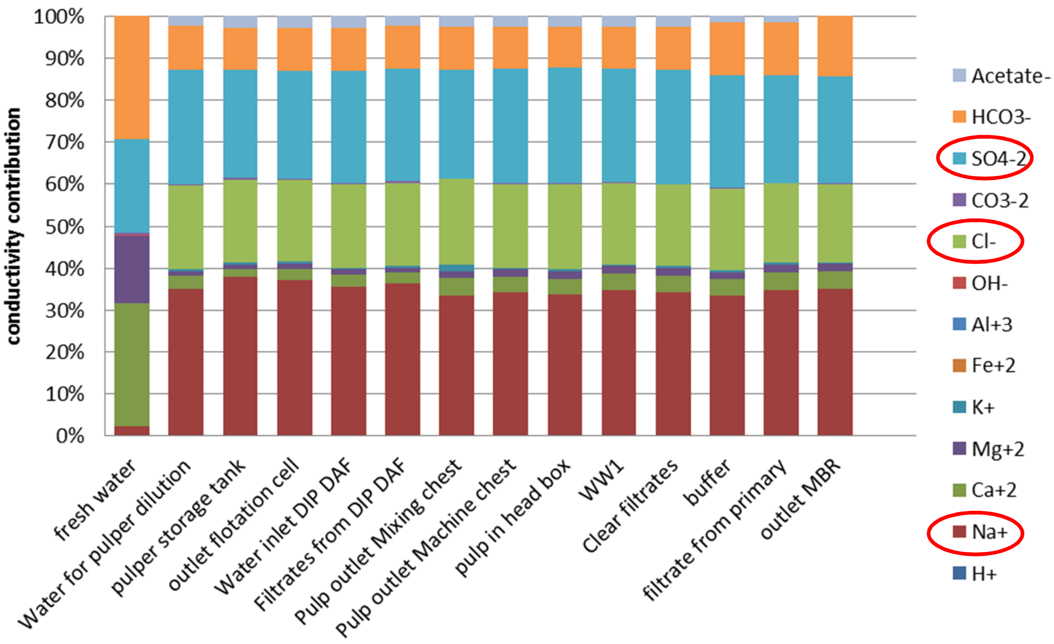




Contributions to conductivity

- Major ionic species

Simulation results



Contributions to conductivity

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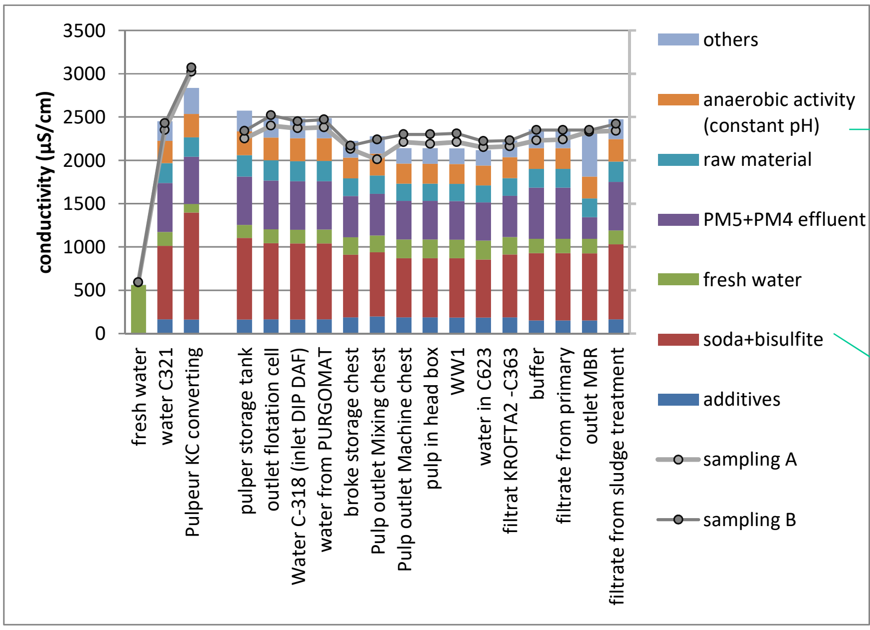
- Sources

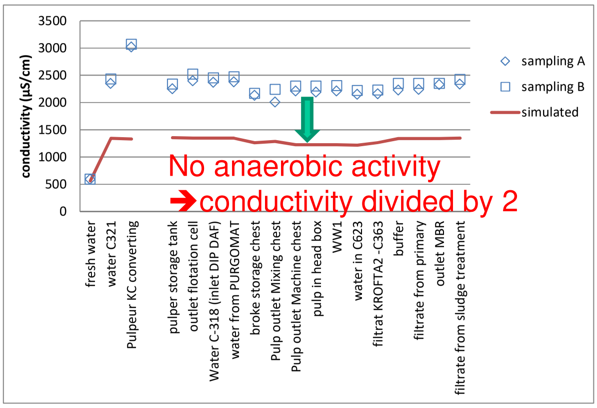
Simulation results

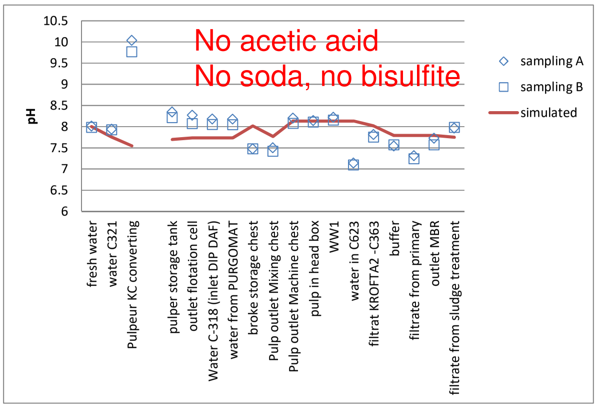


(contribution without considering reduced soda + bisulfite)

Major impact of broke repulping chemicals (mill-dependent, WSR)

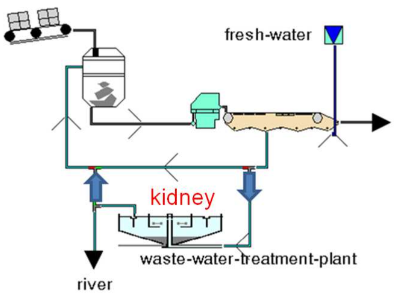
Main potential to reduce conductivity is to cut anaerobic activity



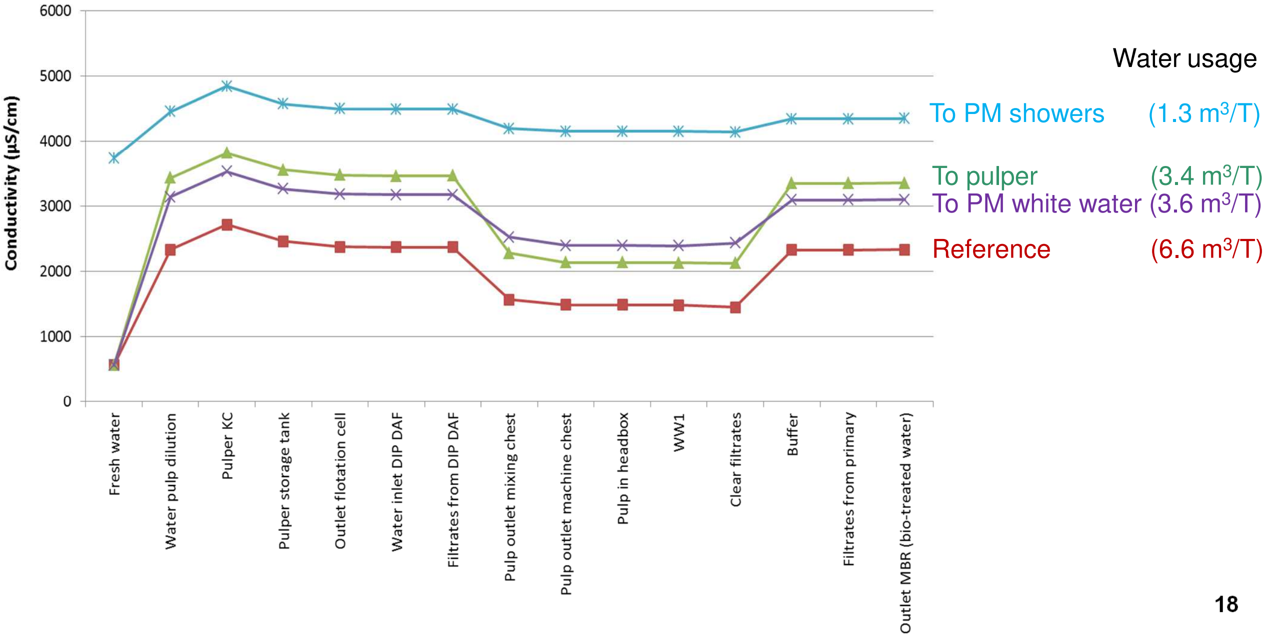


– Reduced acetate
– Reduced dissolution of $CaCO_3$ filler
– Reduced soda and bisulfite needs to maintain pH (for broke repulping)

Simulation of bio-treated effluent reuse



Predicted conductivity rise



Conclusions & Perspectives

- Pressures to further reduce fresh water usage in papermills
- Recycling bio-treated effluent is an option
- ➔Causes conductivity rise
- Contribution of conductivity sources is mill-dependent
  - Raw material (virgin pulp vs. recovered paper)
  - Chemicals
- Need for a dedicated chemical process simulation to predict the outcome
- Conductivity rise may be reduced by inhibiting anaerobic activity or tertiary treatment

Acknowledgements

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