Water reuse and valuable substances recovery in the Paper recycling industry

PTS Fachtagung - Altpapier im Fokus

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SpotView

Horizon 2020 European Union Funding for Research & Innovation

SPIRE PROJECT

Presentation outline

- **SpotView** project introduction
- Effluent reuse for fresh water reduction
  - Water COD and salinity control
- Valuable substance recovery from process water

Concept of the project

- **Objectives:**
  - To develop and demonstrate innovative, sustainable and efficient processes and technology components, in order to **optimize the use of natural resources, especially water,** in three industrial sectors (**Dairy, Pulp and Paper and Steel**)

  - 14 **existing and new technologies** will be assessed, including solid/liquid separation, ultrafiltration, deionization, biological treatment, disinfection and chemical heat pump
  - 9 **water management practices** assessed in simulated or operational environment for in the three industrial sectors
  - 7 **selected technologies demonstration** in industrial environment

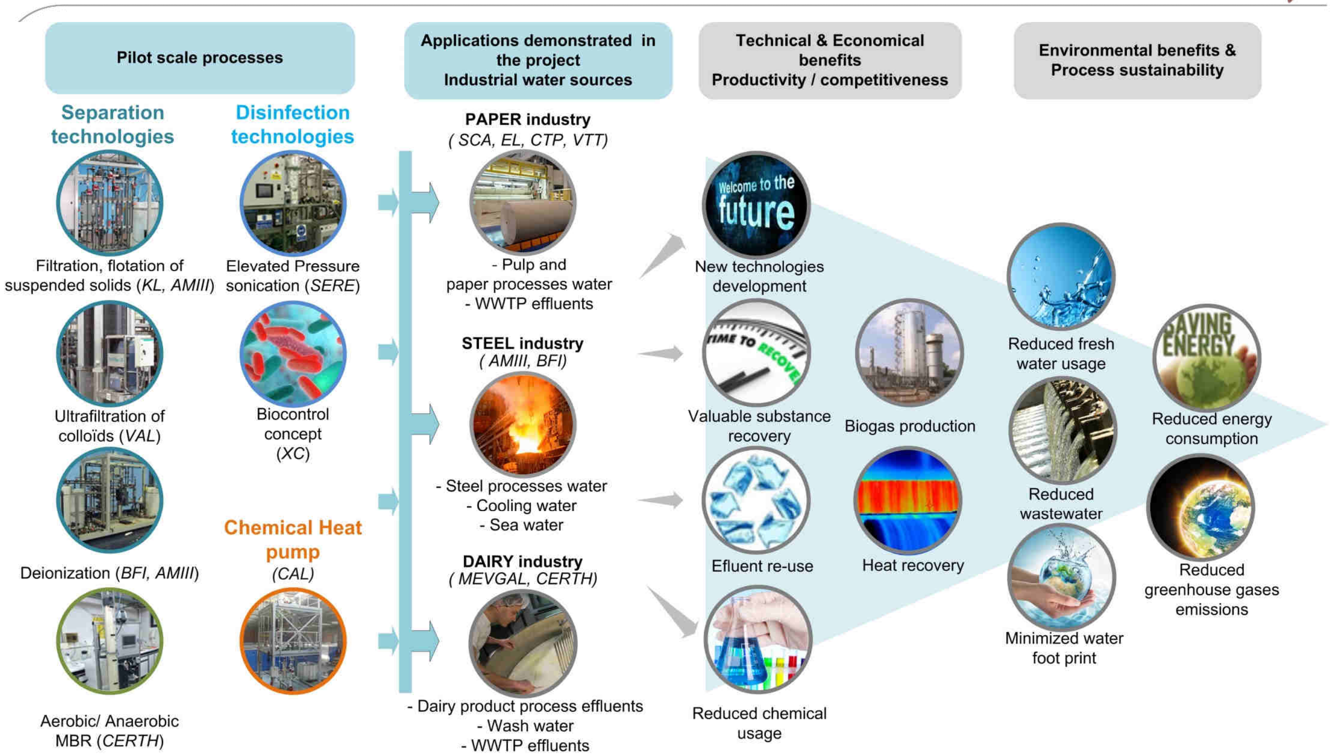
European consortium

The XV of Europe

Knowledge Providers → New Technologies developers → Technologies suppliers → Technologies end users

from 9 EU countries

Concept of the project



Technologies and Strategies

- Strategies – Technologies – SpotView demonstrators

Technologies	Dairy	Paper	Steel
Thickener		D_T4.4	
Dissolved Air Flotation (DAF)		D_T4.4	D_T4.1
Sand filter			D_T4.1
Ultrafiltration (UF)	D_T4.2	D_T4.4 / D_T4.5	D_T4.1
Reverse osmosis (R)), ion exchange (IX), Capacitive Deionization (CDI)		D_T4.5	D_T4.1
Enhanced biological treatment		D_T3.4.2	
Micellar Enhanced Ultrafiltration (MEUF)	D_T4.2		
Elevated Pressure Sonication (EPS)	D_T4.2	D_T4.4	
Membrane Bio-Reactor (MBR)	D_T4.3		
Biocontrol Concept		D_T4.5	
Chemical Heat Pump (CHP)		D_T4.6	D_T4.6

Strategies	Dairy	Paper	Steel
Separative technologies to recycle process water and recover valuable substances	D_T4.2 (CIP)	D_T4.4 (stock preparation)	D_T4.1 (back flush water)
Improve WWTP to recycle water and produce biogas	D_T4.3	D_T3.4.2	
Water reuse without treatment (cascade technique)			D_T3.1.2
Microbial control for water recycling		D_T4.5	
Saving fresh water using rain/sea water			D_T4.1
Waste heat recovery		D_T4.6	D_T4.6

D = Demonstrator
T = Task
Reference is made to the DoW/Annex 1

Visit our website

http://www.spotview.eu/

- Project presentation Video

Effluent reuse for fresh water reduction

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Spot View

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SPIRE PROJECT

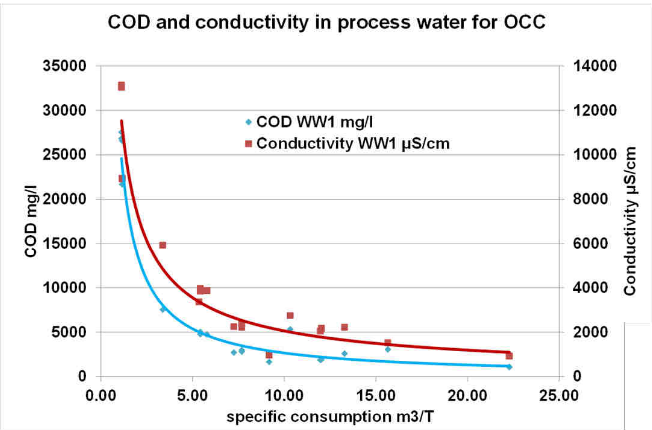
Towards fresh water reduction

- **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…**

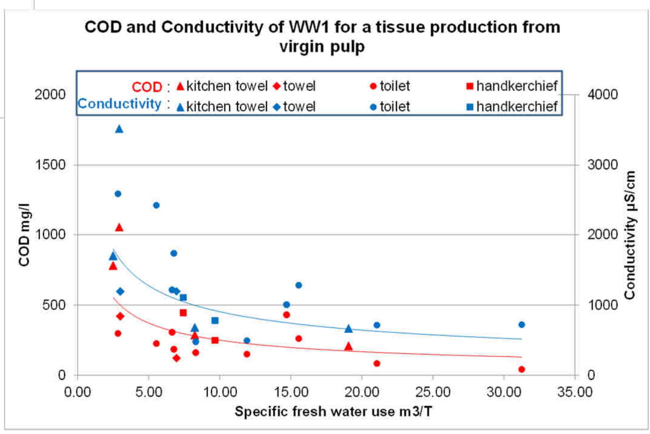
Consequences of circuits closure

- **Process water contaminants** concentrations increase:
  - Suspended solids,
  - Organic dissolved and colloidal substances (mainly from raw material)
  - Inorganic dissolved substances (from raw material, chemicals, fresh water)
- **Temperature** increase
- **Oxygen** content decrease
- **Volatile fatty acids** increase due to bacteria fermentation (anaerobic conditions) ⇨ pH ⇘

Consequences of circuits closure



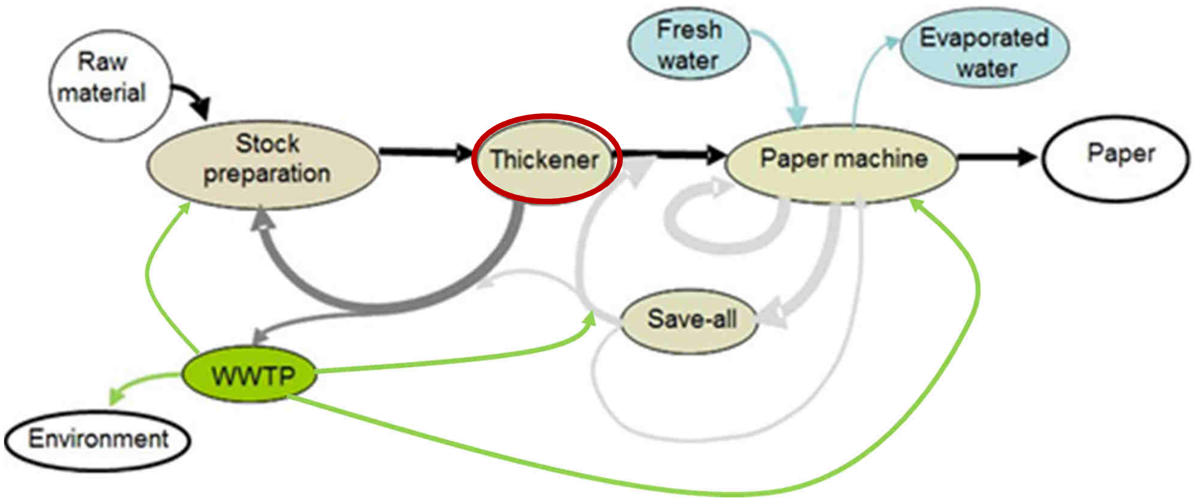
- Increase of COD and conductivity when fresh water use is reduced



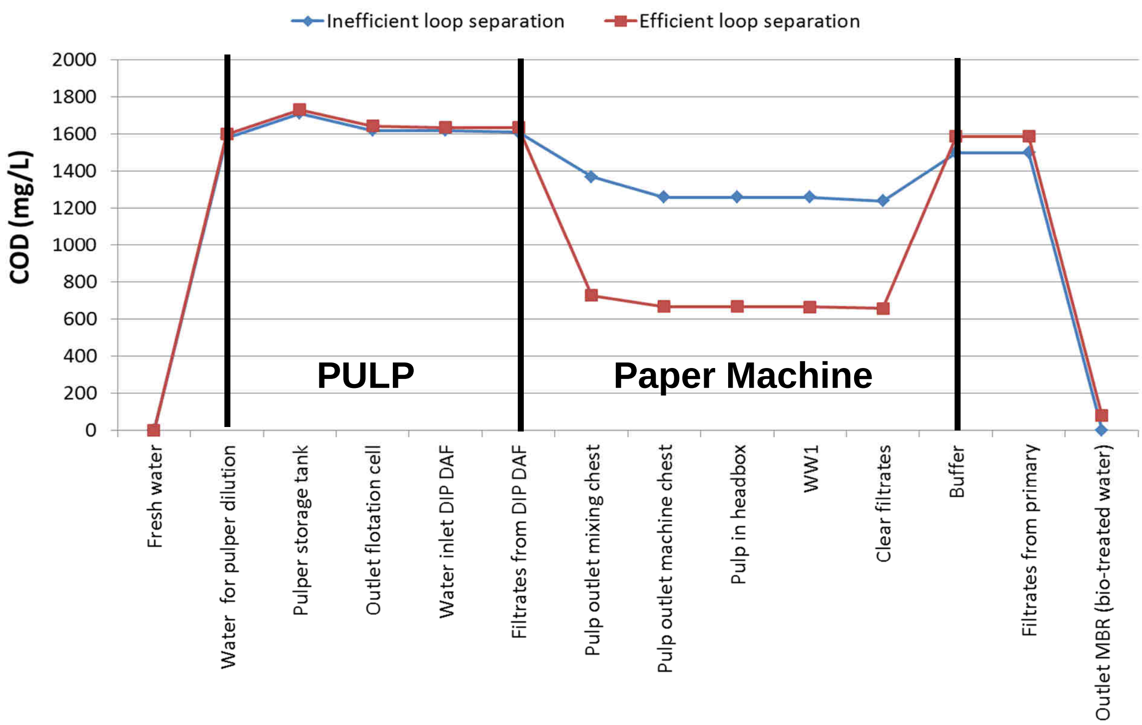
- Similar consequences, at different levels, in all types of production (OCC, tissue)

Optimal Water management

- How to control COD build-up ?
  - ⇨ **Water loop separation principle**
  - ⇨ **Counter-current circulation of process waters**
  - ⇨ **Effluent reuse after biological treatment**

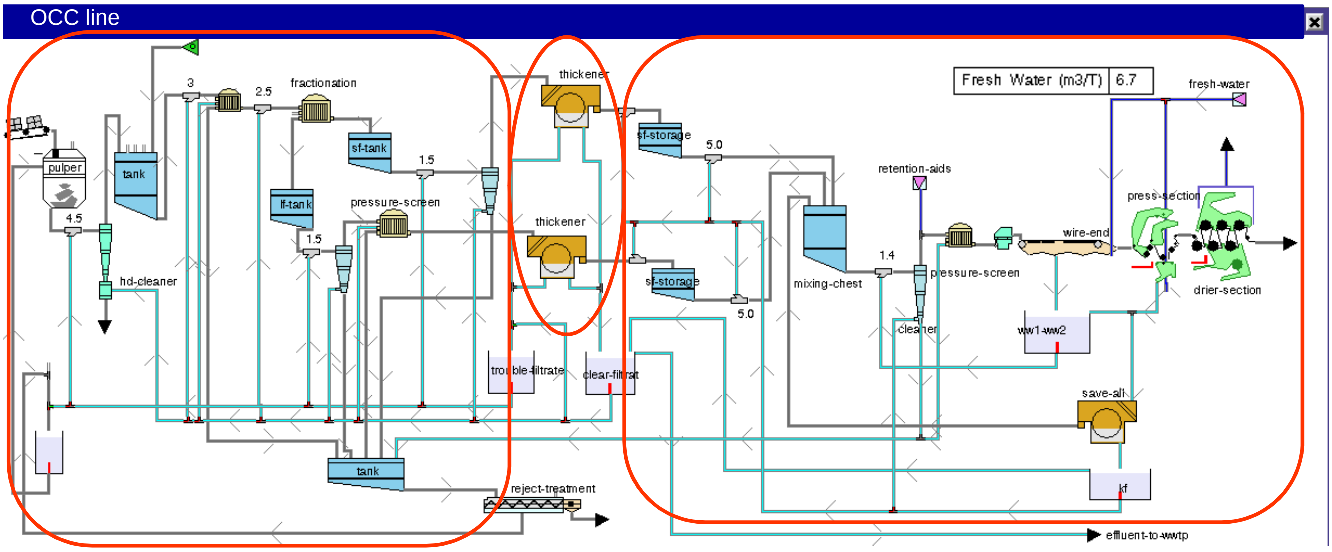


Water management: loop separation



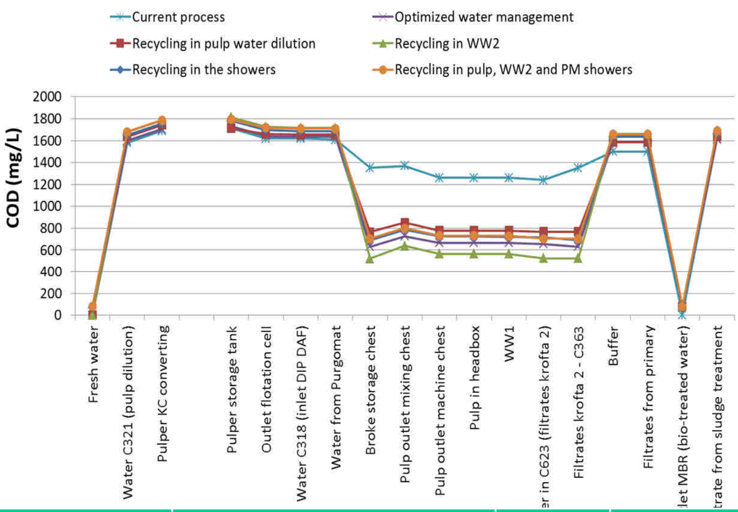
Optimal water management
Process simulation

- Example : theoretical simplified OCC line



Effluent reuse for fresh water saving

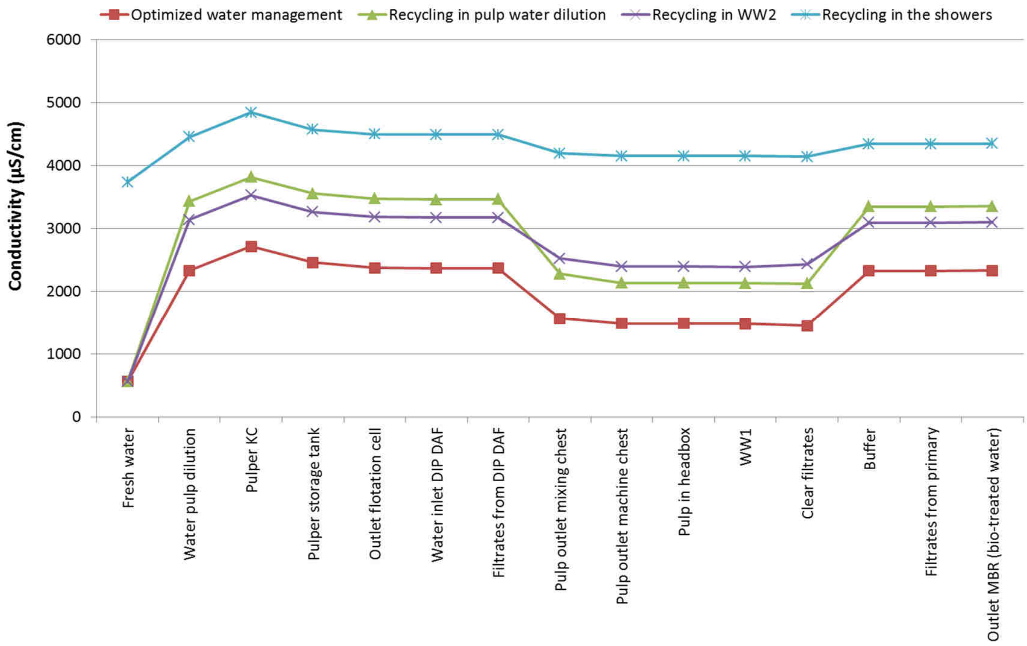
- Simulation realised from the modelled tissue mill
  - Evolution of COD, pH, calcium, VFA, ionic species can be assessed



	Current process	Efficient loop separation process	S1	S2	S3	S4
Fresh water (m^3/t)	7.1	6.6	3.4	3.6	1.3	0.3

Effluent reuse for fresh water saving

- Simulation of conductivity



Sources of water salinity

- Fresh water contribution: 80 to 1200 µS/cm
  – Based on 36 paper mill sites CTP database (Ca^{2+}, HCO_3^-, SO_4^{2-}…)

- Pulp sources
  – from lab test and simulation

Raw material	Conductivity µS/cm/(kg/m³)
Kraft Pulp	1 to 3
TMP	4 to 6
DIP	5 to 6
RCF	2 to 9

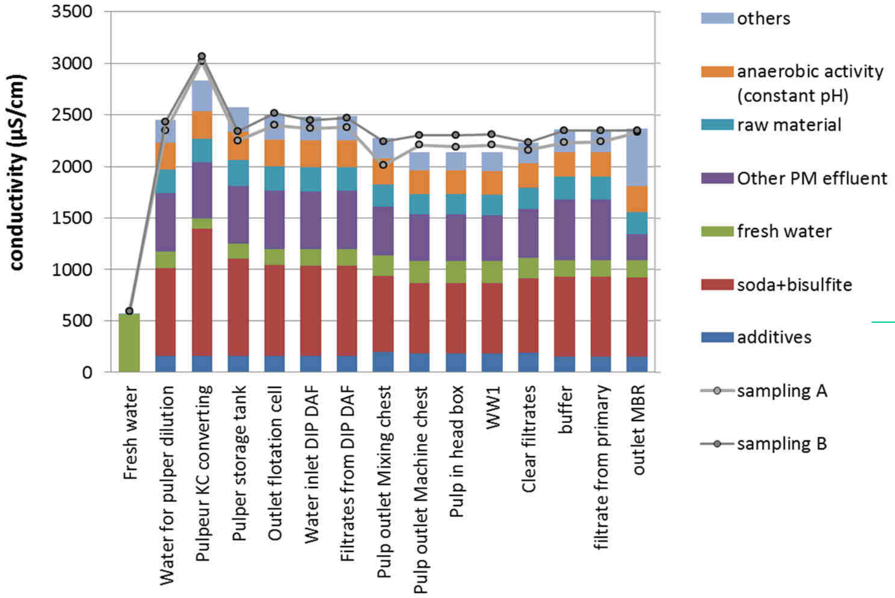
- Main process chemicals
  – ex: DIP + tissue mill

Additives	Conductivity µS/cm/(kg/m³)
NaOH (DIP alcali)	1.0
NaHSO3 (bleaching)	0.43
DAF floculant	0.32
Wet Strength Resin	0.34

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

Water conductivity increase

- Conductivity "balance" in process water
  - Ex: DIP + tissue mill producing 3.6 T/h with 6.8 m^3 fresh water /T

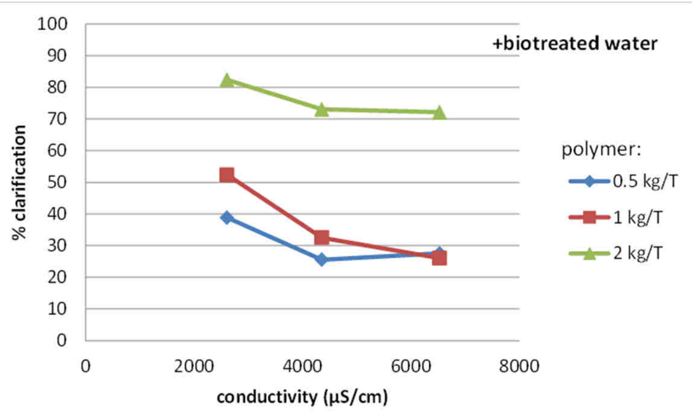


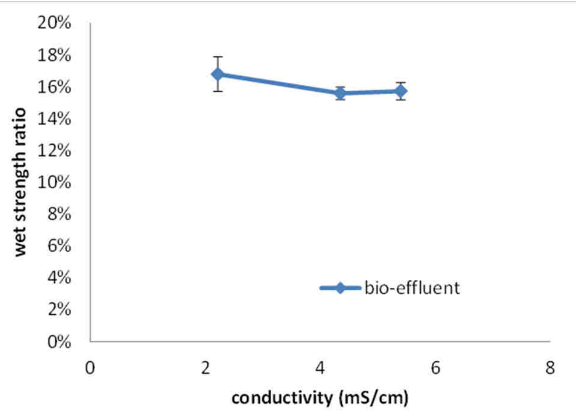
Main ions:
Sodium (Na^+)
Sulphate (SO_4^{2-})
Chloride (Cl^-)
Carbonate (HCO_3^-)

Major impact of broke repulping chemicals and caustic soda to balance microbial acidification

Effects of bio-treated effluent reuse

- Effect of conductivity increase on process additives
  - Negative impact on DAF flocculant performance
  - No impact on wet-strength development





(conductivity increase in the process water was simulated by concentrating the aerobic treatment effluent sample through gentle evaporation)

Conclusions

- **Raw materials** contribution to process water conductivity vary widely depending on their nature
  - Recovered papers contribute more than kraft pulps
  - Major ions are sodium, calcium, and sulfate
- **Fresh water** can be a non-negligible ions source depending on paper mills geographical situation
- **Chemicals** are important ions source, especially alcaline and bisulfite in DIP mills.
- **Anaerobic microbial activities** have major consequence on conductivity (acidification, calcium dissolution, neutralisation…)
- **Bio-treated water recycling** has no impact on Wet-Strength and negative impact on DAF flocculant.

⇨ Increase DAF polymer dosage (+50%) or use DAF polymer with higher DS

⇨ Neutralise residual cationic demand of bio-treated water with tertiary physico-chemical treatment before recycling

Conclusion

- Strategies for water reduction and effluent reuse:

Possible Drawbacks	Solutions
Organic matters build-up	Efficient water management: • Loops separation • Counter-current circulation • Bio-treated effluent recycling
Volatile fatty acids	Control of anaerobic bacteria development • Antimicrobial treatments • Circuits and tanks design and management • Bio-treated effluent recycling
Ionic species increase • Calcium dissolution • Sodium or Sulphate build-up	Bio-treated effluent recycling Tertiary deionization: RO, EDI, CDI

Valuable substances recovery from stock preparation

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Outline

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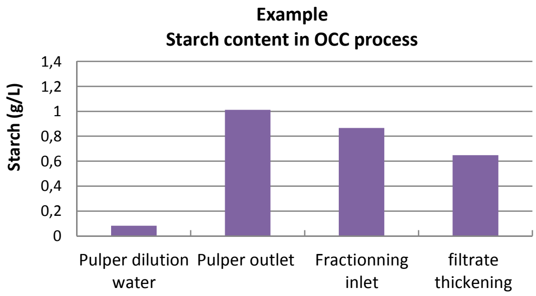
- Context for valuable substance recovery from OCC
- Starch release during pulping (laboratory / industrial scale)
- Assessment of the recyclable organic materials recovery
- Recovered organic matter valorisation
- Conclusion

Valuable substance recovery

Context

- **Starch and other organic substances are released in water** during pulping of recovered paper for packaging board production
  - Loss of valuable substance
  - Starch fermentation produces negatives effects
- **Potential** for starch recovery: 20 to 40 kg/t
- **Organic substances** removal could be a strategy to reduce bacterial activities and negative impacts



Starch release during pulping

- **Lab and pilot scale measurements - Methodology**

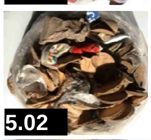
Samples : unused cardboard or recovered paper bales

Unused

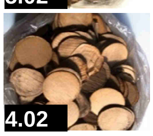
UCB4.01: Unused Corrugated Board

Recovered

1.05: Old Corrugated Cardboard / Board OCC



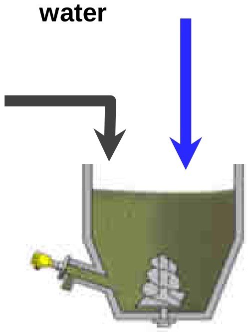
5.02: Household Recovered Packaging HRP



4.01: Unused boxes, sheets and shaving of corrugated board

Pulping

Tap or Industrial water



Measurements

Pulp
- **Starch**
  - Iodometric method (Tappi 0m-418)

Dilution water
- **Starch (colloïdal and hydrolysed fraction)**
  - Enzymatic method
- **COD / TOC**
- **Volatile Fatty Acids**

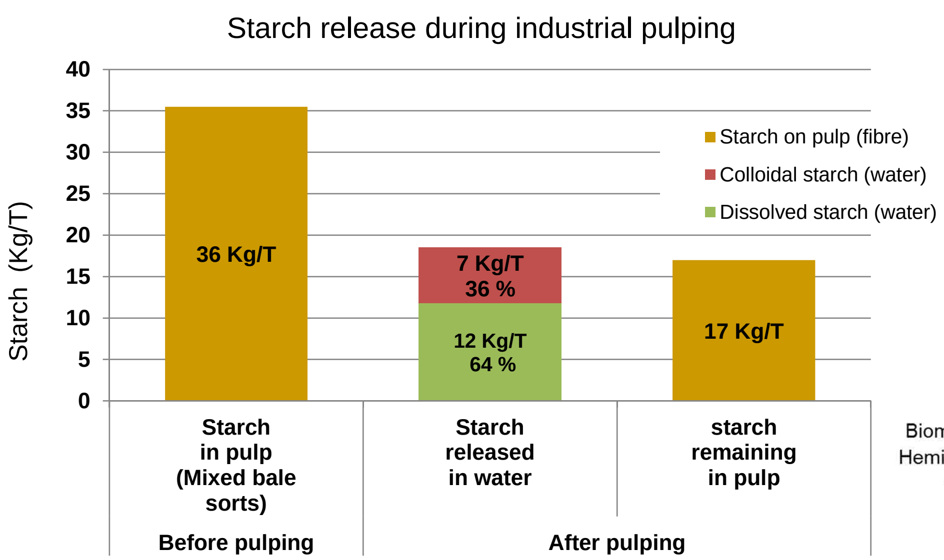
Starch release during pulping

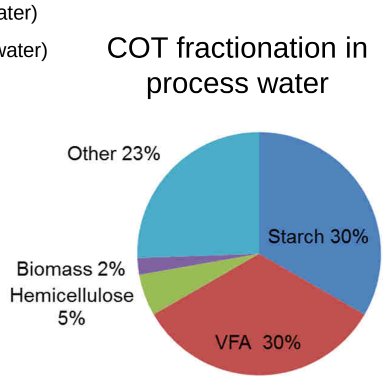
- **Laboratory scale measurement - Results**

OCC samples	Before pulping	After pulping				
			Starch released in water			
	Starch content (kg/T)	COD (kg/T)	Total (kg/T)	Colloids (kg/T)	Dissolved (kg/T)	Starch remaining in the pulp (kg/T)
UCB 4.01.	76	52	33	20 (60%)	13 (40%)	43
4.01	62	51	26	14 (54%)	12 (46%)	36
5.02	37	39	15	6.3 (42%)	8.7 (58%)	22
1.05	39	39	14	4.6 (33%)	9.4 (67%)	25

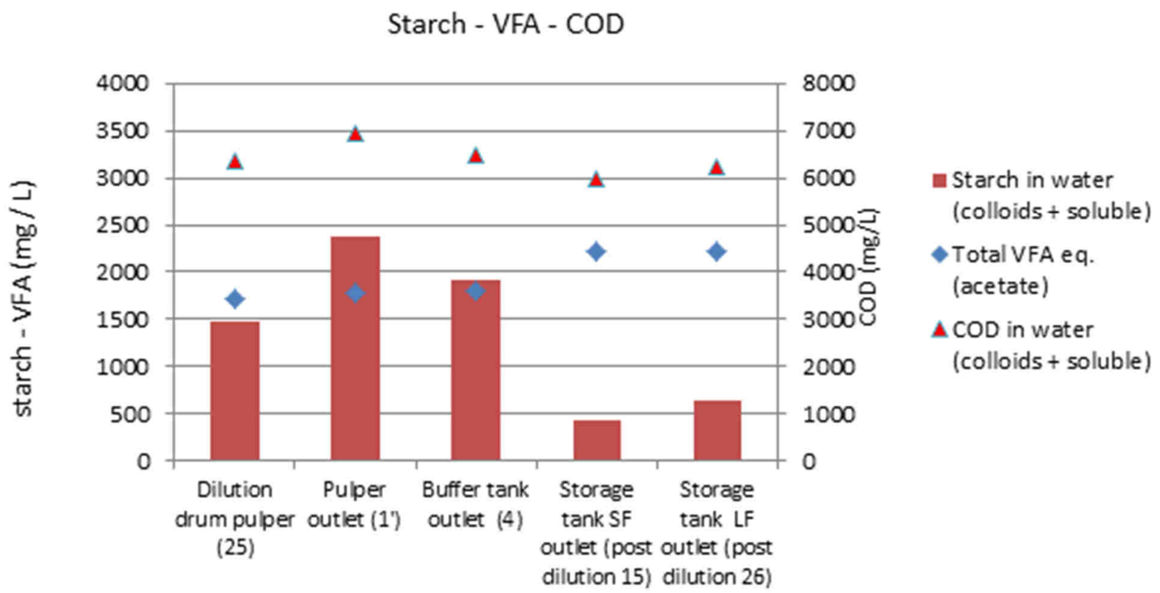
Starch release during pulping

- **Industrial scale measurements - Results**





Starch release during pulping



Valuable organic materials recovery

- **Pulp washing stage**
  - To extract dissolved and colloidal organic matter released from the fibre stock
    - Belt washers
    - Screw press
    - Disk Filter
    - Rotative screen
  - Technologies comparison

Technologies	Advantages	Drawbacks
Screw press + Rotary filter	Hydraulic capacity	Cost (+) Low fibre retention
Disk filter	Fine retention	Cost (++)
Washer	Washing rate removal (Starch and TSS) - Cost	Poor selectivity Fine retention

Selected for pilot trials

Valuable organic materials recovery

– Concentration stage technologies comparison

Technologies	Advantages	Drawbacks
Micro-filtration	- Separation efficiency > 90% - Adjustable Cut-off	- Cost (++) - Maintenance
Centrifugation (Continuous flow)	- High thickening rate	- Cost (+) - Limited centrifuge velocity for high flow rate
Dissolve Air Flotation (DAF)	- Cost (-)	- Floculation required - Coagulant / flocculant needed

Selected for pilot trials

Conclusion

- Valuable organic matter released during pulping of recovered paper
  - ~50% of starch contained in paper is released in water
  - ~25 % of initial pulp starch content can be recovered
- Technologies were selected for pilot trials (Kadant Lamort, CTP)
  - Extraction stage: washer thickener
  - Concentrator stage: Dissolved Air Flotation or Centrifuge Decanter
- Recovered starch valorisation to be evaluated…
  - Fresh starch partial substitution
    - Wet end additive
    - Size press
  - Biogas production
  - Organic synthesis
- …taking into account detrimental impurities effect

Thank You !

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