SpotView WorkShop

Sustainable Processes and Optimized Techniques for Industrially Efficient Water Usage

Avilés, October 4th, 2018

Eric Fourest, Project Coordinator - CTP, France

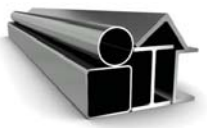
Horizon 2020 European Union Funding for Research & Innovation

SPIRE PROJECT

Concept of the project

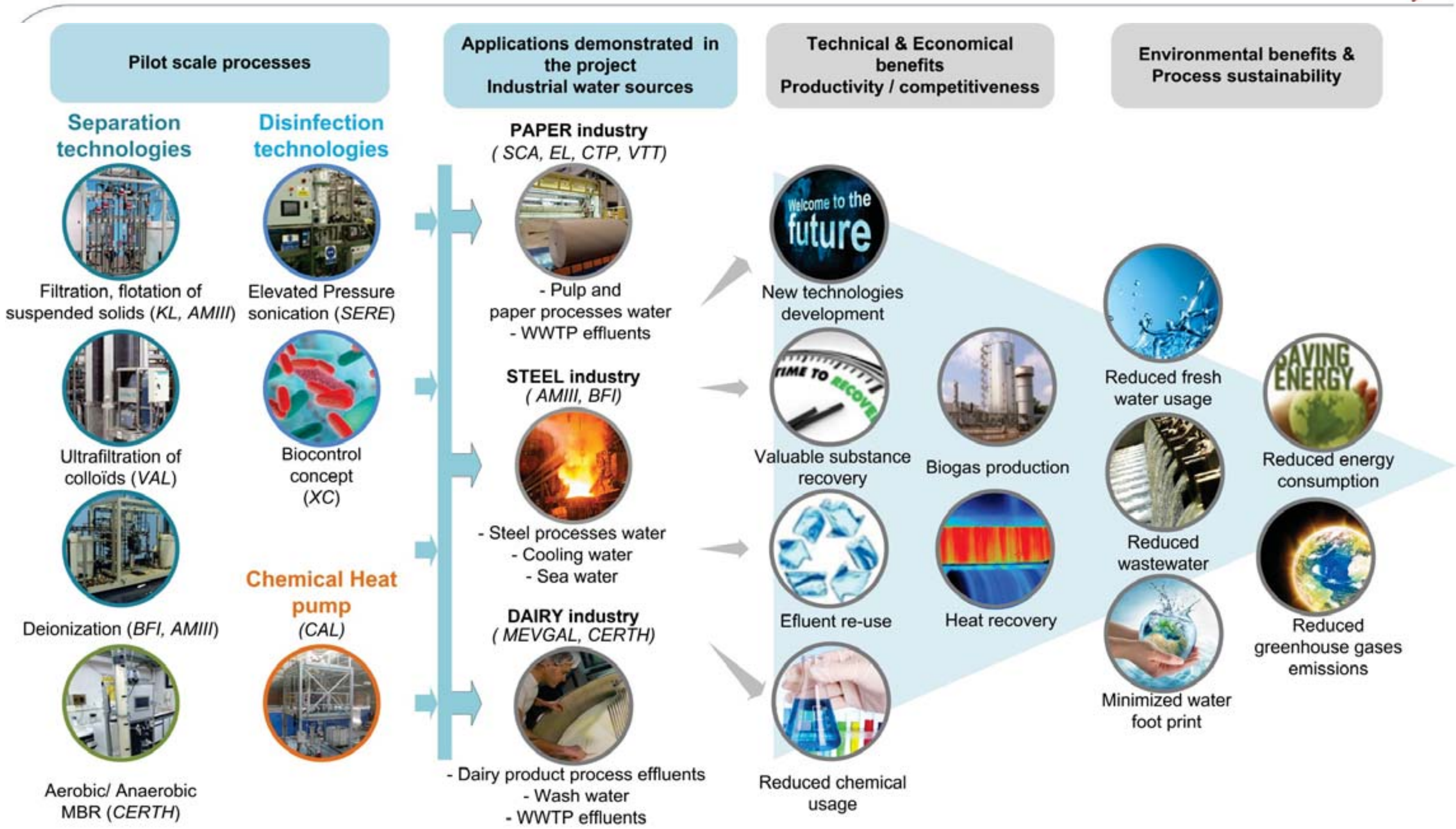
- **Objectives:**
  - To develop and demonstrate innovative, sustainable and efficient processes and technology components, in order to **optimize the use of natural resources, especially water,** in three industrial sectors (**Dairy, Pulp and Paper and Steel**)





  - 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

Concept of the project



European consortium

The XV of Europe

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

from 9 EU countries

Technologies and Strategies

- Strategies – Technologies – SpotView demonstrators

Strategies			
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

Technologies			
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

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

Concept of the project

- **Objectives**
  - Each **process and technology** will be evaluated in terms of **environmental impacts and benefits** (**SpotView** targets: **20% to 90%** reduction of water usage, wastewater emissions, chemicals and energy use).
  - **Economic exploitation** of the proposed technologies is pursued through a well described business case scenario and market penetration strategy

- **Expectations**
  - **Market opportunities for future services and technology products**
    - up to **2800 new equipment** and **7000 new jobs** in Europe
  - **Total market potential for the industrial sectors:** **1.5 b€** for Europe
    - recovery of by-products
    - cost economy related to energy, chemicals and additives saving,
  - **Production capacity increased** for technology end-users: up to **20 b€**.

SpotView project structure

TRL 5 · TRL 6 · TRL 7

WP1 - Project management and coordination – CTP, All
T 1.1 Administrative and financial management T 1.2 Operating management and quality assurance

WP2 – Technologies components testing in realistic environment CERTH

T 2.1 - CERTH, MEVGAL, AMIII, BFI, CTP, KL, EL
Water quality requirements and water/wastewater streams characterization

T 2.2 - CERTH, MEVGAL, SERE, **CTP**, KL, EL, Selective separation technologies for valuable substances recovery

T 2.3 – CTP, SCA, VTT, CERTH, MEVGAL, AMIII, BFI Close loop recycling and alternative water sources

T 2.4 – VTT, VAL, XC Alternative process chemistry and disinfection techniques

T 2.5 - CAL, PDC CERTH, CTP, AMIII Alternative cooling/ heating technologies

WP3 – Technologies assembling in simulated or operational environment VTT

T 3.1 BFI, AMIII, PDC, Sustainable strategy for process and cooling water reuse in the steel industry
T 3.2 CERTH, MEGVAL, PDC Sustainable strategy for process and cooling water reuse in dairy industry
T 3.3 CTP, KL, EL, SERE Sustainable strategy for valuable substances recovery in paper industry
T 3.4 VTT, VAL, XC, SCA, CTP, EL, KL, PDC Sustainable strategy for process water and WWTP effluent reuse in P&P

WP4 - Technologies demonstration in real operational environment ArcelorMittal

T4.1– Demonstration of selected technique for solid and salt removal in the steel industry **AMIII,** BFI

T4.2– Valuable organic substance recovery and water recycling in dairy **MEVGAL,** CERTH, SERE

T4.3 – Demonstration of anaerobic/aerobic MBR at the dairy industry **MEVGAL,** CERTH,

T4.4- Valuable organic substance recovery and water recycling at paper mill EL, KL,CTP

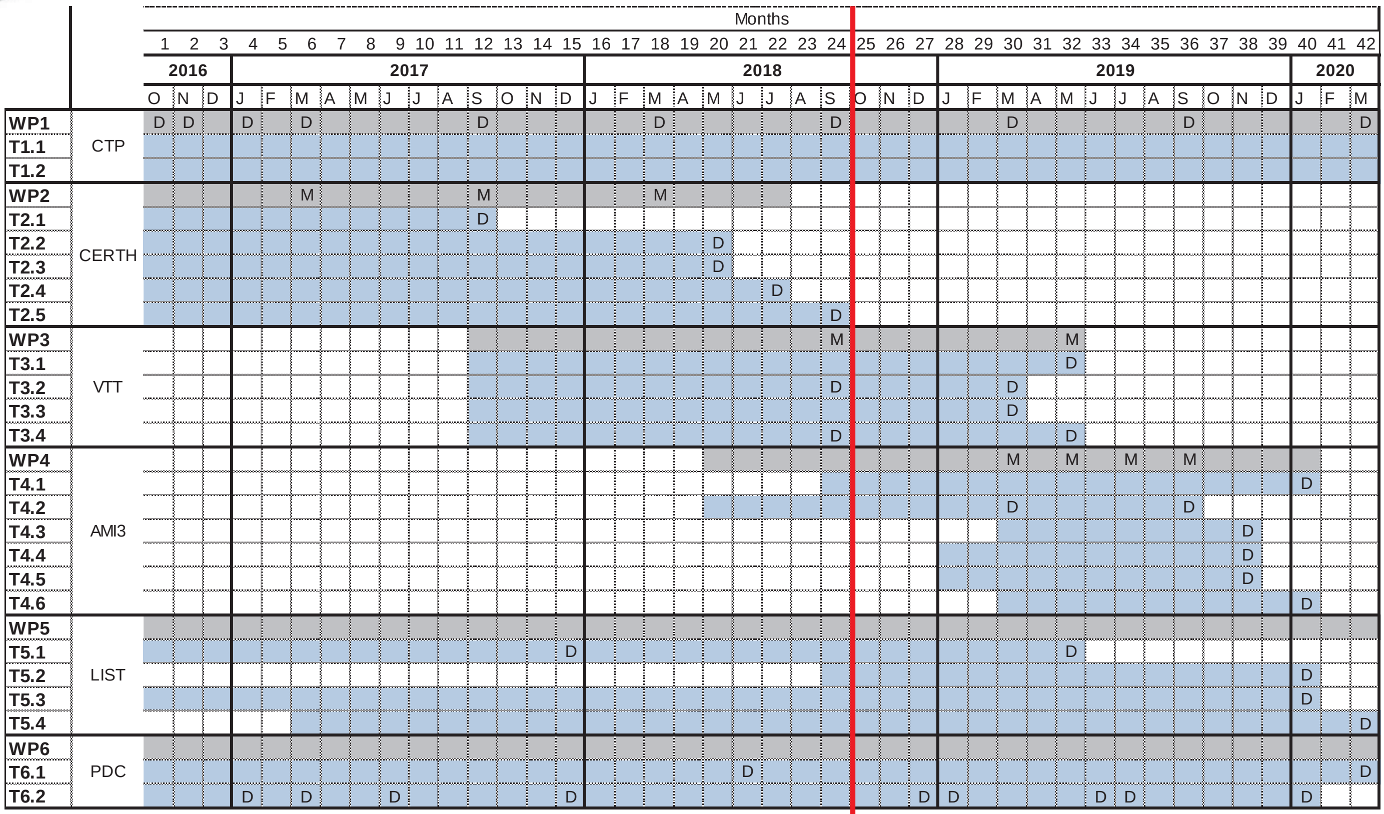
T4.5 – Water reuse and Biocontrol proof of concept (paper mill) VAL,VTT,SCA,XC,CTP

T4.6– Chemical heat pump technology demonstration in steel process (or P&P) CAL, PDC, AMIII

WP- 5 Environmental and techno-economic evaluation – LIST & All
T 5.1 Performances screening of technology solutions **PDC** **T 5.2** Life Cycle Assessment **LIST** **T 5.3** Occupational Risk assessment **LIST** **T 5.4** Techno-economic assessment **PDC**

WP6 - Innovation outreach, impact, and exploitation– PDC & All
T 6.1 Exploitation strategies & business cases **PDC,All** **T 6.2** Innovation outreach **CTP, all**

Gantt Chart



Work Programme

- **WP2 – Technologies components testing in realistic environment**
  - **Select and assess existing or innovative technologies and process components**.
  - **Test individual technologies or process components in realistic environment**,
    - under 'high-fidelity' laboratory set-ups
    - with real or closely simulated water and wastewater samples.

- **WP3 - Technologies assembling in simulated or operational environment**
  - **Combination of selected technologies and processes** to optimize water usage in each industrial sectors,
  - **Assessment** of these combinations in **simulated** (process model) or **operational environment** (pilot).

Work Programme

- **WP4 - Technologies demonstration in operational environment**
  - **Demonstrate** the techniques selected in the WP3 **at industrial sites** from the **dairy, paper and steel industries**.
  - As basis for the business cases the **pilot plant** will be installed in situ..
  - Results will be compared with the ones obtained in WP3 to **define rules for the scale up** used for the later business

- **WP5 - Environmental and techno-economic evaluation**
  - Supporting the **development of technology solutions** in WP2 and WP3 and at assessing the sustainability of the demonstrators from WP4 through **environmental, hazard and techno-economic evaluations**
- **WP6 - Innovation outreach, impact, and exploitation**
  - Maximize the outreach and impact of innovations of the SPOTVIEW project in terms of **enhanced market and business opportunities**, growth and jobs in Europe, and **dissemination of non-proprietary results**

Task 6.2 – Innovation outreach

Visit our website

http://www.spotview.eu/

Task 6.2 – Innovation outreach

- SpotView presentation Video

Thank You !

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Effluent reuse for fresh water reduction in Pulp & Paper industry

4th October, 2018 - Avilés, SPAIN

Stéphanie PRASSE, Patrick HUBER, Eric FOUREST,
Jérôme LEMERCIER, Catherine DESCHAMPS, (**CTP**)

SpotView

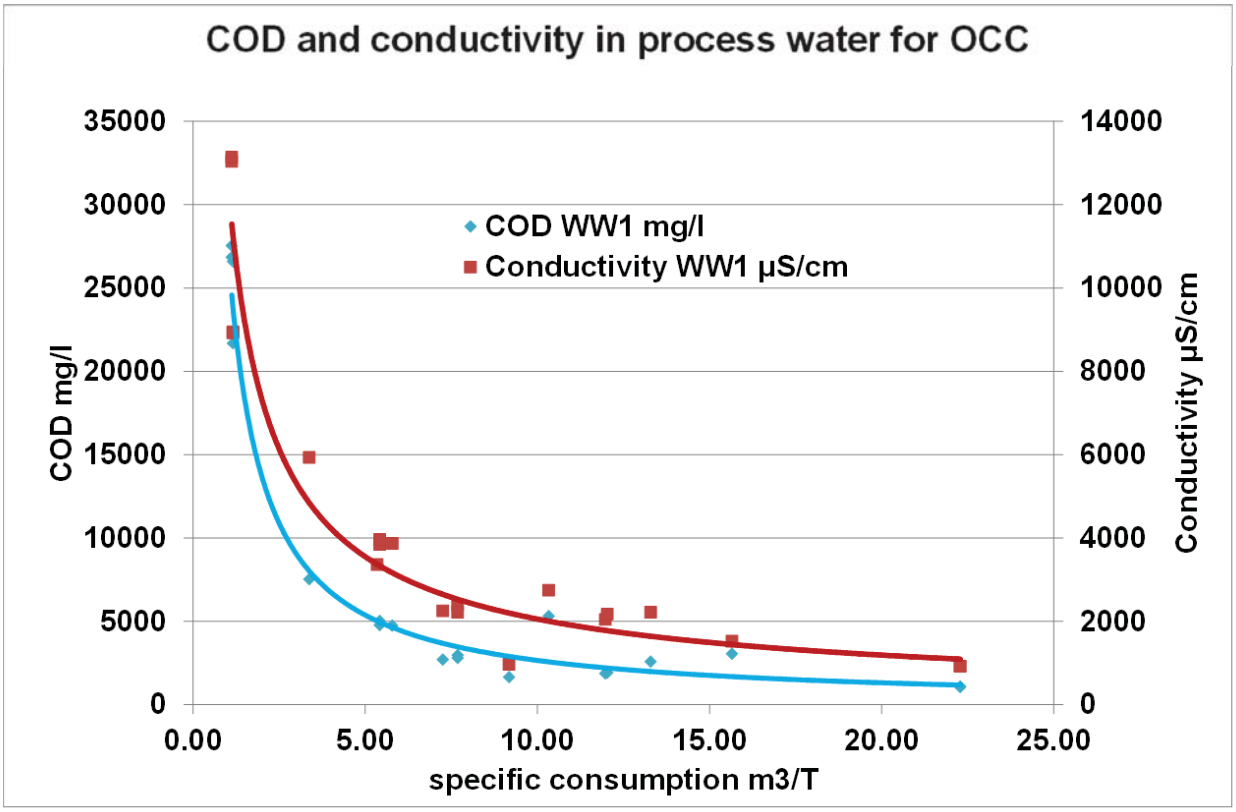
Horizon 2020
European Union Funding
for Research & Innovation

SPIRE PROJECT

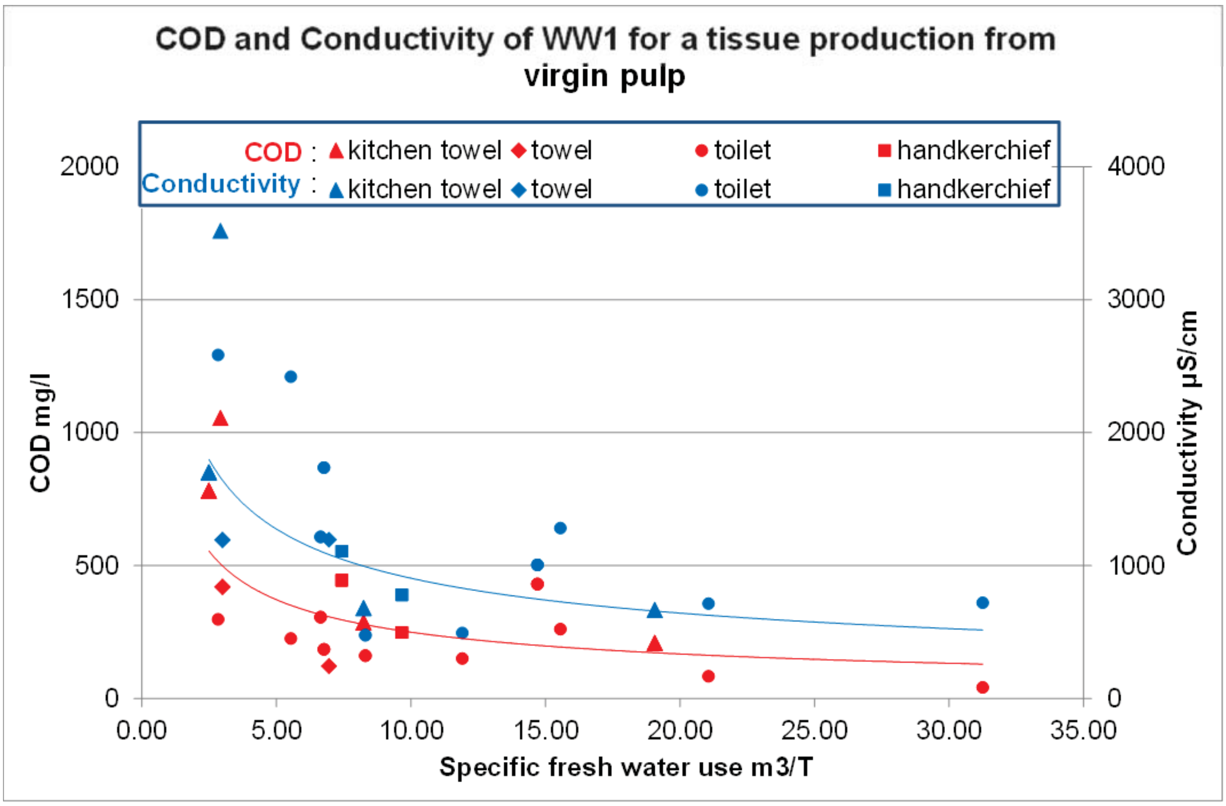
Effluent reuse for fresh water reduction

- 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



Consequences of circuits closure

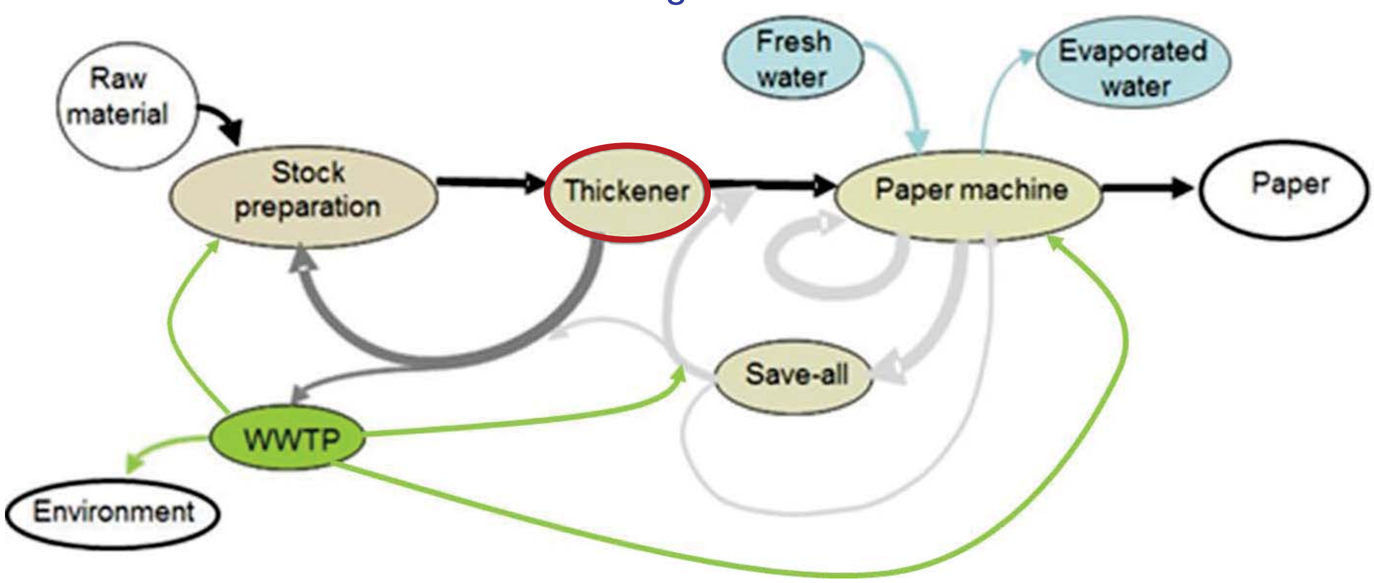


Fresh water reduction consequences

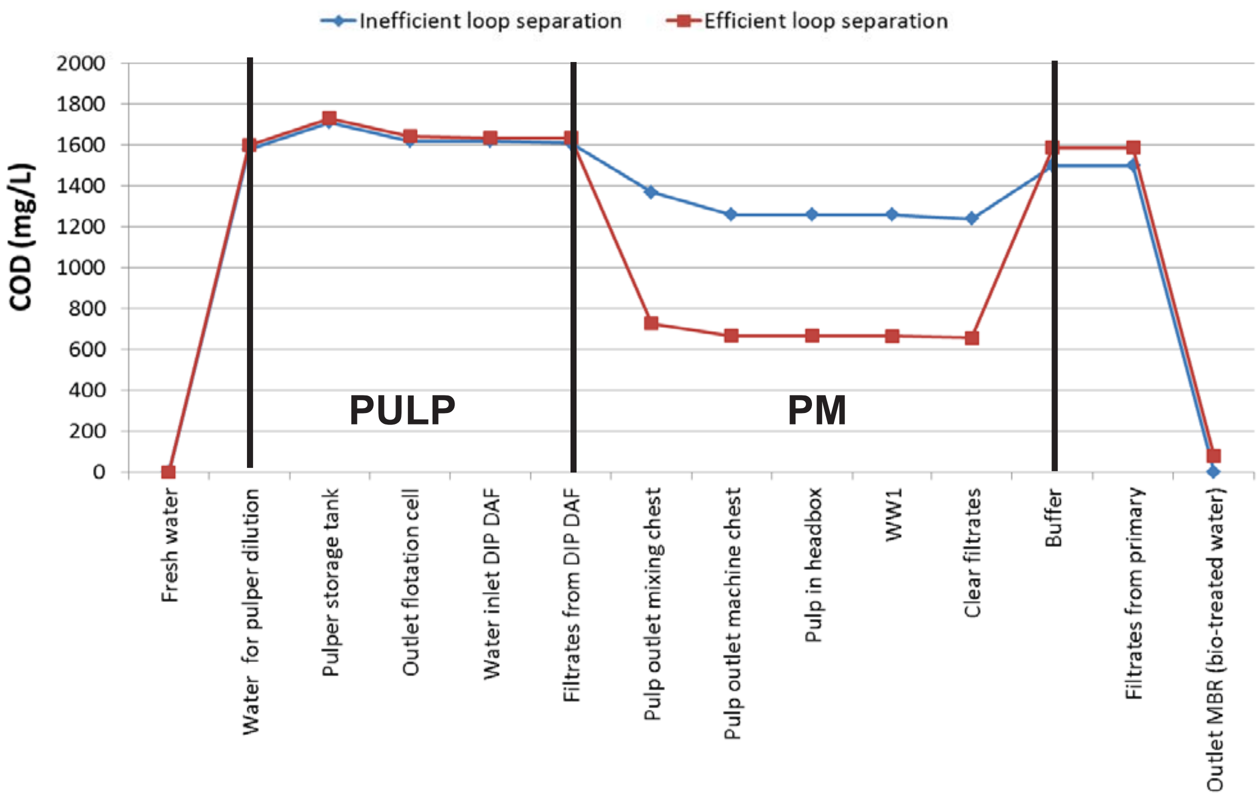
- **Process water contaminants** concentrations increase:
  - Suspended solids,
  - Organic dissolved and colloidal substances (mainly from raw material)
  - Inorganic dissolved substances (from raw material, chemicals, fresh water)
- **Temperature** increase
- **Oxygen** content decrease
- **Volatile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

Water management

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



Water management: loop separation

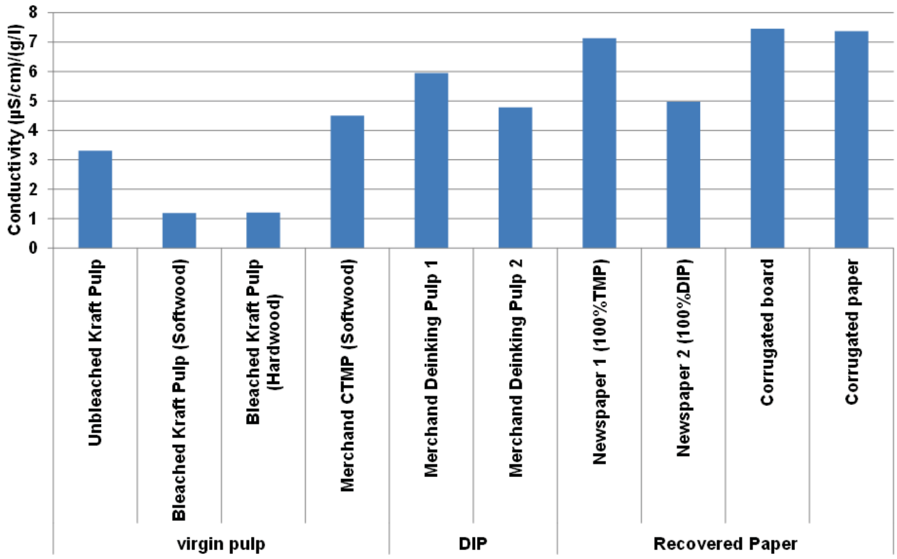


Water management

- With an efficient water management, detrimental effects due to organic matters can be well controlled but what about inorganics matters accumulation?
- Consequences of salinity increase:
  - Mineral deposits (wire, pipes)
  - Chemicals inefficiency (retention agents, wet-ends additives, flocculants)
- What is the main source of conductivity?
  - Raw material ?
  - Fresh water ?
  - Chemicals ?
  - Effluent reuse?

Effects of conductivity increase: Sources

- Raw materials
  - Results come from lab test (repulping of different raw materials) and simulation



Raw material	Conductivity (µS/cm/kg)
Tissue	3.0
Liquid packaging	9.2
Office paper	1.8
Woodfree office paper	5.5

⇨ Contribution of raw materials to conductivity depends on their nature

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

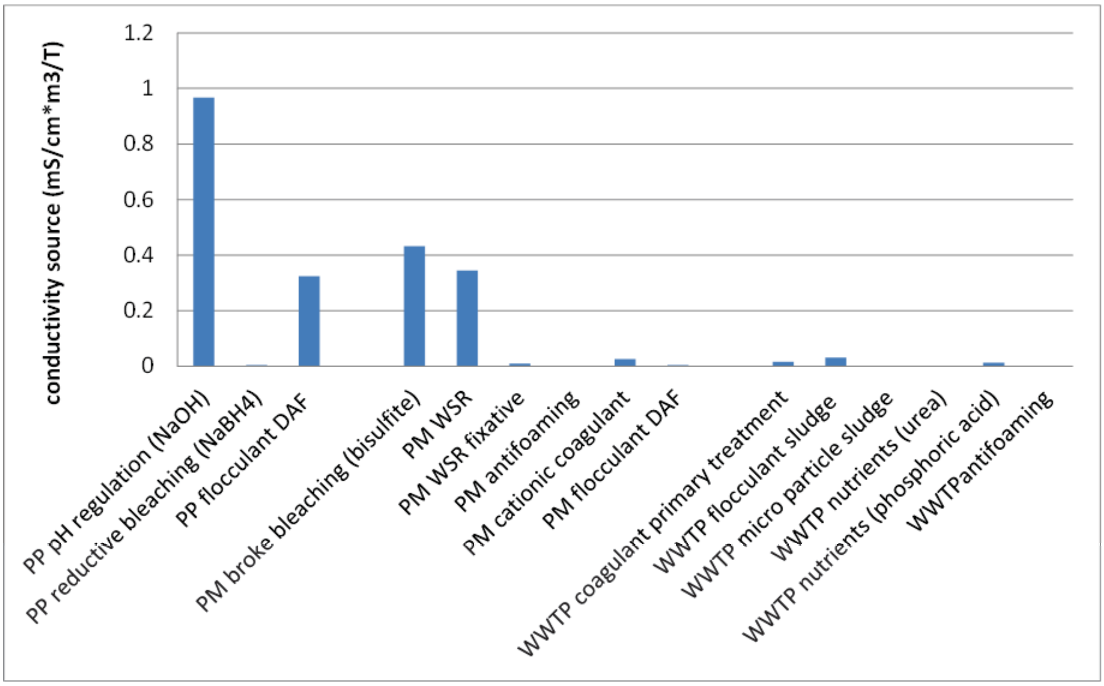
Effects of conductivity increase: Sources

- Fresh water contribution

	based on 36 papermills	
	min	max
pH	6.93	8.7
temperature °C	6.5	29.5
COD mg/l	6	149
Conductivity µS/cm	79	1220
calcium mg/l	11	156
chloride mg/l	9	140
sulphate mg/l	10	286

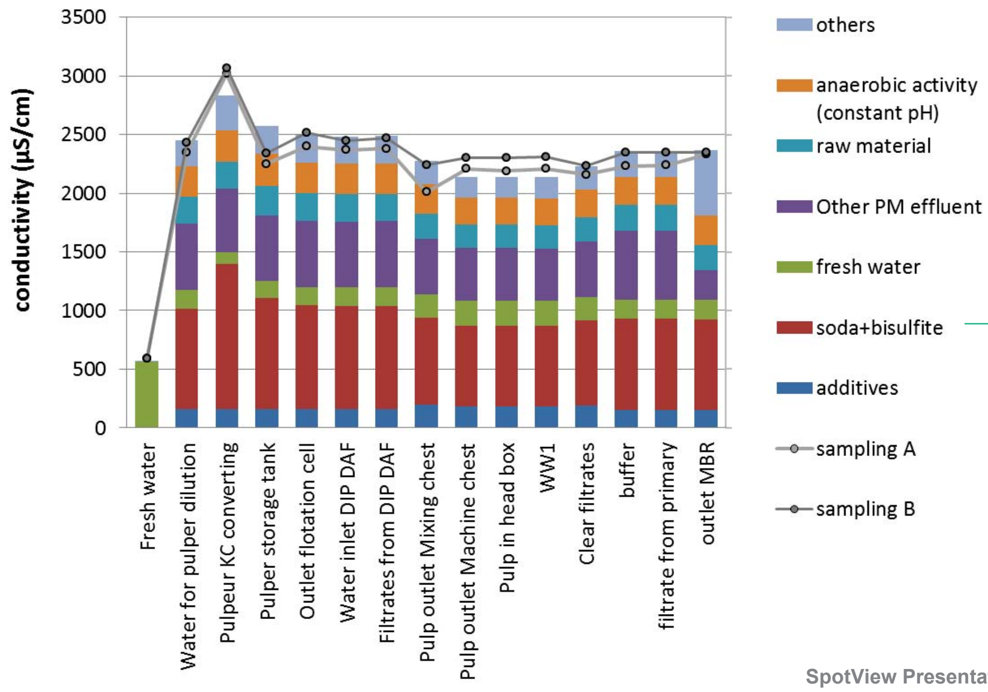
Effects of conductivity increase: Sources

- Process chemicals
  - Source of conductivity taking into account the dosages of the additives in the papermill (DIP + tissue mill)



Effects of conductivity increase: Sources

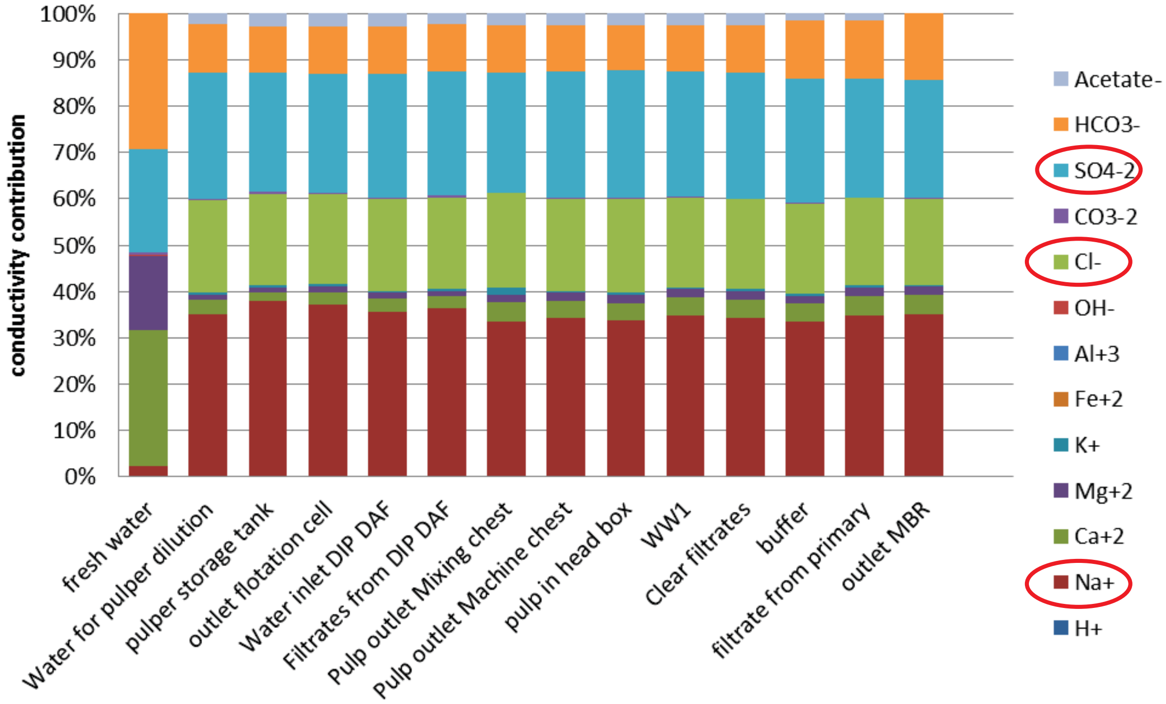
- Conductivity “balance” in a DIP + tissue mill using 6.8 m^3 /T of fresh water and producing 3.6 T/h of paper



Major impact for broke repulping chemicals and pH control to balance microbial acidification

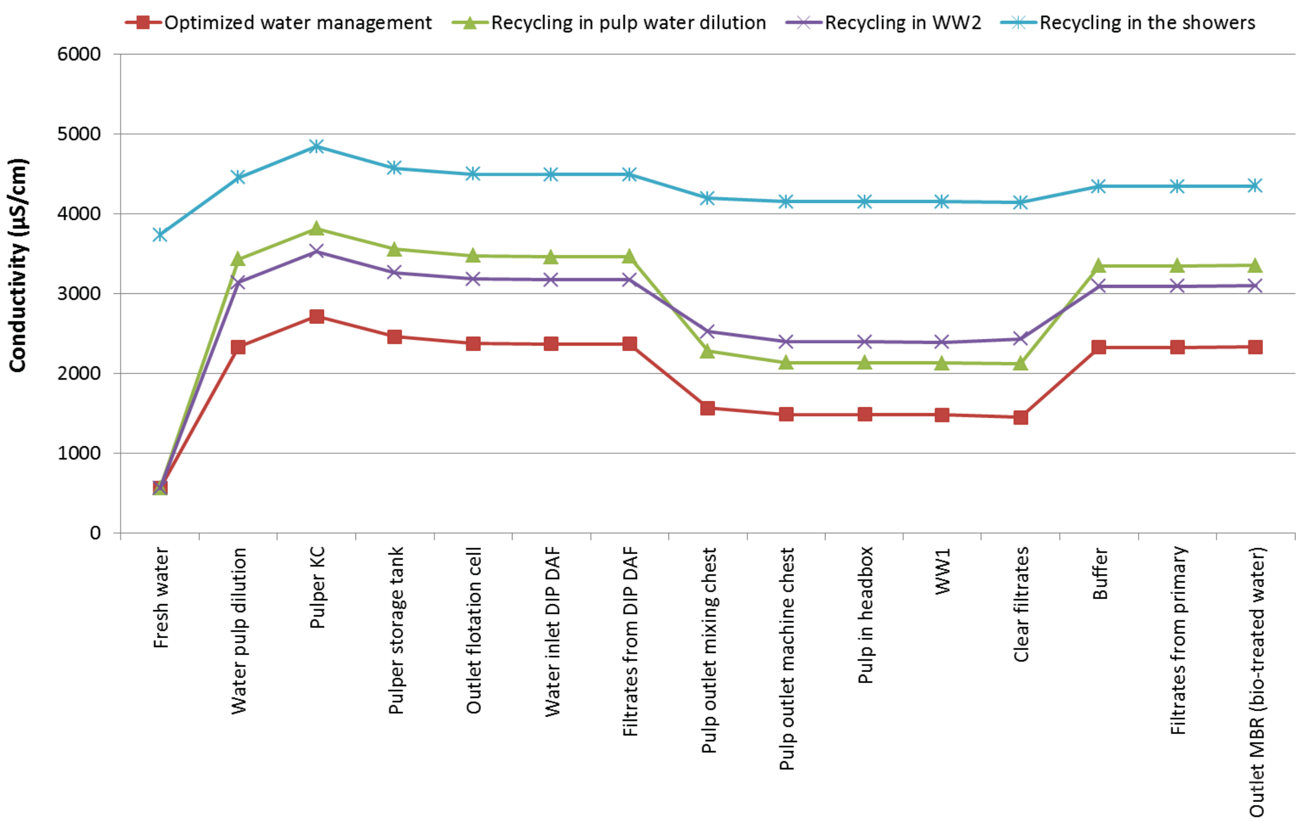
Effects of conductivity increase: Sources

- Major ionic species



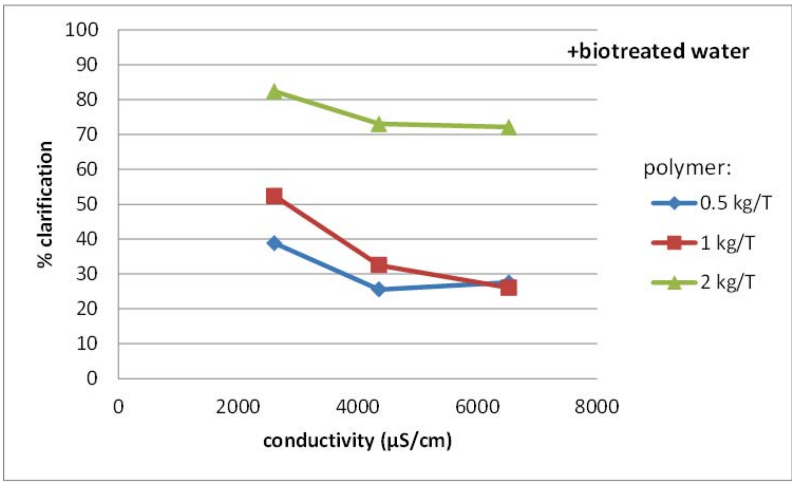
Effects of bio-treated effluent reuse

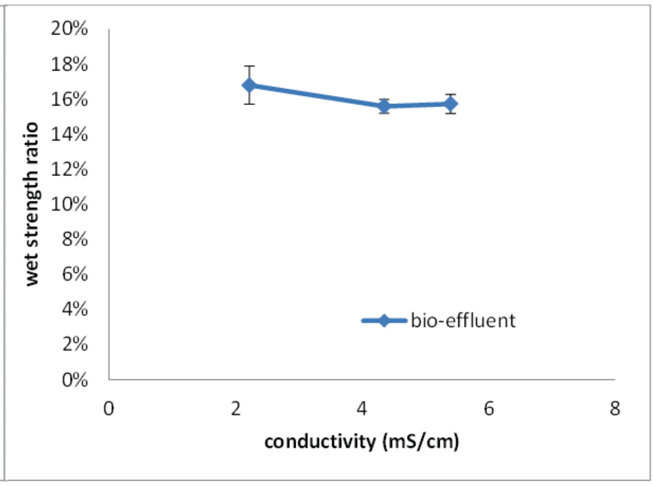
- Simulation results



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)

Conclusion

- **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 the geographical situation of mills
- **Chemicals** are an important ions source, especially sodium and bisulfite in the studied tissue mill.

Conclusion

- **Bio-treated water recycling** has no impact on Wet-Strength and negative impact on DAF flocculant.

- **Solutions:**
  ⇨ Increase polymer dosage at DAF (1 kg/T ➔ 1.5 kg/T)
  ⇨ Use a DAF polymer with higher DS
  ⇨ Neutralise residual cationic demand of bio-treated water with tertiary physico-chemical treatment before recycling

Conclusion

- Consequences of water reduction and bio-treated effluent reuse:

Drawback	Solutions
Organic matters increase	Efficient water management: • Loops separation • Counter-current circulation • Bio-treated effluent recycling
Volatile fatty acids increase	Control of anaerobic bacteria development • Antimicrobial treatments • Circuits and tanks design and management
Ionic species increase	Tertiary treatment • Deionization: RO, CDI, ions exchange

Aknowledgement

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723577

SpotView

Onsite generation of biocides for process water and effluent reuse

Pauliina Tukiainen, Heikki Pajari and Antti Grönroos **(VTT)**

4th October, 2018 - Avilès, Spain

SpotView

Horizon 2020
European Union Funding
for Research & Innovation

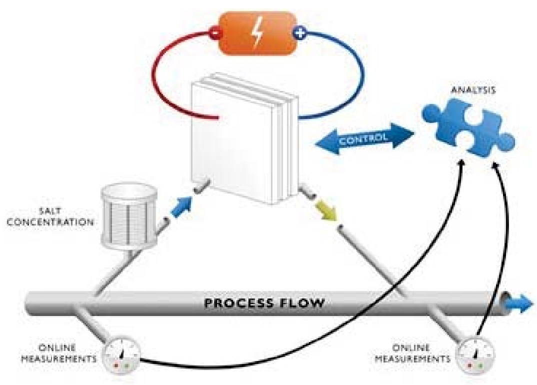
SPIRE PROJECT

Aim and Motivation

Aim is to create a business credible concept by combining membrane technology and electrolysis to replace existing biocide solutions to control microbial growth in aqueous processes, with a cost effective on-site solution.

Motivation

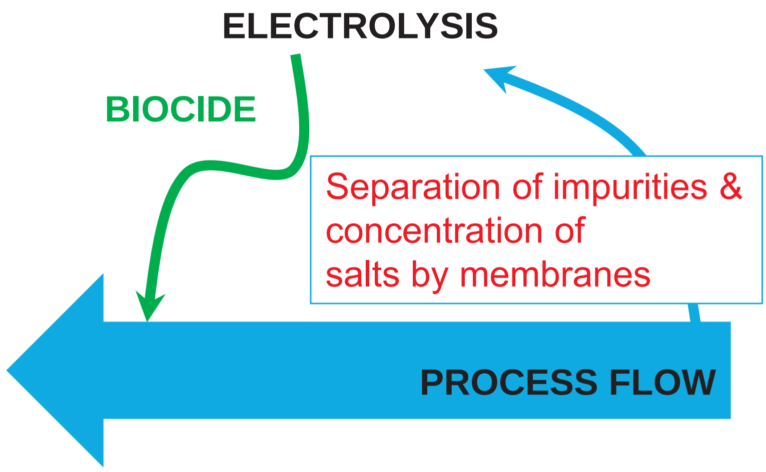
- **Reduced fresh water consumption** and increased internal water circulation to minimize the amount of chemicals introduced in the water circuits.
- **Improved process stability** which furthermore improves the productivity and product quality and enables reduction of the water consumption.
- **Reduced environmental risks** from biocide transportation and **improved worker's safety** due to reduced need to handle harmful chemicals.



Biocontrol - Smart Microbe Management for Water Intensive Processes

The Approach

- Electrochemical generation of biocides
  - Commercial electrolysis unit,
  - Separation of impurities by membranes
  - Concentration of salts by membranes
  - Installed in-line, with a smart control unit
- New solutions to control microbial contamination



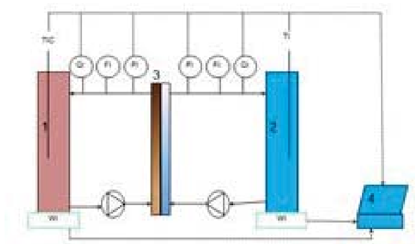
Membrane filtration - Purification and concentration

Conventional membrane pretreatment – Materials and methods

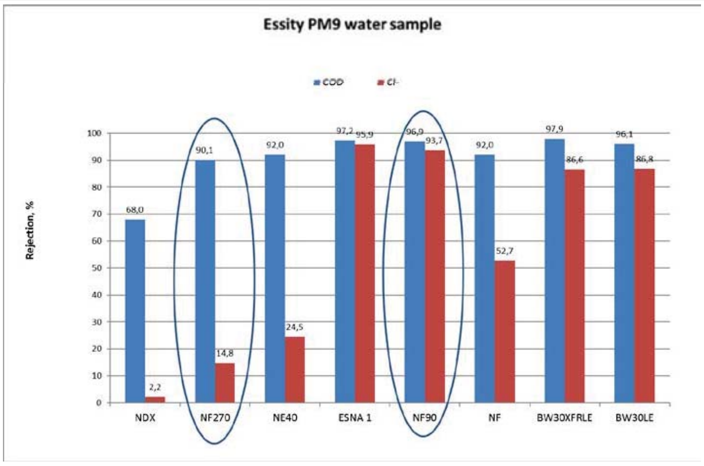
- Test environments
  - CR250 –filtration unit for UF, NF- and RO filtrations at "low" pressure (1 – 8 bar)
  - RO –filtration units at "high" pressure (5 – 70 bar)
- Membranes
  - 4 membranes for ultrafiltration (Valmet PS, Valmet P, Valmet RC and NP010)
  - 6 membranes for nanofiltation (NDX, NF, NF270, NE40, ESNA 1 and NF90)
  - 2 membranes for reverse osmosis (BW30LE and BW30XFRLE)
- Effluents
  - Disk clear filtrate and DAF accept from tissue machine and disk clear filtrate from fine paper machine as a reference
- Methods
  1. Direct chloride concentration by NF and RO membranes
  2. "Purification" of waters by UF or NF membranes after which concentration by NF or RO membranes

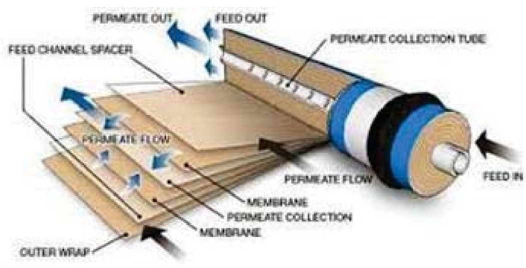
Novel membrane pretreatment – Materials and methods

- Test environments
  - SEPA CF cell with a custom-built laboratory scale test system or a custom-built laboratory-scale crossflow filtration test unit for forward osmosis (FO) experiments
  - SEPA CF cell with a custom-built laboratory scale test system for direct contact membrane distillation (DCMD) experiments
- Membranes
  - Aquaporin flat sheet FO membranes and Aquaporin Inside™ HFFO2 module for VO experiments
  - PTFE 0.2 µm MD membrane (Sterlitech, USA) for MD experiments
- Effluents
  - Disk clear filtrate and DAF accept from tissue machine and disk clear filtrate from fine paper machine as a reference
- Methods
  1. "Purification" of waters by NF membrane after which concentration by FO or MD membranes



Membrane pretreatment for chlorine concentration prior electrolysis

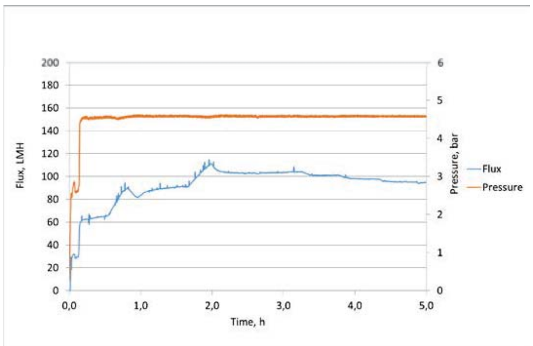


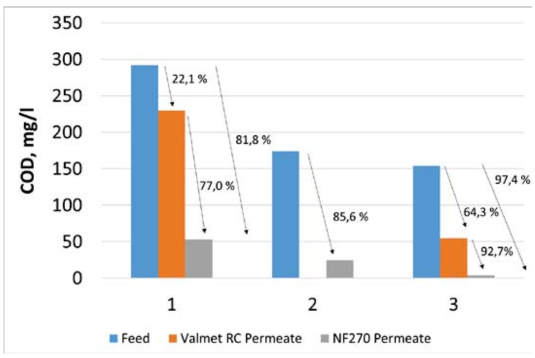


- Tissue and fine paper waters contain too little chloride for economically feasible electrolysis → concentration or "purification" after which concentration by membranes are needed
- Chloride concentration by NF or RO membranes to concentration factor (CF) of 10 (WR 90%)
  - Concentration by NF90 and BW30LE membranes worked well
  - "Purification" before concentration is needed in order to decrease COD concentration before concentration step
- Based on membrane studies for "purification" NF270 membrane and for concentration NF90 membrane were chosen

"Purification" by NF270 membrane

- Filtration properties
  - During the short-term filtrations with NF270 membranes the flux was even and no membrane clogging/fouling was observed.
  - However, the membrane clogging/fouling behaviour has to be verified with long-term filtrations at mill site.
- Purification properties (= COD reductions)
  - COD reductions of the waters studied were dependent on the COD level of the feed water and the purification concept studied.
  - The higher the COD value of the feed the lower the COD rejection.
  - If CR250 filtration with Valmet RC was used before NF270 filtration, COD rejection was the highest.





Chloride concentration to WR 90% by conventional membrane filtration

- Concentration to WR 90% (CF10) by NF90 membrane
  - Chloride could be concentrated with WR 90% about 10 times but unfortunately also COD concentrated about 10 times.
- In electrolysis after purification and concentration it was found, that detrimental compounds (measured as COD) diminished chlorine production.
- It was also found, that after electrolysis, detrimental elements consumed the chlorine produced.

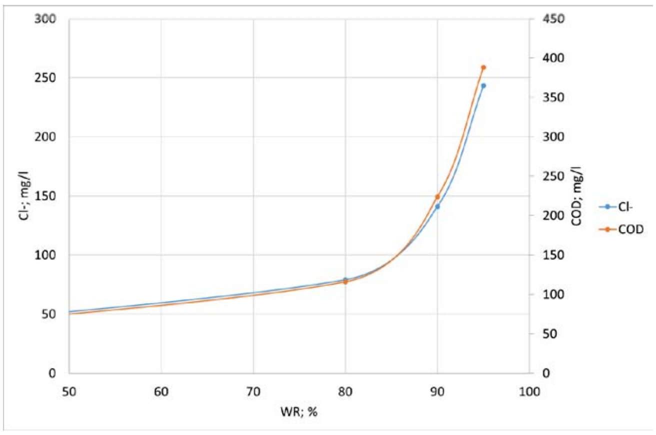
  → Concentration was done to different WRs

Sample	original Cl^-	Cl- after CR250	Cl^- after NF270	Cl^- after NF90
Tissue PM7 21.9.	25 mg/l		23 mg/l	170 mg/l
Tissue PM7 28.11.	23 mg/l	19 mg/l	18 mg/l	190 mg/l
Tissue PM9 21.9.	25 mg/l	22 mg/l	18 mg/l	140 mg/l
Tissue PM9 28.11.	19 mg/l		17 mg/l	140 mg/l
Tissue PM9 26.02	24 mg/l	24 mg/l	26 mg/l	260 mg/l

Sample	original COD	COD after CR250	COD after NF270	COD after NF90
Tisssue PM7 21.9.	230 mg/l		55 mg/l	475 mg/l
Tissue PM7 28.11.	515 mg/l	380 mg/l	130 mg/l	385 mg/l
Tissue PM9 21.9.	290 mg/l	235 mg/l	55 mg/l	360 mg/l
Tissue PM9 28.11.	175 mg/l		25 mg/l	225 mg/l
Tissue PM9 26.02	155 mg/l	55 mg/l	4 mg/l	50 mg/l

Chloride concentration to different WRs by NF90 membrane

- In the concentration experiments to different WRs it was observed that chloride and COD concentrated hand in hand.
- Up to WR 80-90% concentration increased quite evenly, after which the increase was very fast, as expected because of CF.
- In chlorine production by electrolysis, it was found that for efficient chlorine production the amount of Cl^- should be as high as possible and the amount of COD as small as possible



Chloride concentration to WR 90% by novel membrane filtrations

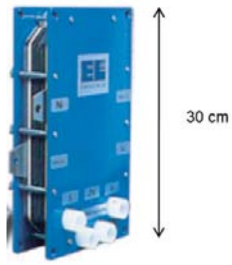
- In the case of FO / SEPA CF and MD the concentration of the chloride increased similarly as with conventional membrane filtrations up to CF10.
- In the case of FO/HFFO2 module the chloride concentration in concentrate after FO was too high.
  - There must be happened salt leakage from the draw solution (1M NaCl) side, because the membrane used.
- In the novel membrane filtrations in general, COD concentrated little less than in the case of conventional filtrations.

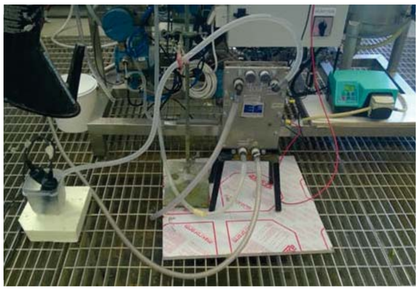
Sample	Cl; mg/l	COD; mg/l
Tissue PM7 FO feed / SEPA CF	19	134
Tissue PM7 FO WR 90% concentrate / SEPA CF	190	384
Tissue PM9 FO feed / HFFO2 module	15	28
Tissue PM9 FO WR 90% concentrate / HFFO2 module	730	134
Tissue PM9 MD feed	18	53
Tissue PM9 MD WR 90% concentrate	142	361
Fine MD feed	93	75
Fine MD WR 80% concentrate	524	189
Fine MD WR 90% concentrate	974	267
Fine MD WR 95% concentrate	1808	454

Electrolysis

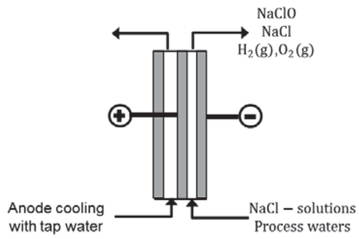
Hypochlorite generation with electrolysis

- Electro MP Cell (Electrocell, Denmark)
  - Cooled DSA-anode and titanium cathode with 2 mm distance
  - Electrode area 200 cm^2



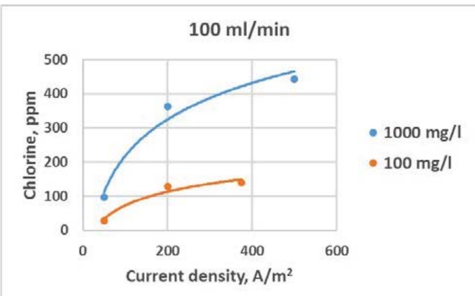


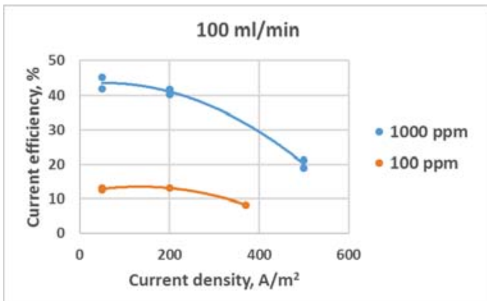
- Variables
  - Chloride ion concentration in the feed
  - Current density
  - Volumetric flow rate (dwell time)
  - Water samples
    - Tap/di water (reference)
    - Membrane filtrated disk clear filtrate and DAF accept from tissue machine and disk clear filtrate from fine paper machine as a reference
- Figures of merit
  - Chlorine (NaClO) concentration in the product
  - Current efficiency
  - Energy consumption
  - Conversion



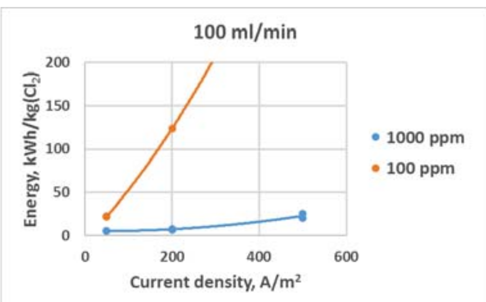
Hypochlorite generation with electrolysis – tap water

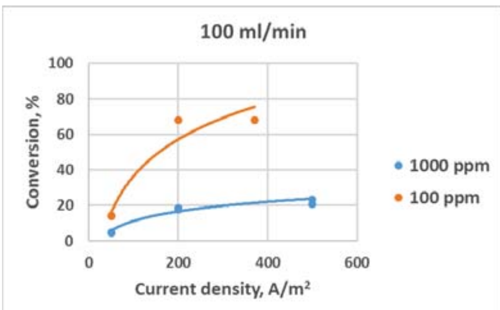
- Chloride ion concentration in the feed is by far the most important variable in electrolysis





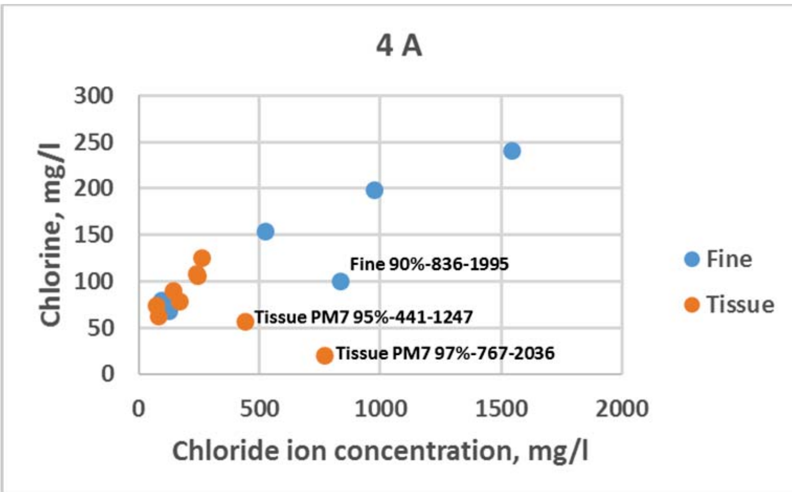
- Higher chloride ion concentration gives better economics in electrolysis, however pretreatment costs increase





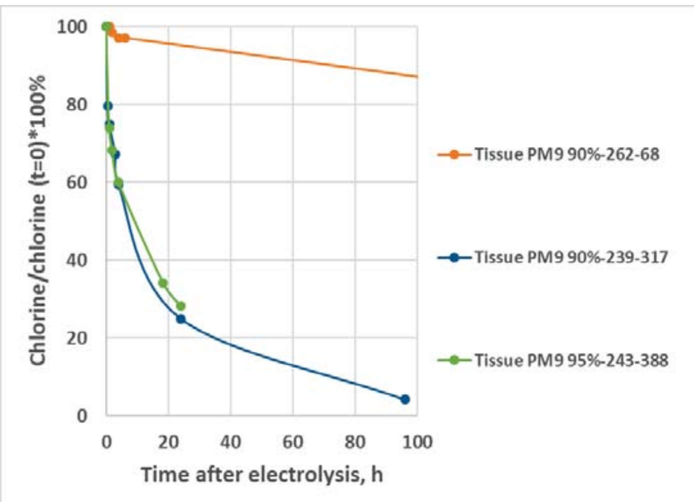
Hypochlorite generation - PM waters

- For tap water (100 ppm and 1000 ppm chloride), all of the figures of merit, except conversion, were better with the solution at higher concentration.
- This was true also for the purified and concentrated mill waters in general, but increase of detrimental substances (measured as COD) deteriorated electrolysis resulting to decreased chlorine concentration in the product.



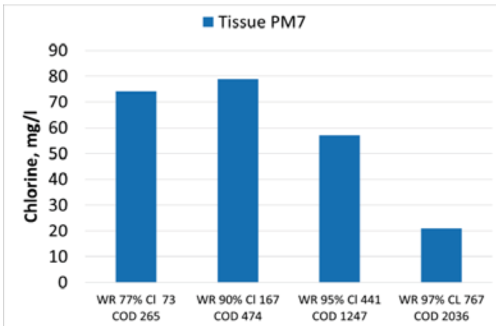
Effect of detrimental substances on chlorine consumption

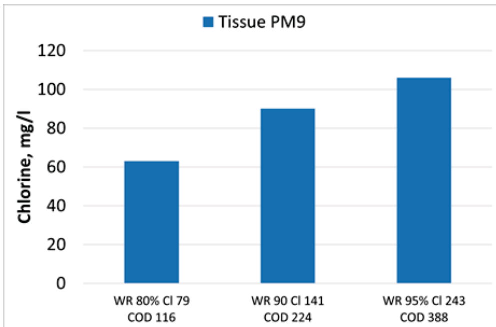
- Decay of chlorine was faster with higher COD concentrations
- With deionized and tap water samples no decay of chlorine was observed.



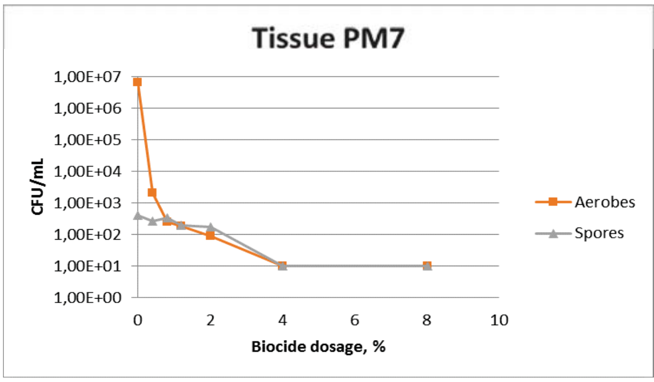
The effect of concentration factor on the chlorine production

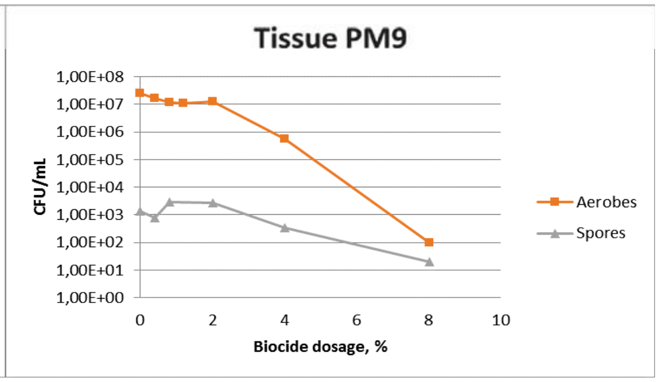
- PM waters were concentrated to different CFs (WR%s)
- Chlorine production of concentrated PM waters was significantly lower than tap water
- “Impurities” consumed active chlorine produced by electrolysis
- There seems to be optimum concentration factor for electrolysis when using PM waters
  - Optimization of concentration factor needs to be done case by case
  - Economical feasibility needs to be evaluated case by case





Biocidal efficiency - PM process waters





PM7 100 % chemical pulp; COD 300 mg/l

PM9 – DIP 70%, Chem pulp 30%, COD 350 mg/l

- Electrochemically produced biocide eliminated bacteria, however economically feasible solution for tissue process using DIP might be challenging

Biocontrol concept needs to be tailored case by case

Biocontrol concept - WWTP effluent

- An activated sludge process is capable of removing more than 90 % of the total suspended solids and dissolved organic material, but does not remove inorganic material efficiently. Microbial activity of the biologically treated effluent are major sources of concern for effluent reuse.
- Electrolysis of waste water treatment plant (WWTP) effluent without pre-treatment eliminated efficiently both vegetative cells and bacterial spores from effluent.
- Also biocide treatment of WTTP effluent with biocide produced from tissue mill white water with Biocontrol concept is option for elimination of microbial activity.

Sample	pH	Conductivity µS/cm	Aerobic bacteria CFU/mL	Spores CFU/mL	Chlorine mg/L
WWTP effluent	7.8	1090	8000	460	0
WWTP effluent after electolysis	8.3	1030	20	10	28

Conclusions 1/2

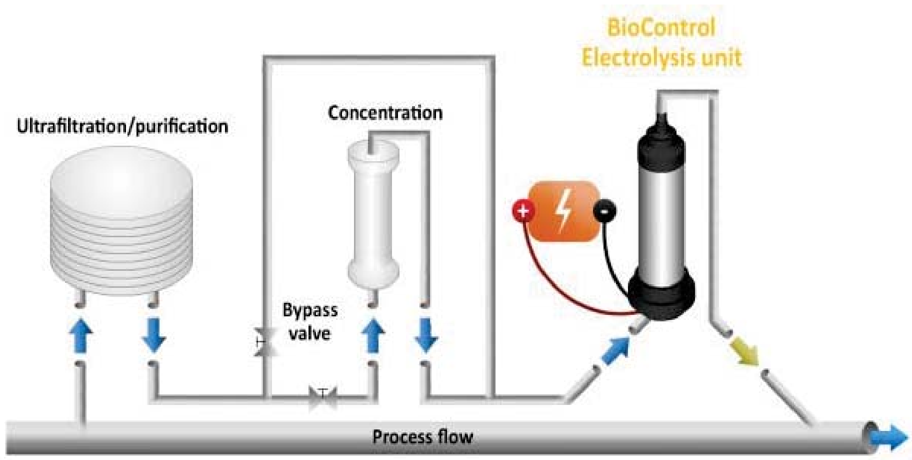
- This study showed that **production of total chlorine by electrolysis** was **more efficient** and **economic**, when the **concentration of chloride ion** was **increased** and **COD decreased** in the electrolysis cell feed.
- **The purification and concentration** trials indicated that either **conventional membrane technologies** or **novel membrane technologies** (forward osmosis and membrane distillation) are suitable for the purification and concentration before biocide production.
  - Membrane distillation (MD) is option if waters have temperature difference available at mill site. In the case of forward osmosis (FO) the availability of usable draw solution at mill site is in the key role.
  - Within SpotView project concept development with membranes will focus on conventional membrane filtrations due to maturity of the technology and equipment availability for full scale installations at the moment.

Conclusions 2/2

- Decrease of COD reduced the decay of chlorine after electrolysis.
- Biocontrol concept eliminated microbes efficiently
  - Optimal microbial control strategy is highly application specific. Optimization of the concept needs to be performed case-by-case at mill site.
- Economical and technical feasibility of concept needs to be evaluated with pilot trials.
  - Optimal operation parameters for onsite biocide production
  - Longer test periods in mill scale trial will provide information on lifetime of cell and therefore more accurate estimation of the payback period of equipment.

Next steps
Concept development

XerChem will validate lab scale trials results at mill site trials.



Please visit poster and **discuss** details with **XerChem**

- In situ biocide production from chlorides of process water, Juha Tikkanen, XerChem

Aknowledgement

This project has received funding from the European Union's Horizon 2020 research and innovation programme under grant agreement No 723577

Strategies and Technologies for valuable substance recovery in the Pulp & Paper industry

4th October, 2018 - Avilés, SPAIN

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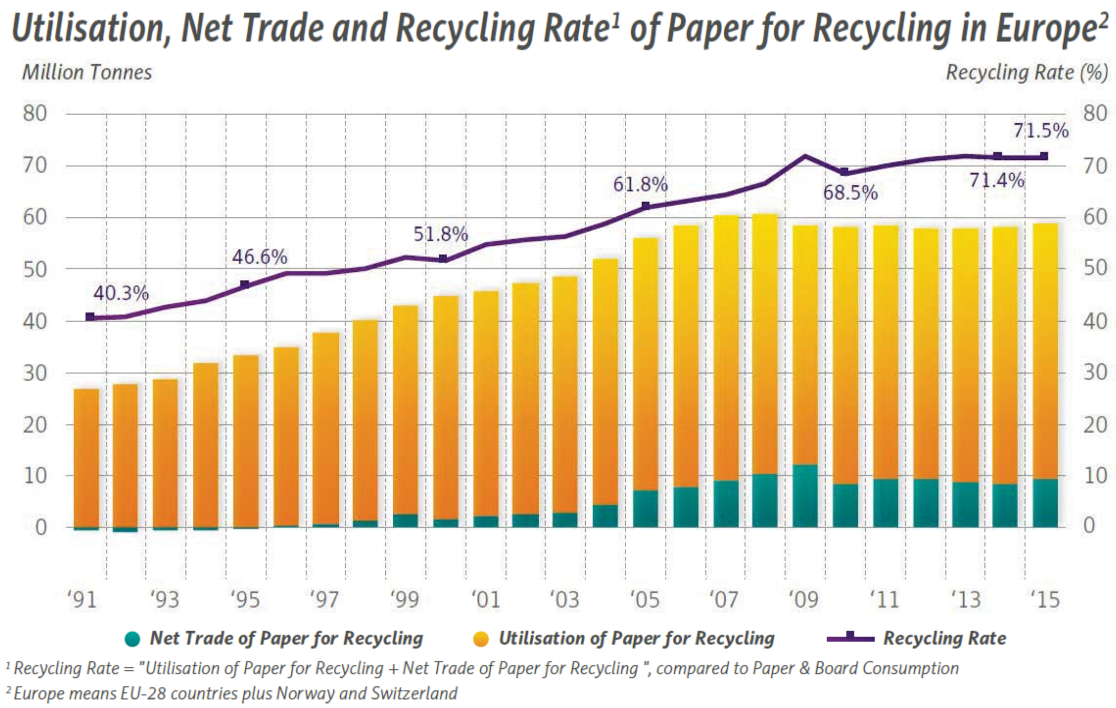
Horizon 2020
European Union Funding
for Research & Innovation

Outline

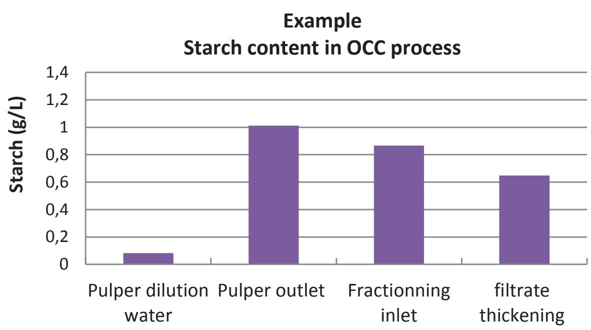
- Context for valuable substance recovery
- Starch release during pulping (laboratory / industrial scale)
- Assessment of the recyclable organic materials recovery
- Recovered organic matter valorisation
- Conclusion

Context



Valuable substance recovery

- **Starch and other organic substances are released in water** during the recovered paper pulping
  - 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
- **OCC users (packaging board)** and other users of starch-rich recovered paper



Starch release during pulping

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

Samples : unused cardboard or recovered paper bales

Unused

UCB4.01: Unused Corrugated Board

Recovered

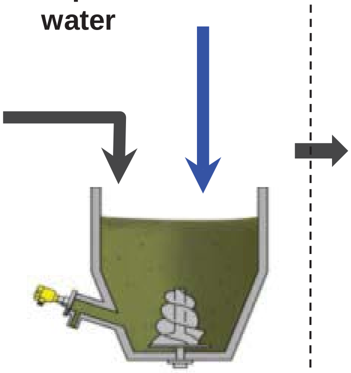
1.05: Old Corrugated Cardboard / Board OCC

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**

Corrugated Cardboard samples	Before pulping: Starch content (kg/T)	After pulping: COD (kg/T)	Starch released in water: Total (kg/T)	Starch released in water: Colloids (kg/T)	Starch released in water: 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

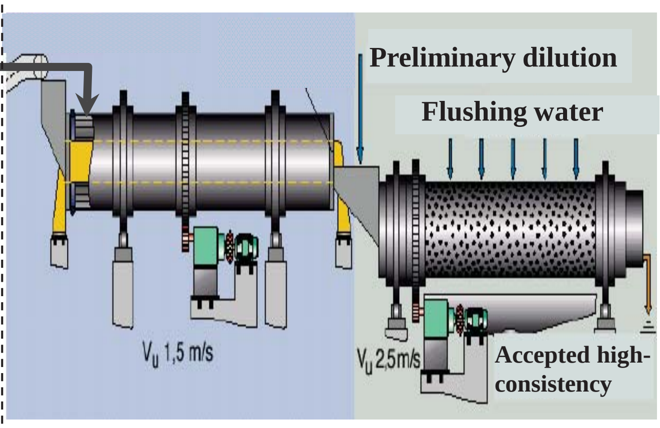
Starch release during pulping

• Industrial scale measurement - Methodology

Raw material :

Recovered paper bales mixture (4.01 - 5.02 - 1.05)

Industrial Pulping : Trommel (Drum)



Measurements

Pulp

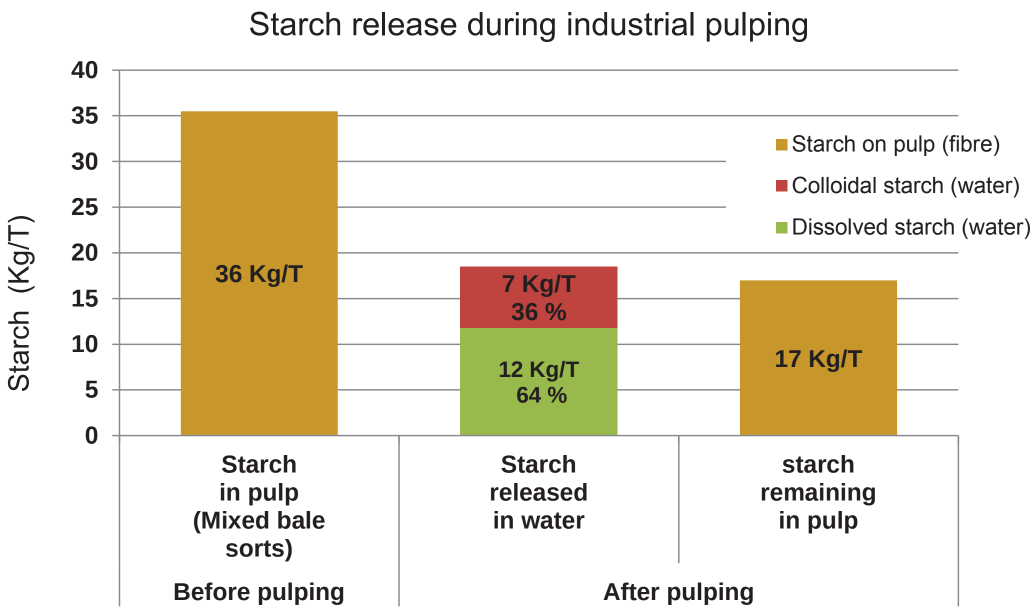
- **Starch**
  - Iodometric method (Tappi 0m-418)

Dilution water

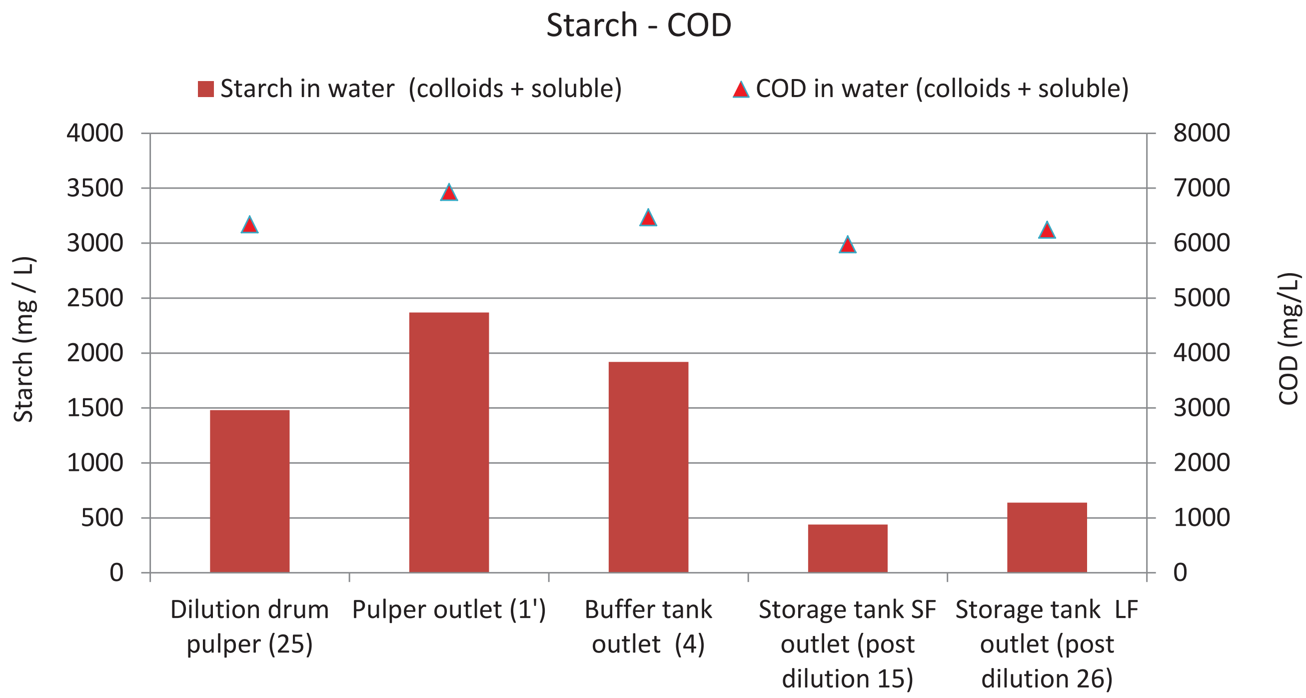
- **Starch (colloïdal and hydrolysed fraction)**
  - Enzymatic method
- **COD / TOC**
- **Volatile Fatty Acids**

Starch release during pulping

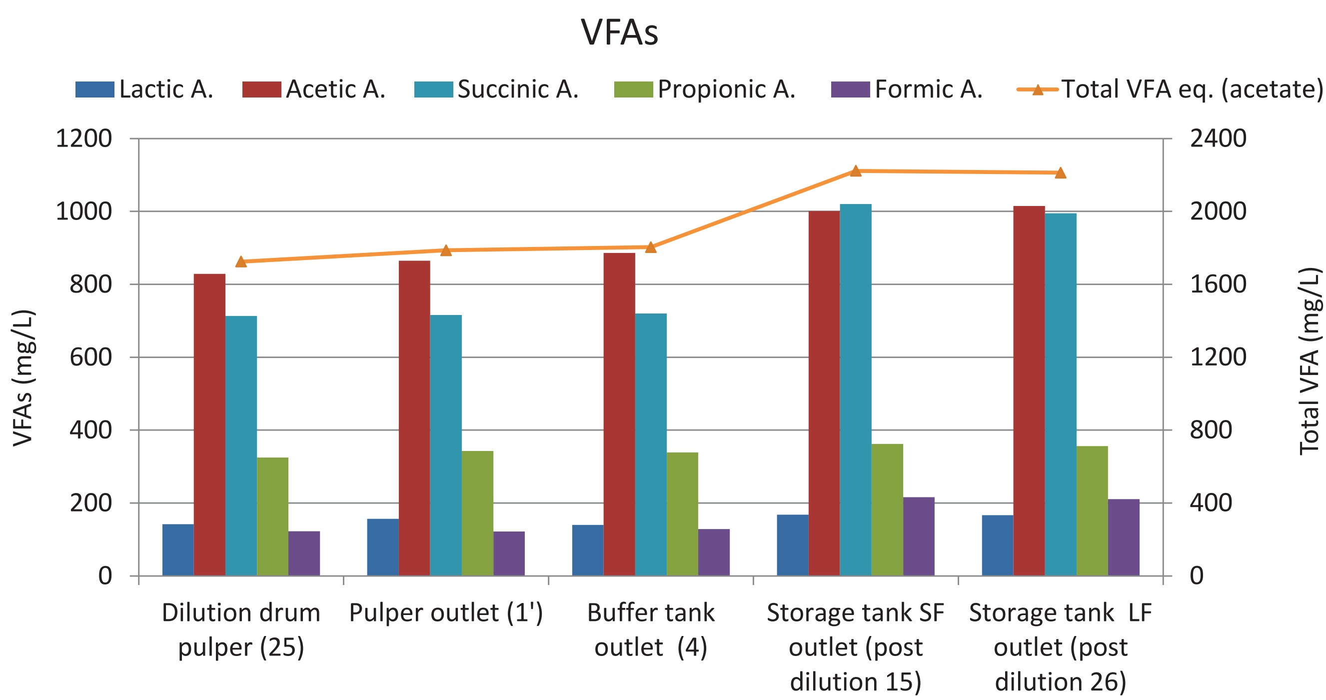
• Industrial scale measurements - Results



Starch release during pulping

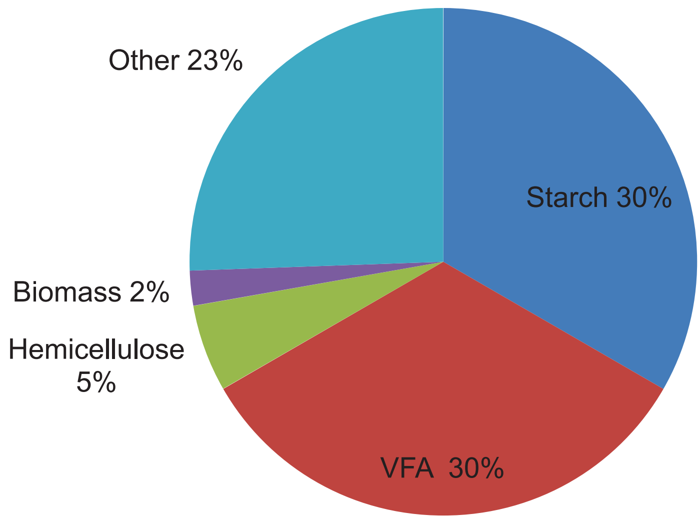


Starch release during pulping



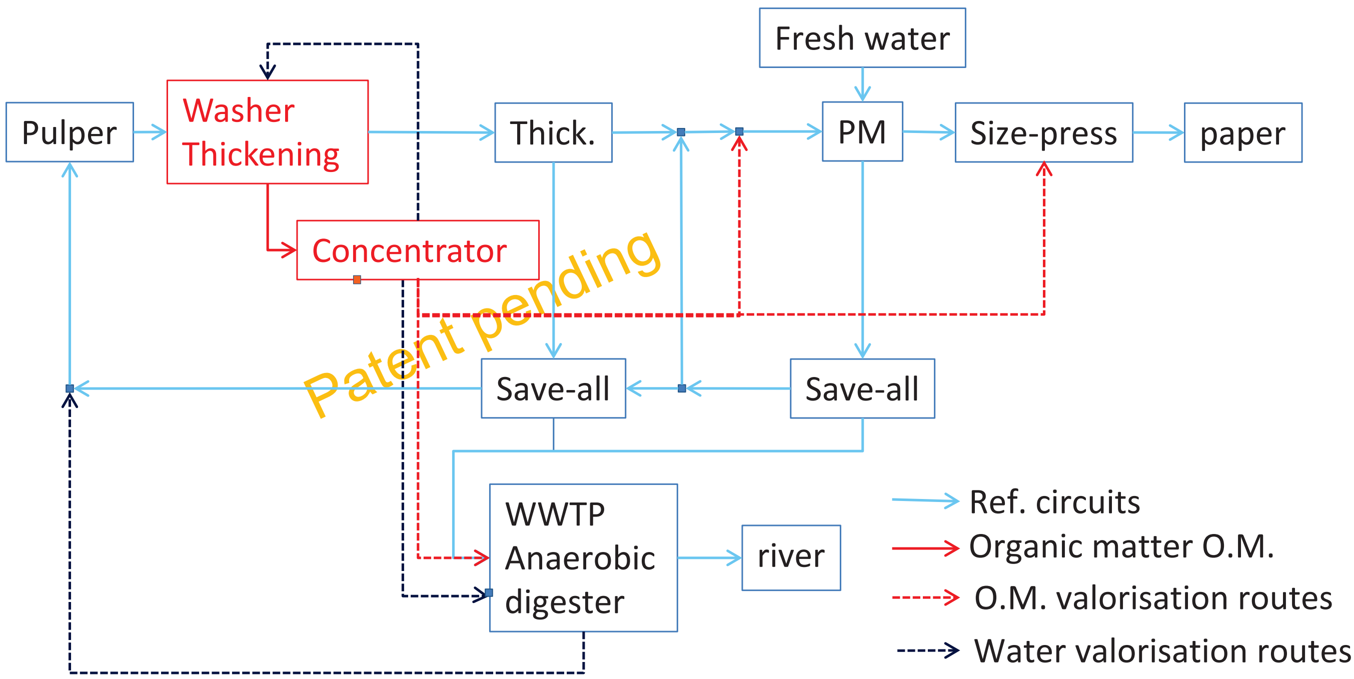
Starch release during pulping

- **Total organic carbon (TOC) in pulping water**



Organic matter valorisation route

- Strategies for organic matter extraction and possible valorisation routes



Assessment of the recyclable 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	-	- Cost (+) - Removal (no good for starch and TSS simultaneously)
Disk filter	- Removal	- Cost (++)
Washer	-Washing rate removal (Starch and TSS) - Cost	-

Selected for pilot trials

Assessment of the recyclable organic materials recovery

- **Organic matter separation + Concentration techniques**
  - To recover organic matters and reuse the clarified process water
  - Microfiltration
    - Removes and concentrate particles larger than 0.1 µm (>90% of colloids)
  - Centrifugation
    - Separates suspended particles according to settling properties
    - Continuous flow
  - Dissolved Air Flotation
    - Adsorptive bubble separation process
    - Separates surface active or colloidal matter
    - After coagulation + floculation

Assessment of the recyclable organic materials recovery

SpotView
Horizon 2020 European Union Funding for Research & Innovation
SPIRE PROJECT

– Concentration stage technologies comparison

Technologies	Advantages	Drawbacks
Micro-filtration	- Efficiency (Cut-off adjustable) (removal > 90%)	- Cost (++) - Maintenance (Not realistic at industrial scale)
Centrifugation (Continuous flow)	- Cost (-)	- Efficiency - Not continuous for small size particle removal - Coagulant / flocculant to be added
Dissolve Air Flotation (DAF)	- Cost (- -)	- Only fraction of colloids removed - Coagulant / flocculant to be added

Selected for pilot trials

ctp centre technique du papier

SpotView
Horizon 2020 European Union Funding for Research & Innovation
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Laboratory scale evaluation

Potential starch recovery - Lab scale evaluation

Raw Material

Raw Material : UCB4.01

Enter sort : New **UCB4.01** 76 kg/T
OCC **MIX** 36 kg/T
(1.05 - 4.01 - 5.02)

Starch in Raw Material :
76 kg/T ± 8

Pulping stage

Starch release 70%
Enter Pulper : Pilot

Raw Material C			Extraction rate
UCB4.01	3,5%	**Lab**	43%
UCB4.01	10%	**Pilot**	70%
MIX	4%	**Mill**	50%

Starch remaining in pulp :
23 kg/T ± 3

Starch release in water :

Total :	53 kg/T ± 8	
Colloids :	32 kg/T ± 5	60%
Dissolved :	21 kg/T ± 3	40%

Washing / Thickening stage

Technology : washer
Enter technology : M9 or Washer

Washing rate
Colloids : 89%
Dissolved : 68%

Starch recovery in water :

Total :	43 kg/T ± 6
Colloids :	28 kg/T ± 4
Dissolved	14 kg/T ± 2

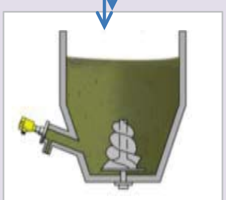
Concentrator stage

Technology : DAF

Flottation Rate
Colloids : 70%
Dissolved : 0%

Starch frowth recovery in

Total :	20 kg/T ± 3,0
Colloids :	19,9 kg/T ± 3,0
Dissolved	0,0 kg/T ± 0,0



Recovered organic matter valorisation

- Reuse of recovered starch currently investigated:
  - To replace partly fresh starch (Paper mechanical properties)
    - In treatment surface (ex: size press)
    - In the pulp (Wet end)
  - To use as nutriment to produce biogas (anaerobic treatment)
    - Biogas for steam production reducing fossil gas consumption

Conclusion

- Valuable organic matter are released during pulping of recovered paper
  - Around 50% of starch contained in paper is released in water
- Two technologies selected at laboratory scale
  - Washing stage: Washer
  - Concentrator stage: Dissolved Air Flotation
- Around 25 % of initial pulp starch content removed
  - Starch removal to be improve for industrial recovery
- Recovered starch valorisation to evaluate
  - Fresh starch replacing / Energy (Biogas production)
  - Taking into account detrimental impurities effect (mineral)

Aknowledgement

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