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Wet air oxidation for industrial wastewater and sludge treatment: first results of a new research program in Quebec

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WET AIR OXIDATION FOR INDUSTRIAL WASTEWATER AND SLUDGE TREATMENT: FIRST RESULTS OF A NEW RESEARCH PROGRAM IN QUÉBEC

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CENTRE DE TRANSFERT TECHNOLOGIQUE EN **ÉCOLOGIE INDUSTRIELLE (CTTÉI)**

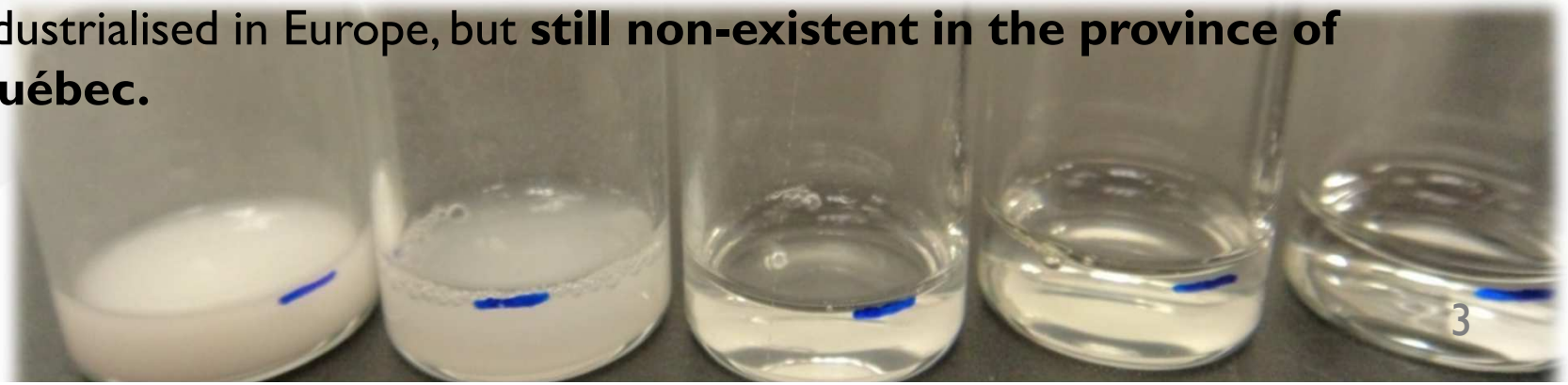
Technology Transfer Center

Applied research on :

- Industrial waste valorization
- Clean processes
- Industrial symbiosis

WET AIR OXIDATION PROCESS (WAO)

- Subcritical water enriched with air or oxygen (≈150–350 °C, ≈3–20 MPa)
- Oxygen reacts with organic compounds → propagation of radicals: $R^{\bullet}$, $OH^{\bullet}$, $HO_2^{\bullet}$, $ROO^{\bullet}$ → **Exothermic oxidation** of organic compounds mostly into CO_2, H_2O, NH_3, SO_4^{2-}, PO_4^{3-}
- Industrial opportunities for WAO : **wastewater too toxic or too concentrated** for biological processes, and too diluted for suitable incineration (> 80 % H_2O)
- Better energy output than incineration (for sludge or wastewater)
- Cleaner gas emissions: no NO_X, dioxins or furans
- Better efficiency and faster treatment than other advanced oxidation processes (AOPs) for highly concentrated waste (>10 g/L DCO)
- Economically-competitive and environmentally-friendly process industrialised in Europe, but **still non-existent in the province of Québec.**



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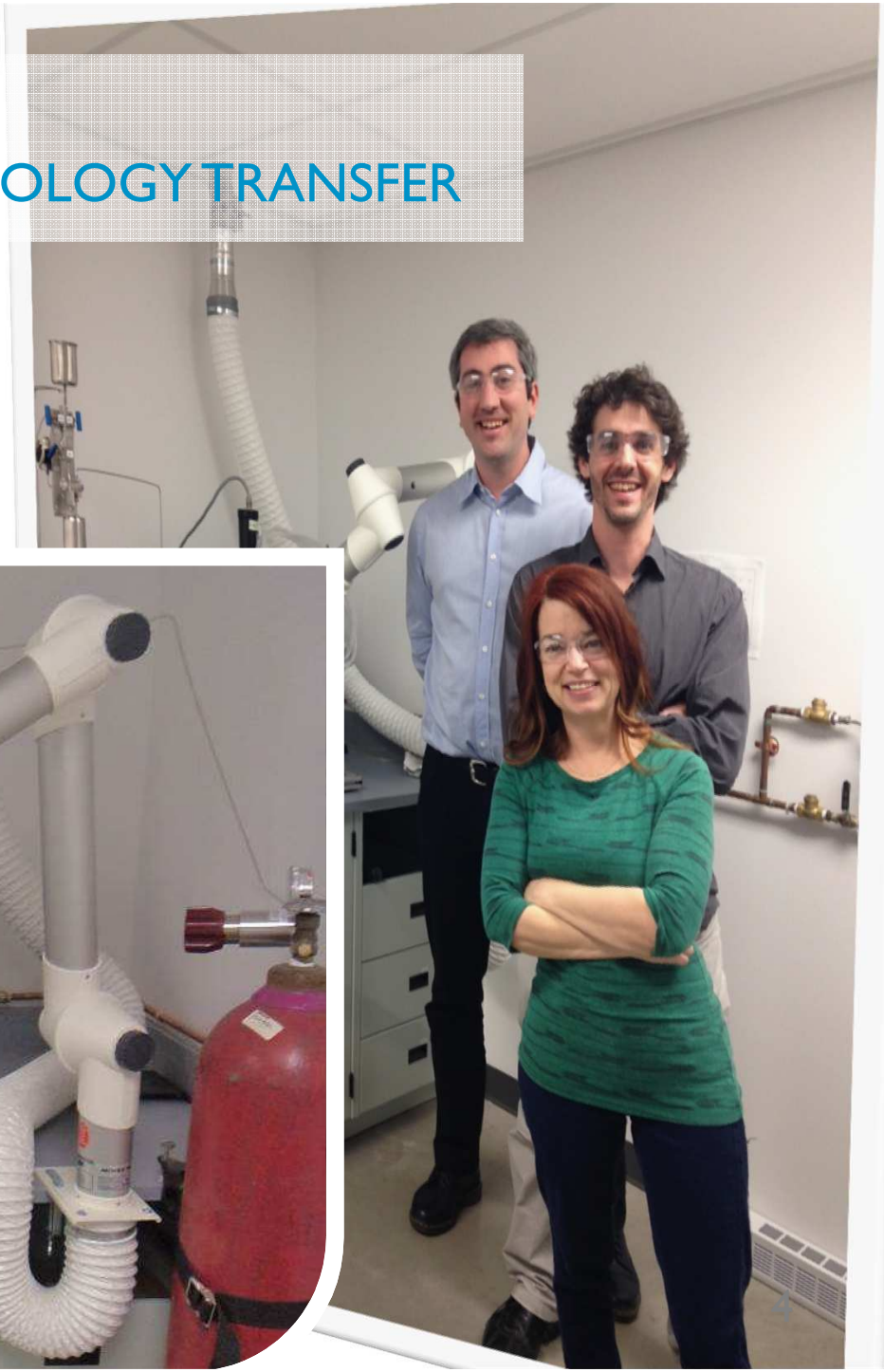
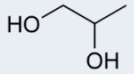
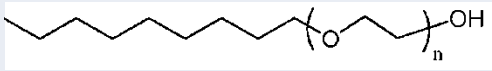
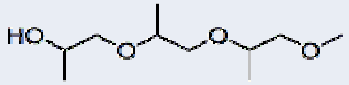
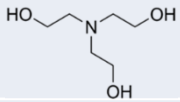
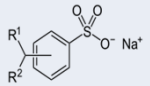
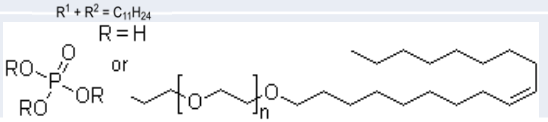
WAO AT CTTÉI
APPLIED RESEARCH AND TECHNOLOGY TRANSFER



MODEL WASTEWATER

Propylene glycol	$C_3H_8O_2$	76 g/mol	
Ethoxylated alcools	$C_{22}H_{46}O_7$ (average compound)	422 g/mol	
Tripropylene glycol methyl ether	$C_{10}H_{22}O_4$	206 g/mol	
Triethanolamine	$C_6H_{15}NO_3$	149 g/mol	
Dodecylbenzene sulfonic acid	$C_{18}H_{29}SO_3Na$	348 g/mol	
Polyoxyethylene monooleyl ether phosphate	$C_{28}H_{59}O_{10}P$ (average compound)	587 g/mol	

- Industrial reality: heterogeneous mix of products.
- Modelling a precise oxidation mecanism becomes very difficult (numerous degradation by-products, interaction and recombination).
- Necessity of case-by-case lab studies and experimental design.
- A model wastewater was synthetised and studied:
  - Mix of 6 common chemicals used by our industrial partners (coolants, lubricants, solvants, surfactants)
  - COD: 10 – 60 g/L (range studied)
  - pH: 8

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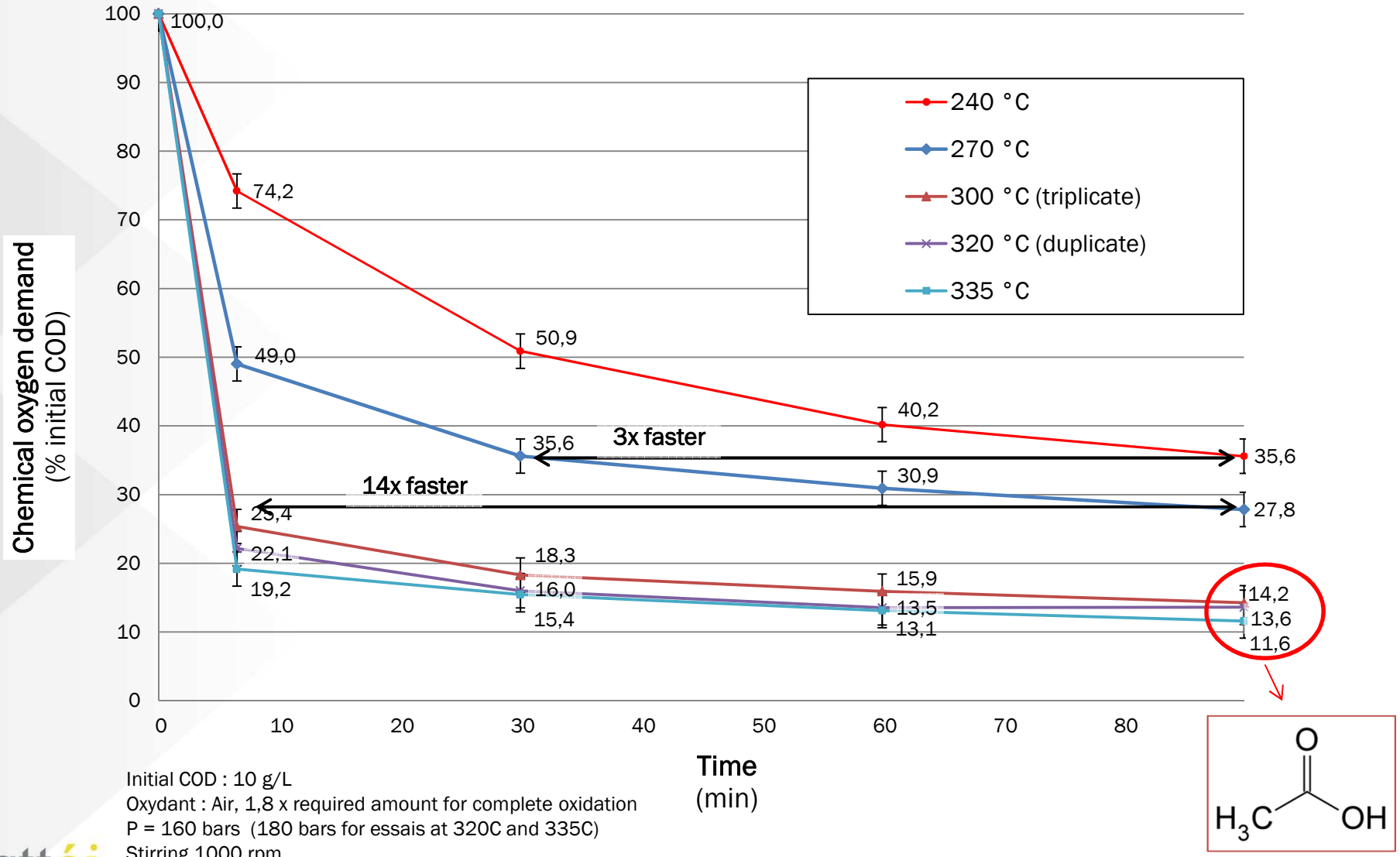
WAO OF MODEL WASTEWATER - EFFECT OF TEMPERATURE



Initial COD : 10 g/L
Oxydant : Air, 1,8 x required amount for complete oxidation
P = 160 bars (180 bars for essais at 320C and 335C)
Stirring 1000 rpm

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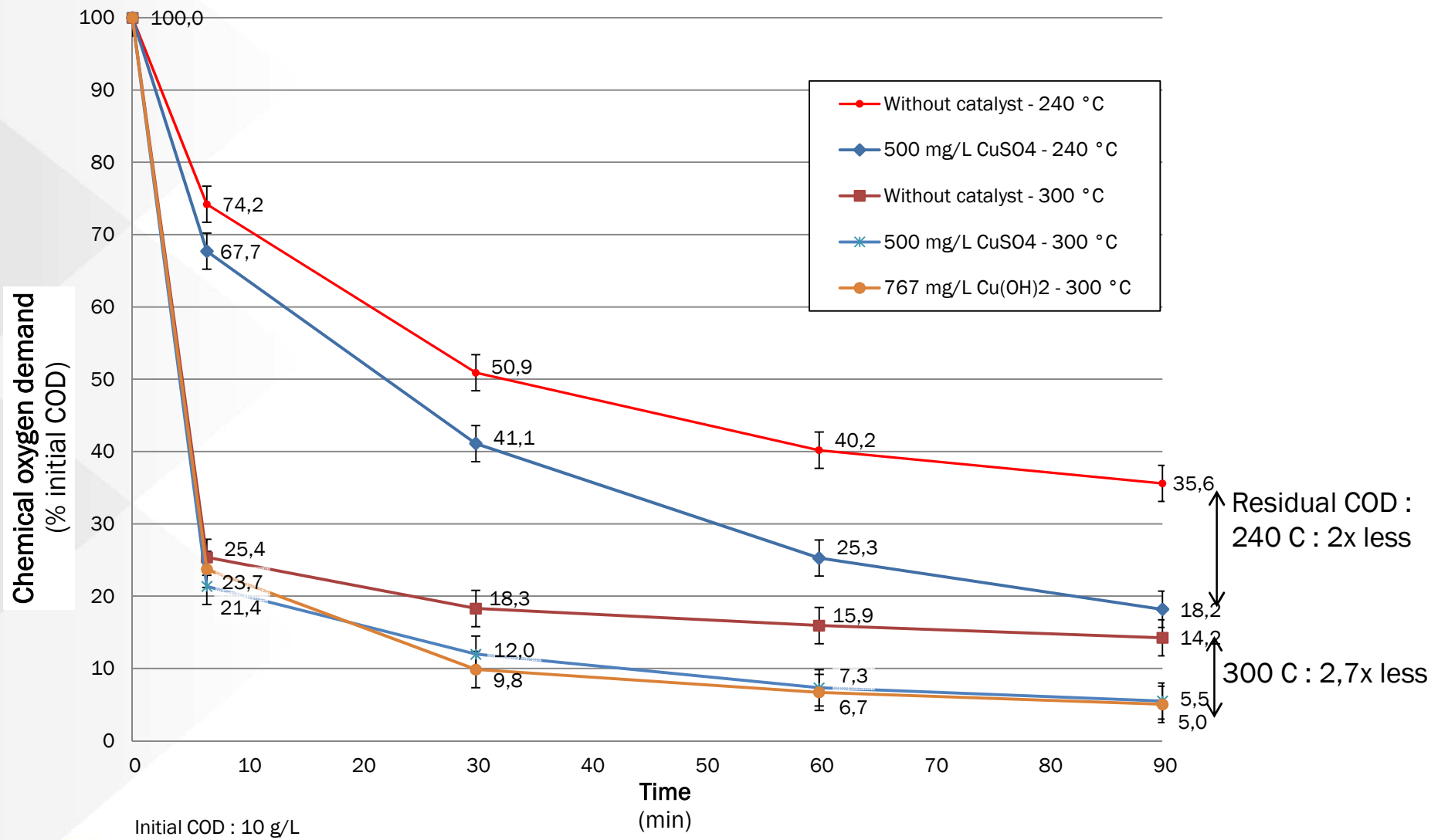
WAO OF MODEL WASTEWATER – EFFECT OF COPPER CATALYST



Initial COD : 10 g/L
Oxydant : Air, 1,8 x required amount for complete oxidation
P = 160 bars
Stirring 1000 rpm

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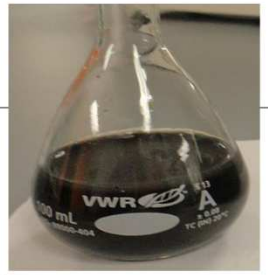
AERATED LAGOON SLUDGES

- Sewage sludges are treated by WAO at industrial scale in Europe (ex.: Brussels, Aix-en-Provence, Trucazzanno, etc.)
- Aerated lagoons are common in Québec (require large surface areas). No study was found on WAO of lagoon sludge.
- In Sorel-Tracy, Québec : 20 000 tons of sludges to dispose. The **cost of dewatering + landfilling** would be prohibitive.

VILLE DE SOREL-TRACY

WAO - AERATED LAGOON SLUDGES



Initial diluted sludges:
5200 mg/L

210°C - 100 bars
210°C - 175 bars
240°C - 100 bars
270°C - 100 bars
270°C - 175 bars
300°C - 100 bars
300°C - 175 bars

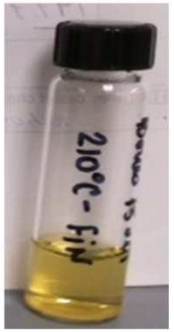
COD of sludge samples (mg/L)

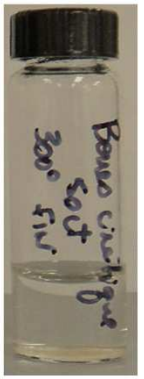
5000
4000
3000
2000
1000
0

0 10 20 30 40 50 60 70 80 90

Reaction time (min)

210°C
240°C
270°C
300°C





WAO - AERATED LAGOON SLUDGES

Example of Sorel-Tracy :
Before WAO : 20 000 tons of sludges
After : 1 400 tons of solid (> 99% inorganic) + biodegradable liquid

	Before WAO (sludge)	After WAO 300 °C (liquid phase)
COD	52 g/L	10 g/L
BOD_5	1,0 g/L	6,3 g/L
Biodegradability index (BOD_5/COD)	0,02	0,63

CONCLUSION AND FUTURE WORK

- Interesting opportunities for WAO and other green processes in Québec.
- Model wastewater : temperature has a major impact between 240 and 300 °C. Homogeneous copper catalyst shows good activity.
- Lagoon sludges can be treated effectivly with ≈ 85% COD removal on liquid phase and > 99% on solids.
- Future work :
  - **Economic analysis** : CAPEX/OPEX of studied scenarios
  - New lab equipment to reach **supercritical conditions** (> 374 °C, 220 bars)
  - Study WAO for **hospital wastewater and micropollutants**
- Always seeking new industrial and academic partners!

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QUESTIONS ?
COMMENTS ?

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Québec

Cégep de Sorel-Tracy
Avoir la réussite à cœur!

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