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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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**ctt*éi***

EXPERT EN LA MATIÈRE

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

**GPE 2016 – MONT -TREMBLANT – JUNE 23<sup>RD</sup> 2016**



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Biophysicist, M. Sc. – Project leader

# CENTRE DE TRANSFERT TECHNOLOGIQUE EN ÉCOLOGIE INDUSTRIELLE (CTTÉI)

## Technology Transfer Center

Applied research on :

- Industrial waste valorization
- Clean processes
- Industrial symbiosis

PROCÉDÉS  
PROPRES



MISE EN  
VALEUR DES  
RÉSIDUS

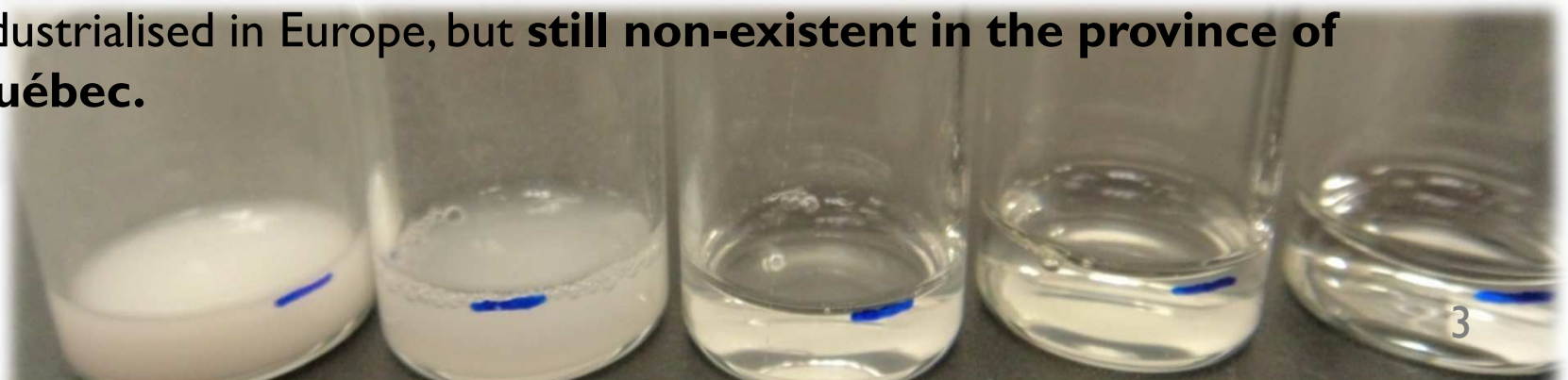


SYMBIOSE  
INDUSTRIELLE



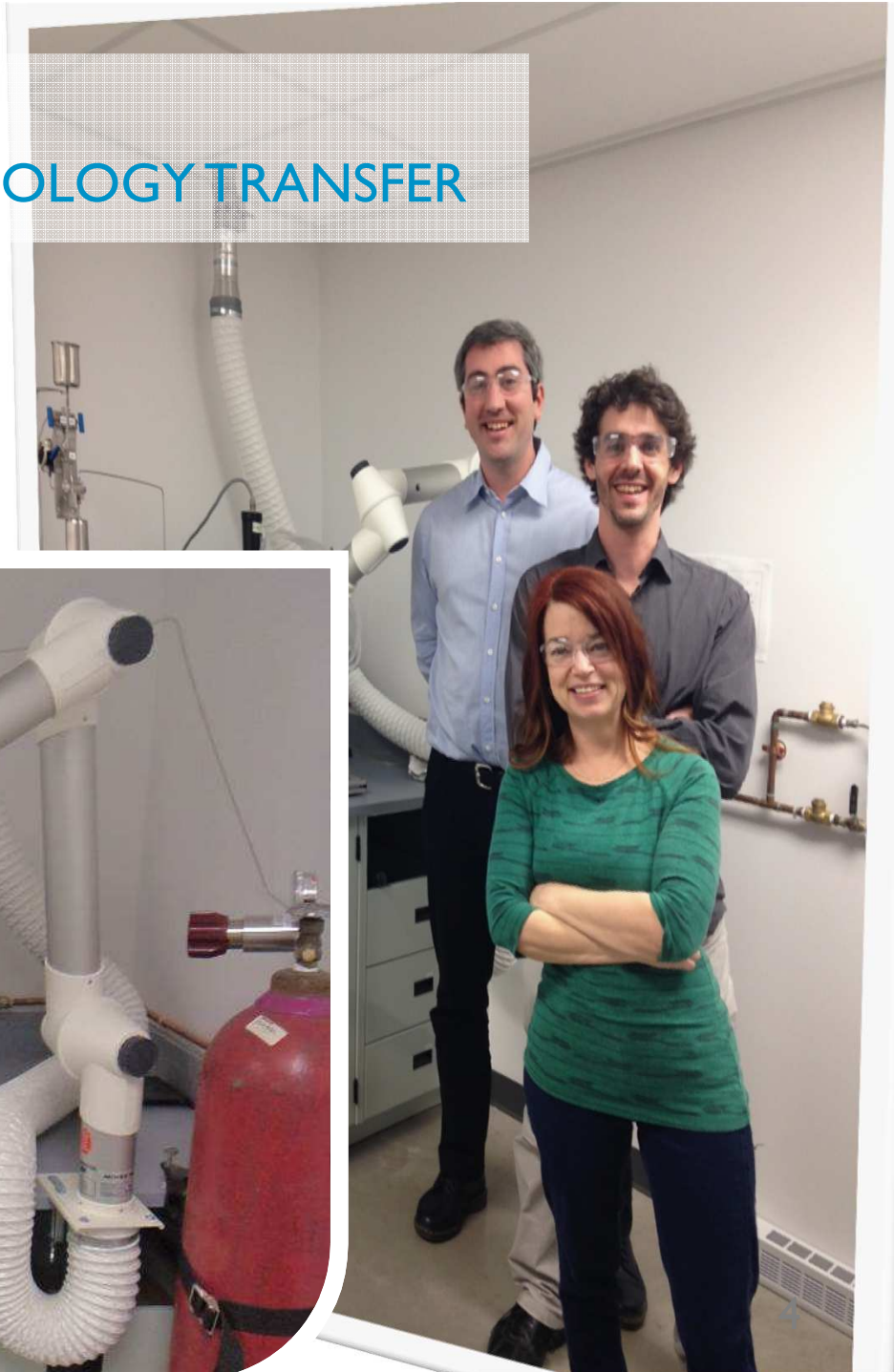
## WET AIR OXIDATION PROCESS (WAO)

- Subcritical water enriched with air or oxygen ( $\approx 150\text{--}350\text{ }^{\circ}\text{C}$ ,  $\approx 3\text{--}20\text{ MPa}$ )
- Oxygen reacts with organic compounds  $\rightarrow$  propagation of radicals:  
 $\text{R}\cdot, \text{OH}\cdot, \text{HO}_2\cdot, \text{ROO}\cdot \rightarrow$  **Exothermic oxidation** of organic compounds mostly into  $\text{CO}_2, \text{H}_2\text{O}, \text{NH}_3, \text{SO}_4^{2-}, \text{PO}_4^{3-}$
- Industrial opportunities for WAO : **wastewater too toxic or too concentrated** for biological processes, and too diluted for suitable incineration ( $> 80\% \text{ H}_2\text{O}$ )
- Better energy output than incineration (for sludge or wastewater)
- Cleaner gas emissions: no  $\text{NO}_x$ , dioxins or furans
- Better efficiency and faster treatment than other advanced oxidation processes (AOPs) for highly concentrated waste ( $> 10\text{ g/L DCO}$ )
- Economically-competitive and environmentally-friendly process industrialised in Europe, but **still non-existent in the province of Québec.**

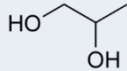
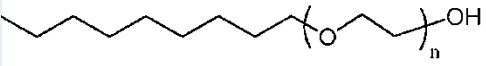
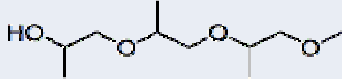
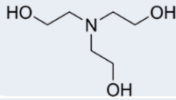
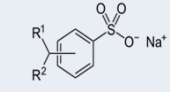
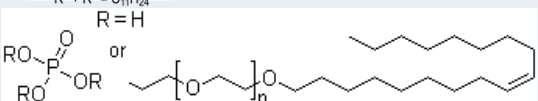




# WAO AT CTTÉI APPLIED RESEARCH AND TECHNOLOGY TRANSFER

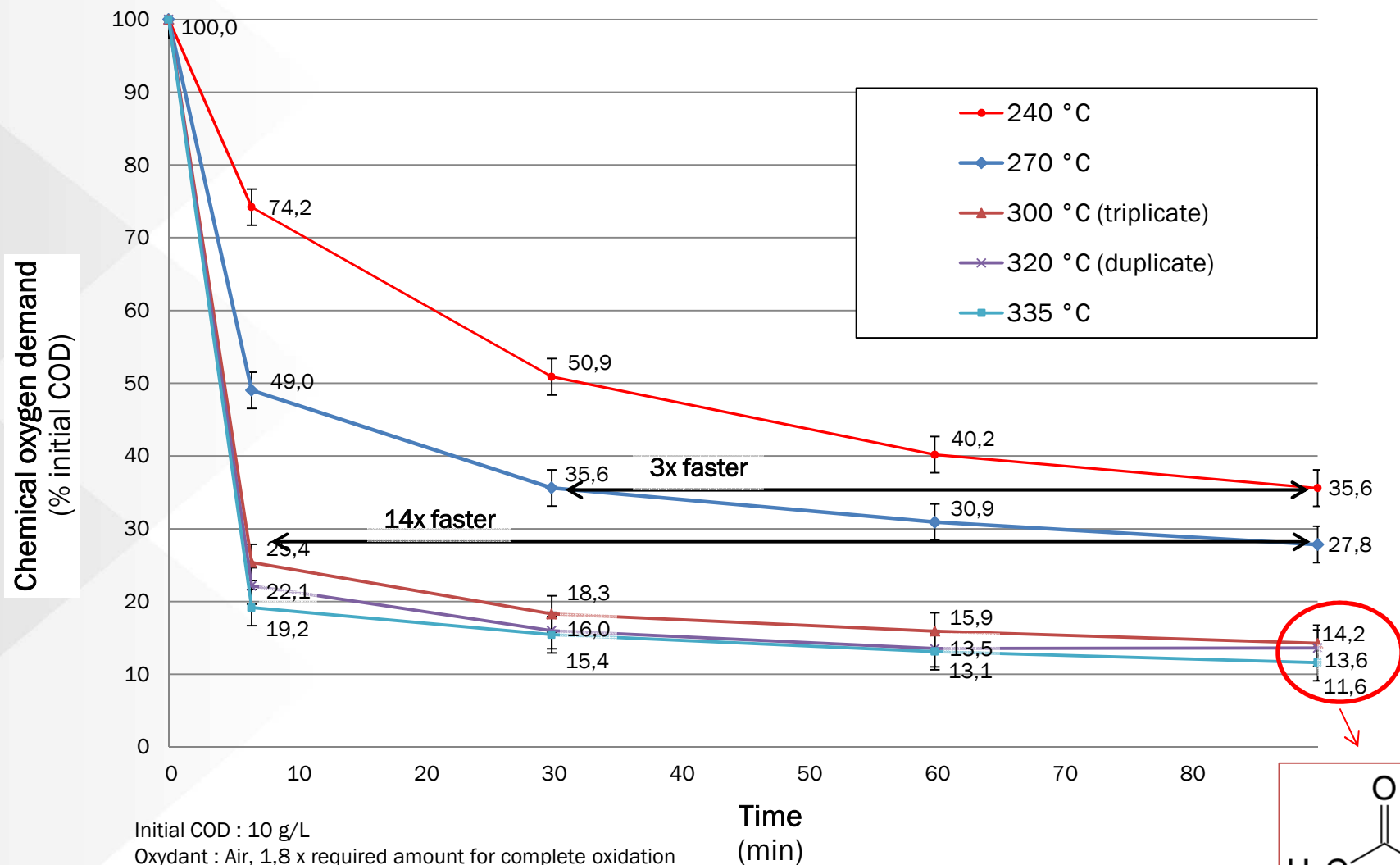


# MODEL WASTEWATER

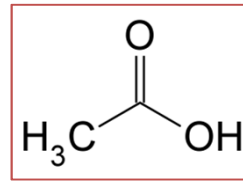
Propylene glycol	$C_3H_8O_2$	76 g/mol	
Ethoxylated alcohols	$C_{22}H_{46}O_7$ (average compound)	422 g/mol	
Tripropylene glycol methyl ether	$C_{10}H_{22}O_4$	206 g/mol	
Triethanolamine	$C_6H_{15}NO_3$	149 g/mol	
Dodecylbenzene sulfonic acid	$C_{18}H_{29}SO_3Na$	348 g/mol	 $R^1 + R^2 = C_{11}H_{24}$
Polyoxyethylene monooleyl ether phosphate	$C_{28}H_{59}O_{10}P$ (average compound)	587 g/mol	 $R = H$

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

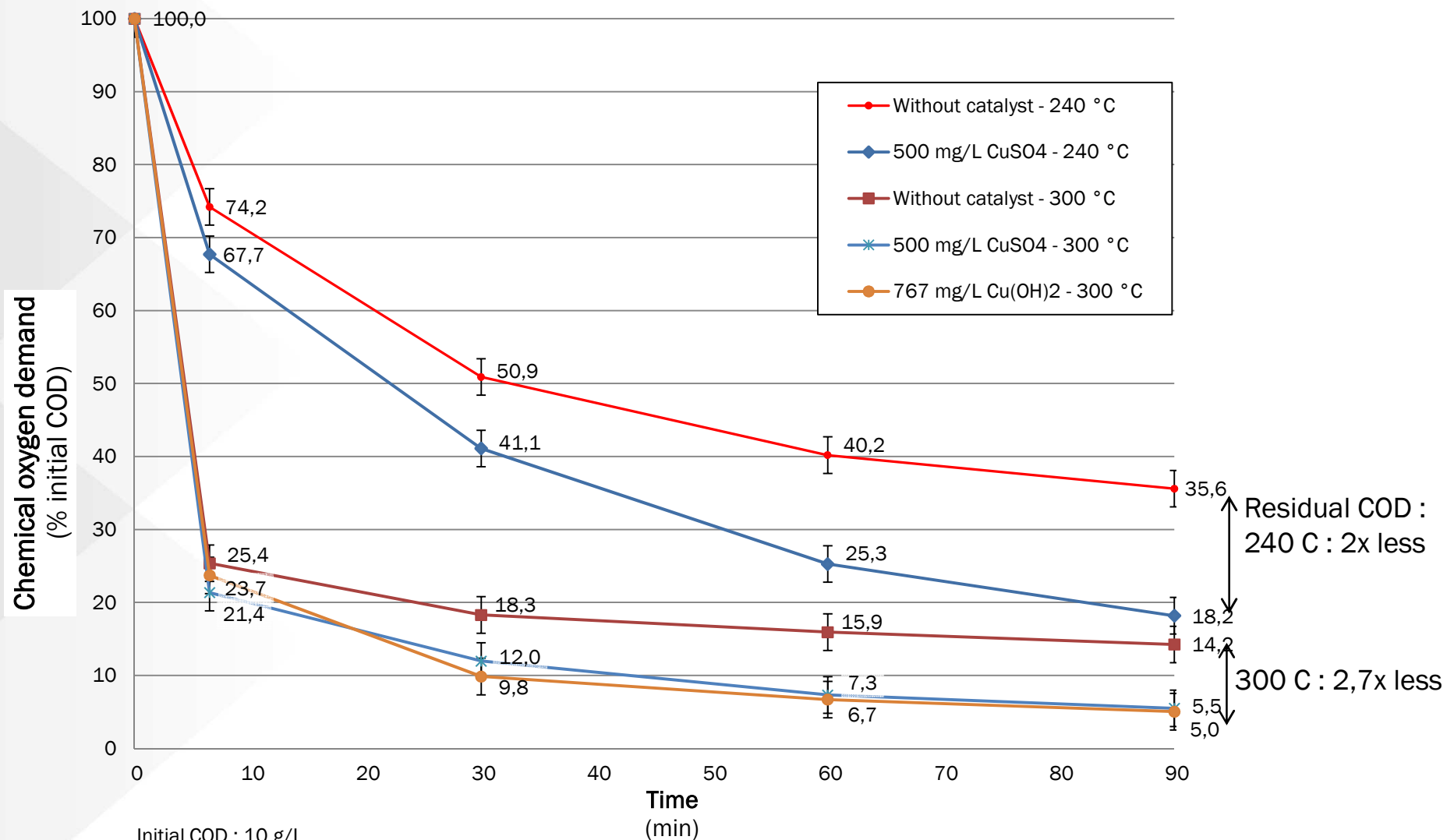
# WAO OF MODEL WASTEWATER - EFFECT OF TEMPERATURE



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



# WAO OF MODEL WASTEWATER – EFFECT OF COPPER CATALYST



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

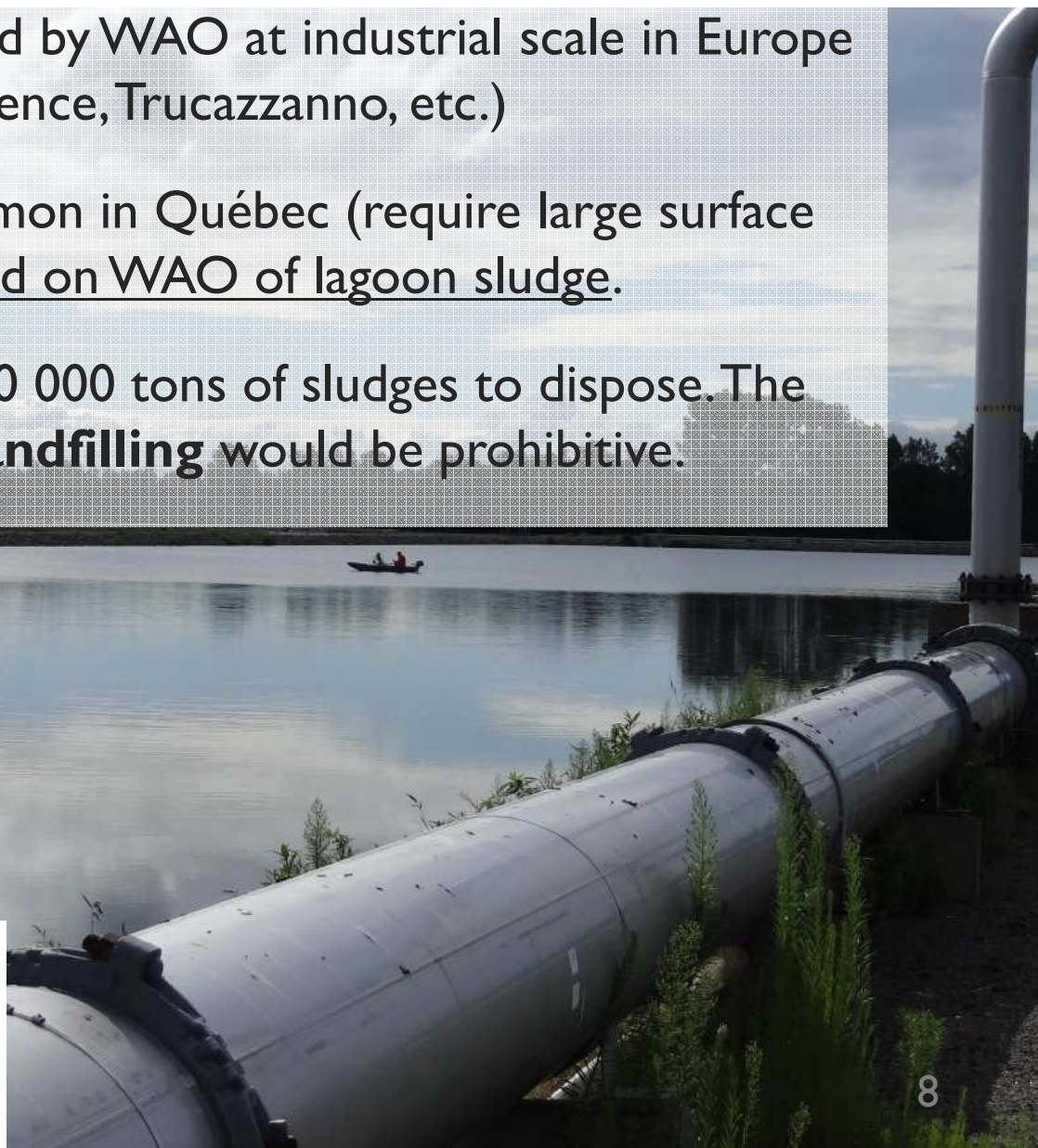


## AERATED LAGOON SLUDGES

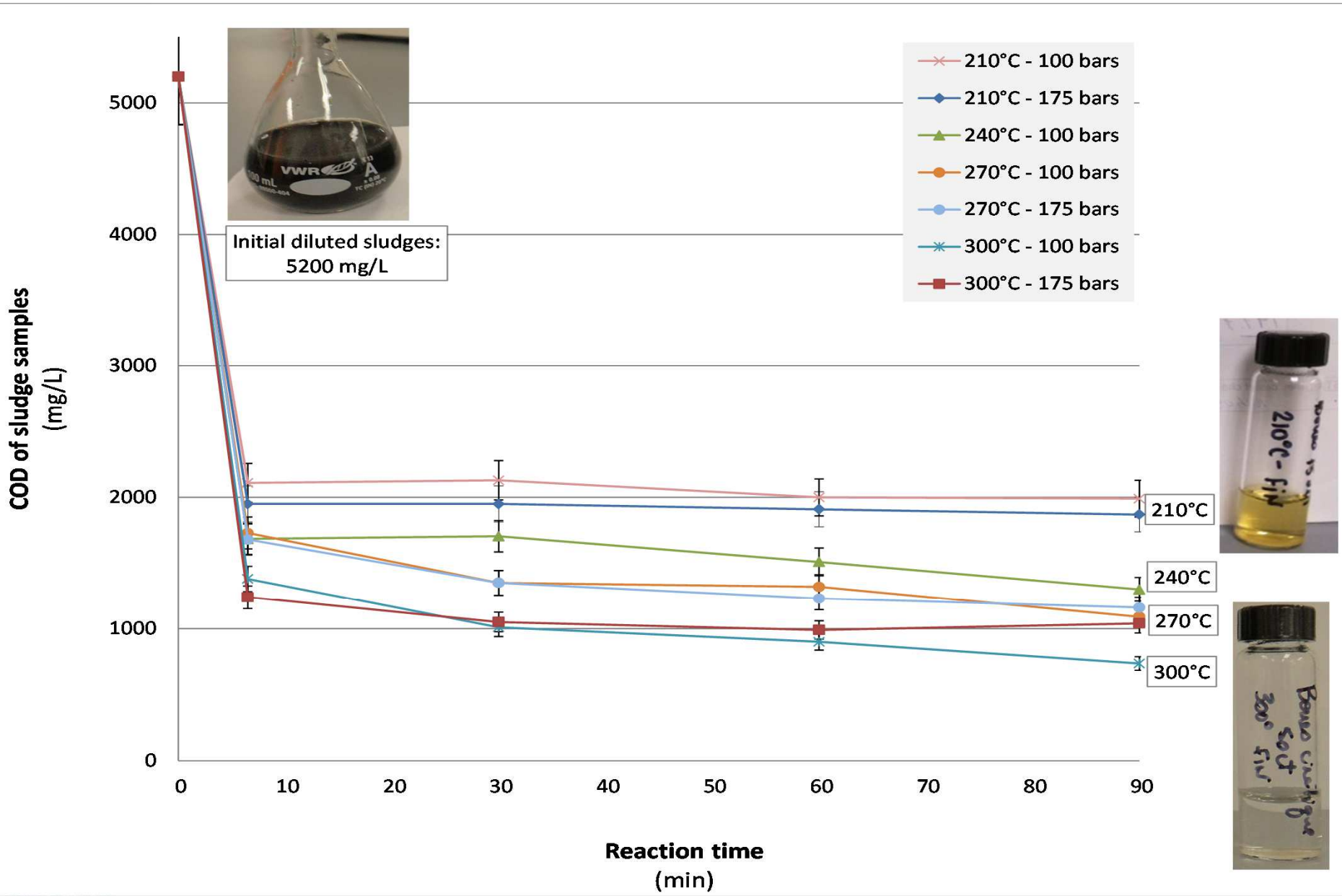
- Sewage sludges are treated by WAO at industrial scale in Europe (ex.: Brussels, Aix-en-Provence, Trucazzanno, etc.)
- Aerated lagoons are common in Québec (require large surface areas). No study was found on WAO of lagoon sludge.
- In Sorel-Tracy, Québec : 20 000 tons of sludges to dispose. **The cost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



VILLE DE  
SOREL-TRACY



# WAO - AERATED LAGOON SLUDGES





# 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 <sub>5</sub>	1,0 g/L	6,3 g/L
Biodegradability index (BOD <sub>5</sub> /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 effectively with  $\approx 85\%$  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!





**QUESTIONS ?  
COMMENTS ?**

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EXPERT EN LA MATIÈRE

Québec 

 Cégep de Sorel-Tracy  
*Avoir la réussite à cœur!*

 **CRSNG  
NSERC**