Seminaire HELIOSPIR – 7 décembre 2010

15 years of ICA in wastewater treatment bioprocesses: What did we learn ?

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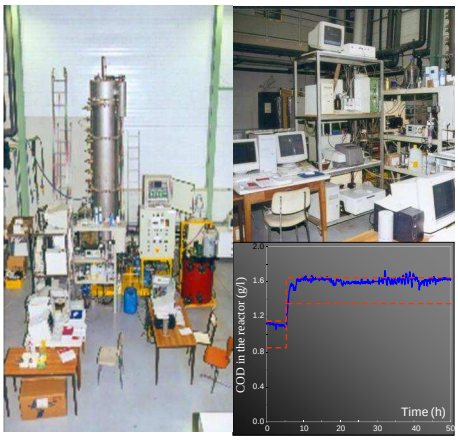


Contents of the presentation

1) ICA in WWTPs

- ✓ *The hidden technology*

2) Instrumentation

- ✓ *From "data poor" to "data rich"*

3) Models and software sensors

- ✓ *From "information poor" to "information rich"*

4) Controllers

- ✓ *Use of data*

5) Diagnosis

- ✓ *Use of information*

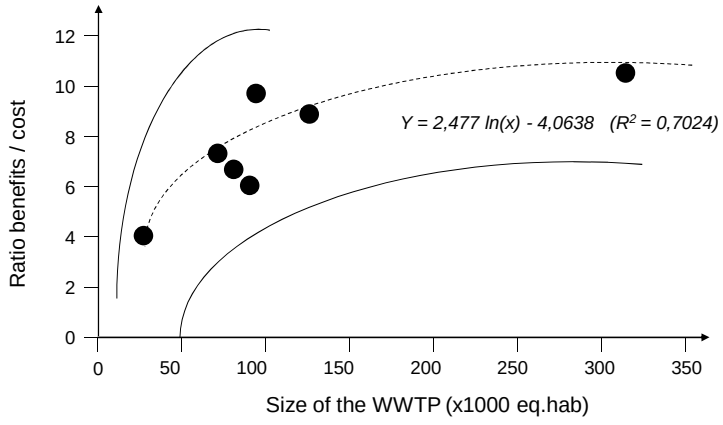
ICA at the international level

What is your judgement of ICA utilisation ?

A lot more could be gained	11 %
More could be gained	55 %
Maybe more could be gained	28 %
Nothing more could be gained	6 %

(from Ingildsen et al., 2001)

Economical aspects of ICA



ICA in wastewater management

ICA: The hidden technology:

You will only notice it when it does not work

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ICA Research at LBE

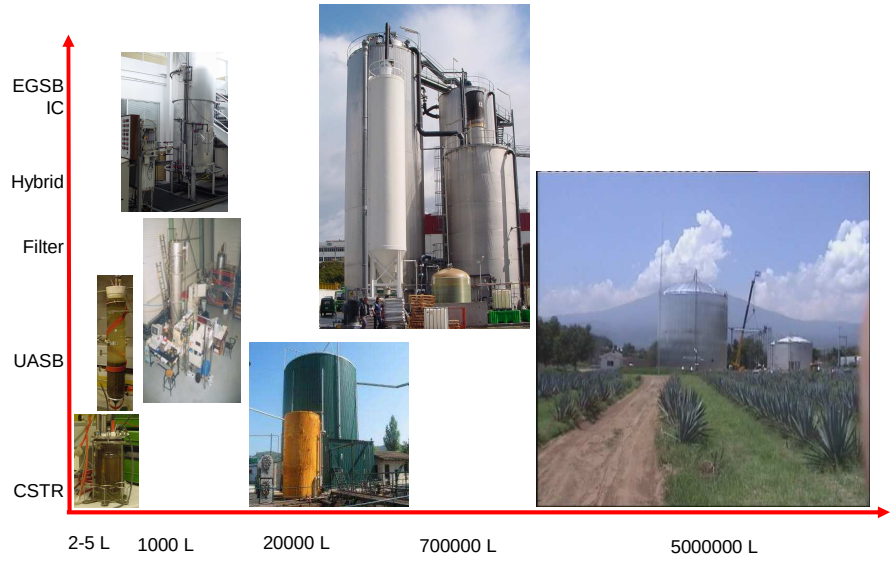
Measurement,

Analysis,

Monitoring

of Uncertainty

AD Processes studied



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The PEACE pilot scale fixed bed reactor

Influent : **Raw industrial distillery vinasses**

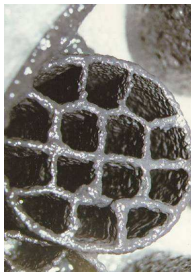
i.e., COD up to 40 g/l (mainly soluble)

Reactor : **Circular column up-flow fixed bed reactor**

- 3.5 m height,
- 0.6 m diameter.

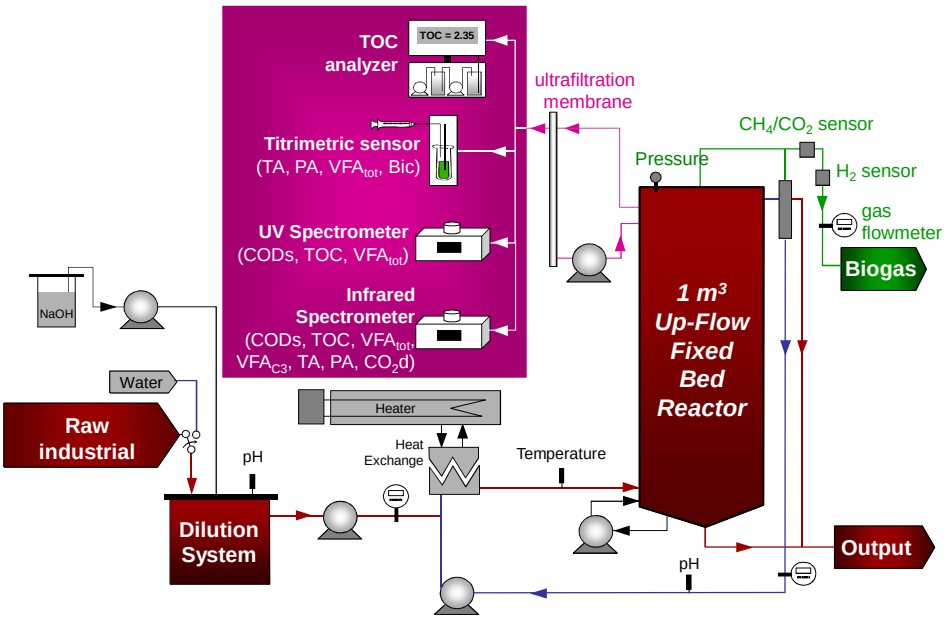
Medium : **Cloisonyle®**

- Specific surface : 180 m^2/m^3
- Volume : 33.7 liters



Liquid Volume : **948 litres**

Schematic layout of the plant

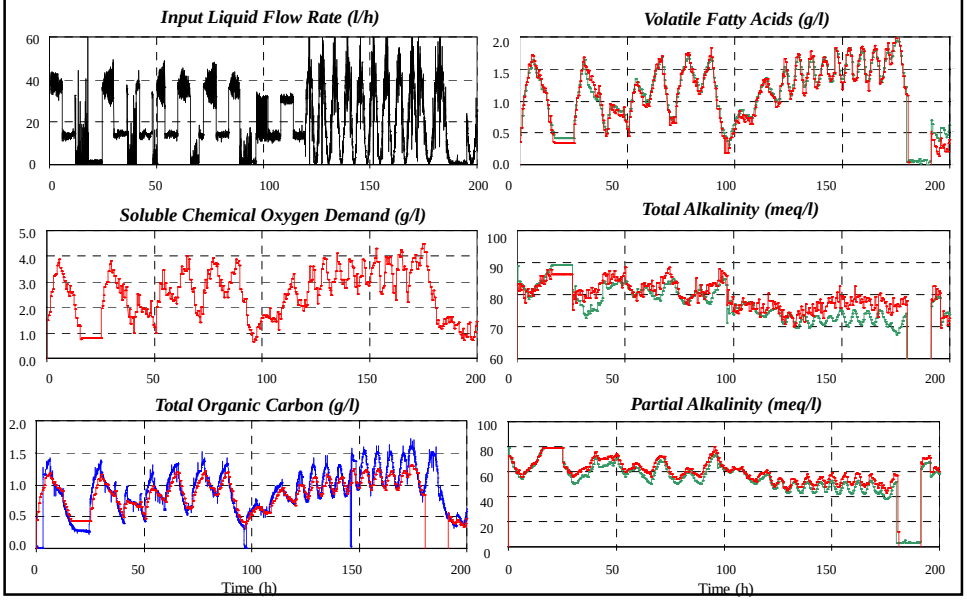


The PEACE pilot scale fixed bed reactor

In 1997

Since 1999

Benefits of a fully instrumented reactor



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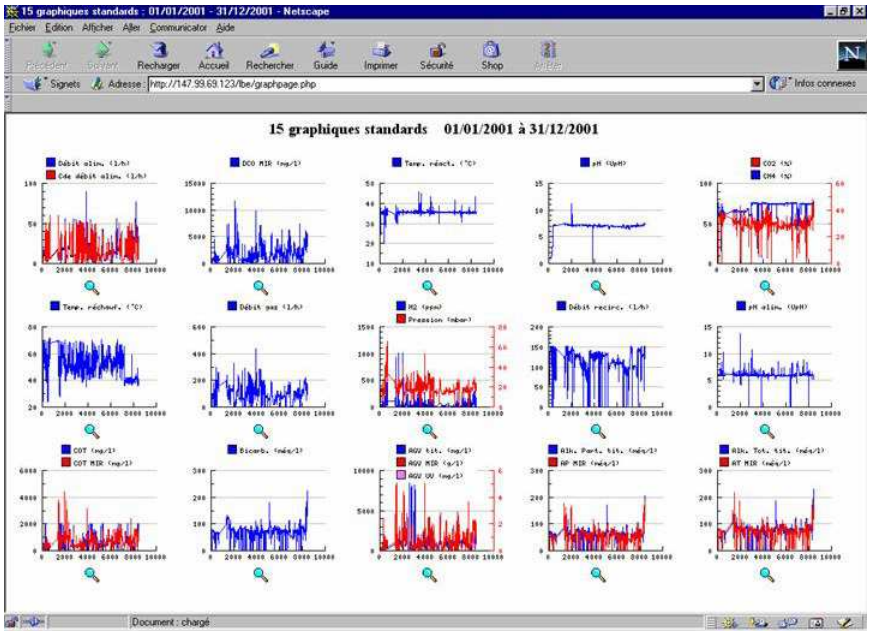


Why so many on-line sensors ?

Practical evalutation

of the respective benefits

of a measuring technique

Which sensor has the largest potential for industrial use ?
(*i.e.*, maximum of information for minimum of maintenance)

Which sensor(s) for which measurement(s)?

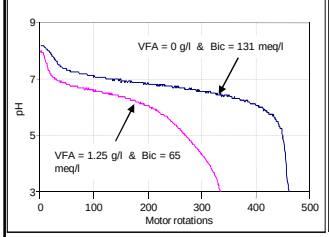
	From classical measurements (pH, T, Qgas, %CO2, P)	TOC analyzer	Titrimetric sensor	UV spectrometer	IR spectrometer
Partial Alkalinity			✓		✓
Total Alkalinity			✓		✓
Bicarbonate	✓		✓		✓
Dissolved CO2	✓				✓
TOC		✓		✓	✓
Soluble COD				✓	✓
Total VFAs			✓	✓	✓
Acetate					✓
Others (*eg.*, N, P)			✓	✓	✓

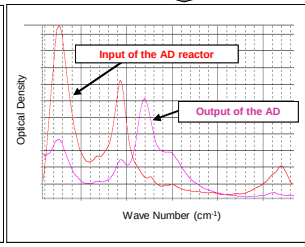
Towards *smart* sensors

Anasense®

TOCmeter

Infrared spectrometer





Towards *smart* sensors

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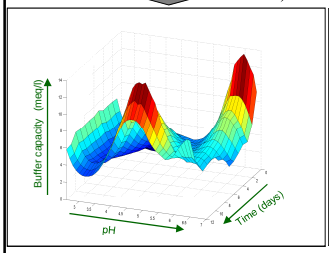
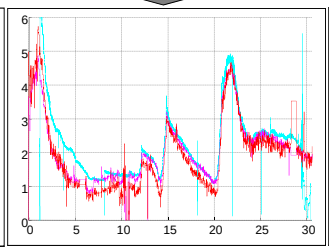
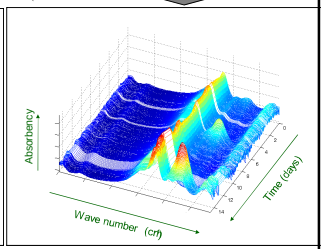




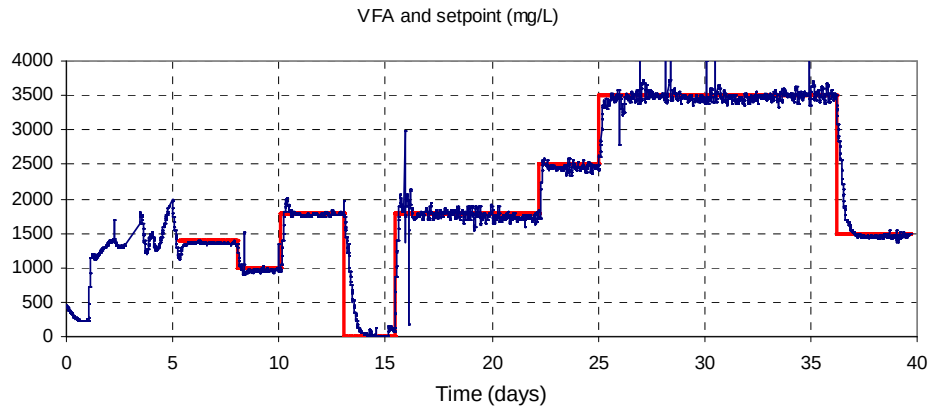


✓ **Sensors should provide a confidence index to the plant managers**

Conclusions on instrumentation

- ***On-line instrumentation is mandatory***
- ***It allows large benefits***
- ***Reliability is coming (smart sensors)***
- ***In the near future : spectral measurements***
- ***In the long future : molecular tools***

Monitoring and control on the long term



Performances of AD Processes

Anaerobic lagoon

Fluidised bed reactor

Same wastewater, same quatity of COD removed and of biogas produced

BUT...

✓ 300 m^3	✓ 0.15 m^3
✓ 21 days	✓ 1 day
✓ open loop (no control)	✓ closed loop control

From my experience in control

	Performances	Mathematical Complexity	Instrument Complexity
PID	☹	☺	☺
Fuzzy Logic	☺ ☺ ☺	☺	😐 😐
Neural Networks	😐 😐	😐 😐	☹ ☹ ☹
Adaptive Control	☺ ☺ ☺	😐 😐	☺
Linear Optimal Control	😐 😐	😐 😐	😐 😐
Non Linear Robust Control	☺ ☺ ☺	☹ ☹ ☹	☹ ☹ ☹

Note *: You need to be "in love" with the process you want to control (or at least to understand it very well) if you want to get good - and relevant - results*

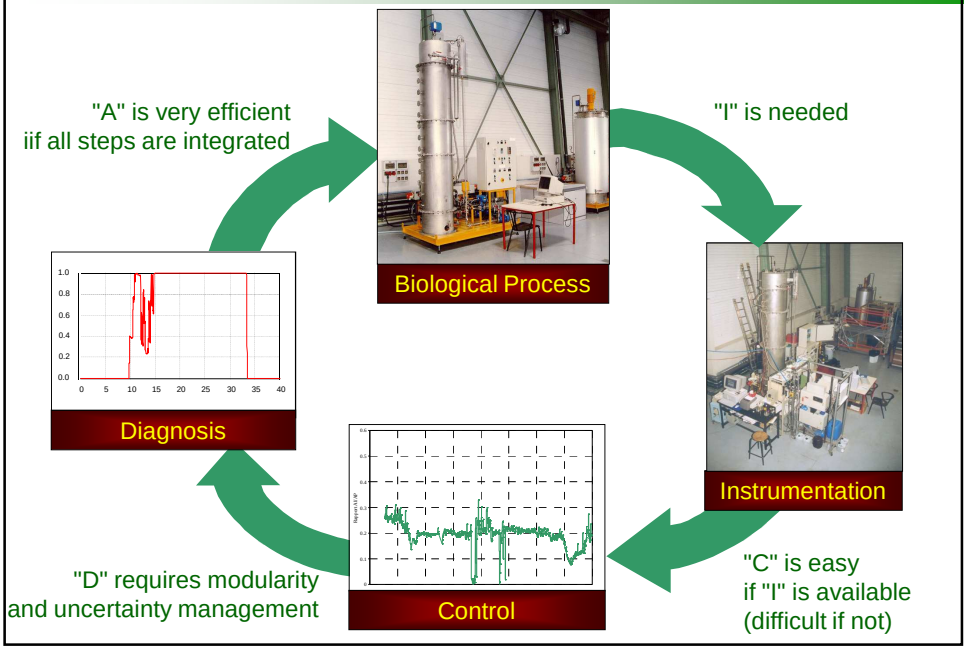
Conclusions on control

The "KISS" principle

"Keep It Simple !!!"

Or at least, "Keep It Structured !!!"

Conclusions



Many people were also involved

Thierry Conte *Pascal Gras* *J-Philippe Delgénès* *Eric Latrille*
Philippe Sousbie *Arnaud Hélias* *Laurent Lardon*
Nicolas Bernet *Jonathan Hess*
Olivier Bernard *Juan Bastidas* *Domi Patureau* *Jérôme Harmand*
Ana Punal *Antoine Genovesi* *Benoit Beraud* *Jean-Claude Bouvier* *Pierre Rousseau*
Victor Alcaraz
Cyrille Bronner
Marion Leclerc *Fred Habouzit* *Maxime Estaben*
Luca Palazzotto
James Lennox *Damien Rolland* *Carlos Salazar*
Gonzalo Ruiz *Martijn Devisscher* *Marianne Dupla*
Mathieu Lesteur
François Miens *Liliana Delgadillo*
Bruno Sialve
Jean-Baptiste Loos *Christophe Bataille* *Jorge Rodriguez*
Hugo Mendez
Ivan Ramirez *Alexis Mottet*
Cyrille Trzebowski
Jean-Pierre Jouanny
Adele Elias *Anne-Gaëlle Manh*
Rafael Munoz
Amaya Franco *Bérengère Vignal*
Ludivine Pacheco *Michel Solatges*
Emmanuel Morel
Belynda Brahimi *Benjamin Bonnet*
Sara Cadeac
Marit Ackerman *Erig Rospape* *Jorge Rodriguez*

To know more…

Instrumentation

- ✓ J-Ph. Steyer, J-C. Bouvier, T. Conte, P. Gras, P. Sousbie *"Evaluation of a four year experience with a fully instrumented anaerobic digestion process"*, Water Science and Technology, vol. 45, n°4-5, pp. 495-502, 2002.
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- ✓ L. Mailleret, O. Bernard, J-Ph. Steyer: *"Robust nonlinear adaptive control for bioreactors with unknown kinetics"*, Automatica, vol. 40, n°8, pp. 1379-1385, Août 2004.

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- ✓ L. Lardon, A. Punal, J-Ph. Steyer: *"On-line diagnosis and uncertainty management in biological wastewater treatment processes"*, Journal of Process Control, vol. 14, pp. 747-763, 2004.
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And also: G. Olsson, M. Nielsen, Z. Yuan, A. Lynggaard-Jensen, J-Ph. Steyer: *"Instrumentation, Control and Automation in Wastewater Systems"*, IWA publishing, 246 pages (2005)

Many thanks to you for your interest !!!

We do not inherit our land from our ancestors
but we borrow it to our children

Antoine de Saint Exupéry