
III.Conference on

"Monitoring & Process Control of Anaerobic Digestion Plants"

SPECIAL EVENTS

March 30 – 31, 2017
Tagung AquaMak (in German):
Aquatische Makrophyten – ökologisch und ökonomisch optimierte Nutzung (BMEL/FNR)

March 28, 2017
Workshop Record Biomap:
Biomethane production in small and medium scale units (EU-HORIZON)

MARCH 29 — 30
2017 IN LEIPZIG

Biomass energy use

Federal Ministry for Economic Affairs and Energy

PtJ Projektträger Jülich Forschungszentrum Jülich

DBFZ

HELMHOLTZ ZENTRUM FÜR UMWELTFORSCHUNG UFZ

Landesbetrieb Hessisches Landeslabor

Instrumentation and control of anaerobic digestion processes :
A review and some research challenges

INRA SCIENCE & IMPACT

Jean-Philippe Steyer

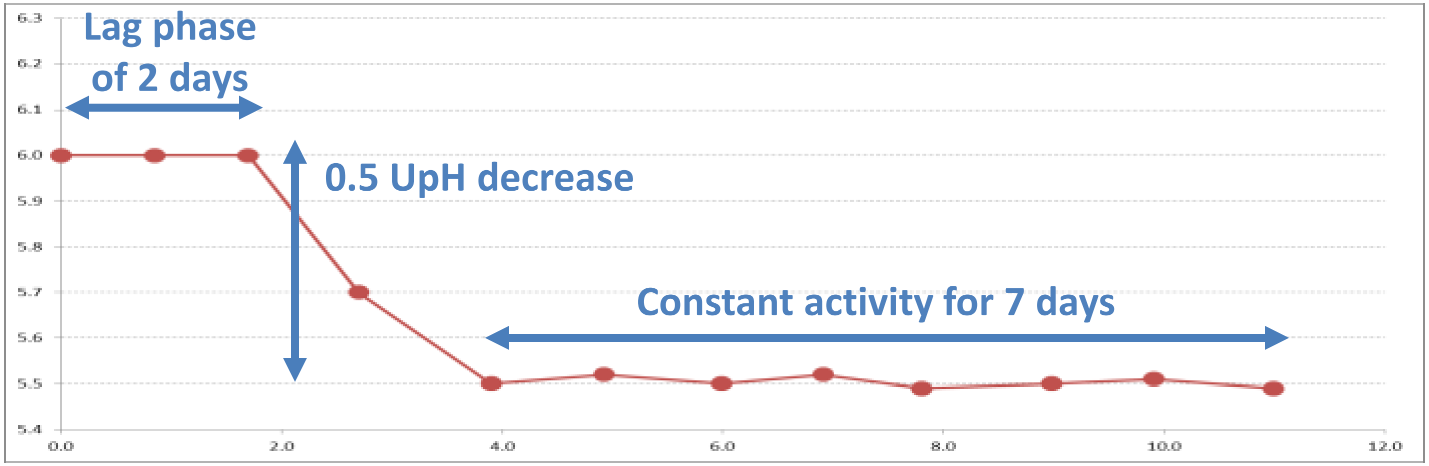
Laboratoire de Biotechnologie de l'Environnement – INRA
Narbonne - France

Content of the presentation

- Instrumentation in WW : Why ?
- Instrumentation in AD : Liquid Samples
- Instrumentation in AD : Solid Samples
- What is next ?

An example of the benefits of on-line instrumentation

Analysis of the start-up of dark fermentation from an *off-line* measurement of pH every day at 9:00 am



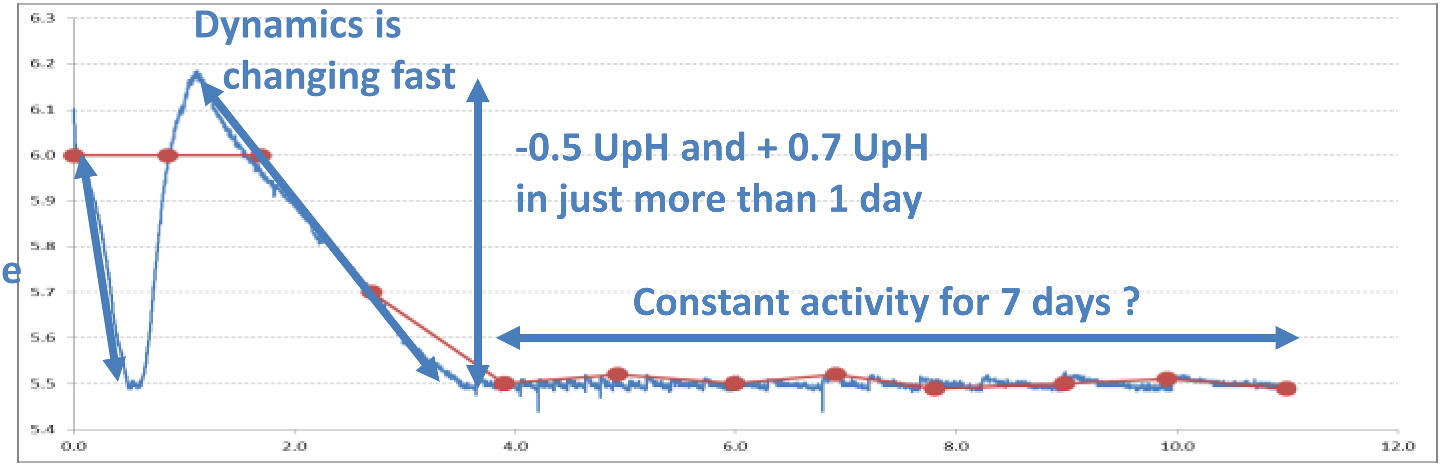
Lag phase of 2 days

0.5 UpH decrease

Constant activity for 7 days

An example of the benefits of on-line instrumentation

The same with *on-line* measurements of pH every 3 minutes

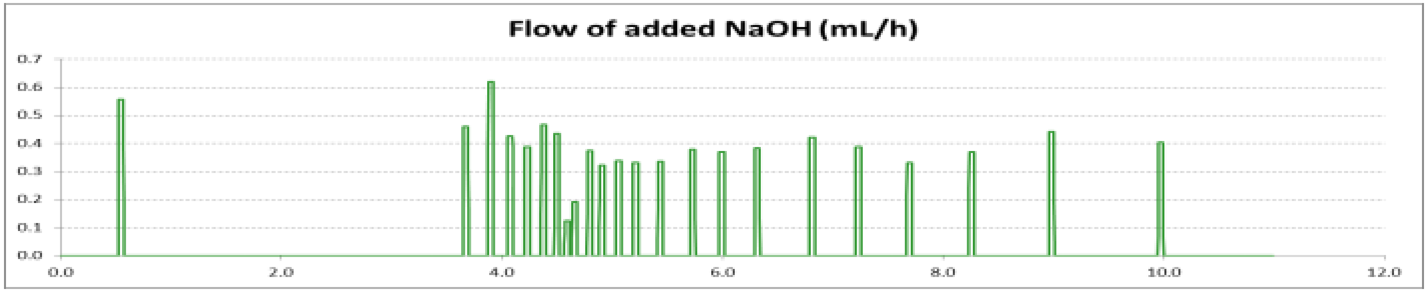


Dynamics is changing fast

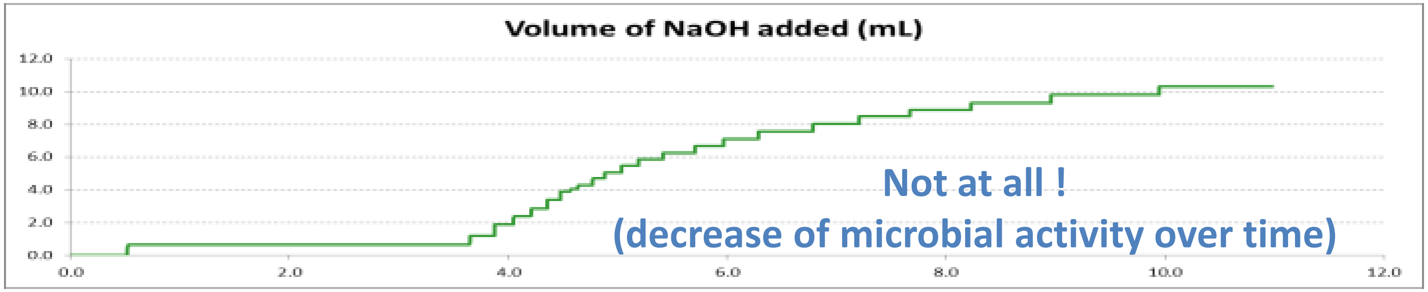
-0.5 UpH and + 0.7 UpH in just more than 1 day

No lag phase at all

Constant activity for 7 days ?



Flow of added NaOH (mL/h)



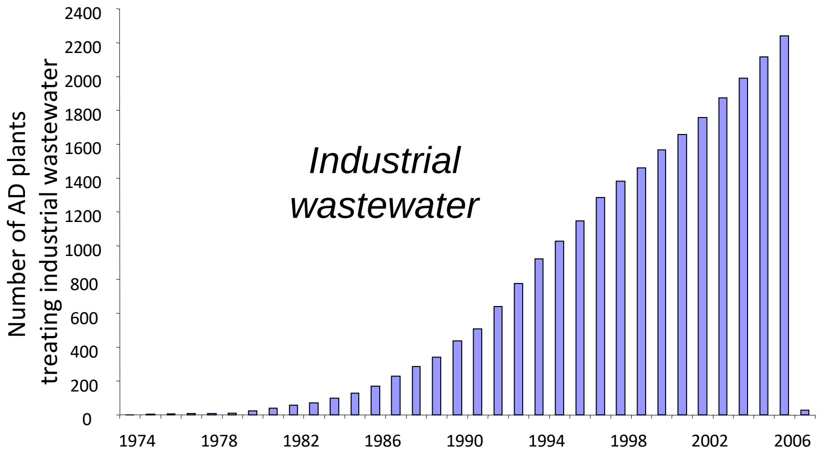
Volume of NaOH added (mL)

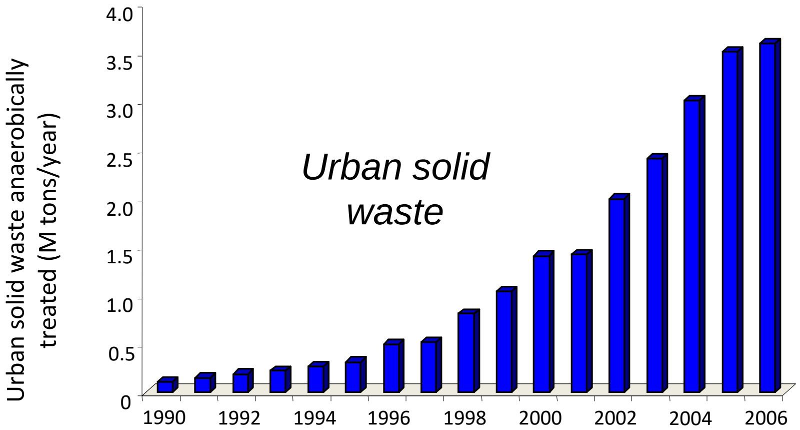
Not at all !

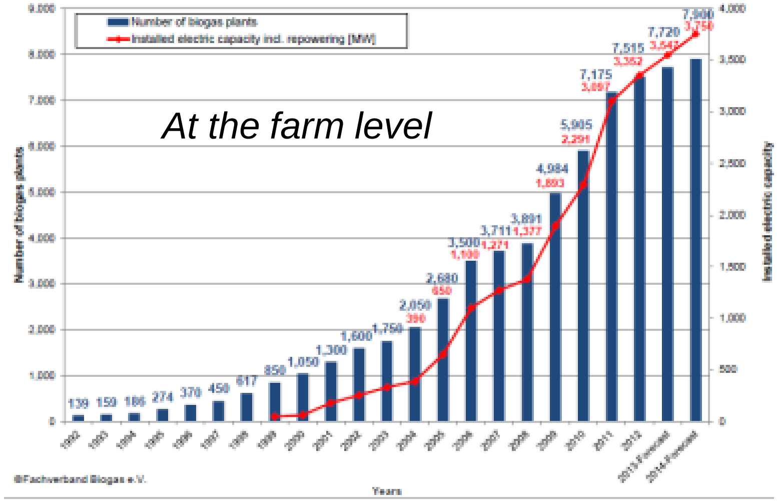
(decrease of microbial activity over time)

There is also a lot of information when looking at the actuators !

Change in AD process dynamics impacts requirements on instrumentation and control







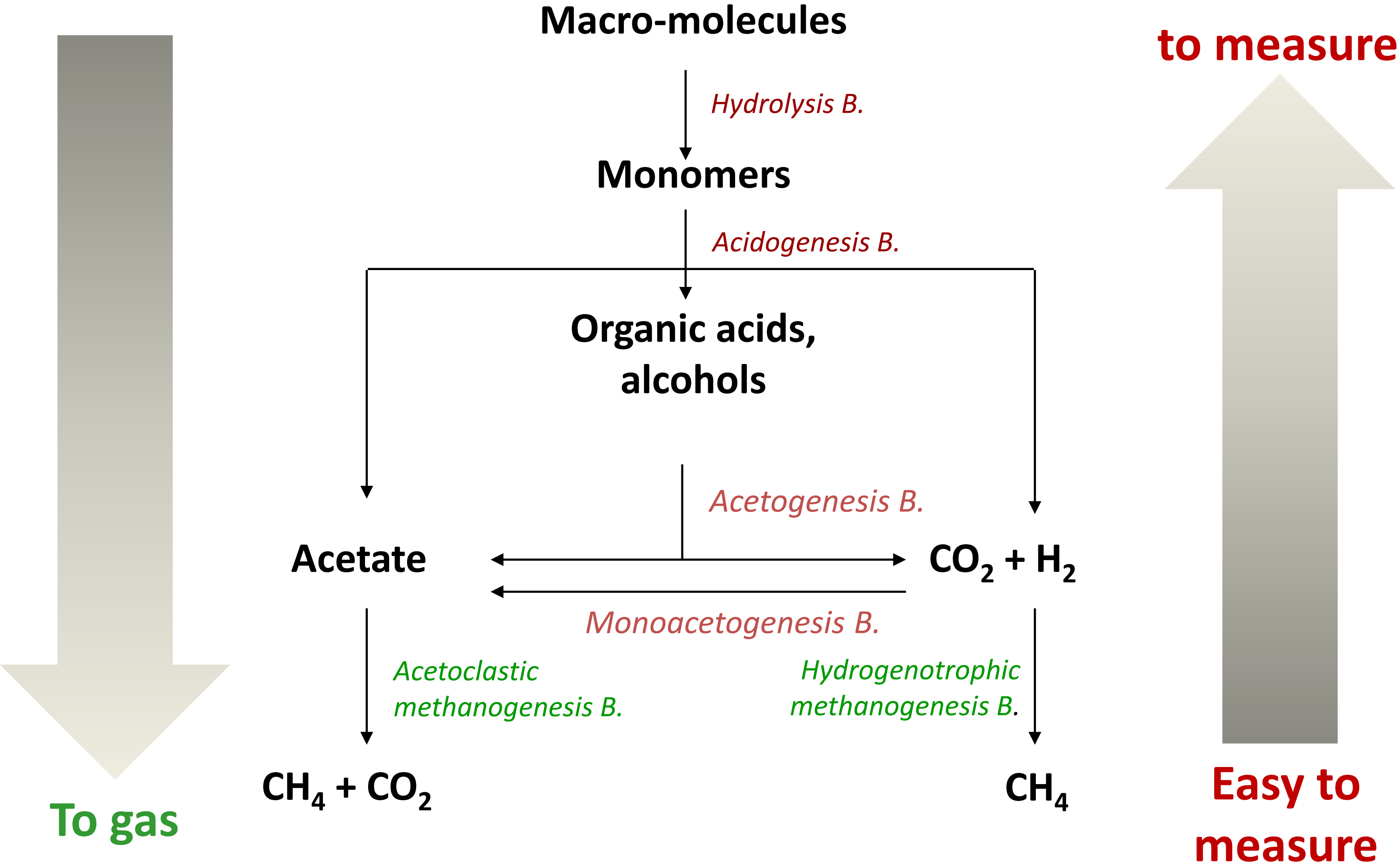
HRT : from hours…

- ⇘ Real time and closed loop control
- ⇘ Monitoring of the overall process

…to days and weeks

- ⇘ Human operator and open loop
- ⇘ Precise characterisation of the inputs (codigestion)

Instrumentation for AD : How ?



From solid

Macro-molecules

Hydrolysis B.

Monomers

Acidogenesis B.

Organic acids, alcohols

Acetogenesis B.

Acetate

$CO_2 + H_2$

Monoacetogenesis B.

Acetoclastic methanogenesis B.

Hydrogenotrophic methanogenesis B.

$CH_4 + CO_2$

CH_4

To gas

Difficult to measure

Easy to measure

An end-product is not really informative

Content of the presentation

- Instrumentation in WW : Why ?
- **Instrumentation in AD : Liquid Samples**
- Instrumentation in AD : Solid Samples
- What is next ?

An Anaerobic Digestion Process in Narbonne

Influent : Raw industrial distillery vinasses

Reactor : Circular column
Up-flow fixed bed reactor

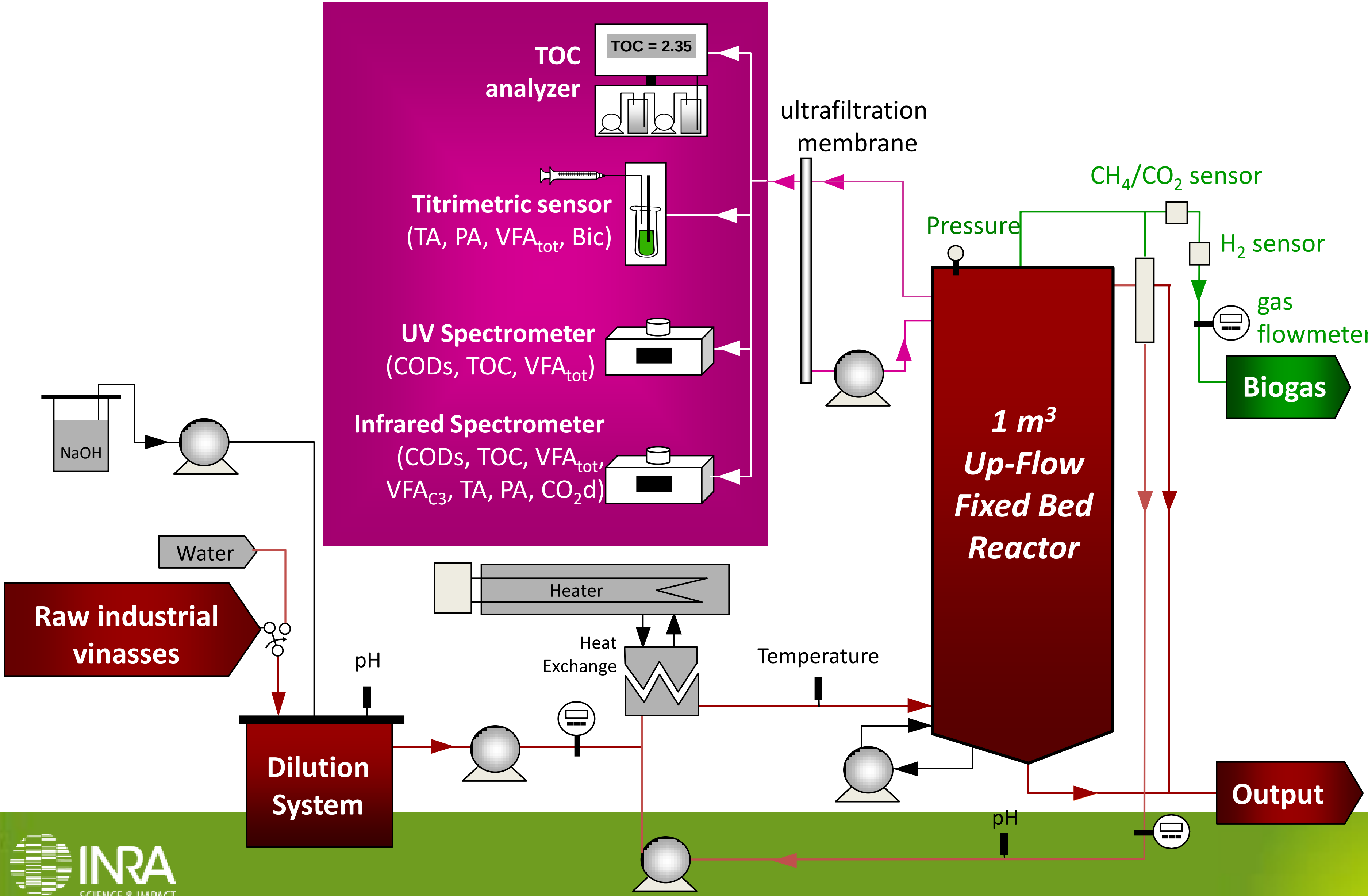
- 3.5 m height,
- 0.6 m diameter,
- 982 liters of total volume.

Media : Cloisonyl

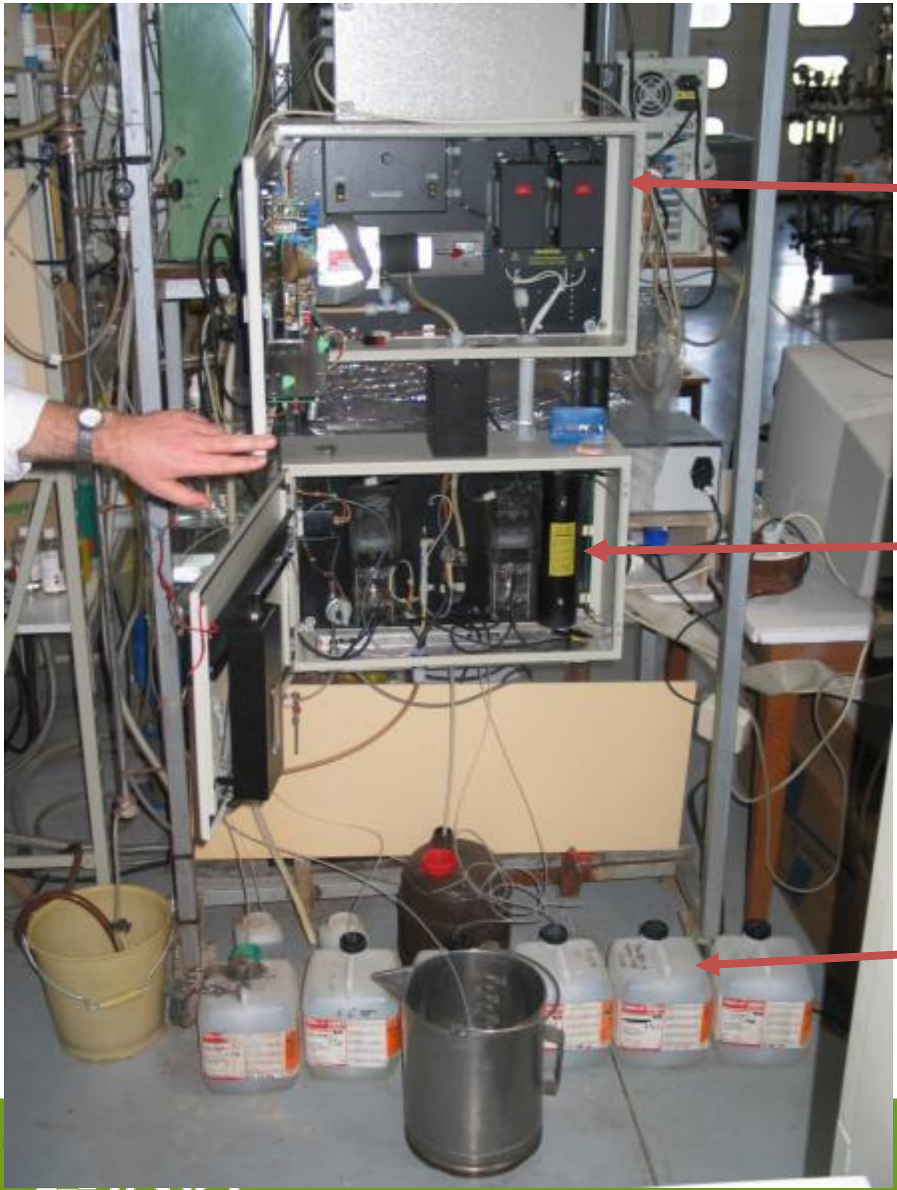
- Specific surf. : 180 m^2/m^3
- Volume : 33.7 liters

Total effective volume : 948 liters

Schematic layout of the plant



TOC analyzer: Automated chemistry

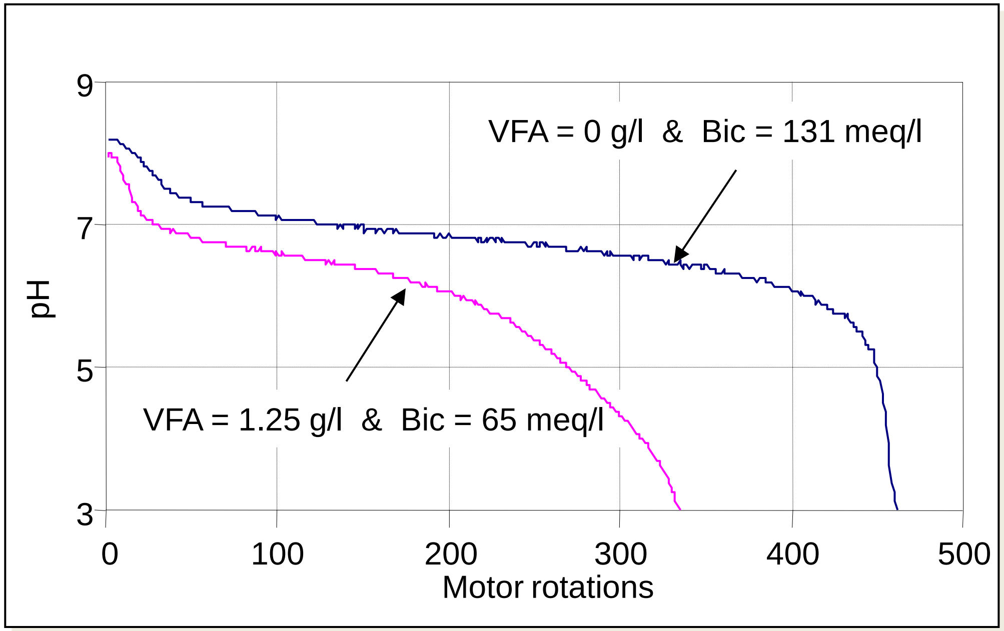


3) The gaseous CO_2 produced is analyzed by an IR sensor and is proportionnal to the TOC concentration

2) The "dissolved CO_2 free" sample is oxydized with a UV lamp

1) Chemicals are added to remove dissolved CO_2 from the sample

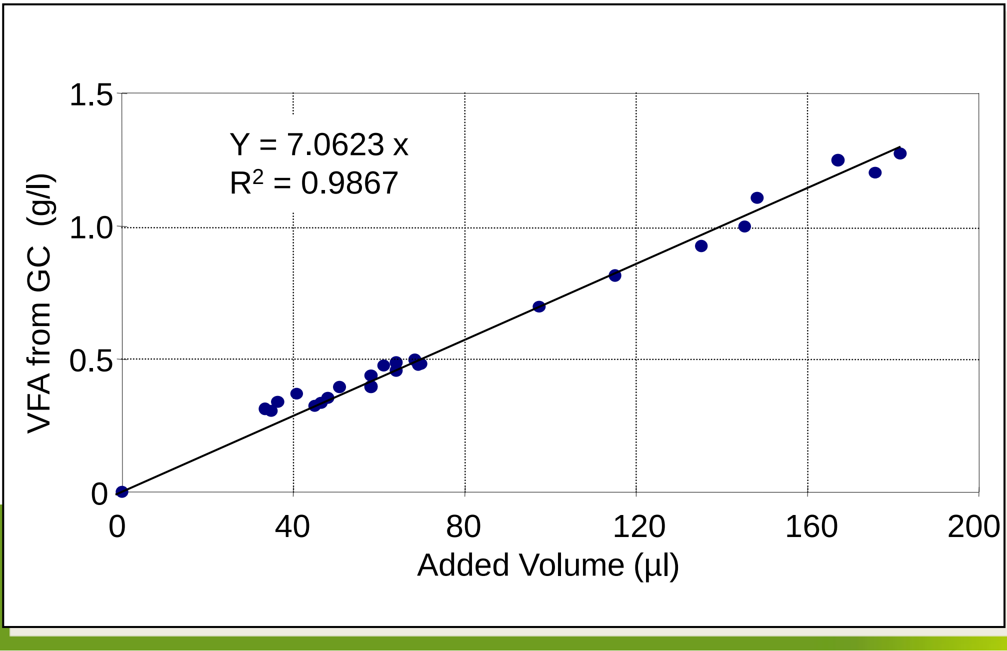
Titrimetric sensor: chemistry + basic maths



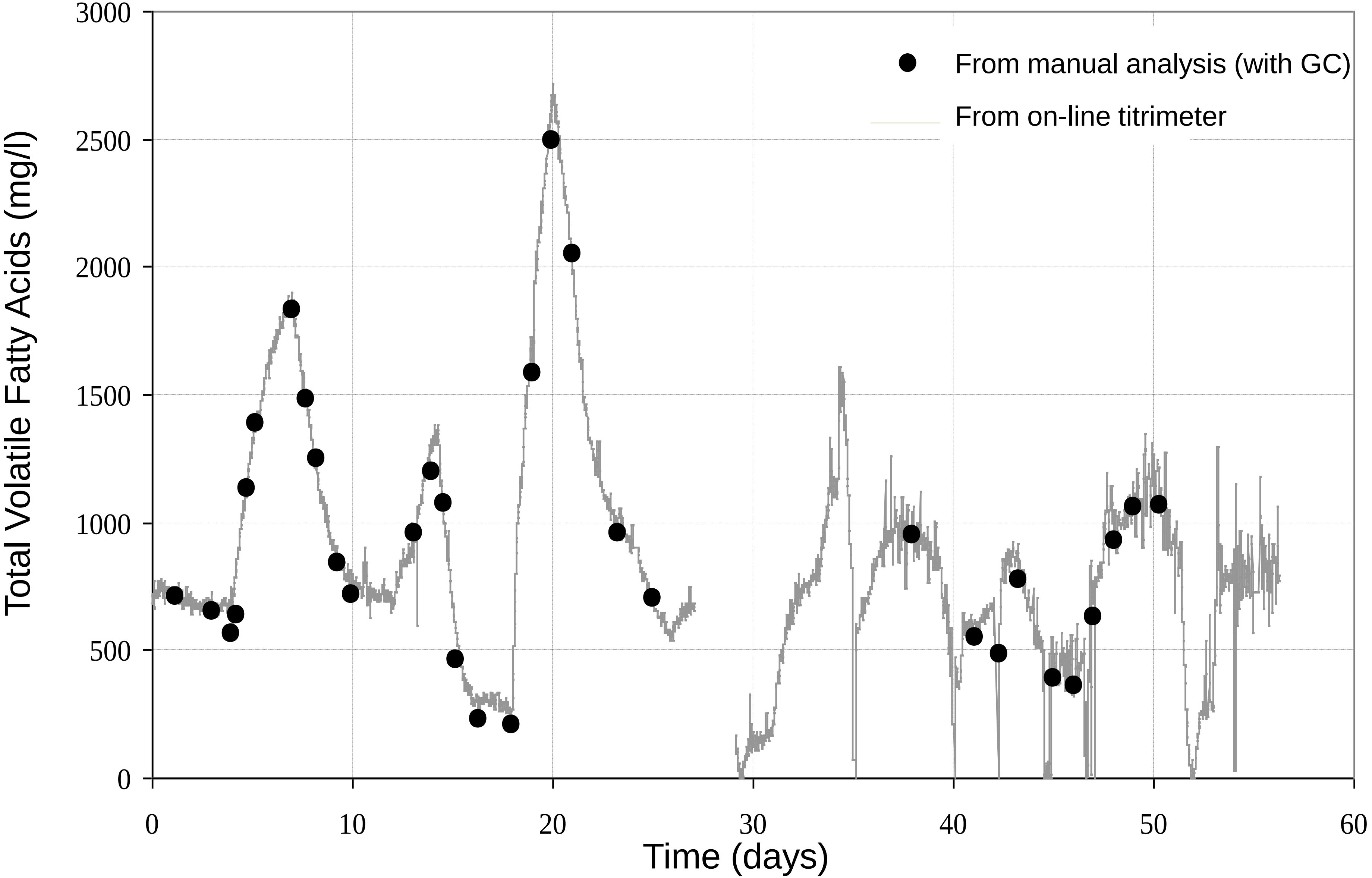
Measurements
of total and partial alkalinities

Estimation
of bicarbonate and VFA
concentrations

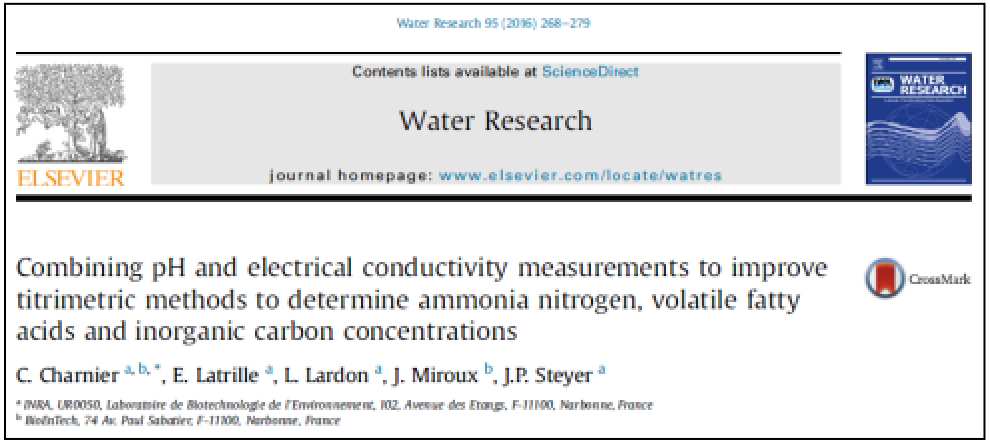
(every 3 minutes if needed)



The titrimetric sensor



Combining titration and conductivity



Water Research 95 (2016) 268–279

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Combining pH and electrical conductivity measurements to improve titrimetric methods to determine ammonia nitrogen, volatile fatty acids and inorganic carbon concentrations

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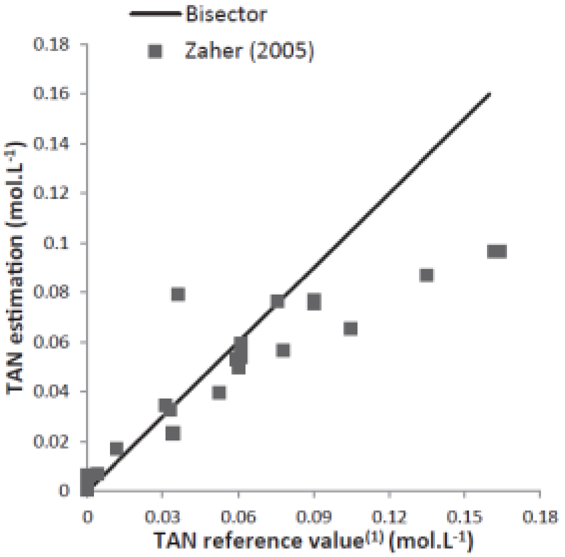
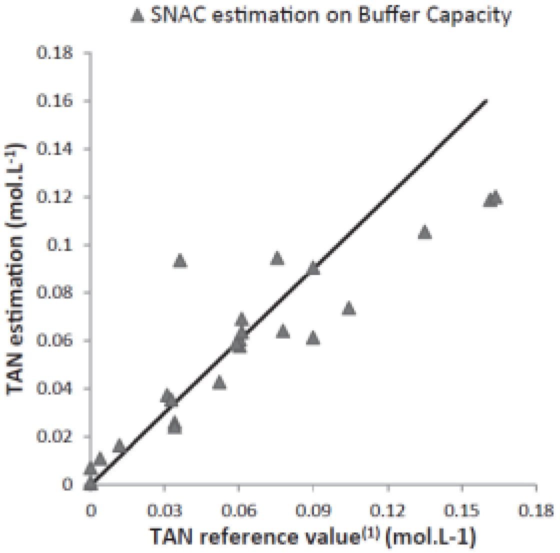
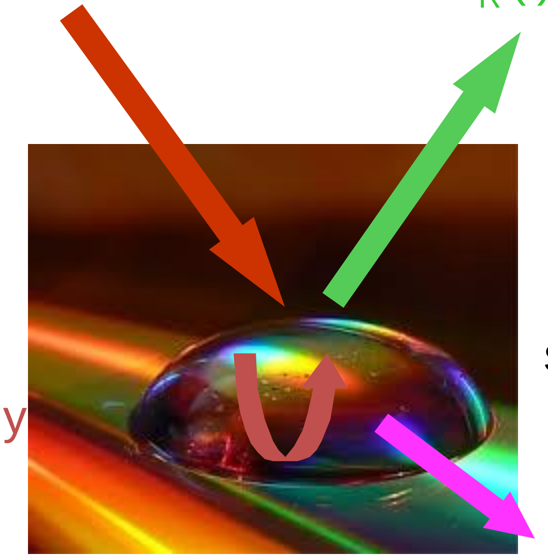
[b] BioEnTech, 74 Av. Paul Sabatier, F-11100, Narbonne, France





Measurements using light

Energy conservation principle



E_I (l) = Incident Energy

E_R (l) = Reflected Energy

E_A (l) = Absorbed Energy

Sample

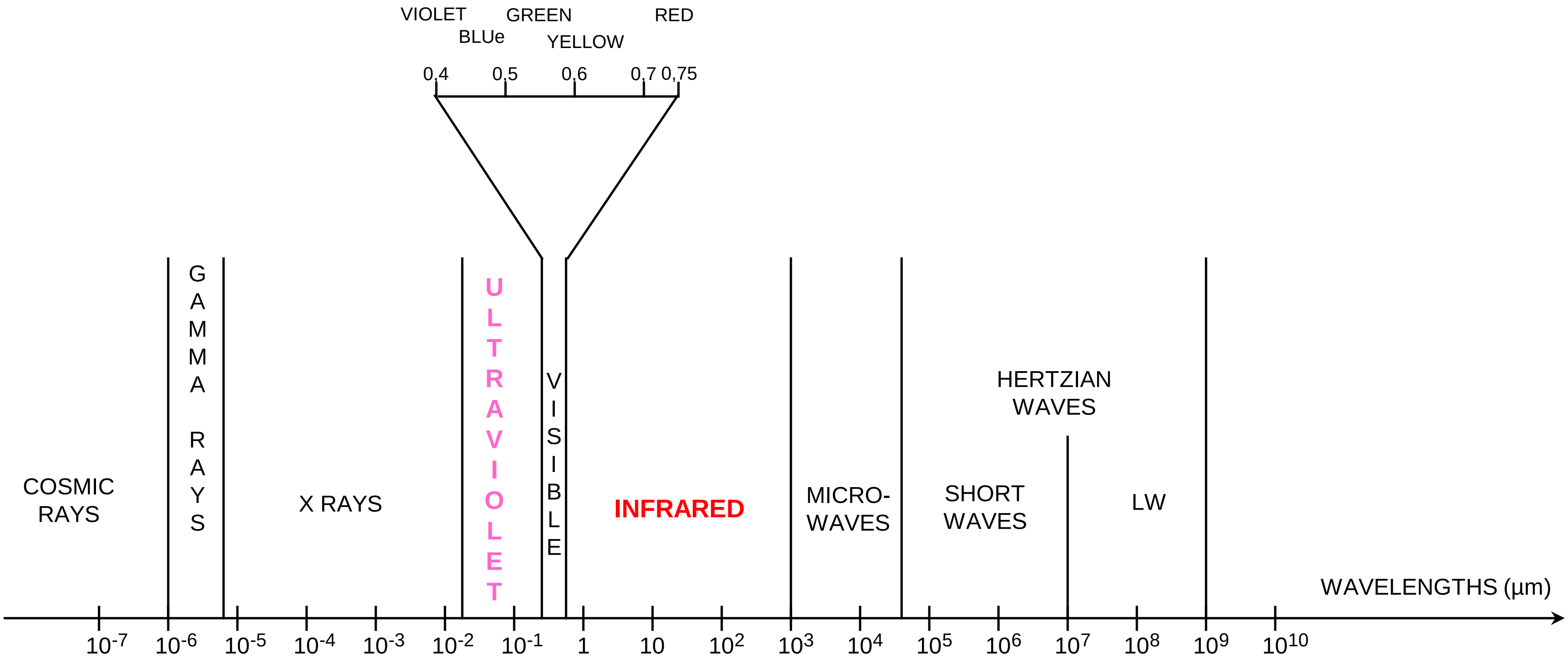
E_T (l) = Transmitted Energy

Incident Energy = Reflected Energy + Absorbed Energy + Transmitted Energy

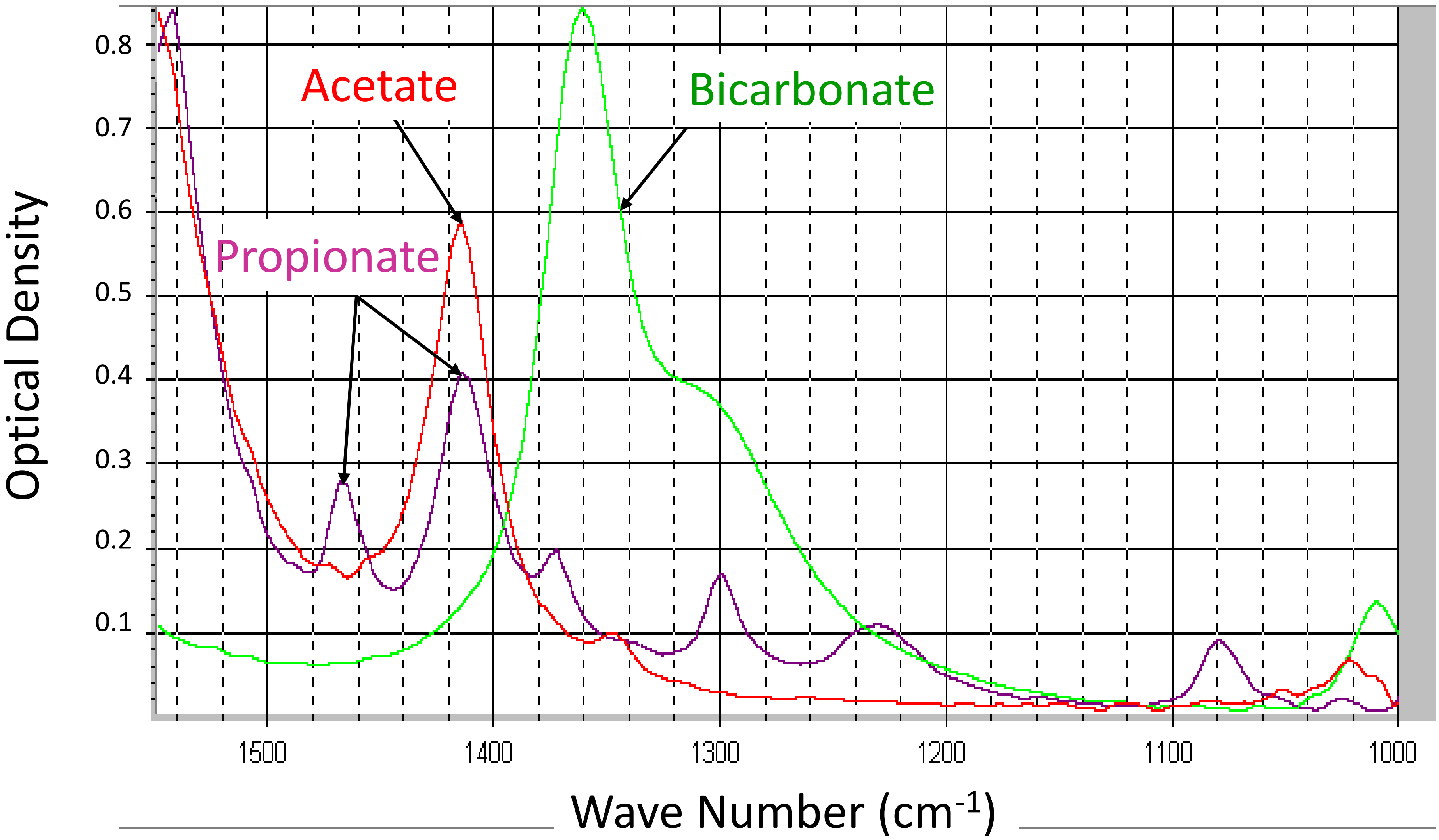
E_I (l) = E_R (l) + E_A (l) + E_T (l)

Measurements using light

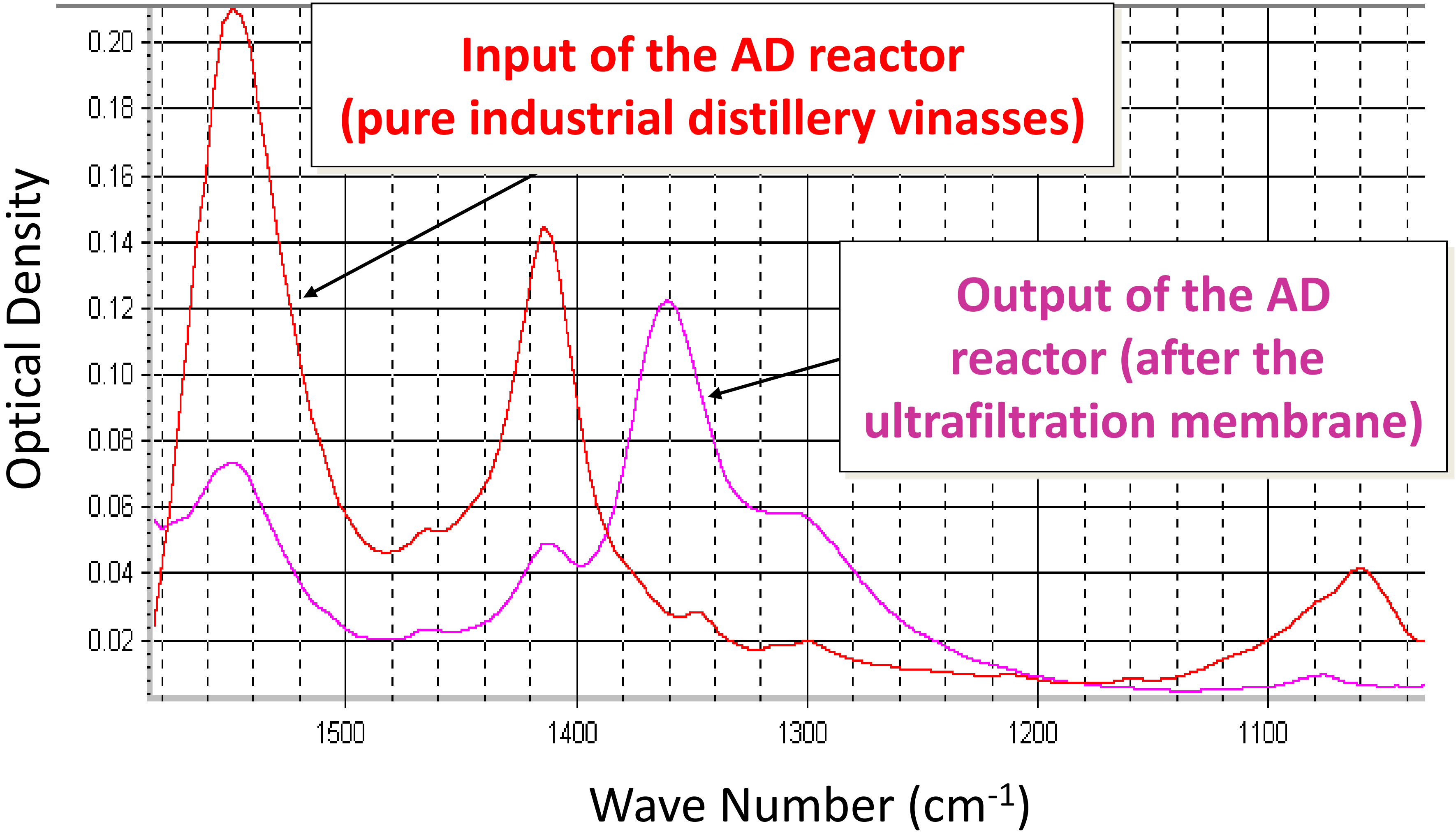
An example of advanced mathematics using light : UV or infrared



Mid Infra-Red Spectra of Pure Samples



Mid Infra-Red Spectra of Complex Samples



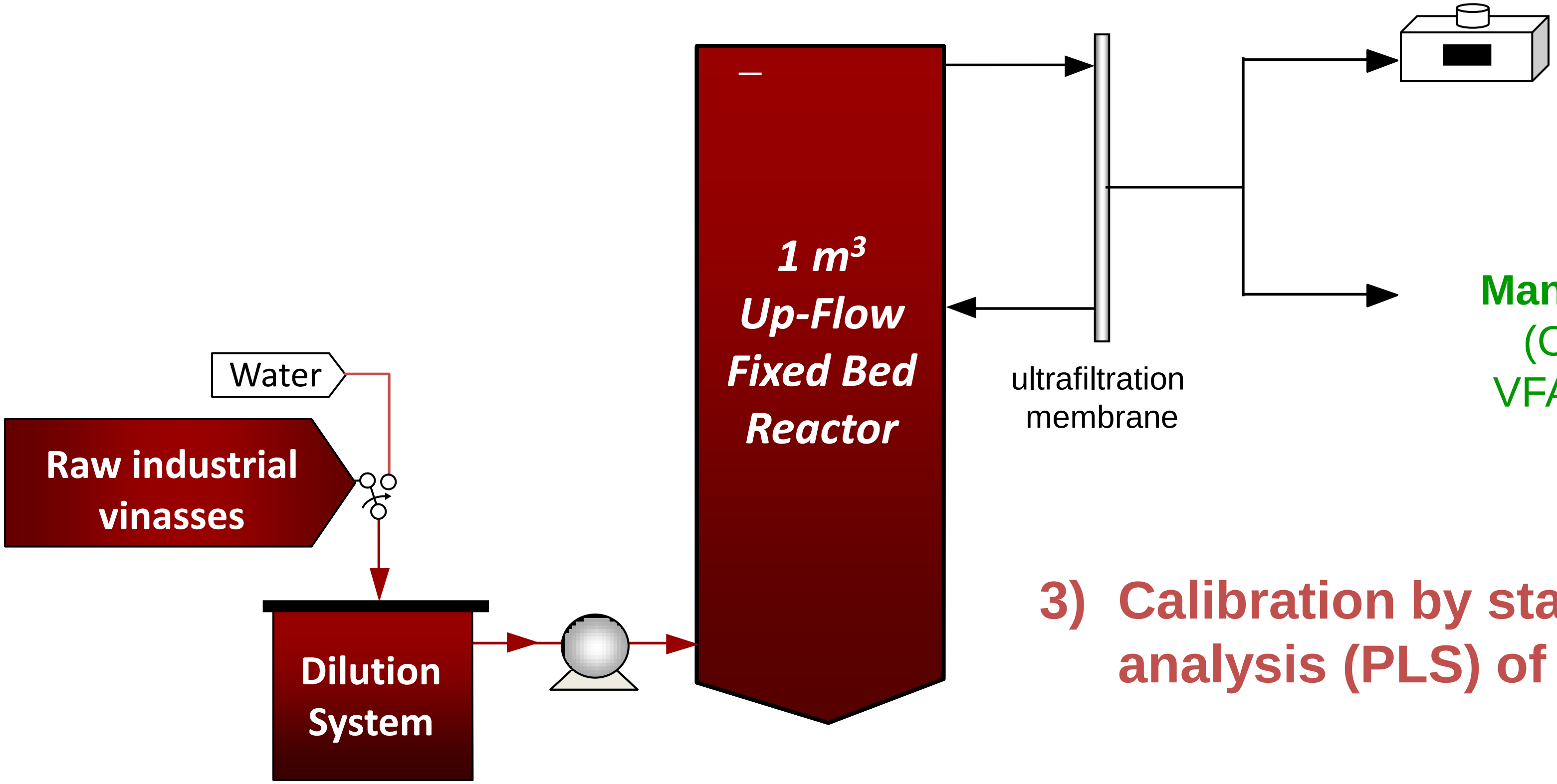
Input of the AD reactor (pure industrial distillery vinasses)

Output of the AD reactor (after the ultrafiltration membrane)

Calibration Principle

1) **Change of the organic loading rate**
(*i.e.*, input flow rate or input concentration)

2) **Samples are taken**

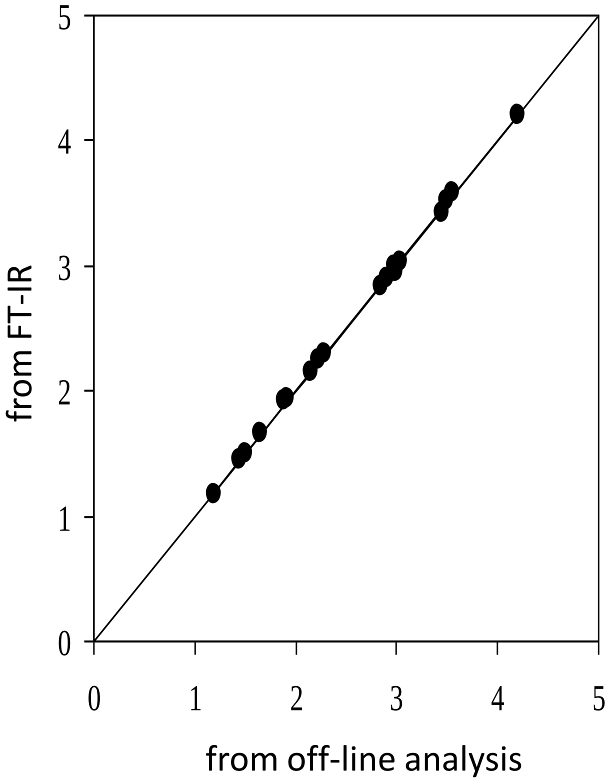


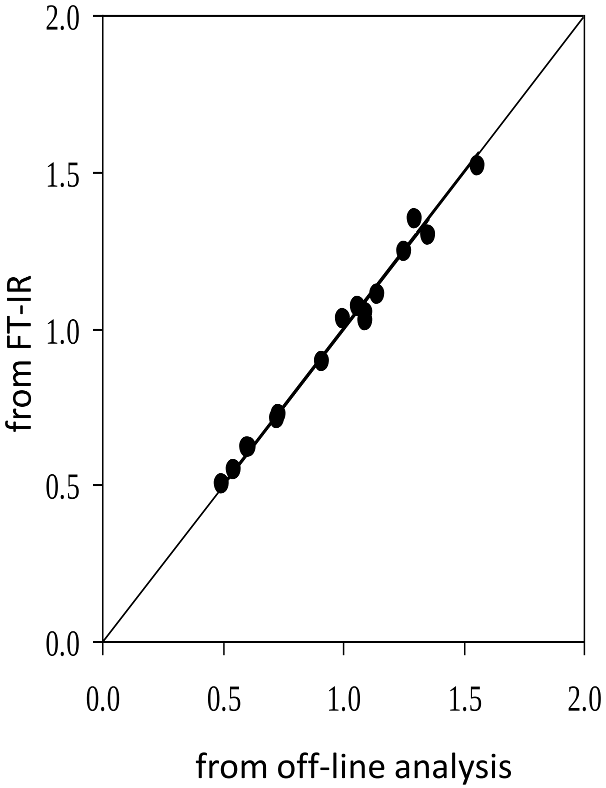
Infrared Spectrometer
(for spectra acquisition)

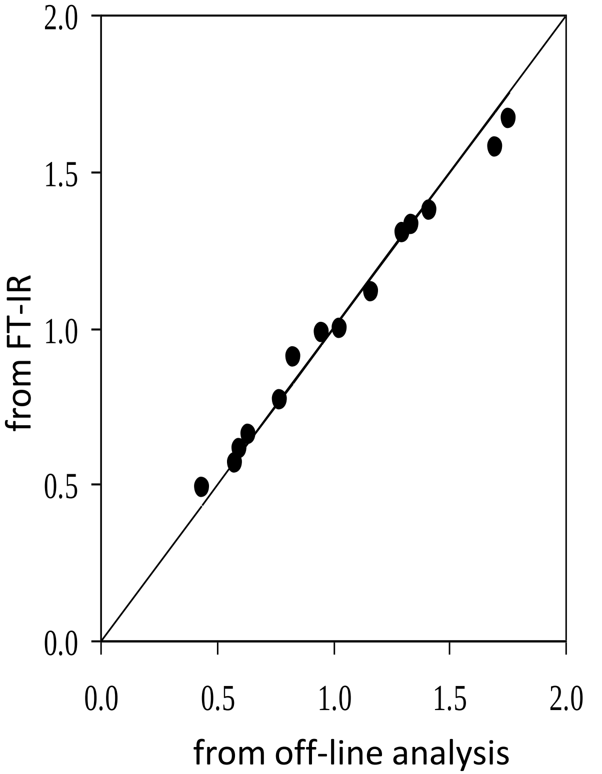
Off-Line Manual Analysis
(COD, TOC, VFA, TA, PA, ...)

3) **Calibration by statistical analysis (PLS) of the results**

Calibration Results

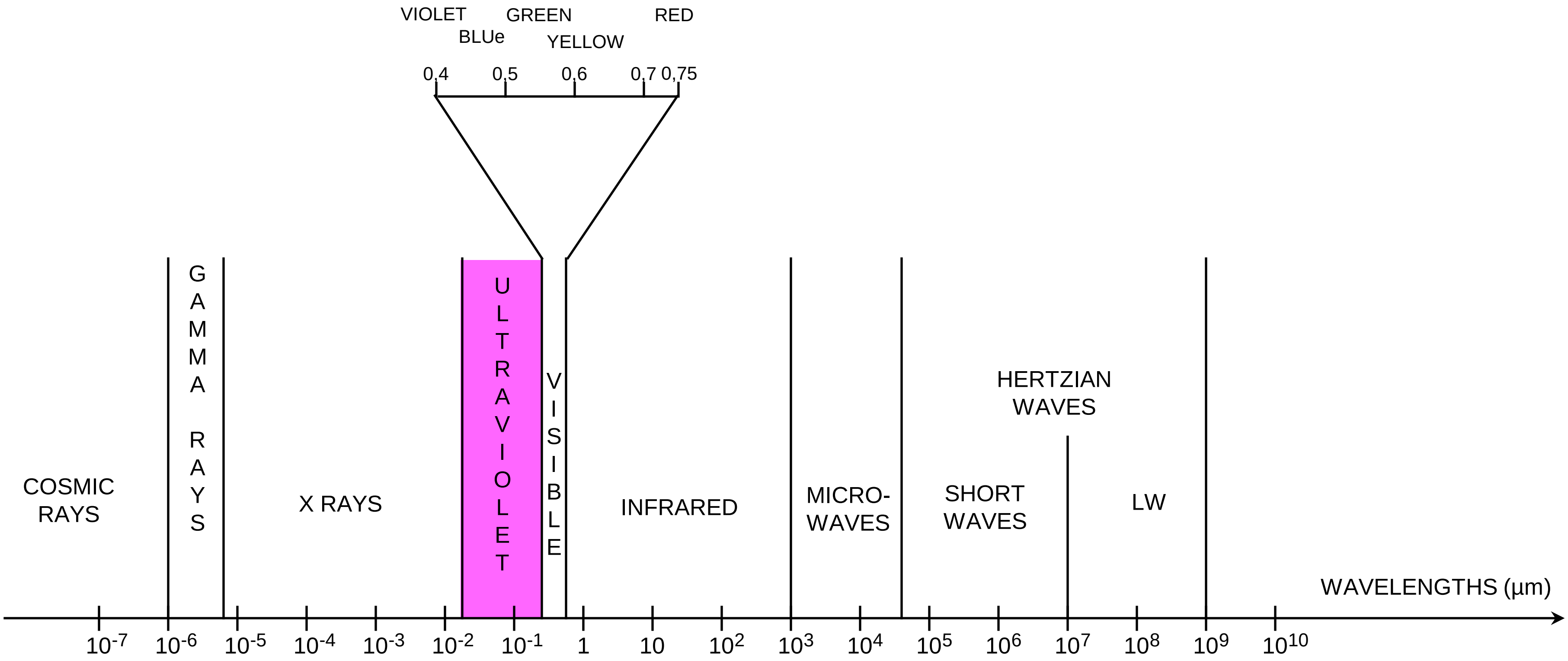

CODs (g/l)


TOC (g/l)

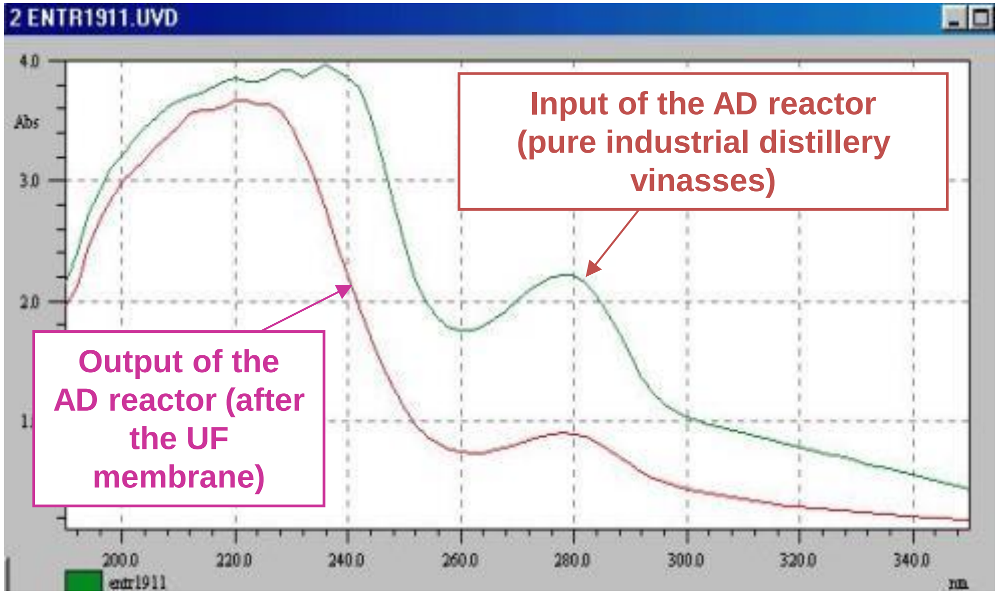

VFA (g/l)

Similar results on partial and total alkalinity

Wavelength in the UV region

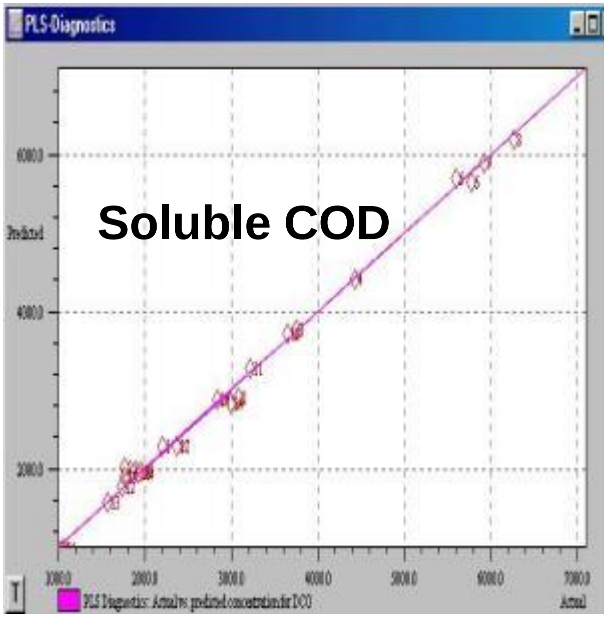


UV spectrometer: light + advanced maths

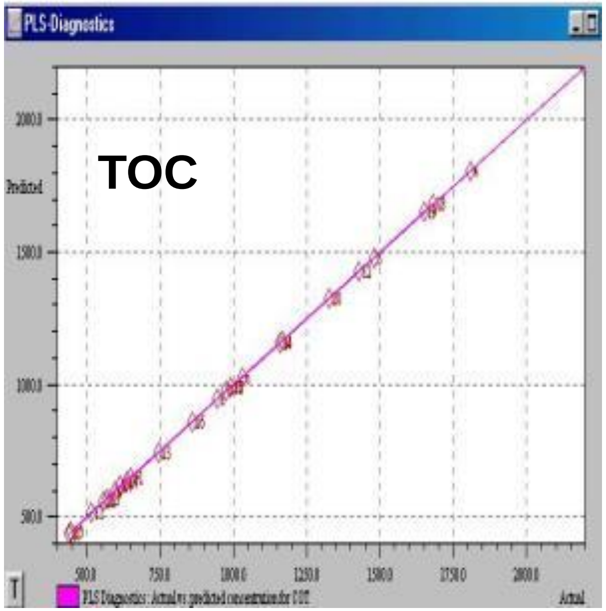


Input of the AD reactor (pure industrial distillery vinasses)

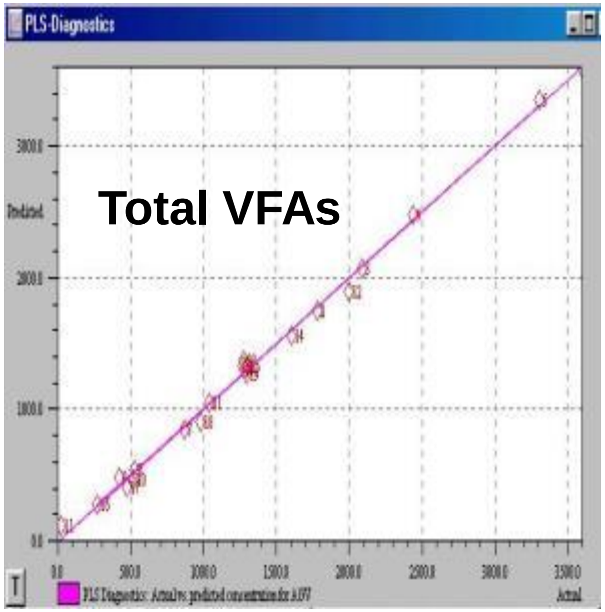
Output of the AD reactor (after the UF membrane)



Soluble COD



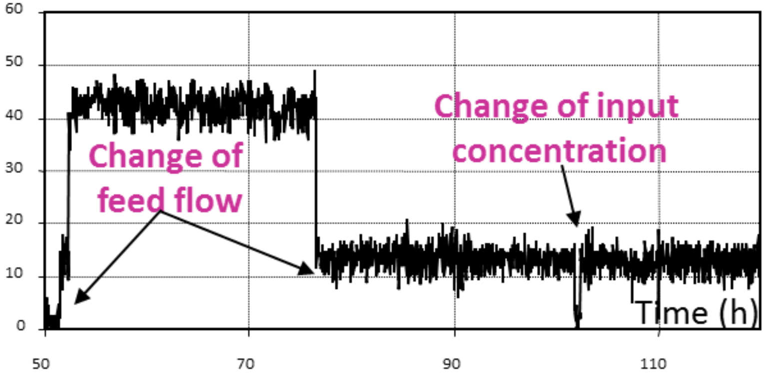
TOC



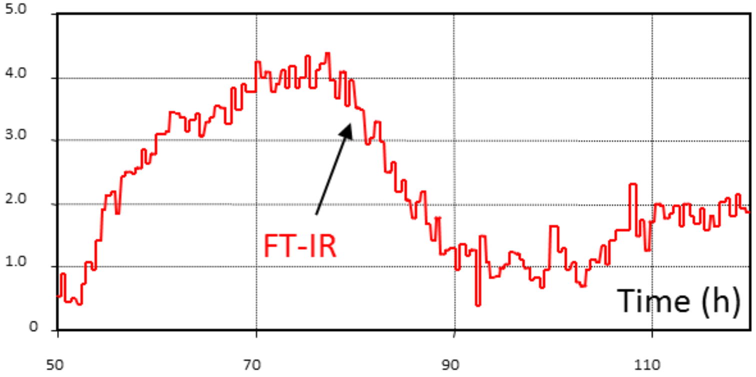
Total VFAs

On-Line Results

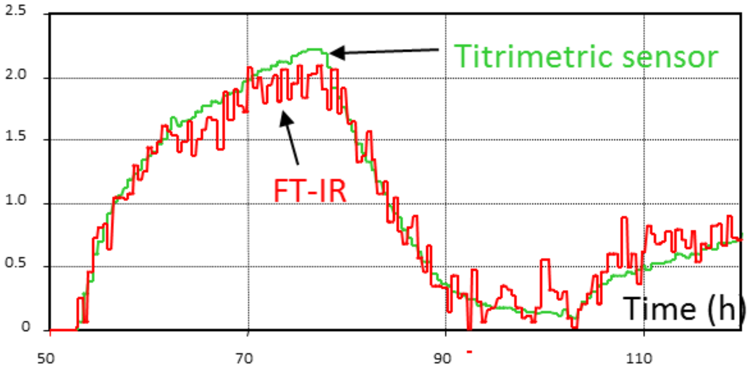
Influent flow rate (l/h)



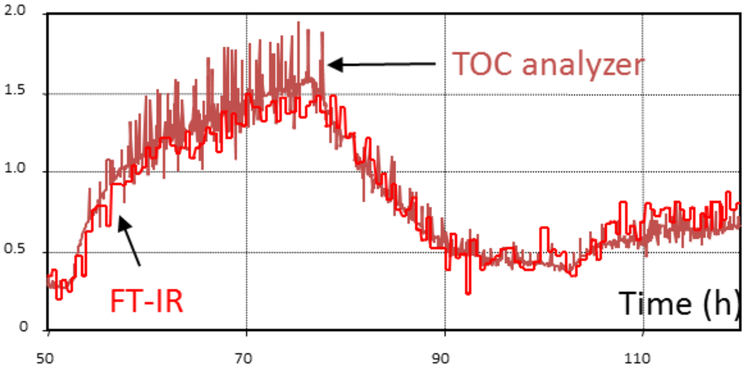
Soluble Chemical Oxygen Demand (g/l)



Volatile Fatty Acids (g/l)



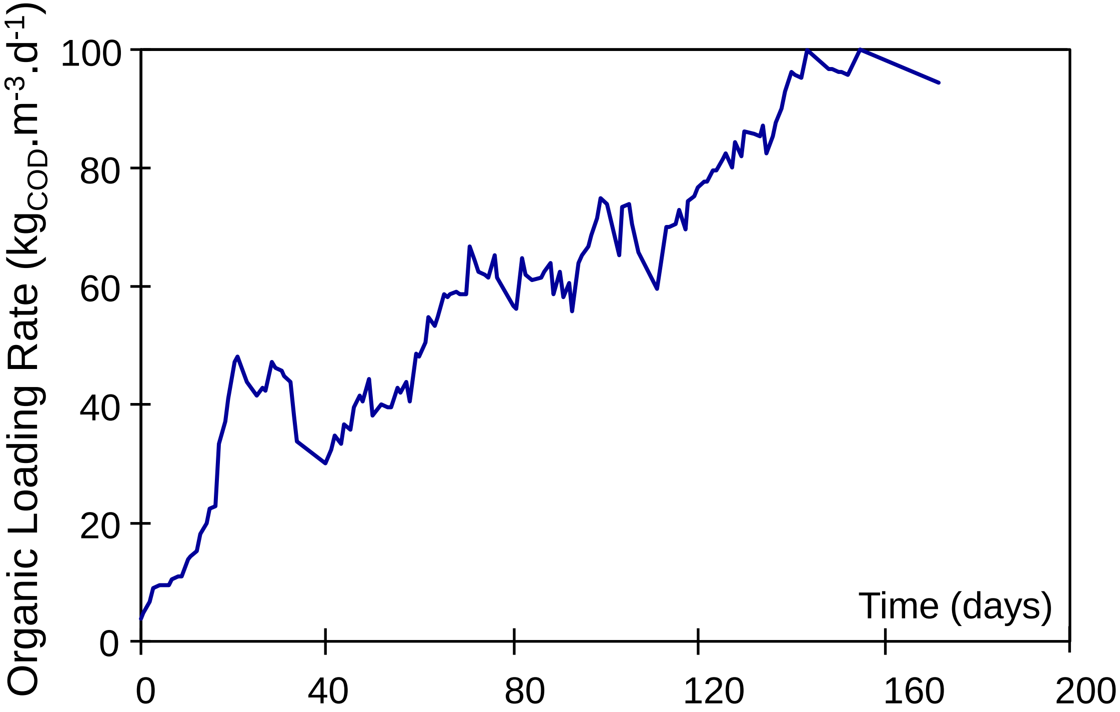
Total Organic Carbon (g/l)

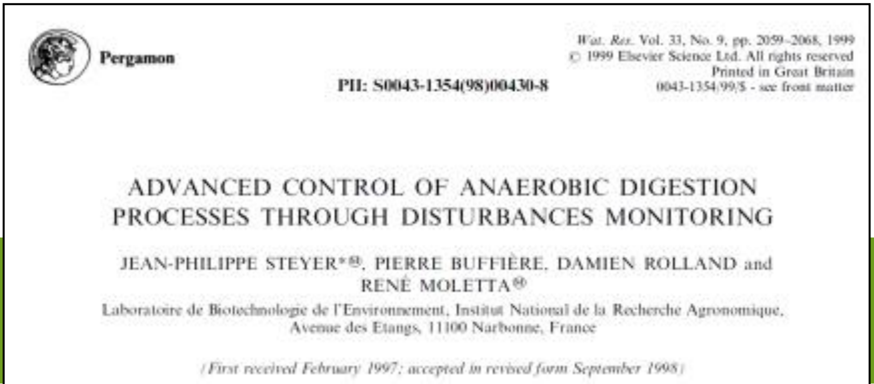


Similar results on partial and total alkalinity

Optimal start-up of processes

Within 5 months, start-up of a fluidised bed reactor from 0 to 100 kg COD.m^{-3}.d^{-1} and 80% removal efficiency




Pergamon

PII: S0043-1354(98)00430-8

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0043-1354/99/$ - see front matter

ADVANCED CONTROL OF ANAEROBIC DIGESTION PROCESSES THROUGH DISTURBANCES MONITORING

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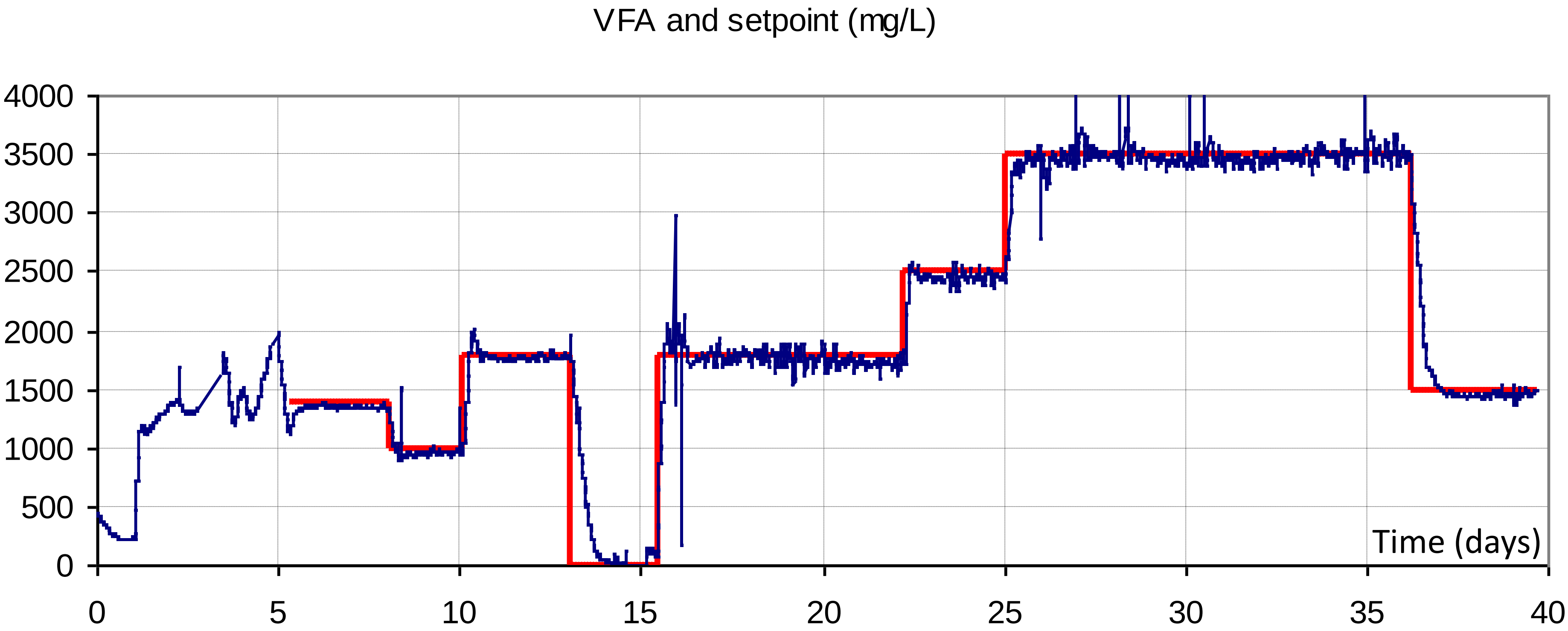
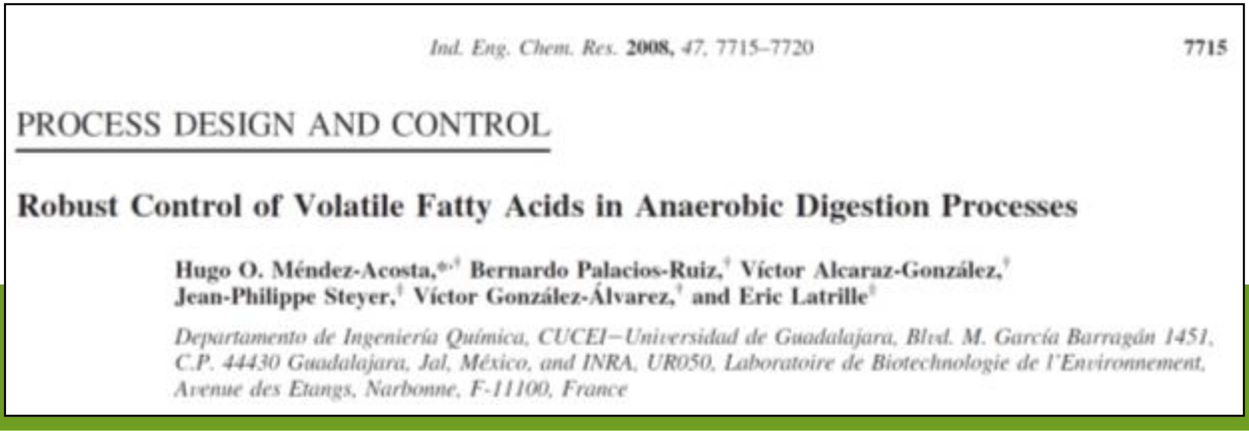
(First received February 1997; accepted in revised form September 1998)

Monitoring and control on the long term




Ind. Eng. Chem. Res. **2008,** 47, 7715–7720 **7715**

PROCESS DESIGN AND CONTROL

Robust Control of Volatile Fatty Acids in Anaerobic Digestion Processes

Hugo O. Méndez-Acosta,*[,†] **Bernardo Palacios-Ruiz,**[†] **Víctor Alcaraz-González,**[†]
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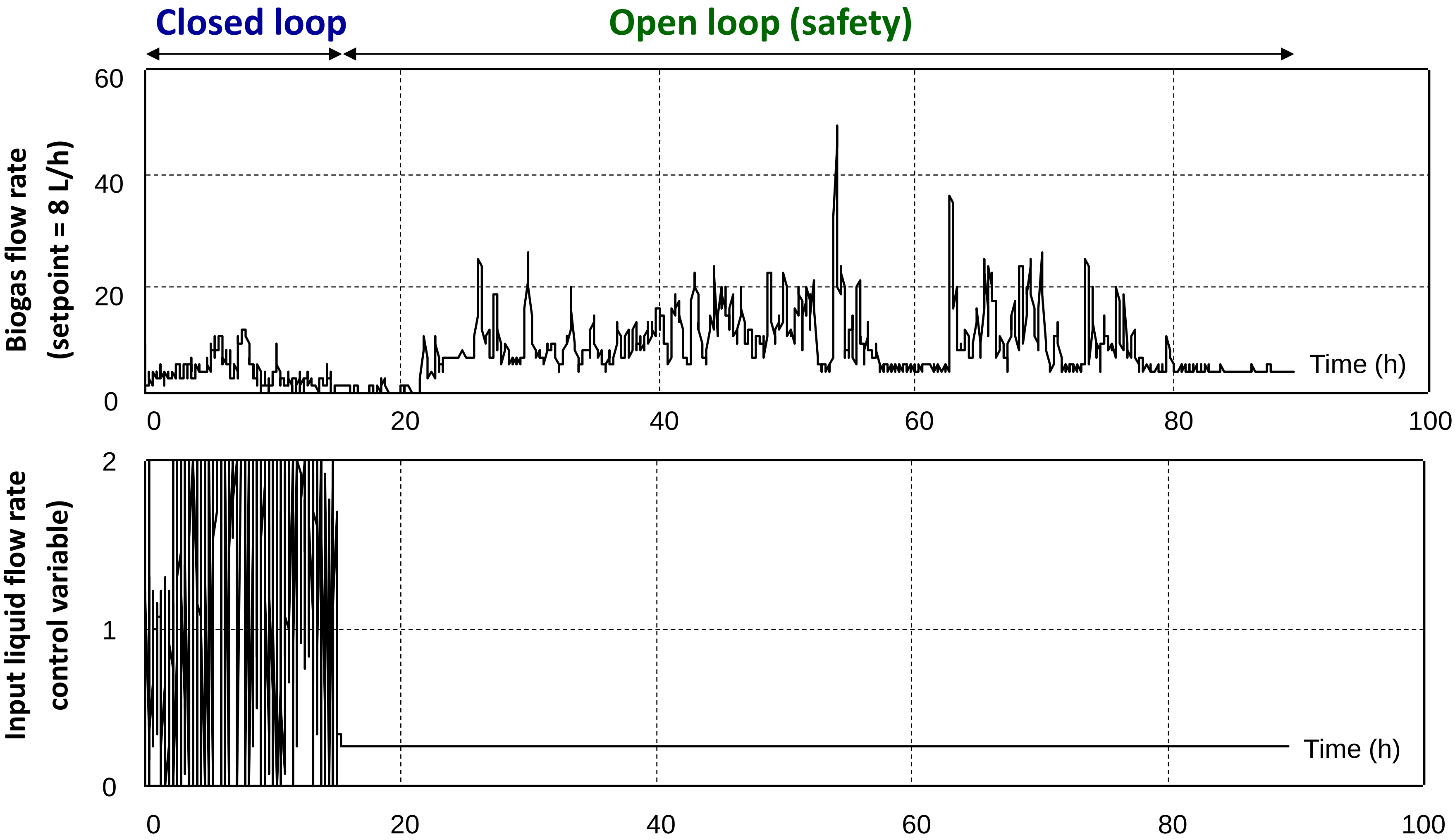
A control law can be badly tuned



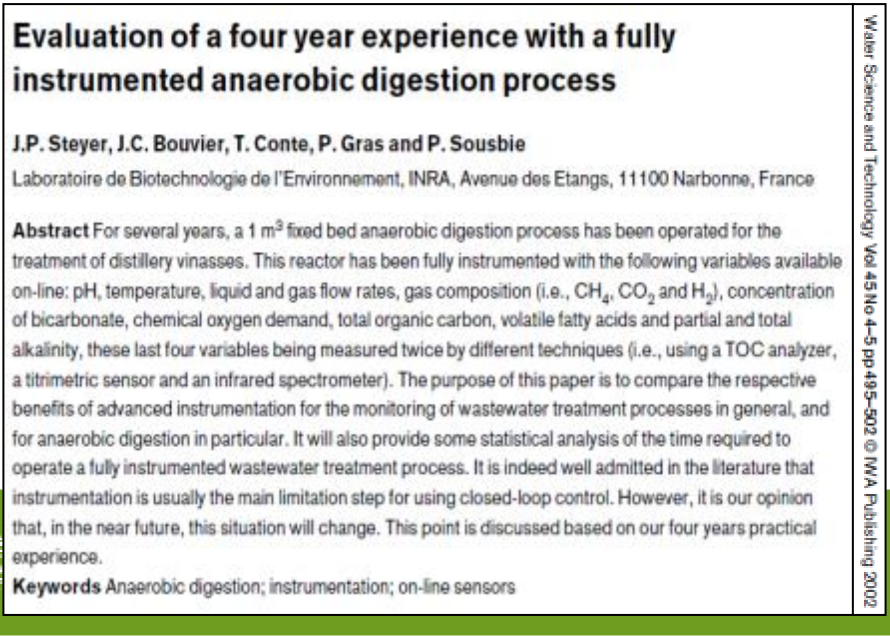
Few hours of bad functionning

and more than a week to go back to normality

Why so many on-line sensors ?

Practical evalutation of the respective benefits of each measuring technique

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



Evaluation of a four year experience with a fully instrumented anaerobic digestion process

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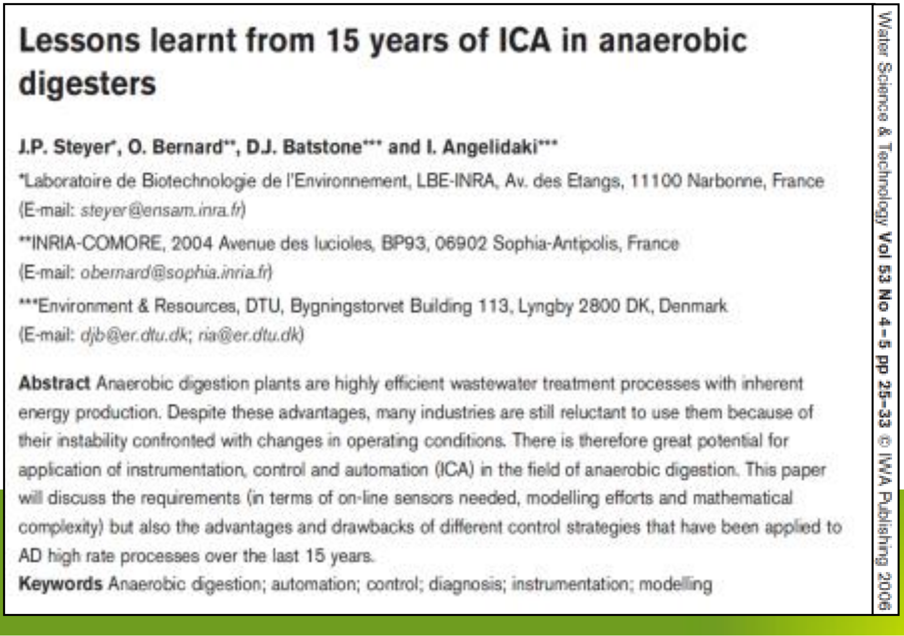
Laboratoire de Biotechnologie de l'Environnement, INRA, Avenue des Etangs, 11100 Narbonne, France

Abstract For several years, a 1 m^3 fixed bed anaerobic digestion process has been operated for the treatment of distillery vinasses. This reactor has been fully instrumented with the following variables available on-line: pH, temperature, liquid and gas flow rates, gas composition (i.e., CH_4, CO_2 and H_2), concentration of bicarbonate, chemical oxygen demand, total organic carbon, volatile fatty acids and partial and total alkalinity, these last four variables being measured twice by different techniques (i.e., using a TOC analyzer, a titrimetric sensor and an infrared spectrometer). The purpose of this paper is to compare the respective benefits of advanced instrumentation for the monitoring of wastewater treatment processes in general, and for anaerobic digestion in particular. It will also provide some statistical analysis of the time required to operate a fully instrumented wastewater treatment process. It is indeed well admitted in the literature that instrumentation is usually the main limitation step for using closed-loop control. However, it is our opinion that, in the near future, this situation will change. This point is discussed based on our four years practical experience.

Keywords Anaerobic digestion; instrumentation; on-line sensors

Water Science and Technology Vol 45 No 4–5 pp 495–502 © IWA Publishing 2002



Lessons learnt from 15 years of ICA in anaerobic digesters

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Abstract Anaerobic digestion plants are highly efficient wastewater treatment processes with inherent energy production. Despite these advantages, many industries are still reluctant to use them because of their instability confronted with changes in operating conditions. There is therefore great potential for application of instrumentation, control and automation (ICA) in the field of anaerobic digestion. This paper will discuss the requirements (in terms of on-line sensors needed, modelling efforts and mathematical complexity) but also the advantages and drawbacks of different control strategies that have been applied to AD high rate processes over the last 15 years.

Keywords Anaerobic digestion; automation; control; diagnosis; instrumentation; modelling

Water Science & Technology Vol 53 No 4–5 pp 25–33 © IWA Publishing 2006

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

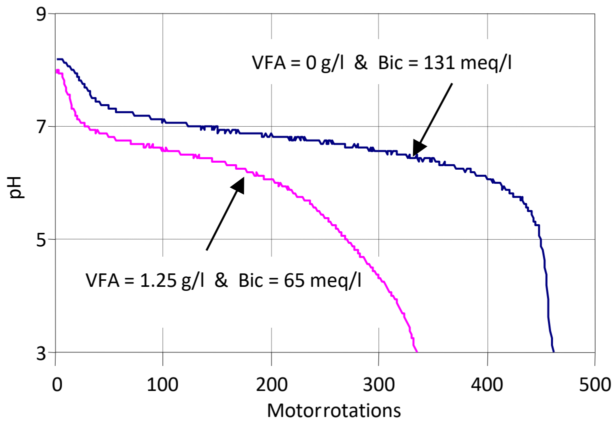
	From classical measurements (pH, T, Qgas, %CO2, P)	TOC analyzer	Titrimetric sensor	UV spectrometer	MIR spectrometer
Partial Alkalinity			✓		✓
Total Alkalinity			✓		✓
Bicarbonate	✓		✓		✓
Dissolved CO2	✓				✓
TOC		✓		✓	✓
Soluble COD				✓	✓
Total VFAs			✓	✓	✓
Acetate					✓
Others (*eg.*, N, P)			✓	✓	✓

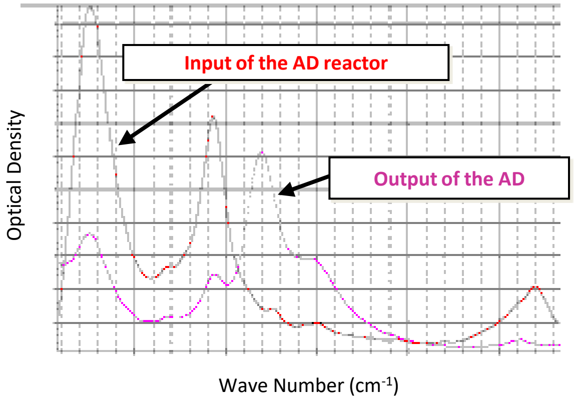
Towards *smart* sensors

Anasense®

TOCmeter

Infrared spectrometer





Sensors should provide a confidence index to plant managers

Content of the presentation

- Who am I ?
- Instrumentation in WW : Why ?
- Instrumentation in AD : Liquid Samples
- **Instrumentation in AD : Solid Samples**
- What is next ?

Biodegradability Aspects

Liquid → **Solid**

Single substrate **Mixed substrates**

Straw

Sludge

Manure

Microalgae

Organic waste

Green waste

CH_4 and/or H_2

Platform Molecules

Digestate, Biosolids

- ✓ **Characterization of the organic matter**
- ✓ **Link with contaminants (eg., pharmaceuticals, detergents,…)**

Biodegradability Aspects

From global… **… to fine characterization**

From quantity… **… to quality**

Dry matter
Volatile solids
Carbon
Nitrogen
Phosphorus

Lipid
Sugar
Protein

Respirometry
(aerobic, anaerobic)

Fractionation
(Van Soest, acid hydrolysis)

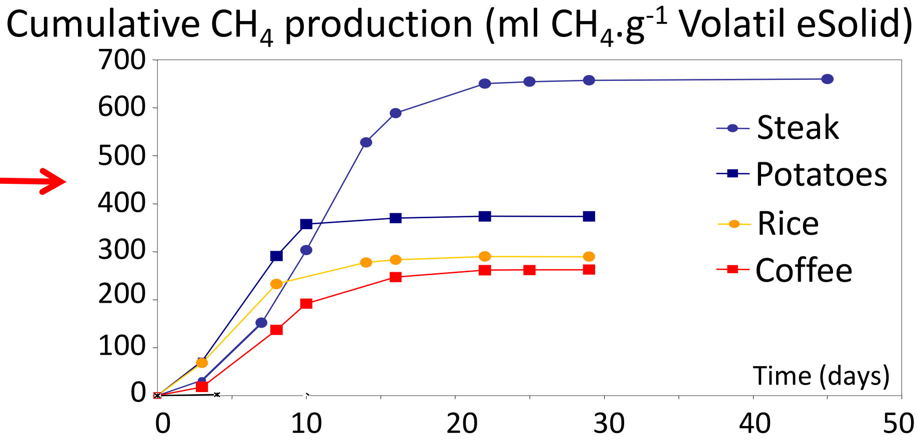
Infrared
2D/3D Fluorescence

Microscopy

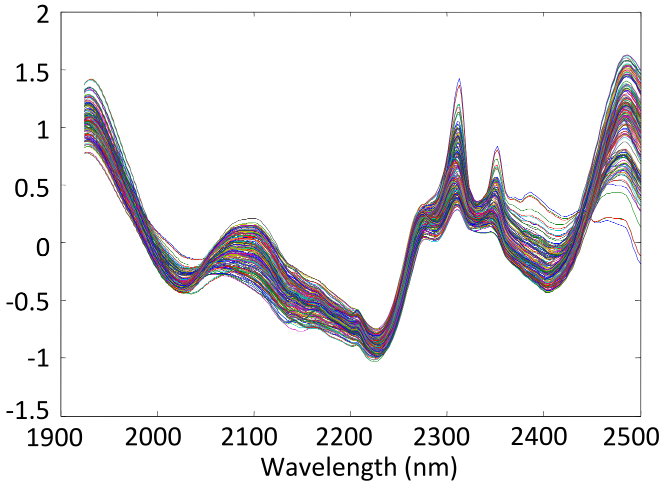
Rheology

Use of infrared to predict OM biodegradability

Biochemical
Methane
Potential



Biodegradability ?



Flash BMP®

Use of infrared spectrometry to predict methane potential (BMP) from solid waste

2006-2009

2009-2013

2014…

TRL

1 2 3 4 5 6 7 8

Process Biochemistry 45 (2010) 431–440

Contents lists available at ScienceDirect

Process Biochemistry

journal homepage: www.elsevier.com/locate/procbio

Review

Alternative methods for determining anaerobic biodegradability: A review

M. Lesteur[a,*], V. Bellon-Maurel[b], C. Gonzalez[c], E. Latrille[a], J.M. Roger[b], G. Junqua[c], J.P. Steyer[a]

Bioresource Technology 102 (2011) 2280–2288

Contents lists available at ScienceDirect

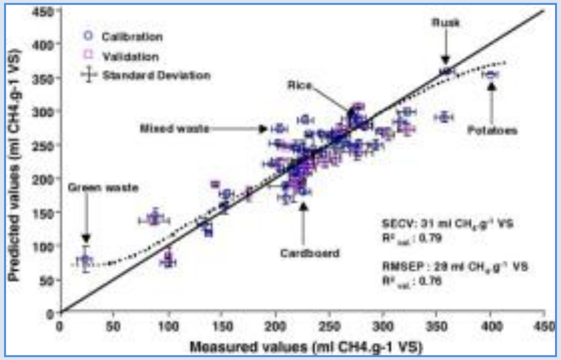
Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

First step towards a fast analytical method for the determination of Biochemical Methane Potential of solid wastes by near infrared spectroscopy

M. Lesteur[a,b,c,*], E. Latrille[a], V. Bellon Maurel[b], J.M. Roger[b], C. Gonzalez[c], G. Junqua[c], J.P. Steyer[a,*]

Fundamental research and proof of concept



Technological development

CATALOGUE ANALYTIQUE 2014

Liste de prix applicables du 01/01/2014 au 31/12/2014

ANALYSES ENVIRONNEMENTALES

METHANISATION

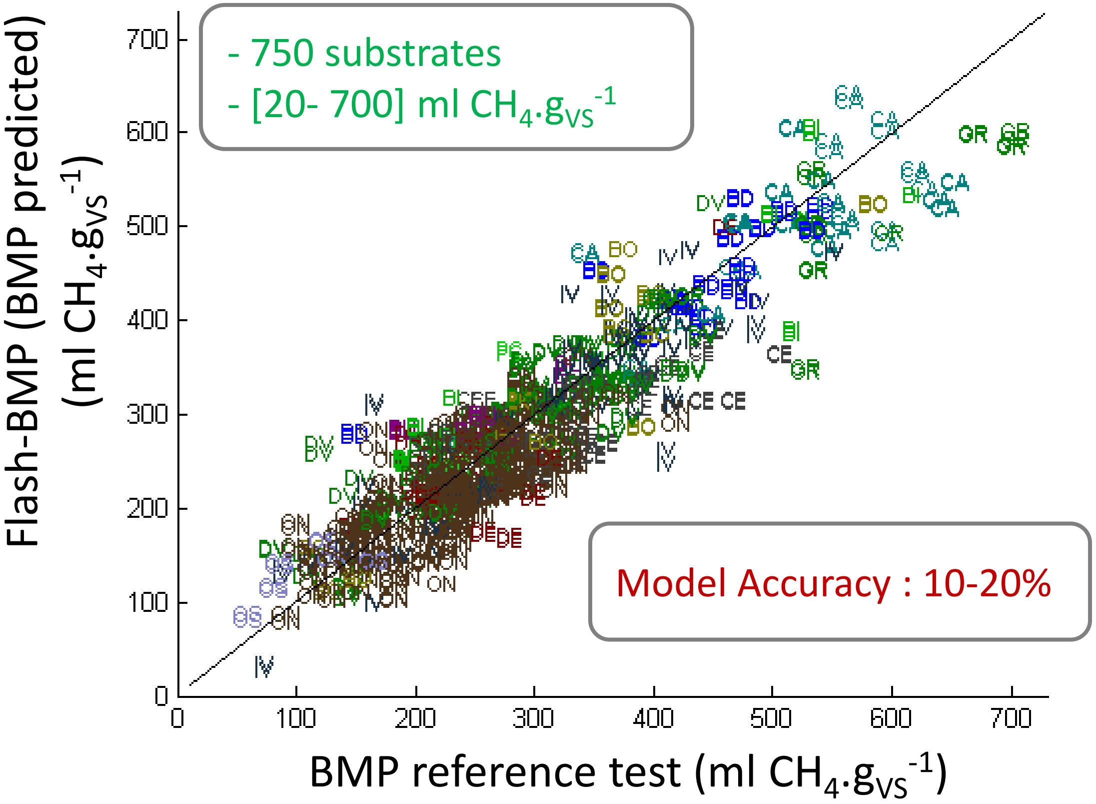
MENUS ANALYTIQUES METHANISATION

Menu Potentiel Méthanogène Flash® : résultats en 5 jours	Prix unitaire HT
Mesure du potentiel méthanogène (Méthode Flash BMP® par spectroscopie infra-rouge), Matière sèche - Matière volatile, Préparation échantillon, Prise en charge	237,79 €

250 analysis sold
since february 2015

Available on the market

Flash BMP® model



- 750 substrates
- [20- 700] ml CH_4.g_{VS}^{-1}

Model Accuracy : 10-20%

Some included substrates:

Municipal Solid Waste

Agro-industrial

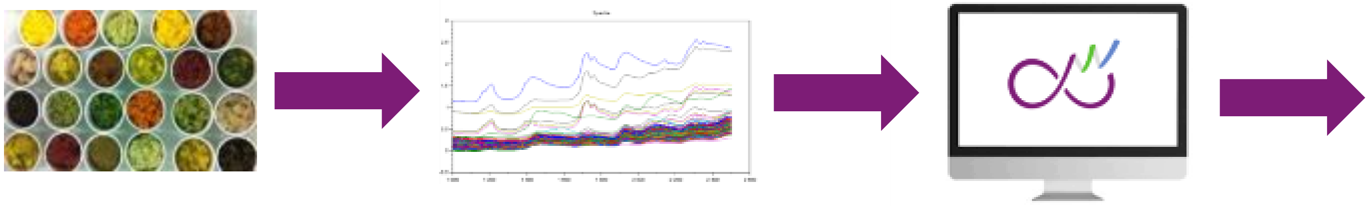
Green waste

Energy crops

Manure

Sludge

Going further with NIRS



Substrate

Near infrared analysis

Spectrum treatment

- BMP
- Carbohydrates
- Proteins
- Lipids
- COD
- CH_4 kinetics

0

4 days

Waste Management 59 (2017) 140–148

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

ELSEVIER

Fast characterization of solid organic waste content with near infrared spectroscopy in anaerobic digestion

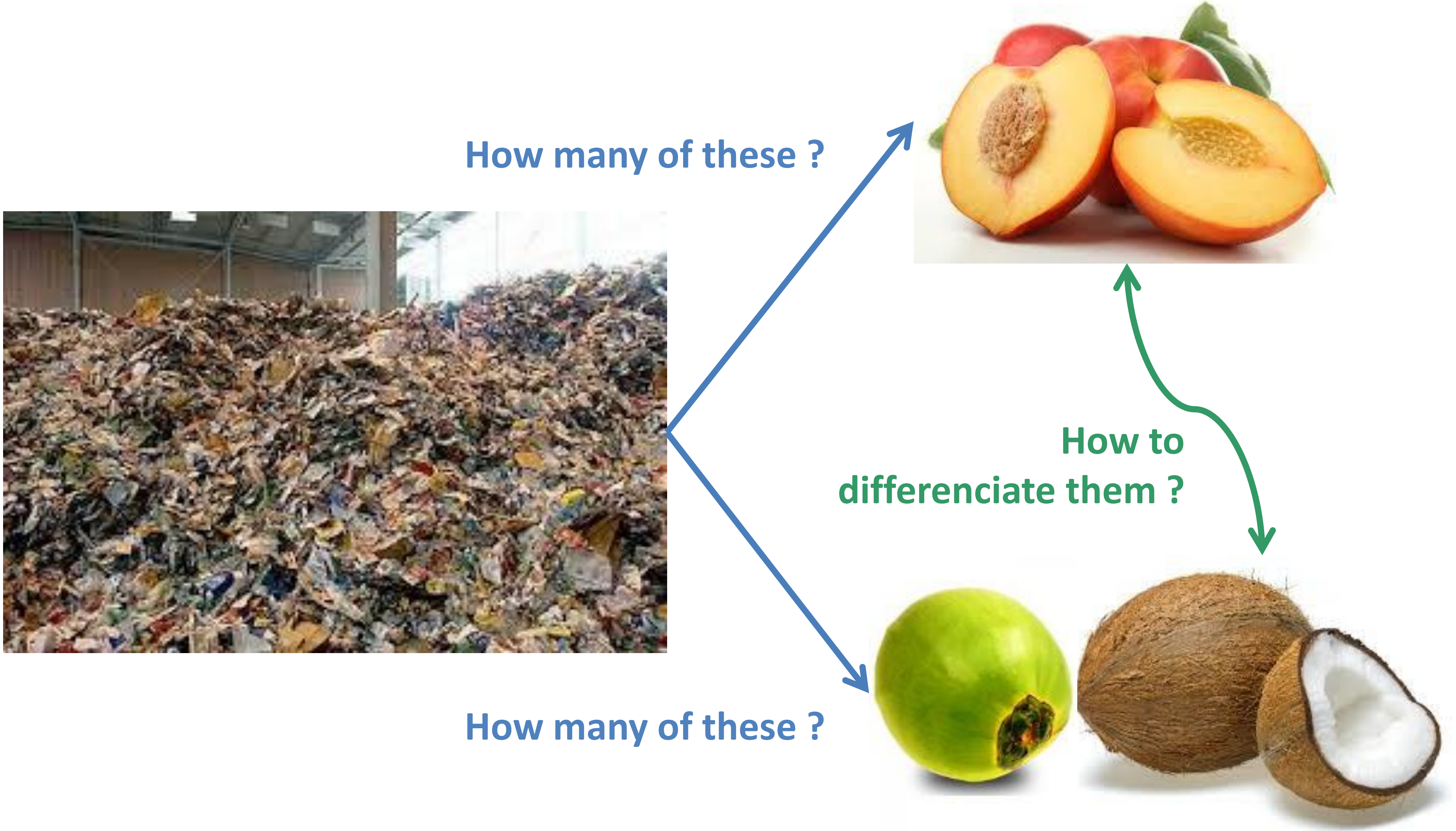
CrossMark

Cyrille Charnier [a,b,*], Eric Latrille [a], Julie Jimenez [a], Margaux Lemoine [a], Jean-Claude Boulet [c], Jérémie Miroux [b], Jean-Philippe Steyer [a]

[a] INRA, UR0050, Laboratoire de Biotechnologie de l'Environnement, 102 Av. des Etangs, Narbonne F-11100, France
[b] BioEnTech, 74 Av. Paul Sabatier, 11100 Narbonne, France
[c] INRA, UMR1083 Sciences pour l'œnologie, 2 Place Viala, F-34060 Montpellier, France

http://bioentech.eu

Biodegradability vs. Bioaccessibility



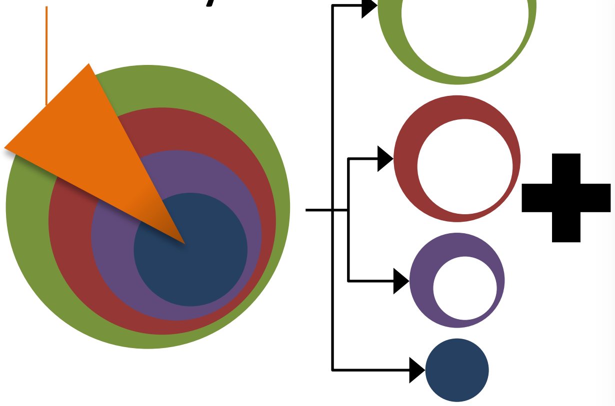
How many of these ?

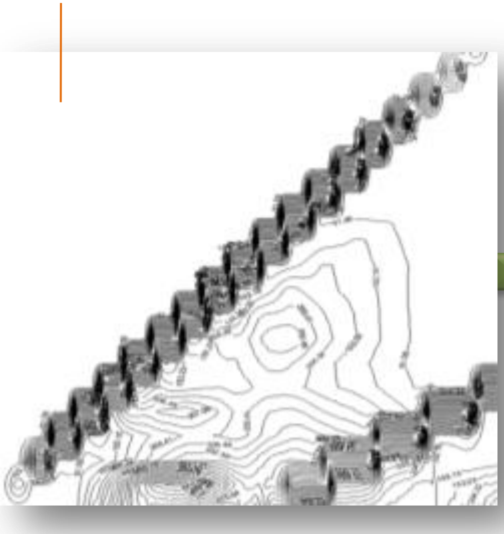
How to
differenciate them ?

How many of these ?

Another way to characterize accessibility and complexity

Developped strategy





PCA applied: Classification according accessibility and complexity

Chemical extractions

COD, N, C

3D fluorescence spectroscopy

60 organic residues

Waste Management 34 (2014) 2572–2580

Contents lists available at ScienceDirect

Waste Management

journal homepage: www.elsevier.com/locate/wasman

Combining chemical sequential extractions with 3D fluorescence spectroscopy to characterize sludge organic matter

Mathieu Muller[a,c,1], Julie Jimenez[c,b,*], Maxime Antonini[c], Yves Dudal[a,1], Eric Latrille[c], Fabien Vedrenne[b], Jean-Philippe Steyer[c], Dominique Patureau[c]

Available online at www.sciencedirect.com

ScienceDirect

journal homepage: www.elsevier.com/locate/watres

Prediction of anaerobic biodegradability and bioaccessibility of municipal sludge by coupling sequential extractions with fluorescence spectroscopy: Towards ADM1 variables characterization

Julie Jimenez[a,*], Estelle Gonidec[a], Jesús Andrés Cacho Rivero[a], Eric Latrille[b], Fabien Vedrenne[a], Jean-Philippe Steyer[b]

3D fluorescence spectroscopy

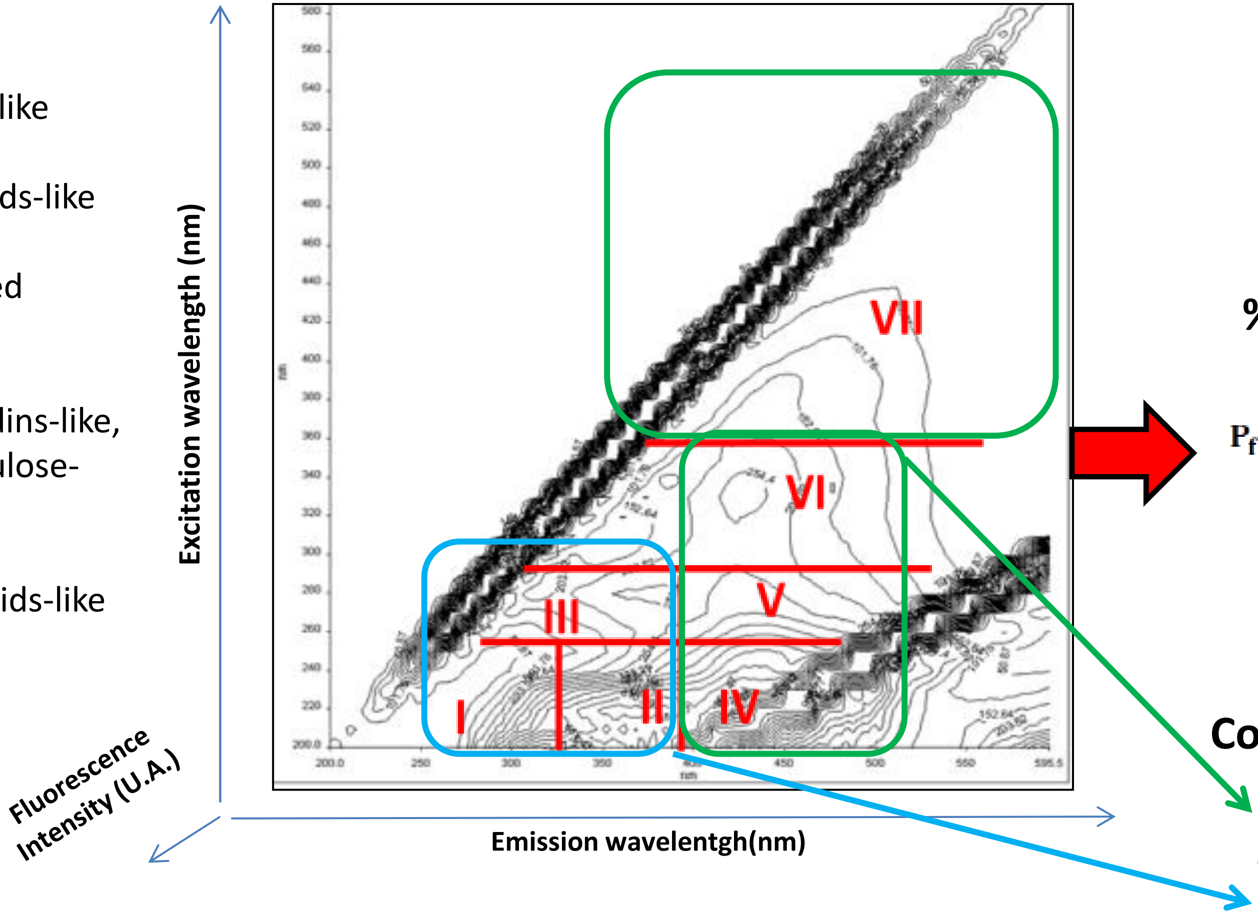
I-II-III: Proteins-like

IV: Fulvic acids-like

V: Glycolysed proteins

VI: Melanoidins-like, lignocellulose-like

VII: Humic acids-like



%age of fluorescence

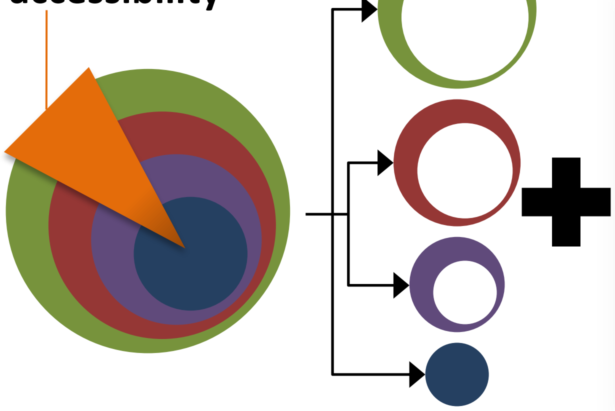
$$P_f(i)(\%) = \frac{V_f(i)}{\sum_{i=1}^{7} V_f(i)} \times 100$$

Complexity ratio

$$\frac{\sum_{i=IV}^{VII} P_f(i)}{\sum_{i=I}^{III} P_f(i)}$$

Another way to characterize accessibility and complexity

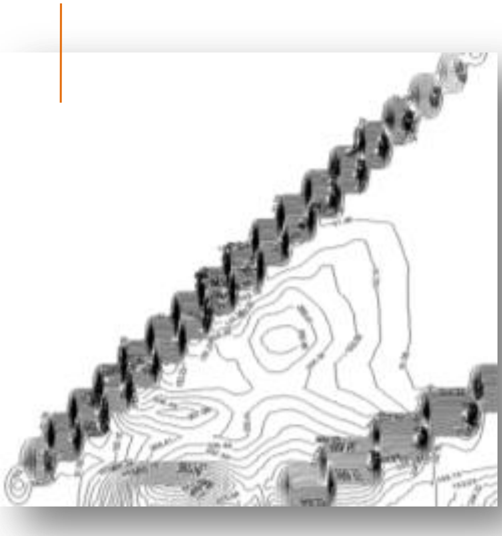
Anaerobic digestion coupled with composting



accessibility

Chemical extractions

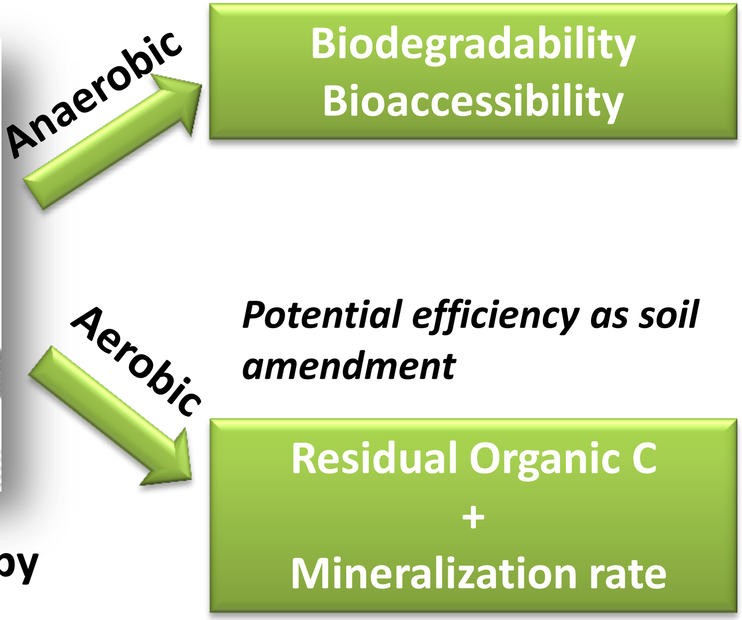
COD, N, C



Complexity

3D fluorescence spectroscopy

Methane potential



Biodegradability
Bioaccessibility

Potential efficiency as soil amendment

Residual Organic C
+
Mineralization rate

Bioresource Technology 194 (2015) 344–351

Contents lists available at ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

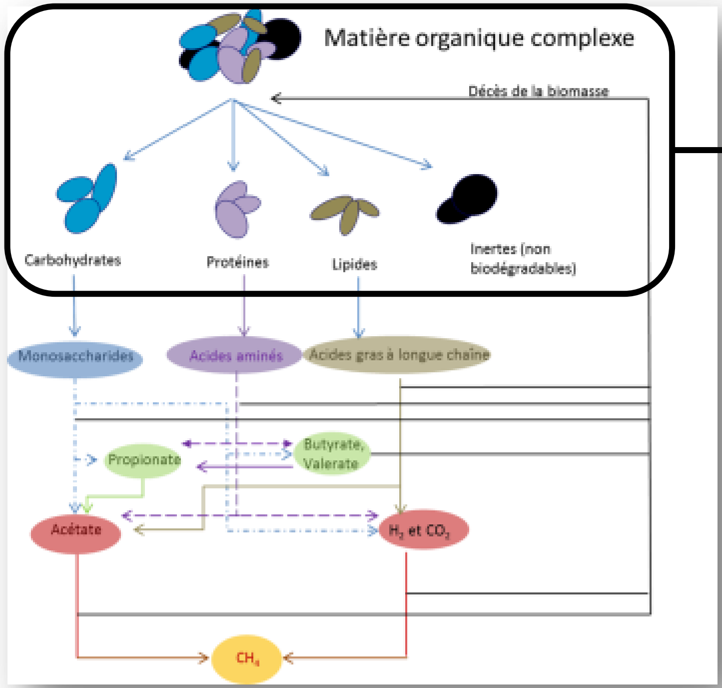
A new organic matter fractionation methodology for organic wastes: Bioaccessibility and complexity characterization for treatment optimization

Julie Jimenez[a,*], Quentin Aemig[a], Nicolas Doussiet[a], Jean-Philippe Steyer[a], Sabine Houot[b], Dominique Patureau[a]

Process modelling

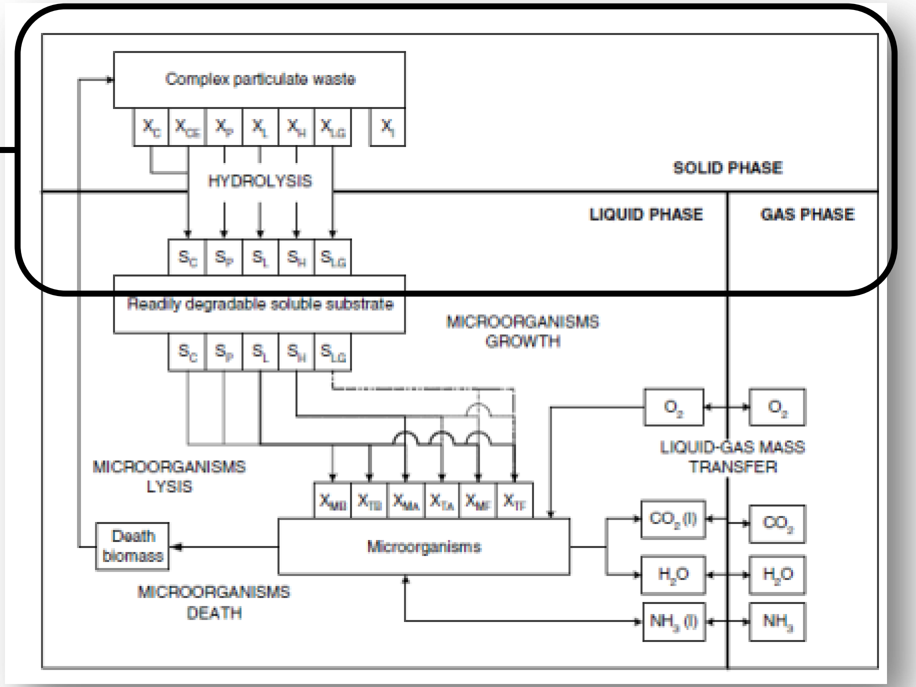
Anaerobic digestion

Composting



ADM1 : Batstone et al.(2002)

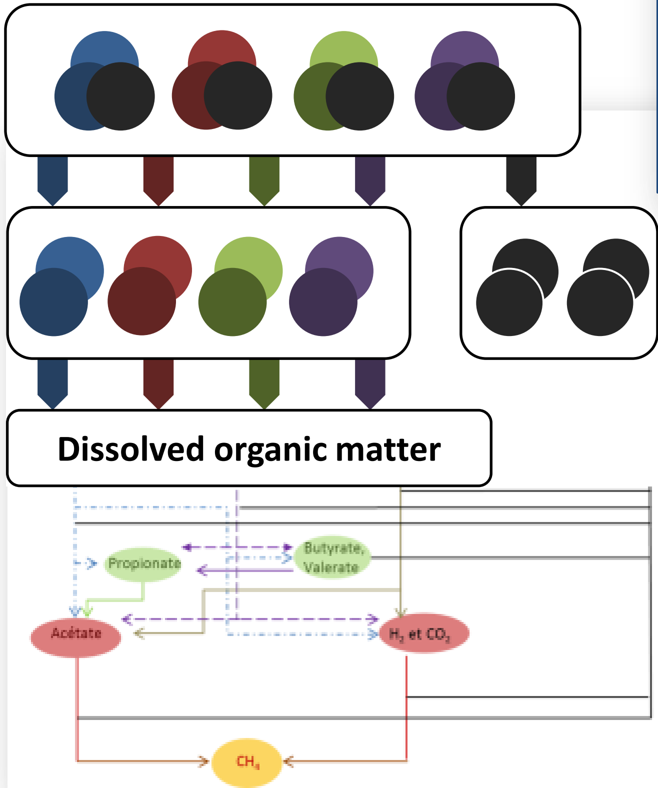
≠



Sole-Mauri et al.(2007)

Process modelling

Anaerobic digestion

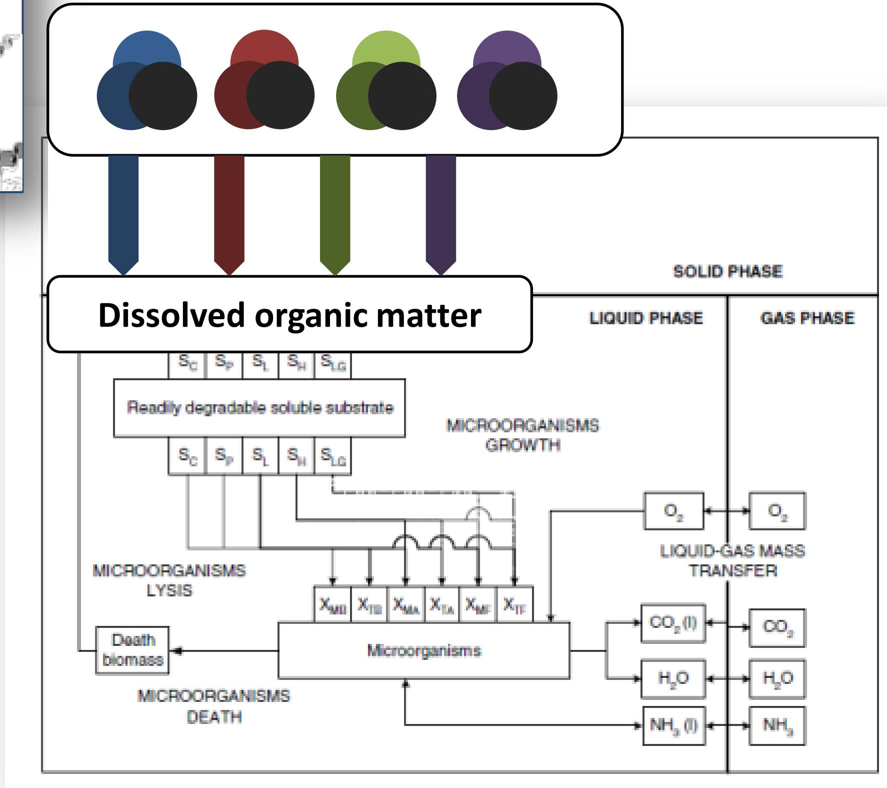


Dissolved organic matter

ADM1 : Batstone et al.(2002)

accessibility

Composting

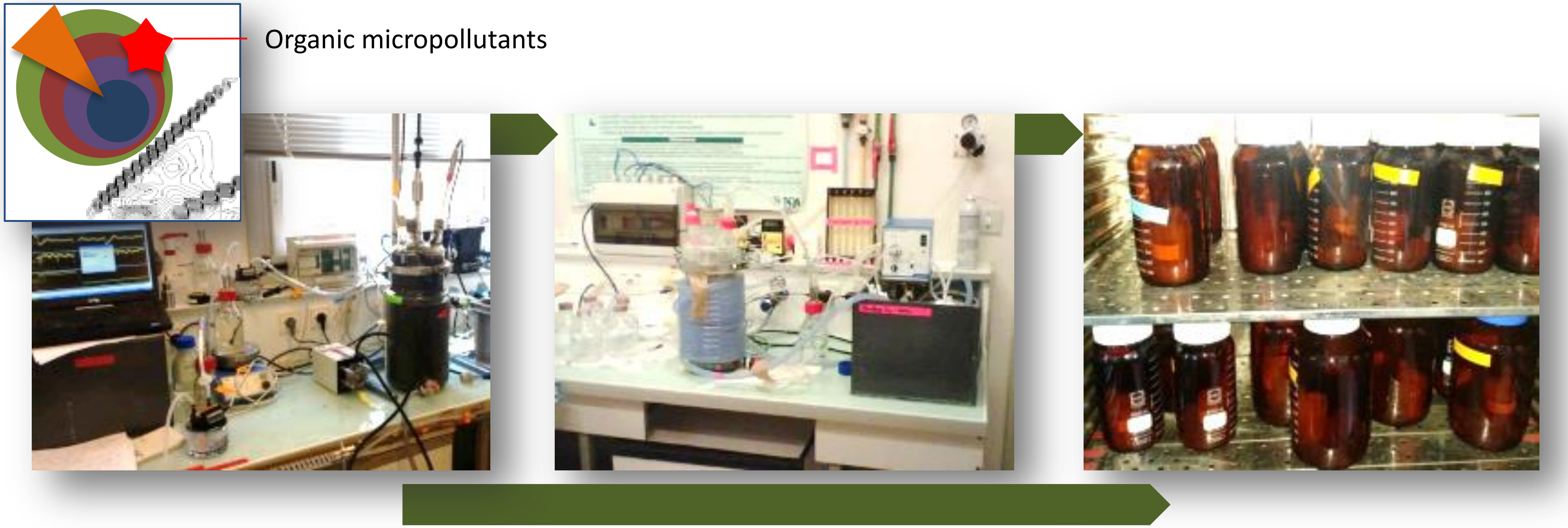


Dissolved organic matter

Sole-Mauri et al.(2007)

Process modelling

Lab scale reactors to generate data for models calibration/validation



Organic micropollutants

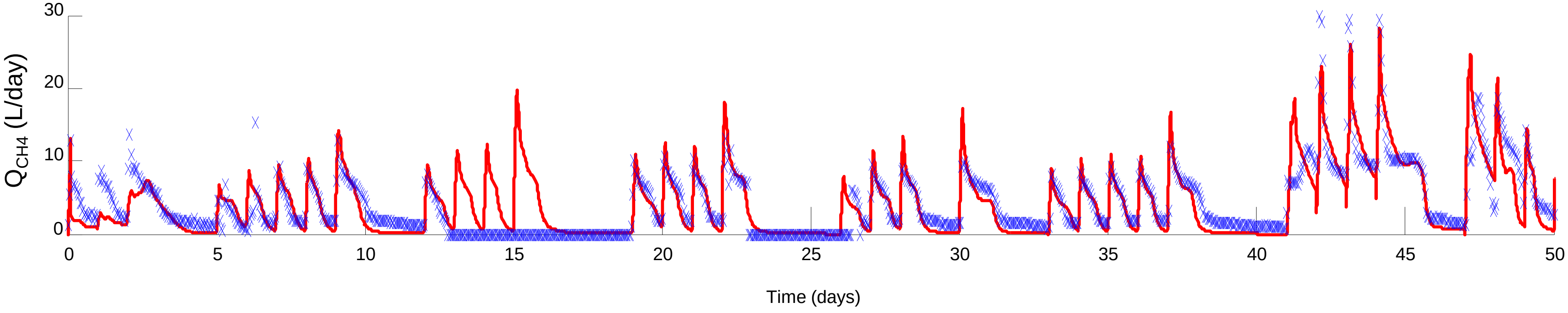
Anaerobic Digestion

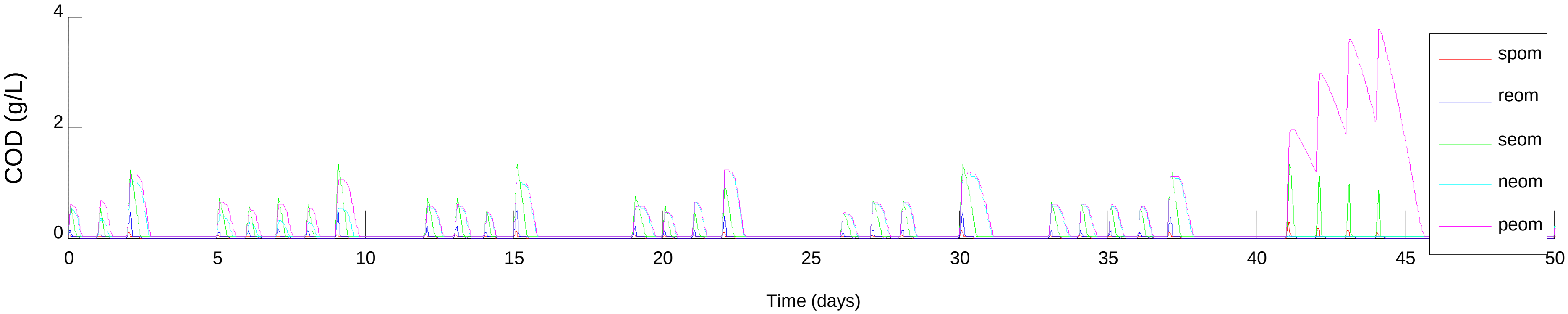
Compost

Cropped soil Incubation

Process modelling

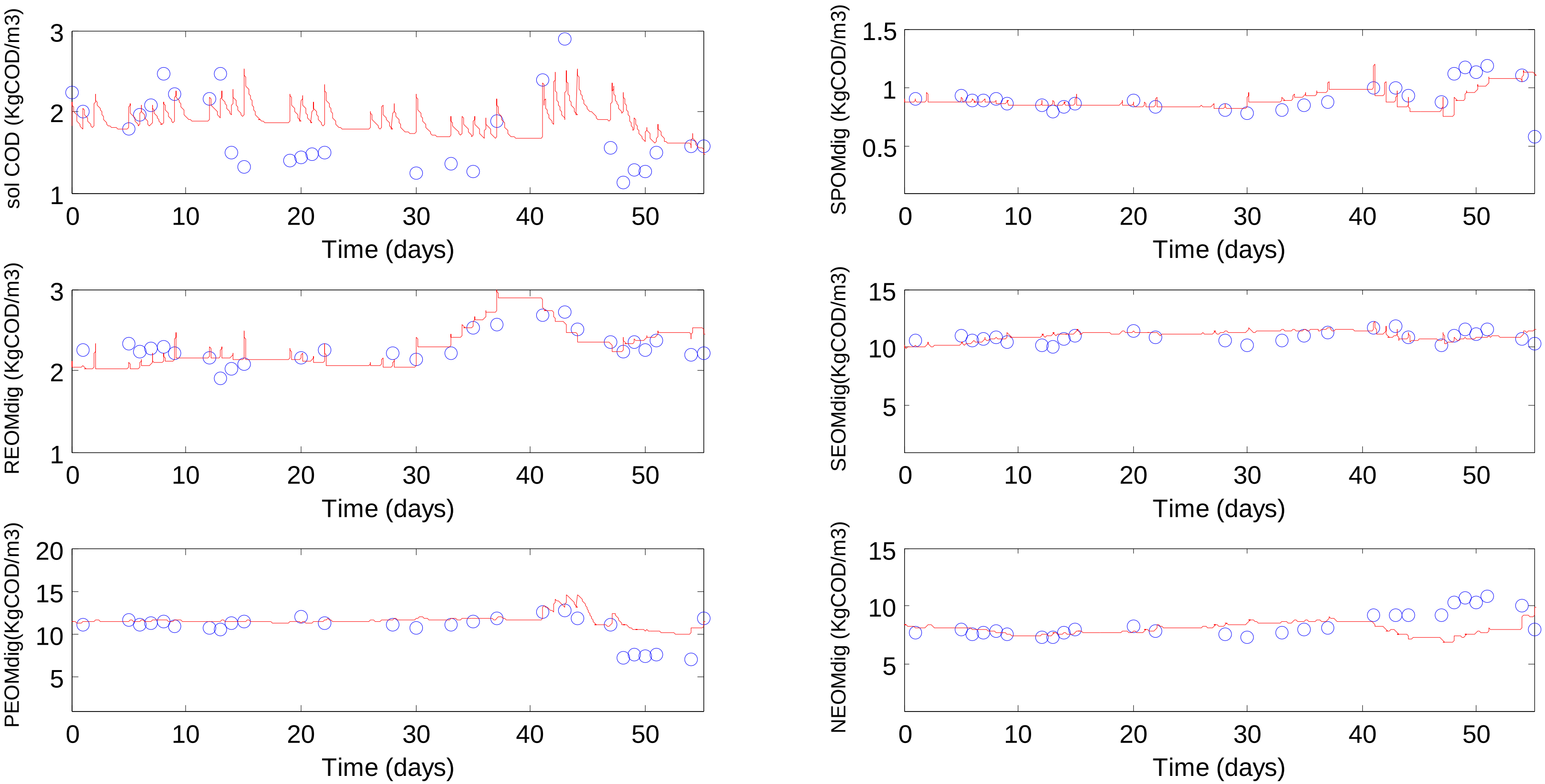
Modeling of the digester performance



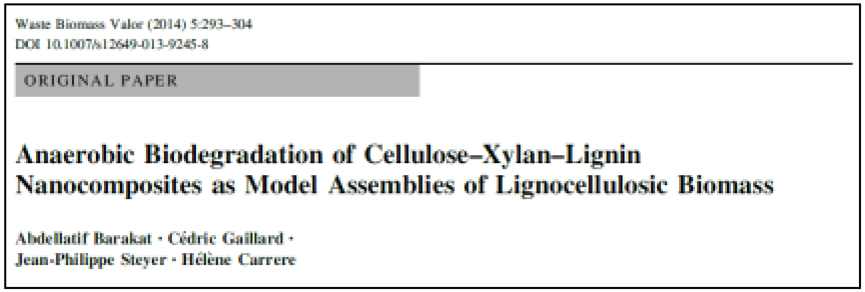


Process modelling

Modeling of the digestate fractions



Better characterization leads to better pretreatments



Waste Biomass Valor (2014) 5:293–304
DOI 10.1007/s12649-013-9245-8

ORIGINAL PAPER

Anaerobic Biodegradation of Cellulose–Xylan–Lignin Nanocomposites as Model Assemblies of Lignocellulosic Biomass

Abdellatif Barakat · Cédric Gaillard ·
Jean-Philippe Steyer · Hélène Carrere

BIOMASS AND BIOENERGY 63 (2014) 33–45

Available online at www.sciencedirect.com
ScienceDirect
http://www.elsevier.com/locate/biombioe

ELSEVIER

Impact of xylan structure and lignin–xylan association on methane production from C_5-sugars

Abdellatif Barakat[*], Amal Kadimi, Jean-Philippe Steyer, Hélène Carrère

INRA, UR0050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, Narbonne F-11100, France

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Industrial Crops and Products 52 (2014) 695–701

Contents lists available at ScienceDirect
Industrial Crops and Products
journal homepage: www.elsevier.com/locate/indcrop

ELSEVIER

Morphological structures of wheat straw strongly impacts its anaerobic digestion

J.-C. Motte, R. Escudié, N. Beaufils, J.-P. Steyer, N. Bernet, J.-P. Delgenès, C. Dumas[*]

INRA, UR0050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, F-11100 Narbonne, France

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INTERNATIONAL JOURNAL OF HYDROGEN ENERGY 37 (2012) 10639–10647

Available online at www.sciencedirect.com
SciVerse ScienceDirect
journal homepage: www.elsevier.com/locate/he

ELSEVIER

Effect of enzyme addition on fermentative hydrogen production from wheat straw

Marianne Quéméneur[a,1], Marine Bittel[a,b], Eric Trably[a,], Claire Dumas[a], Laurent Fourage[b], Gilles Ravot[b], Jean-Philippe Steyer[a], Hélène Carrère[a]*

[a] INRA, UR050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, Narbonne F-11100, France
[b] Proteus, Parc Georges Besse, 70 allée Graham Bell, Nîmes, F-30035 Cedex 1, France

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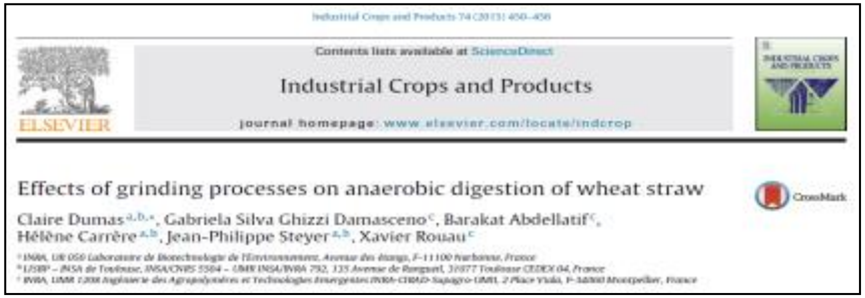

Industrial Crops and Products 74 (2015) 450–456

Contents lists available at ScienceDirect
Industrial Crops and Products
journal homepage: www.elsevier.com/locate/indcrop

ELSEVIER

Effects of grinding processes on anaerobic digestion of wheat straw

Claire Dumas[a,b,*], Gabriela Silva Ghizzi Damasceno[c], Barakat Abdellatif[c], Hélène Carrère[a,b], Jean-Philippe Steyer[a,b], Xavier Rouau[c]

[a] INRA, UR 050 Laboratoire de Biotechnologie de l'Environnement, Avenue des étangs, F-11100 Narbonne, France
[b] LISBP – INSA de Toulouse, INSA/CNRS 5504 – UMR INSA/INRA 792, 135 Avenue de Rangueil, 31077 Toulouse CEDEX 04, France
[c] INRA, UMR 1208 Ingénierie des Agropolymères et Technologies Emergentes INRA-CIRAD-Supagro-UM1, 2 Place Viala, F-34060 Montpellier, France

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Chemical Engineering Journal 260 (2015) 377–385

Contents lists available at ScienceDirect
Chemical Engineering Journal
journal homepage: www.elsevier.com/locate/cej

ELSEVIER

Chemical Engineering Journal

Alkaline pretreatment to enhance one-stage CH_4 and two-stage H_2/CH_4 production from sunflower stalks: Mass, energy and economical balances

F. Monlau[a], P. Kaparaju[a,b,1], E. Trably[a], J.P. Steyer[a], H. Carrere[a,*]

[a] INRA, UR0050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, 11100 Narbonne, France
[b] Department of Biological and Environmental Science, University of Jyväskylä, P.O. Box 35, FI-40014, Finland

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Bioresource Technology 194 (2015) 344–353

Contents lists available at ScienceDirect
Bioresource Technology
journal homepage: www.elsevier.com/locate/biortech

ELSEVIER

A new organic matter fractionation methodology for organic wastes: Bioaccessibility and complexity characterization for treatment optimization

Julie Jimenez[a,*], Quentin Aemig[a], Nicolas Doussiet[a], Jean-Philippe Steyer[a], Sabine Houot[b], Dominique Patureau[a]

[a] INRA, UR050, Laboratoire de Biotechnologie de l'Environnement, Av. des Etangs, Narbonne F-11100, France
[b] INRA UMR 1402 ECOSYS Ecologie fonctionnelle et éco-toxicologie des agro-écosystèmes, 78 850 Thiverval-Grignon, France

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Bioresource Technology 191 (2015) 322–326

Contents lists available at ScienceDirect
Bioresource Technology
journal homepage: www.elsevier.com/locate/biortech

ELSEVIER

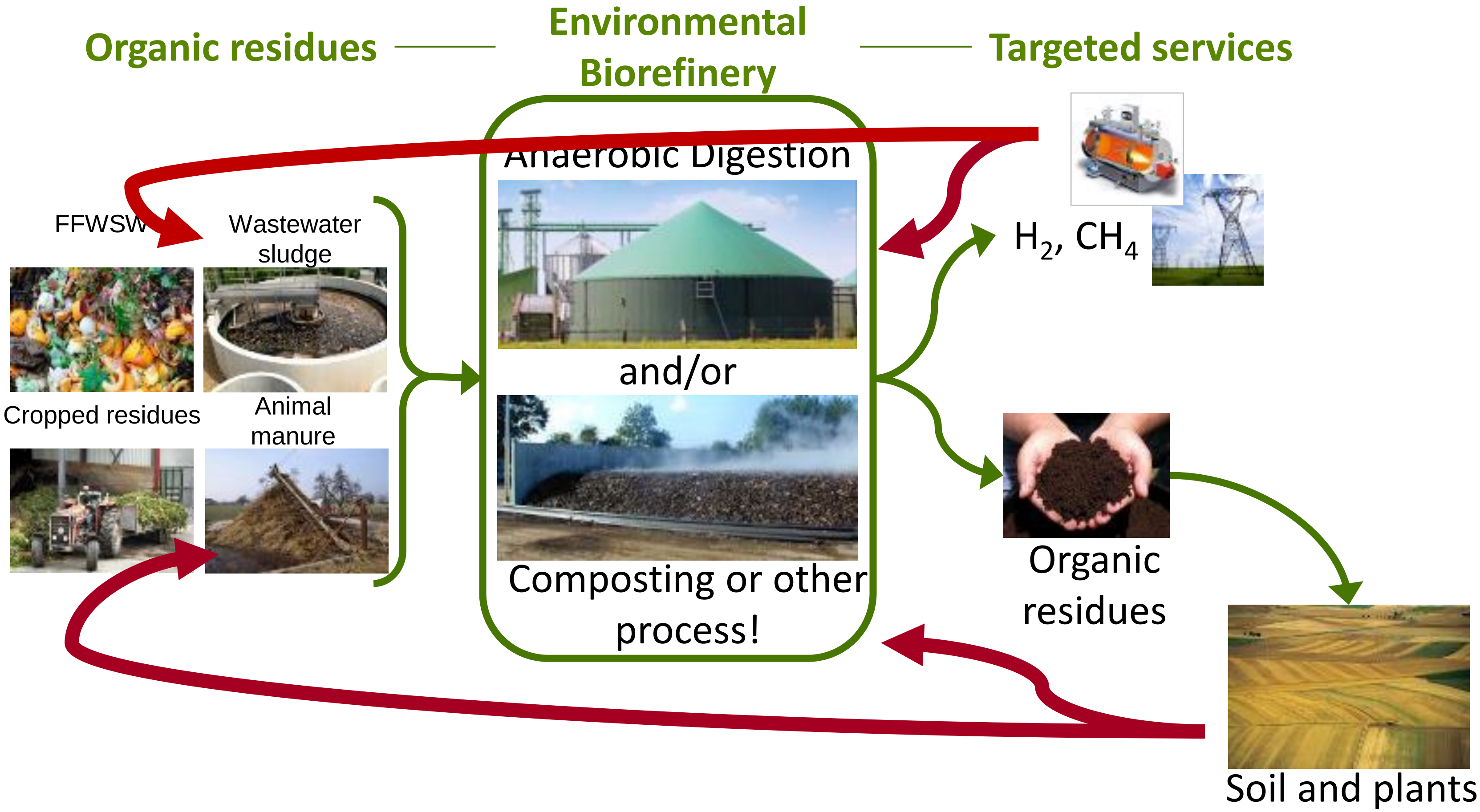
Short Communication

Dynamic observation of the biodegradation of lignocellulosic tissue under solid-state anaerobic conditions

J.-C. Motte[a], F. Watteau[b,c], R. Escudié[a], J.-P. Steyer[a], N. Bernet[a], J.-P. Delgenes[a], C. Dumas[a,d,*]

[a] INRA, UR0050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, Narbonne F-11100, France
[b] Université de Lorraine, LSE, UMR 1120, Vandoeuvre-lès-Nancy F-54505, France
[c] CNRS, UMS 3562, Vandoeuvre-lès-Nancy F-54501, France
[d] LISBP - INSA de Toulouse, INSA/CNRS 5504 - UMR INSA/INRA 792, 135 Avenue de Rangueil, 31077 Toulouse CEDEX 04, France

The added value for optimal valorization of organic residues



Organic residues — **Environmental Biorefinery** — **Targeted services**

FFWSW

Wastewater sludge

Cropped residues

Animal manure

Anaerobic Digestion

and/or

Composting or other process!

H_2, CH_4

Organic residues

Soil and plants

→ C, N, P, K, S and micropollutants fate: **process modelling** and **reverse engineering**

What is next ?

Instrumentation for tomorow


Biosensors and Bioelectronics 47 (2013) 50–55

Contents lists available at SciVerse ScienceDirect

Biosensors and Bioelectronics

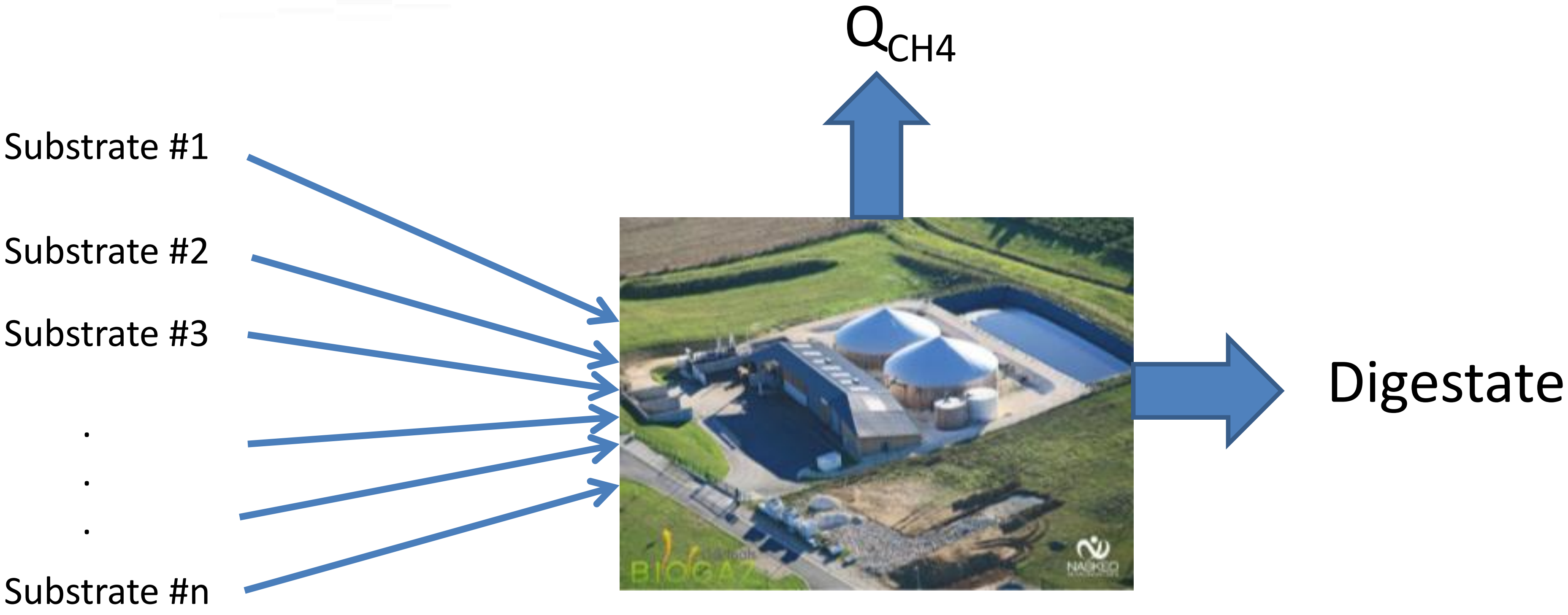
journal homepage: www.elsevier.com/locate/bios

Microbial fuel cell type biosensor for specific volatile fatty acids using acclimated bacterial communities

Amandeep Kaur [a], Jung Rae Kim [b,c], Iain Michie [b], Richard M. Dinsdale [a], Alan J. Guwy [a], Giuliano C. Premier [b,*], Sustainable Environment Research Centre (SERC)

[a] Faculty of Health, Sport and Science, University of Glamorgan, Pontypridd, Mid-Glamorgan CF37 1DL, UK
[b] Faculty of Advanced Technology, University of Glamorgan, Pontypridd, Mid-Glamorgan CF37 1DL, UK
[c] School of Chemical and Biomolecular Engineering, Pusan National University, Jangjeon-Dong, Geumjeong-gu, Busan 609-735, Korea

How to optimise codigestion ?



Q_{CH4}

Substrate #1

Substrate #2

Substrate #3

.

.

.

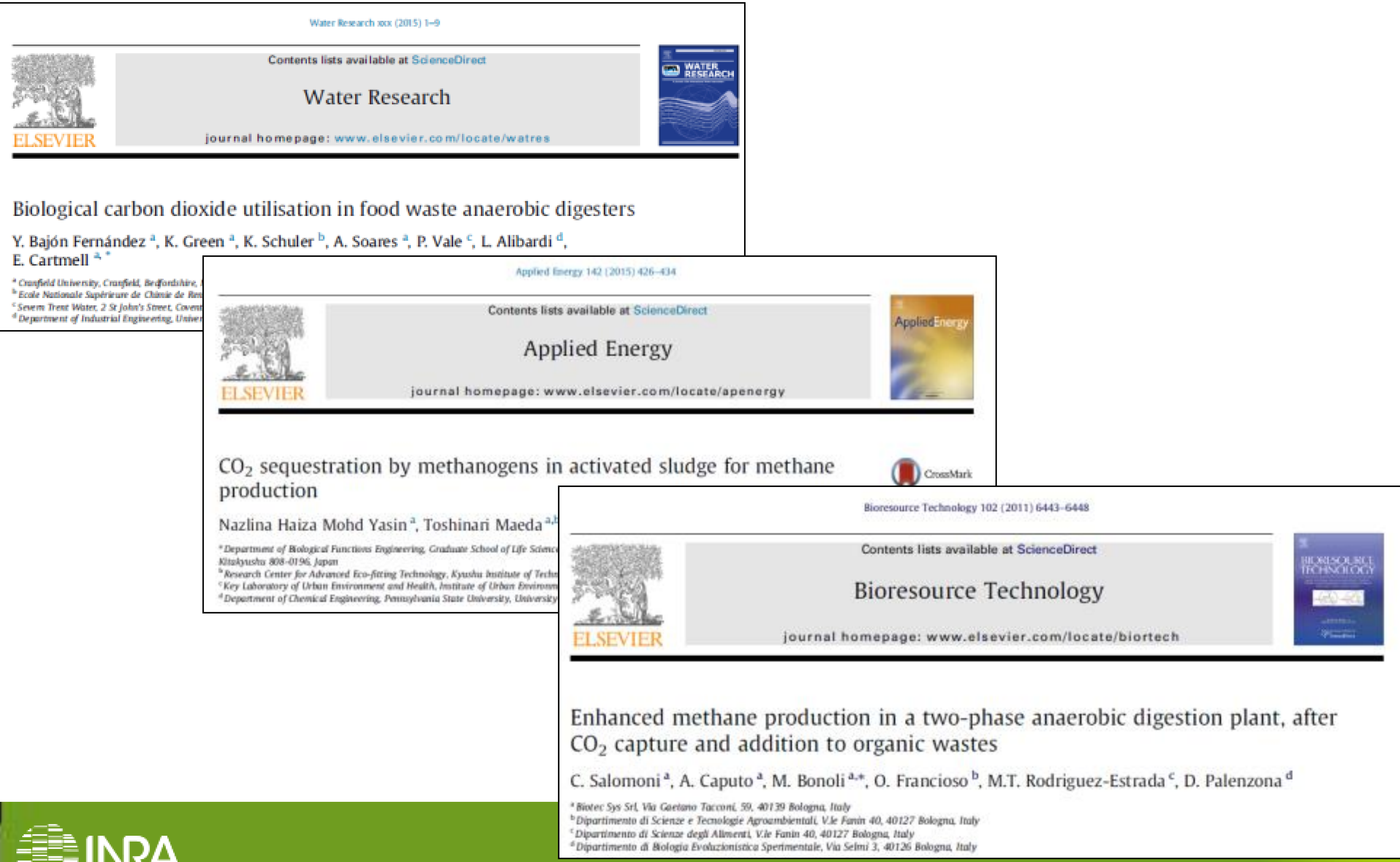
Substrate #n

Digestate

1 + 1 = 2 … or less !

↳ Model based optimisation

Lack of actuators ?



Water Research xxx (2015) 1–9

Contents lists available at ScienceDirect

Water Research

journal homepage: www.elsevier.com/locate/watres

Biological carbon dioxide utilisation in food waste anaerobic digesters

Y. Bajón Fernández [a], K. Green [a], K. Schuler [b], A. Soares [a], P. Vale [c], L. Alibardi [d], E. Cartmell [a, *]

[a] Cranfield University, Cranfield, Bedfordshire,
[b] Ecole Nationale Supérieure de Chimie de Ren
[c] Severn Trent Water, 2 St John's Street, Covent
[d] Department of Industrial Engineering, Univer

Applied Energy 142 (2015) 426–434

Contents lists available at ScienceDirect

Applied Energy

journal homepage: www.elsevier.com/locate/apenergy

CO_2 sequestration by methanogens in activated sludge for methane production

Nazlina Haiza Mohd Yasin [a], Toshinari Maeda [a,b]

[a] Department of Biological Functions Engineering, Graduate School of Life Science
Kitakyushu 808-0196, Japan
[b] Research Center for Advanced Eco-fitting Technology, Kyushu Institute of Techn
[c] Key Laboratory of Urban Environment and Health, Institute of Urban Environm
[d] Department of Chemical Engineering, Pennsylvania State University, University

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Bioresource Technology 102 (2011) 6443–6448

Contents lists available at ScienceDirect

Bioresource Technology

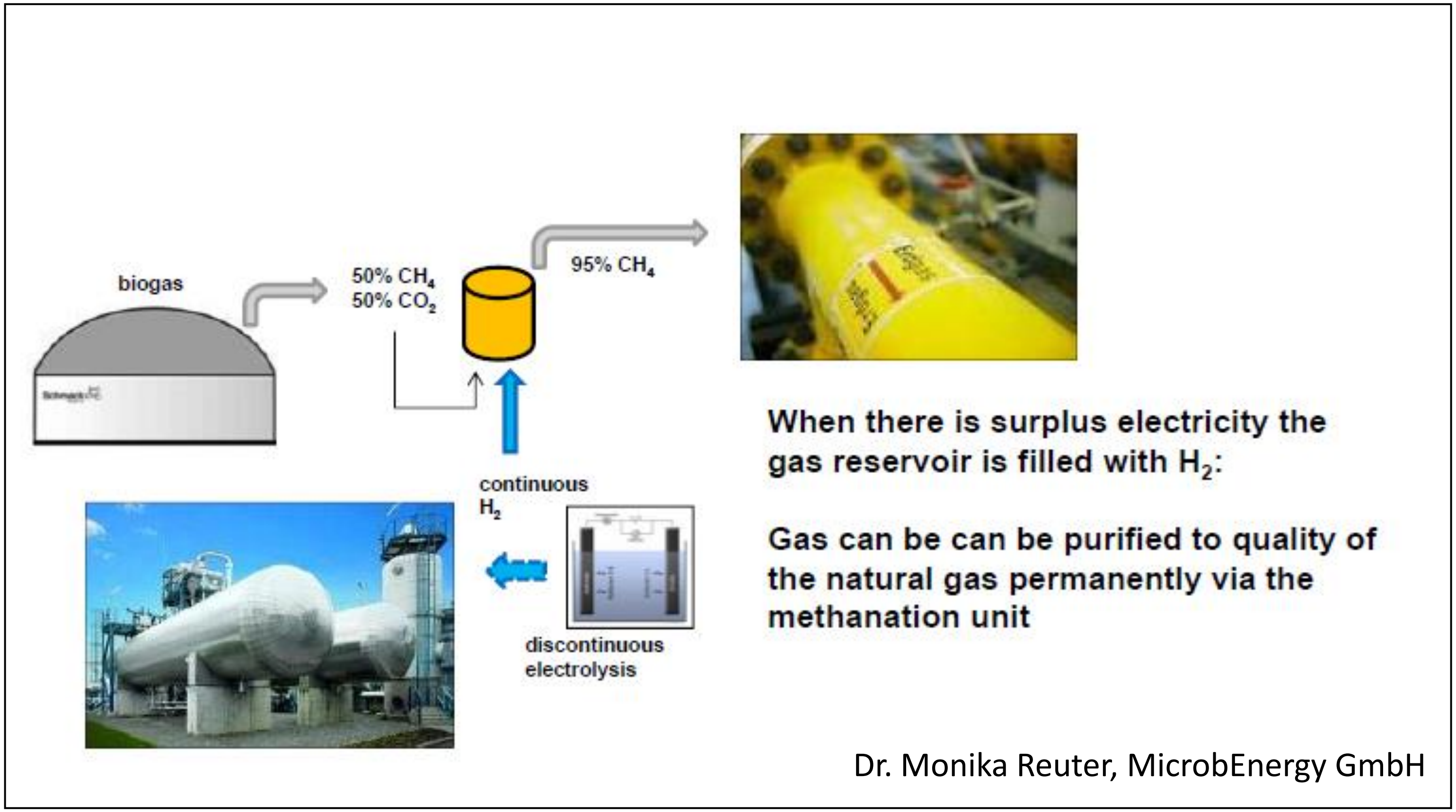
journal homepage: www.elsevier.com/locate/biortech

Enhanced methane production in a two-phase anaerobic digestion plant, after CO_2 capture and addition to organic wastes

C. Salomoni [a], A. Caputo [a], M. Bonoli [a,*], O. Francioso [b], M.T. Rodriguez-Estrada [c], D. Palenzona [d]

[a] Biotec Sys Srl, Via Gaetano Tacconi, 59, 40139 Bologna, Italy
[b] Dipartimento di Scienze e Tecnologie Agroambientali, V.le Fanin 40, 40127 Bologna, Italy
[c] Dipartimento di Scienze degli Alimenti, V.le Fanin 40, 40127 Bologna, Italy
[d] Dipartimento di Biologia Evoluzionistica Sperimentale, Via Selmi 3, 40126 Bologna, Italy

Power to Gas : from H_2 to CH_4 (to store energy)

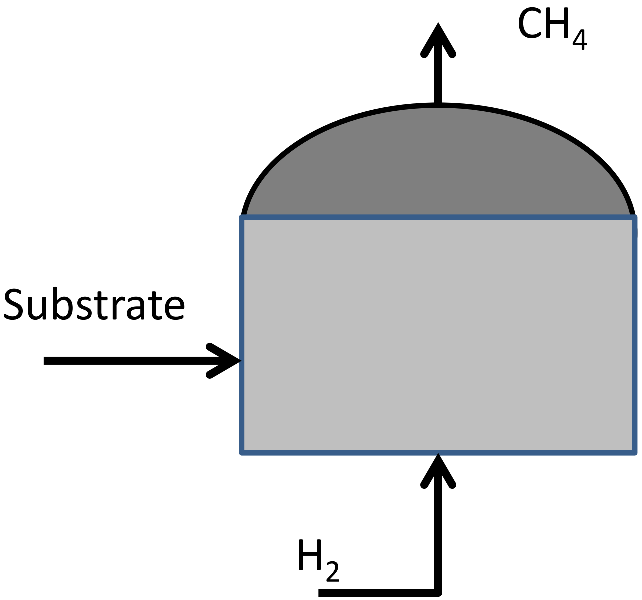


When there is surplus electricity the gas reservoir is filled with H_2:

Gas can be can be purified to quality of the natural gas permanently via the methanation unit

Dr. Monika Reuter, MicrobEnergy GmbH

Power to *BIO*Gas : H_2 to improve CH_4



- ✓ Improved hydrogenetrophic methanogenesis
- ✓ Lower inhibition of hydrolysis
- ✓ Limitation by gas transfer

Bioresource Technology 185 (2015) 246–253

Contents lists available at ScienceDirect

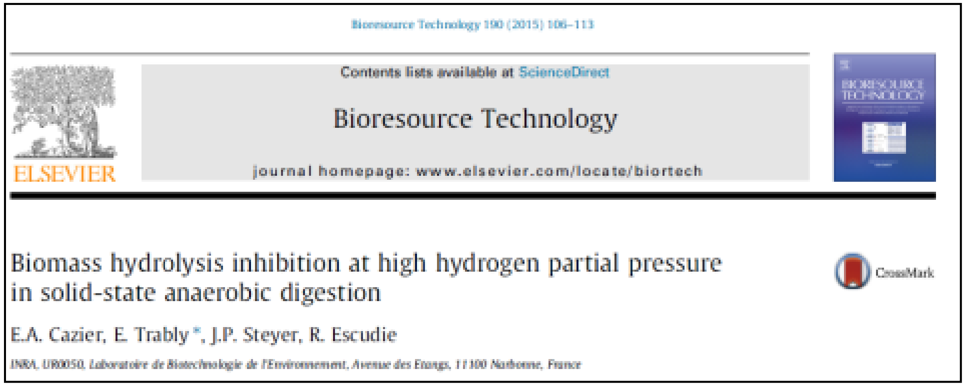
Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

A feasibility study on the bioconversion of CO_2 and H_2 to biomethane by gas sparging through polymeric membranes

I. Díaz [a,*], C. Pérez [b], N. Alfaro [a], F. Fdz-Polanco [a]

[a] Department of Chemical Engineering and Environmental Technology, Escuela de Ingenierías Industriales, Sede Dr. Mergelina, University of Valladolid, Dr. Mergelina s/n, 47011 Valladolid, Spain
[b] Department of Process Engineering, Ros Roca Indox Cryo Energy S.L., Spain



Bioresource Technology 190 (2015) 106–113

Contents lists available at ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

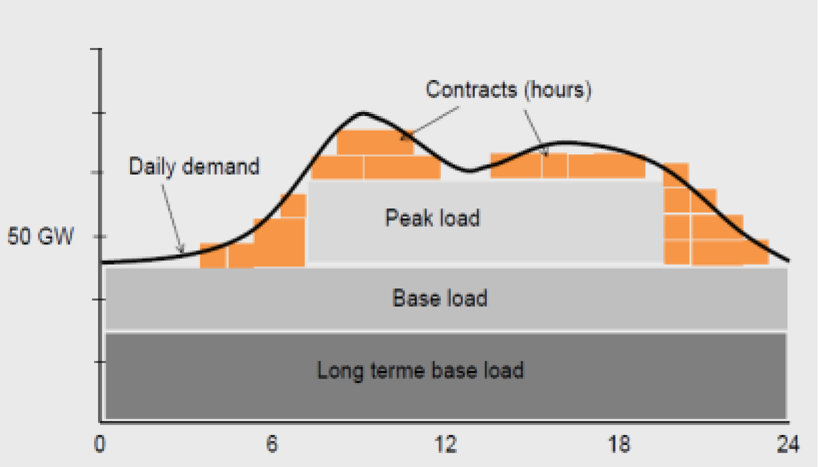
Biomass hydrolysis inhibition at high hydrogen partial pressure in solid-state anaerobic digestion

E.A. Cazier, E. Trably [*], J.P. Steyer, R. Escudie

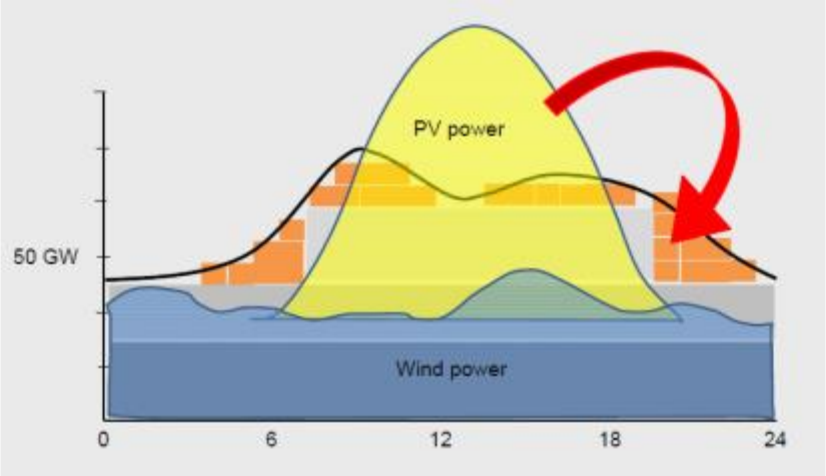
INRA, UR0050, Laboratoire de Biotechnologie de l'Environnement, Avenue des Etangs, 11100 Narbonne, France

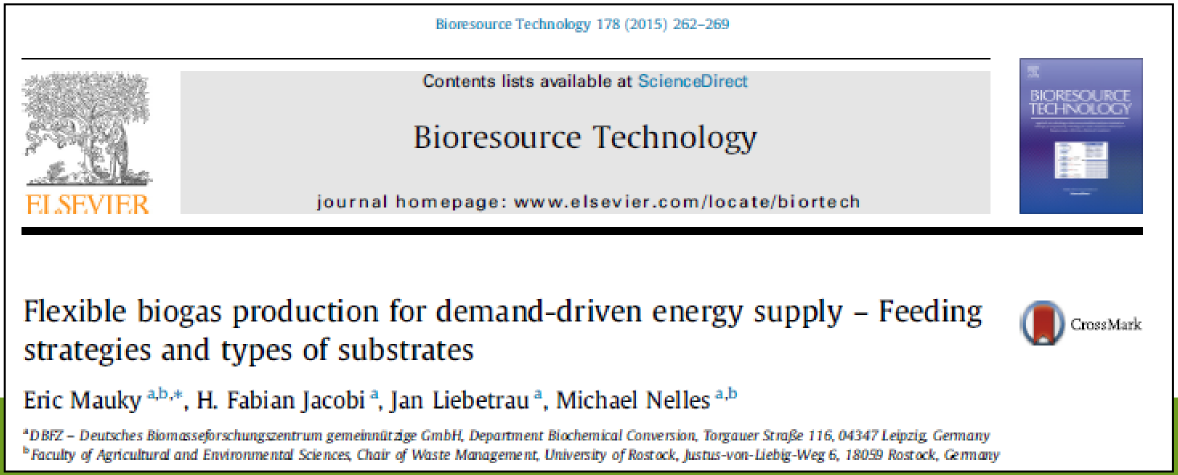
AD as a flexible renewable energy production

Today: energy market is dominated by big central power plants



Future : production based on weather conditions (AD as a central role in flexibility)





Bioresource Technology 178 (2015) 262–269

Contents lists available at ScienceDirect

Bioresource Technology

journal homepage: www.elsevier.com/locate/biortech

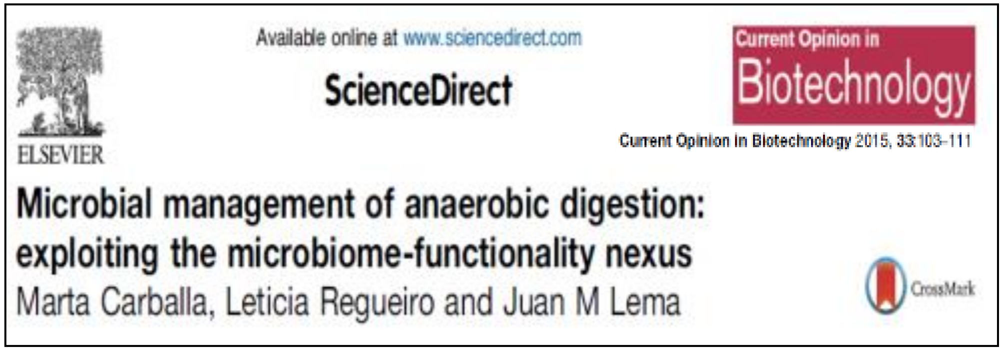
Flexible biogas production for demand-driven energy supply – Feeding strategies and types of substrates

Eric Mauky [a,b,*], H. Fabian Jacobi [a], Jan Liebetrau [a], Michael Nelles [a,b]

[a] DBFZ – Deutsches Biomasseforschungszentrum gemeinnützige GmbH, Department Biochemical Conversion, Torgauer Straße 116, 04347 Leipzig, Germany

[b] Faculty of Agricultural and Environmental Sciences, Chair of Waste Management, University of Rostock, Justus-von-Liebig-Weg 6, 18059 Rostock, Germany

Towards optimal and engineered microbial ressource management ?



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Microbial management of anaerobic digestion: exploiting the microbiome-functionality nexus

Marta Carballa, Leticia Regueiro and Juan M Lema

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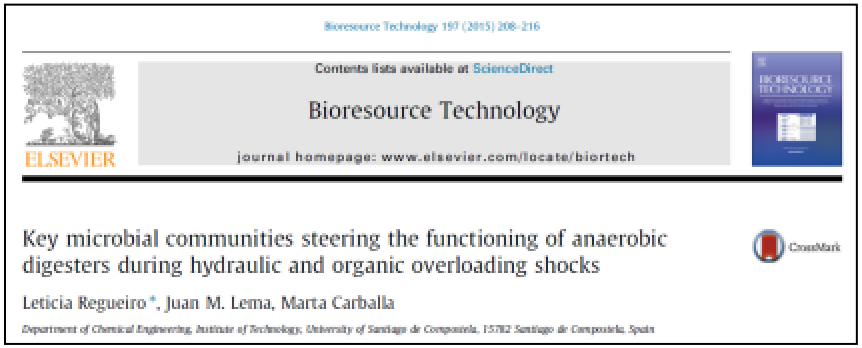

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Key microbial communities steering the functioning of anaerobic digesters during hydraulic and organic overloading shocks

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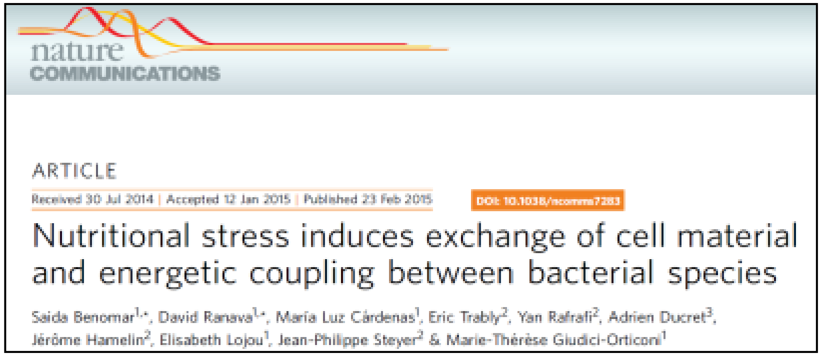

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Nutritional stress induces exchange of cell material and energetic coupling between bacterial species

Saida Benomar[1,*], David Ranava[1,*], María Luz Cárdenas[1], Eric Trably[2], Yan Rafrafi[2], Adrien Ducret[3], Jérôme Hamelin[2], Elisabeth Lojou[1], Jean-Philippe Steyer[2] & Marie-Thérèse Giudici-Orticoni[1]

For more information

Instrumentation and control of anaerobic digestion processes: a review and some research challenges

Julie Jimenez, Eric Latrille, Jérôme Harmand, Angel Robles, José Ferrer, Daniel Gaida, Christian Wolf, Francis Mairet, Olivier Bernard, et al.

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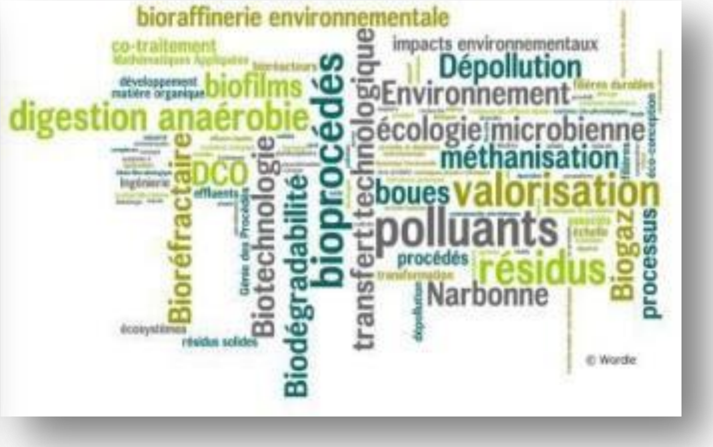

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