EU-India STI Cooperation Days
8-9 November 2012, Hyderabad
www.euindiacoop.org/2012

Low cost recovery of reclaimed water from sewage mixed industrial effluents

'REWATER project'

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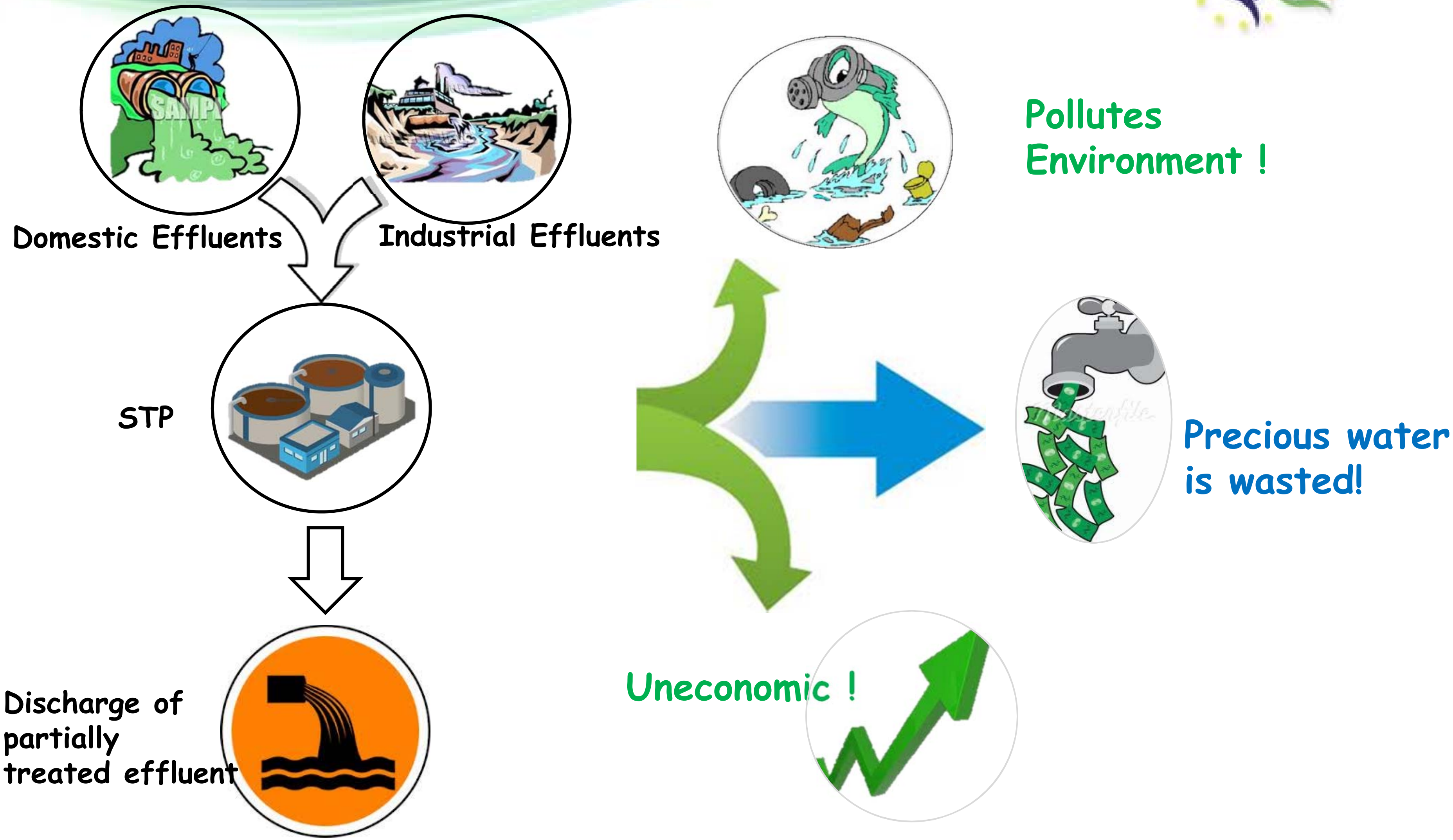
THE PROBLEM



Domestic Effluents
Industrial Effluents
STP
Discharge of partially treated effluent
Pollutes Environment !
Precious water is wasted!
Uneconomic !

REWATER Aim

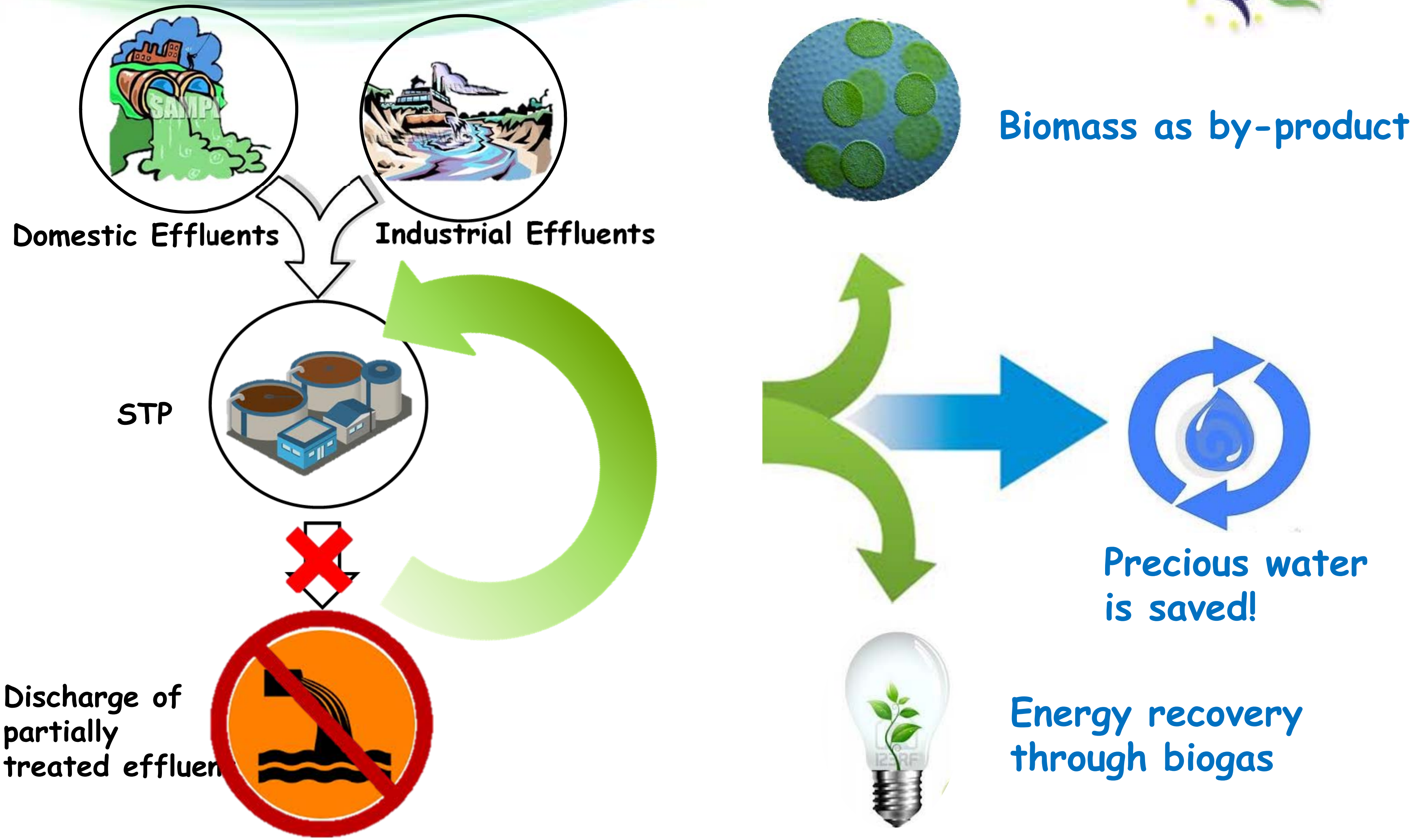
CSIR-NEERI, India

USC, Spain

LabMET, Belgium

'To develop a cost effective, natural and energy efficient process package to treat sewage-mixed industrial effluent to a recyclable quality free that is from pollutants (PPCPs), nutrients, micronutrients and pathogens'

SOLUTION



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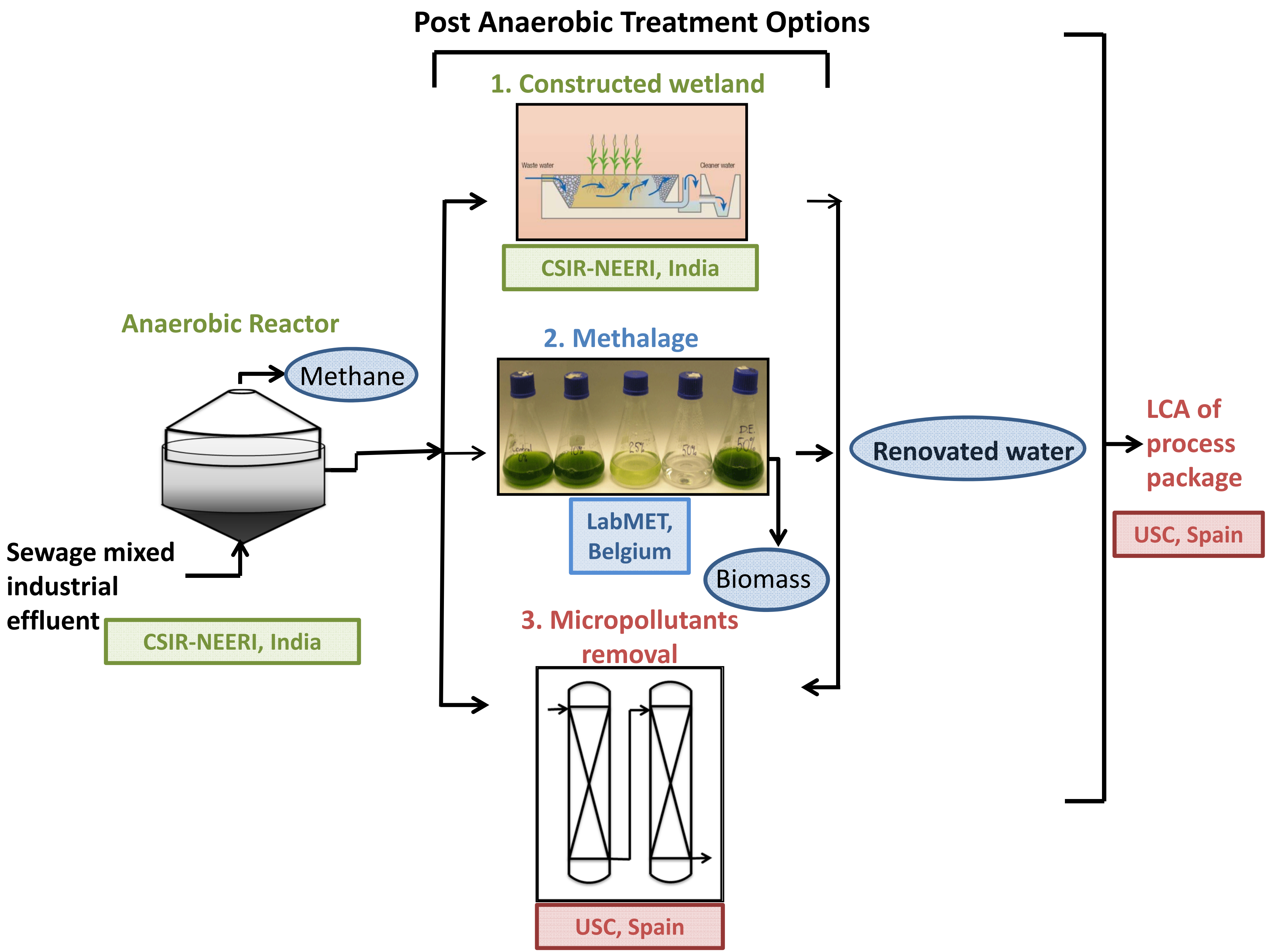

Post Anaerobic Treatment Options
1. Constructed wetland
Waste water
Cleaner water
CSIR-NEERI, India
Anaerobic Reactor
Methane
2. Methalage
LabMET, Belgium
Biomass
Renovated water
LCA of process package
USC, Spain
Sewage mixed industrial effluent
CSIR-NEERI, India
3. Micropollutants removal
USC, Spain

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National Environmental Engineering Research Institute

(CSIR-NEERI)

Wastewater Technology Division

Dr. Rima Biswas Mondal

नीरी
NEERI

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Work at CSIR-NEERI

Strategy

1. Anaerobic Reactor (UASB)

1. Establishing UASB
2. Optimizing operating parameters
3. Harnessing maximum biogas

2. Constructed Wetland System

1. Establishing CWS
2. Optimizing operating parameters
3. Prospecting for recycling treated water

3. UASB + CSW

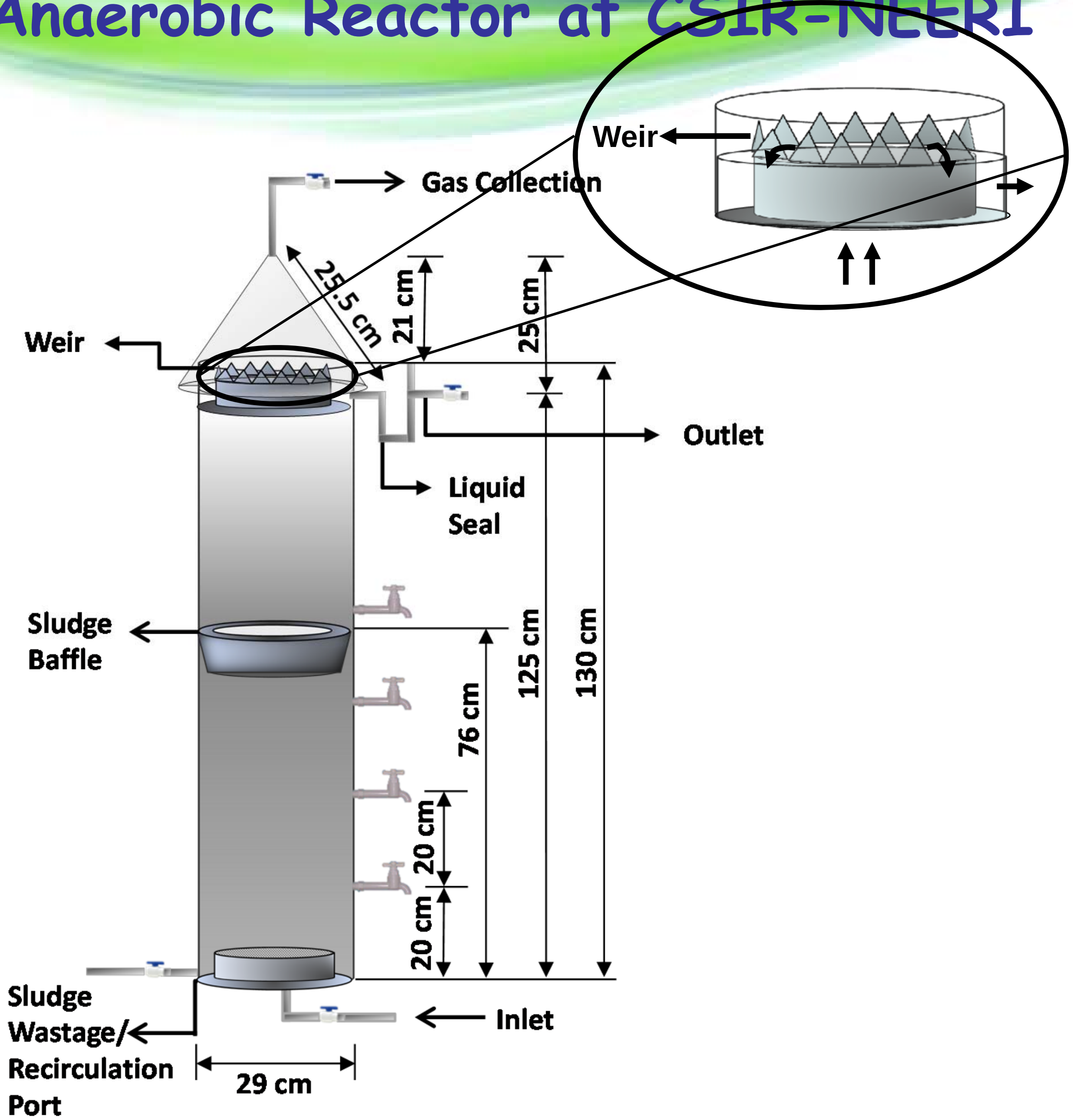
Operation of UASB and CWS in series

4. Reviewing other options

Methalgae

Biological filtration system

Anaerobic Reactor at CSIR-NEERI



Start-Up

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STEP 1	Seed	Anaerobic Digester sludge from STP + Cow Dung (5:1)
STEP 2	Inoculation	Domestic Sewage + Methanolic Wastewater (COD 2500-4000 mg/L)
STEP 3	Start -up	Initial OLR = 1.43 $kg/m^{3}\cdot d$ HRT = 2.8 d

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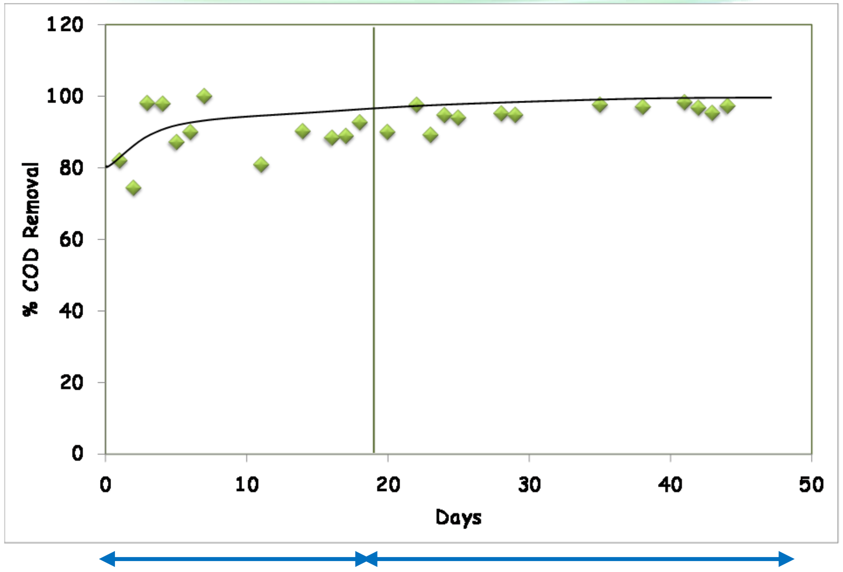
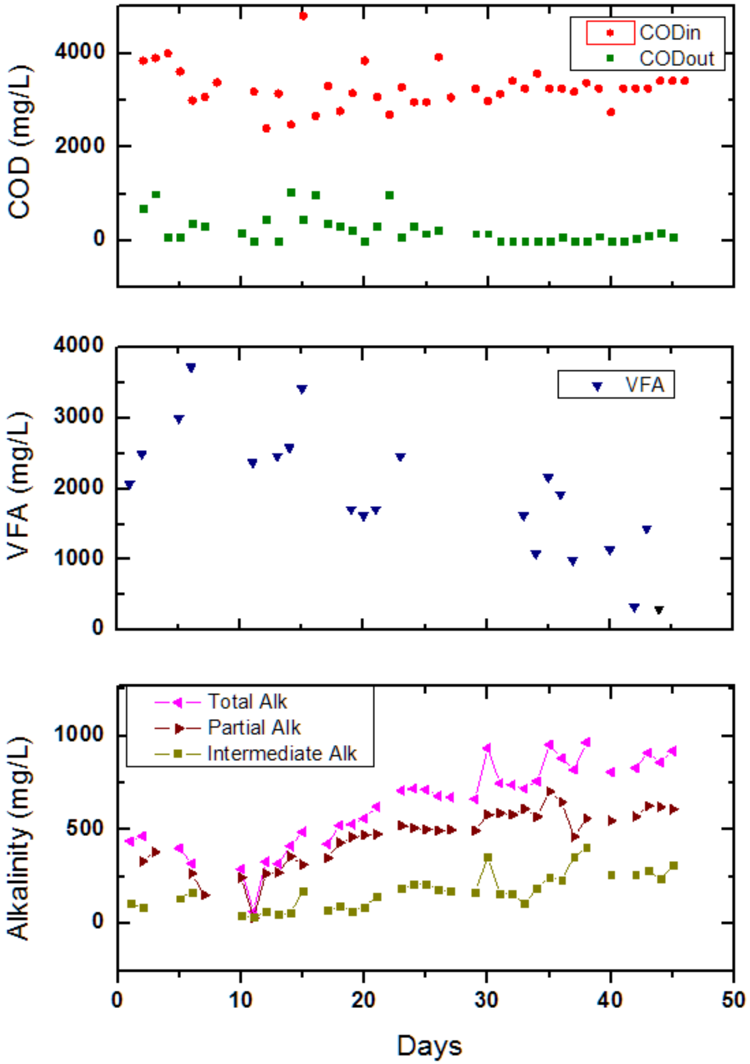
Performance of Anaerobic Unit



OLR 1.43 kg/m^3.d
HRT 2.8 d

OLR 2 kg/m^3.d
HRT 1.9 d



The unit is still under stabilization phase

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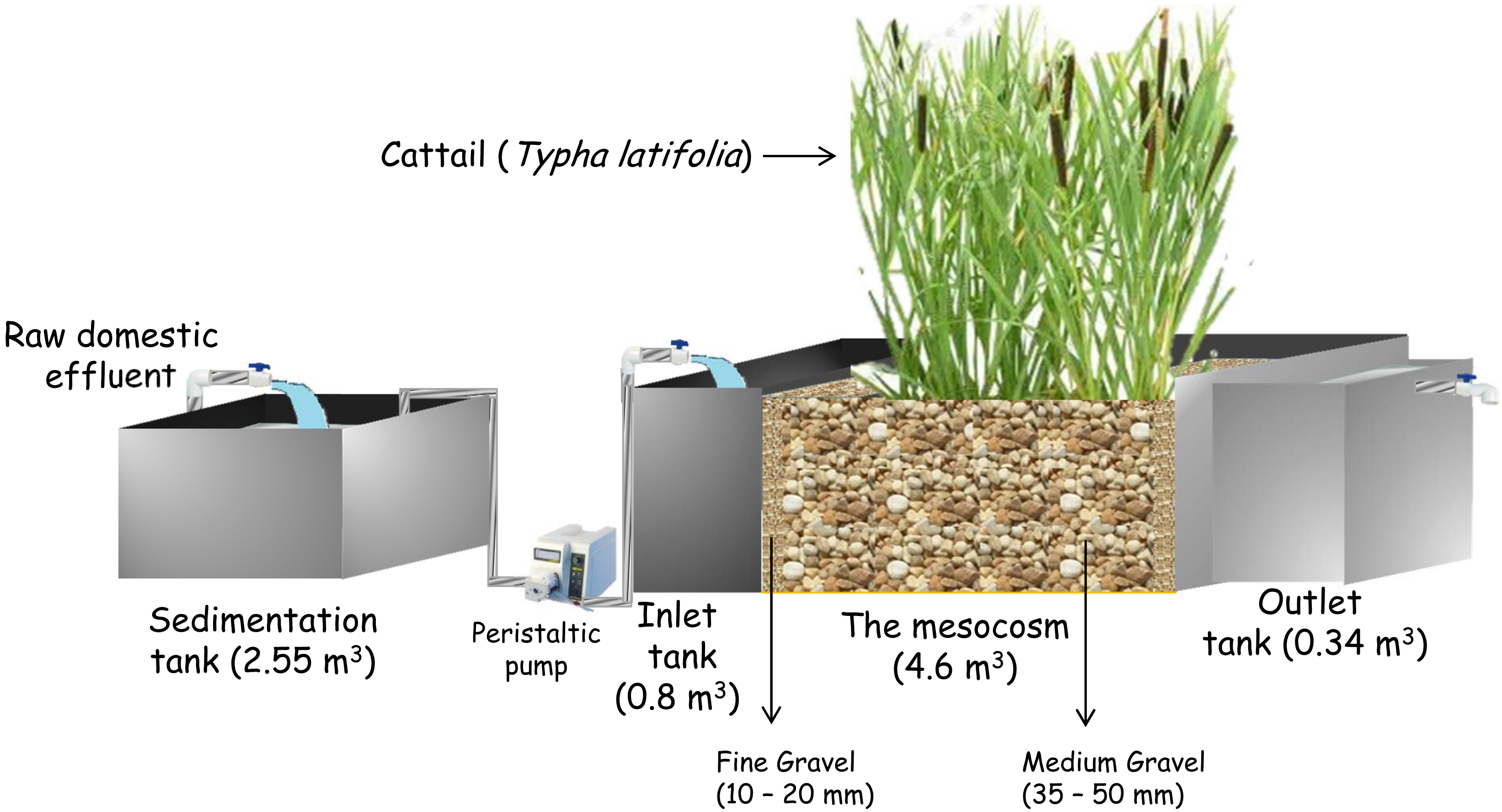
Constructed Wetland System at CSIR-NEERI



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Type: Free water, surface constructed wetland

Flow: Vertical (Up-Flow)

Wetland Plant: *Typha latifolia*

Wastewater: Domestic Effluent

HRT: 2.4 d

OLR: 0.23 m/d

Sedimentation tank (2.55 m^3)

Inlet tank (0.8 m^3)

The mesocosm (4.6 m^3)

Outlet tank (0.34 m^3)

S. No.	Plant Classification	Basis for Classification (Plant Height, m)	Number of Plants	
			August, 2012	October, 2012
1	Mature	2.5 – 3.5	14	16
2	Young	1 – 2.5	33	153
3	New	< 1	7	21
	Total Number of Plants		54	190
	Plant Density (No. of Plants/m^2)		11	38

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Overall Performance of CWS

Parameters		RAW SEWAGE	INLET	OUTLET
pH	Range (Min – Max)	6.7 – 7.4	6.9 – 7.4	6.8 – 7.8
COD (mg/L)	Avg. ± Std Dev.	139.28 ± 59.1	81.79 ± 30.22	39.33 ± 15.53
	Range (Min – Max)	69.12 – 310.4	42.7– 128.04	7.68 – 68
TKN (mg/L)	Avg. ± Std Dev.	29.87 ± 5.83	28 ± 5.6	22.4 ± 4.85
	Range (Min – Max)	25.2 – 36.4	22.4 – 33.6	19.6 – 28
NH_3-N (mg/L)	Avg. ± Std Dev.	9.6±4.2	8.92 ± 3.37	7.7 ± 3.54
	Range (Min – Max)	4.5-16.8	4.44 – 15.53	2.93 – 10.74
PO_4^{3-} - P (mg/L)	Avg. ± Std Dev.	7.2±4.3	6.21 ± 3.74	5.1 ± 2.97
	Range (Min – Max)	3.2-15.6	2.25 – 13.05	2.03 – 12.15
TSS (mg/L)	Avg. ± Std Dev.	200 ± 53.96	34.67 ±23.28	10 ± 4.9
	Range (Min – Max)	132 – 260	20 – 80	4 – 16

Group of Environmental Engineering and Bioprocesses
School of Engineering
University of Santiago de Compostela, Spain
Dr. Marta Carballa

BioGroup

Santiago de Compostela

Santiago de Compostela

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School of Engineering

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Biogroup

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8 Professors

- 5 Full Professors
- 3 Associate Prof.

4 Technicians

1 Technological Manager

40 Researchers

- 7 Post-docs
- 30 PhD Students

Research topics

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- Development of bioprocesses
- Novel wastewater treatment technologies
- Anaerobic (co) Digestion
- Environmental Management: Life Cycle Assessment and carbon footprint
- Biological treatment of gaseous waste streams

http://www.usc.es/biogrup/

Biogroup role in REWATER project:

Micropollutants removal and LCA analysis

Organic micropollutants

Micropollutants: synthetic or natural substances occurring in waters at very low concentrations (μg/L or ng/L)

Pharmaceutical and Personal Care Products (PPCPs): Bioactive ingredients of pharmaceuticals and personal care products and hormones.

Antiphlogistics, neurodrugs, antibiotics and fragrances

Environmental and Health Impact

- Increase of antibiotic resistance
- Bioaccumulation
- Endocrine disruption of aquatic organisms

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Removal mechanisms

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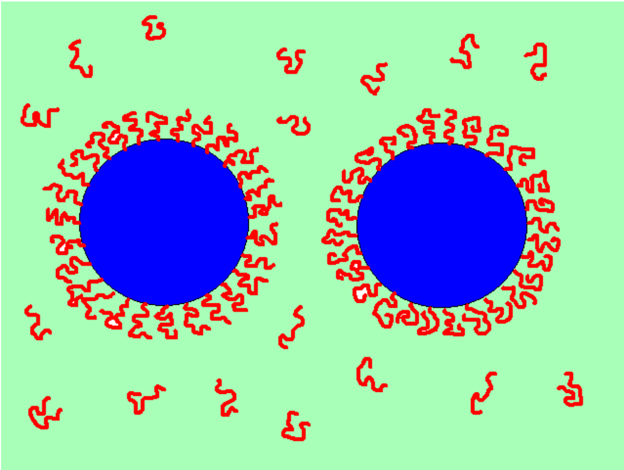
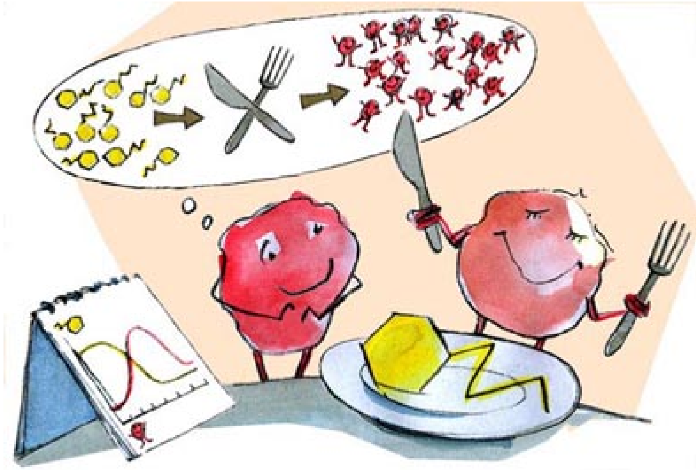
SORPTION



$$K_d = \frac{k_{sor}}{k_{des}} = \frac{C_S}{X_{TSS} \cdot C_W}$$

- Temperature, pH
- Organic matter content
- K_{ow} (absorption)
- pKa (adsorption)

BIODEGRADATION



$$r_{biol} = -\frac{dC}{dt} = k_{biol} \cdot X_{VSS} \cdot C_W$$

- Type of biomass and concentration
- Biomass activity
- Hydraulic Retention Time
- Sludge Retention Time

REWATER strategy for PPCPs removal

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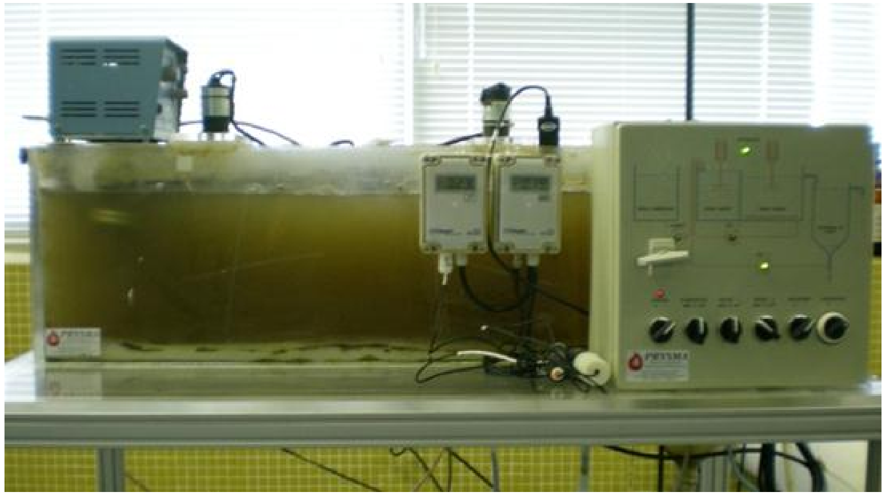
- To evaluate PPCPs removal in other WP processes.
- To design and test a **biological filtration/adsorption system**.



Powedered Activated Carbon

Nitrifying biomass

Sand filtration

PPCPs biodegradation vs. Nitrifying activity

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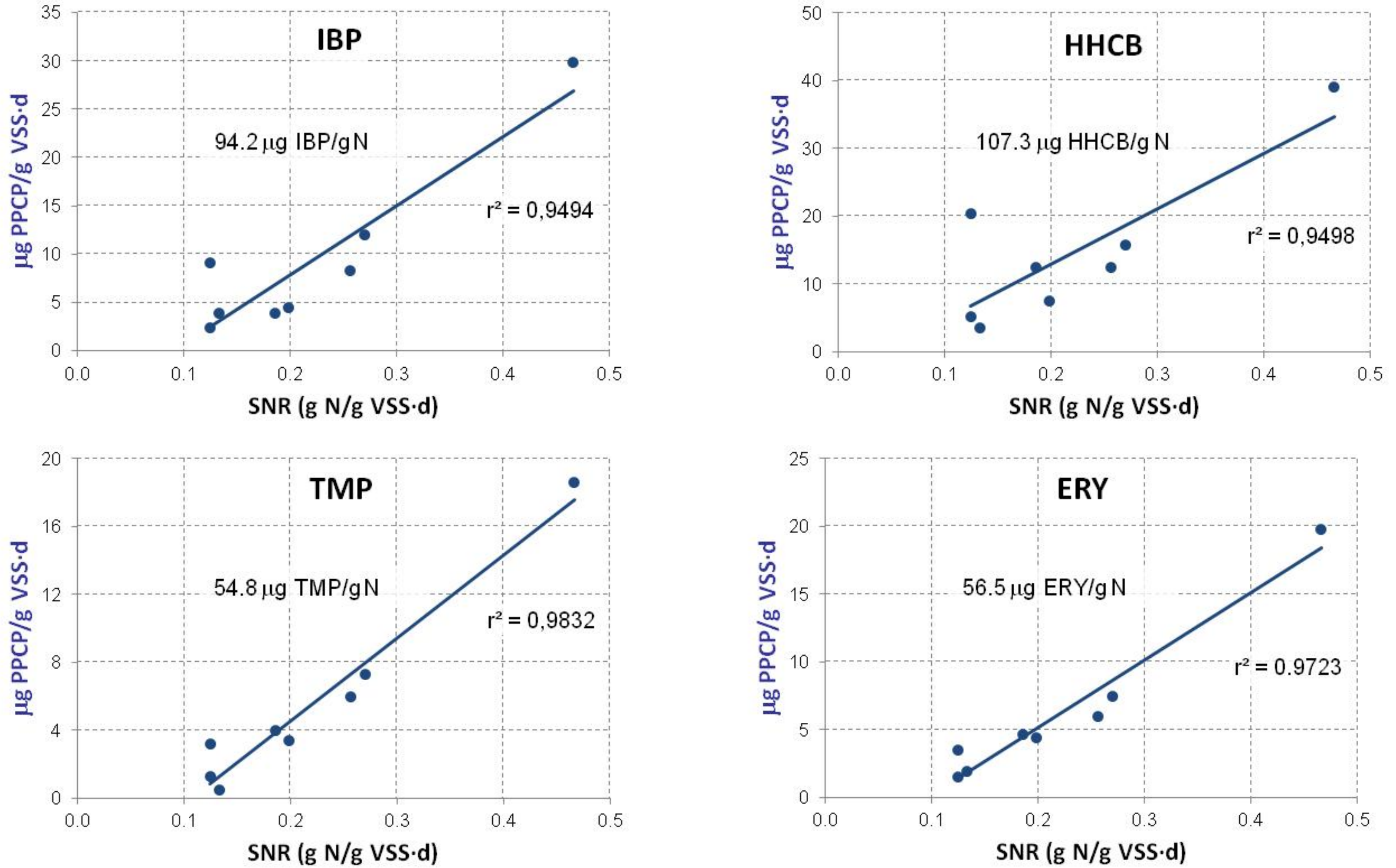

Fernandez-Fontaina et al., *Water Research 46 (2012),5434-5444.*

PPCPs biodegradation vs. HRT

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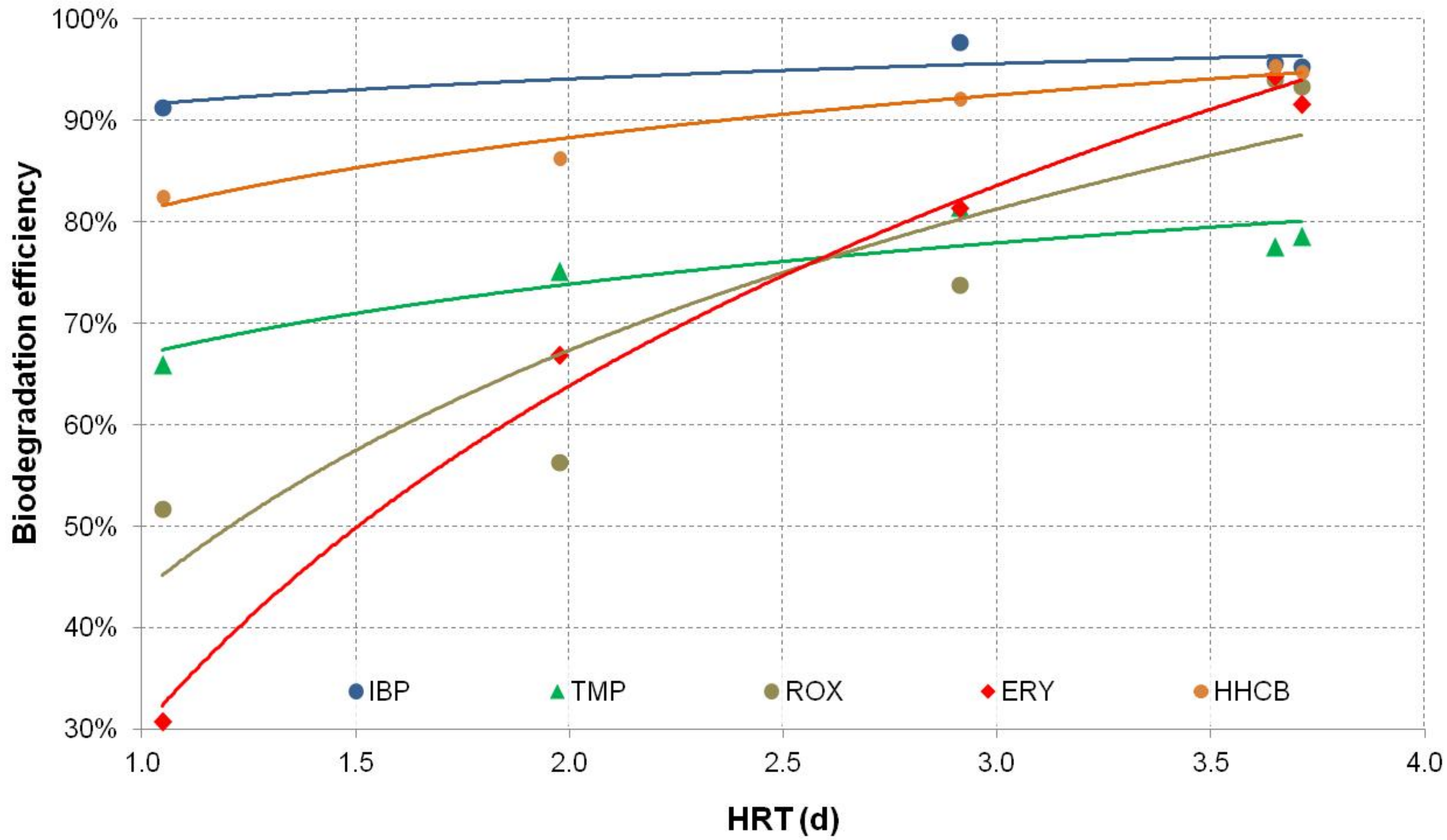

Fernandez-Fontaina et al., *Water Research 46 (2012),5434-5444.*

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Sequential Membrane reactor with PAC addition (SeMPAC)

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Enhances removal of PPCPs

- Biodegradation (↑SRT, ↑X, adaptation)

- Sorption onto sludge

- Sorption onto PAC

Possible applications

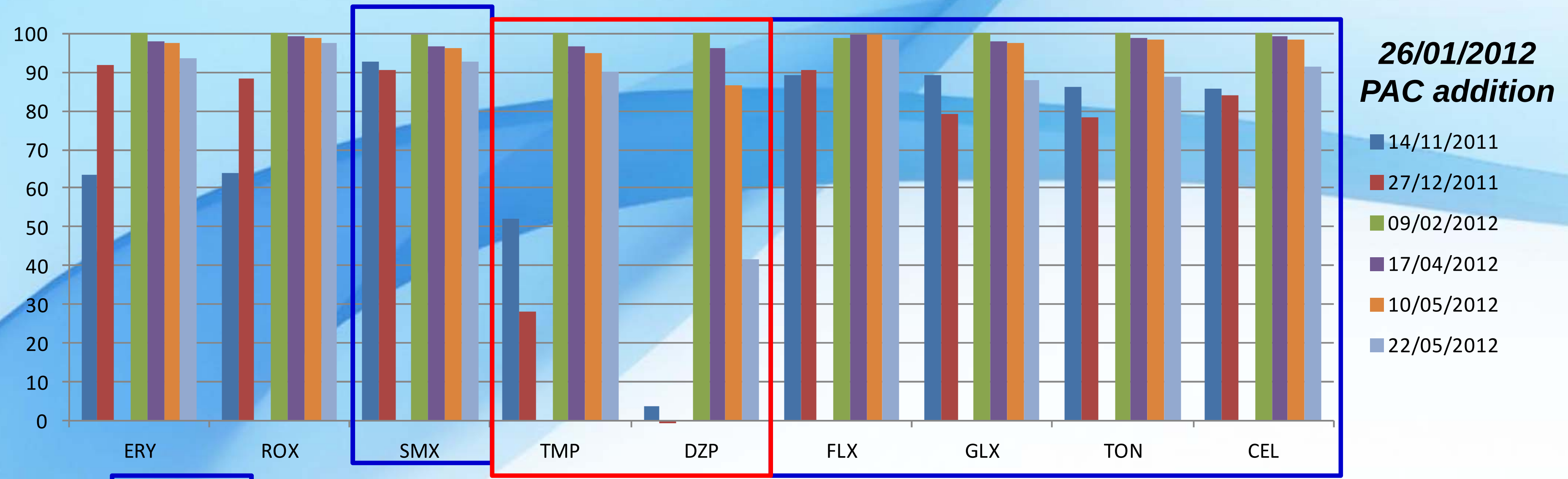
- Hospital effluents

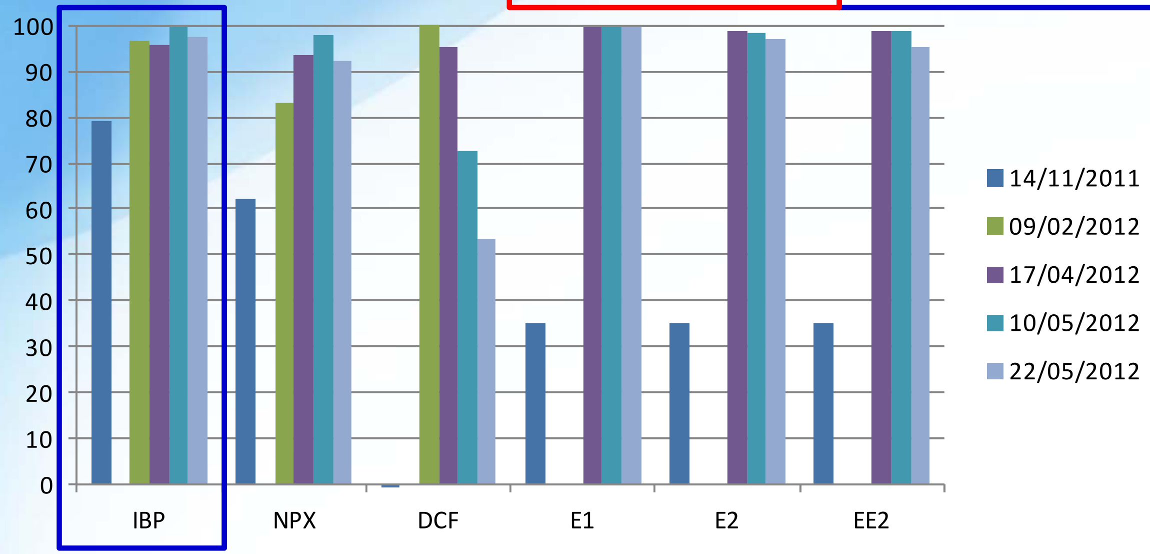
- Industrial wastewater (pharmaceutical, cosmetic production)

- Aquaculture

Patent ES 2 362 298 B2

PPCPs removal (SemPAC)

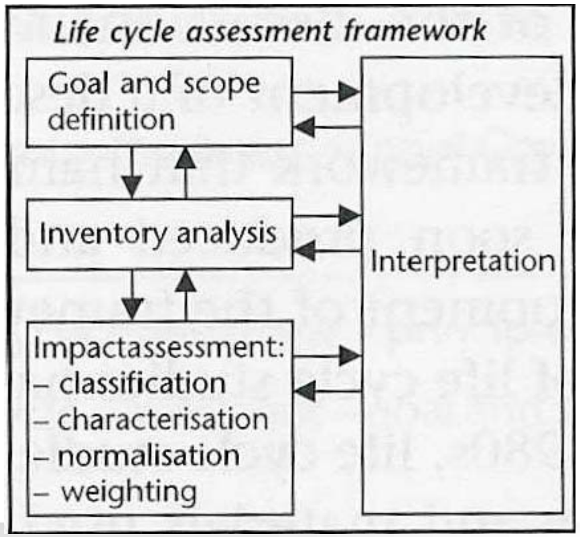




Compounds with more sorption reach more quickly the saturation

Life Cycle Analysis (LCA)

- **Holistic tool** used to evaluate the environmental burdens associated with a product, process or activity (Baumann and Tillman, 2004).
- **Widely used** as a **decision support tool** in the selection of the **best management strategy** for wastewaters and solid wastes (Su and Rousseaux, 2002; Hospido et al., 2005; Clearly, 2009; De Feo and Malvano, 2009; Peters and Rowley, 2009; Hospido et al., 2010).
- **Limited or no information** about the environmental impact of **wetlands, methalgae** and **micropollutants**.



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Laboratory of Microbial Ecology and Technology (LabMET)

Faculty of Bioscience Engineering
Ghent University, Belgium
Prof. Nico Boon

LabMET

LabMET

Teaching staff: N. Boon, T. Van de Wiele, K. Rabaey

Post-doc: 9

Scientific staff: 34 PhD-collaborators

Technical staff: 8 persons

Administrative staff: 3 persons

Master students: 38

3 key domains:

- Applied microbial ecology & management
- Anthropogenic and engineered environments
- Host-microbe interactions, pre/probiotics

LabMET role in REWATER project:

Sustainable carbon neutral methane oxidation

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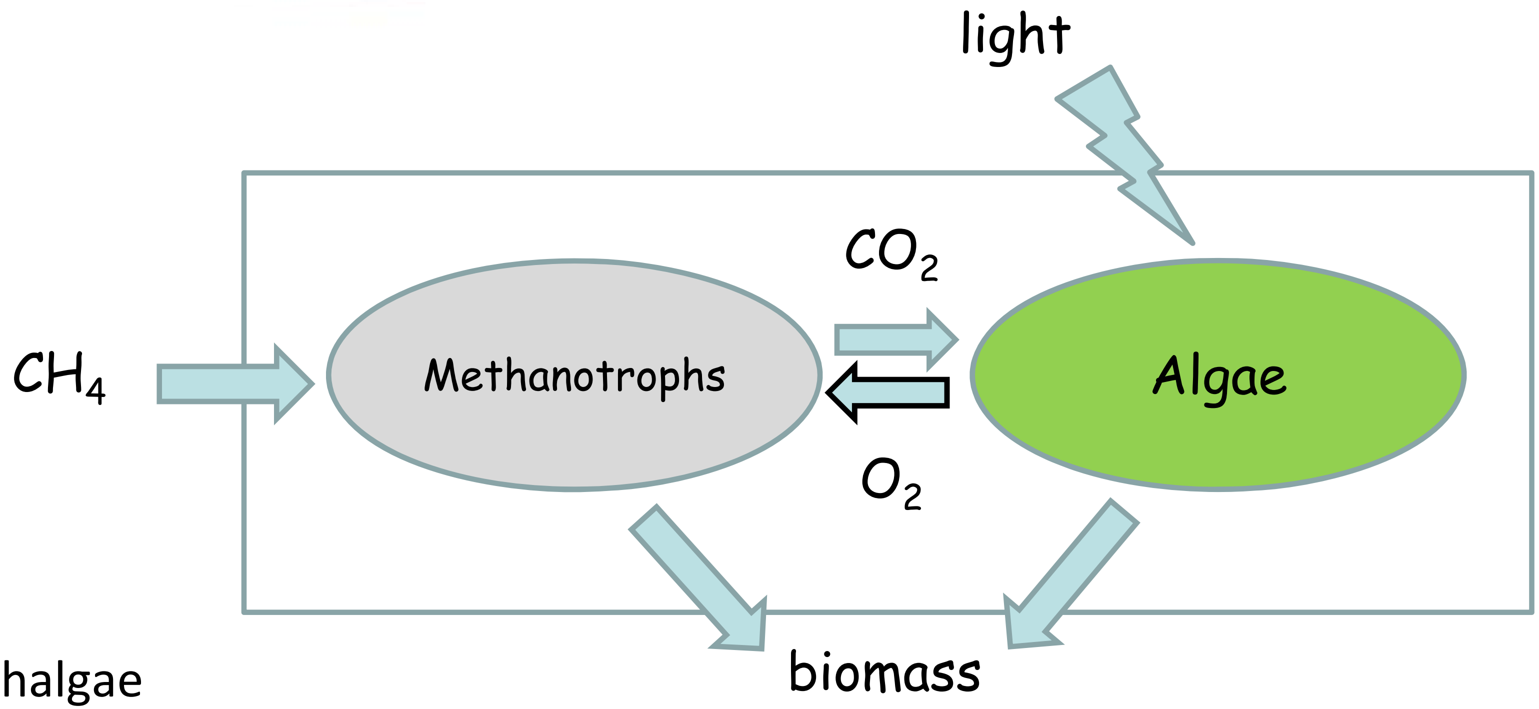
Methane emmisions from AD

- » Anaerobic effluents are oversaturated with CH_4 and CO_2
  (Hartley et al., 2006; Biotech. Bioeng., 95, 384-398)
- » Anaerobic digestion: a novel wastewater treatment technology
  - Up to 25% of the produced CH_4 can be lost to the water phase (Cakir et al., 2005; Wat. Res., 39, 4197-4203)
  - Case study at Agristo plant (Harelbeke, Belgium)

Methalgae: the principle



Methalgae

= coculture of methane oxidizing communities + algae

= total oxidation of CH_4 to biomass without GHG

= no expensive air sparging needed

= removal of nutrients

Methalgae: visual observations

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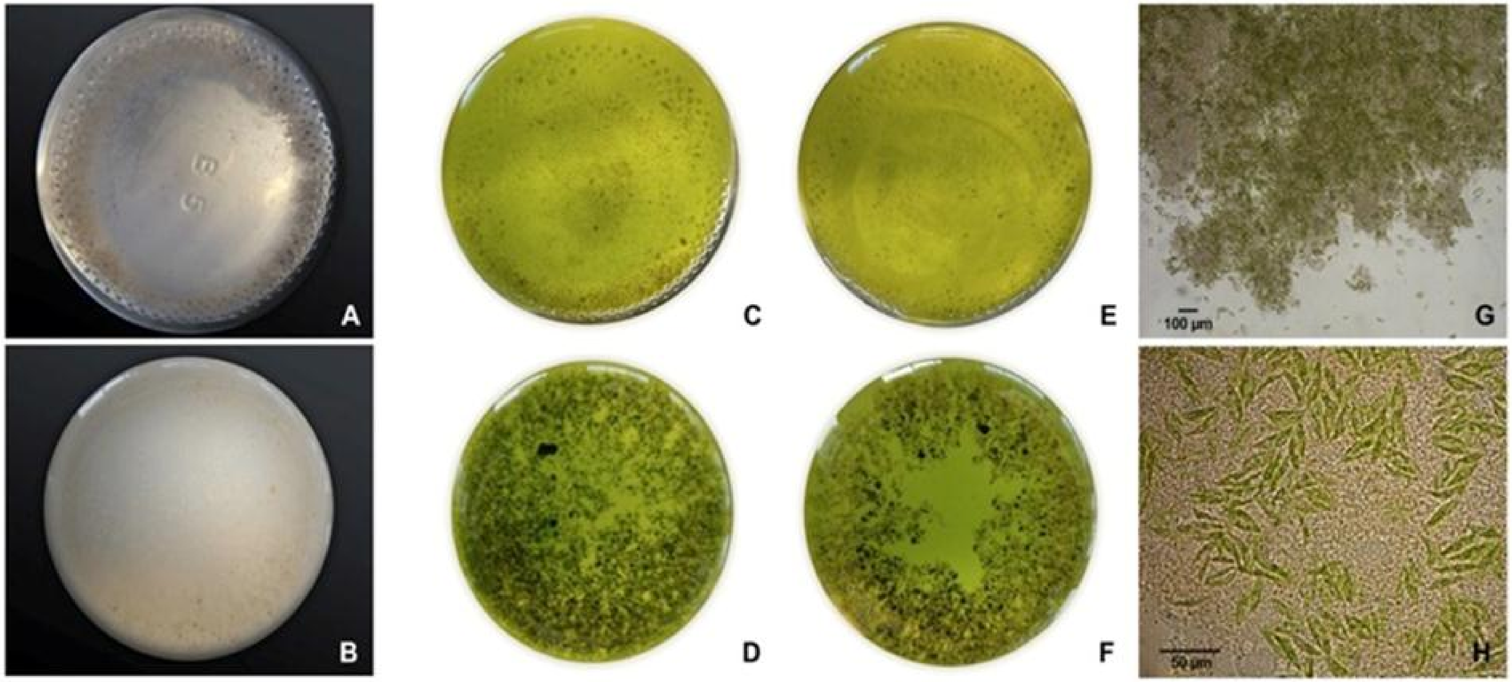
Cycle 1

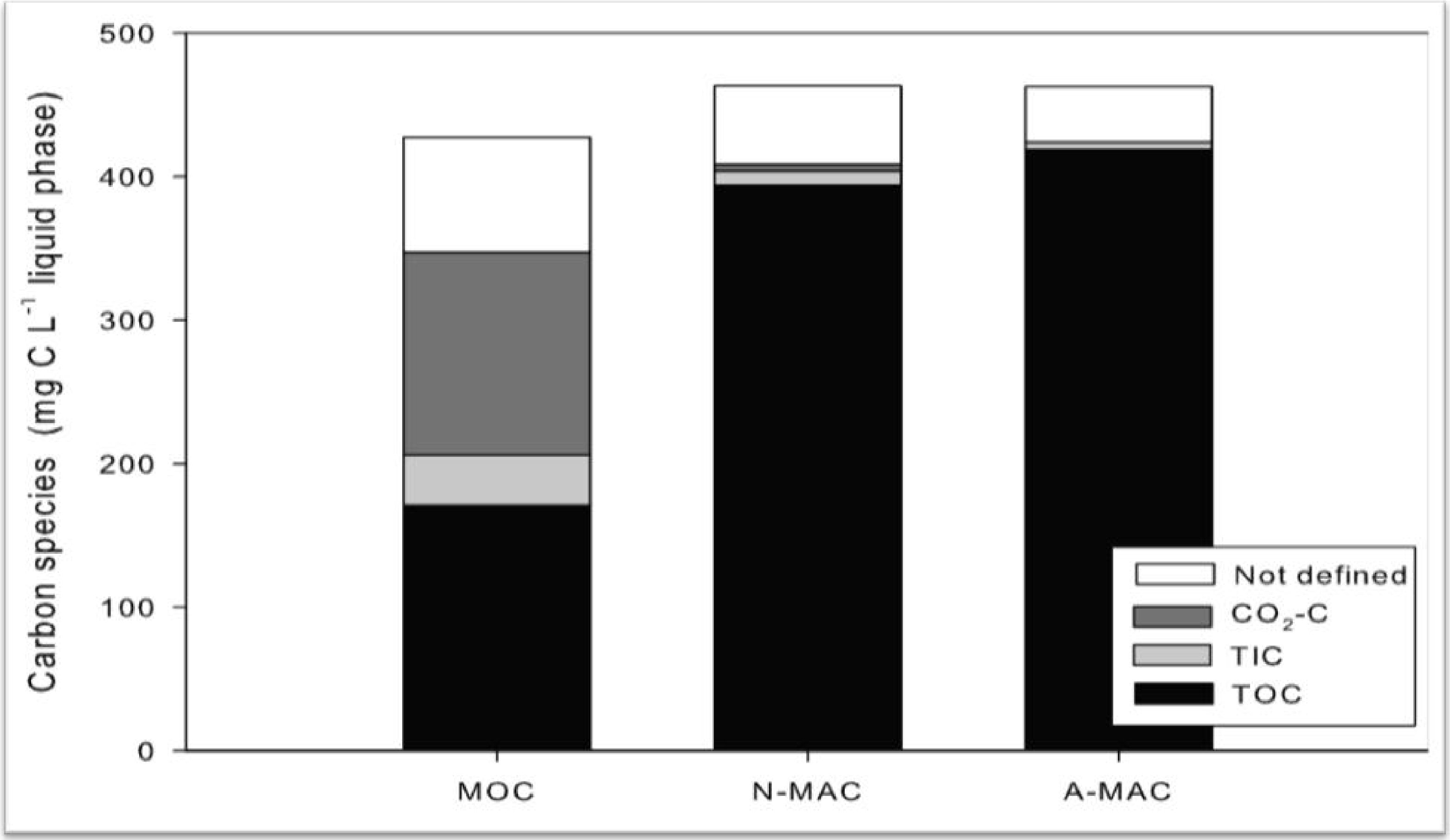
Cycle 5



MOB with NO_3^- (MOC) | Methalgae NO_3^- (N-MAC) | Methalgae NH_4^+ (A-MAC)

Take home: co-existence of MOB and algae is possible

Methalgae: carbon balances



van der Ha, D., et al.. *Water Res* **45**, 2845-2854.

Take home: with methalgae all methane is fixed in organic carbon

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Methalgae: an evaluation

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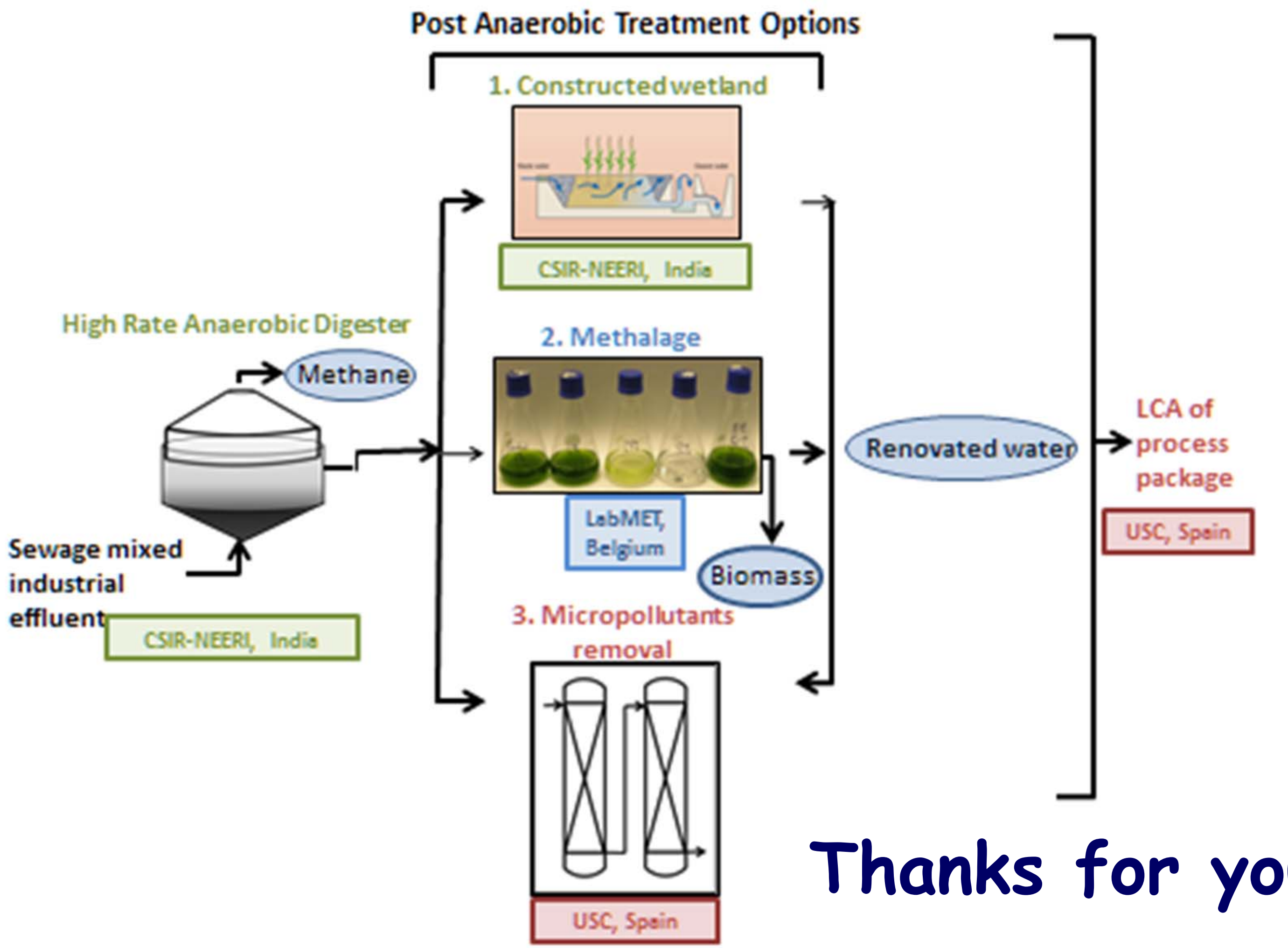
- » Co-culturing of MOB and algae is possible
  - No effect of algae presence on the methane removal rate
- » A GHG free methane removal was achieved
  - Algae oxidized the produced CO_2 almost completely
- » Algae provide MOB *in situ* of necessary oxygen
  - CH_4 removal was achieved with initially anoxic conditions
  - Low light intensities allow enough oxygen production for methane removal
- » Methalgae are useful as tertiary treatment
  - Partial removal of COD, H_2S, N & P
- » **An optimized reactor set-up is a prerequisite for further application and implementation**

REWATER Project



Thanks for your attention