

Effet de nanomatériaux sur l'efficacité des procédés de traitement des eaux usées par boue activée



Physico-chimie

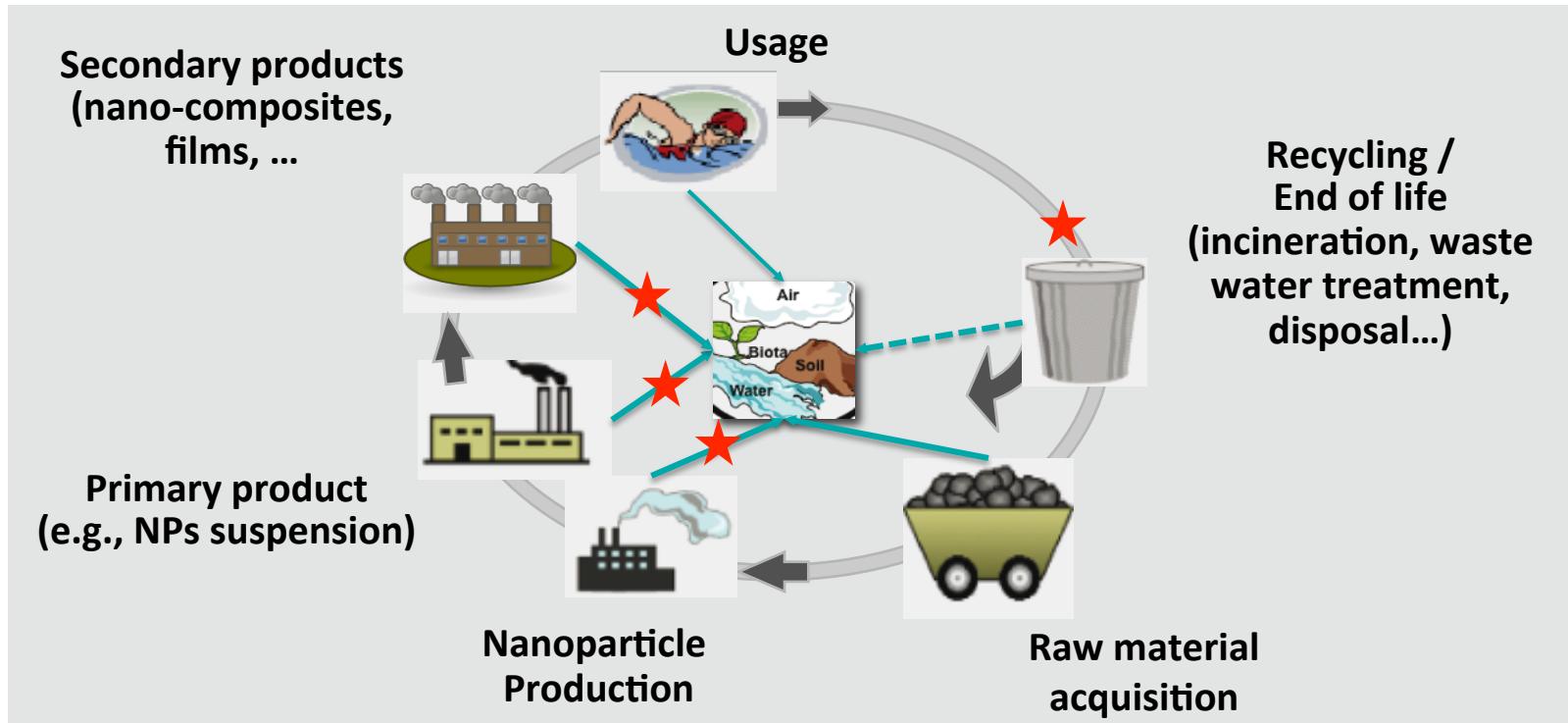


Génie des procédés



Microbiologie

- Lauren Barton, *Ph'D student*
- Melanie AUFFAN, Armand MASION, Daniel BORSCHNECK, Jean-Yves BOTTERO
- Nicolas Roche, Isabelle SEYSSSIEQ
- Catherine SANTAELLA, Mohammed BARAKAT, Marie BERTRAND, Wafa ACHOUAK
- Mark WIESNER



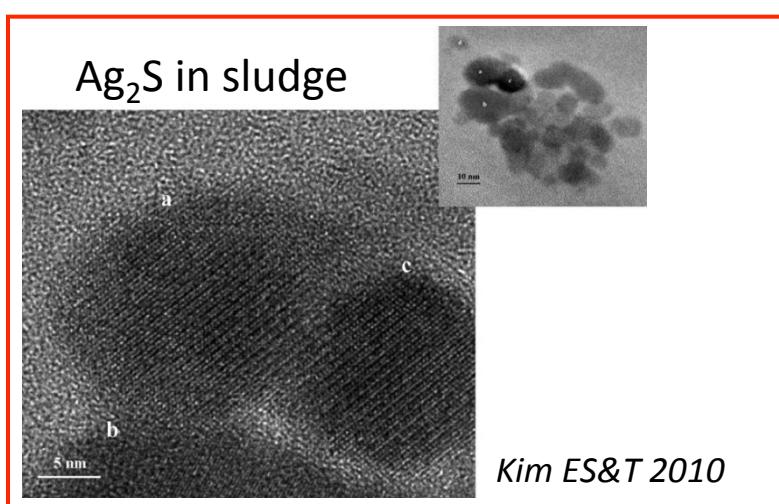
★ Wastewater treatment plant

Sludge ID 68349 (from Midwest region)
 Elemental Analysis

Initially
 nano ?

Element	(mg.kg ⁻¹)	Mg	13500
Ag	856	Mn	1070
Al	57300	Na	6080
Ca	98900	P	57200
Cu	1720	Ti	4510
Fe	51000	Zn	1530

*Targeted National Sewage sludge Survey
 Statistical Analysis Report (2009)*



- How much ENMs are retained by the bioreactor ?
- Are they transformed ?
- Are there changes in the microbial communities and structure due to ENMs ?

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The bioreactor



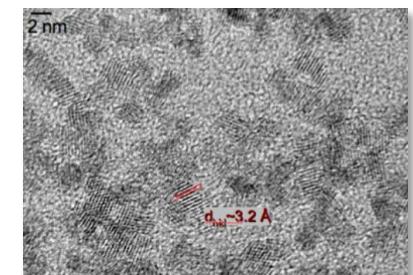
The activated sludge

Aix en Provence, La pioline
 ~200 000 p.e.



The nanomaterials : CeO₂

Estimated US production :
 35-700 tpy (Hendren 2010)

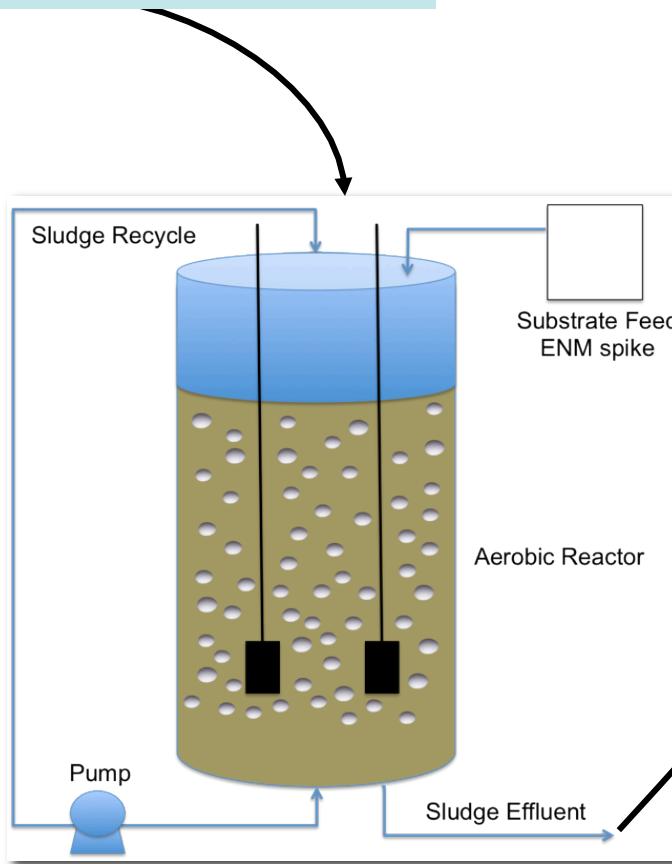


- Volume : 10L
- air flux 200 L/min
- Anaerobic period for denitrification
- Aeration : 1h/day
- Biomass concentration : 20 g/L
- Sludge age : 20 days
- Fed with sugar and meat extract daily

NPs Uncoated and Citrate-coated (woodstain)

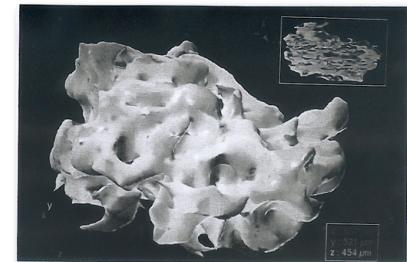
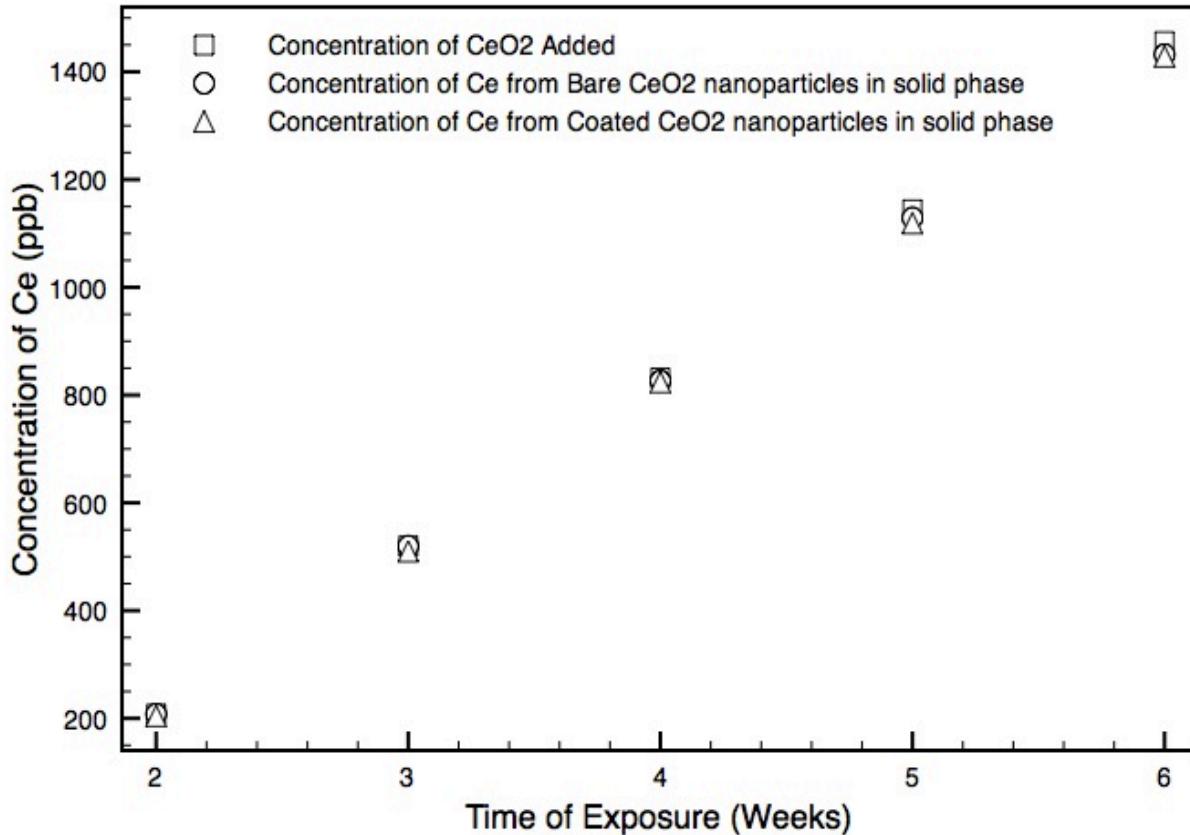
The experimental design

6 weeks of **chronic exposure** to
 ENMs
 $(150 \mu\text{g/L of CeO}_2$ twice a week)



- UV-vis / ^{13}C NMR / Rheology / ATR-FTIR / XRF / XRD / TOC : **sludge structure and composition**
- **Microbiological Community Structure Analysis**
- ICP-AES / MS / XAS Ce-L₃ edge: **Ce dosing and speciation**

Efficiency of bacteria in the retention of Ce



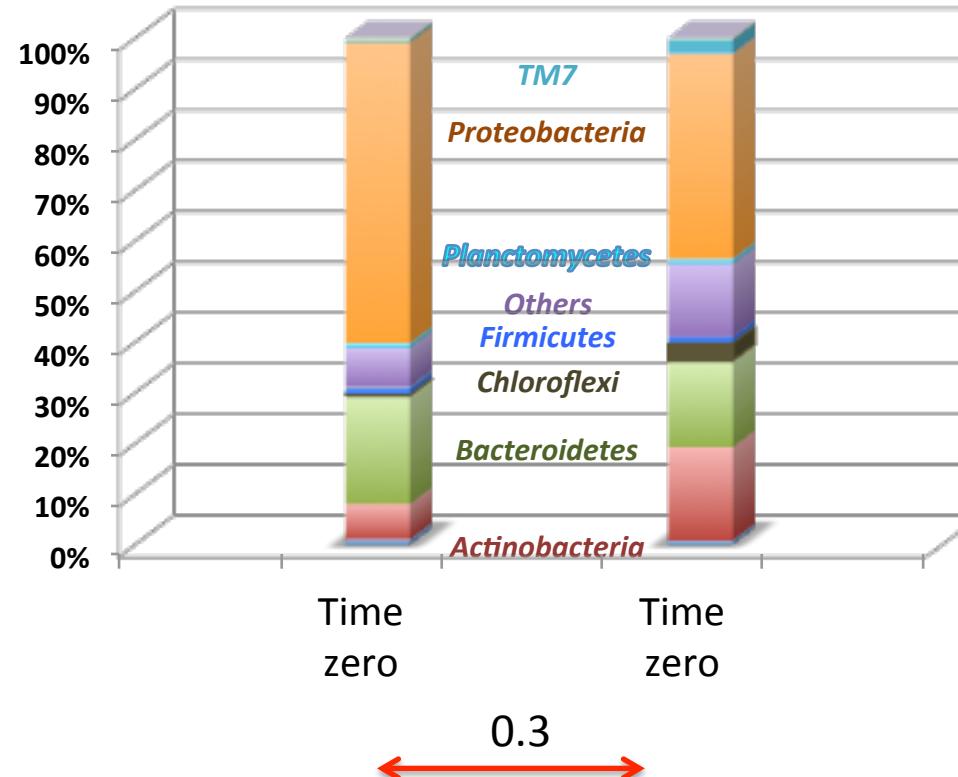
Sorption on the
bacterial flocs



50% of Ce⁴⁺
reduction into
Ce³⁺

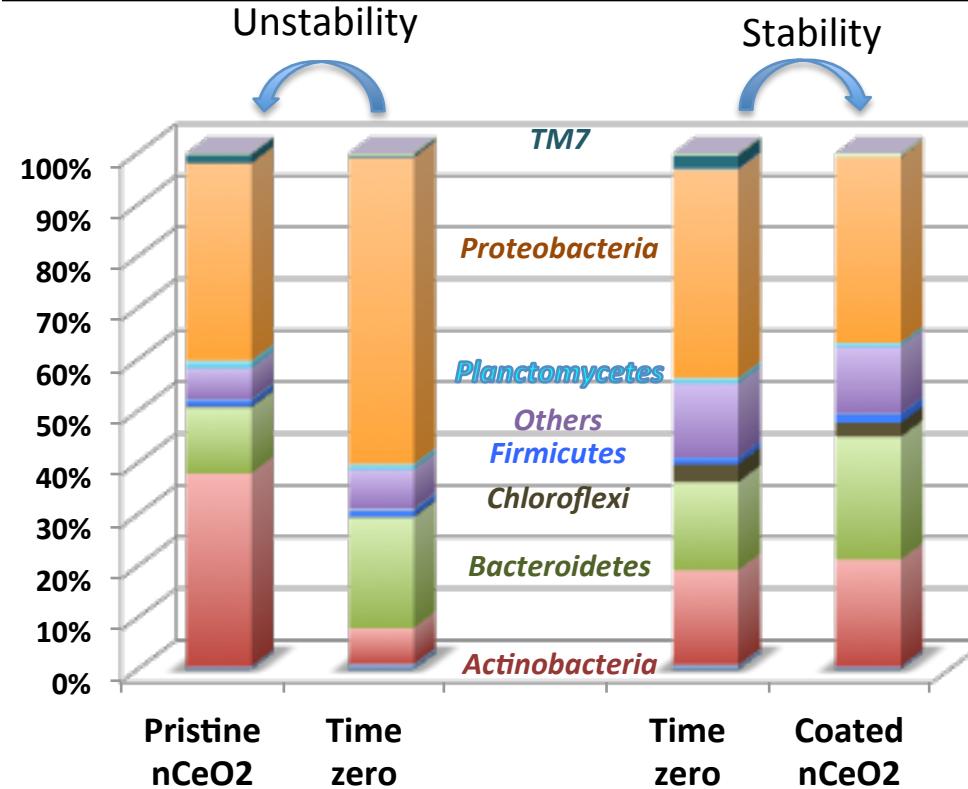
> 90% of the Ce associated with the solid phase

Efficiency of bacteria in the retention of Ce



A T_0 les communautés microbiennes sont proches

Efficiency of bacteria in the retention of Ce



Bray-Curtis dissimilarity index
 From 0 (high similarity) to 1 (no similarity)

0.5

A T₂₈ le bioreacteur contenant les NPs non-enrobées est instable

Estimated US
production of CeO₂
NPs : 35-700 tpy
(Hendren 2010)



NPs phytodisponibility ?



What about Land
Application of
biosolids ?



- > 90% of the Ce is found in the biosolids.
- Strong biotransformation of ENMs

Points faibles :

- Absence d'observation microscopique – *en cours*
- Absence de donnée sur le fonctionnement du bioréacteur contrôle.
- Suivie de la distribution/transformation des NPs dans un réacteur anaérobiose – *en cours*

Points forts :

- Bourse de thèse Chateaubriand pour Lauren Barton (co-tutelle Duke/AMU)
- Modélisation du devenir des NPs dans les STEP : données d'entrée uniques
- Interdisciplinarité : Génie des procédés, microbiologie, physico-chimie

Production scientifique :

Communications orales:

1. Auffan, M., Barton, L., Layet, C., Bertrand, C., Barakat, M., Santaella, C., Doelsch, E., Masion, A., Borschneck, D., Olivi, L., Roche, N., Wiesner, M.R., Bottero, J.-Y., 2013 October. Les problématiques du traitement des nanoparticules par les stations de traitement des eaux. Les futurs enjeux des stations d'épuration, Pole de compétitivité EAU Aix-en-Provence, France.
2. Barton, L., Auffan, M., Roche, N., Santaella, C., Olivi, L., Masion, A., Bottero, J.-Y., Wiesner, M.R., 2013 August. Fate and impacts of nano-CeO₂ in an activated sludge bioreactor. Goldschmidt Conference Florence, Italy.

Publications :

1. Barton, L., Therezien, M., Auffan, M., Bottero, J.-Y., Wiesner, M. *Theory and Methodology for Determining Nanoparticle Affinity for Heteroaggregation in Environmental Matrices Using Batch Measurements*. *Journal of Environmental Engineering*. *En review*
2. Barton, L., Auffan, M., Bertrand, M., Barakat, M., Santaella, C., Masion, A., Borschneck, D., Olivi, L., Roche, N., Wiesner, M., Bottero, J.-Y. The Transformation of Pristine and Citrate-Functionalized CeO₂ in a Laboratory Scale Activated Sludge Reactor. *Environmental Science & Technology*. *Soumis*

- Co-financement de thèse ADEME – LABEX Serenade

Clément Layet

Co-direction : E. Doelsch (CIRAD), M. Auffan (CEREGE)
C. Santaella (LEMiRe)

PHYTODISPONIBILITÉ DES NANOMATÉRIAUX ET IMPACT DE L'EPANDAGE DE BOUE DE STEP

- Projet EC2CO 2014 :

PHYTODISPONIBILITÉ DES NANOMATÉRIAUX ET IMPACT SUR LA DIVERSITÉ MICROBIENNE
CIRAD / CEREGE / LEMiRe

- Soumission d'un projet ANR 2014

ASSESSMENT OF NANOMATERIALS IMPACT IN COMBINATION WITH TRACE ELEMENTS AND CLIMATE CHANGES ON A SOIL-PLANT-MICROBE ECOSYSTEM
LEMiRe / CEREGE / M2P2 / CIRAD

