Persist

Fate and persistence of emerging contaminants and MRB in a continuum of surface water groundwater from the laboratory scale to the regional scale

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Partner : Pr. Josep Mas Pla (ICRA), Dr. Christine Stump (IGOE)

Water JPI
Pilot Call Kick-off meeting
11th of March 2015, Brussels

Consortium "Nîmes University, Catalan Institute for Water Research and Institute of Groundwater Ecology : a groundwater and environmental health scientist's consortium

HelmholtzZentrum münchen
German Research Center for Environmental Health

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PERSIST – the Aims

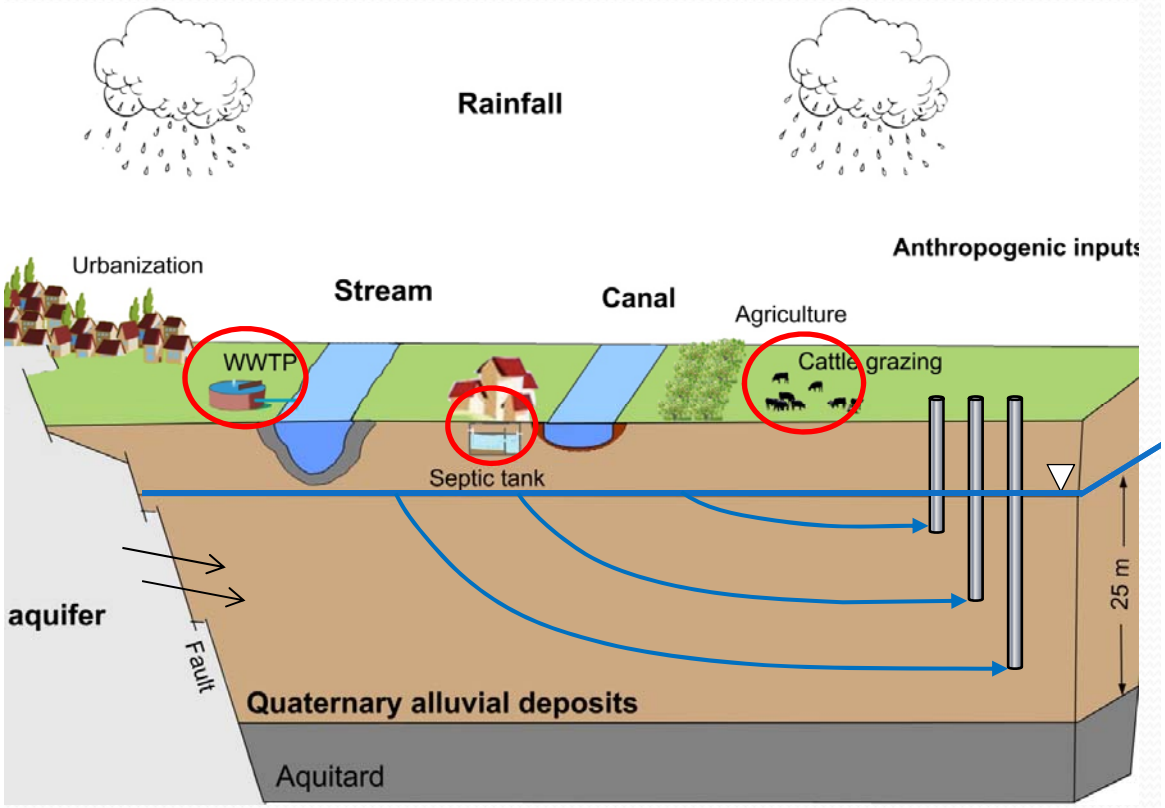
- **Objectifs : Gain fundamental information on the behaviour of EOCs, Targeting pharmaceuticals and resistant microbial communities In both surface water and groundwater**

At a field scale

- Occurrence and fate of EOCs in SW and GW from sources to exploitation wells
- Persistence and fate of pathogens and multiresistant microbiomes under the occurrence of EOCs in SW and GW
- Combined approach with hydrogeology and natural tracers

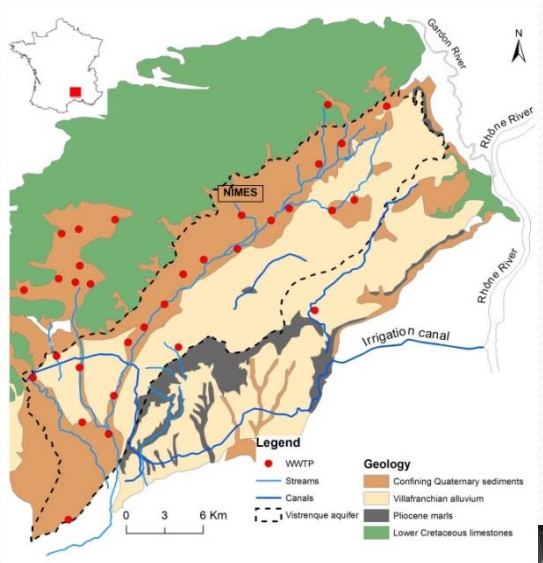
At laboratory scale

- Determine EOCs geochemical behaviour through column and batch experiments

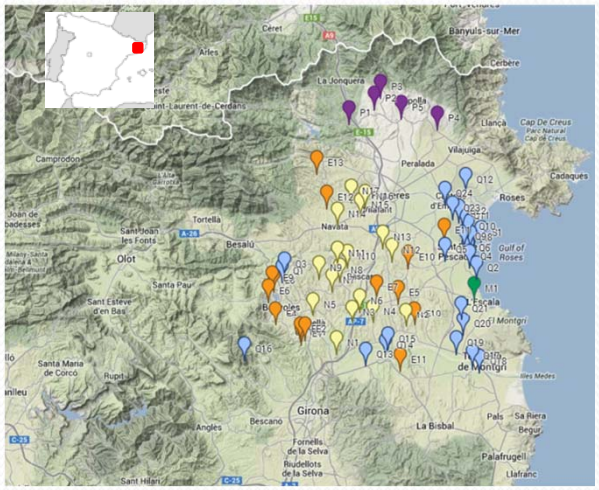


Field sites and workpackages

Vistrenque Basin
WWTP/Septic systems
WP1



Empordà Basin
Cattle grazing activities
WP2



Laboratory experiments
WP3

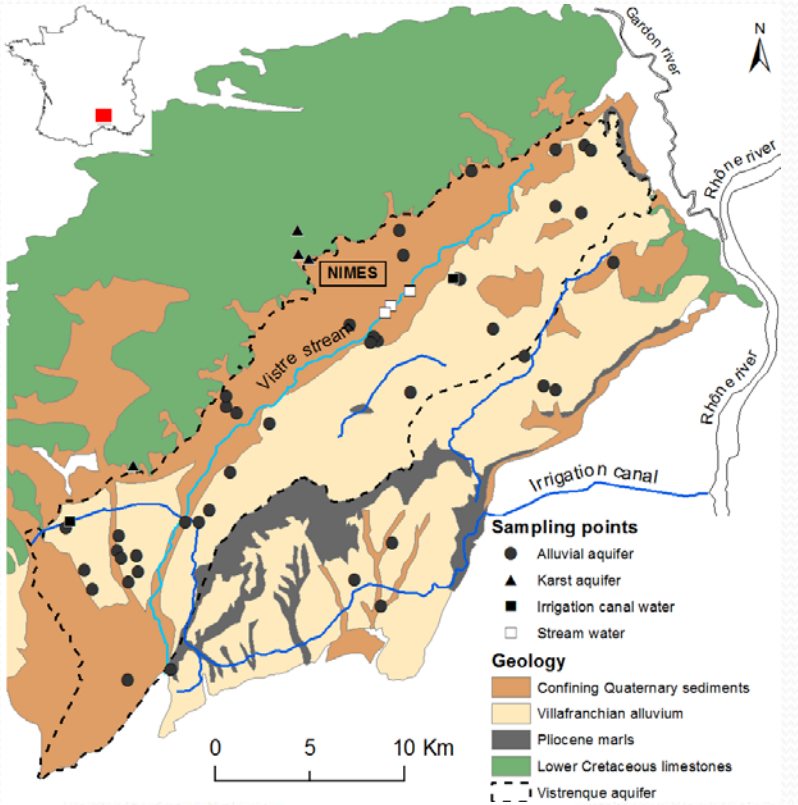
Work Package 1 – Vistrenque Catchment - UNIMES/CHROME

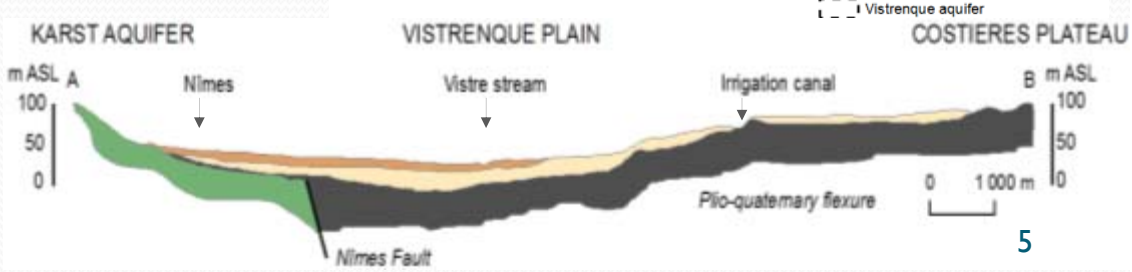
Objectives

1. Occurrence of EOC and MRB in a typical GW basin : influence of hydrodynamics and attenuation rate.

2. Fate of EOC and MRB in surface water, down stream from a waste water treatment plant outlet

3. Transfer of EOC and MRB from SW to GW



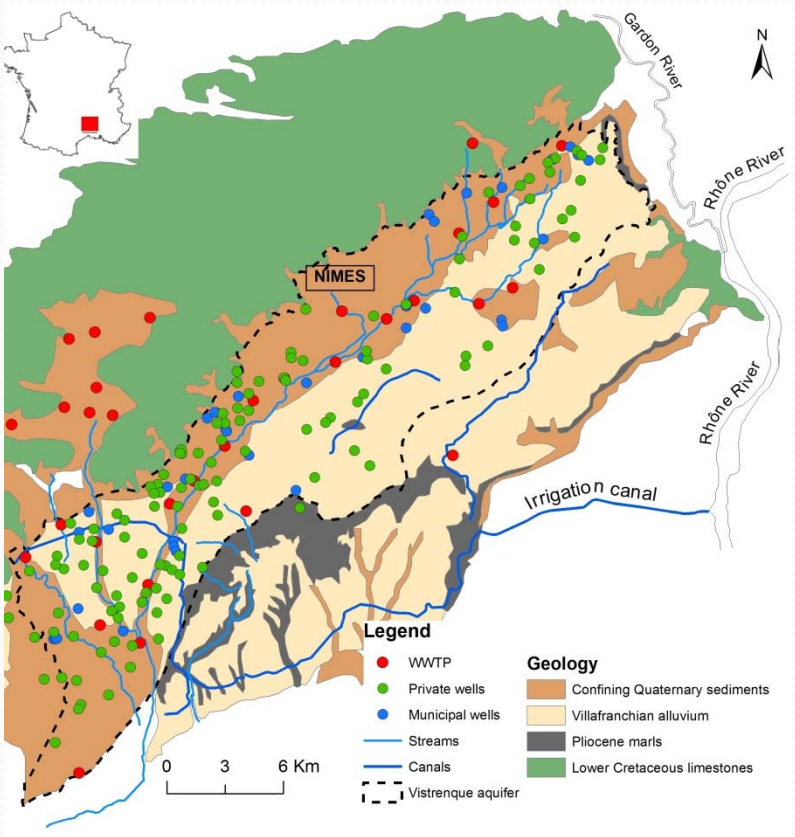


WP1 – Vistrenque Catchment

Task 1 : Characterise the fate and occurrence of EOC at the catchment scale

- **50 wells Public & Private wells**

- Tracers for hydrodynamics
  - Major elements, Br and Sr
  - ^{18}O, ^{2}H, ^{13}C, $^{87}Sr/^{86}Sr$: origin
  - $^{3}H/^{3}He$ GW residence time.



WP1 – Vistrenque Catchment

Task 2 : Fate of EOC and MRB downgradient from a WWTP

- Primary source of EOC
- Attenuation processes:

  Dilution, Degradation, Sorption

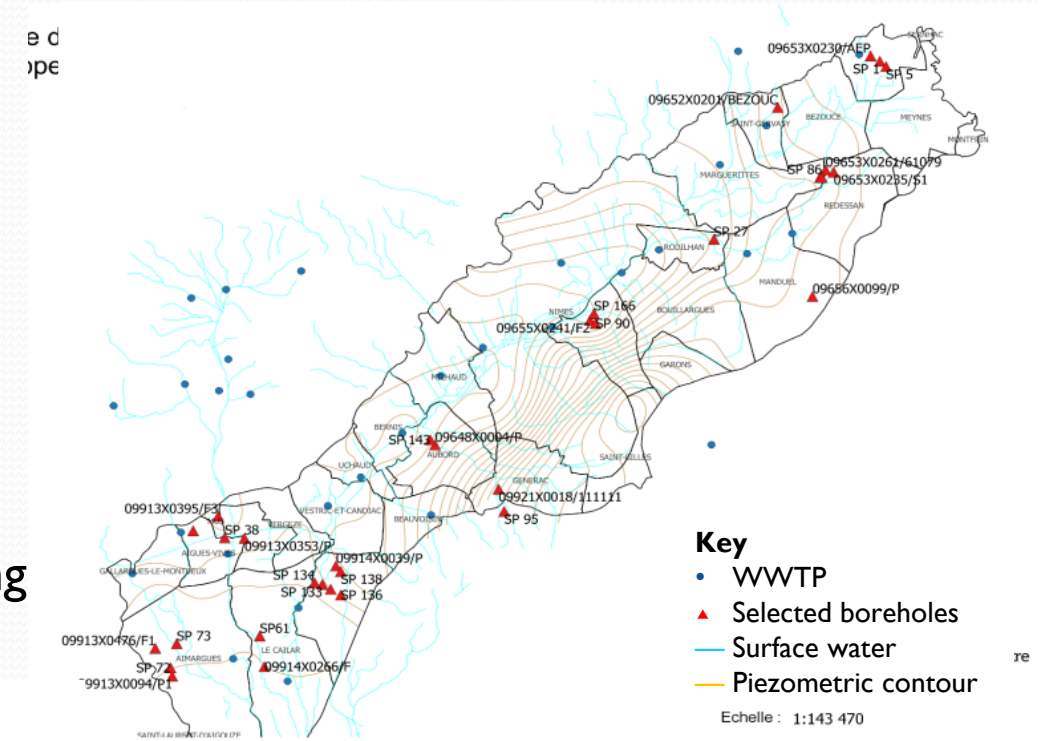
➢ Batch experiments

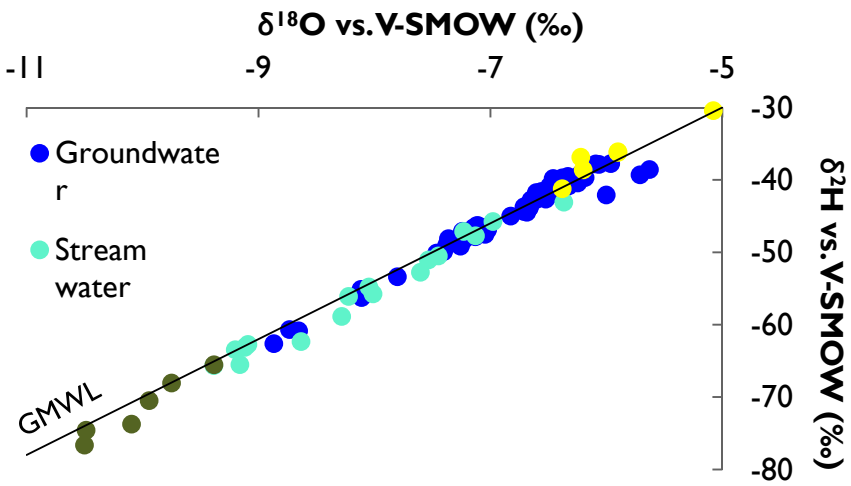
➢ Characterisation of the microbiome

WP1 – Vistrenque Catchment

Task 3 : Transfer from Surface water to groundwater

- Focus on 7 wells in the vicinity of streams
- Verify the hypothesis
- Combine with residence time tracers and hydrodynamic modelling





Evidence for surface water input in monitored wells

WP1 – Vistrenque Catchment - Selected molecules

Surface Water

Targeted molecules

- Diclofenac and ketoprofen (analgesics)
- Carbamazepine (psycholeptics)
- Fenofibric acid (antihyperlipidemics)
- Propanolol hydrochloride (β-blockers)
- Oxazepam (anxiolitics)
- Spiramycin, erythromycin, roxithromycin & ofloxacin (antibiotics)

+ Frequently detected (Vulliet and Cren-Olivé, 2011)

- Sulfamethoxazole
- Trimethoprim
- Metformin
- Acetaminophen

Groundwater

Targeted molecules

- Diclofenac
- Carbamazepine
- Caffeine
- Sulfamethoxazole

+ Frequently detected

(Vulliet and Cren-Olivé, 2011; Loos et al., 2010)

- Salicilic acid
- Oxazepam
- Acetaminophen
- Ketoprofen and ibuprofen

Additional antibiotics of second and third generation (depending on analytical development)

- Fluoroquinolones : ofloxacin (oflocet®) already in the list, ciprofloxacin (ciflox®)
- Cephalosporine : cefotaxim, ceftriaxon, ceforoxim

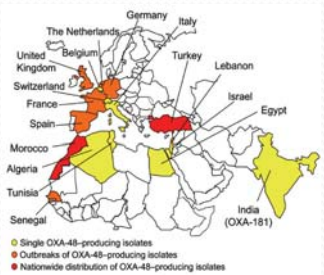
WP1 – Vistrenque Catchment

MDRB analyses

- Objectives
  - Identification of Multidrug resistant bacteria (ESBL, oxacillinases, carbapenemases)
  - Characterisation of the Resistome
  - Link with the antibiotics present in the Vistrenque
- Analyses and Analytical Technics
  - Cultures on different selective media
  - PCR multiplex to characterize the different genes involved in resistance
  - MLST to determine the clones

Pantel et al., Eur J Clin Microbiol Infect Dis 2014 (a et b)
Robert et al., J Antimicrob Chemother 2014
Liapis et al., Clin Microbiol Infect 2014
Agabou et al., Eur J Clin Microbiol Infect Dis 2014

HUMAN INFECTION/COLONIZATION



WORLDWIDE EXPANSION OF OXA-48 STRAINS
Nordmann et al., Emerg Infect Dis 2011

MDR bacteria circulating in South of Europe:
Clone ST131-O25:H4 *E. coli,* CTX-M-15, OXA-48, NDM-1

WORLDWIDE EXPANSION OF ST131 CLONE
Livermore D et al., KJIM 2012

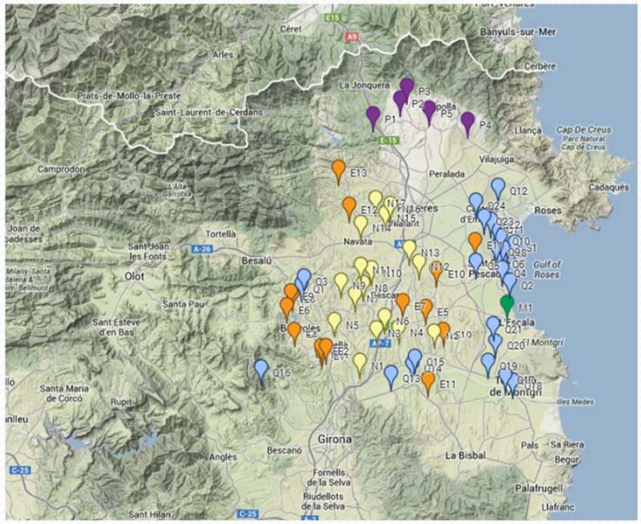
ANIMALS INFECTION/COLONIZATION

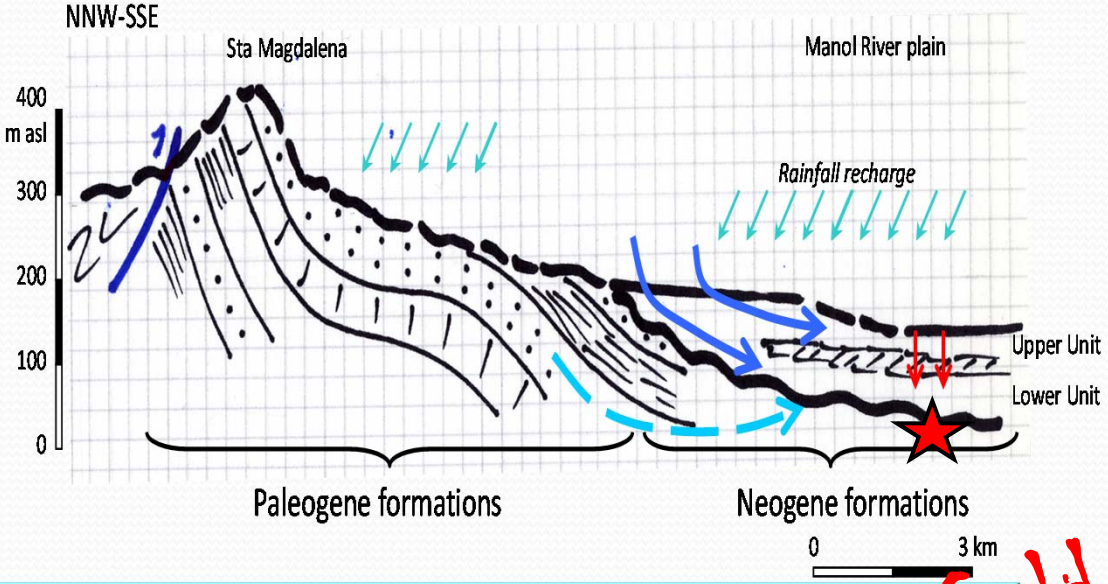
Brahmi et al., Clin Microbiol Infect 2015

ENVIRONMENTAL DIFFUSION

Nicolas-Chanoine et al., Clin Microbiol Rev 2014

Work Package 2 – Empordà Basin – ICRA





1 Field characterization, sampling, analytics and environmental issues — Field

2 EOCs fate and persistence, and resistome characterization — Lab

3 Hydrological interpretation and transport processes modelling — Computer

WP 2 : Empordà Basin - Task 1

Field characterization, sampling, analytics and environmental issues

Milestones:

- ✓ Understanding of the hydrological and environmental factors that influence EOCs fate and transport in the subsurface,
- ✓ Determine microbial diversity, and the impact of EOCs in its community and resistome,
- ✓ A large database compiling all interesting variables to enable further interpretation of the results in the next tasks.

WP 2 : Empordà Basin - Task 2

EOCs fate and persistence, and resistome characterization

Milestones:

- ✓ The relationship between EOCs occurrence and transport processes, based on laboratory and field data, and on intense literature research as well
- ✓ The description of the structure and composition of microbial communities in groundwater in relation to the type and magnitude of EOCs pollution as well as the presence and abundance of antibiotic resistance genes (ARGs) in the selected sites.

westcampus.yale.edu

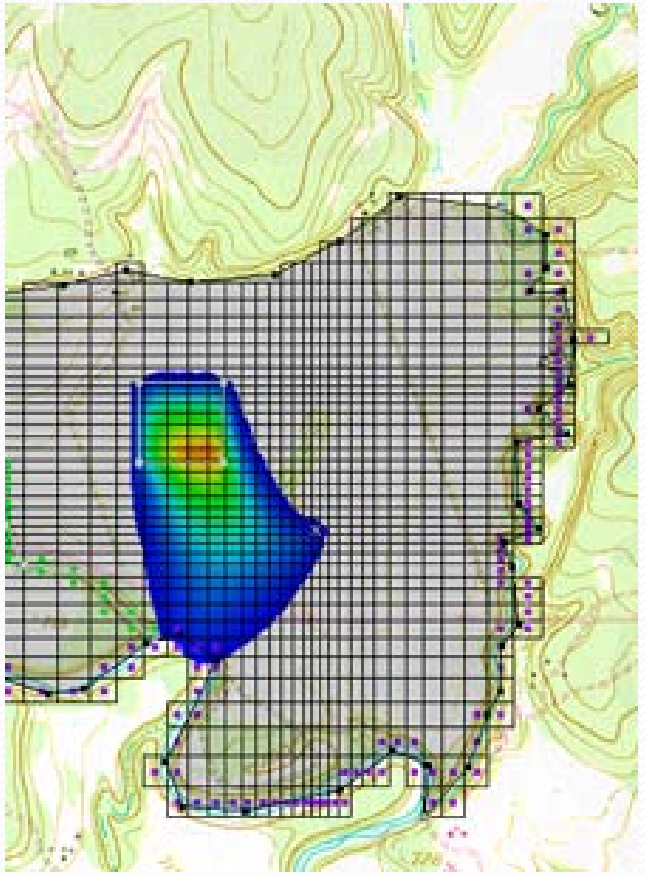
WP 2 : Empordà Basin - Task 3

Hydrological interpretation and transport processes modelling

Milestones:

Evaluate EOCs modelling capacity in field studies:

- ✓ Can EOCs be successfully modelled in large scale aquifer systems?
- ✓ Do hydrogeological heterogeneities and/or chemical complex behavior impede tracing their concentration?
- ✓ Otherwise, which type of sampling strategies and modelling approaches would permit a successful simulation of their behavior in the subsurface?



www.ground-water-models.com

Empordà bassin
Targeted molecules

Azithromycin
Cefalexin
Cefazolin
Chlorotetracycline HCl
Cinoxacin
Clindamycin HCl
Cloxacillin
Danofloxacin
Dicloxacillin
Difloxacin HCl
Enoxacin
Enrofloxacin
Erythromycin
Lincomycin HCl
Marbofloxacin
Metronidazole
Metronidazole-OH
n4-acetilsulfamerazine
n4-acetilsulfametazine
n4acetylsulfamethoxazole
n4-acetylsulfapyridine
Ofloxacin
Oxacillin
Oxytetracycline HCl
Penicillin V
PenicillinG
Piperacillin Na
Spiramycin
sulfadimethoxin
sulfamethazine
sulfamethoxazole
sulfanitran
sulfapyridine
sulfathiazole
Tilmicosin
Amoxicillin
Tylosin phosphate
Doxycycline HCl
Roxithromycin
Cefatoxima
Cefuroxime
Nalidixic acid
Sulfabenzamide
sulfisomidin
N4-acetilsulfadiazine
Ampicillin
Oxolinic acid
Tetracycline HCl
Flumequine
Sulfamerazine
Pipemidic acid
Ciprofloxacin
Ceftiofur
sulfisoxazole
Sulfmethizole
Cefapirin
Sulfadiazine
Sulfamethoxypiridazine
Orbifloxacin
Clarithromycin

WP 3 - Laboratory migration experiments
Impact of water transit times on the fate of EOCs

HYPOTHESIS

- Fate of EOCs strongly depends on water transit time distributions

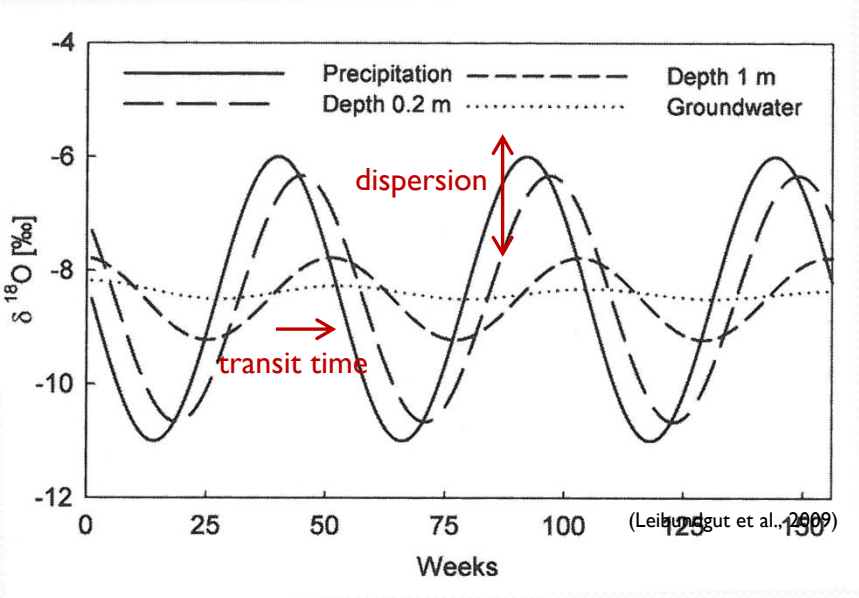
OBJECTIVES

- Determine range of transit times and flow velocities at the pilot field sites
- Study the impact of flow velocity on sorption and degradation rates in controlled lab experiments
- Transfer the lab results to the field sites for vulnerability assessment

➢ **Field-Lab-Field Approach**
complementary to WP1 and WP2

WP 3 – Transit Time Distributions in the Field

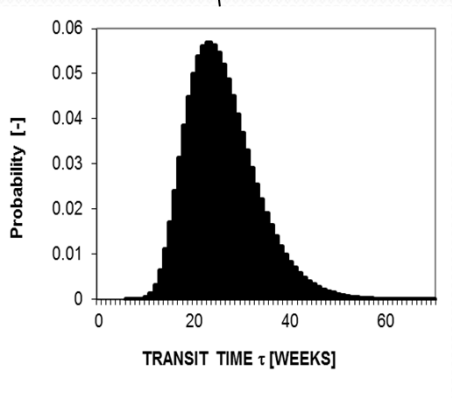
Task 1 : Use of tracers to evaluate transit time distributions

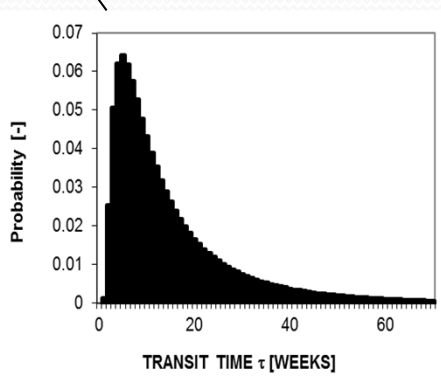


(Leibundgut et al., 2009)

$$C_{out}(t) = \int_0^{\infty} C_{in}(t-\tau) \cdot g(\tau) d\tau$$

C: concentration of conservative tracer
t: real time [T]
t: transit time of tracer particle [T]
g(t): weighting function → transit time distribution

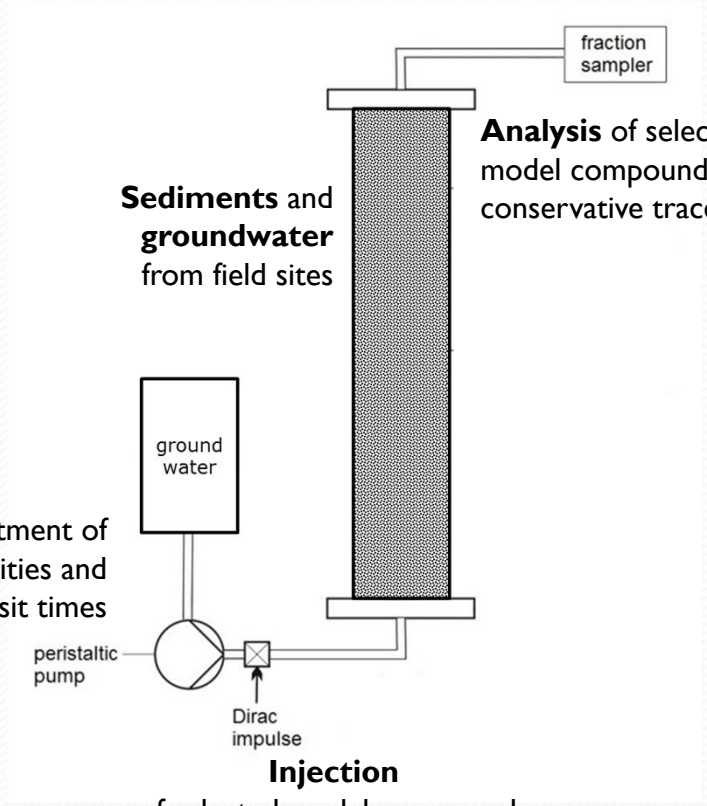


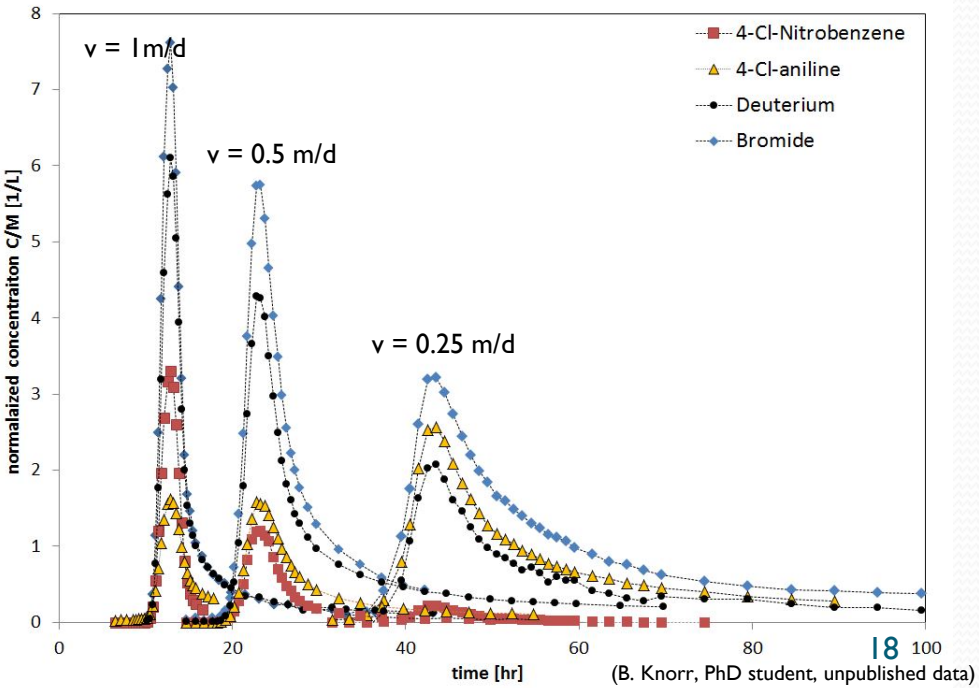


(Maloszewski & Zuber, 1982, J Hydrol 57)

WP 3 - Laboratory migration experiments

Task 2 : Column experiments





(B. Knorr, PhD student, unpublished data)

WP 3 – Mathematical Modelling

Task 3 : Breakthrough curves modelling

$$\frac{\partial C}{\partial t}+\frac{\rho(1-\varepsilon)}{\varepsilon}\frac{\partial S}{\partial t}=D\frac{\partial^2 C}{\partial x^2}-v\frac{\partial C}{\partial x}-\lambda\left[C+\frac{\rho(1-\varepsilon)S}{\varepsilon}\right]$$

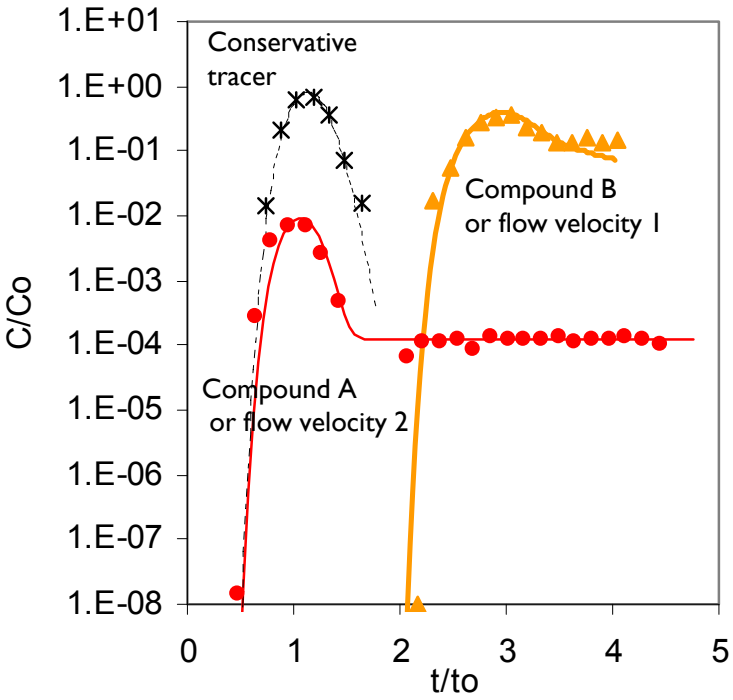
$$\frac{\partial S}{\partial t}=\frac{\varepsilon C}{\rho(1-\varepsilon)}k_f-(k_r+\lambda)S$$

- Advection : v
- Dispersion : D

} conservative tracers

- Adsorption : k_f
- Desorption : k_r
- Degradation : l

} reactive tracers



Sorption and degradation rates expected to be specific for :

- selected EOCs &
- selected flow velocities

Target the aims of the call

Promotion of multi-disciplinary work

	Geologists & Hydrogeochemist	Environmental Health	Analytic & Organist chemist	Microbiology & Geoecology
CHROME Team & Nîmes University Hospital	Le Gal La Salle C., Pr. Verdoux P. , IR	Roig, B. , Pr	Meffre P., Pr. Benfodda Z, PhD	Lavigne J.P. Pr of Medicine
ICRA Team	Mas-Pla J., PhD Brusi D., PhD	Menció A., PhD	Petrovic M. PhD	Borrego C., PhD; Marcé R., PhD.
IGE Helmholtz Zentrum	Stumpp C., Dr. Maloszewski P., Pr.		Elsner M., Dr.	Maier M.

Target the aims of the call

- Encourage proposals with fundamental and/or applied approaches
  - Build on the consortium experience
  - Draw on interaction with stakeholders to include EOC data and aquifer vulnerability in their planning strategies.
  - Contribute to define water guideline

- Stimulate mobility of researchers within the Consortium

Senior researchers and postdoc / grad students will visit other partners labs and institutions to :

- Insure a good development of the project
- Compare and homogenize analytical techniques
- Share work and expertise

➢ **14 months of mobility**

Project PERSIST : *Expected outcome*

- Improve the understanding of mechanisms and processes that control EOCs transport in aquifers. Include laboratory data on sorption parameters and degradation rates in regional scale studies.
- Link hydrological framework with EOCs occurrence and microbiological data.
- Test modelling capabilities to cope with ECs fate and persistence in groundwater.
- Evaluate potential multi-resistent behaviour or bacteria.
- Derive, assess and communicate water management strategies for polluted groundwater resources.

Project PERSIST : Scientific and societal relevance

- **Scientific**
  - Gain fundamental information on the behavior of EOCs (i.e., targeting pharmaceuticals) and resitant micriobial communities in surface water and groundwater
  - Modeling EOCs fate and migration in the subsurface, and effects of their occurrence on the aquifer resistome, as a threat for public health
- **Societal**
  - Assess the **quality of water** supply re EOCs and MRB at a catchement scale
  - Contribution to define WQ **guidelines**
  - Derive, assess and communicate water **management strategies** for EOCs polluted water resources based on sound scientific basis (conceptual and regional)

Involvement of the stakeholders in the project

CHROME Stakeholders

- Administrative SMNVC, Vistrenque Catchment board
  ONEMA, The French National Agency for Water and Aquatic Environments
  Water Agency
- Private water supply companies

ICRA Stakeholders

- Administrative Catalan Water Agency
- Private water supply companies

IGOE Stakeholders

- Spin-off company : Isodetect

Involvement of stake holders

- Local managers are involved in the project meetings
- Regular reporting to agencies through seminars and reports
- Private water supply companies are interested in the project outcome
  - Long term collaboration with agents insure a worthing dissemination and application of the obtained results.

Dissemination and exploitation of the results

- Scientific papers
- Presentations in international congresses as well as local forums
- Meetings with stakeholders
- Contacts with local communication media
- Web site

Thank you for your attention

Funding agencies:

ONEMA – France

MINECO (Ministerio de Economia y Competitividad) - Spain

BMBF (Ministry of Education & Research) - Germany