ACWAPUR

Accelerated Water Purification during Artificial Recharge of Aquifers – A tool to restore drinking water resources

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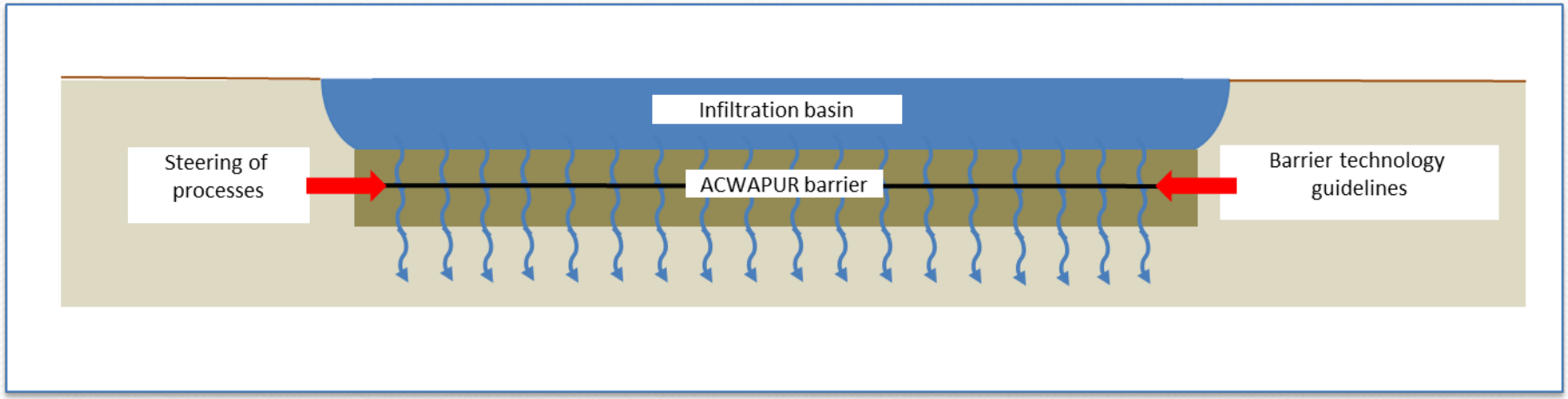
Managed Aquifer Recharge (MAR)

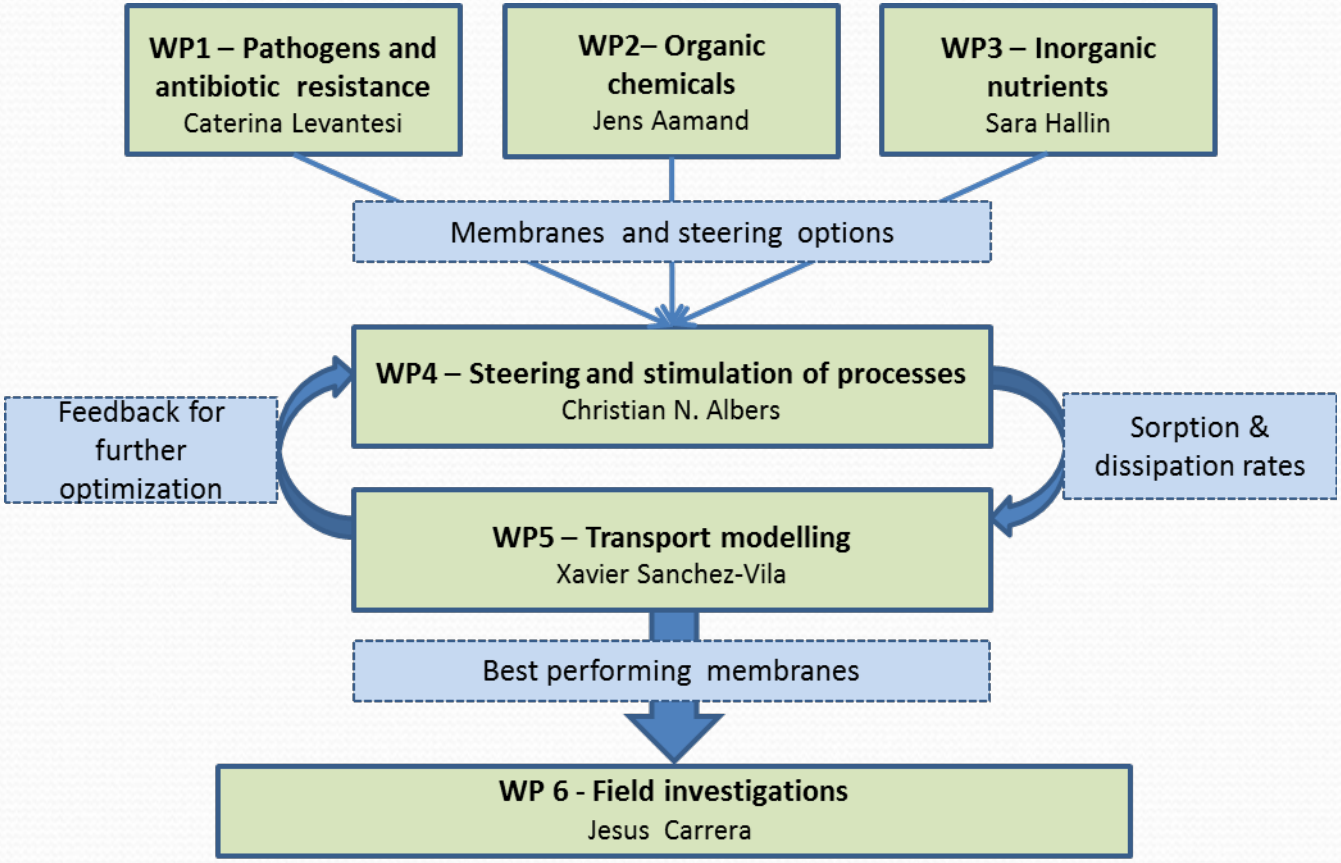
MAR is are used worldwide, but is most often operated as a 'black box' technology

The technology face problems related to

- Leaching of nutrients (e.g. NO_3)
- Leaching of organic pollutants (e.g. pesticides, pharmaceuticals)
- Leaching of pathogens and antibiotic resistance



Project structure



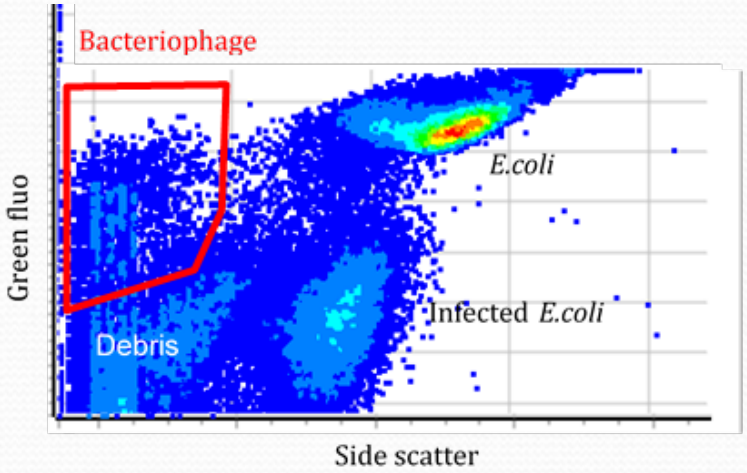
Scientific and technological progress (WP1 - pathogens)

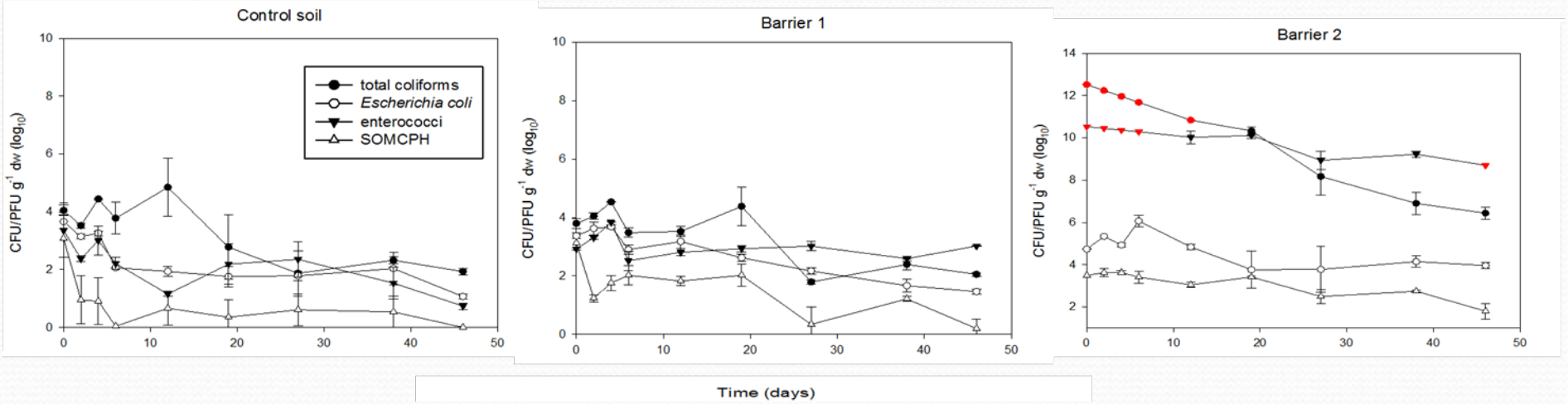
Development of protocols

- Immunofluorescence assay for pathogenic *E.coli*
- Analysis of virus by flow cytometry
- Analysis of protists by flow cytometry
- DNA extraction for analysis of antibiotic resistance genes (ARG)

Test of barrier materials

- Green waste compost (barrier 1)
- Mushroom spent compost (barrier 2)

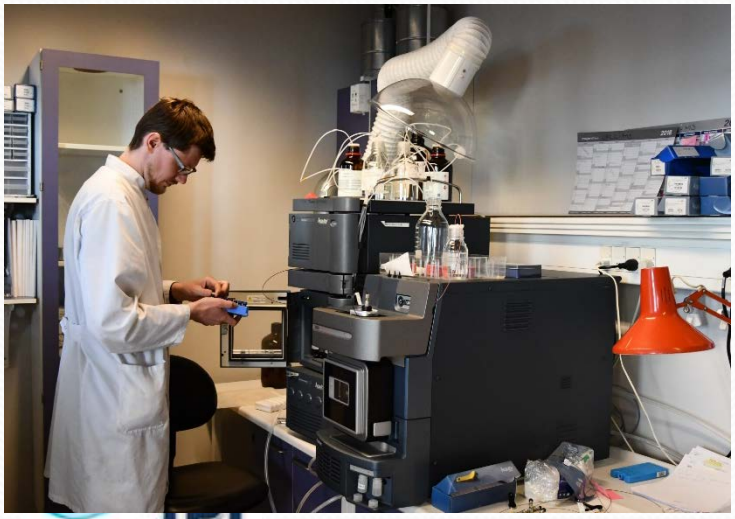




SOMCPH: Somatic coliphages
CFU: Colony forming units, a measure of bacteria
PFU: Plaque forming units; a measure of virus.

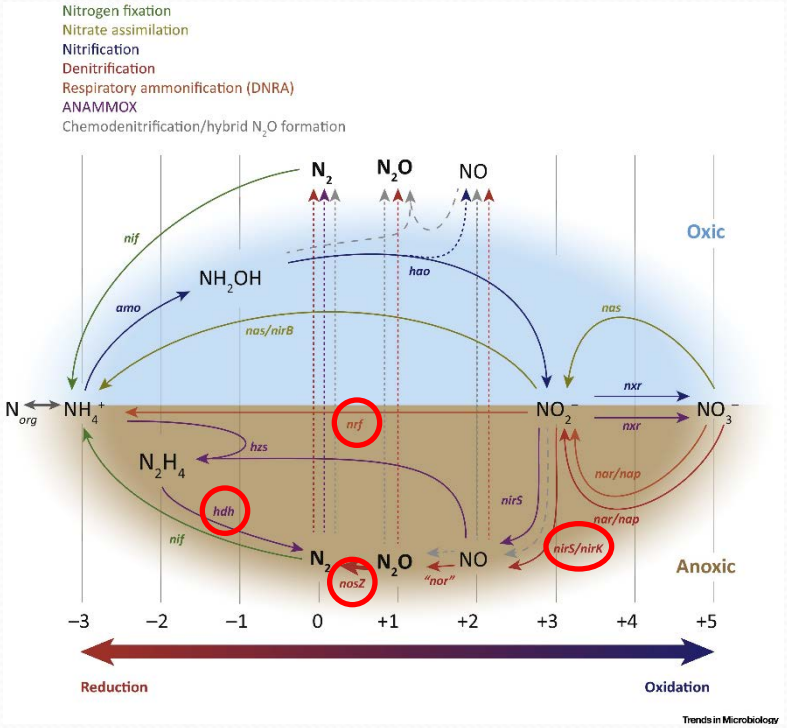
Scientific and technological progress (WP2 –organic pollutants)

- Development of protocols for analysis of organic micropollutants
- Mineralisation of organic micro pollutants (on-going)
- Effect of dissolved organic carbon on micropollutant degradation (on-going)

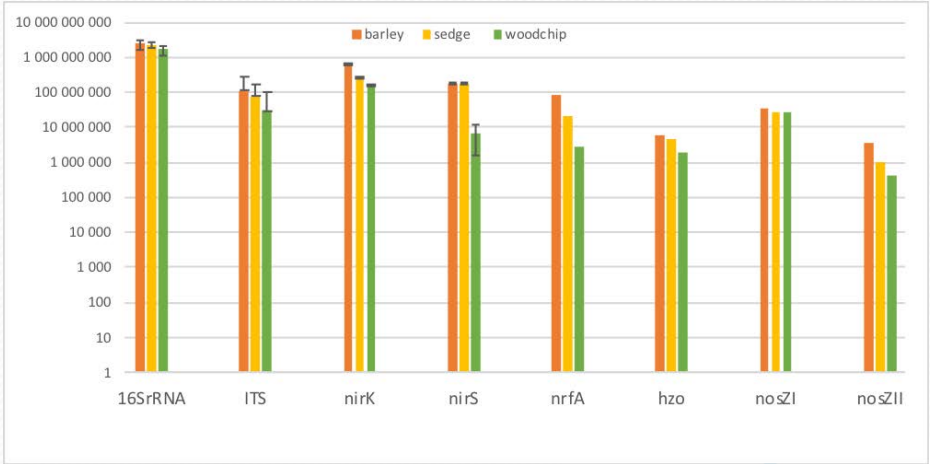


compound name	abbre-viation	CAS number	^{14}C-labelled for mineralization studies	structure	category
Diuron	DCMU	330-54-1	YES		pesticide
Mecoprop	MCPP	93-65-2	YES		pesticide
Sulfadiazine	SDZ	68-35-9	YES		antibiotic, sulfonamide
Sulfamethoxazole	SMX	723-46-6	YES		antibiotic, sulfonamide
Erythromycin	EMC	114-07-8			antibiotic, macrolide
Carbamazepine	CBZ	298-46-4			psychiatric drug
Paracetamol (Acetaminophen)	PAR (APAP)	103-90-2	YES		analgesic
Ibuprofen	IBU	15687-27-1	YES		analgesic and anti-inflammatory
1H-Benzotriazole	BTA	95-14-7			anti-corrosive
5-Methyl-Benzotriazole	MBTA	95-14-7			anti-corrosive
Benzophenone-3 (Oxybenzone)	BP3	131-57-7	YES		UV filter

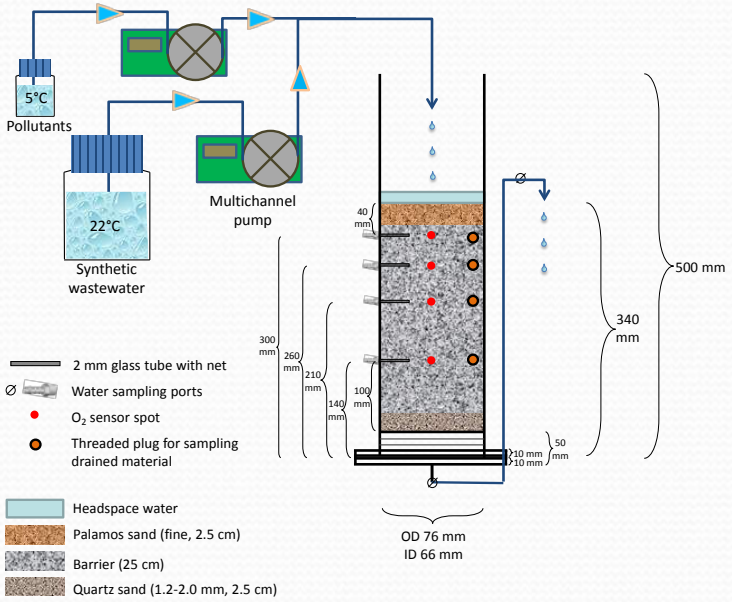
Scientific and technological progress (WP3 – inorganic nutrients)

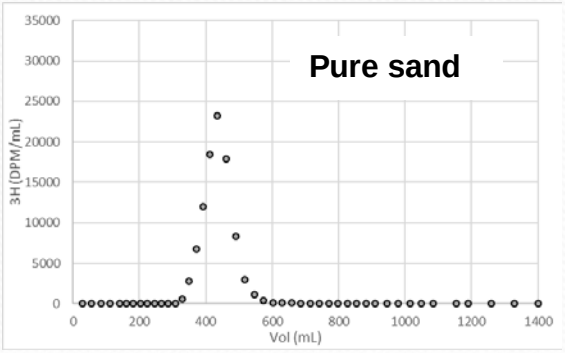


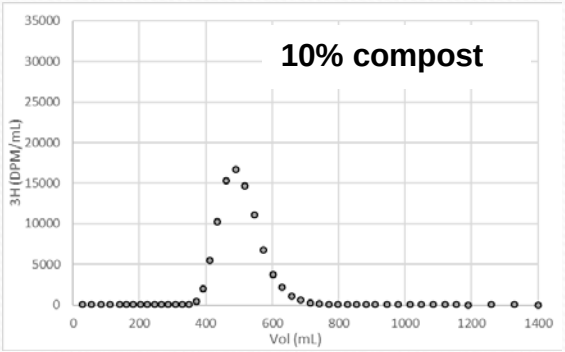
Columns were seeded with activated sludge, operated for 8 months, and outlet analysed for nitrate, nitrite, ammonia, sulfate, and pH (ongoing).

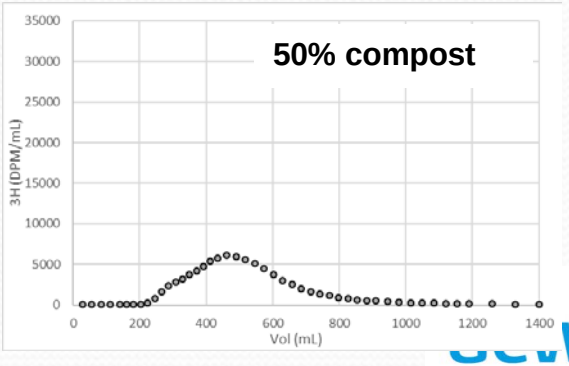


Scientific and technological progress (WP4 – steering and stimulation)









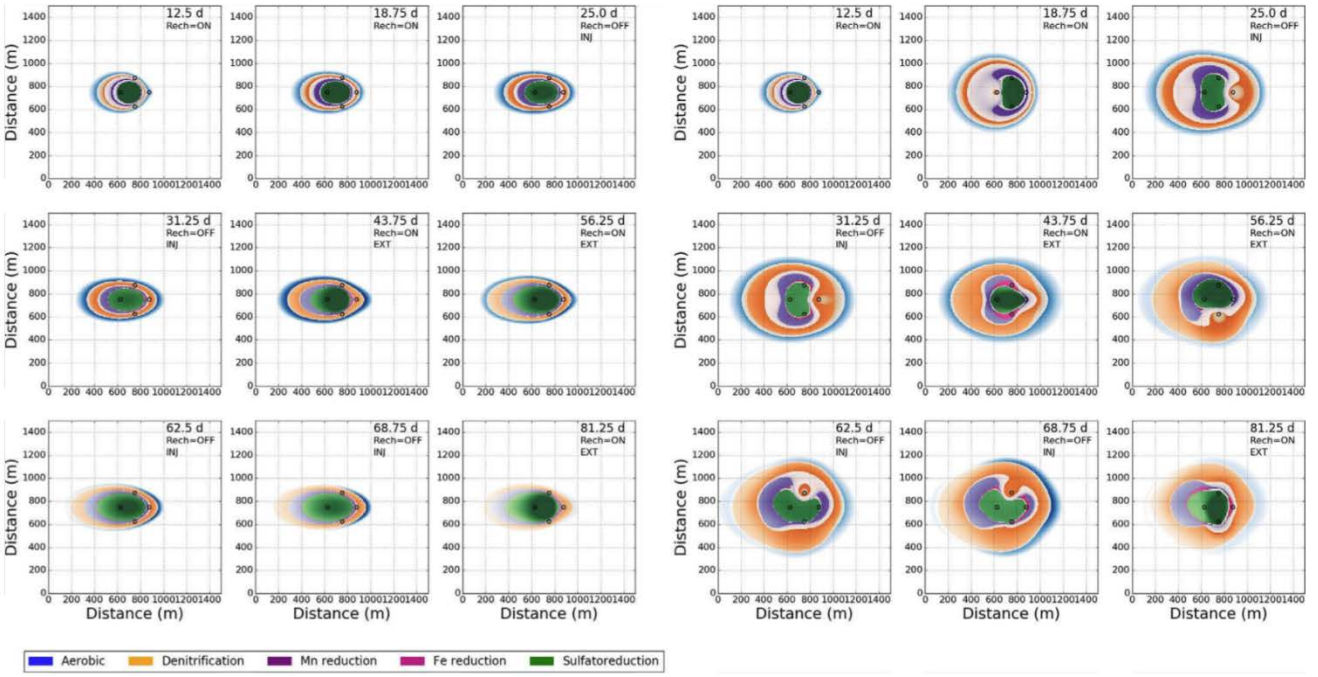
Scientific and technological progress (WP5 - modelling)

Aim: To integrate input parameters from WP1-4 in a mathematical framework to simulate pathogen transport, removal of inorganic nutrients, and organic chemicals during MAR

A model has been set up to evaluate the enhancement of degradation in a heterogeneous porous medium as an effect of introduced mixing (sequence of injection and extraction).

Without chaotic flow

With chaotic flow

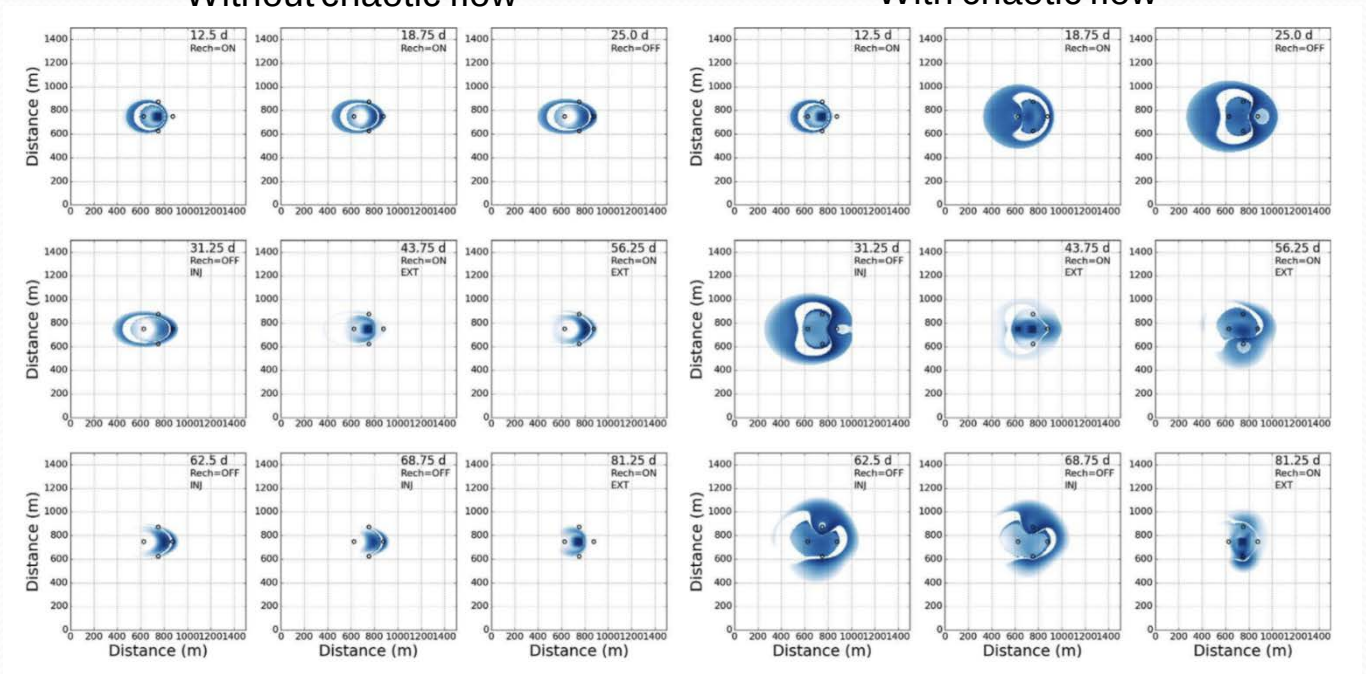


Scientific and technological progress (WP5 - modelling)

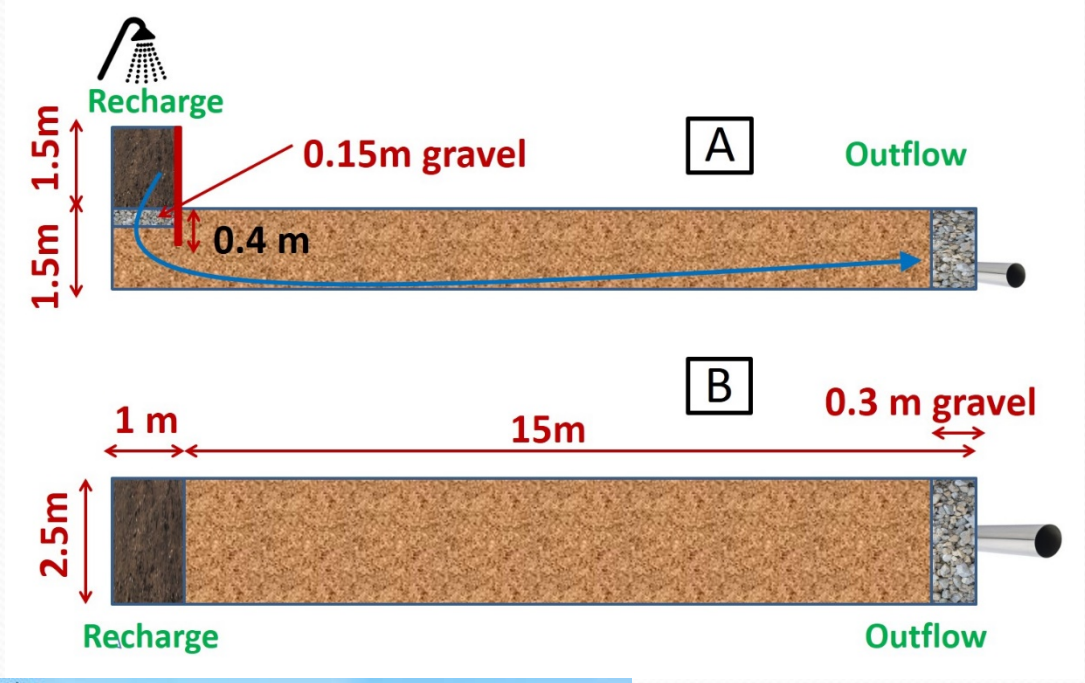
If degradation rates are available then distribution of degradation potentials as affected by introduced mixing can be modelled as shown here for 5-chlorobenzotriazole.

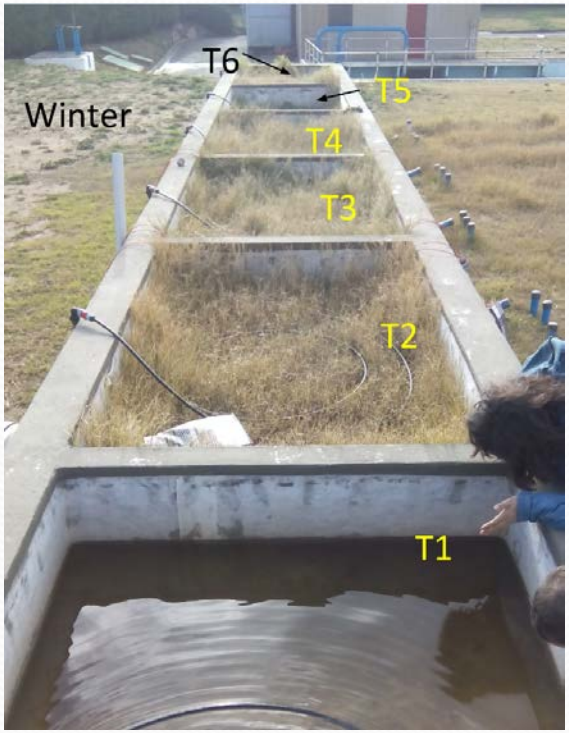
Without chaotic flow

With chaotic flow



Scientific and technological progress (WP6 - field investigations)





T1:	Sand (reference)
T2-4:	49% vegetable compost, 49% sand, 2% clay
T5:	49% wood chip, 49% sand, 2% clay
T6:	39% vegetable compost, 59% sand, 2% clay

Collaboration, coordination and mobility

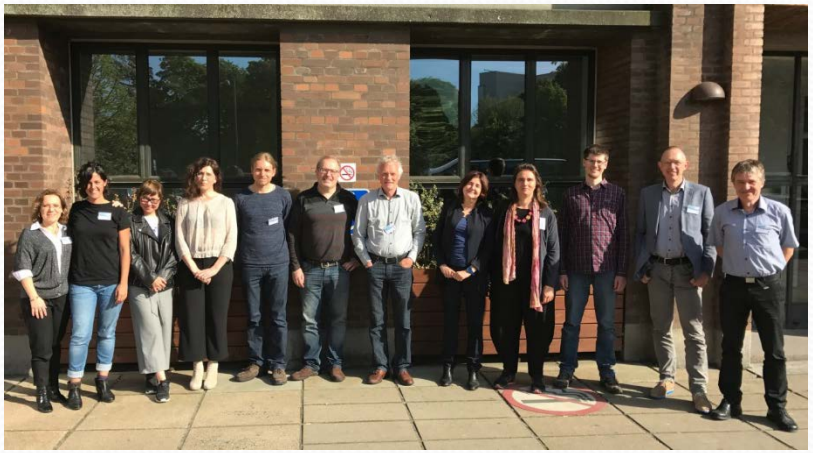
- Consortium agreement signed by all partners
- Homepage up and running (www.acwapur.eu)
- Project-meetings in Uppsala, Copenhagen, Barcelona and Rome
- Several WP-meetings via SKYPE

Mobility

- Interim stay of Danish postdoc at CSIC, Barcelona
- Interim stay of Spanish postdoc at GEUS, Copenhagen
- Researchers stay in Denmark during the joint column experiment
- Exchange of samples from the joint field study in Palermos

Stakeholder/industry engagement

- Collaboration with the Uppsala Water Association (Uppsala Vatten)
- Stakeholder meeting at the Swedish Water and Wastewater Association (SWWA)
- Continous dialog with the owner and manager of the WWTP to be used for the joint field experiments in Spain
- Successful meeting with the ACWAPUR End-user Board in Copenhagen May 2017



Dissemination of the results

- Valhondo, C.; Martinez-Landa, L.; Carrera, J.; Ayora, C.; Nödler, K.; Licha, T (Under review). Evaluation of EOCs removal processes during artificial recharge through a reactive barrier. 2017. Science of the total environment.
- Rodriguez-Escales, P.; Fernandez-Garcia, D,; Drechsel, J.; Folch, A.; and Sanchez-Vila, X (2017). Improving degradation of emerging organic compounds by applying chaotic advection in Managed Aquifer Recharge in randomly heterogeneous porous media, Water Resour. Res., 53, doi:10.1002/2016WR020333
- Valhondo, C.; Martinez-Landa, L.; Carrera, J.; Hidalgo, J.; Tubau, I.; De Pourcq, K.; Grau-Martinez, A. & Ayora, C. (2016). Tracer test Modeling for Local Scale Residence Time Distribution characterization in an artificial recharge site, Hydrol. Earth Syst. Sci., 20, 4209-4221. doi:10.5194/hess-20-4209-2016.

- Presentation. Improving emerging organic compound degradation through chaotic advection in a Managed Aquifer Recharge: the case of benzotriazoles. AGU Fall Meeting 2016. San Francisco, USA 12-16 December 2016. (https://agu.confex.com/agu/fm16/meetingapp.cgi/Paper/ 140526)
- Presentation. Cristina Valhondo, Lurdes Martínez-Landa Jesús Carrera, Carlos Ayora. Removal of emerging contaminants during artificial recharge through a reactive barrier: Evaluation of processes. AquaConSoil2017. Lyon, 26-30 June 2017.
- Poster. Lurdes Martinez-Landa, Cristina Valhondo, Jesús Carrera, Juan, J. Hidalgo, Carlos Ayora. Groundwater flow and conservative transport model as a basis for an EOC behavior study in a surface MAR system. AquaConSoil2017. Lyon, 26-30 June 2017.
- Presentation. Cristina Valhondo, Lurdes Martinez-Landa, Jesús Carrera, Carlos Ayora. Tracer test modelling for characterizing heterogeneity and local scale residence time distribution in an artificial recharge site. EGU2017. Vienna, Austria, 24-28 April 2017. (http://meetingorganizer.copernicus.org/EGU2017/EGU2017-17867.pdf)
- Poster. Cristina Valhondo, Lurdes Martinez-Landa Jesús Carrera, J. J. Hidalgo, Carlos Ayora. Estimation of biotransformation and sorption of emerging organic compounds (EOCs) during artificial recharge through a reactive barrier. AGU fall meeting 2016. San Francisco, USA 12-16 December 2016.
- Aamand, J., C. N. Albers, J. Carrera, S. Hallin, C. Levantesi, and Xavier Sanchez-Vila (2016) ACWAPUR: Accelerated water purification during artificial recharge of aquifers - a tool to restore drinking water resources. WaterWorks2014 Kick off meeting 18th May 2016, Rome, Italy.
- Aamand, J., C. N. Albers, J. Carrera, S. Hallin, C. Levantesi, and Xavier Sanchez-Vila (2016) ACWAPUR: Accelerated water purification during artificial recharge of aquifers - a tool to restore drinking water resources. Workshop on Alignment of On-going Projects “Emerging Pollutants, including pathogens” 30th November 2016, Vienna, Austria.

Identified problems or specific risks

The project has been delayed due to difficulties recruiting qualified personel especially for WP2 and WP4. The relevant national funding body has been applied for an extension until 31st December 2019 and this has been granted.

No other problems or specific risks are foreseen

Scientific and technological progress (Conclusion)

- Methods has been established for the analysis of pathogens, virus and antibiotic resistant genes
- Methods has been established for the analysis of selected organic pollutants
- Green waste and mushroom spent compost has been tested for their capacity to remove potential pathogens and antibiotic resistance genes (ARG)
- Wood chips, barley straws, and clippings of sedge (*Carex rostrata*) has been tested for their ability to support bacteria involved i N-cycling
- The joint column experiment for simultaneous testing of organic contaminant, nutrient and pathogen transport during MAR has been established
- A modelling framework has been established for integration of input parameters from WP1-4 to simulate pathogen transport, removal of inorganic nutrients, and organic chemicals during MAR.
- A joint field site has been established in Palamos, Spain

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