Outcomes from WA1

Practical tools and guidelines for MAR operators. Application in real MAR sites.

Final Project meeting

17th – 18th June, Dübendorf

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This project has received funding from the European Union's Seventh Programme for Research, Technological Development and Demonstration under Grant Agreement no. 308339.

- Evaluation of fate of micropollutants: Removal matrix
- Column experiment with reclaimed water
- Real application of knowledge gathered:
  - MAR in Castellón
  - MAR in Sant Vicenç dels Horts
  - Bioasssays
  - LCC / LCA
- Available material
- Conclusions

LITERATURE REVIEW

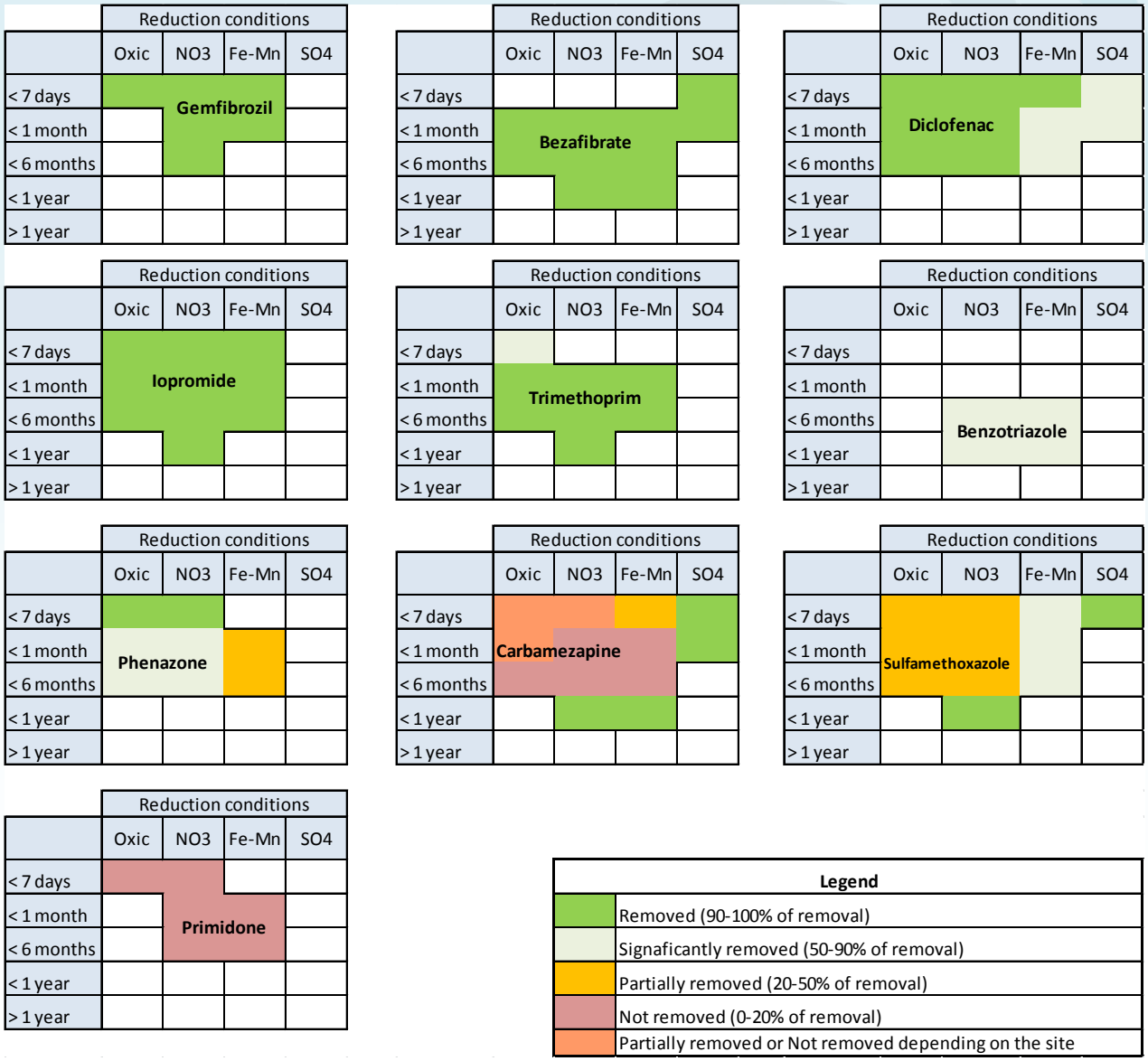
Review of 46 Scientific Papers

MOST SIGNIFICANT FIELD CONDITIONS INFLUENCING MICROPOLLUTANTS REMOVAL:

- **Residence time**
- **Redox conditions**
  - **Aerobic (Oxic)**
  - **Nitrate reduction**
  - **Fe – Mn reduction**
  - **Sulphate reduction**

OTHER RELEVANT CONDITIONS

- **Temperature**
- **Organic Carbon**
- **Initial concentration**
- **Type of aquifer**



EXPERIMENTAL METHODOLOGY

OBJECTIVE

- **Improvement of removal rates of emerging micropollutants.**
- **Use low-cost technology using sub-products, recycled waste.**
- **Confirm at lab-scale trends observed at field scale.**

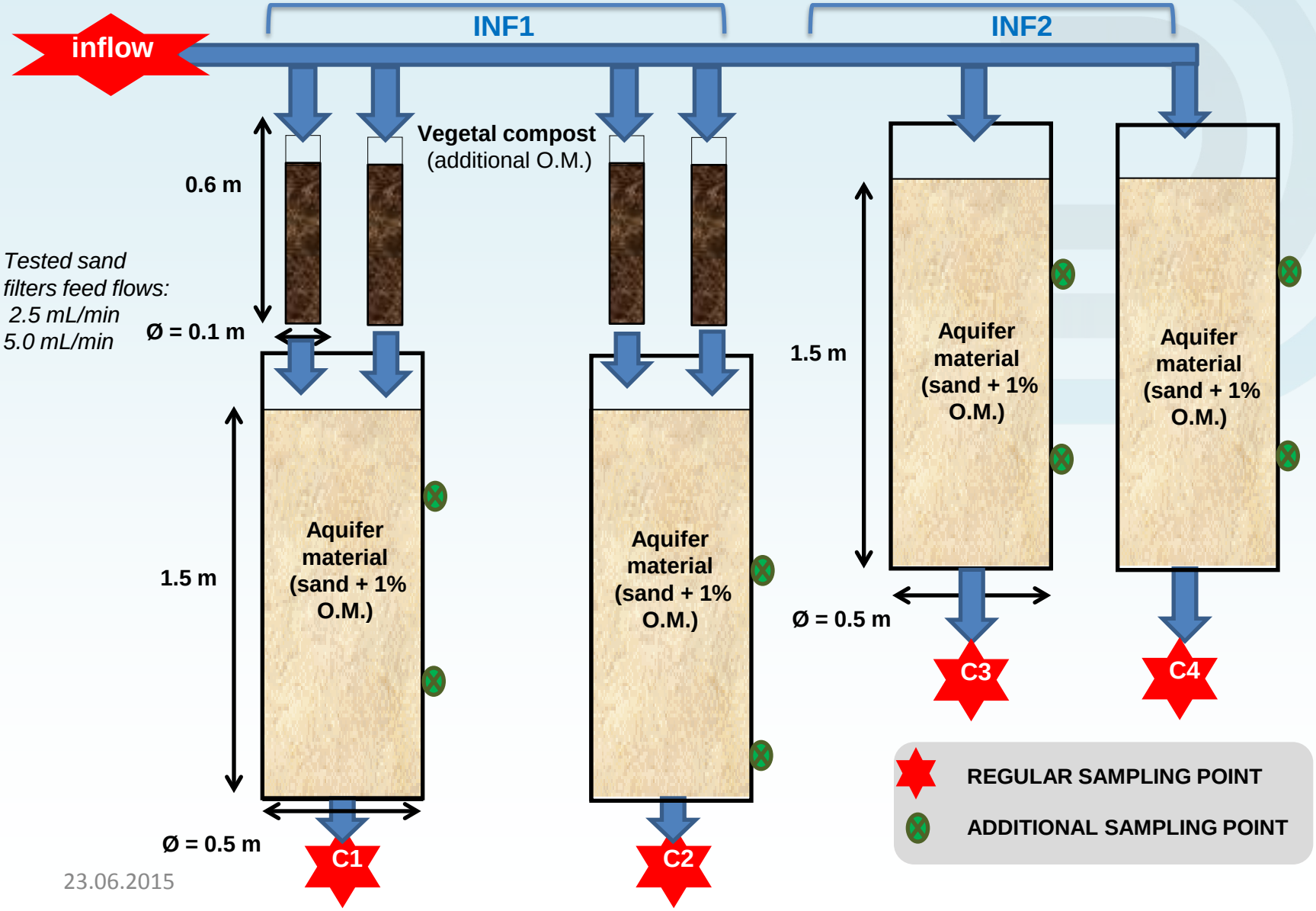
ENSAT site (2011):

- MAR system in Sant Vicenç dels Horts
- Infiltration capacity: 1 Mm^3/year
- Infiltration rate: 1$m^3/m^2/d$ (5600 m^2)
- Recharge water: Raw Llobregat River water
- Presence of emerging micropollutants: YES

DEMEAU site (2013):

- WWTP of El Prat del Llobregat
- Treatment capacity of 420.000 m^3/day
- Population: 2.275.000
- Recharge water: Secondary Effluent
- Presence of emerging micropollutants: YES

EXPERIMENTAL METHODOLOGY



RESULTS

INF 1

Compound	Mean [ng L^{-1}]	Min [ng L^{-1}]	Max [ng L^{-1}]	Std. dev. [ng L^{-1}]	QF[a] [%]
DICLOFENAC*	1334	876	1799	251	100
PHENAZONE*	2170	1474	3043	381	100
METROPROLOL	48	23	121	27	76
IOPPROMIDE	740	317	1358	301	100
SULFAMETHOXAZOLE*	1443	1176	1759	131	100
TRIMETHOPRIM	207	17	1342	377	62
BEZAFIBRATE	53	22	95	24	95
GEMFIBROZIL	1052	504	2207	515	100
CARBAMAZEPINE	242	199	270	19	100
PRIMIDONE	85	69	102	9	100
1H-BENZOTRIAZOLE	2895	1829	4803	752	100

[a] detection frequency above LOQ, n= 21 samples. (*) Spiked contaminant

INF 2

Compound	Mean [ng L^{-1}]	Min [ng L^{-1}]	Max [ng L^{-1}]	Std. dev. [ng L^{-1}]	QF[a] [%]
DICLOFENAC*	979	680	1281	153	100
PHENAZONE*	2278	1728	3018	304	100
METROPROLOL	59	35	112	23	95
IOPPROMIDE	747	227	1667	357	100
SULFAMETHOXAZOLE*	1448	1138	1747	133	100
TRIMETHOPRIM	122	62	711	138	100
BEZAFIBRATE	39	19	80	18	100
GEMFIBROZIL	1350	570	3261	735	100
CARBAMAZEPINE	242	215	264	13	100
PRIMIDONE	89	64	125	15	95
1H-BENZOTRIAZOLE	2471	1764	3831	540	100

[a] detection frequency above LOQ, n= 21 samples. (*) Spiked contaminant

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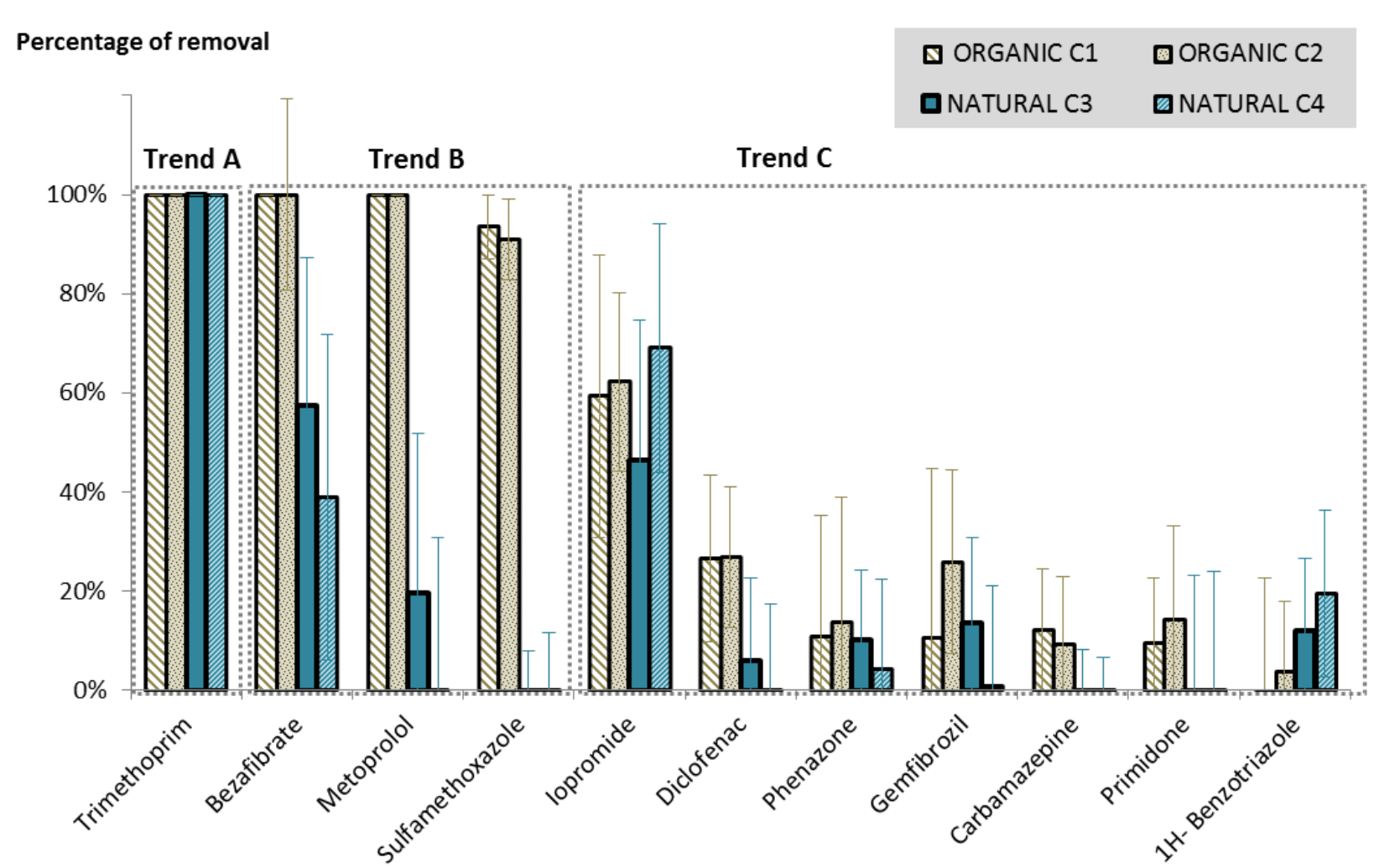
Percentage of removal
ORGANIC C1
ORGANIC C2
NATURAL C3
NATURAL C4
Trend A
Trend B
Trend C
100%
80%
60%
40%
20%
0%
Trimethoprim
Bezafibrate
Metoprolol
Sulfamethoxazole
Iopromide
Diclofenac
Phenazone
Gemfibrozil
Carbamazepine
Primidone
1H- Benzotriazole

- **Scientific publication:**

WATER RESEARCH 74 (2015) 110–121

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ELSEVIER

Influence of a compost layer on the attenuation of 28 selected organic micropollutants under realistic soil aquifer treatment conditions: Insights from a large scale column experiment

CrossMark

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5. RESULTS

- **28 selected compounds results and analysis:**

16/28: influence of reactive layer!!!

Table 3 – Attenuation behavior of the investigated compounds in the column systems.

Compounds		Retardation C1/C2	Retardation C3/C4	Degradation C1/C2	Degradation C3/C4	Influence of reactive layer	Comments
Neutral	AAA	+	+	+	+	0	
	BZL	++	+	0	(+)	0	
	CBZ	++	+	0	0	(+)	() due to stronger retardation
	DIA	+++	++	0	0	(+)	() due to stronger retardation
	ISO	++	+	+	0	+	
	PHE	0	0	0	0	0	
	PRM	0	0	0	0	0	
	TZL	++	++	0	0	0	
Anionic	ACE	0	0	0	0	0	
	BZF	(++)	+	++	+	+	Complete removal (C2)
	DCL	++	+	+	0	+	
	GFZ	+	+	+	0	+	
	IBP	+	+	+	0	+	
	IRB	+++	++	+	+	(+)	() due to stronger retardation
	LOS	++	+	+	+	(+)	() due to stronger retardation
	MCP	+	0	0	0	(+)	() due to stronger retardation
	NPX	ø	+	ø	0	+	Complete removal (C1/C2)
	SMX	+	0	++	0	+	
	VAL	+	0	+	(0)	+	
	VAA	0	0	–	–	(–)	Formed transformation product
Cationic	ATE	ø	+	ø	++	+	Complete removal (C1/C2)
	CIT	ø	ø	ø	ø	0	
	CLA	ø	ø	ø	ø	0	
	FLX	ø	ø	ø	ø	0	
	HAL	ø	ø	ø	ø	0	
	MET	ø	+	ø	0	+	Complete removal (C1/C2)
	TMX	ø	ø	ø	ø	0	
Zwitter	ATA	+	0	+	0	(+)	Formed transformation product

0…no retardation (R = 1.0)	0…no degradation	0…no effect
+…slight retardation (R > 1.0–1.5)	+…low degradation (≈10–50% of c_0)	+…positive effect
++…Moderate retardation (R > 1.5–2.5)	++…high degradation (>50% of c_0)	–…negative effect
+++…strong retardation (R > 2.5)	–…concentration increase (TP)	
ø…not detected in the outflow	ø…not detected in the outflow	

- Field experiences (Literature):

Legend	
	Removed (90-100% of removal)
	Signaficantly removed (50-90% of removal)
	Partially removed (20-50% of removal)
	Not removed (0-20% of removal)

- Column experiments:
  - Residence time < 7 days
  - Reduction state: denitrification

	Column results

Main conclusion: **less removal in column experiment than in real sites (field conditions): optimistic expectations in field experiences!**

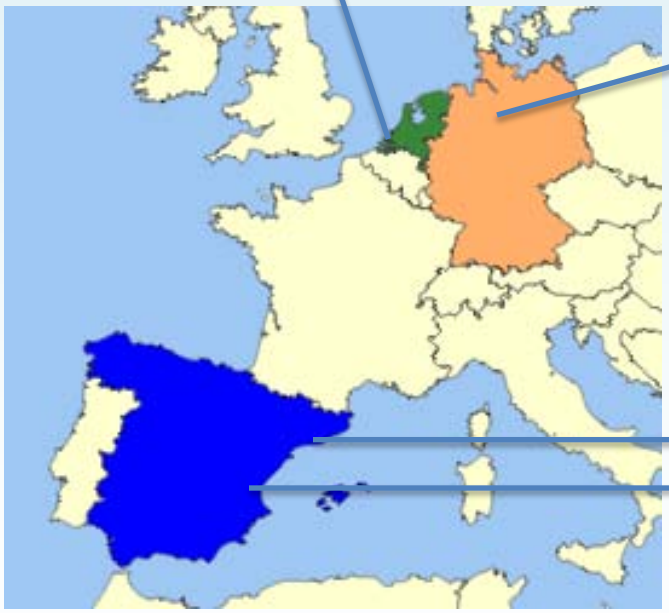
FIELD WORK DONE

MATURE MAR FACILITY:
Den Haag, The Netherlands

- Assessment of micropollutants fate using historical data

MATURE MAR FACILITY:
Tegel, Berlin (Germany)

- Assessment of micropollutants fate using historical data



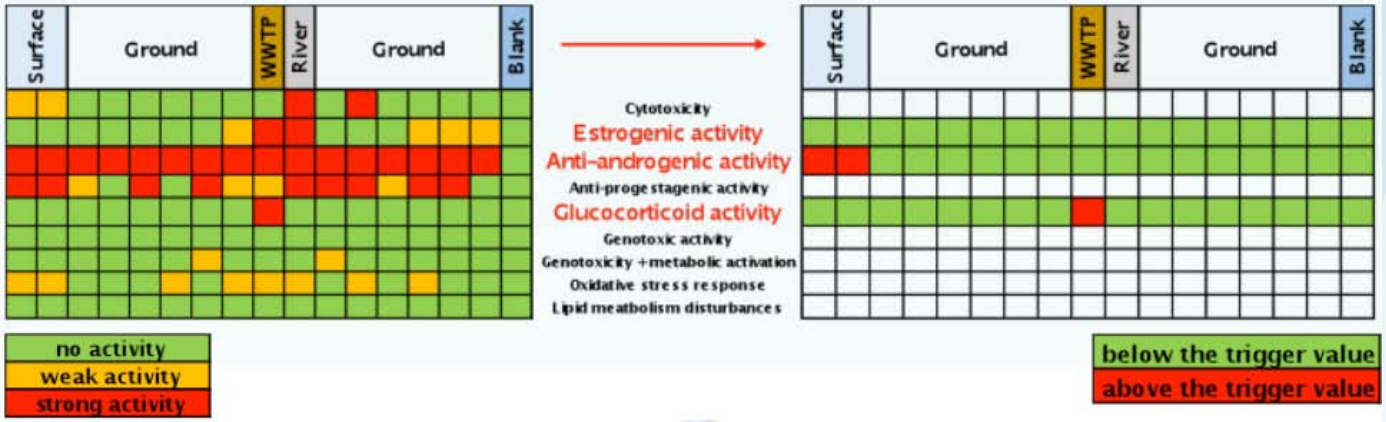
MATURE MAR FACILITY:
Sant Vicenç dels Horts (Barcelona, ES):

- Leaching tests (organic layer)
- Bioassays (toxicity)
- Micropollutants quantification (July 2014 – Feb 2015 – May 2015) (wet cond. – dry cond. – mixed cond.)

NEW MAR IMPLEMENTATION:
Vall d'Uixó (Castellón, ES):

- Risk assessment reclaimed water
- Bioassays (toxicity)
- Micropollutants quantification (June 2014 – Jan 2015 – Apr 2015)

WA4: Evaluating toxicity of MAR samples



MATURE MAR FACILITY:
Sant Vicenç dels Horts (Barcelona, ES):
- Bioassays (toxicity)

NEW MAR IMPLEMENTATION:
Vall d'Uixó (Castellón, ES):
- Bioassays (toxicity)

Quadruplicated samples:
- Bulk chemistry (AB, IGME)
- Emerging compounds (Gottingen, KWB Berlin, UJI Castellon)
- Toxicity BDS (Amsterdam)
- Toxicity EAWAG (Switzerland)

SYNERGIES WITH OTHER WAs

WA5: Evaluating drivers and barriers

MATURE MAR FACILITY:
Den Haag, The Netherlands

- LCC/LCA

MATURE MAR FACILITY:
Sant Vicenç dels Horts (Barcelona, ES):

- LCC / LCA
- Workshop Drivers and Barriers in Barcelona: October 2015

CONCLUSIONS

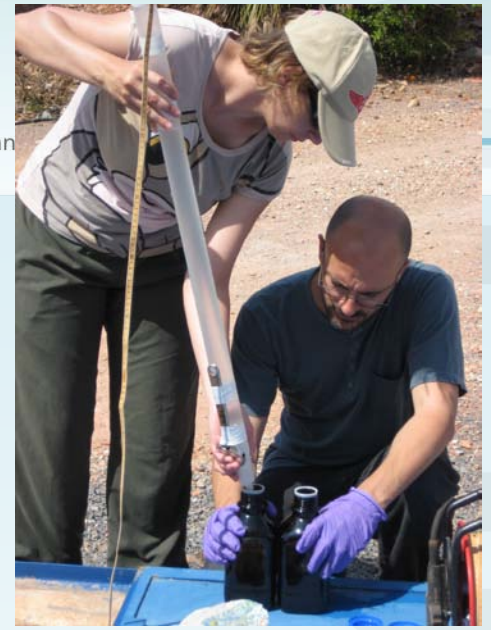
- DEMEAU project demonstrates that it is possible to enhance the removal of **some micropollutants** with organic matter addition. The incorporation of a reactive layer increases the elimination percentage of 16 of the 28 target emerging pollutants.

- **Residence time** is one of the key parameters to increase the percentage of elimination, according to the literature review carried out. Redox conditions can also influence in the percentage of elimination.

- Field test micropollutants' elimination percentages are higher than in column experiments. Hence, **some properties/processes occurring in soil-aquifer treatment** cannot be simulated at column scale.

- **Collaboration** with other WAs has allow to open **new research lines** (Bioassays & toxicity) and to develop a **new language to communicate** with our stakeholders (participative sessions, LCA, LCC)

- DEMEAU project contributes to bring **practical tools and guidelines** to MAR operators and is a driver for **MAR implementation in Europe**.


MANY THANKS TO THE TECHCNICAL TEAM FOR THEIR WORK AND….

THANK YOU FOR YOUR ATTENTION!!

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Thank you for your attention!

AMPHOS 21

aquatune

eawag aquatic research

HYDOR

CETaqua WATER TECHNOLOGY center

CORDOUAN Technologies

eco logic

KWR Watercycle Research Institute

Quantis Sustainability counts

IWW

SIGRIST PROCESS-PHOTOMETER

BDS BioDetection Systems

n|w University of Applied Sciences and Arts Northwestern Switzerland School of Life Sciences

KOMPETENZZENTRUM Wasser Berlin

Van Remmen UV Techniek

VEOLIA ENVIRONNEMENT Recherche & Innovation

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