Can we trust in MAR to deal with emerging contaminants present in reclaimed water?

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INTRODUCTION

The list of priority substances for which environmental quality standards were set in 2008 has been recently modified, increasing the number of substances or groups of substances from 33 to 45 (DIRECTIVE 2013/39/EU). In this context, DEMEAU project means a unique opportunity to demonstrate how conventional and alternative water treatment processes can deal with the emerging pollutants elimination in drinking water processes and anthropogenicaly-impacted environments.

OBJECTIVES

- To evaluate the capacity of Managed Aquifer Recharge (MAR) systems in the reduction of emerging pollutants concentration during subsurface passage.
- To assess the improvements achieved by using an additional organic reactive layer to increases the purification effect of MAR for WWTP's effluent after a secondary treatment (biological).

EXPERIMENTAL SITE

El Prat del Llobregat (Barcelona, NE Spain) Waste Water Treatment Plant (WWTP):

- Treatment capacity of 420,000 m^3/day (Figure 1).
- WWTP will provide reclaimed water to the artificial aquifer recharge schemes located in Sant Vicenç dels Horts (SVH), increasing groundwater resources at local scale with the following characteristics:
- Current recharge water: Llobregat River raw water
- Decantation pond (5600 m^2)
- Infiltration pond (4000 m^2)
- Annual volume recharged in 2011: 1.11 Mm^3
- Annual volume recharged in 2012: 1.16 Mm^3

Figure 1: Location of the WWTP in El Prat del Llobregat and the MAR system in Sant Vicenç dels Horts (SVH).

METODOLOGY

Real water effluent from the secondary treatment of the WWTP was used as inflow water in the column experiment. The experiment consisted in two duplicated systems. Both simulated MAR operation conditions (i.e. with and without the application of an organic layer before the column inlet). Inlet water from INF1 and INF2 containers were spiked with 1000 ng/L of phenazone, diclofenac and sulfamethoxazole, which were not present in the inflow water. Initial concentrations of the 12 target micropollutants are showed in Table 1. The filling material was homogeneous silica sand (porosity 40%) mixed with 1% of organic matter. Residence time in the column was established in 7.5 days, using a duplicate tracer test (electrical conductivity and fluorescein).

RESULTS

12 sampling campaigns with stabilized output conditions were selected for the interpretation of the results of the experiment. Bulk chemistry analysis (not showed in the poster) revealed that according to nitrate concentration and total organic carbon removal, denitrification conditions were predominant in the experiment. Concentration of nitrate in the output of reactive column was generally found under detection limit (0.5 mg NO_3/L).

Figure 3 classifies the elimination of emerging pollutants in three categories: Trend A corresponds to emerging pollutants that are totally removed in both natural and enhanced conditions, reaching removal percentages of 100%. Trend B is characterised by improvement of the elimination percentage with enhanced conditions when additional DOC is provided by the organic layer. Trend C shows the micropollutants seem to be slightly eliminated in any experimental conditions, with elimination percentage mostly below 25%.

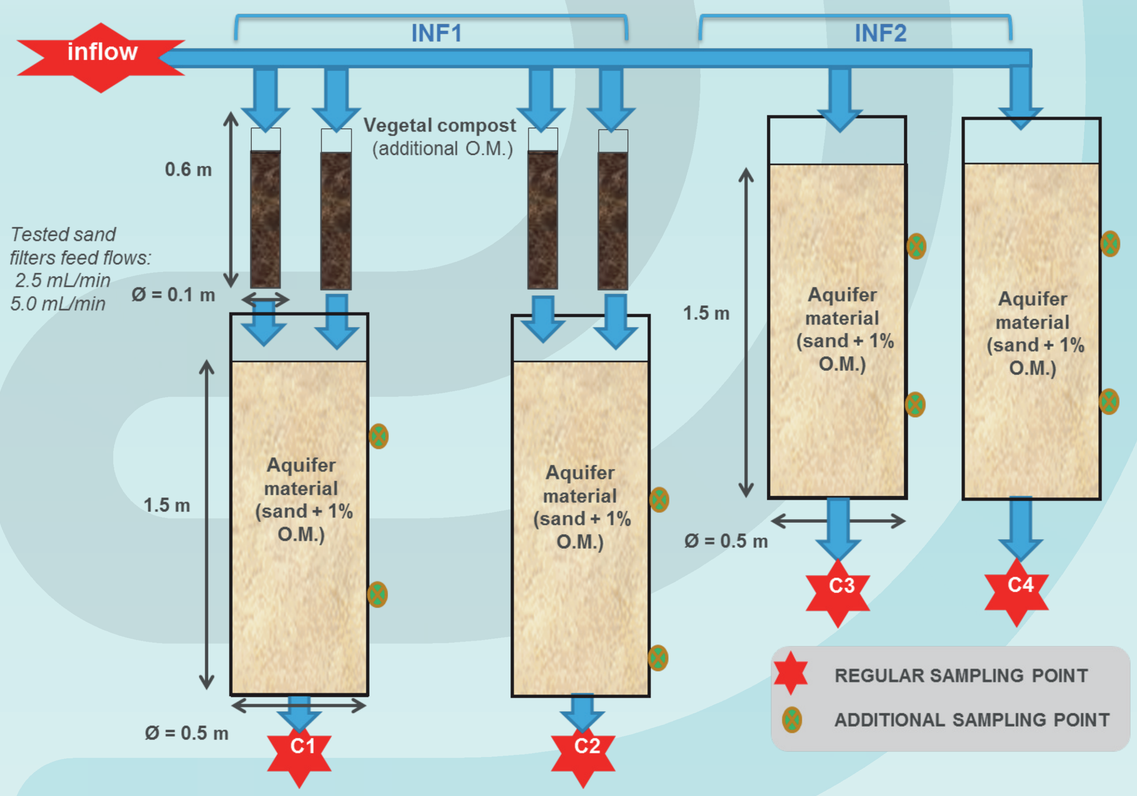

Figure 2: Operational scheme of the column experiment

Compound & Application	Code	INF1 Mean [ng L^{-1}]	INF1 Min [ng L^{-1}]	INF1 Max [ng L^{-1}]	INF1 Std. dev. [ng L^{-1}]	INF1 DF[a] [%]	INF2 Mean [ng L^{-1}]	INF2 Min [ng L^{-1}]	INF2 Max [ng L^{-1}]	INF2 Std. dev. [ng L^{-1}]	INF2 DF[a] [%]
*Diclofenac** anti-inflammatory drug	DCL	1334	876	1799	251	100	979	680	1281	153	100
*Phenazone** Analgesic, anti-inflammatory and antipyretic	PHEN	2170	1474	3043	381	100	2278	1728	3018	304	100
Metoprolol Anti-hypertensive	MET	48	23	121	27	76	59	35	112	23	95
Iopromide Contrast medium	IOP	740	317	1358	301	100	747	227	1667	357	100
*Sulfamethoxazole** Antibiotic	SMX	1443	1176	1759	131	100	1448	1138	1747	133	100
Trimethoprim Bacteriostatic antibiotic	TRI	207	17	1342	377	62	122	62	711	138	100
Bezafibrate Fibrate drug used for the treatment of hyperlipidaemia	BZF	53	22	95	24	95	39	19	80	18	100
Gemfibrozil Blood lipid and cholesterol-modifying drug.	GFZ	1052	504	2207	515	100	1350	570	3261	735	100
Carbamazepine Anticonvulsant	CBZ	242	199	270	19	100	242	215	264	13	100
Primidone Anti-epileptic drug	PRM	85	69	102	9	100	89	64	125	15	95
Benzotriazole Corrosion inhibitor	BZL	2895	1829	4803	752	100	2471	1764	3831	540	100

Table 1: Concentration of organic micropollutants in INF1 and INF2

CONCLUSIONS

- The column experiment simulating the MAR system of Sant Vicenç dels Horts operated under denitrification conditions.
- MAR systems seems to be a reliable alternative for the elimination of emerging pollutants as TRI (100%), BZF (52%), MET (94%) and SMX (92%), when these systems are enhanced with an additional input of dissolved organic carbon.
- The short residence time in the columns (7.5 days) and the lack of acclimatisation period during the recharge might have affected the poor elimination percentage observed for some of the emerging pollutants.
- MAR is a reliable and potential alternative in combating the presence of undesired organic substances in the environment and in the full water cycle.

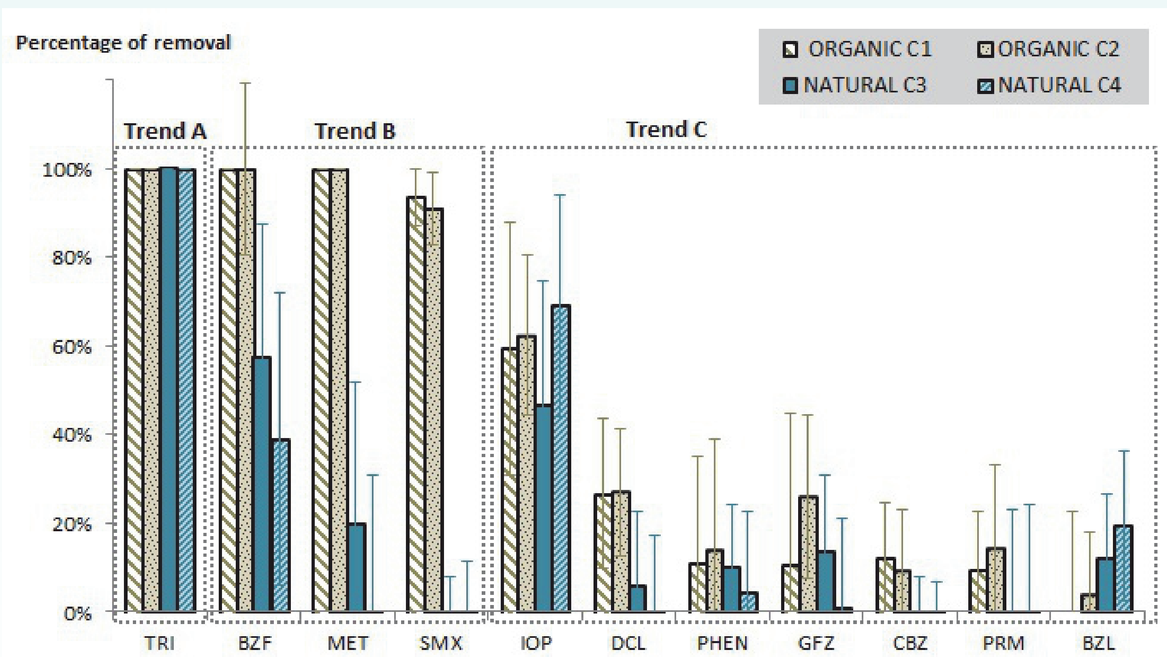

Figure 3: Elimination of organic micropollutants in natural and enhanced conditions

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