WATER RECOVERY PROJECT: THE FIRST EXPERIENCE OF DEEP INJECTION IN CASTELLÓN. RESULTS OF THE FIRST PHASE AND NEXT STEPS

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PILOT AREA LOCATION

Selected Area

La Rambleta
Vall de Uxó (Castellón, Spain)

Plioquaternary Castellón Plain Aquifer

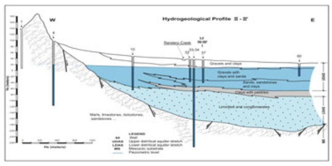
Detritic and free aquifer (490 Km²)

Hydrodynamic parameters:
- Thickness: 50-200 m
- Transmissivity: 500-6000 m²/day
- Specific yield: 1-20 L/s/m
- Permeability: 30-50 to 100-120 m/day

Reasons to choose this area:
- Area with seawater intrusion
- Salinity of the WWTP effluent is around 1400 µS/cm
- The farmers communities of Vall de Uxó make intensive use of the wastewater coming discharged from the WWTP. There are many wells in the study area which have been abandoned due to the high salinity of the water
- The option of using abandonated wells as recharge points or monitoring network could reduce the number of new piezometers
- There is a recharge system with penetrating wells and water reservoir constructed by ACUAMED

HYDROGEOLOGICAL AND HYDROCHEMICAL CHARACTERIZATION

HYDROGEOLOGY



Upper detritic aquifer (UDAS): Sands and gravels (80-90 m). The aquifer exploited by the most of the wells

Lower detritic aquifer (LDAS): Siltstones, clays, sandstones and conglomerates (50-100 m)

Mesozoic substratum: Triassic limestones, marls and dolomites (Muschelkalk facies), orthoquarzite sandstones (Buntsandstein facies), marl with gypsums (Keuper facies)

HYDROCHEMISTRY

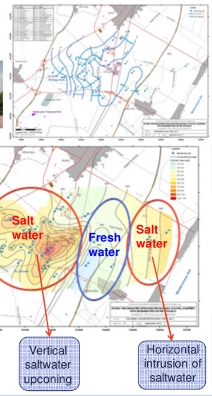
Monitoring network → 32 points: 29 irrigation; 19 abandoned; 11 divers

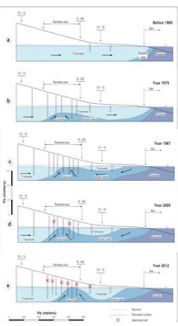
Sampling → To 5 m below the free water surface

Parameters *In situ*: Piezometric level; Electrical Conductivity (EC); pH; Temperature (T); Eh

Monitoring period:
- Two-monthly: In situ; Cl; NO_3
- Biannual: Major ions; Minor ions; Emerging contaminants

Schematic representation of saline water evolution in the pilot area



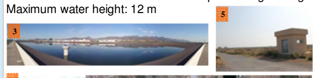


RECHARGE SYSTEM

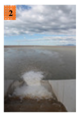
RECHARGE USING PENETRATING WELLS

Recharge 2 wells
PRO and PRE
Depth: 100m
Drilling diameter: 500 mm
Screened between 50 and 95 m
Gravel pack along its length

Storage reservoir
Capacity: 2 hm³
Surface: 20 ha
Maximum water height: 12 m



Water from the Belcaire river
Admission capacity: 4.4 m³/s



Recharge water
Low mineralization
Water calcium or calcium-magnesium bicarbonate
Electrical conductivity: 249-366 µS/cm

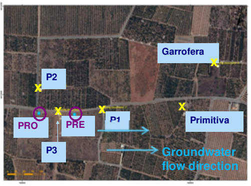
Iron pipe transporting the water to two injection wells
Length: 1700 m

ARTIFICIAL RECHARGE

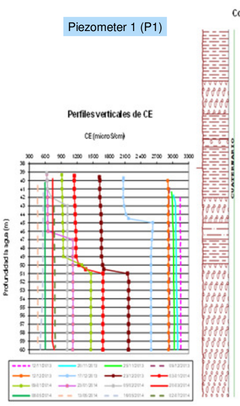
RECHARGE PILOT TEST

The recharge pilot test was carried out in the West Recharge well (PRO) during 2 weeks (9th April- 23th April 2013) with an average flow of 15 L/s and a total injected volume of 15,500 m³. During the pilot test, the artificial recharge was controlled in the East Recharge well (PRE).

The objectives of this test were:
1. To sure that the PRO well was adequated for the injection
2. To observer how the aquifer responds to the recharge
3. To design an efficient methodology to monitoring the artificial recharge including piezometers (P) construction



Piezometer 1 (P1)



ARTIFICIAL RECHARGE

- Recharge system → Penetrating wells
- Recharge wells → PRO and PRE
- Recharge period → Nov. 2013 - May 2014
- Total volume → 300,000 m³
- Specific control network → P1, P2, P3, Primitiva and Garrofera
- Monitoring period: Daily (Nov. 2013 - Dec. 2013); Weekly (Jan. 2014 - June 2014); Biweekly (Jul. 2014 - Sept. 2014)

Monitoring well	Piezometric level	EC vertical profil	Sample 5 m depht	Sample different depht	isotopes	Emerging Contaminants * [1]	EC, pH, Tª, Eh (in situ) [2]	CTD-Divers
P1	X	X	X	X	X	X	X	X
P2	X	X	X		X	X	X	X
P3	X	X	X	X	X		X	X
Garrofera	X	X	X		X	X	X	
Primitiva	X	X	X		X	X	X	

* Date: 5th June 2014

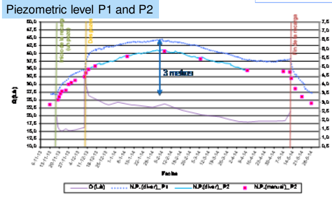
Compound	LOQ [ng/l]	BALSA	S. VICENTE	LA PAZ	RANDERO	RAMBLETA 2	PRIMITIVA	GARROFERA	P2	P1	LOQ [ng/l]	EDAR 1	EDAR 2	EDAR 3	EDAR 4
	SW/GW samples										WWTP samples				
Diclofenac	2.0	-	21	18	24	15	-	-	-	6.7	10	965	1026	1084	1128
Ibuprofen	3.6	-	-	-	-	-	-	-	-	-	18				
Naproxen	4.8	-	-	-	-	-	-	-	-	-	24	35	54	95	103
Paracetamol	3.7	-	-	-	-	-	-	-	-	-	19	-	-	-	-
Phenazone	2.0	-	28	-	-	-	-	-	-	-	10	567	614	468	452
Caffeine	4.3	-	303	6.3	9.4	28	4.8	26	-	10	22	1895	2002	2525	3062
Paraxanthine	3.2	-	64	-	3.4	8.0	-	11	-	4.3	16	1383	1380	2247	2306
Theobromine	5.1	-	77	5.5	9.5	18	-	15	-	10	26	1796	1882	3132	3212
Theophylline	3.4	-	12	-	-	-	-	-	-	-	17	468	489	447	582
1-Methylxanthine	21	-	-	-	-	-	-	-	-	-	105	2380	2452	4901	5381
3-Methylxanthine	28	-	191	-	-	-	-	-	-	-	140	5888	6379	10413	10856
Atenolol	3.5	-	-	-	-	-	-	-	-	-	18	48	45	49	49
Metoprolol	4.1	-	-	-	-	-	-	-	-	-	21	-	-	-	-
Sotalol	4.8	-	10	-	-	-	-	-	-	-	24	-	-	-	-
Iopromide	18	-	-	-	-	-	-	-	-	-	90	8995	8942	4794	4694
Clarithromycin	7.5	-	-	-	-	-	-	-	-	-	38	-	-	-	-
Erythromycin	4.3	-	-	-	-	-	-	-	-	-	22	-	-	-	-
Roxithromycin	9.5	-	-	-	-	-	-	-	-	-	48	-	-	-	-
Sulfamethoxazole	2.6	-	7.5	7.3	6.3	-	7.2	-	-	3.9	13	301	303	342	328
Trimethoprim	2.5	-	-	-	-	-	-	-	-	-	13	241	248	197	185
Bezafibrate	3.5	-	-	-	-	-	-	-	-	-	18	-	-	-	-
Clofibric acid	3.4	-	-	-	-	-	-	-	-	-	17	-	-	-	-
Gemfibrozil	2.0	-	46	-	-	-	-	-	-	-	10	-	-	19	17
Cetirizine	2.2	-	8.6	-	-	-	-	-	-	-	11	308	327	285	299
Loratadine	2.7	-	-	-	-	-	-	-	-	-	14	-	-	-	-
Carbamazepine	2.2	-	28	-	-	-	-	-	-	-	11	148	137	124	128
Diazepam	1.4	-	3.4	-	-	61	-	-	30	-	7.0	27	30	24	25
Primidone	2.7	-	-	-	3.4	-	2.8	-	-	-	14	39	44	28	23
Tetrazepam	2.5	-	-	-	-	-	-	-	-	-	13	-	-	-	-
Citalopram	3.2	-	-	-	-	-	-	-	-	-	16	83	86	70	72
Fluoxetine	16	-	-	-	-	-	-	-	-	-	80	-	-	-	-
Sertraline	16	-	-	-	-	-	-	-	-	-	80	-	-	-	-
Atrazine	1.4	-	-	-	-	6.8	-	-	-	-	7.0	-	-	-	-
Desethylatrazine	1.7	-	28	20	48	54	44	-	17	36	8.5	-	-	-	-
Desisopropylatrazine	5.6	-	48	72	15	66	34	-	-	43	28	-	-	-	-
Diuron	3.3	-	10	5.6	-	10	7.3	3.3	-	9.7	17	-	-	-	-
Isoproturon	3.0	-	-	-	-	17	-	-	4.3	-	15	-	-	-	-
Mecoprop	1.2	-	-	-	-	15	-	-	5.1	-	6.0	-	-	-	-
Metazachlor	1.8	-	-	-	-	22	-	-	4.7	-	9.0	-	-	-	-
1H-Benzotriazole	4.7	7.8	-	18	53	-	57	11	16	26	24	2152	2222	2056	2163
Tolyltriazole	4.9	10	-	8.7	5.4	-	10	11	12	-	25	4729	4996	4857	4875
Benzoylecgonine	2.3	-	14	-	-	-	-	-	-	-	12	550	588	1274	1274
Pantoprazole	4.8	-	-	-	-	-	-	-	-	-	24	26	34	32	42

Analytes according to Müller et al. 2010

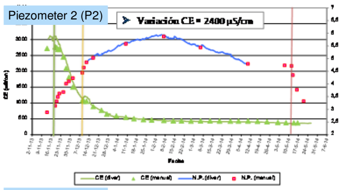
Compound	LOQ [ng/l]	BALSA	S. VICENTE	LA PAZ	RANDERO	RAMBLETA 2	PRIMITIVA	GARROFERA	P2	P1	LOQ [ng/l]	EDAR 1	EDAR 2	EDAR 3	EDAR 4
	SW/GW samples										WWTP samples				
Haloperidol	4.0	-	-	-	-	-	-	-	-	-	20	-	-	-	-
Tamoxifen	6.0	-	-	-	-	-	-	-	-	-	30	-	-	-	-
Cotinine	3.0	7.6	-	-	-	-	-	-	3.2	-	15	-	-	-	-
Terbuthylazine	2.0	75	16	20	-	8.9	-	23	5.9	6.0	10	150	155	122	125
Atenololic acid	4.0	-	25	-	-	-	-	-	-	-	20	-	-	-	-
Desamino-SMX	1.5	-	-	-	-	-	-	-	-	-	7.5	-	-	-	-
4-Nitro-SMX	1.0	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-
4-Acetaminoantipyrine	3.0	-	276	-	-	-	-	-	-	-	15	3018	3386	6095	7132
Valsartan acid	2.0	9.7	127	-	-	-	2.93	-	17	-	10	256	283	306	297
Acesulfame	1.0	105	717	1594	682	15	557	111	163	318	5.0	6910	6758	15476	15736
Cyclamate	1.0	173	38	-	16	-	16	23	61	48	5.0	598	611	1651	1643
Irgarol	1.0	-	-	-	-	-	-	-	-	-	5.0	-	-	-	-
Valsartan	3.0	-	100	-	-	-	-	-	-	-	15	24632	25523	23946	25168
Losartan	2.0	-	-	-	-	-	-	-	-	-	10	1144	1164	1098	1141
Irbesartan	2.0	-	-	-	-	-	-	-	-	-	10	2550	2527	2434	2351

RESULTS

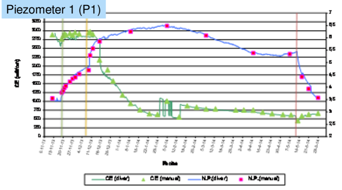
Piezometric level P1 and P2



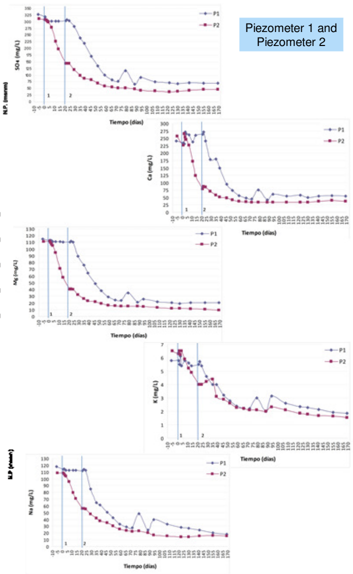
Piezometer 2 (P2)



Piezometer 1 (P1)



Piezometer 1 and Piezometer 2



CONCLUSIONS AND NEXT STEPS

The chosen area is suitable for an experience of artificial recharge due to the poor water quality of the groundwater (seawater intrusion) and the recharge system installed. The artificial recharge test has proved to be efficient (300,000 m³ has been injected) and has provoked intense hydrodynamical and hydrochemical processes. The result of the process has moved into a rise of the piezometric levels (maximum of 3 m) and a decrease the groundwater salinity (EC decreases 2000 µS/cm), obtaining and noticeable improvement of the groundwater quality in this part of the aquifer.

The next step would be to recharge with regenerated water. Some thecnical, economical and administrative problems should be previously solved.

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