

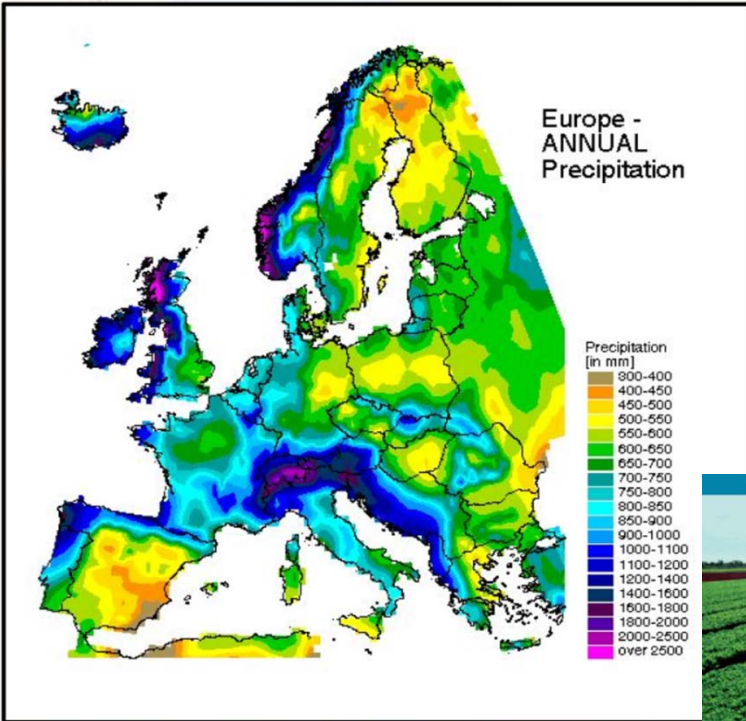
## WORKSHOP LIFE PHOENIX

# WASTEWATER REGENERATION: NEW LEGISLATION, INNOVATIVE TECHNOLOGIES & SUCCESS CASES

## MURCIA'S EXPERIENCE IN THE USE OF RECLAIMED WATER FOR AGRICULTURAL IRRIGATION

4th November 2021, A Coruña

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Average rainfall :  
350 mm/year



**MORE THAN 2,5 MILLION TONS OF  
AGRICULTURAL PRODUCTS ARE PRODUCED  
EVERY YEAR**



## MURCIA REGION

1,5 million inhabitants

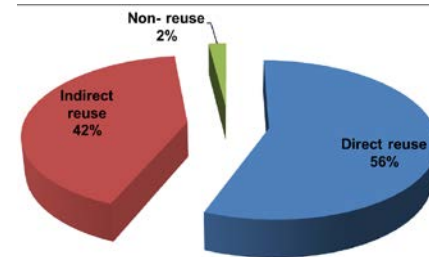
11.313 km<sup>2</sup>

<b>Number of WWTP</b>	<b>99</b>
<b>Population served</b>	<b>99,3 %</b>
<b>% Reuse</b>	<b>98 %</b>

Annual volume of treated water : 109 Hm<sup>3</sup>



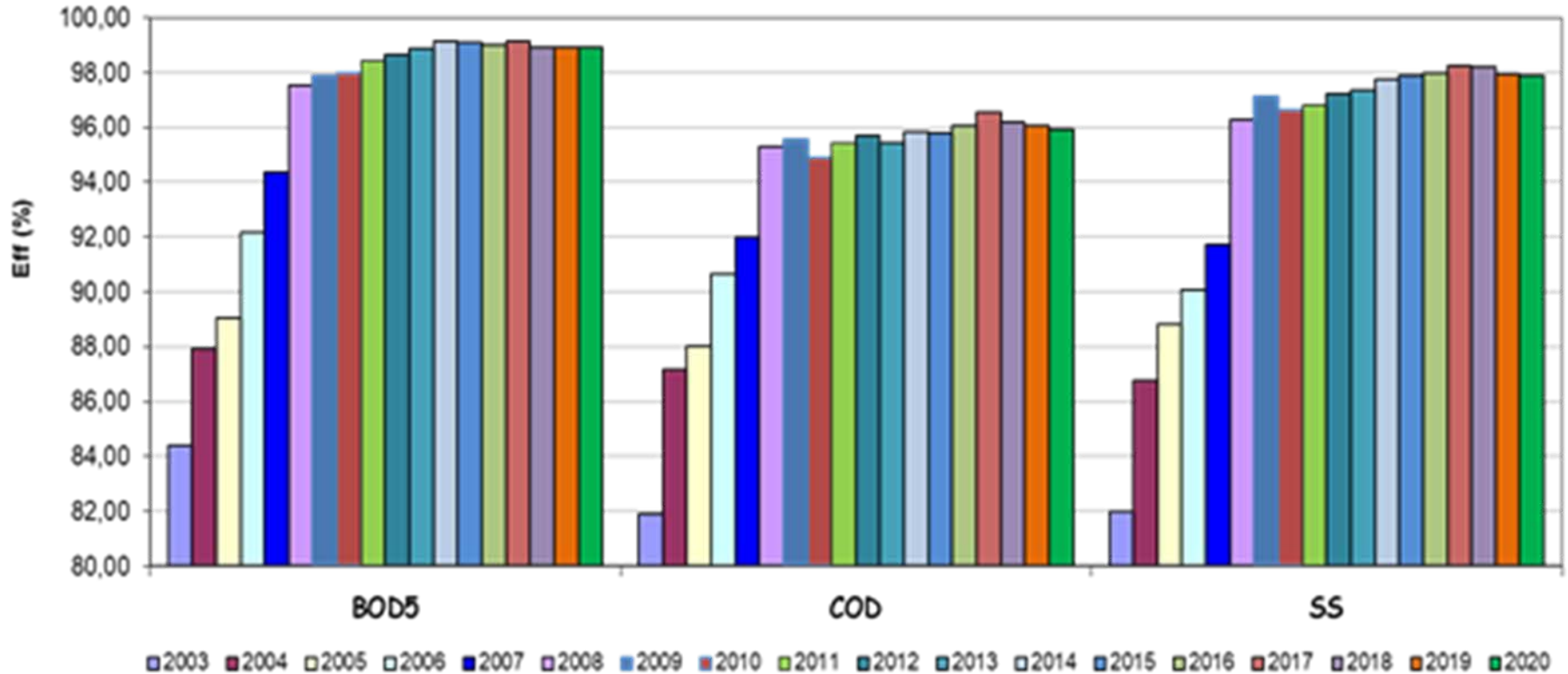
**% OF WATER REUSE = 98 % Direct (56 %) and Indirect (42 %)**



Reclaimed water is other water source in the water pool ( 15 % of the total needs )



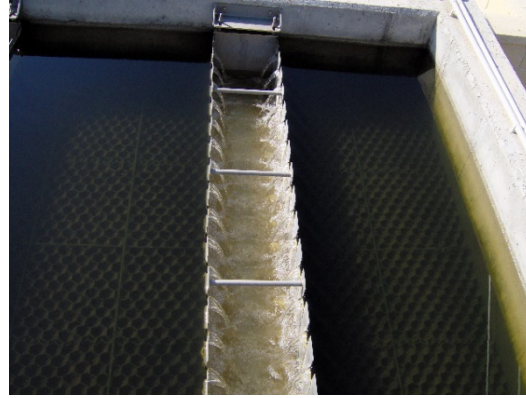
## WWTPs MURCIA REGION EFFICIENCY EVOLUTION IN REMOVAL OF POLLUTION



## Most common tertiary treatment



Physical-Chemical Process



Lamellar settlement



Filtration



UV systems



Chlorine compounds



MBR

## PILLARS OF WATER REUSE

- VIABILITY
- RELIABILITY
- CONFIDENCE ( No problems for People Health and Environment)

TO COMPLY THE REGULATION (UE 741/2020)

## VIABILITY

## New treatments and combination of them



Electrochlorination



Photocatalysis UV in reactor of titanium dioxide



Solar photocatalysis



Ozone



### Other chemicals :

- H<sub>2</sub>O<sub>2</sub> + UV
- Peracetic acid



Ultrafiltration



ozone



## Maximum reliability of the facilities



Very strict and predictive maintenance



Flux cytometer

**EN 15975-2 Guidelines for  
risk and crisis  
management in drinking  
water supply**

Control on-line and fast  
detection of pathogens



## Works related with food safety



**Greenhouse in a WWTP to study microorganisms survival in crops**

## Two large – scale risk assessment ( qualitative and quantitative )



- Different treatments ( Chlorine and UV )
- Different irrigation networks ( with and without storage )
- Different irrigation systems ( Flood, sprinkler, drip )

- Crops of lettuce and spinach
- Measuring indicators and pathogens

# EMERGING COMPOUNDS

## Removal systems

**Analysis of pharmaceuticals compounds in WWTPs from Region of Murcia. Comparison between different technologies.**

LA MM UCAM

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### Abstract

The presence of certain pharmaceuticals in grounds and surface waters is a serious environmental problem as these compounds are biologically active and could affect non-targeted and potentially susceptible species. The occurrence of pharmaceuticals in the environment indicates incomplete removal of these drugs from municipal wastewater treatment plants (WWTP).

The first objective of this proposal is to identify and quantify four representative pharmaceutical compounds in 12 WWTPs throughout the Region of Murcia to know the influence of these compounds in the aquatic ecosystem. The second objective is to evaluate the relative efficiency of different technologies in eliminating these four pharmaceutical compounds.

### Methodology

Influent and effluent wastewater in 12 WWTPs were sampled on a weekly basis during four consecutive weeks. Pooled samples were collected over a period of 24 hours in automated samplers. Compound concentrations were quantitatively determined with HPLC-MS.

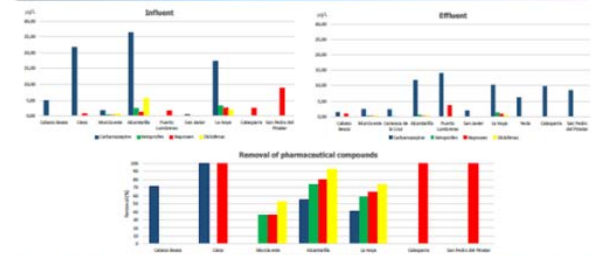
The pharmaceuticals studied were carbamazepine (antiepileptic), diclofenac, levetiracetam and naproxen (NSAIDs). The WWTPs selected have different stages of treatment except some that are the same to improve the comparison. For analysis, we have used the analytic process of organic compounds in aqueous samples. This one is done in several stages.

First, we sampled the average from different WWTPs in different parts of each treatment plant (influent and effluent) to proceed to pre-treatment in the laboratory and leave the samples ready for treatment where enhanced the compound by Solid Phase Extraction (SPE), to be analysed later by high performance liquid chromatography with diode array (HPLC-MS).

WWTP	Treatment
Callosa Bueca	A.S.-C+D
Cieza	A.S.-E.A + S.F + UV + D
Murcia San	A.S.-E.A + D
Caravaca de la Cruz	A.S.-E.A + C + P + S.F + UV
Molina de Segura Norte	A.S.-D.S + L + C + P + S.F + UV
Alcantarilla	A.S.-D.S + L + C + P + S.F + UV
Puerto Realmenor	A.S.-E.A + C + P + S.F + UV
San Javier	A.S.-E.A + L + C + P + S.F + UV
La Hoya Lúcia	A.S.-D.S + L + C + P + S.F + UV
Torre	A.S.-E.A + L + C + P + S.F + UV
Calasparra	A.S.-R.S.S + UV
San Pedro del Pinatar	A.S.-R.S.S + UV

S+Activated carbon	SF+Ultra-fine
UV + Ozonation	L + Ozonation
C+Conventional	F + Flotation
D+Dissolved aeration	R.S.S + Resonance frequency
A.S.+Active Sludge	UV + Ozonation

### Results



### Conclusions

Pharmaceuticals were detected at µg/L levels using the HPLC-MS method in influent and effluent samples from 9 of the 12 WWTPs sampled.

Approx. effluence rates between 40% and 100% and did not appear to be related to the treatment technology but we can say that the type of treatment of La Hoya and Alcantarilla appears better than the rest. However, levetiracetam and diclofenac from the WWTP of Murcia. Also we can observe that treatment of Callosa Bueca (Cartridge) removes better the carbamazepine than La Hoya and Alcantarilla.

Further sampling and analysis using LC-MS will be performed in order to gain a more complete data set.

### References

Caravaca-López G, Martín J, Santos JL, Aparicio L, Moreno E. An affordable method for the simultaneous determination of the most studied pharmaceutical compounds as wastewater and surface water pollutants. J. Sep. Sci. 32, (2009) 3064-3073.

Gracia-Lux E, Sánchez JM, Semero R, Hernández F. Occurrence and removal of pharmaceuticals in wastewater treatment plants at the Spanish Mediterranean area of Valencia. Chemosphere. 67(2012) 453-462.

Jelic A, Gros M, Grolendica A, Cepedel-Sánchez R, Ventura F, Petrovic M, Benati D. Occurrence, partition and removal of pharmaceuticals in sewage water and sludge during wastewater treatment. Water Res. 2011; 45(2):1185-95.

Removal in WWTP

# IWA WATER REUSE 2019



Ozone



Ozone + US



Filtration with different materials



Membranes



Solar photocatalysis



**Dosage: 13 gr  
 O3/m3**

HORMONAS		Estrona (E1) (ug/l)		
		> 0,05 (ug/l) 1-FPLCAMSAS		
num	fecha	antes O3	tras O3	Rdto (%)
1	06/02/2019	0,00000	0,00000	0,00
2	14/02/2019	0,00000	0,00000	0,00
3	04/03/2019	0,00000	0,00000	0,00
4	21/03/2019	0,00000	0,00000	0,00
5	02/04/2019	0,00000	0,00000	0,00
6	24/04/2019	0,01160	0,00000	100,00
7	22/05/2019	0,00000	0,00000	0,00
8	29/05/2019	0,00000	0,00000	0,00
9	03/06/2019	0,00000	0,00000	0,00
10	10/07/2019	0,00000	0,00000	0,00
11	25/07/2019	0,00000	0,00000	0,00
12	29/07/2019	0,00000	0,00000	0,00
PROMEDIO		0,01160	0,00000	100,00

Tabla-1: Hormonas

ANTIBIÓTICOS		Eritromicina (ug/l)			Ofloxacina (ug/l)			Sulfametoxazol (ug/l)		
		> 0,05 (ug/l) 2-FPLCAMSAS			> 0,05 (ug/l) 2-FPLCAMSAS			> 0,05 (ug/l) 2-FPLCAMSAS		
num	fecha	antes O3	tras O3	Rdto (%)	antes O3	tras O3	Rdto (%)	antes O3	tras O3	Rdto (%)
1	06/02/2019	0,02335	0,00000	100,00	0,07700	0,00000	100,00	0,00000	0,00000	0,00
2	14/02/2019	0,05741	0,00000	100,00	0,00000	0,00000	0,00	0,02377	0,00000	100,00
3	04/03/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
4	21/03/2019	0,00000	0,00000	0,00	0,24900	0,00000	100,00	0,00000	0,00000	0,00
5	02/04/2019	0,00000	0,00000	0,00	0,05740	0,00000	100,00	0,05140	0,00000	100,00
6	24/04/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
7	22/05/2019	0,00000	0,00000	0,00	0,13400	0,00000	100,00	0,39200	0,00000	100,00
8	29/05/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,33200	0,14100	57,53
9	03/06/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,17800	0,11200	37,68
10	10/07/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
11	25/07/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
12	29/07/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,08070	0,00000	100,00
PROMEDIO		0,04038	0,00000	100,00	0,12535	0,00000	100,00	0,17631	0,12656	82,43

Tabla-2: Antibióticos

HERBICIDAS		Duron (ug/l)			Metribuzina (ug/l)			Terbutilazina (ug/l)		
		> 0,05 (ug/l) 3-FPLCAMSAS			> 0,05 (ug/l) 3-FPLCAMSAS			> 0,05 (ug/l) 3-FPLCAMSAS		
num	fecha	antes O3	tras O3	Rdto (%)	antes O3	tras O3	Rdto (%)	antes O3	tras O3	Rdto (%)
1	06/02/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
2	14/02/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,09570	0,00000	100,00
3	04/03/2019	0,06900	0,00000	100,00	0,06190	0,00000	100,00	0,00000	0,00000	0,00
4	21/03/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
5	02/04/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
6	24/04/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
7	22/05/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
8	29/05/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
9	03/06/2019	0,00000	0,01870	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
10	10/07/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
11	25/07/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
12	29/07/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,00000	0,00000	0,00
PROMEDIO		0,06900	0,01870	100,00	0,06190	0,00000	100,00	0,09570	0,00000	100,00

Tabla-3: Herbicidas

FUNGICIDAS		Imazalil (ug/l)			Tebuconazol (ug/l)		
		> 0,05 (ug/l) 3-FPLCAMSAS			> 0,05 (ug/l) 3-FPLCAMSAS		
num	fecha	antes O3	tras O3	Rdto (%)	antes O3	tras O3	Rdto (%)
1	06/02/2019	1,90280	0,00000	100,00	0,65830	0,00000	100,00
2	14/02/2019	1,55170	0,00000	100,00	0,90480	0,00000	100,00
3	04/03/2019	3,08000	0,00000	100,00	0,51300	0,00000	100,00
4	21/03/2019	3,25000	0,00000	100,00	0,23800	0,00000	100,00
5	02/04/2019	1,94000	0,00000	100,00	0,31100	0,00000	100,00
6	24/04/2019	0,85700	0,00000	100,00	0,08770	0,00000	100,00
7	22/05/2019	1,69000	0,00000	100,00	0,00000	0,00000	0,00
8	29/05/2019	3,05000	0,00000	100,00	0,06210	0,00000	100,00
9	03/06/2019	1,77000	0,05060	97,14	0,05300	0,00000	100,00
10	10/07/2019	3,14000	0,00000	100,00	0,00000	0,00000	0,00
11	25/07/2019	1,21000	0,00000	100,00	0,00000	0,00000	0,00
12	29/07/2019	1,03000	0,00000	100,00	0,00000	0,00000	0,00
PROMEDIO		2,03929	0,05060	99,76	0,35349	0,00000	100,00

Tabla-4: Fungicidas

PESTICIDAS		Dimetoato (ug/l)		
		> 0,05 (ug/l) 3-FPLCAMSAS		
num	fecha	antes O3	tras O3	Rdto (%)
1	06/02/2019	0,00000	0,00000	0,00
2	14/02/2019	0,00000	0,00000	0,00
3	04/03/2019	0,06460	0,00000	100,00
4	21/03/2019	0,00000	0,00000	0,00
5	02/04/2019	0,39200	0,00000	100,00
6	24/04/2019	0,00000	0,00000	0,00
7	22/05/2019	0,00000	0,00000	0,00
8	29/05/2019	0,00000	0,00000	0,00
9	03/06/2019	0,00000	0,00000	0,00
10	10/07/2019	0,00000	0,00000	0,00
11	25/07/2019	0,30000	0,00000	100,00
12	29/07/2019	0,00510	0,00000	100,00
PROMEDIO		0,20543	0,00000	100,00

Tabla-5: Pesticidas

ANTIDEPRESIVOS		Carbamazepina (ug/l)		
		> 0,05 (ug/l) 2-FPLCAMSAS		
num	fecha	antes O3	tras O3	Rdto (%)
1	06/02/2019	0,16520	0,00000	100,00
2	14/02/2019	0,18904	0,00000	100,00
3	04/03/2019	0,16500	0,00000	100,00
4	21/03/2019	0,20700	0,00000	100,00
5	02/04/2019	0,16500	0,00000	100,00
6	24/04/2019	0,05600	0,00000	100,00
7	22/05/2019	0,13100	0,00000	100,00
8	29/05/2019	0,13800	0,00000	100,00
9	03/06/2019	0,15900	0,00000	100,00
10	10/07/2019	0,32800	0,00000	100,00
11	25/07/2019	0,13600	0,00000	100,00
12	29/07/2019	0,13500	0,00000	100,00
PROMEDIO		0,16477	0,00000	100,00

Tabla-6: Antidepresivos

ANTIINFLAMATORIOS		Ibuprofeno (ug/l)			Ketoprofeno (ug/l)			Diclofenac (ug/l)		
		> 0,05 (ug/l) 1-FPLCAMSAS			> 0,05 (ug/l) 1-FPLCAMSAS			> 0,01 (ug/l) 2-FPLCAMSAS		
num	fecha	antes O3	tras O3	Rdto (%)	antes O3	tras O3	Rdto (%)	antes O3	tras O3	Rdto (%)
1	06/02/2019	0,28877	0,00000	100,00	0,22971	0,00000	100,00	0,07317	0,00000	100,00
2	14/02/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,05538	0,00000	100,00
3	04/03/2019	0,77900	0,00000	100,00	0,41500	0,00000	100,00	0,66100	0,00000	100,00
4	21/03/2019	0,00000	0,00000	0,00	0,09970	0,00000	100,00	0,77000	0,00000	100,00
5	02/04/2019	0,00000	0,00000	0,00	0,10200	0,00000	100,00	0,66900	0,00000	100,00
6	24/04/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,29900	0,00000	100,00
7	22/05/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,58000	0,00000	100,00
8	29/05/2019	0,10800	0,00000	100,00	0,29600	0,00000	100,00	0,88700	0,00000	100,00
9	03/06/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,74500	0,01490	98,00
10	10/07/2019	0,54100	0,12900	76,16	0,00000	0,11600	0,00	0,56300	0,00000	100,00
11	25/07/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,38200	0,00000	100,00
12	29/07/2019	0,00000	0,00000	0,00	0,00000	0,00000	0,00	0,48000	0,00000	100,00
PROMEDIO		0,42919	0,12900	94,04	0,22848	0,11600	100,00	0,51205	0,01490	99,83

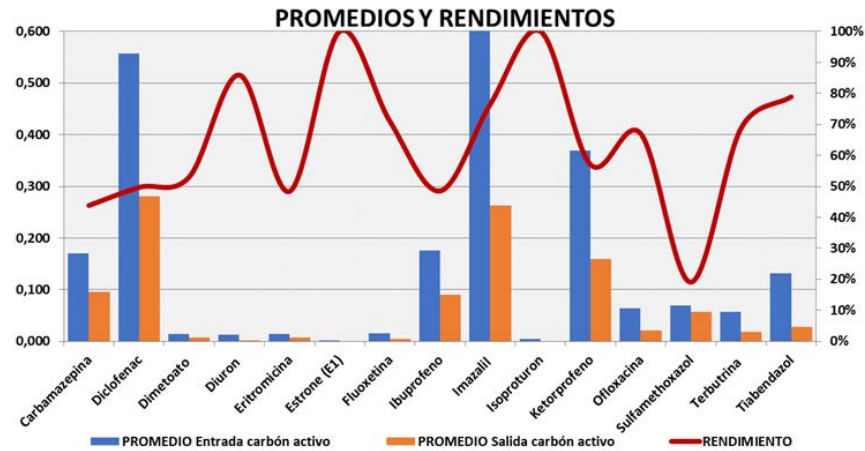
Tabla-7: Antiinflamatorios



Electricity consumption: 0,55 KWh/m3

OPEX: (5 c€/m3)

CAPEX: (150 €/m3/día (tamaño pequeño y mediano))



OPEX: ( 3,5 c€/m3)

Replacement: ( Every 20 weeks)

Active Carbon

## CURRENT ESAMUR RESEARCH LINES ON WATER REUSE

- Effects of emerging compounds
- Anti-microbial resistance
- Microplastics



