WASTEWATER TREATMENT AND WATER REUSE IN MURCIA

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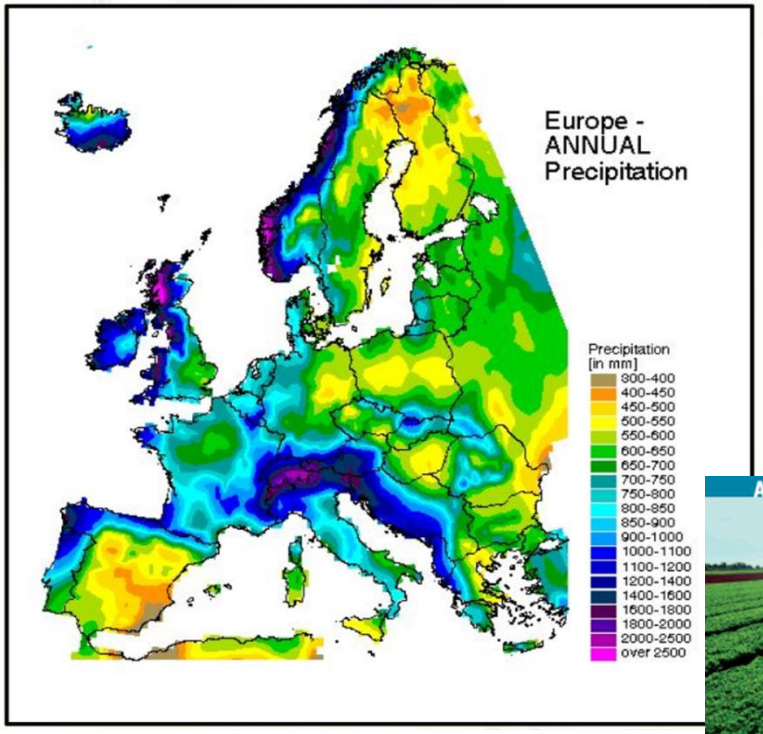
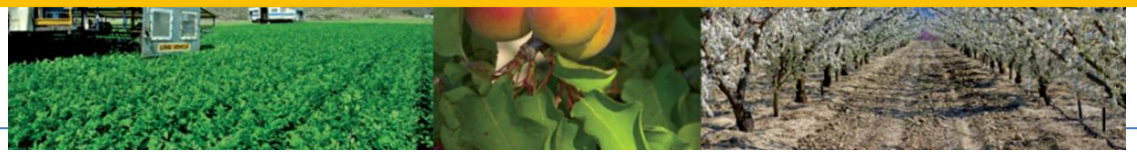
Technical Director ESAMUR

Murcia, 23rd of April, 2024



Average rainfall : 350 mm/year

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



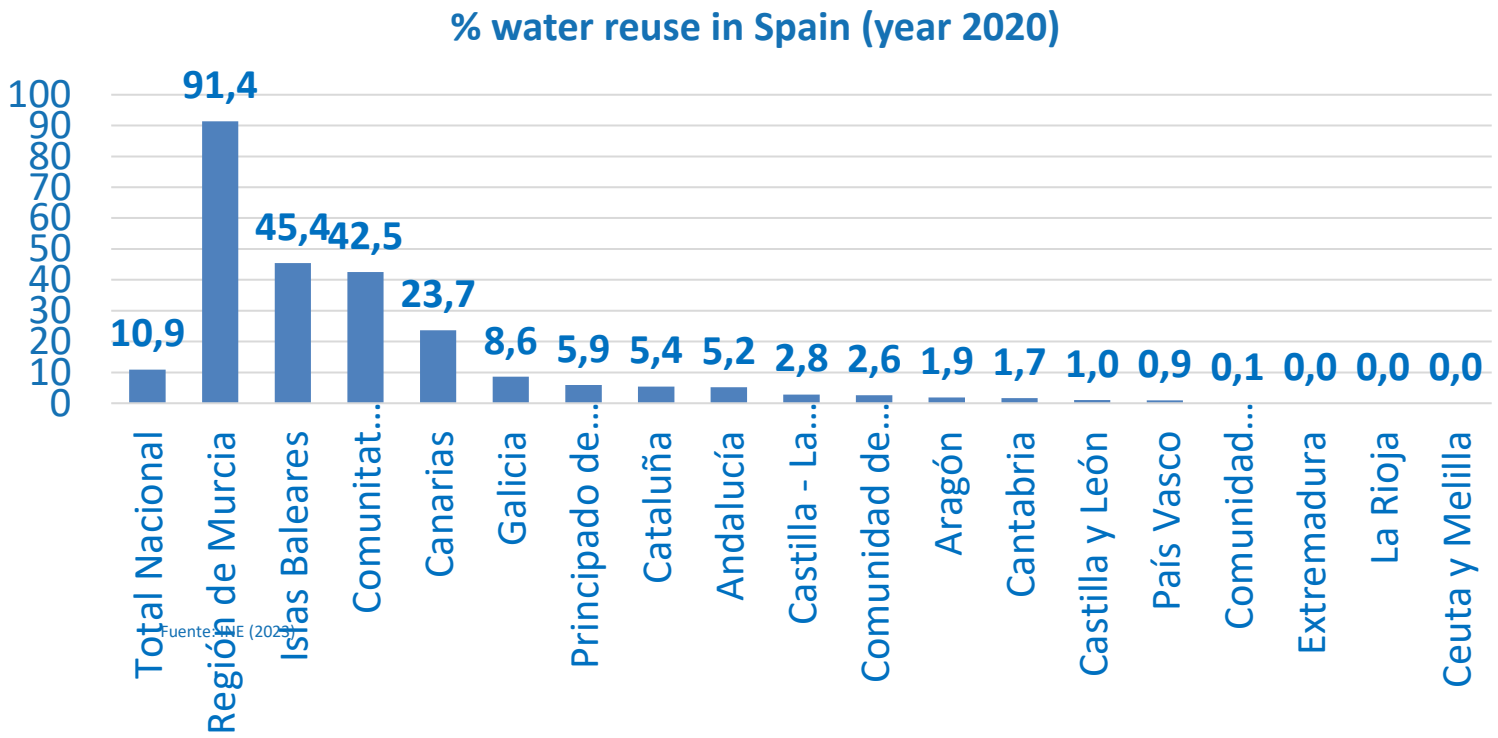
MURCIA REGION

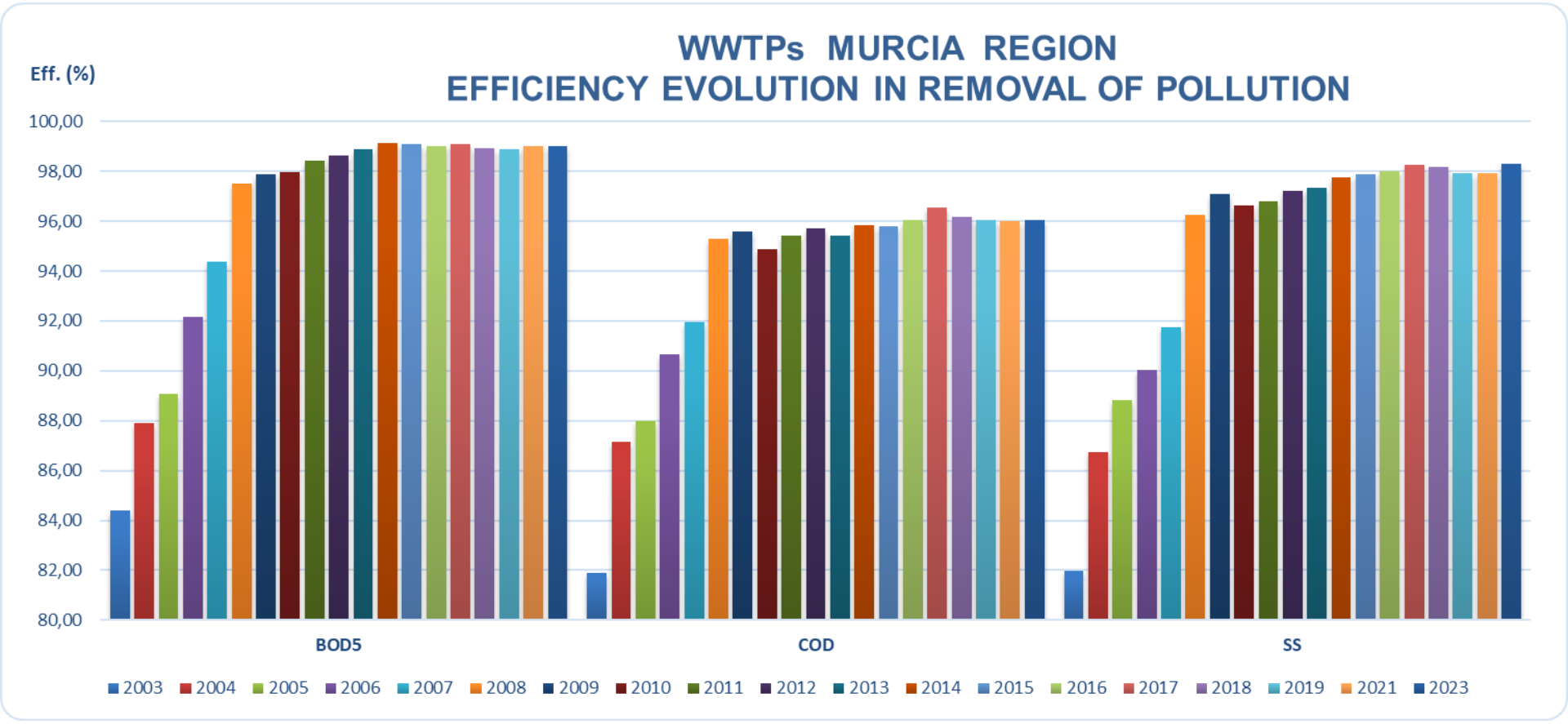
1,5 million inhabitants

11.313 km2

Number of WWTP	100
Population served	**99,3 %**
% Reuse	**98 %**

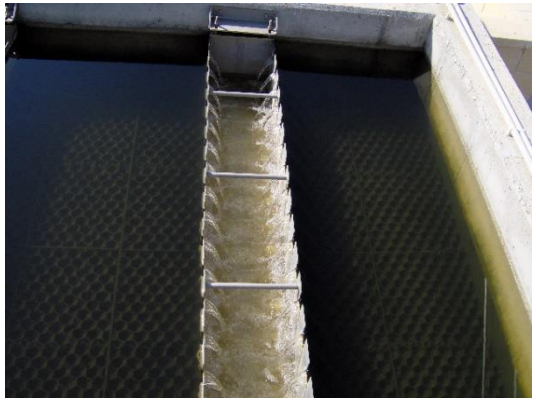
Annual volume of treated water : 114 Hm3


% water reuse in Spain (year 2020)
100
90
80
70
60
50
40
30
20
10
0
10,9
91,4
45,4
42,5
23,7
8,6
5,9
5,4
5,2
2,8
2,6
1,9
1,7
1,0
0,9
0,1
0,0
0,0
0,0
Total Nacional
Región de Murcia
Islas Baleares
Comunitat...
Canarias
Galicia
Principado de...
Cataluña
Andalucía
Castilla - La...
Comunidad de...
Aragón
Cantabria
Castilla y León
País Vasco
Comunidad...
Extremadura
La Rioja
Ceuta y Melilla
Fuente: INE (2023)


WWTPs MURCIA REGION
EFFICIENCY EVOLUTION IN REMOVAL OF POLLUTION
Eff. (%)
100,00
98,00
96,00
94,00
92,00
90,00
88,00
86,00
84,00
82,00
80,00
BOD5
COD
SS
2003 2004 2005 2006 2007 2008 2009 2010 2011 2012 2013 2014 2015 2016 2017 2018 2019 2021 2023

Most common tertiary treatment

Physical-Chemical Process



Lamellar settlement

Filtration

UV systems

Chlorine compounds

MBR

Nuevo reglamento europeo de reutilización

L 177/32 EN Official Journal of the European Union 5.6.2020

REGULATION (EU) 2020/741 OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 25 May 2020

on minimum requirements for water reuse

(Text with EEA relevance)

Article 2

Scope

1. This Regulation applies whenever treated urban waste water is reused, in accordance with Article 12(1) of Directive 91/271/EEC, for agricultural irrigation as specified in Section 1 of Annex I to this Regulation.

2. A Member State may decide that it is not appropriate to reuse water for agricultural irrigation in one or more of its river basin districts or parts thereof, taking into account the following criteria:

(a) the geographic and climatic conditions of the district or parts thereof;

(b) the pressures on and the status of other water resources, including the quantitative status of groundwater bodies as referred to in Directive 2000/60/EC;

(c) the pressures on and the status of the surface water bodies in which treated urban waste water is discharged;

(d) the environmental and resource costs of reclaimed water and of other water resources.

Any decision taken pursuant to the first subparagraph shall be duly justified on the basis of the criteria referred to in that subparagraph and submitted to the Commission. It shall be reviewed as necessary, in particular taking into account climate change projections and national climate change adaptation strategies, and at least every six years taking into account river basin management plans established pursuant to Directive 2000/60/EC.

3 years to come into force

Table 1 Classes of reclaimed water quality and allowed agricultural use and irrigation method

Minimum reclaimed water quality class	Crop category*	Irrigation method
A	All food crops, including root crops, consumed raw and food crops where the edible part is in direct contact with reclaimed water	All irrigation methods
B	Food crops consumed raw where the edible part is produced above ground and is not in direct contact with reclaimed water, processed food crops and non-food crops including crops to feed milk- or meat-producing animals	All irrigation methods
C	Food crops consumed raw where the edible part is produced above ground and is not in direct contact with reclaimed water, processed food crops and non-food crops including crops to feed milk- or meat-producing animals	Drip irrigation** or other irrigation method that avoids direct contact with the edible part of the crop
D	Industrial, energy, and seeded crops	All irrigation methods***

Table 2 Reclaimed water quality requirements for agricultural irrigation

Reclaimedwater quality class	Indicative technology target	Quality requirements				
		E. coli (number/100 ml)	BOD_5 (mg/l)	TSS (mg/l)g/l)	Turbidity (NTU)U)	Other
A	Secondary treatment, filtration, and disinfection	≤10	≤10	≤10	≤5	*Legionella* spp.: <1,000 cfu/l where there is risk of aerosolization
B	Secondary treatment, and disinfection	≤100	According to Council Directive 91/271/EEC[1] ((Annex I, Table 1)	According to Directive 91/271/EEC ((Annex I, Table 1)	-	Intestinal nematodes (helminth eggs): ≤1 egg/l for irrigation of pastures or forage
C	Secondary treatment, and disinfection	≤1,000			-	
D	Secondary treatment, and disinfection	≤10,000			-	

[1] Council Directive 91/271/EEC of 21 May 1991 concerning urban waste water treatment (OJ L 135, 30.5.1991, p. 40).

Table 4 Validation monitoring of reclaimed water for agricultural irrigation

Reclaimed water quality class	Indicator microorganisms (*)	Performance targets for the treatment chain (log_{10} reduction)
A	*E. coli*	≥ 5.0
	Total coliphages/ F-specific coliphages/somatic coliphages/coliphages(**)	≥ 6.0
	Clostridium perfringens spores/spore-forming sulfate-reducing bacteria(***)	≥ 4.0 (in case of *Clostridium perfringens* spores) ≥ 5.0 (in case of spore-forming sulfate-reducing bacteria)

(*) The reference pathogens *Campylobacter*, Rotavirus and *Cryptosporidium* can also be used for validation monitoring purposes instead of the proposed indicator microorganisms. The following log_{10} reduction performance targets should then apply: *Campylobacter* (≥ 5.0), Rotavirus (≥ 6.0) and *Cryptosporidium* (≥ 5.0).

(**) Total coliphages is selected as the most appropriate viral indicator. However, if analysis of total coliphages is not feasible, at least one of them (F-specific or somatic coliphages) has to be analyzed.

(***) *Clostridium perfringens* spores is selected as the most appropriate protozoa indicator. However sporeforming sulfate-reducing bacteria is an alternative if the concentration of *Clostridium perfringens* spores does not allow to validate the requested log10 removal.

Also risk analysis is required

- **Regulations and ítems to check:**

The following requirements and obligations shall, as a minimum, be taken into account in the risk assessment:

(e) the requirement to reduce and prevent water pollution from nitrates in accordance with Council Directive 91/676/EEC[2];

(f) the obligation for drinking water protected areas to meet the requirements of Council Directive 98/83/EC[3];

(g) the requirement to meet the environmental objectives set out in Directive 2000/60/EC of the European Parliament and of the Council[4];

(h) the requirement to prevent groundwater pollution in accordance with Directive 2006/118/EC of the European Parliament and of the Council[5];

(i) the requirement to meet the environmental quality standards for priority substances and certain other pollutants laid down in Directive 2008/105/EC of the European Parliament and of the Council[6];

(j) the requirement to meet the environmental quality standards for pollutants of national concern (i.e. river basin specific pollutants) laid down in Directive 2000/60/EC;

(k) the requirement to meet the bathing water quality standards laid down in Directive 2006/7/EC of the European Parliament and of the Council[7];

(l) the requirements concerning the protection of the environment, and in particular of the soil, when sewage sludge is used in agriculture under Council Directive 86/278/EEC[8];

(m) the requirements regarding hygiene of foodstuffs as laid down in Regulation (EC) No 852/2004 of the European Parliament and of the Council[9] and the guidance provided in the Commission Notice on guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene;

(n) the requirements for feed hygiene laid down in Regulation (EC) No 183/2005 of the European Parliament and the Council[10].

(o) the requirement to comply with the relevant microbiological criteria set out in Commission Regulation (EC) No 2073/2005[11];

(p) the requirements regarding maximum levels for certain contaminants in foodstuffs set out in Commission Regulation (EC) No 1881/2006[12];

(q) the requirements regarding maximum residue levels of pesticides in or on food and feed set out in Regulation (EC) No 396/2005 of the European Parliament and of the Council[13];

(r) the requirements regarding animal health in Regulation (EC) 1069/2009 of the European Parliament and of the Council[14] and Commission Regulation (EC) 142/2011 of the European Parliament and of the Council[15].

5. When necessary and appropriate to ensure sufficient protection of the environment and human health, **specify requirements for water quality and monitoring that are additional to and/or stricter than those specified in Annex I**.

Depending on the outcome of the risk assessment referred to in point 4, such additional requirements may in particular concern:

(a) heavy metals;

(b) pesticides;

(c) disinfection by-products;

(d) pharmaceuticals;

(e) other substances of emerging concern;

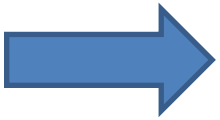
(f) anti-microbial resistance.

New Wastewater Treatment Directive, approved by European Parliament on 10th of April

Article 15

Water reuse and discharges of urban wastewater

Member States shall systematically promote the reuse of treated wastewater from all urban wastewater treatment plants ***where appropriate, especially in water-stressed areas, and for all appropriate purposes. The potential for the reuse of treated wastewater shall be assessed taking into account the river basin management plans established under the Water Framework Directive 2000/60/EC and Member States' decisions under Article 2(2) of Regulation (EU) 2020/741. Member States shall ensure that when treated wastewater is reused or if the reuse is planned, it does not endanger the ecological flow in the receiving waters and there is no adverse effect for the environment and human health***. Where treated wastewater is reused for agricultural irrigation, it shall comply with the requirements established under Regulation (EU) 2020/741. ***When strategies on water resilience at Member States level are available, measures on promoting the reuse of treated wastewater and on the actual reuse shall be considered in these strategies***.

WATER REUSE  TECHNOLOGY AND RESPONSABILITY

OUR CURRENT CHALLENGES IN WATER REUSE

- To improve every day the treatments reliability , efficiency and harmlessness.
- To advance in food health with affordable treatments
- To study new threats in advance
- To fight with the irrational fear

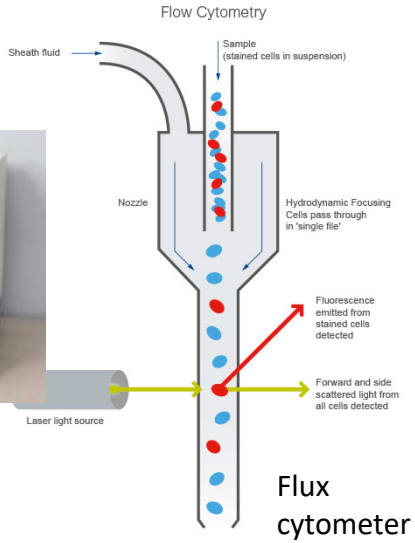
Maximum reliability of the facilities

Very strict maintenance

Continuos detection of possible troubles

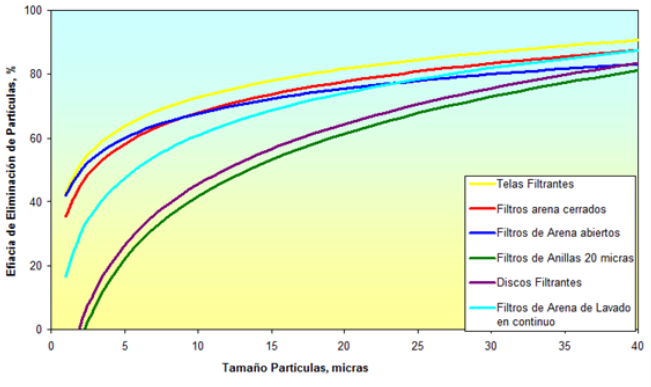
On-line sensors of Chlorine and Redox with alarms

Fast detection of pathogens



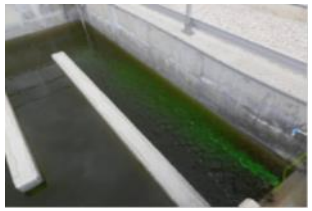
Flux cytometer

Maximum knowledge of the facilities



Size particles studies

Tracers



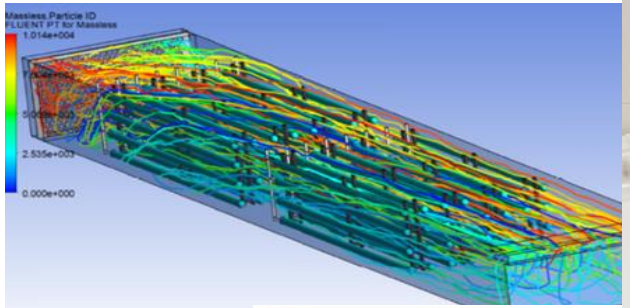
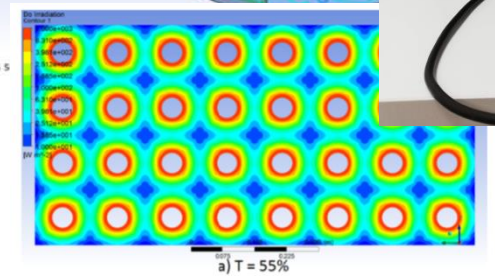
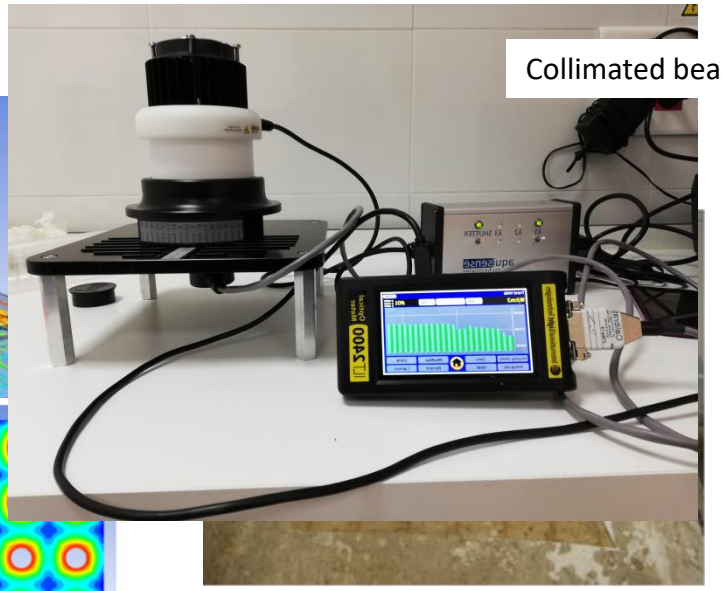


Figura 21. Trayectorias de 100 partículas s



CFD studies

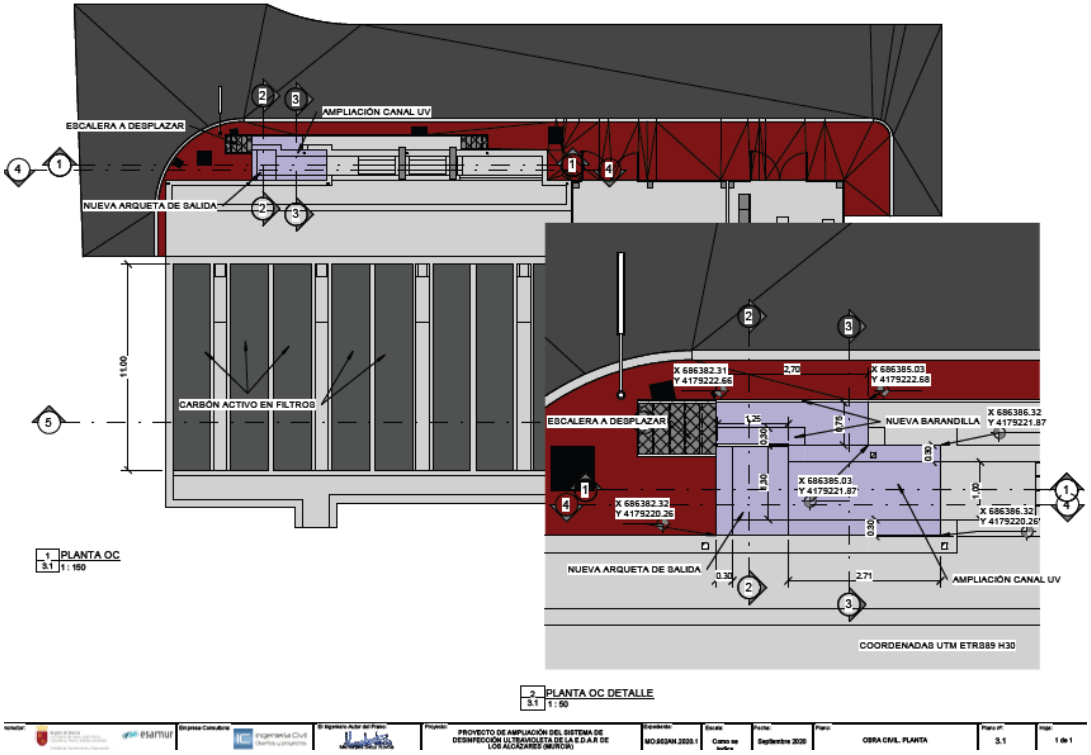


Collimated beam assays

Membrane studies

New treatments

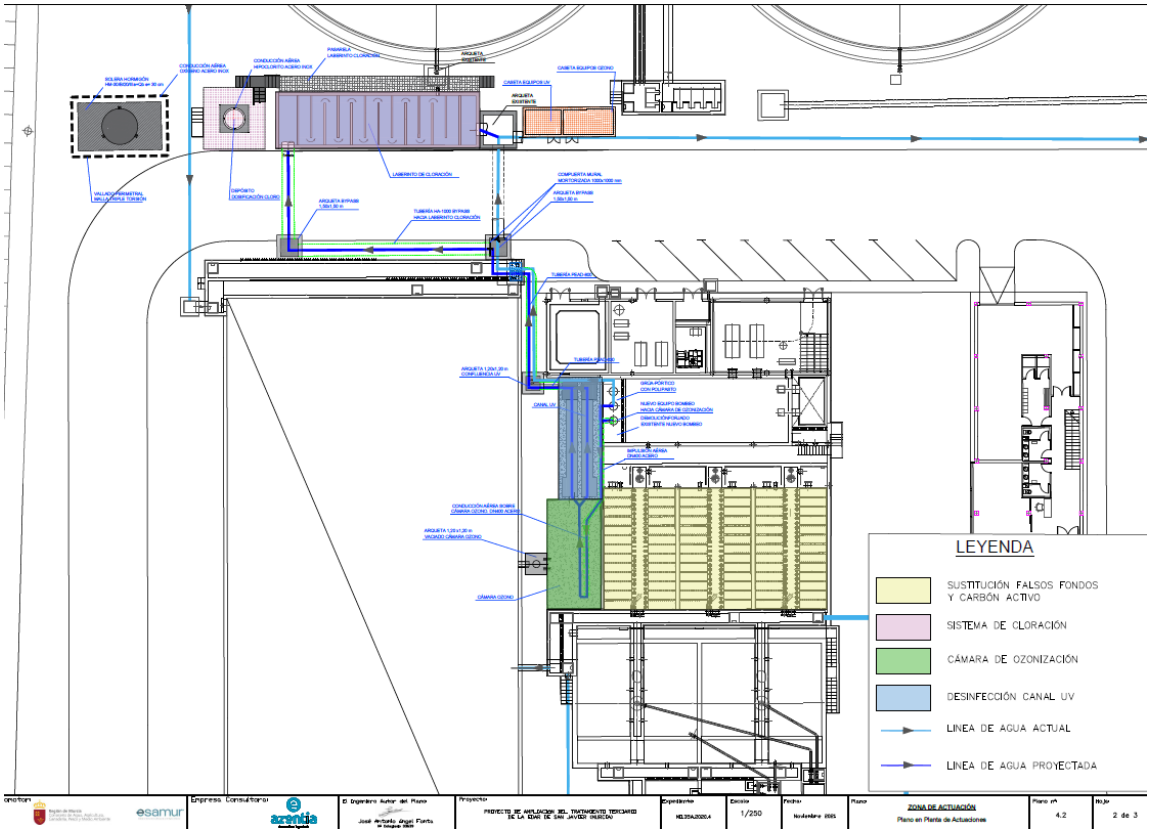
Upgrading of facilities



Upgrading Los Alcázares WWTP:

- Active carbon in sand filters
- Increase the number of UV lamps
- Upgrading cost : 539. 304 €

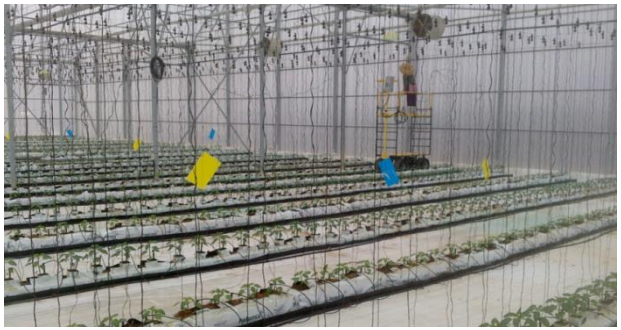
Upgrading of facilities



Upgrading San Javier WWTP:

- Active carbon in sand filters
- Ozone
- Increase the number of UV lamps
- Labyrinth and dosaje of sodium hypochlorite
- Upgrading cost: 2.047.248 €

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

Is water reuse safe ?

2017/C 163/01 Commission notice on guidance document on addressing microbiological risks in fresh fruits and vegetables at primary production through good hygiene

Intended use of the water	Source of water (*)						Indicator of faecal contamination: *E. coli* (*)
	Untreated surface water/open water channels (*)	Untreated ground water collected from wells (*)	Untreated Rain water	Treated (*) sewage/surface/waste water/water reuse	Disinfected water (*)	Municipal water	
PRE-HARVEST and HARVEST							
Irrigation of FFVs likely to be eaten uncooked (i.e. ready-to-eat FFV) (Irrigation water comes into direct contact with the edible portion of the FFV) Dilution or application of pesticide, fertiliser or agrochemicals and cleaning equipment for ready-to-eat FFV and direct contact.	x	x	▲	•	•	√	100 CFU/100 ml
Irrigation of FFVs likely to be eaten uncooked (i.e. ready-to-eat FFV) (Irrigation water does not come into direct contact with the edible portion of the FFV) Dilution or application of pesticide, fertiliser or agrochemicals and cleaning equipment for ready-to-eat FFV and no direct contact	x	x	▲	•	•	√	1 000 CFU/100 ml (*)
Irrigation of FFVs likely to be eaten cooked (irrigation water comes into direct contact with the edible portion of the FFV). Dilution or application of pesticide, fertiliser or agrochemicals and cleaning equipment used in this FFV direct contact).	▲	▲	•	•	•	√	1 000 CFU/100 ml
Irrigation of FFVs likely to be eaten cooked (irrigation water does not come into direct contact with the edible portion of the FFV). Dilution or application of pesticide, fertiliser or agrochemicals and cleaning equipment used in this FFV (no direct contact)	•	•	√	√	√	√	10 000 CFU/100 ml
POST-HARVEST							
Post-harvest cooling and post-harvest transport for non-ready-to-eat FFVs. Water used for first washing of products in case of ready-to-eat products. Cleaning equipment and surfaces where the products are handled.	x	x	▲	•	•	√	100 CFU/100 ml

23.5.2017 EN Official Journal of the European Union C 163/37

4.3.2006 EN Official Journal of the European Union L 64/37

DIRECTIVE 2006/7/EC OF THE EUROPEAN PARLIAMENT AND OF THE COUNCIL

of 15 February 2006

concerning the management of bathing water quality and repealing Directive 76/160/EEC

L 64/46 EN Official Journal of the European Union 4.3.2006

ANNEX I

For inland waters

	A	B	C	D	E
	Parameter	Excellent quality	Good quality	Sufficient	Reference methods of analysis
1	Intestinal enterococci (cfu/100 ml)	200 (*)	400 (*)	330 (**)	ISO 7899-1 or ISO 7899-2
2	Escherichia coli (cfu/100 ml)	500 (*)	1 000 (*)	900 (**)	ISO 9308-3 or ISO 9308-1

(*) Based upon a 95-percentile evaluation. See Annex II.
(**) Based upon a 90-percentile evaluation. See Annex II.

EMERGING COMPOUNDS

Removal systems

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

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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 (WWTPs).

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 ecosystems. The second objective is to evaluate the relative efficiency of different technologies in eliminating these four pharmaceuticals compounds.

Methodology

Influents and effluents 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-DAD.

The pharmaceuticals studied were carbamazepine (antiepileptic), diclofenac, ketoprofen and naproxen (NSAID). The WWTPs selected have different stages of treatment except some that are the same to improve the comparative. 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 sewage 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 extracted the compound by Solid Phase Extraction (SPE), to be analyzed later by High performance liquid chromatography with diode array (HPLC-DAD).

WWTP	Treatment
Cabezo Beaza	A.S.- C + Cl
Cieza	A.S.-EA + S.F + UV + Cl
Murcia Este	A.S.-EA + Cl
Caravaca de la Cruz	A.S.- EA + C + F + S.F + UV
Molina de Segura-Norte	A.S.-D.S + L + C + F + S.F + UV
Alcantarilla	A.S.-D.S + L + C + F + S.F + UV
Puerto Lumbreras	A.S.- EA + C + F + S.F + UV
San Javier	A.S.-EA + L + C + F + S.F + UV
La Hoya-Lorca	A.S.-D.S + L + C + F + S.F + UV
Yecla	A.S.-EA + L + C + F + S.F + UV
Calasparra	A.S. – M.B.R + UV
San Pedro del Pinatar	A.S. – M.B.R + UV

EA=Extended aeration, Cl= Chlorination, C= Conventional, D.S = Double stage, A.S = Activate Sludge, S.F =Sand filters, L= Lamination, F= Flocculation, M.B.R = Membrane bioreactor, UV = Ultraviolet

Results

Conclusions

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

Removal efficiencies were 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 removes better the naproxen, ketoprofen and diclofenac than the WWTP of Murcia. Also we can observe that treatment of Cabezo Beaza (Cartagena) 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

Camacho-Muñoz D., Martín J., Santos J.L., Aparicio I., Alonso 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-Lor, E., Sancho, J.V., Serrano, R., Hernández, F. Occurrence and removal of pharmaceuticals in wastewater treatment plants at the Spanish mediterranean area of Valencia. Chemosphere, 87(2012) 453-462

Jelic A, Gros M, Ginebreda A, Cespedes-Sánchez R, Ventura F, Petrovic M, Barceló D. Occurrence, partition and removal of pharmaceuticals in sewage water and sludge during wastewater treatment. Water Res. 2011; 45(3):1165-76.

Removal in WWTP

Ozone

Ozone + US

Filtration with different materials

Membranes

Solar photocatalysis

Dosage: 13 gr O3/m3

HORMONAS		Estrona (E1) (ug/l)		
		> 0,005 (ug/l)		
		1 - HPLC/MS-MS		
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)			Sulfamethoxazol (ug/l)		
		> 0,05 (ug/l)			> 0,05 (ug/l)			> 0,05 (ug/l)		
		2 - HPLC/MS			2 - HPLC/MS			2 - HPLC/MS		
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	37,08
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	0,12935	0,00000	100,00	0,17631	0,12650	82,43

Tabla-2: Antibióticos

HERBICIDAS		Diuron (ug/l)			Metribuzina (ug/l)			Terbutilazina (ug/l)		
		> 0,05 (ug/l)			> 0,05 (ug/l)			> 0,05 (ug/l)		
		3 - HPLC/MS-MS			3 - HPLC/MS-MS			3 - HPLC/MS-MS		
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)			Tiabendazol (ug/l)		
		> 0,05 (ug/l)			> 0,05 (ug/l)		
		3 - HPLC/MS-MS			3 - HPLC/MS-MS		
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 - HPLC/MS-MS		
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	0,06510	0,00000	100,00
PROMEDIO		0,20543	0,00000	100,00

Tabla-5: Pesticidas

ANTIDEPRESIVOS		Carbamazepina (ug/l)		
		> 0,05 (ug/l)		
		2 - HPLC/MS		
num	fecha	antes O3	tras O3	Rdto (%)
1	06/02/2019	0,16820	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)			Ketorprofeno (ug/l)			Diclofenac (ug/l)		
		> 0,05 (ug/l)			> 0,05 (ug/l)			> 0,01 (ug/l)		
		1 - HPLC/MS-MS			1 - HPLC/MS-MS			2 - HPLC/MS		
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	0,36200	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

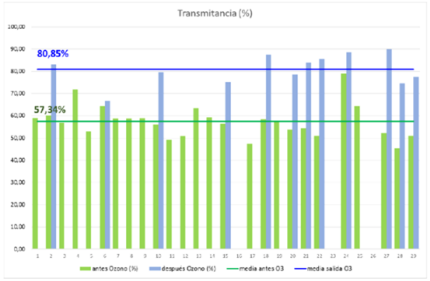
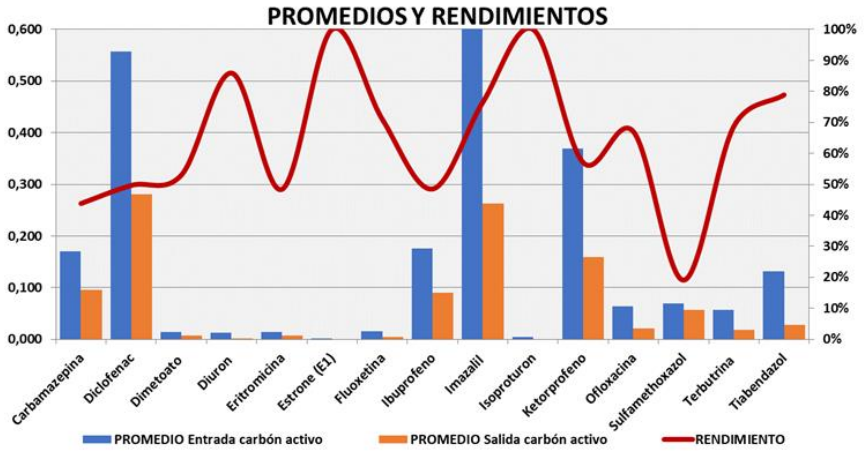


Gráfico-1: Transmitancia

Electricity consumption: 0,55 KWh/m3

OPEX: (5 c€/m3)

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



OPEX: (3,5 c€/m3)

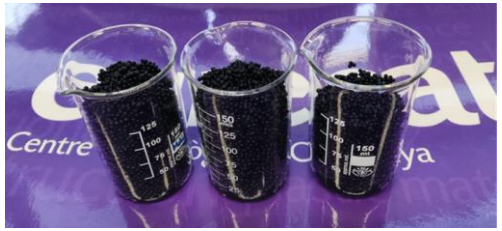
Replacement: (Every 20 weeks)

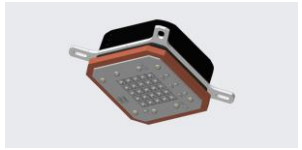
Active Carbon

Advanced technologies

PRISTINE

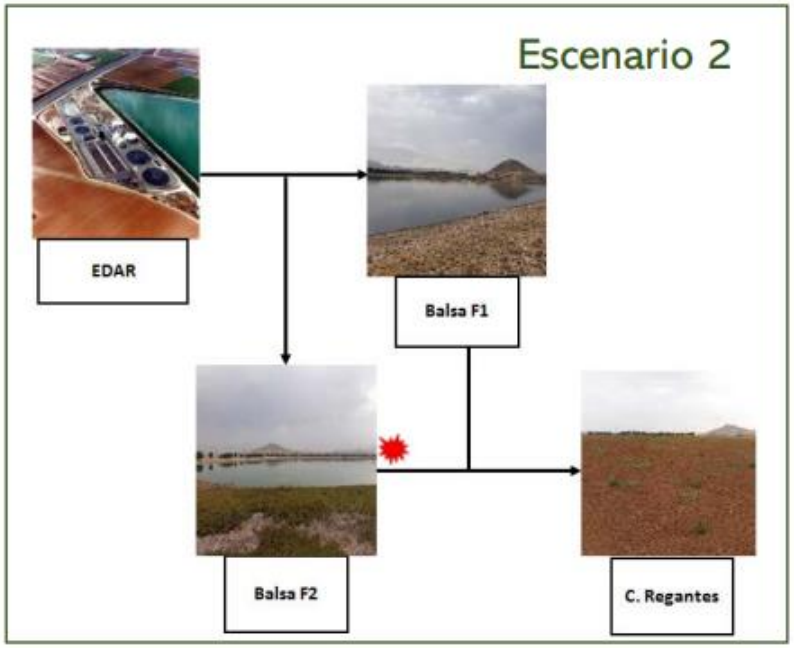
- Encapsulated adsorbents
- Hollow-fibre nanofiltration membranes
- Advanced Oxidation UV-LED reactor
- Artificial intelligence based soft sensors





Emerging compounds

Measured 150 compounds in water, detected 29



Agua clorada de la SAT (media 4 analíticas, 2022-2023) EDAR Cabezo Beaza	µg/L
4-Aminoantipirina	0,171
4-Methylbenzotriazole	0,460
6-methyl-benzotriazole	0,540
Acetamiprid	0,085
Amisulprida	0,026
Azoxistrobin	0,029
Benzotriazole	2,400
Candesartan	1,500
Carbamazepine	0,140
Ciprofloxacino	0,050
Citalopram	0,140
Claritromicina	0,050
Diclofenac	0,195
Diuron	0,046
Gemfibrocil	0,155
Glifosato	2,300
Hydrochlorothiazide	0,700
Imidacloprid	0,097
Irbesartan	1,500
Ketoprofen	0,092
Levamisol	0,083
Lindano	0,004
Metoprolol	0,020
Ofloxacin	0,237
Sulfamethoxazole	0,510
Terbutrina	0,092
Trimethoprim	0,098
Tributilestaño	0,001
Venlafaxin	0,520
SUMA	**12,241**

Emerging compounds in agricultural soil

FASE DE REUTILIZACIÓN

Sustancias de preocupación emergente y subproductos de desinfección

	SUELO AGRÍCOLA				
	µg/Kg		mg/Kg		µg/Kg
	Fitosanitarios	Fármacos	Clorato	Perclorato	THM
MUESTREO 1	Benfluralina 140 Boscalida 1,03 DDE-p.p' 2,17 DDT-o.p' 0,19 DDT-p.p' 0,63 Dimetomorf 4,3 Dodina 0,7 Imidacloprid 0,33 Metafrenona 5,67 Pendimetalina 0,43 Propizamida 163,3 Teflutrina 2,07	Ácido salicílico 1,1 Venlafaxina 0,07	0,34	<0,01	<100
MUESTREO 2	Benfluralina 16 Boscalida 0,83 DDE-p.p' 1,3 DDT-o.p' 0,4 DDT-p.p' 1,03 Dimetomorf 1,1 Metafrenona 2,3 Ortofenilfenol 0,43 Propizamida 2,23 Teflutrina 0,37	Ácido salicílico 3	0,064	<0,01	<100

	SUELO AGRÍCOLA				
	µg/Kg		mg/Kg		µg/Kg
	Fitosanitarios	Fármacos	Clorato	Perclorato	THM
MUESTREO 3	Ametoctradin 0,4 Benfluralina 30,3 Boscalida 1,43 DDE-p.p' 1,67 DDT-o.p' 0,27 Dimetomorf 1,63 Indoxacarb 0,93 Metrafenona 4 Pendimetalina 0,67 Propizamida 1,53 Teflutrina 0,83	Acetaminofen 90,33 Ácido Salicílico 0,9 Venlafaxina 0,13	0,019	<0,01	<100 (Cloroformo 2,8)
	Ametoctradin 0,87 Benfluralina 63,3 Boscalida 1,43 DDT* 6 DDT-o.p' 0,4 Dimetomorf 1,23 Indoxacarb 1,4 Metrafenona 11 Pendimetalina 0,97 Propizamida 3,27 Teflutrina 2,53	Ácido Salicílico 0,97 Claritromicina 0,07 Venlafaxina 0,17	0,016	<0,01	<100 (Cloroformo 3)

*DDT(DDD-p,p'+DDE-p,p'+DDT-o,p'+ DDT-p,p')

Emerging compounds in crops

FASE DE REUTILIZACIÓN

Sustancias de preocupación emergente y subproductos de desinfección

		MATERIAL VEGETAL				
		µg/Kg		mg/Kg		µg/Kg
		Fitosanitarios	Fármacos	Clorato	Perclorato	THM
MUESTREO 1	Cepellón	Benfluralina 17 DDT* 22 DDE-p.p' 20 DDT-p.p' 2 Metrafenona 4,8 Teflutrina 3,9	Ácido Salicílico 5,875	0,31	0,027	<100
	Parte aérea	<LQ	Ácido Salicílico 10 Carbamazepina 0,07 Venlafaxina 0,16	0,036	<0,01	<100
MUESTREO 2	Cepellón 1	Ametoctradin 0,4 Benfluralina 16 Boscalida 2,3 DDE-p.p' 2,87 DDT-o.p' 0,33 Dimetomorf 2,87 Indoxacarb 1,97 Metafrenona 4 Pendimetalina 0,87 Propizamida 5 Teflutrina 0,7	Ácido Salicílico 4,67 Venlafaxina 0,13	0,12	<0,01	<100 (Cloroformo 1,9)
	Parte aérea 1	Benfluralina 4,7 Pendimetalina 3 Propizamida 5,9	Ácido Salicílico 0,64 Carbamazepina 0,1	0,091	<0,01	<100
	Cepellón 2	Ametoctradin 0,33 Benfluralina 25,3 Boscalida 1,7 DDT* 3,67 DDT-o.p' 0,33 Dimetomorf 6 Indoxacarb 3,1 Metafrenona 3,67 Pendimetalina 0,78 Propizamida 4,33 Teflutrina 1,1	Ácido Salicílico 3,33 Venlafaxina 0,11	0,27	<0,01	<100 (Cloroformo 3,5)
	Parte aérea 2	Benfluralina 5,8 Pendimetalina 3,2 Propizamida 8,9	Ácido Salicílico 0,46 Carbamazepina 0,1	0,071	<0,01	<100

Emerging compounds in crops

FASE DE REUTILIZACIÓN

Sustancias de preocupación emergente y subproductos de desinfección

		MATERIAL VEGETAL				
		µg/Kg		mg/Kg		µg/Kg
		Fitosanitarios	Fármacos	Clorato	Perclorato	THM
MUESTREO 1	Parte aérea 1	Cipermetrina 32 Clorantraniliprole 13 Difenoconazol 12 Fluopicolide 300 Fluopyram 64 Metalaxilo 67 Pendimetalina 180 Propamocarb 1290 Propizamida 84	Carbamazepina 1,17 Ibuprofeno 8,83 Naproxeno 1,5	0,21	<0,01	<100
	Parte aérea 2	Clorantraniliprole 17 Cipermetrinas 5,8 Difenoconazol 3,3 Fluopicolide 260 Fluopyram 71 Metalaxilo 38 Pendimetalina 130 Propamocarb 760 Propizamida 77	Ácido salicílico 3,17 Carbamazepina 1,17	0,17	<0,01	<100
MUESTREO 2	Parte aérea 1	Clorantraniliprole 520 Deltametrin 110 Metalaxilo 49 Pendimetalina 86 Propizamida 56 Spirotetramat-keto hydroxy 43	Ácido Salicílico 0,27	0,23	<0,01	<100
	Parte aérea 2	Clorantraniliprole 790 Deltametrin 150 Metalaxilo 98 Pendimetalina 47 Propizamida 71 Spirotetramat 29 Spirotetramat-keto hydroxy 80	Ácido Salicílico 0,23	0,27	<0,01	<100

		MATERIAL VEGETAL				
		µg/Kg		mg/Kg		µg/Kg
		Fitosanitarios	Fármacos	Clorato	Perclorato	THM
MUESTREO 3	Parte aérea 1	Clorantraniliprole 54 Deltametrin 35 Fluopicolide 570 Fluopyram 17 Metalaxil 7,3 Pendimetalina 18 Propamocarb 3100 Propizamida 120 Spirotetramat 57 Spirotetramat-keto hydroxy 18 Tebuconazol 970 Trifloxistrobina 300	Ácido salicílico 0,83 Gemfibrocil 1,17 Venlafaxina 0,67	0,1	<0,01	<100
	Parte aérea 2	Clorantraniliprole 79 Deltametrin 39 Fluopicolide 720 Fluopyram 23 Metalaxil 9,3 Pendimetalina 20 Propamocarb 4000 Propizamida 140 Spirotetramat 66 Spirotetramat-keto hydroxy 12 Tebuconazol 1410 Trifloxistrobina 390	Ácido salicílico 0,84 Gemfibrocil 0,65 Venlafaxina 0,4	0,08	<0,01	<100
MUESTREO 4	Fruto 1	<LQ	Ácido salicílico 16	0,017	<0,01	<100
	Fruto 2	<LQ	Ácido salicílico 17,5	0,017	<0,01	<100

Example to evaluate the toxicity:

ADI: Acceptable daily intake (µg/kg.day)

Daily consumption of Carbamazepine: (0,001175 µg/g x 70 g/day)/70 kg = 0,001175 µg/kg.day

ADI Carbamazepine = 0,34 µg/kg.day

300 kgs of lettuces/day

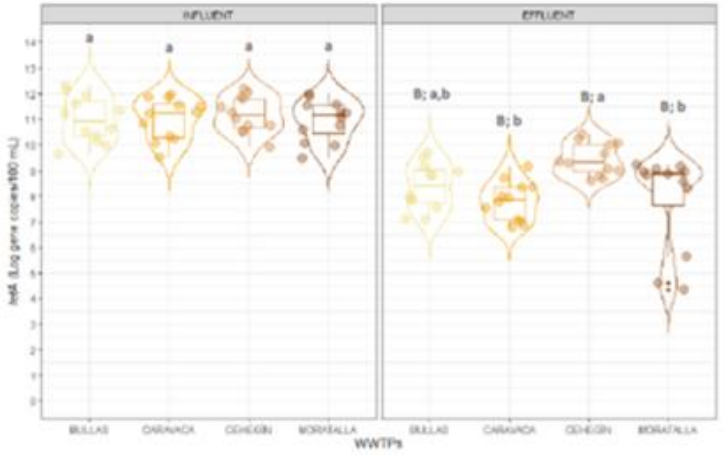
To study new threats in advance:

Antimicrobial resistance

Las depuradoras de aguas residuales urbanas provocan la resistencia de algunas bacterias a los antibióticos

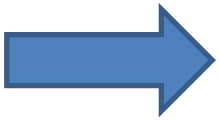
El estudio observó que cerca de algunas EDAR había mayor número de bacterias resistentes a antibióticos

- Un estudio en el río Támesis, de Inglaterra, ha permitido observar poblaciones de bacterias resistentes a los antibióticos, especialmente cerca de depuradoras de aguas residuales, que serían responsables de al menos la mitad del aumento de la resistencia observado
- Las bacterias han desarrollado capacidad para sobrevivir a los antibióticos, y también en entornos ricos en metales



- Analyzing 5 main families of antibiotics
- Studying resistome in Murcia region
- Looking for the removal increase in WWTPs

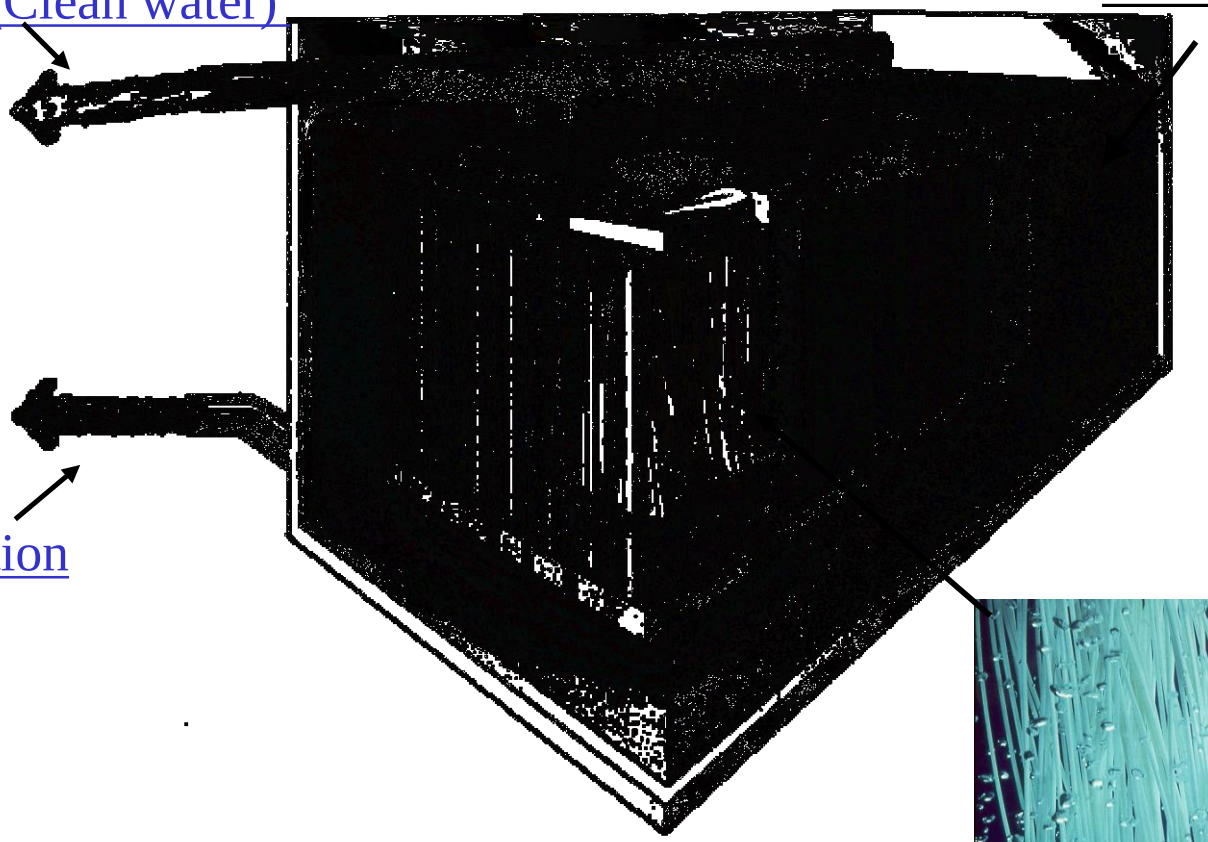
CURRENT SITUATION ON WATER REUSE

- There is a lot of experience on water reuse
- Water reuse is safe with good practices
- New european regulation will increase the safety
- Indirect water reuse is a fact. Is it safer ?
- Precautionary principle  Research  Confidence

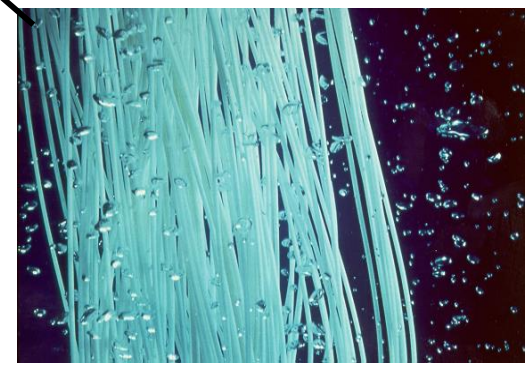
Salinity from the infiltrations in the sewage pipes is the main problem

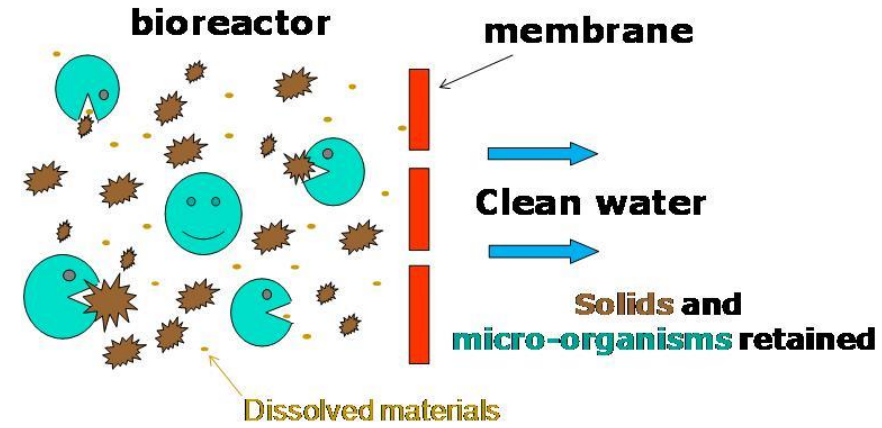
Permeate (Clean water)

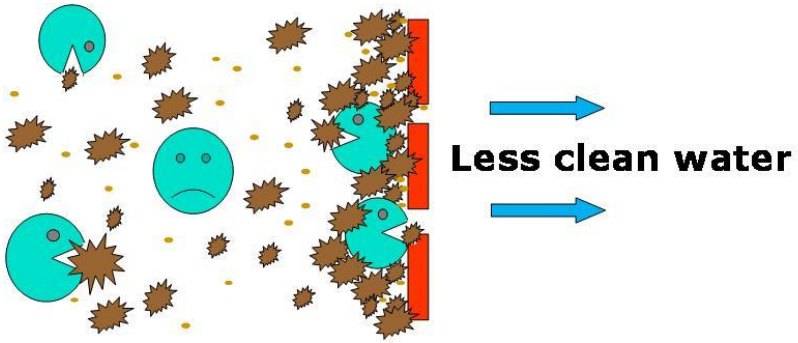
Mixed liquor



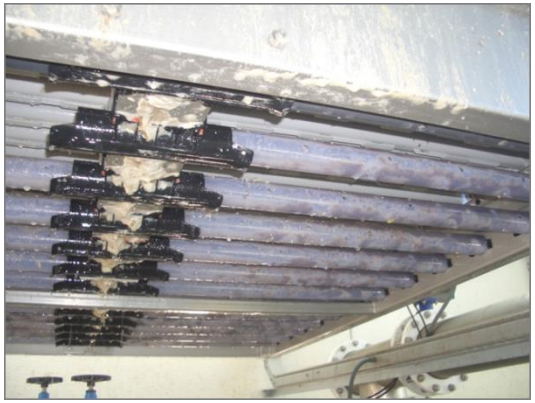
Recirculation

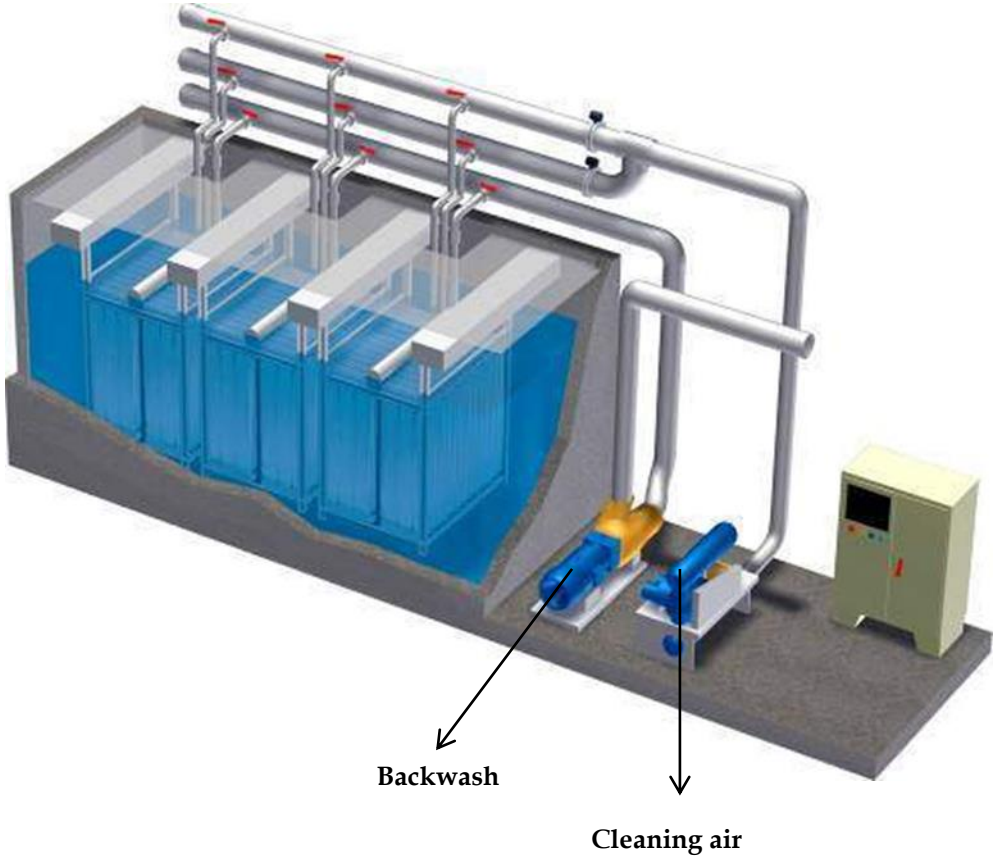



bioreactor
membrane
Clean water
Solids and
micro-organisms retained
Dissolved materials


Less clean water

Sistema limpieza





Thank you very much for your attention