



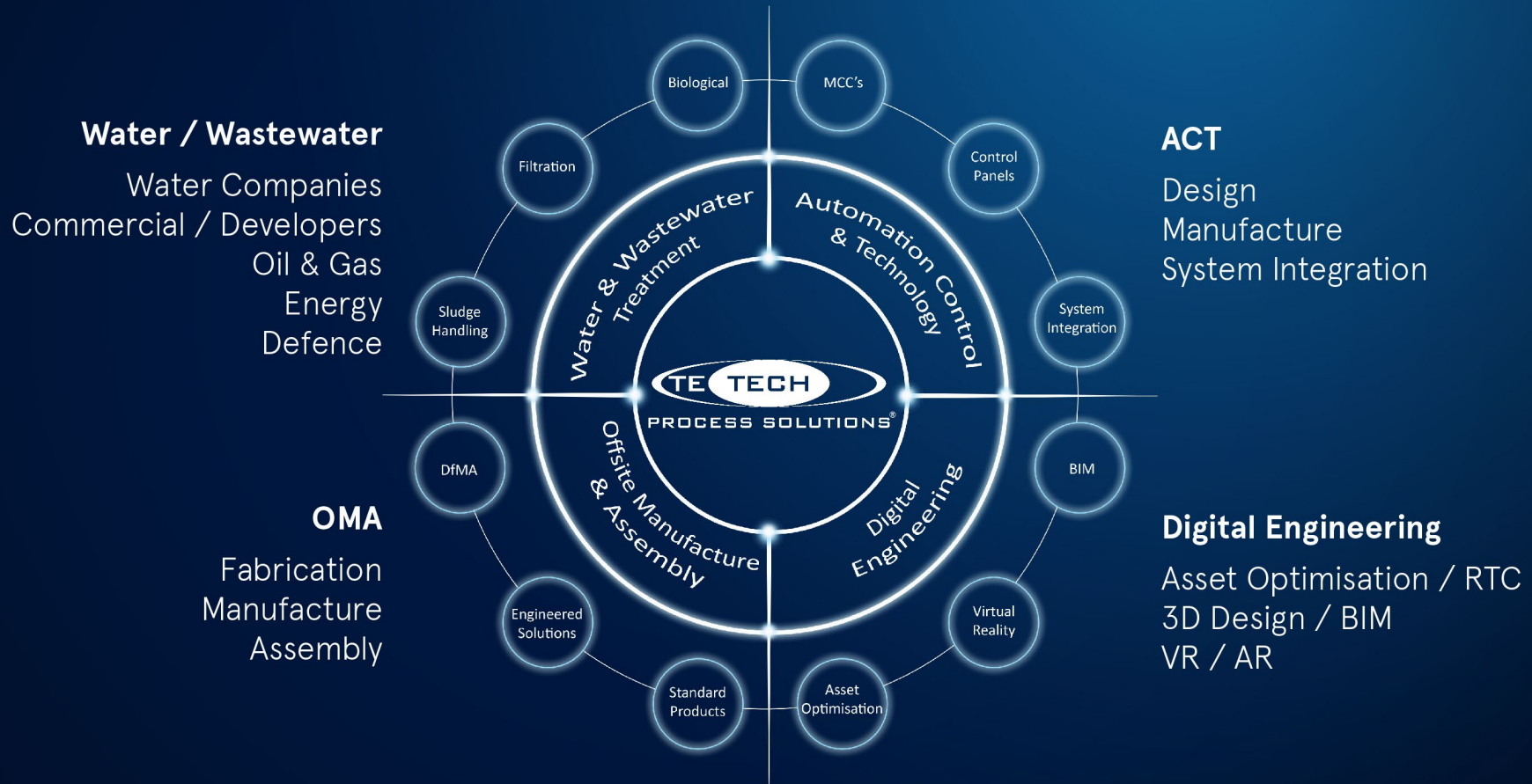
Treatment of emerging contaminants – An evaluation  
of the te-ion™ non-thermal plasma based oxidation  
process

Ben Hazard, Process Engineer

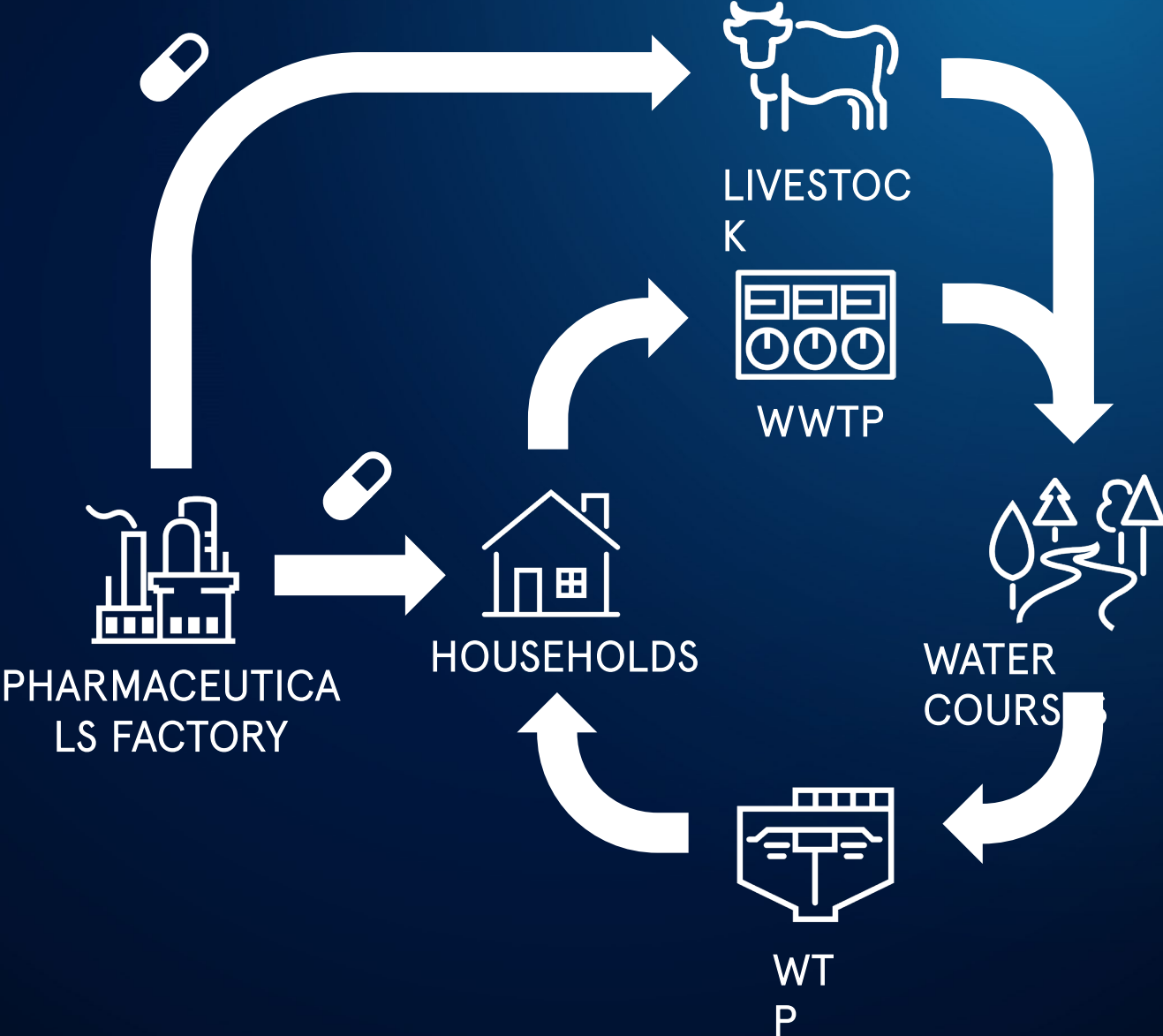
28/03/2023



# Company Overview

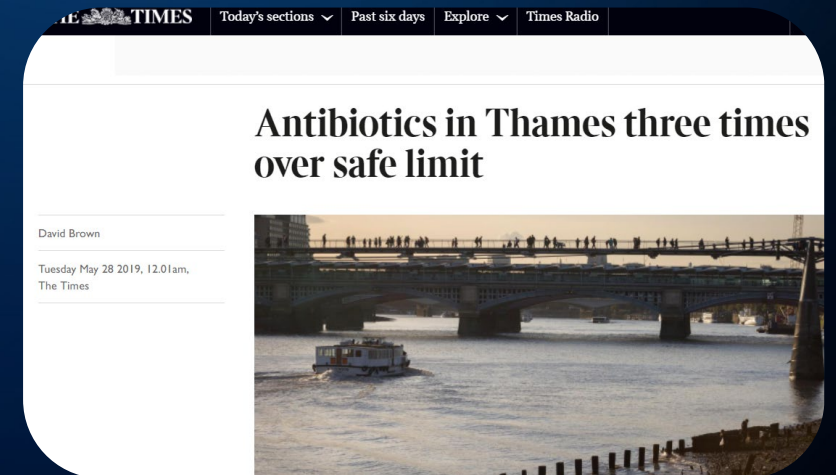
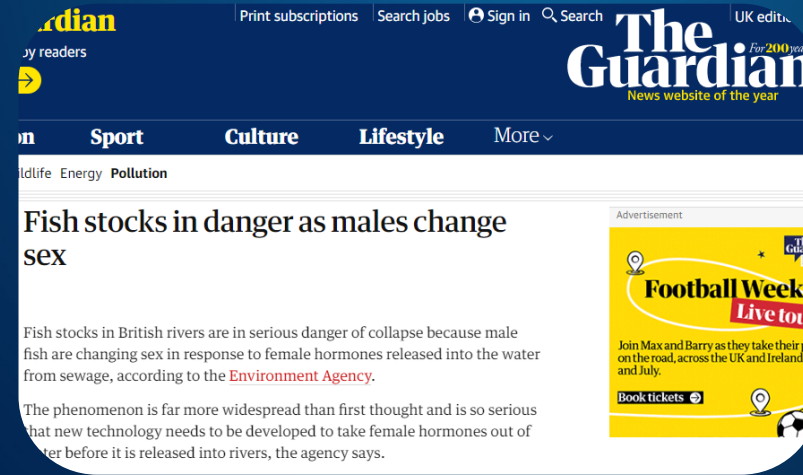


# Pharmaceuticals – what’s the problem?



# Pharmaceuticals – what’s the problem?

- Harm to aquatic life
- Antimicrobial Resistance (AMR)



# Regulation

## Water Framework Directive

- Priority Substance List
- Substance Watch List

Watch list of substances for Union-wide monitoring as set out in Article 8b of Directive 2008/105/EC

Name of substance/group of substances	CAS number (1)	EU number (2)	Indicative analytical method (3) (4)	Maximum acceptable method detection limit (ng/l)
Metaflumizone	139968-49-3	604-167-6	LLE-LC-MS-MS or SPE-LC-MS-MS	65
Amoxicillin	26787-78-0	248-003-8	SPE-LC-MS-MS	78
Ciprofloxacin	85721-33-1	617-751-0	SPE-LC-MS-MS	89
Sulfamethoxazole (5)	723-46-6	211-963-3	SPE-LC-MS-MS	100
Trimethoprim (6)	738-70-5	212-006-2	SPE-LC-MS-MS	100

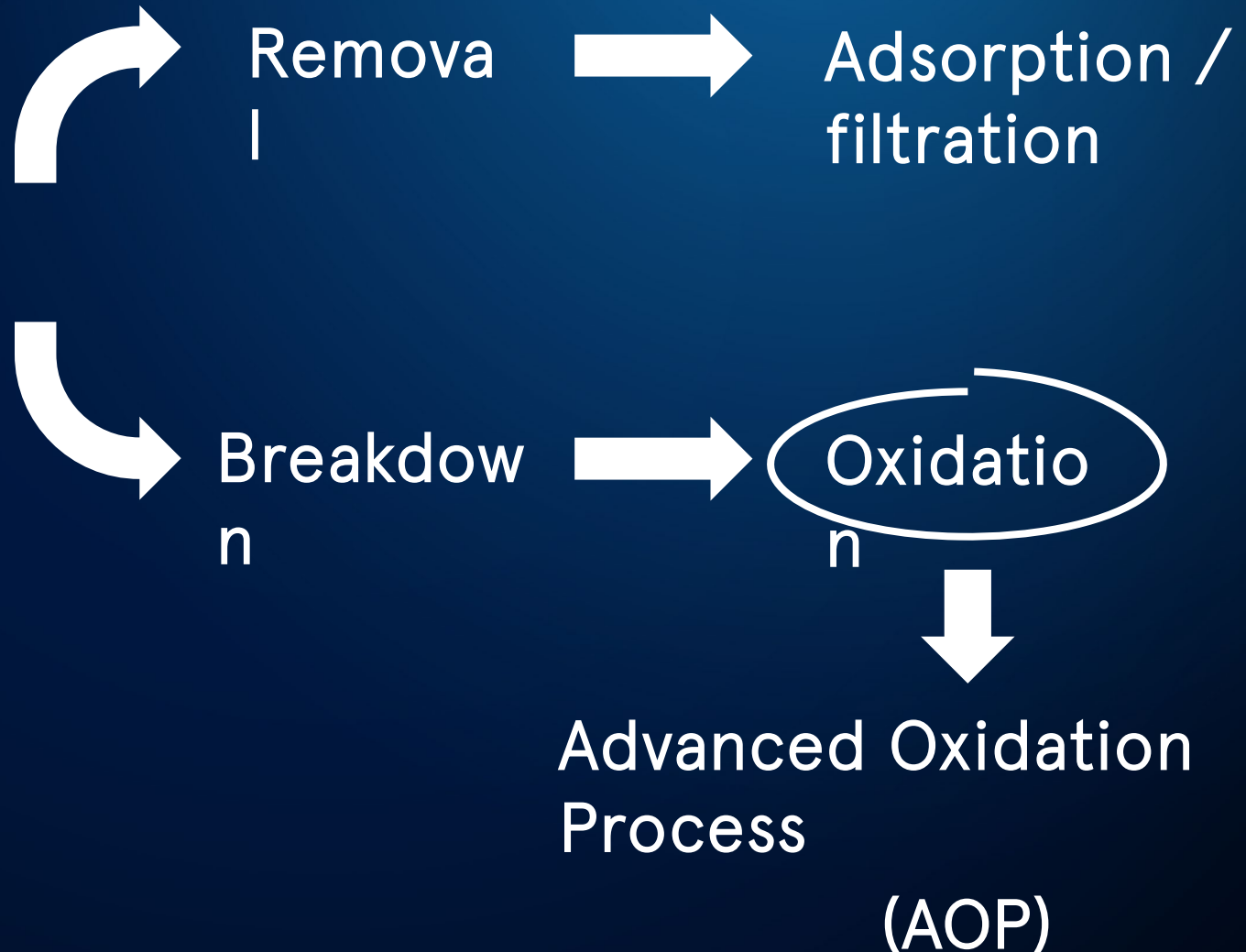
## Chemical Investigations Programme

- Data from CIP2 suggest that some painkillers, antibiotics, and hormones are of potential concern.



# What's the solution?

Pharmaceuticals  
Treatment



# Non-thermal Plasma

## (NTP) –

### Plasma

- 4<sup>th</sup> State of matter
- Generated from gas
- Mostly made up of charged particles → ions, electrons, and radicals

### Non-thermal

- Plasma generated at ambient temperature

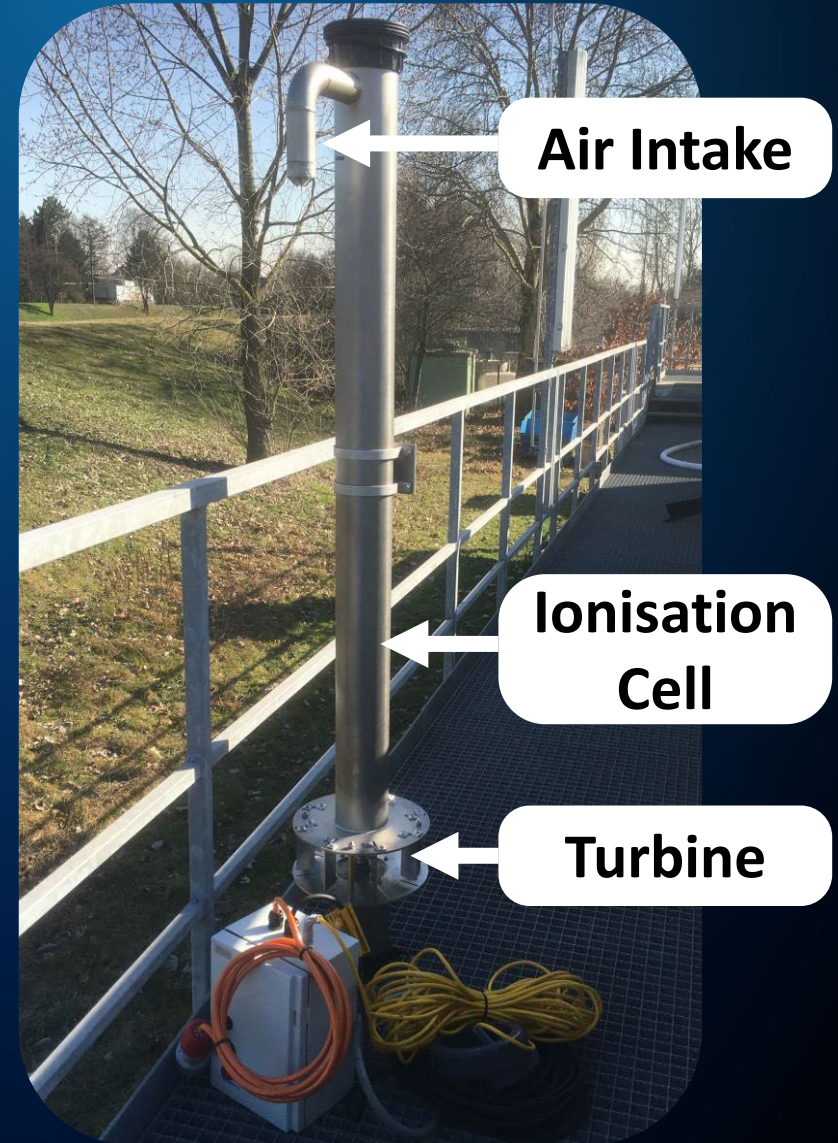
# What is Current

## Applications



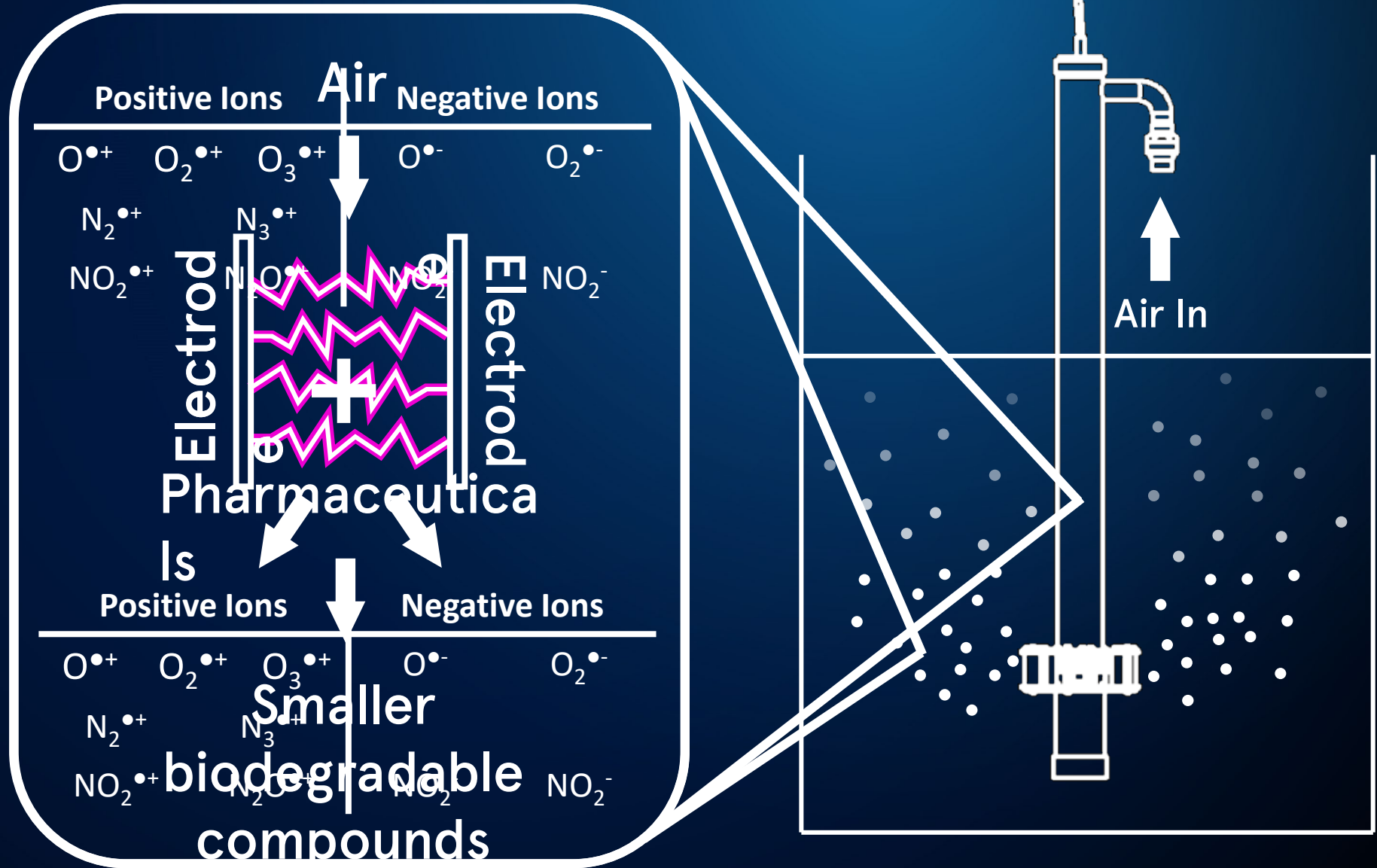
# te-ion™ Process

*Utilising non-thermal plasma for water and wastewater treatment*





# te-ion™ Process – how does it work?



# Pilot Trials – Farmasense Project, Portugal



## Partners

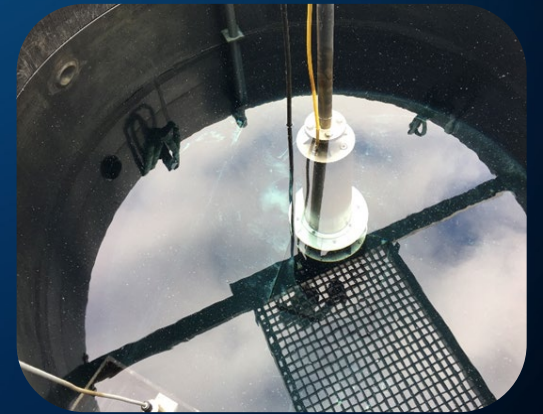


# Pilot Trials – Farmasense Project, Portugal

Trial 1:

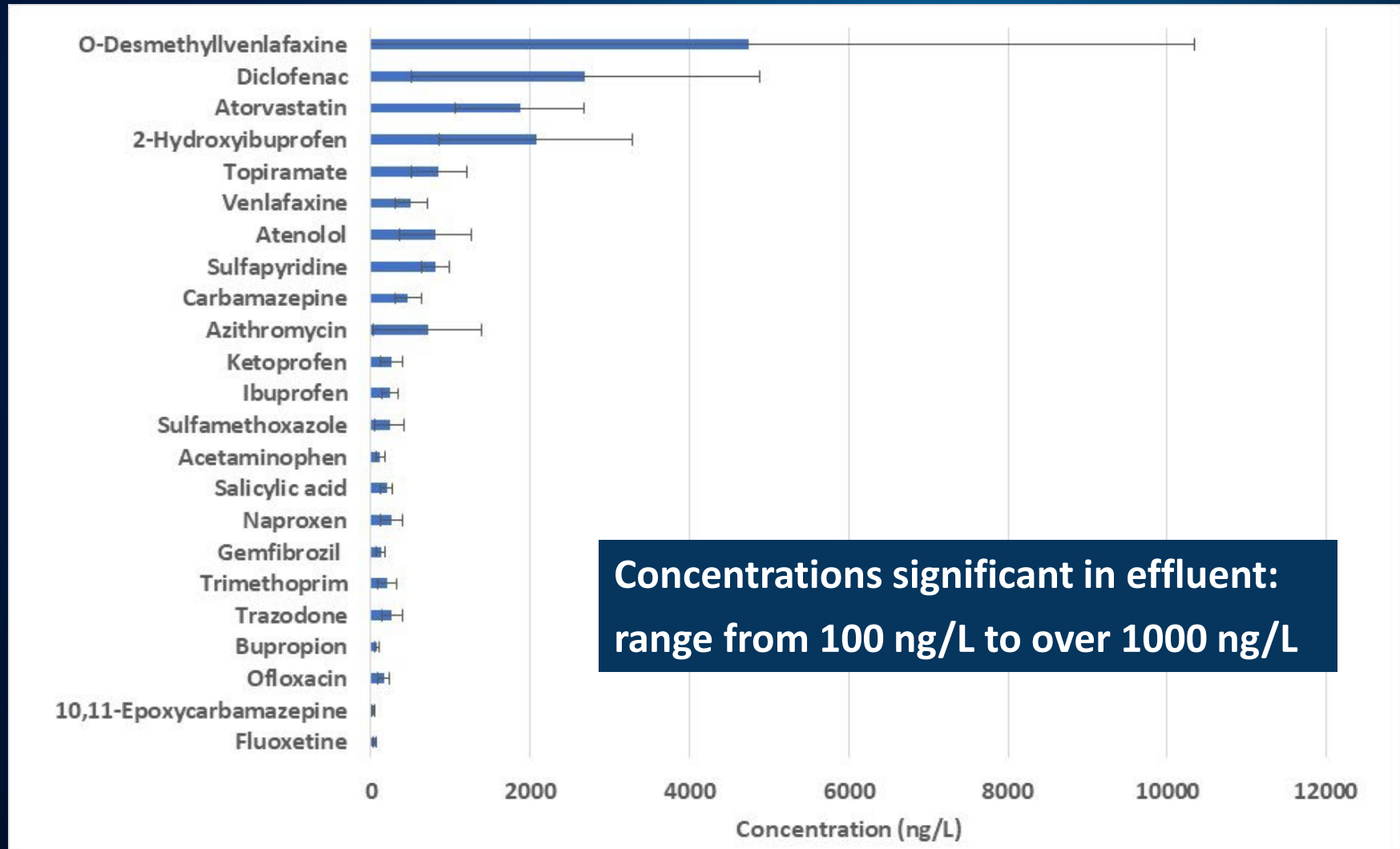


Trial 2:

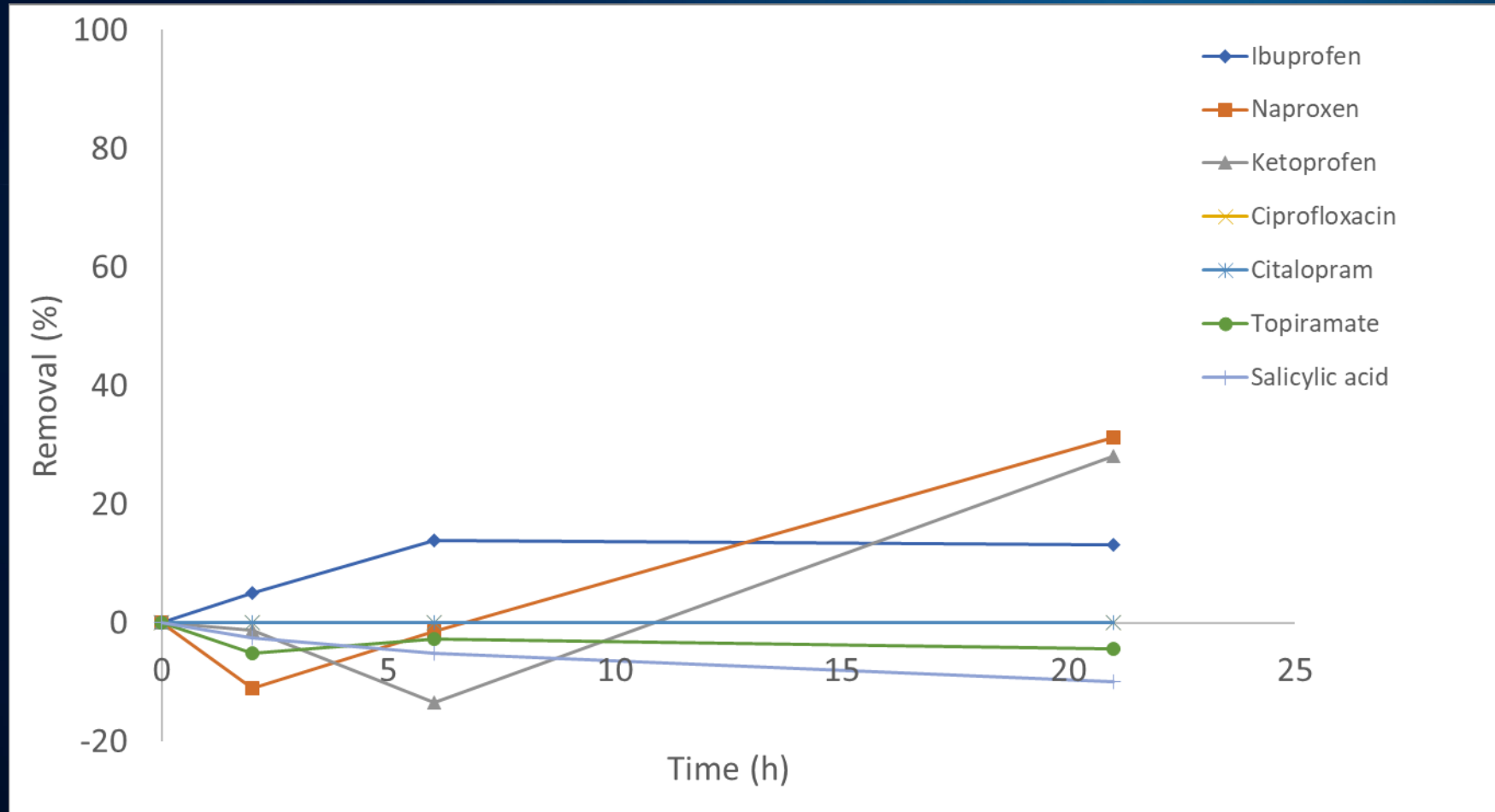


# Pilot Trials – Farmasense Project,

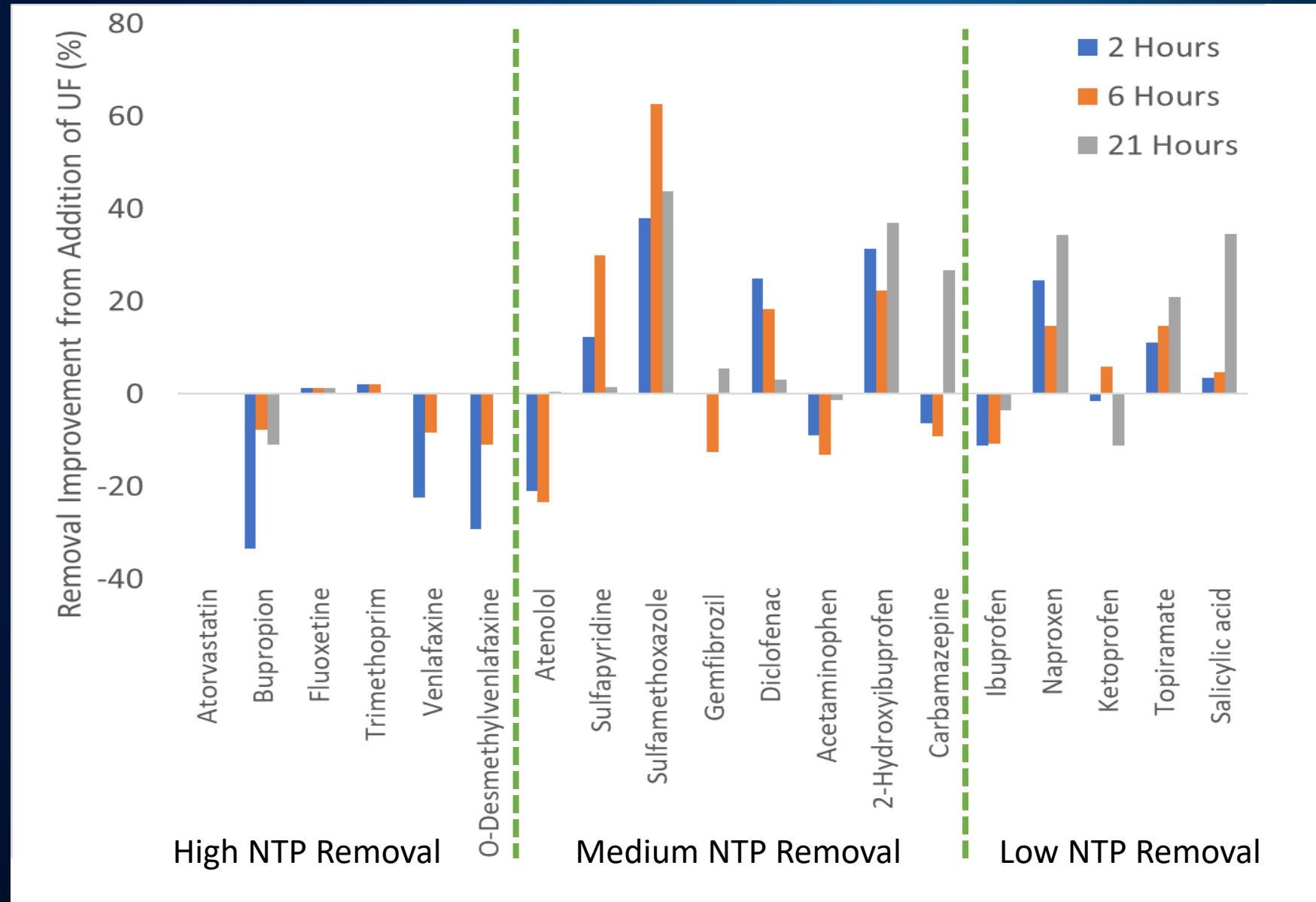
Portugal Effluent characterisation by UHPLC-MS/MS, > 20 substances detected:



# Pilot Trials – Farmasense Project, Portugal Only:



# Pilot Trials – Farmasense Project, Portugal



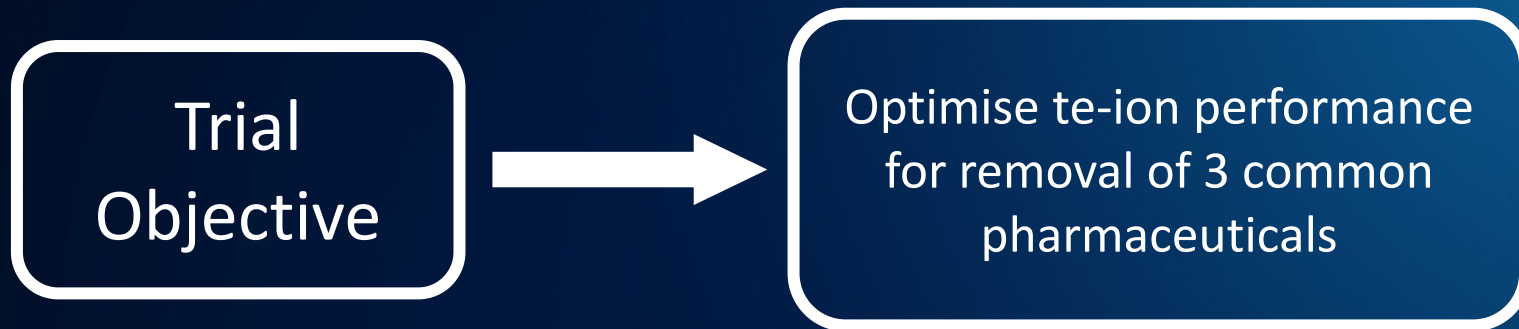
# Pilot Trials – Farmasense Project,

## Conclusions:

1. NTP shows good potential for treatment of pharmaceutical compounds present in real effluent from WWTP.
2. Different pharmaceuticals respond differently to NTP treatment.
3. NTP + UF treatment generally improved overall removal, but only for compounds that showed medium to low removal from NTP alone.
4. Pilot trials will continue to optimise NTP treatment to improve removal performance of the more difficult to remove pharmaceuticals.
5. Energy requirement – 2 kWh/m<sup>3</sup> (aiming to reduce to 1 kWh/m<sup>3</sup> for full-scale optimised plant.)



# Pilot Trials – Bad Reichenhall, Germany

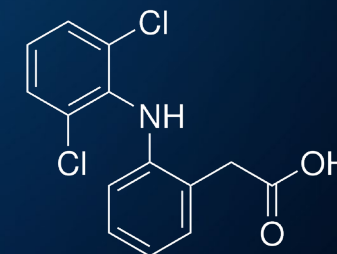


## Operating Parameters:

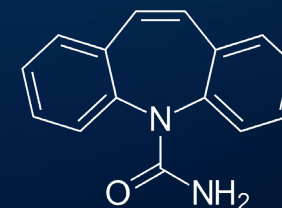
1. With or without UF pre-treatment.
2. Plasma flowrate.
3. Plasma frequency → ozone production

## Pharmaceuticals

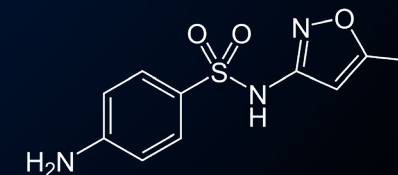
1. Diclofenac



2. Carbamazepine

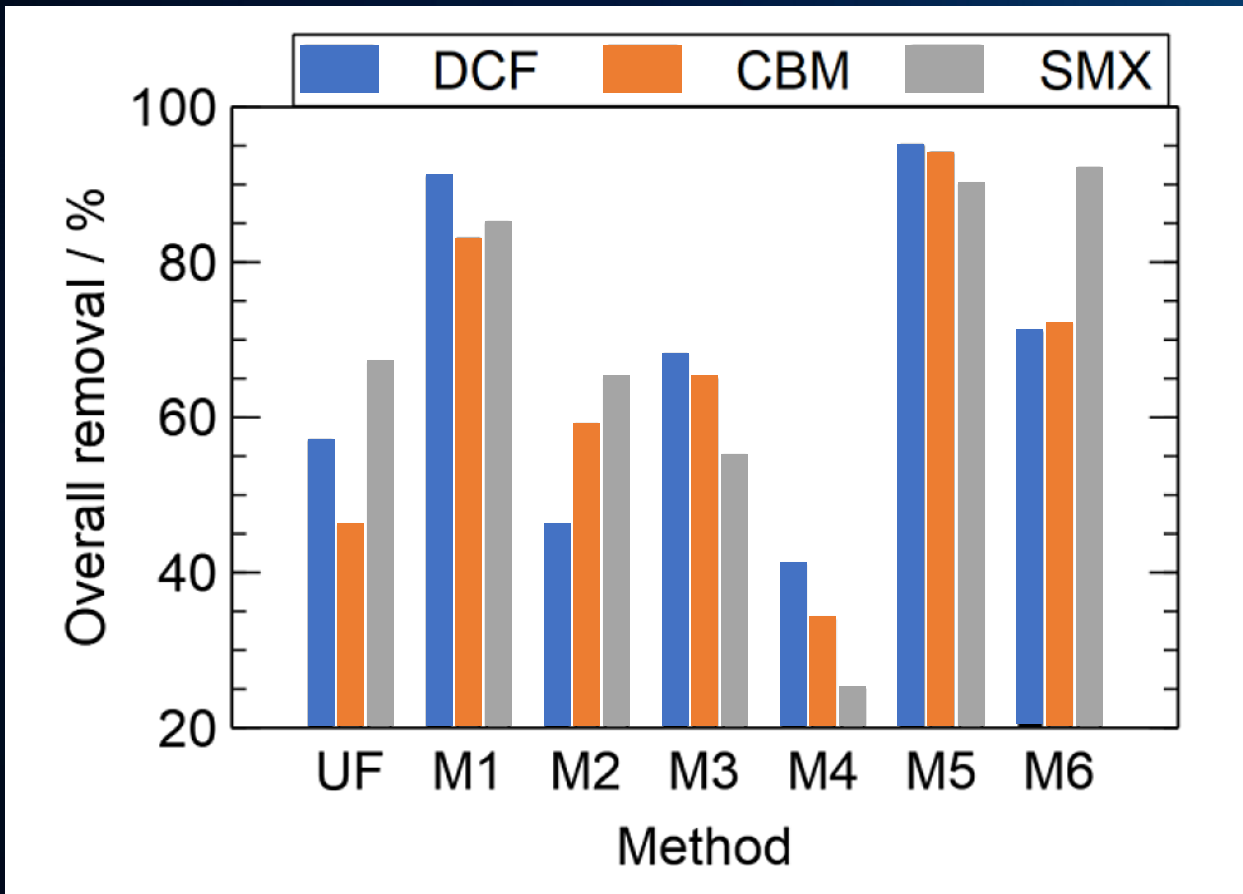


3. Sulfamethoxazole





# Pilot Trials – Bad Reichenhall, Germany



Method	UF	Plasma Flowrate (l/min)	Plasma Frequency (Hz)	Ozone Content in Plasma (ppm)
1	Yes	150	2,000	120
2	Yes	150	500	20
3	No	150	2,000	120
4	No	150	500	20
5	Yes	70	2,000	120
6	Yes	70	500	20



# Pilot Trials – Bad Reichenhall, Germany

## Conclusions:

1. Over 90% removal of Diclofenac, Carbamazepine, and Sulfamethoxazole can be achieved with combination of UF and NTP treatment.
2. Addition of UF improves overall pharmaceutical removal performance.
3. A higher plasma frequency and therefore plasma ozone content improves the overall performance of NTP treatment.
4. A lower plasma flowrate improves the overall performance of NTP treatment.



# Other Applications

Other applications of the te-ion™ that have already been tested or are in the pipeline include:

- Wastewater disinfection
- Bulking sludge suppression in activated sludge plants
- Heavy metal removal
- Sludge disintegration to increase biogas yield of AD plants
- PFAS Removal



Before te-ion™ Treatment



After te-ion™ Treatment



*Thank you for listening*

