

# PerFormWater 2030: Evaluation of advanced treatment technologies for removal of CECs in urban WW

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# PerFORM WATER 2030

Innovation and competitiveness project funded by Lombardy Region in the framework of ERDF 2014-2020

The strategic partnership is composed by

- 8 industrial companies with an important role in the eco-industry field, in addition to the project Coordinator Gruppo CAP, and
- 2 Universities and 1 Research Institutes as essential support for all the experimentations and which will closely collaborate with the industrial partners.

PROJECT COORDINATOR: Gruppo CAP



SCIENTIFIC PROJECT MANAGEMENT: Politecnico di Milano

PROJECT MANAGEMENT SUPPORT: Fondazione Politecnico

INDUSTRIAL PARTNERS:

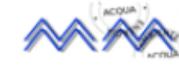
GENEGIS GI



HyDEP



MMI IDRO



PASSAVANT



SEAM ENGENEERING



SIAD



VEOLIA



VOMM



UNIVERSITIES AND RESEARCH INSTITUTES PARTNERS:

Politecnico di Milano



Università degli Studi Milano Bicocca



Istituto di Ricerca sulle Acque  
Consiglio Nazionale delle Ricerche



Budget: 8,795,950 €

# PerFORM WATER 2030

## PlatForm for Integrated Operation Research and Management of public WATER towards 2030

For the public water management sector: innovative technologies and practices will promote a more efficient and sustainable future for the Integrated urban water management.

The project **aims to support water utility managers**, so that they can act as **key players and promoters** of innovation in the water sector.

The project covers **4 main thematic areas**, besides those associated with technical and scientific management and dissemination and transfer of the results:

- Water
- Biosolid valorization
- Recovery of energy and materials
- Economic and social issues

**WP WATER:** 5 main objectives -9 related tasks-5 pilot plants -4 research activities

- Cold Anammox process
- Emerging contaminants
- Emissions in the atmosphere
- Drinking water quality monitoring
- Water supply network optimization
- Measurements in sewer systems and modeling activities

**WP SLUDGE:** 4 main objectives -4 related tasks-2 pilot plants -2 research activities

- Reduction of extra sludge production
- Sludge thermal valorization
- Modeling activities

**WP MATERIALS AND ENERGY RECOVERY** 5 main objectives -6 related tasks-5 pilot plants - 1 research activity

- Recovery of water, material and energy resources
- Biogas upgrade
- Anaerobic Digestion optimization

**WP ECONOMIC SUSTAINABILITY AND SOCIAL ACCEPTABILITY OF NEW TECHNOLOGIES:** 3 main objectives -3 related tasks-4 research activities

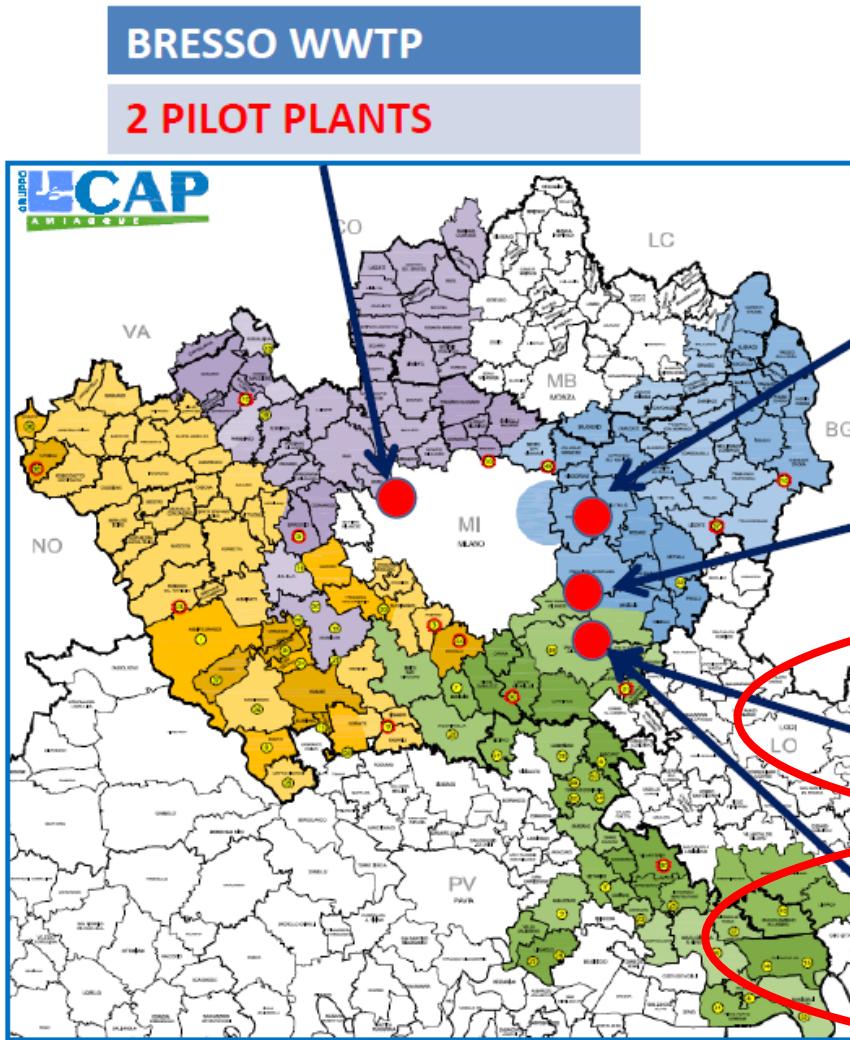
- Stakeholders engagement
- Advanced costs and tariffs analysis
- Operation & Maintenance

# Workpackage 5: Water

**WP WATER:** 5 main objectives -9 related tasks -5 pilot plants -4 research activities

- WP-A1-2 innovative treatments for removal of N and CECs
- WP-A3 Drinking water quality monitoring
- WP-A4 Water supply network optimisation
- WP-A5 Measurements in sewer systems and modeling activities

# Demo sites: in various WWTPs managed by CAP Group in the Metropolitan City of Milan.



*...An Innovation Green  
Ring around Milan...*

**SALA AZZURRA RESEARCH AND  
INNOVATION CENTER - SEGRATE**

4 RESEARCH ACTIVITIES

**PESCHIERA BORROMEO WWTP**

1 PILOT PLANT

**SAN GIULIANO OVEST WWTP**

8 PILOT PLANTS

**SAN GIULIANO EST WWTP**

1 PILOT PLANT

WWTP	Population equivalent	Discharge (m <sup>3</sup> /d)
SGO	17,500	12,000
SGE	50,000	28,500

SGO

SGE

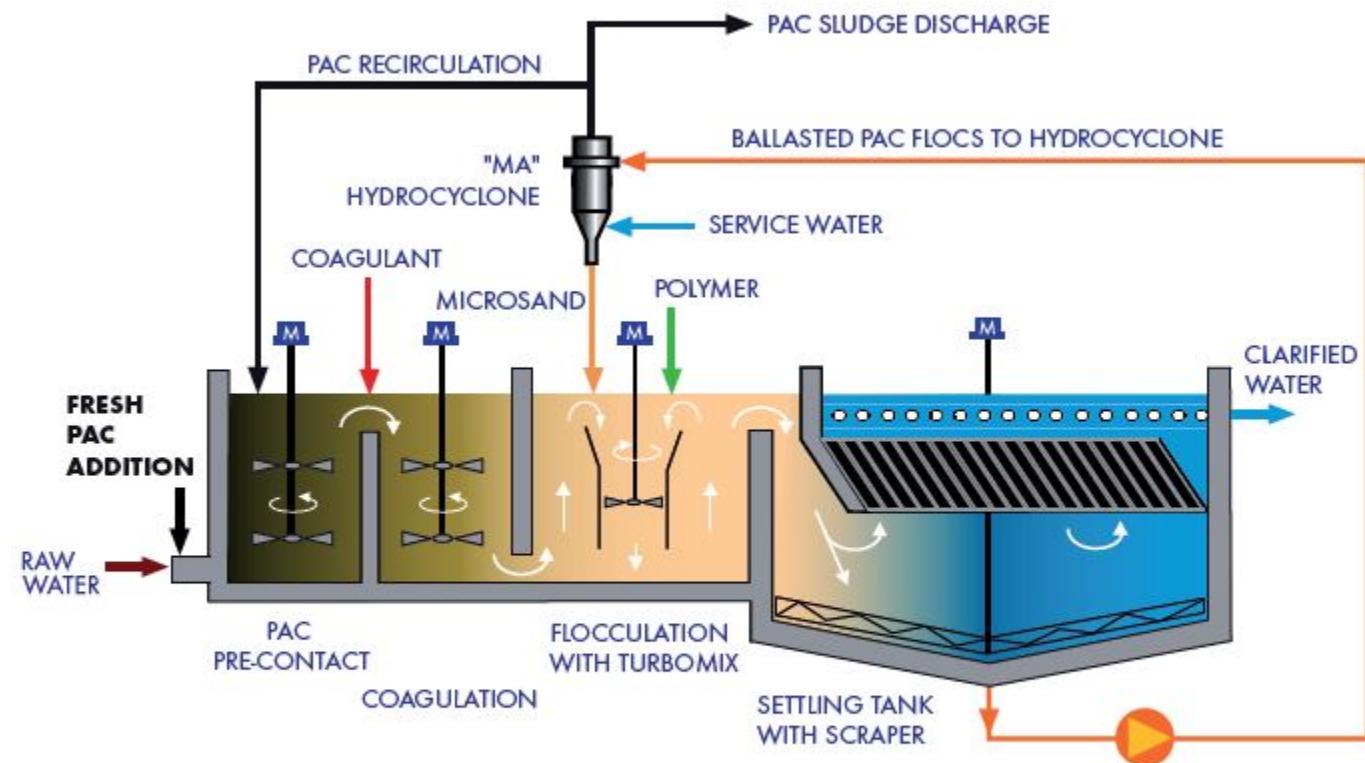
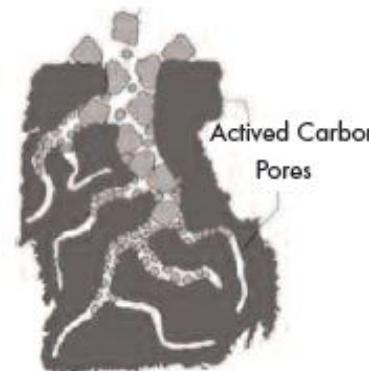
# PerFORM WATER 2030: pilotplant CECs removal

	TASK	PLANT	TECHNOLOGY	PARTNER
WP_A_1	<b>Actiflo-carb technology</b>	SGE	<p>The tertiary treatment uses <b>Powdered Activated Carbon (PAC)</b> as adsorption substrate.</p> <p>The technology is based on chemico-physical separation process, accelerated with the dosage of microsand and polymer for the recovery of PAC</p>	<ul style="list-style-type: none"><li>• VEOLIA Technologies S.P.A.</li><li>• POLIMI - Politecnico di Milano (DICA)</li><li>• IRSA-CNR</li></ul>
WP_A2	<b>Advanced Oxidation Process with ozone and active carbon</b>	SGO	<p>The tertiary treatment is based on a chemical oxidation process with <b>ozone and active carbons</b> adsorption</p>	<ul style="list-style-type: none"><li>• SIAD S.P.A.</li><li>• POLIMI - Politecnico di Milano (DICA)</li><li>• IRSA-CNR</li></ul>

# Actiflo-carb technology

Actiflo® Carb features a pre-contact tank, in which Powdered Activated Carbon (PAC) is added to remove through physical adsorption, **Natural Organic Matter (NOM)**, **Pesticides**, **Emerging Micro-Pollutants & Micro-Algae** that cannot be removed by chemical flocculation. Existing Actiflo® plants can be easily upgraded to the Actiflo® Carb process.

- ▶ Actiflo® Carb combines low turbidity and organics removal in a single step
- ▶ Used for both municipal and industrial applications
- ▶ Applied Rise Rate 30 – 40 m/h
- ▶ PAC dose 5 – 30 mg/l
- ▶ Sludge concentration 20 – 40 g/l
- ▶ Use of "MA" hydrocyclone
- ▶ Water loss < 1%



# Oxidation process with Ozone and AOP Pilot plant

The tertiary treatment will be based on a chemical oxidation process with Ozone and/or AOP combined with activated carbon adsorption.

Goal of the Research:

- CECs removal
- Best operating conditions
- Oxidative by-products
- Organic residual content
- Microbiological removal
- Evaluate the environmental sustainability compared to the final receptors



# Study strategy for CECs removal



# CECs' SCREENING IN WASTEWATER

- **INLET** and **OUTLET** of two conventional activated sludge WWTPs (San Giuliano East – SGE and San Giuliano West - SGO) for **7 days**
- **24-hour composite sample**, collected using an automatic sampler (1 grab sample per hour)
- Suspect screening by **LC-HRMS**



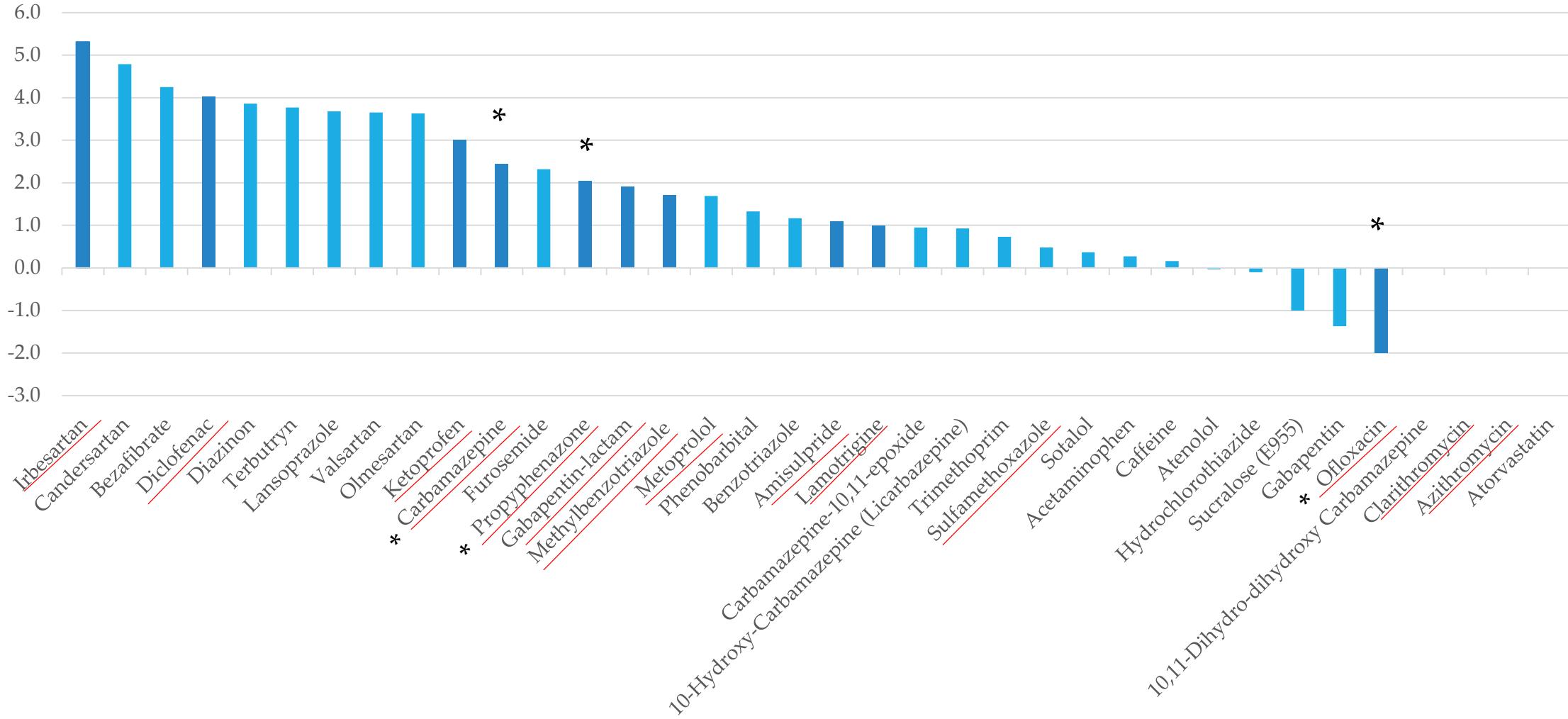
# Criteria for compound selection

- Compounds of environmental concern, **mentioned in current legislation** (Watch list 1 and 2; revision of DWD, GOW-DE , FOEN2017-CH, WWList2011-CH) and detected in WW of the study area
- **Not removed/produced** by conventional treatments (i.e. activated sludge treatment)
- Present in **both** demo sites
- Easy to detect by **LC-MS** (present in high concentration)
- **Removable by adsorption/absorption and oxidation**

	NAME	CAS	CLASS	AREA SGO OUT	AREA SGE OUT	removal WWTP % (Ref. Margot 2013, 2015)	Polarity	Log Kow	Log Koc	CHEMSPIDER EPI Suite	
										ozone (half-life)	Ready biodegradability prediction
1	Diclofenac	15307-86-5	Pharmaceutical/anti-inflammatory (NSAID)	192859356	464624265	<10%	+	4.0	2.9	No Ozone Reaction Estimation	NO
2	Carbamazepine	298-46-4	Pharmaceutical/antiepileptic	563423691	2239816487	<10%	+	2.5	3.6	1.091 Hrs	NO
3	10,11-Dihydro-dihydroxy Carbamazepine	58955-94-5	Pharmaceutical/carbamazepine metabolite	86900597	452326120	<10%	+				
4	Carbamazepine-10,11-epoxide	36507-30-9	Pharmaceutical/carbamazepine metabolite	129037653	822116681	<10%	+	1.0	2.6	No Ozone Reaction Estimation	NO
5	10-Hydroxy-Carbamazepine (Licarbazepine)	29331-92-8	Pharmaceutical/carbamazepine metabolite	107333364	338305303	<10%	+	0.9	2.3	No Ozone Reaction Estimation	NO
6	Amisulpride	71675-85-9	Pharmaceutical/anti depressive	327299789	295836302	<10%	+	1.1	2.8	No Ozone Reaction Estimation	NO
7	Metoprolol	1404-90-6	Pharmaceutical/beta blocker	317639491	822475418	<10%	+	1.7	1.8	No Ozone Reaction Estimation	NO
8	Lamotrigine	84057-84-1	Pharmaceutical/antiepileptic	173928616	667468474	<10%	+	1.0	3.1	No Ozone Reaction Estimation	NO
9	Phenobarbital	50-06-6	Pharmaceutical/antiepileptic	12196808	51471143	<10%	-	1.3	2.4	No Ozone Reaction Estimation	NO
10	Sucralose (E955)	56038-13-2	Life style product/Artificial sweetener	69592919	250838927	<10%	-	-1.0	1.0	No Ozone Reaction Estimation	NO
11	Benzotriazole	95-14-7	Industrial chemical/Corrosion inhibitor	430397183	1056186200	<30%	+	1.2	3.0	No Ozone Reaction Estimation	NO
12	Candersartan	139481-59-7	Pharmaceutical/Antihypertensive	57589263	133791224	<30%	+	4.8	5.9	No Ozone Reaction Estimation	NO
13	Hydrochlorothiazide	58-93-5	Pharmaceutical/diuretic	186743609	1340541051	<30%	-	-0.1	1.9	No Ozone Reaction Estimation	NO
14	Methylbenzotriazole	136-85-6 (5)/29878-31-7 (4)	Industrial chemical/Corrosion inhibitor	2584909245	2519903317	<30%	+	1.7	3.2	No Ozone Reaction Estimation	NO
16	Sotalol	3930-20-9	Pharmaceutical/beta blocker	152136103	645393262	<30%	+	0.4	1.6	No Ozone Reaction Estimation	NO
17	Prophenazone	479-92-5	Pharmaceutical/analgesic-antipyretic	265535534	271735122	<30%	+	2.1	3.1	3.72 Hrs	NO
18	Valsartan	137862-53-4	Pharmaceutical/Cardiovascular drug	566010465	199279194	<30%	+	3.7	6.0	No Ozone Reaction Estimation	NO
19	Irbesartan	138402-11-6	Pharmaceutical/Cardiovascular drug	1326943247	4421968180	<30%	+	5.3	7.9	No Ozone Reaction Estimation	NO
20	Bezafibrate	41859-67-0	Pharmaceutical/Lipid-regulator	14707571	18742930	<30%	+	4.3	3.2	No Ozone Reaction Estimation	NO
21	Atenolol	29122-68-7	Pharmaceutical/Cardiovascular drug	126531116	259743370	30-80%	+	0.0	2.2	No Ozone Reaction Estimation	NO
22	Azithromycin	83905-01-5	Pharmaceutical/Antibiotic macrolide	51272195	126707808	30-80%	+				
23	Clarithromycin	81103-11-9	Pharmaceutical/Antibiotic macrolide	294081851	417309734	30-80%	+	3.16			
24	Diazinon	333-41-5	PPP/Organophosphate insecticide	134996334	87310335	30-80%	+	3.9	3.1	No Ozone Reaction Estimation	NO
25	Furosemide	54-31-9	Pharmaceutical/Diuretic	86325717	266100264	30-80%	-	2.3	2.3	No Ozone Reaction Estimation	NO
26	Ketoprofen	22071-15-4	Pharmaceutical/anti-inflammatory (NSAID)	339527680	214361973	30-80%	+	3.0	2.5	No Ozone Reaction Estimation	NO
27	Ofloxacin	82419-36-1	Pharmaceutical/Antibiotic/Fluoroquinolone	183436873	564516505	30-80%	+	-2.0	1.6	20.017 Hrs	NO
28	Sulfamethoxazole	129378-89-8	Pharmaceutical/Antibiotic/sulfonamidic	53116426	158751251	30-80%	+	0.5	3.2	No Ozone Reaction Estimation	NO
29	Terbutryn	886-50-0	PPP/Pesticide	66467383	21831933	30-80%	+	3.8	2.8	No Ozone Reaction Estimation	NO
30	Trimethoprim	738-70-5	Pharmaceutical/Antibiotic	197404320	315268417	30-80%	+	0.7	3.0	No Ozone Reaction Estimation	NO
31	Lansoprazole	103577-45-3	Pharmaceutical/Proton-pump inhibitor	34293905	44387672	30-80%	+	3.7	4.4	No Ozone Reaction Estimation	NO
32	Atorvastatin	134523-00-5	Pharmaceutical/Lipid-regulator	757765	6491783	80-100%	+				
33	Olmesartan	144689-24-7	Pharmaceutical/Antihypertensive	463847866	1599503613	80-100%	+	3.6	4.8	No Ozone Reaction Estimation	NO
34	Caffeine	58-08-2	Life style product/Stimulant	-2979593	4897434	80-100%	+	0.2	1.0	No Ozone Reaction Estimation	NO
35	Acetaminophen	103-90-2	Pharmaceutical/Analgesic-Antipyretic	82678796	36871492	80-100%	+	0.3	1.8	No Ozone Reaction Estimation	NO
36	Gabapentin	60142-96-3	Pharmaceutical/antiepileptic	0	0		+	-1.4	1.8	No Ozone Reaction Estimation	YES
37	Gabapentin-lactam	64744-50-9	TP Gabapentin	162904223	2937992019		+	1.9	2.5	No Ozone Reaction Estimation	NO

	<b>NAME</b>	<b>CAS</b>	<b>CLASS</b>	<b>PEAK AREA SGO OUT</b>	<b>PEAK AREA SGE OUT</b>	<b>Log Kow</b>	<b>Log Koc</b>	<b>ozone (half-life)</b>	<b>Ready biodegradability prediction</b>
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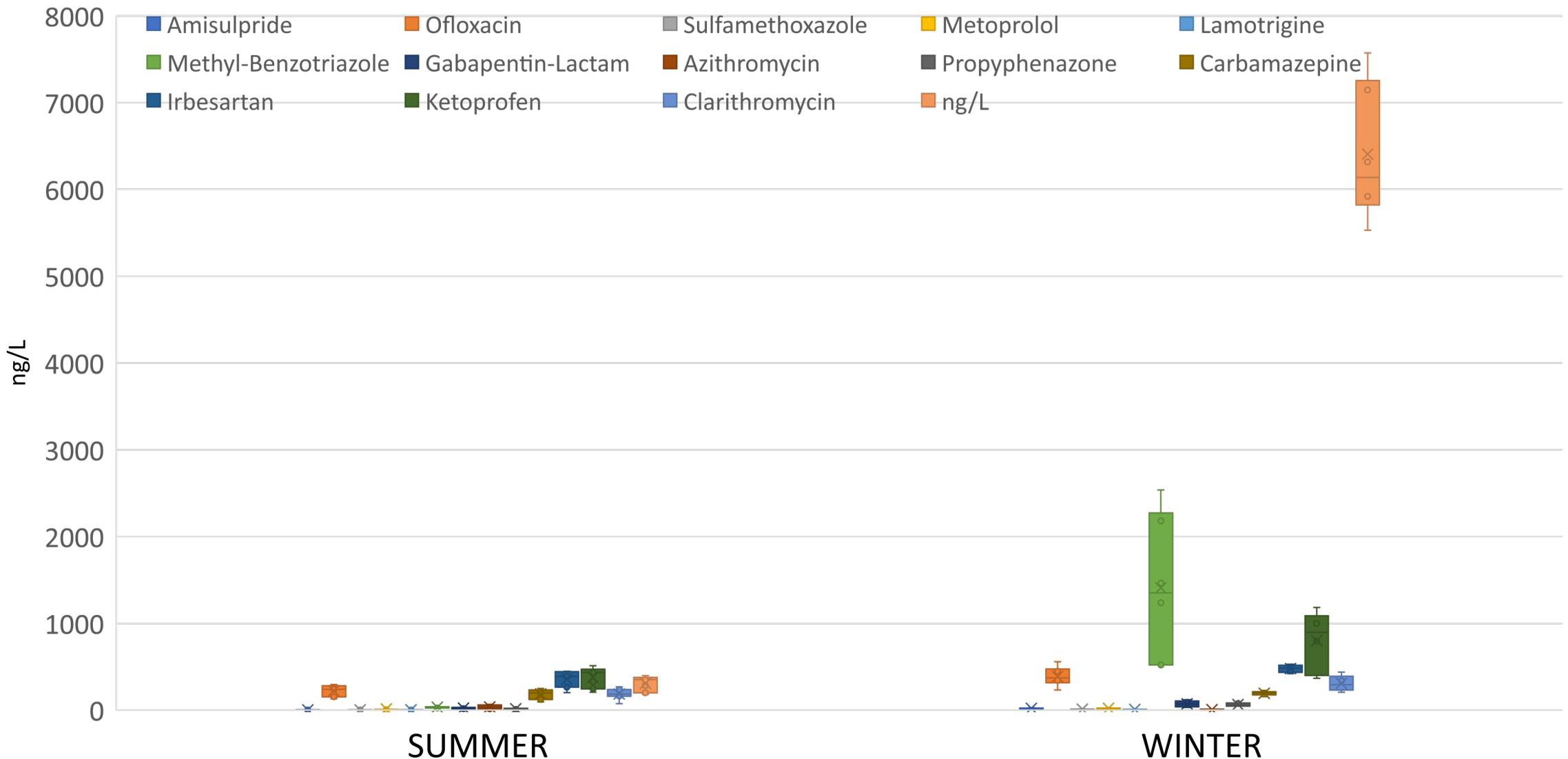
# Log Kow (CHEMSPIDER EPI Suite) \*: Ozone Reaction



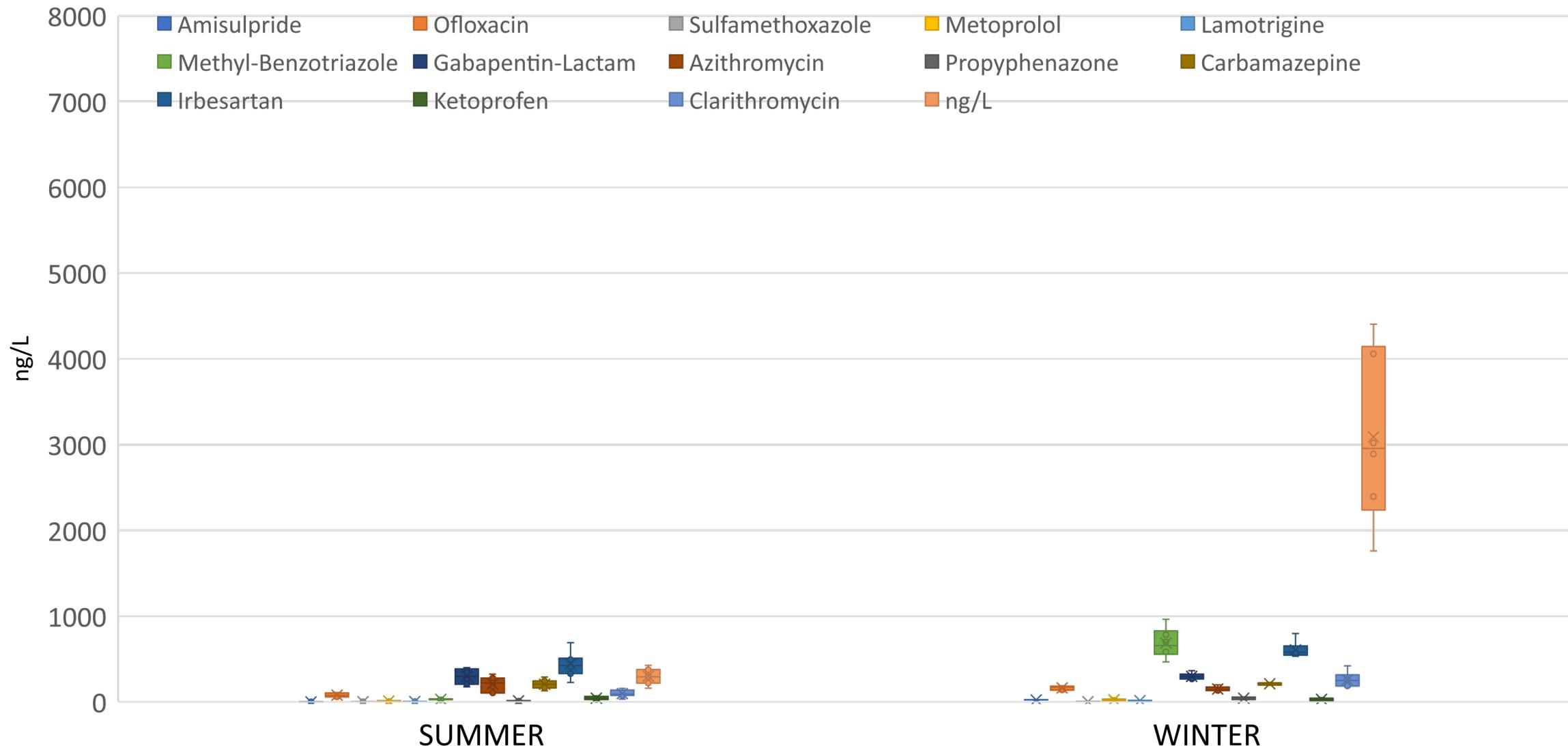
# Selected CECs for evaluation of best process conditions

NAME	CAS	CLASS
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Lamotrigine	84057-84-1	Antiepileptic
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Diclofenac	15307-86-5	Anti-inflammatory (NSAID)
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Ofloxacin	82419-36-1	Antibiotic/Fluoroquinolone
Clarithromycin	81103-11-9	Antibiotic macrolide
Azithromycin	83905-01-5	Antibiotic macrolide
Sulfamethoxazole	129378-89-8	Antibiotic/sulfonamidic
Gabapentin-lactam	64744-50-9	TP Gabapentin

# WWTP-INLET



## WWTP-OUTLET (activated sludge treatment)



# Thanks to

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INDUSTRIAL PARTNERS:

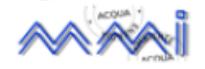
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