

Supplementary Material

for

Evaluation of heterogenous catalytic ozonation for micropollutants' removal from wastewater. Application of a pre-industrial level unit.

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Supplementary Tables

Table S1 Specifications of the membrane module used

Membrane	PTFE Hollow Fiber
Inner Diameter (mm)	1.47
Outer Diameter (mm)	1.88
Density (g/cm ³)	0.97
Porosity (%)	53
Pure Water Flux (L/min/m ² @ 2 bar)	180
Water Entry Pressure (bar)	1.93
Maximum Pore Diameter (μm)	0.741
Mean Pore Diameter (μm)	0.589
Minimum Pore Diameter (μm)	0.52
Length, L (m)	0.96
Effective Contact Area (m ²)	4.8
Number of fibers	846

Table S2 Main physicochemical characteristics of materials tested as catalysts

Zeolite	
PZC	6.8
IEP	2.2
S _{BET} , m ² /g	21
Pore volume, mL/g	0.164
PET (Polyethylene terephthalate)	
PZC	6.2
Granule size, mm	0.8-2.5
Granule Density, g/mL	0.79
Specific Surface Area, m ² /m ³	405

Table S3 Chemical composition of zeolite

%								mg/Kg	
SiO ₂	Al ₂ O ₃	MgO	CaO	Na ₂ O	K ₂ O	Fe ₂ O ₃	LOI	NiO	Cr ₂ O ₃
70.5	12.1	0.58	2.91	1.45	2.82	0.67	8.9*	ND	ND

*Determination at 900 °C as clarified by TG-DTA

Table S4 Sampling Points

Symbol	Name	Description
P0	Secondary effluent	- Secondary treatment effluent wastewater before conventional disinfection (simple ozonation) and - Influent wastewater to the pre-industrial pilot unit
P1	1 st Bed effluent	Effluent wastewater after the post filtration (1 st Fix-Bed) in the pre-industrial pilot unit
P2	Membrane	Effluent wastewater after the membrane in the pre-industrial pilot unit
P3	2 nd Bed effluent	Effluent wastewater after the catalytic ozonation (2 nd Fix-Bed) in the pre-industrial pilot unit
P4	3 rd Bed effluent	Effluent wastewater after the biological stabilization (3 rd Fix-Bed) in the pre-industrial pilot unit

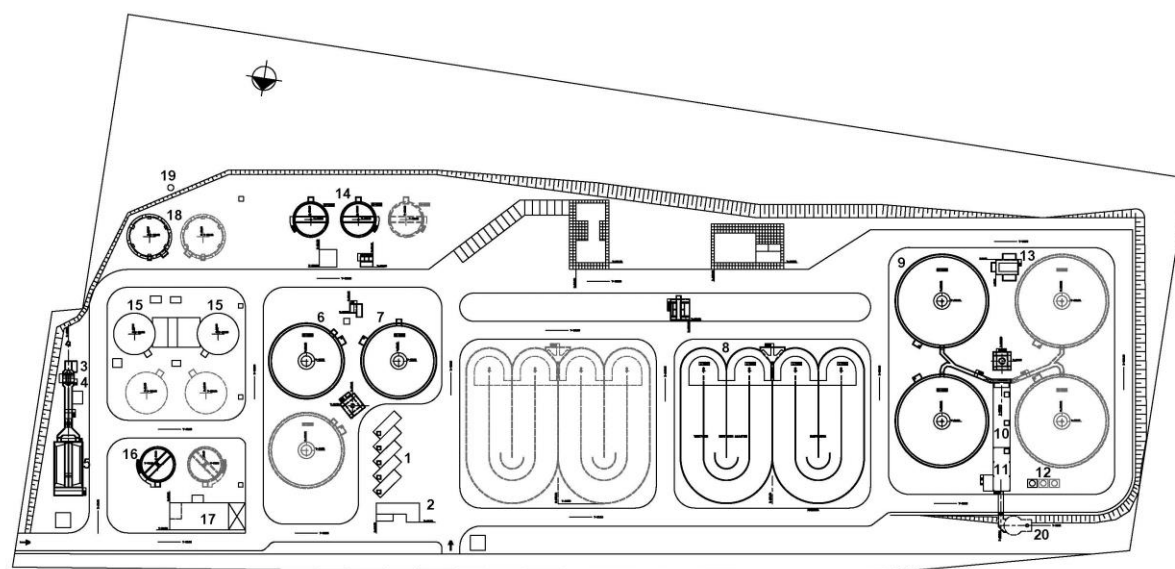
Table S5 Physicochemical characteristics of selected micropollutants at 20°C.

Micropollutant	Molecular weight	Log D at pH 8	pK _a	k _{O₃} (M ⁻¹ s ⁻¹)	k _{OH·} (M ⁻¹ s ⁻¹)	Reference
p-CBA	156.6	-1.15	4.07	0.15	5*10 ⁹	[1,2]
Benzotriazole	119.1	1.21	9.04	20	7.6*10 ⁹	[1,3]
Paracetamol	151.2	0.91	9.5	2.57*10 ⁶	7.1*10 ⁹	[1,4]
Caffeine	194.2	-0.55	14	650	4.1*10 ⁹	[1,5]

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Supplementary Figures



GENERAL ARRANGEMENT PLAN LEGEND

- 1 SEPTIC WASTEWATER RECEPTION STATION
- 2 SEPTIC WASTEWATER PRETREATMENT UNIT
- 3 INFLOW CHAMBER
- 4 SCREENING STATION
- 5 GRIT & GREASE REMOVAL
- 6 PST (PRIMARY SEDIMENTATION TANK)
- 7 SEPTIC WASTEWATER BALANCING TANK
- 8 BIOREACTOR
- 9 FST (FINAL SEDIMENTATION TANK)

- 10 OZONE CONTACT UNIT
- 11 OZONE PRODUCTION STATION
- 12 LIQUID OXYGEN STORAGE TANK
- 13 RAS & SAS PUMPING STATION
- 14 SLUDGE THICKENERS
- 15 ANAEROBIC SLUDGE DIGESTERS
- 16 SLUDGE POST-THICKENER
- 17 SLUDGE DEWATERING STATION
- 18 GAS HOLDER
- 19 GAS FLARE
- 20 EFFLUENT CHAMBER

LINE'S LEGEND

- OPERATING UNITS
 —— FUTURE UNITS

(a)



(b)

Figure S1 Diagram (a) and view (b) of wastewater treatment plant "AINEIA"

Influent of WWTP

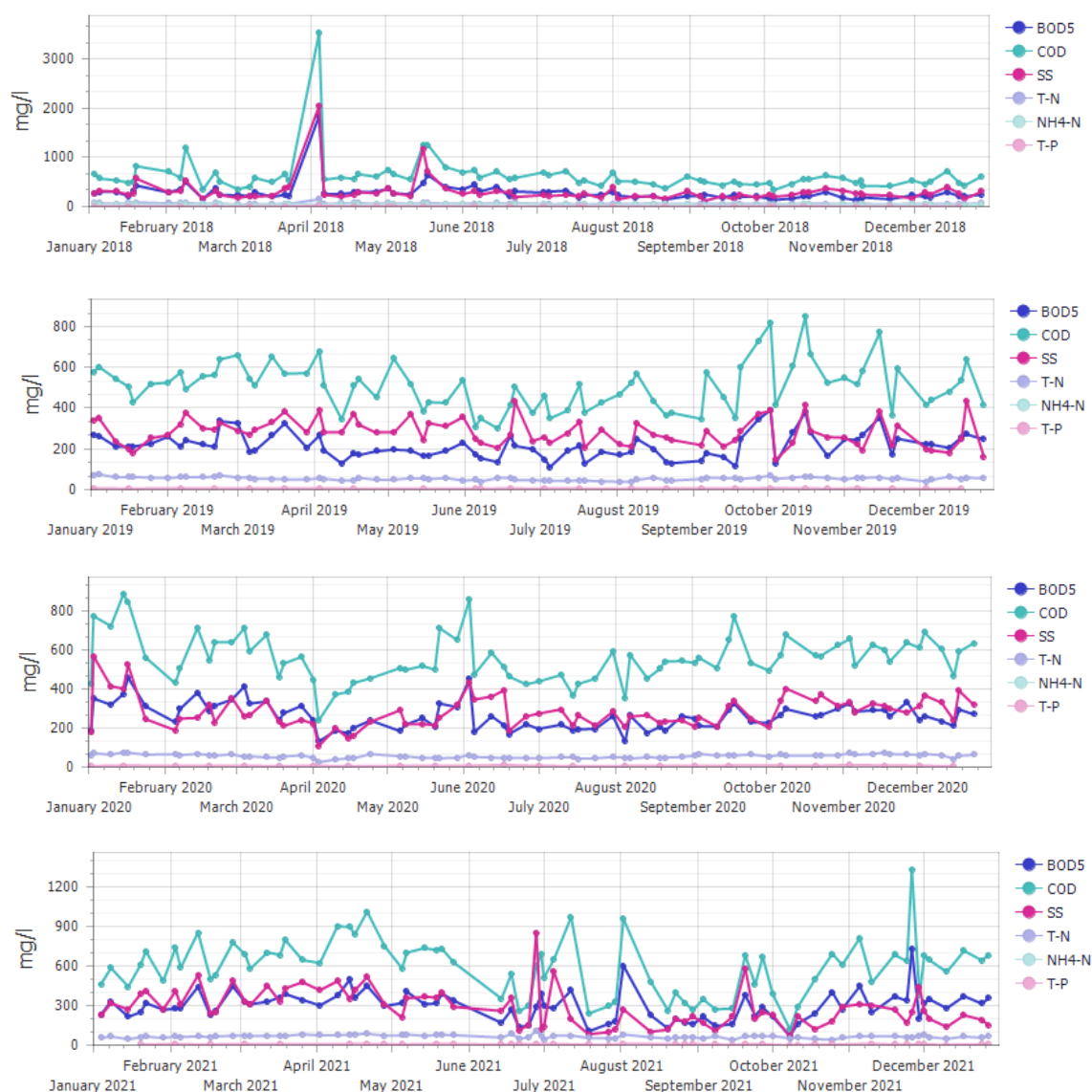


Figure S2 Variation of BOD₅, COD, SS, T-N, NH₄-N, NO₃-N and T-P in the influent of WWTP for 2018-2021 (Data obtained from <http://astikalimata.ypeka.gr/Services/Pages/WtpViewApp.aspx#>)

where,

BOD₅: Biological oxygen demand (in five days)

COD: Chemical oxygen demand

SS: Suspended solids

T-N: Total nitrogen

NH₄-N: Ammonium nitrogen

NO₃-N: Nitrate nitrogen

T-P: Total phosphorus

Treated effluent of WWTP

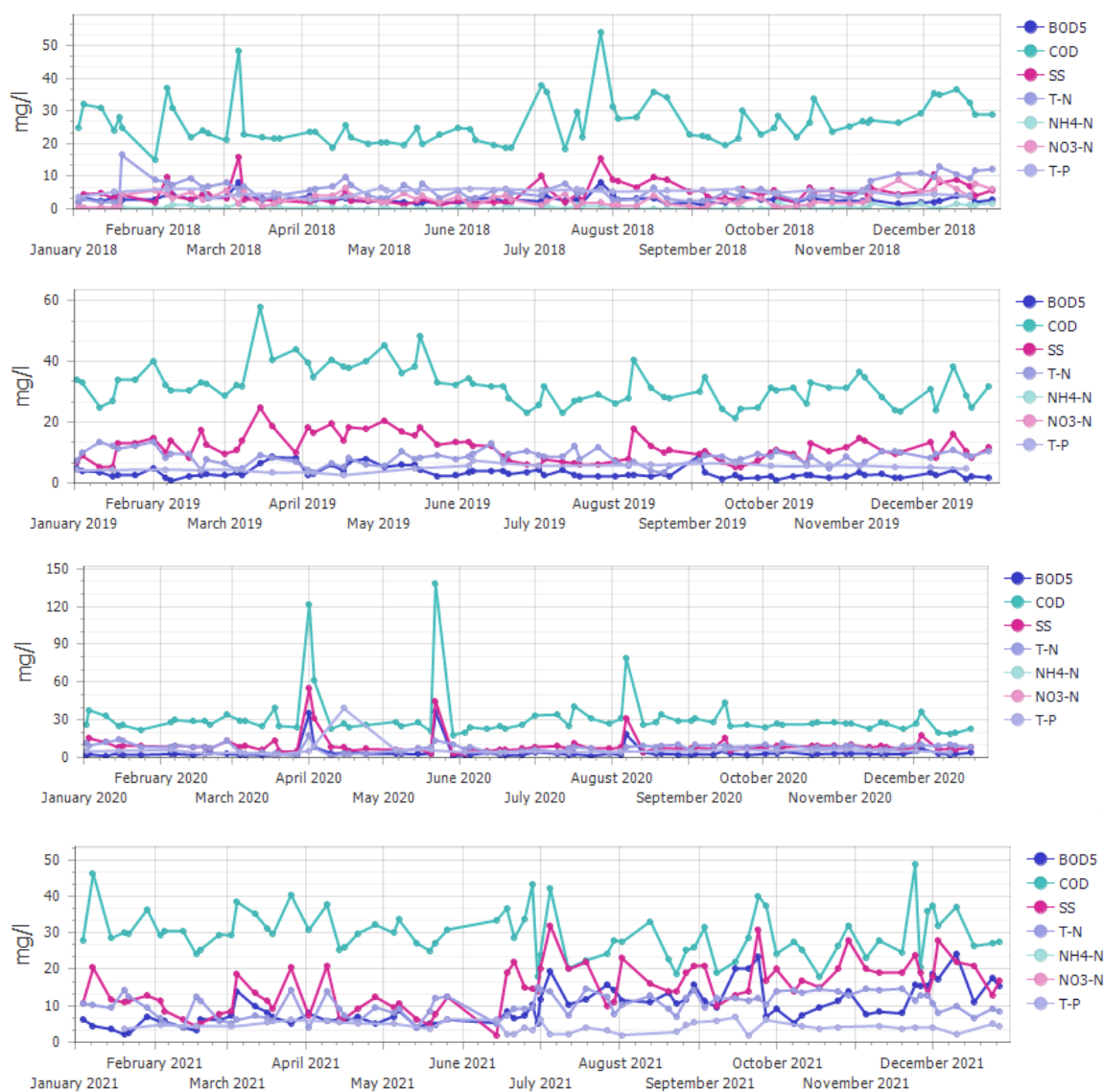


Figure S3 Variation of BOD₅, COD, SS, T-N, NH₄-N, NO₃-N and T-P in the treated effluent of WWTP for 2018-2021 (Data obtained from <http://astikalimata.ypeka.gr/Services/Pages/WtpViewApp.aspx#>)

where,

BOD₅: Biological oxygen demand (in five days)

COD: Chemical oxygen demand

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NH₄-N: Ammonium nitrogen

NO₃-N: Nitrate nitrogen

T-P: Total phosphorus

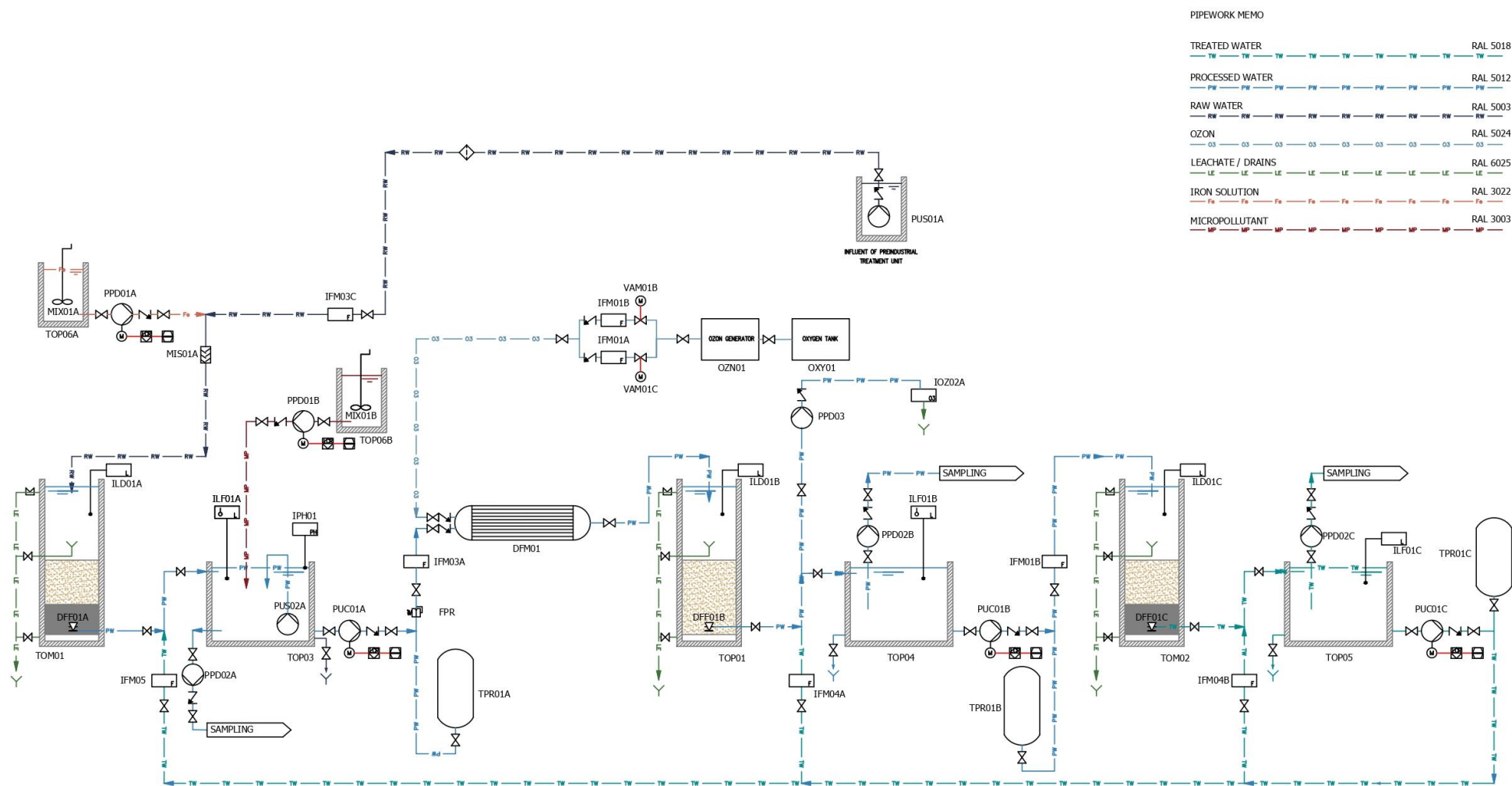
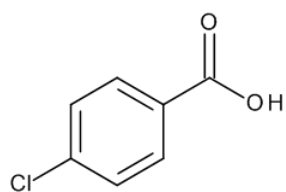


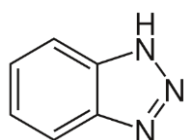
Figure S4 Detailed flowchart of the pre-industrial level unit



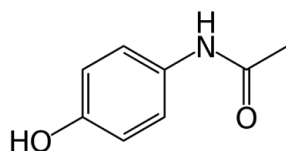
Figure S5 Photograph of the pre-industrial level unit



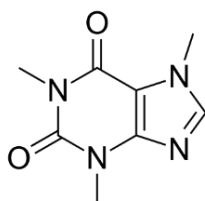
p-Chlorobenzoic acid



Benzotriazole



Paracetamol



Caffeine

Figure S6 Chemical structures of selected micropollutants