Supporting information for:

Elimination of micropollutants during post-treatment of hospital wastewater with powdered activated carbon, ozone and UV

*Lubomira Kovalova[1], Hansruedi Siegrist[1], Urs von Gunten[1,2], Jakob Eugster[1], Martina Hagenbuch[1], Anita Wittmer[1], Ruedi Moser[3], Christa S. McArdell[1]**

[1] Eawag, Swiss Federal Institute of Aquatic Science and Technology, CH-8600 Duebendorf, Switzerland.
[2] School of Architecture, Civil and Environmental Engineering (ENAC), Ecole Polytechnique Fédérale de Lausanne (EPFL), CH-1015, Lausanne, Switzerland.
[3] Hunziker Betatech AG, CH-8411 Winterthur, Switzerland.

*Corresponding author: phone +41 58 765 5483; fax +41 58 765 5311; e-mail christa.mcardell@eawag.ch

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1. Analyzed micropollutants

Table S1. Alphabetical list of analysed micropollutants

Compound	CAS number (supplyer)	Description
4-Acetamidoantipyrine	83-15-8 (S-A)	3rd metabolite of Aminopyrine / Metamizole
4-Aminoantipyrine	83-07-8 (R)	2nd metabolite of Aminopyrine / Metamizole
4-Dimethylaminoantipyrine (Aminopyrine) [1]	58-15-1 (R)	analgesic / antipyretic
4-Formylaminoantipyrine	1672-58-8 (S-A)	4th (final) metabolite of Aminopyrine / Metamizole
4-Methylaminoantipyrine	519-98-2 (H)	active substance of Aminopyrine / Metamizole - analgesic, N02BB02
4/5-Methylbenzotriazole (2 isomers) [2]	136-85-6, 29878-31-7 (S-A)	corrosion inhibitors
Atenolol	29122-68-7 (S-A)	beta blocking agent
Atenolol acid (Metoprolol acid)	56392-14-4 (TRC)	metabolite of Atenolol / Metoprolol
Azithromycin	83905-01-5 (S-A)	macrolide antibacterial
Benzotriazole	95-14-7 (S-A)	corrosion inhibitor
Bezafibrate	41859-67-0 (S-A)	lipid modifying agent
Carbamazepine	298-46-4 (S-A)	antiepileptic
Cilastatin	82009-34-5 (TRC)	enzyme inhibitor (used with Imipenem - antibacterial, J01DH51)
Ciprofloxacin	85721-33-1 (F)	fluoroquinolone antibacterial
Clarithromycin	81103-11-9 (IDC)	macrolide antibacterial
Clindamycin	18323-44-9 (S-A)	lincosamide antibacterial
Clofibric acid	882-09-7 (S-A)	metabolite of Clofibrate - lipid modifying agent, C10AB01
Cyclophosphamide	50-18-0 (S-A)	cytostatic
D617	34245-14-2 (TRC)	metabolite of Verapamil
Dexamethasone	50-02-2 (S-A)	corticosteroid
Diatrizoate (Amidotrizoic, or diatrizoic acid)	117-96-4 (BS)	iodinated X-ray contrast medium
Diazepam	439-14-5 (Ro)	anxiolytic
Diclofenac	15307-86-5 (S-A)	antiinflammatory / antirheumatic
Erythromycin [3]	114-07-8 (S-A)	macrolide antibacterial
Fluconazole	86386-73-4 (E)	antimycotic
Fluoxetine	54910-89-3 (TRC)	antidepressant
Furosemide	54-31-9 (S-A)	diuretic
Gabapentin	60142-96-3 (TRC)	antiepileptic
Hydrochlorothiazide	58-93-5 (S-A)	diuretic
Ifosfamide	3778-73-2 (S-A)	cytostatic
Indometacin	53-86-1 (S-A)	antiinflammatory / antirheumatic
Iohexol	66108-95-0 (F)	iodinated X-ray contrast medium
Iomeprol	78649-41-9 (BG)	iodinated X-ray contrast medium
Iopamidol	62883-00-5 (BG)	iodinated X-ray contrast medium
Iopromide	73334-07-3 (BS)	iodinated X-ray contrast medium
Ioxitalamic acid	28179-44-4 (BG)	iodinated X-ray contrast medium
Levetiracetam	102767-28-2 (TRC)	antiepileptic
Lidocaine	137-58-6 (S-A)	anesthetic, local
Mefenamic acid	61-68-7 (S-A)	antiinflammatory / antirheumatic
Methylprednisolone	83-43-2 (F)	corticosteroid
Metoprolol	37350-58-6 (S-A)	beta blocking agent
Metronidazole	443-48-1 (R)	imidazole antibacterial
Morphine	57-27-2 (L)	analgesic (opioid)
N4-Acetylsulfamethoxazole	21312-10-7 (S-A)	metabolite of Sulfamethoxazole
Naproxen	22204-53-1 (S-A)	antiinflammatory / antirheumatic

[1] 4-Dimethylaminoantipyrine (Aminophenazone, or aminopyrine) is not used in Switzerland due to severe side effects (agranulocytosis)
[2] Methylbenzotriazole measured in this study is a sum of 4-Methylbenzotriazole and 5-Methylbenzotriazole (mixture called Tolyltriazole)
[3] Erythromycin measured in this study is a sum of Erythromycin and Erythromycin-H_2O

table continues

Table S1. Alphabetical list of analyzed micropollutants *(continued)*

Compound	CAS number (supplyer)	Description
Norfloxacin	70458-96-7 (R)	fluoroquinolone antibacterial
Oseltamivir	196618-13-0 (Ro)	antiviral
Oseltamivir carboxylate	187227-45-8 (Ro)	active substance of Oseltamivir
Oxazepam	604-75-1 (L)	anxiolytic
Paracetamol (Acetaminophen)	103-90-2 (S-A)	analgesic / antipyretic
Phenazone (Antipyrine)	60-80-0 (E)	analgesic / antipyretic
Primidone	125-33-7 (S-A)	antiepileptic (barbiturate)
Propranolol	525-66-6 (S-A)	beta blocking agent
Ranitidine	66357-35-5 (S-A)	acid disorders - alimentary system
Ritalinic acid	19395-41-6 (S-A)	metabolite of Methylphenidate (Ritalin) - psychostimulant, N06BA04
Ritonavir	155213-67-5 (TRC)	antiviral
Roxithromycin	80214-83-1 (S-A)	macrolide antibacterial
Sotalol	3930-20-9 (S-A)	beta blocking agent
Sulfadiazine	68-35-9 (S-A)	sulfonamide antibacterial
Sulfamethoxazole	723-46-6 (S-A)	sulfonamide antibacterial
Sulfapyridine	144-83-2 (R)	sulfonamide antibacterial
Thiopental	76-75-5 (TRC)	anesthetic, general (barbiturate)
Tramadol	27203-92-5 (F)	analgesic (opioid)
Trimethoprim	738-70-5 (S-A)	antibacterial
Valsartan	137862-53-4 (TRC)	angiotensin II receptor antagonist
Venlafaxine	93413-69-5 (TRC)	antidepressant
Verapamil	152-11-4 (S-A)	calcium channel blocker

List of supplyers:

(BG)	courtesy of Byk Gulden, Singen, Germany
(BS)	courtesy of Bayer Schering Pharma, Berlin, Germany
(CDN)	CDN Isotopes INC., Pointe-Claire, Canada
(E)	Dr. Ehrenstorfer GmbH, Augsburg, Germany
(F)	Fluka, Sigma-Aldrich, Buchs, Switzerland
(H)	in-house synthesis (hydrolysis of metamizole)
(IDC)	IDC, Abbott Laboratories, Zug, Switzerland
(L)	Lipomed AG, Arlesheim, Switzerland
(R)	Riedel-de Haen Laborchemikalien GmbH & Co., Seelze, Germany
(Ro)	courtesy of F. Hoffmann-La Roche Ltd., Basel, Switzerland
(S-A)	Sigma-Aldrich, Seelze, Germany
(TRC)	Toronto Research Chemicals, North York, Canada

Table S2. Classification of analyzed pharmaceuticals and industrial chemicals

	Compound	ATC code	Description
ANTIINFECTIVES			
Antibacterials	Azithromycin	J01FA10	macrolide antibacterial
	Ciprofloxacin	J01MA02	fluoroquinolone antibacterial
	Clarithromycin	J01FA09	macrolide antibacterial
	Clindamycin	J01FF01	lincosamide antibacterial
	Erythromycin [1]	J01FA01	macrolide antibacterial
	Metronidazole	J01XD01	imidazole antibacterial
	Norfloxacin	J01MA06	fluoroquinolone antibacterial
	Roxithromycin	J01FA06	macrolide antibacterial
	Sulfadiazine	J01EC02	sulfonamide antibacterial
	Sulfamethoxazole	J01EC01	sulfonamide antibacterial
	Sulfapyridine	J01EB04	sulfonamide antibacterial
	Trimethoprim	J01EA01	antibacterial
Antimycotics	Fluconazole	J02AC01	antimycotic
Antivirals	Oseltamivir	J05AH02	antiviral
	Ritonavir	J05AE03	antiviral
Metabolites	N4-Acetylsulfamethoxazole		metabolite of Sulfamethoxazole
	Oseltamivir carboxylate		active substance of Oseltamivir
ANTIINFLAMMATORY PREPARATIONS			
Non-steroidal antiiflamatory	Diclofenac	M01AB05	NSAID / antirheumatic
	Indometacin	M01AB01	NSAID / antirheumatic
	Mefenamic acid	M01AG01	NSAID / antirheumatic
	Naproxen	M01AE02	NSAID / antirheumatic
ANTINEOPLASTICS			
Cytostatics	Cyclophosphamide	L01AA01	cytostatic
	Ifosfamide	L01AA06	cytostatic
CARDIOVASCULAR SYSTEM PREPARATIONS			
Diuretics	Furosemide	C03CA01	diuretic
	Hydrochlorothiazide	C03AA03	diuretic
Beta blocking agents	Atenolol	C07AB03	beta blocking agent
	Metoprolol	C07AB02	beta blocking agent
	Propranolol	C07AA05	beta blocking agent
	Sotalol	C07AA07	beta blocking agent
Calcium channel blocker	Verapamil	C08DA01	calcium channel blocker
Angiotensin II receptor antagonist	Valsartan	C09CA03	angiotensin II receptor antagonist
Lipid modifying agent	Bezafibrate	C10AB02	lipid modifying agent
Metabolites	Atenolol acid (Metoprolol acid)		metabolite of Atenolol / Metoprolol
	Clofibric acid		metabolite of Clofibrate - lipid modifying agent, C10AB01
	D617		metabolite of Verapamil
CONTRAST MEDIA			
X-ray contrast media	Diatrizoate (Diatrizoic acid)	V08AA01	iodinated X-ray contrast medium
	Iohexol	V08AB02	iodinated X-ray contrast medium
	Iomeprol	V08AB10	iodinated X-ray contrast medium
	Iopamidol	V08AB04	iodinated X-ray contrast medium
	Iopromide	V08AB05	iodinated X-ray contrast medium
	Ioxitalamic acid	V08AA05	iodinated X-ray contrast medium

[1] Erythromycin measured in this study is a sum of Erythromycin and Erythromycin-H_2O

table continues

Table S2. Classification of analyzed pharmaceuticals and industrial chemicals *(continued)*

	Compound	ATC code	Description
HORMONAL PREPARATIONS			
	Dexamethasone	H02AB02	corticosteroid
	Methylprednisolone	H02AB04	corticosteroid
NERVOUS SYSTEM PREPARATIONS			
Anesthetics	Lidocaine	N01BB02	anesthetic, local
	Thiopental	N01AF03	anesthetic, general (barbiturate)
Analgesics / antipyretics	4-Dimethylaminoantipyrine [2]	N02BB03	analgesic / antipyretic
	Morphine	N02AA01	analgesic (opioid)
	Paracetamol (Acetaminophen)	N02BE01	analgesic / antipyretic
	Phenazone (Antipyrine)	N02BB01	analgesic / antipyretic
	Tramadol	N02AX02	analgesic (opioid)
Antiepileptics	Carbamazepine	N03AF01	antiepileptic
	Gabapentin	N03AX12	antiepileptic
	Levetiracetam	N03AX14	antiepileptic
	Primidone	N03AA03	antiepileptic (barbiturate)
Psycholeptics	Diazepam	N05BA01	anxiolytic
	Oxazepam	N05BA04	anxiolytic
Psychoanaleptics	Fluoxetine	N06AB03	antidepressant
	Venlafaxine	N06AX16	antidepressant
Metabolites	4-Acetamidoantipyrine		3rd metabolite of Aminopyrine / Metamizole
	4-Aminoantipyrine		2nd metabolite of Aminopyrine / Metamizole
	4-Formylaminoantipyrine		4th (final) metabolite of Aminopyrine / Metamizole
	4-Methylaminoantipyrine		active substance of Aminopyrine / Metamizole - analgesic, N02BB02
	Ritalinic acid		metabolite of Methylphenidate (Ritalin) - psychostimulant, N06BA04
OTHER PHARMACEUTICALS			
	Cilastatin		enzyme inhibitor (used with Imipenem - antibacterial, J01DH51)
	Ranitidine	A02BA02	acid disorders - alimentary system
INDUSTRIAL CHEMICALS			
	Benzotriazole		corrosion inhibitor
	4/5-Methylbenzotriazole (2 isomers) [3]		corrosion inhibitor

[2] 4-Dimethylaminoantipyrine (Aminophenazone, or aminopyrine) is not used in Switzerland due to severe side effects (agranulocytosis)

[3] Methylbenzotriazole measured in this study is a sum of 4-Methylbenzotriazole and 5-Methylbenzotriazole (mixture called Tolyltriazole)

Table S3. Speciation, pK_a, and Log D_{ow} values of analyzed micropollutants (JChem for Excel, ChemAxon)

Compound	Strongest Basic pK_a	Strongest Acidic pK_a	Speciation at pH 1 - 14	Log D_{ow}						
				pH 4	pH 5	pH 6	pH 7	pH 8	pH 9	pH 10
4-Acetamidoantipyrine	(-)	12.52	1	0.15	0.15	0.15	0.15	0.15	0.15	0.15
4-Aminoantipyrine	(-)	(-)	1	0.33	0.33	0.33	0.33	0.33	0.33	0.33
4-Dimethylaminoantipyrine	3.46	(-)	1	1.04	1.14	1.15	1.15	1.15	1.15	1.15
4-Formylaminoantipyrine	(-)	12.66	1	0.11	0.11	0.11	0.11	0.11	0.11	0.10
4-Methylaminoantipyrine	1.22	(-)	1	0.77	0.77	0.77	0.77	0.77	0.77	0.77
4/5-Methylbenzotriazole	1.01	8.86	1	1.81	1.81	1.81	1.81	1.76	1.45	0.77
Atenolol	9.67	14.08	1	-2.82	-2.80	-2.68	-2.14	-1.24	-0.33	0.26
Atenolol acid	9.67	3.54	1	-2.59	-3.42	-4.05	-4.17	-3.80	-3.03	-2.46
Azithromycin	9.57	12.43	1	-4.54	-4.41	-3.64	-1.99	-0.08	1.55	2.29
Benzotriazole	0.58	8.63	1	1.30	1.30	1.30	1.29	1.21	0.80	0.11
Bezafibrate	(-)	3.83	1	3.59	2.79	1.83	0.97	0.55	0.47	0.46
Carbamazepine	(-)	(-)	1	2.77	2.77	2.77	2.77	2.77	2.77	2.77
Cilastatin	9.14	2.53	1	-1.44	-2.00	-2.91	-3.86	-4.58	-4.99	-5.53
Ciprofloxacin	8.68	5.76	1	-1.68	-1.62	-1.46	-1.38	-1.43	-1.68	-1.92
Clarithromycin	8.38	12.46	1	-0.21	0.10	0.89	1.84	2.71	3.15	3.23
Clindamycin	7.55	12.16	1	-2.19	-1.47	-0.52	0.38	0.91	1.02	1.03
Clofibric acid	(-)	3.37	1	2.18	1.27	0.32	-0.38	-0.60	-0.63	-0.63
Cyclophosphamide	(-)	12.78	1	0.10	0.10	0.10	0.10	0.10	0.10	0.10
D617	10.54	(-)	1	-0.28	-0.28	-0.26	-0.10	0.50	1.42	2.31
Dexamethasone	(-)	12.42	1	1.68	1.68	1.68	1.68	1.68	1.68	1.68
Diatrizoate	(-)	2.17	1	-1.54	-2.46	-3.06	-3.22	-3.23	-3.24	-3.24
Diazepam	2.92	(-)	1	3.04	3.07	3.08	3.08	3.08	3.08	3.08
Diclofenac	(-)	4.00	1	3.96	3.21	2.26	1.37	0.85	0.74	0.73
Erythromycin	8.38	12.44	1	-0.85	-0.54	0.25	1.20	2.06	2.50	2.58
Fluconazole	2.56	12.71	1	0.55	0.56	0.56	0.56	0.56	0.56	0.56
Fluoxetine	9.80	(-)	1	0.93	0.94	1.04	1.50	2.38	3.31	3.96
Furosemide	(-)	4.25	1	1.56	0.93	0.00	-0.93	-1.58	-1.81	-2.10
Gabapentin	9.91	4.63	1	-1.88	-1.61	-1.52	-1.51	-1.51	-1.55	-1.80
Hydrochlorothiazide	(-)	9.09	1	-0.58	-0.58	-0.58	-0.58	-0.61	-0.82	-1.60
Ifosfamide	(-)	12.39	1	0.10	0.10	0.10	0.10	0.10	0.10	0.09
Indometacin	(-)	3.80	1	3.12	2.31	1.35	0.50	0.08	0.01	0.00
Iohexol	(-)	11.73	1	-1.95	-1.95	-1.95	-1.95	-1.95	-1.95	-1.96
Iomeprol	(-)	11.73	1	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45	-1.45
Iopamidol	(-)	11.00	1	-2.04	-2.04	-2.04	-2.04	-2.04	-2.05	-2.08
Iopromide	(-)	11.09	1	-1.74	-1.74	-1.74	-1.74	-1.75	-1.75	-1.78
Ioxitalamic acid	(-)	2.13	1	-1.12	-2.04	-2.63	-2.77	-2.79	-2.79	-2.79
Levetiracetam	(-)	(-)	1	-0.59	-0.59	-0.59	-0.59	-0.59	-0.59	-0.59
Lidocaine	7.75	13.78	1	-1.77	-1.14	-0.21	0.72	1.35	1.52	1.54
Mefenamic acid	(-)	3.89	1	5.04	4.25	3.30	2.42	1.97	1.88	1.87
Methylprednisolone	(-)	12.58	1	1.56	1.56	1.56	1.56	1.56	1.56	1.56
Metoprolol	9.67	14.09	1	-1.48	-1.47	-1.34	-0.81	0.09	1.01	1.59
Metronidazole	3.09	(-)	1	-0.51	-0.46	-0.46	-0.46	-0.46	-0.46	-0.46
Morphine	9.12	10.26	1	-2.30	-2.23	-1.83	-0.99	-0.03	0.74	0.89
N4-Acetylsulfamethoxazole	0.38	5.88	1	0.85	0.81	0.55	0.10	-0.06	-0.08	-0.09
Naproxen	(-)	4.19	1	2.77	2.11	1.18	0.25	-0.36	-0.52	-0.54
Norfloxacin	8.68	5.77	1	-1.79	-1.73	-1.56	-1.48	-1.52	-1.78	-2.03

LEGEND:

1 cationic at pH 1 | 6 zwitterionic at pH 6 | 14 anionic at pH 14

table continues

Table S3 Speciation, pKa, and Log Dow values of analyzed micropollutants *(continued)*

Compound	Strongest Basic pK_a	Strongest Acidic pK_a	Speciation at pH 1 - 14	Log D_{ow}						
				pH 4	pH 5	pH 6	pH 7	pH 8	pH 9	pH 10
Oseltamivir	9.31	14.03	1	-1.87	-1.85	-1.69	-1.07	-0.16	0.68	1.08
Oseltamivir carboxylate	9.33	4.38	1	-2.37	-2.13	-2.08	-2.07	-2.09	-2.22	-2.66
Oxazepam	(-)	10.61	1	2.92	2.92	2.92	2.92	2.92	2.91	2.83
Paracetamol	(-)	9.46	1	0.91	0.91	0.91	0.91	0.89	0.78	0.27
Phenazone	(-)	(-)	1	1.22	1.22	1.22	1.22	1.22	1.22	1.22
Primidone	(-)	11.50	1	1.12	1.12	1.12	1.12	1.12	1.12	1.11
Propranolol	9.67	14.09	1	-0.66	-0.64	-0.52	0.02	0.92	1.83	2.42
Ranitidine	8.08	(-)	1	-2.46	-1.96	-1.09	-0.13	0.64	0.93	0.98
Ritalinic acid	10.08	3.73	1	-0.63	-0.51	-0.49	-0.49	-0.50	-0.52	-0.71
Ritonavir	2.84	13.68	1	5.20	5.22	5.22	5.22	5.22	5.22	5.22
Roxithromycin	9.08	12.45	1	-0.50	-0.40	0.06	0.93	1.89	2.66	2.95
Sotalol	9.43	10.07	1	-3.19	-3.18	-3.04	-2.48	-1.58	-0.71	-0.41
Sulfadiazine	2.01	6.99	1	0.38	0.38	0.35	0.13	-0.33	-0.52	-0.55
Sulfamethoxazole	1.97	6.16	1	0.78	0.76	0.60	0.14	-0.11	-0.15	-0.15
Sulfapyridine	2.63	8.52	1	0.99	1.01	1.01	1.00	0.91	0.53	0.16
Thiopental	(-)	7.85	1	2.77	2.77	2.77	2.72	2.43	1.90	1.67
Tramadol	9.23	13.80	1	-1.04	-0.98	-0.59	0.24	1.20	2.02	2.38
Trimethoprim	7.16	(-)	1	-0.18	-0.11	0.27	0.92	1.23	1.28	1.28
Valsartan	(-)	4.28	1	4.31	3.49	1.92	0.46	-0.36	-0.60	-0.63
Venlafaxine	8.91	14.42	1	-0.75	-0.62	-0.07	0.84	1.78	2.48	2.70
Verapamil	9.68	(-)	1	1.54	1.57	1.76	2.42	3.36	4.28	4.87

LEGEND:

1 cationic at pH 1

6 zwitterionic at pH 6

14 anionic at pH 14

Table S4. Analytical quality control and limits of quantification (for more details on analytics, see [1])

Expanded uncertainty at 95% confidence interval	Quality control (QC) label	Number of analytes
Uncertainty less than 14%	**a** (best)	**23**
Uncertainty 15 – 29%	**b** (good)	**20**
Uncertainty 30 – 100%	**c** (high uncertainty)	**20**
Uncertainty above 100%	**d** (semiquantitative)	**5**

	Matching internal standard	QC label	Estimated limits of quantification – LOQ (ng/L)						
			Nanopure water	Effluent of MBR and UV			PAC effluent		O_3 effluent	
				no dilution	dilution 1:10	dilution 1:100	no dilution	dilution 1:10	no dilution	dilution 1:10
4-Acetamidoantipyrine	-	c	1		50	220		33	3	17
4-Aminoantipyrine	-	d	250		1800	18000		3000	140	2400
4-Dimethylaminoantipyrine	-	c	50	7	200	2900	200	2700	8	290
4-Formylaminoantipyrine	-	c	1		21	200		27	2	15
4-Methylaminoantipyrine	-	d	500		4100	19000		500	240	2000
4/5-Methylbenzotriazole (2 isomers)	- *	d	5		1000	480		76		300
Atenolol	yes	a	10	3	58	770	3	76	2	64
Atenolol acid	yes	a	5		25	300	2	31	1	27
Azithromycin	yes	b	5	9	40	1800	13	190	28	150
Benzotriazole	yes	b	50		630	5800		860		630
Bezafibrate	yes	a	1	2	12	120	1	13	1	13
Carbamazepine	yes	b	1	2	16	160	2	18	2	13
Cilastatin	-	c	25	6	90	1100	8	120	7	110
Ciprofloxacin	yes	c	50		300	3100	18	220	16	150
Clarithromycin	-	a	1	2	24	280	2	33	3	26
Clindamycin	-	c	5		51	690	3	73	2	56
Clofibric acid	yes	b	5	8	46	450	8	56	14	49
Cyclophosphamide	yes	a	5	11	90	930	11	110	9	83
D617	-	b	1	2	27	340	2	33	2	24
Dexamethasone	-	a	5	17	86	840	15	95	13	84
Diatrizoate	yes	c	250		5000			3000		3000
Diazepam	yes	a	1	2	15	160	2	18	2	15
Diclofenac	yes	b	1	3	12	120	3	15	2	15
Erythromycin	yes	c	5	8	160	2000	12	210	8	91
Erythromycin-H2O	-	c	5	28	140	3300	17	220	33	230
Fluconazole	yes	a	5		48	500	6	59		46
Fluoxetine	yes	b	1	2	23	270	3	31	2	21
Furosemide	yes	b	5		43	450	4	48	4	47
Gabapentin	yes	b	250		950	11000	100	1100		2000
Hydrochlorothiazide	yes	a	5		45	400	12	50	13	53
Ifosfamide	-	b	1	3	18	200	3	23	2	16
Indometacin	yes	a	1	3	13	130	3	15	3	17
Iohexol	yes	c	100	170	980	10000	160	1400	150	1200
Iomeprol	yes	d	100		14000	10000		10000		960
Iopamidol	yes +	d	250			10000		2000		2000
Iopromide	yes	c	100		7000	4500		3000		3000
Ioxitalamic acid	yes	c	250		5000			3000		3000
Levetiracetam	yes	a	10	24	180	1800	23	210	42	300
Lidocaine	yes	a	5		64	760	5	82	3	64
Mefenamic acid	yes	a	1	1	9	97	2	11	2	13
Methylprednisolone	yes	a	5	15	79	800	11	88	11	84
Metoprolol	yes	a	25	15	260	3300	18	340	14	260
Metronidazole	-	c	25		190	2000	23	220	30	230
Morphine	yes	b	25	6	140	1600	3000	450	7	180
N4-Acetylsulfamethoxazole	yes	a	1	2	14	140	2	16	1	11
Naproxen	yes +	c	100	680	3400	46000	680	4600	860	5800
Norfloxacin	yes +	c	500		1200	27000	150	1800	150	1200

table continues

Table S4. Analytical quality control and limits of quantification *(continued)*

	Matching internal standard	QC label	Estimated limits of quantification – LOQ (ng/L)						
			Nanopure water	Effluent of MBR and UV			PAC effluent		O_3 effluent	
				no dilution	dilution 1:10	dilution 1:100	no dilution	dilution 1:10	no dilution	dilution 1:10
Oseltamivir	yes	c	5	3	10	710	3	73	3	57
Oseltamivir carboxylate	-	b	25	1	15	200	1	18	1	19
Oxazepam	yes	a	1	1	10	95	1	11	1	10
Paracetamol	yes	b	50	130	790	7100	220	1000	120	780
Phenazone	yes	c	5	9	66	660	10	86	8	58
Primidone	yes	b	5	9	57	600	10	68	8	54
Propranolol	yes	b	5	8	13	160	10	170	8	130
Ranitidine	yes	b	10	3	49	670	3	61	2	52
Ritalinic acid	yes	b	5	1	16	190	1	20	1	17
Ritonavir	yes	b	1	3	21	230	3	26	3	18
Roxithromycin	-	b	1	1	60	250	2	41	3	33
Sotalol	yes	a	25	7	140	1800	7	190	5	150
Sulfadiazine	yes	a	1	2	16	140	2	20	2	13
Sulfamethoxazole	yes	a	5		77	770		100	8	60
Sulfapyridine	- *	c	5	10	73	730	9	94	7	66
Thiopental	-	c	5	22	67	530	22	84	28	71
Tramadol	yes	a	5	3	47	550	3	58	3	47
Trimethoprim	yes	c	25	14	230	2400	16	290	13	250
Valsartan	yes	b	1	1	11	120	1	13	1	11
Venlafaxin	yes	a	5	7	99	1200	7	120	6	100
Verapamil	yes	a	5	5	16	180	5	15	5	16

LEGEND:

* internal standard (IS) later during the study available, uncertainty with IS was not determined

+ low intensity of IS, low sensitivity

black LOQ: dilution factor used for quantification

grey LOQ: dilution factor rarely used for quantification

Table S5. List of measured analytes not detected in the MBR effluent

	Not detected in the MBR influent /effluent	Removed in the MBR
4-Dimethylaminoantipyrine	not detected	-
Cilastatin	-	yes
Clofibric acid	not detected	-
Dexamethasone	not detected	-
Diazepam	not detected	-
Fluoxetine	not detected	-
Iohexol	not detected	-
Methylprednisolone	not detected	-
Naproxen	not detected	-
Paracetamol	-	yes
Roxithromycin	not detected	-

Table S6. Structures, formulas, Log K_{ow}, and estimation of ozone reactivity of analyzed micropollutants at pH 8-8.5. Log K_{ow} and pK_a values estimated by JChem for Excel, ChemAxon. O_3 reactivity estimated based on the molecular structure as described by von Sontag and von Gunten.[2]

Reactivity: → high ● → intermediate ● - - - → low ●

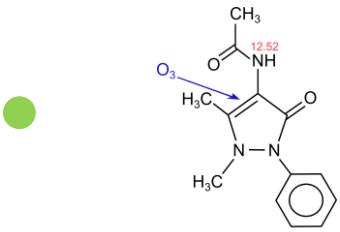
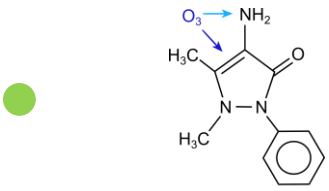
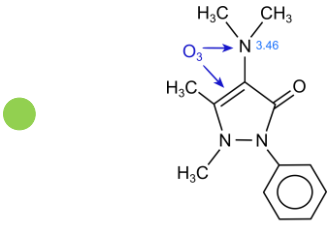
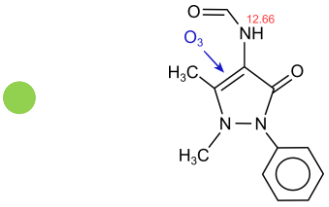
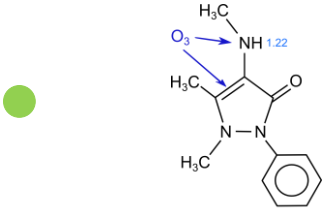
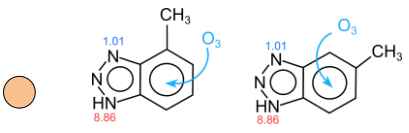
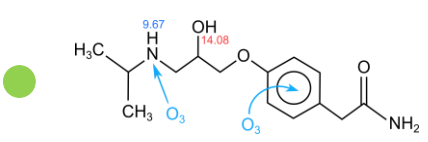
Compound	Structure / O_3 reactivity estimation / pK_a (red acidic, blue basic)	Formula	Smile	Log K_{ow} (uncharged)	O_3 reactivity estimation
4-Acetamidoantipyrine		C13H15N3O2	CC(=O)NC=2C(=O)N(c1ccccc1)N(C)C=2C	0.15	HIGH (olefin)
4-Aminoantipyrine		C11H13N3O1	c(ccc1N(N(C=2C)C)C(=O)C2N)cc1	0.33	HIGH (olefin, primary amine)
4-Dimethylaminoantipyrine (Aminopyrine)		C13H17N3O	c(ccc1N(N(C=2C)C)C(=O)C2N(C)C)cc1	1.15	HIGH (olefin, tertiary amine)
4-Formylaminoantipyrine		C12H13N3O2	O=C2C(\NC=O)=C(\C)N(C)N2c1ccccc1	0.11	HIGH (olefin)
4-Methylaminoantipyrine		C12H15N3O	CNC1=C(C)N(C)N(C1=O)C2=CC=CC=C2	0.77	HIGH (olefin, secondary amine)
4-Methylbenzotriazole 5-Methylbenzotriazole		C7H7N3	Cc1cccc2[nH]nnc12 Cc1ccc2[nH]nnc2c1	1.81	INTERMEDIATE (benzene derivative)
Atenolol		C14H22N2O3	CC(C)NCC(O)COc1ccc(cc1)CC(N)=O	0.43	HIGH (protonated sec. amine, benzene derivative)

table continues

Table S6. Structures, formulas, Log K_{ow}, and estimation of ozone reactivity *(continued)*

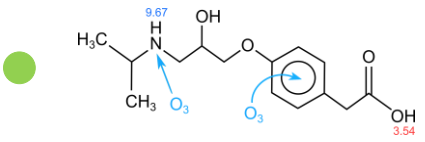
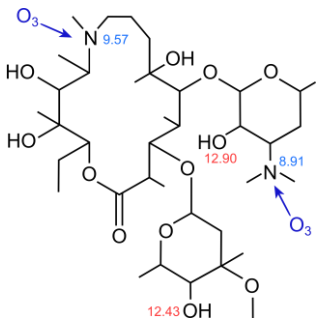
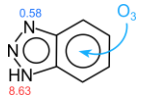
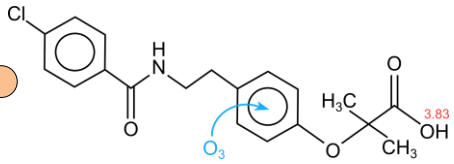
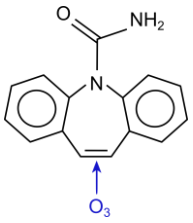
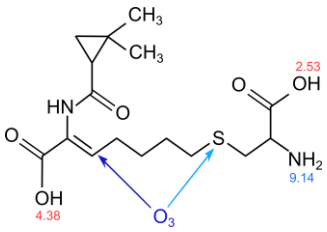
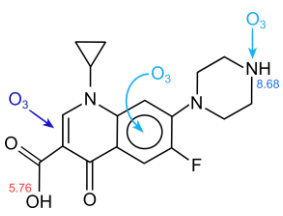
Compound	Structure / O_3 reactivity estimation / pK_a (red acidic, blue basic)	Formula	Smile	Log K_{ow} (uncharged)	O_3 reactivity estimation
Atenolol acid (Metoprolol acid)		C14H21N1O4	CC(C)NCC(O)COc1ccc(cc1)CC(=O)O	-4.17	HIGH (protonated sec. amine, benzene derivative)
Azithromycin		C38H72N2O12	CC[C@H]1OC(=O)[C@H](C)[C@@H](O[C@H]2C[C@@](C)(OC)[C@@H](O)[C@H](C)O2)C(C)[C@@H](O[C@@H]3O[C@H](C)C[C@@H]([C@H]3O)N(C)C)[C@](C)(O)C[C@@H](C)CN(C)[C@H](C)[C@@H](O)[C@]1(C)O	2.44	HIGH (2x tertiary amine, both protonated)
Benzotriazole		C6H5N3	c12c(nn[nH]1)cccc2	1.30	INTERMEDIATE (benzene derivative)
Bezafibrate		C19H20ClNO4	c1(C(NCCc2ccc(OC(C(O)=O)(C)C)cc2)=O)ccc(Cl)cc1	3.99	INTERMEDIATE (benzene derivative)
Carbamazepine		C15H12N2O	N1(c2c(cccc2)C=Cc2c1cccc2)C(N)=O	2.77	HIGH (olefin)
Cilastatin		C16H26N2O5S	[H][C@](N)(CSCCCC\C=C(/NC(=O)[C@@]1([H])CC1(C)C)C(O)=O)C(O)=O	-1.39	HIGH (olefin, thioether)
Ciprofloxacin		C17H18F1N3O3	C(C1)C1N(C=C(C(=O)C2=O)C(=O)O)-c(cc(c3F)N(CCN4)CC4)c2c3	-1.38	HIGH (olefin, protonated secondary amine, aniline type)

table continues

Table S6. Structures, formulas, Log K_{ow}, and estimation of ozone reactivity *(continued)*

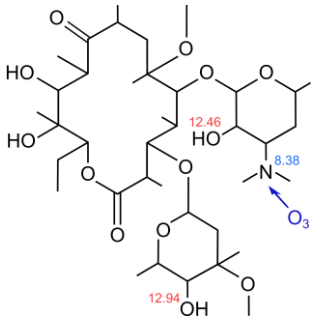
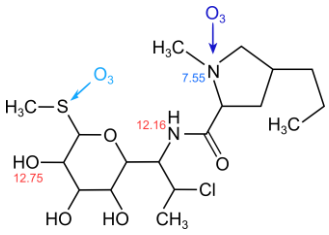
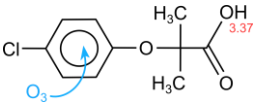
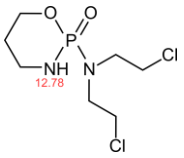
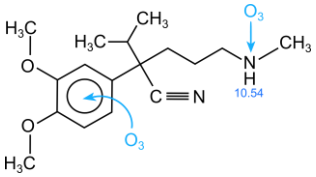
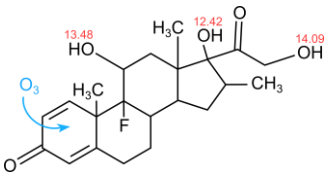
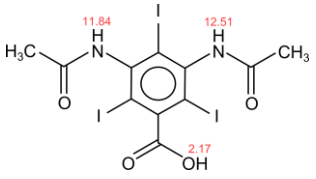
Compound	Structure / O_3 reactivity estimation / pK_a (red acidic, blue basic)	Formula	Smile	Log K_{ow} (uncharged)	O_3 reactivity estimation
Clarithromycin		C38H69NO13	CC[C@H]1OC(=O)[C@H](C)[C@@H](OC2CC(C)(OC)C(O)C(C)O2)[C@H](C)[C@@H](OC3OC(C)CC(C3O)N(C)C)[C@@](C)(C[C@@H](C)C(=O)[C@H](C)[C@@H](O)[C@]1(C)O)OC	3.24	HIGH (tertiary amine)
Clindamycin		C18H33ClN2O5S1	S(C)C(OC(C1O)C(NC(=O)C(N(C)C2)CC2CCC)C(Cl)C)C(O)C1O	1.04	HIGH (tertiary amine, thioether)
Clofibric acid		C10H11ClO3	CC(C)(OC1=CC=C(Cl)C=C1)C(O)=O	2.90	INTERMEDIATE (deactivated benzene derivative)
Cyclophosphamide		C7H15Cl2N2O2P	ClCCN(CCCl)P1(=O)NCCCO1	0.10	LOW-NONE
D617		C17H26N2O2	CNCCC[C@@](C#N)(C(C)C)c1ccc(OC)c(OC)c1	2.96	HIGH (anisole, protonated secondary amine)
Dexamethasone		C22H29FO5	[H][C@@]12C[C@@H](C)[C@](O)(C(=O)CO)[C@@]1(C)C[C@H](O)[C@@]3(F)[C@@]2([H])CCC4=CC(=O)C=C[C@]34C	1.68	INTERMEDIATE (quinone type)
Diatrizoate		C11H9I3N2O4	CC(=O)NC1=C(I)C(C(O)=O)=C(I)C(NC(C)=O)=C1I	0.29	LOW-NONE

table continues

Table S6. Structures, formulas, Log K_{ow}, and estimation of ozone reactivity *(continued)*

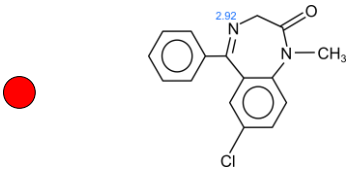
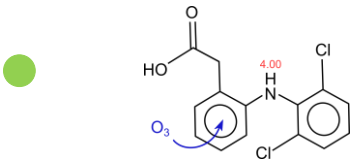
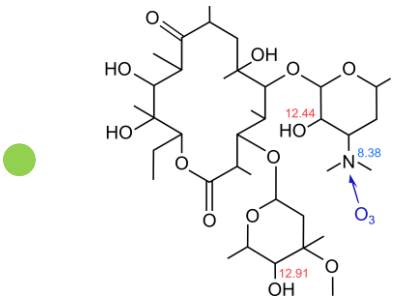
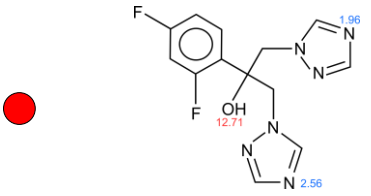
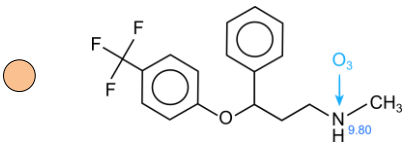
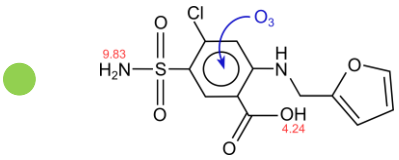
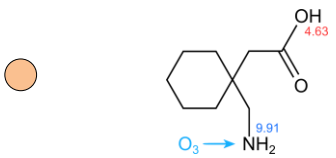
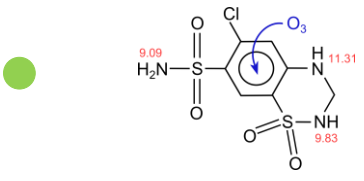
Compound	Structure / O_3 reactivity estimation / pK_a (red acidic, blue basic)	Formula	Smile	Log K_{ow} (uncharged)	O_3 reactivity estimation
Diazepam		C16H13ClN2O	CN1C2=C(C=C(Cl)C=C2)C(=NCC1=O)C3=CC=CC=C3	3.08	LOW-NONE
Diclofenac		C14H11Cl2N1O2	c1c(c(ccc1)Nc1c(cccc1Cl)Cl)CC(=O)O	4.26	HIGH (aniline type)
Erythromycin [1]		C37H67NO13	O(C(C(O)C1(OC)C)C)C(C1)OC(C(C(=O)OC(C(O)(C(O)C2C)C)CC)C)C(C)C(C(O)(CC(C2=O)C)C)OC(OC(C3)C)C(O)C3N(C)C	2.60	HIGH (tertiary amine)
Fluconazole		C13H12F2N6O	OC(CN1C=NC=N1)(CN2C=NC=N2)C3=C(F)C=C(F)C=C3	0.56	LOW-NONE
Fluoxetine		C17H18F3NO	c1([C@@H](Oc2ccc(C(F)(F)F)cc2)CCNC)ccccc1	4.17	INTERMEDIATE (protonated secondary amine)
Furosemide		C12H11ClN2O5S	NS(=O)(=O)C1=CC(C(O)=O)=C(NCC2=CC=CO2)C=C1Cl	1.75	HIGH (aniline type)
Gabapentin		C9H17NO2	NCC1(CC(O)=O)CCCCC1	-1.51	INTERMEDIATE (protonated primary amine)
Hydrochlorothiazide		C7H8ClN3O4S2	NS(=O)(=O)C1=CC2=C(NCNS2(=O)=O)C=C1Cl	-0.58	HIGH (aniline type)

table continues

Table S6. Structures, formulas, Log K_{ow}, and estimation of ozone reactivity *(continued)*

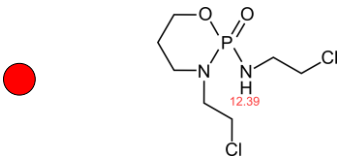
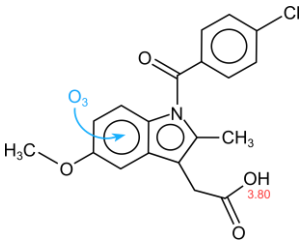
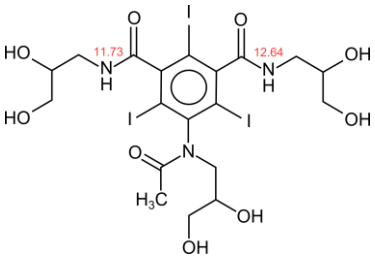
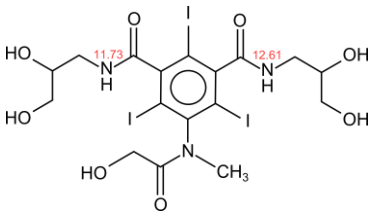
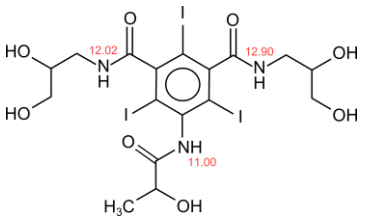
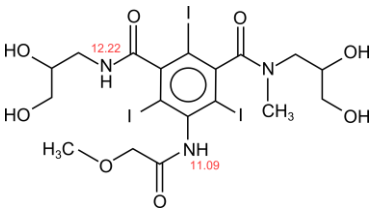
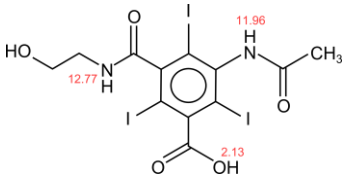
Compound	Structure / O_3 reactivity estimation / pK_a (red acidic, blue basic)	Formula	Smile	Log K_{ow} (uncharged)	O_3 reactivity estimation
Ifosfamide		C7H15Cl2N2O2P	ClCCN(P(OC1)(=O)NCCCl)CC1	0.10	LOW-NONE
Indometacin		C19H16ClNO4	COC1=CC2=C(C=C1)N(C(=O)C3=CC=C(Cl)C=C3)C(C)=C2CC(O)=O	3.53	INTERMEDIATE (anisole)
Iohexol		C19H26I3N3O9	OCC(O)CNC(=O)c1c(I)c(N(CC(O)CO)C(C)=O)c(I)c(c1I)C(=O)NCC(O)CO	-1.95	LOW-NONE
Iomeprol		C17H22I3N3O8	Ic1c(c(I)c(c(I)c1N(C)C(=O)CO)C(=O)NCC(O)CO)C(=O)NCC(O)CO	-1.45	LOW-NONE
Iopamidol		C17H22I3N3O8	CC(O)C(=O)NC1=C(I)C(C(=O)NC(CO)CO)=C(I)C(C(=O)NC(CO)CO)=C1I	-2.04	LOW-NONE
Iopromide		C18H24I3N3O8	c1(c(c(c(I)c(c1I)NC(COC)=O)C(NC[C@@H](CO)O)=O)I)C(N(C[C@@H](CO)O)C)=O	-1.74	LOW-NONE
Ioxitalamic acid		C12H11I3N2O5	CC(=O)NC1=C(I)C(C(O)=O)=C(I)C(C(=O)NCCO)=C1I	0.74	LOW-NONE

table continues

Table S6. Structures, formulas, Log K_{ow}, and estimation of ozone reactivity *(continued)*

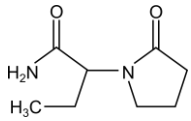
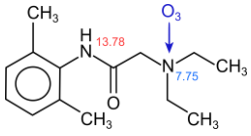
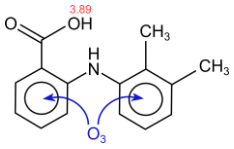
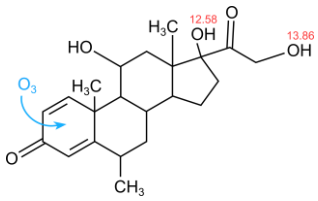
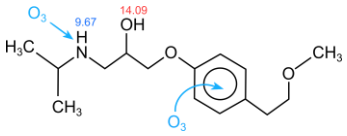
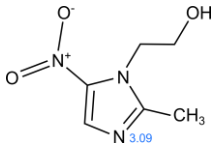
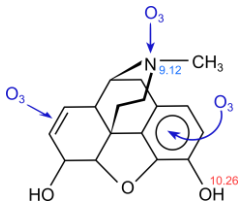
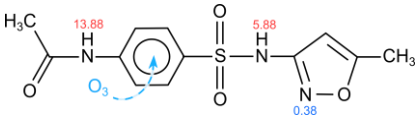
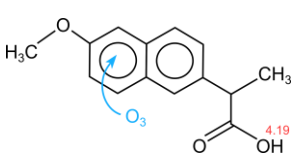
Compound	Structure / O_3 reactivity estimation / pK_a (red acidic, blue basic)	Formula	Smile	Log K_{ow} (uncharged)	O_3 reactivity estimation
Levetiracetam		C8H14N2O2	[H]C(CC)(N1CCCC1=O)C(N)=O	-0.59	LOW-NONE
Lidocaine		C14H22N2O	CCN(CC)CC(=O)NC1=C(C)C=CC=C1C	1.54	HIGH (tertiary amine)
Mefenamic acid		C15H15N1O2	c1(c(cccc1)C(O)=O)Nc1c(c(ccc1)C)C	5.40	HIGH (2x aniline type)
Methylprednisolone		C22H30O5	[H][C@@]12CC[C@](O)(C(=O)CO)[C@@]1(C)C[C@H](O)[C@@]3([H])[C@@]2([H])C[C@]([H])(C)C4=CC(=O)C=C[C@]34C	1.56	INTERMEDIATE (quinone type)
Metoprolol		C15H25NO3	COCCC1=CC=C(OCC(O)CNC(C)C)C=C1	1.76	HIGH (protonated sec. amine, benzene derivative)
Metronidazole		C6H9N3O3	CC1=NC=C(N1CCO)[N+]([O-])=O	-0.46	LOW-NONE
Morphine		C17H19NO3	c12[C@]34[C@@H]5[C@H]([N@](C)CC4)Cc2ccc(c1O[C@H]3[C@@H](O)C=C5)O	0.89	HIGH (olefin, phenol, protonated tertiary amine)
N4-Acetylsulfamethoxazole		C12H13N3O4S	c1(ccc(cc1)NC(C)=O)S(Nc1cc(C)on1)(=O)=O	0.86	LOW (N-phenyl amide)
Naproxen		C14H14O3	c12c(cc(OC)cc2)ccc(c1)[C@@H](C(O)=O)C	2.99	INTERMEDIATE (naphtalene)

table continues

Table S6. Structures, formulas, Log K_{ow}, and estimation of ozone reactivity *(continued)*

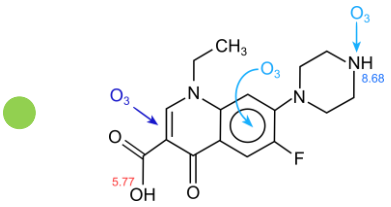
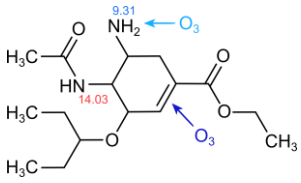
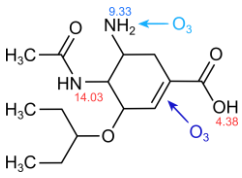
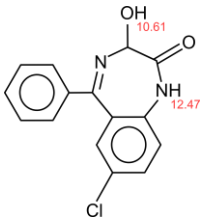
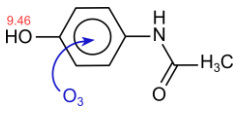
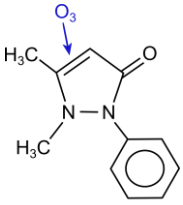
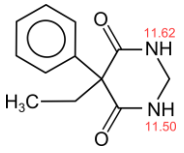
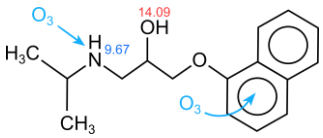
Compound	Structure / O_3 reactivity estimation / pK_a (red acidic, blue basic)	Formula	Smile	Log K_{ow} (uncharged)	O_3 reactivity estimation
Norfloxacin		C16H18F1N3O3	CCN1C=C(C(O)=O)C(=O)C2=CC(F)=C(C=C12)N3CCNCC3	-1.48	HIGH (olefin, protonated secondary amine, aniline type)
Oseltamivir		C16H28N2O4	CCOC(=O)C1=CC(OC(CC)CC)C(NC(C)=O)C(N)C1	1.16	HIGH (olefin, protonated primary amine)
Oseltamivir carboxylate		C14H24N2O4	CCC(CC)OC1C=C(CC(N)C1NC(C)=O)C(O)=O	-2.07	HIGH (olefin, protonated primary amine)
Oxazepam		C15H11ClN2O2	c12C(c3ccccc3)=N[C@@H](O)C(Nc1ccc(c2)Cl)=O	2.92	LOW-NONE
Paracetamol (Acetaminophen)		C8H9N1O2	CC(=O)NC1=CC=C(O)C=C1	0.91	HIGH (phenol)
Phenazone (Antipyrine)		C11H12N2O	CN1N(C(=O)C=C1C)C2=CC=CC=C2	1.22	HIGH (olefin)
Primidone		C12H14N2O2	c1(ccccc1)C2(C(=O)NCNC2=O)CC	1.12	LOW-NONE
Propranolol		C16H21NO2	c12c(OC[C@@H](CNC(C)C)O)cccc1cccc2	2.58	HIGH (protonated sec. amine, naphtalene)

table continues

Table S6. Structures, formulas, Log K_{ow}, and estimation of ozone reactivity *(continued)*

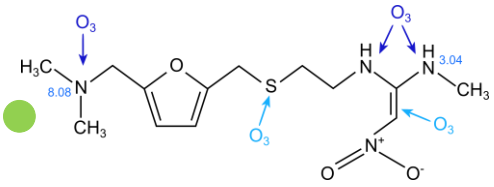
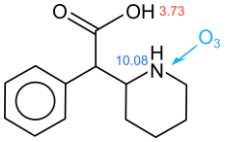
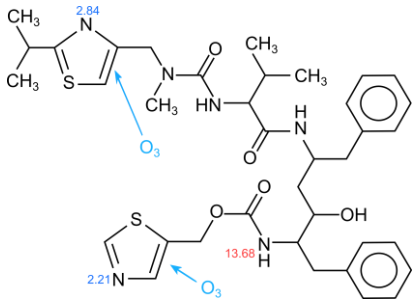
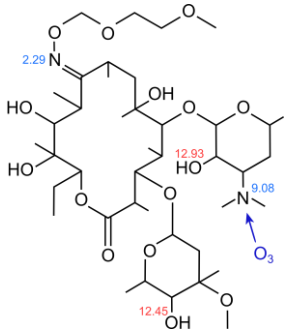
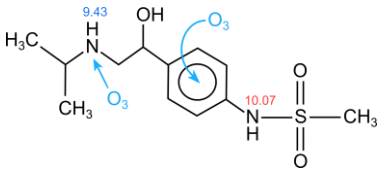
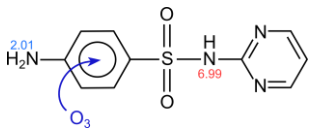
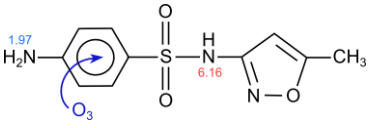
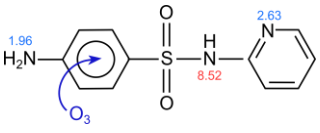
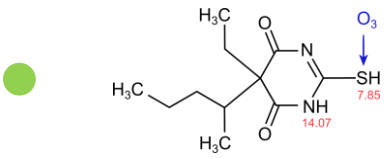
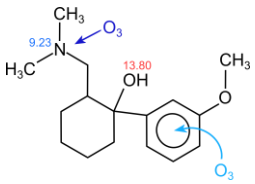
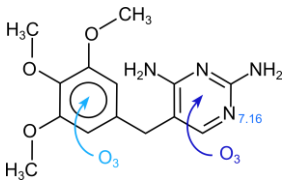
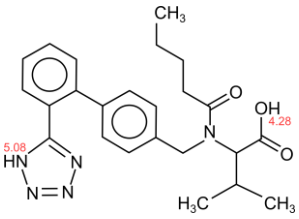
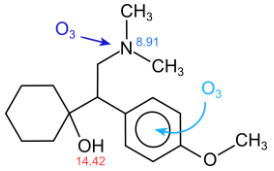
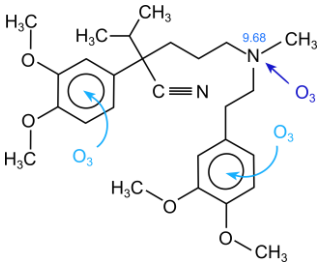
Compound	Structure / O_3 reactivity estimation / pK_a (red acidic, blue basic)	Formula	Smile	Log K_{ow} (uncharged)	O_3 reactivity estimation
Ranitidine		C13H22N4O3S	CN\C(NCCSCC1=CC=C(CN(C)C)O1)=C/[N+]([O-])=O	0.98	HIGH (tertiary and secondary amines, thioether, olefin)
Ritalinic acid		C13H17NO2	c(ccc1C(C(=O)O)C(NCC2)CC2)cc1	-0.49	INTERMEDIATE (protonated secondary amine)
Ritonavir		C37H48N6O5S2	CC(C)C(NC(=O)N(C)CC1=CSC(=N1)C(C)C)C(=O)N[C@H](CC(O)[C@H](CC2=CC=CC=C2)NC(=O)OCC3=CN=CS3)CC4=CC=CC=C4	5.22	INTERMEDIATE
Roxithromycin		C41H76N2O15	CC[C@H]1OC(=O)[C@H](C)[C@@H](OC2CC(C)(OC)C(O)C(C)O2)[C@H](C)[C@@H](OC2OC(C)CC(C2O)N(C)C)[C@](C)(O)C[C@@H](C)\C(=N/OCOCCOC)[C@H](C)[C@@H](O)[C@]1(C)O	3.00	HIGH (protonated tertiary amine)
Sotalol		C12H20N2O3S	c1([C@@H](CNC(C)C)O)ccc(NS(C)(=O)=O)cc1	-0.41	INTERMEDIATE (deactivated aniline t., protonated sec. amine)
Sulfadiazine		C10H10N4O2S	NC1=CC=C(C=C1)S(=O)(=O)NC2=NC=CC=N2	0.39	HIGH (aniline)
Sulfamethoxazole		C10H11N3O3S1	c1(S(Nc2cc(C)on2)(=O)=O)ccc(N)cc1	0.79	HIGH (aniline)
Sulfapyridine		C11H11N3O2S1	c1(S(Nc2ccccn2)(=O)=O)ccc(N)cc1	1.01	HIGH (aniline)

table continues

Table S6. Structures, formulas, Log K_{ow}, and estimation of ozone reactivity *(continued)*

Compound	Structure / O_3 reactivity estimation / pK_a (red acidic, blue basic)	Formula	Smile	Log K_{ow} (uncharged)	O_3 reactivity estimation
Thiopental		C11H18N2O2S	C1([C@@](C(N=C(N1)S)=O)([C@@H](CCC)C)CC)=O	2.77	HIGH (deprotontated thiol)
Tramadol		C16H25NO2	COC1=CC=CC(=C1)[C@@]2(O)CCCC[C@@H]2CN(C)C	2.45	HIGH (protontated tertiary amine, anisole)
Trimethoprim		C14H18N4O3	c1(Cc2c(nc(N)nc2)N)cc(c(OC)c(c1)OC)OC	1.28	HIGH (aniline type, anisole)
Valsartan		C24H29N5O3	CCCCC(=O)N(CC1=CC=C(C=C1)C2=C(C=CC=C2)C3=NN=NN3)[C@@H](C(C)C)C(O)=O	4.51	LOW-NONE
Venlafaxine		C17H27NO2	C1CCCC(C1)([C@@H](c1ccc(cc1)OC)CN(C)C)O	2.74	HIGH (protontated tertiary amine, anisole)
Verapamil		C27H38N2O4	COC1=C(OC)C=CC(C(C(C)C)(C#N)CCCN(CCC2=CC(OC)=C(OC)C=C2)C)=C1	5.04	HIGH (protontated tertiary amine, anisoles)

2. Additionally measured gadolinium and platinum

Gadolinium

The main source of gadolinium in hospital wastewater is very likely coming from magnetic resonance imaging (MRI) contrast media from the ATC class V08CA.

V08C MAGNETIC RESONANCE IMAGING CONTRAST MEDIA

V08CA Paramagnetic contrast media

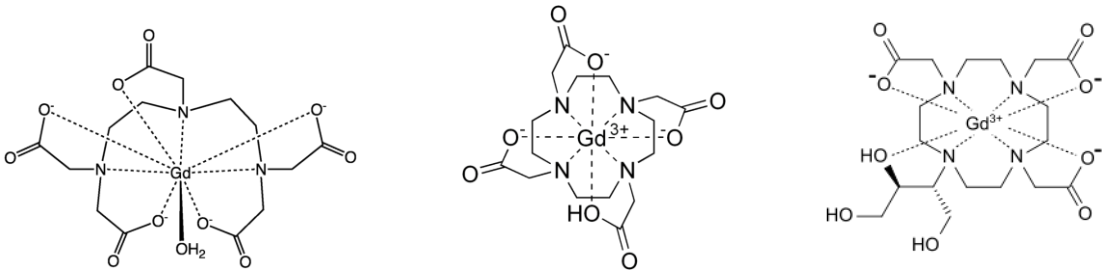
V08CA01	gadopentetic acid	contains Gd
V08CA02	gadoteric acid	contains Gd
V08CA03	gadodiamide	contains Gd
V08CA04	gadoteridol	contains Gd
V08CA05	mangafodipir	
V08CA06	gadoversetamide	contains Gd
V08CA07	ferric ammonium citrate	
V08CA08	gadobenic acid	contains Gd
V08CA09	gadobutrol	contains Gd
V08CA10	gadoxetic acid	contains Gd
V08CA11	gadofosveset	contains Gd

V08CB Superparamagnetic contrast media

V08CB01	ferumoxsil
V08CB02	ferristene
V08CB03	iron oxide, nanoparticles

V08CX Other magnetic resonance imaging contrast media

V08CX01	perflubron



gadopentetic acid **gadoteric acid** **gadobutrol**

Figure S1. Examples of gadolinium containing MRI contrast media

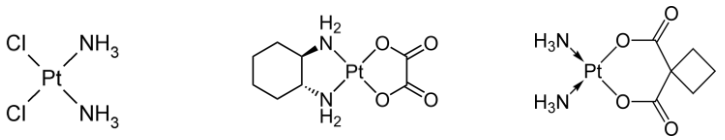
Platinium

The platinum containing cytostatics (antineoplastic agents) from the ATC class L01XA, used for treatment of oncologic patients, are the main source of platinum in hospital wastewater.

L01X OTHER ANTINEOPLASTIC AGENTS

L01XA Platinum compounds — all contain Pt

L01XA01	cisplatin
L01XA02	carboplatin
L01XA03	oxaliplatin
L01XA04	satraplatin
L01XA05	polyplatillen

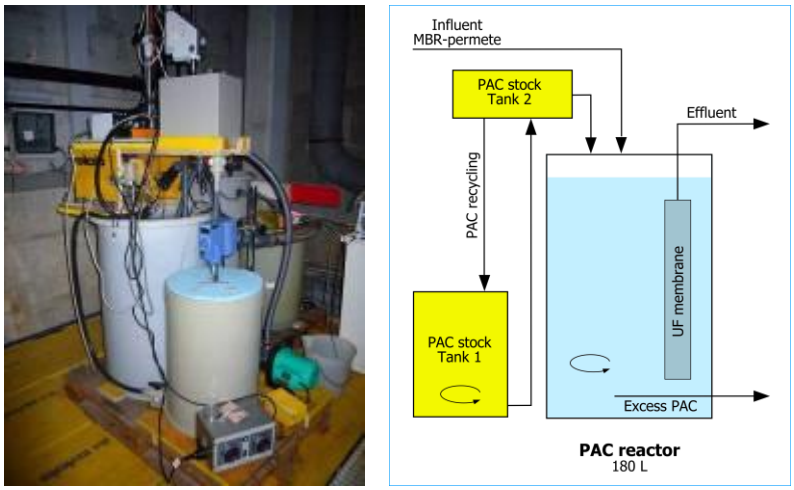


cisplatin **oxaliplatin** **carboplatin**

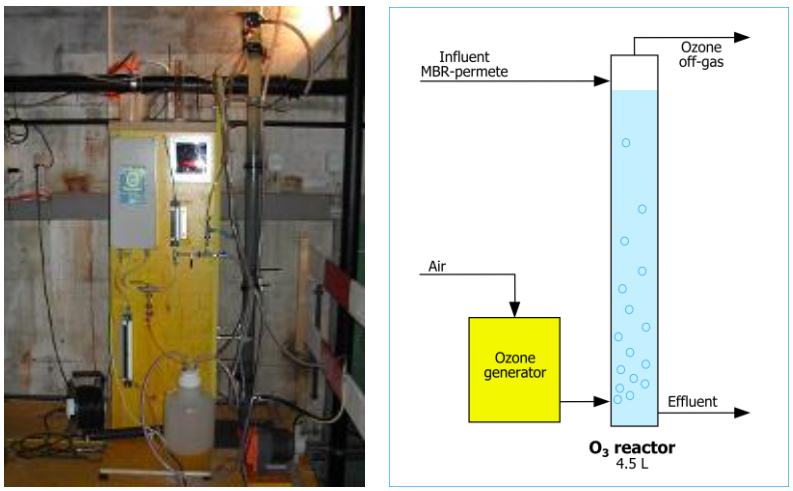
Figure S2. Examples of platinum containing cytostatics

3. Post-treatment by activated carbon, ozone and UV

A



B



C

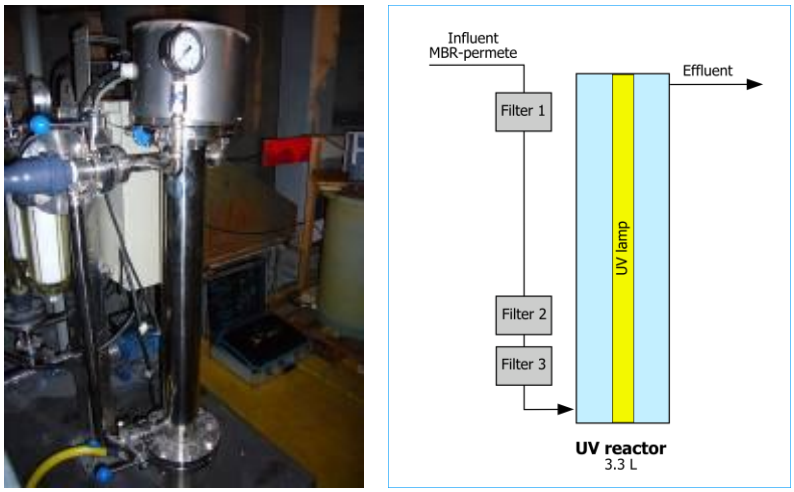


Figure S3. Set-up of the three post-treatments: A adsorption to powdered activated carbon, B oxidation by ozone, and C photolysis by ultraviolet light.

Table S7. Experimental conditions of adsorption experiments with powdered activated carbon (PAC) Norit SAE Super (1300 m^2/g, 15μm, pH_{PZC} 9.8)

	Replicate (date)	DOC [mg C/L]		COD_{dis} [mg O/L]		pH		Temp. (PAC-reactor) [°C]
		Infl.	Effl.	Infl.	Effl.	Infl.	Reactor	
8.2±4 mg PAC/ L	**A** (12.-16.10.2009)	7.2	4.5	18.3	11.3	8.4	8.7	26.8
	B (16.-19.10.2009)	6.8	4.2	19.2	n.a.	8.3	8.8	30.0
23±7 mg PAC/ L	**A** (2.-6.11.2009)	6.8	n.a.	16.3	7.1	8.4	8.8	31.7
	B (6.-9.11.2009)	8.3	3.7	20.8	8.2	8.2	8.8	33.2
	C (19.-23.11.2009)	7.0	2.7	19.7	7.2	8.3	n.a.	31.5
	D (23.-26.11.2009)	7.5	3.0	21.3	8.5	8.2	8.8	32.9
43±14 mg PAC/ L	**A** (15.-19.2.2010)	6.7	2.0	13.3	<5.0	8.4	8.9	26.7
	B (19.-22.2.2010)	5.9	1.9	13.0	<5.0	8.8	9.0	28.0

n.a. – data not available

Table S8. Experimental conditions of ozonation experiments

	Replicate	Transferred ozone dose [mg O_3/L]	Contact time [min]	DOC [mg C/L]	COD_{dis} [mg O/L]	pH	T [°C]
O_3-reactor influent (MBR permeate)	A	-	-	6.7	15.8	8.4	21.4
	B	-		6.4	16.1	8.5	22.4
O_3-reactor effluent (dose 0.64 ± 0.01 g O_3/g DOC)	A	4.3	12	6.3	13.4	8.7	20.4
	B	4.1		6.2	16.0	8.5	22.8
O3-reactor effluent (dose 0.89 ± 0.03 g O_3/g DOC)	A	5.8	17	6.2	12.7	8.6	22.1
	B	5.8		5.8	15.3	8.5	22.4
O3-reactor effluent (dose 1.08 ± 0.05 g O_3/g DOC)	A	6.9	23	6.0	15.1	8.6	21.3
	B	7.2		5.6	13.0	8.5	22.3

Table S9. Experimental conditions of UV experiments

	Replicate	DOC [mg C/L]	COD_{dis} [mg O/L]	pH	Temp. [°C]
Influent	**A**	7.8	20.5	8.1	n.a.
	B	n.a.	22.3	n.a.	n.a.
1 run	**A**	7.4	20.6	8.2	n.a.
	B	n.a.	24.7	n.a.	n.a.
3 cycles	**A**	8.8	23.3	8.5	24.7
	B	n.a.	22.8	n.a.	n.a.
9 cycles	**A**	7.8	22.7	8.6	26.7
	B	n.a.	19.9	n.a.	n.a.

n.a. – data not available

Effective fluence rate calculation

Partial depletion of pharmaceuticals has been shown to occur during the disinfection of drinking water at 400 J/m^2 with a UV-C (254 nm) lamp.[3] Depletion rates (under conditions of negligible optical density) were mostly unaffected by the presence of natural water components. At pH 8, a depletion of 27% for diclofenac and 15% for sulfamethoxazole and iopromide was found at this fluence. The nominal fluence rate of the UV/TiO_2 reactor given by the manufacturer is 10 mW/cm^2. With a residence time of 20 seconds in the reactor (without fibers), a fluence of 200 mW·sec/cm^2 = 200 mJ/cm^2 = 2000 J/m^2 is calculated.

For a fluence of 2000 J/m^2, the expected elimination rate of diclofenac can be calculated as follows:

$$R_{2000} = R_{400}^{\left(\frac{2000}{400}\right)} = 0.73^5 = 0.21$$

where R_x is the remaining fraction at a certain fluence (73% for diclofenac at 400 J/m^2, see Canonica et al. (2008)). Therefore, the expected elimination of diclofenac without the fibers is 79%, which is not reached at all. Obviously, the hospital wastewater has a screening effect and is adsorbing radiation, so the effective fluence rate is smaller than the theoretical nominal fluence rate.

From the observed elimination rates, the effective fluence rate can be calculated.

$$E^0 = \frac{H^0}{t_r} = \frac{H_p^0 \cdot cf}{t_r} = \frac{H_p^0 \cdot 4.71 \cdot 10^5}{t_r} = \frac{-\frac{\ln R}{k_{EP}} \cdot 4.71 \cdot 10^5}{t_r}$$

E^0 (W/m^2): effective fluence rate
t_r (s): residence time in column (20 seconds without fibers)
H^0_p (einstein/m^2): photon fluence
H^0 (J/m^2): fluence
cf: conversion factor from photon fluence to fluence: 4.71 x 10^5 J/einstein at the wavelength of 254 nm [3]
R: remaining fraction of pharmaceutical in experiment (0.53 for diclofenac, 0.72 for iopromide without fibers)
k_{Ep} (m^2/einstein): photon fluence-based rate constant (Table 1 in Canonica et al. 2008): 376 m^2/einstein for diclofenac, 191 m^2/einstein for iopromide at pH 7-8.

With this equation, an effective fluence rate of 4.0 mW/cm^2 was calculated for the UV/TiO_2 reactor with hospital wastewater (39.8 W/m^2 for diclofenac, 40.5 W/m^2 for iopromide). Therefore, the fluence rate is lower by a factor of 2.5 than the nominal value (10 mW/m^2), probably mostly due to the adsorption of light by the wastewater.

With the photocatalytic fibers, we (might) have an additional indirect phototransformation. However, the elimination is smaller than with UV only. Obviously, the screening and sorption of the light by the fibers is higher than the possible indirect phototransformation.

If we assume there is no indirect phototransformation happening for diclofenac and iopromide, we can calculate the fluence rate for the system with the fibers the same way as above (R=0.79 for diclofenac and 0.88 for iopromide, t_r=18 sec with photocatalytic fibers). The calculated fluence rate with the fiber is only 1.7 mW/cm^2 (16.4 W/m^2 for diclofenac, 17.5 W/m^2 for iopromide), so by a factor 2.4 lower then without the fibers (4.0 mW/cm^2).

Table S10. PAC elimination - comparison with prediction and literature for the micropollutants with: A – high elimination efficiency; B – intermediate and low elimination efficiency; and C – unknown or approximate experimental data. Elimination of micropollutants from an MBR permeate by 23±7 mg/L PAC (Norit SAS Super) from this study (DOC 7.0 ± 0.7 mg/L, pH 8.8, hydraulic residence time 1 day) compared to: adsorbability at pH 8.5 predicted from Log D_{ow} values (Table S3); and results of other studies.

A

CHARGE at pH 8.5	This study: PREDICTION	This study: HIGH removal (>97%)	Literature: % Removal	Literature: Ref.
+	°	Azithromycin	-	-
		Carbamazepine	100, 98	4, 5
+/-		Ciprofloxacin	69**	6
(+)		Clarithromycin	99	5
(+)	°	Clindamycin	100	4
+	°	D617	-	-
-	°	Diclofenac	97, 78	4, 7
-		Furosemide	-	-
(-)		Hydrochlorothiazide	-	-
(+)	°	Lidocaine	-	-
-	°	Mefenamic acid	35**	5
+	°	Metoprolol	98	4
+/-		Norfloxacin	-	-
		Oxazepam	98	5
+		Tramadol	-	-
-		Valsartan	-	-
+		Venlafaxine	90**	5

B

CHARGE at pH 8.5	This study: PREDICTION	This study: INTERMEDIATE and LOW removal	This study: % Removal	Literature: % Removal	Literature: Ref.
	°	4-Acetamidoantipyrine	73 ± 4	-	-
	°	4-Aminoantipyrine	95 ± 2	-	-
	°	4-Formylaminoantipyrine	81 ± 5	-	-
	°	4-Methylaminoantipyrine	75 ± 4	-	-
-	°	4/5-Methylbenzotriazole	93 ± 2	95**	5
+/-		Atenolol acid	94 ± 2	-	-
-	°	Benzotriazole	84 ± 2	85-98	5
	°	Cyclophosphamide	73 ± 7	-	-
-		Diatrizoate	14 ± 2	44, 55-70	4, 5
	°	Fluconazole	95 ± 2	-	-
+/-		Gabapentin	42 ± 4	-	-
		Iomeprol	65 ± 10	96, 46	4, 7
		Iopamidol	69 ± 11	91, 42	4, 7
		Iopromide	85 ± 8	87, 50	4, 7
-		Ioxitalamic acid	9 ± 12	-	-
		Levetiracetam	73 ± 2	-	-
		Metronidazole	67 ± 9	90	4
-		N4-Acetylsulfamethoxazole	92 ± 2	45-70	5
+/-		Oseltamivir carboxylat	36 ± 4	-	-
	°	Phenazone	88 ± 11	90*	5
	°	Primidone	79 ± 10	55-90, 84	5, 7
+/-		Ritalinic acid	40 ± 4	-	-
+/(-)		Sotalol	96 ± 1	96	4
-		Sulfadiazine	40 ± 15	85*	5
-		Sulfamethoxazole	33 ± 9	25-70	5
-	°	Sulfapyridine	95 ± 1	-	-

C

CHARGE at pH 8.5	This study: PREDICTION	This study: Absence in PAC influent or concentrations in effluent below LOQ	This study: % Removal	Literature: % Removal	Literature: Ref.
	°	4-Dimethylaminoantipyrine	absent	-	-
+		Atenolol	> 88	92, 98*	4, 5
-	°	Bezafibrate	> 86	99	4
+/-		Cilastatin	absent	-	-
-		Clofibric acid	absent	-	-
	°	Dexamethasone	absent	-	-
		Diazepam	absent	95-100	5
(+)		Erythromycin	> 88	66*	7
+	°	Fluoxetine	absent	91*	8
	°	Ifosfamide	> 60	-	-
-	°	Indometacin	> 91	73	4
		Iohexol	absent	20-85	5
	°	Methylprednisolone	absent	-	-
+/(-)	°	Morphine	> 63	-	-
-		Naproxen	absent	75**,97	4, 5
+	°	Oseltamivir	> 63	-	-
(-)	°	Paracetamol	absent	78*	8
+	°	Propranolol	> 94	-	-
(+)	°	Ranitidine	> 96	100**	5
		Ritonavir	> 87	-	-
+		Roxithromycin	absent	98	5
-	°	Thiopental	> 66	-	-
	°	Trimethoprim	> 83	92	4
+		Verapamil	> 88	-	-

Legend:

+	positively charged
-	negatively charged
+/-	zwitterionic
(+) or (-)	partially charged (less than 50%)

- Log D_{ow} < 0 (low adsorbability)
- ° 0 < Log D_{ow} < 2 (intermediate ads.)
- Log D_{ow} >2 (high adsorbability)

Log D_{ow} at pH 8.5 was calculated by JChem for Excel 5.3.3.165 (ChemAxon Ltd.)

* lower PAC dose: 16 mg/L [Ref. [5]]; 10 mg/L [Ref. [6]]; 5 mg/L [Ref. [8]]

** higher PAC dose: 30 [Ref. [5]]; 50 (15 min t_c) [Ref. [6]]

Table S11. O_3 elimination - comparison with prediction and literature for the micropollutants with: A – high elimination efficiency; B – intermediate and low elimination efficiency; and C – unknown or approximate experimental data. Elimination by ozonation from this study at 1.08 $gO_3/gDOC$ (pH 8.5, 22°C, hydraulic residence time 23 min.) compared to: prediction from the molecular structure at pH 8-8.5 (see also Table S6); and results of other studies.

A

This study			Literature				
PREDICTION	HIGH elimination (≥97%)	% Elimination	k''_{O3} ($M^{-1}s^{-1}$)			$k''_{O3,app}$ ($M^{-1}s^{-1}$)	
			neutral	charged	Ref.	pH 7	pH 8 (or 8.5)
	4-Acetamidoantipyrine	99*[9]					
	4-Formylaminoantipyrine	-					
	4-Methylaminoantipyrine	-					
°	4/5-Methylbenzotriazole	99[9]	1.6×10^{2}	(-) 1×10^{4}	[2]	1.3×10^{3}	(1.7×10^{4})
	Atenolol acid	93*[9]	6.3×10^{5}	(+) 1.1×10^{2}	[10] structure sim.	1.6×10^{3}	(5.0×10^{4})
	Carbamazepine	100[9]	3×10^{5}		[11]	3×10^{5}	3×10^{5}
	Ciprofloxacin	16*[12]	7.5×10^{3}	(-) 9.0×10^{5}	[13]	1.4×10^{4}	1.3×10^{5}
	Clarithromycin	99[9]	1.1×10^{7}		[14]	6.9×10^{4}	6.5×10^{5}
	Clindamycin	96**[9]					
	D617	-					
	Diclofenac	99[9], 96[8]	1×10^{6}		[11]	1×10^{6}	1×10^{6}
	Furosemide	-		(-) 2.2×10^{4}	QSAR [15]	2.2×10^{4}	(2.2×10^{5})
	Hydrochlorothiazide	-					
°	Indometacin	50*[16]					
	Lidocaine	98*[9]	4.4×10^{5}	(+) 1.1×10^{4}	QSAR [15]	6.0×10^{4}	(3.6×10^{5})
	Mefenamic acid	97[9]		(-) 5.5×10^{6}	QSAR [15]	5.5×10^{6}	(5.5×10^{6})
	Metoprolol	98[9]	8.6×10^{5}	(+) 3.3×10^{2}	[17]	2.0×10^{3}	1.7×10^{4}
	Norfloxacin	-					
	Ranitidine	-	1.1×10^{6}	(+) 3.0×10^{5}	QSAR [15]	3.7×10^{5}	(1.0×10^{6})
	Sulfamethoxazole	96[9]	4.7×10^{4}	(-) 5.7×10^{5}	[13]	5.7×10^{5}	5.7×10^{5}
	Tramadol	-	1.6×10^{6}	(+) 7.7×10^{1}	[18]	4.0×10^{3}	(1.1×10^{5})
	Venlafaxine	99*[9]	8.3×10^{5}	(+) 3.0×10^{3}	QSAR [15]	6.3×10^{3}	(9.6×10^{4})

B

This study			Literature				
PREDICTION	INTERMEDIATE and LOW elimination	% Elimination	% Elimination	k''_{O3} ($M^{-1}s^{-1}$)			$k''_{O3,app}$ ($M^{-1}s^{-1}$)	
				neutral	charged	Ref.	pH 7	pH 8 (or 8.5)
°	Benzotriazole	90 ± 0.3	90[9]	3.5×10^{1}	(-) 2.7×10^{3}	[2]	2.4×10^{2}	1.4×10^{3}
°	Bezafibrate(spike)	87 ± 3.8	99*[19]		(-) 5.9×10^{2}	[11]	5.9×10^{2}	5.9×10^{2}
	Cyclophosphamide	57 ± 0.2	>60[20]					
	Diatrizoate	16 ± 1.9	14*[16]		(-) <1	[11]	<1	<1
	Fluconazole	47 ± 1.7	>91*[9]	<1		QSAR [15]	<1	(<1)
°	Gabapentin	74 ± 0.9	-	2.2×10^{5}		QSAR [15]	4.4×10^{1}	(1.4×10^{3})
	Ifosfamide	62	-					
	Iomeprol	52 ± 3.4	48*[19]	<1		[11]	<1	<1
	Iopamidol	55 ± 0.5	47*[19]	<1		[11]	<1	<1
	Iopromide	60 ± 1.9	49**[9], 59*[19]	<0.8		[11]	<0.8	<0.8
	Ioxitalamic acid	25 ± 6.8	1-66*[9]					
	Levetiracetam	54 ± 3.0	12-55*[9]	<1		QSAR [15]	<1	(<1)
	Metronidazole	49 ± 3.7	-					
	N4-AcSMX	80 ± 0.2	85*[19]	2.6×10^{2}	(+) 2.0×10^{1}	[13]	2.6×10^{2}	2.6×10^{2}
	Oxazepam	83 ± 0.6	not removed*[21]	<10		QSAR [15]	<10	(<10)
	Primidone	78	91**[9]	<10		QSAR [15]	<10	(<10)
	Valsartan	78 ± 1.5	-		(-) 2.4×10^{1}	QSAR [15]	2.4×10^{1}	(2.4×10^{1})

table continues

Table S11. O_3 elimination - comparison with prediction and literature *(continued).*

C

This study			Literature					
PREDICTION	Absence in O_3 influent or concentrations in effluent below LOQ	% Elimination	% Elimination	k''_{O3} ($M^{-1}s^{-1}$)			$k''_{O3,app}$ ($M^{-1}s^{-1}$)	
				neutral	charged	Ref.	pH 7	pH 8 (or 8.5)
	4-Aminoantipyrine	> 83	-					
	4-Dimethylaminoantipyrine	absent	99*[9]					
	Atenolol	> 23	99[9]	6.3×10^5	(+) 1.1×10^2	[10]	1.6×10^3	(5.0×10^4)
	Azithromycin	> 91	100*[19]	6.0×10^6		[13]	1.2×10^5	9.9×10^5
	Cilastatin	absent	-					
°	Clofibric acid	absent	86**[9]		<20	[19]	~6	~6
°	Dexamethasone	absent	-					
	Diazepam	absent	66[8]	7.5×10^{-1}		[11]	7.5×10^{-1}	7.5×10^{-1}
	Erythromycin	> 93	96[8]					
°	Fluoxetine	absent	98[8]					
	Iohexol	absent	39*[9]	<0.8		[11]	<1	<1
°	Methylprednisolone	absent	-					
	Morphine	> 84	-					
°	Naproxen	absent	86-95[8]		(-) 2.0×10^5	[19]	2.0×10^5	2.0×10^5
	Oseltamivir	> 79	-					
	Oseltamivir carboxylat	> 93	-					
	Paracetamol	absent	90-97[8]	1.4×10^3	(-) 9.9×10^8	[22]	1.3×10^6	3.8×10^7
	Phenazone	> 71	100**[9]					
	Propranolol	> 92	98[9]	1×10^5		[10]	1×10^5	1×10^5
°	Ritalinic acid	> 93	-					
°	Ritonavir	> 74	-					
	Roxithromycin	absent	100*[19]	1.0×10^7		[11]	2.8×10^4	5.9×10^5
°	Sotalol	> 94	98[9]				4.8×10^2	(1.4×10^4)
	Sulfadiazine	> 47	86**[9]	$>10^5$		[11]		
	Sulfapyridine	> 96	98[9]	$>10^5$		[11]	7.1×10^4	(3.6×10^5)
	Thiopental	> 56	-					
	Trimethoprim	absent	94[9], 100[8]	5.2×10^5	(+) 7.4×10^4	[13]	2.7×10^5	4.7×10^5
	Verapamil	> 76	-					

Legend:
* lower ozone dose: 0.6 - 0.8[9, 19]; 0.3[12]; 0.4 – 0.7[16]; 0.3[21] $gO_3/gDOC$)
** higher ozone dose: 1.16 $gO_3/gDOC$[9])

Prediction of reactivity with ozone for pH 8.5 (Tab. S6):
low or no reactivity with ozone ($\approx k''_{O3,app} < 10\ M^{-1}s^{-1}$)
° intermediate reactivity with ozone ($\approx k''_{O3,app}$ between 10 and $1\times10^5\ M^{-1}s^{-1}$)
high reactivity with ozone ($\approx k''_{O3,app} > 1\times10^5\ M^{-1}s^{-1}$)

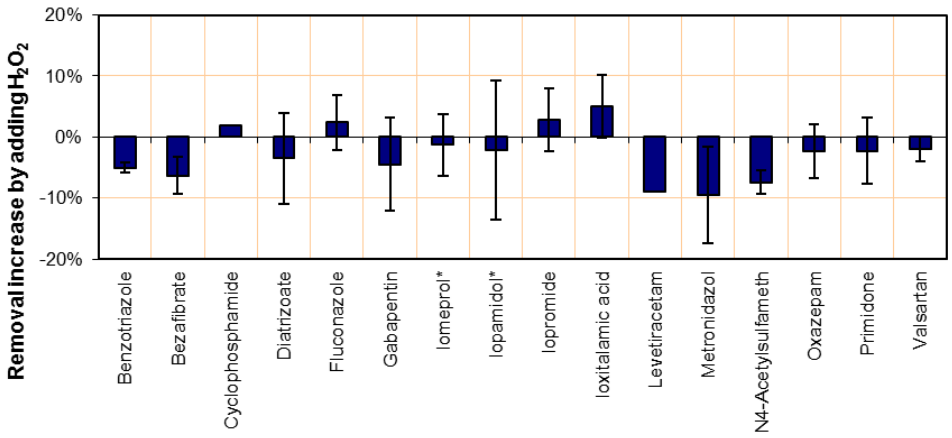


Figure S4. Comparison of ozonation treatment with and without hydrogen peroxide (0.7 $gO_3/gDOC$, 2.5 mg/L H_2O_2).

Table S12. UV elimination – comparison of UV and UV/TiO_2. Average and deviation from the average of two experiments. All compounds with an elimination >20% after 9 cycles UV treatment are shown.

	% Elimination with UV/TiO_2		% Elimination with UV	
	3 cycles (918 J/m^2)	9 cycles (2754 J/m^2)	3 cycles (2400 J/m^2)	9 cycles (7200 J/m^2)
4-Acetamidoantipyrine	16 ± 3.0	89 ± 1.6	87 ± 1.1	99 ± 0.3
4-Aminoantipyrine	54 ± 23	78 ± 3.0	41 ± 6.0	55 ± 5.2
4-Formylaminoantipyrine	62 ± 1.0	88 ± 3.8	85 ± 0.3	98 ± 0.9
4-Methylaminoantipyrine	18 ± 1.1	18 ± 8.8	8.5 ± 16	26 ± 10
Azithromycin	5.1 ± 4.6	6.4 ± 6.0	14 ± 3.6	23 ± 5.4
Ciprofloxacin	19 ± 1.5	35 ± 2.4	29 ± 3.5	57 ± 3.1
Diatrizoate	42 ± 4.8	73 ± 3.0	72 ± 2.4	97 ± 0.4
Diclofenac	62 ± 4.5	90 ± 1.2	88 ± 1.3	98 ± 1.0
Furosemide	0.6 ± 4.6	13 ± 1.4	14 ± 3.5	35 ± 5.6
Hydrochlorothiazide	13 ± 3.5	20 ± 1.3	14 ± 2.9	50 ± 1.6
Indomethacin	9.5 ± 0.6	14 ± 3.0	9.0 ± 13	24 ± 5.3
Iomeprol	11 ± 25	21 ± 46	65 ± 0.4	90 ± 2.1
Iopamidol	25 ± 11	41 ± 26	66 ± 0.4	92 ± 0.8
Iopromide	35 ± 0.6	63 ± 1.7	60 ± 3.0	92 ± 0.5
Ioxitalamic acid	34 ± 2.1	69 ± 0.8	52 ± 4.9	92
Mefenamic acid	7.0 ± 2.2	11 ± 2.8	8.3 ± 0.9	21 ± 4.5
Metronidazole	0 ± 24	0 ± 33	0 ± 36	22 ± 7.6
Morphine	54 ± 4.3	74	66 ± 0.4	84
N4-Acetylsulfamethoxazole	3.7 ± 0.5	11 ± 0.2	14 ± 3.6	33 ± 1.1
Norfloxacin	20 ± 1.1	35 ± 0.3	40 ± 1.4	63 ± 2.4
Oseltamivir	7.8 ± 0.7	13 ± 0.2	19 ± 0.6	40 ± 0.4
Phenazone	42 ± 5.1	55 ± 6.7	50 ± 5.7	64 ± 5.3
Propranolol	8.7 ± 3.8	17 ± 11	13 ± 1.2	23 ± 2.5
Ranitidine	24 ± 1.8	41 ± 3.0	41 ± 1.0	71 ± 0.8
Sotalol	53 ± 5.3	87 ± 3.2	79 ± 1.1	>95
Sulfadiazine	0 ± 2.8	5.3 ± 8.3	21 ± 4.1	25 ± 0.5
Sulfamethoxazole	26 ± 1.4	50 ± 5.9	55 ± 1.9	85 ± 3.2
Sulfapyridine	44 ± 17	64 ± 2.4	6.0 ± 12	69 ± 3.3
Thiopental	18	25	35	47
Tramadol	2.6 ± 2.2	11 ± 2.2	15 ± 1.5	26 ± 1.3
Verapamil	14 ± 4.2	28 ± 5.9	19 ± 3.6	40 ± 4.6

Table S13. AOX (adsorbable organic halogen compounds, expressed as Cl-equivalents) after biological treatment in MBR, after PAC and after ozone treatment.

	AOX (mg/L)
After MBR	0.557
After PAC (43 mg/L)	0.157
After ozonation (1.08 g ozone/g DOC)	0.334

4. Cost estimation

The costs of three different treatment concepts were calculated:

1. Decentralized treatment of hospital wastewater: a biological treatment (with a screen, a fine screen, and a membrane bioreactor) and 10 mg/L ozone, followed by a biofilter
2. Decentralized treatment of hospital wastewater: a biological treatment (with a screen, a fine screen, and a membrane bioreactor) and 20 mg/L PAC
3. Source separation by collecting urine with bottles or road bags from patients being treated with contrast media (stationary and out-patients). Part of the urine is already collected by the means of catheters. The collected urine is incinerated with the household waste.

The parameters of the hospital Baden which were taken as a basis of the cost calculations are listed in Table S14. The calculated costs are shown detailed in Table S15 and summarized in Table S16. The investment and annual operating costs were estimated and then calculated to the total annual costs in Swiss Francs, based on an annual interest rate of 4% and an investment period of 15 years. The investment costs included planning and project management, construction and installation costs of the equipment, electromechanical equipment (sieves, containers, aeration), and requirements specific to the different technologies to remove pharmaceuticals (activated carbon, ozonation, etc.). The hospital has the advantage of an already existing building for the wastewater treatment, what reduced the costs. The operating costs were based on estimates for waste disposal (e.g. sewage sludge, urine bags), energy requirements, and replacement of materials such as membranes, costs of activated carbon, and labor costs for extra personnel.

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Table S14: Parameters of the analyzed hospital (case study hospital Baden).

Parameter	Units	Value
number of hospital beds[1]	[beds]	371
sewage flow[1]	[m^3/y]	116’000
urine collected with catheters[2]	[m^3/y]	68
urine in urine bags (stationary)[2]	[m^3/y]	3.75
urine in urine bags (stationary and out-patients)[2]	[m^3/y]	10.4

[1] measured values in 2007
[2] calculated values based on assumptions

Table S15: Detailed investment and annual operating costs in Swiss Francs.

	screen - fine screen - MBR - ozonation (10mg/l)	screen - fine screen - MBR - PAC (20mg/l)	urine bag - disposal together with municipal waste
Construction of MBR	650'000	650'000	-
containers, screen	80'000	80'000	-
membrane, aeration	300'000	300'000	-
PAC installation	-	400'000	-
ozone installation	120'000	-	-
biofilter as post-treatment	100'000	100'000	-
EMSRL	400'000	400'000	-
planning	248'000	290'000	0
reserve	380'000	444'000	0
Total investment costs	**2'278'000**	**2'664'000**	**0**
waste disposal			166'000
waste in screen	3'000	3'000	
sludge waste	22'000	22'000	4'000
energy MBR	40'000	40'000	-
energy ozonation	8'000	-	-
energy PAC	-	4'000	-
Replacement of MBR	20'000	20'000	-
PAC	-	4'000	-
replacement reserve	10'000	12'000	-
personnel	30'000	30'000	1'000
Total operating costs	**133'000**	**135'000**	**171'000**

Table S16. Costs of different concepts at the hospital in Swiss Francs**.**

		screen - fine screen - MBR - ozonation (10mg/l)	screen - fine screen - MBR - PAC (20mg/l)	urine bag
costs in Swiss francs	investment costs	2'278'000 Fr.	2'664'000 Fr.	0 Fr.
	operating costs	133'000 Fr.	135'000 Fr.	171'000 Fr.
	annual costs	337'886 Fr.	374'603 Fr.	171'000 Fr.
	costs per hospital bed and day	2.50 Fr.	2.77 Fr.	0.46 Fr.[2] 1.26 Fr.
	Costs per m^3 waste water[1]	2.91 Fr.	3.23 Fr.	1.47 Fr.

[1] The costs per m^3 waste water are calculated by dividing the annual costs by the annual waste water amount.
[2] only stationary patients

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