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Review

The Potential of Constructed Wetlands Systems and Photodegradation Processes for the Removal of Emerging Contaminants—A Review

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Table S1. Mechanisms of EOC removal in CW based on the research papers consulted and paper references.

EOCs	Mechanisms	Reference
ACE	Aerobic biodegradation	[81,82,83,86,117,153,154]
	Anaerobic biodegradation	[80,85–87]
	Photodegradation	[82,86]
	Sorption	[80, 82,153]
	Plant uptake	[86,87]
	Other aspects	[84]
OFL	Sorption	[89,91,93,155]
	Biodegradation	[89,91,90,93,94,128,156]
	Other aspects	[84,157]
CBZ	Sorption	[92,99,113,126,154,158–161]
	Plant uptake	[90,96,100,113,158,162,163]
	Aerobic biodegradation	[101]
	Reduction transformation	[97,98]
	Other aspects	[84]
CAF	Aerobic biodegradation	[83,85,97,103,102,109,118,154]
	Plant uptake	[80,86,96,101,119,162,164,165]
	Anaerobic biodegradation	[80,83,97,100,101,109,126]
	Sorption	[85,102,162]
	Other aspects	[84]
KET	Photodegradation	[78,79,107,110,111,166–168]
	Biodegradation	[80,101,107–109,166]
	Other aspects	[108]
IBU	Aerobic biodegradation	[15,17,18,80,82,85,98,101,107,113,117,118,159,165,169,170]
	Sorption	[102,112,158]
	Photodegradation	[85,111,115]
	Plant uptake	[101,107,171–173]
	Other aspects	[84,19]
DCL	Photodegradation	[78–80,82,107,166–168]
	Aerobic biodegradation	[82,97,103,117,158]
	Anaerobic biodegradation	[17,80,97,98,100,103,107,118]
	Plant uptake	[101,119,158,174]
	Other aspects	[84,157]

ACB	Sorption	[92,121,175]
	Photodegradation	[75]
	Biodegradation	[108]
	Plant uptake	[92]
	Other aspects	[102,105]
BPA	Aerobic biodegradation	[17,18,82,117,118,125,176]
	Sorption	[35,125]
	Plant uptake	[123,124]
	Other aspects	[122,177]
SOT	Photodegradation	[78,79,130]
	Sorption	[112]
	Aerobic biodegradation	[112,130]
	Other aspects	[15]

Acronyms: ACE: acetaminophen, OFL: ofloxacin, CAF: caffeine, CBZ: carbamazepine,KET: ketoprofen, IBU: ibuprofen, DCL: diclofenac, ACB: clofibric acid, BPA: bisphenolA, SOT: sotalol.

Table S2. Minimum and maximum (or mean) removal rates for each EOC and each technology evaluated in the literature on WWTPs.

Pollutant	Technology Type	Removal (%) MIN	MAX (Mean)	Reference
ACE	MBR (microfiltration membrane)	(99.9)		[51]
	MBR (microfiltration membrane) with coagulation post-treatment	(99.9)		[51]
	MBR (microfiltration membrane)	72.0	100.0	[51]
	Municipal WWTPs	65.0	100.0	[3]
	Conventional activated sludge	80.0	100.0	[48]
	MBR	80.0	100.0	[48]
OFL	Municipal WWTPs	72.0	99.9	[3]
	Conventional activated sludge	60.0	80.0	[48]
	MBR	80.0	100.0	[48]
	CAS	(75.0)		[44]
	MBR	93.5	93.5	[44]
CBZ	MBR (microfiltration membrane before PAC addition)	(0.0)		[49]
	MBR (microfiltration membrane after PAC addition)	45.0	98.0	[49]
	MBR (ultrafiltration membrane before PAC addition)	(0.0)		[49]
	MBR (ultrafiltration membrane after PAC addition)	70.0	92.0	[49]
	MBR (microfiltration membrane)	(25.5)		[51]
	MBR (microfiltration membrane)	−40.0	23.0	[51]
	Conventional WWTPs	0.0	83.0	[42]
	Municipal WWTPs	−69.4	99.0	[3]
	Conventional activated sludge	60.0	80.0	[48]
	MBR	60.0	80.0	[48]
CAF	MBR (microfiltration membrane)	(98.0)		[51]
	MBR (microfiltration membrane) with coagulation post-treatment	(98.0)		[51]
	MBR (microfiltration membrane)	80.0	100.0	[51]
	Conventional WWTPs	84.0	99.9	[42]
	Municipal WWTPs	70.0	99.0	[3]

	Conventional activated sludge	80.0	100.0	[48]
	MBR	60.0	80.0	[48]
KET	MBR (microfiltration membrane)	(83.0)		[51]
	MBR (microfiltration membrane) with coagulation post-treatment	(89.0)		[51]
	MBR (microfiltration membrane)	70.0	99.0	[51]
	Conventional WWTPs	52.0	92.0	[42]
	Municipal WWTPs	−83.0	100.0	[3]
	Conventional activated sludge	60.0	80.0	[48]
	MBR	0.0	20.0	[48]
IBU	MBR (microfiltration membrane before PAC addition)	(92.0)		[49]
	MBR (microfiltration membrane after PAC addition)	85.0	99.9	[49]
	MBR (ultrafiltration membrane before PAC addition)	(99.0)		[49]
	MBR (ultrafiltration membrane after PAC addition)	97.0	99.9	[49]
	Conventional WWTPs	0.0	99.9	[42]
	Municipal WWTPs	76.0	100.0	[3]
	Conventional activated sludge	80.0	100.0	[48]
	MBR	80.0	100.0	[48]
DLC	MBR (microfiltration membrane before PAC addition)	(29.0)		[49]
	MBR (microfiltration membrane after PAC addition)	40.0	84.0	[49]
	MBR (ultrafiltration membrane before PAC addition)	(62.0)		[49]
	MBR (ultrafiltration membrane after PAC addition)	54.0	95.0	[49]
	MBR (microfiltration membrane)	(−18.0)		[51]
	MBR (microfiltration membrane)	7.0	90.0	[51]
	Conventional WWTPs	0.0	98.0	[42]
	Municipal WWTPs	−232.0	99.9	[3]
	Conventional activated sludge	60.0	80.0	[48]
	MBR	20.0	40.0	[48]
ACB	MBR (microfiltration membrane)	0.0	0.0	[51]
	Conventional WWTPs	28.0	72.0	[42]
	Municipal WWTPs	20.0	76.0	[3]
BPA	Conventional WWTPs	32.0	99.9	[42]
	WWTPs	10.0	99.0	[55]
	Conventional activated sludge	80.0	100.0	[48]
	MBR	80.0	100.0	[48]
SOT	Municipal WWTPs	(11.9)		[3]
	MBR	60.0	80.0	[48]
	CAS	(10.0)		[178]
	CAS	−10.1	52.9	[53]
	MBR (MBR was equipped with hollow-fibre (HF) ultra-filtration (UF) membranes)	29.0	77.2	[53]
	MBR (MBR operated with micro-filtration (MF) flat-sheet (FS) membrane module)	5.1	55.7	[53]

Acronyms: ACE: acetaminophen, OFL: ofloxacin, CAF: caffeine, CBZ: carbamazepine,KET: ketoprofen, IBU: ibuprofen, DCL: diclofenac, ACB: clofibric acid, BPA: bisphenolA, SOT: sotalol.

Table S3. Minimum and maximum (or mean) removal rates for each EOC and each technology evaluated in the literature on ADs.

Pollutant	Technology Type	Removal (%) MIN	Removal (%) MAX	Removal (%) (Mean)	Reference
ACE	Hybrid sludge bed-filter AD (lab)			(84)	[30]
	Hybrid sludge bed-filter AD (pilot)			(59)	[41]
OFL	Hybrid sludge bed-filter AD (lab)			(35)	[30]
CBZ	AD of sewage sludge from a STP	0.0	20.0		[66]
	UASB	5.0	10.0		[19]
	UASB			(15.0)	[58]
	Hybrid sludge bed-filter AD (pilot)			(5)	[31]
CAF	AD (UASB)	10.0	33.0		[19]
	Hybrid sludge bed-filter AD (lab)			(56)	[30]
	Hybrid sludge bed-filter AD (pilot)			(6)	[41]
KET	AD (UASB)	25.0	25.0		[19]
	AD (EGSB)	70.0	70.0		[46]
	Hybrid sludge bed-filter AD (lab)			(42)	[30]
	Hybrid sludge bed-filter AD (pilot)			(21)	[41]
IBU	AD of sewage sludge from a STP	28.0	63.0		[66]
	UASB	10.0	20.0		[19]
	UASB			(30.0)	[70]
	UASB with GAC			(60.0)	[70]
	UASB			(15.0)	[58]
	Hybrid sludge bed-filter AD (pilot)			(0)	[31]
DCL	AD of sewage sludge from a STP	0.0	78.0		[66]
	CAS			(26.0)	[69]
	AD (Digested sludge)			(13.0)	[69]
	UASB			(60.0)	[70]
	UASB with GAC			(67.0)	[70]
	UASB			(0.0)	[71]
	UASB			(15.0)	[58]
	Hybrid sludge bed-filter AD (pilot)			(35)	[31]
ACB	Hybrid sludge bed-filter AD (lab)			(0)	[30]
	Hybrid sludge bed-filter AD (pilot)			(5)	[31]
BPA	UASB			(0.0)	[71]
	Hybrid sludge bed-filter AD (lab)			(8)	[30]
	Hybrid sludge bed-filter AD (pilot)			(0)	[31]
SOT	Hybrid sludge bed-filter AD (lab)			(29)	[30]
	Hybrid sludge bed-filter AD (pilot)			(6)	[31]

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Table S4. Minimum and maximum (or mean) removal rates for each EOC and each technology evaluated in the literature on CWs.

Pollutant	Technology Type	Removal (%) MIN	Removal (%) MAX	Removal (%) (Mean)	Reference
ACE	CW	80.0	100.0		[48]
	SF CW			(89.0)	[83]
	SF CW			(99.0)	[84]
	HF CW	95.0	100.0		[80]
	HF CW	46.0	94.0		[84]
	HF CW	86.0	99.0		[85]
	VF CW			(94.0)	[82]
	VF CW			(90.0)	[83]
	VF CW	96.0	98.0		[84]
	VF CW			71.3	[30]
	VF CW			98.5	[31]
OFL	Hybrid CW			(100.0)	[89]
	SF CW	92.0	98.0		[94]
	HF CW	94.0	100.0		[84]
	HF CW	63.0	92.0		[88]
	HF CW			(90.0)	[90]
	HF CW	89.0	97.0		[94]
	VF CW			(0.0)	[93]
	VF CW			(90.0)	[93]
	VF CW	36.0	93.0		[94]
	VF CW	77.0	97.0		[84]
	VF CW			(100.0)	[30]
CBZ	CW	20.0	40.0		[48]
	SF CW	9.0	53.0		[84]
	SF CW	45.0	55.0		[79]
	HF CW	10.0	54.0		[84]
	HF CW			(2.0)	[97]
	HF CW			(13.0)	[98]
	HF CW			(50.0)	[99]
	HF CW	43.0	62.0		[90]
	HF CW	0.0	21.0		[100]
	VF CW	20.0	60.0		[84]
	VF CW			(−8.0)	[97]
	VF CW			(−9.0)	[98]
	VF CW			(5.1)	[31]
CAF	CW	80.0	100.0		[48]
	SF CW			(94.0)	[83]
	SF CW	33.0	91.0		[84]
	HF CW	93.0	99.0		[80]
	HF CW	68.0	100.0		[84]
	HF CW			(93.0)	[97]
	HF CW			(83.0)	[98]
	HF CW	96.0	100.0		[100]

	HF CW	85.0	100.0	[103]
	HF CW	85.0	100.0	[102]
	VF CW	(97.0)		[83]
	VF CW	95.0	99.0	[84]
	VF CW	(97.0)		[97]
	VF CW	(96.0)		[98]
	VF CW	(55.2)		[30]
	VF CW	(99.9)		[31]
KET	CW	80.0	100.0	[48]
	SF CW	18.0	78.0	[84]
	SF CW	(100)		[79]
	SF CW	52.0	91.0	[107]
	HF CW	47.0	91.0	[80]
	HF CW	12.0	82.0	[84]
	HF CW	48.0	55.0	[107]
	HF CW	0.0	74.0	[110]
	HF CW	(90)		[105]
	VF CW	47.0	53.0	[107]
	VF CW	47.0	53.0	[84]
	VF CW	(7.2)		[30]
	VF CW	(99.1)		[31]
IBU	CW	80.0	100.0	[48]
	SF CW	29.0	85.0	[84]
	SF CW	15.0	25.0	[107]
	SF CW	(94.0)		[82]
	SF CW	3.0	7.0	[17]
	SF CW	49.0	96.0	[11]
	HF CW	(24.0)		[17]
	HF CW	98.0	99.0	[118]
	HF CW	74.0	99.0	[80]
	HF CW	26.0	80.0	[84]
	HF CW	(19.0)		[97]
	HF CW	(28.0)		[98]
	HF CW	65.0	100.0	[100]
	HF CW	41.0	79.0	[107]
	HF CW	(87.0)		[82]
	VF CW	95.0	99.0	[18]
	VF CW	50.0	63.0	[17]
	VF CW	55.0	100.0	[84]
	VF CW	(95.0)		[97]
	VF CW	(95.0)		[98]
	VF CW	40.0	65.0	[107]
	VF CW	(73.0)		[82]
	VF CW	100.0		[31]
DCL	CW	80.0	100.0	[48]
	SF CW	(64.0)		[82]
	SF CW	18.0	66.0	[84]
	SF CW	44.0	68.0	[107]

	SF CW	(22.0)		[17]
	SF CW	(100.0)		[79]
	HF CW	(27.0)		[17]
	HF CW	(99.0)		[118]
	HF CW	17.0	95.0	[80]
	HF CW	15.0	63.0	[84]
	HF CW	(17.9)		[97]
	HF CW	(25.0)		[98]
	HF CW	35.0	61.0	[100]
	HF CW	42.0	52.0	[107]
	HF CW	(44.0)		[82]
	VF CW	33.0	67.0	[84]
	VF CW	59.0	62.0	[17]
	VF CW	(53.0)		[97]
	VF CW	(53.0)		[98]
	VF CW	54.0	70.0	[18]
	VF CW	40.0	43.0	[107]
	VF CW	(32.2)		[82]
	VF CW	(71.3)		[31]
ACB	SF CW	21.0	39.0	[84]
	SF CW	(100.0)		[79]
	HF CW	25.0	73.0	[84]
	HF CW	33.0	39.0	[108]
	HF CW	48.0	75.0	[92]
	VF CW	(0.2)		[30]
	VF CW	(24.2)		[31]
BPA	CW	80.0	100.0	[48]
	SF CW	(100.0)		[82]
	SF CW	5.0	15.0	[17]
	HF CW	(19.0)		[82]
	HF CW	(11.0)		[17]
	HF CW	43.0	97.0	[123]
	HF CW	(76.0)		[124]
	HF CW	(50.0)		[125]
	HF CW	0.0	20.0	[126]
	HF CW	85.0	99.0	[118]
	VF CW	(44.0)		[82]
	VF CW	60.0	83.0	[17]
	VF CW	57.0	95.0	[18]
	VF CW	(2.2)		[30]
	VF CW	(78.1)		[31]
SOT	SF CW	7.0	23.0	[84]
	SF CW	20.0	68.0	[79]
	HF CW	6.0	39.0	[84]
	HF CW	(5.0)		[16]
	VF CW	(8.1)		[30]
	VF CW	(21.8)		[31]

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Table S5. Minimum and maximum (or mean) removal rates for each EOC and each technology evaluated in the literature on PD by UV photolysis and TiO_2–based photocatalysis.

Pollutant	Technology type	Removal (%) (mean)	Reference
ACE	PD (UV)	100.0	[30]
	PD (UV)	70.0	[31]
	UVA/TiO2 2h	90.0	[31]
	Sol/TiO2 2h	23.0	[31]
OFL	PD (UV)	0.0	[30]
	PD (UV)	0.0	[29]
	Solar/TiO_2 (33 Wh/m^2) (WW post-treatment)	85.0	[141]
	Controlled irradiation/TiO_2 (55 Wh/m^2) (WW post-treatment)	70.0	[141]
CBZ	Simulated Sun/TiO_2 96h (WW post-treatment)	76.0	[142]
	Solar/TiO_2 (33 Wh/m^2) (WW post-treatment)	22.0	[141]
	Controlled irradiation/TiO_2 (55 Wh/m^2) (WW post-treatment)	27.0	[141]
	PD (UV)	47.0	[31]
	UVA/TiO_2 2h	77.0	[31]
	Sol/TiO_2 2h	61.0	[31]
CAF	PD (UV)	21.0	[30]
KET	PD (UV)	100.0	[30]
	PD (UV)	94.7	[29]
IBU	PD (UV)	100.0	[29]
	Simulated Sun/TiO_2 96h (WW postreatment)	74.0	[142]
DCL	Simulated Sun/TiO_2 96h (WW postreatment)	100.0	[142]
	Solar/TiO_2 (33 Wh/m^2) (WW postreatment)	100.0	[141]
	Controlled irradiation/TiO_2 (55 Wh/m^2) (WW postreatment)	97.0	[141]
ACB	PD (UV)	100.0	[30]
	PD (UV)	87.2	[29]
	PD (UV)	100.0	[31]
	UVA/TiO_2 2h	76.0	[31]
	Sol/TiO_2 2h	67.0	[31]
BPA	PD (UV)	14.0	[30]
	PD (UV)	88.4	[29]
	PD (UV)	17.0	[31]
	UVA/TiO_2 2h	6.0	[31]
	Sol/TiO_2 2h	33.0	[31]
SOT	PD (UV)	100.0	[30]
	PD (UV)	92.9	[29]
	PD (UV)	97.0	[31]
	UVA/TiO_2 2h	58.0	[31]
	Sol/TiO_2 2h	44.0	[31]

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