SUPPLEMENTARY INFORMATION

A critical assessment of pharmaceutical photodegradation in aquatic environments: Defining our current understanding and identifying knowledge gaps

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Table S1A-G: Complete list of rubric-evaluated studies (120 total studies) and their respective lab/field scores, organized by compound class, in alphabetical order. Means and standard errors for lab/field scores can be plotted for a given compound to produce scoring plots.

Table S1A: Antibiotics

Antibiotic	Data Type and Source		Score				
Compound	**Lab/Field**	**Reference**	**Experimental**	**Direct**	**Indirect**	**Field/Sunlight**	**Total**
Antimicrobial							
Triclocarban	Lab	Ding, 2013	13	14	8	--	35
		Guerard, 2009	11	10	18	--	39
		Mean (SE)					*37(2)*
Triclosan	Lab	Chen, 2010	9	11	--	--	20
		Latch, 2005	15	8	13	--	36
		Sanchez-Prado, 2006	13	9	11	--	33
		Tixier, 2002	10	13	11	--	34
		Mean (SE)					*31(4)*
	Field	Latch, 2005	16	8	7	3	34
		Lindstrom, 2002	8	5	8	5	26
		Tixier, 2002	11	7	3	5	26
		Mean (SE)					*29(3)*
β-Lactam							
Amoxicilin	Lab	Xu, 2011	13	8	14	--	35
		Zhao, 2013	12	10	14	--	36
		Mean (SE)					*36(1)*
Cephalosporin							
Cefazolin	Lab	Wang, 2012	15	15	15	--	45
		Mean (SE)					*45*
Cefazolin	Lab	Wang, 2012	15	15	15	--	45
		Mean (SE)					*45*
Cephalexin	Lab	Wang, 2012	15	15	15	--	45
		Mean (SE)					*45*
Cephapirin	Lab	Wang, 2012	15	15	15	--	45
		Mean (SE)					*45*
Fluoroquinolone							
Balofloxacin	Lab	Ge, 2010	16	19	18	--	53
		Mean (SE)					*53*
Ciprofloxacin	Lab	Babic, 2013	22	11	13	--	46
		Belden, 2007	15	--	10	--	25
		Cardoza, 2005	18	--	17	--	35
		Ge, 2010	16	19	18	--	53
		Lam, 2003	15	8	15	--	38
		Torniainen, 1996	16	10	--	--	26
		Vasconcelos, 2009	13	10	--	--	23
		Wei, 2013	12	18	--	--	30
		Mean (SE)					*35(4)*
	Field	Cardoza, 2005	18	--	9	9	36
		Sturini, 2012	14	--	7	4	25
		Turiel, 2005	16	2	4	3	25
		Mean (SE)					*29(4)*
Danofloxacin	Lab	Ge, 2010	16	19	18	--	53
		Mean (SE)					*53*
	Field	Sturini, 2012	14	--	7	4	25

		Mean (SE)					*25*
Difloxacin	Lab	Ge, 2010	16	19	18	--	53
		Prabhakaran, 2009	13	18	12	--	43
		Mean (SE)					*48(5)*
Enoxacin	Lab	Fasani, 1999	8	8	--	--	16
		Mean (SE)					*16*
Enrofloxacin	Lab	Babic, 2013	22	11	13	--	46
		Ge, 2010	16	19	18	--	53
		Sturini, 2010	20	--	11	--	31
		Wammer, 2013	13	15	11	--	39
		Mean (SE)					42(5)
	Field	Schmitt-Kopplin, 1999	9	4	5	2	20
		Sturini, 2010	20	--	6	2	28
		Mean (SE)					*24(4)*
Flumequine	Lab	Lunestad, 1995	10	--	4	5	19
		Mean (SE)					*19*
Gatifloxacin	Lab	Ge, 2010	16	19	18	--	53
		Mean (SE)					*53*
Levofloxacin	Lab	Ge, 2010	16	19	18	--	53
		Lam, 2005	17	10	11	--	38
		Mean (SE)					*46(8)*
	Field	Lam, 2004	14	--	6	12	32
		Sturini, 2012	14	--	7	4	25
		Mean (SE)					*29(4)*
Lomefloxacin	Lab	Fasani, 1999	8	8	--	--	16
		Mean (SE)					*16*
Marbofloxacin	Lab	Sturini, 2010	20	--	11	--	31
		Mean (SE)					*31*
	Field	Sturini, 2010	20	--	6	2	28
		Mean (SE)					*28*
Moxifloxacin	Field	Sturini, 2012	14	--	7	4	25
		Mean (SE)					*25*
Norfloxacin	Lab	Babic, 2013	22	11	13	--	46
		Fasani, 1999	8	8	--	--	16
		Wammer, 2013	13	15	11	--	39
		Mean (SE)					*34(9)*
Ofloxacin	Lab	Wammer, 2013	13	15	11	--	39
		Mean (SE)					*39*
	Field	Andreozzi, 2003	10	4	4	2	20
		Mean (SE)					*20*
Orbifloxacin	Lab	Morimura, 1995	16	14	--	--	30
		Mean (SE)					*30*
Sarafloxacin	Lab	Ge, 2010	16	19	18	--	53
		Prabhakaran, 2009	13	18	12	--	43
		Mean (SE)					*48(5)*
Sitafloxacin	Lab	Araki, 2002	11	12	3	--	26
		Mean (SE)					*26*
Lincosamide							
Lincomycin	Lab	Calza, 2013	12	--	5	--	17
		Mean (SE)					*17*
Macrolide							
Azithromycin	Lab	Tong, 2011	16	7	9	--	32
		Mean (SE)					*32*

	Field	Tong, 2011	16	--	5	3	24
		Mean (SE)					*24*
Clarithromycin	Lab	Calza, 2013	12	--	5	--	17
		Vione, 2009	15	--	14	--	29
		Mean (SE)					*23(6)*
Roxithromycin	Lab	Vione, 2009	15	--	14	--	29
		Mean (SE)					*29*
Tylosin	Lab	Werner, 2007	10	9	9	--	28
		Mean (SE)					*28*
Methoprim							
Ormetoprim	Lab	Guerard, 2012	12	6	19	--	37
		Mean (SE)					*37*
	Field	Lunestad, 1995	10	--	4	5	19
		Mean (SE)					*19*
Trimethoprim	Lab	Luo, 2012	9	9	16	--	34
		Ryan, 2011	6	13	16	--	35
		Sirtori, 2010	11	5	8	--	24
		Mean (SE)					*31(4)*
	Field	Lam, 2004	14	--	6	12	32
		Lunestad, 1995	10	--	4	5	19
		Ryan, 2011	6	13	16	2	37
		Mean (SE)					*29(5)*
Nitrofuran							
Furaltadone	Lab	Edhlund, 2006	13	17	10	--	40
		Mean (SE)					*40*
Furazolidone	Lab	Edhlund, 2006	13	17	10	--	40
		Mean (SE)					*40*
	Field	Lunestad, 1995	10	--	4	5	19
		Mean (SE)					*19*
Nitrofurantoin	Lab	Edhlund, 2006	13	17	10	--	40
		Mean (SE)					*40*
Nitroimidazole							
Metronidazole	Lab	Dantas, 2010	6	8	--	--	14
		Mean (SE)					*14*
	Field	Dantas, 2010	7	5	--	2	14
		Wu, 2012	16	10	--	4	30
		Mean (SE)					*22(8)*
Quinolone							
Oxolinic acid	Field	Lunestad, 1995	10	--	4	5	19
		Turiel, 2005	16	2	4	3	25
		Mean (SE)					*22(3)*
Sulfonamide							
Sulfachloropyridazine	Lab	Boreen, 2005	12	--	15	--	27
		Mean (SE)					*27*
	Field	Boreen, 2005	12	16	--	2	30
		Mean (SE)					*30*
Sulfadiazine	Lab	Boreen, 2005	12	--	15	--	27
		Mean (SE)					*27*
	Field	Boreen, 2005	12	16	--	2	30
		Lunestad, 1995	10	--	4	5	19
		Mean (SE)					*25(6)*
Sulfadimethoxine	Lab	Boreen, 2005	12	--	15	--	27
		Guerard, 2009	11	10	18	--	39

		Mean (SE)					*33(6)*
	Field	Boreen, 2005	12	16	--	2	30
		Lunestad, 1995	10	--	4	5	19
		Mean (SE)					*25(6)*
Sulfamerazine	Lab	Boreen, 2005	12	--	15	--	27
		Mean (SE)					*27*
	Field	Boreen, 2005	12	16	--	2	30
		Mean (SE)					*30*
Sulfamethazine	Lab	Boreen, 2005	12	--	15	--	27
		Garcia-Galan, 2012	14	7	10	--	31
		Mean (SE)					*29(2)*
	Field	Boreen, 2005	12	16	--	2	30
		Mean (SE)					*30*
Sulfamethizole	Lab	Boreen, 2004	14	--	13	--	27
		Mean (SE)					*27*
	Field	Boreen, 2004	15	16	--	2	33
		Mean (SE)					*33*
Sulfamethoxazole	Lab	Bonvin, 2013	22	19	--	--	41
		Boreen, 2004	14	--	13	--	27
		Jasper, 2013	15	9	24	--	48
		Lam, 2005	17	10	11	--	38
		Moore, 1994	7	11	--	--	18
		Niu, 2013	14	14	12	--	40
		Ryan, 2011	6	13	16	--	35
		Trovo, 2009	15	5	9	--	29
		Mean (SE)					*35(3)*
	Field	Andreozzi, 2003	10	4	4	2	20
		Boreen, 2004	15	16	--	2	33
		Kunkel, 2012	15	--	8	8	31
		Lam, 2004	14	--	6	12	32
		Moore, 1994	8	11	--	3	22
		Ryan, 2011	6	13	16	2	37
		Mean (SE)					*29(3)*
Sulfamethoxypyridazine	Lab	Khaleel, 2013	9	7	7	--	23
		Mean (SE)					*23*
Sulfamoxole	Lab	Boreen, 2004	14	--	13	--	27
		Mean (SE)					*27*
	Field	Boreen, 2004	15	16	--	2	33
		Mean (SE)					*33*
Sulfapyridine	Lab	Challis, 2013	13	18	13	--	44
		Garcia-Galan, 2012	14	7	10	--	31
		Mean (SE)					*38(7)*
Sulfathiazole	Lab	Boreen, 2004	14	--	13	--	27
		Mean (SE)					*27*
	Field	Boreen, 2004	15	16	--	2	33
		Mean (SE)					*33*
Sulfisoxazole	Lab	Boreen, 2004	14	--	13	--	27
		Mean (SE)					*27*
	Field	Boreen, 2004	15	16	--	2	33
		Mean (SE)					*33*
Sulfone							
Dapsone	Lab	Kawabata, 2013	12	4	--	--	16
		Mean (SE)					*16*

	Field	Kawabata, 2013	12	4	--	2	18
		Mean (SE)					*18*
Tetracycline							
Oxytetracycline	Field	Lunestad, 1995	10	--	4	5	19
		Mean (SE)					*19*
Tetracycline	Lab	Chen, 2008	10	11	11	--	32
		Jiao, 2008	11	10	7	--	28
		Oka, 1989	9	3	--	--	12
		Wammer, 2011	10	--	11	--	21
		Werner, 2006	11	22	--	--	33
		Mean (SE)					*25(4)*

Table S1B: Anti-psychotics

Anti-psychotic	**Data Type and Source**		**Score**				
Compound	**Lab or Field**	**Reference**	**Experimental**	**Direct**	**Indirect**	**Field/Sunlight**	**Total**
Anti-depressant							
Chlorpromazine	Lab	Trautwein, 2012	10	10	--	--	20
		Mean (SE)					*20*
Anti-depressant - benzodiazepine							
Alprazolam	Lab	Calisto, 2011b	16	11	11	--	38
		Mean (SE)					*38*
Citalopram	Lab	Kwon, 2005	18	13	11	--	42
		Mean (SE)					*42*
Diazepam	Lab	West, 2012	16	9	11	--	36
		Calisto, 2011b	16	11	11	--	38
		Mean (SE)					*37(1)*
Lorazepam	Lab	Calisto, 2011b	16	11	11	--	38
		Mean (SE)					*38*
Midazolam	Lab	Andersin, 1995	14	5	--	--	19
		Mean (SE)					*19*
Oxazepam	Lab	Calisto, 2011b	16	11	11	--	38
		Mean (SE)					*38*
Anti-depressant – reuptake inhibitors							
Bupropion	Lab	Santoke, 2012	8	2	7	--	17
		Mean (SE)					*17*
Duloxetine	Lab	Santoke, 2012	8	2	7	--	17
		Mean (SE)					*17*
Fluoxetine	Lab	Kwon, 2006	16	12	13	--	41
		Lam, 2005	17	11	13	--	41
		Mean (SE)					*41(0)*
Paroxetine	Lab	Kwon, 2004	17	16	12	--	45
		Mean (SE)					*45*
Sertraline	Field	Lam, 2004	14	--	6	12	32
		Mean (SE)					*32*
Venlafaxine	Lab	Rua-Gomez, 2013	10	11	11	--	32
		Santoke, 2012	8	2	7	--	17
		Mean (SE)					*25(8)*
	Field	Rua-Gomez, 2013	10	11	11	6	38
		Mean (SE)					*38*
Anti-epileptic							
Carbamazepine	Lab	Calisto, 2011a	17	19	--	--	36
		Calza, 2013	12	--	5	--	17

		Chiron, 2006	10	5	14	--	29
		Doll, 2003	19	11	11	--	41
		Jasper, 2013	15	9	24	--	48
		Lam, 2005	17	10	11	--	38
		Matamoros, 2009	12	10	11	--	33
		Peuravuori, 2009	12	5	13	--	30
		Mean (SE)					*34(3)*
	Field	Andreozzi, 2002	13	4	6	9	32
		Andreozzi, 2003	10	4	4	2	20
		Kunkel, 2012	15	--	8	8	31
		Lam, 2004	14	--	6	12	32
		Matamoros, 2009	12	--	11	4	27
		Yamamoto, 2009	13	6	--	5	24
		Mean (SE)					*28(2)*
Phenytoin	Lab	Chen, 2009	18	--	19	--	37
		Kawabata, 2013	12	4	--	--	16
		Mean (SE)					*27(11)*
	Field	Kawabata, 2013	12	4	--	2	18
		Mean (SE)					*18*

Table S1C: β-blockers

β-blocker	**Data Type and Source**		**Score**				
Compound	**Lab or Field**	**Reference**	**Experimental**	**Direct**	**Indirect**	**Field/Sunlight**	**Total**
Acebutolol	Lab	Piram, 2008	11	4	4	--	19
		Mean (SE)					*19*
Alprenolol	Lab	Piram, 2008	11	4	4	--	19
		Mean (SE)					*19*
Atenolol	Lab	Andrisano, 1999	9	11	--	--	20
		Chen, 2012	16	5	26	--	47
		Jasper, 2013	15	9	24	--	48
		Ji, 2012	17	--	20	--	37
		Liu, 2007	19	11	--	--	30
		Liu, 2009	18	6	12	--	36
		Piram, 2008	11	4	4	--	19
		Wang, 2012	13	8	17	--	38
		Zeng, 2012	18	--	13	--	31
		Mean (SE)					*34(3)*
	Field	Yamamoto, 2009	13	7	--	5	25
		Mean (SE)					*25*
Bisoprolol	Lab	Piram, 2008	11	4	4	--	19
		Mean (SE)					*19*
Metoprolol	Lab	Chen, 2012	16	5	26	--	47
		Liu, 2007	19	11	--	--	30
		Liu, 2009	18	6	12	--	36
		Peuravuori, 2009	12	5	13	--	20
		Piram, 2008	11	4	4	--	19
		Wang, 2012	13	8	17	--	38
		Mean (SE)					*32(4)*
	Field	Fono, 2006	14	8	8	14	44
		Kunkel, 2012	15	--	8	8	31
		Mean (SE)					*38(7)*
Nadolol	Lab	Piram, 2008	11	4	4	--	19

		Wang, 2012	13	8	17	--	38
		Mean (SE)					*29(10)*
Pindolol	Lab	Piram, 2008	11	4	4	--	19
		Mean (SE)					*19*
Propranolol	Lab	Chen, 2009	18	--	19	--	37
		Dantas, 2010	6	8	--	--	14
		Jasper, 2013	15	9	24	--	48
		Lin, 2005	14	15	11	--	40
		Liu, 2007	19	11	--	--	30
		Liu, 2009	18	6	12	--	36
		Piram, 2008	11	4	4	--	19
		Robinson, 2007	15	10	--	--	25
		Mean (SE)					*31(4)*
	Field	Andreozzi, 2003	10	4	4	2	20
		Dantas, 2010	7	5	--	2	14
		Kunkel, 2012	15	--	8	8	31
		Yamamoto, 2009	13	7	--	5	25
		Mean (SE)					*23(4)*
Sotalol	Lab	Piram, 2008	11	4	4	--	19
		Mean (SE)					*19*
	Field	Kunkel, 2012	15	--	8	8	31
		Mean (SE)					*31*
Timolol	Lab	Chen, 2013	14	5	24	--	43
		Piram, 2008	11	4	4	--	19
		Mean (SE)					*31(12)*

Table S1D: Hormones

Hormone	**Data Type and Source**		**Score**				
Compound	**Lab or Field**	**Reference**	**Experimental**	**Direct**	**Indirect**	**Field/Sunlight**	**Total**
17α-ethinyl estradiol	Lab	Atkinson, 2011	8	8	9	--	25
		Lin, 2005	14	15	11	--	40
		Liu, 2003	7	7	5	--	19
		Matamoros, 2009	12	10	11	--	33
		Mazellier, 2008	11	8	--	--	19
		Whidbey, 2012	11	7	9	--	27
		Mean (SE)					*27(3)*
	Field	Matamoros, 2009	12	--	11	4	27
		Zuo, 2013	14	--	3	5	22
		Mean (SE)					*25(3)*
17β-estradiol	Lab	Chowdhury, 2011	19	19	11	--	49
		Leech, 2009	14	6	8	--	28
		Lin, 2005	14	15	11	--	40
		Mazellier, 2008	11	8	--	--	19
		Whidbey, 2012	11	7	9	--	27
		Mean (SE)					*33(5)*
Equilenin	Lab	Whidbey, 2012	11	7	9	--	27
		Mean (SE)					*27*
Equilin	Lab	Whidbey, 2012	11	7	9	--	27
		Mean (SE)					*27*
Estriol	Lab	Lin, 2005	14	15	11	--	40
		Mean (SE)					*40*
Estrone	Lab	Atkinson, 2011	8	8	9	--	25

		Caupos, 2011	18	5	13	--	36
		Lin, 2005	14	15	11	--	40
		Whidbey, 2012	11	7	9	--	27
		Mean (SE)					*32(4)*
Raloxifene	Lab	Kawabata, 2013	12	4	--	--	16
		Mean (SE)					*16*
		Kawabata, 2013	12	4	--	2	18
		Mean (SE)					*18*

Table S1E: Lipid-lowering agents

Lipid-lowering	**Data Type and Source**		**Score**				
Compound	**Lab or Field**	**Reference**	**Experimental**	**Direct**	**Indirect**	**Field/Sunlight**	**Total**
Fibrates							
Bezafibrate	Lab	Cermola, 2005	11	1	3	--	15
		Mean (SE)					*15*
	Field	Kunkel, 2012	15	--	8	8	31
		Radke, 2010	13	11	13	7	44
		Mean (SE)					*38(7)*
Clofibric acid	Lab	Doll, 2003	19	11	11	--	41
		Lam, 2003	15	8	15	--	38
		Mean (SE)					*40(2)*
	Field	Andreozzi, 2003	10	4	4	2	20
		Packer, 2003	17	10	14	3	44
		Radke, 2010	13	11	13	7	44
		Mean (SE)					*36(8)*
Fenofibrate	Lab	Cermola, 2005	11	1	3	--	15
		Mean (SE)					*15*
Fenofibric acid	Lab	Cermola, 2005	11	1	3	--	15
		Mean (SE)					*15*
Statins							
Atorvastatin	Lab	Lam, 2005	17	10	11	--	*38*
		Razavi, 2011	6	--	14	--	20
		Mean (SE)					*29(9)*
	Field	Lam, 2004	14	--	6	12	32
		Mean (SE)					*32*

Table S1F: Non-steroidal anti-inflammatory drugs (NSAIDs)

NSAID	**Data Type and Source**		**Score**				
Compound	**Lab or Field**	**Reference**	**Experimental**	**Direct**	**Indirect**	**Field/Sunlight**	**Total**
Diclofenac	Lab	Eriksson, 2010	8	7	5	--	20
		Peuravuori, 2012	16	7	8	--	31
		Zhang, 2011	12	5	14	--	31
		Mean (SE)					*27(4)*
	Field	Aguera, 2005	16	4	4	3	27
		Andreozzi, 2003	10	4	4	2	20
		Bartels, 2007	16	11	1	6	34
		Buser, 1998	15	4	3	7	29
		Kunkel, 2012	15	--	8	8	31
		Lindstrom, 2002	8	5	8	5	26
		Packer, 2003	17	10	14	3	44

		Poiger, 2001	14	7	6	5	32
		Radke, 2010	13	11	13	7	44
		Mean (SE)					*32(3)*
Ibuprofen	Lab	Jacobs, 2011	17	9	13	--	39
		Lin, 2005	14	15	11	--	40
		Matamoros, 2009	12	10	11	--	33
		Packer, 2003	17	10	14	3	44
		Peuravuori, 2009	12	5	13	--	20
		Vione, 2011	9	8	9	--	26
		Mean (SE)					*34(4)*
	Field	Fono, 2006	14	8	8	14	44
		Kunkel, 2012	15	--	8	8	31
		Matamoros, 2009	12	--	11	4	27
		Yamamoto, 2009	13	7	--	5	25
		Mean (SE)					*32(4)*
Indomethacin	Lab	Kawabata, 2013	12	4	--	--	16
		Mean (SE)					*16*
	Field	Kawabata, 2013	12	4	--	2	18
		Yamamoto, 2009	13	7	--	5	25
		Mean (SE)					*22(4)*
Ketoprofen	Lab	Lin, 2005	14	15	11	--	40
		Matamoros, 2009	12	10	11	--	33
		Mean (SE)					*37(4)*
	Field	Matamoros, 2009	12	--	11	4	27
		Mean (SE)					*27*
Mefenamic acid	Lab	Werner, 2005	12	10	15	--	37
		Mean (SE)					*37*
	Field	Werner, 2005	13	10	11	2	36
		Yamamoto, 2009	13	7	--	5	25
		Mean (SE)					*31(6)*
Naproxen	Lab	Kawabata, 2013	12	4	--	--	16
		Lin, 2005	14	15	11	--	40
		Mean (SE)					*28(12)*
	Field	Fono, 2006	14	8	8	14	44
		Kunkel, 2012	15	--	8	8	31
		Packer, 2003	17	10	14	3	44
		Radke, 2010	13	11	13	7	44
		Kawabata, 2013	12	4	--	2	18
		Mean (SE)					*36(5)*
Sulindac	Lab	Kawabata, 2013	12	4	--	--	16
		Mean (SE)					*16*
	Field	Kawabata, 2013	12	4	--	2	18
		Mean (SE)					*18*

Table S1G: Others

Other	**Data Type and Source**		**Score**				
Compound	**Lab or Field**	**Reference**	**Experimental**	**Direct**	**Indirect**	**Field/Sunlight**	**Total**
Analgesic							
Acetaminophen/ paracetomol	Lab	Kawabata, 2013	12	4	--	--	16
		Peuravuori, 2012	7	10	9	--	26
		Mean (SE)					*21(5)*
	Field	Kawabata, 2013	12	4	--	2	18

		Lam, 2004	14	--	6	12	32
		Yamamoto, 2009	13	6	--	5	24
		Mean (SE)					*25(4)*
Antipryrine	Lab	Chen, 2009	18	--	19	--	37
		Mean (SE)					*37*
Salicylic acid	Lab	Gangwang, 2012	13	9	10	--	32
		Mean (SE)					*32*
Tramadol	Lab	Rua-Gomez, 2013	10	11	11	--	32
		Mean (SE)					*32*
	Field	Rua-Gomez, 2013	10	11	11	6	38
		Mean (SE)					*38*
β_2-andrenergic agonist							
Salbutamol	Lab	Dodson, 2011	7	12	--	--	19
		Mean (SE)					*19*
H_2-antagonist							
Cimetidine	Lab	Latch, 2003	12	11	19	--	42
		Mean (SE)					*42*
	Field	Latch, 2003	12	11	--	3	26
		Mean (SE)					*26*
Ranitidine	Lab	Latch, 2003	12	11	19	--	42
		Mean (SE)					*42*
	Field	Latch, 2003	12	11	--	3	26
		Mean (SE)					*26*
Anti-arrhythmic							
Amiodarone	Lab	Kawabata, 2013	12	4	--	--	16
		Mean (SE)					*16*
	Field	Kawabata, 2013	12	4	--	2	18
		Mean (SE)					*18*
Lidocaine	Lab	Rua-Gomez, 2013	10	11	11	--	32
		Mean (SE)					*32*
	Field	Rua-Gomez, 2013	10	11	11	6	38
		Mean (SE)					*38*
Mexiletine	Lab	Chen, 2009	18	--	19	--	37
		Mean (SE)					*37*
Anti-cancer							
Cyclophosphamide	Lab	Lin, 2013	18	14	12	--	44
		Mean (SE)					*44*
5−Fluorouracil	Lab	Lin, 2013	18	14	12	--	44
		Mean (SE)					*44*
Anti-coagulant							
Warfarin	Lab	Peuravuori, 2009	12	5	13	--	20
		Mean (SE)					*20*
Anti-histamine							
Diphenhydramine	Lab	Chen, 2009	18	--	19	--	37
		Mean (SE)					*37*
Anti-viral							
Oseltamivir ester	Lab	Goncalves, 2011	16	12	13	--	41
		Mean (SE)					*41*
	Field	Goncalves, 2011	16	4	6	4	30
		Mean (SE)					*30*
Oseltamivir carboxylate	Lab	Goncalves, 2011	16	12	13	--	41
		Mean (SE)					*41*
	Field	Goncalves, 2011	16	4	6	4	30

		Bartels, 2008	15	8	11	6	40
		Mean (SE)					*35(5)*
Glucocorticoid steroid							
Dexamethasone	Lab	Kawabata, 2013	12	4	--	--	16
		Mean (SE)					*16*
	Field	Kawabata, 2013	12	4	--	2	18
		Mean (SE)					*18*
Vasodilator							
Ifenprodil	Field	Yamamoto, 2009	13	6	--	5	24
		Mean (SE)					*24*
Stimulant							
Caffeine	Lab	Jacobs, 2012	10	6	14	--	30
		Mean (SE)					*30*
	Field	Lam, 2004	14	--	6	12	32
		Mean (SE)					*32*

Table S2: Scoring rubric used as the weight-of-evidence tool to evaluate each study. The coloured dots beside the sections indicate that those sections apply. For example, a study done in the field (field/sun photolysis) is still evaluated on the experimental, direct photolysis, and indirect photolysis criteria, if applicable.

Quality/relevance/extent of photolysis study	0 (no)	1 (yes)	2	3	4
Experimental					
Wavelength distribution of light source	λ <290 nm	mono/polychromatic(λ>290)	290 – 800 nm (Xe lamp/sunlight)		
Sample vessel	absorbs λ >290 nm	absorbs λ <290 nm	absorbs λ <290 nm and reports material (glass, quartz etc.) =2; geometry =3; positioning, λ cut-off etc. =4		
Measured light flux – spectral radiometer/actinometer	no	once – before or after study	before and after; entire study		
Triplicate irradiations	no	yes			
Number of time points	2 or less	3-4	>5		
Study duration	<1 half life	≥1 half life			
Dark control	No (=-2)	yes			
Temperature (°C)	not reported	10> temp >40	environmental temp. (25 ± 15)	multiple temp. including 25 °C	
Sampling (aliquot versus sacrificial)	20 – 30% of sample vol.	5-10% of sample vol.	<5% of sample vol./ sacrificial sampling		
Solvent carrier	any solvent	in H_2O			
Concentration of test chemical (absorbance)	not optically dilute (>0.05)	optically dilute (<0.05)	close to environ. conc. (i.e., ppb)		
Photodegradation product (pp) identification (id)	no	yes	pp id – LC-UV+ standards; MS(/MS)	pp id – TOF, NMR	quantify pp loss/ produc.; pp pathway
Direct photolysis •	**no**	**yes**			
Buffered nanopure H_2O	no	yes			
pH of sample	not reported	@ 1 pH: 5> pH >9	@ 1 pH: 5 – 9	@ 2 pH: 5 – 9	@ 3 pH: 5 – 9
Considered pKa of test compound	no	yes	single species (i.e., ≥ 2 pH from pKa)		
UV-vis spectra of compound	no	yes – shown/ described			
Pseudo-1st-order plot	C_t vs. time	C_t / C_o vs. time	ln[C_t / C_o] vs. time	ln[C_t / C_o] vs. time and reports k	
R^2-1st-order decay curve; rate ± error (k, time^{-1}); Ø ± error	no	k /Ø±error: +1 given; -1 if not	R^2<0.8	R^2<0.9	R^2>0.9
Quantum yield (Ø)	no	yes	calculations and formulas shown		
Use Ø to estimate sunlight half-life	no	L_λ data (latitude-season)	compare estimation to environ. fate		
Indirect photolysis • •	**no**	**yes**			
Natural water (NW) or simulated NW (SNW)		source of NW/ SNW reported	Species relevant to photolysis: DOC/cDOM, NO_3^- (1), Fe (1), DO (1), CO_3^- (1) etc. (must have [DOC/cDOM] to score 4)		
UV-vis spec of NW/SNW	no	yes	S_λ calc, reported, applied		
R^2-1st-order decay curve; rate ± error (k, time^{-1})	no	k±error: +1 if given; -1 if not	R^2<0.7	0.7< R^2 <0.9	R^2>0.9
Quenching/competition/ mechanism experiments	no	1 species	2 species	3 species (i.e. OH, $^1O_2$, ^{3}DOM)	4 species
Field/solar photolysis • • •	**no**	**yes**			
Whole versus isolated system		isolated in sample vessels	small microcosms (1-100 L)	med. microcosms (100-1000 L)	mesocoms (>1000 L) or real system
Diurnal cycle versus partial exposure		partial exposure	full diurnal cycle		
Compare measured flux to L_λ data	no	is the comparison valid (1), do they discuss any differences in flux (1), how well do they match (1)			
R^2-1st-order decay curve; rate ± error (k, time^{-1})	no	k±error: +1 if given; -1 if not	R^2<0.7	R^2<0.8	R^2>0.9
Consider depth/attenuation	no	yes			
Report weather conditions	no	yes			
Other processes considered as they relate to photolysis	no	sediment binding (1), biota binding (1), microbial degradation (1), plant uptake (1), hydrolysis (1), photo-toxicity (1), etc.			

LC-UV=liquid chromatography (LC) – ultra-violet (UV) detection. MS=mass spectrometry. TOF=time of flight. NMR=nuclear magnetic resonance. DOC/cDOM=dissolved organic carbon/chromaphoric dissolved organic matter

Table S3A-B: Two examples of scored and evaluated studies showing the filled in rubric with scores and a brief description of the study. All scored studies included in this review were evaluated in an identical manner. See the comments following Table S3B for a demonstration of how lab, field, and total scores are derived for Table S1A-G. Individual scoring sheets for specific studies are available from the contact author upon request.

Table S3A: M. W. Lam and S. A. Mabury, *Aquatic Sciences*, 2005, **67**, 177-188

Keywords: *atorvastatin, carbamazepine, levofloxacin, sulfamethoxazole, lab irradiations, direct and indirect photolysis, photo-products, quenching/competition mechanism experiments*

Quality/relevance/extent of photolysis study		Score
Experimental		**17**
Wavelength distribution of light source	Suntest CPS Photosimulator equipped with Xe lamp as the UV radiation source and glass filters restricting the transmission of wavelengths below 290 nm	2
Sample vessel	10 mL quartz vessels	1
Measured light flux – spectral radiometer/actinometer	The lamp was set to maximum intensity 765 W/m^2 on irradiation apparatus (Suntest). PNA/PYR used as actinometer	2
Triplicate irradiations	Yes	1
Number of time points	5 time points	2
Study duration	To at least one half life	1
Dark control	Yes	1
Temperature (^{o}C)	A cold water tray was used to maintain the internal temperature at 27 ^{o}C	2
Sampling (aliquot versus sacrificial)	Not reported	0
Solvent carrier	No, stocks were made up pure water	1
Concentration of test chemical (absorbance)	10 µM (approximately >1 ppm) – not optically dilute or environmentally relevant	0
Photodegradation products (pp)	Yes. LC-MS/MS used to identify pp. Pathway proposed for some of the pp	4
Direct photolysis •		**10**
Buffered nanopure H_2O	DI water	1
pH of sample	pH = 4, 7, 9	3
Considered pKa of test compound	No	0
UV-vis spectra of compound	Yes	1
Pseudo-1st-order decay plot	ln[C_t/C_o] vs. time plotted for sulfamethoxazole. Rate constants/half lives reported for others	3
R^2-1st-order decay curve; rate ± error (k, time^{-1}); Ø ± error	R^2 not reported. Errors in half lives given, not for quantum yields	1
Quantum yield (Ø)	Yes. Calculations for quantum yields not reported	1
Use Ø to estimate sunlight half-life	No	0
Indirect photolysis • •		**11**
Natural water (NW) or simulated NW (SNW)	SNW – water spiked with different concentrations of DOM, nitrate, and carbonate according to the PhotoFate solutions. Differing concentrations (=1)	4
pH of sample	Not reported	0
UV-vis spec of NW/SNW	Spectra not shown but screening factors were calculated	1
Pseudo-1st-order decay plot	Not given. Half lives of drugs are reported based on first order kinetics and plotted as a bar graph as a function of SNW solution	3
R^2-1st-order decay curve; rate ± error (k, time^{-1})	R^2 not reported. Errors in half lives given	1
Quenching experiments	2-propanol used as OH-radical quencher	1
Other processes considered as they relate to photolysis	OH-radical second order rate constants determined through competition kinetics	1
Field/sun photolysis • • •	No	**0**

Comments: This is a very good photochemical study examining the direct and indirect photolytic fate of four pharmaceuticals under simulated sunlight. They found that direct photolysis was the major photodegradation mechanism for some of the target compounds, while indirect photolysis more significantly enhanced degradation for others. Carbamazepine was the most persistent drug in all cases and saw a large enhancement in removal in SNW. Interestingly, some of the quantum yield determinations from this study did not agree with others in the literature, specifically Andreozzi et al. (2003) which determined quantum yields for some of the same compounds in sunlight.

Total (lab) score = 38 (17+10+11)

Table S3B: A. L. Boreen, W. A. Arnold and K. McNeill, *Environmental Science & Technology*, 2004, **38**, 3933-3940

Keywords: *sulfamethoxazole, sulfisoxazole, sulfamethizole, sulfathiazole, sulfamoxole, lab and sunlight irradiations, direct and indirect photolysis, photo-products, quenching/competition mechanism experiments*

Quality/relevance/extent of photolysis study		Score
Experimental		**15/14**
Wavelength distribution of light source	Natural sunlight – 45° N (May 13, June 5, 9). (2 – for sunlight irradiations) Lab irradiations - turntable apparatus with 4x Pyrex-filtered 175 W medium-pressure Hg-vapor lamp (1 – for lab irradiations)	2/1
Sample vessel	Natural sunlight - uncapped quartz test tubes (o.d.=1.3 cm, i.d.=1.1 cm, 10 mL) – held at 45° to sunlight. Lab irradiations - uncapped borosilicate test tubes	3
Measured light flux – spectral radiometer/actinometer	PNA/PYR actinometer for sunlight. Not reported for lab irradiations. Frequency of measurement not reported. Sounds like they may have used L_λ data for sunlight experiments (mentioned in footnote of Table 2).	1
Triplicate irradiations	Not reported	0
Number of time points	Not reported but based on plots, looks like 6	2
Study duration	Not reported. Based on plots between minutes to hours	1
Dark control	Yes	1
Temperature (°C)	Not reported	0
Sampling (aliquot versus sacrificial)	Aliquot, 500 µL from 10 mL (5% v/v) for both experiments	1
Solvent carrier	No. Dissolved in water	1
Concentration of test chemical (absorbance)	100 µM (≈25 ppm) for both experiments – not optically dilute or environmentally relevant.	0
Photodegradation products (pp)	Yes. LC-UV and LC-MS/MS and authentic standards to confirm some products. Monitored formation of sulfanilic acid as a pp and breakdown of sulfa drugs. Proposed some cleavage sites for the formation of identified pp	3
Field/sun photolysis	Direct photolysis experiments done under natural sunlight	
Direct photolysis •		**16**
Buffered nanopure H_2O	Yes, various buffers in DI water	1
pH of sample	Between 5 – 6 pH values between 2 – 10, depending on compound. Generally pH ≈ 2, 4, 5, 7, 9, 10	4
Considered pKa of test compound	Yes. The pK_{a1} and pK_{a2} were determined for all sulfa drugs using spectrophotometric titration techniques. Irradiations were done at each protonation state for all sulfa drugs	2
UV-vis spectra of compound	Yes, at multiple pH's	1
Pseudo-1st-order decay plot	$\ln[C_t / C_o]$ vs. time and reports k	3
r^2-1st-order decay curve; rate ± error (k, time^{-1}); Ø ± error	r^2 not reported. k ± error, Ø ± error reported	2
Quantum yield (Ø)	Yes, quantum yields given for all compounds at the various protonation states. Formula provided.	2
Use Ø to estimate sunlight half-life	Yes, direct photolysis half lives estimated for mid-spring, noon, 45° N and for "half light attenuation" (rate constant is halved).	1
Indirect photolysis • •	Indirect experiments done using laboratory irradiation techniques	**13**
Natural water (NW) or simulated NW (SNW)	NW - taken from Lake Josephine and Lake Superior, filtered. All important cations and anions analyzed (18 ions in total). DOC=2-6 mg/L	4
pH of sample	Josephine pH = 8.4; Superior pH = 8.3	2
UV-vis spectra of compound	Yes, at multiple pH's	1
UV-vis spec of NW/SNW	Not provided	0
Pseudo-1st-order decay plot	$\ln[C_t / C_o]$ vs. time. Rate constants not reported for indirect experiments	2
r^2-1st-order decay curve; rate ± error (k, time^{-1})	r^2 not reported. k ± error not reported	0
Quenching experiments	Yes, experiments were done to consider singlet oxygen (1) and hydroxyl radicals (1). Laser flash photolysis determined $k_{tot}{}^1O_2$ (substrate can quench and react with $^1O_2$). Steady state photolysis was used to determine $k_{rxn}{}^1O_2$ (by comparison with FFA). Bimolecular hydroxyl radical rate constants for the sulfa drugs were also determined using Fenton's reagent (determining bimolecular rate constants =1)	3
Other processes considered as they relate to photolysis	Using the OH radical and $^1O_2$ rate constants, environmental half lives of each sulfa drug were estimated assuming environmental conc. of OH radicals and $^1O_2$	1

Field/sun photolysis • • •		**2**
Whole versus isolated system	Isolated system	1
Diurnal cycle versus partial exposure	Unclear, but based on data it seems like exposures were short, i.e. less than 1 day. Partial exposure	1
Compare measured flux to L_λ data	No, L_λ data was used	0
Consider depth/attenuation	No	0
Report weather conditions	No	0

Comments: This is an excellent study looking at the photochemical fate of sulfa drugs in the environment. Natural sunlight was used for the direct photolysis experiments and lab irradiations were done for indirect photolysis and quenching experiment. Based on the many different photolysis mechanisms that were studied here, the authors determined that direct photolysis is the primary mechanism of photolysis in the environment. Singlet oxygen and OH-radicals may only play a role in nitrate and humic rich waters where the concentration of these species would be quite high.

Lab score = 27 (14+13)

Field score = 33 (15+16+2)

Total (lab/field) score = 46 (15+16+13+2)