

Table 1. Fluences for multiple log reductions for various spores

Spore	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation					Proto- col?	Notes	Reference
		1	2	3	4	5			
<i>Aspergillus brasiliensis</i> (previously known as <i>Aspergillus niger</i>) ATCC 16404 (dark culture)	LP	122	226	293			yes		Taylor-Edmonds et al. 2015
<i>Aspergillus niger</i>									
ATCC 32625	LP	116	245	370	560		yes		Clauß 2006
ATCC 32625	Excimer 222 nm	90	220	325	430		yes		Clauß 2006
<i>Bacillus anthracis</i>									
Sterne	LP	28	37	52			yes		Nicholson & Galeano 2003
Sterne	LP	23	30				yes		Blatchley III et al. 2005
Ames	LP	25	~40	>120 with tailing			yes		Rose & O'Connell 2009
34F2 (Sterne) method: soil extract- peptone-beef extract agar	LP	23	~40	>120 with tailing			yes		Rose & O'Connell 2009
34F2 (Sterne) method: Schaeffer's sporulation medium	LP	23	36	80			yes		Rose & O'Connell 2009
<i>Bacillus atrophaeus</i>									
ATCC 9372	LP	22	38	55	71		yes		Zhang et al. 2014
	LP	10	16	26	39		yes		Sholtes et al. 2016
	UV-LED 260 nm	6	10	14	19	31	yes		Sholtes et al. 2016
<i>Bacillus cereus</i>									
ATCC 11778	Excimer 222 nm	25	43	69			yes		Clauß 2006
ATCC 11778	LP	52	93	140			yes		Clauß 2006
T	LP	23	30	35	40		yes		Blatchley III et al. 2005
<i>Bacillus megaterium</i> (spores) QMB 1551	265 nm	28	42	55			no		Donnellan & Stafford 1968
<i>Bacillus pumilus</i>									
ASFUVR	Filtered MP 258 nm	87	130	184			yes		Beck et al. 2015
ASFUVR	LP	173	348				yes		Boczek et al. 2016
ATCC 27142	LP	68	138	204	272		yes		Boczek et al. 2016
<i>Bacillus subtilis</i>									
ATCC 6633	LP	12	18	24	30	36	yes		Quails & Johnson 1983
ATCC 6633	LP	36	48	59	77		yes		Chang et al. 1985
ATCC 6633	LP	28	40	50			yes		Sommer et al. 1998
ATCC 6633	LP	19	40	60	81		yes		Sommer et al. 1999

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		1	2	3	4	5			
<i>Bacillus subtilis</i> (cont.)									
ATCC 6633	LP	31	47	64	80		yes	Action spectrum	Cabaj et al. 2002
ATCC 6633	LP	25	39	50	60		yes		Nicholson & Galeano 2003
ATCC 6633	LP	24	35	47	79		yes		Mamane-Gravetz & Linden 2004
ATCC 6633 (surface cultured)	LP	11	18	24	31		yes	Action spectrum	Mamane-Gravetz et al. 2005
ATCC 6633 (liquid cultured)	LP	13	23	33			yes		Bohrerova et al. 2006
ATCC 6633 (surface cultured)	LP	9	15				yes		Bohrerova et al. 2006
ATCC 6633 (surface cultured)	Excimer 222 nm	7	12	18	23		yes		Pennell et al. 2008
ATCC 6633 (surface cultured)	LP	19	24	30	35		yes		Pennell et al. 2008
ATCC 6633 (surface cultured)	282 nm	19	29	39	49		yes		Pennell et al. 2008
ATCC 6633	LP	9	17	26	34		yes		Bichae et al. 2009
ATCC 6633	LP	21	32	43	55		yes	Action spectrum	Chen et al. 2009
ATCC 6633 (surface cultured)	LP	18	39	61	82		yes		Sun & Liu 2009
ATCC 6633	LP	24	37	51	80 + tailing		yes		Mamane et al. 2009
ATCC 6633	LP	26	40	55	69		yes		Wang et al. 2010
ATCC 6633	Excimer 222 nm	13	21	30	38		yes		Wang et al. 2010
ATCC 6633	Excimer 172 nm	435	869				yes		Wang et al. 2010
ATCC 6633	UV-LED 269 nm	2	10	17	25		yes		Würtele et al. 2010
ATCC 6633	UV-LED 282 nm	3	11	18	26		yes		Würtele et al. 2010
ATCC 6051	LP	8	13	17	20 + tailing		yes		Jin et al. 2006
TKJ 6312	LP	0.7	1.5	2.3	3.7		yes		Sommer et al. 1999
WN624	LP	25	36	49	60		yes		Nicholson & Galeano 2003
<i>Cylindrospermum</i> spores	LP	14	26	43			no		Singh 1975
<i>Clostridium pasteurianum</i>									
ATCC 6013	LP	3.4	5.3	6.7	8.4		yes		Clauß 2006
ATCC 6013	Excimer 222 nm	4.3	6.1	7.9	9.6		yes		Clauß 2006
<i>Encephalitozoon intestinalis</i>									
	LP	2.8	5.6	8.4			yes		John et al. 2003
(microsporidia)	LP & MP	<3	3	<6			yes		Huffman et al. 2002

Spore	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation					Proto- col?	Notes	Reference
		1	2	3	4	5			
<i>Fischerella muscicola</i> spores	LP	189					no		Singh 1975
<i>Penicillium expansum</i>									
ATCC 36200	LP	11	38	49	65		yes		Clauß 2006
ATCC 36200	Excimer 222 nm	22	33	42			yes		Clauß 2006
<i>Streptomyces griseus</i>									
ATCC 10137	LP	8.5	13	15	18		yes		Clauß 2006
ATCC 10137	Excimer 222 nm	13	17	20	26		yes		Clauß 2006
<i>Thermoactinomyces vulgaris</i>									
ATCC 43649	LP	55	90	115	140		yes		Clauß 2006
ATCC 43649	Excimer 222 nm	25	38	46	55		yes		Clauß 2006

Table 2. Fluences for multiple log reductions for various bacteria

Bacterium	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation						Protocol?	Notes	Reference
		1	2	3	4	5	6			
<i>Aeromonas hydrophila</i> ATCC 7966	LP	1.1	2.5	4.0	5.5	6.9	8.4	yes		Wilson et al. 1992
<i>Aeromonas salmonicida</i> AL 2017	LP	1.5	2.7	3.1	5.9			yes		Liltved & Landfald 1996
<i>Arthrobacter nicotinovorans</i>										
ATCC 49919	LP	8	10	12	14			yes		Clauß 2006
ATCC 49919	Excimer 222 nm	10	15	18	20			yes		Clauß 2006
<i>Bacillus cereus</i> (veg. bacteria)										
ATCC 11778	LP	6	7	9	12			yes		Clauß 2006
ATCC 11778	Excimer 222 nm	9	11	14	18			yes		Clauß 2006
<i>Bacillus megaterium</i> (veg. cells) QMB 1551	265 nm	4.6						no		Donnellan & Stafford 1968
<i>Burkholderia mallei</i>										
M9	LP	1.0	2.4	3.8	5.2			yes		Rose & O'Connell 2009
M13	LP	1.2	2.7	4.1	5.5			yes		Rose & O'Connell 2009
<i>Brucella melitensis</i>										
ATCC 23456	LP	2.8	5.3	7.8	10.3			yes		Rose & O'Connell 2009
IL195	LP	3.7	5.8	7.8	9.9			yes		Rose & O'Connell 2009
<i>Burkholderia pseudomallei</i>										
ATCC 11688	LP	1.7	3.5	5.5	7.4			yes		Rose & O'Connell 2009
CA650	LP	1.4	2.8	4.3	5.7			yes		Rose & O'Connell 2009
<i>Brucella suis</i>										
KS528	LP	2.7	5.3	7.9	10.5			yes		Rose & O'Connell 2009
MO 562	LP	1.7	3.6	5.6	7.5			yes		Rose & O'Connell 2009
<i>Campylobacter jejuni</i>										
ATCC 43429	LP	1.0	2.1	3.4	4.6	5.8		yes		Wilson et al. 1992
biotype 1 strain 709/84	LP	0.8	1.3	1.7	2.1			yes		Butler et al. 1987
<i>Citrobacter diversus</i>	LP	5	7	9	11.5	13		yes		Giese & Darby 2000
<i>Citrobacter freundii</i>	LP	5	9	13				yes		Giese & Darby 2000
<i>Corynebacterium diphtheriae</i>	LP	3.4						no		Sharp 1939
<i>Deinococcus radiodurans</i>										
ATCC 13939	LP	113	142	170	205			yes		Clauß 2006
ATCC 13939	Excimer 222 nm	44	57	91				yes		Clauß 2006
<i>Eberthella typhosa</i>	LP	2.1						no		Sharp 1939
<i>Enterococcus faecium</i> Vancomycin-resistant	LP	7	9	11	13	15		yes		McKinney & Pruden 2012

Bacterium	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation						Protocol?	Notes	Reference
		1	2	3	4	5	6			
<i>Enterococcus faecalis</i>										
ATCC27285	LP	3.7	8.0	14 + tailing				yes		Moreno-Andrés et al. 2016
DSM 20478	LP	7.1	8.7	13 + tailing				yes		Chen et al. 2015
DSM 20478	MP	5.5	7.6	12 + tailing				yes		Chen et al. 2015
<i>Escherichia coli</i>										
ATCC 11229	LP	3.0	4.8	6.7	8.4	10.5		yes		Chang et al. 1985
ATCC 11229	LP	2.5	3.0	3.5	5	10	15	yes		Harris et al. 1987
ATCC 11229	LP	7	8	9	11	12		no		Hoyer 1998
ATCC 11229	LP	3.4	5.0	6.7	8.3	10		yes		Sommer et al. 1998
ATCC 11229	LP	3.5	4.7	5.5	6.5	7.5	9.6	yes		Sommer et al. 2000
ATCC 11229	LP	2.5	3.0	3.5	4.5	5.0	6.0	yes		Sommer et al. 2001
ATCC 11229	LP	3.9	5.4	6.8	8.2	9.7		yes		Zimmer & Slawson 2002
ATCC 11229	LP	3.3	4.9	5.7	6.6			yes		Clauß et al. 2005
ATCC 11229	Excimer 222 nm	4.9	7.7	9.1	10.3			yes		Clauß et al. 2005
ATCC 11229	LP or MP	1.6	3.0	5.0	6.5			yes		Bohrerova et al. 2008
ATCC 11229	LP	4.7	6.2	7.2	8.3	9.3		yes		Quek & Hu 2008
ATCC 11229	MP	2.5	4.0	4.7	5.3	6.0	7.3	yes		Quek & Hu 2008
ATCC 11229	LP	4.1	5.1	6.2				yes		Bowker et al. 2011
ATCC 11229	UV-LED 255 nm	5.9	7.9					yes		Bowker et al. 2011
ATCC 11229	UV-LED 275 nm	4.3	6.2	7.7				yes		Bowker et al. 2011
ATCC 11303	LP	4	6	9	10	13	15	yes		Wu et al. 2005
ATCC 11775	LP	1.1	2.0	3.0	3.4	4.0		yes		Quek & Hu 2008
ATCC 11775	MP	0.9	1.6	2.4	3.0	3.4		yes		Quek & Hu 2008
ATCC 15597	LP	6.4	8.9	11	12	13		yes		Quek & Hu 2008
ATCC 15597	MP	5.0	6.8	8.3	9.4	11	12	yes		Quek & Hu 2008
ATCC 25922	LP	6.0	6.5	7.0	8.0	9	10	yes		Sommer et al. 1998
ATCC 29425	LP	5.4	8.5	20				yes		Chatterley & Linden 2010
ATCC 29425	UV-LED 265 nm	3.6	5.9	17	20			yes		Chatterley & Linden 2010
ATCC 700891	LP	7.3	10	12	13	15		yes		Quek & Hu 2008
ATCC 700891	MP	4.8	6.8	8.2	9.0	9.8		yes		Quek & Hu 2008
B	LP	1.0	2.4	4.4	6			yes		Shin et al. 2008
B	MP	0.9	2.1	4.2	6			yes		Shin et al. 2008
B ATCC 13033	LP	1.2	3.0	4.7	6.5	8.2	10	yes		Sholtes et al. 2016
B ATCC 13033	UV-LED 260 nm	1.2	3.0	4.7	6.5	8.2	10	yes		Sholtes et al. 2016
C	LP	2	3	4	5.6	6.5	8	yes		Otaki et al. 2003

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		1	2	3	4	5	6			
<i>Escherichia coli</i> (cont.)										
C3000	LP or MP	3.0	4.3	5.5	7.0			yes		Eischeid & Linden 2007
CGMCC 1.3373	LP	3.1	5.9	8.0	13			yes		Guo et al. 2009
CGMCC 1.3373	MP	3.1	5.9	9.6	13			yes		Guo et al. 2009
CN13	XeBr Exci-lamp 282 nm	5.5	7.5	9.6	12					Matafonova et al. 2012
K12	LP	1.1	1.9	2.6	3.4			no		Qiu et al. 2004
K12 IFO 3301	LP & MP	2	4	6	7	9		yes		Oguma et al. 2002
K12 IFO 3301	LP	1.5	2.0	3.5	4.2	5.5	6.2	yes		Otaki et al. 2003
K12 IFO 3301	LP & MP	2.2	4.4	6.7	8.9	11		yes		Oguma et al. 2004
K12 IFO 3301	UV-LED 265 nm	2.6	4.7	6.6	9.0	12		yes		Oguma et al. 2013
K12 IFO 3301	UV-LED 280nm	3.4	6.9	10	14			yes		Oguma et al. 2013
K12 IFO 3301	LP	1.9	4	6	8			yes		Rattanakul et al. 2014
K12 IFO 3301	UV-LED 285 nm	7.8	13	16	23	34		yes		Oguma et al. 2015
K12 IFO 3301	LP	2	4	6				yes		Oguma et al. 2001
NBIMB 9481	LP	5.9	8.0	9.3	10.5	12		yes		Quek & Hu 2008
NBIMB 9481	MP	4.3	6.2	7.3	8.6			yes		Quek & Hu 2008
NBIMB 10083	LP	2.8	4.4	5.6	6.6	7.6		yes		Quek & Hu 2008
NBIMB 10083	MP	2.5	4.3	5.1	6.0	6.8	7.6	yes		Quek & Hu 2008
OP50	LP	2.0	4.4	6.7	9.1			yes		Bichai et al. 2009
O157: H7	LP	1.5	3.0	4.5	6.0			no		Tosa & Hirata 1999
O157: H7	LP	<2	<2	2.5	4	8	17	??		Yaun et al. 2003
O157: H7 ATCC 43894	LP	1.4	2.8	4.2	5.5	6.9		yes		Wilson et al. 1992
O157: H7 CCUG 29193	LP	3.5	4.7	5.5	7			yes		Sommer et al. 2000
O157: H7 CCUG 29197	LP	2.5	3.0	4.6	5.0	5.5		yes		Sommer et al. 2000
O157: H7 CCUG 29199	LP	0.4	0.7	1.0	1.1	1.3	1.4	yes		Sommer et al. 2000
O25: K98: NM	LP	5.0	7.5	9	10	12		yes		Sommer et al. 2000
O26	LP	5.4	8.0	10.5	12.8			no		Tosa & Hirata 1999
O50: H7	LP	2.5	3.0	3.5	4.5	5	6	yes		Sommer et al. 2000
O78: H11	LP	4	5	5.5	6	7		yes		Sommer et al. 2000
145 Ampicillin resistant	LP	0.8	1.9	3.0	4.7			yes		Templeton et al. 2009
018 Trimethoprim resistant	LP	1.5	3.0	4.0	4.9			yes		Templeton et al. 2009
SMS-3-5	LP	3	5.1	6.5	7.6			yes		McKinney & Pruden 2012
wild type	LP	2.7	4.0	5.3	6.6			yes		Butler et al. 1987
wild type	LP	4.4	6.2	7.3	8.1	9.2		yes		Sommer et al. 2000
	LP	2.0	3.6	5.2	6.8			yes		Hu et al. 2012

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		1	2	3	4	5	6			
<i>Faecal coliforms</i>	LP	6	9	13	22			yes		Maya et al. 2003
<i>Francisella tularensis</i>										
LVS	LP	1.3	3.1	4.8	6.6			yes		Rose & O'Connell 2009
NY98	LP	1.4	3.8	6.3	8.7			yes		Rose & O'Connell 2009
<i>Faecal streptococci</i>	LP	9	14	22	30			yes		Maya et al. 2003
<i>Halobacterium elongata</i> ATCC 33173	LP	0.4	0.7	1.0				no		Martin et al. 2000
<i>Halobacterium salinarum</i> ATCC 43214	LP	12	15	18	20			no		Martin et al. 2000
<i>Helicobacter pylori</i>										
Texas isolate	LP	2.2	3.0	3.8	4.6	5.7	6.6	yes		Hayes et al. 2006
ATCC 43504	LP	4.5	5.7	6.7	7.5	8.0		yes		Hayes et al. 2006
ATCC 49503	LP	1.7	3.1	4.0	5.3	7		yes		Hayes et al. 2006
<i>Klebsiella pneumoniae</i>	LP	5	7	10	12			yes		Giese & Darby 2000
<i>Klebsiella terrigena</i> ATCC 33257	LP	3.6	6.4	9.3	12	15		yes		Wilson et al. 1992
<i>Legionella longbeachae</i> ATCC 33462	LP	1.4	3.0	4.7	6.3			yes		Cervero-Arago et al. 2014
<i>Legionella pneumophila</i>										
Philadelphia 2	LP	0.9	1.8	2.8	3.7			no		Antopol & Ellner 1979
ATCC 33152	LP	1.6	3.2	4.8	6.4	8.0		yes		Oguma et al. 2004
ATCC 33152	MP	1.9	3.8	5.8	7.7	9.6		yes		Oguma et al. 2004
ATCC 33152	LP	1.7	3.0	4.3	5.7			yes		Cervero-Arago et al. 2014
ATCC 33823	LP	1.7	3.1	4.5	5.8			yes		Cervero-Arago et al. 2014
ATCC 43660	LP	3.0	5.0	7.2	9.3			yes		Wilson et al. 1992
Sero group 1	LP	1.7	2.9	4.2	5.4			yes		Cervero-Arago et al. 2014
Sero group 8	LP	1.8	3.3	4.7	6.1			yes		Cervero-Arago et al. 2014
<i>Leptospira</i>										
<i>biflexa</i> serovar patoc Patoc I	LP	2.3	3.8	5.1	6.7			no		Stamm and Charon 1988
<i>illini</i> 3055	LP	2.8	3.8	4.8				no		Stamm and Charon 1988
<i>interrogans</i> serovar Pomona Pomona	LP	0.8	1.2	1.7				no		Stamm and Charon 1988
<i>Listeria monocytogenes</i>	LP	2.2	3.0	3.2	4.1	4.6		no		Collins 1971
<i>Mycobacterium avium</i>										
33B	LP	5.8	8.1	10	13			yes		Hayes et al. 2008
W41	LP	5.7	7.9	10	12	15		yes		Hayes et al. 2008

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		1	2	3	4	5	6			
<i>Mycobacterium avium</i> (cont.)										
D55A01	LP	6.4	9.4	12	15			yes		Hayes et al. 2008
<i>Mycobacterium avium</i> hominissuis										
HMC02 (white transparent) (WT)	LP	7.7	12	17	22			yes		Shin et al. 2008
HMC02 (white transparent) (WT)	MP	8.1	12	16				yes		Shin et al. 2008
HMC02 (white opaque) (WO)	LP	7.1	11	17				yes		Shin et al. 2008
HMC02 (white opaque) (WO)	MP	6.6	11	15	19			yes		Shin et al. 2008
<i>Mycobacterium bovis</i> BCG	LP	2.2	4.4					no		Collins 1971
<i>Mycobacterium intracellulare</i>										
B12CC2	LP	7.8	11	13	16			yes		Hayes et al. 2008
ATCC 13950	LP	7.4	11	15	19			yes		Hayes et al. 2008
<i>Mycobacterium phlei</i>	LP	3.6						no		Collins 1971
<i>Mycobacterium terrae</i>										
ATCC 15755	LP	3.9	9.3	16 + tailing				yes	(1)	Bohrerova & Linden 2006a
ATCC 15755	LP	3.7	9.3	16				yes		Bohrerova & Linden 2006b
ATCC 15755	MP	3.2	11	39				yes		Bohrerova & Linden 2006b
<i>Mycobacterium tuberculosis</i>	LP	2.2	4.3					no		Collins 1971
<i>Pseudomonas aeruginosa</i>										
ATCC 9027	LP	3.8	6.5	10	17			no		Abshire & Dunton 1981
ATCC 10145	LP	4.6						no		Abshire & Dunton 1981
ATCC 14207	LP	3.7						no		Abshire & Dunton 1981
ATCC 15442	LP	3.8						no		Abshire & Dunton 1981
ATCC 27853	LP	4.9						no		Abshire & Dunton 1981
ATCC 27853	LP	0.8	1.6	2.3	3.1			yes		Clauß 2006
ATCC 27853	Excimer 222 nm	3.1	4.8	5.9	7.5	10		yes		Clauß 2006
01	LP	1.3	2.7	4.3	6.3	10		yes		McKinney & Pruden 2012
B2	LP	5.6						no		Abshire & Dunton 1981
G2	LP	3.0						no		Abshire & Dunton 1981
BS4	LP	3.5						no		Abshire & Dunton 1981
WB1	LP	5.8						no		Abshire & Dunton 1981
SH-2918	LP	3.5						no		Abshire & Dunton 1981
NCTC 10662	LP	1.5	2.6	3.8	5.0	6.2		yes		Blatchley et al. 2016
<i>Salmonella</i> spp.	LP	<2	2	3.5	7	14	29	??		Yaun et al. 2003

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		1	2	3	4	5	6			
<i>Salmonella typhimurium</i>										
ATCC 6539	LP	2.6	4.5	5.8	7	8		yes		Chang et al. 1985
ATCC 19430	LP	2.0	4.1	6.2	8.3			yes		Wilson et al. 1992
(in act. sluge)	LP	3	12	22	50			yes		Maya et al. 2003
LT2 SL3770	LP	4	5.7	7.8				yes	Action spectrum	Chen et al. 2009
	LP	3.9	5.3	6.7	7.7	13		yes		Hu et al. 2012
<i>Serratia marcescens</i>	LP	2.2						no		Sharp 1939
<i>Shewanella algae</i>	LP	0.9	1.7	2.4	3.2			no		Qiu et al. 2004
<i>Shewanella oneidensis</i>										
DLM7	LP	0.3	0.5	0.8	1.1			no		Qiu et al. 2004
MR4	LP	0.7	1.4	2.1	2.8			no		Qiu et al. 2004
MR1	LP	0.2	0.4	0.6	0.9			no		Qiu et al. 2004
<i>Shewanella putrefaciens</i> 200	LP	0.5	0.8	1.1	1.4			no		Qiu et al. 2004
<i>Shigella dysenteriae</i>										
ATCC 29027	LP	0.1	1.0	1.9	2.8	3.8	4.7	yes		Wilson et al. 1992
	LP	0.5	1.1	1.9	2.5	3.1		yes		Hu et al. 2012
<i>Shigella paradysenteriae</i>	LP	1.7						no		Sharp 1939
<i>Shigella sonnei</i>										
ATCC 9290	LP	3.2	4.9	6.5	8.2			yes		Chang et al. 1985
<i>Staphylococcus albus</i>										
	LP	1.8						no		Sharp 1939
	LP	1.1	3.2	4.0	4.8			no		Collins 1971
<i>Staphylococcus aureus</i>										
	LP	2.1	3.2					no	Action spectrum	Gates 1929
(hem)	LP	2.6						no		Sharp 1939
ATCC 25923	LP	3.9	5.4	6.5	10			yes		Chang et al. 1985
ATCC 25923	LP	4.4	5.8	6.4	7.3	9		yes		Clauß 2006
ATCC 25923	Excimer 222 nm	9.3	12	14	18			yes		Clauß 2006
ATCC BAA-1556 (Methicillin resistant)	LP	4.5	7.2	8.8	10			yes		McKinney & Pruden 2012
<i>Streptococcus faecalis</i> ATCC 29212	LP	6.6	8.6	9.8	11.1			yes		Chang et al. 1985
<i>Streptococcus hemolyticus</i>	LP	2.2						no		Sharp 1939
<i>Vibrio anguillarum</i>	LP	0.5	1.2	1.5	2.0			yes		Liltved & Landfald 1996
<i>Vibrio cholerae</i>										
Classical OGAWA 154	LP	0.8	1.4	2.3	3.9	6.8		no		Banerjee & Chatterjee 1977

Bacterium	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation						Protocol?	Notes	Reference
		1	2	3	4	5	6			
<i>Vibrio cholerae</i> (cont.)										
el tor MAK 154	LP	1.7	4.1	7.1				no		Banerjee & Chatterjee 1977
NAG 1976	LP	2.5	8.9					no		Banerjee & Chatterjee 1977
ATCC 25872	LP	0.7	1.4	2.1	2.8	3.6		yes		Wilson et al. 1992
<i>Vibrio parahaemolyticus</i> 2977	LP	4.4						no		Banerjee & Chatterjee 1977
<i>Yersinia enterocolitica</i>										
Sero-group 0:3 strain 304/84	LP	1.2	2.2	3.0	3.6			yes		Butler et al. 1987
ATCC 4780	LP	2.1	4.1	5.0	5.8			yes		Clauß et al. 2005
ATCC 4780	Excimer 222 nm	3.1	6.1	7.6	8.8	10	12	yes		Clauß et al. 2005
ATCC 27729	LP	1.6	2.7	4.0	5.1			yes		Wilson et al. 1992
<i>Yersinia pestis</i>										
A1122	LP	1.4	2.6	3.7	4.9			yes		Rose & O'Connell 2009
Harbin	LP	1.3	2.2	3.2	4.1			yes		Rose & O'Connell 2009
<i>Yersinia ruckeri</i>	LP	1	2	3	4			yes		Liltved & Landfald 1996

Table 3. Fluences for multiple log reductions for various protozoa

Protozoan	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation					Proto-col?	Notes	Reference
		1	2	3	4	5			
<i>Acanthamoeba castellanii</i>									
ATCC 30234 (life stage: trophozoites; plaque assay)	LP	40					yes		Chang et al. 1985
CCAP 15342 (life stage: trophozoites; method: MPN)	LP	32	52	72			yes		Cervero-Arago et al. 2014
CCAP 15342 (life stage: cysts; method: MPN)	LP	45	75	91	125		yes		Cervero-Arago et al. 2014
<i>Acanthamoeba culbertsoni</i> ATCC 30171 (mouse infectivity assay; <i>Mus musculus</i> species, strain CD-1)	LP	38	58	125	148		yes		Maya et al. 2003
<i>Acanthamoeba spp.</i>									
isolated strain (life stage: trophozoites; mouse infectivity assay; <i>Mus musculus</i> species, strain CD-1)	LP	39	75	132	160		yes		Maya et al. 2003
155 (life stage: trophozoites; method: MPN)	LP	28	31	66	71		yes		Cervero-Arago et al. 2014
155 (life stage: cysts; method: MPN)	LP	34	67	99			yes		Cervero-Arago et al. 2014
<i>Cryptosporidium Hominis</i> [cell culture infectivity assay using HCT-8 cells (CCL-244) & MDBK cells]	LP & MP	3.0	5.8				yes		Johnson et al. 2005
<i>Cryptosporidium parvum</i>									
[mouse infectivity assay (neonatal CD-1 mice)]	MP	<3	<3	<3	19		yes		Bolton et al. 1998; Bukhari et al. 1999
[mouse infectivity assay (neonatal CD-1 mice)]	LP	<3	<3	3-6	>16		yes		Clancy et al. 2000
[mouse infectivity assay (neonatal CD-1 mice)]	MP	<3	<3	3-9	>11		yes		Clancy et al. 2000
[mouse infectivity assay (neonatal CD-1 mice)]	LP & MP	2.4	<5	5.2	9.5		yes		Craik et al. 2001

Protozoan	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation					Protocol?	Notes	Reference
		1	2	3	4	5			
<i>Cryptosporidium parvum</i> (cont.)									
[mouse infectivity assay & cell culture infectivity assay using MDCK cells (CCL-34)]	LP	1	2	>5			yes		Shin et al. 2001
[mouse infectivity assay (neonatal CD-1 mice)]	MP	<10	<10	>10			yes		Belosevic et al. 2001
[mouse infectivity assay (SCID mice)]	LP	0.5	1.0	1.4	2.2		no		Morita et al. 2002
[cell culture infectivity assay using HCT-8 cells (CCL-244)]	LP	2	<3	<3			yes		Zimmer et al. 2003
[cell culture infectivity assay using HCT-8 cells (CCL-244)]	MP	<1	<1	<1			yes		Zimmer et al. 2003
[culture-immunofluorescence (CC-IFA) based infectivity assay]	MP	1	2	2.9	4		yes		Bukhari et al. 2004
[mouse infectivity assay (neonatal CD-1 mice)]	LP	<2	<2	<2	<4	<10	yes		Clancy et al. 2004
[mouse infectivity assay (neonatal CD-1 mice)]	MP	<5	<5	<5	~6		yes		Amoah et al. 2005
[cell culture infectivity assay using HCT-8 cells (CCL-244)]	LP	1.8	5.6	25			yes		Ryu et al. 2008
HNJ-1 [mouse infectivity assay (SCID mice)]	LP	<0.7	<1.4	2.2			yes		Oguma et al. 2001
[cell culture infectivity assay using HCT-8 cells (CCL-244)]	Laser 254 nm	1.3	1.9	2.3	2.8		yes	Action spectrum	Beck et al. 2015
<i>Cryptosporidium spp.</i>	LP & MP	0.8	1.5	3.0	6.0		yes	(2)	Qian et al. 2004
<i>Giardia lamblia</i>									
(excystation assay)	LP?	40	180				no?		Karanis et al. 1992
(gerbil infectivity assay)	LP	<10	~10	20			yes		Campbell & Wallace 2002
(gerbil infectivity assay)	LP	<0.5	<0.5	<0.5	<1		yes		Linden et al. 2002
(gerbil infectivity assay)	LP	<2	<2	<4			yes		Mofidi et al. 2002
<i>Giardia muris</i>									
(mouse infectivity assay)	MP	1	4.5	28 + tailing			yes		Craik et al. 2000
(mouse infectivity assay)	MP	<10	<10	<25	~60		yes		Belosevic et al. 2001
(mouse infectivity assay)	LP	<2	<2	<4			yes		Mofidi et al. 2002
(mouse infectivity assay)	LP	<2	<2	~2	~2.3		no		Hayes et al. 2003
(mouse infectivity assay)	LP	<5	<5	5			yes		Amoah et al. 2005

Protozoan	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation					Protocol?	Notes	Reference
		1	2	3	4	5			
<i>Giardia spp.</i>	LP & MP	0.6	1.1	1.9	3.4		yes	(2)	Qian et al. 2004
<i>Naegleria fowleri</i>									
Cysts (method: MPN)	LP	32	63	104	121		yes		Sarkar and Gerba 2012
Trophozoites (method: MPN)	LP	8	13	18	24		yes		Sarkar and Gerba 2012
<i>Toxoplasma gondii</i>									
oocysts [immunofluorescence assay (IFA)]	LP	7.2	13	17	19		yes		Dumètre et al. 2008
[mouse infectivity assay (SCID mice)]	LP	3.4	6.8	10			yes		Ware et al. 2010
<i>Vermamoeba vermiformis</i>									
CCAP 15434 /7A (life stage: trophozoites; method: MPN)	LP	11	19	26	34		yes		Cervero-Arago et al. 2014
CCAP 15434/7A (life stage: cysts; method: MPN)	LP	17	38	54	78		yes		Cervero-Arago et al. 2014
195 (life stage: trophozoites; method: MPN)	LP	10	17	24	32		yes		Cervero-Arago et al. 2014
195 (life stage: cysts; method: MPN)	LP	32	60	76	110		yes		Cervero-Arago et al. 2014

Table 4. Fluences for multiple log reductions for various viruses

Virus	Host	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation						Proto-col?	Notes	Reference
			1	2	3	4	5	6			
Adenovirus											
Type 1 method: MPN	PLC/ PRF/5 and HeLa cell line	LP	35	69	103	138			yes		Nwachuku et al. 2005
Type 2	PLC/ PRF/5	LP	40	78	119	160	195	235	yes		Gerba et al. 2002
Type 2	Human lung cell line	LP	35	55	75	100			yes		Ballester & Malley 2004
Type 2	A549 cell line	LP	20	45	80	110			yes		Shin et al. 2005
Type 2	A549 cell line	LP	~30	~60					yes		Linden et al. 2007
Type 2	A549 cell line	MP	~10	~20	~30	~40	~50		yes		Linden et al. 2007
Type 2	A549 cell line	MP <240 nm blocked	~15	~30	~45	~60			yes		Linden et al. 2007
Type 2	A549 cell line	LP	8	31	50	80	117		yes		Eischeid et al. 2009
Type 2 method: TCID50	A549 cell line	LP	35	78	126	168			yes		Linden et al. 2009
Type 2 method: TCID50	A549 cell line	MP	14	29	44	80	120		yes	(3)	Linden et al. 2009
Type 2 method: cell culture	HEK293 cells human embryonic kidney	LP	37	88	120				yes		Baxter et al. 2007
Type 2 adenoid 6 (VR-846)	A-549 cell line (CCL-185)	LP	42	83	124	166			yes		Sirikanchana et al. 2008
Type 2	A549 cell line	MP	4	7	14	22	40 + tailing		yes		Eischeid et al. 2009
Type 2 method: TCID50	A549 cell line (CCL-185)	LP	36	82					yes		Shin et al. 2009
Type 2 method: TCID50	A549 cell line (CCL-185)	MP	15	29	45	59	80		yes		Shin et al. 2009
Type 2 ATCC VR-846; method: TCID50	A549 cell line (CCL-185)	LP	56	108	159	206			yes		Bounty et al. 2012
Type 2 method: plaque assay	A549 cell line (CCL-185)	LP	39	71	98	125			yes		Rodriguez et al. 2013

			Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation									
Virus	Host	Lamp Type	1	2	3	4	5	6	Protocol?	Notes	Reference	
Adenovirus (cont.)												
Type 2 method: plaque assay	A549 cell line (CCL-185)	MP	7	18	28	47			yes		Rodriguez et al. 2013	
Type 2 method: LR-qPCR 6 kb fragment	A549 cell line (CCL-185)	LP	5	20-50	100				yes		Rodriguez et al. 2013	
Type 2 method: LR-qPCR 6 kb fragment	A549 cell line (CCL-185)	MP	4	15-50	100				yes		Rodriguez et al. 2013	
Type 2 method: LR-qPCR 1 kb fragment	A549 cell line (CCL-185)	LP	18	50	100				yes		Rodriguez et al. 2013	
Type 2 method: LR-qPCR 1 kb fragment	A549 cell line (CCL-185)	MP	5 + tailing							yes		Rodriguez et al. 2013
Type 2 method: LR-qPCR 10 kb fragment	A549 cell line (CCL-185)	LP	15						yes		Rodriguez et al. 2013	
Type 2 method: LR-qPCR 10 kb fragment	A549 cell line (CCL-185)	MP	39	94					yes		Rodriguez et al. 2013	
Type 2 ATCC VR-846 method: MPN	A549 cell line (CCL-185)	LP	43	86	130	174			yes	Action spectrum	Beck et al. 2014	
Type 2 ATCC VR-846; method: LR-PCR 1.1 kbp fragment	A549 cell line (CCL-185)	LP	45	68					yes		Beck et al. 2014	
Type 2 ATCC VR-846; method: LR-PCR 1.1 kbp fragment	A549 cell line (CCL-185)	Laser 254 nm	32	80-90 + tailing						yes		Beck et al. 2014
Type 2 ATCC VR-846 method: MPN	A549 cell line (CCL-185)	LP	40	76	120				yes		Beck et al. 2014	

		Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation										
Virus	Host	Lamp Type	1	2	3	4	5	6	Protocol?	Notes	Reference	
Adenovirus (cont.)												
Type 2 ATCC VR-846 method: MPN	A549 cell line (CCL-185)	MP	8	18	34				yes	(3)	Beck et al. 2014	
Type 2 ATCC VR-846 method: MPN	A549 cell line (CCL-185)	MP	32	71	135				yes	(4)	Beck et al. 2014	
Type 2; method: cell culture	A549 cell line (CCL-185)	Laser 254 nm	40	70	101				yes		Beck et al. 2014	
Type 2; method: infectivity	A549 cell line	LP	33	118					no		Calgua et al. 2014	
Type 2; method: qPCR	A549 cell line	LP	140						no		Calgua et al. 2014	
Type 2; method: MPN	A549 cell line (CCL-185)	LP	47	86	129	172			yes		Ryu et al. 2015	
Type 2; ATCC VR-846; method: ICC-qPCR	A549 cell line (CCL-185)	LP	40	81	121	161			yes		Ryu et al. 2015	
Type 2; method: total culturable virus assay	A549 cell line (CCL-185)	LP	26	100	135	168	203	234	yes		Boczek et al. 2016	
Type 4; ATCC VR-1572; method: ICC qPCR	PLC/ PRF/5 ATCC CRL-8024	LP	10	34	69	116			yes		Gerrity et al. 2008	
Type 5; method: cell culture	HEK 293 cells human embryonic kidney	LP	45	76	120				yes		Baxter et al. 2007	
Type 5	HEK293	LP	38	76	114	152			yes		Guo et al. 2010	
Type 5	HEK293	MP	23	45	68	90			yes		Guo et al. 2010	
Type 5	PLC/PRF/5	LP	31	62	93	123			yes		Guo et al. 2010	
Type 5	PLC/PRF/5	MP	22	43	65	87			yes		Guo et al. 2010	
Type 5	XP17BE	LP	13	26	39	52			yes		Guo et al. 2010	
Type 5	XP17BE	MP	9	18	27	36			yes		Guo et al. 2010	
Type 5	A549 cell line (CCL-185)	LP	51	101	151				yes		Rattanakul et al. 2014	

		Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation									
Virus	Host	Lamp Type	1	2	3	4	5	6	Proto-col?	Notes	Reference
Adenovirus (cont.)											
Type 5	A549 cell line (CCL-185)	LP	63	100	151				yes		Rattanakul et al. 2015
Type 5 ATCC VR5	A549 cell line (CCL-185)	UV-LED 285 nm	50	82	126				yes		Oguma et al. 2015
Type 6; method: MPN	PLC/ PRF/5 and HeLa cell line	LP	39	77	115	154			yes		Nwachuku et al. 2005
Type 40; strain: Dugan	PLC/PRF5 cell line	LP	50	109	167				yes		Thurston-Enriquez et al. 2003
Type 40; method: MPN	PLC/PRF5 cell line	MP	16	23	~30	~40			yes		Linden et al. 2007
Type 40; method: MPN	PLC/PRF5 cell line	LP	63	88	109	>120			yes		Blatchley et al. 2008
Type 40	HEK293	LP	35	70	105	139			yes		Guo et al. 2010
Type 40	HEK293	MP	17	33	50	66			yes		Guo et al. 2010
Type 40	PLC/PRF/5	LP	34	67	101	134			yes		Guo et al. 2010
Type 40	PLC/PRF/5	MP	16	33	49	65			yes		Guo et al. 2010
Type 41; ATCC VR-930; method: ICC-RT-PCR	HEK 293 cells ATCC CRL-1573	LP	56	111	167	222			yes		Ko et al. 2005
Type 41; method: cell culture	HEK 293 cells human embryonic kidney & PLC/PRF/5 (heaptoma) cells	LP	62	120					yes		Baxter et al. 2007
Type 41	HEK293	LP	45	91	136	182			yes		Guo et al. 2010
Type 41	HEK293	MP	20	39	59	78			yes		Guo et al. 2010
Type 41	PLC/PRF/5	LP	34	68	103	137			yes		Guo et al. 2010
Type 41	PLC/PRF/5	MP	18	36	53	71			yes		Guo et al. 2010
Type 41	XP17BE	LP	14	29	43	57			yes		Guo et al. 2010
Type 41	XP17BE	MP	11	21	32	42			yes		Guo et al. 2010
Atlantic halibut nodavirus (AHNV)	SSN-1 cell line	LP	35	70	104	140	176	211	yes		Liltved et al. 2006
B40-8 (phage)											
	<i>B. fragilis</i> HSP-40	LP	12	18	23	28			yes		Sommer et al. 1998
	<i>B. fragilis</i>	LP	11	17	23	29	35	41	yes		Sommer et al. 2001

		Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation									
Virus	Host	Lamp Type	1	2	3	4	5	6	Proto-col?	Notes	Reference
Calicivirus feline											
	CRFK cell line	LP	5	15	23	30	39		yes		Thurston-Enriquez et al. 2003
	MDCK cell line	LP	7	15	22	30	36		yes		de Roda Husman et al. 2004
	CRFK cell line	LP	7	16	25				yes		de Roda Husman et al. 2004
FCV ATCC VR-782	Crandell Reese feline kidney cell CRfk, ATCC CCL-94	LP	5	12	18	26			yes		Park et al. 2011
Coxsackievirus											
B3	BGM cell line	LP	8	16	25	33			yes		Gerba et al. 2002
B4	BGM cell line	LP	7	13	18	24	29		yes		Shin et al. 2005
B5	BGM cell line	LP	9.5	18	27	36			yes		Gerba et al. 2002
B5	BGM cell line	LP	7	14	21				yes		Battigelli et al. 1993
Echovirus											
I	BGM cell line	LP	8	17	25	33			yes		Gerba et al. 2002
II	BGM cell line	LP	7	14	21	28			yes		Gerba et al. 2002
12	foetal rhesus monkey kidney cell FRhK-4, ATCC CRL-1688	LP	8	13	18	28	40		yes		Park et al. 2011
GA phage	<i>E. coli</i> Hfr K12 ATCC 23631	LP	18	38	58	87	121		yes		Simonet & Gantzer 2006
Hepatitis											
A HM175	FRhK-4 cell	LP	5.4	15	25	35			yes		Wilson et al. 1992
A HM175	FRhK-4 cell	LP	4	8	12	16			yes		Battigelli et al. 1993
A	HAV/HFS/GBM	LP	6	10	15	21			no		Wiedenmann et al. 1993
Infectious pancreatic necrosis virus (IPNV)	BF-2 cell line	LP	82	165	246	325			yes		Liltved et al. 2006
Infectious salmon anaemia virus (ISAV)	SHK-1 cell line	LP	2.5	5.0	7.5				yes		Liltved et al. 2006

			Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation								
Virus	Host	Lamp Type	1	2	3	4	5	6	Protocol?	Notes	Reference
JC polyomavirus											
Mad-4 method: cell culture	SVG-A cells	LP	60	124	171				no		Calgua et al. 2014
Mad-4 method: qPCR	SVG-A cells	LP	>180						no		Calgua et al. 2014
MS2 coliphage											
	N/A	UV-LED 255 nm	14	26	38				yes		Aoyagi et al. 2011
	<i>E. coli</i> Famp	LP	13	25	44	64			yes		Rodriguez et al. 2014
	<i>E. coli</i> Famp	MP	9	17	31	46	56		yes		Rodriguez et al. 2014
	<i>E. coli</i> Cr63	LP	17	34					yes		Rauth 1965
	<i>E. coli</i> C3000	LP	35						yes		Battigelli et al. 1993
	<i>E. coli</i> ATCC15597	LP?	19	40	61				no		Oppenheimer et al. 1993
	<i>Salmonella typhimurium</i> WG49	LP	16	35	57	83	114	152	no		Nieuwstad & Havelaar 1994
	<i>E. coli</i> ATCC15597	LP	13	29	45	62	80		yes		Meng & Gerba 1996
	<i>E. coli</i> C3000	LP	13	28					yes		Shin et al. 2001
	<i>E. coli</i> K-12 Hfr	LP	21	36					yes		Sommer et al. 1998
	<i>E. coli</i> K-12	LP	19	36	55				yes		Sommer et al. 2001
	<i>E. coli</i> C3000	LP	20	42	68	90			yes		Linden et al. 2002
	<i>E. coli</i> ATCC 15977	LP	20	50	85	120			yes		Thurston-Enriquez et al. 2003
	<i>E. coli</i> ATCC 15977	LP	20	42	70	98	133		no		Lazarova & Savoye 2004
	<i>E. coli</i> C3000	LP	20	42	69	92			yes		Batch et al. 2004
	<i>E. coli</i> ATCC 15977	LP	29	58	87	116			yes		Nwachuku et al. 2005
	<i>E. coli</i> ATCC 15977	LP	14	33	50	66			yes		Hu et al. 2012
	<i>E. coli</i> K12 A/λ(F+)	LP	22	48					yes		Rattanakul et al. 2014

			Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation								
Virus	Host	Lamp Type	1	2	3	4	5	6	Protocol?	Notes	Reference
MS2 coliphage (cont.)											
	<i>E. coli</i> Famp ATCC 700891	LP	14	30	45	60			yes		Sholtes et al. 2016
	<i>E. coli</i> Famp ATCC 700891	UV-LED 260 nm	13	36	40	53			yes		Sholtes et al. 2016
method: cell culture	<i>Salmonella typhimurium</i> WG49	LP	20	40	61	91	119	146	no		Calgua et al. 2014
method: qPCR	<i>Salmonella typhimurium</i> WG49	LP	<180						no		Calgua et al. 2014
ATCC15977-B1	<i>E. coli</i> ATCC 15977	LP	17	38	59	81	103	123	yes		Wilson et al. 1992
ATCC15977-B1	<i>E. coli</i> HS(pFamp)R	LP	16	45	72	100	128	154	yes		Thompson et al. 2003
ATCC15977-B1	<i>E. coli</i> ATCC 15977	LP	15	32	51	72	98		yes		Lazarova & Savoye 2004
ATCC15977-B1	<i>E. coli</i> ATCC 15977	LP	25	42	66	97			yes		Butkus et al. 2004
ATCC15977-B1	<i>E. coli</i> ATCC 15977	LP	20	40	62	92	141	173	yes		Ko et al. 2005
ATCC15977-B1	<i>E. coli</i> ATCC 15977	LP	20	40	62	92	141	173	yes		Ko et al. 2005
ATCC15977-B1	<i>E. coli</i> ATCC 15977	LP	18	38	59	80			yes		Sun & Liu 2009
ATCC15977-B1	<i>E. coli</i> NCTC12486	LP	20	40	60				yes	Action spectrum	Mamane-Gravetz et al. 2005
ATCC15977-B1	<i>E. coli</i> Hfr K12 ATCC 23631	LP	20	40	68	95	125		yes		Simonet & Gantzer 2006
ATCC15977-B1	<i>E. coli</i> ATCC 15597	LP	18	40					yes		Templeton et al. 2006
ATCC15977-B1	<i>E. coli</i> ATCC 15597 C3000	LP	14	29	45				yes		Bohrerova et al. 2006
ATCC15977-B1	<i>E. coli</i> Famp	LP	16	>30					yes		Lee et al. 2008
ATCC15977-B1	<i>E. coli</i> ATCC 15597	LP	20	39	61	83			yes		Blatchley III et al. 2008
ATCC15977-B1	<i>E. coli</i> ATCC 15597	LP	18	41					yes		Bowker et al. 2011
ATCC15977-B1	<i>E. coli</i> ATCC 15597	UV-LED 255 nm	25	50					yes		Bowker et al. 2011

				Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation									
Virus	Host	Lamp Type	1	2	3	4	5	6	Proto-col?	Notes	Reference		
MS2 coliphage (cont.)													
ATCC15977-B1	<i>E. coli</i> ATCC 15597	UV-LED 275 nm	25	55					yes		Bowker et al. 2011		
ATCC15977-B1	<i>E. coli</i> Famp ATCC 700891	LP	14	32	51				yes		Park et al. 2011		
ATCC15977-B1	N/A	LP	13	30	53	70			yes		Timchak & Gitis 2012		
ATCC15977-B1	<i>E. coli</i> ATCC 15597 Migula	LP	18	52	75	92	106	116	yes		Guo & Hu 2012		
ATCC15977-B1	<i>E. coli</i> ATCC 15597	LP	20	40	70	95	120	138	no		Sherchan et al. 2014		
ATCC15977-B1	<i>E. coli</i> ATCC 15597 C3000	LP	20	45					yes		Jenny et al. 2014		
ATCC15977-B1	<i>E. coli</i> ATCC 15597 C3000	UV-LED 260 nm	15	32	48				yes		Jenny et al. 2014		
ATCC15977-B1	<i>E. coli</i> ER2738	UV-LED 255 nm	19	42	72				no		Simons et al. 2014		
ATCC15977-B1	<i>E. coli</i> Hfr K12 ATCC23631	LP	6	13	21	29	37	46	yes		Song et al. 2015		
ATCC15977-B1	<i>E. coli</i> HS(pFamp)R ATCC 700891	LP	18	33	63				yes	Action spectrum	Beck et al. 2015		
ATCC15977-B1 (Action spectrum weighted fluence)	<i>E. coli</i> HS(pFamp)R ATCC 700891	MP	15	32	52				yes	Action spectrum	Beck et al. 2015		
ATCC15977-B1	<i>E. coli</i> HS(pFamp)R ATCC 700891	LP	20	40	60				yes	Action spectrum	Beck et al. 2016		
ATCC15977-B1	<i>E. coli</i> K12 A/λ(F+)	UV-LED 285 nm	32	70	106				yes		Oguma et al. 2015		
ATCC15977-B1	<i>E. coli</i> Famp ATCC 700891	LP	17	35	60	88	116		yes		Boczek et al. 2016		

		Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation									
Virus	Host	Lamp Type	1	2	3	4	5	6	Proto-col?	Notes	Reference
MS2 coliphage (cont.)											
F-specific	<i>E. coli</i> WG21	LP	8	17	25	33			yes		Havelaar et al. 1990
F-specific	<i>E. coli</i> WG21	MP	9	19	28	38			yes		Havelaar et al. 1990
ATCC15977-B1 F-specific	<i>E. coli</i> C3000	LP	14	29	49				yes		Shin et al. 2005
ATCC15977-B1 F-specific	<i>E. coli</i> ATCC 15597 C3000	LP	19	42	69				yes		Shin et al. 2009
ATCC15977-B1 F-specific	<i>E. coli</i> ATCC 15597 C3000	MP	16	33	53	90			yes		Shin et al. 2009
DSM5694	<i>E. coli</i> NCIB 9481	LP?	4	16	38	68	110		no		Wiedenmann et al. 1993
Myoviridae	<i>E. coli</i> C	LP	1.8	3.6	5.1	6.7	8.5		yes		Shin et al. 2005
Murine norovirus											
NCIMB10108	RAW 264.7 cells	LP	10	15	22	27	30		yes		Lee et al. 2008
CW3	RAW 264.7 macropags ATCC TIB-71	LP	10	15	22	27	30		yes		Park et al. 2011
Phage B124-54	<i>B. fragilis</i> strain GB-124	LP	14	21	28				yes		Diston et al. 2012
PHI X 174											
(phage)	<i>E. coli</i> C3000	LP?	2.1	4.2	6.4	8.5	11	13	yes		Battigelli et al. 1993
(phage)	<i>E. coli</i> ATCC 15597	LP?	4	8	12				no		Oppenheimer et al. 1993
(phage)	<i>E. coli</i> WG5	LP	2.2	5.3	7.3	10.5			yes		Sommer et al. 1998
(phage)	<i>E. coli</i> ATCC 13706	LP	2.0	3.5	5	7			yes		Giese & Darby 2000
(phage)	<i>E. coli</i> WG5	LP	3	5	7.5	10	13	15	yes		Sommer et al. 2001
	N/A	UV-LED 255 nm	1.6	3.3	5.1				yes		Aoyagi et al. 2011
	N/A	UV-LED 280 nm	2.3	5.1	8.6				yes		Aoyagi et al. 2011
ATCC 13706	N/A	LP	7.1	14	21	28	37	47	yes		Timchak & Gitis 2012
	<i>E. coli</i> CN13	LP	N/A	N/A	N/A	8.9			yes		Rodriguez et al. 2014
	<i>E. coli</i> CN13	MP	N/A	N/A	N/A	6.7			yes		Rodriguez et al. 2014

		Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation										
Virus	Host	Lamp Type	1	2	3	4	5	6	Protocol?	Notes	Reference	
Picornaviridae aphthovirus (foot and mouth disease virus)												
O189	baby hamster kidney (BHK-21) cell line	LP	25	50	75	100			no	(5)	Nuanualsuwan et al. 2008	
A132	baby hamster kidney (BHK-21) cell line	LP	20	39	59	78			no	(5)	Nuanualsuwan et al. 2008	
A Sakol	baby hamster kidney (BHK-21) cell line	LP	22	44	67	89			no	(5)	Nuanualsuwan et al. 2008	
AS 1	baby hamster kidney (BHK-21) cell line	LP	31	63	94	125			no	(5)	Nuanualsuwan et al. 2008	
Poliovirus												
Type 1 LSc2ab	MA104 cells	LP	N/A	5.6	11	17	22		yes		Chang et al. 1985	
Type 1 ATCC Mahoney	N/A	LP	6	14	23	30			yes		Harris et al. 1987	
Type 1 LSc2ab	BGM cell line	LP	2.8	11	20	28	37	46	yes		Wilson et al. 1992	
Type 1	BGM cell line	LP	8.0	16	23	31			yes		Gerba et al. 2002	
Type 1 LSc2ab	BGM cell line	LP	7	17	28	37			yes		Thompson et al. 2003	
Vaccine strain method: plaque assay	N/A	LP	6.4	14	22	33			no		Lazarova & Savoye 2004	
Vaccine strain method: TCID50	N/A	LP	6.4	14	21	31			no		Lazarova & Savoye 2004	
Type 1	BGM cell line	LP	8.7	17	25				yes		Shin et al. 2005	
Type 1	BGM cell line	LP	7	14	21	29	39	50 + tailing	yes		Simonet & Gantzer 2006	
PRD-1 (Tectiviridae)												
phage	<i>Salmonella typhimurium</i> Lt2	LP	10	17	24	30			yes		Meng & Gerba 1996	
ATCC BAA-769-B1	<i>Salmonella typhimurium</i> Lt2	LP	18	50	81	108	138		yes		Shin et al. 2005	

			Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation								
Virus	Host	Lamp Type	1	2	3	4	5	6	Proto-col?	Notes	Reference
PRD-1 (Tectiviridae) (cont.)											
	<i>Salmonella typhimurium</i> Lt2	LP	N/A	N/A	N/A	36			yes		Rodriguez et al. 2014
	<i>Salmonella typhimurium</i> Lt2	MP	N/A	N/A	N/A	32			yes		Rodriguez et al. 2014
Qβ											
	N/A	UV-LED 255 nm	11	23					yes		Aoyagi et al. 2011
	N/A	UV-LED 280 nm	27						yes		Aoyagi et al. 2011
	<i>E. coli</i> ATCC 15597 C3000	LP	12	25	40				yes		Jenny et al. 2014
	<i>E. coli</i> ATCC 15597 C3000	UV-LED 260 nm	9	19	29	41			yes		Jenny et al. 2014
ATCC 23631-B1	<i>E. coli</i> ATCC 23631	LP	8	18	28	40			yes		Blatchley III et al. 2008
ATCC 23631-B1	<i>E. coli</i> ATCC 23631	LP	N/A	20					yes	Action spectrum	Beck et al. 2015
ATCC 23631-B1	<i>E. coli</i> ATCC 23631	laser 254 nm	11	22	34	46			yes	Action spectrum	Beck et al. 2015
phage	<i>E. coli</i> Hfr K12 ATCC 23631	LP	12	23	36	50	66	83	yes		Simonet & Gantzer 2006
phage	<i>E. coli</i> K12 A/ λ (F+)	LP	10	23	35				yes		Rattanakul et al. 2014
ATCC 23631 B1	<i>E. coli</i> K12 A/ λ (F+)	UV-LED 285 nm	27	54	81				yes		Oguma et al. 2015
phage	<i>E. coli</i> K12 A/ λ (F+)	LP	11	26	40	55			yes		Oguma et al. 2013
Reovirus											
3	Mouse L-60	LP?	11	22					yes		Rauth 1965
Type 1 Lang strain	N/A	LP	16	36					yes		Harris et al. 1987

		Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation										
Virus	Host	Lamp Type	1	2	3	4	5	6	Protocol?	Notes	Reference	
Rotavirus												
SA-11	Monkey kidney Cell line MA 104	LP	8	15	27	38			yes		Sommer et al. 1989	
	MA 104 cell line	LP	20	80	140	200			no		Caballero et al. 2004	
SA-11	MA 104 cell line	LP	7	15	25				yes		Chang et al. 1985	
SA-11	MA 104 cell line	LP	9	19	26	36	48		yes		Wilson et al. 1992	
SA-11	MA 104 cell line	LP	7	15	23				yes		Battigelli et al. 1993	
SA-11 ATCC VR-1565 method: cell culture; assay based on CPE	MA 104 cells ATCC CRL-2378.1	LP	7	15	31 + tailing				yes		Li et al. 2009	
SA-11 ATCC VR-1565 method: RT-qPCR assay	MA 104 cells ATCC CRL-2378.1	LP	29	58	88	117 + tailing			yes		Li et al. 2009	
Human (HRV-Wa)	N/A	LP	16	24	32	40			yes		Hu et al. 2012	
SA-11	MA-104 cell line	LP	10	21	32	43	53		yes		Wilson et al. 1992	
Siphoviridae	<i>E. coli</i> C	LP	1.8	3.6	5.7	7.5	9.3		yes		Shin et al. 2005	
T1												
	<i>E. coli</i> CN13	LP	N/A	N/A	N/A	13			yes		Rodriguez et al. 2014	
	<i>E. coli</i> CN13	MP	N/A	N/A	N/A	19			yes		Rodriguez et al. 2014	
T1UV												
HER 468	<i>E. coli</i> CN13 ATCC 700609	LP	N/A	8.3					yes	Action spectrum	Beck et al. 2015	
HER 468	<i>E. coli</i> CN13 ATCC 700609	Laser 254 nm	4.3	8.5	13	17			yes	Action spectrum	Beck et al. 2015	
T4												
	<i>E. coli</i>	LP	1.1	2.0	3.0	4.0	6.7		yes		Bohrerova et al. 2008	
	<i>E. coli</i>	MP	1.1	1.7	2.6	4.0	7		yes		Bohrerova et al. 2008	
	<i>E. coli</i>	LP	3.6	8.0	13				yes		Hu et al. 2012	
ATCC 11303	N/A	LP	3.7	7.4	11	17	23	29	yes		Timchak & Gitis 2012	

		Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation										
Virus	Host	Lamp Type	1	2	3	4	5	6	Protocol?	Notes	Reference	
T7												
	<i>E. coli</i>	LP	1.7	5.8	11	16	20		yes		Bohrerova et al. 2008	
	<i>E. coli</i>	MP	1.3	3.7	8	13	18		yes		Bohrerova et al. 2008	
coliphage	<i>E. coli</i> ATCC 11303	LP	2.7	6.0	11				yes		Bowker et al. 2011	
coliphage	<i>E. coli</i> ATCC 11303	LP	2.7	6.0	11				yes		Bowker et al. 2011	
coliphage	<i>E. coli</i> ATCC 11303	UV-LED 255 nm	2.9	6.9	14				yes		Bowker et al. 2011	
coliphage	<i>E. coli</i> ATCC 11303	UV-LED 275 nm	2.7	6.0	12	17			yes		Bowker et al. 2011	
ATCC BAA-1025-B2	<i>E. coli</i> CN13 ATCC 700609	LP	N/A	3.8					yes	Action spectrum	Beck et al. 2015	
ATCC BAA-1025-B2	<i>E. coli</i> CN13 ATCC 700609	Laser 254 m	1.6	3.6	6.6				yes	Action spectrum	Beck et al. 2015	
T7m												
ATCC 11303-B38	<i>E. coli</i> B ATCC 11303	LP	N/A	3.4					yes	Action spectrum	Beck et al. 2015	
ATCC 11303-B38	<i>E. coli</i> B ATCC 11303	Laser 254 m	1.7	3.8	6.3	11			yes	Action spectrum	Beck et al. 2015	
V₁ (Podoviridae)	<i>E. coli</i> WG5	LP	3.1	5.9	8.8				yes		Shin et al. 2005	

Table 5. Fluences for multiple log reductions for various algae and other microorganisms

Microorganism	Lamp Type	Fluence (UV dose) (mJ/cm ²) for a given log reduction without photoreactivation					Protocol?	Notes	Reference
		1	2	3	4	5			
<i>Ascaris suum</i>									
(intact eggs) from worms	LP	100	328 + tailing				yes		Brownell & Nelson 2006
(decorticated eggs) from worms	LP	30					yes		Brownell & Nelson 2006
<i>Cryptococcus carnescens</i> yeast PYCC 5988	LP	18	32				yes		Pereira et al. 2013
<i>Candida sp.</i> New species similar to <i>C. pomicola</i> yeast PYCC 5991	LP	<10	25				yes		Pereira et al. 2013
<i>Metschnikowia viticola/Candida kofuensis</i> yeast									
PYCC 5993	LP	10	20				yes		Pereira et al. 2013
PYCC 5994	LP	8	17				yes		Pereira et al. 2013
<i>Metschnikowia viticola/Candida kofuensis</i> yeast PYCC 5992	LP	10	23				yes		Pereira et al. 2013
<i>Microcystis aeruginosa</i>									
PCC7806	LP	10	28	>60			no		Sakai et al. 2011
PCC7806	MP	15	130	>200			no		Sakai et al. 2011
<i>Rhodospiridium babjevae</i> yeast PYCC 5996	LP	40	90				yes		Pereira et al. 2013
<i>Rhodotorula minuta</i> (Saito) yeast PYCC 5990	LP	43	90				yes		Pereira et al. 2013
<i>Rhodotorula mucilaginosa</i> yeast									
PYCC 5989	LP	44	81				yes		Pereira et al. 2013
PYCC 5995	LP	57	113				yes		Pereira et al. 2013
<i>Saccharomyces cerevisiae</i> XS800	LP	42	70	100			no		Kim et al. 2004
<i>Tetraselmis suecica</i> algae K0297	LP	370	540	720			no		Olsen et al. 2015

Table Notes

1. Spiked into wastewater.
2. These data are medians derived from a Bayesian analysis of many studies.
3. DNA weighted fluence.
4. Action spectrum weighted fluence.
5. The water depth was only 2 mm, so the water factor would have been very close to 1.0. Thus although the Protocol corrections were not made, the corrections would have been small.

References

- Abshire, R.L.; and Dunton, H. 1981. Resistance of selected strains of *Pseudomonas aeruginosa* to low-intensity ultraviolet radiation, *Appl. Environ. Microbiol.*, 41(6): 1419–1423.
- Amoah, K.; Craik, S.; Smith, D.W.; and Belosevic, M. 2005. Inactivation of *Cryptosporidium* oocysts and *Giardia* cysts by ultraviolet light in the presence of natural particulate matter, *J. Water Supply: Res. Technol. – Aqua*, 54(3): 165-178.
- Antopol, S.C.; and Ellner, P.D. 1979. Susceptibility of *Legionella pneumophila* to ultraviolet radiation, *Appl. Environ. Microbiol.*, 38(2): 347–348.
- Aoyagi, Y.; Takeuchi, M.; Yoshida, K.; Kurouchi, M.; Yasui, N.; Kamiko, N.; Araki, T.; and Nanishi, Y. 2011. Inactivation of bacterial viruses in water using deep ultraviolet semiconductor light-emitting diode. *J. Environ. Eng.*, 137(12): 1215–1218.
- Ballester, N.A.; and Malley, J.P., Jr. 2004. Sequential disinfection of adenovirus type 2 with UV-chlorine-chloramine, *J. AWWA*, 96(10): 97–103.
- Banerjee, S.K.; and Chatterjee, S.N. 1977. Sensitivity of the vibrios to ultraviolet-radiation, *Int. J. Rad. Biol.*, 32(2): 127–133.
- Batch, L.F.; Schulz, C.R.; and Linden, K.G. 2004. Evaluating water quality effects on UV disinfection of MS2 coliphage, *J. AWWA*, 96(7): 75–87.
- Battigelli, D.A.; Sobsey, M.D.; and Lobe, D.C. 1993. The inactivation of hepatitis A virus and other model viruses by UV irradiation, *Water Sci. Technol.*, 27(3-4): 339–342.
- Baxter, C.S.; Hofmann, R.; Templeton, M.R.; Brown, M; and Andrews, R.C. 2007. Inactivation of adenovirus types 2, 5 and 41 in drinking water by UV light, free chlorine, and monochloramine, *J. Environ. Eng.*, 133(1): 95–103.
- Beck, S.E.; Rodriguez, R.A.; Linden, K.G.; Hargy, T.M.; Larason, T.C.; and Wright, H.B. 2014. Wavelength dependent UV inactivation and DNA damage of adenovirus as measured by cell culture infectivity and long range quantitative PCR, *Environ. Sci. Technol.*, 48: 591–598.
- Beck, S.E.; Wright, H.R.; Hargy, T.M.; Larason, T.C.; and Linden, K.G. 2015. Action spectra for validation of pathogen disinfection in medium-pressure ultraviolet (UV) systems, *Water Res.*, 70: 27–37.
- Beck, S.E.; Rodriguez, R.A.; Hawkins, M.A.; Hargy, T.M.; Larason, T.C.; and Linden, K.G. 2016. Comparison of UV-induced inactivation and RNA damage in MS2 phage across the germicidal spectrum, *Appl. Environ. Microbiol.*, 82(5): 1468–1474.

- Belosevic, M.; Craik, S.A.; Stafford, J.L.; Neumann, N.F.; Kruithof, J.; and Smith, D.W. 2001. Studies on the resistance/reactivation of *Giardia muris* cysts and *Cryptosporidium parvum* oocysts exposed to medium-pressure ultraviolet radiation, *FEMS Microbiol. Lett.*, 204(1): 197–203.
- Bichai, F.; Barbeau, B.; and Payment, P. 2009. Protection against UV disinfection of *E. coli* bacteria and *B. subtilis* spores ingested by *C. elegans* nematodes, *Water Res.*, 43(14): 3397–3406.
- Blatchley, E.R. III; Meeusen, A.; Aronson, A.I.; and Brewster, L. 2005. Inactivation of *Bacillus* spores by ultraviolet or gamma radiation, *J. Environ. Eng.*, 131(9): 1245–1252.
- Blatchley, E.R. III; Shen, C.; Scheible, O.K.; Robinson, J.P.; Ragheb, K.; Bergstrom, D.E.; Rokjer, D. 2008. Validation of large-scale, monochromatic UV disinfection systems for drinking water using dyed microspheres, *Water Res.*, 42(3): 677–688.
- Blatchley E.R. III; Oguma, K.; and Sommer, R. 2016. Comment on the ‘UV disinfection induces a VBNC state in *Escherichia coli* and *Pseudomonas aeruginosa*,’ *IUVA News*, 18(3): 12–16.
- Boczek, L.A.; Rhodes, E.R.; Cashdollar, J.L.; Ryu, J.; Popovici, J.; Hoelle, J.M.; Sivaganesan, M.; Hayes, S.L.; Rodgers, M.R.; and Ryu, H. 2016. Applicability of UV resistant *Bacillus pumilus* endospores as a human adenovirus surrogate for evaluating the effectiveness of virus inactivation in low-pressure UV treatment systems, *J. Microbiol. Meth.*, 122: 43–49.
- Bohrerova, Z.; and Linden, K.G. 2006a. Ultraviolet and chlorine disinfection of *Mycobacterium* in wastewater: effect of aggregation, *Water Environ. Res.*, 78(6): 565–571.
- Bohrerova, Z.; and Linden, K.G. 2006b. Assessment of DNA damage and repair in *Mycobacterium terrae* after exposure to UV irradiation, *J. Appl. Microbiol.*, 101: 995–1001.
- Bohrerova, Z.; Mamane, H.; Ducoste, J.; and Linden, K.G. 2006. Comparative inactivation of *Bacillus subtilis* spores and MS-2 coliphage in a UV reactor: implications for validation, *J. Environ. Eng.*, 132(12): 1554–1561.
- Bohrerova, Z.; Shemer, H.; Lantis, R.; Impellitteri, C.A.; and Linden, K.G. 2008. Comparative disinfection efficiency of pulsed and continuous-wave UV irradiation technologies, *Water Res.*, 42(12): 2975–2982.
- Bolton, J.R.; and Linden, K.G. 2003. Standardization of methods for fluence (UV dose) determination in bench-scale UV experiments, *J. Environ. Eng.*, 129(3): 209–215.
- Bolton, J.R.; Dussert, B.; Bukhari, Z.; Hargy, T.; and Clancy, J.L. 1998. Inactivation of *Cryptosporidium parvum* by medium pressure ultraviolet light in finished drinking water, in *Proceedings of the AWWA Annual Conference*, June, 1998, Dallas, TX, Vol. A, pp 389-403; American Water Works Association, Denver, CO.
- Bolton, J.R.; Beck, S.E.; and Linden, K.G. 2015a. Protocol for the determination of fluence (UV dose) using a low-pressure or low-pressure high-output UV lamp in bench-scale collimated beam ultraviolet experiments, *IUVA News*, 17(1): 11–16.
- Bolton, J.R.; Mayor-Smith, I.; and Linden, K.G. 2015b. Rethinking the concepts of fluence (UV dose) and fluence rate: The Importance of photon-based units – A systemic review, *Photochem. Photobiol.*, 91: 1252–1262.
- Bounty, S.; Rodriguez, R.A.; and Linden, K.G. 2012. Inactivation of adenovirus using low-dose UV/H₂O₂ advanced oxidation, *Water Res.*, 46(19): 6273–6278.

- Bowker, C.; Sain, A.; Shatalov, M.; and Ducoste, J. 2011. Microbial UV fluence-response assessment using a novel UV-LED collimated beam system, *Water Res.*, 45(5): 2011–2019.
- Brownell, S.A.; and Nelson, K.L. 2006. Inactivation of single-celled *Ascaris suum* eggs by low-pressure UV radiation, *Appl. Environ. Microbiol.*, 72(3): 2178–2184.
- Bukhari, Z.; Hargy, T.M.; Bolton, J.R.; Dussert, B.; and Clancy, J.L. 1999. Medium-pressure UV for oocyst inactivation, *J. AWWA*, 91(3): 86–94.
- Bukhari, Z.; Abrams, F.; and LeChevallier, M. 2004. Using ultraviolet light for disinfection of finished water, *Water Sci. Technol.*, 50(1): 173–178.
- Butkus, M.A.; Labare, M.P.; Starke, J.A.; Moon, K; and Talbot, M. 2004. Use of aqueous silver to enhance inactivation of coliphage MS-2 by UV disinfection, *Appl. Environ. Microbiol.*, 70(5): 2848–2853.
- Butler, R.C.; Lund, V.; and Carlson, D.A. 1987. Susceptibility of *Campylobacter jejuni* and *Yersinia enterocolitica* to UV radiation, *Appl. Environ. Microbiol.*, 53(2): 375–378.
- Cabaj, A.; Sommer, R.; Pribil, W.; and Haider, T. 2002. The spectral UV sensitivity of microorganisms used in biosimetry, *Water Sci. Technol. – Water Supply*, 2(3): 175–181.
- Caballero, S.; Abad, F.X.; Loisy, F.; Le Guyader, F.S.; Cohen, J.; Pintó, R.M.; and Bosch, A. 2004. Rotavirus virus-like particles as surrogates in environmental persistence and inactivation studies, *Appl. Environ. Microbiol.*, 70(7): 3904–3909.
- Calgua, B.; Carratalà, A.; Guerrero-Latorre, L.; de Abreu Corrêa, A.; Kohn, T.; Sommer, R.; and Girones, R. 2014. UVC inactivation of dsDNA and ssRNA viruses in water: UV fluences and a qPCR-based approach to evaluate decay on viral infectivity, *Food Environ. Virol.*, 6: 260–268.
- Campbell, A.T.; and Wallis, P. 2002. The effect of UV irradiation on human-derived *Giardia lamblia* cysts, *Water Res.*, 36(4): 963–969.
- Cervero-Aragó, S.; Sommer, R.; and Araujo, R.M. 2014. Effect of UV irradiation (253.7 nm) on free *Legionella* and *Legionella* associated with its amoebae hosts, *Water Res.*, 67: 299–309.
- Chang, J.C.H.; Ossoff, S.F.; Lobe, D.C.; Dorfman, M.H.; Dumais, C.M.; Qualls, R.G.; and Johnson, J.D. 1985. UV inactivation of pathogenic and indicator microorganisms, *Appl. Environ. Microbiol.*, 49(6): 1361–1365.
- Chatterley, C.; and Linden, K. 2010. Demonstration and evaluation of germicidal UV-LEDs for point-of-use water disinfection, *J. Water Health*, 8(3): 479–486.
- Chen, P.-Y.; Chu, X.-N.; Liu, L.; and Hu, J.-Y. 2015. Effects of salinity and temperature on inactivation and repair potential of *Enterococcus faecalis* following medium- and low-pressure ultraviolet irradiation, *J. Appl. Microbiol.*, 120: 816–825.
- Chen, R.-Z.; Craik, S.A.; and Bolton, J.R. 2009. Comparison of the action spectra and relative DNA absorbance spectra of microorganisms: information important for the determination of germicidal fluence (UV dose) in an ultraviolet disinfection of water, *Water Res.*, 43: 5087–5096.
- Chevrefils, G.; Caron, É.; Wright, H.; Sakamoto, G.; Payment, P.; Barbeau, B.; and Cairns, B. 2006. *IUVA News*, 8(1): 38–45.
- Clancy, J.L.; Bukhari, Z.; Hargy, T.M.; Bolton, J.R.; Dussert, B.W.; and Marshall, M.M. 2000. Using UV to inactivate *Cryptosporidium*, *J. AWWA*, 92(9): 97–104.

- Clancy, J.L.; Marshall, M.M.; Hargy, T.M.; and Korich, D.G. 2004. Susceptibility of five strains of "*Cryptosporidium parvum*" oocysts to UV light, *J. AWWA*, 96(3): 84–93.
- Clauß, M. 2006. Higher effectiveness of photoinactivation of bacterial spores, UV resistant vegetative bacteria and mold spores with 222 nm compared to 254 nm wavelength, *Acta Hydrochim. Hydrobiol.*, 34(6): 525–532.
- Clauß, M.; Mannesmann, R.; and Kolch, A. 2005. Photoreactivation of *Escherichia coli* and *Yersinia enterocolitica* after irradiation with a 222 nm excimer lamp compared to a 254 nm low-pressure mercury lamp, *Acta Hydrochim. Hydrobiol.*, 33(6): 579–584.
- Collins, F.M. 1971. Relative susceptibility of acid-fast and non-acid-fast bacteria to ultraviolet light, *Appl. Microbiol.*, 21(3): 411–413.
- Coohill, T.P.; and Sagripanti, J.-L. 2008. Overview of the inactivation by 254 nm ultraviolet radiation of bacteria with particular relevance to biodefense, *Photochem. Photobiol.*, 84(5): 1084–1090.
- Craik, S.A.; Finch, G.R.; Bolton, J.R.; and Belosevic, M. 2000. Inactivation of *Giardia muris* cysts using medium-pressure ultraviolet radiation in filtered drinking water, *Water Res.*, 34(18): 4325–4332.
- Craik, S.A.; Weldon, D.; Finch, G.R.; Bolton, J.R.; and Belosevic, M. 2001. Inactivation of *Cryptosporidium parvum* oocysts using medium- and low-pressure ultraviolet radiation, *Water Res.*, 35(6): 1387–1398.
- de Roda Husman, A.M.; Bijkerk, P.; Lodder, W.; van den Berg, H.; Pribil, W.; Cabaj, A.; Gehringer, P.; Sommer, R.; and Duizer, E. 2004. Calicivirus inactivation by nonionizing (253.7-nanometer-wavelength [UV]) and ionizing (gamma) radiation, *Appl. Environ. Microbiol.*, 70(9): 5089–5093.
- Diston, D.; Ebdon, J.E.; and Taylor, H.D. 2012. The effect of UV-C radiation (254 nm) on candidate microbial source tracking phages infecting a human-specific strain of *Bacteroides fragilis* (GB-24), *J. Water Health*, 10(2): 262–270.
- Donnellan, Jr., J.E.; and Stafford, R.S. 1968. The ultraviolet photochemistry and photobiology of vegetative cells and spores of *Bacillus megaterium*, *Biophys. J.*, 8:17–28.
- Dumètre, A.; Le Bras, C.; Baffet, M.; Meneceur, P.; Dubey, J.P.; Derouin, F.; Duguet, J.-P.; Joyeux, M.; and Moulin, L. 2008. Effects of ozone and ultraviolet radiation treatments on the infectivity of *Toxoplasma gondii* oocysts, *Vetin. Parasitol.*, 153: 209–213.
- Eischeid, A.C.; and Linden, K.G. 2007. Efficiency of pyrimidine dimer formation in *Escherichia coli* across UV wavelengths, *J. Appl. Microbiol.*, 103: 1650–1656.
- Eischeid, A.C.; Meyer, J.N.; and Linden, K.G. 2009. UV disinfection of adenoviruses: molecular indications of DNA damage efficiency, *Appl. Environ. Microbiol.*, 75(1): 23–28.
- Gates, F.L. 1929. A study of the bacterial action of ultraviolet light I. The reaction to monochromatic radiations, *J. Gen. Physiol.*, 13: 231–248.
- Gerba, C.P.; Gramos, D.M.; and Nwachuku, N. 2002. Comparative inactivation of enteroviruses and adenovirus 2 by UV light, *Appl. Environ. Microbiol.*, 68(10): 5167–5169.
- Gerrity, D.; Ryu, H.; Crittenden, J.; and Abbaszadegan, M. 2008. UV inactivation of adenovirus type 4 measured by integrated cell culture qPCR, *J. Environ. Sci. Health, Part A*, 43(14): 1628–1638.
- Giese, N.; and Darby, J. 2000. Sensitivity of microorganisms to different wavelengths of UV light: implications on modeling of medium pressure UV systems, *Water Res.*, 34(16): 4007–4013.

- Guo, H.; and Hu, J. 2012. Effect of hybrid coagulation–membrane filtration on downstream UV disinfection, *Desalin.*, 290: 115–124.
- Guo, H.; Chu, X.; and Hu, J. 2010. Effect of host cells on low- and medium-pressure UV inactivation of adenoviruses, *Appl. Environ. Microbiol.*, 76(21): 7068–7075.
- Guo, M.; Hu, H.; Bolton, J.R.; and Gamal El-Din, M. 2009. Comparison of low- and medium-pressure ultraviolet lamps: Photoreactivation of *Escherichia coli* and total coliforms in secondary effluents of municipal wastewater treatment plants, *Water Res.*, 43(3): 815–821.
- Harris, G.D.; Adams, V.D.; Sorensen, D.L.; and Curtis, M.S. 1987. Ultraviolet inactivation of selected bacteria and viruses with photoreactivation of the bacteria, *Water Res.*, 21(6): 687–692.
- Havelaar, A.H.; Meulemans, C.C.E.; Pot-Hogbeem, W.M.; and Koster, J. 1990. Inactivation of bacteriophage MS2 in wastewater effluent with monochromatic and polychromatic ultraviolet light, *Water Res.*, 24(11): 1387–1393.
- Hayes, S.L.; Rice, E.W.; Ware, M.W.; and Schaefer III, F.W. 2003. Low pressure ultraviolet studies for inactivation of *Giardia muris* cysts, *J. Appl. Microbiol.*, 94(1): 54–59.
- Hayes, S.L.; White, K.M.; and Rodgers, M.R. 2006. Assessment of the effectiveness of low-pressure UV light for inactivation of *Helicobacter pylori*, *Appl. Environ. Microbiol.*, 72(5): 3763–3765.
- Hayes, S.L.; Sivaganesan, M.; White, K.M.; and Pfaller, S.L. 2008. Assessing the effectiveness of low-pressure ultraviolet light for inactivating *Mycobacterium avium* complex (MAC) micro-organisms, *Lett. Appl. Microbiol.*, 47(5): 386–392.
- Hijnen, W.A.M.; Beerendonk, E.F.; and Medema, G.J. 2006. Inactivation credit of UV radiation for viruses, bacteria and protozoan (oo)cysts in water: A review, *Water Res.*, 40(1): 3–22.
- Hoyer, O. 1998. Testing performance and monitoring of UV systems for drinking water disinfection, *Water Supply*, 16(1/2): 419–424.
- Hu, X.; Geng, S.; Wang, X.; and Hu, C. 2012. Inactivation and photorepair of enteric pathogenic microorganisms with ultraviolet irradiation, *Environ. Eng. Sci.*, 29(6): 549–553.
- Huffman, D.E.; Gennaccaro, A.; Rose, J.B.; and Dussert, B.W. 2002. Low- and medium-pressure UV inactivation of microsporidia *Encephalitozoon intestinalis*, *Water Res.*, 36(12): 3161–3164.
- Jenny, R.M.; Simmons III, O.D.; Shatalov, M.; and Ducoste, J.J. 2014. Modeling a continuous flow ultraviolet Light Emitting Diode reactor using computational fluid dynamics, *Chem. Eng. Sci.*, 116: 524–535.
- Jin, S.; Mofidi, A.A.; and Linden, K.G. 2006. Polychromatic UV fluence measurement using chemical actinometry, biodosimetry, and mathematical techniques, *J. Environ. Eng.*, 132(8): 831–841.
- John, D.E.; Nwachuku, N.; Pepper, I.L.; and Gerba, C.P. 2003. Development and optimization of a quantitative cell culture infectivity assay for the microsporidium *Encephalitozoon intestinalis* and application to ultraviolet light inactivation, *J. Microbiol. Meth.*, 52: 183–196.
- Johnson, A.M.; Linden, K.; Ciociola, K.M.; De Leon, R.; Widmer, G.; and Rochelle, P.A. 2005. UV inactivation of *Cryptosporidium hominis* as measured in cell culture, *Appl. Environ. Microbiol.*, 71(5): 2800–2802.
- Karanis, P.; Maier, W.A.; Seitz, H.M.; and Schoenen, D. 1992. UV sensitivity of protozoan parasites, *J. Water SRT – Aqua*, 41(2): 95–100.

- Kim, J.K.; Petin, V.G.; and Tkhabisimova, M.D. 2004. Survival and recovery of yeast cells after simultaneous treatment of UV light radiation and heat, *Photochem. Photobiol.*, 79(4): 349–355.
- Ko, G.; Cromeans, T.L.; and Sobsey, M.D. 2005. UV inactivation of adenovirus type 41 measured by cell culture mRNA RT-PCR, *Water Res.*, 39(15): 3643–3649.
- Lazarova, V.; and Savoye, Ph. 2004. Technical and sanitary aspect of wastewater disinfection by UV irradiation for landscape irrigation, *Water Sci. Technol.*, 50(2): 203–209.
- Lee, J.; Zoh, K.; and Ko, G. 2008. Inactivation and UV disinfection of murine norovirus with TiO₂ under various environmental conditions, *Appl. Environ. Microbiol.*, 74(7): 2111–2117.
- Li, D.; Gu, A.Z.; He, M.; Shi, H.-C.; and Yang, W. 2009. UV inactivation and resistance of rotavirus evaluated by integrated cell culture and real-time RT-PCR assay, *Water Res.*, 43(13): 3261–3269.
- Liltved, H.; and Landfald, B. 1996. Influence of liquid holding recovery and photoreactivation on survival of ultraviolet-irradiated fish pathogenic bacteria, *Water Res.*, 30(5): 1109–1114.
- Liltved, H.; Vogelsang, C.; Modahl, I.; and Dannevig, B.H. 2006. High resistance of fish pathogenic viruses to UV irradiation and ozonated seawater, *Aquacult. Eng.*, 34(2): 72–82.
- Linden, K.G.; Shin, G.-A.; Faubert, G.; Cairns, W.; and Sobsey, M.D. 2002. UV disinfection of *Giardia lamblia* cysts in water, *Environ. Sci. Technol.*, 36(11): 2519–2522.
- Linden, K.G.; Thurston, J.; Schaefer, R.; and Malley, Jr., J.P. 2007. Enhanced UV inactivation of adenoviruses under polychromatic UV lamps, *Appl. Environ. Microbiol.*, 73(23): 7571–7574.
- Linden, K.G.; Lee, J.-K.; Scheible, K.; Shen, C.; and Posy, P. 2009. Demonstrating 4-log adenovirus inactivation in a medium-pressure UV disinfection reactor, *J. AWWA*, 101(4): 90–99.
- Mamane, H.; Bohrerova, Z.; and Linden, K.G. 2009. Evaluation of *Bacillus* spore survival and surface morphology following chlorine and ultraviolet disinfection in water, *J. Environ. Eng.*, 135(8): 692–699.
- Mamane-Gravetz, H.; and Linden, K.G. 2004. UV disinfection of indigenous aerobic spores: implications for UV reactor validation in unfiltered waters, *Water Res.*, 38: 2898–2906.
- Mamane-Gravetz, H.; Linden, K.G.; Cabaj, A.; and Sommer, R. 2005. Spectral sensitivity of *Bacillus subtilis* spores and MS2 Coliphage for validation testing of ultraviolet reactors for water disinfection, *Environ. Sci. Technol.*, 39(20): 7845–7852.
- Martin, E.L.; Reinhardt, R.L.; Baum, L.L.; Becker, M.R.; Shaffer, J.J.; and Kokjohn, T.A. 2000. The effects of ultraviolet radiation on the moderate halophile *Halomonas elongata* and the extreme halophile *Halobacterium salinarum*, *Can. J. Microbiol.*, 46(2): 180–187.
- Matafonova, G.G.; Batoev, V.B.; and Linden, K.G. 2012. Impact of scattering of UV radiation from an exciplex lamp on the efficacy of photocatalytic inactivation of *Escherichia coli* cells in water, *J. Appl. Spect.*, 79(2): 296–301.
- Maya, C.; Beltrán, N.; Jiménez, B.; and Bonilla, P. 2003. Evaluation of the UV disinfection process in bacteria and amphizoic amoeba inactivation. *Water Sci. Technol.: Water Supply*, 3(4): 285–291.
- McKinney, C.W.; and Pruden, A. 2012. Ultraviolet disinfection of antibiotic resistant bacteria and their antibiotic resistance genes in water and wastewater, *Environ. Sci. Technol.*, 46: 13393–13400.
- Meng, Q.S.; and Gerba, C.P. 1996. Comparative inactivation of enteric adenoviruses, poliovirus and coliphages by ultraviolet irradiation, *Water Res.*, 30(11): 2665–2668.

- Mofidi, A.A.; Meyer, E.A.; Wallis, P.M.; Chou, C.I.; Meyer, B.P.; Ramalingam, S.; and Coffey, B.M. 2002. The effect of UV light on the inactivation of *Giardia lamblia* and *Giardia muris* cysts as determined by animal infectivity assay (P-2951-01), *Water Res.*, 36(8): 2098–2108.
- Moreno-Andrés, J.; Romero-Martínez, L.; Acevedo-Merino, A.; and Nebot, E. 2016. Determining disinfection efficiency on *E. faecalis* in saltwater by photolysis of H₂O₂: Implications for ballast water treatment. *Chem Eng. J.*, 283: 1339–1348.
- Morita, S.; Namikoshi, A.; Hirata, T.; Oguma, K.; Katayama, H.; Ohgaki, S.; Motoyama, N.; and Fujiwara, M. 2002. Efficacy of UV irradiation in inactivating *Cryptosporidium parvum* oocysts, *Appl. Environ. Microbiol.*, 68(11): 5387–5393.
- Nicholson, W.L.; and Galeano, B. 2003. UV resistance of *Bacillus anthracis* spores revisited: validation of *Bacillus subtilis* spores as UV surrogates for spores of *B. anthracis* Sterne, *Appl. Environ. Microbiol.*, 69(2): 1327–1330.
- Nieuwstad, Th.J.; and Havelaar, A.H. 1994. The kinetics of batch ultraviolet inactivation of bacteriophage MS2 and microbiological calibration of an ultraviolet pilot plant, *J. Environ. Sci. Health Part A*, 29(9): 1993–2007.
- Nuanualsuwan, S.; Thongtha, P.; Kamolsiripichaiporn, S.; and Subharat, S. 2008. UV inactivation and model of UV inactivation of foot-and-mouth disease viruses in suspension, *Int. J. Food Microbiol.*, 127(1–2): 84–90.
- Nwachuku, N.; Gerba, C.P.; Oswald, A.; and Mashadi, F.D. 2005. Comparative inactivation of adenovirus serotypes by UV light disinfection, *Appl. Environ. Microbiol.*, 71(9): 5633–5636.
- Oguma, K.; Katayama, H.; Mitani, H.; Morita, S.; Hirata, T.; and Ohgaki, S. 2001. Determination of pyridine dimers in *Escherichia coli* and *Cryptosporidium parvum* during UV light inactivation, photoreactivation, and dark repair, *Appl. Environ. Microbiol.*, 67(10): 4630–4637.
- Oguma, K.; Katayama, H.; and Ohgaki, S. 2002. Photoreactivation of *Escherichia coli* after low- or medium-pressure UV disinfection determined by an endonuclease sensitive site assay, *Appl. Environ. Microbiol.*, 68(12): 6029–6035.
- Oguma, K.; Katayama, H.; and Ohgaki, S. 2004. Photoreactivation of *Legionella pneumophila* after inactivation by low- or medium-pressure ultraviolet lamp, *Water Res.*, 38(11): 2757–2763.
- Oguma, K.; Kita, R.; Sakai, H.; Murakami, M.; and Takizawa, S. 2013. Application of UV light emitting diodes to batch and flow-through water disinfection systems, *Desalin.*, 328: 24–30.
- Oguma, K.; Rattanukul, S.; and Bolton, J.R. 2015. Application of UV Light–Emitting Diodes to adenovirus in water, *J. Environ. Eng.*, 142(3): 1–6.
- Olsen, R.O.; Hess-Erga, O.-K.; Larsen, A.; Thuestad, G.; Tobiesen, A.; and Hoell, I.A. 2015. Flow cytometric applicability to evaluate UV inactivation of phytoplankton in marine water samples, *Marine Pollut. Bull.*, 96: 279–285.
- Oppenheimer, J.A.; Hoagland, J.E.; Laine, J.-M.; Jacangelo, J.G.; and Bhamrah, A. 1993. Microbial inactivation and characterization of toxicity and by-products occurring in reclaimed wastewater disinfected with UV radiation, in *Water Environment Federation Plan, Description and Operations of Effluent Disinfection Systems*, Water Environment Federation, Alexandria, VA.

- Otaki, M.; Okuda, A.; Tajima, K.; Iwasaki, T.; Kinoshita, S.; and Ohgaki, S. 2003. Inactivation differences of microorganisms by low pressure UV and pulsed xenon lamps, *Water Sci. Technol.*, 47(3): 185–190.
- Park, G.W.; Linden, K.G. and Sobsey, M.D. 2011. Inactivation of murine norovirus, feline calicivirus and echovirus 12 as surrogates for human norovirus (NoV) and coliphage (F+) MS2 by ultraviolet light (254 nm) and the effect of cell association on UV inactivation, *Lett. Appl. Microbiol.*, 52: 162–167.
- Pennell, K.G.; Naunovic, Z.; and Blatchley, III, E.R. 2008. Sequential inactivation of *Bacillus subtilis* spores with ultraviolet radiation and iodine, *J. Environ. Eng.*, 134(7): 513–520.
- Pereira, V.J.; Ricardo, J.; Galinha, R.; Benoliel, M.J.; and Barreto Crespo, M.T. 2013. Occurrence and low pressure ultraviolet inactivation of yeasts in real water sources, *Photochem. Photobiol. Sci.*, 12: 626–630.
- Qian, S.S.; Donnelly, M.; Schmelling, D.C.; Messner, M.; Linden, K.G.; and Cotton, C. 2004. Ultraviolet light inactivation of protozoa in drinking water: a Bayesian meta-analysis, *Water Res.*, 38(2): 317–326.
- Qian, S.S.; Linden, K.; and Donnelly, M. 2005. A Bayesian analysis of mouse infectivity data to evaluate the effectiveness of using ultraviolet light as a drinking water disinfectant, *Water Res.*, 39(17): 4229–4239.
- Qiu, X.; Sundin, G.W.; Chai, B.; and Tiedje, J.M. 2004. Survival of *Shewanella oneidensis* MR-1 after UV radiation exposure, *Appl. Environ. Microbiol.*, 70(11): 6435–6443.
- Quails, R.G.; and Johnson J.D. 1983. Bioassay and dose measurement in UV disinfection, *Appl. Environ. Microbiol.*, 45(3): 872–877.
- Quek, P.H.; and Hu, J. 2008. Indicators for photoreactivation and dark repair studies following ultraviolet disinfection, *J. Ind. Microbiol. Biotechnol.*, 35: 533–541.
- Rattanakul, S.; Oguma, K.; Sakai, H.; and Takizawa, S. 2014. Inactivation of viruses by combination processes of UV and chlorine, *J. Water Environ. Technol.*, 12(6): 511–523.
- Rattanakul, S.; Oguma, K.; and Takizawa, S. 2015. Sequential and simultaneous applications of UV and chlorine for Adenovirus inactivation, *Food Environ. Virol.*, 7: 295–304.
- Rauth, A.M. 1965. The physical state of viral nucleic acid and the sensitivity of viruses to ultraviolet light, *Biophys. J.*, 5(3): 257–273.
- Rodríguez, R.A.; Bounty, S.; and Linden, K.G. 2013. Long-range quantitative PCR for determining inactivation of adenovirus 2 by ultraviolet light, *J. Appl. Microbiol.*, 114: 1854–1865.
- Rodríguez, R.A.; Bounty, S.; Beck, S.; Chan, C.; McGuire, C.; and Linden, K.G. 2014. Photoreactivation of bacteriophages after UV disinfection: Role of genome structure and impacts of UV source, *Water Res.*, 55: 143–149.
- Rose, L.J.; and O’Connell, H. 2009. UV light inactivation of bacterial biothreat agents, *Appl. Environ. Microbiol.*, 75(9): 2987–2990.
- Ryu, H.; Gerrity, D.; Crittenden, J.C.; and Abbaszadegan, M. 2008. Photocatalytic inactivation of *Cryptosporidium parvum* with TiO₂ and low-pressure ultraviolet irradiation, *Water Res.*, 42(6-7): 1523–1530.

- Ryu, H.; Cashdollar, J.L.; Fout, G.S.; Schrantz, K.A.; and Hayes, S. 2015. Applicability of integrated cell culture quantitative PCR (ICC-qPCR) for the detection of infectious adenovirus type 2 in UV disinfection studies, *J. Environ. Sci. Health, Part A*, 50(8): 777–787.
- Sakai, H.; Katayama, H.; Oguma, K.; and Ohgaki, S. 2011. Effect of photoreactivation on ultraviolet inactivation of *Microcystis aeruginosa*, *Water Sci. Technol.*, 63(6): 1224–1229.
- Sarkar, P.; and Gerba, C.P. 2012. Inactivation of *Naegleria fowleri* by chlorine and ultraviolet light, *J. AWWA*, 104(3): E173–E180.
- Sharp, D.G. 1939. The lethal action of short ultraviolet rays on several common pathogenic bacteria, *J. Bacteriol.*, 37: 447–460.
- Sherchan, S.P.; Snyder, S.A.; Gerba, C.P.; and Pepper, I.L. 2014. Inactivation of MS2 coliphage by UV and hydrogen peroxide: Comparison by cultural and molecular methodologies, *J. Environ. Sci. Health, Part A*, 49(4): 397–403.
- Shin, G.-A.; Linden, K.G.; Arrowood, M.J.; and Sobsey, M.D. 2001. Low-Pressure UV inactivation and DNA repair potential of *Cryptosporidium parvum* oocysts, *Appl. Environ. Microbiol.*, 67(7): 3029–3032.
- Shin, G.-A.; Linden, K.G.; and Sobsey, M.D. 2005. Low pressure ultraviolet inactivation of pathogenic enteric viruses and bacteriophages, *J. Environ. Eng. Sci.*, 4(Suppl. 1): S7–S11.
- Shin, G.-A.; Lee, J.-K.; Freeman, R.; and Cangelosi, G.A. 2008. Inactivation of *Mycobacterium avium* complex by UV irradiation, *Appl. Environ. Microbiol.*, 74(22): 7067–7069.
- Shin, G.-A.; Lee, J.-K.; and Linden, K.G. 2009. Enhanced effectiveness of medium-pressure ultraviolet lamps on human adenovirus and its possible mechanism, *Water Sci. Technol.*, 60(4): 851–857.
- Sholtes, K.A.; Lowe, K.; Walters, G.W.; Sobsey, M.D.; Linden, K.G.; and Casanova, L.M. 2016. Comparison of ultraviolet light-emitting diodes and low-pressure mercury-arc lamps for disinfection of water, *Environ. Technol.*, Online: DOI: 10.1080/09593330.2016.1144798
- Simonet, J.; and Gantzer, C. 2006. Inactivation of poliovirus 1 and F-specific RNA phages and degradation of their genomes by UV irradiation at 254 nanometers, *Appl. Environ. Microbiol.*, 72(12): 7671–7677.
- Simons, R.; Gabbai, U.E.; and Moram, M.A. 2014. Optical fluence modelling for ultraviolet light emitting diode-based water treatment systems, *Water Res.*, 66: 338–349.
- Singh, P.K. 1975. Photoreactivation of UV-irradiated blue-green algae and algal virus LPP-1, *Arch. Microbiol.*, 103: 297–302.
- Sirikanchana, K.; Shisler, J.L.; and Mariñas, B.J. 2008. Effect of exposure to UV-C irradiation and monochloramine on adenovirus serotype 2 early protein expression and DNA replication, *Appl. Environ. Microbiol.*, 74(12): 3774–3782.
- Sommer, R.; Weber, G.; Cabaj, A.; Wekerle, J.; Keck, G.; and Schauburger, G. 1989. [UV-inactivation of microorganisms in water] (article in German), *Zentralblatt für Hygiene und Umweltmedizin = Int. J. Hygiene Environ. Med.*, 189(3): 214–224.
- Sommer, R.; Haider, T.; Cabaj, A.; Pribil, W.; and Lhotsky, M. 1998. Time dose reciprocity in UV disinfection of water, *Water Sci. Technol.*, 38(12): 145–150.

- Sommer, R.; Cabaj, A.; Sandu, T.; and Lhotsky, M. 1999. Measurement of UV radiation using suspensions of microorganisms. *J. Photochem. Photobiol. B: Biol.*, 53(1-3), 1–6.
- Sommer, R.; Lhotsky, M.; Haider, T.; and Cabaj, A. 2000. UV inactivation, liquid-holding recovery, and photoreactivation of *Escherichia coli* O157 and other pathogenic *Escherichia coli* strains in water, *J. Food Protect.*, 63(8): 1015–1020.
- Sommer, R.; Pribil, W.; Appelt, S.; Gehringer, P.; Eschweiler, H.; Leth, H.; Cabaj, A.; and Haider, T. 2001. Inactivation of bacteriophages in water by means of non-ionizing (UV-253.7 nm) and ionizing (gamma) radiation: a comparative approach, *Water Res.*, 35(13): 3109–3116.
- Song, A.; Liu, X.; Zhang, Y.; Liu, Y. 2015. Effect of sodium alginate on UVC inactivation of coliphage MS2, *RSC Adv.*, 5(127): 104779-104784.
- Stamm, L.V.; and Charon, N.W. 1988. Sensitivity of pathogenic and free-living *Leptospira spp.* to UV radiation and mitomycin C, *Appl. Environ. Microbiol.*, 54(3): 728–733.
- Sun, W.; and Liu, W. 2009. A pilot-scale study on ultraviolet disinfection system for drinking water, *J. Water Supply: Res. Technol. – Aqua*, 58(5): 346–353.
- Taylor-Edmonds, L.; Lichi, T.; Rotstein-Mayer, A.; and Mamane, H. 2015. The impact of dose, irradiance and growth conditions on *Aspergillus niger* (renamed *A. brasiliensis*) spores low-pressure (LP) UV inactivation, *J. Environ. Sci. Health, Part A*, 50: 341–347.
- Templeton, M.R.; Hofmann, R.; Andrews, R.C.; and Whitby, G.E. 2006. Biodosimetry testing of a simplified computational model for the UV disinfection of wastewater, *J. Environ. Eng. Sci.*, 5(1): 29–36.
- Templeton, M.; Oddy, F.; Leung, W.-K.; and Rogers, M. 2009. Chlorine and UV disinfection of ampicillin-resistant and trimethoprim-resistant *Escherichia coli*, *Can. J. Civil Eng.*, 36(5): 889–894.
- Thompson, S.S.; Jackson, J.L.; Suva-Castillo, M.; Yanko, W.A.; El Jack, Z.; Kuo, J.; Chen, C.-L.; Williams, F.P.; and Schnurr, D.P. 2003. Detection of infectious human adenoviruses in tertiary-treated and ultraviolet-disinfected wastewater, *Water Environ. Res.*, 75(2): 163–170.
- Thurston-Enriquez, J.A.; Haas, C.N.; Jacangelo, J.; Riley, K.; and Gerba, C.P. 2003. Inactivation of feline calicivirus and adenovirus Type 40 by UV radiation, *Appl. Environ. Microbiol.*, 69(1): 577–582.
- Timchak, E.; and Gitis, V. 2012. A combined degradation of dyes and inactivation of viruses by UV and UV/H₂O₂, *Chem. Eng. J.*, 192: 164–170.
- Tosa, K.; and Hirata, T. 1999. Photoreactivation of enterhemorrhagic *Escherichia coli* following UV disinfection, *Water Res.*, 33(2): 361–366.
- Tree, J.A.; Adams, M.R.; and Lees, D.N. 2005. Disinfection of feline calicivirus (a surrogate for Norovirus) in wastewaters, *J. Appl. Microbiol.*, 98(1): 155–162.
- Wang, D.; Oppenländer, T.; Gamal El-Din, M.; and Bolton, J.R. 2010. Comparison of the disinfection effects of vacuum-UV (VUV) and UV light on *Bacillus subtilis* spores in aqueous suspensions at 172, 222, 254 nm, *Photochem. Photobiol.*, 86(1): 176–181.
- Ware, M.W.; Augustine, S.A.J.; Erisman, D.O.; See, M.J.; Wymer, L.; Hayes, S.L.; Dubey, J.P.; and Villegas, E.N. 2010. Determining UV inactivation of *Toxoplasma gondii* oocysts by using cell culture and a mouse bioassay, *Appl. Environ. Microbiol.*, 76(15): 5140–5147.

- Wiedenmann, A.; Fischer, B.; Straub, U.; Wang, C.-H.; Flehmig, B.; and Schoenen, D. 1993. Disinfection of hepatitis A virus and MS-2 coliphage in water by ultraviolet irradiation: comparison of UV-susceptibility, *Water Sci. Technol.*, 27(3-4): 335–338.
- Wilson, B.R.; Roessler, P.F.; Van Dellen, E.; Abbaszadegan, M.; and Gerba, C.P. 1992. Coliphage MS2 as a UV water disinfection efficacy test surrogate for bacterial and viral pathogens, Proceedings of the American Water Works Association Water Quality Technology Conference, Nov 15–19, Toronto, Canada, 1992.
- Wright, H.; and Sakamoto, G. 1999. UV dose required to achieve incremental log inactivation of bacteria, virus, and protozoa, Trojan Technologies, London, ON, Canada.
- Wu, Y.; Clevenger, T.; and Deng, B. 2005. Impacts of goethite particles on UV disinfection of drinking water, *Appl. Environ. Microbiol.*, 71(7): 4140–4143.
- Würtele, M.A.; Kolbe, T.; Lipsz, M.; Külberg, A.; Weyers, M.; Kneissl, M.; Jekel, M. 2010. Application of GaN-based ultraviolet-C light emitting diodes – UV LEDs – for water disinfection. *Water Res.*, 45: 1481–1489.
- Yaun, B.R.; Sumner, S.S.; Eifert, J.D.; and Marcy, J.E. 2003. Response of *Salmonella* and *Escherichia coli* O157:H7 to UV Energy, *J. Food Protect.*, 66(6): 1071–1073.
- Zhang, Y.; Zhang, Y.; Zhou, L.; and Tan, C. 2014. Factors affecting UV/H₂O₂ inactivation of *Bacillus atrophaeus* spores in drinking water, *J. Photochem. Photobiol. B: Biol.*, 134: 9–15.
- Zimmer, J.L. and Slawson, R.M. 2002. Potential repair of *Escherichia coli* DNA following exposure to UV radiation from both medium- and low pressure UV sources used in drinking water treatment, *Appl. Environ. Microbiol.*, 68(7): 3293–3299.
- Zimmer, J.L.; Slawson, R.M.; and Huck, P.M. 2003. Inactivation and potential repair of *Cryptosporidium parvum* following low- and medium-pressure ultraviolet irradiation, *Water Res.*, 37(14): 3517–3523.