Vorkommen der wichtigsten Vertreter aus den einzelnen Indikationsgruppen in der aquatischen Umwelt und im Trinkwasser

Arzneimittel bzw. Metabolit	Kläranlagen		Fließ-gewässer	Grund-wasser	Trink-wasser
	Zulauf	Ablauf			
Analgetika und Antiphlogistika					
Acetylsalicylsäure		-1,51 µg/l, (8 12)	(8)		
Gentisinsäure	-4,6 µg/l (8-10)	(8)	(8)		
Salicylursäure	-6,8µg/l (8 9)				
Salicylsäure	-54 µg/l (8-11)	Spuren -0,10 µg/l (8-11 13 14 16) -13 µg/l (10 15)	Spuren (8 10 11 13 15 16 17 18)		
Diclofenac	3,02 µg/l (8 10-12 19)	-5,42 µg/l (8 10 11 15 17 19 22-24 26 27 30-37 43 50 56 62)	-304 ng/l (8 10 11 15 17 19 22-24 26 27 30-37 43 51-54)	-380 ng/l (10 21, 28 53)	1-6 ng/l (10 19 20 33 38-40 55 56)
Ibuprofen	–7,11 µg /l (8 11 31 32 43 58 59-62)	-85 µg/l (8 10 15 23 26 29 30-33 36 43-45 57 58 60-62)	-2.7 µg /l (8 10 15 23 26 27 30 32 36 43-45 49) Seewasser (60)	-200 ng/l (21 28 46 55)	1-3 ng/l (10 12 40 55)
Carboxyibuprofen	(41 43 60)		-0.02 µg/l (41)		
Carboxyhydratropasäure	(41 43 60)				
Hydroxyibuprofen	(41 43 60)	-0.92 µg/l, (41 60)	-0.34 µg/l (41)		
Acetaminophenazon	(10)	-4,8 µg/l (18 65)	-0,94 µg/l (33 49 52 65 66)		(68)
Aminophenazon	(8)	(8, 10 32 64)	(8, 64)		
Codein			(49 62)	-0,47 µg/l (19 21 28 46-48)	
Fenoprofen		(32)	(33 52)		(33)
Flurbiprofen		(32)			
4-Formylaminophenazon		-6,5 µg/l (65)	-0,71 µg/l (33 52 65 67)		
Indometacin	(8 10)	-520 ng/l (8 10-12)	-60 ng/l (5 12 33 36 51 52 54)		(33)
Ketoprofen	(9 10 11)	–1,62 µg/l (8-13 17 26 31 32 36)	(8 11 15 26 33)	(10)	
Mefenaminsäure		–1,0 µg/l (62)	(25)		
N-Methylphenacetin			(53)	(53)	
Naproxen	(8 10 11)	–6,2 µg/l (8 10-12 15 16 18 23 26 32 36 50 61 62)	(8 15 16 18 23 25 26 33 36 51 52 54 61 62 67)		
Paracetamol	(8)	-10 µg/l (8 49 33)	-106 ng/l (25 33 52 65)		
Phenazon	(8 10)	-570 ng/l (8 10 32 33 65)	(8 33 52-53)	-1,25 µg/l (10 21 48 53)	(21 28 56)
Propyphenazon	(10)	-610 ng/l (10, 62 64 65)	(10 15 19 21-23 25-27 33 40 41 49 52 53 62 64 65)	-1,47 µg/l (10 21 48 53)	(10 19 21 40 55 56) -1,25 µg/l-1,25 µg/l
Antibiotika und Chemotherapeutika					
Azithrymocin	(69 70)	(69 70)			
Chloramphenicol		-0,56 µg/l (72)	-0,06 µg/l (72)		
Chlortetracyclin			-0,15 µg/l (49, 77 78)		

Arzneimittel bzw. Metabolit	Kläranlagen		Fließ-gewässer	Grund-wasser	Trink-wasser
	Zulauf	Ablauf			
Ciprofloxacin	(58 71)	-0,41 µg/l (32 58 73)	(49 75 76)		
Clarithromycin	(58 70)	-0,24 µg/l (58 70 72)	-0,26µg/l (33 51 52 72 75)		
Clindamycin		(69)	(75)		
Dehydroerythromycin		-6,00 µg/l (69 72)	-1,70 µg/l (33 49 51 52 54 63 66 72 75)	-49 ng/l (28)	
Doxycyclin			(78)		
Enoxacin		–30 ng/l (32)			
Levofloxacin		(70)			
Lincomycin	(58)	(58)	(49 63)		
Lomefloxacin		–0,32 µg/l (32)			
Norfloxacin		-0,37 µg/l (32 73)	(49 75 76)		
Ofloxacin	(58)	-0,58 µg/l (32 58)	(75)		
Oxytetracyclin			-1,34 µg/l (49 77 78)		
Roxithromycin		-1,00 µg/l (69 72)	-0,56 µg/l (33 49 51 52 72, 75)		
Sulfadiazin		-50 ng/l (6 74)			
Sulfadimethoxin			-15 µg/l (77 78)	(80)	
Sulfadimidin			-220 ng/l (49 77 78)		
Sulfamethazin				0,16-0,24 µg/l (49, 72 77 74 79 80)	
Sulfamethizol		<10 ng/l (10 74)			
Sulfamethoxazol	(58 72)	-2,00 µg/l, (10 32 58 69 72 74)	-1,9 µg/l (33 49 51 52 54 66 69 72 75 77)	-410 ng/l (28 72 74 77)	(82,83 84)
Sulfathiazol			(77)		
Tetracyclin			-110 ng/l (49)	-0,13 µg/l /l (79 81)	
Trimethoprim		-0,66 µg/l, (32 69 72)	-0,71 µg/l (49,72 66 33 51 75 52)		
Tylosin (Tierarzneimittel)			(49 63 75)		(63)
Antidiabetika					
Chlorpropamid				Nevada, USA (85)	
Glibenclamid		< 100 ng/l. (64)	(64)		
Metformin			(49)		
Antiepileptika					
Carbamazepin	(8 10 42 58)	-6,3 µg/l (8 10 18 19 22 25 26 29 32 33 36 42 45 58 50)	1,08 µg/l (8 10 18 19 22 25 26 29 32 33 36 42 45 51 52 54 57 64 86)	-1,1 µg/l (28, 40 85)	-258 ng/l (33 40 66 72)
Metabolite von Carbamazepin	(42)	(42)	(42)		
Pheneturid	(22)	(22)			
Phenobarbital		(10)			

Arzneimittel bzw. Metabolit	Kläranlagen		Fließ-gewässer	Grund-wasser	Trink-wasser
	Zulauf	Ablauf			
Phenytoin	(10)	-100 ng/l (10)			
Primidon	(10)	-0,73 µg/l (10 19 20 22 29 62)	(10 19 20 22 62)		(55 87)
Betablocker					
Acebutolol		–0,13 µ/l (8 27 32 33 88-90)			
Betaxolol	(88)	-188 ng/l (8 27 32 33 88-90)	-28 ng/l (8 88)		
Bisoprolol	(88)	-370 ng/l (8 27 32 33 88-90)	-124 ng/l (8 88)		
Carazolol	(88)	-117 ng/l (8 88)	-124 ng/l (8 88)		
Metoprolol	(8 88)	–2,2 µg/l (8 18 27 32 33 88-90)	–1,54 µg/l (8 18 33 51 54 88)		
Nadolol		-57 ng/l (8 27 32 33 88-90)	-9 ng/l (88)		
Oxprenolol		–50 ng/l (8 27 32 33 88-90)			
Propranolol	(8)	-1,9 µg/l (8 27 32 33 88-90)	-98 ng/l (8 33 51 54 88 91)		
Sotalol			(18 51)	-560 ng/l (27 28 91)	
Timolol		-69 ng/l (8 88)	-10 ng/l (8 88)		
Bronchospasmolytika					
Clenbuterol		-181 ng/l (8 72 88)	(8)		
Fenoterol		-67ng/l (8 72 88)	-8 ng/l (8 88)		
Salbutamol	(58 72)	-174 ng/l (8 58 72 88)	(8 63)		
Terbutalin	(72)	-115 ng/l (8 27 72 88 91)	-9 ng/l (88 91)		
Calciumantagonisten					
Dehydronifedipin		(49)	(49)		
Diltiazem			(49)		
Nifedipin		(64)	(64)		
Verapamil	(45)	(45)			
Histamin-H_2-Antagonisten					
Cimetidin			(49)		
Ranitidin	(58)	(58)	(49 63)		
Kontrazeptiva					
17α-Ethinylestradiol		(10 92 93 94 95 96 97 98 99 100-106)	–831 ng/l (49 92 95 100 102)	-2,4ng/l (100 102)	-2,4 ng/l (100 102 107
Mestranol		-4 ng/l (93 96 97)	-0,47 µg/l (49)		
Lipidsenker					
Atorvastatin		(108)	(108)		
Bezafibrat	(8 11 12 58)	4,6 µg/l (8 10-12 15 20 23-25 29 30 32 33 50 52 55 57 62)	–295 ng/l (8 10-12 15 20 23-25 27 29 30 32 33 52 54 55 57 62 63)	-190 ng/l (40)	27 ng/l (12 40)

Arzneimittel bzw. Metabolit	Kläranlagen		Fließ-gewässer	Grund-wasser	Trink-wasser
	Zulauf	Ablauf			
Clofibrinsäure	(8 10-12 23 31 36 64 109)	- 10 µg/l (8 10-12 20-26 31-33 36 44 50 53 55 62 67 109 110 111)	- 51 ng/l (8 10-13 19 21 23-26 31-33 36 40 44 51-56 62 67 109 112 -114)	-7,3 µg/l (8 10 19 21 23-25 31-33 36 40 44 53 55 56 62 64 109 112 113	- 270 ng/l (10 12 21 33 40 56 63 112 115)
Fenofibrinsäure	(8 50)	-1,19 µg/l (8 10 12 15 19 20 23-25 27 29 30 32 33 52 55 57 58 62 64)	-µg/l-Bereich (8 9 10 12 13 15 19 20-25 27 29 30 32 33 51 52 55 57 62 64)	45 ng/l (10 21 53)	42 ng/l (40 56)
Gemfibrozil	(8 50)	-6,0 µg/l (8 10 12 15 16 20 23 24 25 27 29 30 32 33 55 57 62)	(8 10 12 15 16 20 23 24 25 27 29 30 32 33 49 55 57 62)	-340 ng/l, (10 40)	(33 55)
Lovastatin	(108)				
Pravastatin		(108)			
Simvastatin	(108)				
Psychopharmaka					
Diazepam	-200 ng/l (58 64)	-53 ng/l (8 58 64 116)	-93 ng/l (63 64 116)		-10 ng/l (63 116 118 119)
Fluoxetin		-99 ng/l (117)	-46 ng/l (49 117)		
Oxazepam		60 ng/l (10)			
Röntgenkontrastmittel					
Diatrizoat		µg/l-Bereich (51 120-123)	- µg/l-Bereich (51 54 120-123)	µg/l-Bereich (28 108 120 121 123)	-1µg/l (40 120 122 123)
Iohexol		µg/l-Bereich (51 120-123)	- µg/l-Bereich (51 54 120-123)		
Iomeprol		µg/l-Bereich (51 120-123)	- µg/l-Bereich (51 54 120-123)		
Iopamidol		µg/l-Bereich (51 120-123)	- µg/l-Bereich (51 54 120-123)	µg/l-Bereich (28 108 120 121 123)	-79 ng/l (40 120 121 123)
Iopromid		µg/l-Bereich (51 120-123)	- µg/l-Bereich (51 54 120-123)	µg/l-Bereich (28 108 120 121 123)	-86 ng/l (40 120 121 123)
Iothalaminsäure		ng/l- Bereich (120)	ng/l-Bereich (54 120)	ng/l- Bereich (120)	
Ioxithalaminsäure		ng/l- Bereich (120)		ng/l- Bereich (120)	
Zytostatika					
Bleomycin ??? (RIA)			11-19 ng/l (125)	<5-17 ng/l (125)	5-13 ng/l (125)
Cyclophosphamid	**von Kliniken:** 146 ng/l (125-127)	20 ng/l (8 128)	(63)		
Ifosfamid	**von Kliniken:** 109 ng/l (125 127 128 129)	(8 129)			
Methotrexat ??? (RIA)					< 6,25 ng/l (131)
Pt-Verbindungen	**von Kliniken:** 4,7-145 µg Pt/l (130)				

Arzneimittel bzw. Metabolit	Kläranlagen		Fließ-gewässer	Grund-wasser	Trink-wasser
	Zulauf	Ablauf			
Sonstige					
Ambroxol		-0,13 µg/l (52 65)	(65 33 88)		
Cocain, Benzoylecgonin	(132)		(132)		
Cotinin (Nikotinmetabolit)			–0,9 µg/l (49 66)		(66 68)
5,5-Diallylbarbitursäure				(46)	
Enalaprilat	(58)	(58)	ng/l-Level (49)		
Furosemid	(58)	(58)	(63)		
Gadoliniumkomplexe	**von Kliniken:** -100 µg/l (133 134)		-0,2 µg/l (133-135)		
Hydrochlorothiazid	(58)	(58)			
Koffein	-640 µg/l. (10 20 60)	–1,9 /µg/l. (10 16 20 64)	-6µg/l (64 49 16) Seewasser (60)	–0,23 µg/l (85)	-119 ng/l (66 68)
Pentobarbital				-1 µg/l (138)	
Pentoxifyllin	(22)	-21 ng/l (10 22 92)	(33 80)		
Xylometazolin		9 ng/l (65)	(65)		

Literatur

Die bisher zu dem Thema erschienene Literatur ist äußerst umfangreich. Eine vollständige Erfassung aller Publikationen war daher nicht möglich.

(1) Frimmel, F. H., Müller, M. B. (Hrsg.). Heil-Lasten, Arzneimittelrückstände in Gewässern, Springer Berlin, Heidelberg, New York 2006

(2) Dietrich, D. R., Webb, S. F., Petry, T. (Hrsg.). Hot Spot Pollutants: Pharmaceuticals in the Environment, Academic Press – Elsevier Amsterdam u. a. 2005

(3) Kümmerer, K. (Hrsg.) Pharmaceuticals in the Environment. Sources, Fate, Effects and Risks. 2. Auflage, Springer Berlin, Heidelberg, New York 2004

(4) Daughton, Ch. G., Jones-Lepp, T. L. (Hrsg.) Pharmaceuticals and Personal Care Products in the Environment: Scientific and Regulatory Issues, Symposium Series 791, American Chemical Society Washington, DC 2001

(5) Sattelberger, R. Arzneimittelrückstände in der Umwelt. Umweltbundesamt GmbH, Reports R-162, Wien 1999 ISBN-85457-510-6

(6) Hessische Landesanstalt für Umwelt (Hrsg.), Fachtagung „Arzneimittel in Gewässern – Risiko für Mensch, Tier und Umwelt?“ 4. Juni 1998, Landesmuseum Wiesbaden. ISSN 0933 - 2391, ISBN 3–89026–279–1

(7) Heberer, Th., Occurrence, fate, and removal of pharmaceutical residues in the aquatic environment: a review of recent research data. Toxicology Letters 131 (2002) 5–17

(8) Ternes, T. A. Occurrence of drugs in German sewage treatment plants and rivers. Water Res. 32 (1998). 3245–3260

(9) Ternes, T. A. et al. Simultaneous determination of antiseptics and acidic drugs in sewage and river water. Vom Wasser 90 (1998) 295-309

(10) Heberer, Th. Tracking down persistent pharmaceutical residue from municipal sewage to drinking water in Grischek, Th., Hiscock, K. (Hrsg.)."Attenuation of Groundwater Pollution by Bank Filtration". J. Hydrol. 266 (2002) 175-189

(11) Quintana, J. B., Reemtsma, Th. Sensitive determination of acidic drugs and triclosan in surface and wastewater by ion-pair reverse-phase liquid chromatography/tandem mass spectrometry. Rapid Commun. Mass Spectrom. 18 (2004) 765–774

(12) Stumpf, M. et al. Nachweis von Arzneimittelrückständen in Kläranlagen und Fließgewässern. Vom Wasser 86 (1996) 291-303

(13) Buser, H.-R., Müller, M. D., Theobald, N. Occurrence of the pharmaceutical drug clofibric acid and the herbicide mecoprop in various Swiss lakes and in the North Sea. Environ. Sci. Technol. 32 (1998) 188–192

(14) Flaherty, S. et al. Investigation of capillary electrophoresis-laser induced fluorescence as a tool in the characterization of sewage effluent for fluorescent acids: Determination of salicylic acid. Electrophoresis 23 (2002) 2327-2332

(15) Farre´, M. et al.,. Determination of drugs in surface water and wastewater samples by liquid chromatography–mass spectrometry: methods and preliminary results including toxicity studies with Vibrio fischeri. J. Chromatography. A 938, (2001) 187–197

(16) Verenitch, S. S., Lowe, Ch. J., Mazumder, A. Determination of acidic drugs and caffeine in municipal wastewaters and receiving waters by gas chromatography–ion trap tandem mass spectrometry Journal of Chromatography A, 1116 (2006) 193–203

(17) Moldovan, Z. Occurrences of pharmaceutical and personal care products as micropollutants in rivers from Romania. Chemosphere 64 (2006) 1808–1817

(18) Brun, G. L. et al. Pharmaceutically active compounds in Atlantic Canadian sewage treatment plant effluents and receiving waters, and potential for environmental effects as measured by acute and chronic aquatic toxicity. Environmental Toxicology and Chemistry 25 (2006) 2163-2176

(19) Heberer Th. et al. Occurrence of Pharmaceutical in sewage, river, ground and drinking water in Greece and Germany in (4). S. 70-83

(20) Heberer, Th., Reddersen, K., Mechlinski, A. From Municipal Sewage to Drinking Water: Fate and Removal of Pharmaceutical Residue in the Aquatic Environment in Urban Areas. Water Sci. Technol. 46 (2002) 81-88

(21) Heberer, Th. et al. Detection of drugs and drug metabolites in groundwater samples of a drinking water treatment plant. Fresenius'Environ. Bull. 6 (1997) 438–443

(22) Möhle, E. et al. Bestimmung von schwer abbaubaren organischen Verbindungen im Abwasser — Identifizierung von Arzneimittelrückständen. Vom Wasser 92 (1999) 207–223

(23) Stumpf, M. et al. Polar drug residues in sewage and natural waters in the state of Rio de Janeiro, Brazil. Sci. Total Environ. 225 (1999) 135–141

(24) Werres, F. et al. Automatisierte Bestimmung polarer Arzneimittelrückstände in Wässern mittels Festphasenmikroextraktion (SPME) und Derivatisierung. Vom Wasser 94 (2000) 135–147

(25) Ahrer, W., Scherwenk, E., Buchberger, W. Determination of drug residues in water by the combination of liquid chromatography or capillary electrophoresis with electrospray mass spectrometry. J. Chromatography. A 919 (2001) 69–78

(26) Öllers, S. et al.. Simultaneous quantification of neutral and acidic pharmaceuticals and pesticides at the low-ng/l level in surface and waste water. J. Chromatography A 911 (2001) 225–234

(27) Sedlak, D. L., Pinkston, K. E.,. Factors affecting the concentrations of pharmaceuticals released to the aquatic environment. Water Resources Update, (2001) 56–64

(28) Sacher, F. et al. Pharmaceuticals in groundwaters. Analytical methods and results of a monitoring program in Baden-Württemberg, Germany. J. Chromatography A 938 (2001) 199–210

(29) Drewes, J., Heberer, Th., Reddersen, K. Fate of pharmaceuticals during indirect potable reuse. Water Sci. Technol. 46 (2002) 73-80

(30) Miao, X. S., König, B. G., Metcalfe, C. D. Analysis of acidic drugs in the effluents of sewage treatment plants using liquid chromatography-electrospray ionization tandem mass spectrometry. Journal of Chromatography A, 952 (2002) 139-147)

(31) Soulet, B., Tauxe, A. Taradellas, J. Analysis of acidic drugs in Swiss waste-waters. Int. J. Environ. Anal. Chem. 82 (2002) 659-667

(32) Andreozzi, R., Marotta, R., Paxéus, N. Pharmaceuticals in STP effluents and their solar photodegradation in aquatic environment, Chemosphere 50 (2003) 1319–1330

(33) ARGE (Arbeitsgemeinschaft für die Reinhaltung der Elbe). Arzneistoffe in Elbe und Saale. ARGE Hamburg 2003, http.//www.arge-elbe.de/wge/Download/Berichte/03 Arzn.pdf

(34) Deng, A. et al. Residue analysis of the pharmaceutical diclofenac in different water types using ELISA and GC-MS. Environ. Sci. Technol. 37 (2003) 3422-3429

(35) Koutsouba, V. et al. Determination of polar pharmaceuticals in sewage water of Greece by gas chromatography-mass spectrometry. Chemosphere 51 (2003) 69-75

(36) Tixier, C. et al. Occurrence and fate of carbamazepine, clofibric acid, diclofenac, ibuprofen, ketoprofen, and naproxen in surface waters. Environ. Sci. Technol. 37 (2003) 1061-1068

(37) Reddersen, K., Heberer, Th. Formation of an artifact of diclofenac during acidic extraction of environmental water samples. Journal of Chromatography A, 1011 (2003) 221–226

(38) Brauch, H. J. et al. Wirksamkeit der Uferfiltration für die Entfernung von polaren organischen Spurenstoffen. gwf (Gas- und Wasserfach) Wasser Abwasser 14 (2000) 226–234

(39) Kühn, W., Müller, U. Riverbank filtration—an overview. J. AWWA (2000) 60–69

(40) Ternes, T. A. Pharmaceuticals and metabolites as contaminants of the aquatic environment in (4) S. 39 – 54

(41) Stumpf, M. et al. Isolierung von Ibuprofen-Metaboliten und deren Bedeutung als Kontaminanten in der aquatischen Umwelt. Vom Wasser 91 (1998) 291–303

(42) Miao, X. –Sh., Metcalfe, Ch. D. Determination of Carbamazepine and Its Metabolites in Aqueous Samples Using Liquid Chromatography-Electrospray Tandem Mass Spectrometry. Analytical Chemistry 75 (2003) 3731-3738

(43) Buser, H.-R., Poiger, T., Müller, M. D. Occurrence and environmental behavior of the pharmaceutical drug ibuprofen in surface waters and in wastewater. Environ. Sci. Technol. 33 (1999) 2529–2535

(44) Winkler, M., Lawrence, J. R., Neu, T. R. Selective degradation of ibuprofen and clofibric acid in two model river biofilm systems. Water Res. 35 (2001) 3197-3205

(45) Gans, O., Sattelberger, R., Scharf, S. Analysis of selected pharmaceuticals effluents of municipal sewage treatment plants in Austria. Vom Wasser 98 (2002) 165-176

(46) Holm, J. V. et al. Occurrence and distribution of pharmaceutical organic compounds in the groundwater downgradient of a landfill (Grindsted, Denmark). Environ. Sci. Technol. 29 (1995) 1415–1420

(47) Ahel, M., Jelicic, I. Phenazone analgesics in soil and groundwater below a municipal solid waste landfill in (4) S. 100–115

(48) Reddersen, K., Heberer, Th., Dünnbier, U. Occurrence and identification of phenazone drugs and their metabolites in ground- and drinking water. Chemosphere 49 (2002) 539- 545

(49) Kolpin, D. W. et al. Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999–2000: methods, development and national reconnaissance. Environ. Sci. Technol. 36 (2002) 1202-1211, 4007-4008

(50) Sächsisches Staatsministerium für Umwelt und Landwirtschaft (SMUL): Messungen und Auswertungen zu ausgewählten Arzneimittelinhaltsstoffen in bedeutenden kommunalen Abwassereinleitungen im Freistaat Sachsen. Werkvertrag mit dem Technologiezentrum (TZW) Außenstelle Dresden 2001

(51) Ternes, Th. A. et al. Ozonation: A tool for removal of pharmaceuticals, contrast media and musk fragrances from wastewater? Water Res. 37 (2003) 1976-1982

(52) Wiegel, S. et al. Pharmaceuticals in the river Elbe and its tributaries. Chemosphere 57 (2004) 107–126

(53) Heberer, Th. et al. Occurrence and distribution of organic contaminants in the aquatic system in Berlin, Germany. Part 1. Drug residues and other polar contaminants in Berlin surface and groundwater. Acta Hydrochimica et Hydrobiologica 26 (1998) 272-278

(54) Ternes, T.A. et al. Nachweis und Screening von Arzneimittelrückständen, Diagnostika und Antiseptika in der aquatischen Umwelt. Abschlussbericht des ESWE-Institutes für Wasserforschung und Wassertechnologie GmbH zum Forschungsvorhaben 02WU9567/3 des BMBF 1999

(55) Heberer, Th. et al. Occurrence and fate of pharmaceuticals during bank filtration – preliminary results from investigations in Germany and the United States. Water Res. Update 120 (2001) 4-17, www.ucowr.siu.edu/updates/pdfn/V120_A2.pdf

(56) Heberer, Th., Stan, H. J. Determination of clofibric acid and N-(phenylsulfonyl)-sarcosine in sewage, river and drinking water. Int. J. Environ. Anal. Chem. 67, (1997) 113–124

(57) Drewes, J. et al. Fate of pharmaceuticals during groundwater recharge. Ground Wat. Monit. Remed. 23 (2003) 73-80

(58) Castiglioni, S.et al. Removal of Pharmaceuticals in Sewage Treatment Plants in Italy. Environmental Science and Technology 40 (2006) 357-363

(59) Wen, X., Tu, Ch., Lee, H. K. Two-Step Liquid-Liquid-Liquid Microextraction of Nonsteroidal Antiinflammatory Drugs in Wastewater. Anal. Chem. 76 (2004) 228-232

(60) Weigel, St. et al. Determination of selected pharmaceuticals and caffeine in sewage and seawater from Tromsø/Norway with emphasis on ibuprofen and its metabolites Chemosphere 56 (2004) 583–592

(61) Rodriguez, I. et al. Determination of acidic drugs in sewage water by gas chromatography-mass spectrometry as tert-butyldimethylsilyl derivates. Journal of Chromatography A, 985 (2003) 265–274

(62) Heberer, Th., Feldmann, D. Removal of pharmaceutical residues from contaminated raw water sources by membrane filtration in (3), Chapter 29, 391-410

(63) Zuccato, E. et al. Presence of therapeutic drugs in the environment. Lancet 355 (2000) 1789-1790

(64) Ternes, T. A., Bonerz, M., Schmidt, T. Determination of neutral pharmaceuticals in wastewater and rivers by liquid chromatography–electrospray tandem mass spectrometry. J. Chromatography A 938 (2001) 175–185

(65) Schmidt, R., Brockmeyer, R. Vorkommen und Verhalten von Expektorantien, Analgetika und Xylometazolin und deren Metaboliten in Gewässern und bei der Uferfiltration. Vom Wasser 98 (2002) 37-54

(66) Stackelberg, P. E. et al. Persistence of pharmaceutical compounds and other organic wastewater contaminants in a conventional drinking-water-treatment plant. Sci. Total Environ. 329 (2004) 99-113

(67) Boyd, G. R., Grimm, D. A. Occurrence of pharmaceutical contaminants and screening of treatment alternatives for southeastern Louisiana. Ann. N.Y. Acad. Sci. 948 (2001) 80-89

(68) Henderson, A. K. et al. Presence of wastewater tracers and endocrine disrupting chemicals in treated wastewater effluent and in municipal drinking water, metropolitan Atlanta, 1999 Abstracts in Proceedings of the 2nd International Conference on Pharmaceuticals and Endocrine Disrupting Chemicals in Water. National Ground Water Association, Minneapolis 2001

(69) Göbel, A. et al. Trace Determination of Macrolide and Sulfonamide Antimicrobials, a Human Sulfonamide Metabolite, and Trimethoprim in Wastewater Using Liquid Chromatography Coupled to Electrospray Tandem Mass Spectrometry Anal. Chem. 76 (2004) 4756-4764

(70) Yasojima, M. et al. Occurrence of levofloxacin, clarithromycin and azithromycin in wastewater treatment plant in Japan. Water Science and Technology 53 (2006), 227-233

(71) Hartmann, A. et al. Identification of fluoroquinolone antibiotic as the main source of umuC genototoxicity in native hospital wastewater. Environ. Toxicol. Chem. 17 (1998) 377-382

(72) Hirsch, R. et al. Occurrence of antibiotics in the aquatic environment. Sci. Total Environ. 225 (1999) 109–118

(73) Golet, E. M. et al. Trace determination of fluoroquinolone antibacterial agents in urban wastewater by solid-phase extraction and liquid chromatography with fluorescence detection. Anal. Chem. 73, (2001) 3632–3638

(74) Hartig, C., Storm, T., Jekel, M. Detection and identification of sulphonamide drugs in municipal waste water by liquid chromatography coupled with electrospray ionisation tandem mass spectrometry. J. Chromatography A 854 (1999) 163–173

(75) Christian, T. et al. Determination of antibiotic residue in manure, soil, and surface waters. Acta Hydrochim. Hydrobiol. 31 (2003) 36-44

(76) Golet, E. M., Alder, A. C., Giger, W. Environmental exposure and risk assessment of fluoroquinolone antibacterial agents in wastewater and river water of the Glatt Valley Watershed, Switzerland. Environ. Sci. Technol. 36 (2002) 3645-3651

(77) Lindsey, M. E., Meyer, M., Thurman, E. M. Analysis of trace levels of sulfonamide and tetracycline antimicrobials in groundwater and surface water using solid-phase extraction and liquid chromatography/mass spectrometry. Anal. Chem. 73 (2001) 4640–4646

(78) Yang, S., Cha, J., Carlson, K. Quantitative determination of trace concentrations of tetracycline and sulfonamide antibiotics in surface water using solid-phase extraction and liquid chromatography/ion trap tandem mass spectrometry. Rapid Commun. Mass Spectrom. 18 (2004) 2131-2145

(79) Hamscher, G. et al. Tierarzneimittel in Böden – eine Grundwassergefährdung? In: Tagungsband des Fachgespräches „Arzneimittel in der Umwelt – Zu Risiken und Nebenwirkungen fragen Sie das Umweltbundesamt“, Umweltbundesamt Berlin (Hrsg.), UBA-Texte 29/05 ISSN 0722-186X, 175-184

(80) Batt, A. L., Snow, D. D., Aga, D. S. Occurrence of sulfonamide antimicrobials in private water wells in Washington County, Idaho, USA. Chemosphere 64 (2006) 1963–1971

(81) Campagnolo, E. R. et al. Antimicrobial residues in animal waste and water resources proximal to large-scale swine and poultry feeding operations. Sci.Total Environ. 299 (2002) 89-95

(82) ARD Videotext 06.06.03

(83) Anon.Waters Co. Drugs in the environment - analysis of surface water and underground water by using LC-MS/MS method. Huanjing Huaxue 24 (2005) 491-493. Chem. Abstr. 144:26951 (2006)

(84) Jongbloed, R. H. et al. Milieurisico`s van diergeneesmiddelen en veevoederadditieven in Nederlands oppervlaktewater; een verkennende studie. RIZA Lelystad, The Netherlands 2001 (Report 2001.053)

(85) Seiler, R. L. et al. Caffeine and pharmaceuticals as indicators of waste water contamination in wells. Ground Water 37 (1999) 405–410

(86) Andreozzi, R. et al. Carbamazepine in water: Persistence in the environment, ozonation treatment and preliminary assessment on algal toxicity. Wat. Res. 36 (2002) 2869-2877

(87) Heberer, Th. et al. Drug residues in the aquatic environment. LaborPraxis 28 (2004) 16,18, 21

(88) Hirsch, R. et al. Vorkommen von Betablockern und Bronchospasmolytika in Kläranlagen und Fließgewässern. Vom Wasser 87 (1996) 263-274

(89) Huggett, D. B. et al. Determination of beta-adrenergic receptor-blocking pharmaceuticals in United States wastewater effluent. Environ. Pollut. 121 (2003) 199-205

(90) Ternes, Th. A. et al. Ozonation: a tool for removal of pharmaceuticals, contrast media and musk fragrances from wastewater? Water Res.37 (2003) 1976-1982

(91) Hirsch, R. et al. Determination of antibiotics in different water compartments via liquid chromatography–electrospray tandem mass spectrometry. J. Chromatogr. A 815 (1998) 213–223

(92) Stumpf, M. et al. Nachweis von natürlichen und synthetischen Östrogenen in Kläranlagen und Fließgewässern. Vom Wasser 87 (1996) 251–261

(93) Ternes, T. A. et al. Behavior and occurrence of estrogens in municipal sewage treatment plants—I. Investigations in Germany, Canada and Brazil. Sci. Total Environ. 225 (1999) 81–89

(94) Desbrow, C. et al. Identification of estrogenic chemicals in STP effluent. I: Chemical fractionation and in vitro biological screening. Environ. Sci. Technol. 32 (1998) 1549–1558

(95) Belfroid, A. C.et al. Analysis and occurrence of estrogenic hormones and their glucuronides in surface water and waste water in The Netherlands. Sci. Total Environ. 225 (1999) 101–108

(96) Spengler, P., Körner, W., Metzger, J. W. Schwer abbaubare Substanzen mit östrogenartiger Wirkung im Abwasser von kommunalen und industriellen Kläranlagenabläufen. Vom Wasser 93 (1999) 141–157

(97) Kuch, H. M., Ballschmiter, K. Determination of endogenous and exogenous estrogens in effluents from sewage treatment plants at the ng/l-level. Fresenius' J. Anal. Chem. 366 (2000) 392–395

(98) Johnson, A., Belfroid, A. C., di Corcia, A. Estimating steroid oestrogen inputs into activated sludge treatment works and observations on their removal from the effluent. Sci. Total Environ. 256 (2000) 163–173

(99) Huang, C. H., Sedlak, D. L. Analysis of estrogenic hormones in municipal wastewater effluent and surface water using enzyme-linked immunoadsorbent assay and gas chromatography/tandem mass spectrometry. Environ. Toxicol. Chem. 20 (2001) 133–139

(100) Adler, P. Steger-Hartmann, Th., Kalbfus, W. Vorkommen natürlicher und synthetischer estrogener Steroide in Wässern des süd- und mitteldeutschen Raumes. Acta Hydrochim. Hydrobiol. 29 (2001) 227-241

(101) Xiao, X.-Y., McCalley, D. V., McEvoy, J. Analysis of estrogens in river water and effluents using solid-phase extraction and gas chromatography-negative chemical ionisation mass spectrometry of the pentafluorobenzoyl derivatives. J. Chromatography A 923 (2001) 195–204

(102) Kuch, H. M., Ballschmiter, K. Determination of endocrine-disrupting phenolic compounds and estrogens in surface and drinking water by HRGC-(NCI)-MS in the picogram per litre range Environ. Sci. Technol. 35 (2001) 3201-6

(103) Zühlke, S., Dünnbier, U., Heberer, Th. Determination of estrogenic steroids in drinking, surface and wastewater by liquid chromatography-electrospray tandem mass spectrometry, J. Separation Sci., 28 (2005) 52-58

(104) Baronti, C. et al. Monitoring natural and synthetic estrogens at activated sludge sewage treatment plants and in a receiving river water. Environ. Sci. Technol. 34 (2000) 5059–5066

(105) Bruchet, A. et al. A broad spectrum analytical scheme for the screening of endocrine disruptors (Hrsg.), pharmaceuticals and personal care products in wastewater and natural waters Wat. Sci. Technol.46 (2002) 97-104

(106) Verstraeten, I. M. et al. Overview of occurrence of endocrine-disrupting and other wastewater compounds during water treatment with case studies from Lincoln, Nebraska (USA), and Berlin, Germany in Endocrine Disrupting Compounds in the Environment. Practice Periodical of Hazardous, Toxic and Radioactive Waste Management, C. Adam (Hrsg.) (2003)7 S 253-263

(107) Aherne, G. W., Briggs, R. The relevance of the presence of certain synthetic steroids in the aquatic environment. J. Pharm. Pharmacol. 41. (1989) 735-736

(108) Miao, X.-Sh., Metcalfe, Ch. D., Determination of cholesterol-lowering statin drugs in aqueous samples using liquid chromatography-electrospray ionization tandem mass spectrometry. Journal of Chromatography A 998 (2003) 133-141

(109) Patterson, D. B. et al. Application of US EPA methods to the analysis of pharmaceuticals and personal care products in the environment: Determination of clofibric acid in sewage effluent by GC-MS Am. Lab. 34 (2002) 20-28

(110) Garrison, A. W., Pope, J. D., Allen, F. R. GC/MS analysis of organic compounds in domestic wastewaters in Keith, C. H. (Hrsg.), Identification and Analysis of Organic Pollutants in Water. Ann Arbor Science Publishers, Ann Arbor (1976) 517–556 Kapitel 30

(111) Hignite, C., Azarnoff, D. L. Drugs and drug metabolites as environmental contaminants: Chlorophenoxyisobutyrate and salicylic acid in sewage water effluent. Life Sci. 20.(1977) 337–342

(112) Stan, H. J., Heberer, Th., Linkerhägner, M. Vorkommen von Clofibrinsäure im aquatischen System - Führt die therapeutische Anwendung zu einer Belastung von Oberflächen-, Grund- und Trinkwasser?- Vom Wasser 83 (1994) 57–68

(113) Stan, H.-J., Linkenhägner, M. Identifizierung von 2-(4-Chlorphenoxy)-2-methyl-propionsäure im Grundwasser mittels Kapillar-Gaschromatografie mit Atomemis-sionsdetektion und Massenspektrometrie. Vom Wasser 79 (1992) 75-88

(114) Heberer, Th., Stan, H. J. Vorkommen von polaren organischen Kontaminanten im Berliner Trinkwasser. Vom Wasser 86 (1996) 19–31.

(115) Heberer, Th., Stan, H. J. Arzneimittelrückstände im aquatischen System. Wasser & Boden 50 (1998) 20-25

(116) Halling-Sørensen, S. et al. Occurrence, fate and effects of pharmaceutical substances in the environment - a review. Chemosphere 36 (1998) 357-393

(117) Metcalfe, Ch. D. et al. Distribution of acidic and neutral drugs in surface waters near sewage treatment plants in the lower Great Lakes, Canada. Environ. Toxicol. Chem. 22 (2003) 2881-2889

(118) Waggott, A. Trace organic substances in the River Lee in Cooper, W.J. (Hrsg.) Chemistry in water reuse. Ann. Arbor Publishers Inc. Ann Arbor, MI, USA, 1981 55-59

(119) Zullei-Seibert, N. Your daily 'drugs' in drinking water? State of the art for artificial groundwater recharge in Peters, J. H. (Hrsg.) Artif. Recharge Groundwater, Proc. Int. Symp., 3rd, 405-407. Balkema: Rotterdam, Neth. 1998

(120) Ternes, T. A., Hirsch, R. Occurrence and behavior of X-ray contrast media in sewage facilities and the aquatic environment. Environ. Sci. Technol. 34 (2000) 2741–274

(121) Putschew, A., Wischnack, S., Jekel, M., Occurrence of triiodinated X-ray contrast agents in the aquatic environment. Sci. Total Environ. 255 (2000) 129–134

(122) Putschew, A., Schittko, S., Jekel, M., Quantification of triiodinated benzene derivatives and X-ray contrast media in water samples by liquid chromatography–electrospray tandem mass spectrometry. J. Chromatography A 930 (2001) 127–13

(123) Putschew, A., Jekel, M. Iodierte Röntgenkontrastmittel im anthropogen beeinflussten Wasserkreislauf Vom Wasser 97 (2001) 103–114

(124) Aherne, G. W., Hardcastle, A., Nield, A. H. Cytotoxic drugs and the aquatic environment: Estimation of bleomycin in river and water samples. J. Pharm. Pharmacol. 42 (1990) 741-742

(125) Steger-Hartmann, T., Kümmerer, K., Hartmann, A. Biological degradation of cyclophosphamide and its occurrence in sewage water. Ecotox. Environ. Safety 36 (1997) 174–179

(126) Dema, A. C., Henderson, B. Detection of cyclophosphamide in waste water using GC/MS, 231st ACS National Meeting, Atlanta, GA, United States, March (2006) 26-30, American Chemical Society, Washington (Hrsg.)

(127) Steger-Hartmann, T., Kümmerer, K., Schecker, J. Trace analysis of the antineoplastics ifosfamide and cyclophosphamide in sewage water by two-step solid-phase extraction and gas chromatography–mass spectrometry. J. Chromatography A 726 (1996) 179–184

(128) Kümmerer, K. Abbau von Arzneimitteln in Testsystemen und Möglichkeiten zur Emissionsreduktion in: Wasserforschung e.V. Interdisziplinärer Forschungsverband (Hrsg.), Schriftenreihe Wasserforschung 6: Chemische Stressfaktoren in aquatischen Systemen, 2000 S. 165-178

(129) Kümmerer, K., Steger-Hartmann, T., Meyer, M. Biodegradability of the anti-tumor agent ifosfamide and its occurrence in hospital effluents and communal sewage. Water Res. 31 (1997) 2705–2710

(130) Lenz, K. et al. Presence of cancerostatic platinum compounds in hospital wastewater and possible elimination by adsorption to activated sludge. Science of the Total Environment 345 (2005) 141-152

(131) Aherne G. W., English J., Marks V. The role of immunoassay in the analysis of micro-contaminants in water samples. Ecotoxicol. Environ Saftey 9 (1985) 79-83

(132) Zuccato, E. et al. Cocaine in surface waters: A new evidence-based tool to monitor community drug abuse. Environmental health : a global access science source [electronic resource] 4 (2005), 4-14

(133) Kümmerer, K., Helmers, E. Hospitals as a source of gadolinium in the aquatic environment. Environ. Sci. Technol. 34 (2000) 573–577

(134) Kümmerer, K. Drugs in the environment: Emission of drugs, diagnostic aids and disinfectants into wastewater by hospitals in relation to other sources—a review. Chemosphere 45 (2001) 957–969, 48 (2002) 383

(135) Bau, M., Dulski, P. Anthropogenic origin of positive gadolinium anomalies in river waters. Earth Planet Sci. Lett. 143 (1996) 245–255

(136) Eckel, W. P., Ross, B., Isensee, R. K. Pentobarbital found in ground water. Ground Water 31 (1993) 801–804

(137) DER SPIEGEL: Pille im Brunnen, Arzneimittelrückstände belasten die Gewässer-neue Gefahr für Mensch und Tier? DER SPIEGEL, 26 (1996) 154-155

(138) Grenzwerte für Pestizide: Einzelne Substanz 0,1 µg/l, , insgesamt 0,5 µg/l entsprechend der Trinkwasserverordnung - TrinkwV 2001 vom 21.05.2001/01.01.2003, Anlage 2 zu §6 Abs. 2/10

(139) Persönliche Mitteilung auf dem10. Berliner Kolloquium der Gottlieb Daimler- und Karl Benz-Stiftung, Heil-Lasten, Arzneimittelrückstände in Gewässern, 17.05.06, Berlin

(140) Greim, H. Hormonähnlich wirkende Stoffe in der Umwelt. Nachr. Chem. Techn. Lab. 46 (1998) 63-66

(141) http://www.uni-mainz.de/~eswe/bericht1.htm

(142) Steger-Hartmann, Th. et al. Investigations into the environmental fate and effects of iopromide (ultravist), a widely used iodinated X-ray contrast medium. Water Res. 36 (2002) 266-74

(143) Haiss, A., Kümmerer, K. Biodegradability of the X-ray contrast compound diatrizoic acid, identification of aerobic degradation products and effects against sewage sludge micro-organisms. Chemosphere 62 (2006) 294-302

(144) Aga, D., S. Mass spectrometric identification of biodegradates of pharmaceuticals in wastewater treatment systems. Abstracts of Papers, 231st ACS National Meeting, Atlanta, GA, United States, March 26-30, 2006 ANYL-010, American Chemical Society, Washington, D. C.

(145) Joss, A. et al. Removal of pharmaceuticals and fragrances in biological wastewater treatment. Water Research 39 (2005) 3139-3152

(146) Zwiener, C., Frimmel, F. H. Short-term tests with a pilot sewage plant and biofilm reactors for the biological degradation of the pharmaceutical compounds clofibric acid, ibuprofen, and diclofenac. Sci.Total Environ. 3009 (2003) 201-211

(147) OECD: Guidelines for Testing of Chemicals. Section 3: Degradation and Accumulation, 301 D Closed Bottle Test Adopted by the Council on 17 July 1992. Paris 1992

(148) Deutsche Einheitsverfahren zur Wasser-, Abwasser- und Schlammuntersuchung; Band V, L Testverfahren mit Wasserorganismen Wiley-CH, Weinheim u. a., Beuth Berlin u. a. 2001

(149) EMEA. Note for guidance: Environmental risk assessment for veterinary medicinal products other than GMO-containing and immunological products. London 1997 (EMEA/CVMP/055/96)

(150) Buchberger, W. Arzneimittelrückstände in Wässern - wo stehen wir heute? Nachrichten aus der Chemie, 54 (2006) 673-675

(151) Alda, M. et al. Liquid chromatography-(tandem) mass spectrometry of selected emerging pollutants (steroid sex hormones, drugs and alkylphenolic surfactants) in the aquatic environment. Journal of Chromatography A, 1000 (2003) 503-52

(152) Kimura, K. et al. Rejection of neutral endocrine disrupting compounds (EDCs) and pharmaceutical active compounds (PhACs) by RO membranes. Journal of Membrane Science, 245 (2004) 71-78

(153) Scherzinger, R. et al. A promising prescription: removal of PPCPs and EDCs in wastewater through advanced separation membrane processes. Membrane Technology Conference & Exposition, Proceedings, Phoenix, AZ, United States, Mar. 6-9, (2005)

(154) Fent, K., Weston, A. A. , Caminada, D. Ecotoxicology of human pharmaceuticals. Aquat. Toxicol. 76 (2006) 122–159, 78 (2006) 207

(155) Pomati, F. et al. Effects of a Complex Mixture of Therapeutic Drugs at Environmental Levels on Human Embryonic Cells. Environmental Science & Technology 40 (2006) 2442-2447

(156) Heisig, P., Holzgrabe, U. Hase und Igel: Wettlauf mit resistenten Bakterien, Pharm. Ztg. 150 (2005) 2204-2213

(157) Kümmerer, K. Resistance in the environment. J. Antimicrob. Chemotherap. 54, (2004) 311-320

(158) Bundesverband der Pharmazeutischen Industrie e.V., Verband Forschender Arzneimittelhersteller e.V. (VFA), Bundesfachverband der Arzneimittel-Hersteller e.V. (BAH), Deutscher Generikaverband e.V. Rote Liste® 2006, Arzneimittelverzeichnis für Deutschland (einschließlich EU-Zulassungen und bestimmter Medizinprodukte) Rote Liste® Service GmbH Frankfurt/Main 2006 S. 359 f.

(159) Mutschler, E. et al. Arzneimittelwirkungen, Lehrbuch der Pharmakologie und Toxikologie. 8. Auflage, Wissenschaftliche Verlagsgesellschaft mbH Stuttgart 2001

(160) Wysowski, D. K; Nourjah, P. Deaths attributed to X-ray contrast media on U.S. death certificates. American journal of roentgenology 186 (2006) 613-5

(161) Mützel, W., Speck, U., Weinmann H.-J. in Taenzer, V., Zeitler, E. (Hrsg.) Contrast Media in Urography, Angiography and Computerized Tomography. Thieme Stuttgart, New York, 1981, S. 85-90

(162) Prakash, V. et al. Catastrophic collapse of Indian white-backed Gyps bengalis and long-billed Gyps indicus vulture population. Biol. Conserv. 109 (2003) 381-390

(163) Green, R. E. et al. Diclofenac poisoning as a cause of vulture population declines across the Indian subcontinent. J. Appl. Ecology 41 (2004) 793-800

(164) Risebrough, R. Fatal medicine for vulture. Nature 427 (2004) 596-630

(165) Oaks, J. L. et al. Diclofenac residue as the cause of vulture population decline in Pakistan, Nature 427 (2004) 630-633

(166) Jaenicke, L. Vultur-ex durch Voltaren®. Chem. Unserer Zeit 38, (2004) 226 – 229

(167) Schwaiger, J. et al. Toxic effects of the non-steroidal anti-inflammatory drug diclofenac. Part I: Histopathological alterations and bioaccumulation in rainbow trout. Aquat. Toxicol. 68 (2004) 141-50

(168) Purdom, C. E. et al. Estrogenic effects of effluents from sewage treatment works. Chem. Ecol. 8 (1994) 275-285

(169) Routledge, E. J. et al. Identification of estrogenic chemicals in STP effluent. II: In vivo response in trout and roach. Environ. Sci. Technol. 32 (1998) 1559-1565

(170) Fong, P. P., Huminski, P. T., D´urso, L. M. Induction and potentiation of parturition in fingernail clams (*Sphaerium striatum*) by selective serotonin reuptake inhibitors (SSRIs). J. Exp. Zool. 280 (1998) 260-264

(171) Richtlinie 2004/27 EG des Europäischen Parlaments und des Rates vom 31. März 2004 zur Änderung der Richtlinie 2001/83/EG zur Schaffung eines Gemeinschaftskodexes für Humanarzneimittel (ABl. EU Nr. L 136 S.34)

(172) http://www.umweltdaten.de/publikationen/fpdf-l/2976.pdf

(173) Mutschler, E. Arzneimittelwirkungen, Ein Lehrbuch der Pharmakologie für Pharmazeuten, Chemiker und Biologen. 4. Auflage, Wissenschaftliche Verlagsgesellschaft mbH Stuttgart 1981

(174) Wennmalm, A. A proposed environmental classification system for medicinal products. Envirpharma conference, Lyon, France 2003

(175) Vfw Aktiengesellschaft (Vereinigung für Wertstoffrecycling), Max-Planck-Str. 42, 50858 Köln, Tel. 02234/9587-0

(176) Diener, F. Apothekenwirtschaftsbericht: Konsolidierung der Branche. Pharm. Ztg 151 (2006) 1658-1669, Abbildung 2

(177) Vogna, D. et al. Kinetic and chemical assessment of the UV/H_2O_2 treatment of antiepileptic drug carbamazepine. Chemosphere 54 (2004) 497–505

(178) Vogna, D. et al. Advanced oxidation of the pharmaceutical drug diclofenac with UV/H_2O_2 and ozone. Water Research 38 (2004) 414-422

(179) Heberer, Th. Verhalten von Arzneimittelrückständen bei der Abwasserreinigung. 10. Berliner Kolloquium der Gottlieb Daimler- und Karl Benz-Stiftung, Heil-Lasten, Arzneimittelrückstände in Gewässern, 17.05.06, Berlin