



Sixth  
Framework  
Programme

## KNAPPE

**Knowledge and Need Assessment on Pharmaceutical Products in  
Environmental Waters**

Contract n°036864

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## 1. Introduction

For several years the presence of pharmaceutical products (PPs) has been investigated in various aqueous matrices such as raw sewage (STPi), sewage treatment plant effluents (STPe) [59, 89, 109], surface water (SW) [31], bank filtrate (BF) [46] groundwater (GW), drinking water (TW) [25] and marine water (MW)[20, 23]. Recent reports have shown the presence of a large variety of PPs in the effluent from STP's and surface waters, with concentrations up to several  $\mu\text{g/L}$  [16]. More than 150 PPs have been detected in various environmental matrices [89]. This is due to the development and the continuous improvement of analytical techniques. The majority of the pharmaceuticals enters municipal STP's via domestic and hospital sewages or through industrial discharges. The compounds most frequently detected in STP's are antibiotics, antiepileptics, antiphogistics, X-ray contrast media, lipid regulators betablockers and tranquillizers [VI]. These compounds vary strongly in their chemical structure and their physico-chemical properties [VI]. Considerable effort is being made in the development of analytical techniques for the determination of PPs in complex matrices (including wastewaters and sludge) and in the assessment of their environmental behaviour (sorption, biodegradability).

The aim of this study is to evaluate and to interconnect results from several data base(s) and current knowledge (scientific papers, national and international project, reports from national water management organisations ...), in order to establish a list of PPs most relevant in terms of exposure in the aquatic environment.

This list will then be used, together with output from WP2 and WP4, to develop a classification system, to prioritize the environmental risks of PPs, thus supporting water managers, health authorities and especially panels involved in the establishment of river basin management plans and strategies to minimize point and diffuse pollutions of water.

The environmental relevance of PPs found in rivers and streams is another open question. The establishment of a list of main PPs detected in European surface water ("exposure") will be used together with ecotoxicity evaluation (WP4) to extract those PPs and metabolites with the highest potential do pose risks to the environment. Thus, it is foreseen to identify PPs of most concern (from WP4), which should be integrated in future monitoring programs.

## 2. Revision of literature on PPs

The first major task within WP 1 and subject of this deliverable was the preparation of a list with PPs which are administered and sold in European countries in high quantities, are detected in the aquatic environment or might be known to cause a high ecotoxic risk. Therefore, national and international literature regarding these topics were evaluated and crucial results were summarised in an excel data file. The data file contains data on consumption, physico-chemical properties, pharmacokinetic properties and environmental fate of PPs. In order to facilitate the PP occurrence, data was included as mean, maximum, median, 90-percentiles for STP influents, STP effluents, surface water, bank filtrates, groundwater, tap water and marine/coastal waters.

Until now, the content evaluation of several databases were considered (e.g. SciFinder Scholar [I], Clarke's Analysis of Drugs and Poisons; [II], Hazardous Substances Data Bank (HSDB) of the Toxicology data network [III], McGraw-Hill AccessMedicine [IV]). Additionally, more than 2500 international scientific papers were reviewed concerning keywords such as: pharmaceuticals, environment, water, bank filtrate, groundwater and sewage treatment plant from the years 1998 to 2007. Primarily the list is based on the annual consumption data of pharmaceuticals in the EU, and their occurrence in scientific communication and national databases. Data on occurrence was extracted from a total of 112 scientific papers and national report (Annex).

All data on pharmaceutical residues found in the reviewed literature concerning consumption data or measurements in the aquatic environment were included into the list. National consumption data was contributed by the project partners from the respective countries.

Some pharmaceutical products were excluded, e.g. caffeine and quinine. These substances are widely used as additives in soft drinks, as for quinine in concentrations of up to 85 mg/L in "Tonic-Water". Their impact on the aquatic environment due to their application in pharmaceutical products can be neglected. As well theophyllin is used in soft-drinks and occurs also naturally at low concentrations in tea and chocolate. Same consideration counts holds true for theophyllin as for the exclusion of caffeine and quinine from the list, but this PP is not used in a similar amount in soft-drinks. The impacts of theophyllin as PP in the environment can not be estimated in the moment. Therefore, theophyllin was initially included into the list and might be excluded later if more data about consumption as PP and food additive is available. Natural hormones were also excluded from the list since these substances are naturally excreted by mammals (e.g. humans). Elimination data from STPs for

17 $\alpha$ -ethinylestradiol (EE2) with concentrations in STP influent and effluents are covered by the work within WP 2. Since most today's analytical methods for the determination of EE2 in other aqueous matrices (e.g. surface water, bank filtrate, groundwater, tap water and marine/coastal water) do not prove to be reliable at the very low environmental pg/L-levels, EE2 was totally excluded from the data list. It has to be stated, that the availability of occurrence data for pharmaceutical products in drinking water is very limited. In part, this applies also for marine waters. In general, for tap water and marine water analytical procedure have to be improved or developed to enhance the determination of to PPs in the picogramm per liter range.

### **Consumption data**

The consumption data are based mainly on published data for Germany [104], France and UK [111, 112], since for many of the countries no data are available. French data was provided from the AFFSAPS (Agence Française de Sécurité Sanitaire des Produits de Santé); for 2004 the AFFSPAPS data (top 100 products most consumed, sales numbers) were recalculated to obtain kg/year by Besse and Garric 2007 [VII].

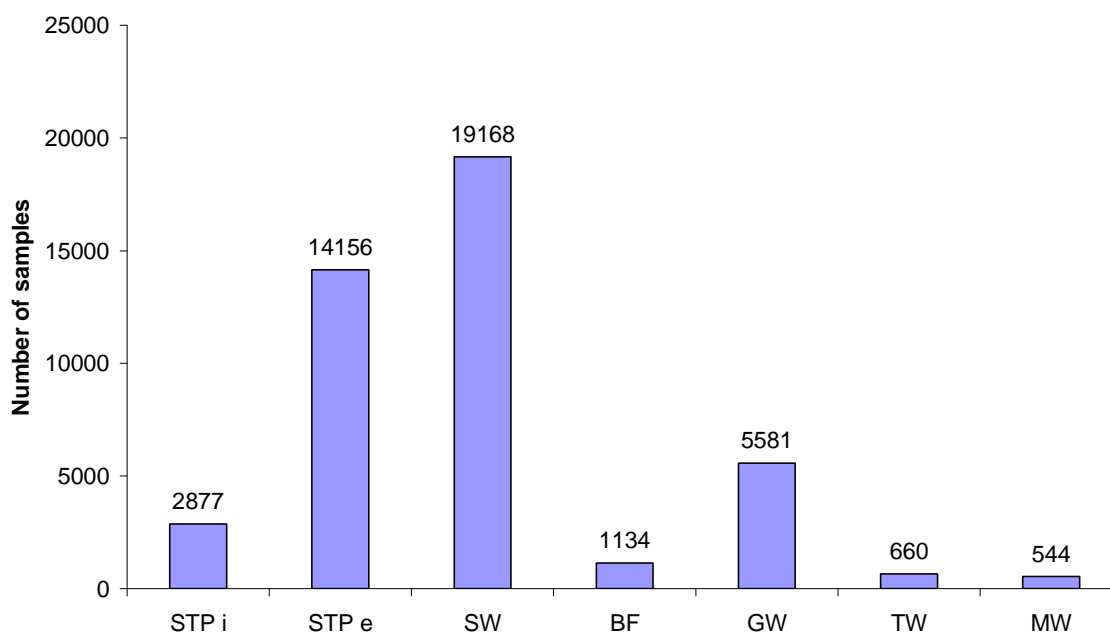
No consumption data in relation to the quantity of the active compounds were available for Poland and Spain. Only the numbers of sold packages/containers were available for these countries. Therefore, consumption were predicted by the following calculation. We used a simple approach by multiplying the quantity of the pharmaceutical with number of pills in the smallest available package and the number of packages sold. As an example for Poland 38,687,702 packages of paracetamol were sold in 2006. The smallest package contains 10 pills with each 500 mg of the active compound. The result of 193,439 kg of paracetamol in 2006 is comparable with other European countries on an annual per capita basis ( 5 g / capita Poland, 8 g / capita Germany, 4 g / capita Spain, 7 g / capita UK). The other PPs behave similar to this approach. However, the consumption of Paracetamol in France is different to the other EU-countries (54 g /capita per year).

Table 2 shows the evaluated list of 135 pharmaceutical products and metabolites which were detected in the aquatic environment. A total of 44120 records of environmental measurements were included from the reviewed literature. For 14 pharmaceuticals with a high consumption of up to 510 tons per year no measurement data from the aquatic environment were found. Hence, those compounds are candidates for future research.

### 3. Results and Discussion

This data list presents the state of the our work at September 1<sup>st</sup>, 2007. From all data included, STP effluent and surface water samples represent 75% of all measurements (Figure 1). Most frequently measured were antibiotics followed by the anti-inflammatory drugs (Figure 2). STP influent samples seems under-represented, as probably not all analytical groups were able or willing to measure in highly matrix loaded STP influents. This might be due to the fact, that analytical methods for surface water or groundwater frequently have to be improved to be applicable for raw sewage.

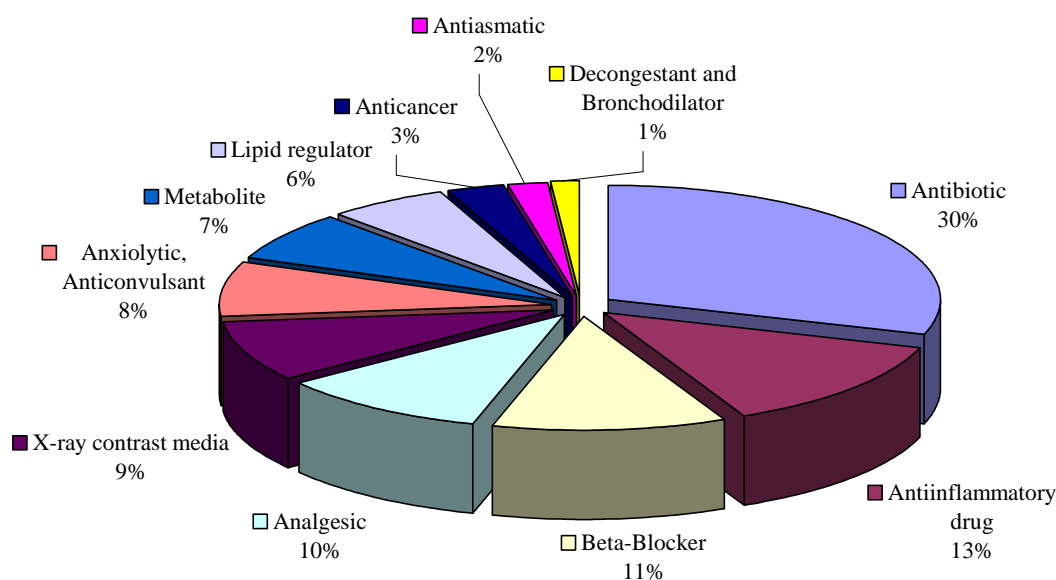
**Figure 1: Sum about the quantity of samples of all pharmaceuticals products in influents sewage treatment plants (STP i), effluents of sewage treatment plants (STP e), surface water (SW), bank filtrate (BF), groundwater (GW), tap water (TP) and marine water (MW)**



Known metabolites, excreted by humans, and iodinated X-ray contrast medias were frequently quantified in relatively high concentrations in the aquatic environment [33, 91]. As a consequence, further work should be concentrated on the detection and quantification of metabolites and environmental transformation products in environmental water compartments.

Figure 2 shows the distribution of studied samples according to therapeutic classes of PPs. Antibiotics are the first in the rank, followed by antiinflammatories (anti-inflammatory drugs) and betablockers

**Figure 2: Partitioning of all quantified samples based on their pharmaceutical sub-class**



In addition, as indicated in Table 2, fourteen pharmaceuticals were not measured in the aquatic environment in spite of high consumption with up to 510 tons per year in Germany. However, based on the POSEIDON approach [VI] a PEC<sup>1</sup> in raw sewage could be calculated for Germany (Table 1).

**Table 1: Calculated PEC values for fourteen non measured pharmaceuticals. PEC in raw waste water is based on the approach of the EU-project Poseidon for Germany [VI].**

Name	Annual consumption of the active compound in Germany[kg]	Renal excretion of parent compound	PEC in raw waste water [µg/L]
Captopril	31565	50%	2.0
Allopurinol	131821	12%	2.0
Theophylline	146431	18%	3.4
Sulfasalazine	46420	15%	0.9
Ioversol	43581	100%	5.6
Carbocisteine	31565	29%	1.2
Piracetam	134048	66%	11.4
Troxerutin	146131	9%	1.6
Povidone-Iodine	508694	0%	
Zopiclone	1948	0%	
Diosmin	373543	0%	
Valproic acid	112162	0%	
Mesalazine	56947	0%	
Lactiol	22967	0%	

metabolites expected

<sup>1</sup> PEC: (Predicted Environmental Concentration is an indication of the expected concentration of a material in the environment, taking into account the amount initially present (or added to) the environment, its distribution, and the probable methods and rates of environmental degradation and removal, either forced or natural)

## 4. Conclusions

This data list presents the state of the work at September 1<sup>st</sup>, 2007. Three-quarters of the exposure data stems from measurements of STP effluents and surface water. The substances most frequently measured were antibiotics followed by the anti-inflammatory drugs. Due to a lack of analytical methods, most of the human metabolites of PPs have not been measured in the aquatic environment yet. Hence, further work should be concentrated on the detection and quantification of metabolites and environmental transformation products in environmental water compartments.

The next step in WP 1 is to develop a classification system, together with output from WP 2 and WP 4, to prioritize the environmental risks of PPs, thus supporting water managers, health authorities and especially panels involved in the establishment of river basin management plans and strategies to minimize point and diffuse pollutions of water.

Furthermore, a prediction system of PPs in different aquatic environmental matrices will be established based on the consumption, excretion data, physicochemical chemistry and measured concentration in the environment. From the data collection a first outcome was the identification of data gaps for 14 PPs for which no occurrence data was found despite a high consumption. A PEC based on the POSEIDON approach was already calculated for these 14 compounds and will be provided for all others in each water compartment and compared with MEC data.

The established list of PPs detected in European surface water (“exposure”) will be used together with ecotoxicity evaluation (WP 4) to extract those PPs and metabolites with the highest potential do pose risks to the environment. Thus, it is foreseen to identify PPs of most concern (from WP 4), which should be integrated in future monitoring programs (WP 5).

## **5. List of abbreviations and acronyms**

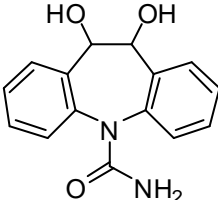
<b>BF</b>	<b>Bank filtrate</b>
<b>EE2</b>	<b>17<math>\alpha</math>-Ethinylestradiol</b>
<b>GW</b>	<b>Ground water</b>
<b>MEC</b>	<b>Measured Environmental Concentration</b>
<b>MW</b>	<b>Marine water</b>
<b>PEC</b>	<b>Predicted Environmental Concentration</b>
<b>STP e</b>	<b>Sewage treatment plants effluents</b>
<b>STP i</b>	<b>Sewage treatment plants influent</b>
<b>SW</b>	<b>Surface water</b>
<b>TW</b>	<b>Tap water</b>

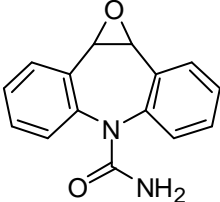
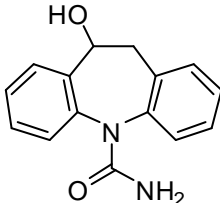
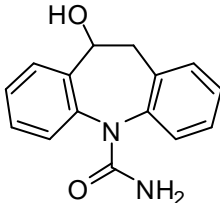
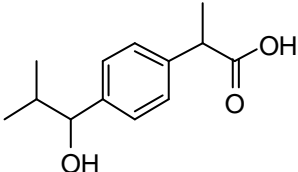
## 6. References

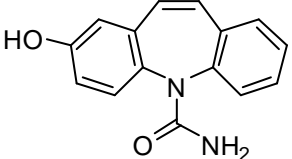
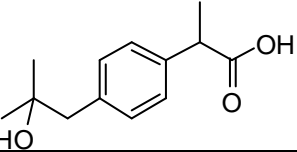
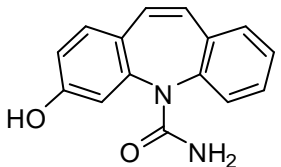
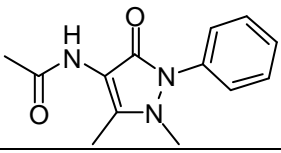
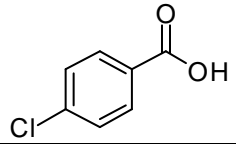
- [I] SciFinder Scholar includes the databases of: CAPLUS, CASREACT, CHEMLIST, CHEMCATS, REGISTRY: all Copyright © 2007 American Chemical Society and MEDLINE: Produced by the U.S. National Library of Medicine
- [II] Clarke's Analysis of Drugs and Poisons; Moffat, A. C., Osselton, M. D., Widdop, B., Eds; Pharmaceutical Press 2004; London, UK
- [III] Hazardous Substances Data Bank (HSDB) of the Toxicology data network (Toxnet) <http://www.toxnet.nlm.nih.gov/cgi-bin/sis/htmlgen?HSDB> , U.S. National Library of Medicine
- [IV] McGraw-Hill AccessMedicine, <http://www.accessmedicine.com/> Copyright ©2007 The McGraw-Hill Companies. All rights reserved
- [V] IMS Health AG, European Intercontinental Marketing Service Health: PharmaScope National Service, <http://www.imshealth.de/sixcms/detail.php/237>
- [VI] Human Pharmaceuticals, Hormones and Fragrances - The challenge of micropollutants in urban water management, Ternes, T. A.; Joss, A. ed. ;IWA Publishing 2006, London, UK
- [VII] JP Besse and J Garric, Médicaments à usage humain : risque d'exposition et effets sur les milieux récepteurs, rapport AE RM&C, 2007, 238 p

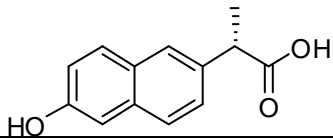
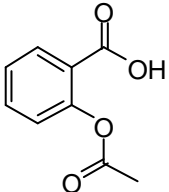
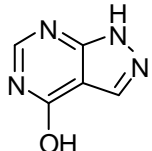
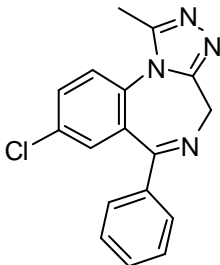
## 7. List of relevant PPs

**Table 2: List of pharmaceutical products and metabolites with name and chemical structure including the annular consumption, CAS number, molecular weight and number occurrence in influents sewage treatment plants (STP i), effluents of sewage treatment plants (STP e), surface water (SW), bank filtrate (BF), groundwater (GW), tap water (TP) and marine water (MW)**

Name  Structure	Consumption in an European country [kg/a]  Molecular weight [g/mol]	Sub-Class  CAS-No.	STP i	STP e	SW	BF	GW	TW	MW
10,11-Dihydro-10,11-dihydroxycarbamazepine  	-  270.2833	Metabolite  35079-97-1	14	15	6	0	0	0	0

<p>10,11-Dihydro-10,11-epoxycarbamazepine</p> 	- 252.268	Metabolite -	3	3	3	0	0	0	0
<p>10,11-Dihydro-10-hydroxycarbamazepine</p> 	- 254.2839	Metabolite 29331-92-8	3	3	3	0	0	0	0
<p>10,11-Dihydrocarbamazepine</p> 	- 238.2845	Metabolite 3564-73-6	1	1	3	0	0	0	0
<p>1-Hydroxyibuprofen</p> 	- 222.2802	Metabolite -	2	5	27	0	2	0	20

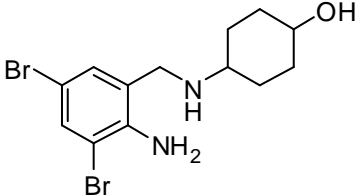
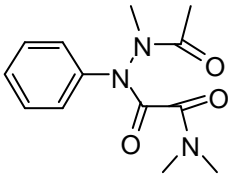
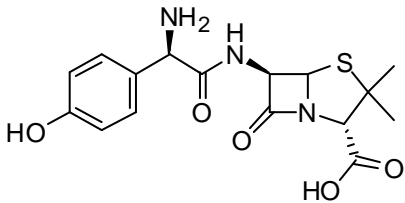
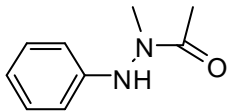
2-Hydroxycarbamazepine 	- 252.268	Metabolite 68011-66-5	3	3	3	0	0	0	0
2-Hydroxyibuprofen 	- 222.2802	Metabolite -	0	10	27	0	2	0	8
3-Hydroxycarbamazepine.wmf 	- 252.268	Metabolite -	3	3	3	0	0	0	0
4-Acetoamidoantipyrine 	- 245.2804	Metabolite 83-15-8	12	12	20	0	0	0	0
4-Chlorobenzoic acid 	- 156.5683	Metabolite 74-11-3	0	0	27	0	2	0	8

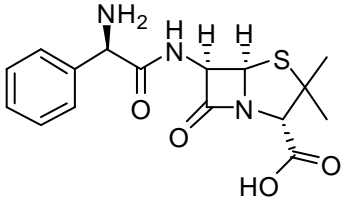
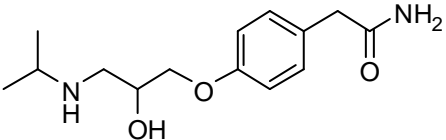
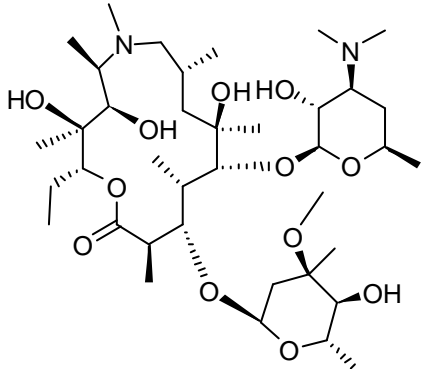
<p>6-o-desmethyl naproxen</p> 	<p>39000 (F) 216.2326</p>	<p>Metabolite 60756-73-2</p>	0	0	27	0	2	0	8
<p>Acetylsalicylic acid</p> 	<p>902272 (D) 180.1598</p>	<p>Anti-inflammatory 50-78-2</p>	45	145	119	0	0	55	0
<p>Allopurinol</p> 	<p>131821 (D) 136.1128</p>	<p>Antigout 315-30-0</p>	0	0	0	0	0	0	0
<p>Alprazolam</p> 	<p>- 308.7695</p>	<p>Sedative 28981-97-7</p>	0	0	27	0	2	0	8

**KNAPPE**

Knowledge and Need Assessment on Pharmaceutical Products in Environmental Waters

**D1.1: List of relevant PPs**

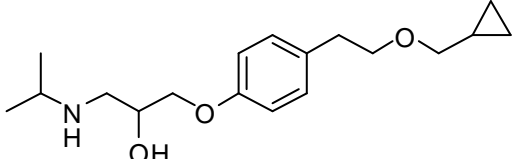
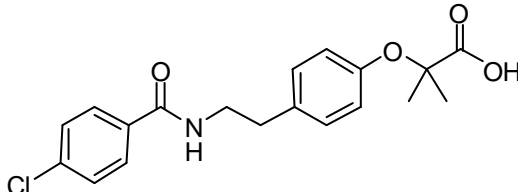
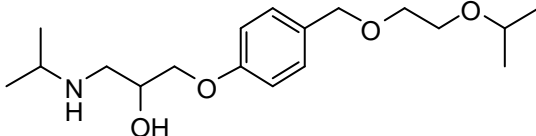
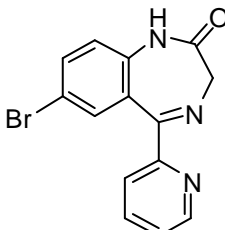
<p>Ambroxol</p> 	<p>14472 (D) 378.106</p>	<p>Mucolytic 18683-91-5</p>	<p>0</p>	<p>3</p>	<p>22</p>	<p>4</p>	<p>0</p>	<p>0</p>	<p>0</p>
<p>AMDOPH</p> 	<p>- 263.2924</p>	<p>Metabolite 519-65-3</p>	<p>12</p>	<p>12</p>	<p>21</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>
<p>Amoxicillin</p> 	<p>333223 (F) 365.4032</p>	<p>Antibiotic 61336-70-7</p>	<p>19</p>	<p>86</p>	<p>58</p>	<p>0</p>	<p>16</p>	<p>0</p>	<p>0</p>
<p>AMPH</p> 	<p>- 164.2044</p>	<p>Metabolite 38604-70-5</p>	<p>12</p>	<p>22</p>	<p>5</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>

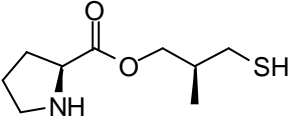
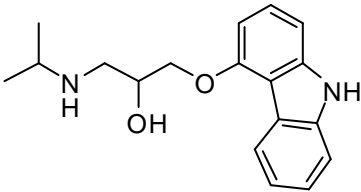
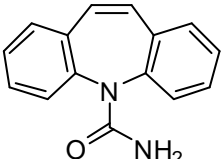
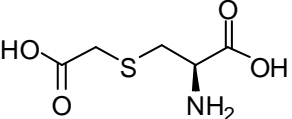
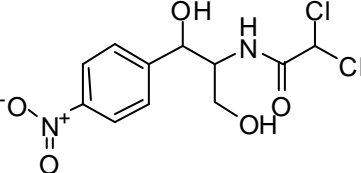
<p style="text-align: center;">Ampicillin</p>  <p>The chemical structure of Ampicillin shows a phenylacetamido group attached to the 6-aminopenicillanic acid core. The core consists of a four-membered beta-lactam ring fused to a five-membered thiazolidine ring, with a carboxylic acid group at the 3-position.</p>	<p>13419 (D) 349.4038</p>	<p>Antibiotic 69-53-4</p>	<p>0</p>	<p>70</p>	<p>42</p>	<p>0</p>	<p>10</p>	<p>0</p>	<p>0</p>
<p style="text-align: center;">Atenolol</p>  <p>The chemical structure of Atenolol features a 1-(4-aminophenoxy)propan-2-yl group attached to a 1-isopropylaminoethanol moiety. The phenoxy ring has an amino group at the para position.</p>	<p>18336 (F) 266.3394</p>	<p>Beta-Blocker 29122-68-7</p>	<p>35</p>	<p>171</p>	<p>288</p>	<p>32</p>	<p>81</p>	<p>0</p>	<p>8</p>
<p style="text-align: center;">Azithromycin</p>  <p>The chemical structure of Azithromycin is a complex macrolide consisting of a 14-membered ring with two nitrogen atoms and a side chain containing a 1,2,4-triazole ring system. It has multiple hydroxyl groups and methyl substituents.</p>	<p>4073 (F) 748.993</p>	<p>Antibiotic 83905-01-5</p>	<p>14</p>	<p>90</p>	<p>45</p>	<p>0</p>	<p>10</p>	<p>0</p>	<p>0</p>

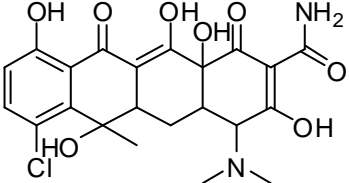
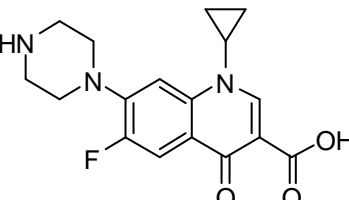
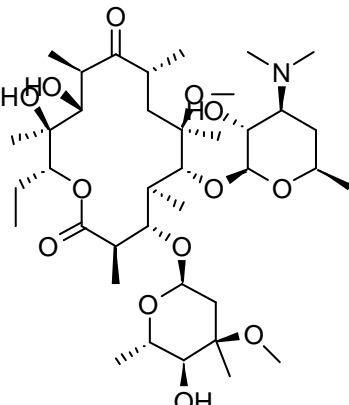
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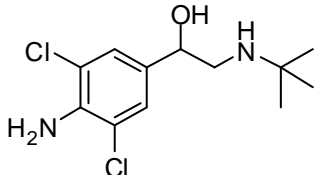
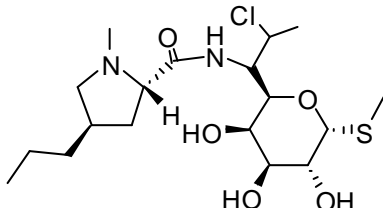
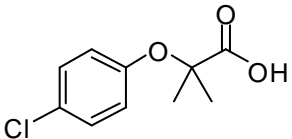
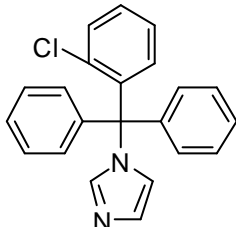
 Knowledge and Need Assessment on Pharmaceutical  
 Products in Environmental Waters

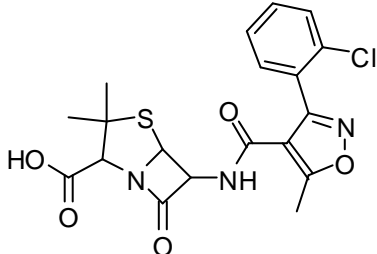
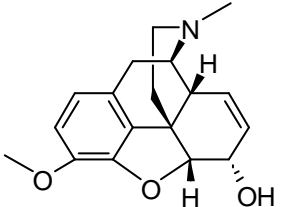
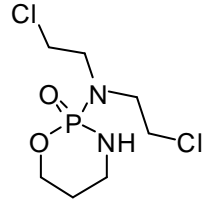
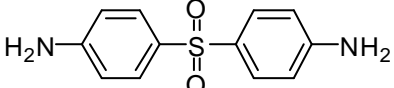
**D1.1: List of relevant PPs**

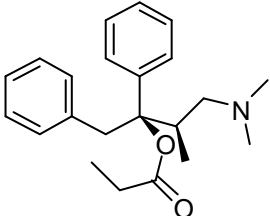
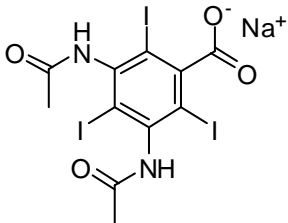
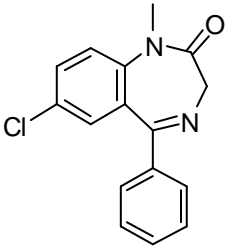
<p style="text-align: center;">Betaxolol</p> 	437 (D) 307.432	Beta-Blocker 63659-18-7	0	164	177	0	29	0	0
<p style="text-align: center;">Bezafibrate</p> 	39073 (D) 361.8243	Lipid regulator 41859-67-0	55	396	461	49	277	55	8
<p style="text-align: center;">Bisoprolol</p> 	2957 (D) 325.4472	Beta-Blocker 66722-44-9	15	283	413	32	117	0	0
<p style="text-align: center;">Bromazepam</p> 	2603 (F) 316.1565	Sedative, Anxiolytic 1812-30-2	0	0	27	0	2	0	8

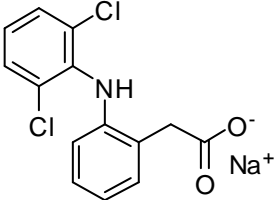
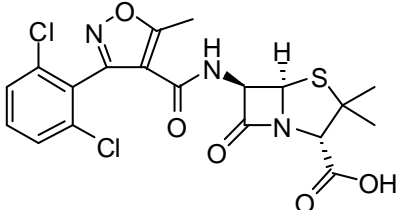
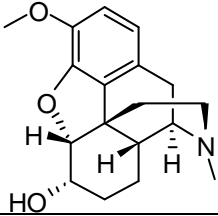
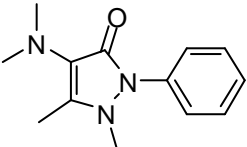
<p>Captopril</p> 	31565 (D) 203.3018	Antihyperten sion 62571-86-2	0	0	0	0	0	0	0
<p>Carazolol</p> 	2 (D) 298.384	Beta-Blocker 57775-29-8	0	112	121	0	23	0	0
<p>Carbamazepine</p> 	87605 (D) 236.2726	Anticonvulsa nt 298-46-4	120	495	786	70	531	12	34
<p>Carbocisteine</p> 	232308 (F) 179.1904	Mucolytic 2387-59-9	0	0	0	0	0	0	0
<p>Chloramphenicol</p> 	437 (D) 323.1322	Antibiotic 56-75-7	24	107	320	11	98	1	0

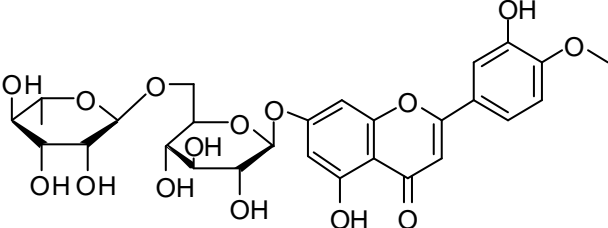
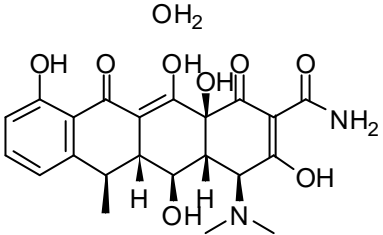
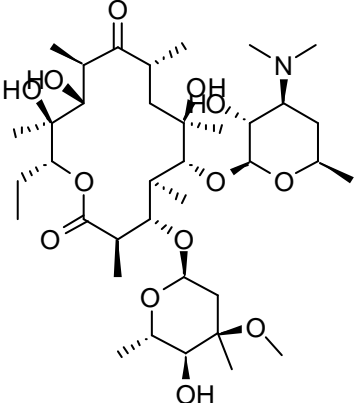
<p>Chlortetracycline</p>  <p>The chemical structure of Chlortetracycline is a tetracycline derivative. It features a central tetracycline core with a chlorine atom at the 7-position, a methylamino group at the 4-position, and a dimethylamino group at the 12-position. The structure is shown with various hydroxyl and carbonyl groups.</p>	<p>140 (D)</p> <p>478.8853</p>	<p>Antibiotic</p> <p>57-62-5</p>	3	83	262	0	58	0	0
<p>Ciprofloxacin</p>  <p>The chemical structure of Ciprofloxacin is a fluoroquinolone. It consists of a central quinolone ring system with a piperazine ring at the 7-position, a cyclopropyl group at the 8-position, a fluorine atom at the 6-position, and a carboxylic acid group at the 4-position.</p>	<p>17973 (D)</p> <p>331.3459</p>	<p>Antibiotic</p> <p>85721-33-1</p>	44	138	196	0	10	0	0
<p>Clarithromycin</p>  <p>The chemical structure of Clarithromycin is a macrolide. It features a 14-membered macrolide ring with a diethylamino group at the 13-position, a methyl group at the 14-position, and a hydroxyl group at the 15-position. The structure is highly complex with multiple stereocenters and various functional groups.</p>	<p>15104 (F)</p> <p>747.962</p>	<p>Antibiotic</p> <p>81103-11-9</p>	125	326	360	13	128	1	0

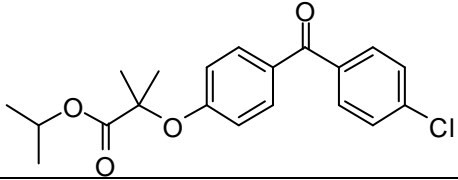
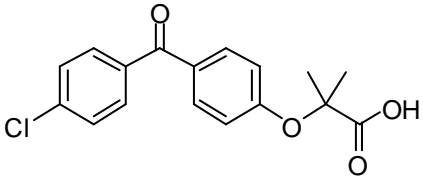
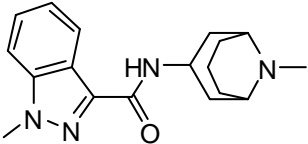
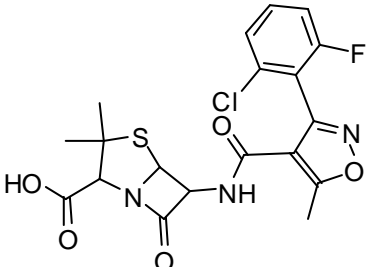
<p>Clenbuterol</p> 	<p>1 (D) 277.193</p>	<p>Decongestant and Bronchodilat or  37148-27-9</p>	14	237	200	32	87	0	0
<p>Clindamycin</p> 	<p>16081 (D) 424.9821</p>	<p>Antibiotic  18323-44-9</p>	19	98	41	0	0	0	0
<p>Clofibric acid</p> 	<p>- 214.6455</p>	<p>Metabolite  882-09-7</p>	62	452	535	66	383	90	30
<p>Clotrimazole</p> 	<p>8324 (D) 344.8427</p>	<p>Antifungal  23593-75-1</p>	3	3	46	0	2	0	8

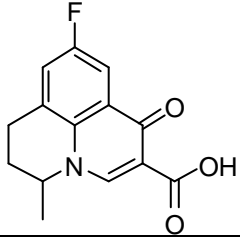
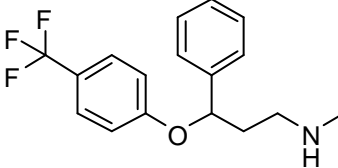
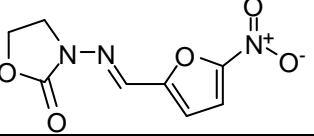
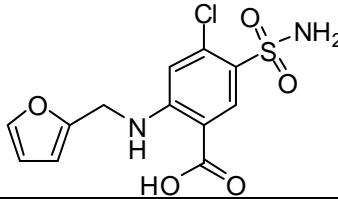
<p><b>Cloxacillin</b></p> 	- 435.8813	Antibiotic 61-72-3	0	11	34	0	37	0	0
<p><b>Codeine</b></p> 	26600 (UK) 299.3688	Analgesic, Antitussive and Antidiarrheal 76-57-3	16	48	90	0	2	0	27
<p><b>Cyclophosphamide</b></p> 	430 (D) 261.0875	Anticancer 50-18-0	52	190	272	32	85	12	0
<p><b>Dapsone</b></p> 	76 (D) 248.299	Antibacterial 80-08-0	0	0	14	0	6	0	0

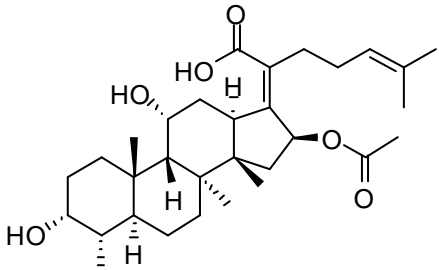
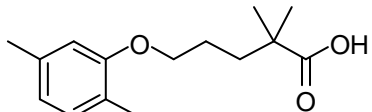
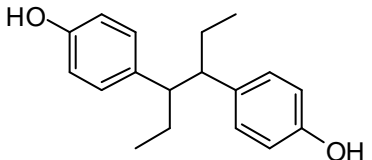
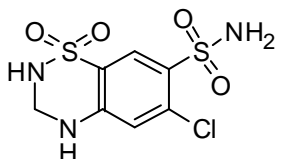
<p>Dextropropoxyphene</p> 	<p>51962 (F) 339.4766</p>	<p>Analgesic 469-62-5</p>	<p>3</p>	<p>6</p>	<p>42</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>
<p>Diatrizoate sodium</p> 	<p>60687 (D) 635.8985</p>	<p>X-ray contrast media 737-31-5</p>	<p>7</p>	<p>106</p>	<p>135</p>	<p>30</p>	<p>47</p>	<p>10</p>	<p>0</p>
<p>Diazepam</p> 	<p>1184 (D) 284.7445</p>	<p>Anxiolytic, Anticonvulsant, Sedative 439-14-5</p>	<p>37</p>	<p>279</p>	<p>437</p>	<p>32</p>	<p>90</p>	<p>12</p>	<p>8</p>

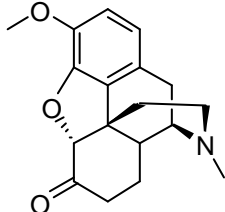
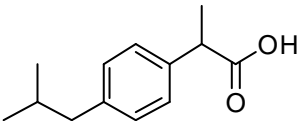
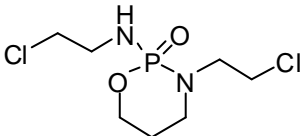
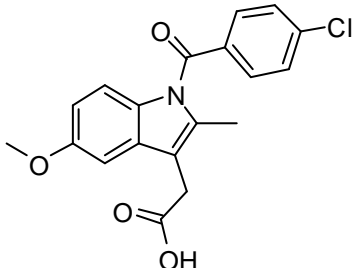
<p>Diclofenac</p> 	<p>85801 (D) 318.1343</p>	<p>Analgesic and Antiinflamm 15307-86-5</p>	93	591	820	74	459	56	8
<p>Dicloxacillin</p> 	<p>125 (D) 470.3264</p>	<p>Antibiotic 3116-76-5</p>	0	70	77	0	53	0	0
<p>Dihydrocodeine</p> 	<p>6830 (UK) 301.3846</p>	<p>Antitussive 125-28-0</p>	6	38	36	0	2	0	0
<p>Dimethylaminophenazone</p> 	<p>218 231.2968</p>	<p>Analgesic 58-15-1</p>	25	106	179	0	33	2	0

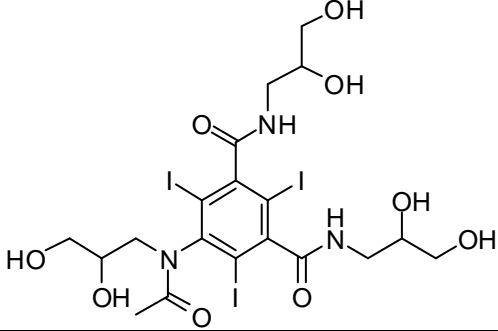
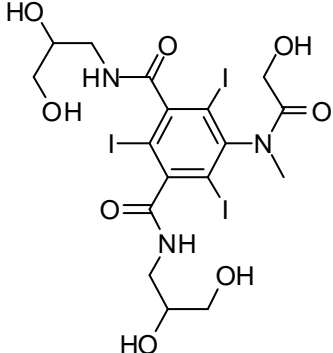
<p style="text-align: center;">Diosmin</p> 	<p>373543 (F) 608.5518</p>	<p>Phlebotropic 520-27-4</p>	0	0	0	0	0	0	0
<p style="text-align: center;">Doxycycline</p> 	<p>14056 (D) 462.4554</p>	<p>Antibiotic 564-25-0</p>	32	104	170	0	37	0	0
<p style="text-align: center;">Erythromycin</p> 	<p>27042 733.9352</p>	<p>Antibiotic 114-07-8</p>	123	348	559	13	128	1	0

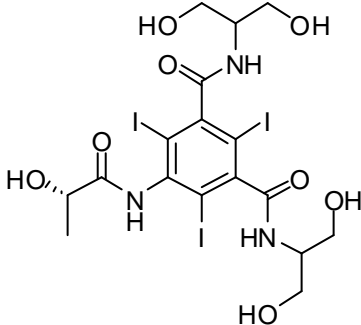
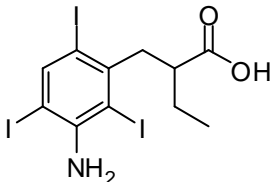
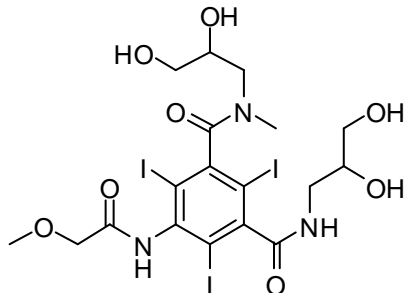
<p>Fenofibrate</p> 	<p>85669 (F) 360.8365</p>	<p>Lipid regulator 49562-28-9</p>	5	55	190	17	28	12	35
<p>Fenofibric acid</p> 	<p>- 318.7516</p>	<p>Metabolite 42017-89-0</p>	0	258	258	0	20	55	8
<p>Fenoterol</p> 	<p>170 (D) 312.4138</p>	<p>Antiasmthic 13392-18-2</p>	0	112	121	0	3	0	0
<p>Flucloxacillin</p> 	<p>23380 (UK) 453.8718</p>	<p>Antibiotic 5250-39-5</p>	0	54	6	0	0	0	0

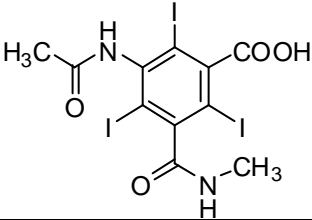
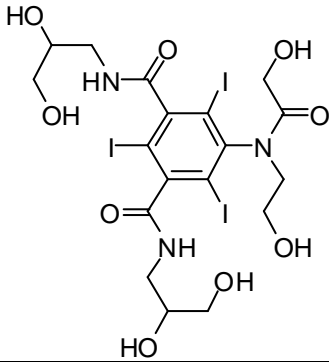
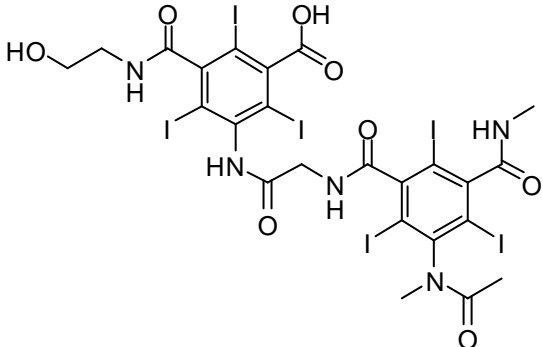
<p>Flumequine</p> 	- 261.2521	Antibiotic 42835-25-6	19	19	0	0	0	0	0
<p>Fluoxetine</p> 	3740 (F) 309.3305	Antidepressant 54910-89-3	18	28	50	0	2	5	27
<p>Furazolidone</p> 	17 (D) 225.1604	Antibiotic 67-45-8	0	0	14	0	6	0	0
<p>Furosemide</p> 	32189 (D) 330.7423	Diuretic 54-31-9	9	8	34	0	2	0	8

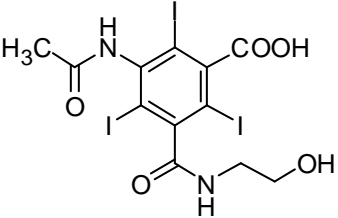
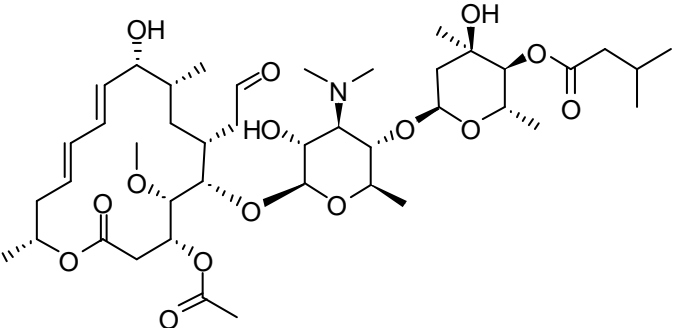
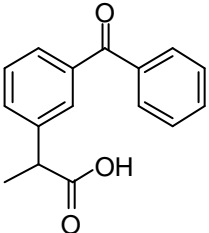
<p>Fusidine</p> 	- 516.7166	Antibiotic 6990-06-3	19	19	0	0	0	0	0
<p>Gemfibrozil</p> 	8908 (D) 250.337	Lipid regulator 25812-30-0	31	283	485	0	17	55	8
<p>Hexestrol</p> 	- 270.3706	Contraceptive 5635-50-7	0	0	14	0	2	0	0
<p>Hydrochlorothiazide</p> 	26722 (D) 297.7309	Diuretic 58-93-5	9	8	15	0	0	0	0

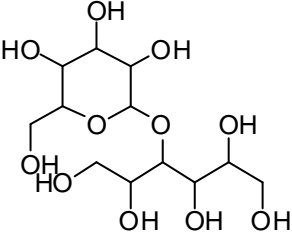
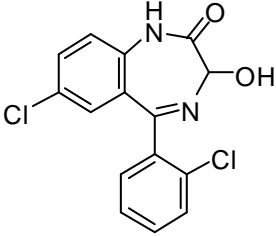
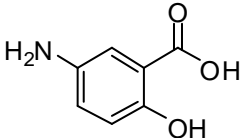
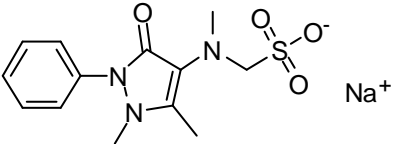
<p>Hydrocodone</p> 	<p>9 (D) 299.3688</p>	<p>Analgesic and Antitussive 125-29-1</p>	7	40	43	0	2	0	26
<p>Ibuprofen</p> 	<p>344884 (D) 206.284</p>	<p>Anti-inflammatory 15687-27-1</p>	86	516	773	47	79	60	22
<p>Ifosamide</p> 	<p>204 (D) 261.0875</p>	<p>Anticancer 3778-73-2</p>	30	156	250	32	85	12	0
<p>Indometacin</p> 	<p>4436 (D) 357.7927</p>	<p>Antiinflammatory 53-86-1</p>	18	312	496	49	81	55	0

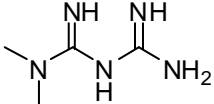
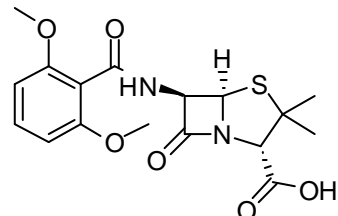
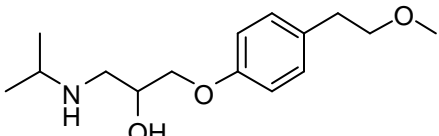
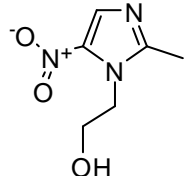
<p style="text-align: center;">Iohexol</p> 	<p>8053 (D) 821.1426</p>	<p>X-ray contrast media 66108-95-0</p>	<p>130</p>	<p>366</p>	<p>12</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>
<p style="text-align: center;">Iomeprol</p> 	<p>83370 (D) 777.0896</p>	<p>X-ray contrast media 78649-41-9</p>	<p>137</p>	<p>437</p>	<p>110</p>	<p>31</p>	<p>27</p>	<p>1</p>	<p>0</p>

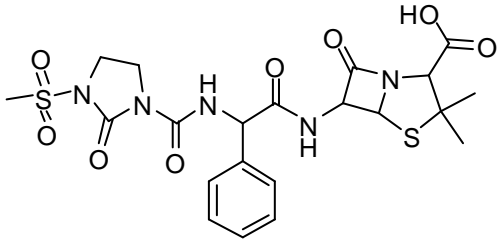
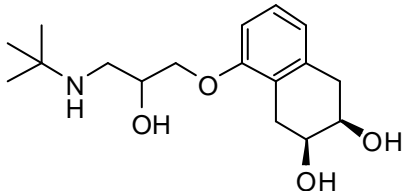
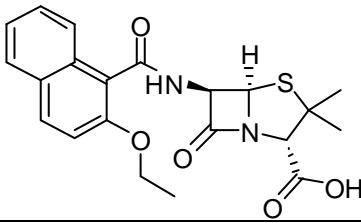
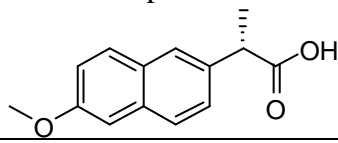
<p>Iopamidol</p> 	<p>42994 (D) 77.0896</p>	<p>X-ray contrast media  62883-00-5</p>	<p>137</p>	<p>463</p>	<p>136</p>	<p>31</p>	<p>152</p>	<p>11</p>	<p>0</p>
<p>Iopanoic acid</p> 	<p>- 570.9348</p>	<p>X-ray contrast media  96-83-3</p>	<p>0</p>	<p>3</p>	<p>6</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>
<p>Iopromide</p> 	<p>65533 (D) 791.1164</p>	<p>X-ray contrast media  73334-07-3</p>	<p>147</p>	<p>477</p>	<p>148</p>	<p>32</p>	<p>54</p>	<p>12</p>	<p>0</p>

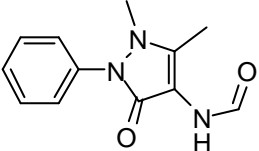
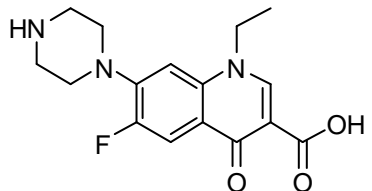
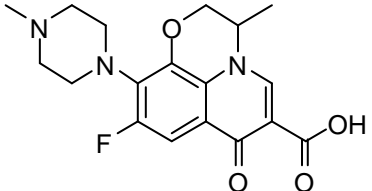
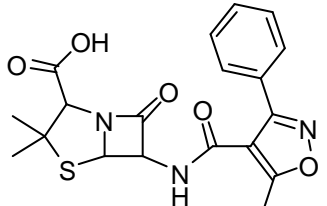
<p style="text-align: center;">Iotalamic acid</p> 	<p style="text-align: center;">- 613.9136</p>	<p style="text-align: center;">X-ray contrast media  2276-90-6</p>	0	17	31	0	0	10	0
<p style="text-align: center;">Ioversol</p> 	<p style="text-align: center;">43581 (D) 807.1158</p>	<p style="text-align: center;">X-ray contrast media  87771-40-2</p>	0	0	0	0	0	0	0
<p style="text-align: center;">Ioxaglic acid</p> 	<p style="text-align: center;">- 1268.8856</p>	<p style="text-align: center;">X-ray contrast media  59017-64-0</p>	0	3	6	0	0	0	0

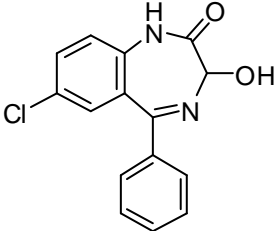
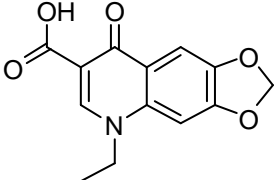
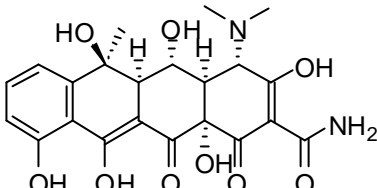
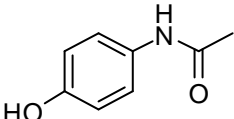
<p>Ioxithalamic acid</p> 	<p>8895 (D) 643.9396</p>	<p>X-ray contrast media 28179-44-4</p>	<p>0</p>	<p>17</p>	<p>31</p>	<p>0</p>	<p>20</p>	<p>10</p>	<p>0</p>
<p>Josamycin</p> 	<p>12802 (F) 828.0048</p>	<p>Antibiotic 16846-24-5</p>	<p>19</p>	<p>19</p>	<p>1</p>	<p>1</p>	<p>0</p>	<p>1</p>	<p>0</p>
<p>Ketoprofen</p> 	<p>21696 (F) 254.2848</p>	<p>Antiinflamm atory drug 22071-15-4</p>	<p>56</p>	<p>389</p>	<p>601</p>	<p>30</p>	<p>89</p>	<p>25</p>	<p>8</p>

<p style="text-align: center;">Lactitol</p>  <p>The structure shows a lactose molecule (a disaccharide of galactose and glucose) with an additional hydroxyl group on the glucose ring, making it a polyol.</p>	<p>22967 (D) 344.315</p>	<p>Antihypertensive 585-86-4</p>	0	0	0	0	0	0	0
<p style="text-align: center;">Lorazepam</p>  <p>The structure shows a benzodiazepine core with a 5-chlorophenyl group at position 5 and a 2-chlorophenyl group at position 1.</p>	<p>584 (F) 321.1622</p>	<p>Sedative/Hypnotic, Muscle relaxant, Anxiolytic, Amnesic and Anticonvulsant 846-49-1</p>	5	0	27	0	2	0	8
<p style="text-align: center;">Mesalazine</p>  <p>The structure shows a benzene ring with an amino group (-NH<sub>2</sub>) at position 4, a hydroxyl group (-OH) at position 3, and a carboxylic acid group (-COOH) at position 1.</p>	<p>56947 (D) 153.1372</p>	<p>Antiinflammatory 89-57-6</p>	0	0	0	0	0	0	0
<p style="text-align: center;">Metamizole sodium</p>  <p>The structure shows a pyrazolone ring system with a phenyl group at position 5, a methyl group at position 4, and a sodium sulfonate group (-SO<sub>2</sub>Na) at position 3.</p>	<p>163457 (D) 333.33687</p>	<p>Analgesic 68-89-3</p>	0	14	11	0	0	0	0

<p>Metformin</p> 	<p>716858 (F)</p> <p>129.1644</p>	<p>Antidiabetic</p> <p>657-24-9</p>	5	6	84	0	0	0	3
<p>Methicillin</p> 	<p>-</p> <p>380.4148</p>	<p>Antibiotic</p> <p>61-32-5</p>	0	11	34	0	37	0	0
<p>Metoprolol</p> 	<p>92974 (D)</p> <p>267.3674</p>	<p>Beta-Blocker</p> <p>37350-58-6</p>	24	352	473	36	104	0	8
<p>Metronidazole</p> 	<p>36545 (F)</p> <p>171.1554</p>	<p>Antibiotic</p> <p>443-48-1</p>	19	19	17	1	6	1	0

<p>Mezlocillin</p> 	<p>7429 (D) 539.5772</p>	<p>Antibiotic 51481-65-3</p>	0	54	27	0	0	0	0
<p>Nadolol</p> 	<p>938 (F) 309.4046</p>	<p>Beta-Blocker 42200-33-9</p>	0	12	121	0	21	0	0
<p>Nafcillin</p> 	<p>- 414.4752</p>	<p>Antibiotic 147-52-4</p>	0	11	34	0	37	0	0
<p>Naproxen</p> 	<p>37332 (F) 230.2628</p>	<p>Antiinflamm atory 22204-53-1</p>	60	318	379	30	72	5	8

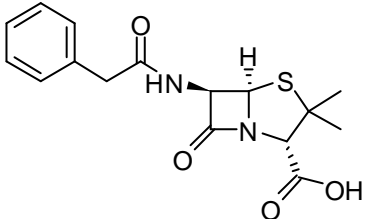
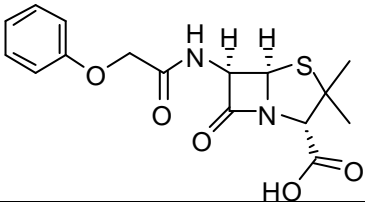
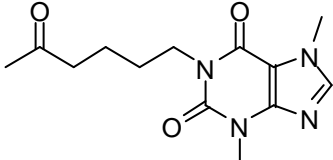
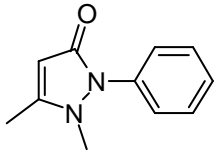
<p>N-Formyl-4-aminoantipyrine (FAA)</p> 	- 231.2505	Metabolite 1672-5-8-8	12	12	21	0	0	0	0
<p>Norfloxacin</p> 	- 319.3349	Antibiotic 70458-96-7	35	50	120	0	0	0	0
<p>Ofloxacin</p> 	4641 (D) 361.3721	Anitbiotic 83380-47-6	46	122	49	0	0	0	0
<p>Oxacillin</p> 	313 (D) 401.4362	Antibiotic 66-79-5	0	78	77	0	53	0	0

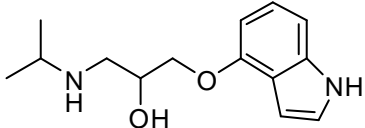
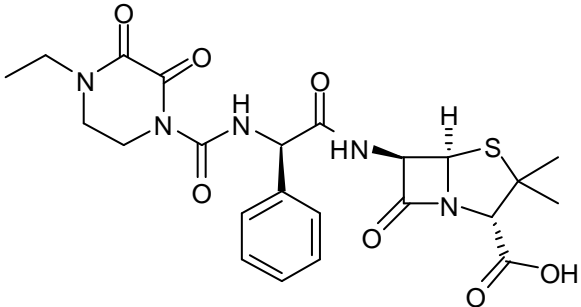
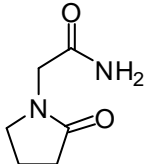
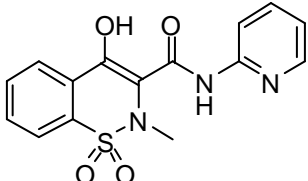
<p>Oxazepam</p> 	<p>6194 (F) 286.7171</p>	<p>Anxiolytic, Anticonvulsant, Sedative</p> <p>604-75-1</p>	<p>16</p>	<p>12</p>	<p>38</p>	<p>0</p>	<p>2</p>	<p>0</p>	<p>8</p>
<p>Oxolinic acid</p> 	<p>- 261.2336</p>	<p>Antibiotic</p> <p>14698-29-4</p>	<p>19</p>	<p>19</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>
<p>Oxytetracycline</p> 	<p>27190 (UK) 460.4396</p>	<p>Antibiotic</p> <p>6153-64-6</p>	<p>22</p>	<p>94</p>	<p>254</p>	<p>0</p>	<p>48</p>	<p>0</p>	<p>0</p>
<p>Paracetamol</p> 	<p>3303076 (F) 151.1646</p>	<p>Antiinflammatory</p> <p>103-90-2</p>	<p>13</p>	<p>120</p>	<p>146</p>	<p>4</p>	<p>2</p>	<p>0</p>	<p>35</p>

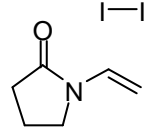
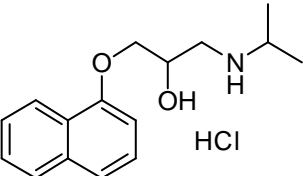
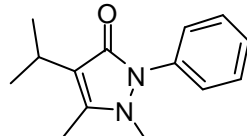
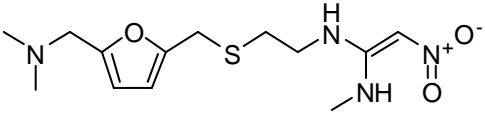
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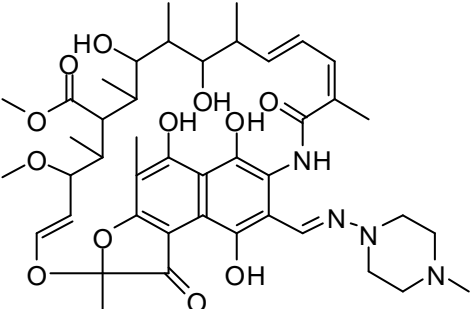
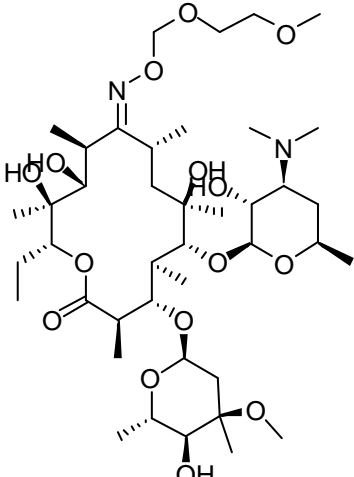
Knowledge and Need Assessment on Pharmaceutical Products in Environmental Waters

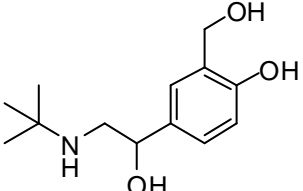
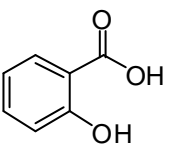
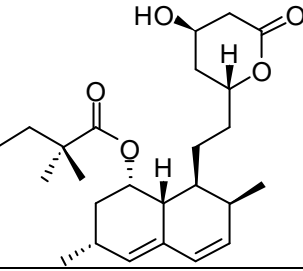
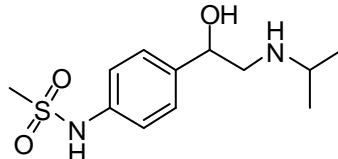
**D1.1: List of relevant PPs**

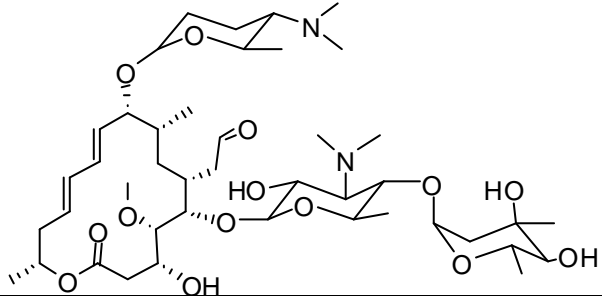
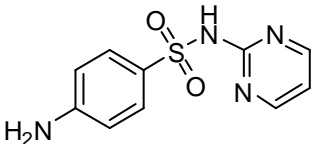
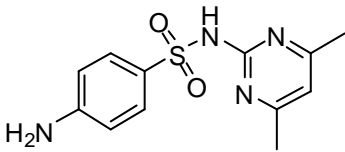
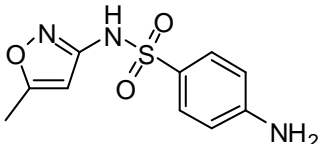
<p>Penicillin G</p> 	<p>7094 (D) 334.3892</p>	<p>Antibiotic 61-33-6</p>	0	78	77	0	48	0	0
<p>Penicillin V</p> 	<p>89983 (D) 350.3886</p>	<p>Antibiotic 87-08-1</p>	0	62	69	0	43	0	0
<p>Pentoxifylline</p> 	<p>103567 (D) 278.3102</p>	<p>treat intermittent claudication 6493-05-6</p>	0	11	105	0	6	0	0
<p>Phenazon</p> 	<p>32534 188.2286</p>	<p>Analgesic 60-80-0</p>	53	334	511	49	222	18	27

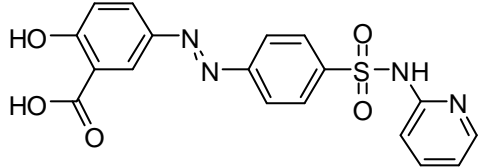
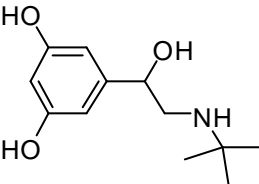
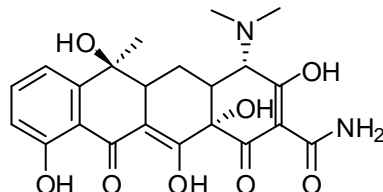
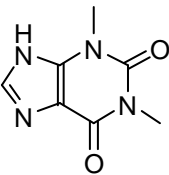
<p>Pindolol</p> 	<p>74 (D)</p> <p>248.3242</p>	<p>Beta-Blocker</p> <p>13523-86-9</p>	0	3	20	0	6	0	0
<p>Piperacillin</p> 	<p>13512 (D)</p> <p>517.5556</p>	<p>Antibiotic</p> <p>61477-96-1</p>	0	54	27	0	0	0	0
<p>Piracetam</p> 	<p>134048</p> <p>142.1572</p>	<p>Nootropic</p> <p>7491-74-9</p>	0	0	0	0	0	0	0
<p>Piroxicam</p> 	<p>2008 (F)</p> <p>331.3454</p>	<p>Antiinflamm atory</p> <p>36322-90-4</p>	1	32	41	0	49	0	0

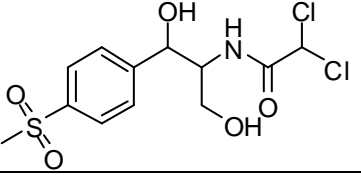
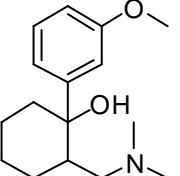
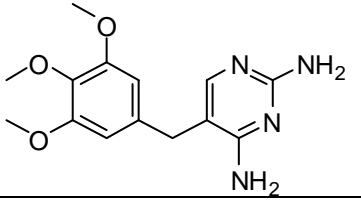
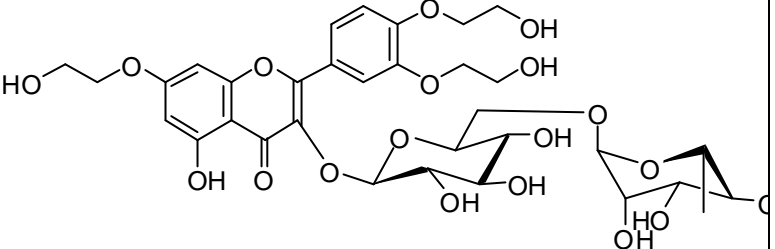
<p>Povidone-iodine</p> 	<p>508694 (D)</p> <p>364.9522</p>	<p>Antiseptics</p> <p>25655-41-8</p>	0	0	0	0	0	0	0
<p>Propranolol</p> 	<p>12486 (F)</p> <p>295.8044</p>	<p>Beta-Blocker</p> <p>318-98-9</p>	30	321	432	32	119	0	8
<p>Propyphenazon</p> 	<p>46016 (D)</p> <p>230.309</p>	<p>Analgesic</p> <p>479-92-5</p>	24	85	213	64	27	0	0
<p>Ranitidine</p> 	<p>85409 (D)</p> <p>314.4018</p>	<p>H2-receptor antagonist, Antihistamin ic</p> <p>66357-35-5</p>	19	19	109	0	0	0	3

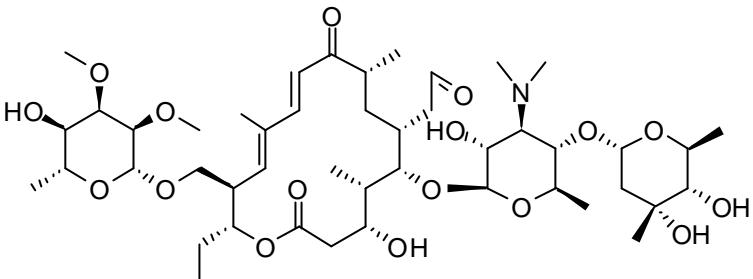
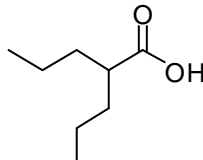
<p style="text-align: center;"><b>Rifampin</b></p>  <p>The chemical structure of Rifampin is a complex polycyclic molecule. It features a central naphthalene ring system with multiple hydroxyl groups and a dimethylpiperazine ring attached via a methylene bridge. There are also several methyl groups and a side chain with a double bond and a methyl group.</p>	<p>2383 (F) 822.9508</p>	<p>Antibiotic 13292-46-1</p>	<p>19</p>	<p>19</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>
<p style="text-align: center;"><b>Roxithromycin</b></p>  <p>The chemical structure of Roxithromycin is a macrolide antibiotic. It consists of a 14-membered macrolide ring with a hydroxyl group and a methyl group. It has a diethylaminoethyl side chain and a butyrate ester group. There are also several methyl groups and a hydroxyl group on the ring.</p>	<p>9555 (D) 837.0465</p>	<p>Antibiotic 80214-83-1</p>	<p>146</p>	<p>361</p>	<p>519</p>	<p>14</p>	<p>135</p>	<p>2</p>	<p>0</p>

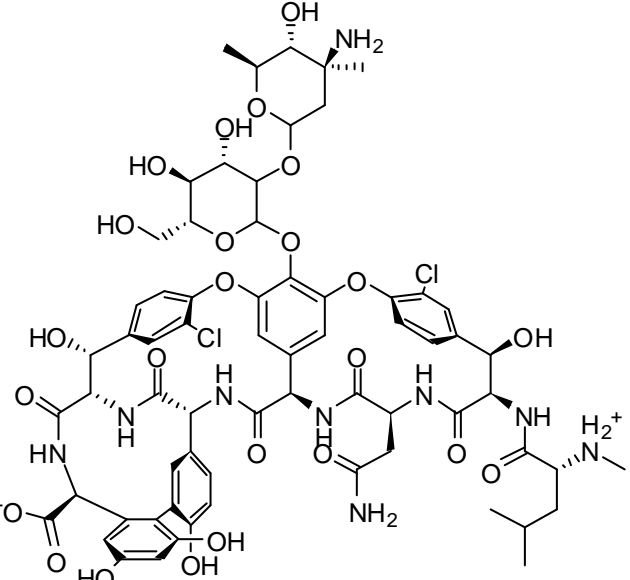
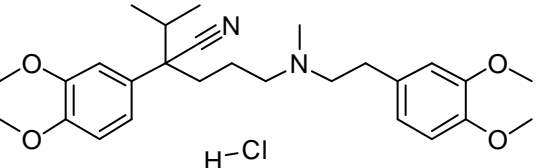
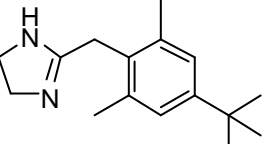
<p>Salbutamol</p> 	<p>460 (D) 239.3138</p>	<p>Antireumatic 18559-94-9</p>	28	280	427	32	93	0	27
<p>Salicylic acid</p> 	<p>89701 (D) 138.1226</p>	<p>Metabolite and antiseptic 69-72-7</p>	26	110	136	0	2	0	0
<p>Simvastatin</p> 	<p>6943 (F) 418.5722</p>	<p>Antihyperlipi demic 79902-63-9</p>	0	10	51	0	6	0	0
<p>Sotalol</p> 	<p>27139 (D) 272.3616</p>	<p>Beta-Blocker 3930-20-9</p>	26	139	246	40	183	0	0

<p style="text-align: center;"><b>Spiramycin</b></p> 	<p>495 (D) 843.0527</p>	<p>Antibiotic 8025-81-8</p>	<p>28</p>	<p>97</p>	<p>64</p>	<p>0</p>	<p>11</p>	<p>0</p>	<p>0</p>
<p style="text-align: center;"><b>Sulfadiazine</b></p> 	<p>2082 (D) 250.2746</p>	<p>Antibiotic 68-35-9</p>	<p>0</p>	<p>8</p>	<p>14</p>	<p>0</p>	<p>17</p>	<p>0</p>	<p>0</p>
<p style="text-align: center;"><b>Sulfamethazine</b></p> 	<p>800 (D) 277.3404</p>	<p>Antibiotic 57-68-1</p>	<p>34</p>	<p>236</p>	<p>553</p>	<p>13</p>	<p>140</p>	<p>1</p>	<p>0</p>
<p style="text-align: center;"><b>Sulfamethoxazole</b></p> 	<p>58407 (D) 253.2752</p>	<p>Antibiotic 723-46-6</p>	<p>82</p>	<p>219</p>	<p>678</p>	<p>22</p>	<p>245</p>	<p>1</p>	<p>34</p>

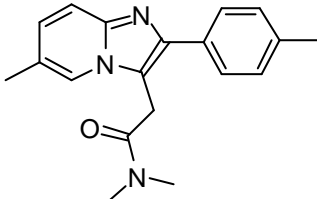
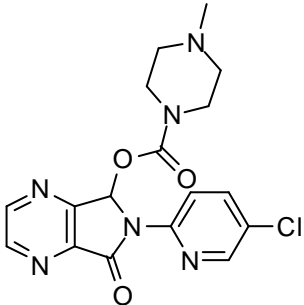
<p>Sulfasalazine</p> 	<p>46420 (UK) 398.3924</p>	<p>Antibiotic 599-79-1</p>	0	0	0	0	0	0	0
<p>Terbutaline</p> 	<p>183 (D) 225.287</p>	<p>Antiasmatic 23031-25-6</p>	12	200	273	16	76	0	0
<p>Tetracycline</p> 	<p>1954 (D) 444.4402</p>	<p>Antibiotic 60-54-8</p>	22	94	254	0	48	0	0
<p>Theophylline</p> 	<p>146431 (D) 180.1658</p>	<p>Antiasmatic 58-55-9</p>	0	0	0	0	0	0	0

<p><b>Thiamphenicol</b></p> 	- 356.2202	Antibiotic 15318-45-3	19	19	0	0	0	0	0
<p><b>Tramadol</b></p> 	25896 (F) 263.379	Analgesic 27203-92-5	1	1	4	0	0	0	0
<p><b>Trimethoprim</b></p> 	12496 (D) 290.3212	Bacteriostatic Antibiotic 738-70-5	70	325	682	20	140	0	34
<p><b>Troxeutin</b></p> 	444339 (F) 742.6834	Antihypertensive 7085-55-4	0	0	0	0	0	0	0

<p style="text-align: center;">Tylosin</p> 	<p style="text-align: center;">-</p> <p style="text-align: center;">916.1108</p>	<p style="text-align: center;">Antibiotic</p> <p style="text-align: center;">1401-69-0</p>							
<p style="text-align: center;">Valproic acid</p> 	<p style="text-align: center;">112162 (F) (Sodium Valproate)</p> <p style="text-align: center;">144.2132</p>	<p style="text-align: center;">Anticonvulsant</p> <p style="text-align: center;">99-66-1</p>							

<p style="text-align: center;">Vancomycin</p> 	<p>1048 (D) 1449.2704</p>	<p>Antibiotic 1404-90-6</p>	<p>0</p>	<p>54</p>	<p>27</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>
<p style="text-align: center;">Verapamil</p>  <p style="text-align: center;">H-Cl</p>	<p>72393 (D) 491.0691</p>	<p>Antihypertensive 152-11-4</p>	<p>1</p>	<p>1</p>	<p>1</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>
<p style="text-align: center;">Xylometazoline</p> 	<p>486 (D) 244.379</p>	<p>Decongestant 526-36-3</p>	<p>0</p>	<p>0</p>	<p>1</p>	<p>0</p>	<p>0</p>	<p>0</p>	<p>0</p>

**KNAPPE**Knowledge and Need Assessment on Pharmaceutical  
Products in Environmental Waters**D1.1: List of relevant PPs**

<p>Zolpidem</p>  <chem>Cc1ccc2nc3c(nc12)CCN(C)C3</chem>	3343 (F) 307.3944	Anticonvulsant 82626-48-0	5	0	27	0	2	0	8
<p>Zopiclone</p>  <chem>C1CN(CCN1)C(=O)Oc2nc3c(ncn2C3=O)C4=CC=CC=C4Cl</chem>	1948 (F) 388.8127	Sedative 43200-80-2	0	0	0	0	0	0	0

## 8. Annex

### List of scientific papers used for the data list on occurrence data

- [1] Heberer, T.; Duennbier, U.; Reilich, C.; Stan, H.-J., Detection of Drugs and Drug Metabolites in Ground Water samples of a drinking water treatment plant. Fresenius Environmental Bulletin 1997, 6, (7-8), 438-443.
- [2] Stumpf, M.; Ternes, T. A.; Haberer, K.; Seel P.; Baumann, W., Nachweis von Arzneimittelrückständen in Kläranlagen und Fließgewässern. Vom Wasser 1996, 86, 291-303.
- [3] Sacher, F.; Lochow, E.; Bethmann, D.; Brauch, H.-J., Vorkommen von Arzneimittelwirkstoffen in Oberflächenwässern. Vom Wasser 1998, 90, 233-243.
- [4] Heberer, T.; Stan, H.-J., Vorkommen von polaren organischen Kontaminanten im Berliner Trinkwasser. Vom Wasser 1996, 86, 19-31.
- [5] Stumpf, M.; Ternes, T. A.; Haberer, K.; Baumann, W., Isolierung von Ibuprofen-Metaboliten und deren Bedeutung als Kontaminanten der aquatischen Umwelt. Vom Wasser 1998, 91, 291-303.
- [6] Stan, H.-J.; Heberer, T.; Linkerhägner, M., Vorkommen von Clofibrinsäure im aquatischen System - Führt die therapeutische Anwendung zu einer Belastung von Oberflächen-, Grund- und Trinkwasser ?-. Vom Wasser 1994, 83, 57-68.
- [7] Hirsch, R.; Ternes, T. A.; Haberer, K.; Kratz, K.-L., Occurrence of antibiotics in the aquatic environment. The Science of the Total Environment 1999, 225, 109-118.
- [8] Ternes, T. A., Occurrence of Drugs in German Sewage Treatment Plants and Rivers. Water Research 1998, 32, (11), 3245-3260.

- [9] Poiger, T.; Buser, H.-R.; Müller, M. D., Photodegradation of the Pharmaceutical Drug Diclofenac in a Lake: Pathway, Field Measurements, and Mathematical Modeling. *Environmental Toxicology and Chemistry* 2001, 20, (2), 256-263.
- [10] Hektoen, H.; Berge, J. A.; Hormazabal, V.; Yndestad, M., Persistence of antibacterial agents in marine sediments. *Aquaculture* 1995, 133, 175-184.
- [11] Buser, H.-R.; Poiger, T.; Müller, M. D., Occurrence and Environmental Behavior of the Chiral Pharmaceutical Drug Ibuprofen in Surface Waters and in Wastewater. *Environmental Science & Technology* 1999, 33, 2529-2535.
- [12] Kuo, C.-E.; Chi, W.-C.; Liu, S.-M., Biotransformation of p-toluic acid in anoxic estuarine sediments under a CO<sub>2</sub> or N<sub>2</sub>/H<sub>2</sub> atmosphere. *Chemosphere* 2001, 45, 835-842.
- [13] Hartig, C.; Jekel, M., Analytik aromatischer Sulfonamide in biologischen und aquatischen Matrices. *Vom Wasser* 2001, 96, 131-158.
- [14] Sacher, F.; Lange, F. T.; Brauch, H.-J.; Blankenhorn, I., Pharmaceuticals in groundwaters. Analytical methods and results of a monitoring program in Baden-Württemberg, Germany. *Journal of Chromatography A* 2001, 938, 199-210.
- [15] Hercegova, A.; Polonsky, J., Determination of non-steroidal anti-inflammatory drugs in biological fluids. *Pharmazie* 1999, 54, 479-486.
- [16] Kolpin, D. W.; Furlong, E. T.; Meyer, M. T.; Thurman, E. M.; Zaugg, S. D.; Barber, L. B.; Buxton, H. T., Pharmaceuticals, hormones, and other organic wastewater contaminants in U.S. streams, 1999-2000: a national reconnaissance. *Environ. Sci. Technol.* 2002, 36, 1202-1211.
- [17] Ternes, T. A.; Bonerz, M.; Schmidt, T., Determination of neutral pharmaceuticals in wastewater and rivers by liquid chromatography-electrospray tandem mass spectrometry. *Journal of Chromatography A* 2001, 938, 175-185.

- [18] Schmidt, R.; Brockmeyer, R., Vorkommen und Verhalten von Expektorantien, Analgetika, Xylometazolin und deren Metaboliten in Gewässern und bei der Uferfiltration. *Vom Wasser* 2002, 98, 37-54.
- [19] Ternes, T. A., Analytical methods for the determination of pharmaceuticals in aqueous environmental samples. *Trends in analytical chemistry* 2001, 20, (8), 419-434.
- [20] 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.* 1998, 32, (1), 188-192.
- [21] Putschew, A.; Wischnack, S.; Jekel, M., Occurrence of triiodinated X-ray contrast agents in the aquatic environment. *The Science of the Total Environment* 2000, 255, 129-134.
- [22] 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. *Journal of Chromatography A* 2001, 930, 127-134.
- [23] Weigel, S.; Kuhlmann, J.; Hühnerfuss, H., Drugs and personal care products as ubiquitous pollutants: occurrence and distribution of clofibric acid, caffeine and DEET in the North Sea. *The Science of the Total Environment* 2002, 295, 131-141.
- [24] Heberer, T., Tracking persistent pharmaceutical residues from municipal sewage to drinking water. *Journal of Hydrology* 2002, 266, 175-189.
- [25] Reddersen, K.; Heberer, T.; Duennbier, U., Identification and significance of phenazone drugs and their metabolites in ground- and drinking water. *Chemosphere* 2002, 49, 539-544.
- [26] Ternes, T. A.; Hirsch, R., Occurrence and behaviour of X-ray contrast media in sewage facilities and the aquatic environment. *Environ. Sci. Technol.* 2000, 34, 2741-2748.
- [27] Pouliquen, H.; Le Bris, H., Sorption of oxolinic acid and oxytetracycline to marine sediments. *Chemosphere* 1996, 33, (801-815).

- [28] Jones, O. A. H.; Voulvoulis, N.; Lester, J. N., Aquatic environmental assessment of the top 25 English prescription pharmaceuticals. *Water Research* 2002, 36, 5013-5022.
- [29] Mc Ardell, C. S.; Molnar, E.; Giger, W., Occurrence and Fate of Macrolide Antibiotics in Wastewater Treatment Plants and in the Glatt River Watershed, Switzerland. *Environmental Science and Technology* in press.
- [30] Rodríguez, I.; Quintana, J. B.; Carpinteiro, J.; Carro, A. M.; Lorenzo, R. A.; Cela, R., Determination of acidic drugs in sewage water by gas chromatography–mass spectrometry as tert.-butyldimethylsilyl derivatives. *Journal of Chromatography A* 2003, 985, 265-274.
- [31] Tixier, C.; Singer, H. P.; Oellers, S.; Müller, S. R., Occurrence and Fate of Carbamazepine, Clofibrac Acid, Diclofenac, Ibuprofen, Ketoprofen, and Naproxen in Surface Waters. *Environ. Sci. Technol.* 2003, 37, (6), 1061-1068.
- [32] Calamari, D.; Zuccato, E.; Castiglioni, S.; Bagnati, R.; Fanelli, R., Strategic Survey of Therapeutic Drugs in the Rivers Po and Lambro in Northern Italy. *Environ. Sci. Technol.* 2003.
- [33] Ternes, T., Pharmaceuticals and metabolites as contaminants of the aquatic environment. In *Pharmaceuticals and personal care products in the environment*, Daughton, C. G.; Jones-Lepp, T. L., Eds. American Chemical Society: Washington, DC, 2001.
- [34] Kreuzig, R.; Kullmer, C.; Matthies, B.; Hölting, S.; Dieckmann, H., Fate and behaviour of pharmaceutical residues in soils. *Fresenius Environmental Bulletin* 2003, 12, (6), 550-558.
- [35] Deng, A.; Himmelsbach, M.; Zhu, Q.-Z.; Frey, S.; Sengl, M.; Buchberger, W.; Niessner, R.; Knopp, D., Residue Analysis of the Pharmaceutical Diclofenac in Different Water Types Using ELISA and GC-MS. *Environ. Sci. Technol.* 2003, 37, 3422-3429.

- [36] Boyd, G. R.; Reemtsma, H.; Grimm, D. A.; Mitra, S., Pharmaceuticals and personal care products (PPCPs) in surface and treated waters of Louisiana, USA and Ontario, Canada. *Science of the Total Environment* 2003, 311, (1-3), 135-149.
- [37] Hilton, M. J.; Thomas, K. V., Determination of selected human pharmaceutical compounds in effluent and surface water samples by high-performance liquid chromatography-electrospray tandem mass spectrometry. *J Chromatogr A* 2003, 1015, (1-2), 129-41.
- [38] Miao, X. S.; Metcalfe, C. D., Determination of carbamazepine and its metabolites in aqueous samples using liquid chromatography-electrospray tandem mass spectrometry. *Analytical Chemistry* 2003, 75, (15), 3731-3738.
- [39] Weigel, S.; Kallenborn, R.; Hühnerfuss, H., Simultaneous solid-phase extraction of acidic, neutral and basic pharmaceuticals from aqueous samples at ambient (neutral) pH and their determination by gas chromatography-mass spectrometry. *Journal of Chromatography A* 2004, 1023, 183-195.
- [40] Petrovic, M.; Gonzalez, S.; Barcelo, D., Analysis and removal of emerging contaminants in wastewater and drinking water. *Trends in analytical chemistry* 2003, 22, (10), 685-756.
- [41] Packer, J.; Werner, J.; Latch, D.; McNeill, K.; Arnold, W., Photochemical fate of pharmaceuticals in the environment: Naproxen, diclofenac, clofibric acid, and ibuprofen. *Aqua. Sci.* 2003, 65, 342-351.
- [42] Metcalfe, C. D.; Miao, X.-S.; Koenig, B. G.; Struger, J., Distribution of acidic and neutral drugs in surface waters near sewage treatment plants in the lower great lakes, Canada. *Environmental Chemistry and Toxicology* 2003, 22, (12), 2881-2889.
- [43] Miao, X. S.; Bishay, F.; Chen, M.; Metcalfe, C. D., Occurrence of antimicrobials in the final effluents of wastewater treatment plants in Canada. *Environmental Science & Technology* 2004, 38, (13), 3533-3541.

- [44] Carballa, M.; Omil, F.; Lema, J. M.; Llupart, M.; Garcia-Jares, C.; Rodriguez, I.; Gomez, M.; Ternes, T., Behavior of pharmaceuticals, cosmetics and hormones in a sewage treatment plant. *Water Research* 2004, 38, (12), 2918-2926.
- [45] Renew, J. E.; Huang, C. H., Simultaneous determination of fluoroquinolone, sulfonamide, and trimethoprim antibiotics in wastewater using tandem solid phase extraction and liquid chromatography-electrospray mass spectrometry. *Journal of Chromatography A* 2004, 1042, (1-2), 113-121.
- [46] Heberer, T.; Mechlinski, A.; Fanck, B.; Knappe, A., Field studies on the fate and transport of pharmaceutical residues in bank filtration. *Ground Water Monitoring & Remediation* 2004, 24, (2), 70-77.
- [47] Thomas, P. M.; Foster, G. D., Determination of nonsteroidal anti-inflammatory drugs, caffeine, and triclosan in wastewater by gas chromatography-mass spectrometry. *Journal of Environmental Science and Health Part a-Toxic/Hazardous Substances & Environmental Engineering* 2004, 39, (8), 1969-1978.
- [48] van der Ven, K.; van Dongen, W.; Maes, B. U. W.; Esmans, E. L.; Blust, R.; de Coen, W. M., Determination of diazepam in aquatic samples by capillary liquid chromatography-electrospray tandem mass spectrometry. *Chemosphere* 2004, 57, 967 - 973.
- [49] Ashton, D.; Hilton, M.; Thomas, K. V., Investigating the environmental transport of human pharmaceuticals to streams in the United Kingdom. *Science of the Total Environment* 2004, 333, 167 - 184.
- [50] Beausse, J., Selected drugs in solid matrices: A review of environmental occurrence, determination and properties of principal substances. *Horizontal* 2004, 26, 3 - 36.
- [51] Kreuzinger, N.; Clara, M.; Strenn, B.; Vogel, B., Investigation on the behaviour of selected pharmaceuticals in the groundwater after infiltration of treated wastewater. *Water Science and Technology* 2004, 50, (2), 221-228.

- [52] Wiegel, S.; Aulinger, A.; Brockmeyer, R.; Harms, H.; Löffler, J.; Reincke, H.; Schmidt, R.; Stachel, B.; von Tümplingen, W.; Wanke, A., Pharmaceuticals in the river elbe and its tributaries. *Chemosphere* 2004, 57, 107-126.
- [53] Doll, T. E.; Frimmel, F. H., Fate of pharmaceuticals-photodegradation by simulated solar UV-light. *Chemosphere* 2003, 52, (10), 1757-1769.
- [54] Andreozzi, R.; Raffaele, M.; Nicklas, P., Pharmaceuticals in STP effluents and their solar photodegradation in aquatic environment. *Chemosphere* 2003, 50, (10), 1319-1330.
- [55] Thomas, K. V.; Hilton, M. J., The occurrence of selected human pharmaceutical compounds in UK estuaries. *Marine Pollution Bulletin* 2004, 49, (5-6), 436-444.
- [56] Weigel, S.; Berger, U.; Jensen, E.; Kallenborn, R.; Thoresen, H.; Huhnerfuss, H., Determination of selected pharmaceuticals and caffeine in sewage and seawater from Tromsø/Norway with emphasis on ibuprofen and its metabolites. *Chemosphere* 2004, 56, (6), 583-592.
- [57] Vanderford, B. J.; Pearson, R. A.; Rexing, D. J.; Snyder, S. A., Analysis of endocrine disruptors, pharmaceuticals, and personal care products in water using liquid chromatography/tandem mass spectrometry. *Analytical Chemistry* 2003, 75, (22), 6265-6274.
- [58] Packer, J. L.; Werner, J. J.; Latch, D. E.; McNeill, K.; Arnold, W. A., Photochemical fate of pharmaceuticals in the environment: Naproxen, diclofenac, clofibrac acid, and ibuprofen. *Aquatic Sciences* 2003, 65, (4), 342-351.
- [59] Paxeus, N., Removal of selected non-steroidal anti-inflammatory drugs (NSAIDs), gemfibrozil, carbamazepine, beta-blockers, trimethoprim and triclosan in conventional wastewater treatment plants in five EU countries and their discharge to the aquatic environment. *Water Science and Technology* 2004, 50, (5), 253-260.

- [60] Zuehlke, S.; Duennbier, U.; Heberer, T., Determination of polar drug residues in sewage and surface water applying liquid chromatography-tandem mass spectrometry. *Analytical Chemistry* 2004, 76, (22), 6548-6554.
- [61] Drillia, P.; Stamatelatou, K.; Lyberatos, G., Fate and mobility of pharmaceuticals in solid matrices *Chemosphere* 2005, 60, 1034-1044.
- [62] Scheytt, T.; Mersmann, P.; Lindstädt, R.; Heberer, T., Determination of sorption coefficients of pharmaceutically active substances carbamazepine, diclofenac, and ibuprofen, in sandy sediments. *Chemosphere* 2005, 60, 245-253.
- [63] Dsikowitzky, L.; Schwarzbauer, J.; Kronimus, A.; Littke, R., The anthropogenic contribution to the organic load of the Lippe River (Germany). Part 1: qualitative characterisation of low-molecular weight organic compounds. *Chemosphere* 2004, 57, (10), 1275-1288.
- [64] Lindberg, R. H.; Wennberg, P.; Johansson, M. I.; Tysklind, M.; Andersson, B. A. V., Screening of Human Antibiotic Substances and Determination of Weekly Mass Flows in Five Sewage Treatment Plants in Sweden *Environ. Sci. & Technol.*
- [65] Quintana, J. B.; Reemtsma, T., Sensitive determination of acidic drugs and triclosan in surface and wastewater by ion-pair reverse-phase liquid chromatography/tandem mass spectrometry. *Rapid Communications in Mass Spectrometry* 2004, 18, (7), 765-774.
- [66] Marchese, S.; Perret, D.; Gentili, A.; Curini, R.; Pastori, F., Determination of non-steroidal anti-inflammatory drugs in surface water and wastewater by liquid chromatography-tandem mass spectrometry. *Chromatographia* 2003, 58, (5-6), 263-269.
- [67] Sacher, F.; Raue, B.; Brauch, H.-J., Analysis of iodinated X-ray contrast agents in water samples by ion chromatography and inductively-coupled plasma mass spectrometry *Journal of Chromatography A* 2005, 1085, 117-123.
- [68] Drillia, P.; Stamatelatou, K.; Lyberatos, G., Fate and mobility of pharmaceuticals on solid matrices. *Chemosphere* 2005, 60, 1034-1044.

- [69] Quintana, J. B.; Weiss, S.; Reemtsma, T., Pathways and metabolites of microbial degradation of selected acidic pharmaceutical and their occurrence in municipal wastewater treated by a membrane bioreactor. *Water Research* 2005, 39, 2654-2664.
- [70] Kaniou, S.; Pitarrakis, K.; Barlagianni, I.; Poullos, I., Photocatalytic oxidation of sulfamethazine. *Chemosphere* 2005, 60, 372-380.
- [71] Lindqvist, N.; Tuhkanen, T.; Kronberg, L., Occurrence of acidic pharmaceuticals in raw and treated sewages and in receiving waters. *Water Research* 2005, 2219-2228.
- [72] Göbel, A.; Thomsen, A.; Mcardell, C. S.; Joss, A., Occurrence and Sorption Behavior of Sulfonamides, Macrolides, and Trimethoprim in Activatd Sludge Treatment Environ. Sci. Technol. 2005, 39, (11), 3981-3989.
- [73] Roberts, P. H.; Thomas, K. V., The occurrence of selected pharmaceuticals in wastewater effluent and surface waters of the lower Tyne catchment. *Science Of The Total Environment* 2006, 356, (1-3), 143-153.
- [74] Sassman, S. A.; Lee, L. S., Sorption of three tetracyclines by several soils: Assessing the role of pH and cation exchange. *Environmental Science & Technology* 2005, 39, (19), 7452-7459.
- [75] Miao, X. S.; Yang, J. J.; Metcalfe, C. D., Carbamazepine and its metabolites in wastewater and in biosolids in a municipal wastewater treatment plant. *Environmental Science & Technology* 2005, 39, (19), 7469-7475.
- [76] Castiglioni, S.; Bagnati, R.; Calamari, D.; Fanelli, R.; Zuccato, E., A multiresidue analytical method using solid-phase extraction and high-pressure liquid chromatography tandem mass spectrometry to measure pharmaceuticals of different therapeutic classes in urban wastewaters. *Journal Of Chromatography A* 2005, 1092, (2), 206-215.

- [77] Metcalfe, C. D.; Koenig, B. G.; Bennie, D. T.; Servos, M.; Ternes, T. A.; Hirsch, R., Occurrence of neutral and acidic drugs in the effluents of Canadian sewage treatment plants. *Environmental Toxicology and Chemistry* 2003, 22, (12), 2872-2880.
- [78] Kanda, R.; Griffin, P.; James, H. A.; Fothergill, J., Pharmaceutical and personal care products in sewage treatment works. *Journal of Environmental Monitoring* 2003, 5, (5), 823-830.
- [79] Koch, D. E.; Bhandari, A.; Close, L.; Hunter, R. P., Azithromycin extraction from municipal wastewater and quantitation using liquid chromatography/mass spectrometry. *Journal Of Chromatography A* 2005, 1074, (1-2), 17-22.
- [80] Bruchet, A.; Hochereau, C.; Picard, C.; Decottignies, V.; Rodrigues, J. M.; Janex-Habibi, M. L., Analysis of drugs and personal care products in French source and drinking waters: the analytical challenge and examples of application. *Water Science And Technology* 2005, 52, (8), 53-61.
- [81] Carlson, J. C.; Mabury, S. A., Dissipation kinetics and mobility of chlortetracycline, tylosin, and monensin in an agricultural soil in Northumberland County, Ontario, Canada. *Environmental Toxicology And Chemistry* 2006, 25, (1), 1-10.
- [82] Zuccato, E.; Castiglioni, S.; Fanelli, R.; Reitano, G.; Bagnati, R.; Chiabrando, C.; Pomati, F.; Rossetti, C.; Calamari, D., Pharmaceuticals in the environment in Italy: Causes, occurrence, effects and control. *Environmental Science And Pollution Research* 2006, 13, (1), 15-21.
- [83] Karthikeyan, K. G.; Meyer, M. T., Occurrence of antibiotics in wastewater treatment facilities in Wisconsin, USA. *Science of the Total Environment* 2006, 361, 196-207.
- [84] Cha, J. M.; Yang, S.; Carlson, K. H., Trace determination of  $\beta$ -lactam antibiotics in surface water and urban wastewater using liquid chromatograph combined with electrospray tandem mass spectrometry. *Journal of Chromatography A* 2006, 1115, 46-57.

- [85] Vasskog, T.; Berger, U.; Samuelsen, P.-J.; Kallenborn, R.; Jensen, E., Selective serotonin reuptake inhibitors in sewage influents and effluents from Tromso, Norway. *Journal of Chromatography A* 2006, 1115, 187-195.
- [86] Abuin, S.; Codony, R.; Compano, R.; Granados, M.; Prat, M. D., Analysis of macrolide antibiotics in river water by solid-phase extraction and liquid chromatography-mass spectrometry. *Journal Of Chromatography A* 2006, 1114, (1), 73-81.
- [87] Lam, M. W.; Young, C. J.; Mabury, S. A., Aqueous photochemical reaction kinetics and transformations of fluoxetine. *Environmental Science & Technology* 2005, 39, (2), 513-522.
- [88] Lee, H. B.; Peart, T. E.; Svoboda, M. L., Determination of endocrine-disrupting phenols, acidic pharmaceuticals, and personal-care products in sewage by solid-phase extraction and gas chromatography-mass spectrometry. *Journal Of Chromatography A* 2005, 1094, (1-2), 122-129.
- [89] Gros, M.; Petrovic, M.; Barcelo, D., Multi-residue analytical methods using LC-tandem MS for the determination of pharmaceuticals in environmental and wastewater samples: a review. *Analytical and Bioanalytical Chemistry* 2006, 386, (4), 941-952.
- [90] Vieno, N. M.; Tuhkanen, T.; Kronberg, L., Analysis of neutral and basic pharmaceuticals in sewage treatment plants and in recipient rivers using solid phase extraction and liquid chromatography-tandem mass spectrometry detection. *Journal of Chromatography A* 2006, 1134, (1-2), 101-111.
- [91] Seitz, W.; Weber, W. H.; Jiang, J.-Q.; Lloyd, B. J.; Maier, M.; Maier, D.; Schulz, W., Monitoring of iodinated X-ray contrast media in surface water. *Chemosphere* 2006, 64, 1318-1324.
- [92] Buerge, I. J.; Buser, H.-R.; Poiger, T.; Müller, M. D., Occurrence and fate of the cytostatic drugs cyclophosphamide and ifosfamide in wastewater and surface water. *Environ. Sci. Technol.* 2006, 40, (23), 7242-7250.

- [93] Rabiet, M.; Togola, A.; Brissaud, F.; Seidel, J.-L.; Budzinski, H.; Elbaz-Poulichet, F., Consequence of treated water recycling as regards pharmaceuticals and drugs in surface and ground waters of a medium-sized mediterranean catchment. *Environ. Sci. & Technol.* 2006, 40, (17), 5285-5288.
- [94] Bayerisches Landesamt für Wasserwirtschaft, Arzneimittel in der Umwelt, F+E-Vorhaben 2000-2002 Kennnummer 73e 04010049, Schlussbericht. Bayerisches Landesamt für Wasserwirtschaft
- [95] Ternes, T. A., Janex-Habibi, M.-L., Knacker, T., Kreuzinger, N., Siegrist, H., Assessment of Technologies for the Removal of Pharmaceuticals and Personal Care Products in Sewage und Drinking Water Facilities to Improve the Indirect Potable Water Reuse. *Energy, Environment and Sustainable Development.* 2004.
- [96] Miège, C., Favier, M., Brosse, C., Canler J-P., Coquery, M., Occurrence of betablockers in effluents of wastewater treatment plants from the Lyon area (France) and risk assessment for the downstream rivers. *Talanta* 2006, 70, 739-745.
- [97] Verenitch, S. S., Lowe, C. 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* 2006, 1116, 193-203.
- [98] Maurer, M., Escher, B.I., Richle, P., Schaffner, C., Alder, A.C., Elimination of beta-blockers in sewage treatment plants. *Water research* 2007, 41, 1614-1622.
- [99] Benotti, M. J., Brownawell, B. J., Distributions of Pharmaceuticals in an Urban Estuary during both Dry- and Wet-Weather Conditions. *Environ. Sci. Technol.* 2007, 41, 5795-5802.
- [100] Ericson, J.F., An Evaluation of the OECD 308 Water/Sediment Systems for Investigating the Biodegradation of Pharmaceuticals. *Environ. Sci. Technol.* 2007, 41, 5803-5811.

- [101] Federal Countries: Schleswig-Holstein, Mecklenburg-Western Pomerania, Brandenburg, Lower Saxony, Hamburg, Saxony-Anhalt, Saxony. Arbeitsgemeinschaft für die Reinhaltung der Elbe. Arzneistoffe in Elbe und Saale, Germany, 2003.
- [102] Ternes, T.A., Rückstände von Arzneimitteln, Diagnostika und Antiseptika in Abwasser, Flüssen und Grundwasser. Postdoctoral lecture qualification, 2000, Mainz, Germany.
- [103] Ministry for the Environment and Nature Conservations, Agriculture and Consumer Protection of the state of North Rhine Westphalia, Untersuchungen zum Eintrag und zur Elimination von gefährlichen Stoffen in kommunalen Kläranlagen. final report, Düsseldorf (2004). STP Cologne Stammheim
- [104] Federation and federal state committee of Germany for the safety of chemical products (BLAC); Arzneimittel in der Umwelt, Auswertung der Untersuchungsergebnisse, BLAC-AG, Hamburg 2003.
- [105] Determination of pharmaceutical compounds in surface and ground waters in Loire-Bretagne basin, final report BRGM/RP-55578-FR, L. Amalric and S. Bristeau, BRGM Orléans France, 2007
- [106] Paffoni, C., B. Welte, et al. (2006). "New molecules involved by the european directives : from wastewater to drinking water treatment plants." European journal of water quality 37(1): 21-38. (France)
- [107] Potential contamination of sample from wastewater treatment plants (raw and treated water, sludge) and effluents from breeding by human and veterinary pharmaceutical drugs ADEME IRH Environnement, final report 20.02.2007 E Algros and M.-J. Jourdain
- [108] Ministry for the Environment and Conservations, Agriculture and Consumer Protection of the state of North Rhine Westphalia, Untersuchungen zum Eintrag und zur Elimination von gefährlichen Stoffen in kommunalen Kläranlagen. final report, Düsseldorf (2004). STP Duesseldorf South

- [109] M.P. Schluesener, Fate, pathways and methods for the determination of selected antibiotics and steroid hormones in the environment, PhD Thesis, University of Duisburg-Essen, 2006
- [110] Analysis of organic pollutants in environment, final report BRGM/RP-53749-FR, Dagnac T., Bristeau S., Leroy C., Coton C., Fleury N. and Jeannot R., BRGM Orléans, France 2005
- [111] Sebastine I.M. Wakeman R.J., Consumption and environmental hazards of pharmaceutical substances in the UK. Trans. IChemE. 2003, 81, 229-235
- [112] Webb S.F. ERA of human pharmaceuticals II – aquatic risk characterisation, Pharmaceuticals in the environment second edition, ed. Kümmerer K. Springer 2004, Berlin, Germany