

Pharmaceuticals in the environment

- The global perspective

Dr. Tim aus der Beek (IWW Water Centre)

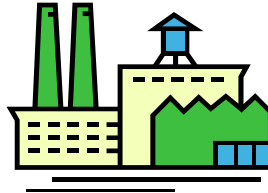
**Workshop: Pharmaceuticals and priority chemicals
in the Highlands and Islands environment**
Inverness, 21st June 2017

How do pharmaceuticals enter the environment?

Consumer



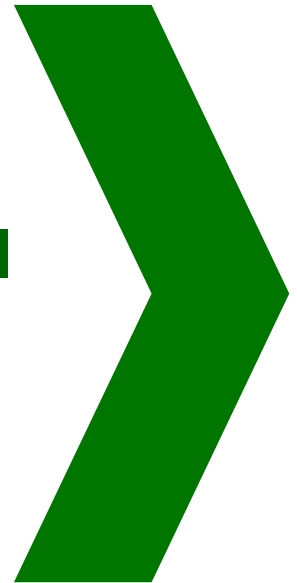
Pharmaceutical Industry



Hospital



Agriculture/Aquaculture

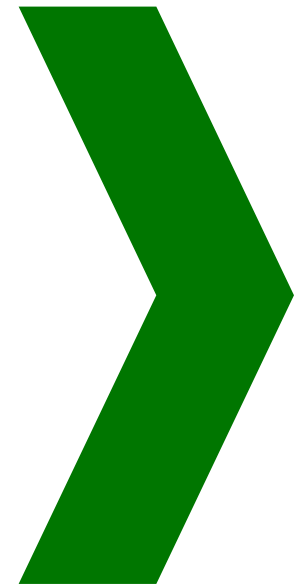


How do pharmaceuticals enter the environment?

**Waste water
treatment plants
(WWTP)**

Waste / Wastewater

Sludge / Manure

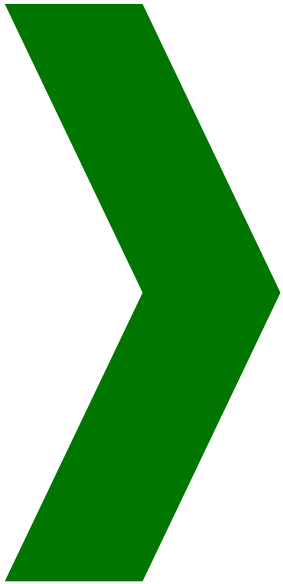


How do pharmaceuticals enter the environment?

Drinking water

**Surface and
Groundwater**

Agricultural soil



Motivation

- Multiple studies have shown that pharmaceuticals are occurring ubiquitarily in the environment of industrialized countries.
- In developing and emerging countries?
- Integration of the topic as emerging pollutants in UNEP-SAICM (www.saicm.org).
- IWW Water Centre and adelphi are conducting a study to determine the state of knowledge on the global scale.

The image shows the cover of a report titled "Pharmaceuticals in the environment - the global perspective". The cover features the logos of the Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety and the Umwelt Bundesamt. The title is in green text, followed by the subtitle "Occurrence, effects, and potential cooperative action under SAICM". Below the text are two images: a lush green stream flowing over rocks in a forest, and a close-up of several blue and white pills. At the bottom, the logos for IWW and adelphi are displayed.

Federal Ministry for the Environment, Nature Conservation, Building and Nuclear Safety

Umwelt Bundesamt

Pharmaceuticals in the environment
– the global perspective

Occurrence, effects, and potential
cooperative action under SAICM

IWW adelphi

Literature Compilation

Endnote© database:

- **1016 publications** reporting MECs of pharmaceuticals in various countries (plus 139 review articles)
- **Publications collected by**
 - Database search (ISI Web of Knowledge™, library catalogues, etc.)
 - Internet
 - Contacting of stakeholders (41 in 18 countries)
 - Research projects (NORMAN, KNAPPE, FATE-SEES included)
- **Types of publication**
 - Mostly English-language scientific papers
 - Relative little governmental reports
 - German-, Chinese-, French-, Russian-, Slovenian-, Portuguese-, Dutch-, Swedish- and Spanish-language publications evaluated

MEC Database (measured environmental concentrations)

■ 123,761 MEC entries from 1016 publications

Count	Matrix_English	Count	Matrix_English
49.330	1.891 Sewage urban (untreated)	3.070	283 Sediment - unspecific
	729 Sewage industrial (untreated)		1.247 Sediment - River/Stream
	2.889 Sewage hospital (untreated)		612 Sediment - Lake
	351 Sewage hospital (treated)		55 Sediment - Sea or Ocean
	13.219 WWTP inflow (untreated)		184 Sediment - Aquaculture
	27.579 WWTP effluent (treated)		155 Sediment - Estuary
	2.672 WWTP sludge		9 Suspended particulate matter - unspecific
67.987	3.245 Surface Water - unspecific		5 Suspended particulate matter - Estuary
	50.686 Surface Water - River/Stream		146 Suspended particulate matter - Sewage
	1.711 Surface Water - Lake		12 Suspended particulate matter - Sea or Ocean
	1.420 Surface Water - Sea or Ocean	362 Suspended particulate matter - River/Stream	
	467 Surface Water - Aquaculture	3.374	15 Rain
	743 Surface Water - Estuary		1.295 Soil
	485 Riverbank filtration		372 Soil Water
	3.304 Groundwater		999 Manure - liquid
	1.713 Well Water (untreated)		580 Manure - dung
	382 Tap water		18 Dust
	3.831 Drinking Water		95 Unknown

MEC: measured environmental concentration

Database Analyses

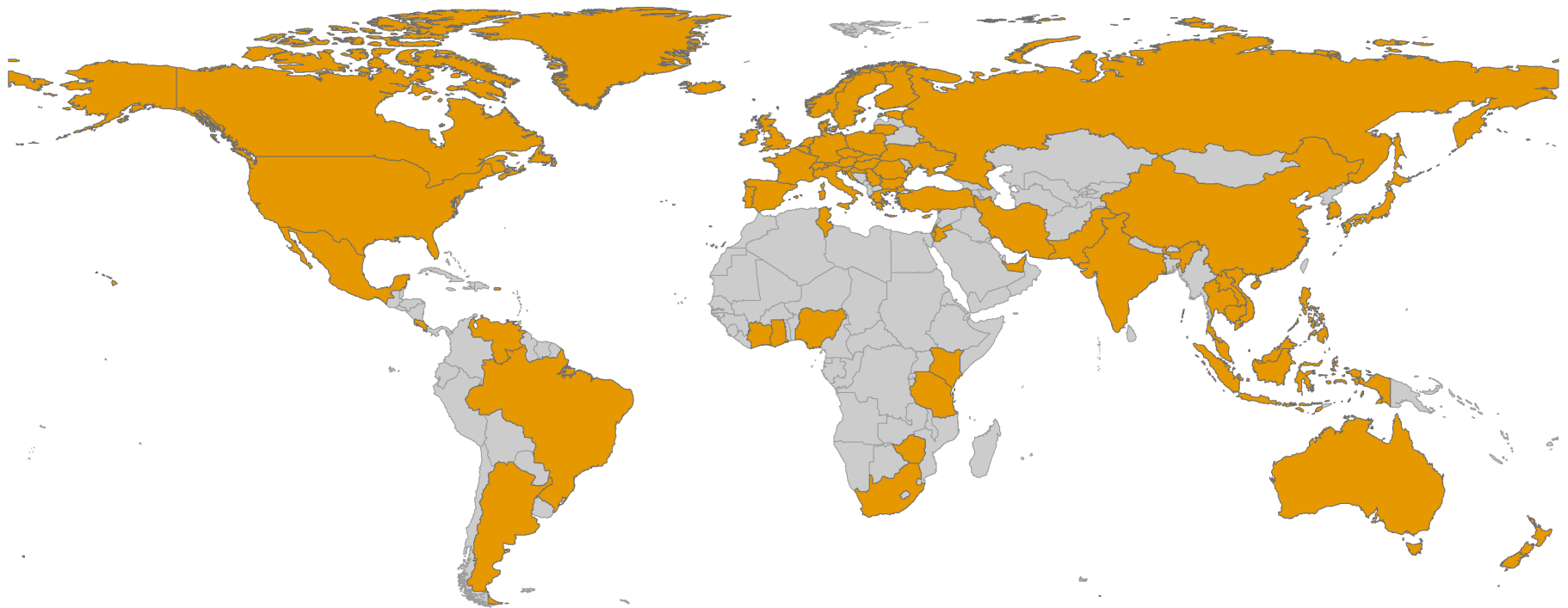
Questions to be answered:

- On a global scale, where have pharmaceuticals been found in the environment ?
- How many and what kind of pharmaceuticals have been found ?
- Are the same pharmaceuticals detected in each UN regional group?
- What is the source of the pharmaceuticals found ?
- At which concentrations are pharmaceuticals found in the environment?
- Can pharmaceuticals have ecotoxicological effects at these concentrations?

Data Analyses

In which countries have pharmaceuticals been found in the environment?

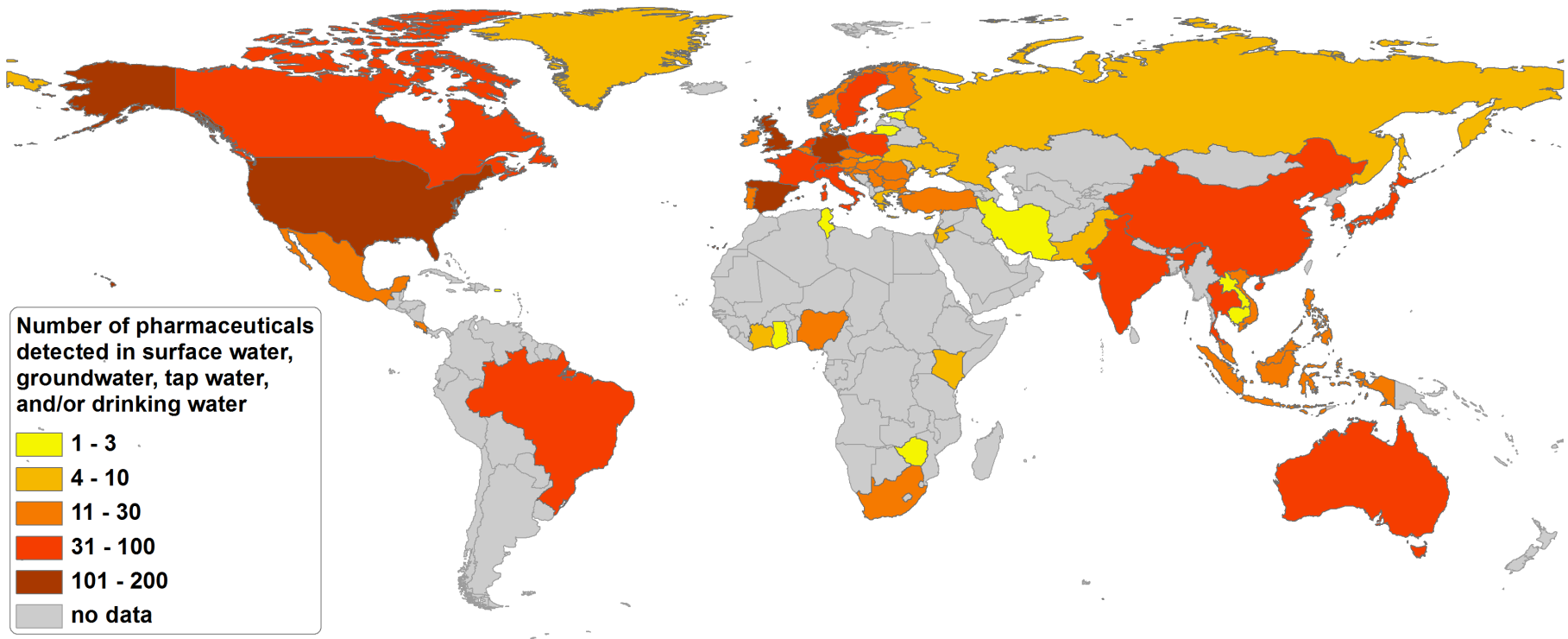
- In 71 countries (covering all 5 UN regional groups), pharmaceuticals have been detected in the environment. (concentration of at least one MEC in one matrix > detection limit)



Data Analyses

How many pharmaceuticals have been found in each UN regional group?

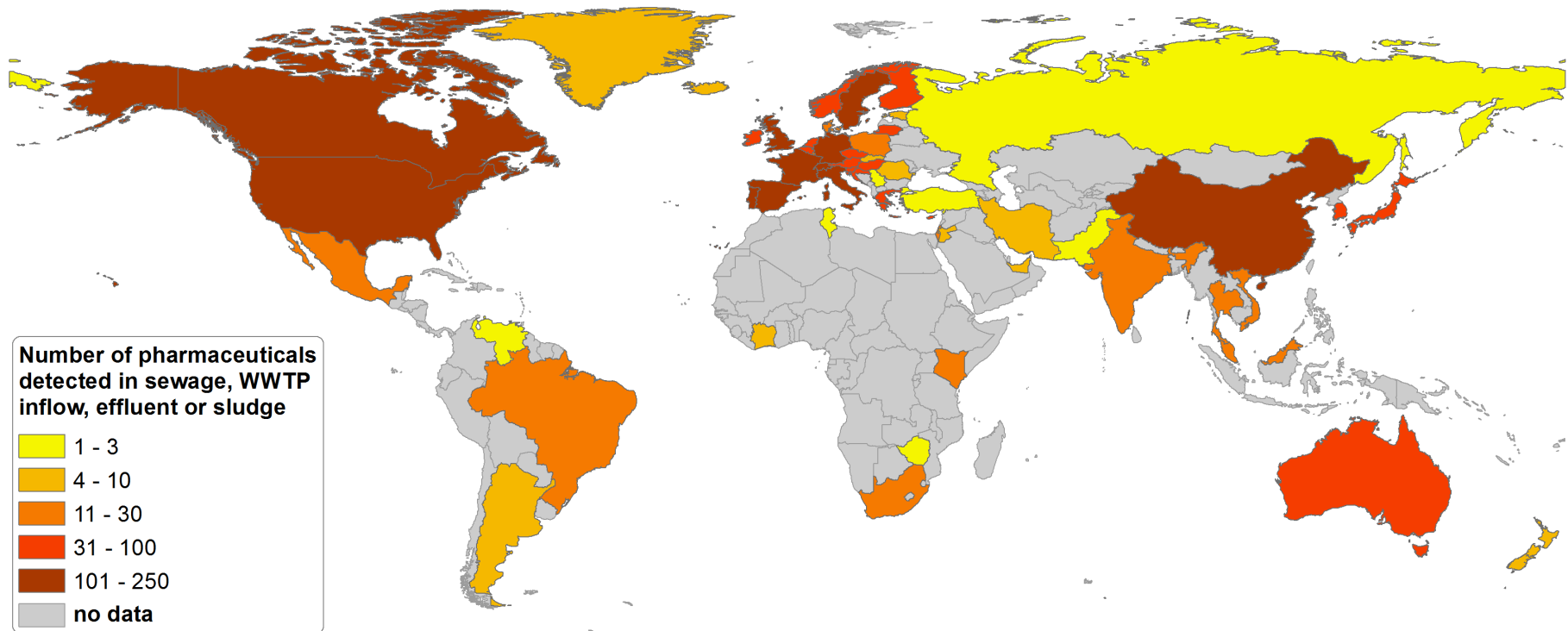
- In each UN regional group, ≥ 38 different pharmaceuticals have been found in surface water / groundwater / drinking water / tap water.



Data Analyses

How many pharmaceuticals are found in sewage or WWTP influent/effluent/sludge?

- Worldwide, 559 pharmaceuticals or their transformation products have been found in sewage or WWTP influent/effluent/sludge.



- **713 pharmaceuticals have been analysed (of which 142 are transformation products).**
- **631 have been found above their detection limits in the environment (of which 127 are transformation products).**

**631 pharmaceuticals detected
(of 713 analysed)**

Data Analyses

Are the same pharmaceuticals detected in each UN regional group?

**126 (205)
in EEC**

**249 (313)
in Asia-Pacific**

**574 (646)
in WEOC**

**55 (84)
in GRULAC**

**40 (59)
in Africa**

Data Analyses

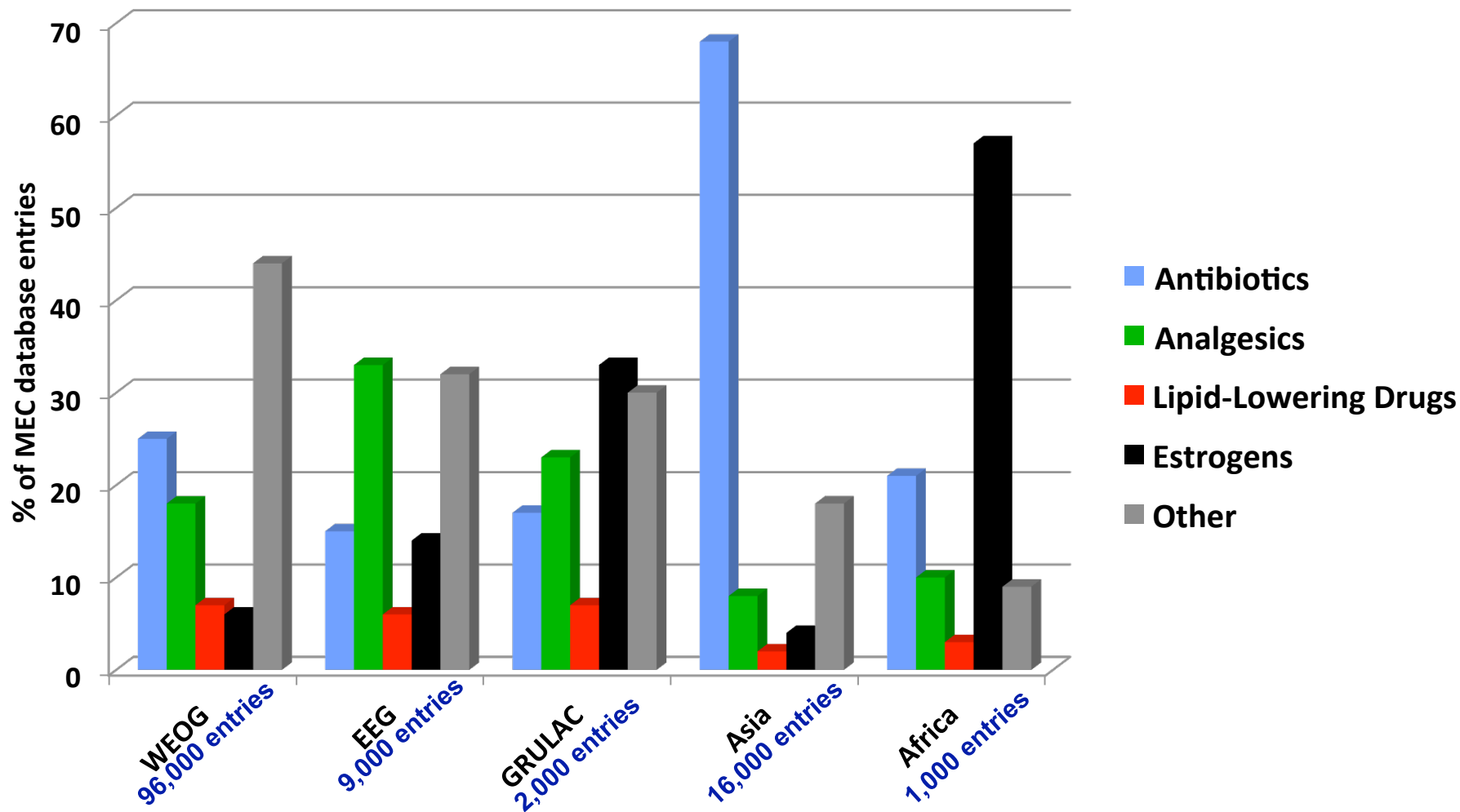
Are the same pharmaceuticals detected in each UN regional group?

- 16 pharmaceuticals were found in surface water / groundwater / drinking / tap water in each of the five UN regional groups

Name	Therapy Group	Number of Countries with Positive Detection in Surface Water, Groundwater, Drinking Water					
		African Group	Asia Pacific Group	EEG	GRULAC	WEOG	global
Diclofenac	Analgesics	3	8	13	3	23	50
Carbamazepine	Antiepileptic drugs	3	6	13	2	24	48
Ibuprofen	Analgesics	3	8	10	2	24	47
Sulfamethoxazole	Antibiotics	5	9	10	2	21	47
Naproxen	Analgesics	2	8	10	2	23	45
Estrone	Estrogen	1	10	6	2	16	35
17-beta-Estradiol	Estrogen	2	9	4	2	17	34
17-alpha-Ethinylestradiol	Estrogen	1	8	3	2	17	31
Trimethoprim	Antibiotics	2	9	3	2	13	29
Paracetamol	Analgesics	1	6	4	3	15	29
Clofibric acid	Lipid-lowering drugs	1	3	5	2	12	23
Ciprofloxacin	Antibiotics	1	5	1	2	11	20
Ofloxacin	Antibiotics	1	4	1	1	9	16
Estriol	Estrogen	1	1	2	1	10	15
Norfloxacin	Antibiotics	1	4	1	2	7	15
Acetylsalicylic acid	Analgesics	1	4	1	2	7	15

Data Analyses

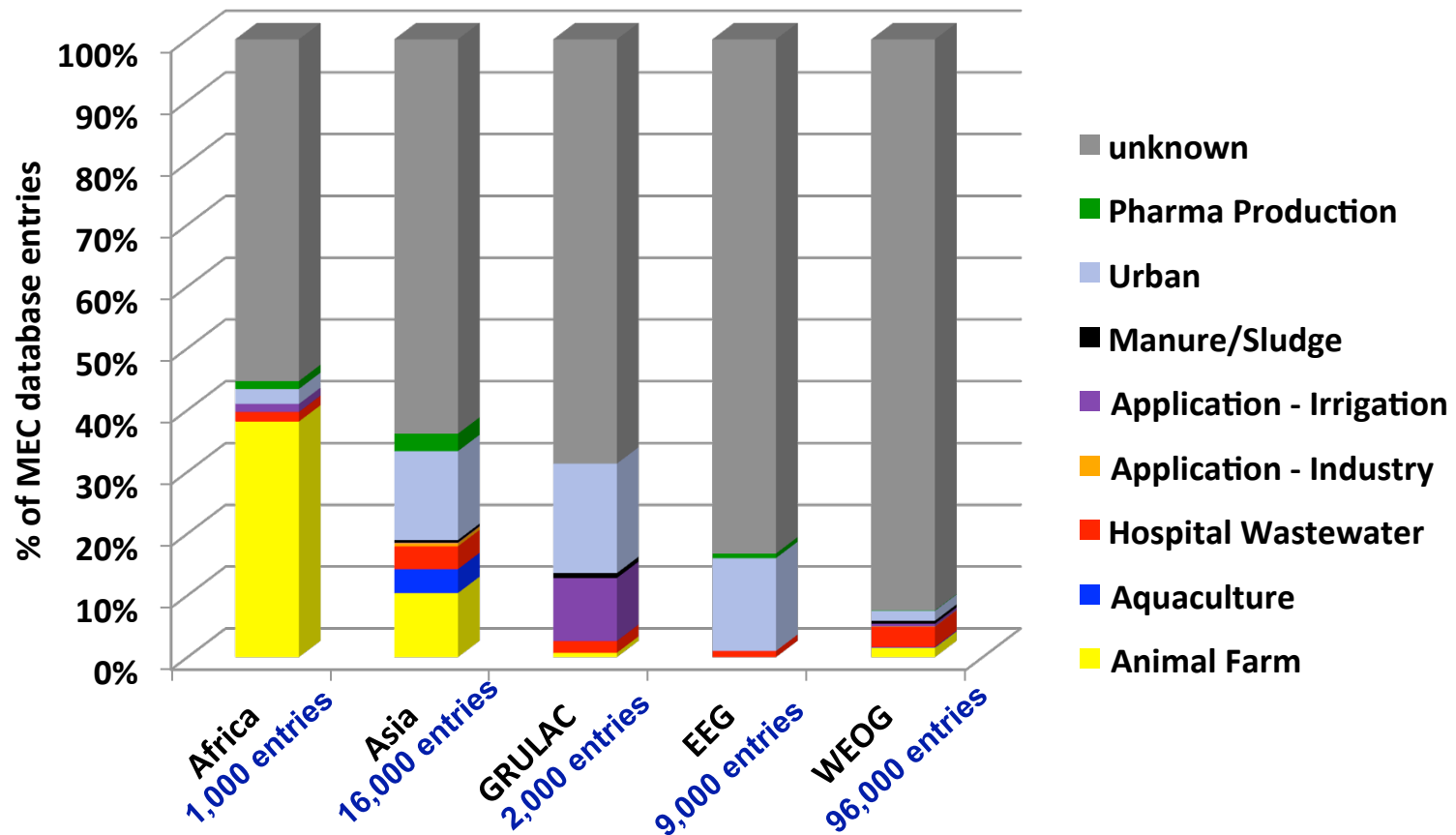
What kind of pharmaceuticals have been found in each UN groups?



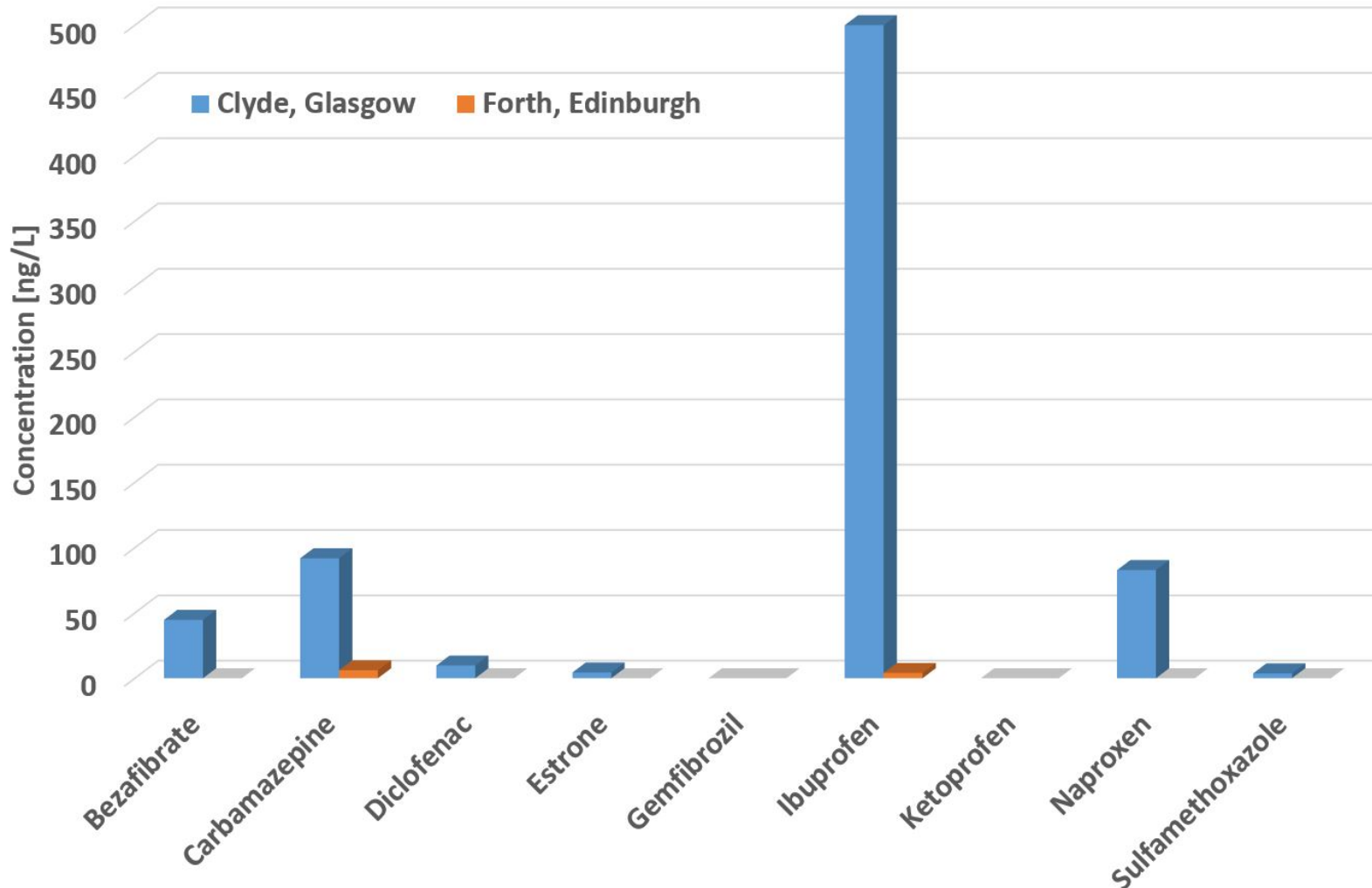
Data Analyses

What is the source of the pharmaceuticals found in the environment?

- Urban areas are a major contributor.
- Discharge from manufacturing, animal husbandry, and aquaculture are important regionally.

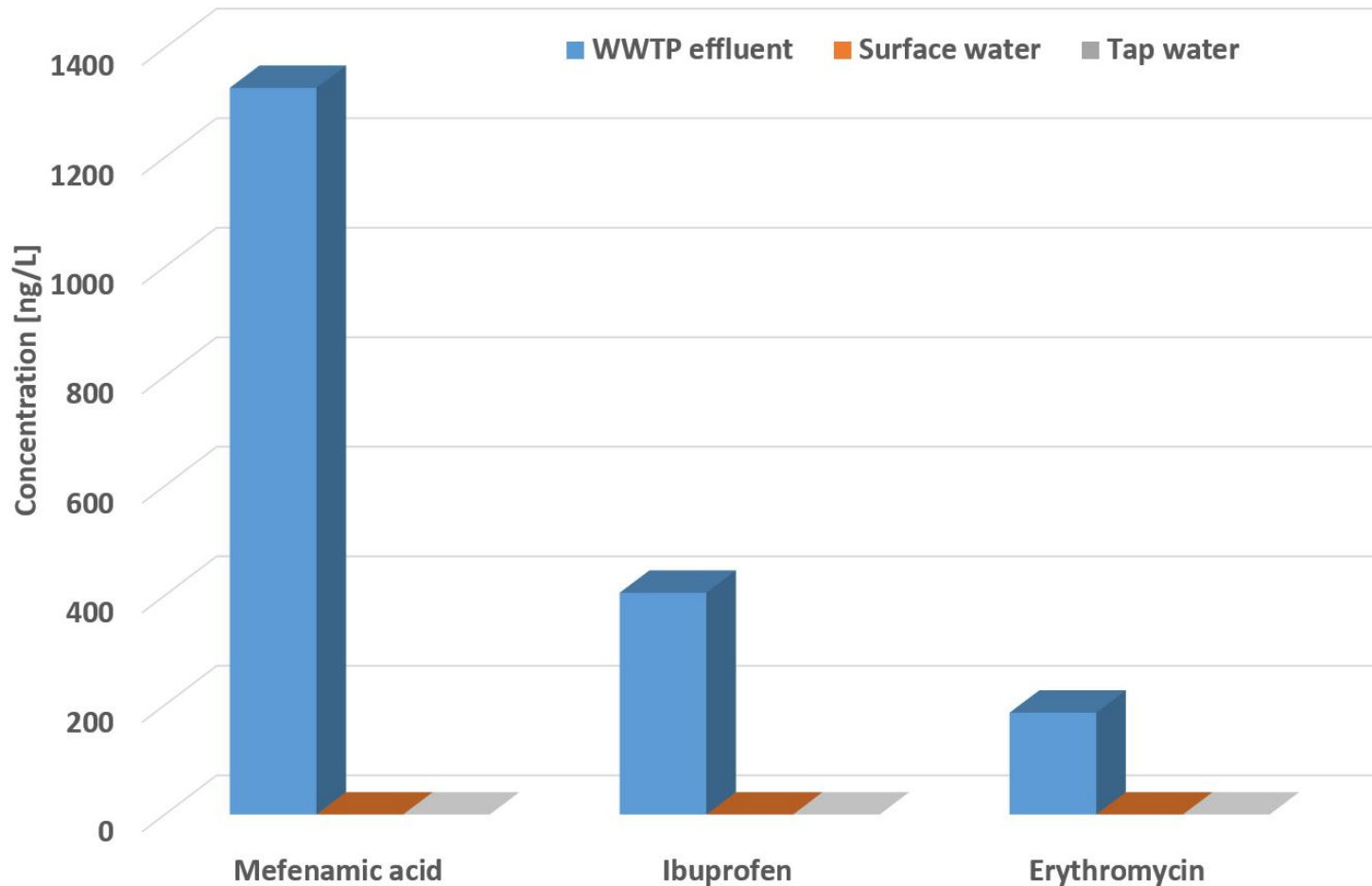


Measurement of 9 pharmaceuticals in two Scottish rivers



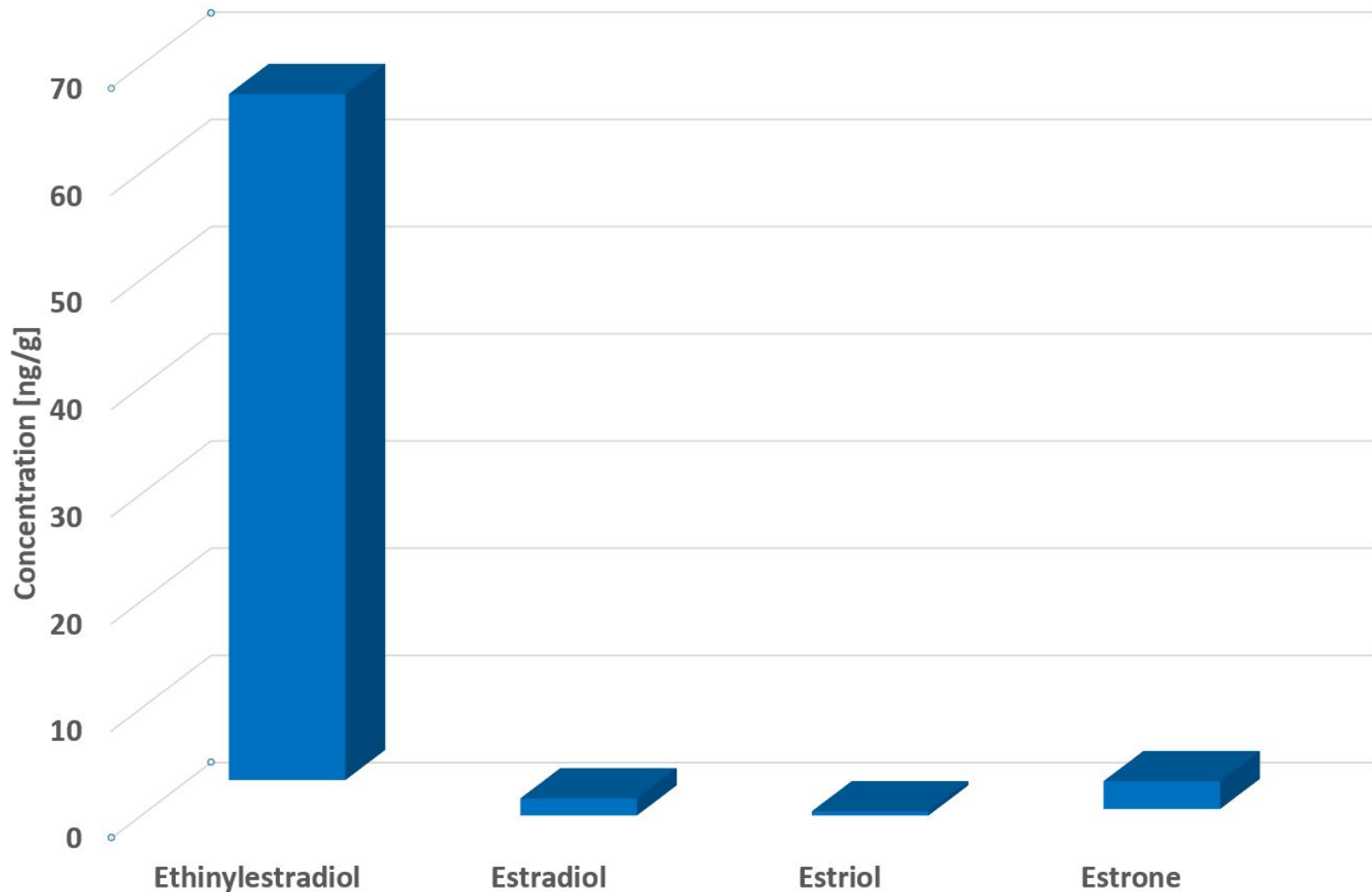
(Loos et al. 2008)

Measurement of 3 pharmaceuticals in wastewater, surface water, drinking water in Northern Scotland



(Nebot et al. 2007)

Measurement of range of 4 estrogens in 8 soils (Hartwood)



(Zhang et al. 2011)

Effects of human medicines in the environment – case studies

17 α -Ethinylestradiol

Synthetic estrogen

Fathead minnow (*Pimephales promelas*)

Population collapse due to feminization of male fish

Whole-lake experiment

Kidd et al. 2007

Fluoxetine

Antidepressant

Leopard Frog (*Rana pipiens*)

Delayed tadpole development

Laboratory

Foster et al. 2010

Enrofloxacin, Ciprofloxacin

Antibiotics

Cyanobacterium (*Anabaena flosaquae*)

Duckweed (*Lemna minor*)

Growth inhibition

Laboratory

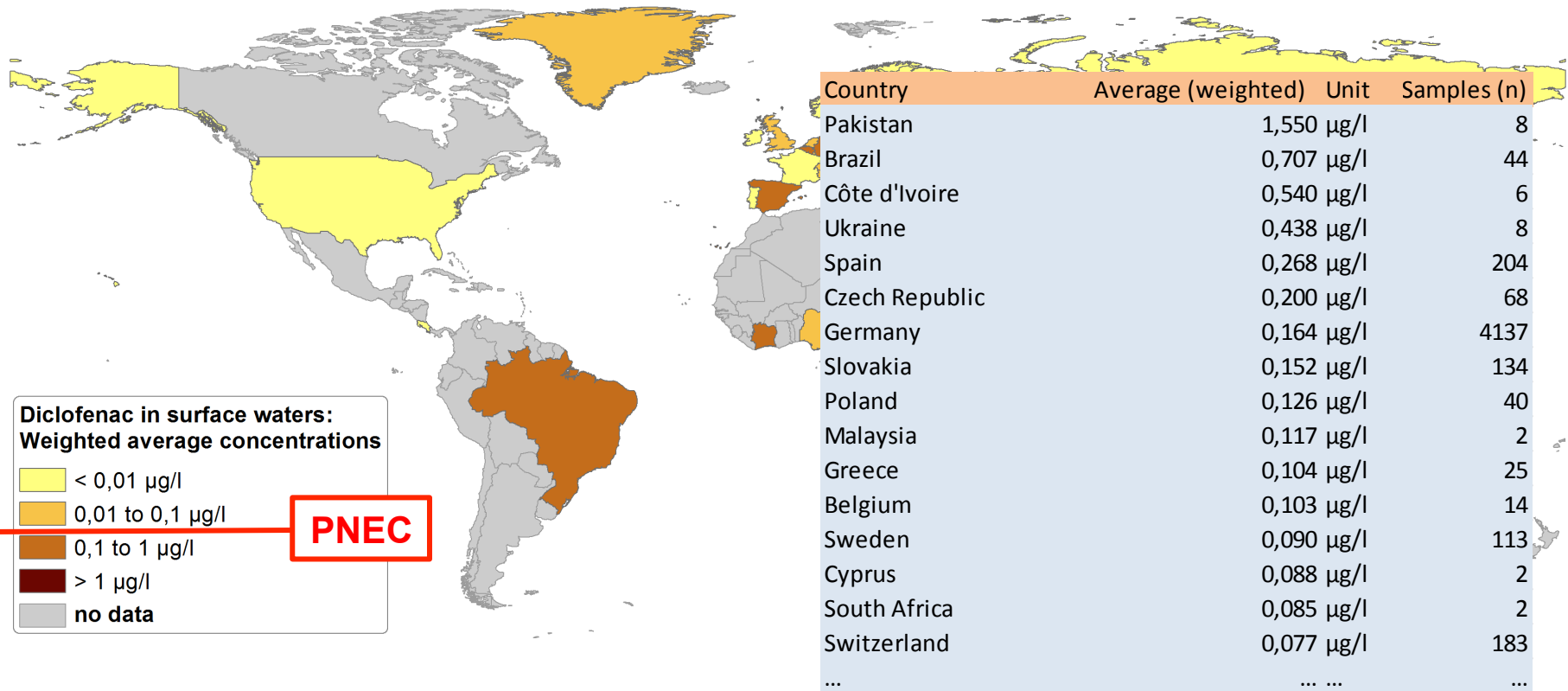
Ebert et al. 2011

Data Analyses

Can pharmaceuticals have ecotoxicological effects at these concentrations?

■ Average Diclofenac concentration in surface waters

(only monitoring campaigns in which “single values” or “average values” with known sample size n are reported)



**Diclofenac in surface waters:
Weighted average concentrations**

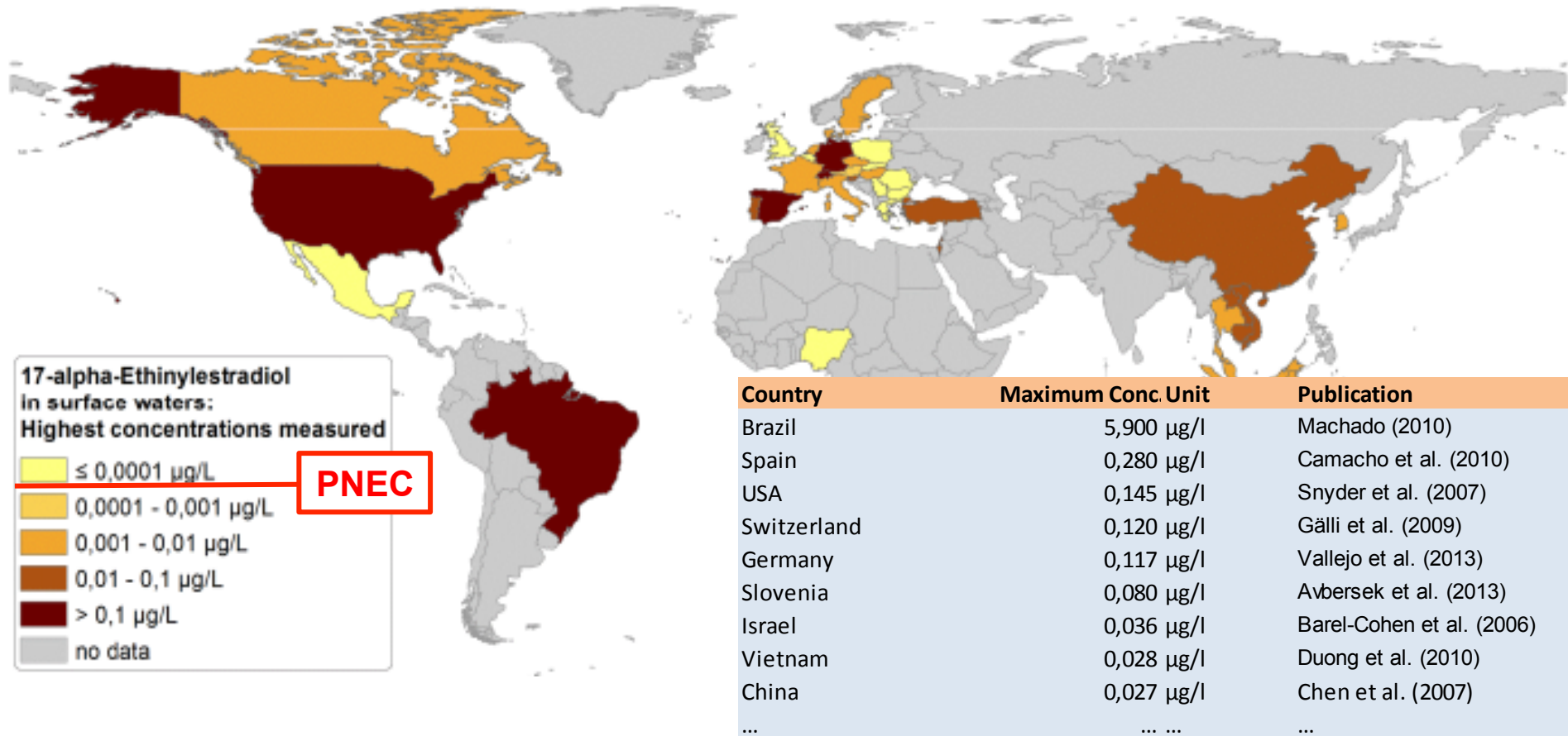
- < 0,01 µg/l
- 0,01 to 0,1 µg/l
- 0,1 to 1 µg/l
- > 1 µg/l
- no data

PNEC

Data Analyses

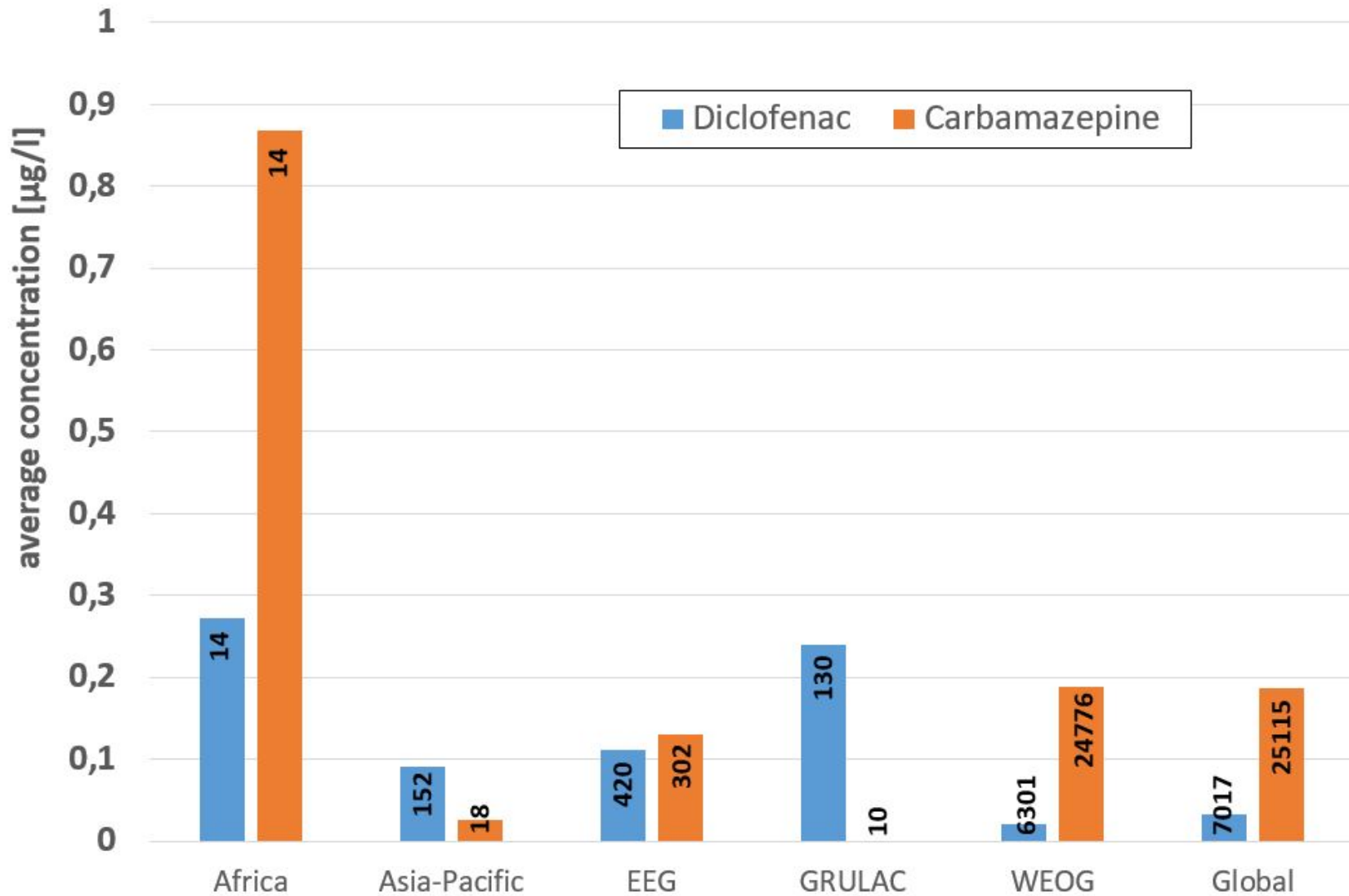
At which concentration are pharmaceuticals found in the environment?

■ Maximum 17- α -Ethinylestradiol (EE2, birth control pill) concentrations in surface waters



Data Analyses

At which concentration are pharmaceuticals found in the environment?



Conclusions

- **Pharmaceuticals occur globally in the environment (not just in industrialized countries):**
 - Detected in 71 countries covering all 5 UN regional groups
 - Data availability for emerging and developing countries increasing, but still lower than in western countries
- **In most countries, certain pharmaceuticals prevail at concentrations above PNEC in surface waters, suggesting adverse ecotoxicological effects in these locations.**
- **Different pharmaceutical groups have been in focus of monitoring in different UN regions, e.g. antibiotics in Asia and estrogens in Africa.**
- **Urban wastewater discharge is the dominant emission pathway, while discharge from manufacturing, animal husbandry and aquaculture are important regionally.**
- **Available data on production/consumption not sufficient for regional analysis of relevant pharmaceuticals.**

Home - Mozilla Firefox

Datei Bearbeiten Ansicht Chronik Lesezeichen Extras Hilfe

Home

pharmaceuticals-in-the-environment.org/en/home/dok/2.php

Umwelt Bundes Amt for our Environment

Pharmaceuticals in the environment

Occurrence, effects, and options for action

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Home

Pharmaceuticals are known to occur widely in the aquatic environment of industrialized countries. In developing and emerging countries, information on the occurrence of pharmaceuticals in the environment has become more readily available in recent years. However, a concise picture on the relevant pharmaceutical, their prevailing concentrations in the environment, and their potential effects on human and ecosystem health is still elusive in these countries.

The International Society of Doctors for the Environment has suggested the topic "Environmentally Persistent Pharmaceutical Pollutants" (EPPP) for nomination as an emerging issue under the Strategic Approach on International Chemicals Management (SAICM) of the United Nation Environmental Programme (UNEP).

As the basis for further considerations and more concrete discussions, the goal of the current project is to clearly define the state of knowledge on the global relevance of pharmaceuticals in the environment.

The main tasks of the project are thus to

- compile Measured Environmental Concentrations (MEC) of human and veterinary pharmaceuticals from all five UN regional groups,
- compare regional consumption data and future trends,
- assess the relevance of different emission pathways (production, use, disposal),
- assess the role of infrastructure, population, pharmaceutical availability, agricultural practice, etc. on the emissions of pharmaceuticals into the environment,
- provide databases and maps that could illustrate the global relevance of pharmaceuticals in the environment as an emerging issue, and
- prepare possible activities for inclusion into the global plan for action.

Umwelt Bundes Amt for our Environment

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Conference Management

adelphi

PHARMACEUTICALS IN THE ENVIRONMENT—GLOBAL OCCURRENCES AND PERSPECTIVES

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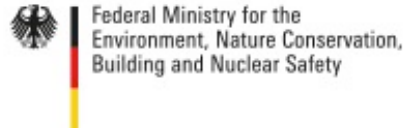
[‡]Section IV 2.2 Pharmaceuticals, Washing and Cleaning Agents, Umweltbundesamt (German Federal Environment Agency), Dessau, Germany

(Submitted 27 February 2015; Returned for Revision 3 July 2015; Accepted 11 December 2015)

Abstract: Pharmaceuticals are known to occur widely in the environment of industrialized countries. In developing countries, more monitoring results have recently become available, but a concise picture of measured environmental concentrations (MECs) is still elusive. Through a comprehensive literature review of 1016 original publications and 150 review articles, the authors collected MECs for human and veterinary pharmaceutical substances reported worldwide in surface water, groundwater, tap/drinking water, manure, soil, and other environmental matrices in a comprehensive database. Due to the heterogeneity of the data sources, a simplified data quality assessment was conducted. The database reveals that pharmaceuticals or their transformation products have been detected in the

Acknowledgement

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 - BMUB: V. Karavezyris, J. Emig
 - Adelphi: G. Gruettner, A. Carius
- The database and the full report is available at <https://www.umweltbundesamt.de/en/database-pharmaceuticals-in-the-environment-figures-0> free of charge.



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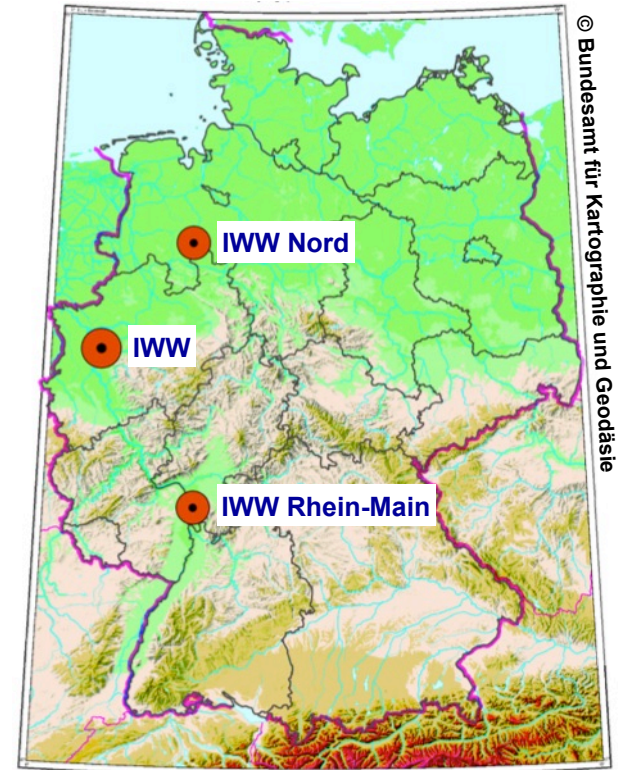
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