Emerging issues of micro-pollutants in wastewater reuse and challenges for low and middle income countries

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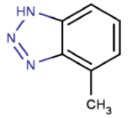
World Water Week, 27 August – 1 September, 2017
Event: Contaminants of Emerging Concern – a challenge for wastewater reuse?

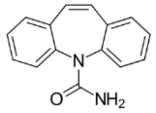
Outline

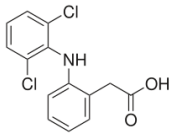
- Background on micro-pollutants
- Emerging issues of micro-pollutants in wastewater reuse
- Challenges for low and middle income countries

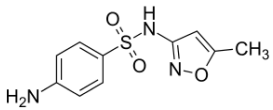
Background

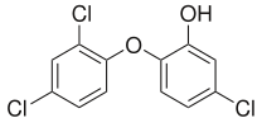
Definitions











Micro-pollutants are substances that originate from anthropogenic sources and appear in small concentrations below several µg/L in natural waters*

Micro-pollutants are so called Contaminants of Emerging Concern (CEC) if they are

- Poorly characterized in terms of sources, analytical detection limits, environmental pathways and persistence
- Having the potential, or are suspected, to cause adverse ecological and/or health effects
- Unregulated, thresholds do not exist
- Not routinely monitored

Adapted from State of Massachusetts and NORMAN Network

*P. Fuhrmann, Ministry of the *Environment*, Climate Protection and the Energy Sector Baden-Württemberg

Background

CEC: Compound groups and their functions

Compound Group	Function
Pharmaceuticals	Beta blockers, lipid-lowering agents, anti-epileptics, anti-inflammatories, pain relievers, fever reducer, antibiotics, ...
Personal care products (e.g. cosmetics, shower gels, shampoos, lotions, sunscreens)	Fragrances, preservatives, insect repellents, dispersants, UV-filters, antimicrobial agents …
Industrial products (e.g. textiles, plastics, detergents, food, beverages)	Plasticizers, corrosion inhibitors, antimicrobial agents, sweeteners, preservatives, stain repellents, flame retardants, dispersants, anti-caking agents, impregnates, binders, colorants, ….
Natural compounds	Caffeine, cyanotoxins, „metabolites of pesticides and pharmaceuticals“, …

Background

Input of CEC into municipal wastewater

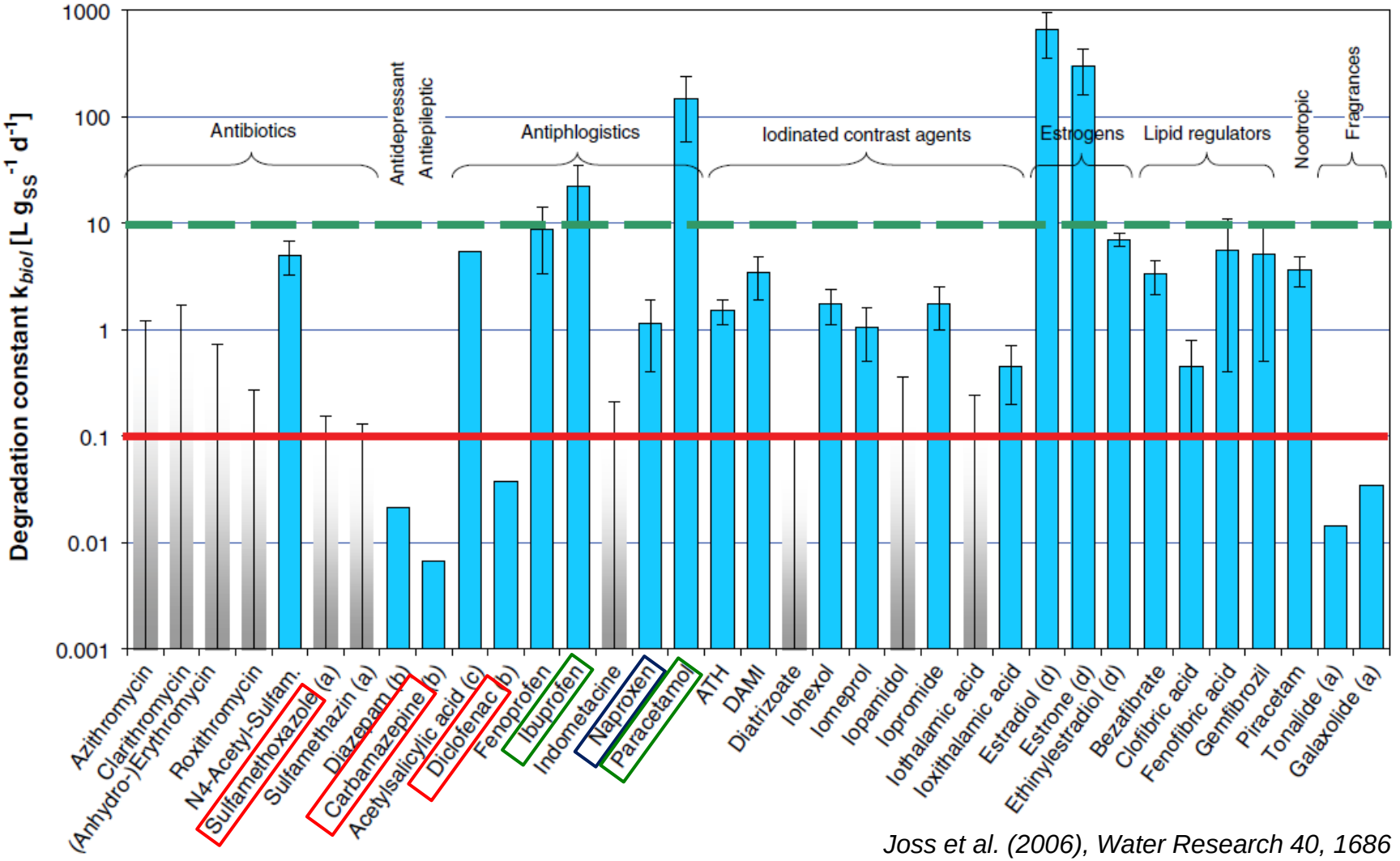
„CEC products“

„Home activities“

„Wastewater sink“

Emerging issues

CEC are not completely removed from wastewater



Joss et al. (2006), Water Research 40, 1686

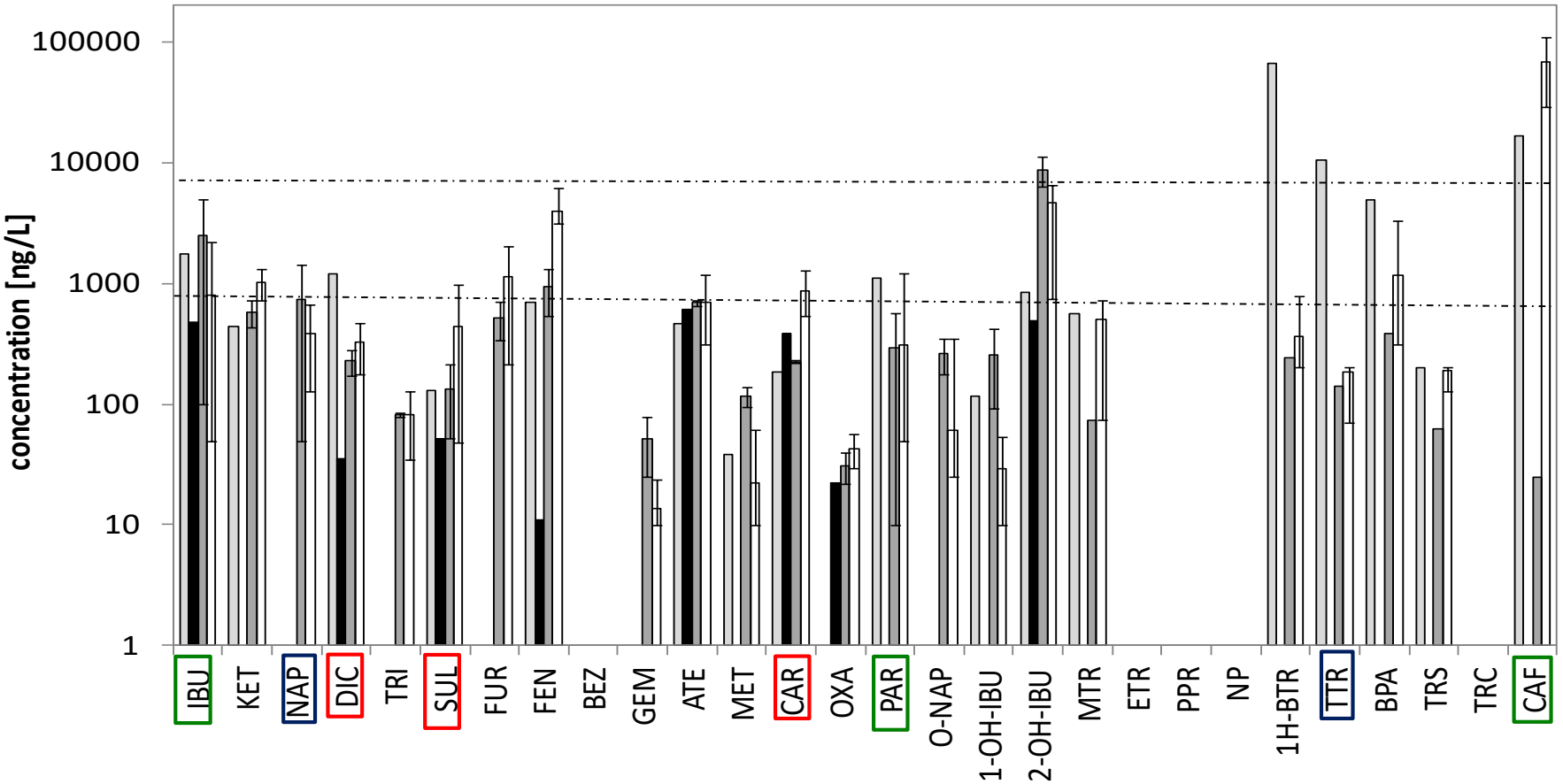
Error bars: 95% confidence interval

Faded columns: values for which the limited experimental resolution allows only an upper limit for k_{biol}

BGR Bundesanstalt für Geowissenschaften und Rohstoffe
GEOZENTRUM HANNOVER

Emerging issues

Mean concentrations of CEC in treated wastewater (Tunisia)



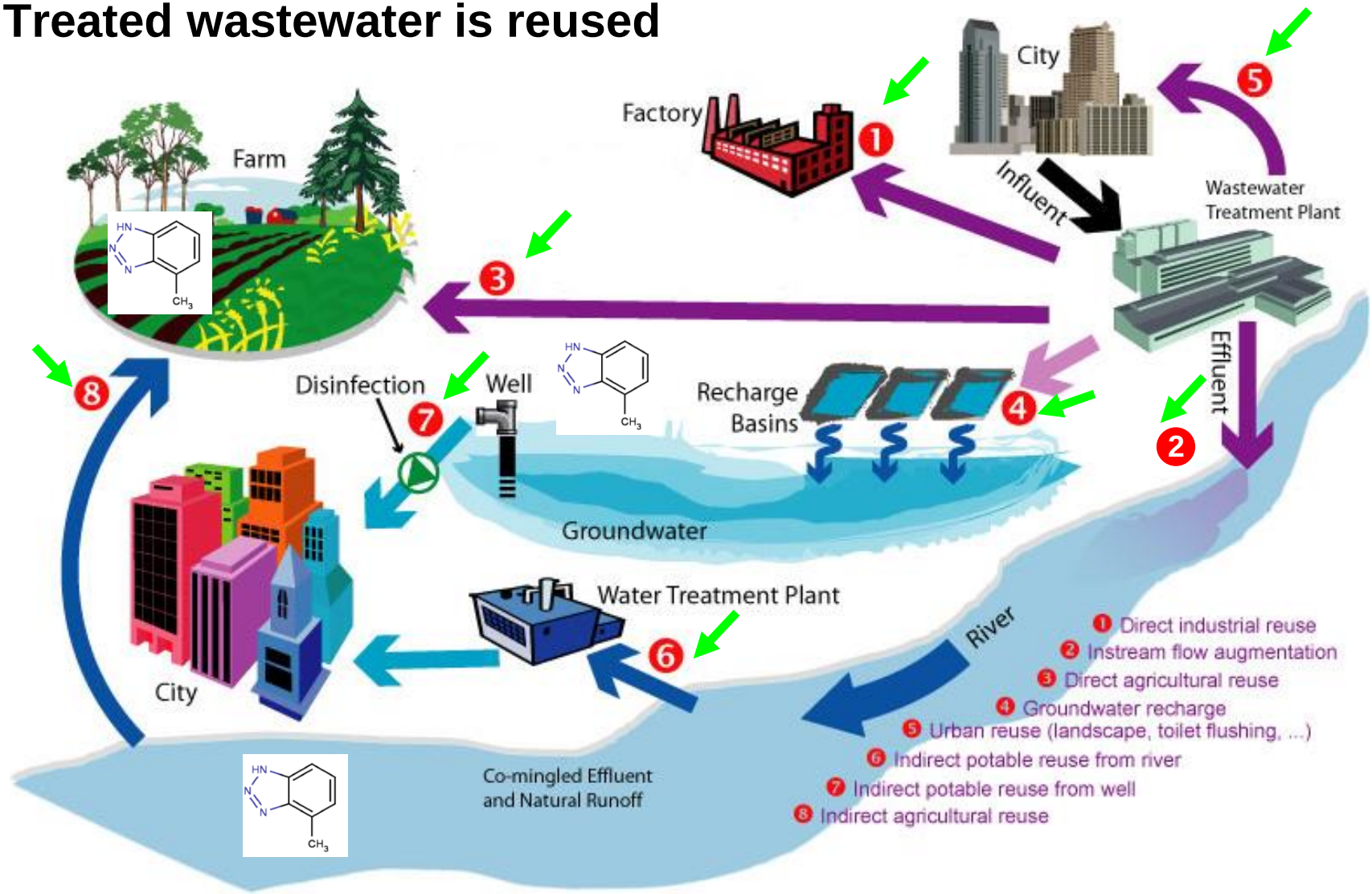
Survey in 2014, 15 samples, 28 CEC

Removal efficiency < 20%, 20 -90 %, > 90%

(Voutsa et al., 2006, Joss et al., 2006, Luo et al., 2014)

Emerging issues

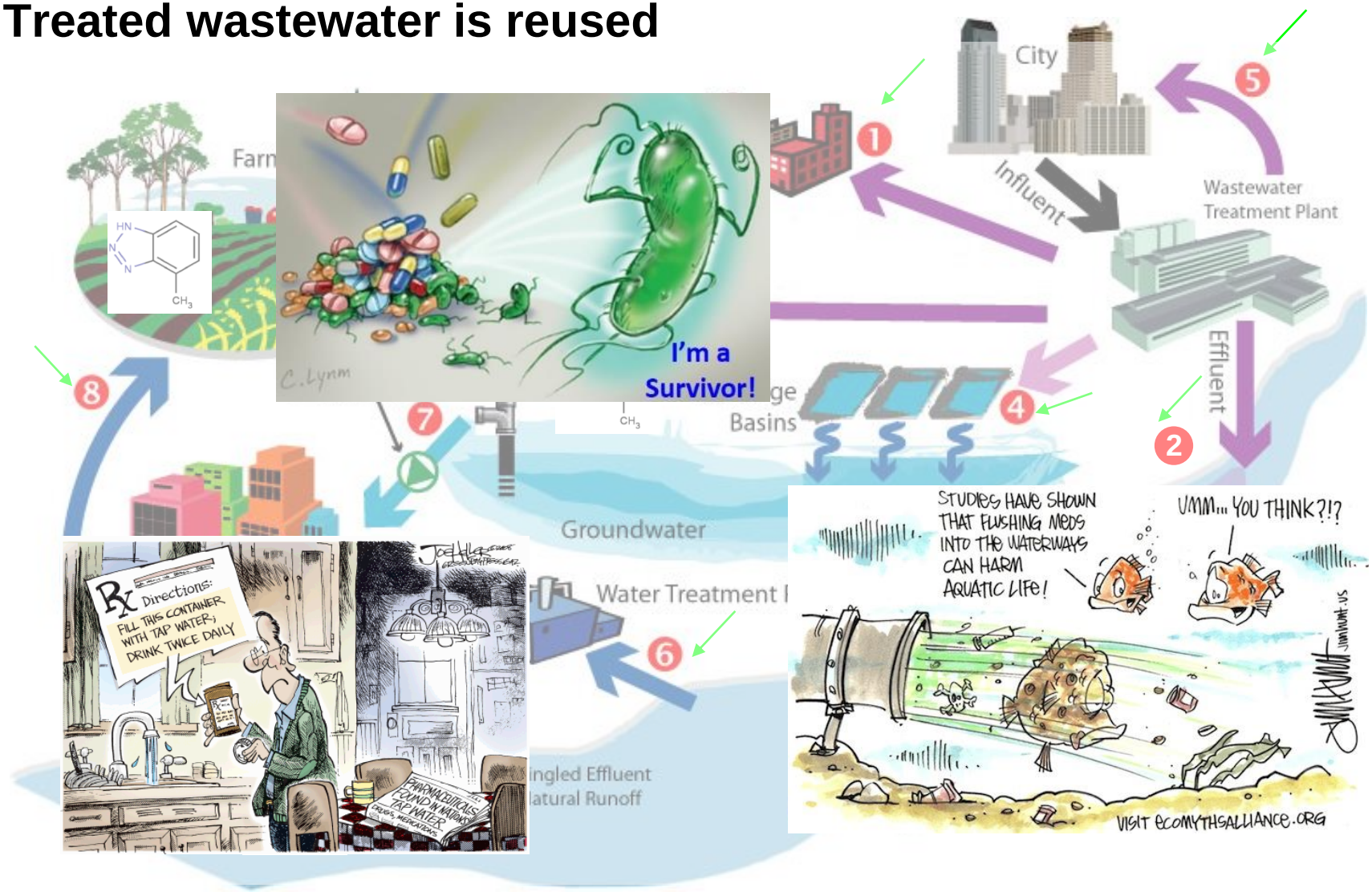
Treated wastewater is reused



Adapted from California Department of Water Resources (2013)

Emerging issues

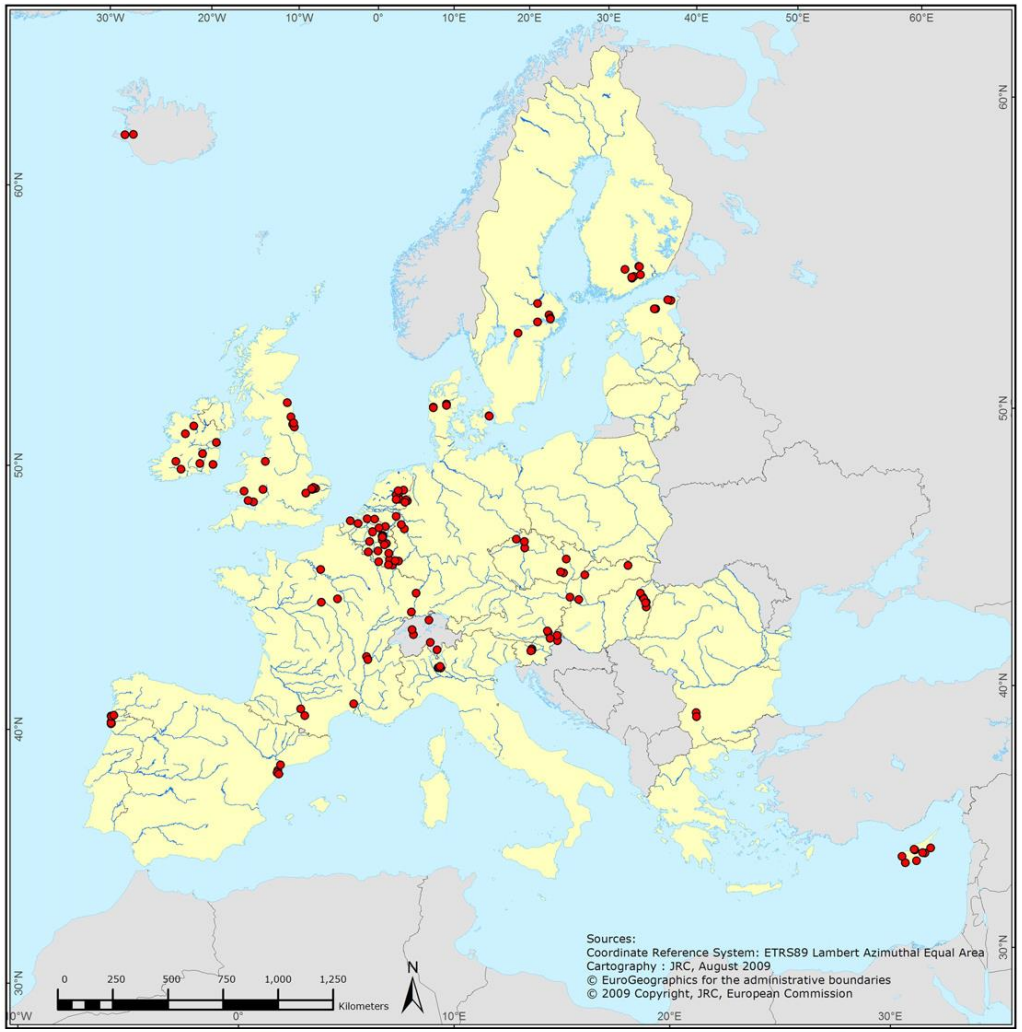
Treated wastewater is reused



Adapted from California Department of Water Resources (2013)

Emerging issues

CEC in groundwater (European survey in 2008)



164 samples, 59 CEC

Detection frequency of Cmax of selected CEC:

caffeine: 82.9%; 189 ng/L
tolyltriazoles: 51.8%, 516 ng/L
carbamazepine: 42.1%; 390 ng/L
sulfamethoxazole: 24%; 38 ng/L
ibuprofen: 6.7 %, 395 ng/L
diclophenac: 4.9%, 24 ng/L

Different sources!

Loos et al. (2008), Water Research

Emerging issues

CEC in groundwater (Tunisia, 2014) 12 samples, 28 CEC

sulfamethoxazole
carbamazepine
methylparabene
propylparabene
1H-benzotriazole
bisphenol A
triclosan

Sources:
- Irrigation of treated wastewater
- liquid manure

antibiotic resistances

	Well 1 AA	Well 2 RA	Well 3 NA	Well 2	Well 8	Control Well
Sampling time: 22.07.2014						
SUL	nd	<LOQ	<LOQ	<LOQ	46	29
CAR	nd	55	<LOQ	22	149	<LOQ
MTR	<LOQ	<LOQ	63	<LOQ	<LOQ	<LOQ
PPR	<LOQ	<LOQ	30	<LOQ	<LOQ	<LOQ
1H-BTR	<LOQ	45	24	25	40	<LOQ
BPA	<LOQ	<LOQ	189	<LOQ	24	<LOQ
TRS	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
Sampling time: 26.08.2014						
SUL	nd	<LOQ	<LOQ	<LOQ	37	33
CAR	nd	74	<LOQ	<LOQ	155	<LOQ
MTR	109	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
PPR	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
1H-BTR	23	21	22	<LOQ	40	21
BPA	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ	<LOQ
TRS	289	83	34	68	22	42

Fries E., Mahjoub O. et al., 2016, Fresenius Environmental Bulletin 25, 3317

Challenges

1. Contamination of natural resources

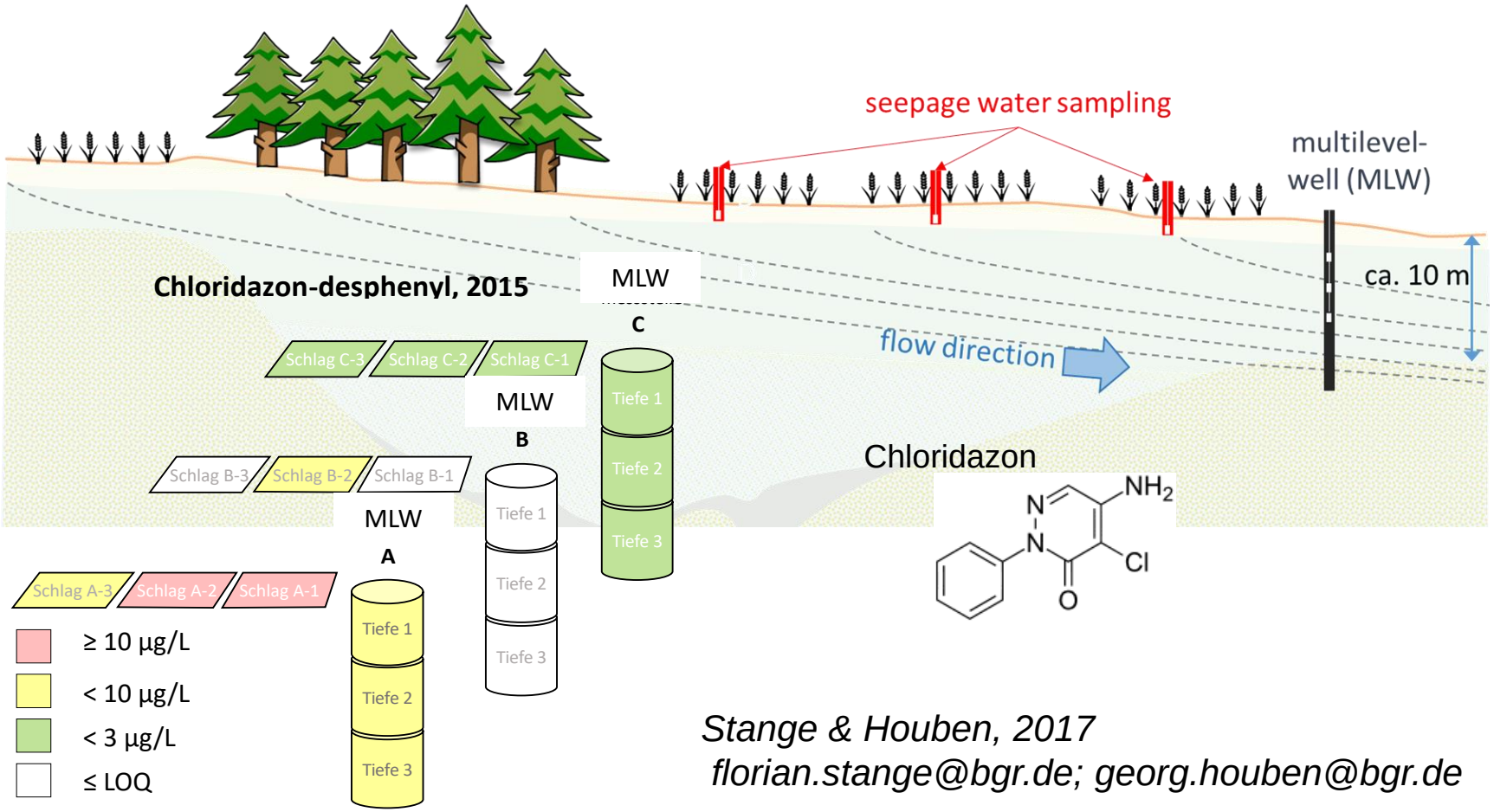
- Define and minimize pollution sources
- Treat wastewater sustainably
- Add regulations related to wastewater discharge and reuse
- Estimate aquifer vulnerability
- Introduce monitoring of water and soil resources
- Investigate consumer behaviour
- Perform public awareness campaigns
- Introduce take-back programmes for pharmaceuticals

Challenges

2. Metabolites of pesticides

MetaBoTig (2015-2017):

"Transport and persistence of metabolites of pesticides in the unsaturated zone and in groundwater at Fuhrberger Feld, Germany"



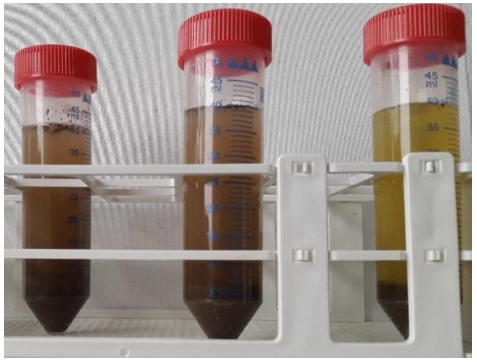
Stange & Houben, 2017
florian.stange@bgr.de; georg.houben@bgr.de

Challenges

DENANA (2014-2017):

"Design Criteria for Sustainable Nanomaterials"

- 17 German partners (Science, Industry, Authorities)
- Funded by Federal Ministry of Education and Research



Batch experiments with soils

Column experiments with soils

Aims of BGR project:

Release of silver and cerium dioxide nanoparticles from sewage sludge and soil

Lysimeter experiments
(in collaboration with Fraunhofer-Institut, Schmallenberg)

Hoppe et al., 2017, martin.hoppe@bgr.de

Challenges

4. Cooperation and stakeholder dialog

TOPSOIL (2015-2020)

"Top soil and water - The climate challenge in the near subsurface"

- 23 partners (Netherlands, Denmark, England, Belgium, Germany)
- Funded by EU

<u>Aims of BGR project:</u>

- investigate the transport behavior of **veterinary pharmaceuticals** through the unsaturated zone (South of Oldenburg, Germany)
- Develop, together with stakeholders, strategies to minimize the groundwater pollution

Stadler et al., 2017, susanne.stadler@bgr.de

Thank you for your attention

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Sousse, Tunisia August 2013

Emerging issues of micro-pollutants in wastewater reuse

Input of wastewater related CEC into the environment

Instream flow augmentation 2

Direct and indirect agricultural reuse 3 8

CEC in SURFACE WATER:
Negative effects on organisms

CEC in SOIL:
Negative effects on organisms and functions

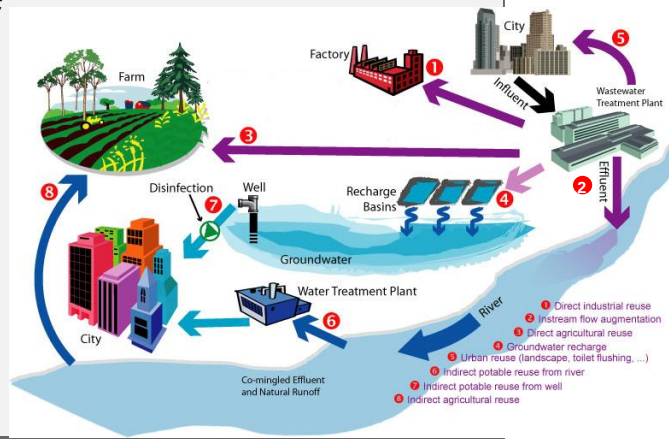
- *Toxic and endocrine effects*
- *"cocktail" effect*

Indirect potable use from river 6
(bank filtration)

Transport in the unsaturated zone

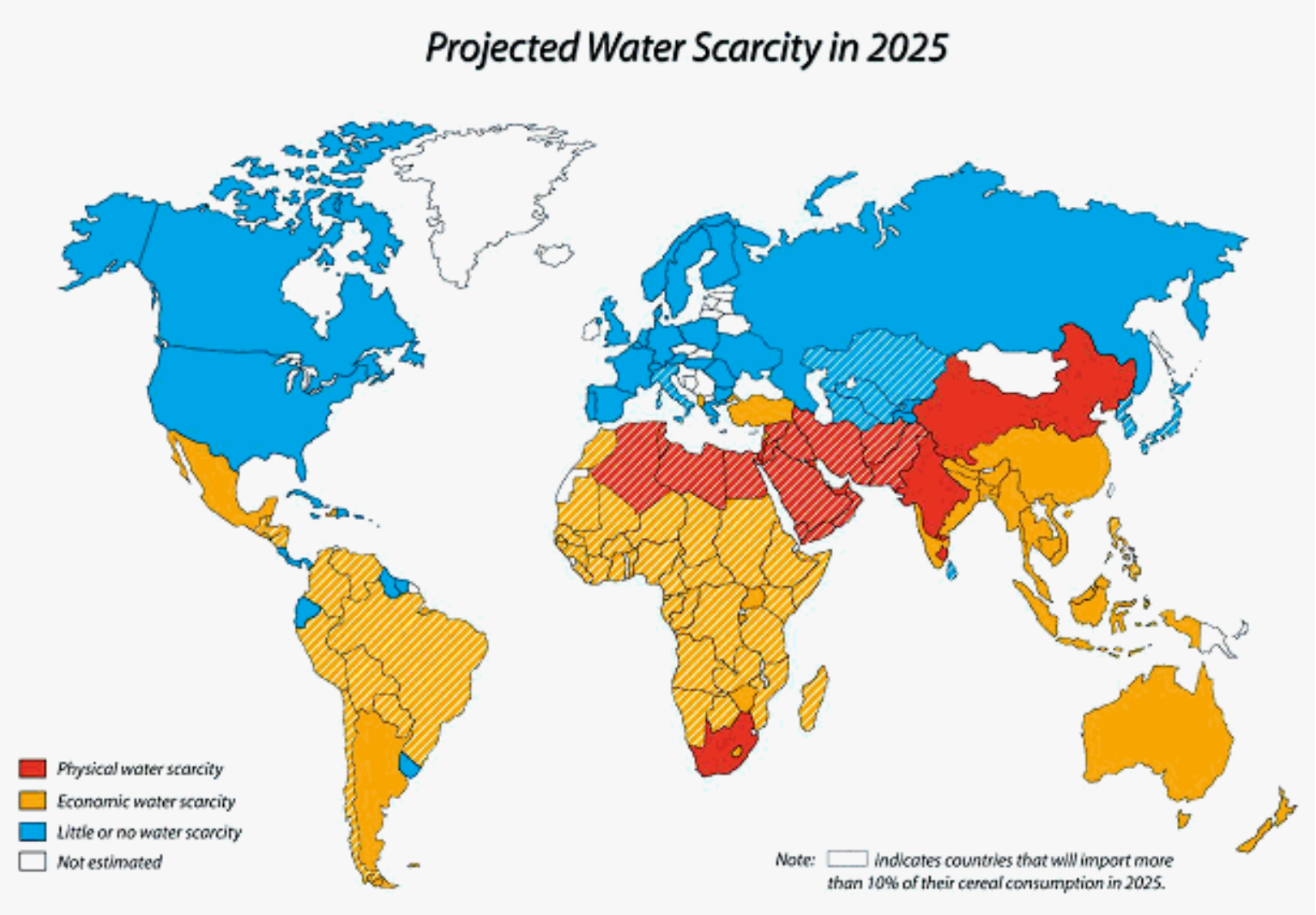
CEC in GROUNDWATER:
Risk for drinking water

Groundwater recharge 4



Emerging issues of micro-pollutants in wastewater reuse

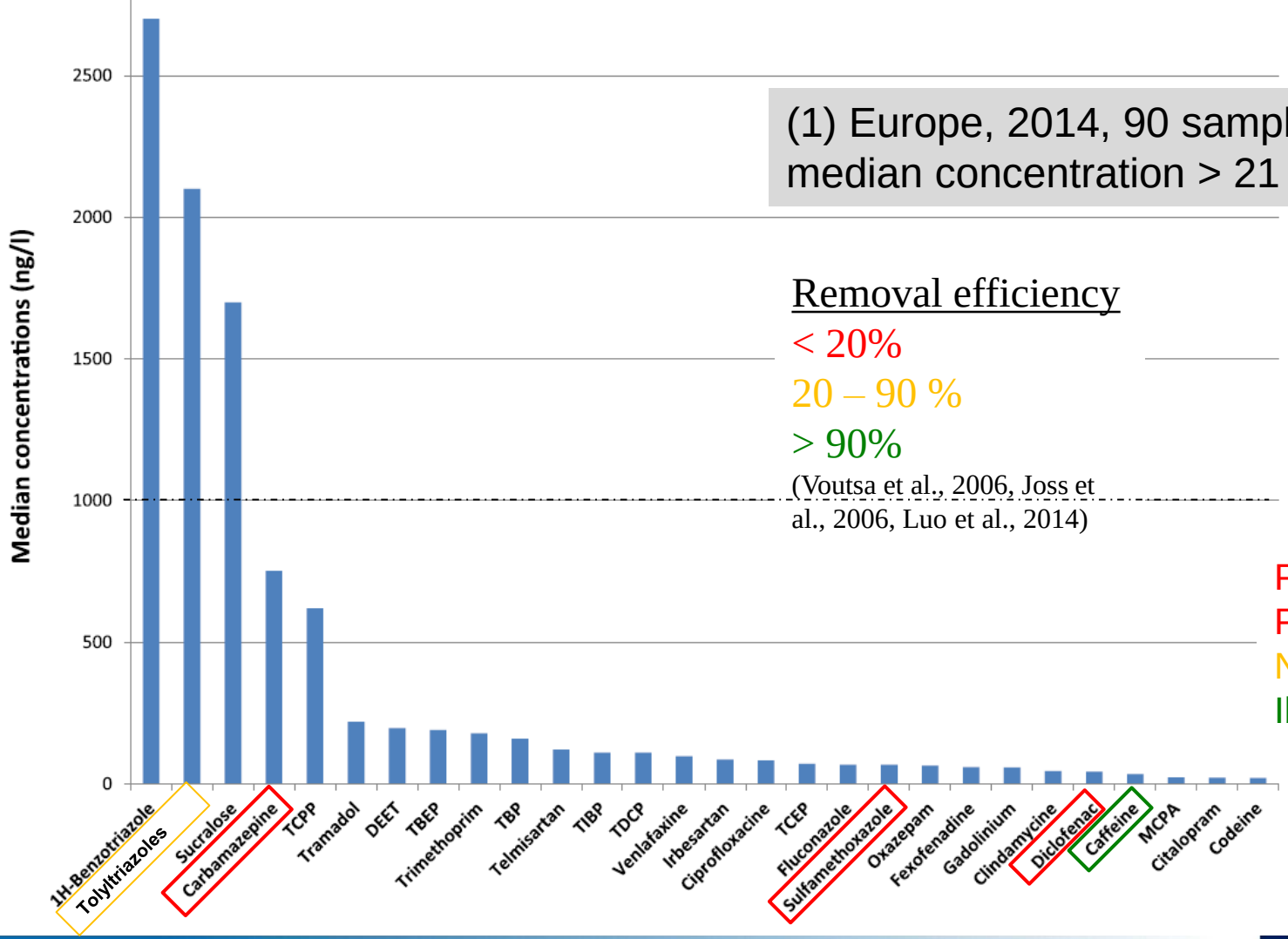
...especially in medium and low income countries



IWMI, 2000

Emerging issues of micro-pollutants in wastewater reuse

2. CEC occur in wastewater effluents



(1) Europe, 2014, 90 samples, 156 CEC, median concentration > 21 ng/L

Removal efficiency

< 20%

20 – 90 %

> 90%

(Voutsa et al., 2006, Joss et al., 2006, Luo et al., 2014)

PFOS: 12 ng/L

PFOA: 13 ng/L

Naproxen: 8 ng/L

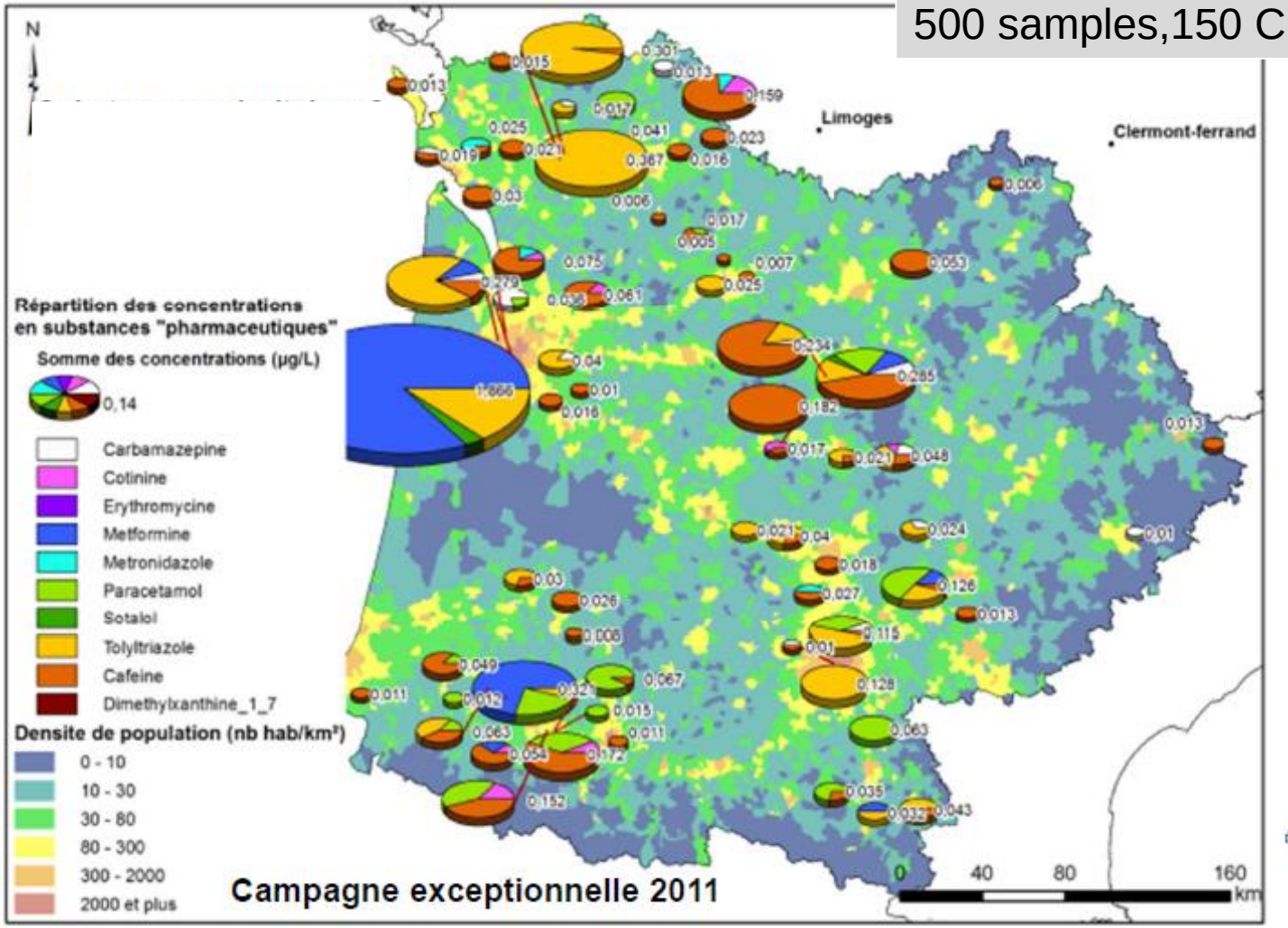
Ibuprofen: 7 ng/L

Loss et al. (2014), Water Research 47, 6475

Emerging issues of micro-pollutants in wastewater reuse

CEC occur in groundwater

(2) France, 2011,
500 samples,150 CEC



Lopez et al., 2013