Source control measures to minimize contamination of rivers and streams

Adriano Joss

Neptune Workshop
21-22 April 2009
Koblenz, Germany

Contents

Pharmaceuticals: relevant micropollutant load

Measures at the source complement centralized treatment

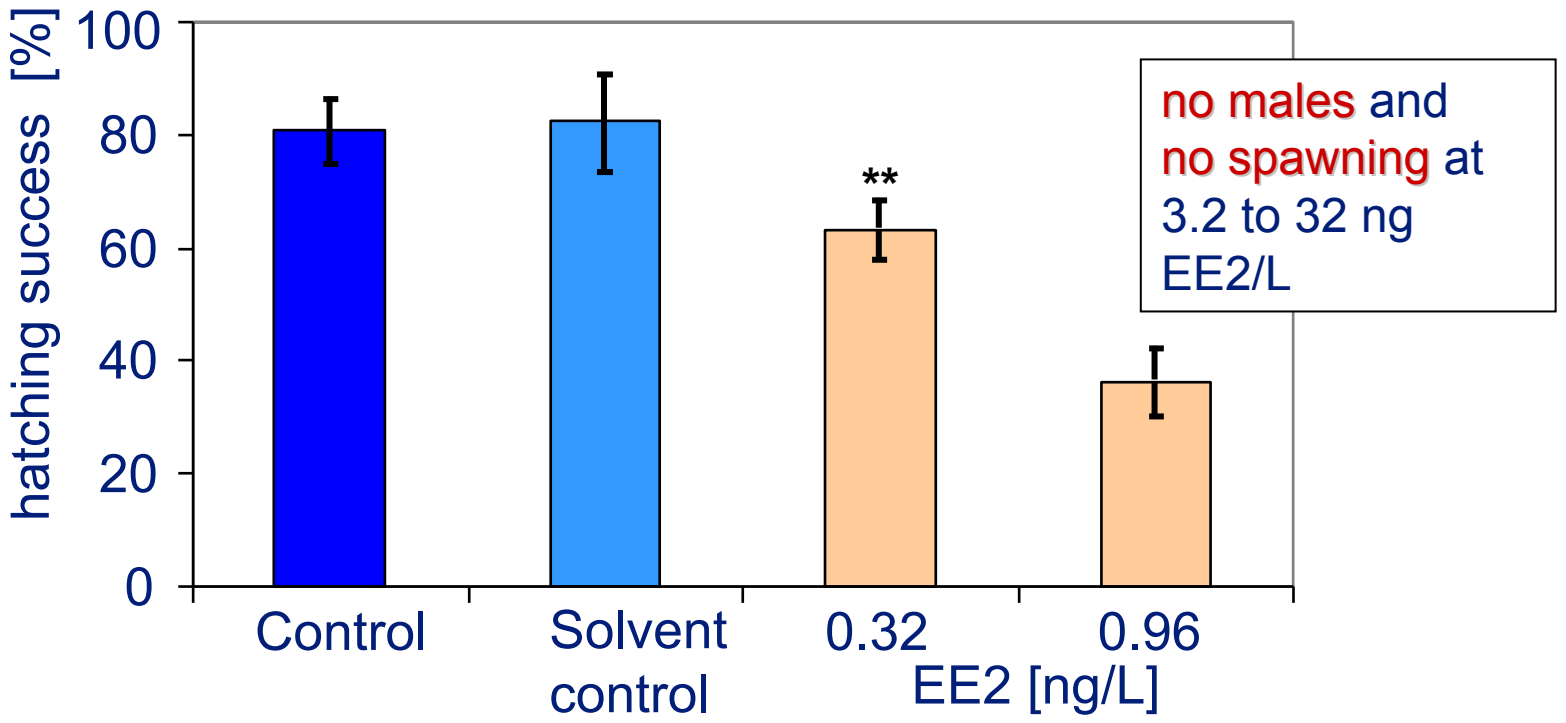
Consumer‘s and producer‘s choice

Source separation

On site treatment

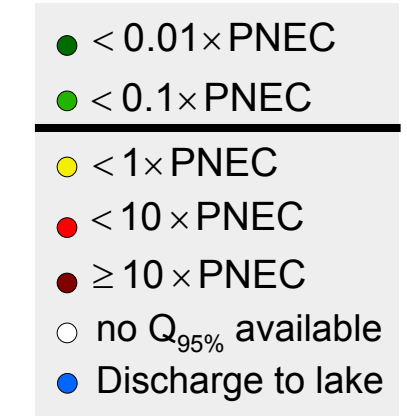
Pharmaceutical: Relevant micropollutant load

- 5 ngEE2/L: young generation missing in entire lake experiment (Kidd et al, 2005, PNAS)
- ≥1 ng EE2/L: lack of males and no reproduction in fathead minnows (Joanne Parrott, NWRI, Burlington, Canada)

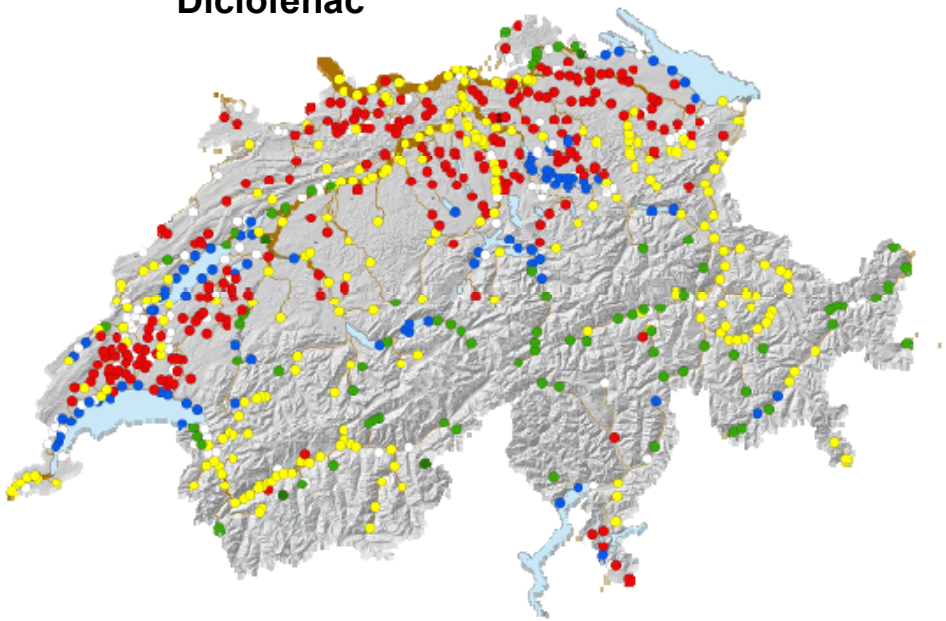


Pharmaceutical: Relevant micropollutant load

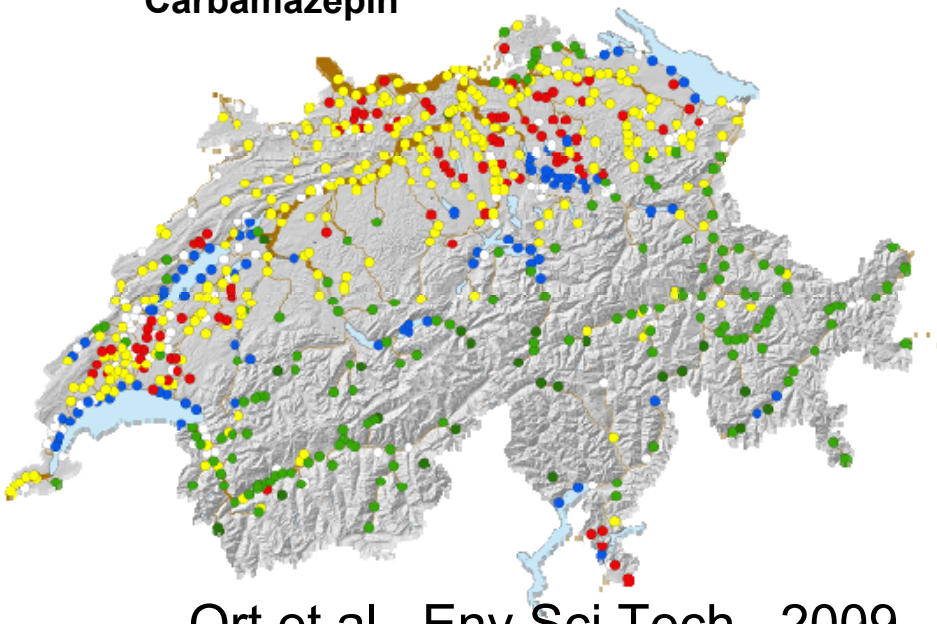
- Single persistent pharmaceuticals trespass PNEC in surface water



Diclofenac



Carbamazepin



Ort et al., Env.Sci.Tech., 2009

Urban water cycle

Pharmaceutical industry

Households, hospitals

Sewer

Wastewater treatment

Surface and groundwater

Drinking water treatment

Tab

Urban water cycle

Measures at the source:
Efficiency gain?

Pharmaceutical industry

Consider water cycle

Households, hospitals

Compound choice

Source separation

5% - 20% losses

Wastewater treatment

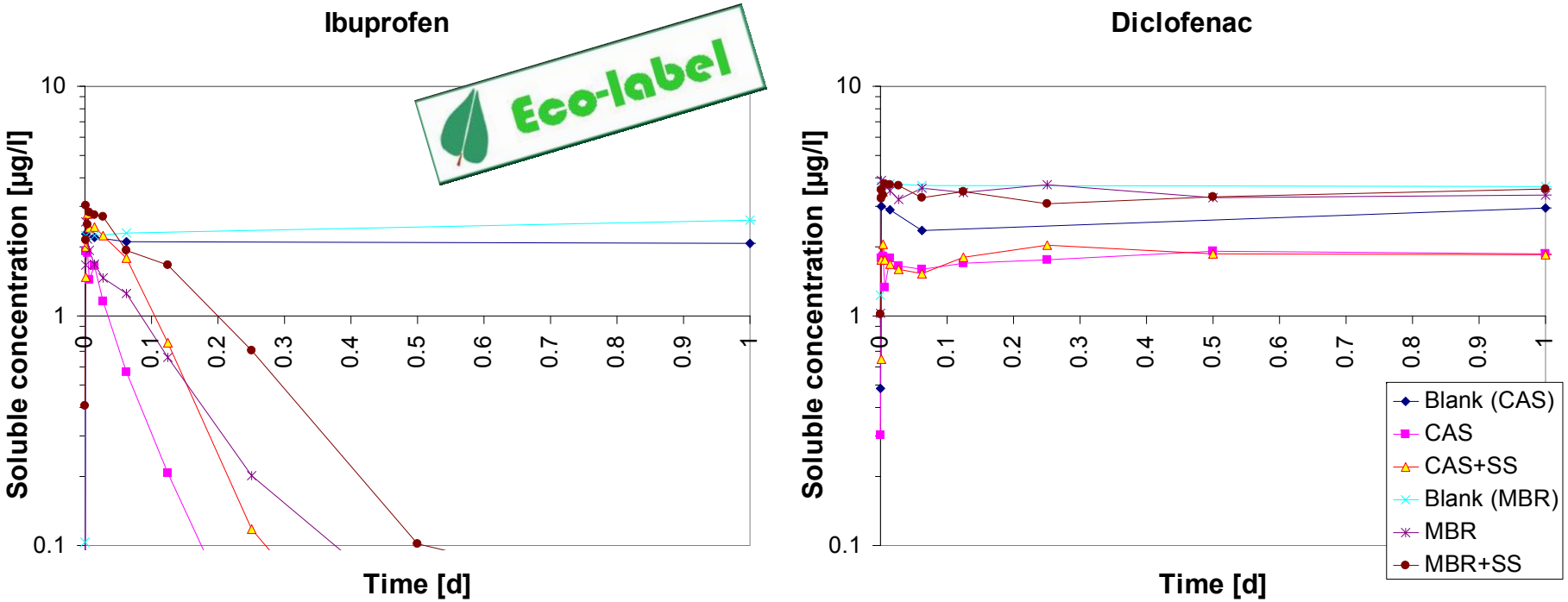
Good water quality status?

Drinking water treatment

Measurable concentr
acceptable?

Source control:
Develop and choose degradable compounds

Degradation experiment with activated sludge from a typical wastewater treatment plant



Example

- Ibuprofen and diclofenac: analgesics with comparable mode of action
- Ibuprofen: >95% degradation during wastewater treatment
- Diclofenac: ≤25% degradation
- Diclofenac has killed 90% of vulture population in regions of India

Compound labelling: Scope

- Supply patients and doctors with environmental information on pharmaceuticals
- Initiate public discussion
- Testing acceptability of new products
- Voluntary basis, testing feasibility of new legislative tools

- Successful label: Influencing consumer behaviour by 5% – 15%

Compound labelling: Swedish model (PBT)

Persistence - ability to resist degradation in the aquatic environment

Bioaccumulation - accumulation in adipose tissue of aquatic organisms

Toxicity – the potential to poison aquatic organisms

Property assessed	Method/Cut off value	Score
Persistence	Mineralization	
Easy biodegradable	>60% in 28 d	0
Not biodegradable	≤60% in 28 d	3
Bioaccumulation	Log P_{OW}	
Potential to bioaccumulation	≥3	3
Not potential to bioaccumulation	<3	0
Eco-toxicity	$LC/EC/IC_{50}$ (fish, daphnia, algae)	
Low	>100 $mg \cdot L^{-1}$	0
Moderate	10-100 $mg \cdot L^{-1}$	1
High	1-10 $mg \cdot L^{-1}$	2
Very high	<1 $mg \cdot L^{-1}$	3

Label exists since 2005

www.janusinfo.se

Compound classification scheme: Considering removability

Not considered in the Swedish model

- Drinking water relevance: public acceptance of impurities
- Removability with state-of-the-art treatment

Extended classification scheme

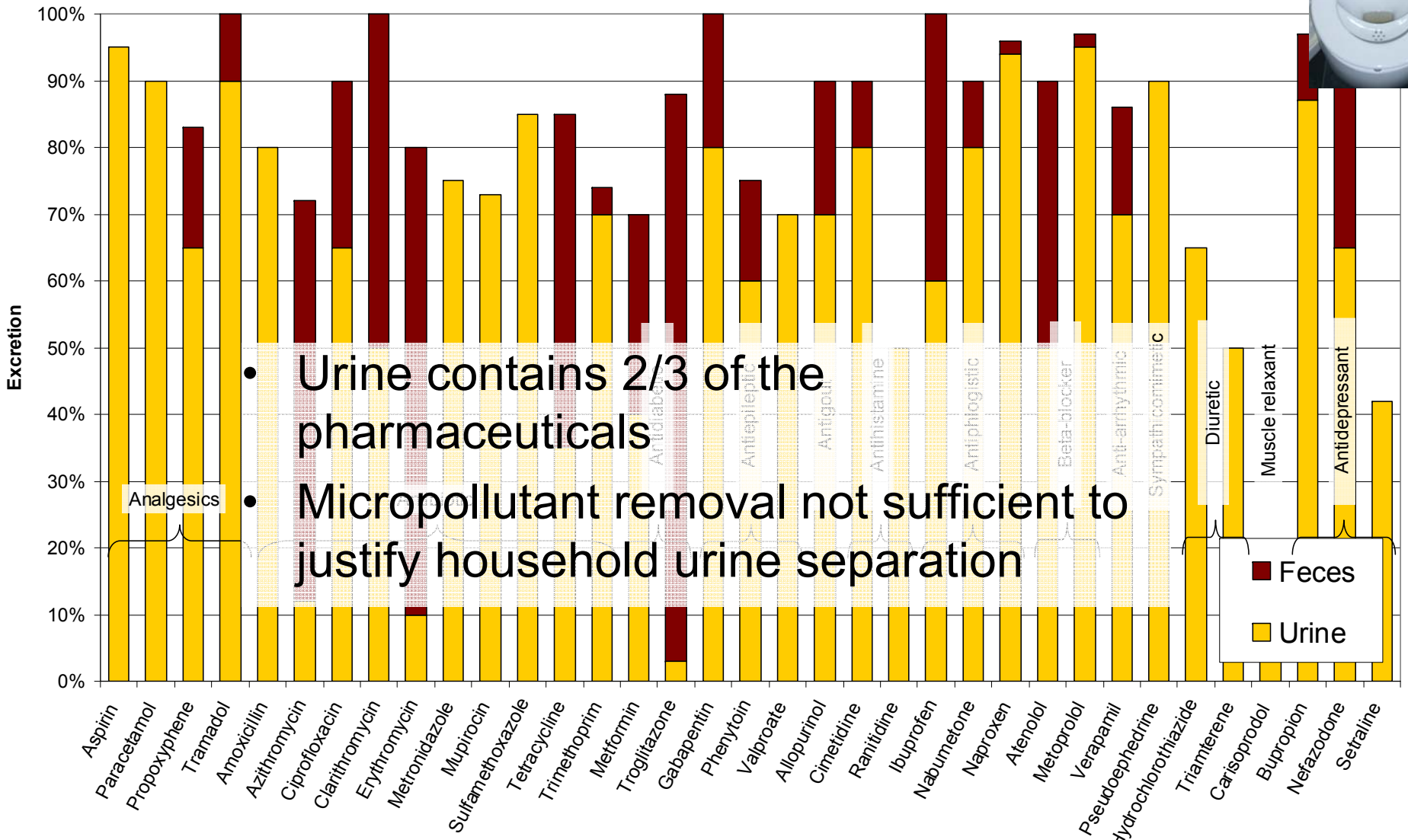
- Persistence
- Bioaccumulation
- Toxicity

} PBT, Swedish model

- Removability with activated carbon
- Removability by ozonation
- Removability by flocculation

Ternes and Joss, IWA-Publishing, 2006

Urine separation



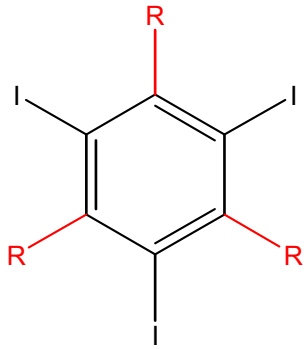
- Urine contains 2/3 of the pharmaceuticals
- Micropollutant removal not sufficient to justify household urine separation

Lienert et al., Env.Sci.Tech., 2007

Source separation for iodinated constrast media

Persistent compounds, costly removal

- Drinking water: >100 ng/L (public acceptability?)
- Chlorination: formation of carcinogenics?
- Oxidative degradation: only side chains
- Low sorption to activated carbon: high dosing & costs
- Low reactivity with O_3: high dosing & costs



Load caused by 1 person of 10'000

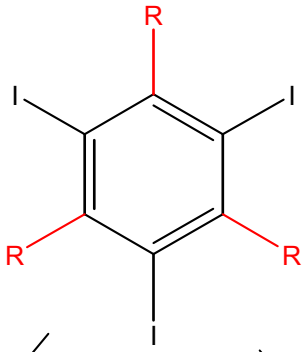
- Excretion in urine, 90% within 24h (e.g. iopromide)

Options for source control

- Urine collection + anaerobic digestion (dehalogenation)
- Urine collection + incineration
- Substitute with CO_2 as contrast agent (not always indicated)

Source separation feasible for iodinated constrast media?

What do you prefer?

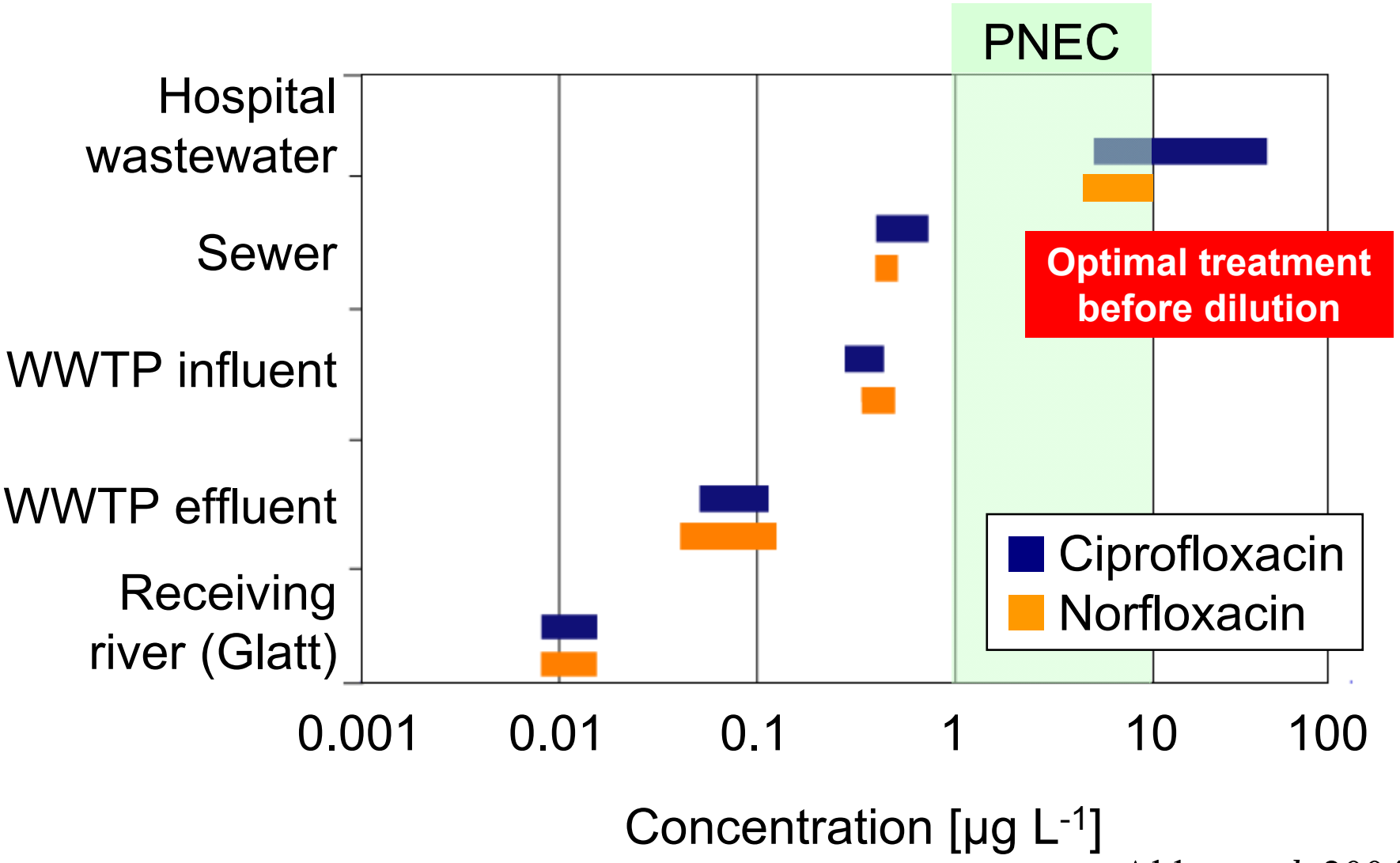


Toxicology covers all relevant aspects of human toxicology?

In the bag? Not sure

Yes Or in the tab?

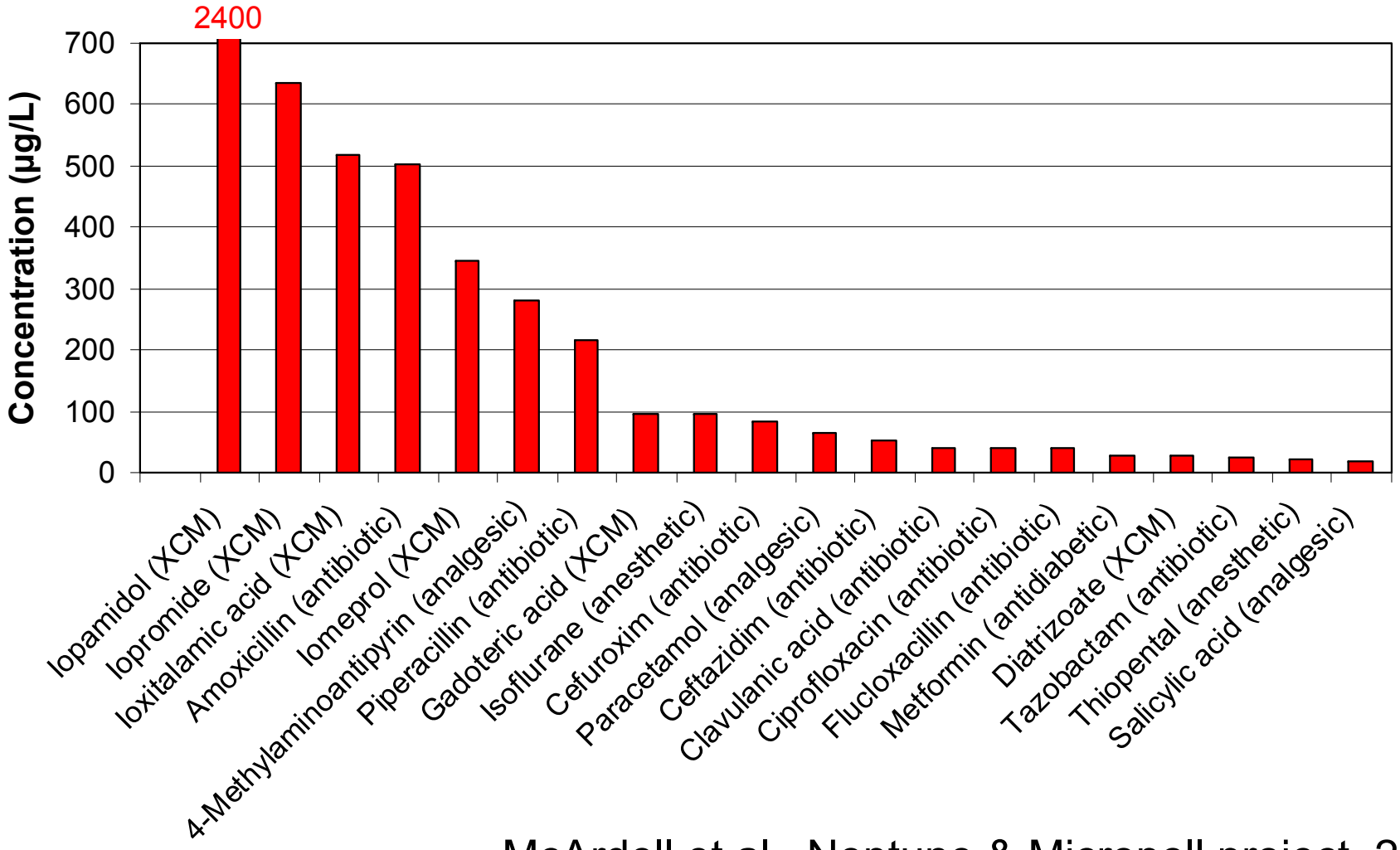
On site treatment: Hospital wastewater



Alder *et al.* 2004

Consumption at the cantonal hospital in Baden (2007)

Predicted concentration in wastewater (from consumption, excretion rate, 315 m^3/day wastewater)



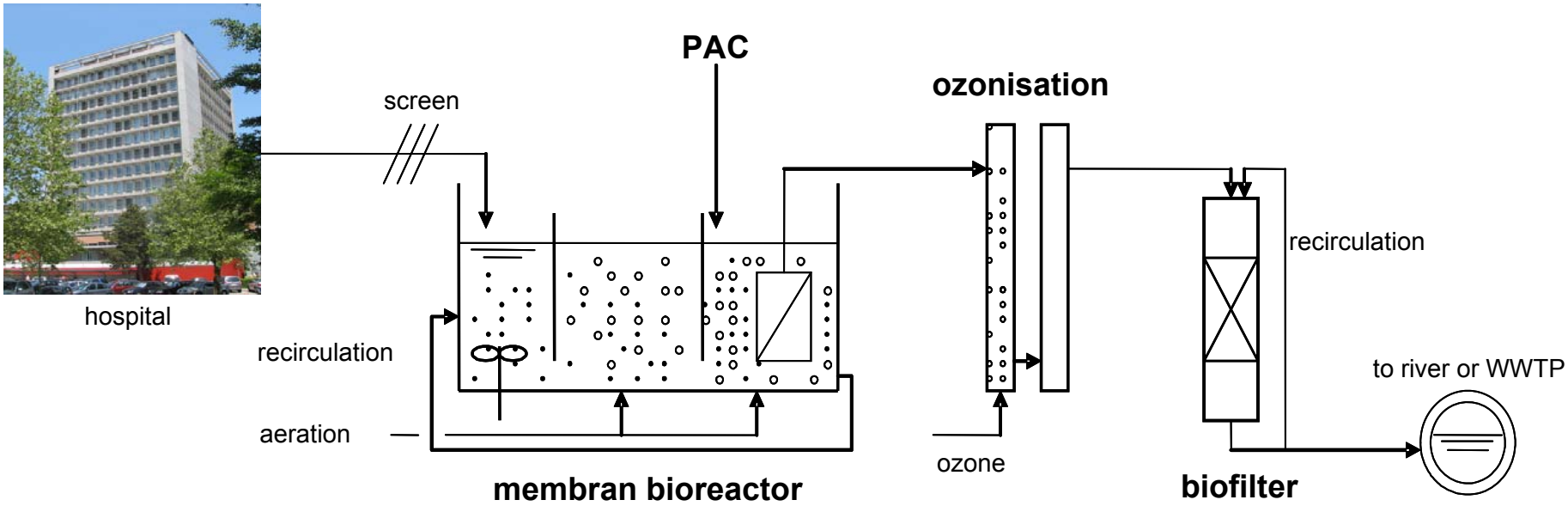
McArdell et al., Neptune & Micropoll project, 2009

Hospital wastewater on site treatment

Amount of pharmaceuticals in hospital wastewater:

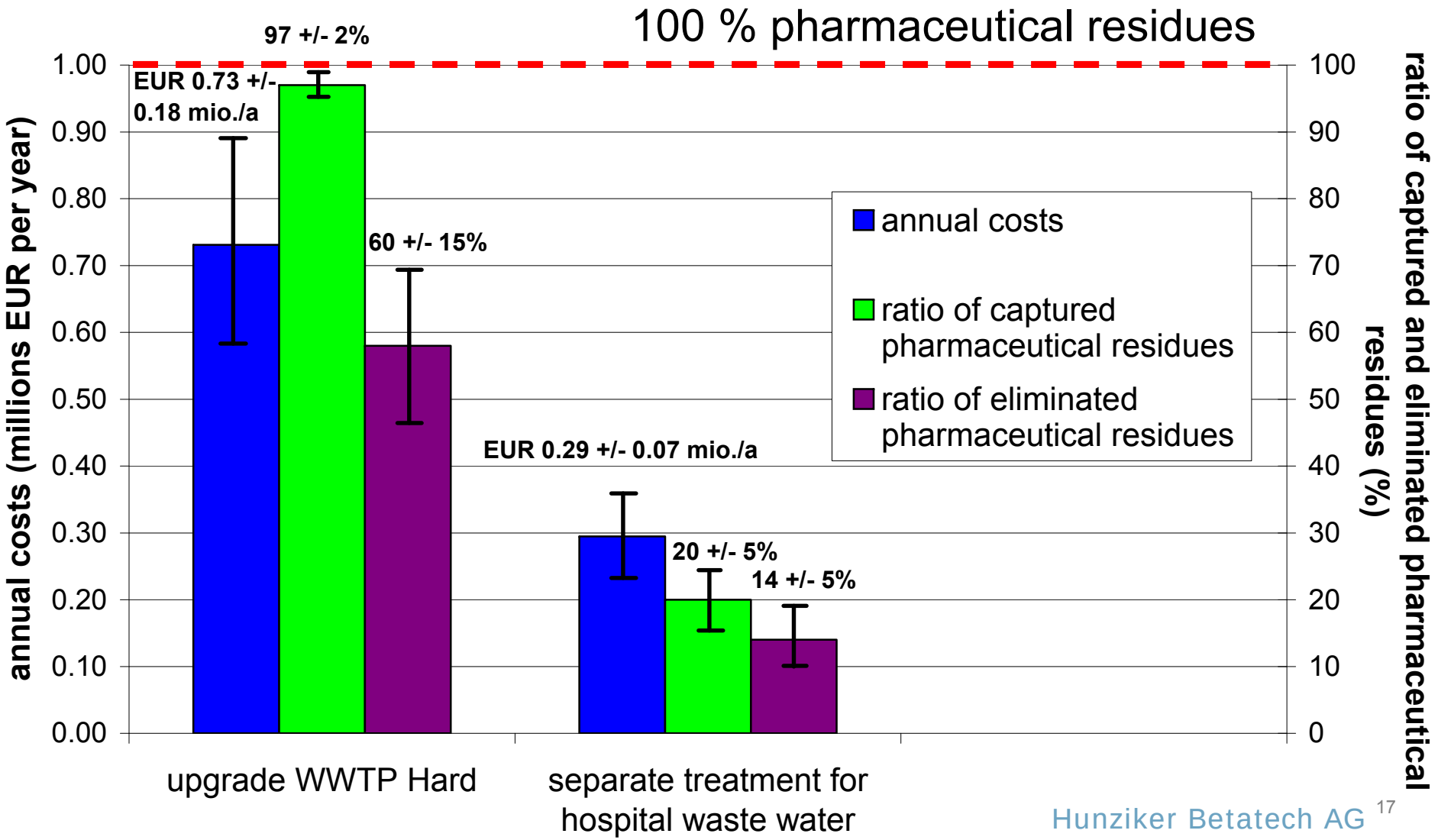
- X-ray contrast media: 50% of the hospital consumption
- Cytostatics: 1.2 - 4.5% of the hospital consumption
- refined modeling of mass flows under way

Costs: efficiency gain?



Moser et al., Neptune & Micropoll project, 2009

Case Study Hospital Winterthur: cost-benefit



Conclusion

Measures at the source complement centralized treatment

- Efficiency gain
- Elimination before loss from sewer

Compound labelling

- Is useful also for pharmaceuticals
- Initiates public discussion

Classification scheme: include PBT and removability

Urine separation

- Suitable for specific therapies (e.g. X-ray imagery)
- On average only 2/3 of the pharmaceuticals removed

On site treatment

- Currently being tested

Thank you …

… and the EU for financing Poseidon and NEPTUNE, 6th Framework Programme

This study was part of the EU Neptune project (Contract No 036845, SUSTDEV-2005-3.II.3.2), which was financially supported by grants obtained from the EU Commission within the Energy, Global Change and Ecosystems Program of the Sixth Framework (FP6-2005-Global-4)