Temporal and spatial trends of pharmaceuticals in the Rhine

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Where we are

IAWR

Umbrella organization
of 3 Associations

RIWA: Netherlands

ARW: lower Germany

AWBR: upstream Germany,
Switzerland

110 utilities
30 million consumers

Mission: source water quality should allow drinking water production using simple treatment only

WQ monitoring network

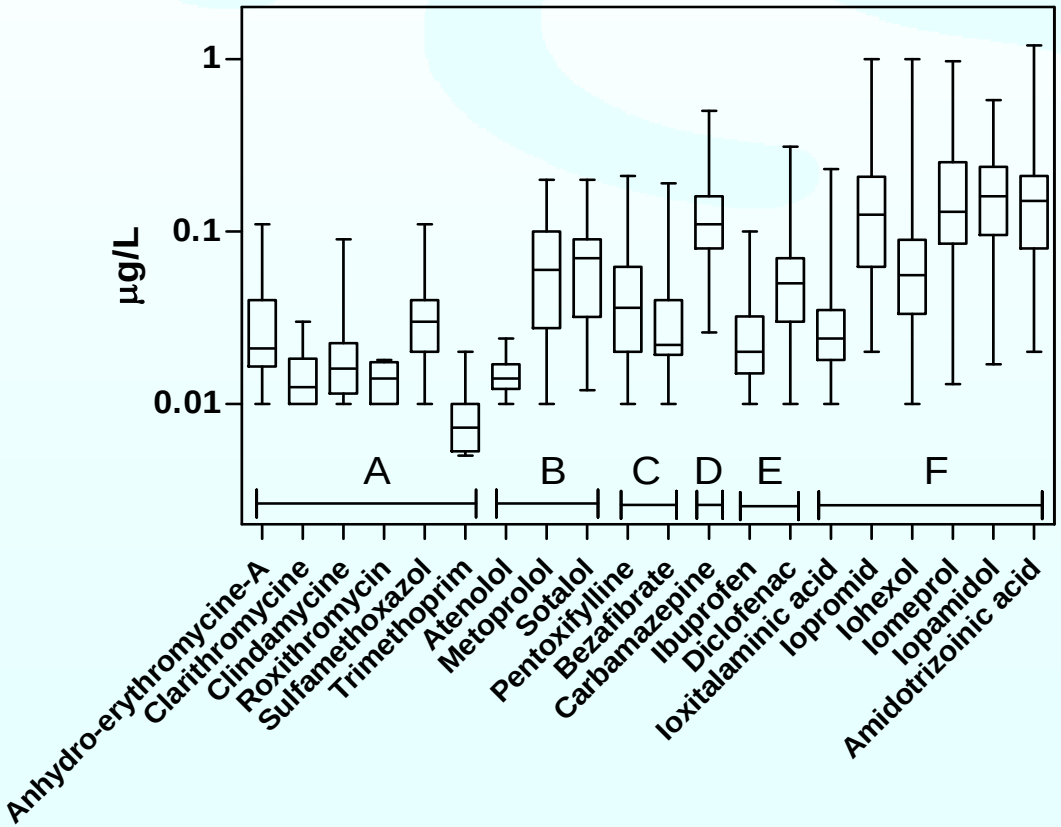
- **Cooperation with Nat'l Dutch and German water authorities**
  - *Harmonized program (WQ variables, methods, data exchange,…)*
- **Five locations in the Dutch part of the Rhine basin**
  - *German-Dutch border, intake sites*
- **28 locations in total**
  - *10 main sites (mostly intakes)*
  - *freq ≥ 13; > 300 variables*
- **Trend detection and compliance testing**
  - *Legal standards & emerging contaminants*
  - *Chemical & biological*

Sampling sites

Pharmaceuticals

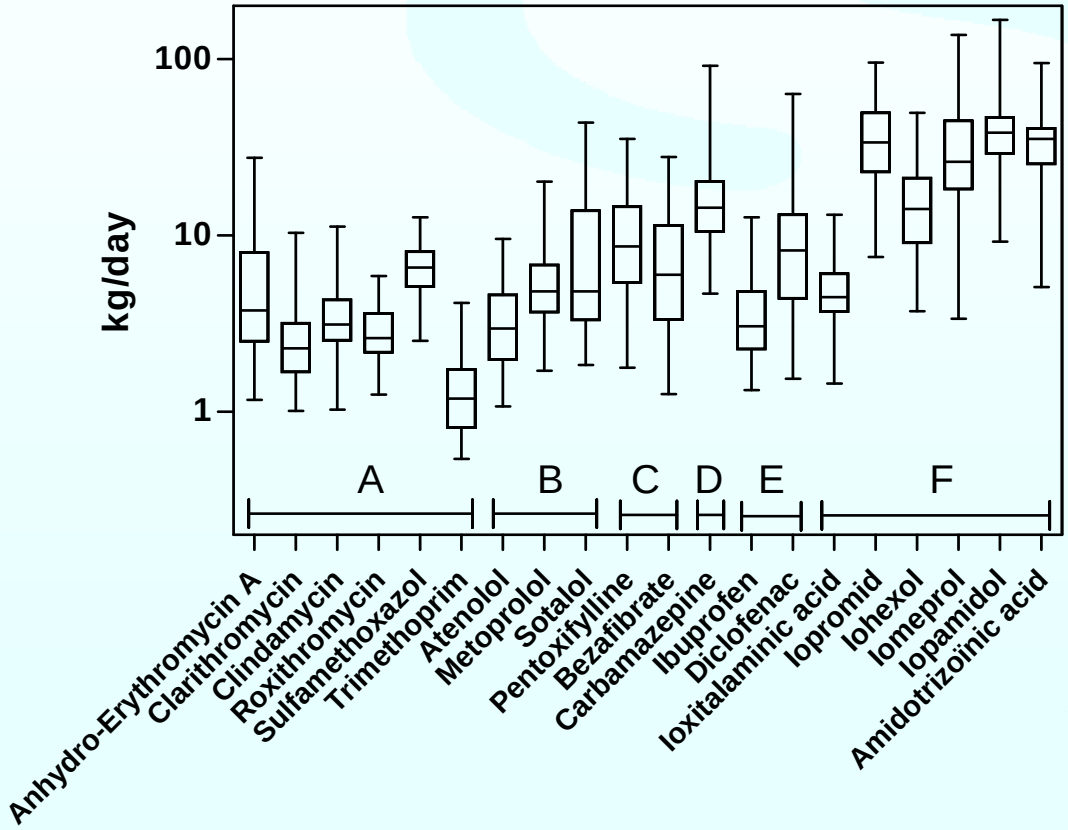
- **Monthly sampling / analysis (13x / yr) from 2002**
  - *only at main sites*
- **127 individual compounds**
  - *pharmaceuticals, X-ray contrast media, EDCs*
- **Over 50 compounds detected**
  - *total dataset around 3500 entries*
- **20 most frequently observed compounds selected**

Concentrations in the Rhine (at D/NL border site)



A= Antibiotics
B= Beta blockers
C= Lipid regulators
D= Anti-epileptic drugs
E= Analgesics/anti-inflammatory drugs
F= X-ray contrast media

Daily loads in the Rhine (at D/NL border site)



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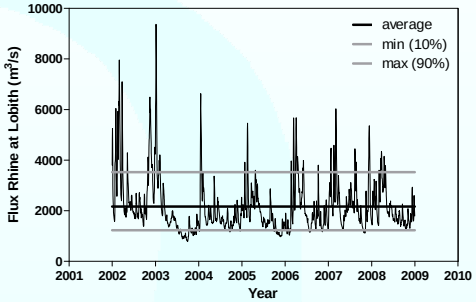
Periodic variations

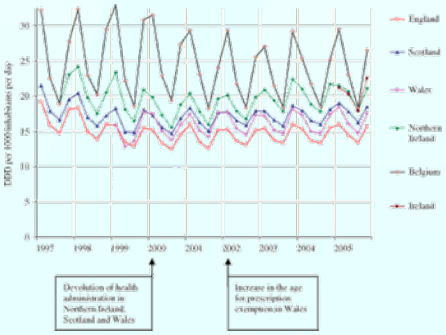
Variations in discharge

- *average 2200 m3/sec; Max/min=20*



Variation in consumption

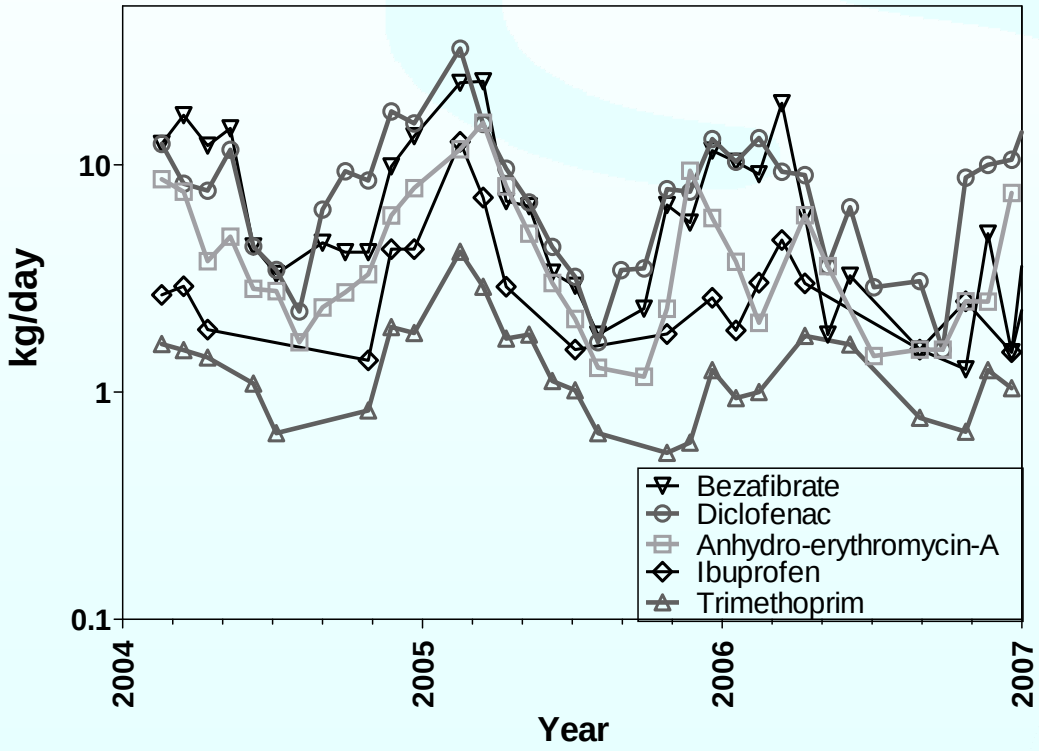
- *Davey et al., Antimicrobial Therapy (2008) 62: 1442-1447*



Variation in SWPT removal

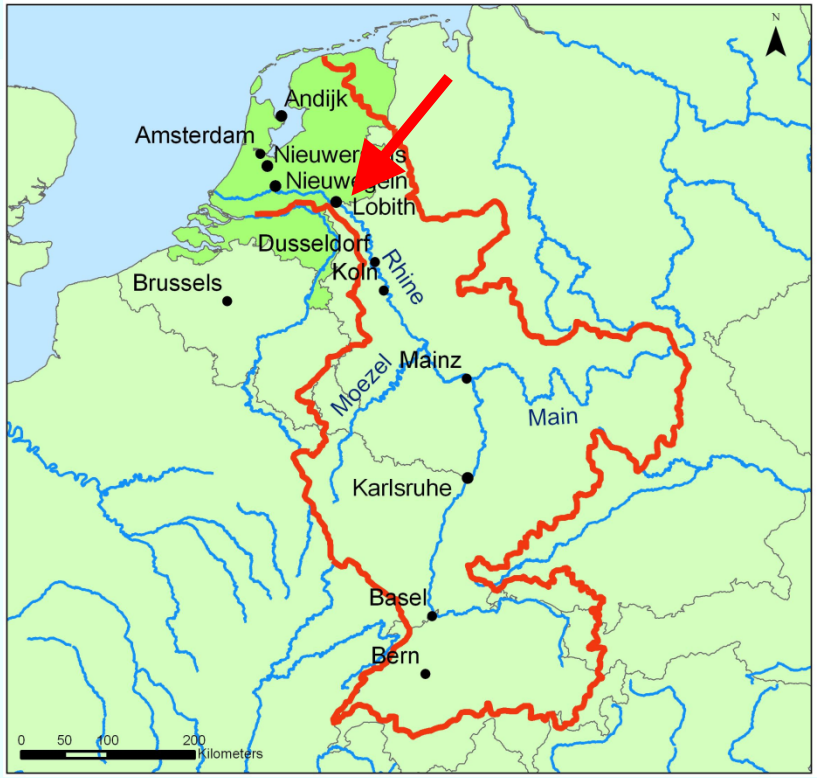
- *Temp-dependent degradation*

Temporal trends of daily loads



Collecting data

- Pharmaceutical consumption in Rhine catchment area
- Excretion by human body
- Removal by STP
- Compare loads @ Lobith to consumption upstream of Lobith



Modeling loads

$$Q_{Rhine} = Q_{Cons} \cdot f_{Excr} \cdot f_{WWTP}$$

Human consumption

Metabolism

↓ %

Degradation in STP

↓ %

Sorption in STP (to sludge)

↓ %

Veterinary consumption

?

Metabolism

↓ %

Degradation in manure tank

↓ %

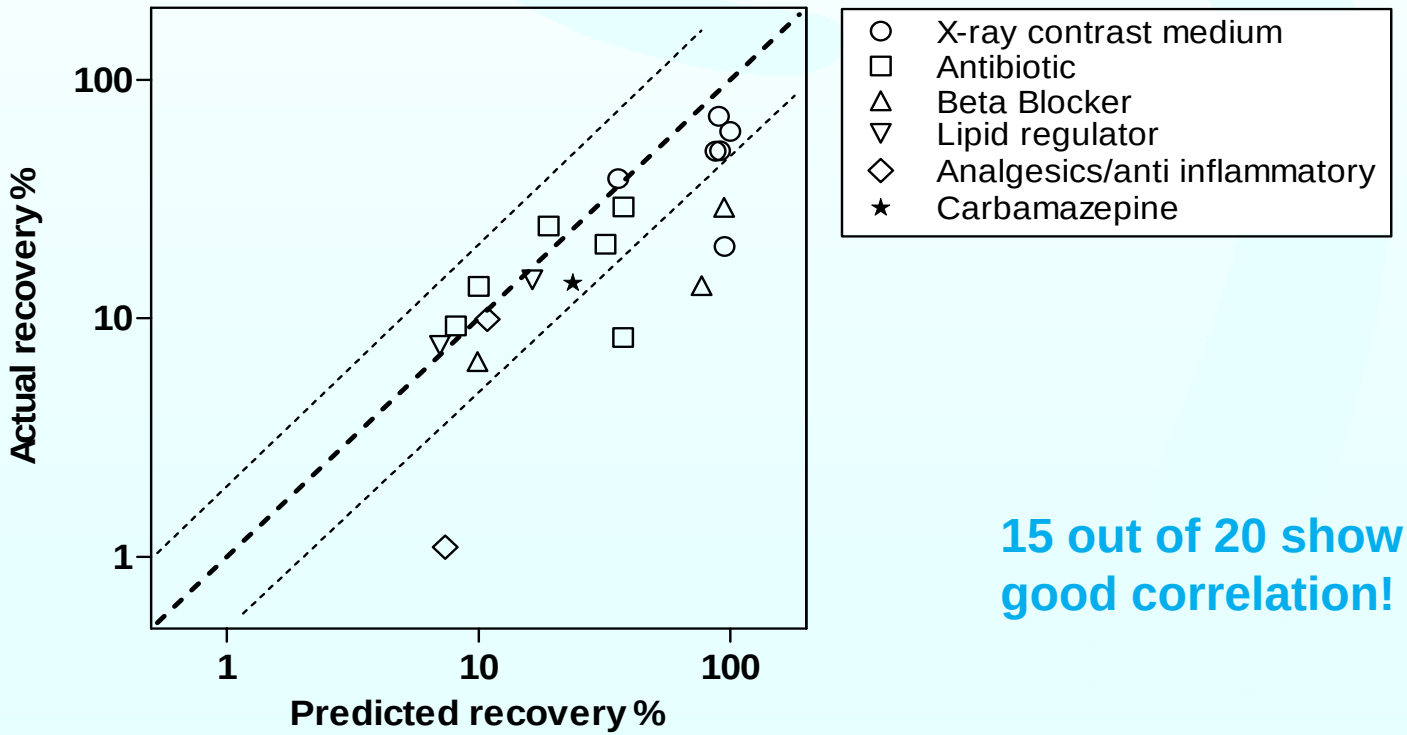
Degradation and sorption in the environment

? ↓ %

Removal in drinking water treatment, Residue 0%?

Actual recovery vs. Predicted recovery

$$\text{Predicted recovery} = f_{Excr} \cdot f_{WWTP}$$



15 out of 20 show good correlation!

Conclusions - 1

- Substances occur in ng – ug/L range
- X-ray contrast media highest levels
- Concentrations and loads vary over time
- No significant upward trend @ D/NL border

Conclusions - 2

- **Around 25% of pharmaceuticals consumed are found at D/NL border site**
- **Very simplistic mass balance / removal model gives reasonable prediction of measured vs consumed**
- **Applicability**
  - *Estimating loads / concentrations when monitoring data are not available*
  - *Estimating consumption data from monitoring data when consumption data are difficult to obtain (DOA)*

What goes around comes around…