HET WATERLABORATORIUM BDS BioDetection Systems Aqualab Zuid TU Delft Delft University of Technology

Analysis and risk assessment of pharmaceuticals in the drinking water chain

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Contents

- Introduction
  - Drinking water production in the Netherlands
  - Why are pharmaceuticals relevant for dw companies?
- A multicomponent 'snapshot' of pharmaceuticals and pesticides in the river Meuse basin
- Human health risk assessment of pharmaceuticals in water

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Drinking water production in the Netherlands

A short history:

- Historically mainly ground water: pumps, wells
- 1853: first drinking water supply: fresh ground water extracted from the dunes.
- Consumption from 10 (1850) to 120-160 L p.p.p.d.
- >1950: infiltration of surface water from rivers

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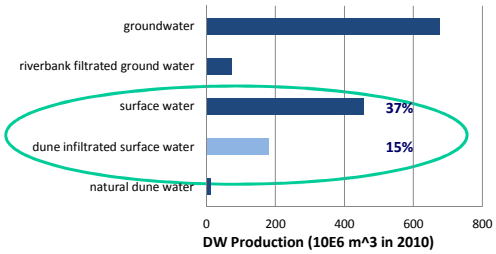
Drinking water production in the Netherlands

- Production 1.1 billion cubic meters /y
- Microbiologically safe without chlorination



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Why are pharmaceuticals relevant for dw companies?

Sources: DW production philosophy

- Aim: 'impeccable' drinking water: chemically and microbiologically safe
- DW is a natural product; simple treatment should be sufficient
- Sustainable protection of surface water sources: prevention > removal > transformation / degradation

Drinking water:

- Safety of consumers if there might be a health risk (precautionary principle)
- Legislation: Drinking Water Act: 1 ug/L anthropogenic contaminants
- Public Perception: consumer worries about hormones, pharmaceuticals etc. in dw
- Environment: switch to bottled water without microbiological need => higher carbon footprint

→ **Careful monitoring of sources and produced drinking water**
→ **Research on treatment techniques, toxicology, risk assessment**
→ **Thoughtful communication with customers about DW quality**

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→ **Careful monitoring of sources and produced drinking water**
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Use of target analyses, screening, bioassays and combinations thereof.

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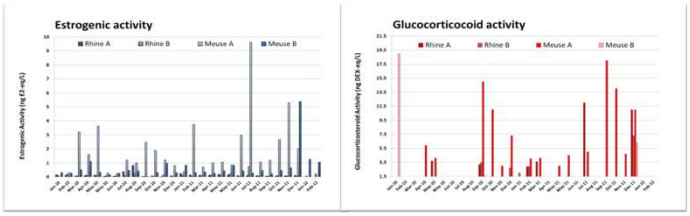
Example of bioassays: Estrogenic and glucocorticoid acticity



- Estrogenic activity detected at all 4 surface water locations, glucocorticoid at 3 of them.

=> Some samples analysed for causative compounds with UPLC-tQ-MS method for steroid hormones

- Successful identification of steroids from various classes:
  estrogenic (17α-E2), androgenic (androstenedione), progestagenic (progesterone, cyproterone-Ac) and glucocorticoid steroids.
- In agreement with CALUX results no steroids detected in drinking water samples.

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A multicomponent snapshot of pharmaceuticals and pesticides in the river Meuse basin

(Houtman et al., Env. Toxicology & Chemistry 2013, 2013 (11):2449-2459)

Aims:

A. Snapshot of pharmaceuticals and pesticides in the river Meuse

B. Correlation between locations and contamination patterns?

→ *Can multi-component methods help to answer these questions?*

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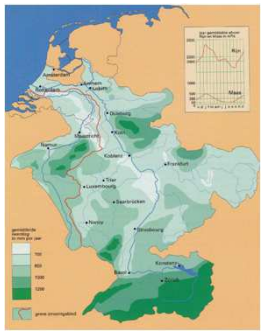
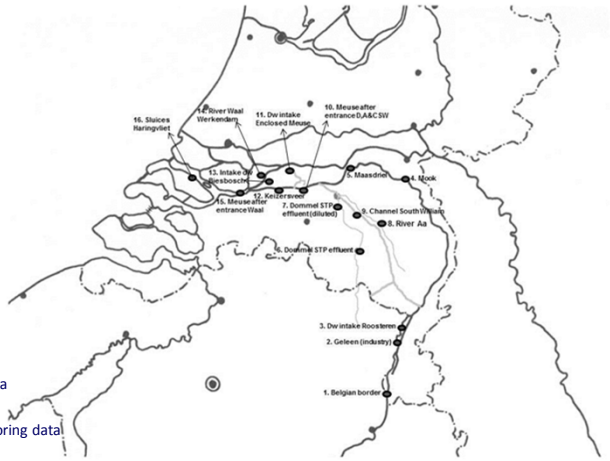
Multi-component snapshot river Meuse - sampling





- 16 locations Belgian border => North Sea
- 1 wk
- Loc. 11: dw intake site, historical monitoring data
- Main stream
- Feeding rivers

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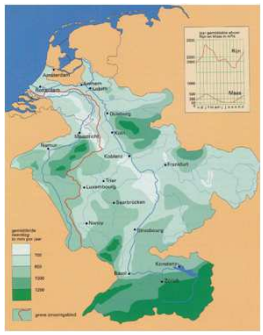
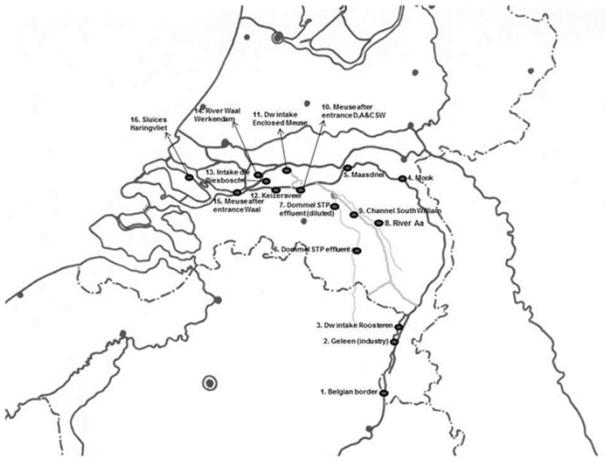
Multi-component snapshot river Meuse - analyses





- General WQ parameters
- Multicomponent methods for pharmaceuticals and pesticides

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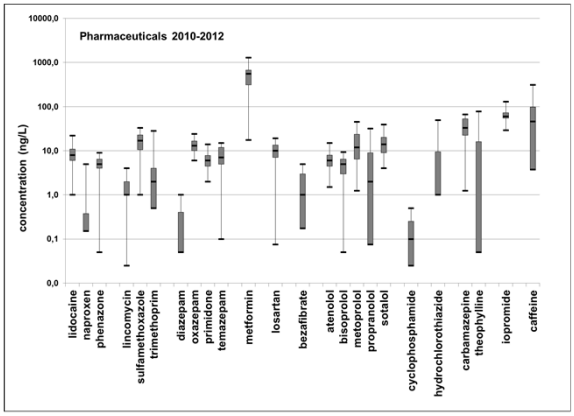
A. Snapshot of pharmaceuticals: historical data



- Representatives of all therapeutic classes
- Range of conc.: (<) 0.1 ng/L – 1 ug/L)
- Conform consumption volumes:
  - antidiabetic (metformin)
  - stimulants (caffeine)
  - beta blockers

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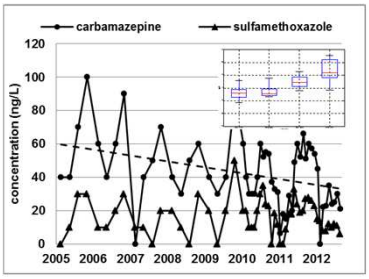
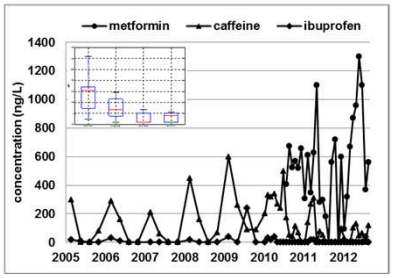
A. Snapshot of pharmaceuticals





Seasonal patterns:
- carbamazepine, sulfamethoxazole, caffeine, ibuprofen
- degradation winter < summer

Temporal trend:
- carbamazepine
- agrees with consumption ↓

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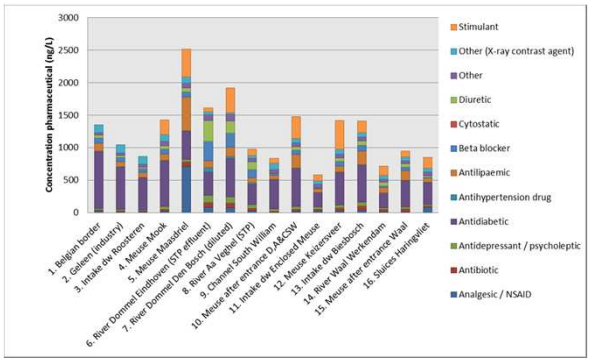
B. Correlation between locations and contamination patterns- Pharmaceuticals



- Individual concentrations low, but in total up to 2 µg/L.
- Meuse diffusely contaminated with pharmaceuticals of all kinds: 90% of analysed pharmaceuticals detected.

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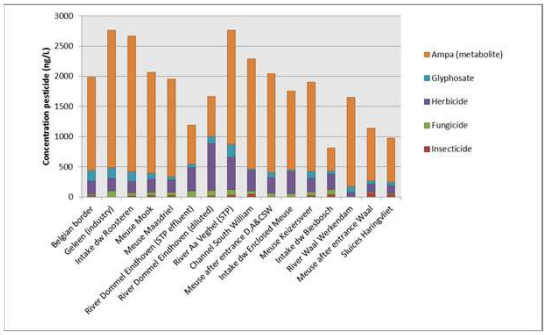
B. Correlation between locations and contamination patterns-
Pesticides



- Concentrations between <10 ng/L to 2 µg/L; in total up to 2,8 µg/L.
- 14% of analysed pesticides detected (higher LOD than pharmaceuticals).
- Most prominently present: AMPA (metabolite of glyphosate) and herbicides.

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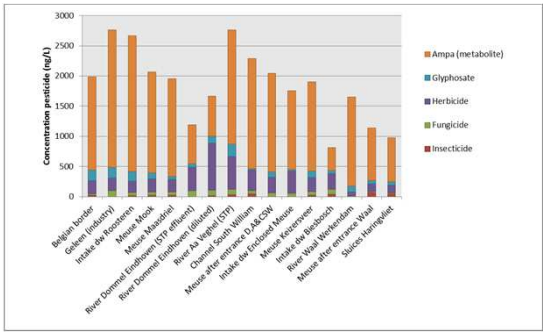
Pesticides



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Contamination patterns intercorrelated and max four-fold difference => difficult to relate to locations at first sight

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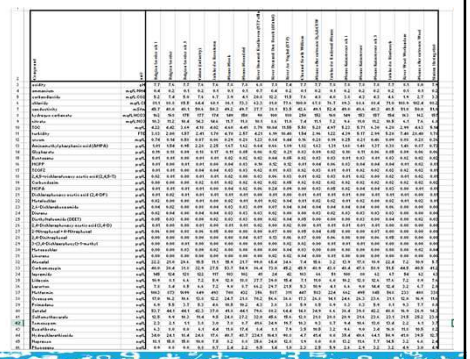
B. Correlation between locations and contamination patterns

⇒ **Use multivariate statistics Principal component analysis (PCA):**

→ Clustering of locations according to contamination pattern



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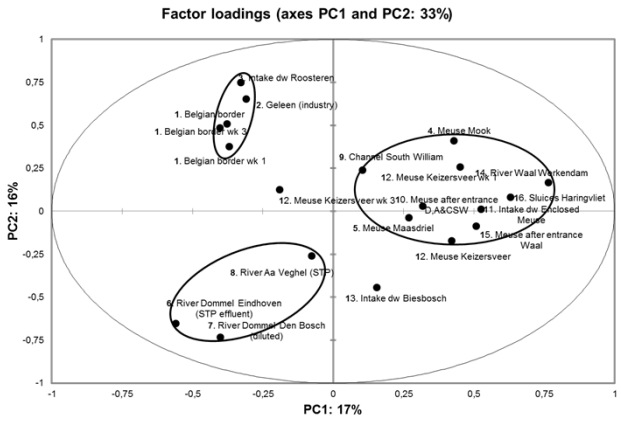
B. Correlation between locations and contamination patterns – **Factor loadings**



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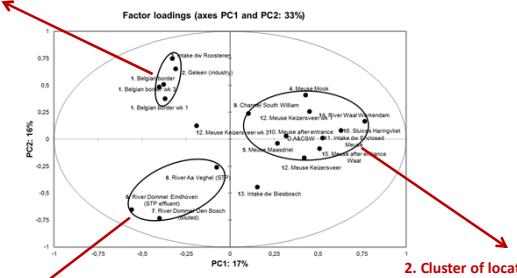
B. Correlation between locations and contamination patterns - **Factor loadings**

1. Cluster of locations close to Belgian border



2. Cluster of locations in western part of river basin closer to North Sea

3. Cluster of feeding rivers receiving STP effluent

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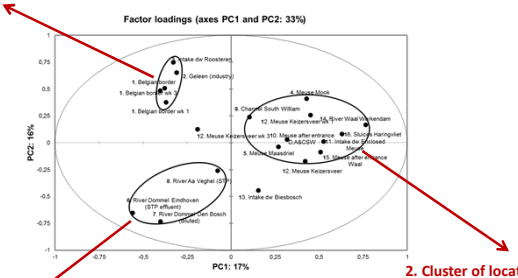
B. Correlation between locations and contamination patterns - **Factor loadings**

PC 2: water composition first part of river basin

1. Cluster of locations close to Belgian border



2. Cluster of locations in western part of river basin closer to North Sea

3. Cluster of feeding rivers receiving STP effluent

PC 1: less influence by STP effluent

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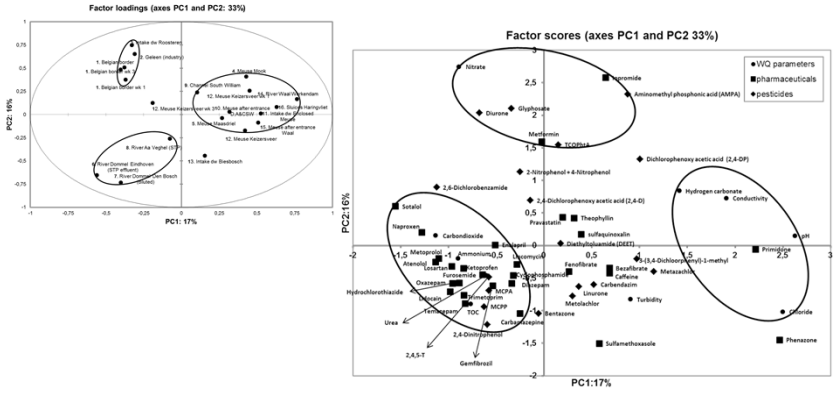
B. Correlation between locations and contamination patterns - **Factor scores**



Factor scores: which compounds are found at which type of locations

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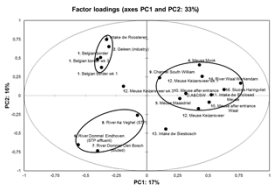
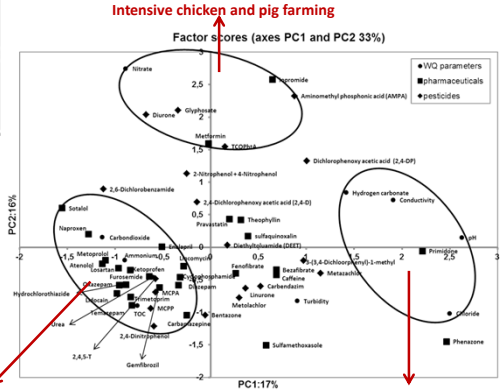
B. Correlation between locations and contamination patterns - **Factor scores**



1. **Nitrate, pesticides glyphosate, AMPA, diurone**
   Leaching from sandy soil treated with manure
   Intensive chicken and pig farming



3. **NH_4^+, TOC, urea: markers for STP**
   Pharmaceuticals with low removal rates in STP

2. **HCO_3^-, pH correlated via carbonate equilibrium**
   pH and Cl^- high in delta area (influence North Sea)

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To conclude

- Water quality monitoring requires bioassays, screening, target analyses and combinations thereof.
- Legislation:
  sometimes target analyses serve litteral interpretation whereas bioassays serve purpose!
- Collecting data is only half the work => interpretation & risk assessment

Risk assessment

- Pharmaceuticals present at ng/L concentrations in dw.
- Nevertheless: dw complies with Drinking Water Acts and ethical limits.

- RA: risk of adverse health effects of life-long exposure can be considered negligibly low.
- Application of mixture toxicity confirms this picture for combined exposure.
- Inclusion of mixtures in RA methodology research deserves more attention to support RA in applied fields.

Thanks for your attention!