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Fate of xenobiotics in restored fen peatlands - a case study with treated waste water application

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Outline

- Background
- Hypotheses
- Pilot site Biesenbrow
- Hydrological regime
- Treated waste water experiment
- Conclusions

Background

- common practice → treated wastewater discharged into rivers and streams, bypassing soils and wetland ecosystems
- investigation whether recycled wastewater can be used as one element of sustainable water and land management
  → to stabilize the regional water budget
  → for the protection of valuable wetlands
  → for further purification of remaining micropollutants
- in Germany, groundwater protection has a higher priority than surface water
- required function of an aerated unsaturated soil horizon (> 1,5 m) for groundwater protection → in wetlands groundwater table is near the soil surface
  → contamination risk
- nevertheless, permission for top-down experiment under real field conditions (e.g. hydrology, soil, biota)

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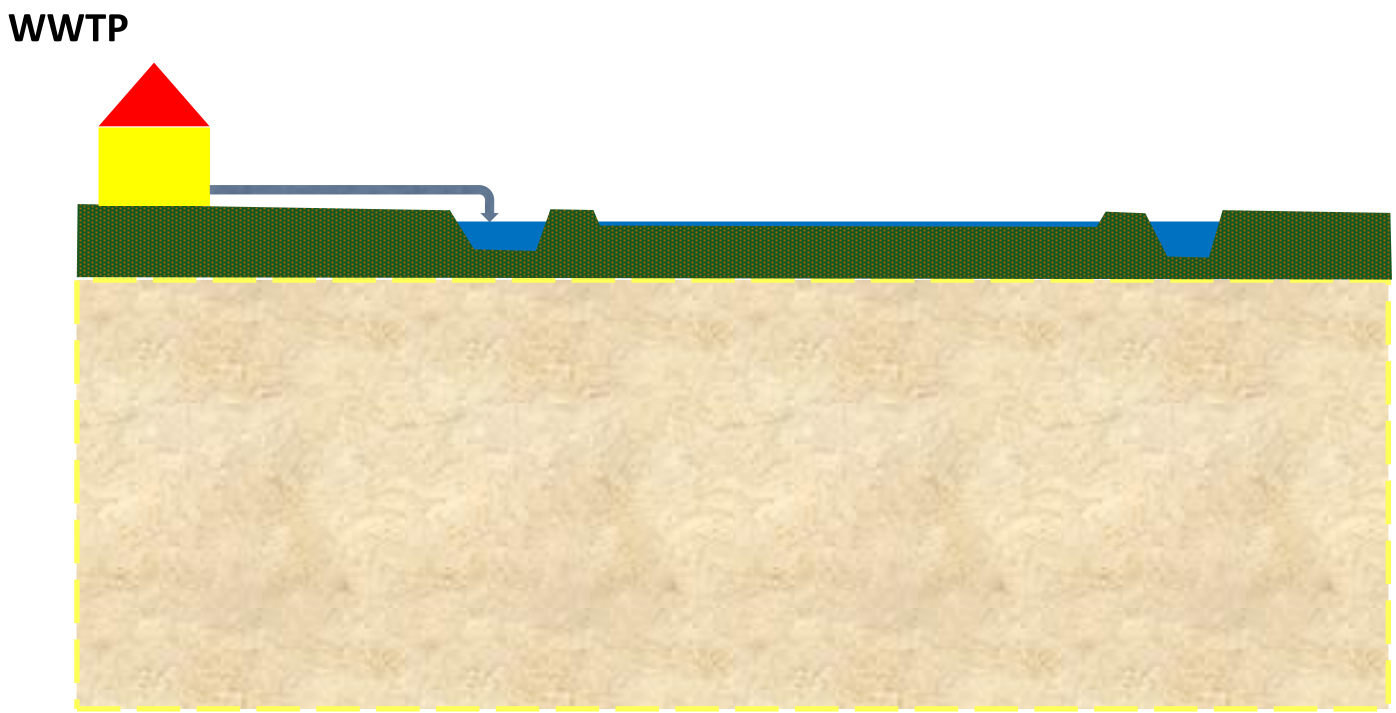
Hypotheses

- use of peatlands for additional sewage purification via **anaerobic microbial degradation** (e.g. pharmaceuticals, organic pollutants, endocrine substances)



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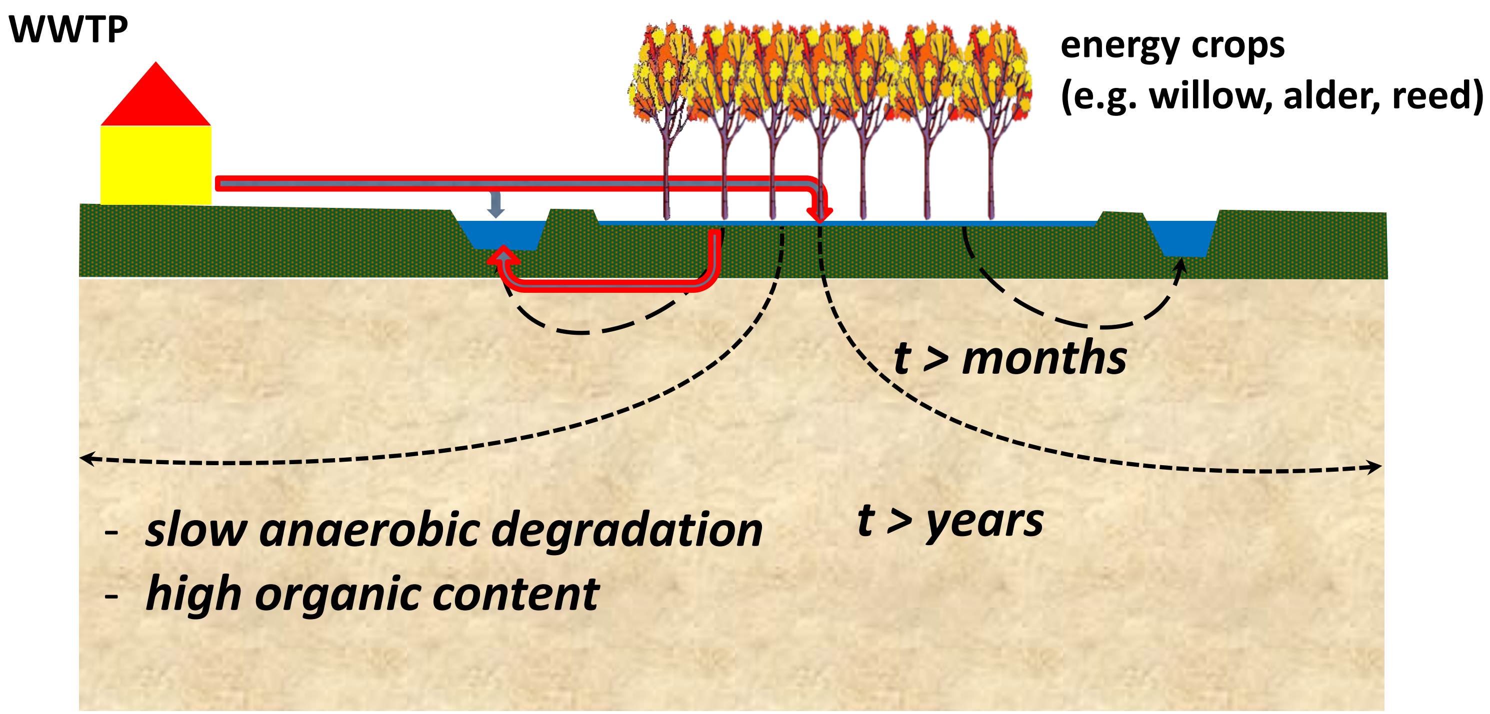

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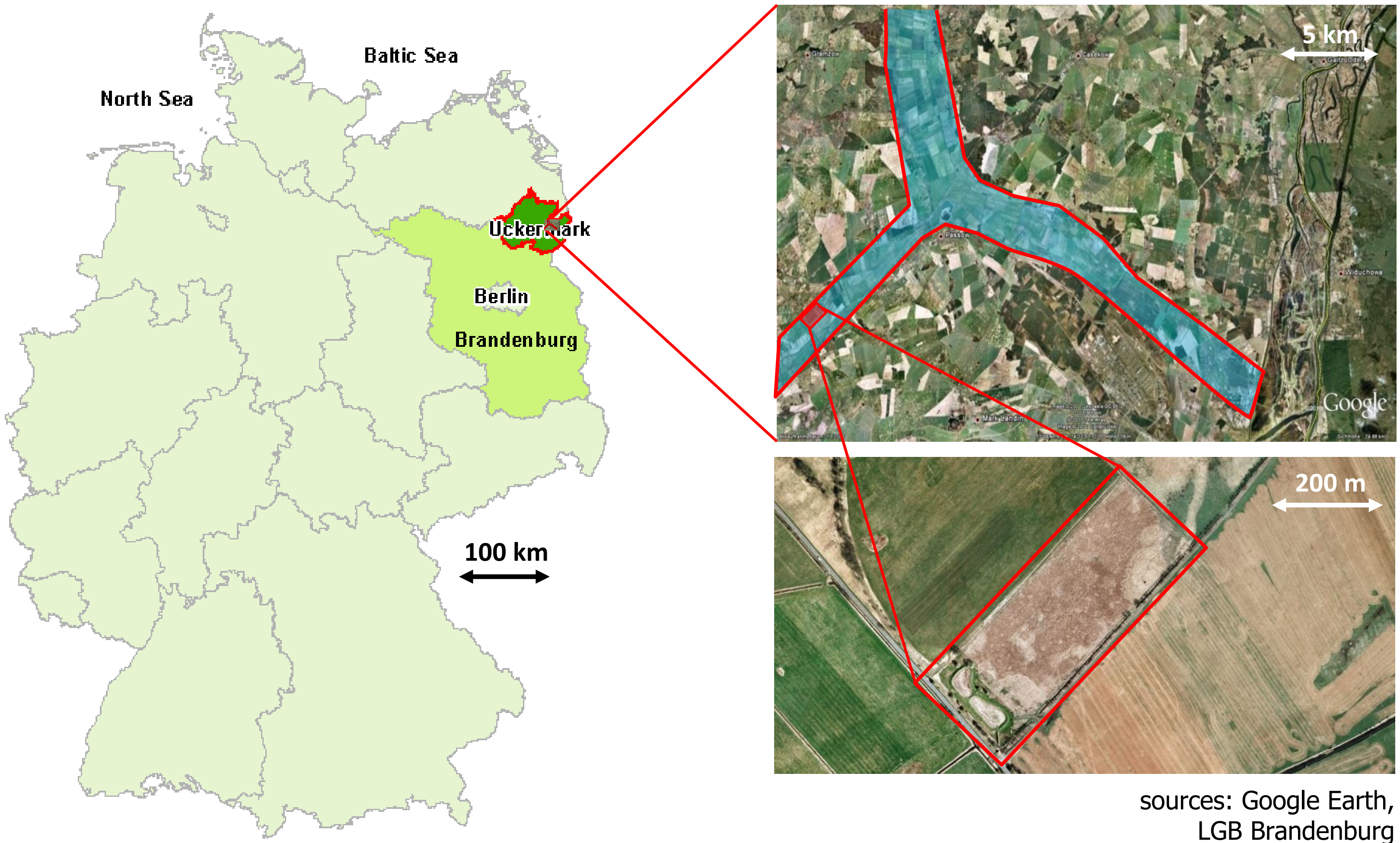
Biesenbrow pilot site

Rural district Uckermark

Randow-Welse valley



sources: Google Earth,
LGB Brandenburg

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Biesenbrow pilot site – Site characteristics

- fen peat site (8 ha)
- peat layer ca. 0.5 – 1.5 m
- strongly degraded from agricultural use
- planted 1996 with reed (*Phragmites)*
- since 1997 renaturation, partly rewetting by subsurface and surface irrigation
- rewetting for nature conservation with respect to sustainable peat protection and carbon sequestration
- water level management supported by weirs

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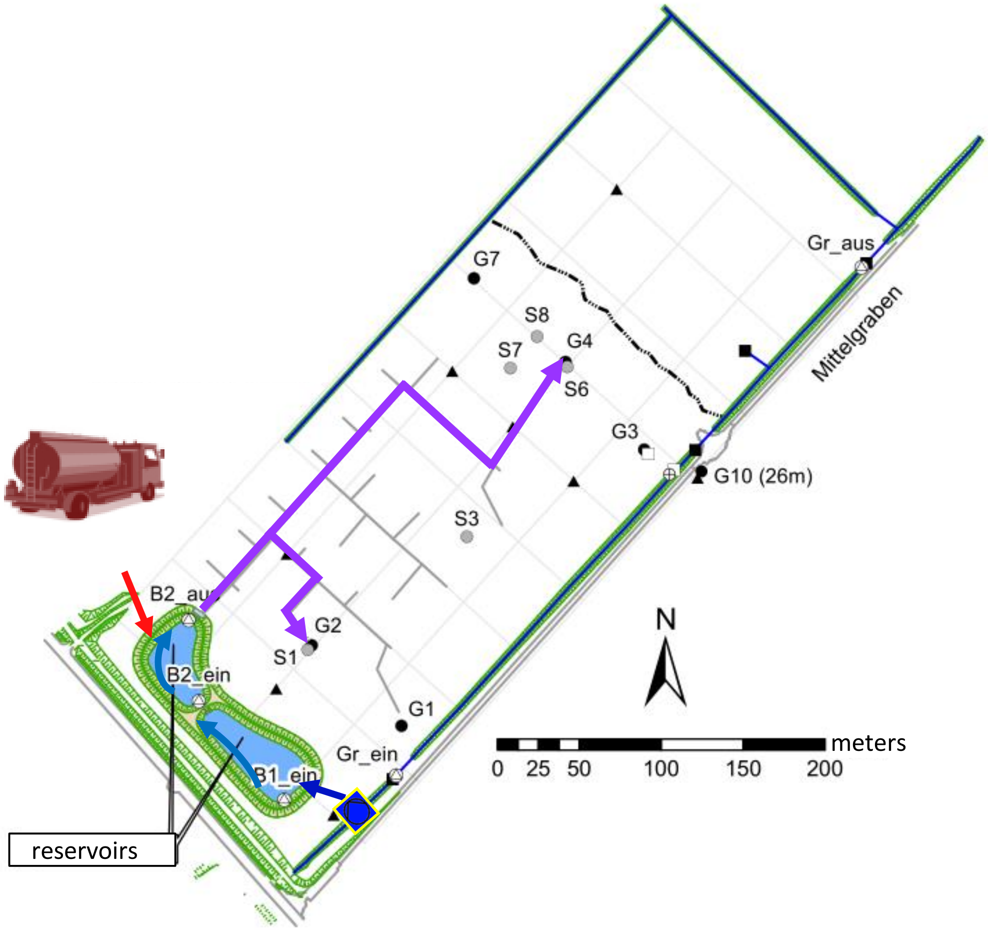
Biesenbrow pilot site – Recent methods



- 2011-2013 **irrigation** of 6 ha with treated wastewater and surface water (1:10)
- irrigation period during May - October
- **monitoring** of soil, surface, ground- and treated wastewater
  → nutrients, heavy metals, ions
  → organic micropollutants (LC-MS, LC-HRMS)
  → microbial enzyme activities (FDA hydrolase, beta-glucosidase)
- geohydraulic studies: matter fluxes and residence time

Top priority →

water protection with regard to organic micropollutants (EU water framework directive), **groundwater safety**

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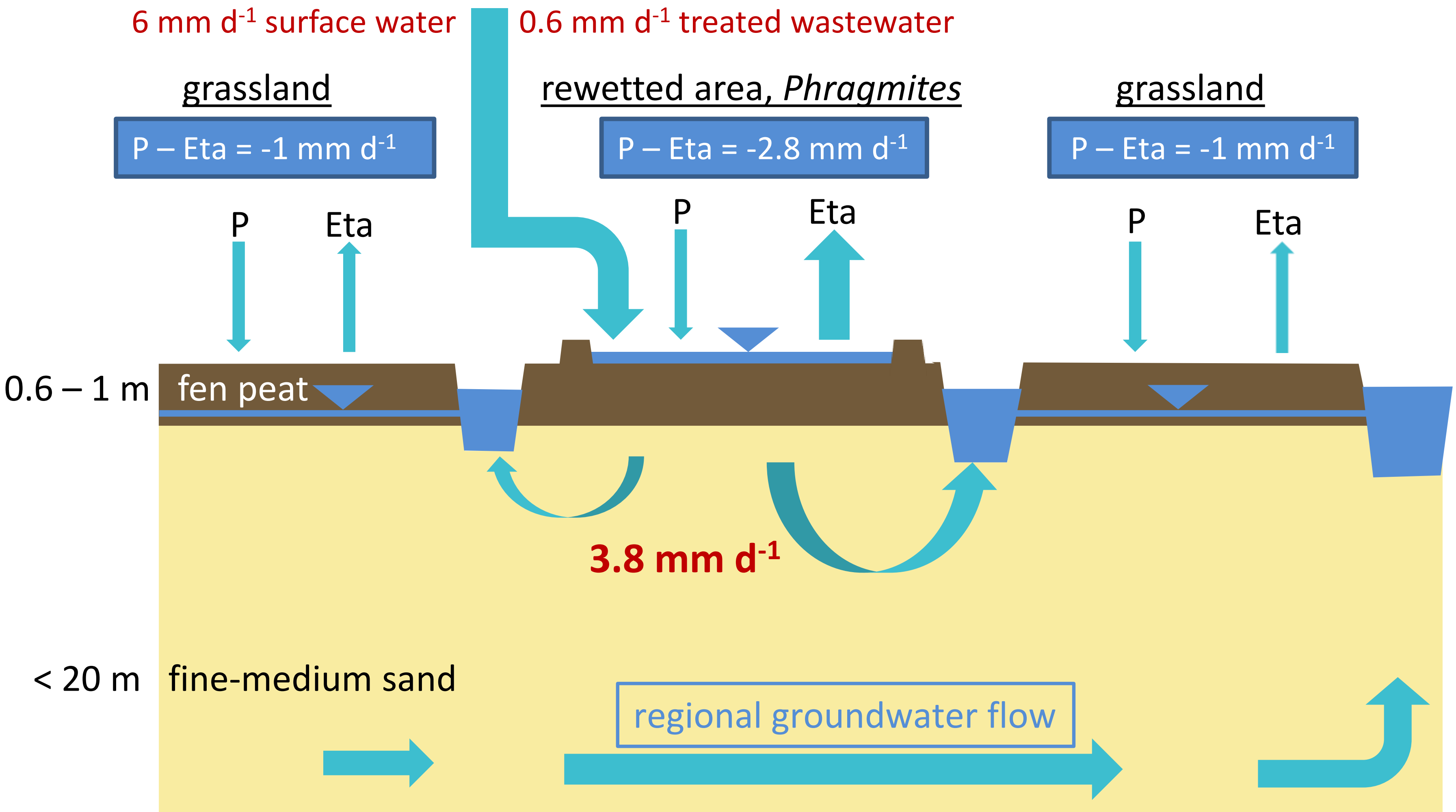
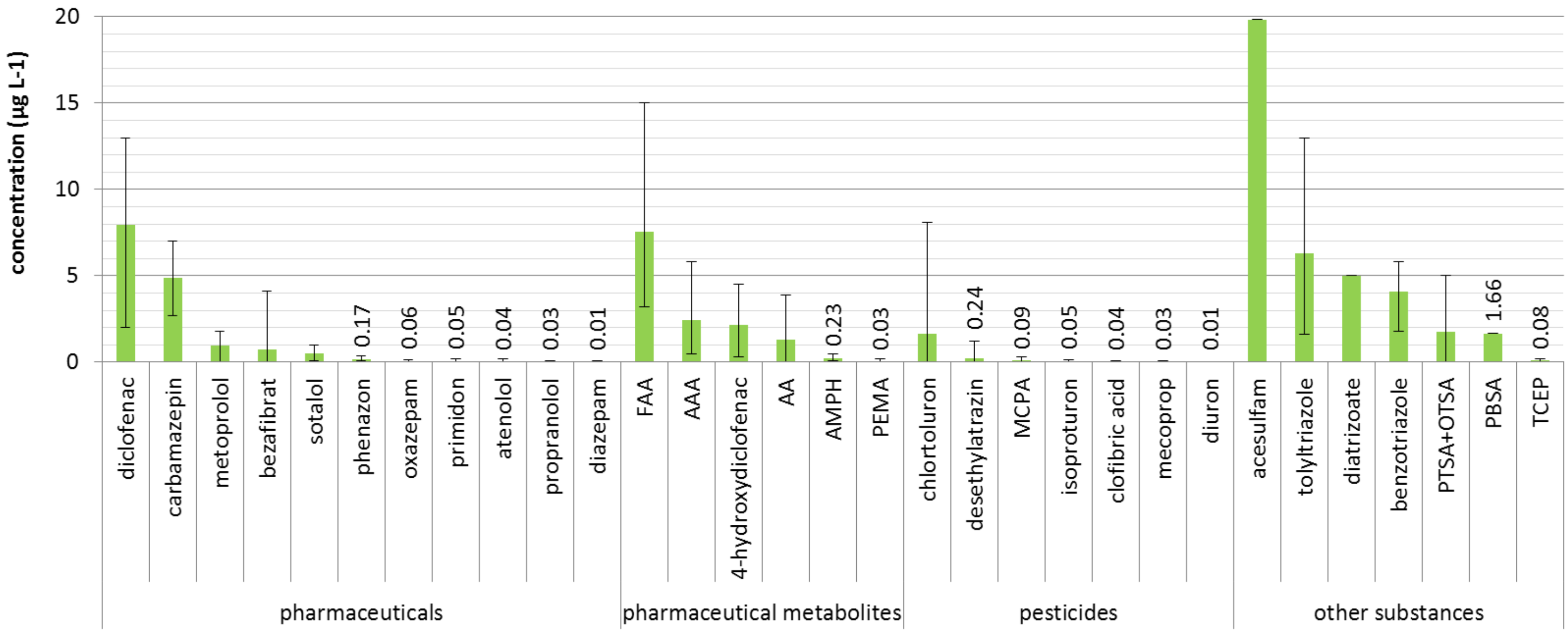
Biesenbrow pilot site – Hydrological regime



Results – Treated wastewater



- analysis of a wide spectrum of 67 micropollutants → 31 substances detectable
- treated wastewater of the rural area → 'hot spots' in concentration of the pharmaceuticals **Diclofenac** (8.0 µg L^{-1}) and **Carbamazepine** (4.9 µg L^{-1}), **FAA** (7.5 µg L-1) and **Acesulfame** (19.9 µg L-1)

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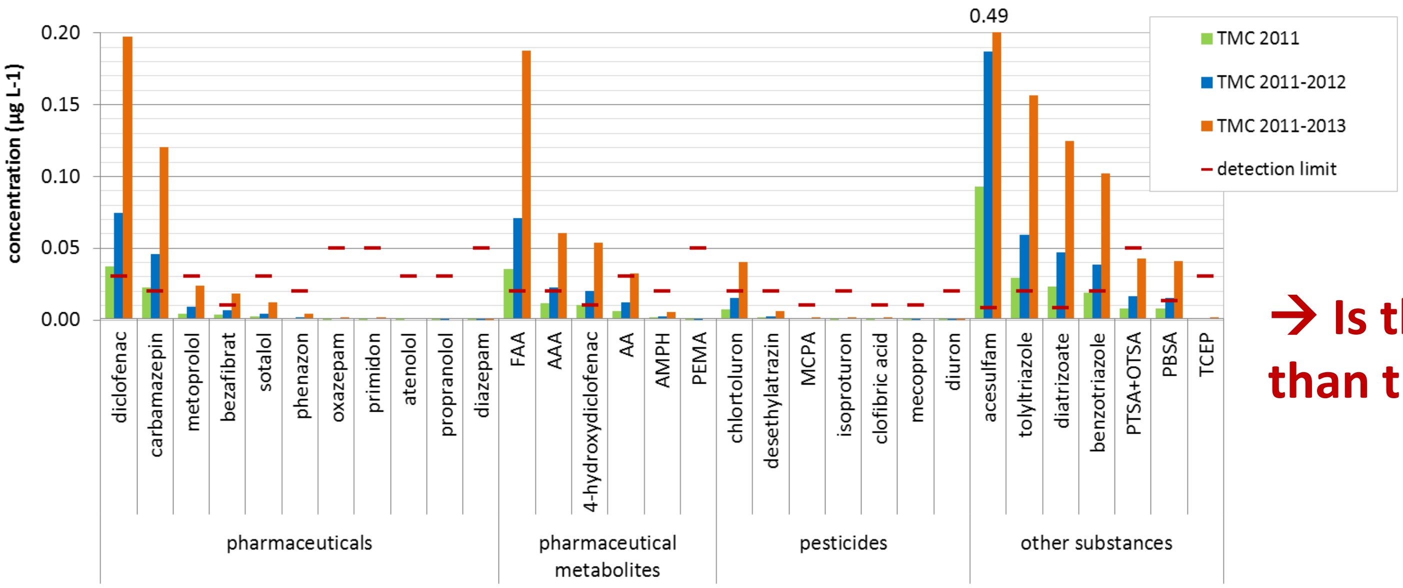
Results – Estimated final dilution

- 10-fold diluted wastewater → further dilution by continuously pumped reservoir water, infiltrating canal water and rainwater
- estimation of final dilution on the site (theoretical minimum concentration - TMC) → calculated from maximum volume of exchangeable groundwater, porosity, mean sewage water concentration
- assumption: homogeneous distribution over the pilot site, all wastewater remains on the site

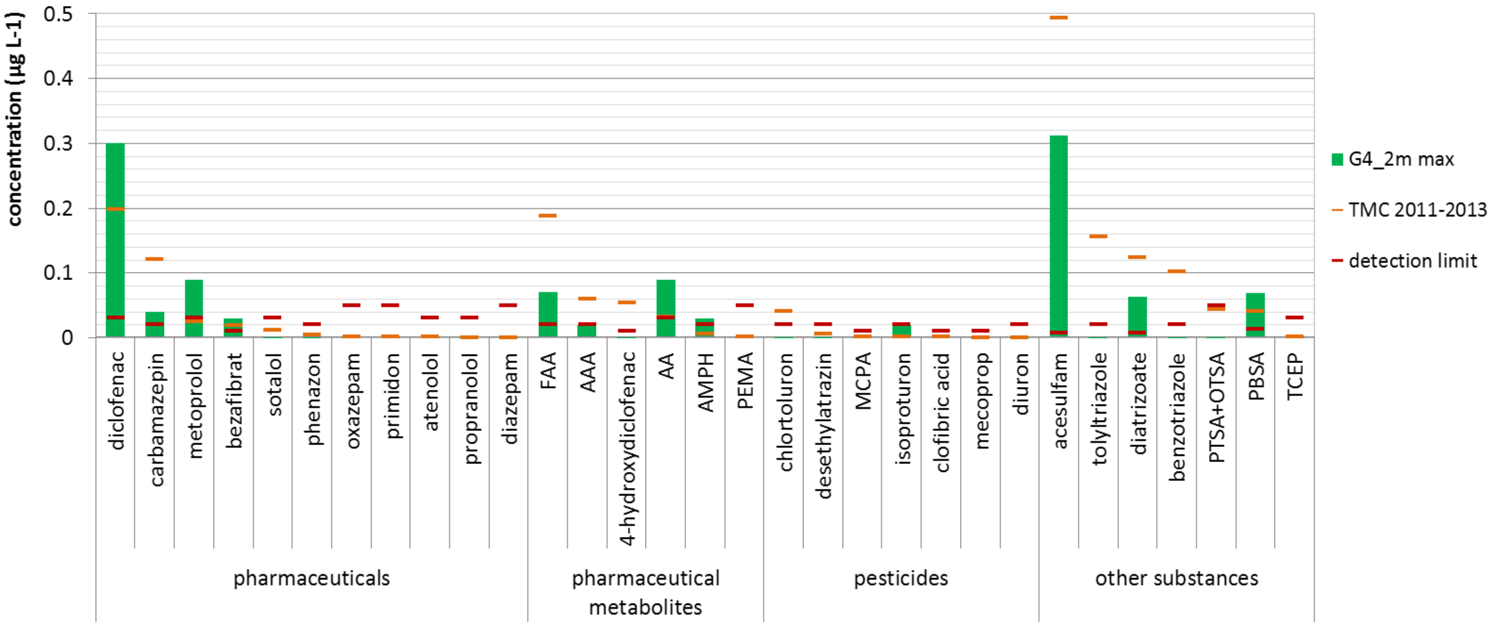


→ Is the TMC higher than the detection limit?

- 13 micropollutants → TMC of the diluted wastewater higher than the detection limit

→ for these 13 substances, traces should be detectable in the groundwater

Results – Groundwater



- all micropollutants → maximum concentrations far below no effect concentration or environmental quality standards (except Diclofenac: lowered dilution due to dry spell in June 2013)
- 10 micropollutants → higher than the detection limit
- 4 micropollutants → clearly higher than the theoretical minimum concentration 2011-2013 (diclofenac, metoprolol, AA – aminoantipyrin, PBSA)

→ Other processes besides dilution must induce the strong concentration decrease of micropollutants in the groundwater.

Possible processes for micropollutant reduction

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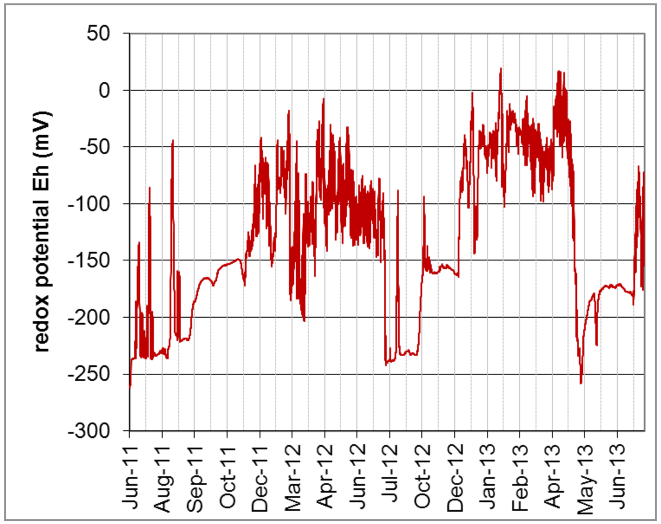
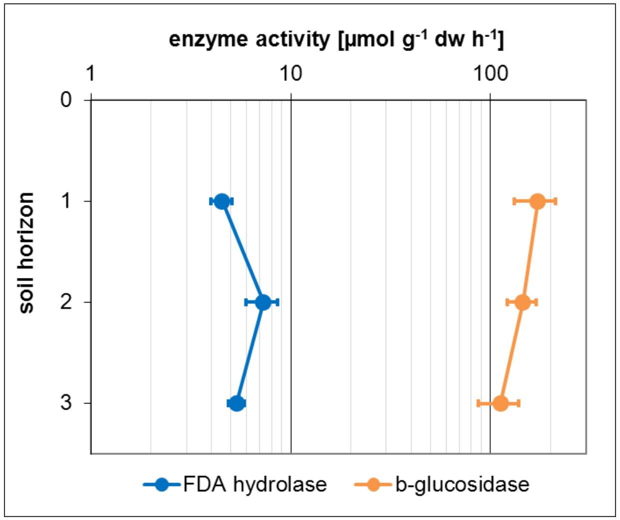
1. Sorption of micropollutants in the peat soil or in plant biomass
2. Photolysis of micropollutants
3. Microbial decay of micropollutants

→ high content of organic matter in the peat soil (≤ 36 % TOC) and in the groundwater (mean 16 mg L-1)



→ low redox potential in the peat soil



→ increased enzyme activities in the peat soil

→ more detailed process analysis necessary (laboratory experiments)

Conclusions & Outlook

Post-cleaning of treated wastewater in groundwater-fed fen peats

- no adverse effects on groundwater quality after 3 years of irrigation using treated wastewater
- top-down experiment → further process analysis in the lab
- reasonable use of **degraded** peat areas (increase of biodiversity, carbon sequestration)
- alternative to cost-expansive technical solutions
- **prevention of direct discharge of nutrients and substances with possible ecotoxic effects into running water systems**

☞ **value adding for rural areas**

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