Sorption and Degradation Parameters of Selected Pharmaceuticals in Controlled Laboratory Column Experiments

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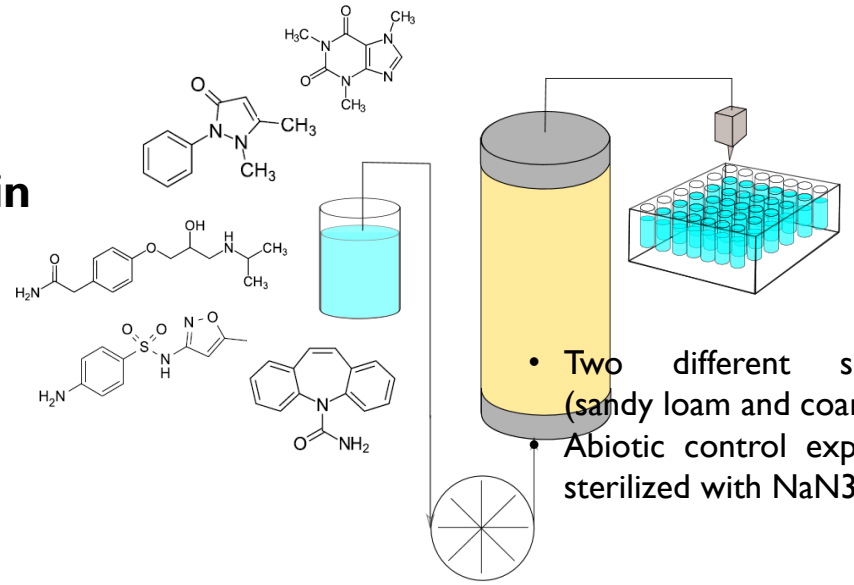
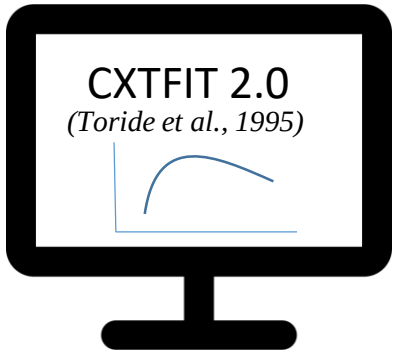
Aims of the study

- Examine the **transport behavior** of selected **pharmaceuticals in groundwater sediment**:
  - Antipyrine
  - Atenolol
  - Caffeine
  - Carbamazepine
  - Sulfamethoxazole
- Focus on **biodegradation** where degradation rates could not properly be established before → Long term experiments
- Use of intracellular adenosine triphosphate **(ATP) as biological control parameter** to estimate microbial activity and differentiate between sorption, biotic and abiotic degradation
- Insights into **interaction** effects of pharmaceutical compounds

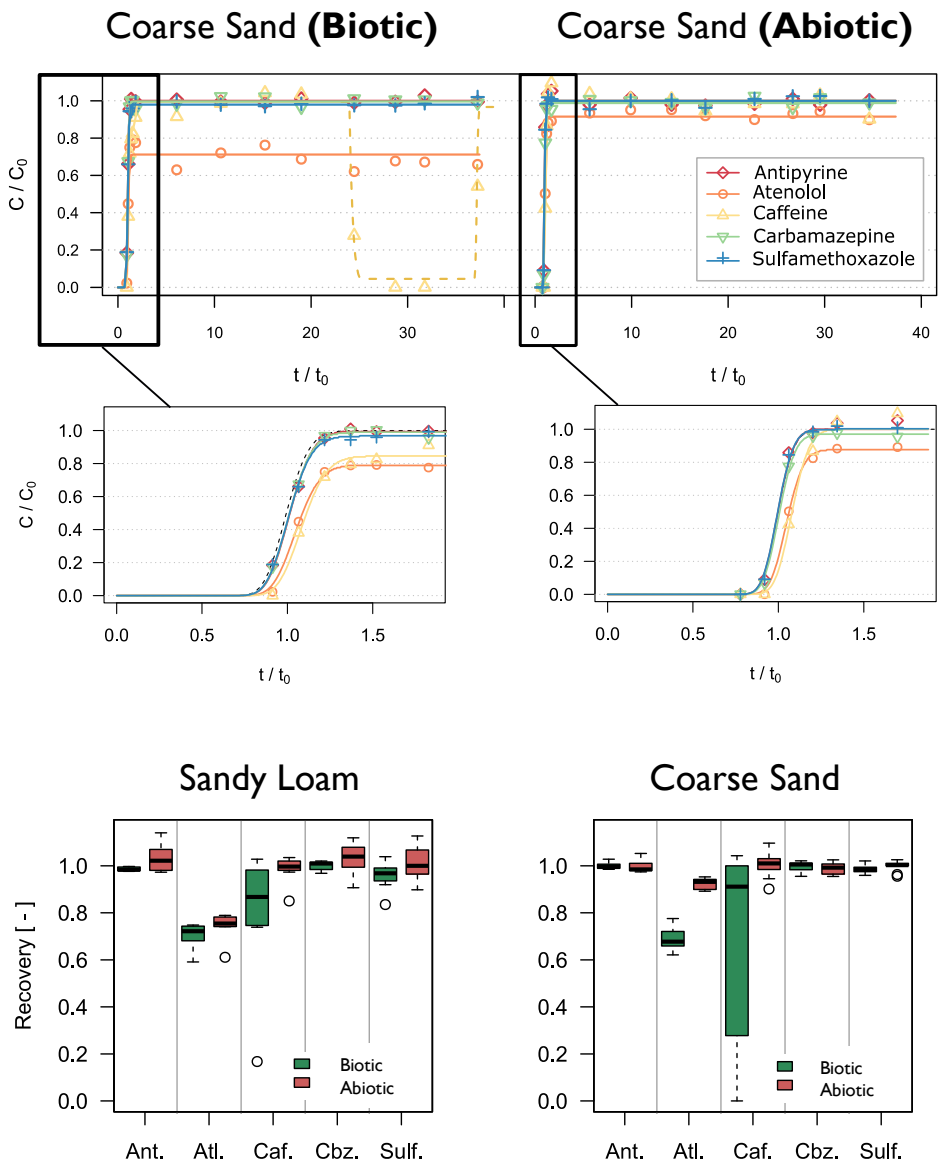


- Two different sediments (sandy loam and coarse sand)
- Abiotic control experiments sterilized with NaN3

$$R_f \frac{\delta c}{\delta t} = D \frac{\delta^2 c}{\delta x^2} - v \frac{\delta c}{\delta x} - \mu c$$



Results



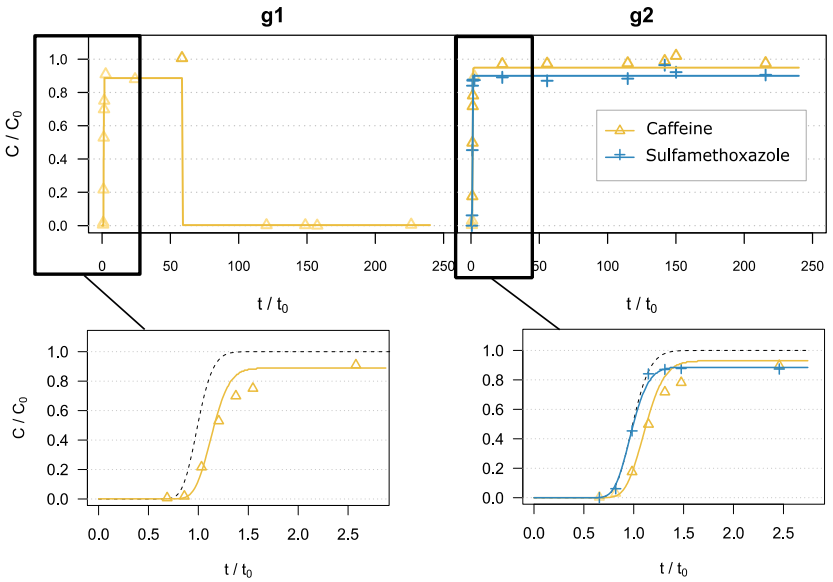
a) Five selected compounds injected simultaneously:

- Antipyrine, carbamazepine, and sulfamethoxazole showed very low to no degradation or sorption in two different sediments and under varying redox conditions.
  → Highest contamination threat of tested compounds

- Atenolol was degraded in coarse sand; in sandy loam sorption seemed to be the dominant atenolol removal process

- Biodegradation of caffeine was found in the biotic settings of both sediments after a lag time of 120 to 420 hours and when enough dissolved oxygen was present.

Results



b) Only caffeine and the antibiotic sulfamethoxazole injected simultaneously:

- Stronger degradation of sulfamethoxazole than in experiment with 5 compounds
- No degradation of caffeine → influenced by low concentrations of dissolved oxygen

Discerning biotic from abiotic processes:

- Abiotic settings spiked with sodium azide: no entirely sterile conditions achieved but considerably reduced microbial activity.
- Intracellular ATP concentrations increased with ongoing degradation of pharmaceuticals, especially of caffeine.

Conclusions

- Sediment type and redox conditions influence sorption and (bio)degradation of pharmaceuticals in groundwater.
- A lag time can be observed before biodegradation comes into effect, corresponding to an adaption period for microorganisms (requiring long term experiments).
- The combination/variety of pharmaceuticals in groundwater affects their transport behavior.