Interreg Baltic Sea Region

Co-funded by the European Union

SUSTAINABLE WATERS

AdvIQwater

AARHUS UNIVERSITY

Removing micropollutants with MBBRs: Dependence of micropollutant degradation kinetics on the adaptation of the biomass to BOD loading; Implications for reactor processes and reactor design

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interreg-baltic.eu/project/adviqwater/

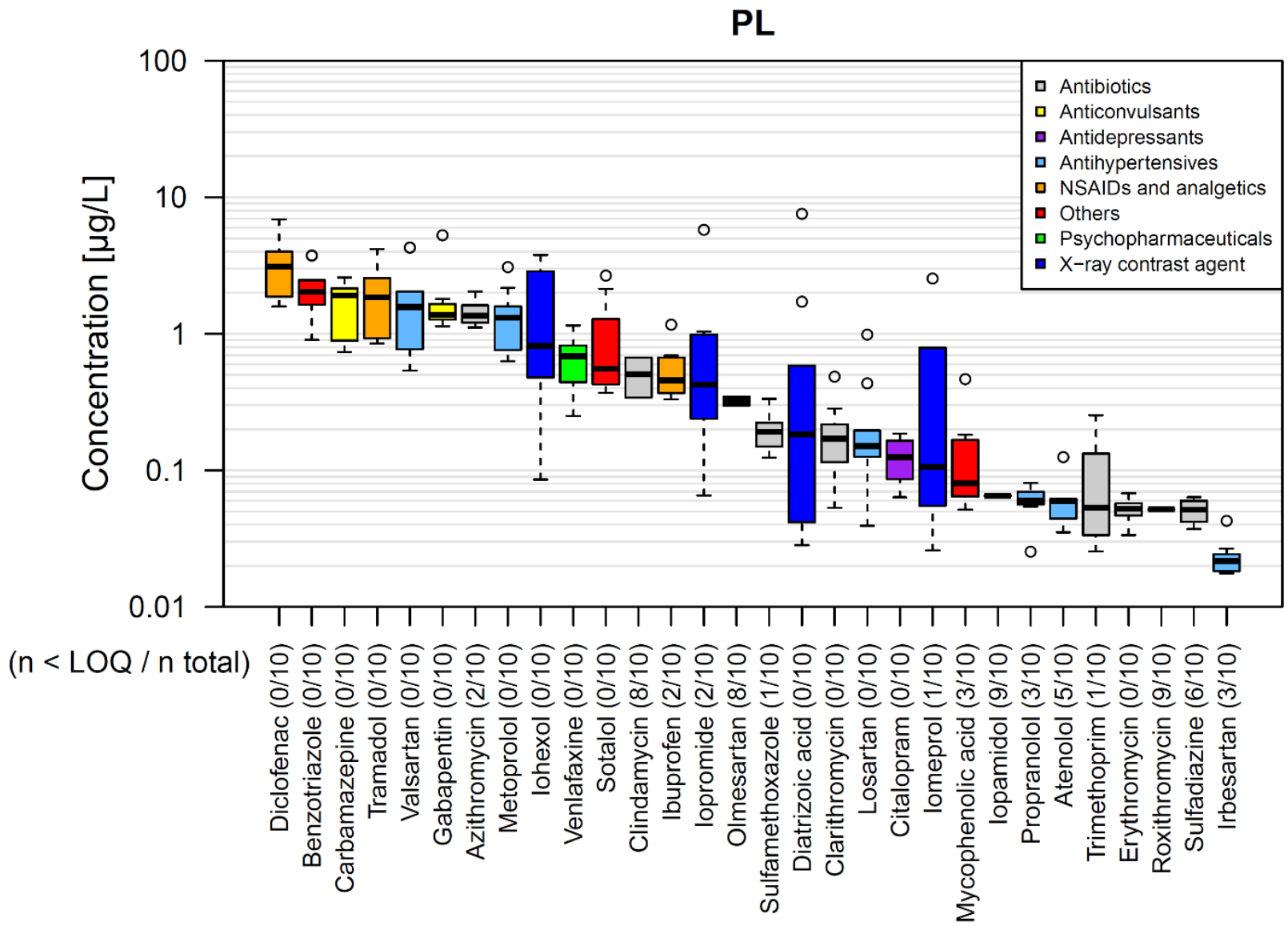
Structure

Some general ideas

Micropollutants MBBR and BOD loading

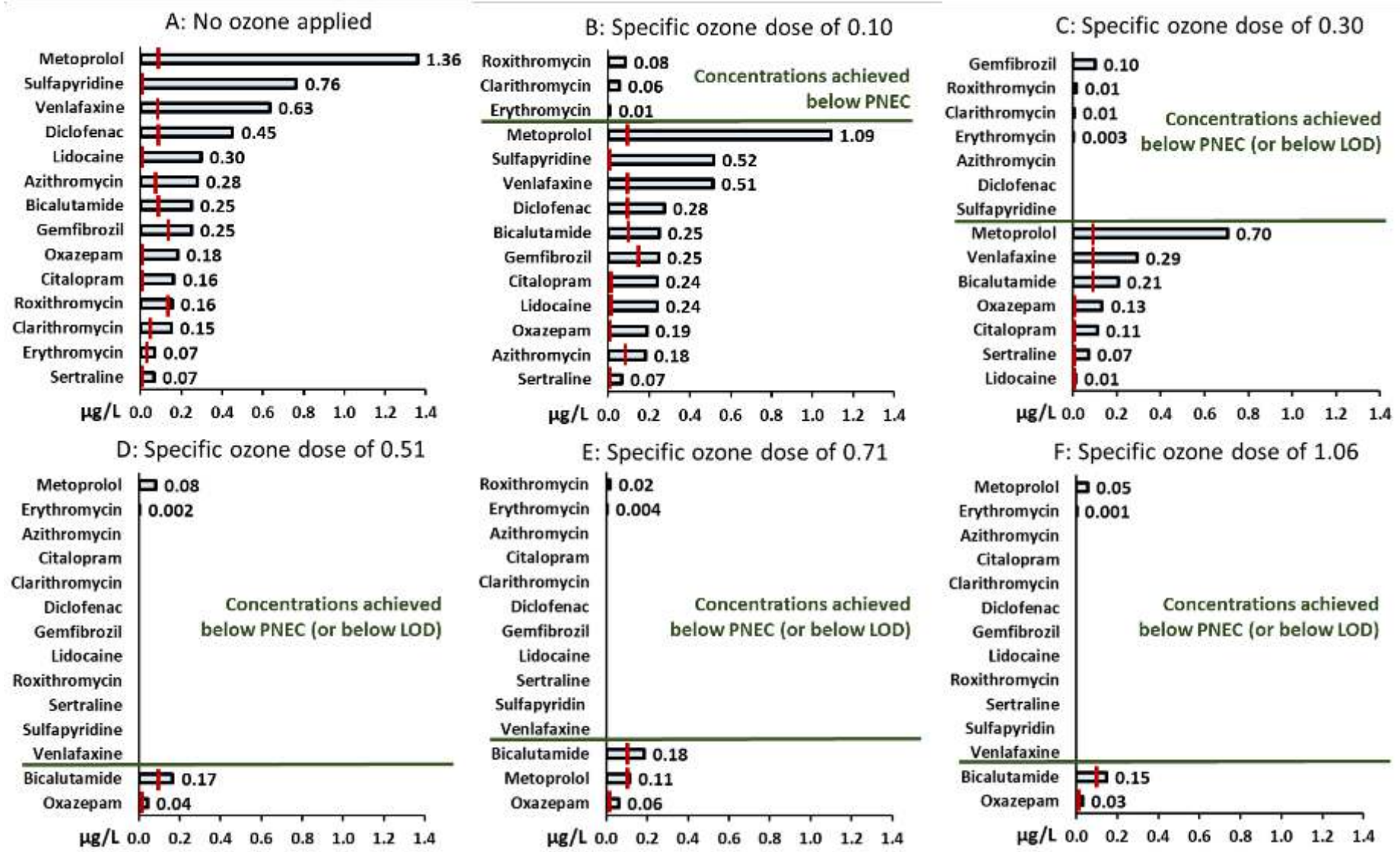
Contribution to the project

Pharmaceuticals in polish eff Wastewater



From
CW Pharma2

Efforts to bring pharmaceuticals below effect levels

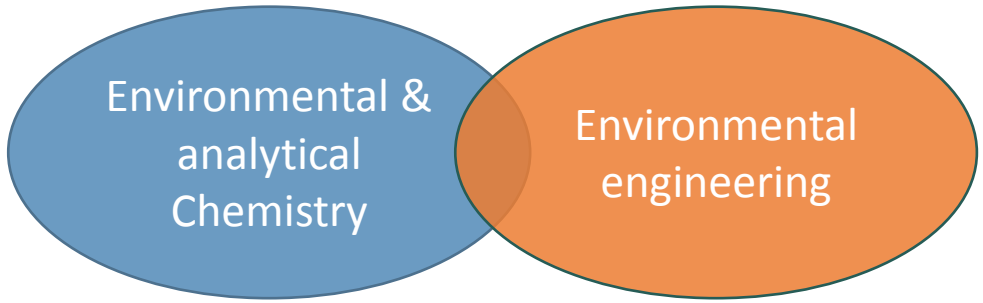


From
CW Pharma2

Profile and contribution of AU to AdvIQwater

Biofilm systems,

HPLC-MS/MS, UPLC-HRMS

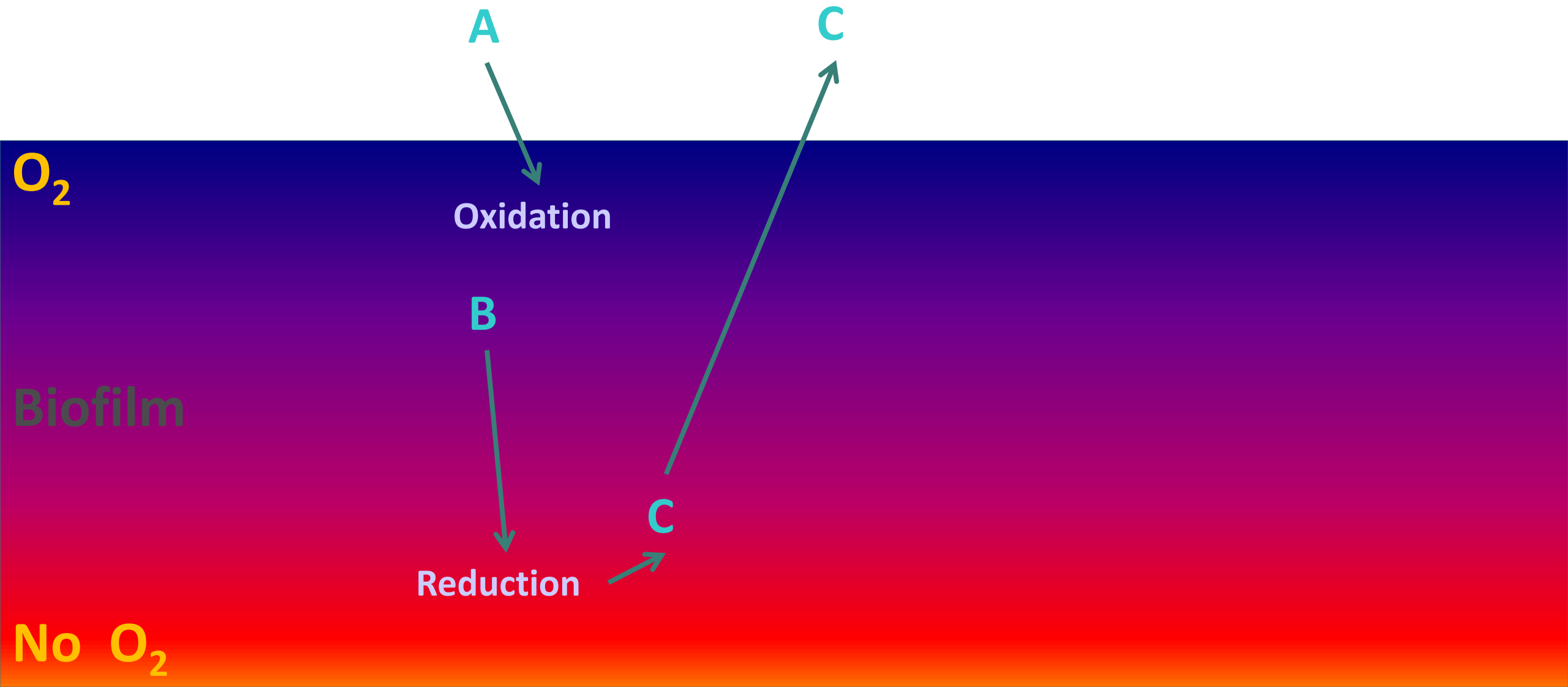


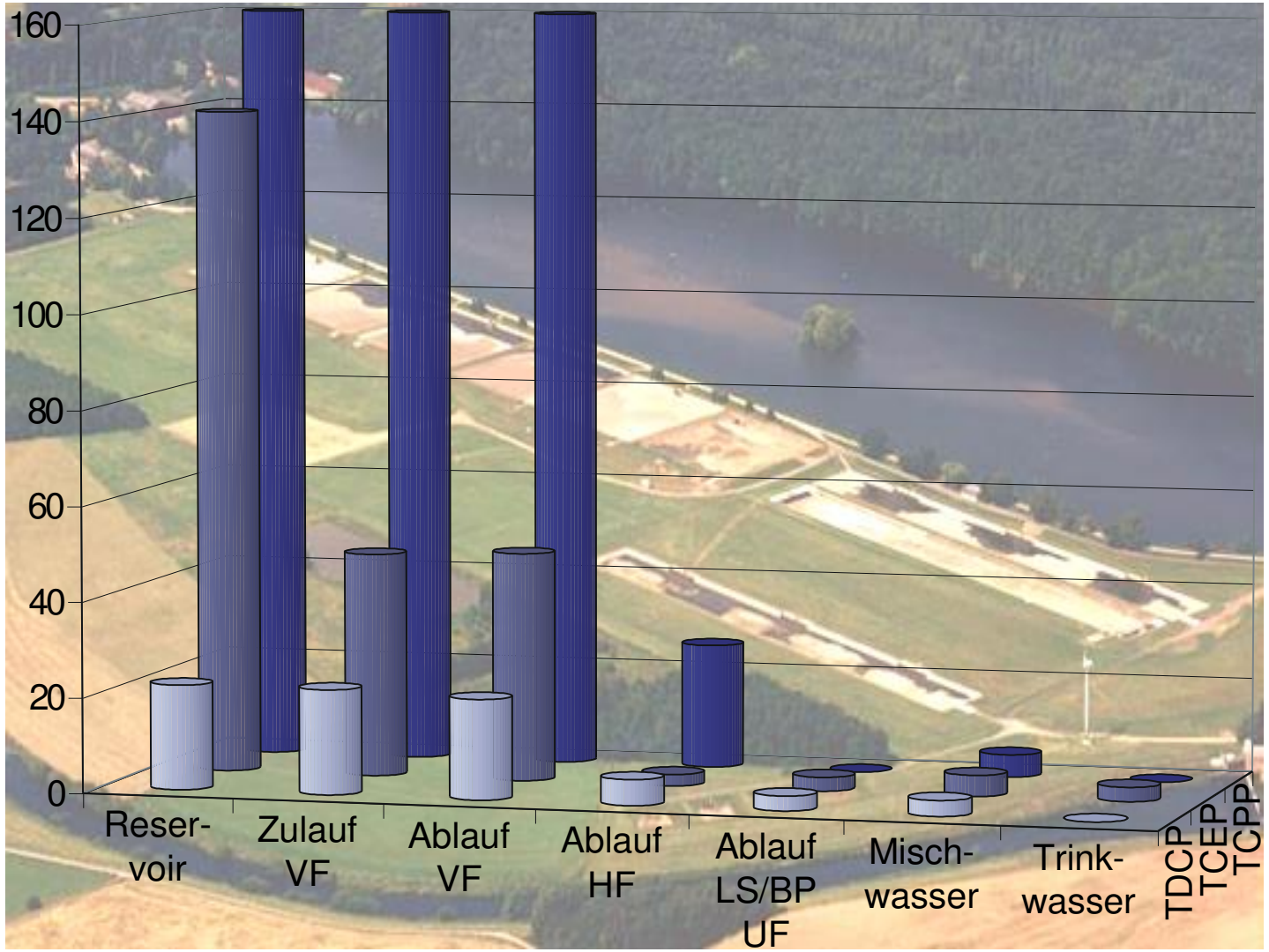
Why Biofilm?

Biofilms can degrade compounds sludge cannot degrade Carbamazepine, Organophosporus flame retardants, Diclofenac, iodinated x-ray contrast media

A lot of biofilm reactors are difficult to operate in wastewater contexts

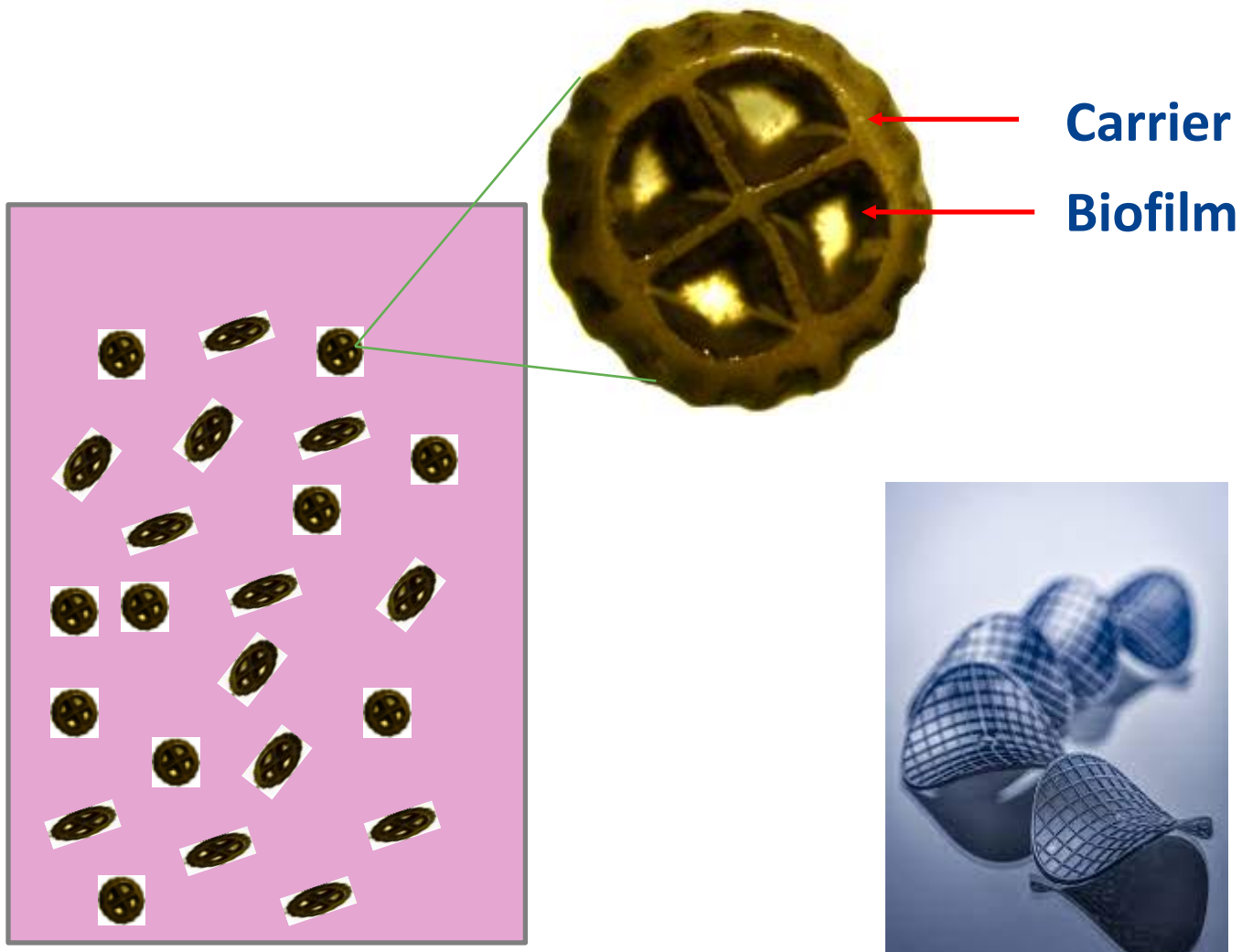
Gradients in Biofilms





- **Efficient removal of undegradable flame retardants**
- **The same installation is not able to remove caffein efficiently**

Moving Bed Biofilm Reactors (MBBRs)



Carriers of one reactor have very similar communities

It is easy to run control, repeat experiments

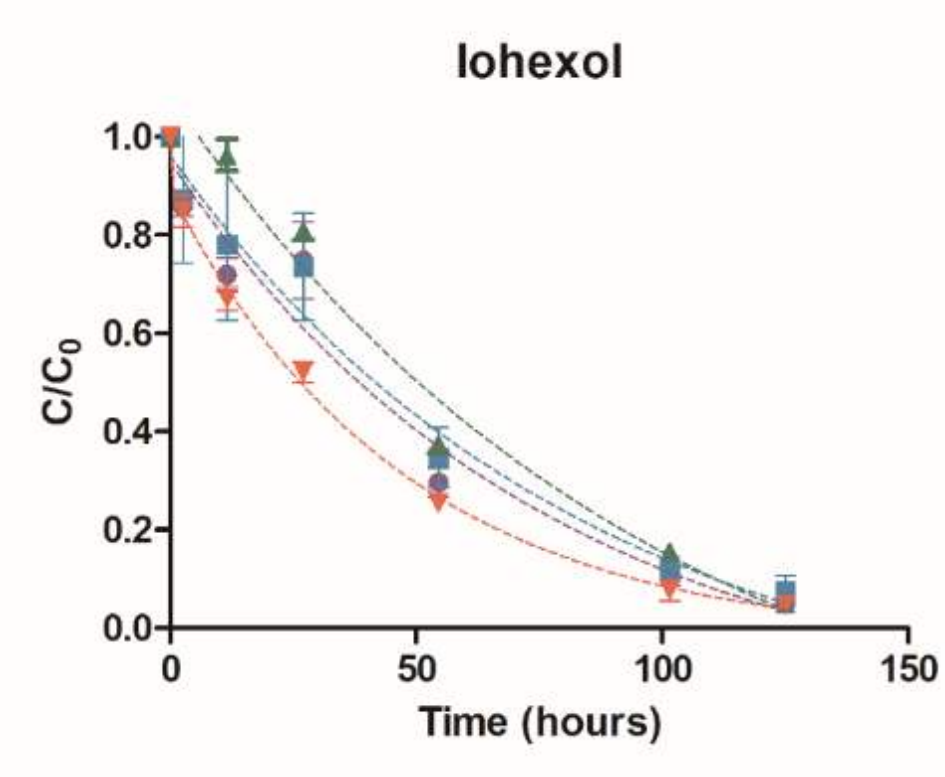
Substrate distribution is homogenous

Film thickness can be controlled

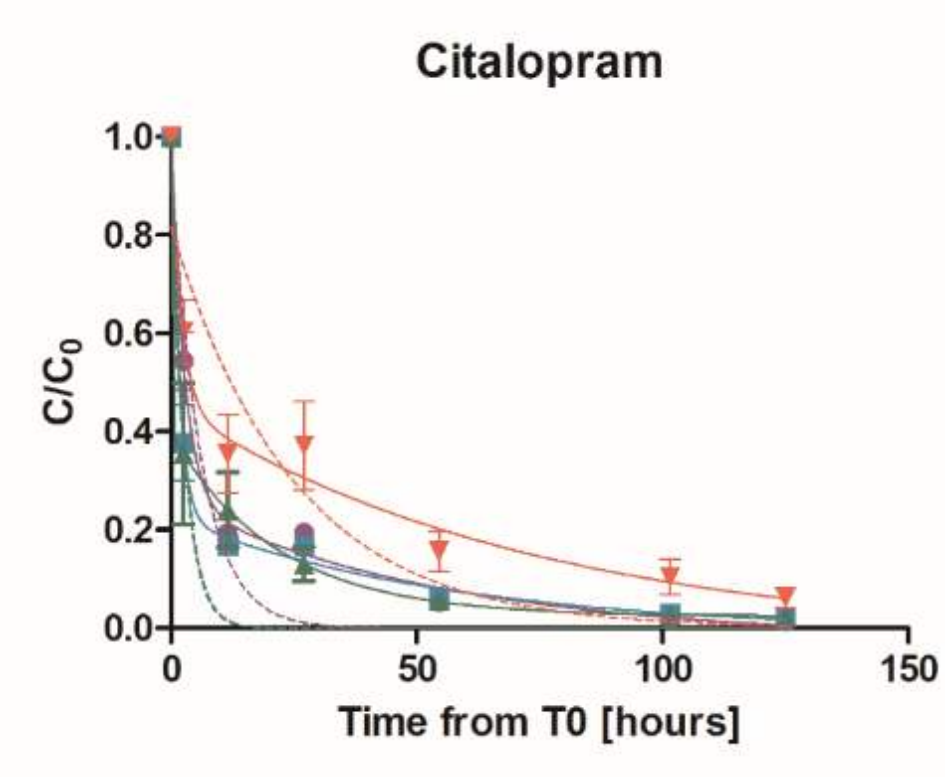
-> supergood scientific toys

MBBR in the Lab

Kinetics in Micropollutant removal in MBBR



Single first order



Two phase first order

Svendsen et al., 2023

Influence of BOD loading

All MP degradation is fortuitous degradation (co-degradation) at environmental concentrations

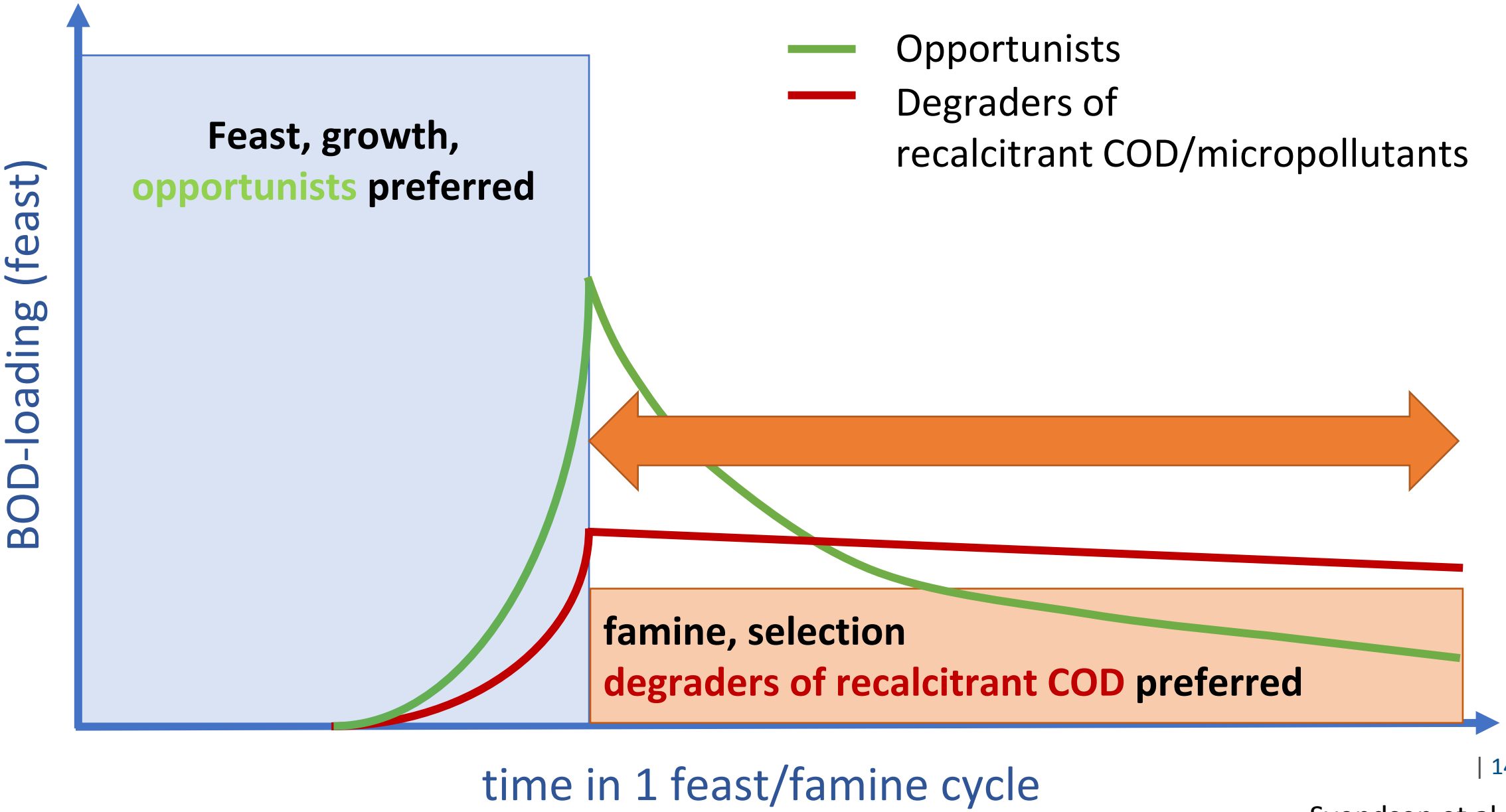
The right substrate (maybe at the right) time matters

Too much food: too lazy biomass

Too little food: too little biomass

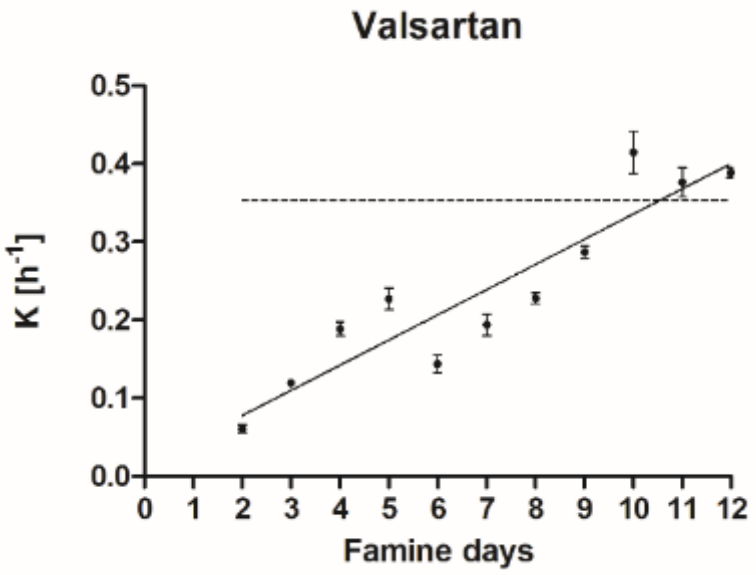
Getting out of the dilemma by feast famine cycles

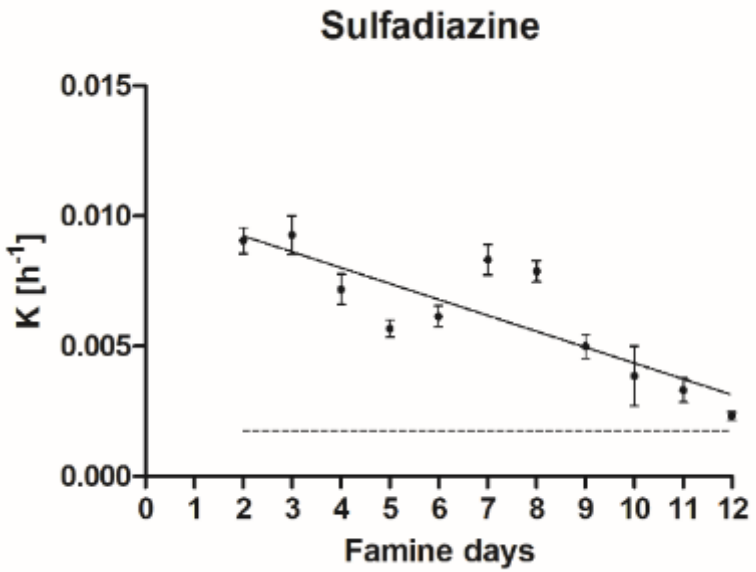
FF ratio

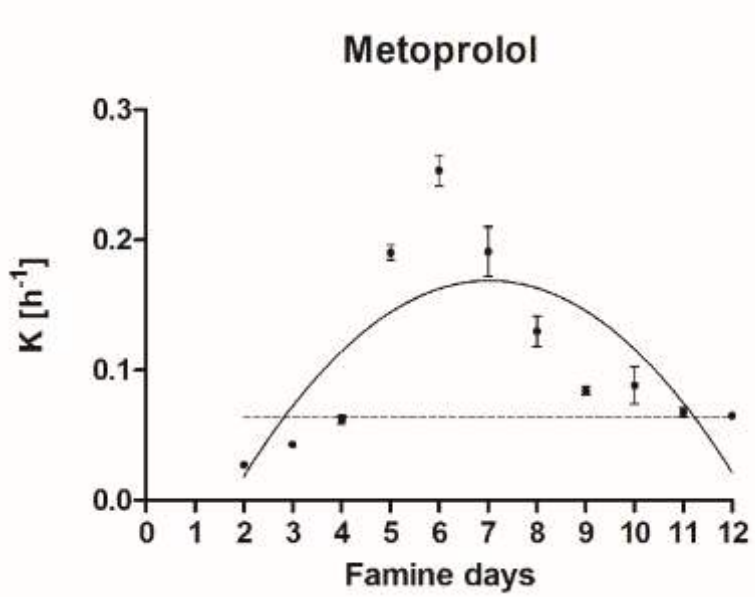


Svendsen et al., 2023

Micropollutant removal in dependency to BOD loading

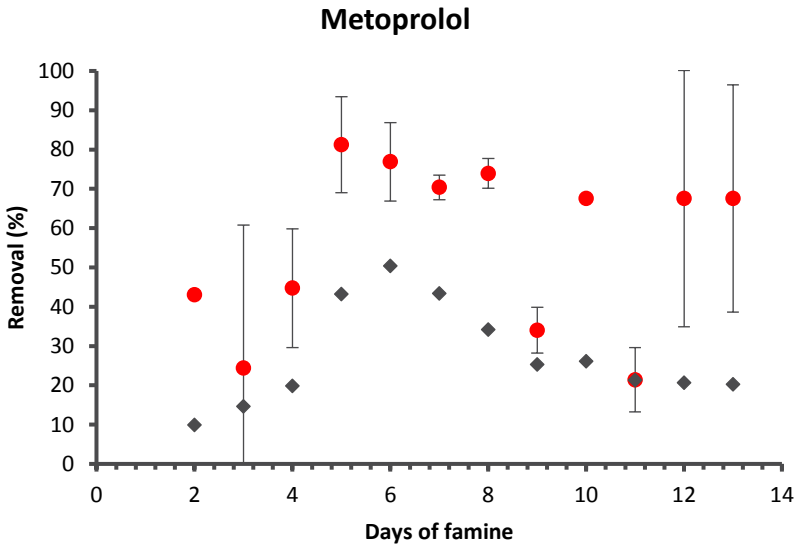


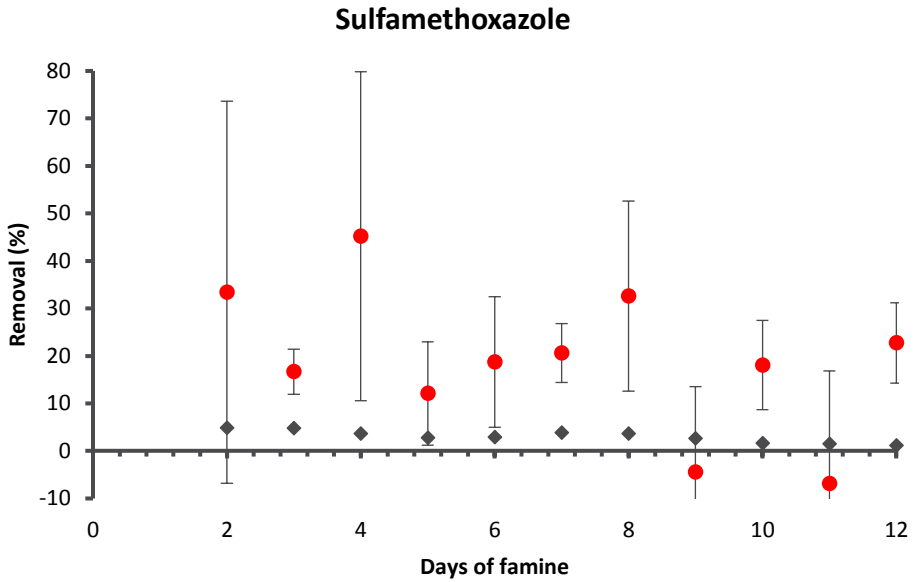




Svendsen et al., 2023

Comparison of batch experiment vs flow through



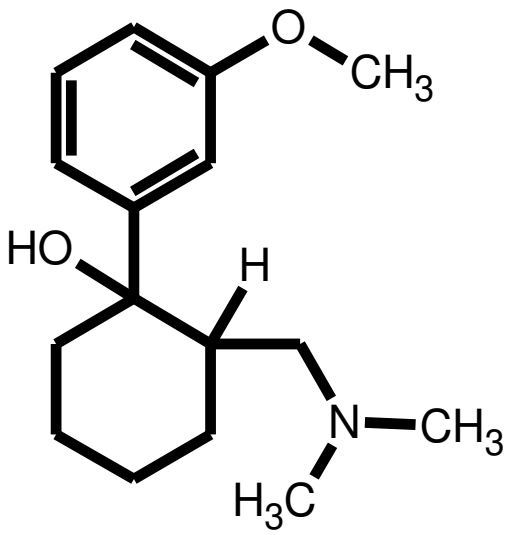


●Famine conditions, flow through wins against ♦batch

Data density/Clarity is considerably higher for batch

Svendsen et al., 2023

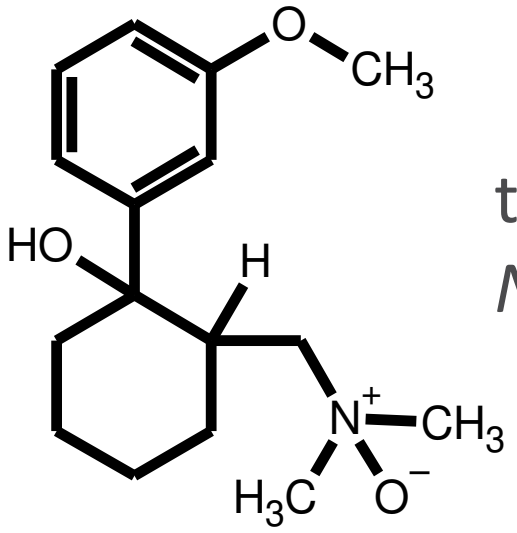
Dependency of preferred reaction pathway on C loading



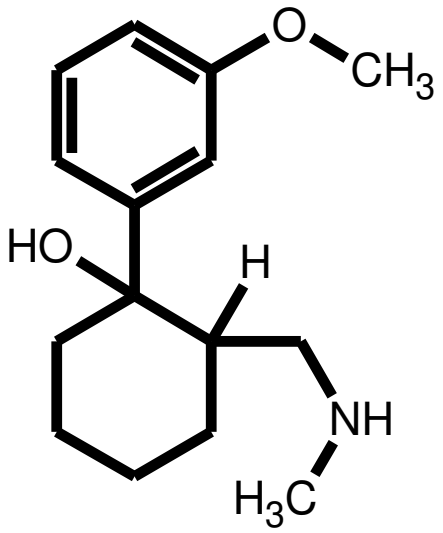
tramadol

Low substrate

High substrate



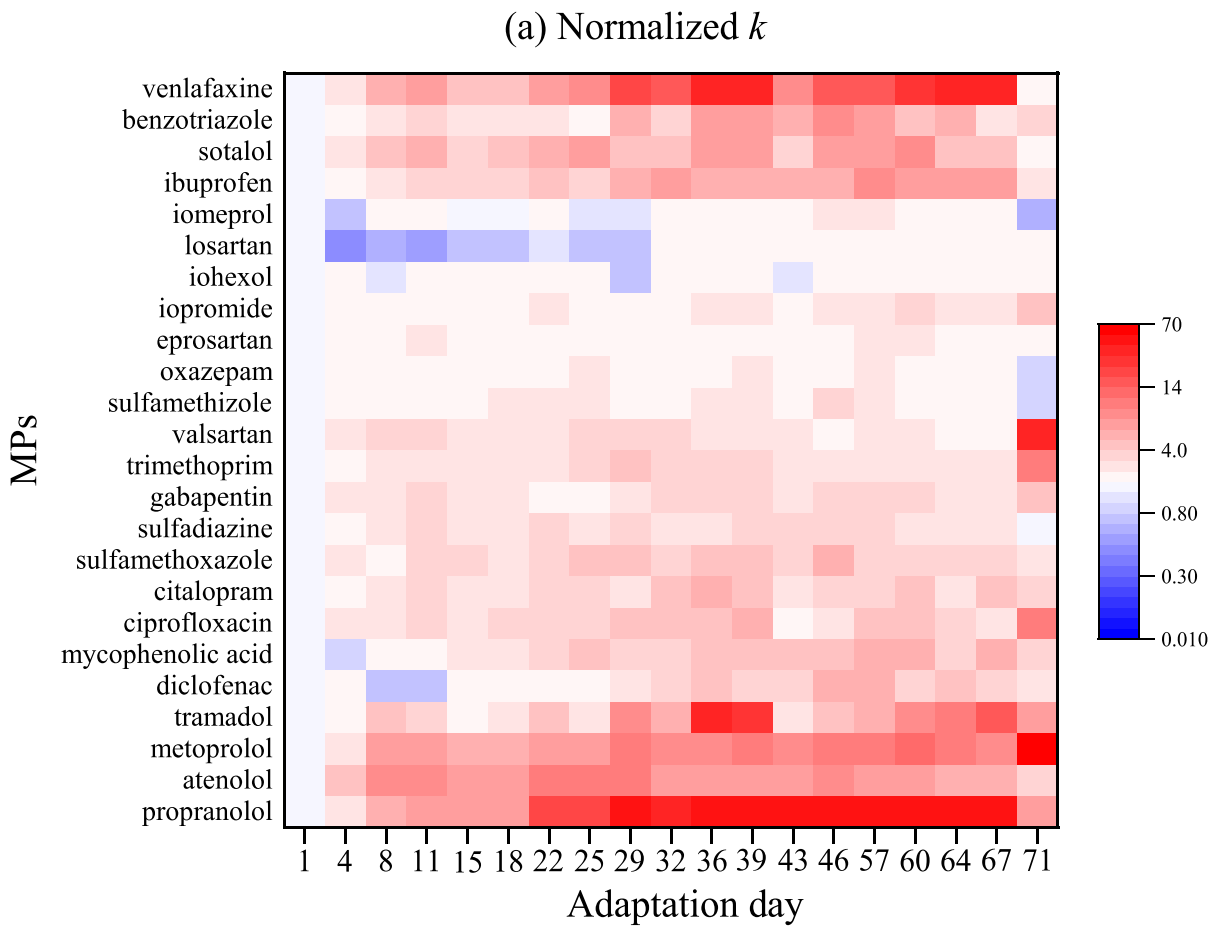
tramadol *N*-oxide

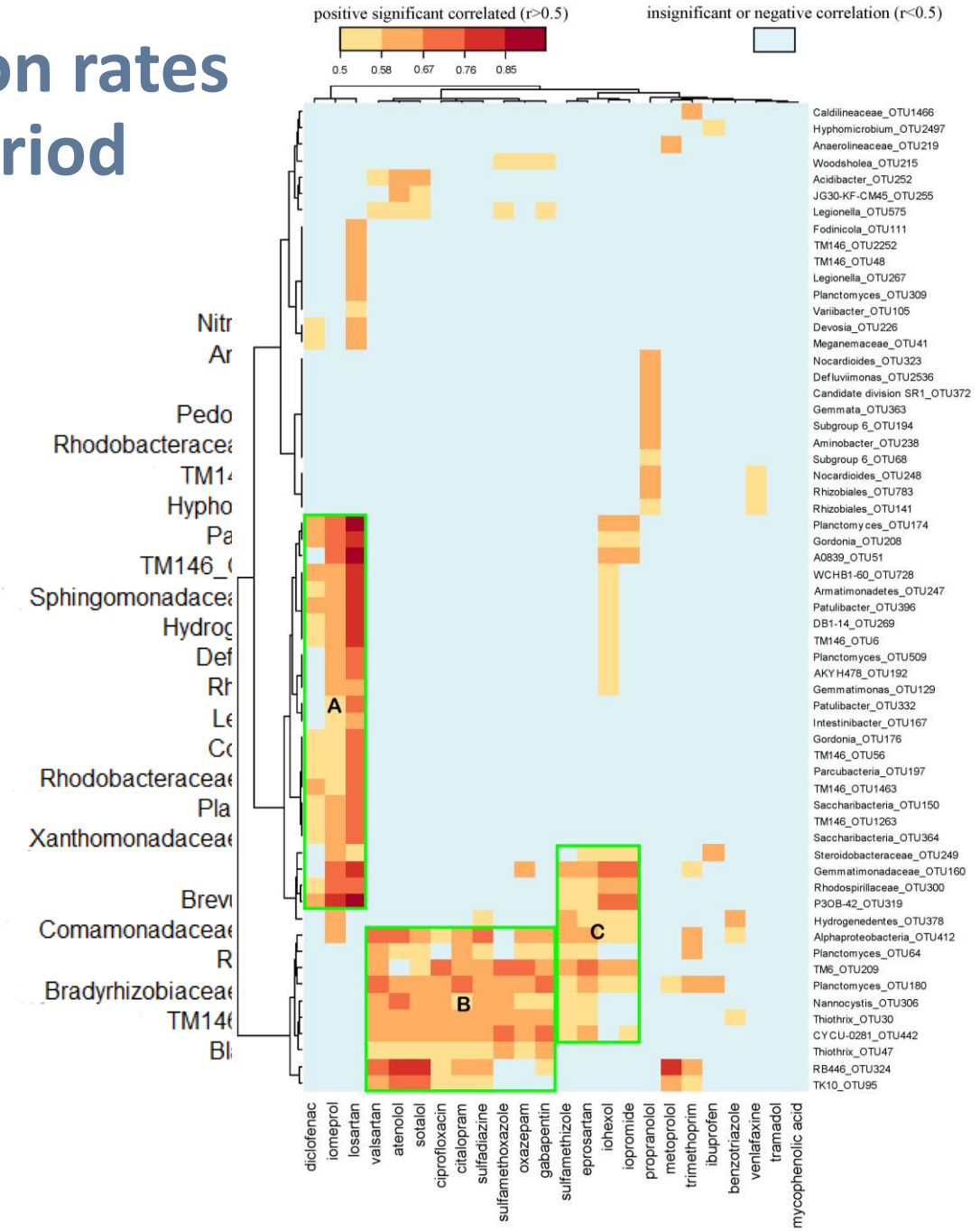


tramadol, des *N*-methyl

Liang et al., 2022

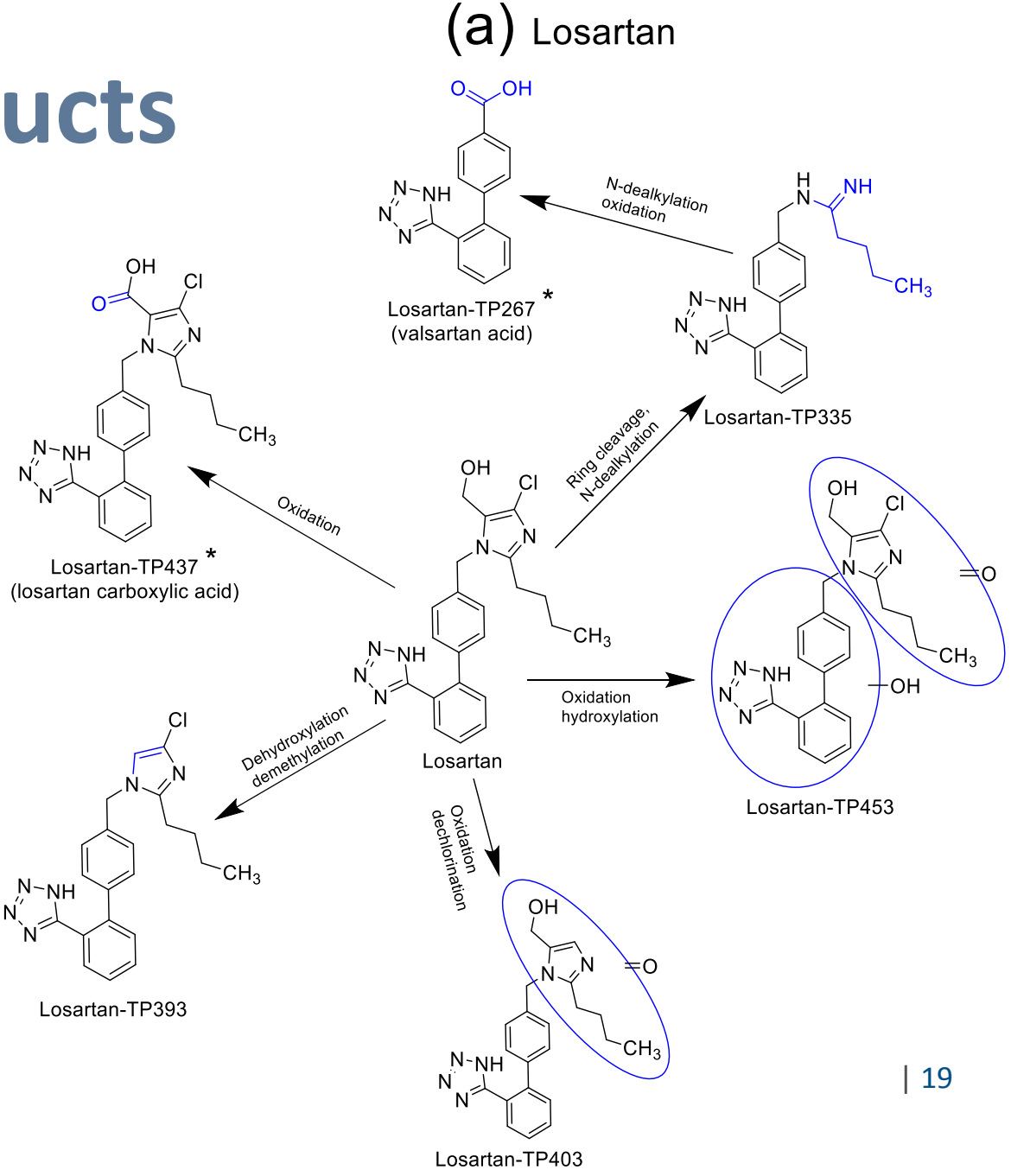
Linking species composition to reaction rates of reactor during an adaptation period





Liang, 2021

Resolving reaction products and -pathways



Li et al., 2023

Analytical facilities at AU-ENVS

3 HPLC-MS/MS -
Quantification of hydrophilic compounds

6 GC MS Quantification of lipophiphilic compounds

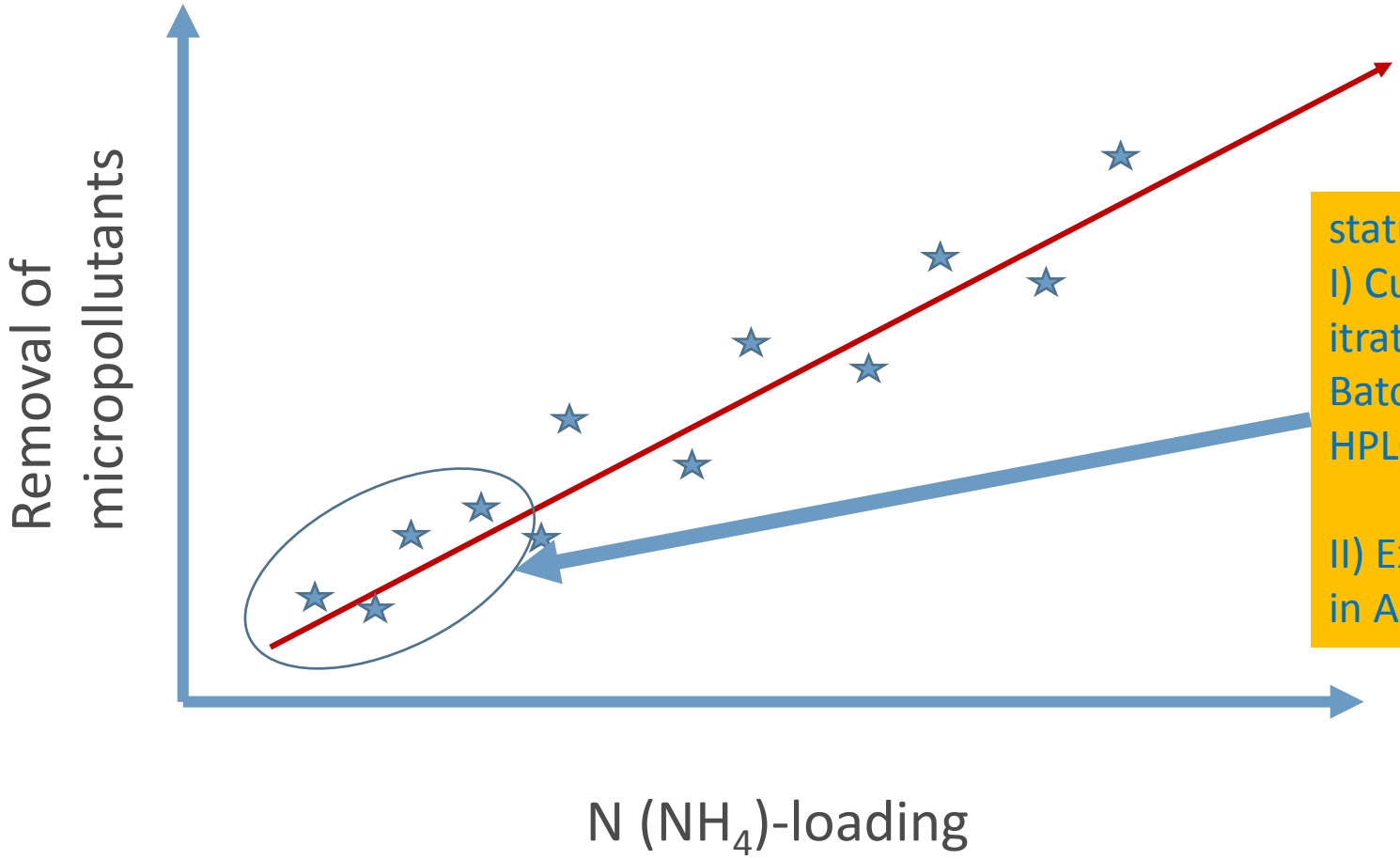
2 HPLC-HR MS/MS –
Identification of compounds, non target analysis

Research question I:

Is the removal of micropollutants in biofilm dependent on N loading? (Ammonium oxidizing bacteria)

Is MP removal linked to nitrification?

In AdvIQwater AU will explore the dependency of N loading on micropollutant removal



status:
I) Currently 4 MBBRs in use first of three itrations on NH_4^+ loading done.
Batch test finished and samples through HPLC-MS/MS

II) Experiments with Ivar prepared (will start in August)

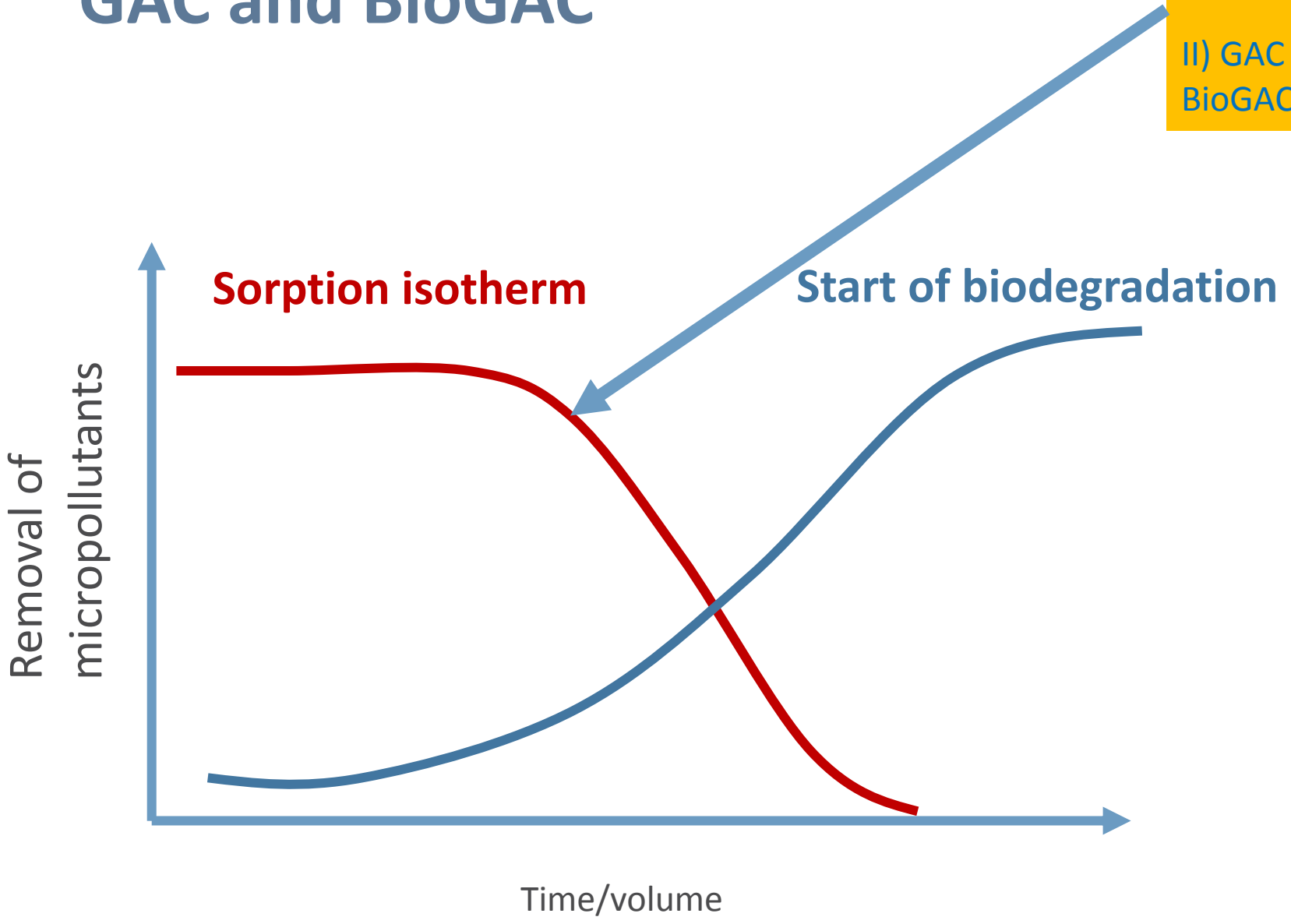
Research question II:

When and how is the biofilm contributing to removal as experienced by GAC

GAC and BioGAC

status:
I) GAC columns in operation since 1/2023

II) GAC columns are slowly turning into BioGAC



Are metabolites formed?

-> target screening for known metabolites

-> non-target screening for un-known metabolites

In AdvIQwater AU will explore the effects of Biofilms on GAC

4 different GACs loaded with effluent wastewater

Outlook:

- **Today MBBRs for micropollutant removal need to operate at 10-20 h HRT to achieve good removal.**
- **In future we hope for we can find processes including fed/famine cycling to enable 80% removal at 4-6 h HRT.**
- **In our view this is needed to make MBBRs cost-wise competitive to GAC and ozone**

Contacts

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AdvIQwater - Improving quality of BSR waters by advanced treatment processes