
Antibiotika beeinflussen Methanproduktion in Süßgewässersedimenten

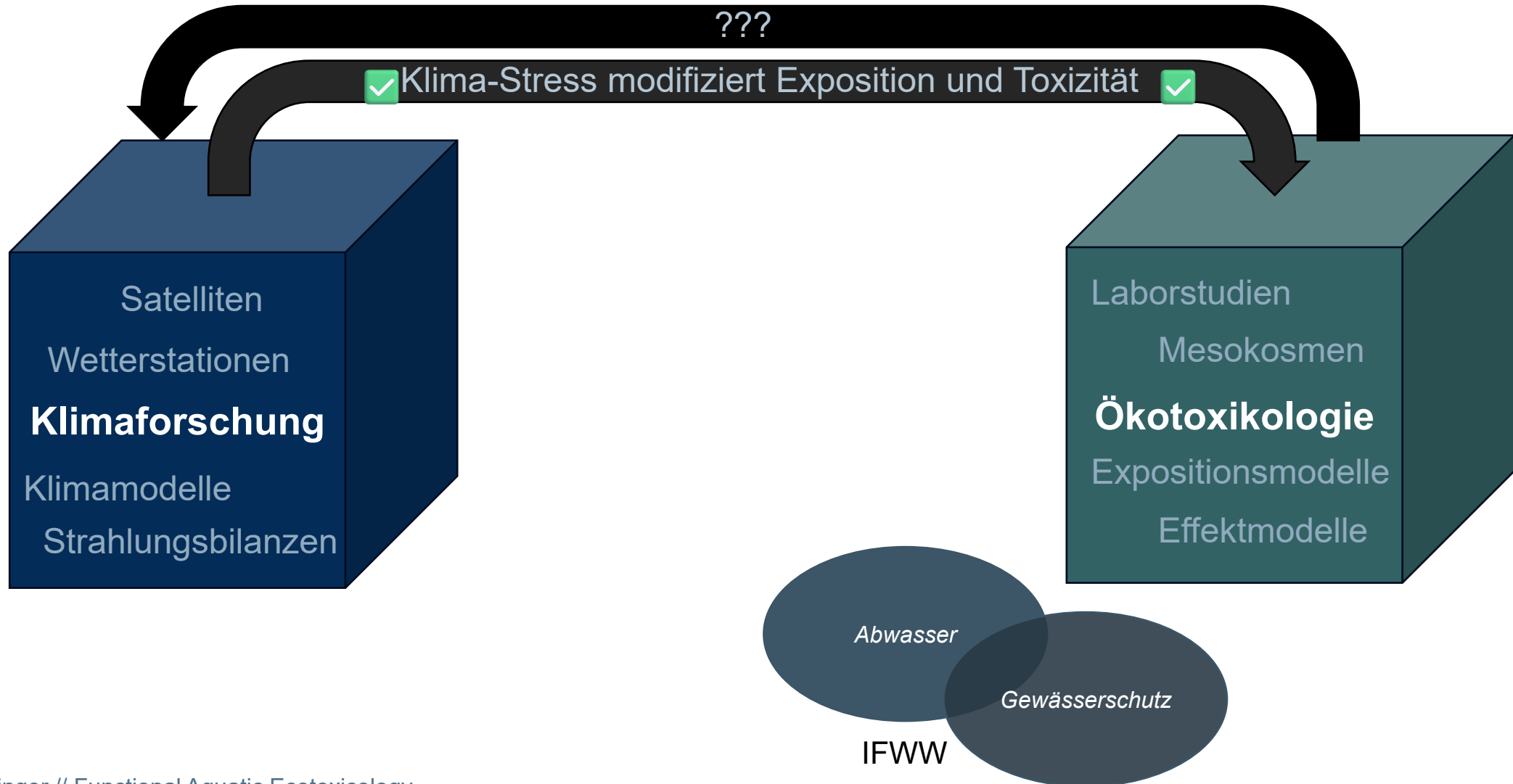
Dr. Eric Bollinger

4. März 2026

59. Essener Tagung für Wasserwirtschaft



Zwei separate Disziplinen



Methan...



wird bis zu 37% aus Mooren und Süßgewässern emittiert



ist 28 mal potenter als CO₂



Nettoanstieg verursacht rund 1/3 der globalen Erwärmung

Methanemissionen steigen wobei Isotopenevidenz natürliche Quellen als primäre Ursache identifizieren

Schäfer et al., 2016



Forschungsziel 1

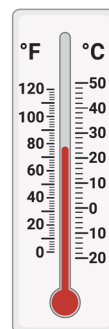
Die Pilotstudie



Publiziert 2021 in:
Ecotoxicology and Environmental Safety, 228, 113025

Forschungsziel 2

Temperaturinteraktion



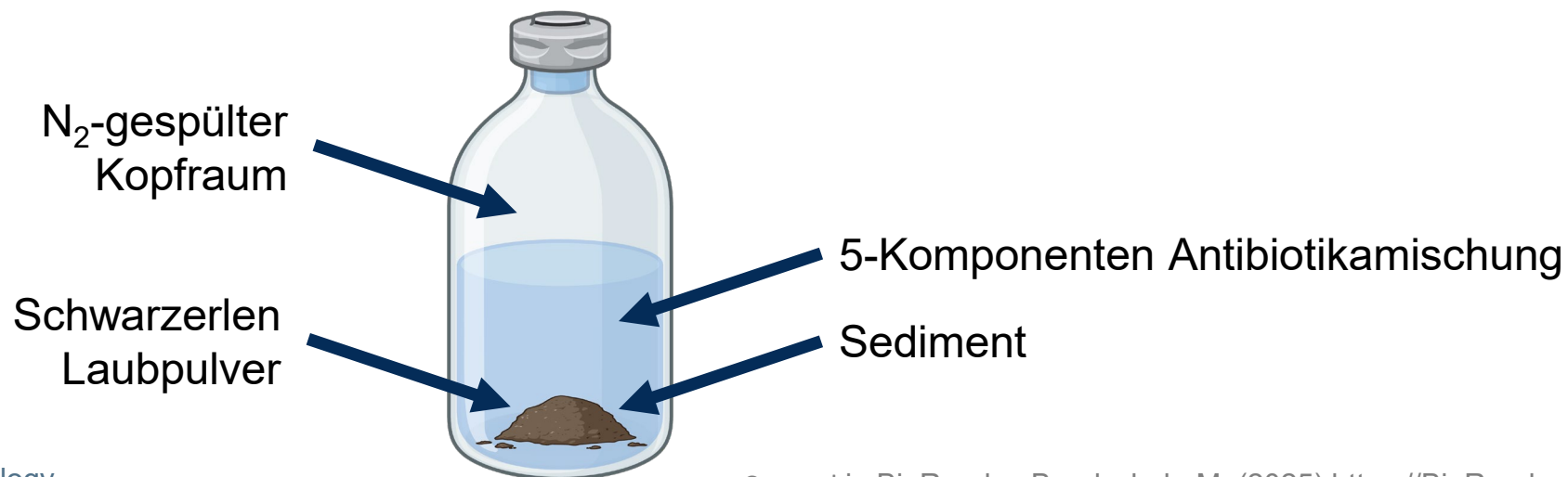
Publiziert 2024 in:
Communications Earth & Environment, 5, 647

Forschungsziel 3

Anpassung

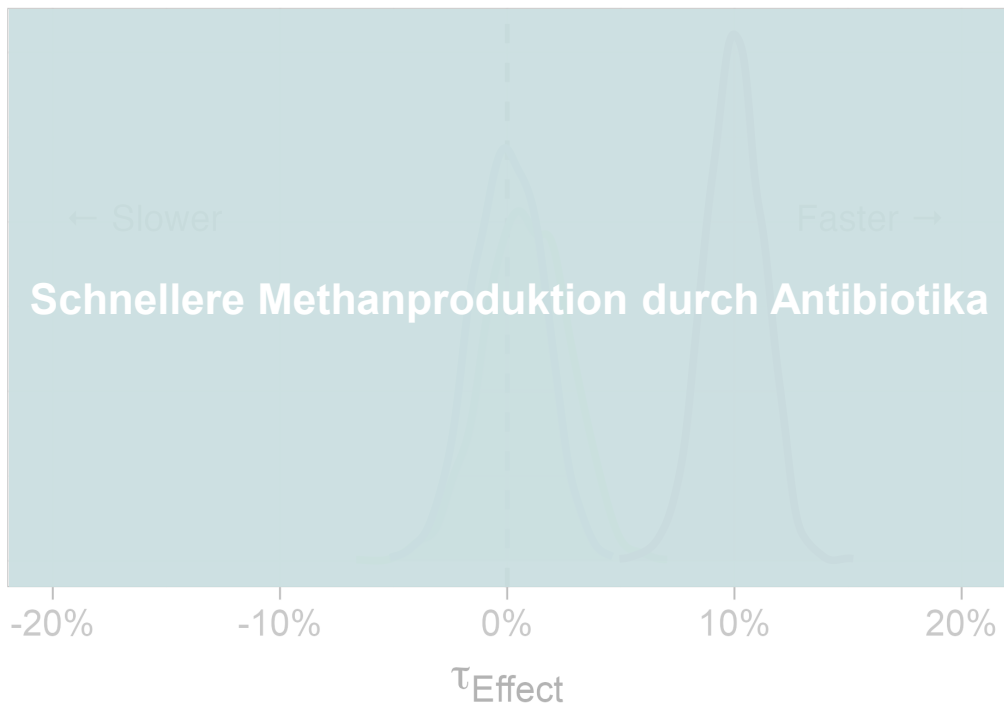


Publiziert 2025 in:
Environmental Pollution, 383, 126828





Sum concentration ■ 0 µg/L ■ 0.5 µg/L ■ 50 µg/L ■ 5000 µg/L



Trotz veränderter Dynamik werden ähnliche Substrate verwendet

→ Mehr Details durch Metabarcoding und Metatranskriptom



Forschungsziel 2: Temperaturinteraktion



Temperatur verändert Antibiotikaeffekte
Indirekte "Verschleppung" direkter Effekte
Gute Übereinstimmung zwischen Struktur und Funktion



Forschungsziel 3: Anpassung



Ursprung

Vorbehandlung

Reservat

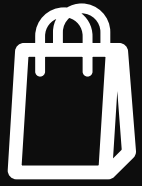
Mit Antibiotika

Effekte in beiden Gemeinschaften trotz Resistenzgenen:
→ Auch "angepasste" Gemeinschaften bleiben vulnerabel

Kläranlage

Ohne Antibiotika

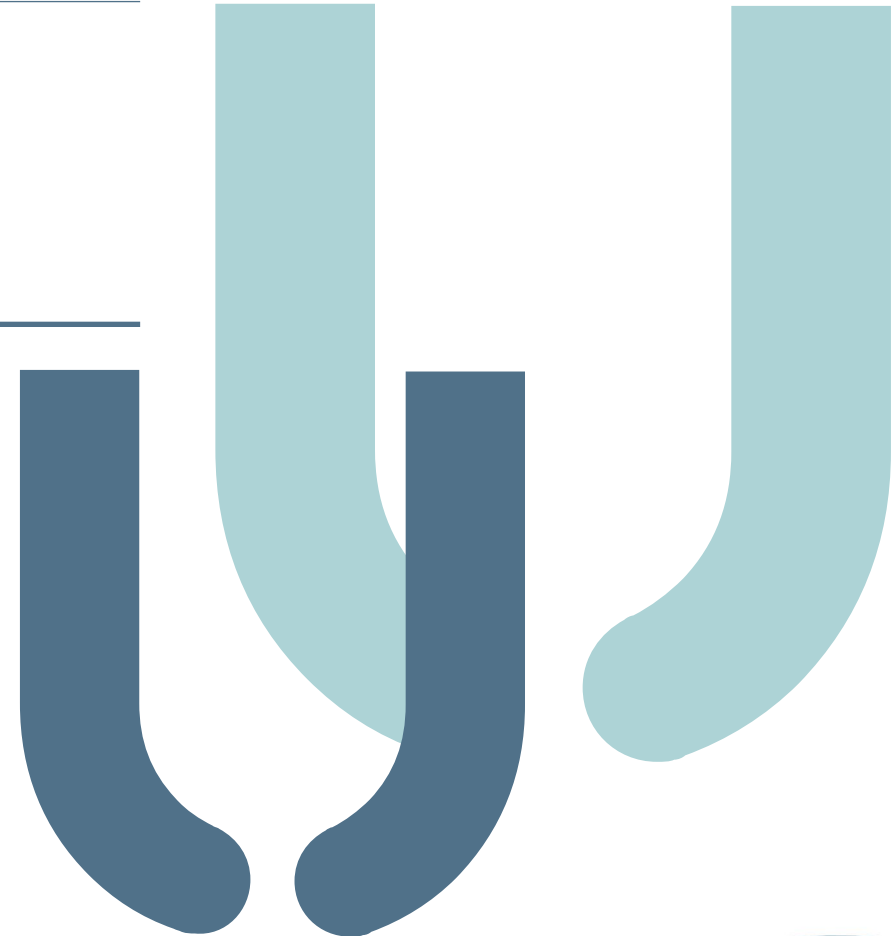
g
Resistenzgenen



Take Home

*Entscheidungen und Entwicklungen in der Wasserwirtschaft
beeinflussen **global relevante Prozesse**
bedürfen einer **interdisziplinären Betrachtungsweise**
betreffen **alle***

**Danke für die
Aufmerksamkeit**





- Bollinger, E., Zubrod, J. P., Lai, F. Y., Ahrens, L., Filker, S., Lorke, A., & Bundschuh, M. (2021). Antibiotics as a silent driver of climate change? A case study investigating methane production in freshwater sediments. In *Ecotoxicology and Environmental Safety* (Vol. 228, pp. 113025–113025).
- Bollinger, E., Schwilden, P., Lai, F. Y., Schulz, R., Bundschuh, M., & Filker, S. (2024). Higher temperatures exacerbate effects of antibiotics on methanogenesis in freshwater sediment. *Communications Earth & Environment*, 5(1), 647. <https://doi.org/10.1038/s43247-024-01828-3>
- Bollinger, E., Mayer, J., Lai, F. Y., Schulz, R., Filker, S., & Bundschuh, M. (2025). Adaptation of methanogenic microbial assemblages to antibiotics: The role of resistance genes and taxonomic composition. *Environmental Pollution*, 383, 126828. <https://doi.org/10.1016/j.envpol.2025.126828>
- Schaefer, H., Fletcher, S. E. M., Veidt, C., Lasseby, K. R., Brailsford, G. W., Bromley, T. M., Dlugokencky, E. J., Michel, S. E., Miller, J. B., Levin, I., Lowe, D. C., Martin, R. J., Vaughn, B. H., & White, J. W. C. (2016). A 21st-century shift from fossil-fuel to biogenic methane emissions indicated by ^{13}C . *Science*, 352(6281), 80–84. <https://doi.org/10.1126/science.aad2705>

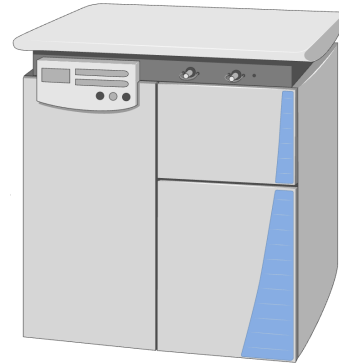


Laserabsorptions- spektrometrie



Wie viel CH₄ und CO₂ wurde produziert?

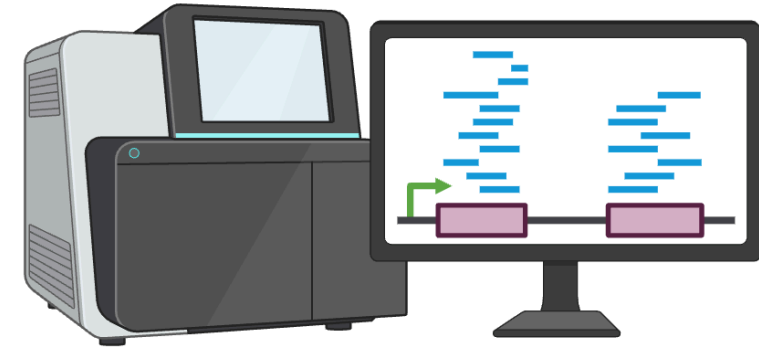
Komponentenspezifische stabile Isotopenanalyse



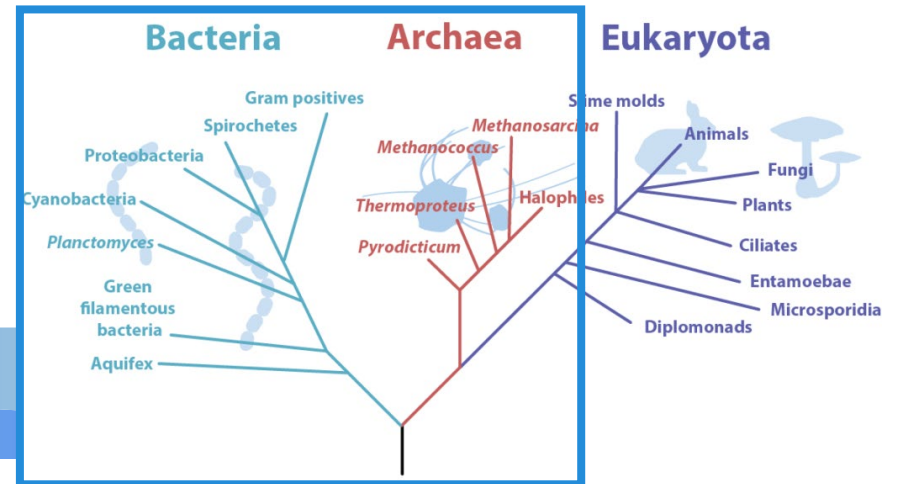
Wie schwer sind Kohlenstoffatome in CH₄ und CO₂?

→ Welcher Methanogenese-
pfad wurde genutzt?

16S rRNA metabarcoding



Welche Prokaryoten sind aktiv?



Funktional

Synopsis

1.a: Do antibiotics change methane production dynamics?

✓ Production rates increased up to 94%, τ ~10% faster

1.b: Do antibiotics affect used substrates?

✗ SIA suggests roughly same substrates

1.c: Do antibiotics alter the prokaryotic community?

✓ As also demonstrated in **RO2** and **RO3**

2.a: Does warming change antibiotic effects?

✓ Highest increases at highest temperature and inversed effects at lowest temperature

3.a: Does short-term adaptation alter sensitivity towards antibiotics?

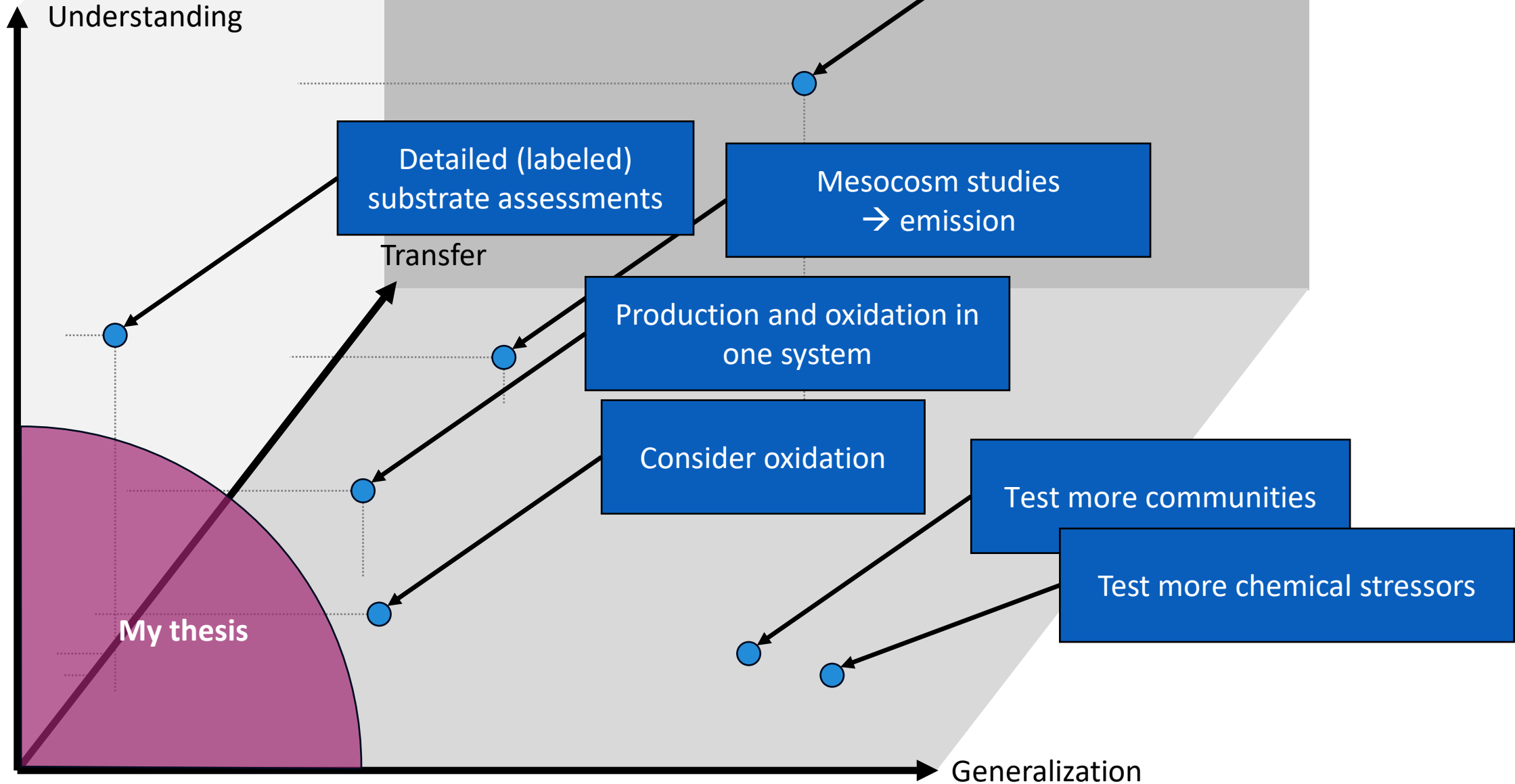
⚖ Depends... no changes in τ but alterations in the early incubation stages

3.b: Does presence and horizontal transfer of antibiotic resistance genes alter sensitivity?

✗ No significant increase in ARGs and also adapted communities remain vulnerable



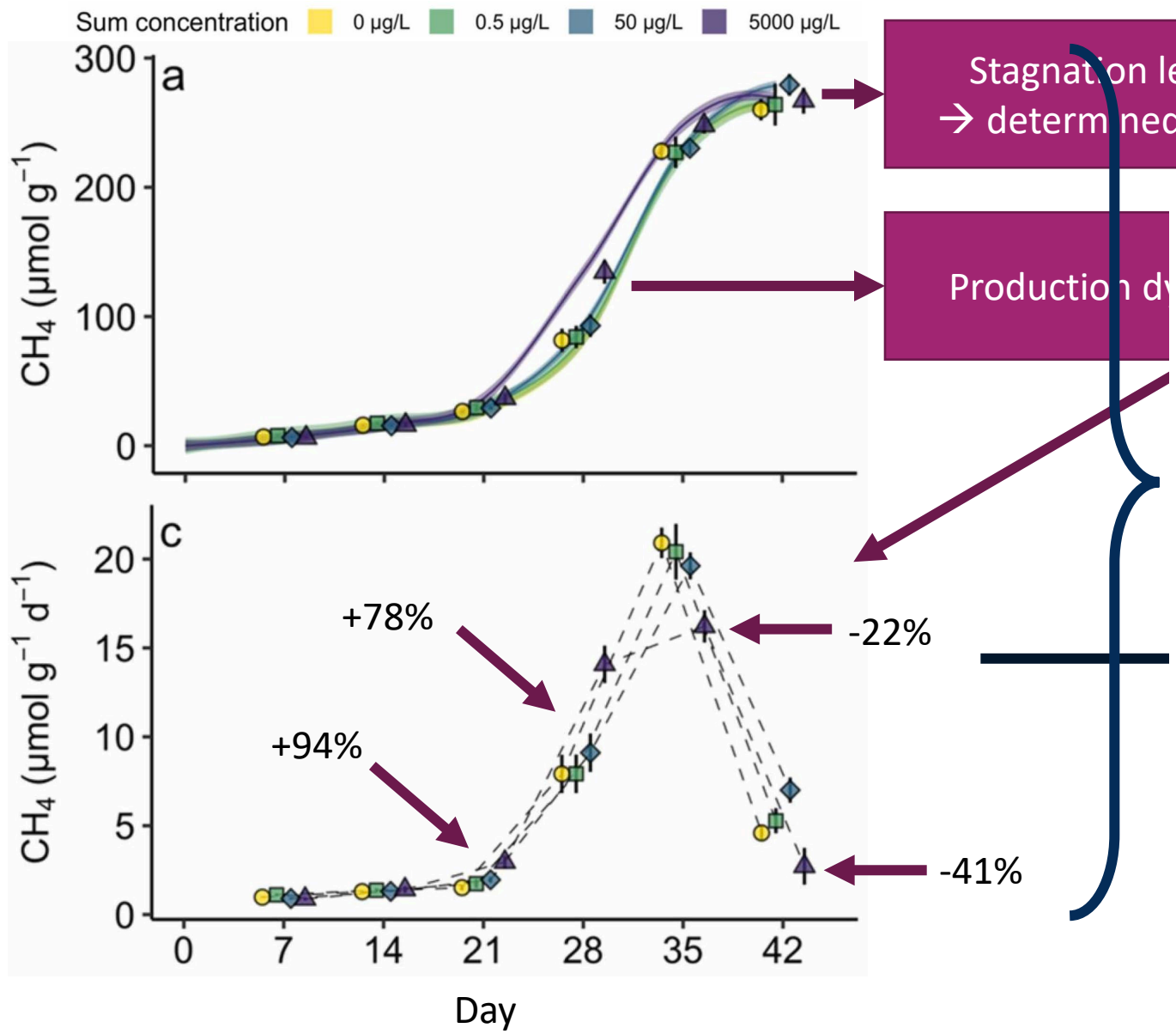
Outlook



For illustrative purpose, no numeric meaning

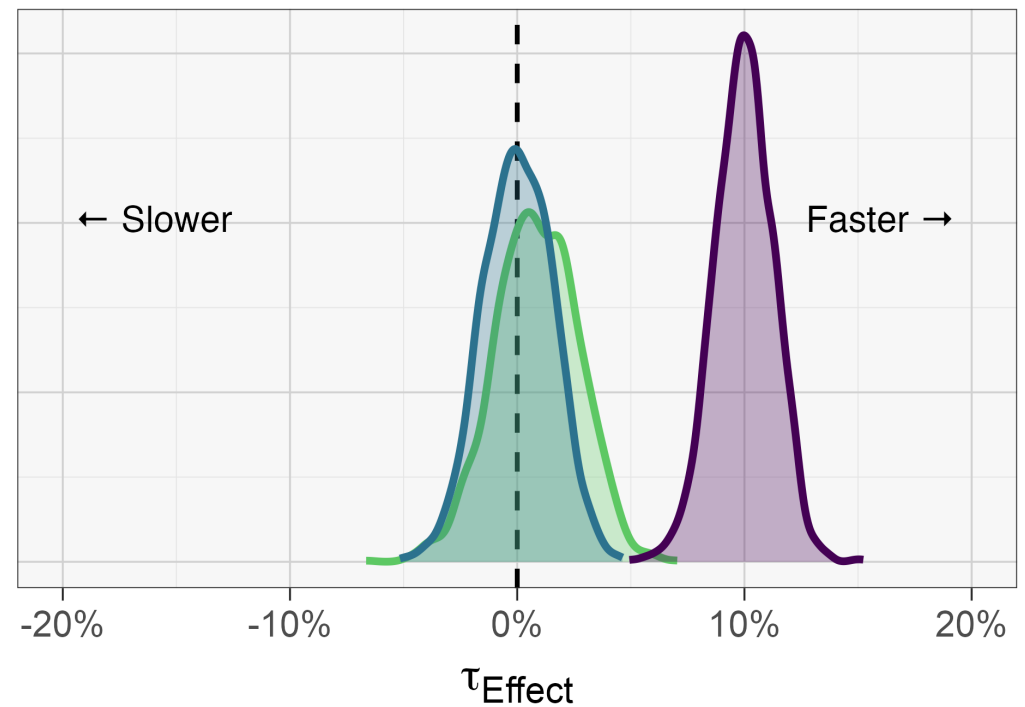


Research objective 1 *Effects on CH₄*

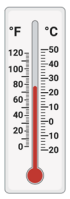


Stagnation level unchanged
→ determined by the substrate

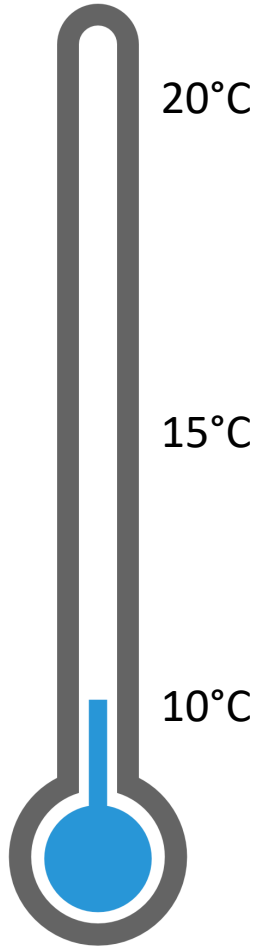
Production d



Time until inflection point (τ) as endpoint of production speed



Research objective 2 *Effects on CH₄*



Medium: 5 µg/L
Dark: 5000 µg/L



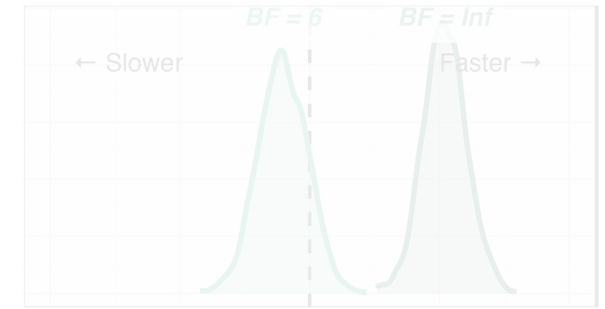
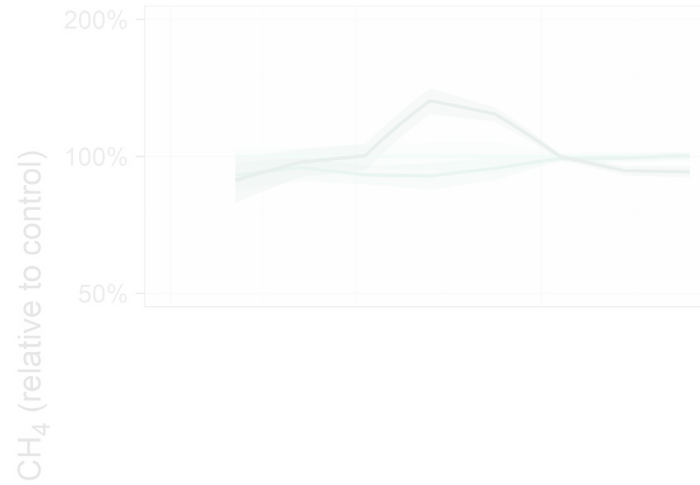
Research objective 3

Main treatment effects on CH_4

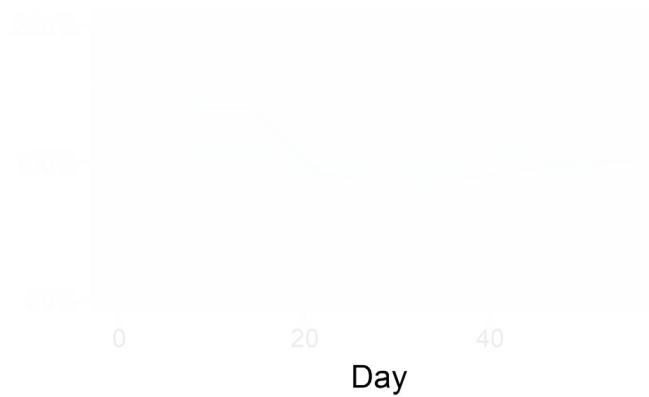
Light: Control

Medium: 5 $\mu\text{g/L}$

Dark: 5000 $\mu\text{g/L}$



Reserve
Without Pre-Treatment



WWTP
Without Pre-Treatment



Research objective 3 *ARGs & community*

