CRC 1253 CATCHMENTS AS REACTORS CAMPOS

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# Biodegradation of pesticides at the limit: kinetics and microbial substrate use at low concentrations

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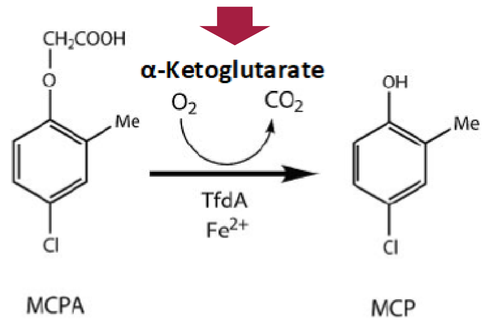
## Context

- **Multiple pesticides persist at low concentrations** in soils despite the general abundance of degrading organisms [1]
- Low pesticide concentrations matter because the **safety thresholds in the EU** for herbicides in drinking water is only **0.1 µg l$^{-1}$** [2]

**Rate limiting step of MCPA degradation**

functional gene *tfdA* encodes:

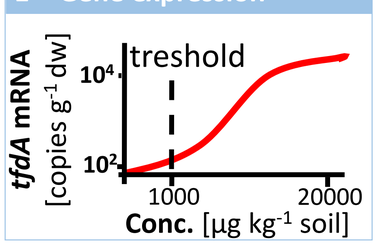



## Highlights

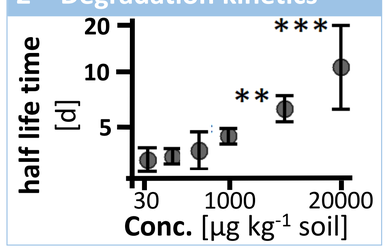
- **MCPA** degradation rates determined at higher concentration cannot be extrapolated to **lower concentrations**
- Degradation of MCPA took place **near the drinking water limit**
- **Data of functional gene** expression cannot explain the **persistence of low pesticide concentration in soils**

.. but first results confirm a concentration-dependent effect :

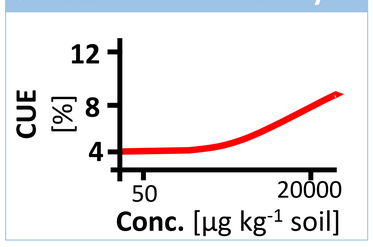
**1 – Gene expression**




**2 – Degradation kinetics**




**3 – Carbon use efficiency**




## Research Questions

**General research Question: What limits pesticide degradation in soils?**

**I. Are there pesticide concentration thresholds that limit functional gene expression?**

**II. Are degraders energy-limited at low pesticide concentrations?**

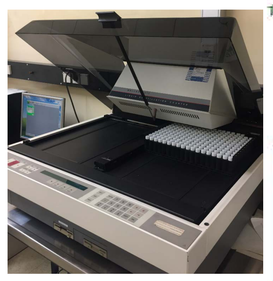
## Material & Methods

**Incubation experiment with increasing $^{14}$C-labelled MCPA concentrations (0, 30, 50, 100, 500, 1000, 5000, 20000 µg kg$^{-1}$ soil)**

### I. $^{14}$C Analysis


Microcosm

- 50 g topsoil from a Luvisol (nearby Tübingen,Germany)
- Incubation for 4 weeks at 21°C

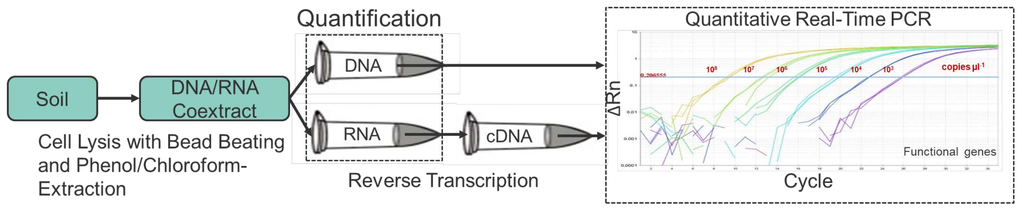


detection of ß-decay

$^{14}$C in microbial biomass C

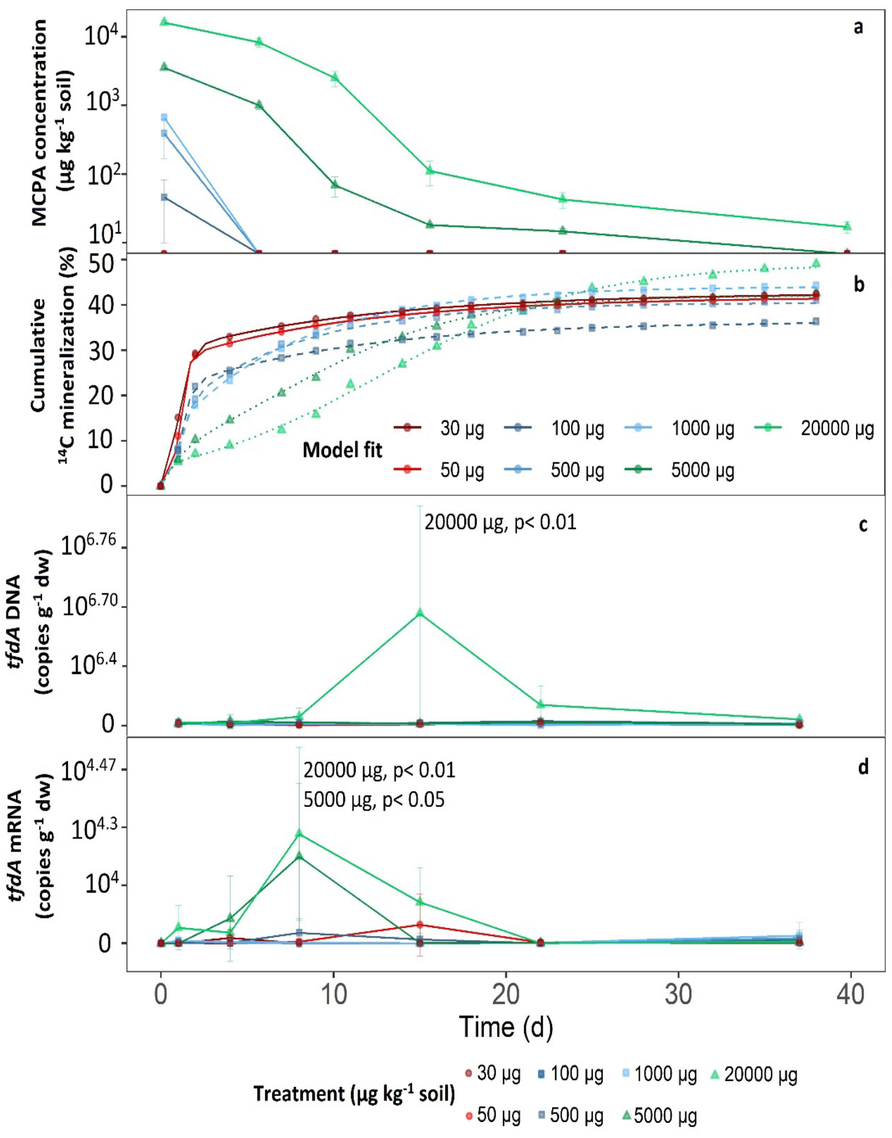
Follow mineralization of model compound via $^{14}$C-$CO_2$ respiration

### II. Molecular analysis of MCPA degradation in soil

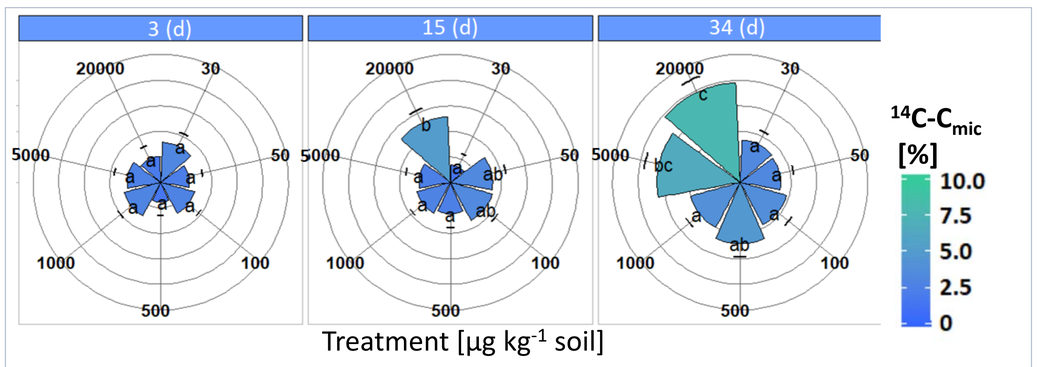



**The quantity of functional genes (DNA) represents the potential of microorganism to degrade MCPA. The transcript abundance (RNA) reflects the activity of specific degraders.**

## Results & Discussion

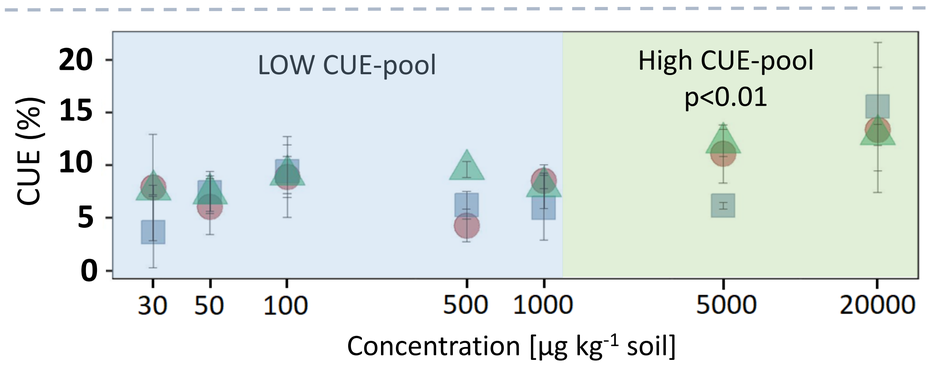



- ≥ 5000 µg inverted logistic decline for MCPA, rapid degradation concentration ≤ 5000 µg kg$^{-1}$ soil
- Half life-time (5 – 14 d) is significantly higher for concentration ≥ 5000 µg kg$^{-1}$ soil than for lower concentration (1 – 3 d)
- At low concentrations, the MCPA degraders are energy-limited and therefore an increase of the *tfdA* gene occurs (at a detectable level) only at high concentrations
- Only the concentration of 20000 µg kg$^{-1}$ soil enables a significant increase of the degrading community




- Assimilation > 5000 µg kg$^{-1}$ soil significantly higher ($p<0.05$) up to 8 %

→ **But even at low concentration microorganism use MCPA as an carbon source (2 ~ 3% incorporation) to growth which proves that it is not just a co-metabolic degradation**




→ **At low conc. (≤ 1000 µg, mean = 0.07 ± 0.005 se) energy limitation leads to catabolic use of MCPA shifting with increasing concentration (≥ 5000 µg, mean = 0.11 ± 0.009 se) towards an anabolic mineralization**

References:
[1] Miglioranza KB, Gonzalez Sagrario M, Aizpun de Moreno JE, Moreno VJ, Escalante AH, Osterrieth ML. (2002). Agriculture soil as a potential source of input of organochlorine pesticides into a nearby pond. Argentina: Environ Sci & Pollut Res 9 (4): 250 - 256.
[2] EU-guidelines 98/33/EG. (1998).

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