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A strategy to determine the fate of active chemicals in soil – applied to antimicrobials

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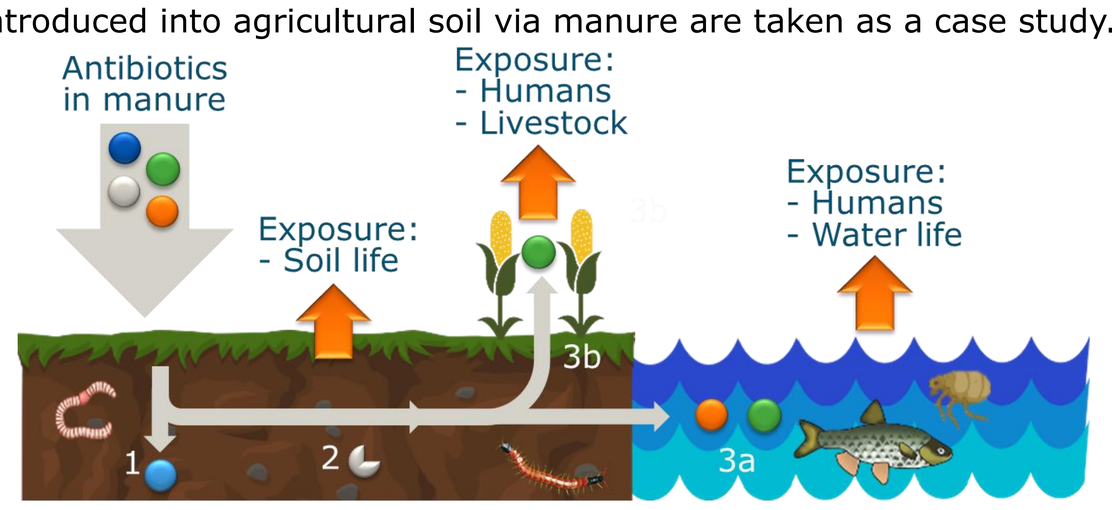
Background

The European Commissions aims for a toxic-free environment. However, some chemical use is unavoidable in our food production system, e.g. for pest control in crops or to treat sick animals. These chemicals are released into the environment. It is of primary concern to understand the safety hazards arising from the use of such chemicals, also on the long term. Particularly persistent chemicals are a potential hazard as residues might accumulate over time and exert negative effects on ecosystems' functions, animals or humans. We need to understand:

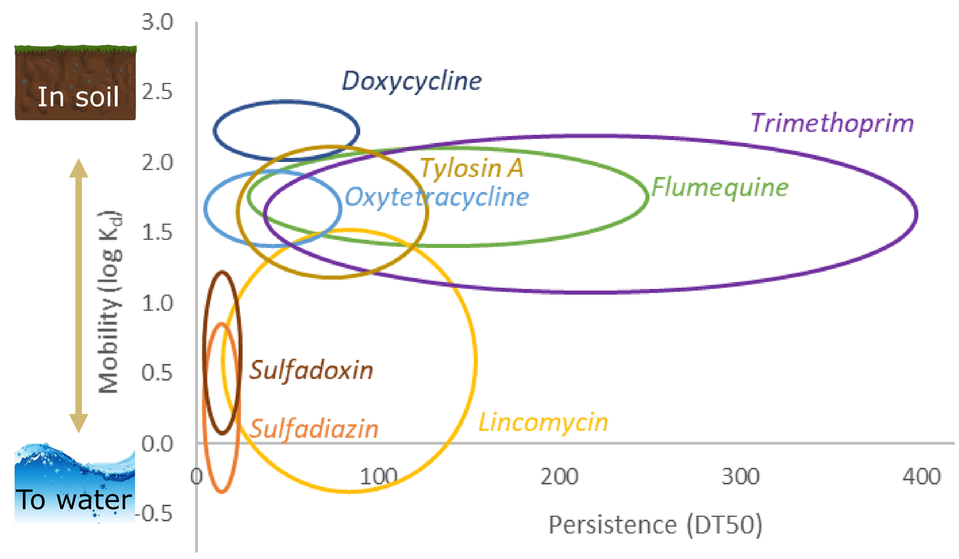
1) what chemicals are introduced into the food production system;
2) the persistence of these chemicals;
3) how these persistent chemicals are translocated among reservoirs and where they potentially accumulate.

Here we present a simple yet effective strategy to determine the fate (persistence and mobility) of chemicals. Antimicrobials that are introduced into agricultural soil via manure are taken as a case study.



Results

The figure presents the 10 – 90 percentile range of persistence (DT50 in days) and mobility (log K_d) of 8 antibiotics in different soil types (n=13 – 25; only data of sufficient analytical quality were included).



Conclusions

Flumequine and trimethoprim are persistent and can accumulate in specific soils. Tylosin A is moderately persistent, but its persistence in underestimated as it degrades to other antimicrobially active substances (e.g. tylosin A and C acid). Lincomycin is also moderately persistent and tends to leach to surface and ground water, depending on the soil type. First, the biodegradable chemicals should be prioritized for use. Second, if persistent chemicals are mandatory for disease or pest control, risk assessment studies should focus on the reservoirs they are expected to accumulate in based on their mobility.

The strategy

1. Persistence study

The degradation of the chemical is determined in relevant types of soil. The chemicals are added to selected soils and aliquots are analyzed after different incubation times to determine DT-50.

Category

- A Persistent chemical
- B. Degradation to inactive products
- C. Degradation to active products

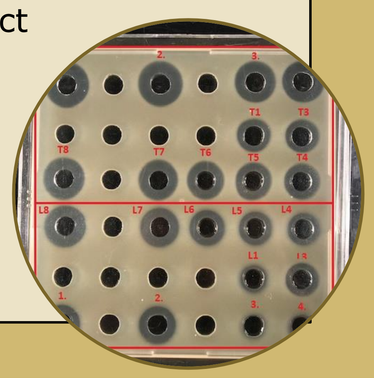
Significant degradation

No significant degradation

Effect = concentration

2a. Persistence of effect

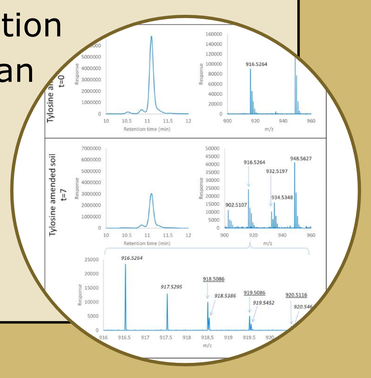
If a chemical degrades, does its effect disappear as well? Effect assays are applied to study the decrease of the chemical's effect over time. This is compared to the chemical degradation.



Effect > concentration

2b. Identification of degradation products

If the chemical degradation is significantly faster than the decrease of its effect, the degradation product is identified with HRMS.



3. Mobility study

The mobility of each chemical is estimated by spiking them onto a soil column. The column is flushed with artificial rainwater. The ratio of each chemical in the water and remaining in soil is a measure for the mobility.

Applicability

Output data can be used for:
- prioritization of chemicals (use chemicals that (bio)degrade in the System);
- spatial modelling;
- risk-assessment.

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