



Interactions of xenobiotics with soil organic matter (SOM)

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Introduction

The fate of xenobiotics in soil not only depends on the chemical and physical properties of the compound itself but also to a great extent on the physical, chemical and biological properties of the soil as well as the site conditions with special importance of soil organic matter (SOM). Investigating their influence needs to subdivide SOM into pools differing in stability and turnover time. Due to the fact that decomposable and more or less inert SOM pools cannot be analytically determined directly methods are used to separate characteristic fractions of relevance having more unique properties. Depending on the hypothesis and scientific questions fractionation criteria may differ. Regarding the position in transformation process SOM can be divided into a stabilized inert pool depending on soil type and site conditions and a decomposable more or less labile pool which can be influenced by management strategies. This labile pool can be estimated from the carbon content of a hot water extractable SOM fraction (Schulz, 2004). A stabilization of SOM can be reached by interacting with the mineral part of soil like clay minerals resulting in true chemical linkages or sorption complexes. The resulting mineral-organic associations decisive determine sorption and availability of xenobiotics. Separating SOM fractions according to particle sizes bases on the hypothesis that SOM of particle fractions differs also in structure and functions (Baldock & Skjemstad 2000). Fractionation of SOM according to specific densities is used to separate SOM only loose associated (not chemical bound) to the mineral part of the soil. The assumption is that different linkage strength to soil matrix is reflected in structure and function of SOM. A characteristic limit seems to be at a specific density of 2 g cm^{-3} discriminating „heavy“ (mineral-organic complexes, inert) and „light“ (not or only loose connected to mineral matrix, decomposable) fractions (Christensen

1992). A combination of fractionation according to particle size and specific densities can be used for separating SOM of different turnover and corresponding functions for transformation processes in soil system (Oades 1995).

Core

An approach of fractionation is presented to estimate the interactions of hydrophobic compounds with SOM pools. Fractionation consists in different steps to separate (1) an easily decomposable SOM fraction using a hot water extraction, (2) clay related SOM (clay sized particle fraction) as well as (3) not to clay related SOM (specific light fractions) using a combination of particle size and density fractionation (Schaimukhamev et al. 1985). From a pot experiment with different soil types and TOC levels the accumulation of SOM will be related (a) to the accumulation of xenobiotics in SOM fractions, (b) to their bioavailability measured as their uptake by plants and (c) to the release of the chemicals in water phase during fractionation process.

Due to the different nature of SOM in these fractions they have different properties of fixation and/or inactivation for nutrients but also pollutants. The uptake of hydrophobic compounds (HC) by plants was inverse correlated to the clay content, TOC and C in the hot water extractable fraction (HWF). We found a strong correlation ($r = 0.996$) between the content of lindane and methoxychlor in HWF and their uptake by maize. In case of two PAH's, their content in HWF and in plant material did not correspond due to the very low water solubility and the only marginal concentration in plant material (PAH content of roots possibly due to soil particles in rhizodermis; no translocation into tops). A clear influence of soil type and soil organic carbon content could be observed. Depending on water solubility enrichment factor (EF) of the HC in clay related SOM fractions was up to tenfold higher in a light sand (5 % clay) compared to a loess (21 % clay) demonstrating the high affinity of PAH's to that SOM pool. However, recovery of PAH's one month after application was quiet low especially for benzo-a-pyrene (BaP) pointing on formation of bound residues.

The enrichment factors of chemicals in the two fractions of lower specific density were only marginal but tended to decrease with increasing contents TOC and clay pointing on interactions with more stable fractions of SOM. For BaP the concentrations in LF 1 (strongly related to hot water fraction) were almost zero. The content of xenobiotics in fractionation residues, possibly containing heavy dispersible clays, allows similar interpretations.

The course of „losses“ of xenobiotics during isolation of clay related SOM fraction are negligible in case of BaP; for fluoranthene up to 20 % of the total may be lost in water phase during application of ultrasonic energy depending on soil type (clay content) and SOM level (TOC).

Perspectives to determine sorption coefficients of the SOM fractions using micro – batch experiments in combination with solid phase micro extraction techniques will be outlined.

Conclusions

Chemical properties of xenobiotics as well as site conditions determine their bioavailability and fate in a soil with special importance of SOM. Investigations on influence of SOM on mobilization or immobilization of chemicals demand a subdivision of SOM into pools of different stability. Enrichment factors of xenobiotics in these fractions allow an interpretation of the preferred interactions of these substances to different SOM pools. This is of special importance to understand the fate of the xenobiotics in soil (mobility, availability, accumulation, interactions, and risk assessment).

References

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