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The effect of land cover/use on antibiotic adsorption in various soil organic carbon pools

HUN-REN Magyar Kutatási Hálózat
CSFK

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Background

Due to the growing problem of climate change, much research is focusing on the largest terrestrial carbon store - soil organic matter (SOM) - as a potential carbon storage system.

Since SOM can attach to mineral phases through physical or chemical sorption, it will not be equally available to the decomposing organisms. On the basis of the degradation time of SOM and therefore C residence time, we can separate the **fast** and **slow** OM **pools.**

The degradation time and C residence time are influenced by many anthropogenic conditions, including the spreading of sewage sludge in arable land.

Because of their targeted mode of action, **antibiotics**, even at low concentrations, **disrupt the soil microbial ecosystem**, and thus the degradation times.

The impact of antibiotics on SOM degradation in soils has already been studied, but little attention has been paid to **which OM pools are most affected by the antibiotic contamination**.

Aim of study

The aim of this study was to investigate the effect of land use on the adsorption of antibiotics in different OM pools.
The research sought to answer three main questions:

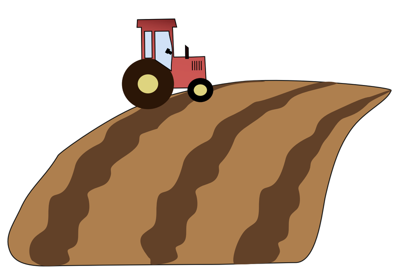
Which OM pool (slow or fast pool) is most involved in antibiotic adsorption?
Is there a difference in the **adsorption** properties of soils from **different land use area**?
What are the main **parameters affecting adsorption** in different land use areas and **in different pools**?

Samples and research methods

3 land use:


Forest

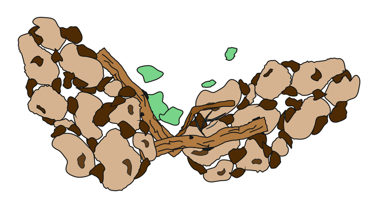

Grassland

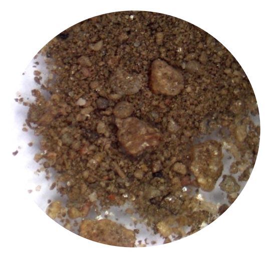

Arable land

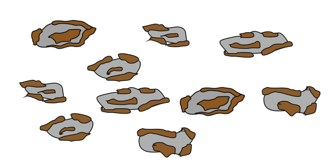
All soil samples are of **Luvisol** soil type and from Sopron (Hungary). 2-15 cm depth.

Batch eequilibrium method -OECD[5]-was performed on the bulk soils and on both OM pools for **3 antibiotics** (Ciprofloxacin, Norfloxacin and Ofloxacin). Non-adsorbed concentrations were measured by UHPLC (Shimadzu-Nextera,FR detector)

Each soil was fractionated into slow and fast OM pool based on Zimmermann[3] and Elliott[4] physical fractionation methods.

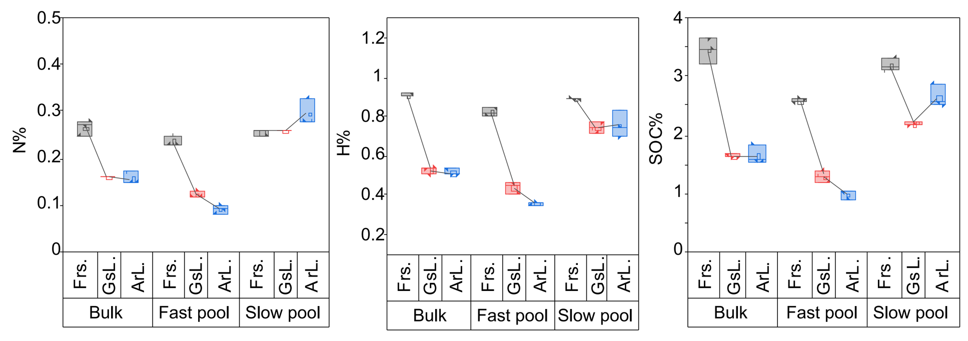

Fast pool
above 250 µm containing sand, aggregates and particulate organic matter with looser **physical bonds**
Frs: 79% GrL: 75% ArL: 66%


Bulk soil


Slow pool
53-250 µm fraction, containing silt and clay which binds the SOM with **strong chemical bonds**
Frs: 21% GrL: 25% ArL: 34%

Results

Elemntal composition



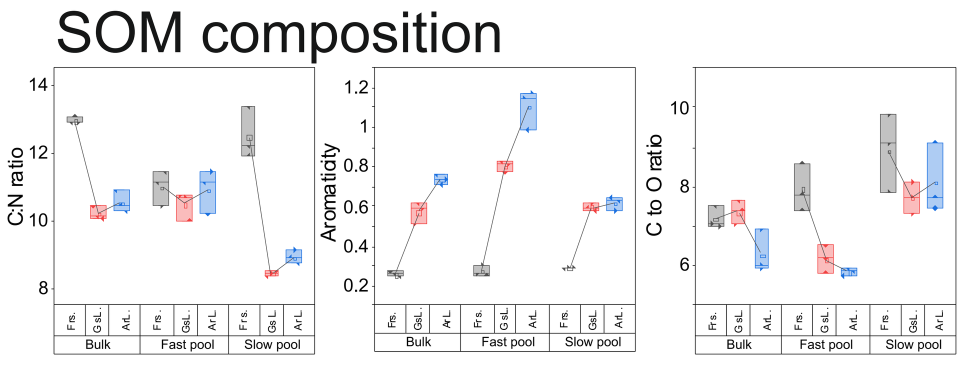
- The SOC, N and H contents of soils and pools decrease with decreasing land use.
- The exception is the ArL slow pool, where the values are higher than in the GrL slow pool

Soil texture,and pH

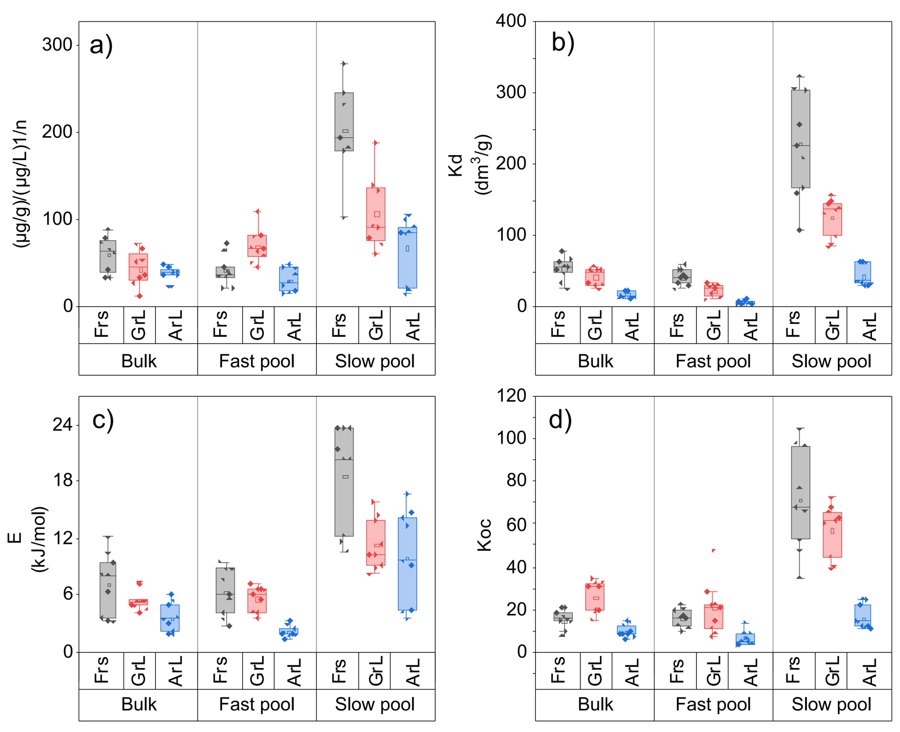
Soil		pH		BET (m2)	Clay v/v%		Silt v/v%		Sand v/v%	
BULK	Frs.	4,97	±0,2	7,05	5,76	±0,0	82,30	±0,5	11,93	±0,5
	GrL.	5,67	±0,1	6,29	6,00	±0,0	52,28	±0,3	41,72	±0,3
	ArL.	6,40	±0,0	5,92	5,38	±0,2	49,19	±1,7	45,43	±1,9
Fast pool	Frs.	5,23	±0,1	6,36	3,76	±0,1	57,48	±1,3	38,37	±0,7
	GrL.	5,67	±0,1	4,22	5,51	±0,2	44,45	±1,4	50,04	±1,5
	ArL.	6,30	±0,1	3,78	3,83	±0,1	25,35	±1,1	67,75	±1,2
Slow pool	Frs.	4,93	±0,1	9,06	5,81	±0,0	88,95	±0,1	5,24	±0,1
	GrL.	5,70	±0,1	8,35	10,07	±0,0	85,03	±0,2	4,90	±0,2
	ArL.	6,19	±0,0	10,54	10,30	±0,0	84,10	±0,0	5,60	±0,1

- TpH increases with soil use, in all pools
- The SSA is always highest in the Frs sample except inthe slow pool
- As land use increases, smaller and smaller particles are dominant

SOM composition

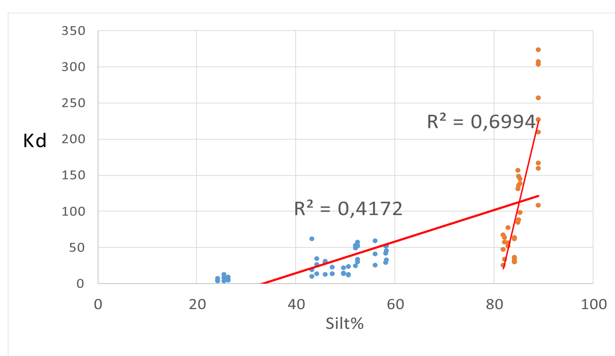


- Low aromaticity, higher C to O and C/N idicates the dominance of fresh, less mature organic matter in Frs soil and their OM pools
- SOM composition differences are less pronounced in the slow pool, excepct C/N ratio



- No significant difference was found in the adsorption properties of the different antibiotics ($p < 0.05$)
- Significant differences in slow pool adsorption parameters. Adsorption capacity decreases with land use
- Slow pool has an order of magnitude higher adsorption capacity than fast pool and bulk soils
- Bulk and fast pool adsorption values overlap for all land uses

- When all data are considered, the adsorption Kd values are positively correlated with the silt% SSA, C-O bond of polysaccharides and C to O functional group ratio, and negatively with the sand% and C-O bond of polialcohols and ethers.
- For the correlation between sludge and Kd, we observe a threshold above 80%, above which the correlation becomes steeper
- The relationship between adsorption and soil parameters may differ between pools.



Conclusion

The **slow pool has a much higher vulnerability** as it has an order of magnitude **higher adsorption capacity** than the bulk and fast pools. The aralble land soil is an exception, as the adsorption capacity of the slow pool is not significantly higher.

The effect of **land use only caused a significant difference** in the adsorption properties of **the slow pool**. The soil under the forest adsorbed the most antibiotics tested, the soil under the aralbe land the least.

Among the factors affecting adsorption, textural parameters (silt, sand) and organic matter quality parameters were the strongest. For the **different land use** areas, adsorption was mainly i**nfluenced by the SOM composition**, while differences between **OM pools** were caused **by texture effects**.

Overall, for the whole soil, the fast pool dominates the adsorption properties of the soil, regardless of the proportion of the <53 µm fraction, that contains the slow OM pool in the soil.

References:
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[4] Zimmermann, M., Leifeld, J., Schmidt, M.W.I., Smith, P., Fuhrer, J., 2007. Measured soil organic matter fractions can be related to pools in the RothC model. Eur. J. Soil Sci. 58, 658–667. https://doi.org/10.1111/j.1365-2389.2006.00855.x
[5] Test No. 106: Adsorption -- Desorption Using a Batch Equilibrium Method, 2000. . OECD Guidelines for the Testing of Chemicals, Section 1. https://doi.org/10.1787/9789264069602-EN

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