Carmen Nickel

Mobility of different nanomaterials in unsaturated soil columns

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Institut für Energie und Umwelttechnik e.V.

“Air Quality & Filtration “

Release of NM from products

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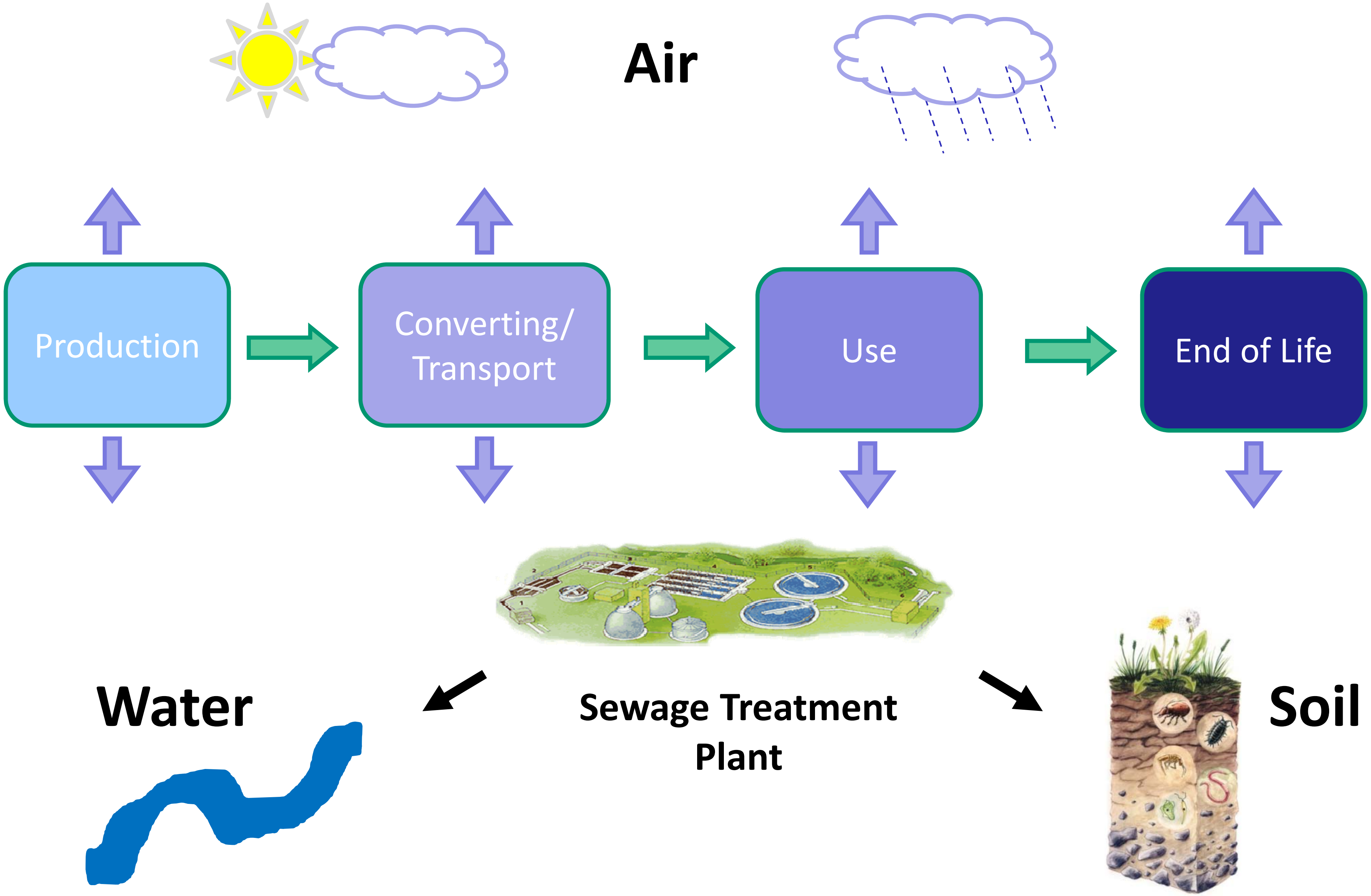
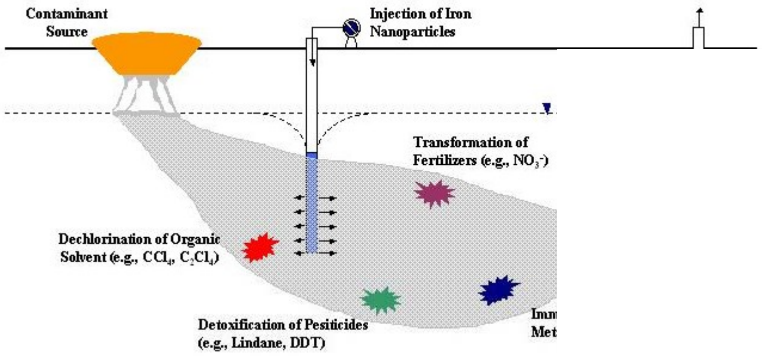
Release of ENM in the environment



Soils

direct

Remidiation



Nano-Iron; Zangh et al., JNR 5: 323–

Pesticides

www.umweltbundesamt.de

?

Application of sewage sludg

http://www.lauda-koenigshofen.de

Mobility of ENM?

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Mobility of three different TiO_2 nanomaterials in soil columns

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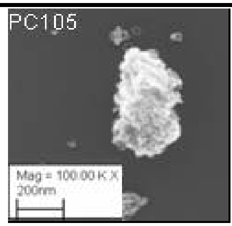
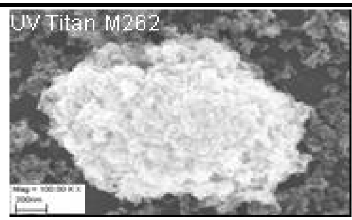
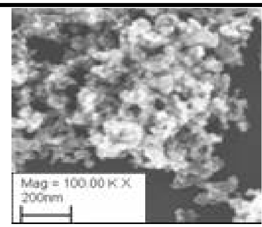
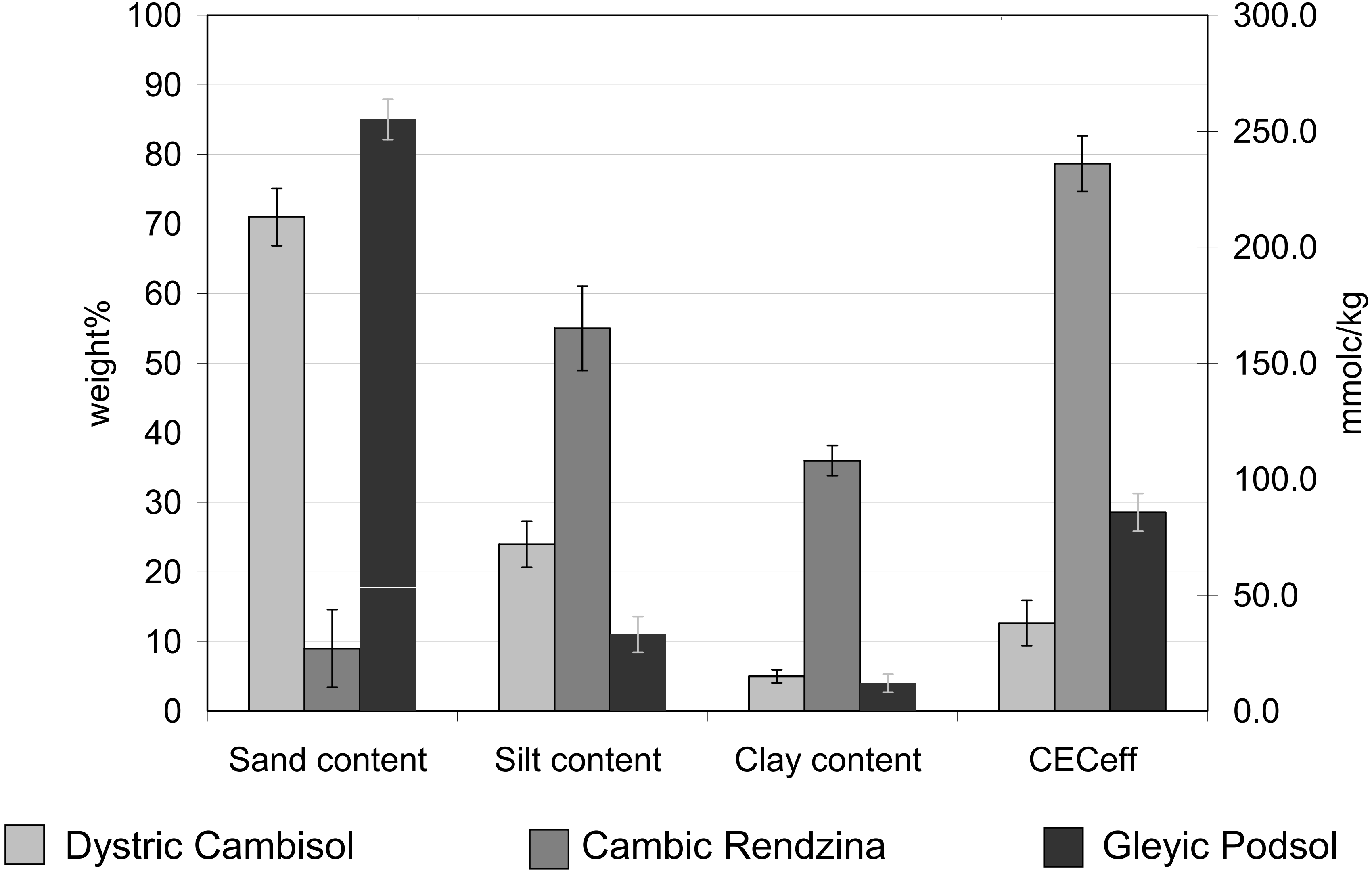
TiO_2 test nanomaterials

	NM102 (PC105)	NM103 (UV Titan M262)	NM105 (P25)
Crystalline form	anatase	rutile	anatase 86 % rutile 14 %
Primary particle shape	essentially spherical	essentially spherical	spherical
Coating	none	Al_2O_3 + dimethicone (hydrophobic)	none
Primary particle size	15 – 25 nm	20 nm	21 nm
Particle size in suspension (pH 5) #	560 nm (SD 4.62)*	180 nm (SD 3.1)*	220 nm (SD 1.01)*
Zeta potential in suspension (pH 5) #	+29 mV*	+26 mV (SD 1.06)*	+23 mV (0.4)*
Use	photo catalyst	cosmetics	photo catalyst, cosmetics
			

* Average of DLS and Zetasizer measurements, 10 min sonication; n = 5

Ultrasonic homogenizer 200 W pulse 0.2/0.8 – 10 min 100 mL

Soil types



pH: 5.67 | pH: 6.78 | pH: 5.14

Methods based on OECD Guideline 312

Leaching in unsaturated soil columns

- Glas columns filled with the matrix (soils)
- Pre-wetted with 0.01 M $CaCl_2$
- Application of the nanomaterials as suspension
- Application of 0.01 M $CaCl_2$ solution on the top of the column for 48 h
- Chemical analysis of the eluate and different column segments

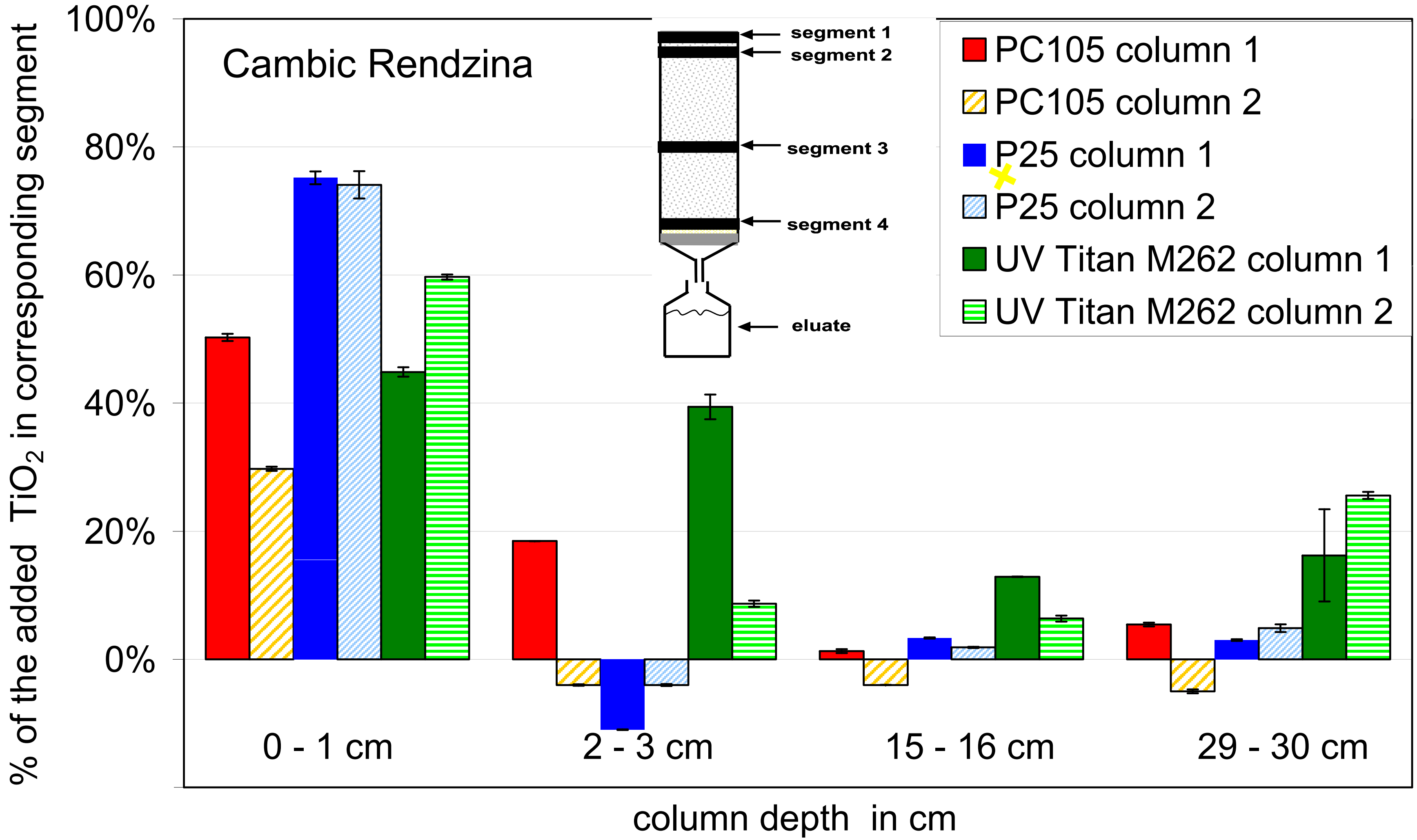
Results

Cambic
Rendzina

Dystric
Cambisol

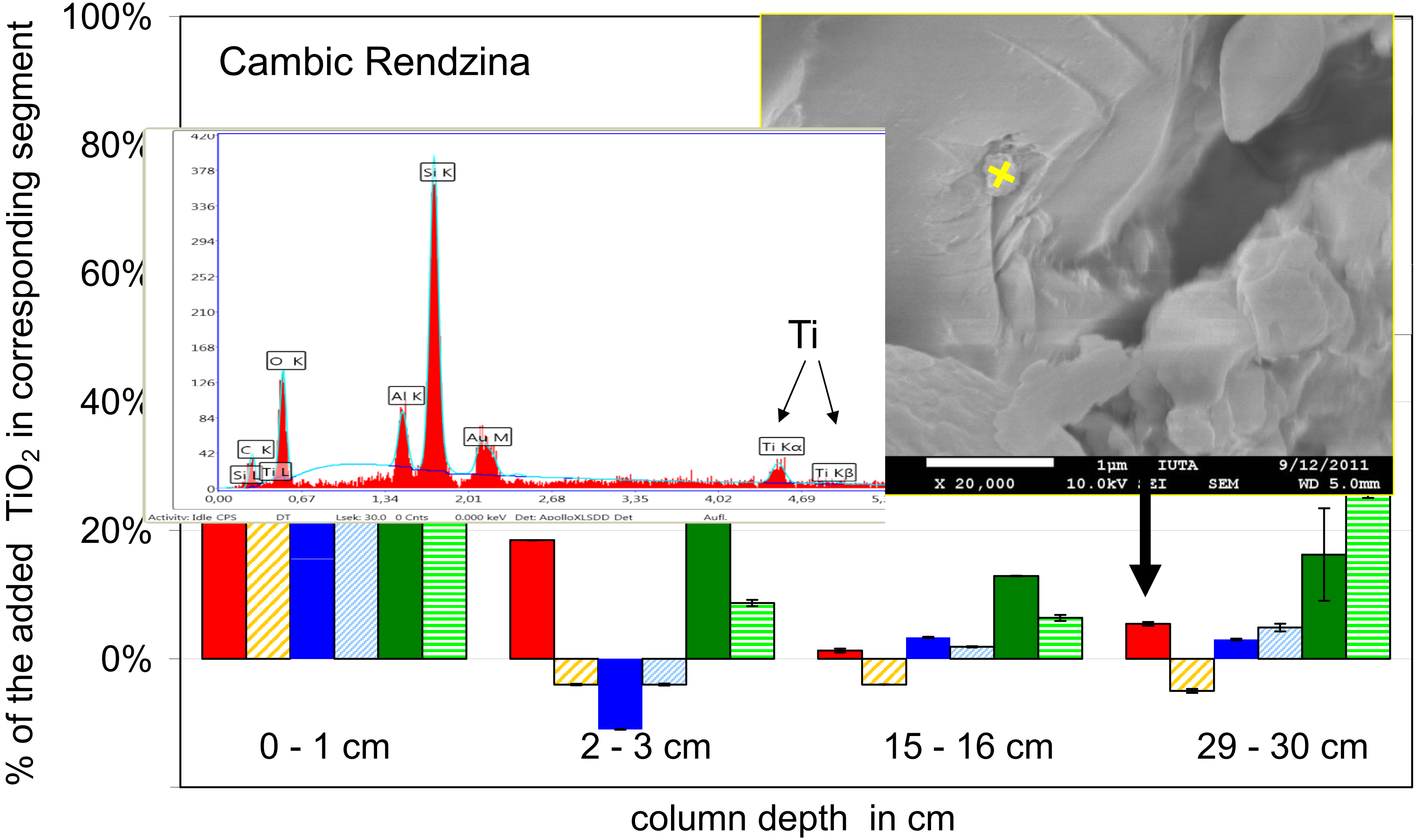
Gleyic
Podsol

Results



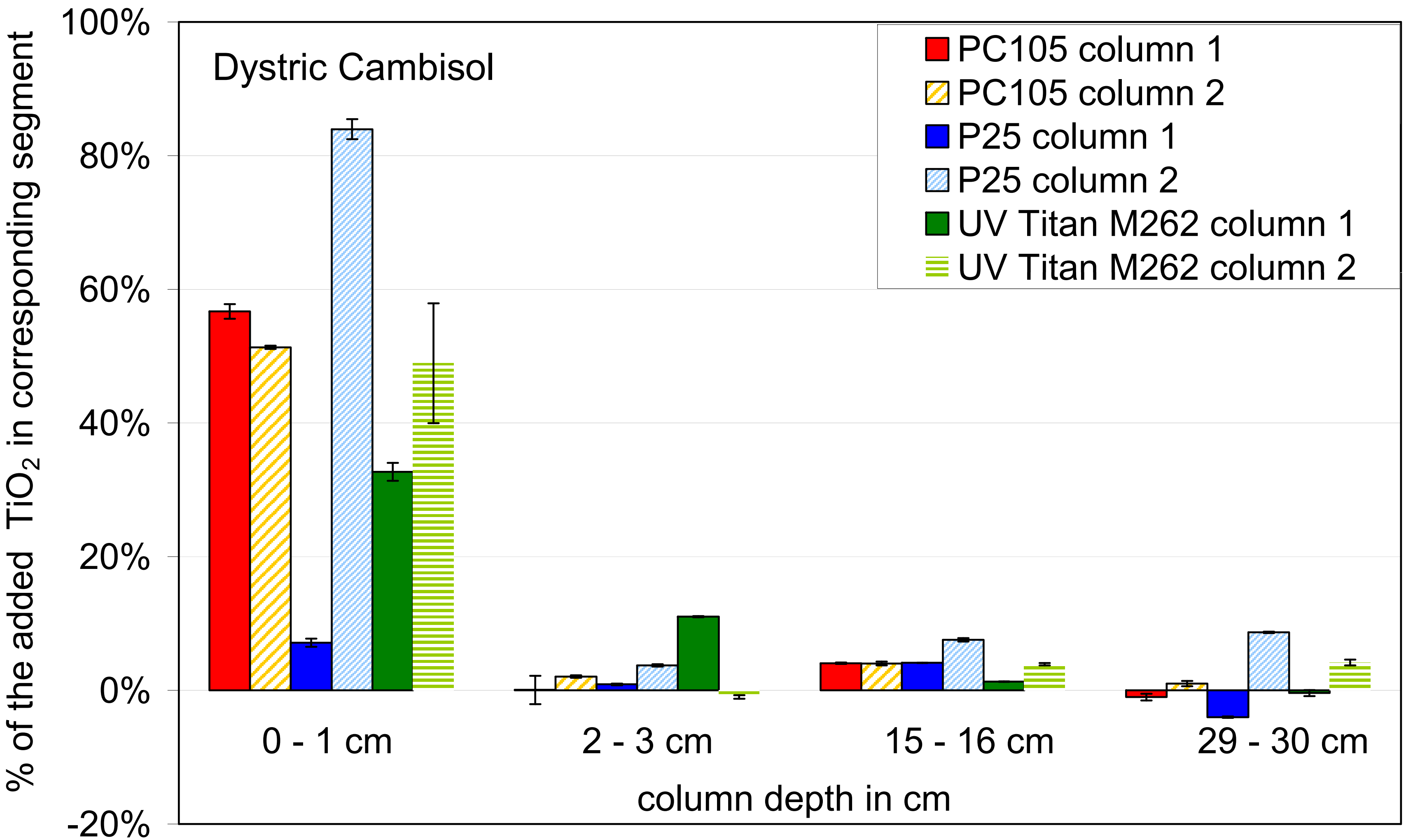
Background Ti: 0.42 % (4.2 g/kg)

Results



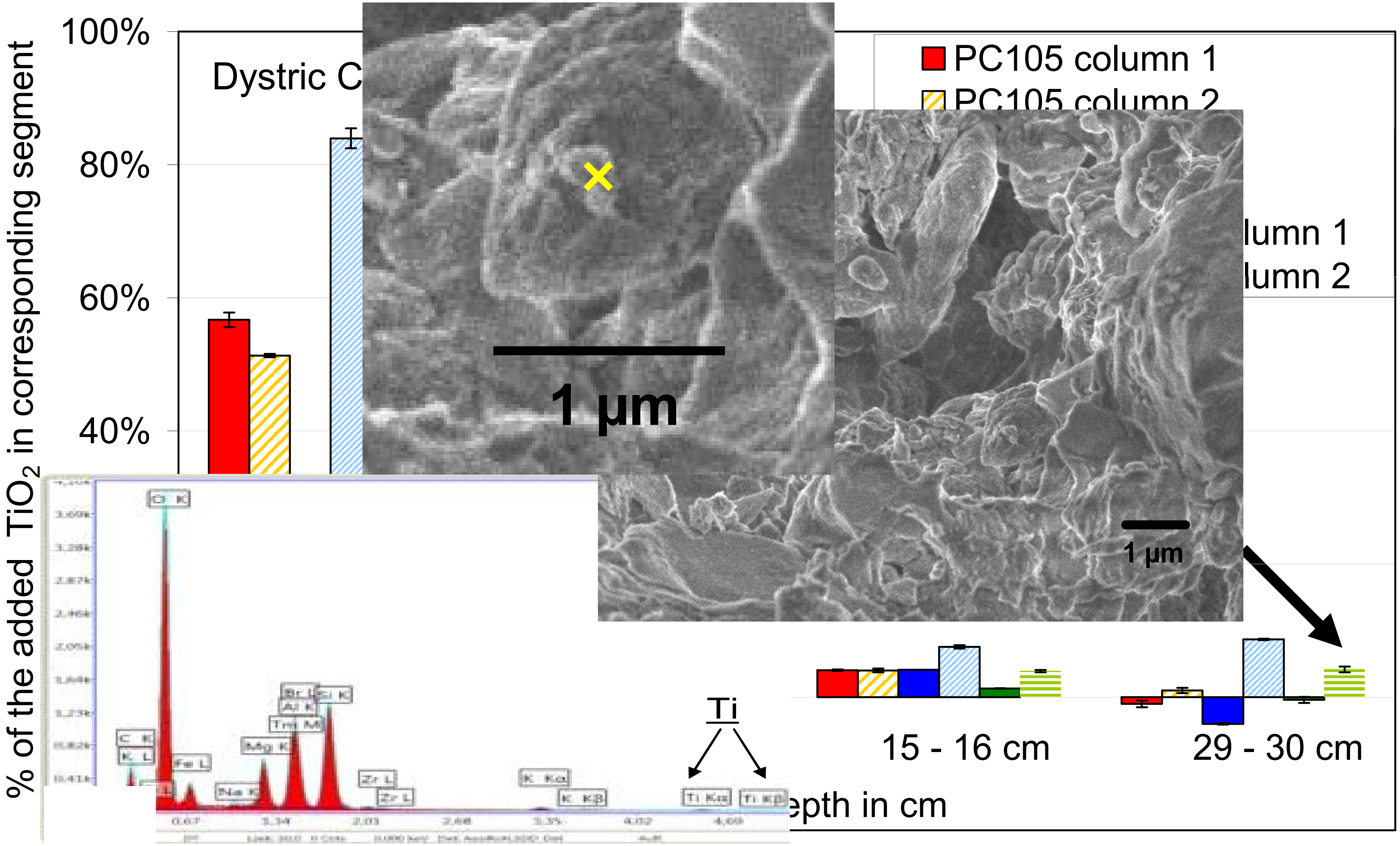
Background Ti: 0.42 % (4.2 g/kg)

Results



Background Ti: 0.19 % (1.9 g/kg)

Results



Background Ti: 0.19 % (1.9 g/kg)

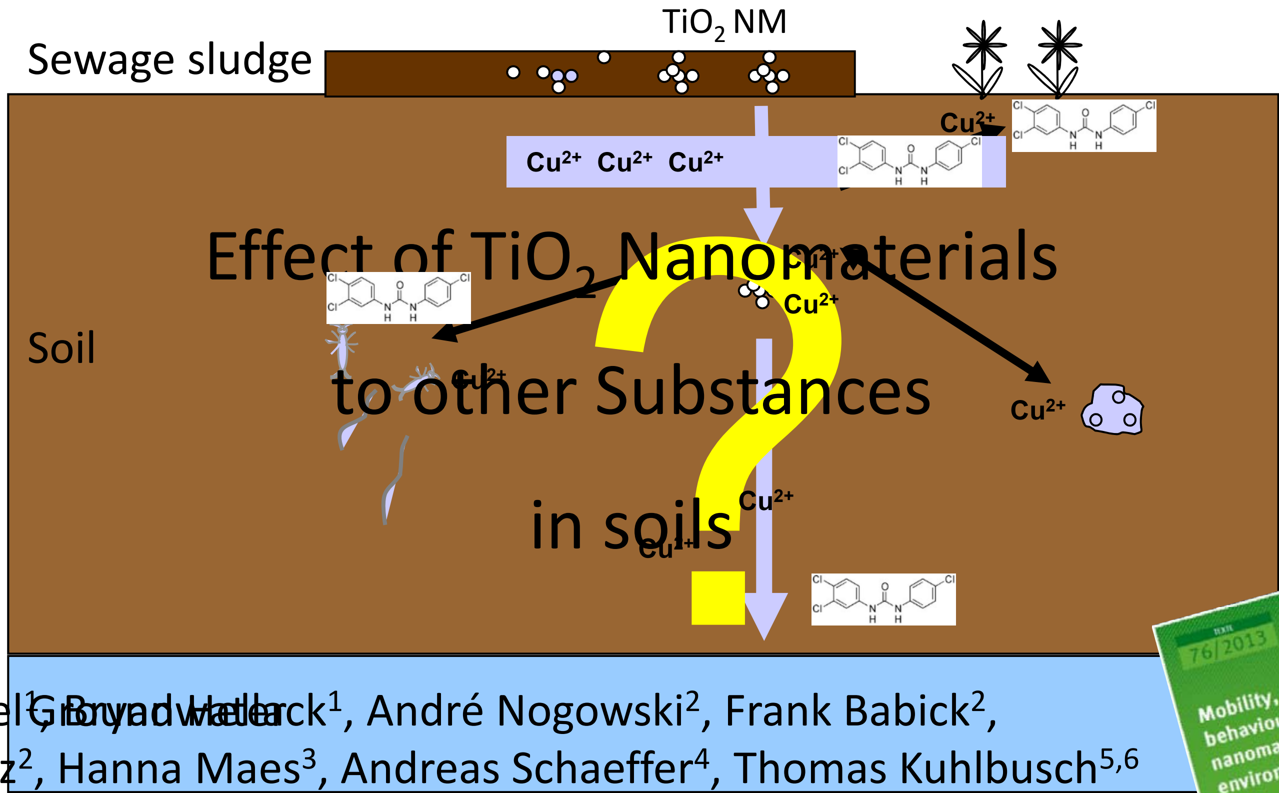
Summary

Soil	NM102 (PC105)	NM103 (UV Titan M262)	NM105 (P25)
Dystric Cambisol	-	+	-
Conclusion	no significant transport detected	transport indicated, between the first and second segment	no significant transport detected
Cambic Rendzina	(+)	+	(+)
Conclusion	chemically no transport detected. SEM / EDX indicate a transport of single agglomerates	transport indicated, down to segment four	chemically no transport detected. SEM / EDX indicate a transport of single agglomerates

- Low mobility → no risk for the Groundwater
- ICP-OES analysis – Transport indicated for the coated NM in the soil with high CEC, pH, carbon content
  - Comparable particle size (NM103 and NM105) and zeta potential in suspension (all)

  → coating effect?

Troyan Horse Effect



Effect of TiO$_2$ Nanomaterials to other Substances in soils

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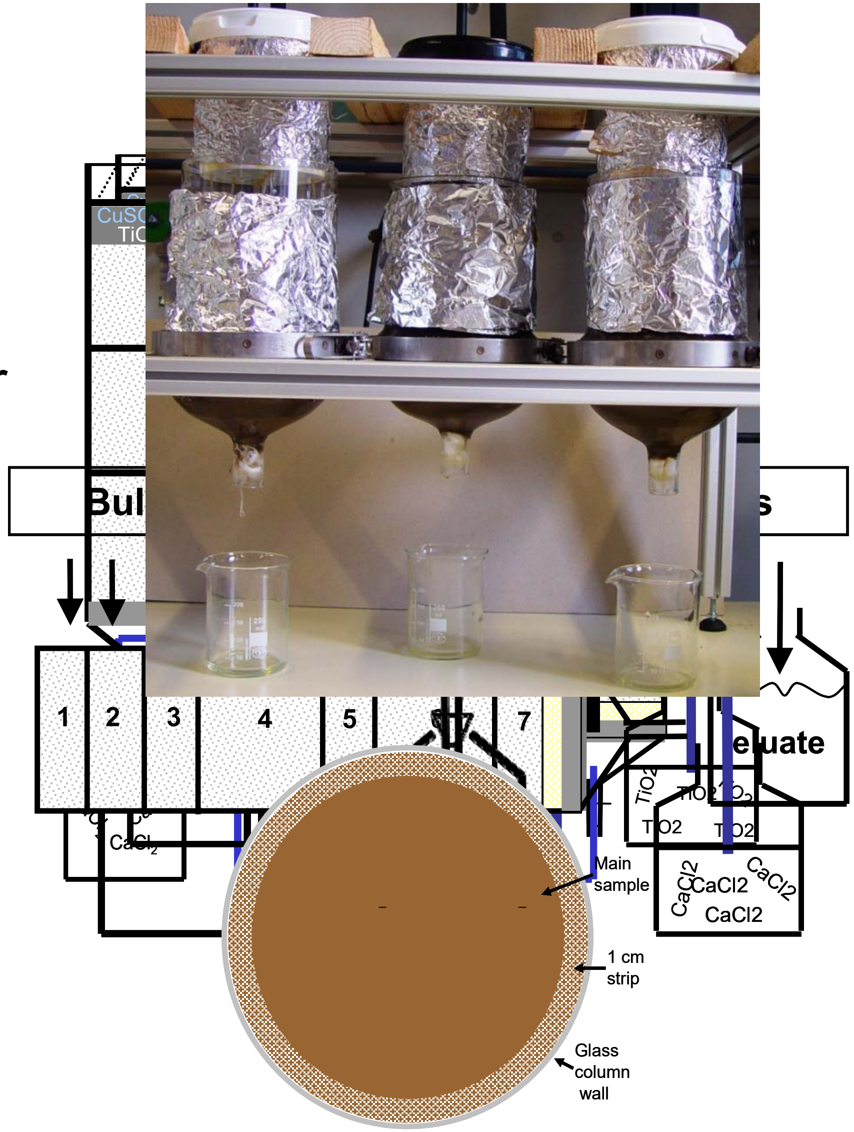
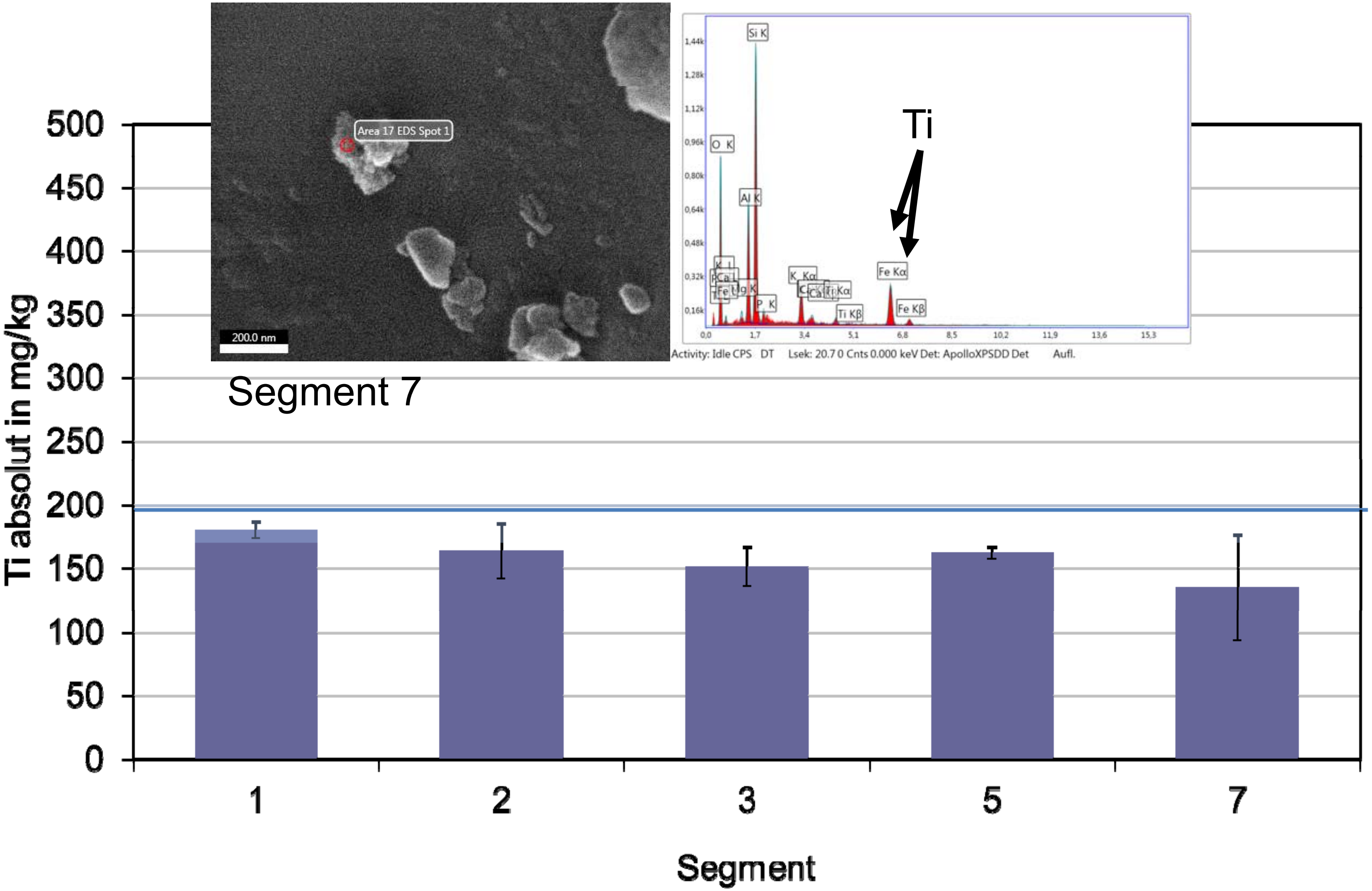
Experimental design

- Saturation 0.01 M $CaCl_2$
- Application of 1cm spiked soil layer (Cu (43 mg/kg) or ^{14}C TCC (2 mg/kg))
- Application of 100 ml P25 Suspension pH 5 test system and 100 ml DI water pH 5 reference system
- 48 h application of „rain“ – 42 ml/min 0.01 M $CaCl_2$
- Sampling of the eluate and soil
- Chemical analysis (Cu and Ti)
- Radioanalytic (^{14}C TCC)

- Different diameter (12 cm)
- Glas wall sample omitted

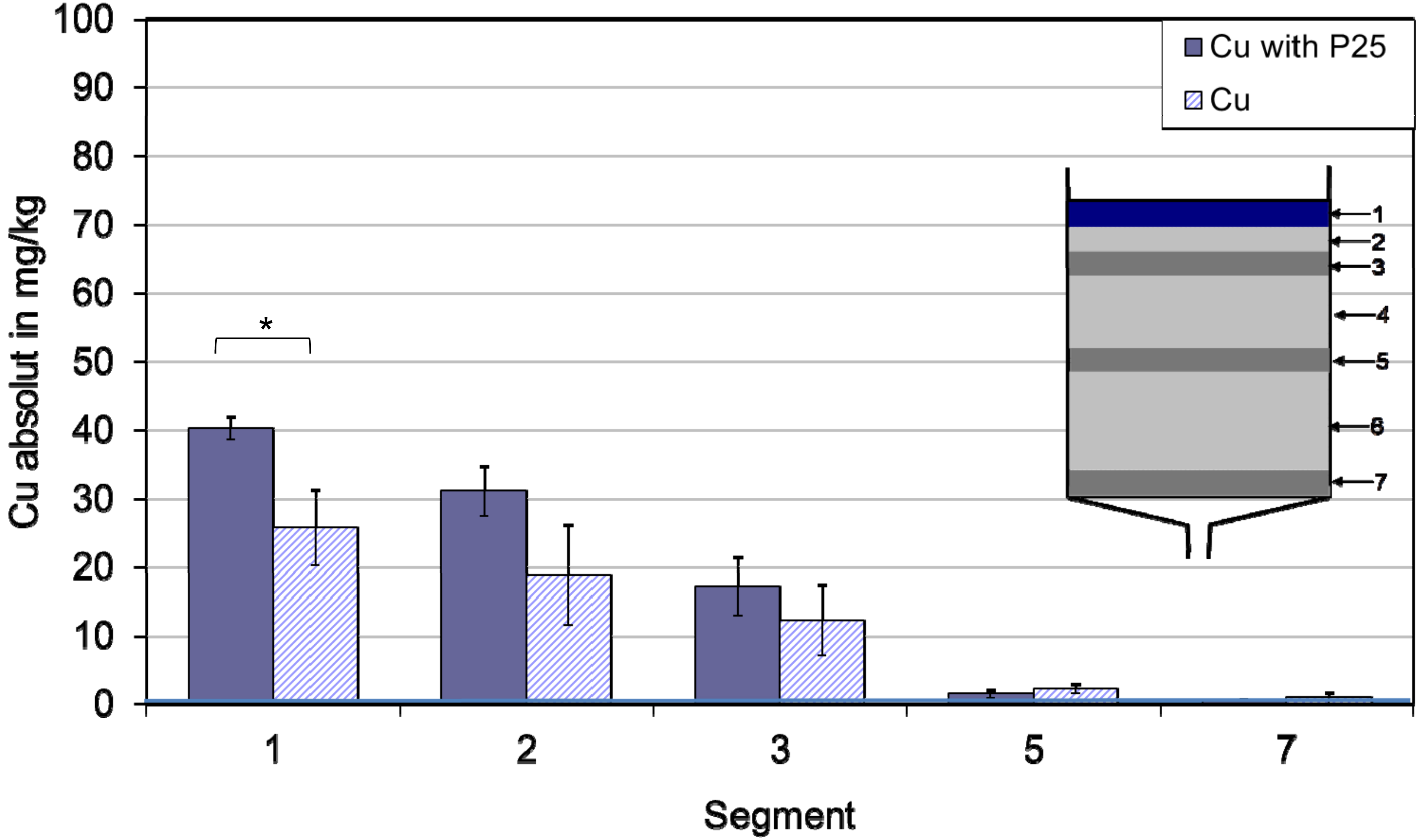


Ti Transport – Example - Soil type Dystric cambisol (A01)

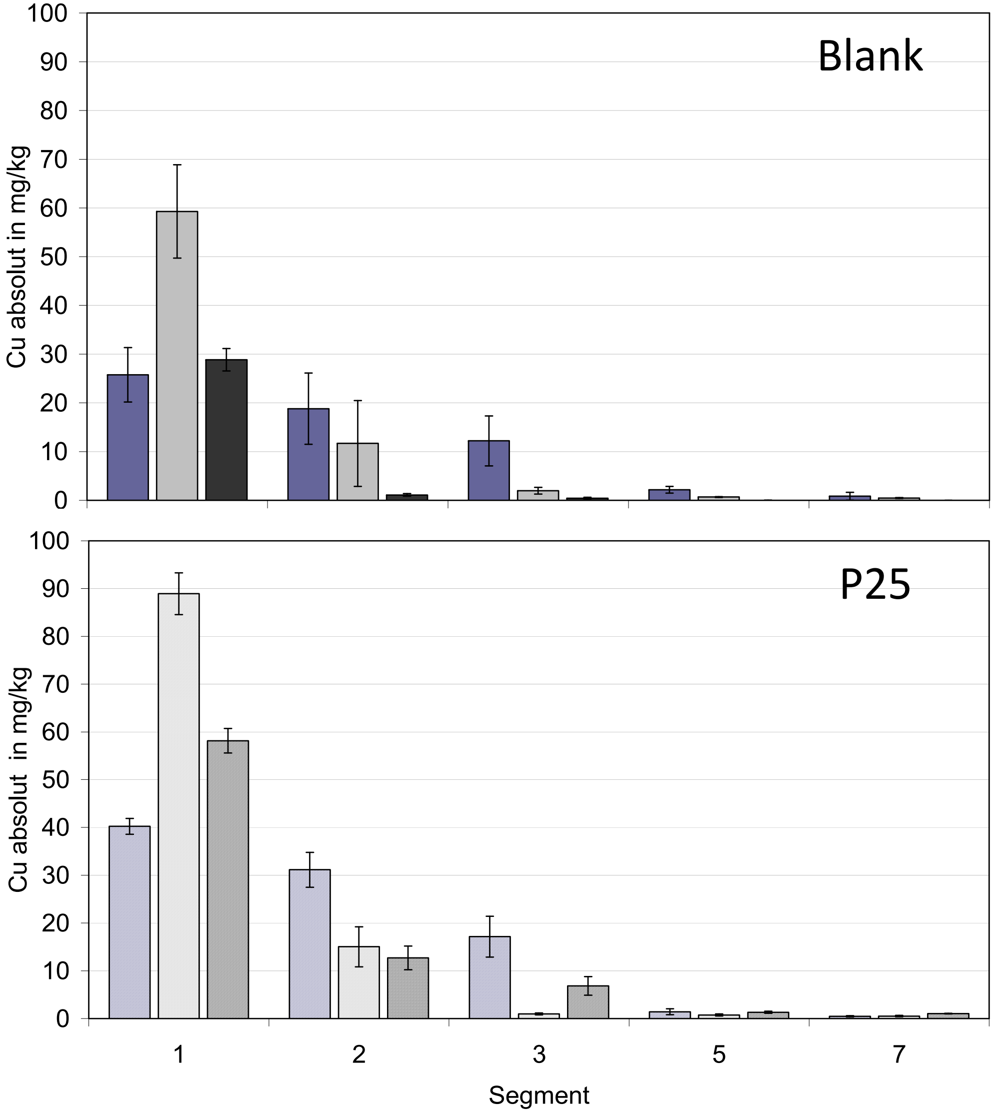


→ Transport of isolated P25 agglomerates

Cu Transport – Example - Soil type Dystric cambisol (A01)



Cu Transport

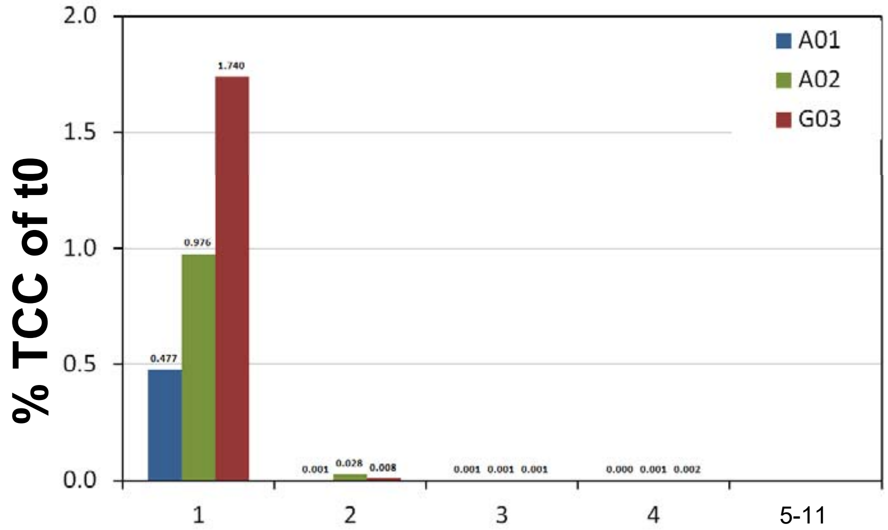


Reference:
Soil type dependent low transport:
Dystric cambisol (A01) > Eutric cambisol (G03) > Stagnic luvisol (A02)

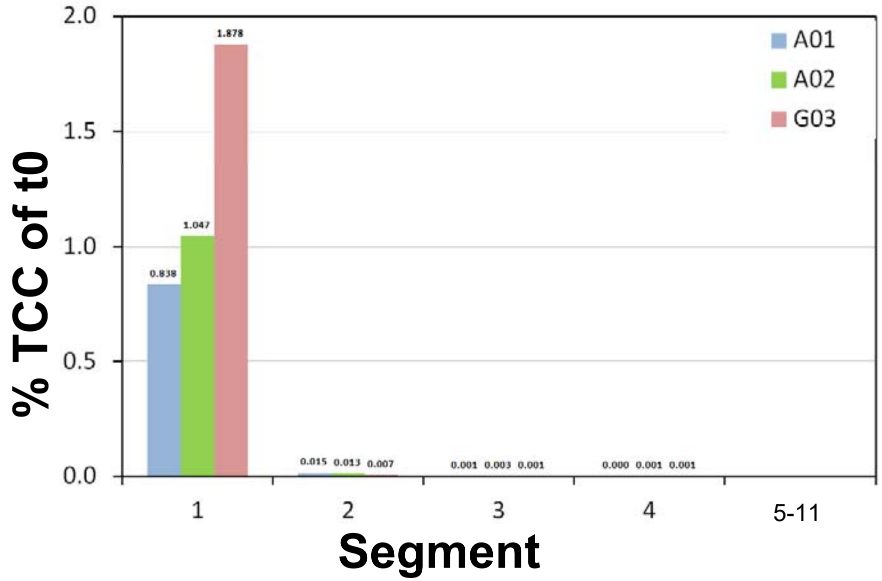
Test system:
Soil type dependent low transport, Cu transport lower compared with the blank
Dystric cambisol (A01) > Eutric cambisol (G03) > Stagnic luvisol (A02)

➔ P25 reduced Cu-transport

TCC Transport



Reference:
Low mobility, no breakthrough of TCC, TCC concentartion higher as LOD only in the first 4 cm
Dystric cambisol (A01) > Stagnic luvisol (A02) > Eutric cambisol (G03)



Test system:
Low mobility, no breakthrough of TCC, TCC concentartion higher as LOD only in the first 4 cm
→ No differences if P25 is available (slightly lower transport for soiltype A01)

Conclusion

- Low mobility of Ti ENM (only single agglomerates)
- Low Cu and very low TCC transport
- Soiltype with the lowest pH (5.7) and CEC (38 mmolc/kg) shows the highest transport - Dystric Cambisol
- Significant lower Cu transport if P25 is available for all soiltypes
- No significant effect of P25 on TCC transport

→ Accumulation of Ti or Cu in the upper soil layers → higher availability for plants → concentration hot spots possible

→ Transferability of other subtances → lower transport of nutrients possible?

Outlook

- Literature → No / low mobility of ENM in soils
- Are these information enough for a comprehensive Risk Assessment?

Open questions?

- Some ENM show a higher mobility

→ Identification of important ENM paramaters which determine the behaviour
→ Identification of important soil parameter like AWI affecting the ENM mobility

- Transformation processes → change of the mobility possible?

- Relevance of the low mobility → Concentration hot spots?
→ Bioavailability for soil organisms / plants?

- Lack of long term studies and mesocosm studies

Thank you for your attention!!!

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