SOIL - PLANT TRANSFER OF ORGANIC CHEMICALS AND RERIVATION OF TRIGGER VALUES

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Definition: soil trigger values

….”values which, if exceeded, shall mean that investigation with respect to the individual case in question is required, taking the relevant soil use into account, to determine whether a harmful soil change or site contamination exists.”

(§ 8 Federal Soil Protection Act)

Procedure for the derivation of trigger values for ”plant quality”

1. **Consideration of maximum residue levels on / in plants**
2. **Quantitative description of soil-plant uptake and derivation of a maximum acceptable soil concentration**
3. **Plausibility check**
4. **Final stipulation of trigger values**

Maximum residue level as prerequisite: available

$$f_{transfer\ (i)} = \frac{C_{plant\ (i)}\ [mg/kg\ dm]}{C_{soil}\ [mg/kg\ dm]}$$

$$\text{Max acceptable soil conc} = \frac{HF \times MRL\ (i)\ [mg/kg\ dm]}{f_{transfer\ (i)}\ (1 - \text{water content}\ [\%] / 100)}$$

I = vegetable food I

HF = hazard factor according to approach “toxicological hazard assessment of chemicals (GvU)

MRL = maximum residue level

Maximum residue level as prerequisite: not available

$$MRL`(i)\ [mg/kg] = \frac{ADI\ [mg/kg\ bw\ d] \times 20\ kg \times portion_{(i)},\ food\ basket\ [\%/100]}{daily\ intake_{(i)}\ [mg/kg]}$$

$$\text{Max. acceptable soil conc.} = \frac{HF \times MRL`(i)\ [mg/kg]}{f_{transfer\ (i)}\ (1 - water\ content\ [\ \%\ ] / 100)}$$

i	=	vegetable food I
HF	=	hazard factor according to approach “toxicological hazard assessment of chemicals (GvU)”
ADI	=	acceptable daily intake
20 kg	=	reference for daily intake: girl 4 – 6 years of age, sensitive subgroup, weight = 20 kg
MRL`	=	derived maximum residue level

Food basket

food	Average intake, girl 4 – 6 years of age [g / d]		
	raw	dressed	total
Vegetable food	**116,4**	**274,0**	**425,5**
vegetable, general	33	75,4	108,4
cereals			108,0
potatoes		71	
fruits, general	72	89,3	161,3

Hexachlorobenzene (1)

Data availability: soil-plant uptake

- **homogeneous data set on small scale laboratory studies available**
- **additional data on lysimeter and field studies**
- **use of a homogenious data set and safety factors for derivation of soil values**

Hexachlorobenzene (2)

Food	Study design	Quality of study	Transfer factor
oat, root	desiccator, 1 soil	low	7
cress	desiccator, 1 soil	low	21
corn, shoot	desiccator, 1 soil	low	21
rape, root shoot	desiccator, 1 soil	low	30 27
carrot, root shoot	desiccator, 1 soil	low	450 168
salad, root shoot	desiccator, 1 soil	low	246 28

safety factor of 5 should be added because of information from 1 soil only

Hexachlorobenzene (3)

Food	Study design	Soil	Transfer factor
Barley, shoot root	Indoor desiccator	64 % sand	26.0 9.0
Wheat, grain	Outdoor pots Ø 22 cm	86 % sand	0.010 (0.9 mg/kg soil) 0.005 (1.7 mg/kg soil) 0.003 (3.0 mg/kg soil)
straw			0.20 (0.9 mg/kg soil) 0.10 (1.7 mg/kg soil) 0.15 (3.0 mg/kg soil)
roots			2.0 (0.9 mg/kg soil) 2.1 (1.7 mg/kg soil) 2.2 (3.0 mg/kg soil)
Wheat, grain	Outdoor, small lysimeters	74 % sand	0.03
straw	Ø 60 cm		0.40

Hexachlorobenzene (4)

$$\text{Max acceptable soil conc.} = \frac{\text{HF x MRL (i) [mg/kg dm]}}{f_{\text{transfer (i)}} \ (1 - \text{water content [\%]} / 100)}$$

⇓

$$\text{Max acceptable soil conc. (carrots)} = \frac{5.5 \times 0{,}05}{450 \times 5 \ (1 - 88{,}2 / 100)} = 1{,}1 \ \mu g/kg$$

Hexachlorobenzene (5)

conclusions: plausibility check

- **trigger value for path soil – human being (playgrounds): 4 mg HCB/kg**
- **background values: 0,2 – 12 µg/kg (grassland), 0,5 – 13 µg/kg (agricultural soils)**

- **principle need to derive trigger value for soil-plant uptake**
- **values derived from lab studies are in the range of background values**
- **results from field and lysimeter studies, respectively, needed**

DDT (1)

data availability: soil-plant uptake

- **comprehensive studies available because of longtime use as pesticide**
- **field study results published**
- **use of safety factors depending on number of soils and food items tested**

DDT (2)

Food	Study design	Quality of study	Transfer factor	Max acceptable soil concentration [mg/kg] [4,]	
				without safety factor	including safety factor
carrots	field, 5 soils [2]	relatively high	0.6 [1]	2.3	2.3
beets	field, 1 soil [3]	relatively high	0.05	33.5	6.7
potatoes	field, 1 soil	relatively high	0.2	3.5	0.7
radish	field, 1 soil	relatively high	0.35	6.5	1.3
rapeseed	field, > 5 soils	very high	0.3 [1]	0.7	0.7

[1] mean

[2] safety factor = 1 (5 soils tested)

[3] safety factor $_{soil}$ = 5 (1 soil tested)

[4] hazard factor HF = 10

[5] safety factor $_{food}$ = 3 (5 food items tested)

DDT (3)

plausibility check:

- trigger value for path soil – human being (playgrounds): 40 mg DT/kg
- monitoring data: 0,03 – 1,5 mg/kg (agricultural soils),
  0,16 – 0,25 mg/kg (industrial area)

conclusions:

- principle need to derive trigger value for soil-plant uptake
- calculated trigger values are in the range of monitoring data
- trigger value far below trigger for path soil – human being

Pentachlorophenol (1)

- **transfer factors obtained on the basis of short-term lab studies are not comparable to those obtained based on long-term field studie**
- **degradation of pentachlorophenol in soils**
- **plant availability in acid soils lower compared to neutral and alkaline soils**
- **transfer of PCP in plants < 0,01 (alkaline soils) and thus accumulation in the food chain is not to be expected**
- **confirmation by outdoor plot experiments**

Conclusions – lit. study

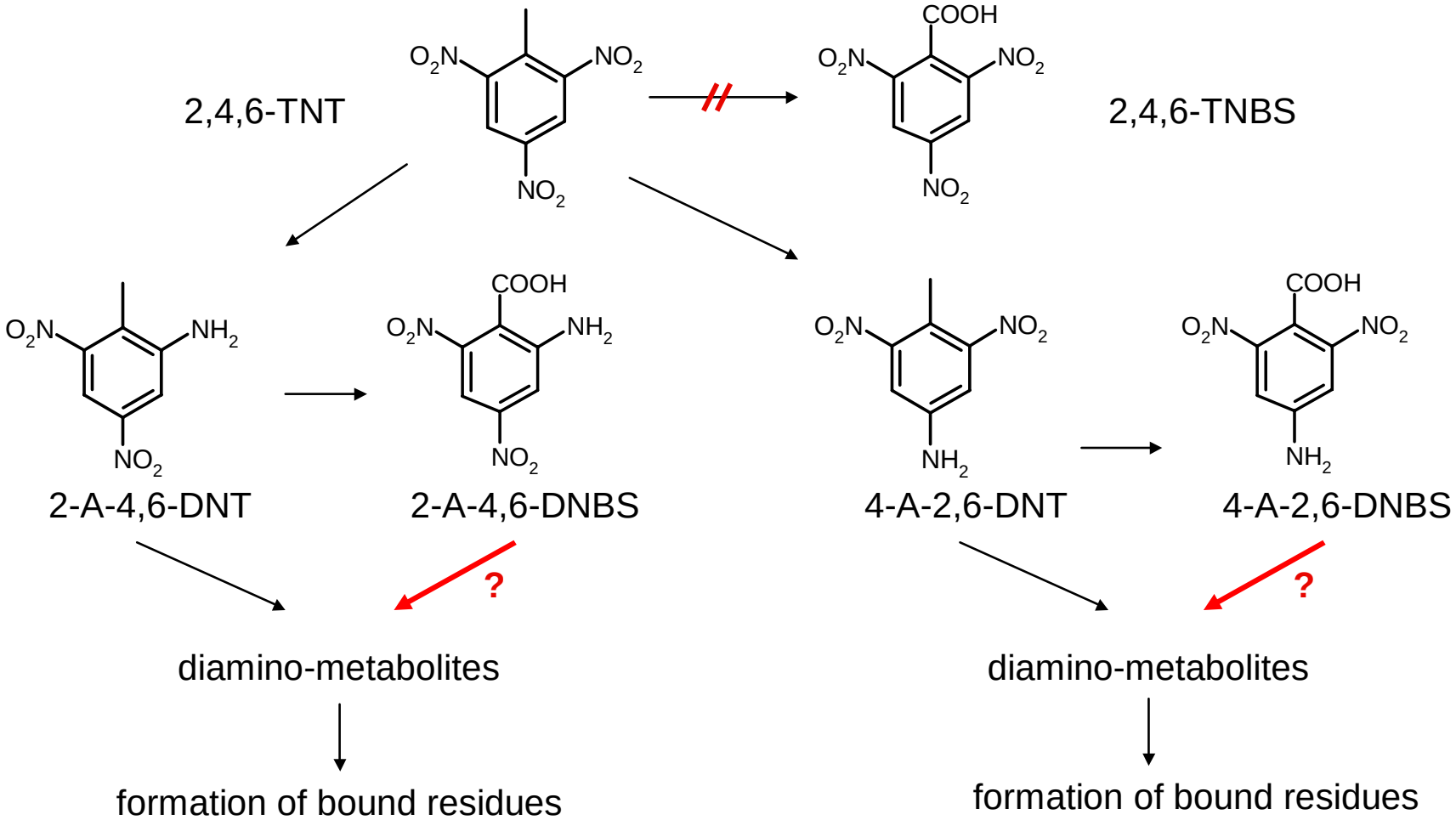
- **pathway soil-plant is a sensible exposure route due to potential accumulation in the food chain**
- **Calculation of max acceptable soil concentrations yields values far below those for pathway soil – human being (playing grounds)**
- **Current lab data result in an overestimation of transfer factors**
- **High quality outdoor plot studies should be performed for priority organic pollutants**

Experimental set up

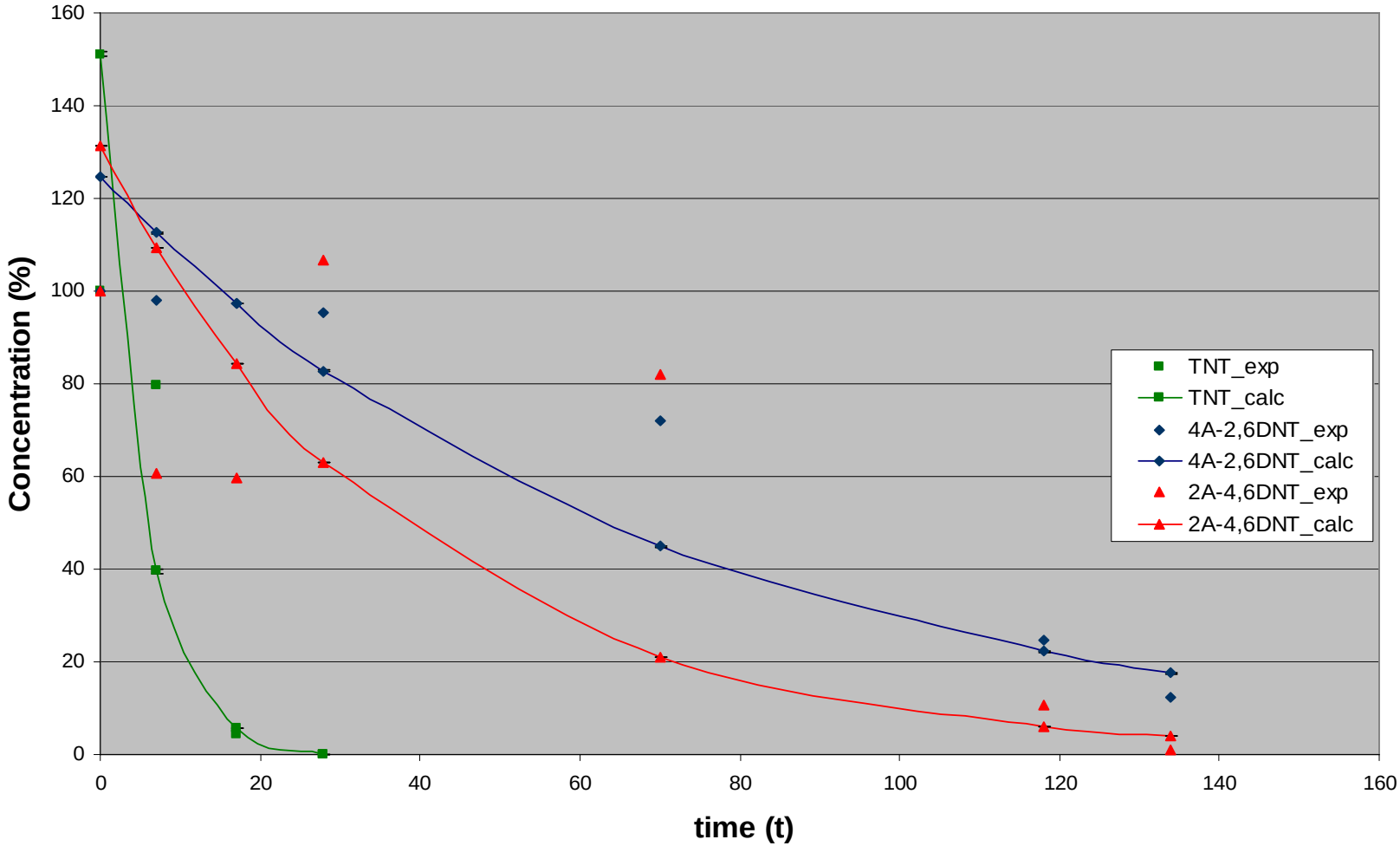
Outdoor lysimeter – experiments were performed with:

carrots	**HCB**
potatoes	**PCP**
barley	**phthalates (DEHP, DBP)**
rape	**nonylphenolethoxylates**
grass	**nitroaromates (TNT, DNT, MNT)**
kale	

Metabolism of TNT in Soil



Degradation of TNT



Data from phytoremediation experiments

pot experiments by Schönmuth et al, 1996

start application: 20 mg TNT/kg sand, analysis after 6 weeks

compartment	TNT [mg/kg dm]		4-A-DNT [mg/kg dm]		2-A-DNT [mg/kg dm]	
	willow (salix)	polar (populus)	willow (salix)	polar (populus)	willow (salix)	polar (populus)
sand as sustrate	0.57	1.17	0.49	0.58	0.62	0.82
root	0.40	0.55	3.12	4.37	6.95	8.59
leaf	0.04	0.03	0.11	0.08	0.13	0.22
branch	0.04	0.09	0.03	0.14	0.04	0.33

Plant uptake at contaminated sites

Görge et., al, 1995 – UWSF, 139-148

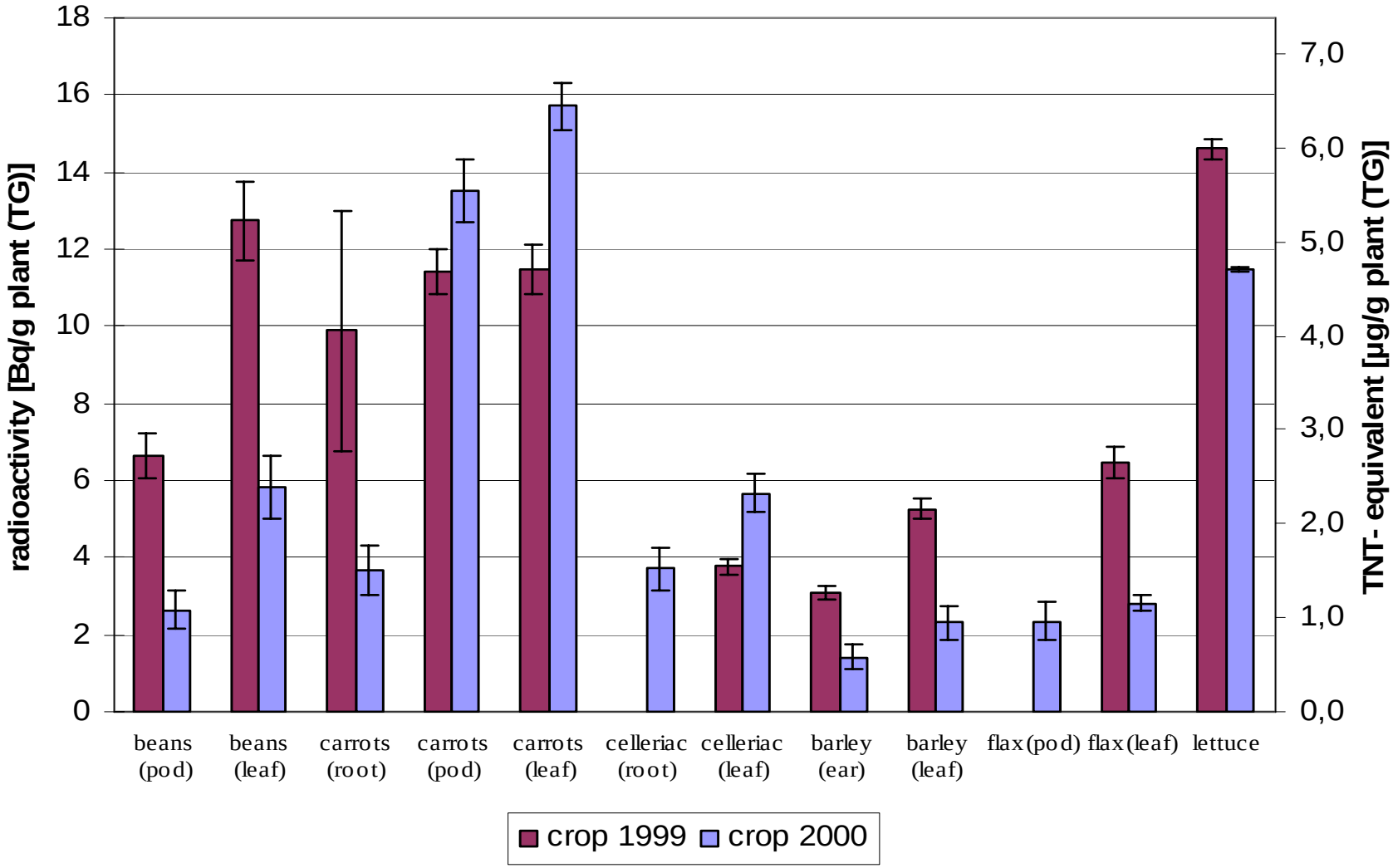
mean TNT-concentration at start of the cultivation: 3mg/kg soil

compart-ment	TNT [mg/kg dm]		4-A-DNT [mg/kg dm]		2-A-DNT [mg/kg dm]	
	bean (phaséolus vulgaris)	lucerne (medieago sativa)	bean (phaséolus vulgaris)	lucerne (medieago sativa)	bean (phaséolus vulgaris)	lucerne (medieago sativa)
soil	0.44	0.69	0.36	0.85	0.29	0.63
root	0.18	0.04	0.63	0.04	1.09	0.04
leaf	0.09	0.02	0.05	0.03	0.03	0.03

no transfer measured in : carrots, strawberries, lettuce etc.

Plant uptake of bound TNT-residues

soil concentration 550 Bq/g



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Conclusions

- **pathway soil-plant is a sensible exposure route due to potential accumulation in the food chain**
- **trigger values for priority organic substances are needed**
- **for non-persistent pollutants their degradation during plant growth should be considered**
- **TNT and related compounds should disappear from well cultivated areas.**
- **bound residue of TNT are not bioavailable for plants**