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Trigger and Action Values for the Pathway Soil-Plant

Contents of the Federal Soil Protection Act

The Federal Soil Protection Act integrates the preventive soil protection and the remediation of contaminated sites. The basic idea is the protection from harmful changes to the soil. Such changes are given

- when the soil functions are impaired and
- when this can lead to danger, to considerable drawbacks or nuisance for individual persons or for the general public.

BBodSchV

Federal Soil Protection and Contaminated Sites Ordinance (BBodSchV)
dated 12 July 1999.
(In German) BGBl. 1999 p. 1554

Download in English and German:
www.bmu.de

Action and Trigger Values

The Federal Ordinance on Soil Protection and Contaminated Sites defines trigger values and action values pursuant to Art. 8 (1) Federal Soil Protection Act. The following definitions apply:

Action values: values for impacts or pollution which, if exceeded, shall normally signal the presence of a harmful soil change or site contamination, taking the relevant soil use into account, and mean that measures are required.

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.

Use-related Categories and Pathways

The action levels and the trigger levels are related to the use of the site. Four use-related categories were defined:

- playing grounds,
- residential areas,
- parks/recreational areas and
- industrial areas.

Three pathways are considered:

- the direct contact (the uptake of contaminated soil by playing children),
- the pathway from the soil to plants and
- the pathway from the soil to the groundwater.

Derivation of Trigger and Action Values

Derivation of trigger and action values is oriented to Art. 8 (1) Federal Soil Protection Act and to its reference to fulfillment of obligations, set forth in Art. 4, for prevention of hazards in connection with existing harmful soil changes or contaminated sites. Such derivation begins largely with soil functions, and their significance for

- people who come into direct contact with the soil,
- maintenance of the purity of food and feed plants, and
- water that leaches into the soil and is destined to become groundwater.

Derivation of Trigger and Action Values

Derivation of trigger and action values takes the following into account in connection with exposure:

- substance properties that influence spreading of substances and, possibly, their availability for resorption,
- soil properties that affect substance compounds and their environmental behavior,
- different types of human behaviour (play, work; different resorption pathways and relevant presence durations), and
- the quality and number of the available data (statistical data, epidemiological findings).

Derivation of Trigger and Action Values

With respect to the plants involved, various types of cases and valuable resources must be differentiated:

- Prevention of human-toxicological effects following consumption of plant foods, especially wheat, potatoes and vegetables,
- Assuring the saleability of food plants, as food, from farms and professional horticulture,
- Safety of feed crops and grassland cover for use as feed.

Derivation of Trigger and Action Values

In assessment of hazards in the soil/plant pathway, the following different types of cases must be differentiated, in keeping with the soil usage involved:

- Sale of food plants from cultivation and commercial vegetable gardens,
- Sale/use of feed plants from cultivated fields and from grasslands,
- Consumption of home-grown fruit and vegetables from private gardens (home/small gardens)

Derivation of trigger and action values

The trigger and action values are derived by means of the following steps:

- Determination of the highest permissible pollutant concentrations in plants (preparation of the plant-oriented assessment standard),
- Description of heavy-metal transfer from the soil into plants, followed by calculatory derivation of the highest soil concentration that will still ensure compliance with the highest permissible plant concentration,
- Checking of the calculated soil values for plausibility, including estimation of the toxicological load from vegetables growing in gardens polluted with heavy metals,
- Definition of test or action values.

The Soil-Plant Pathway

Various research projects are being conducted to derive trigger values for priority organic pollutants in the soil-plant pathway.

Due to a lack of data resources from which to derive trigger values, a study framework first had to be developed to gather empirical data. The results is **TRANSFER**, a database using data from joint Länder research programmes and other data holdings at the Federal Environment Agency. The database allows soil concentrations of both anorganic and organic pollutants to be matched up with plant concentrations on the same site, and forms part of BIS, the national soil information system.

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The Soil-Plant Pathway

The Transfer database combines and integrates stocks of data that have previously been heldseparately in national and Länder repositories. Efficient data exchange at both Länder and federal level is made possible by new data compatibility standards. This aids the uniform enforcement of soil protection law. Data resources have also been set up to update andamend substance classifications and the precautionary, trigger and action values laid down in the Federal Soil Protection and Contaminated Sites Ordinance.

Trigger Values

Such trigger values for soils in agricultural and horticultural use have already been derived for the heavy metals lead, mercury, thallium as well as arsenic. For organic substances trigger values only exist for benzo(a)pyrene.

A concept introducing trigger and action values

For this purpose the working group assessed more than 300.000 on soil concentration of heavy metals and corresponding concentration of these metals in plants.

This data build up the data bank TRANSFER.

It gives soil concentration as either extraction with aqua regia or ammoniumnitrate from field investigation on arable land and grassland.

The statistical relationship between heavy metals in soil and heavy metals in plants gives evidence about the probability of the plant uptake of heavy metal concentrations from soils.

Ad-hoc-Group „Heavy metal transfer soil/plant"

In close co-operation with the ad-hoc-group „Heavy metal transfer soil/plant" of the Federal/State Working group on „Soil Protection“ the transfer behaviour of heavy metals from soil to well-chosen food plants and forage plants was analysed.

Aspects of

- phytotoxicity,
- food quality and
- forage quality are taken into account

Aim of this work was to elaborate a concept introducing trigger and action values

Procedure to Obtain Trigger Values

consideration of maximum residue levels in/on plants.

quantitative description of soil-plant transfer and derivation of a maximum acceptable soil concentration

plausibilty check

final stipulation of trigger values

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Examples of the ZEBS-Levels for contaminants in vegetable provisions (BGVV, 1997) in mg/kg fresh weight

	Pb	Cd
wheat grain	0,30	0,10
rye grain	0,40	0,10
Skin fruits	0,50	0,05
potatoe	0,25	0,10
Leaf vegetables	0,80	0,10
Root vegetables	0,25	0,10
spinach	0,80	0,50

Maximum permissible heavy metal contents in plants

- ZEBS values,
- values of the decree for fodder,
- values of VDI guidelines
- phytotoxical concentrations

Plant species

For calculating a soil standard the large number of plant species included in the data bank required the selection of plants which are frequently cultivated, for which a sufficient number of data records is available and which are accumulating heavy metals.

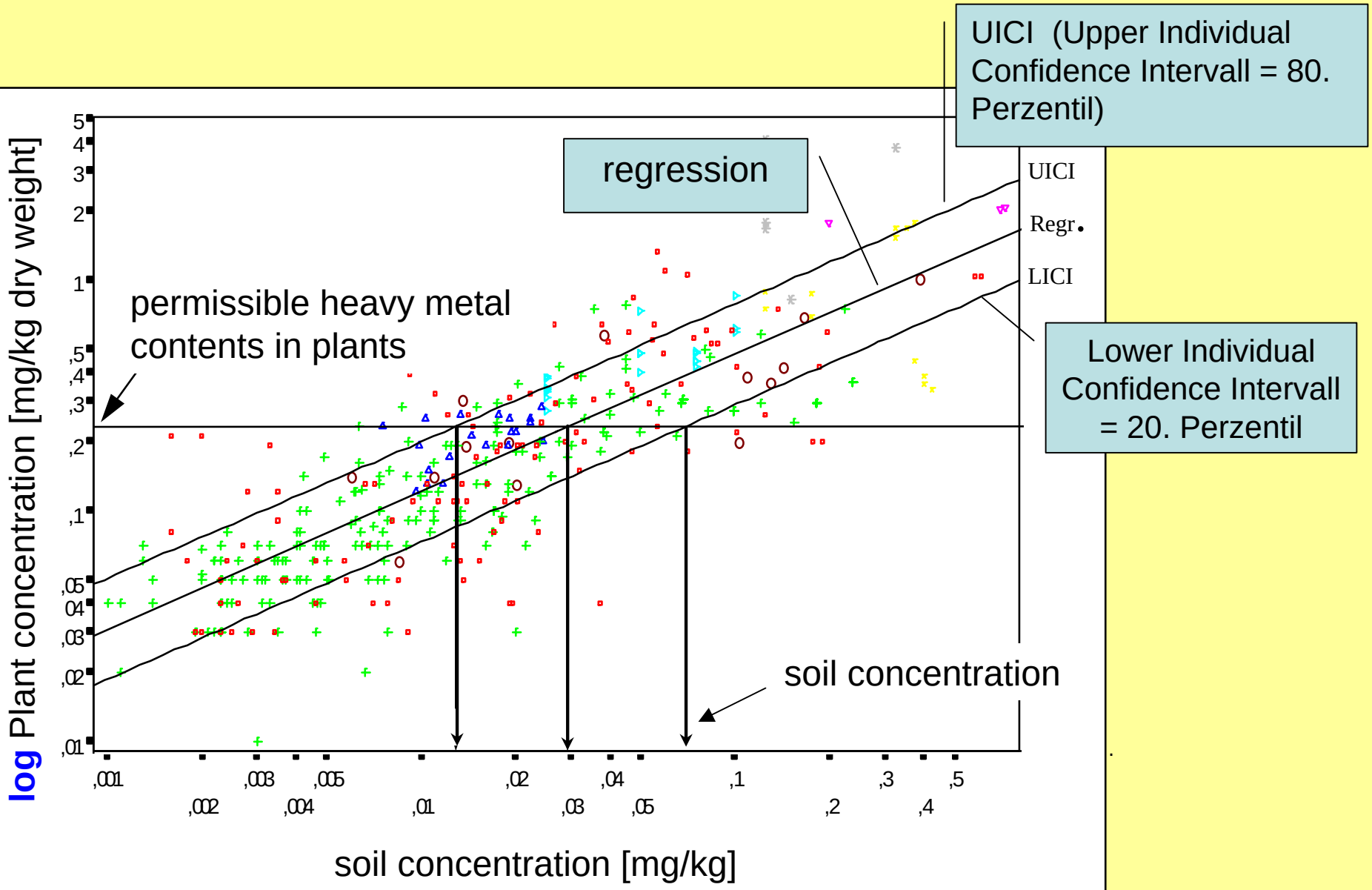
Soil characteristics

The inclusion of soil characteristics like pH value, content of organic matter or clay content only led to negligible improvements of the results.

Calculation of regression statistics

Only extractions with aqua regia and ammoniumnitrate from outdoor investigations on cultivated sites were taken into consideration for calculating regression statistics. With the help of these statistics the relationship between heavy metals in soil and heavy metals in plants can be described, which give evidence about the probability of heavy metal concentrations in plants depending on heavy metal concentrations in soil.

Regression statistics of the heavy metal transfer soil-plant



Contingency ables

The contingency tables show the distribution of heavy metal concentrations in soil and in plants for different concentration levels on the basis of maximum permissible heavy metal contents in plants (ZEBS values, values of the decree for fodder, values of VDI guidelines or phytotoxical concentrations) and on the basis of recommendations of the ad-hoc-group referring to a soil standard value concept with different threshold values.

Contingency tables

The following contingency table show the distribution of heavy metal concentrations in soil and in plants for different concentration levels on the basis of maximum permissible heavy metal contents in plants and on the basis of recommendations of the ad-hoc-group concerning a soil standard value concept with different threshold values.

Example contingency table

1) Maximum permissible heavy metal contents in plants

Soil concentration =

Bodenkonzentration [mg/kg] * ZEBS Werte Crosstabulation

			ZEBS-Werte				
			< 0,5	0,5-1	1-2	> 2	Total
Bodenkonzentration [mg/kg]	< 100	Count	63	10	11	6	90
		% within Bodenkonzentration [mg/kg]	70,0%	11,1%	12,2%	6,7%	100,0%
		% within ZEBS Werte [mg/kg]	57,8%	55,6%	**32,4%**	30,0%	49,7
		% of Total	34,8%	5,5%	6,1%	3,3%	49,7%
		Count	**25**	**1**	**2**	**2**	**30**
		% within Bodenkonzentration [mg/kg]	83,3%	3,3%	6,7%	6,7%	100,0%
		% within ZEBS Werte [mg/kg]	22,9%	5,6%	**5,9%**	10,0%	16,6%
		% of Total	13,8%	,6%	1,1%	1,1%	16,6%
		Count	21	7	21	12	61
		% within Bodenkonzentration [mg/kg]	**34,4%**	**11,5%**	**34,4%**	**19,7%**	**100,0%**
		% within ZEBS Werte [mg/kg]	19,3%	38,9%	**61,8%**	60,0%	33,7%
		% of Total	11,6%	3,9%	11,6%	6,6%	33,7%
Total		Count	109	18	34	20	181
		% within Bodenkonzentration [mg/kg]	60,2%	9,9%	18,8%	11,0%	100,0%
		% within ZEBS Werte [mg/kg]	100,0%	100,0%	**100,0%**	100,0%	100,0%
		% of Total	60,2%	9,9%	18,8%	11,0%	**100,0%**

2) Number of datapairs of this combination soil- and plant-class

3) Amount of plant-data of the respective soil-class

4) Amount of soil-data of the respective plant-class

5) Amount of data-pairs of the respective soil- and plant-class combination of the respective plant-class

Evaluted data for trigger and action values

Aqua regia	Ammonium nitrate
- 26 studies	- 18 studies
- 2.010 regions	- 632 regions
-8,169 soils	- 2,949 soil
- 60,888 result datapairs	- 21,156 result datapairs

Content of the BBodSchV: concerning the pathway soil – plant

2. Soil – plant pathway
2.1 Definition of uses
2.2 Trigger and action and values - agricultural land and vegetable gardens with regard to plant quality
2.3 Action values - green areas with regard to plant quality
2.4 Trigger values - agricultural land with regard to impairments of the growth of cultivated plants
2.5 Application of trigger and action values

Soil – Plant Pathway

Definition of uses

a) Agriculture

areas for the cultivation of varying field crops, including vegetables and field forage plants; this also includes areas used for commercial gardening

b) Vegetable garden

back garden, small garden and any other garden areas used for growing food crops

c) Grassland

permanent green areas

Trigger and action values soil - plant in agricultural land and in vegetable gardens, with regard to plant quality (in mg/kg dry matter, fine soil)

Substance	Extraction process	Trigger value	Action value
Arsenic	Aqua regia	200*	---
Cadmium	NH_4NO_3	---	0.04 / 0.1**
Lead	NH_4NO_3	0.1	---
Mercury	Aqua regia	5	
Thallium	NH_4NO_3	0.1	---
Benzo(a)pyrene	---	1	---

*In the case of soils with temporarily decreasing conditions, a trigger value of 50 mg/kg dry matter must be applied.

**In areas that are used for growing bread wheat or strongly cadmium-accumulating vegetables, an action value of0.04 mg/kg dry matter must be applied; otherwise, the action value is 0.1 mg/kg dry matter

Trigger values soil - plant on agricultural land (in mg/kg dry matter, fine soil, in ammonium nitrate extract)

	Grassland
Substance	Action value
Arsenic	50
Lead	1,200
Cadmium	20
Copper	1,300*
Nickel	1,900
Mercury	2
Thallium	15
Polychlorinated biphenyls (PCB_6)	0.2

*Where sheep are kept on grassland, the applicable action value is 200 mg/kg dry matter.

Trigger values - soil – plant: on agricultural land (in mg/kg dry matter, fine soil, in ammonium nitrate extract)

	Agriculture
Substance	**Trigger value**
Arsenic	0.4
Copper	1
Nickel	1.5
Zinc	2

Priority Substances and Groups of Substances

Soil trigger values are nessary for the following substances and groups of substance:

- Aldrin
- polycyclic aromatic hydrocarbons
- DDT
- Hexachlorobenzene
- Hexachlorocyclohexane (HCH-mix)
- polychlorinated biphenyls (PCB)

Harmonization with the EC Regulation (466/2001)

Further necessary steps are the harmonization with the EC Regulation (466/2001) setting maximum levels for certain contaminants in foodstuffs.

Diffuse Soil Contamination

Minimum data set:

Arsenic (As), Cadmium (Cd), Chromium (Cr), Copper (Cu), Mercury (Hg), Nickel (Ni), Lead (Pb), Phosphorus (P),Selenium (Se), Zinc (Zn)

Radionuclides: 137Cs and 90Sr. (Note: it is unlikely to be useful to monitor radionuclides over large areas of land, but it is important to know the baseline situation in order to assess unusual events.

'Extractable' forms of elements are to reflect greater bio-availability. The proposed minimum dataset is:

Acidity, Aluminium (Al) Cadmium (Cd), Calcium (Ca) Copper (Cu), Fluorine (as fluoride), Lead (Pb), Magnesium (Mg), Nickel (Ni), Phosphorus (P), Potassium (K),

Organic compounds:

Halogenated compounds; Linear alkylbenzene sulfonates ,Di-(2-ethylhexyl)-phthalate Nonyl-phenol and nonylphenol-ethoxylates, Poly-aromatic hydrocarbons Polychlorinated-biphenyls, Di-benzofurans and di-benzodioxins (congeners to be agreed)

Local soil contamination:

- cannot be specified as depends on the local circumstances but could be on the basis of the above.

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(download in English and German: www.bmu.de)

Federal Soil Protection and Contaminated Sites Ordinance (BBodSchV) dated 12 July 1999. (In German) BGBl. 1999 p. 1554
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Promulgation of Methods and Standards for Derivation of Trigger Values and Action Values pursuant to the Federal Soil Protection and Contaminated Sites Ordinance (BBodSchV)dated 12 July 1999

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