SOIL AND CONTAMINANTS

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1 SOIL AND CONTAMINANTS

1.1 Legislation

Soil contaminants (according to Art. 8 of the Federal Soil Protection Act) are regulated as precautionary, trigger and action values. The aim is to prevent hazardous changes to soil functions. For trigger and action values pathway specific values are derived (soil-ground water, soil-human being, soil-plant) but for the precautionary ones a systemic approach was chosen.

The contaminants regulated are persistent and relevant to soil function. So only 7 elements (Pb, Cd, Cr, Cu, Ni, Hg, Zn) and 3 organic compounds (PCB, BAP, PAK) are found in the soil protection ordinance. The recent the new version draft contains As, Tl also and due to recycling of mineral waste materials (Sb, Co, Mo, Se, V) in addition.

Data acquisition:

To execute the law the federal states have several activities getting data about the soil state. To find trends concentration of hazardous compounds in soils a monitoring system was established from 1985 to 1992 in Germany. From more than 800 monitoring sites several data were analyzed (not only the regulated parameters) and reported to the governmental level. These and other relevant data are used for instance to derive soil background values.

1.2 Soil acts as source and sink

The flux of contaminants into the soil may be caused either by immission but also by soil management, e.g., fertilization, sewage sludge treatment and other management factors. So soil acts as a sink and is the long memory of manmade activities to our environment. Opposite to this effect soil can act as a source of contaminant by soil erosion to the surface water, emission of gaseous compounds or carry over to the food chain. Recently we found cadmium, dioxins or dioxin-like PCB in plant or animal products and we have not known yet whether the specific role the soil plays in these findings.

Table 1 Deposition of heavy metals to land (Lazar et al., 2009)

		As	Pb	Cd	Cr	Cu	Ni	Zn
					g / ha*a			
Freiland urban	Median	12,6	151	4,8	32,8	182	25,7	498
	90. Perzentil	24,6	287	5,3	74,3	448	59,7	1497
Freiland ländlich	Median	2,1	29	0,9	5,5	44	7,4	250
	90. Perzentil	6,0	69	1,4	15,9	69	16,9	514
Freiland Verkehr	Median	8,0	149	4,8	17,7	108	26,8	247
	90. Perzentil	22,2	290	5,4	82,7	375	57,0	1592
Nadel-wald	Median	–	54	2,4	8,8	90	53,9	469
	90. Perzentil	–	122	3,1	23,7	117	78,7	884
Laubwald	Median	–	51	2,3	14,7	103	57,9	372
	90. Perzentil	–	124	3,0	19,6	111	11,7	600

Table 2: Average input of heavy metals in conventional farming systems via management (Lazar et.al, 2009)

		As	Pb	Cd	Cr	Cu	Hg	Ni	Tl	Zn
						g/ha*a				
Median	WD	2,9	7,5	0,8	48,9	106	0,07	12,7	0,14	441
	Ko	30,9	313,0	3,5	158,5	388	1,04	108,3	0,80	1385
	KS	6,2	69,4	1,7	62,0	401	0,92	36,3	0,49	986
	MD	1,3	6,2	2,2	51,6	25	0,03	7,6	0,12	119
90.P.	WD	3,6	9,4	1,1	51,3	157	0,08	13,9	0,18	686
	Ko	31,1	314,6	3,9	160,9	392	1,05	108,9	0,81	1420
	KS	7,3	80,7	2,0	66,1	479	1,10	42,6	0,57	1192
	MD	1,4	7,8	2,6	54,1	29	0,03	8,1	0,14	152

WD – farm fertilizer + mineral fertilizer
Ko – compost + mineral fertilizer
KS – sewage sludge + mineral fertilizer
MD - mineral fertilizer only

Other projects focus to find contaminations according to specific regions like floodplain areas. Some data will be presented.

2 REFERENCES

BBodSchG (1998): Gesetz zum Schutz vor schädlichen Bodenveränderungen und zur Sanierung von Altlasten (Bundes-Bodenschutzgesetz). Bundesgesetzblatt I, 502 vom 17. März 1998.

BBodSchV (1999): Bundes-Bodenschutz- und Altlastenverordnung. Verordnung zur Durchführung des Bundes-Bodenschutzgesetzes. BGBl I, 36, S. 1554 – 1582 vom 16.06.1999.

Bund-Länder-Arbeitsgemeinschaft Bodenschutz (LABO) (2003): Hintergrundwerte für anorganische und organische Stoffe in Böden, 3. überarbeitete und ergänzte Auflage (https://www.labo-deutschland.de/Veroeffentlichungen.html)

Lazar, S., Kaufmann, C., Knappe, F., Schmidt, S. (2009): Anreicherungen von Schadstoffen in Böden – Ergebnisse der Bilanzierung von Schadstoffein- und –austrägen, Bodenschutz 3/2009, S. 86 – 90.

Soils and Contaminants

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A 9 near Dessau, June 2013

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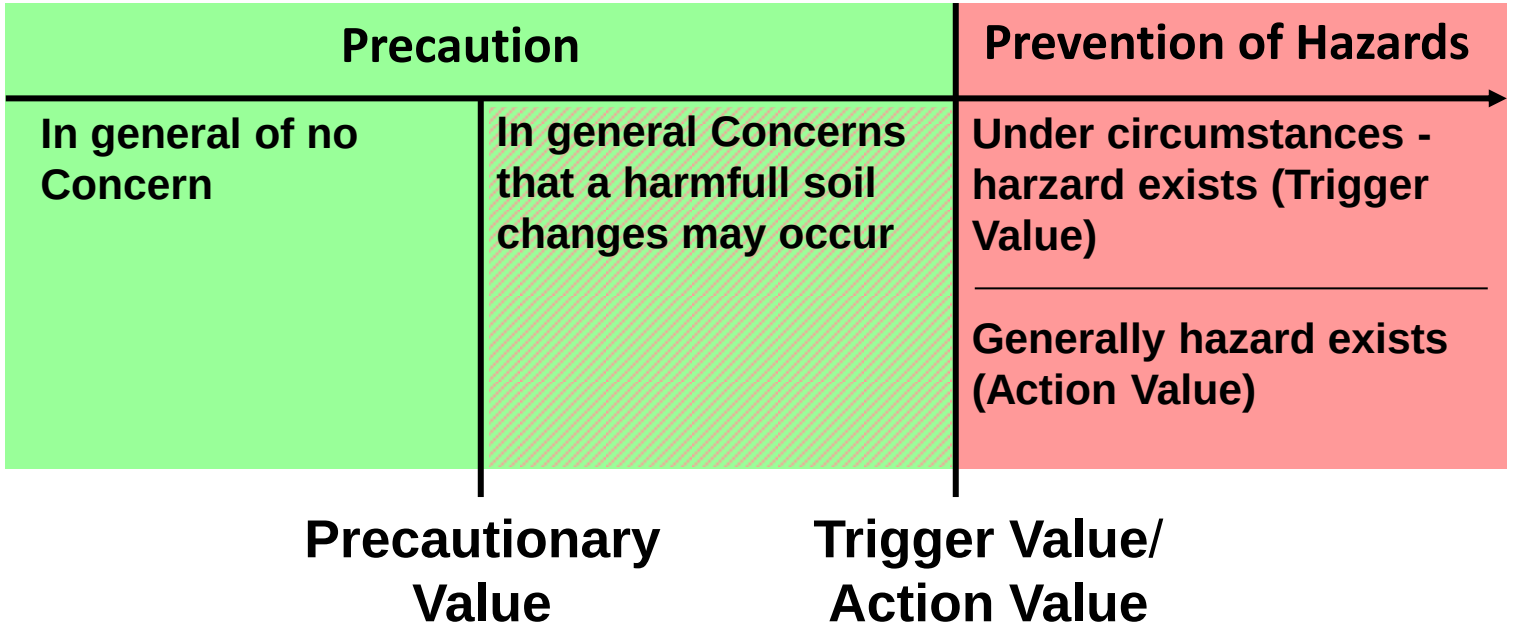
Legislation

According to Art. 8 Federal Soil Protection Act



Precautionary Values: cusp of avoidance for limitation of harmful effects to the soil → input limitation of hazardous compounds = permissible additional pollution load, and requirements for prevention or reduction of substance inputs

Trigger/Action Values: cusp if exceeded, shall mean that investigation with respect to the individual case in question is required, to determine whether a harmful soil change or site contamination exist (TV) **or** shall normally signal the presence of a harmful soil change or site contamination, and to mean that measures are required (AV).

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Precautionary Values

Aim:

- Long term prevention of adverse effects to soils, maintain the multi-functionality of soils, standard for good soil quality

Criteria:

- Persistent compounds, from diffuse sources, accumulation in soils

Compounds:

- 7 trace elements (Pb, Cd, Cr, Cu, Ni, Hg, Zn) - new: As, Tl, and 5 trace elements related to recycling of mineral waste material (Sb, Co, Mo, Se, V)
- 3 organic parameters (PCB, BaP, PAK)

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Trigger and Action Values

Aim:

- Prevention of harmful effects to
  - Men
  - Plants (animals)
  - Groundwater

Criteria:

- Persistence, accumulation
- Relevant to the pathways
- → for floodplains soil plant – pathway / soil groundwater pathway

Compounds:

Compounds:

Soil → Plant Pathway:

	Agriculture, vegetable garden			Agriculture	
Substance	Method	Trigger V	Action V	Method	Trigger V
Arsenic	Aqua regia	200		AN	0,4
Cadmium	AN		0,04 / 0,1		
Copper				AN	1
Lead	AN	0,1			
Mercury	Aqua regia	5			
Nickel				AN	1,5
Thallium	AN	0,1			
Zinc				AN	2
Benzo(a)pyrene	--	1			

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

↘ Compounds:

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↘ Soil → Ground Water Pathway:

Inorganic substances	Trigger value [µg/l]
Antimony	10
Arsenic	10
Lead	25
Cadmium	5
Chromium, total	50
Chromate	8
Cobalt	50
Copper	50
Molybdenum	50
Nickel	50
Mercury	1
Selenium	10
Zinc	500
Tin	40
Cyanides, total	50
Cyanides, volatile	10
Fluoride	750

↘ Compounds:

↘ Soil → Ground Water Pathway:

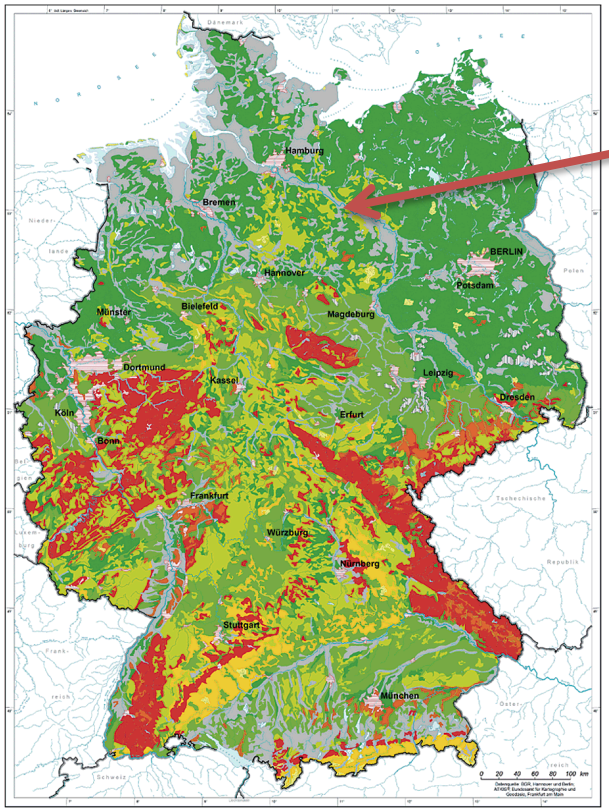
Organic substances	Trigger value [µg/l]
Petroleum hydrocarbons [1)]	200
BTEX [2)]	20
Benzene	1
Volatile halogenated hydrocarbons [3)]	10
Aldrin	0.1
DDT	0.1
Phenols	20
PCB, total[4)]	0.05
PAH, total [5)]	0.20
Naphthalene	2

1) n-alkanes (C10 C39), isoalkanes, cycloalkanes and aromatic hydrocarbons
2) Volatile aromatic hydrocarbons (benzene, toluene, xylenes, ethylbenzene, styrene, cumene)
3) Volatile halogenated hydrocarbons (sum of the halogenated C1 and C2 hydrocarbons)
4) PCB, total: sum of the polychlorinated biphenyls; as a rule, determination by way of the 6 congeners according to Ballschmiter pursuant to Ordinance on Waste Oils (DIN 51527) multiplied by a factor of 5; if applicable, for example in the case of a known substance spectrum, simple formation of the sum of all relevant individual substances (DIN 38407-32 or 3-3).
5) PAH, total: sum of the polycyclic aromatic hydrocarbons without napthhalene and methylnaphthalenes; as a rule, determination by way of the sum of 15 individual substances according to the list of the US Environmental Protection Agency (EPA) without naphthalene; if applicable, inclusion of other relevant PAHs (e.g. quinolines).

Assessment of Contaminants in Soils

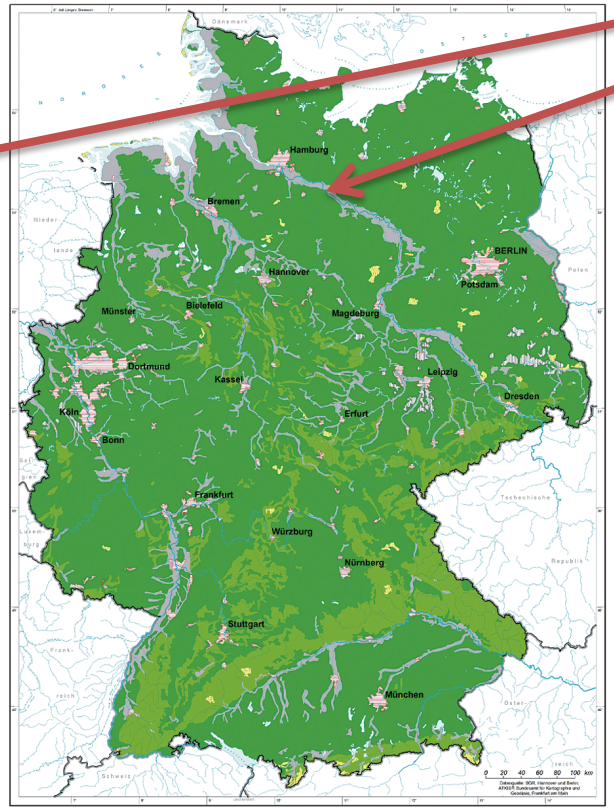
First step: Derivation of Background Values (e.g. Lead, 90th percentile, top soils and subsoils)

Floodplains are not taken into account



Hintergrundwerte Blei (mg/kg)

< 50
> 50–75
> 75 –100
> 100–125
> 125–150
> 150
nicht bewertet
Versiegelte Flächen größerer Städte
Technogen gestaltete Abbauflächen und Halden
Offene Flächen, Strände, Dünen, Kraut- und Strauchvegetation
Flächen im Gezeitenbereich
Feuchtflächen
Binnengewässer



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Offene Flächen, Strände, Dünen, Kraut- und Strauchvegetation
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Binnengewässer

https://www.labo-deutschland.de/Veroeffentlichungen.html

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Second Step: Soil Monitoring

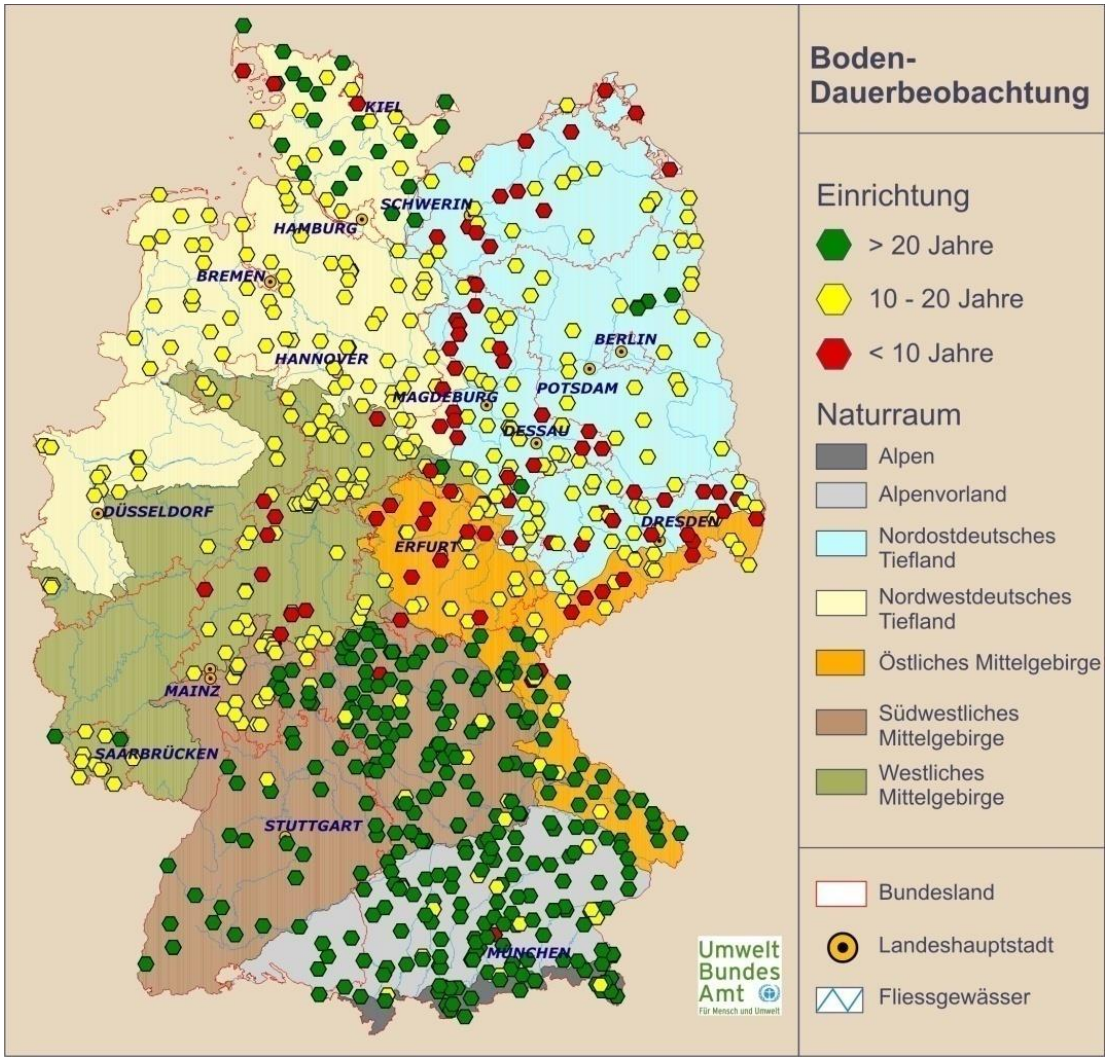
Soil Physical parameters

Soil Chemistry

- pH
- Soil carbon
- Heavy metals
- Radionuclides
- Chloric pesticides
- PCB, PAK, Dioxines

Soil Biology

- Biomass / soil respiration
- Lumbricides and other species
- Microbial activities



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Third Step: Ballancing soil contaminants

Immission via Air (Median; [g/ha*a])

	As	Pb	Cd	Cr	Cu	Ni	Zn
Urban area	12,6	151	4,8	32,8	182	25,7	498
Rural area	2,1	29	0,9	5,5	44	7,4	250
Traffic area	8,0	149	4,8	17,7	108	26,8	247
Conifer Forest	-	54	2,4	8,8	90	53,9	469
Deciduous Forest	-	51	2,3	14,7	103	57,9	372

Immission via Fertilization (Median; [g/ha*a])

	As	Pb	Cd	Cr	Cu	Hg	Ni	Tl	Zn
farm fertilizer + mineral fertilizer	2,9	7,5	0,8	49	106	0,07	12,7	0,14	441
compost + mineral fertilizer	30,9	313	3,5	158	388	1,04	108	0,8	1385
sewage sludge + mineral fertilizer	6,2	69,4	1,7	62	400	0,92	36,3	0,49	986
mineral fertilizer only	1,3	6,2	2,2	52	25	0,03	7,6	0,12	152

http://www.umweltdaten.de/publikationen/fpdf-l/3644.pdf

Fourth Step: Assessment in specific regions / specific land use

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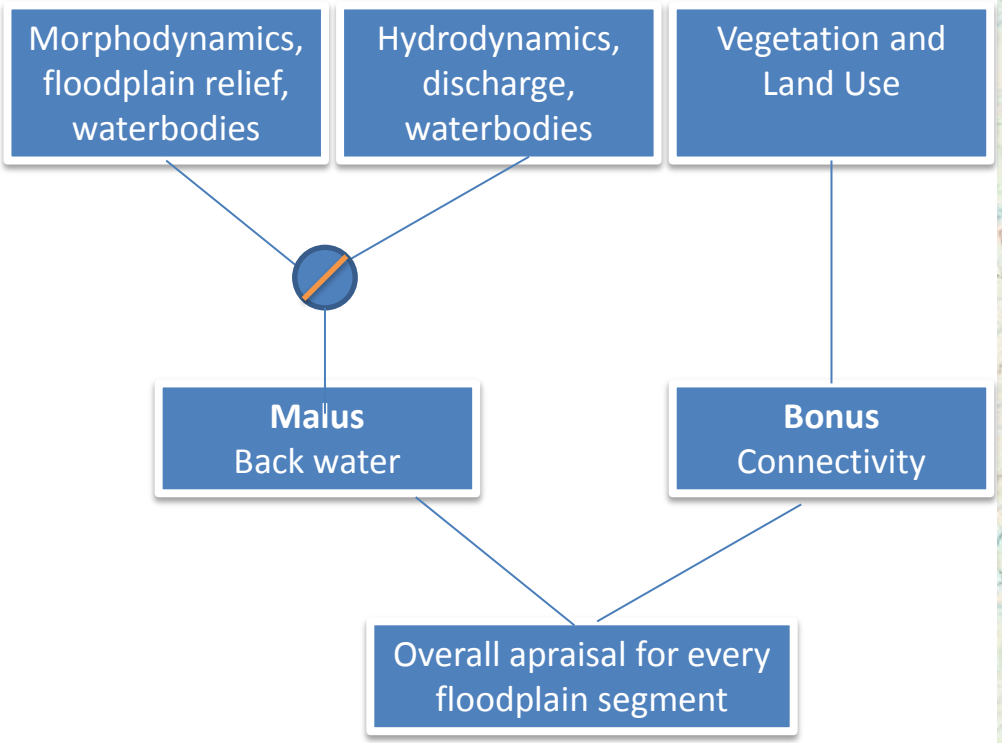
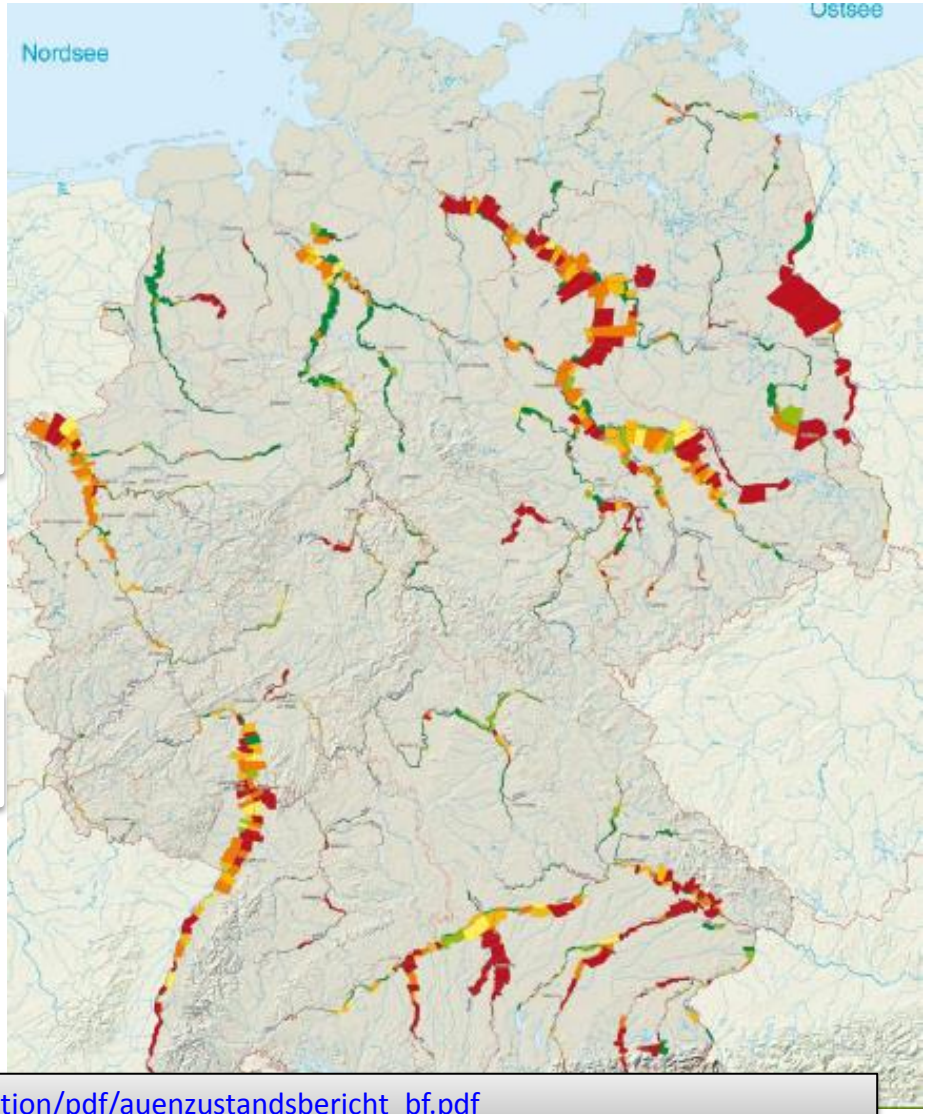
Example: Loss of floodplain areas

- Only 10 per cent of floodplain areas are in a near natural state!

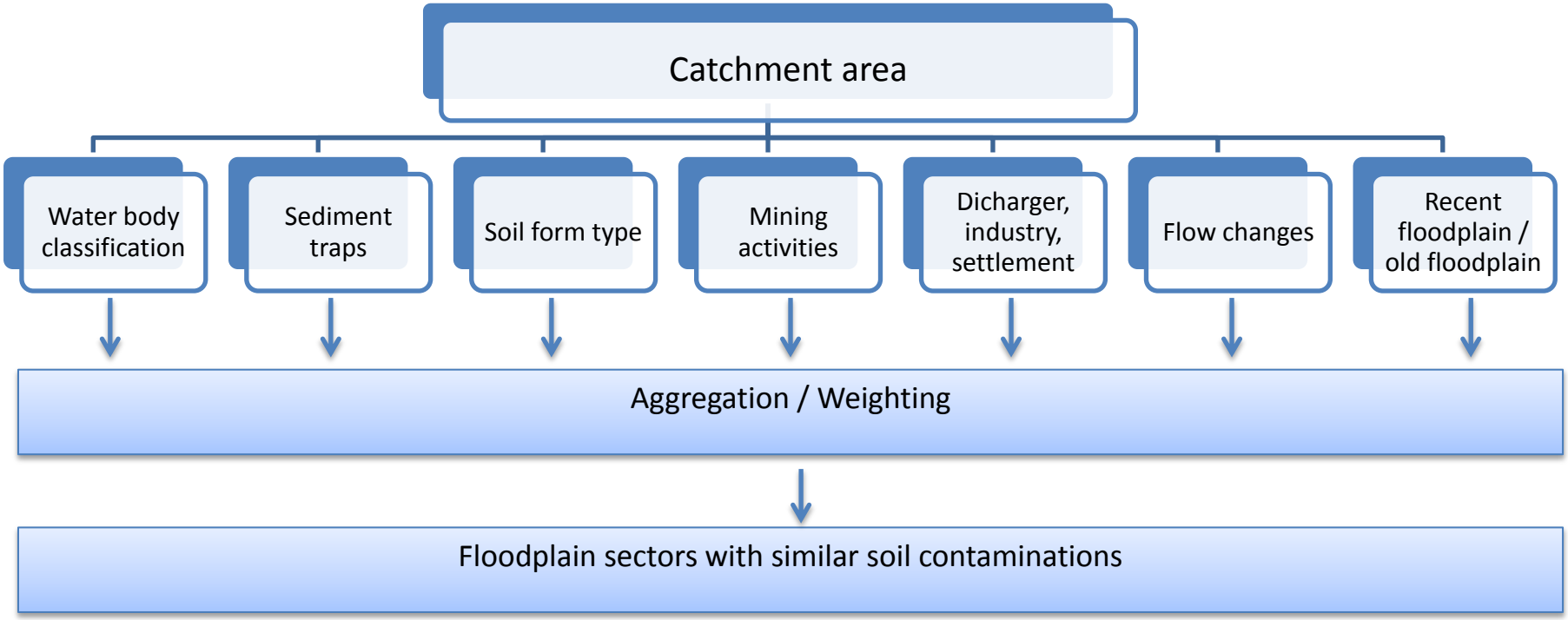




http://www.bmu.de/fileadmin/bmu-import/files/pdfs/allgemein/application/pdf/auenzustandsbericht_bf.pdf

Relevant contaminants:
As, Cd, Cu, Cr, HG, Ni, Pb, Zn, (U)
PAK, PCB, Dioxins, HCH, (HCB, DDX)

Influencing factors:



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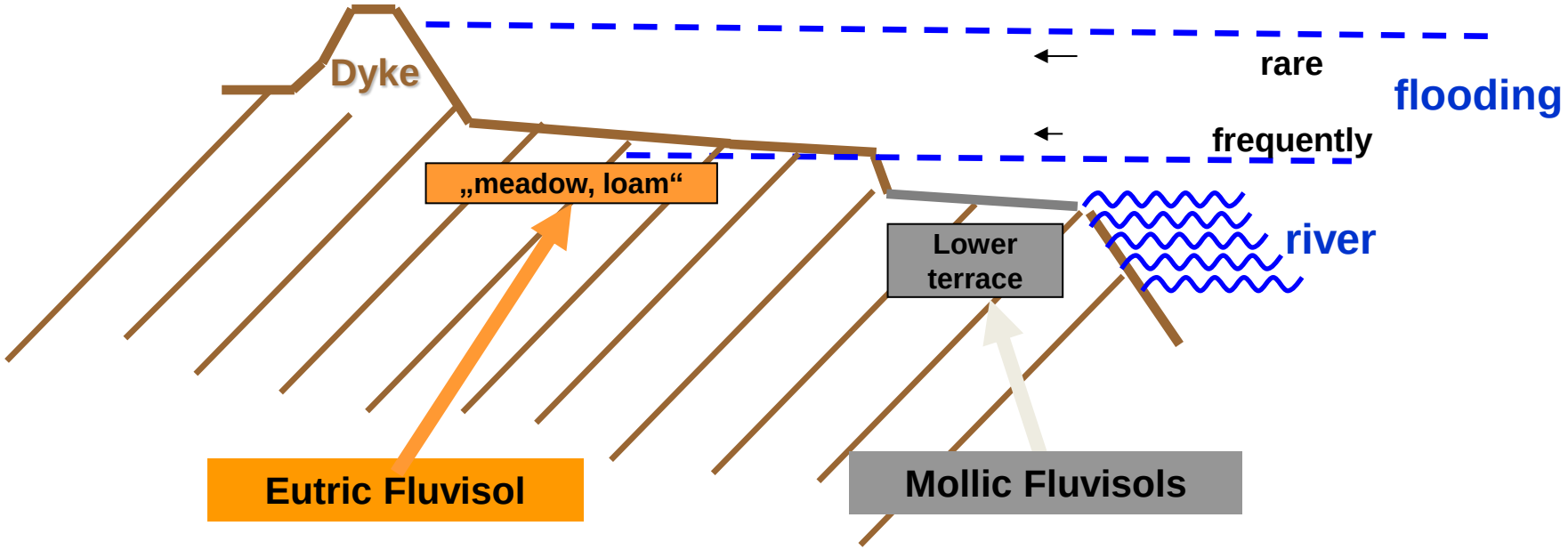
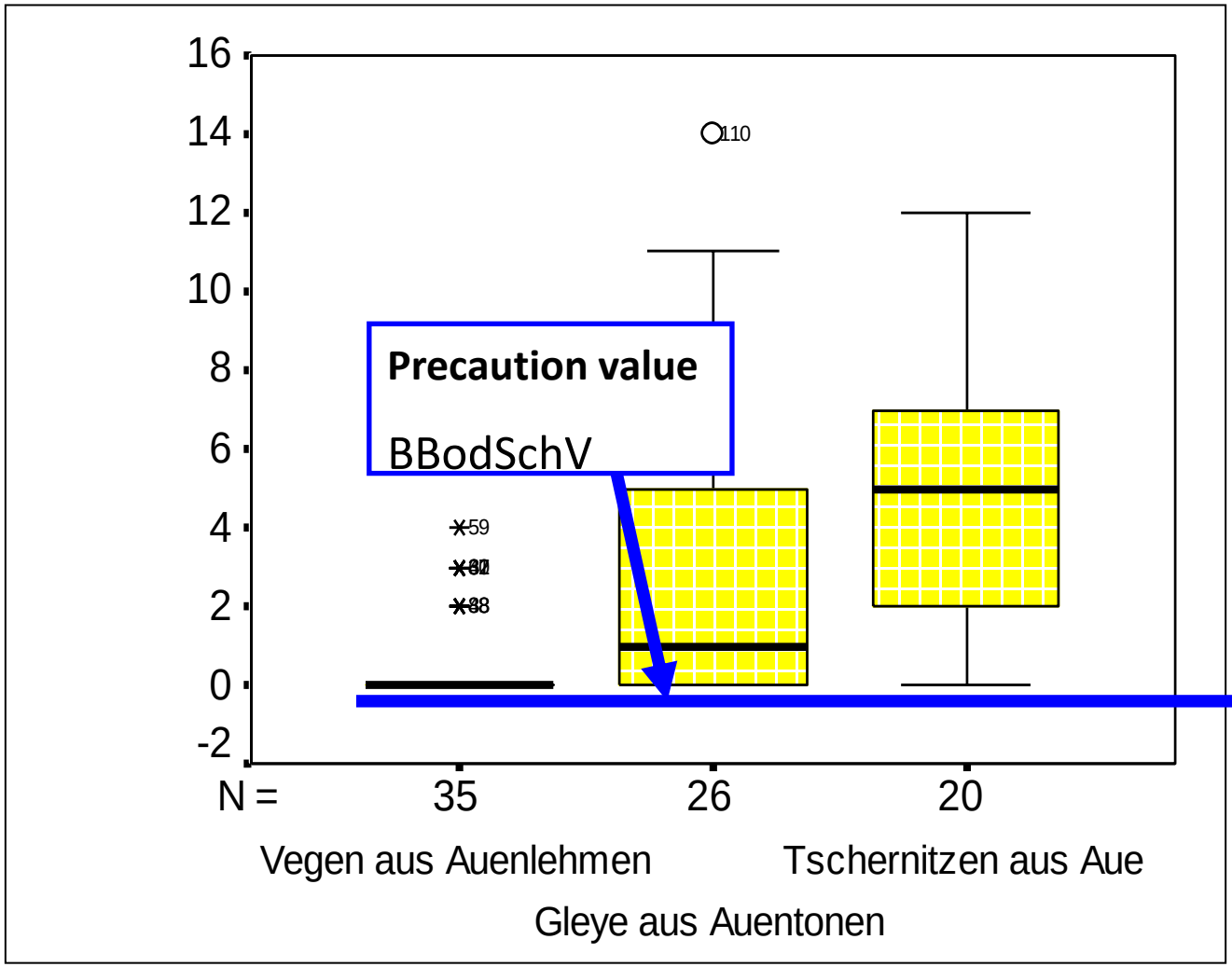
Input of contaminants via Rivers



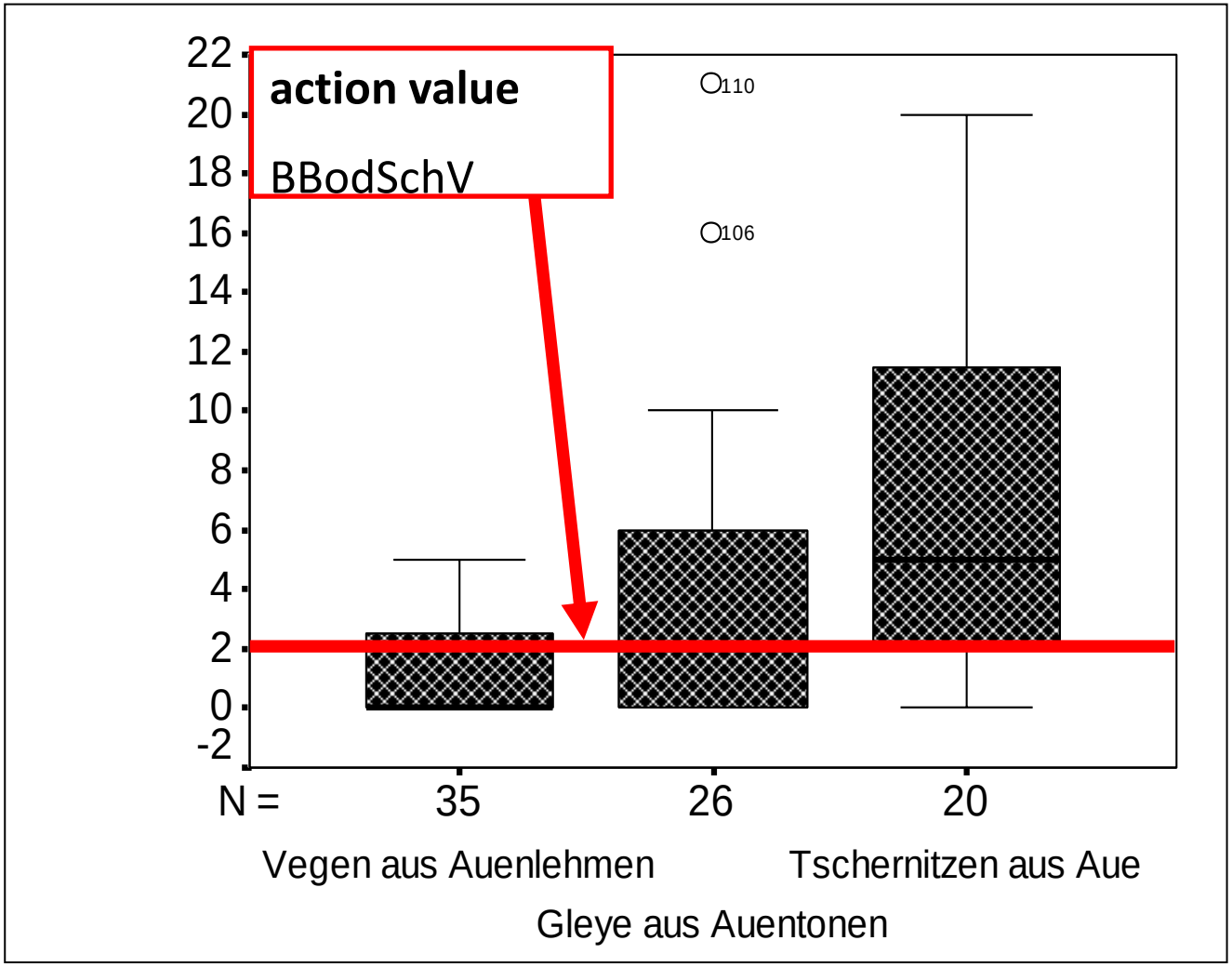
Du Laing, G. et al. (2008)

Cadmium(Cd) content in different foodplain soils



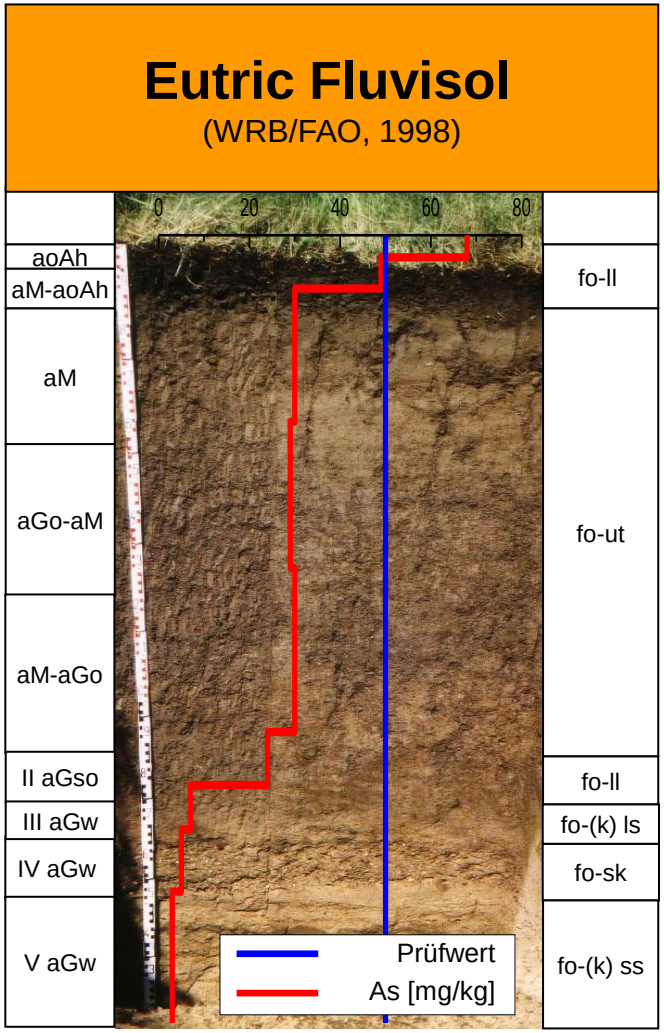
Rinklebe et al.. (**2007**): Aggregation of Floodplain Soils as an Instrument for Predicting Concentrations of Nutrients and Pollutants. **Geoderma** 141, 210-223.

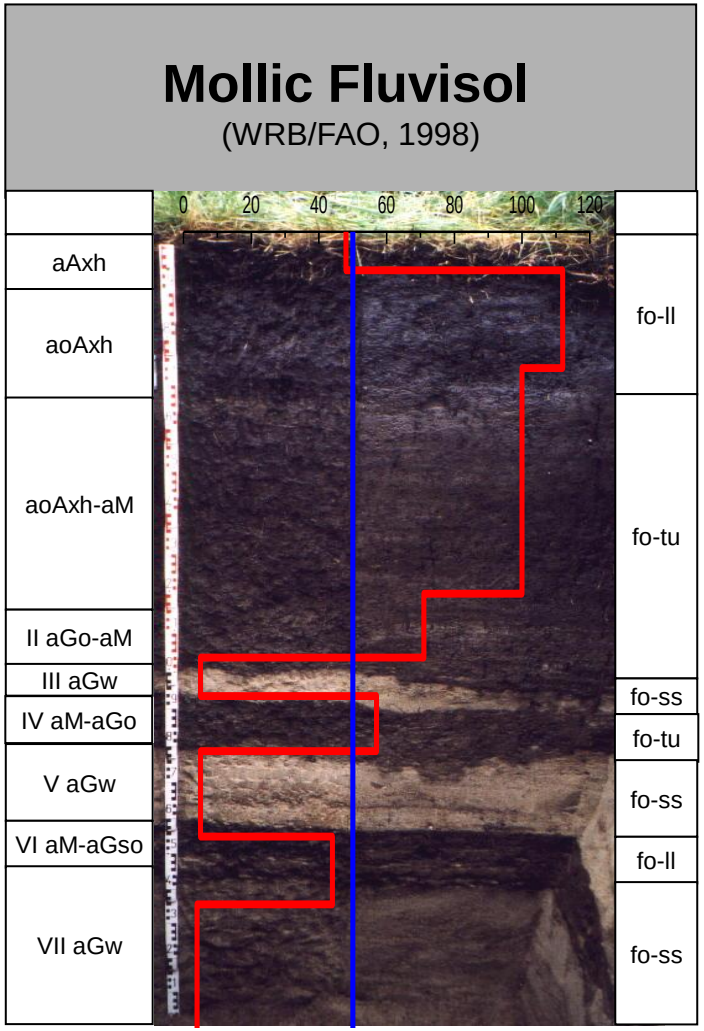
Mercury (Hg) content in different foodplain soils



Rinklebe et al.. (**2007**): Aggregation of Floodplain Soils as an Instrument for Predicting Concentrations of Nutrients and Pollutants. **Geoderma** 141, 210-223.

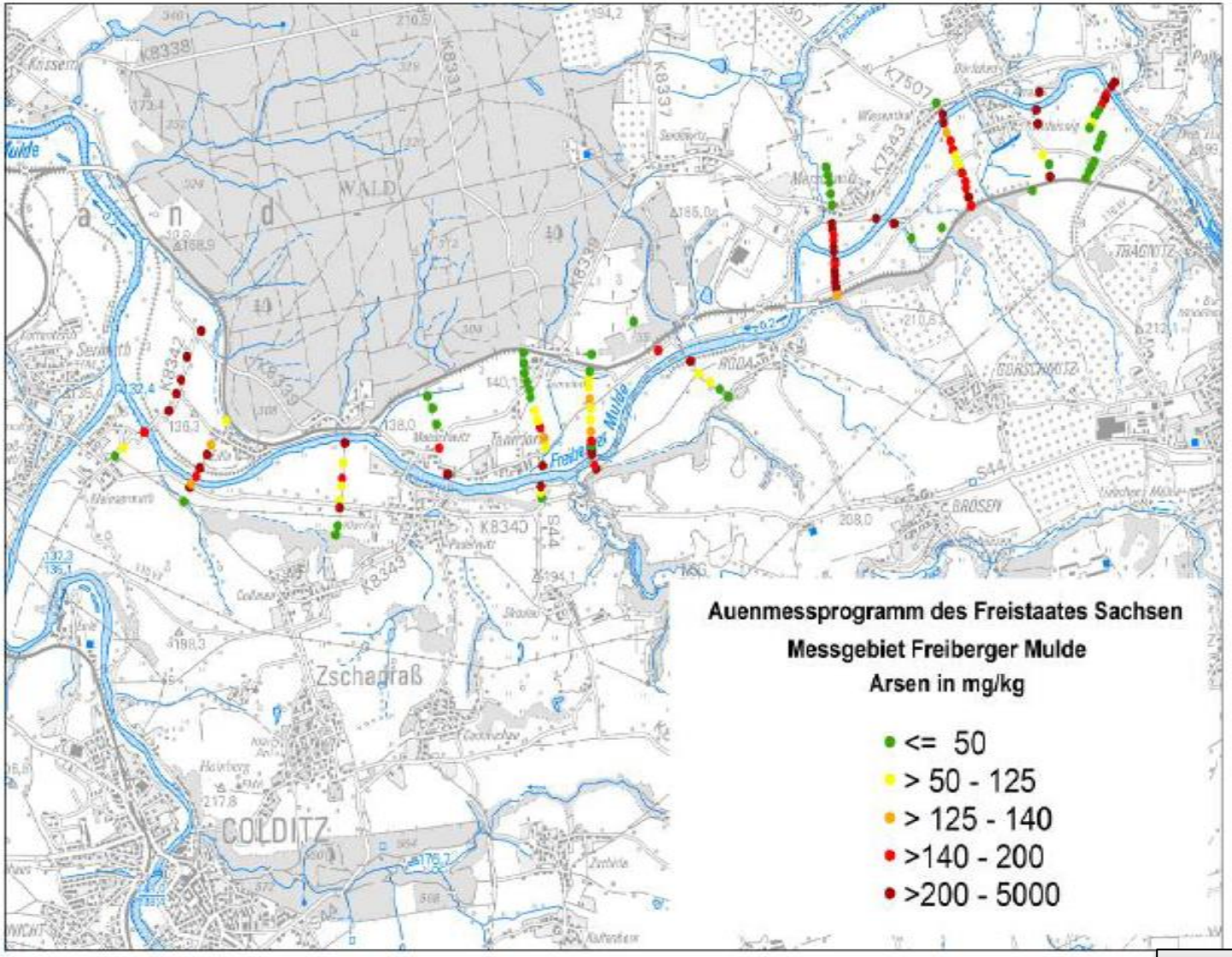
Arsenic (As) content in different foodplain soils





Rinklebe et al. (2000) In: Friese et al. (Hrsg.) Stoffhaushalt von Auenökosystemen. Böden und Hydrologie, Schadstoffe, Bewertungen. Springer Verlag. 27-35 und 37-46

Arsenic (As) content in different foodplain soils



Rank, G. & Kardel, K. (2008)

More Space for Rivers is urgently needed!

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Dessau – East Part, June 5th 2013

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Summary

- Floodplain soils are contaminated due to frequency and other factors like distance, soil type, discharge (history), water body, morphology…
- Concentration of contaminants in the profil depents on several factors too like the contaminant, flood history, soil type…
- Rivers need more space for a better flood management
- Management plans for these areas are needed from the economical point of view but also to deal with potential contaminations. Landscape classification and contamination (classification) have taken into account.
- The UBA-Project „Bundesweite Kennzeichnung der Schadstoffbelastung von Überschwemmungsböden“ (FKZ 3711 71 214) will provide results to this topic 2014.

Thank you for your attention

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http://www.umweltbundesamt.de/boden-und-altlasten/index.htm