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Large-scale arsenic contamination in Saxony (Germany)

Assessment and remediation needs

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Arsenic contamination in soils of Saxony

Risk assessment and remediation needs

- General view on German regulation and its approach
- Main threads (Soil-to-Water, Soil-to-Plants, Soil-to-Human)
- Examining different levels of As concentration (examples)

General view on the German regulation

Soil contamination and brownfields

- German regulation follows the „impact via pathway = thread“ approach
  - → Soil-to-Water
  - → Soil-to-Plant
  - → Soil-to-Human
  - → Soil-to- …

- Values (concentration) in German regulation were laid down steplike:
  - → **Precautionary values (PV)** close to background content indicating full functional capability of soil
  - → **Trigger values (TV)** indicate a potential risk which could be at dangerous level – further detailled investigation is needed to either confirm or deny danger
  - → **Action values (AV)** – exceeding usually confirms danger directly
  - → Risk at dangerous level needs action: remediation (decontamination, securing measures) or protective or restrictive measures (e.g. on land use)

Regulation on metal concentration by BBodSchV in Germany

As, Cd, Pb relevant in Saxony

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Direct Thread to Humans - Trigger Values [mg kg^{-1} d.m., AR-Extraction]				
Element	**Playground**	**Residential area**	**Parks and leisure facilities**	**Industrial, commercial / business area**
Arsenic	**25**	**50**	**125**	**140**

Soil-to-Plant-Thread - Trigger (TV) and Action Values (AV) [mg kg^{-1} d.m.]*			
Element	**Grassland** AR-Extraction	**Arable land** AR-Extraction	**Arable land** AN-Extraction
Arsenic	**AV 50**	**TV 200/50[a]**	**TV 0.4[b]**

Soil-to-Groundwater-Thread - [µg l^{-1}]*			
Element	Trigger Values BBodSchV	Re-use of soil material LAGA TR	*Planned regulation*
Arsenic	**10 (seepage water)**	**14 (eluate 1:10)**	*15 (e. 1:2)*

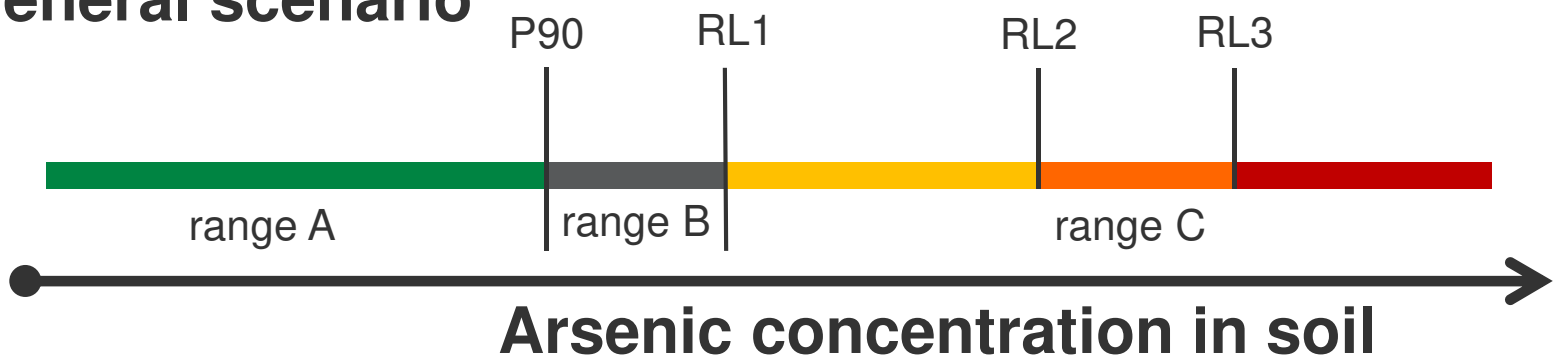
* Regarding plant quality (i.e. meeting the limit values for food and fodder crops) and plant growth

[a] 50 mg kg^{-1} for soil (temporarily) under reducing conditions, e.g. floodplains or other „wet“ soils

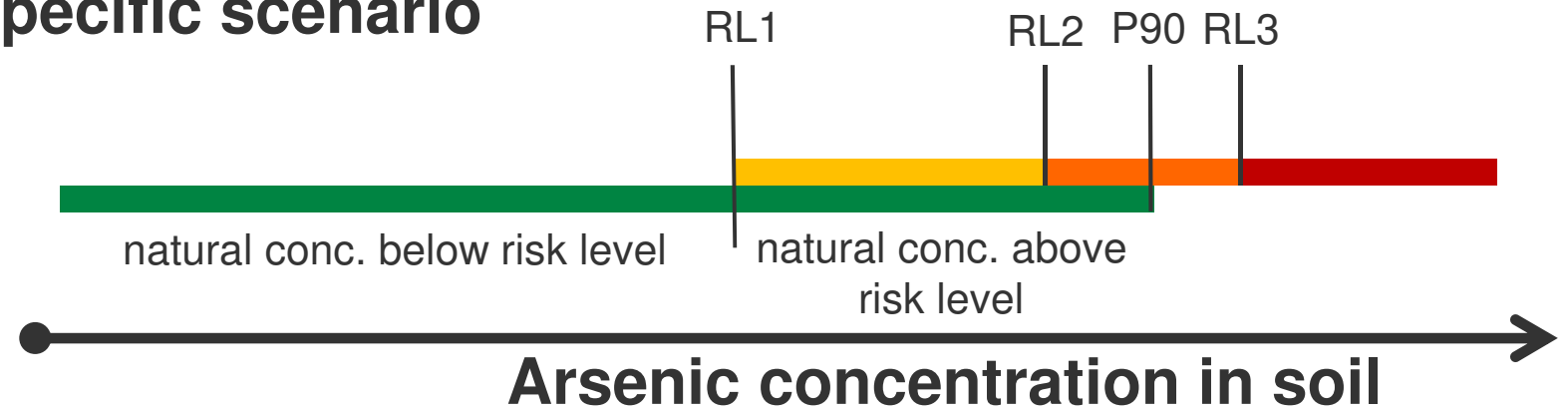
[b] Regarding direct impact on plants (growth depression) only

AR: aqua regia extraction (pseudototal contenct) **AN**: 1 M NH_4NO_3 extraction (plant available fraction)

General scenario



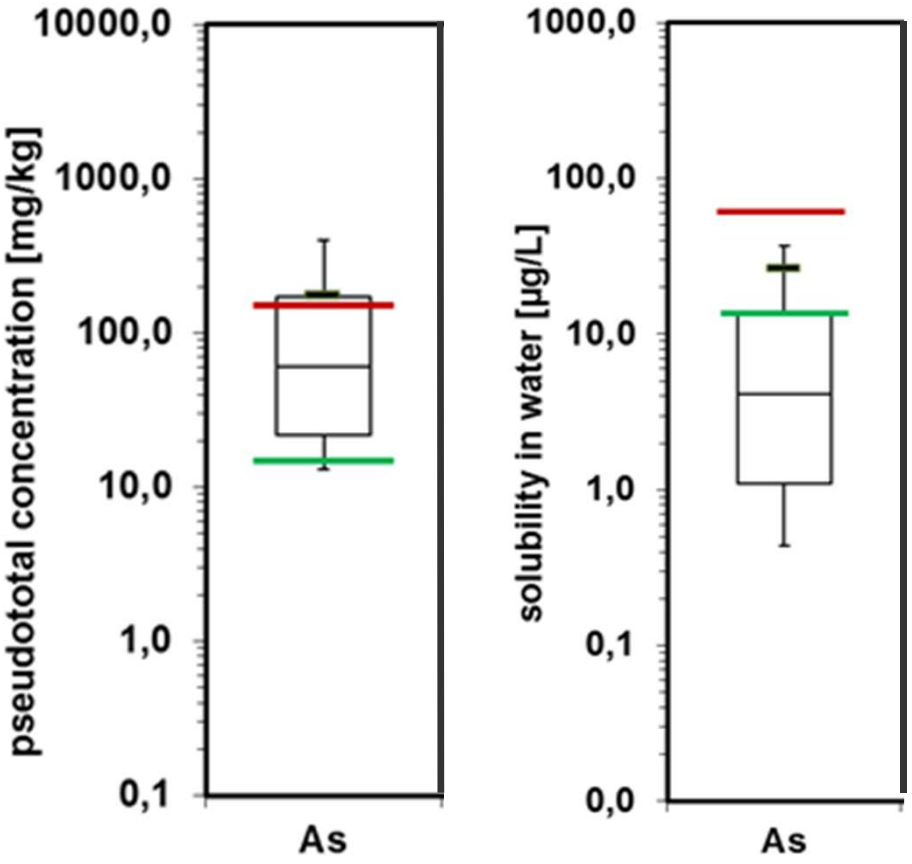
Specific scenario



P90: 90th percentile usually indicating background concentration
RL1, 2, 3: concentration indicating (low, medium, high) risk (based on toxicological evidence)
range A: range of typical and mainly natural concentration
range B: elevated concentration (usually due to anthropogenic sources) but no risk
range C: concentration above risk level (usually due to anthropogenic sources)

General view on the Soil-to-Water-Thread (Arsenic)

Soil eluate investigation and water quality survey



- Arsenic pseudototal conc. is high but water solubility is quite low.
  → No soil material should leave the Ore Mountain region.
- Arsenic conc. in groundwater and surface water in general meets regulation (only a few exceptions)
- Soil erosion and input of mining waste and tailings material via storm water runoff
  → high impact on sediment quality

General view on the Soil-to-Plant-Thread (Arsenic)

Grassland, arable land, gardening

- No (EU) regulation regarding As in food (e.g. cereals like wheat, rye or barley)
- EU-based regulation on As in forage (green fodder, silage, cereals for animals)
- Very low As transfer into plants via root system. Contamination is mainly due to adhering (As-containing) soil material and dust on plant surface.

→ in agriculture in general looking at fodder crop systems only

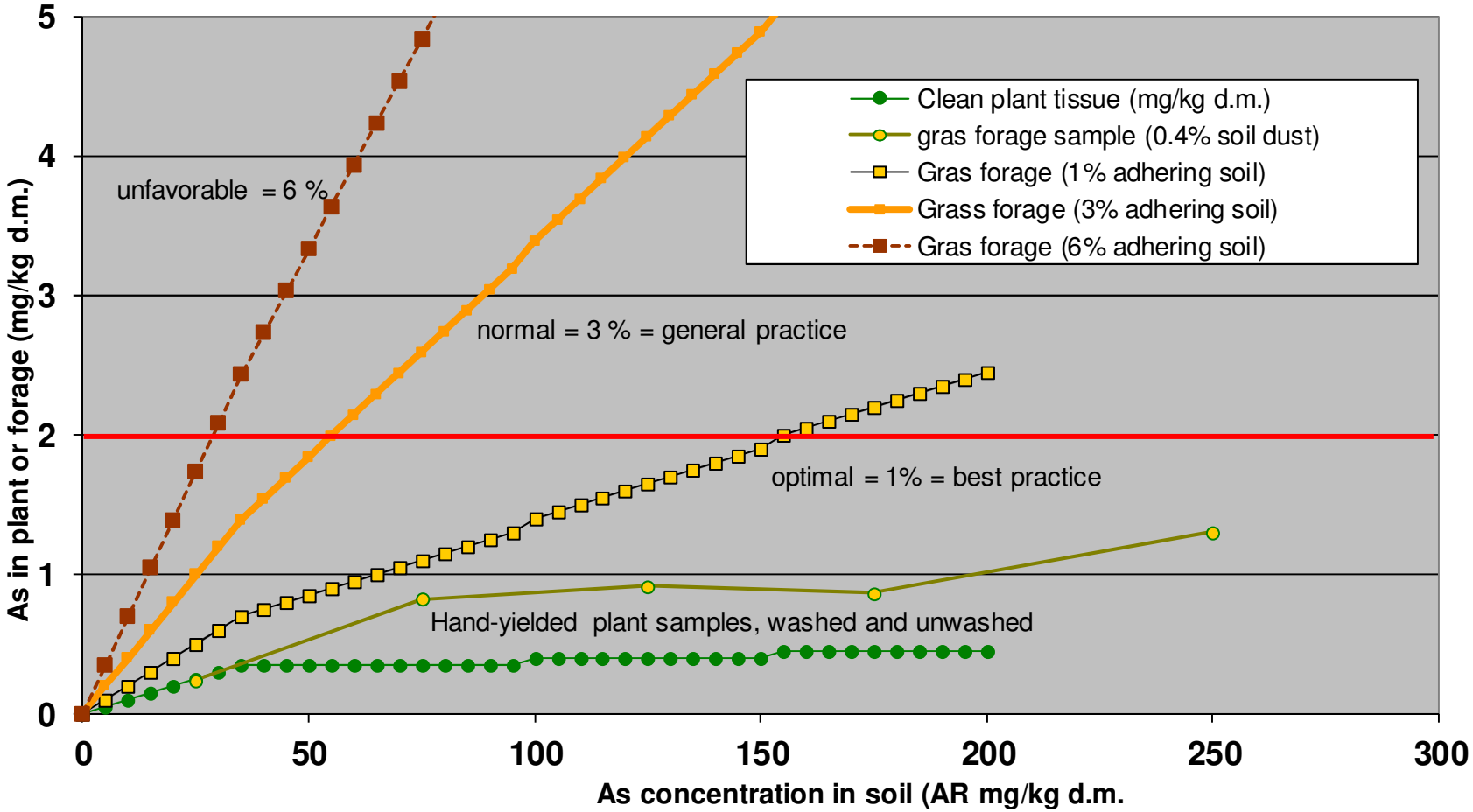
→ Usually Cd associated with As and restrictions are finally based on Cd due to its higher availability to plants and its quite strict regulation in food products

→ recommendations to produce more „clean“ (avoid transfer of soil material)

→ recommentations to gardeners to wash, strip, peel and clean fruits / vegetables

→ Survey of As concentration in fodder (both farmers and administration)

Grassland - problem of adhering contaminated soil



General view on the direct Soil-to-Human-Thread (Arsenic)

Ingestion, inhalation, dermal contact

- Regulation of German BBodSchV is based on 4 standard exposure scenarios delivering Trigger Values (adjusted according to background concentration for As)

- If TV were exceeded, further investigations are needed (site specific or regional scale)

- (Only) for some unfavorable situations „risk could turn to danger“ when concentration is even slightly above TV – and „Danger needs action“

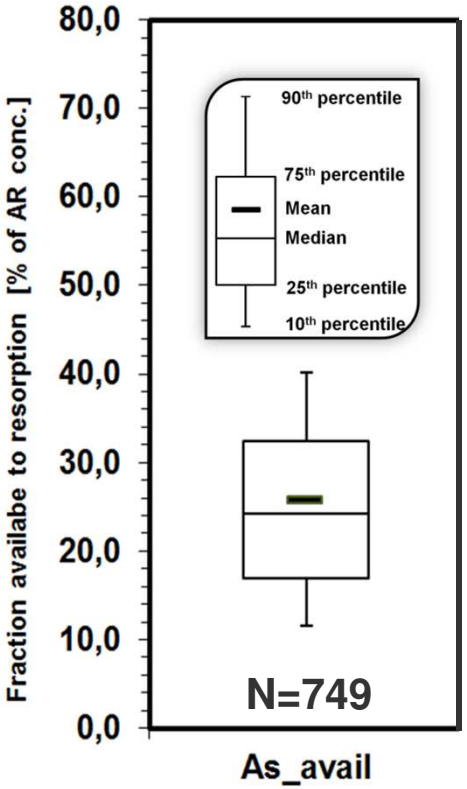
- Therefore, usually an assessment of exposure is done, looking for both:
  → amount of soil which contacts and enters the human body
  → amount of arsenic in this amount of soil which is bioavailable to human digestive, respiratory or dermal system

- In general, for arsenic chronic effects due to oral ingestion outweigh the others

Assessment of the Soil-to-Human-Thread (Arsenic)

Oral Ingestion as a main source of soil related As intake

- Usually in site specific risk assessment only two main factors were evaluated:
  → daily soil ingestion rate (e.g. playground: 0.5 g soil per day at 240 days per year)
  → bioavailability is set to 100% (for all scenarios).



- Usually in site specific risk assessment a lab test (stomach-colon-model procedure) is used to evaluate bioavailability regarding human ingestion

- 90th percentil of the Saxon dataset could be a good estimate of the available fraction, which is about 40% of total As (AR)

	Playground	Residential
German BBodSchV	25	50
Saxon 90th percentile at 40%	63	125
Saxon 50th percentile at 25%	100	200
Saxon 10th percentile at 10%	250	500

Assessment of the Soil-to-Human-Thread (Arsenic)

Oral ingestion as a main source of soil related As intake - Examples

	Playground	Residential	Parks	Industry
BBodSchV	25	50	125	**140**
Saxon 90th / 50th perc. bioavail.	**63 / 100**	**125 / 200**	**313 / 500**	**-- ? --**
Example 30 mg/kg	☺ / ☺	☺ / ☺	☺ / ☺	☺
Example 70 mg/kg	😐 / ☺	☺ / ☺	☺ / ☺	☺
Example 150 mg/kg	☹ / ☹	😐 / ☺	☺ / ☺	😐
Example 300 mg/kg	☹ / ☹	☹ / ☹	☺ / ☺	☹

- Main measures aim at disconnecting soil contact: dense plant cover (gras, thorny shrubbs), exchange polluted soil, soil sealing

- Regional assessment uses these percentiles to address measures – the higher the statistical probability, the higher the priority and the harder/stronger the measures

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Thank you for your attention!

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