# FROM SOIL POLLUTION TO A RISK BASED SOLUTION

Joop Harmsen

International Conference
Protection of soil functions – challenges for the future
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# How do give 3.000.000 contaminated sites in de world a proper function


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# How to solve contamination problems in Benin

Benin, Oganla
Parathion methyl

Benin, Djassin
Dieldrin

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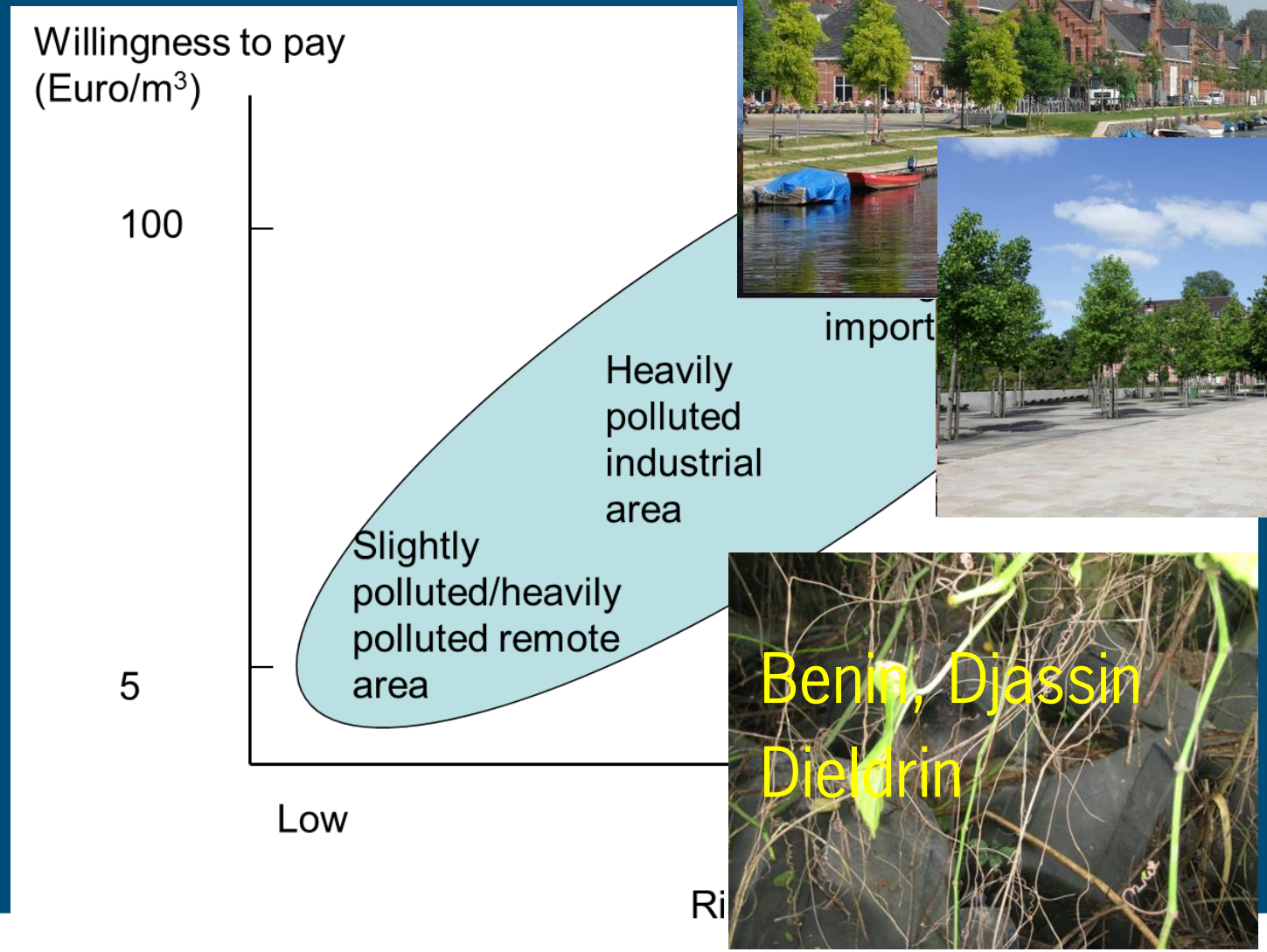
# Willingness to pay









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Sednet

# Traditional approach

- Suspected site (Problem)
  - Sampling and analysis
- Assessment
  - Compare with target
  - Human and ecological risks
- Solution
  - Removal of soil (depot)
  - Treatment on special sites (technological approach)
  - Covering, In-Situ (technological approach)

- Logistic problems
- Sampling
- Analysis

- Insufficient or not the proper data

- Logistic problems
- Distance
- Costs

- Not available
- costs

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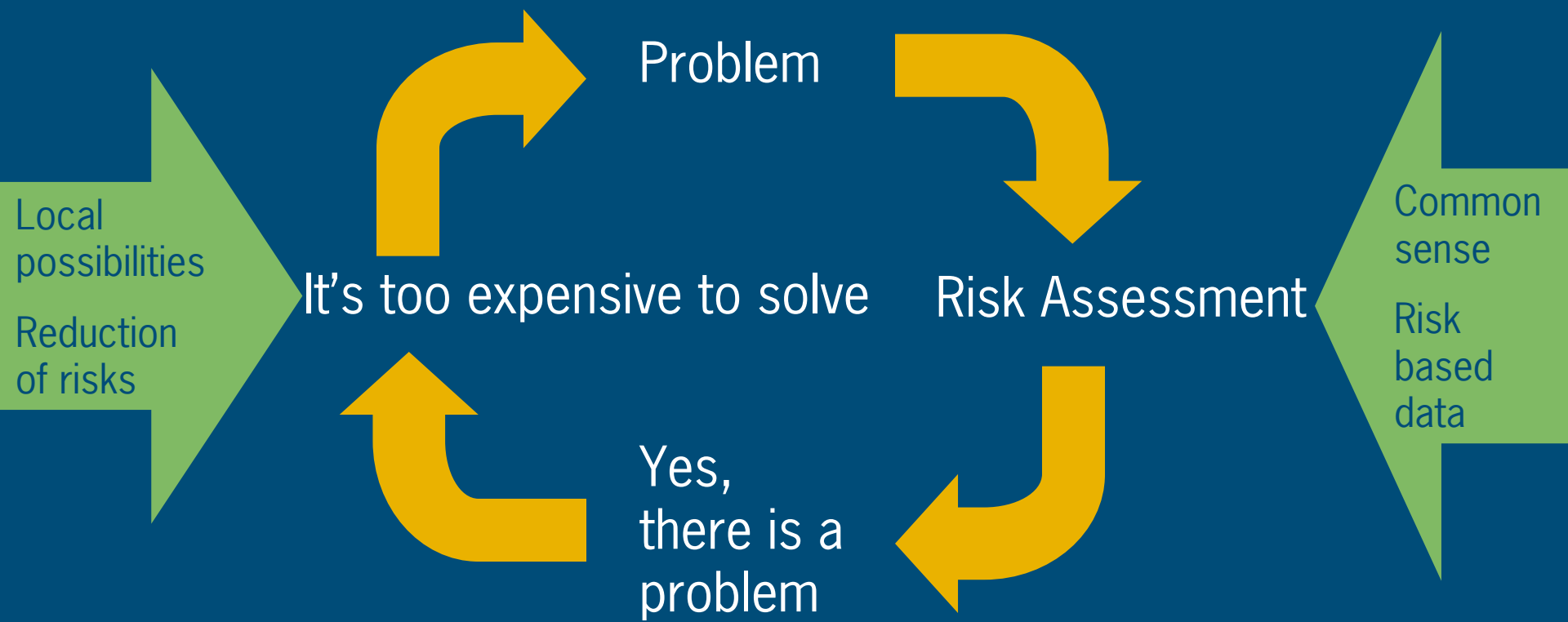
# The assessment circle




**Bioavailability**

# Basic elements of **Reduction of Risks**

## African approach

- Bioavailability
- Prevent direct contact
- Common sense
- Local possibilities

# Bioavailability

"…individual physical, chemical, and biological interactions that determine the exposure of plants and animals to chemicals associated with soils and sedi… Council, 2003)."

Specifically, bioavailability addres… fraction of the contaminant co… environment may be taken up o… result in an effect on an organism!

# Situation in 2013 - Better understanding

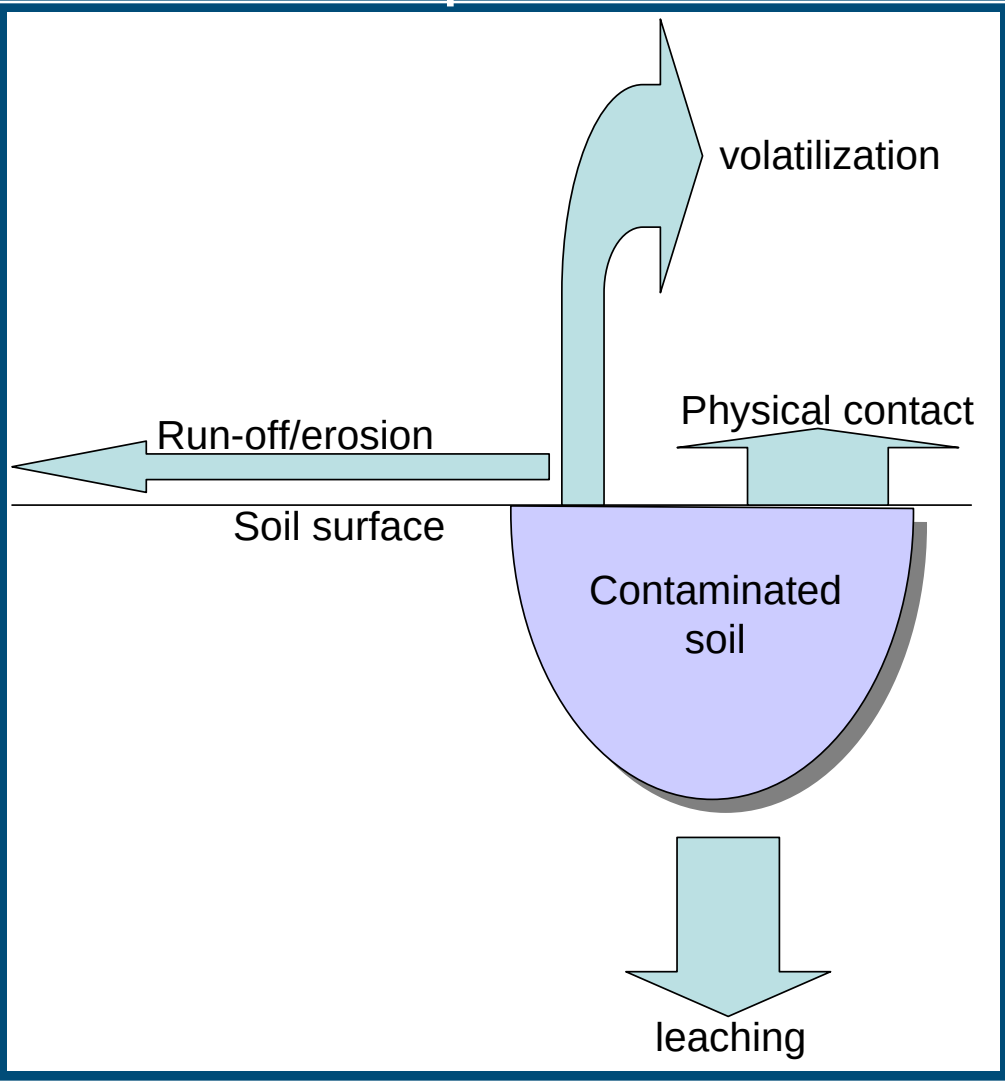
- Bioavailable part is causing risks
  - Bioavailable part can be measured (Guideline, ISO 17402; Use of extracts for trace elements, ISO 14858)
- Actual available (concentration in pore water)
  - Trace elements (0.001 M $CaCl_2$ ISO 21268-1)
  - POP's (Passive sampling)
- Potential  available (amount in equilibrium with pore water, reactive fraction)
  - Trace elements (0.43 M $HNO_3$, ISO 17586)
  - POP's (Tenax; Cyclodextrine, ISO 16751-1)
- Models on fate of contaminants include availability

# How can bioavailability make a difference?

- If contaminants are not physically accessible, or chemically or biologically available, they should not be included in the calculation of risk
- Can optimize the extent of cleanup required to be protective
- Can provide optimization of remedial approach and cost
- Can be an important factor in balancing the risks caused by remedial action

# Common sense: Which risks are present?

- Risks are site specific
- Field observations
- Monitoring to confirm

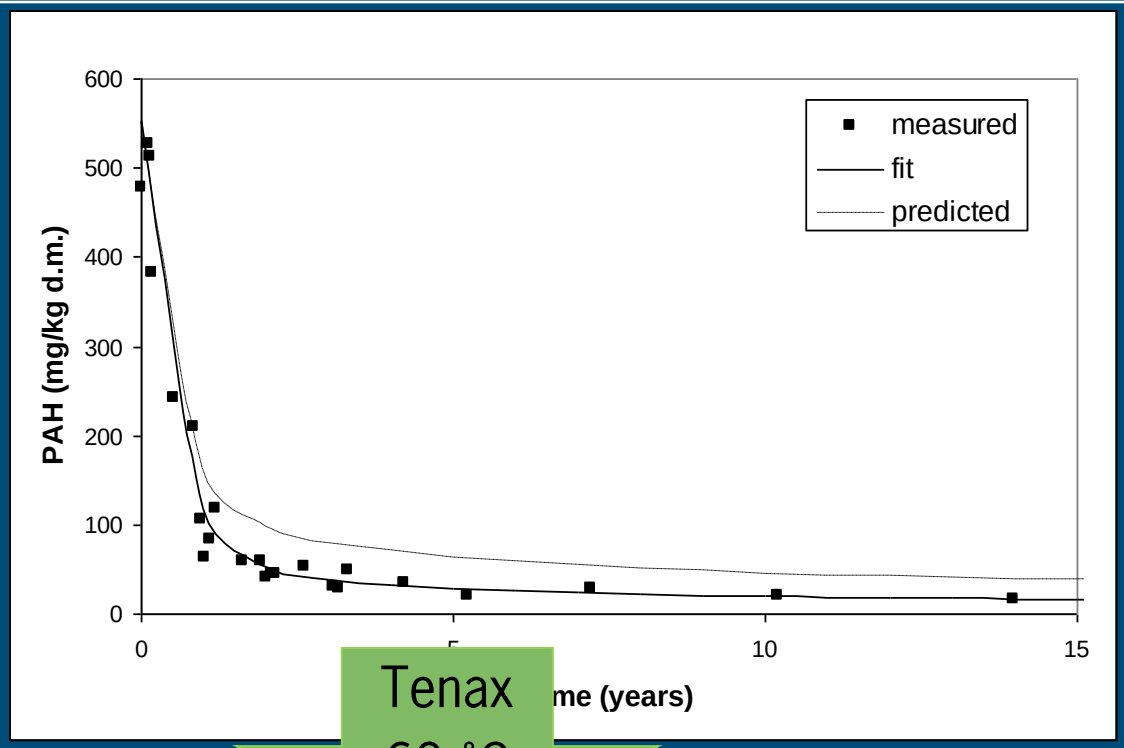


# Local conditions

- Risks are reduced if local conditions:
  - Stimulate biodegradation
  - Reduce bioavailability
  - Isolate the contaminant physically
- Investigate in the field (observation, common sense)

# Biodegradation of PAHs , removal of risks






Tenax
60 °C

$$\frac{C_t}{C_0} = F_{fast} \cdot e^{-k_{fast} \cdot t} + F_{slow} \cdot e^{-k_{slow} \cdot t} + F_{very\ slow} \cdot e^{-k_{very\ slow} \cdot t}$$

Tenax
20 °C

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# Application of this knowledge

- Create situations were PAHs degradation will continue
  - Agricultural function
  - Combination with energy crop
  - Creation of temporary depot
- Improve local conditions (vegetation, ground water level)

# Degradability of pesticides

| *Pesticide* | *DT 50 in Soil (d)* |
|---|---|
| **Degradable** | |
| Aldrin | 20-100 |
| Captafol | 3-55 |
| Carbaryl | 7-28 |
| Chlordimeform | |
| Chlorpyrifos ethyl | 10-120 |
| Chlorvinvos | 10-45 |
| Chlorbenzilate | 10-35 |
| Cyanophos | |
| Cyhalothrin | 28-84 |
| Deltamethrin | 21-25 |
| Diazinon | 9-35 |
| Dimetheoate | 4-122 |
| Dinoseb | 5-31 |
| Endosulfan (alpha) | 60 |
| Fenitrothion | 12-28 |
| Fenthion | 34 |
| Fenvalerate | 75-80 |
| Fluoracetamide | 50 |
| α-HCH | 140 |
| Heptachlor | 250 |
| Lamdacyhalothine | 6-40 |
| Malathion | 4-6 |
| Mancozeb | 1-7 |
| Methamidophos | rapidly |
| Monocrotophos | 17-96 |
| Paraquat | 8-12 |
| Parathion ethyl | rapidly |
| Parathion methyl | rapidly |
| Pentachlorophenol | rapidly |
| Phenthoate | rapidly |
| Phosalone | 1-4 |
| Phosphamidon | 21-32 |
| Propoxur | 44-59 |
| Pyridaphenthion | 11-24 |
| 2,4,5,T | 14-300 |
| Tetrachlorvinphos | 2 |
| **NOT or difficult degradable** | |
| Chlordan | >1500 |
| DDT | >1500 |
| Dieldrin | > 2500 |
| Endosulfan (beta) | >800 |
| Endrin | >1500 |
| β-HCH | >500 |
| Hexachlorobenzene | >1500 |
| γ-HCH (Lindane) | >500 |
| Toxaphene | >2500 |

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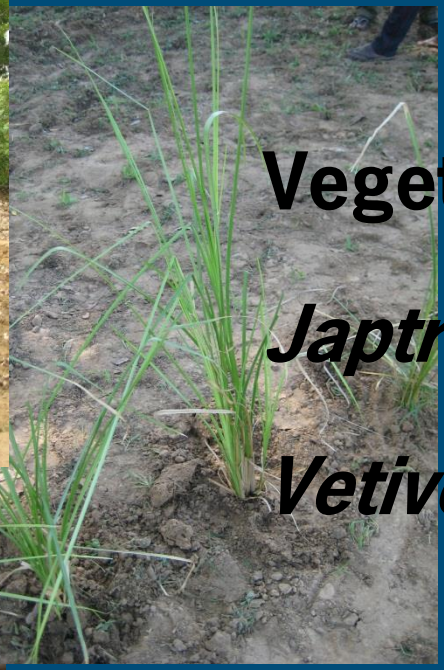
# Create proper conditions to degrade parathion ethyl (Molodo, Mali)

**Soil treatment**



**Vegetation**

***Japtropha***

***Vetiver***


**Biological activity, compost**

Role vegetation

- Increase bioactivity in rooted area
- Evaporation Excess of rain
- Prevent Access

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# Results degradation parathion ethyl

| | *July 16, 2008* | | | **November 11, 2008** | | |
|---|---|---|---|---|---|---|
| | Parathion-ethyl g/kg d.m. | Dieldrin g/kg d.m. | Ratio | Parathion-ethyl g/kg d.m. | Dieldrin g/kg d.m. | Ratio |
| 1 | 0.53 | 0.79 | 0.67 | 0.0095 | 0.44 | 0.021 |
| 2 | 1.50 | 0.52 | 2.89 | 0.021 | 0.75 | 0.028 |
| 3 | 1.62 | 0.87 | 1.86 | 0.011 | 2.78 | 0.004 |
| 4 | 3.09 | 1.08 | 2.85 | 0.01 | 0.78 | 0.013 |
| 5 | 0.87 | 0.46 | 1.89 | < 0.003 | 0.12 | <0.025 |
| **Average** | **1.52** | **0.74** | **2.03** | **0.011** | **0.97** | **0.018** |

Biodegradation of Parathion methyl on Oganla Site, Benin?

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# Risk of heavy metals in a sediment depot





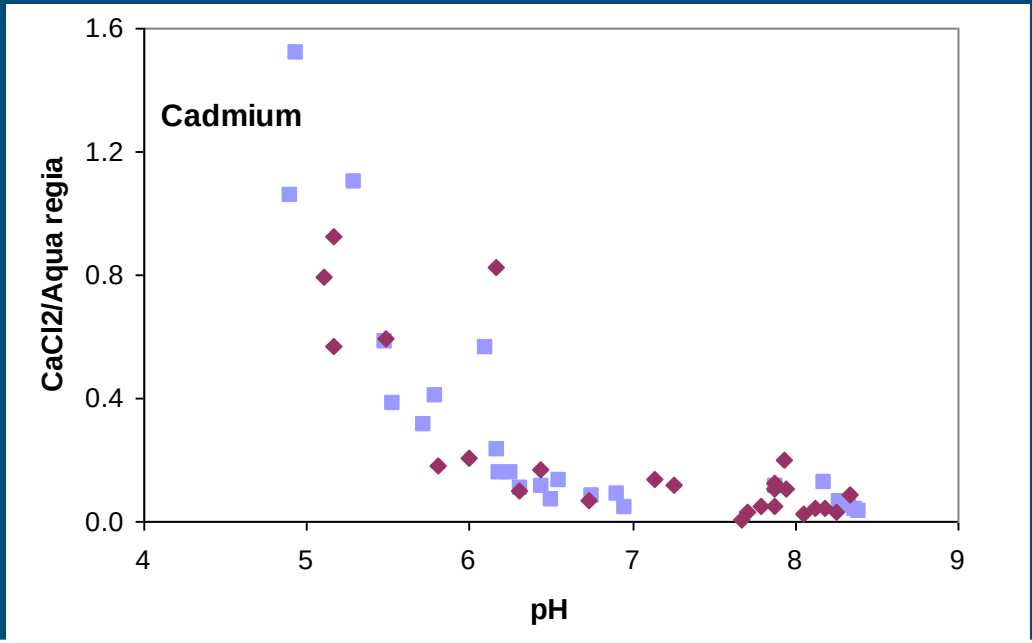


# Without management of depots risks by Cd

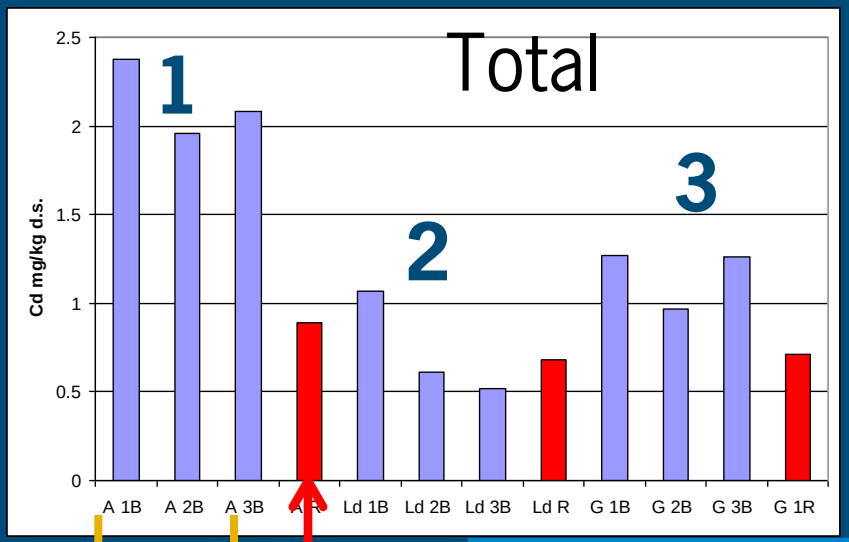
- Sulphides present in sediments will oxidise

  $2FeS + 4\ 1/2\ O_2 + 2H_2O \rightarrow Fe_2O_3 + 2\ SO_4^{2-} + 4H^+$

- pH will drop
- Mobile fraction Cd increases

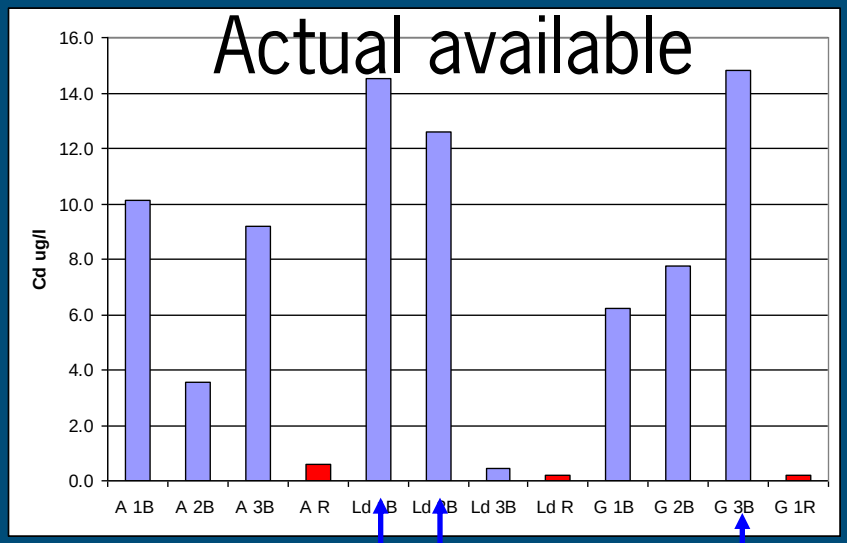


# Cadmium in 3 depots



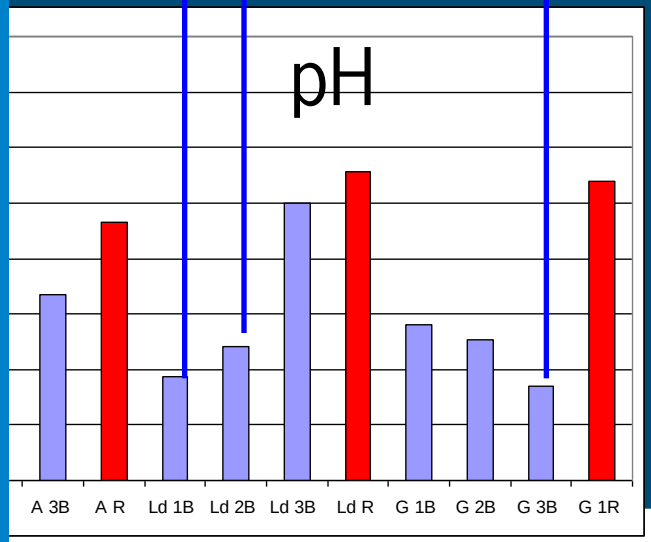

depot

reference




## Preconditions for agricultural function

- Decrease of actual bioavailability
- Compensate for pH drop (Liming)
- Allowable maximum for Cd

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# Development of strategies to immobilize PFOS

- PFOS Perfluoroctane sulfonate (fire fighting agent), persistant compound, not biodegardable
- Development of modified natural material with capacity to immobilize PFOS
- Investigation of bioavailability of PFOS in treated soils.

# Application of MatCARE™

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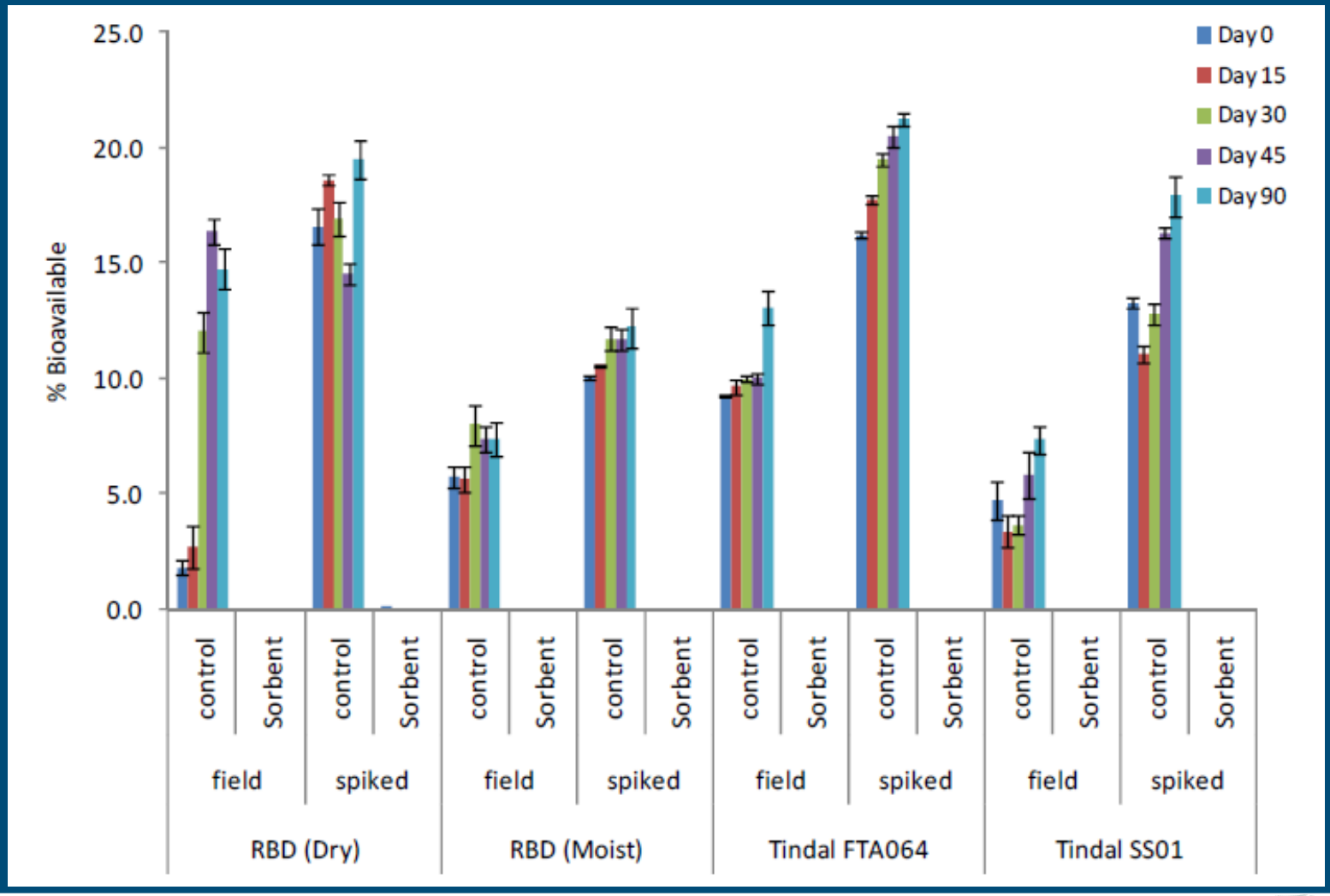
# PFOS biobeschikbaarheid, Darwin

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# Isolation, prevent contact and decrease leaching

- Dieldrin contamination
  - Middle of nowhere
  - Partly covered with sand dunes
  - Removal not an option ($1.500.000)
- Risks
  - Direct contact
  - Transport to groundwater
- Cover
  - Stabilization
  - Evaporation of rainfall
  - Fence vegetation, non consumable, *Vetiver, Jatropha*
- Define use

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# Increase adsorption (non degradable POP's)

- Black carbon (soot, activated carbon….) increases adsorption

- Dieldrin contamination in Mali (Africa)
  - OM is low (high temperture)
  - Char coal is locally available
  - Use for isolation in depot

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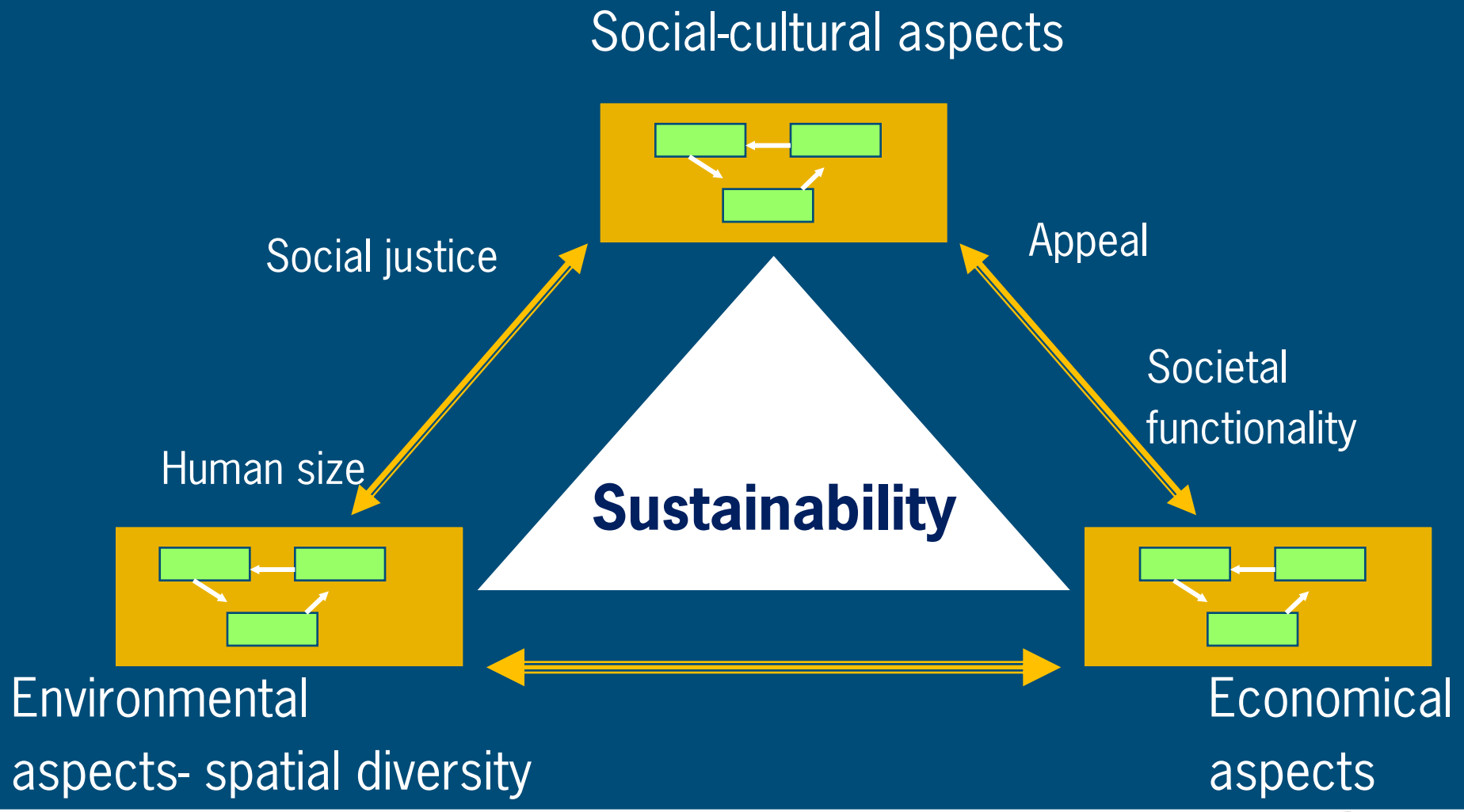
# Conclusions

- On many contaminated sites it is necessary to break the assessment circle to give the site a function
- Tools are:
  - Bioavailability
  - Prevent direct contact
  - Common sense
  - Local possibilities
- Risks can be reduced by using:
  - Stimulation of biodegradation
  - Reduction of bioavailability
  - Isolation of the contaminant
- Regulatory and public acceptance ????

# Sustainable >> Remediation

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# Thank you for your attention