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RESEARCH INSTITUUT VOOR DE GROENE RUIMTE

Priority setting in polluted land management in relation to land use and soil properties

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Objectives

To develop **methodologies** for:

- Priority setting in soil remediation based on "chemical" bioavailability
- Priority setting in soil remediation based on land use options
- Selection of appropriate soil remediation approaches at priority sites

→ **Focus on heavy metals (Cd)**

Priority setting in soil remediation based on "chemical" bioavailability

Priority setting in soil remediation

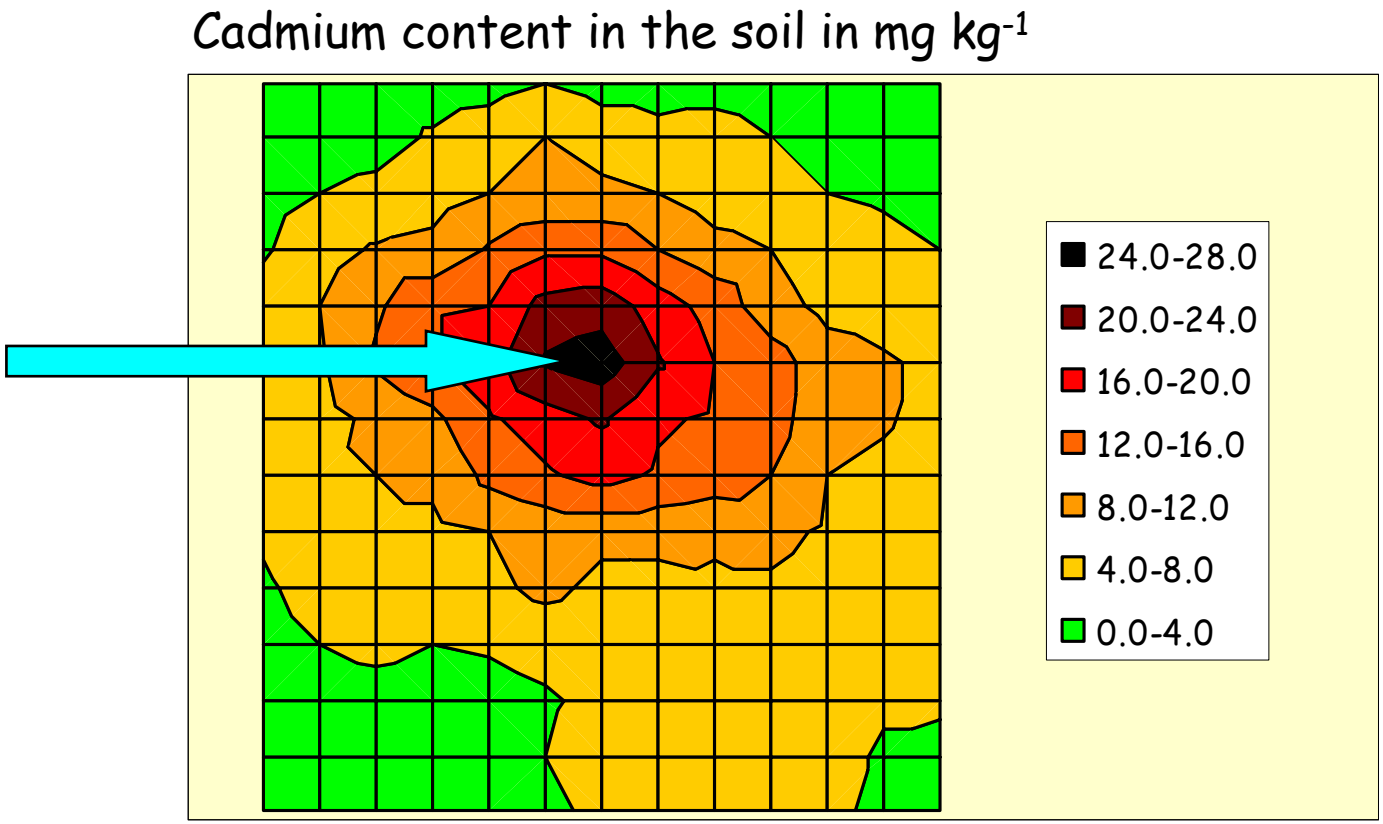
The approach is demonstrated using an hypothetical example case

Case:

A cadmium polluted region (e.g. around a zinc smelter with great spatial variation in (adsorbed) cadmium contents in the soil.

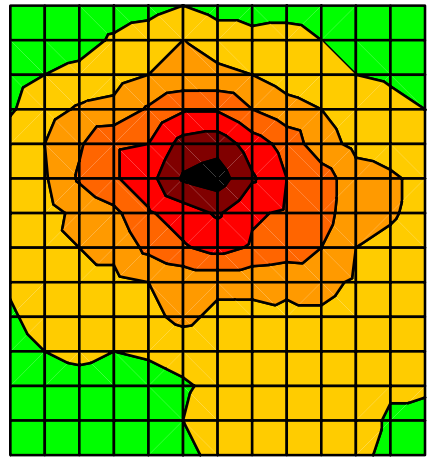
Which are the **most urgent areas** for soil remediation within the region ?

Priority setting in soil remediation



Priority for the most polluted area ?

Priority setting in soil remediation



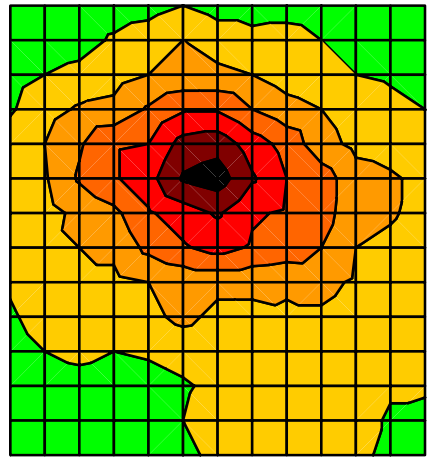
Priorities should be defined on the basis of **actual risks** for:

- Humans
- Ecosystems
- Transfer to vegetation and groundwater

and therefore not in all cases on the basis of total (adsorbed) contents

Priority setting in soil remediation

"**Source-Pathway-Receptor**"



Source:

cadmium content in the soil

(including adsorbed fraction) or

cadmium concentration in the soil solution

dependent on **soil properties**

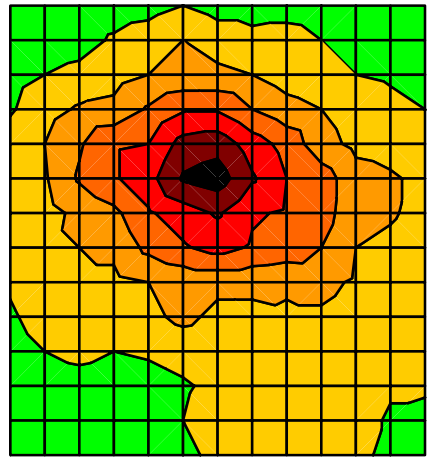
(clay content, organic matter content, pH)

Pathway/Receptor:

dependent on **land use options**

Priority setting in soil remediation

"**Source-Pathway-Receptor**"



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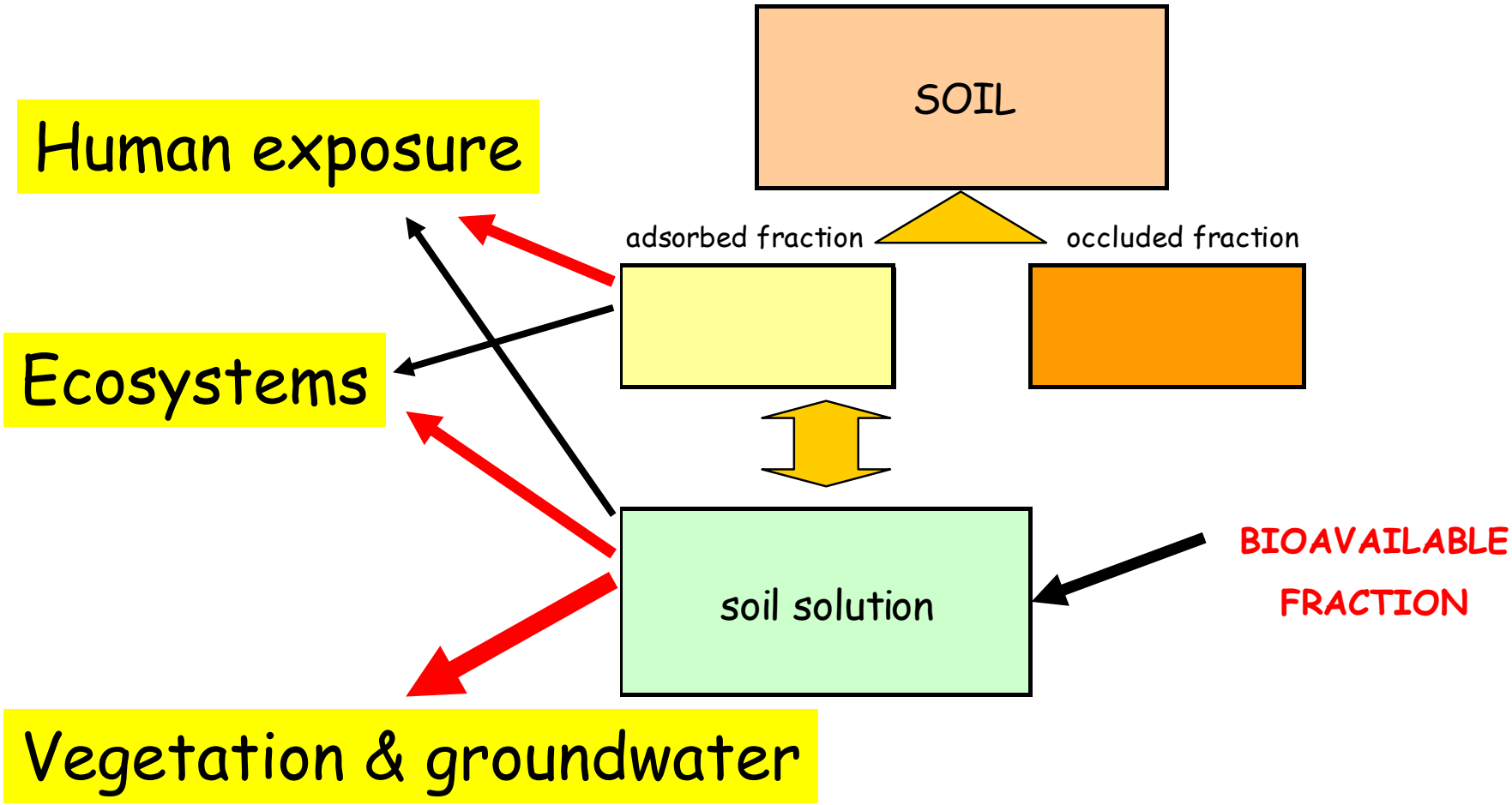
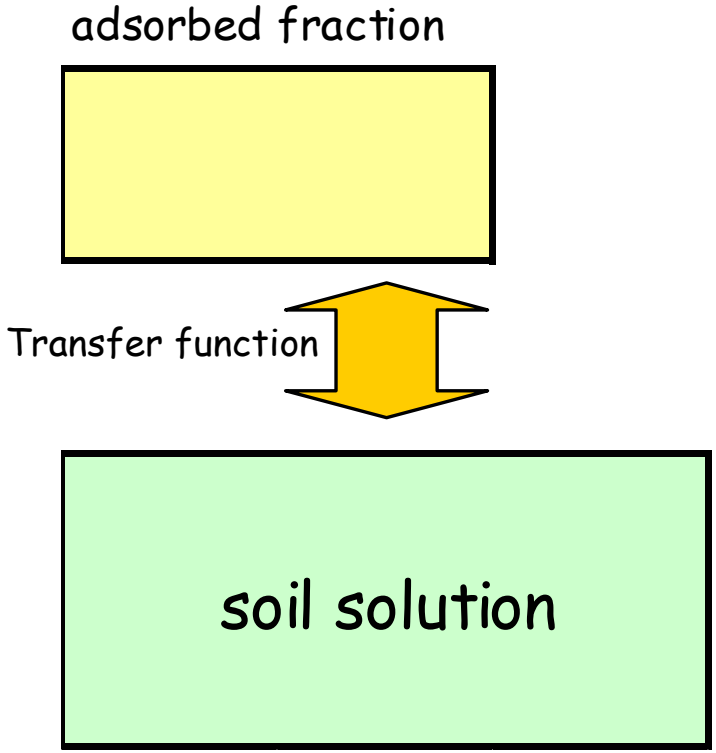
Priority setting in soil remediation

Transfer from the soil to the soil solution



Priority setting in soil remediation

Soil solution >< "bioavailable" fraction



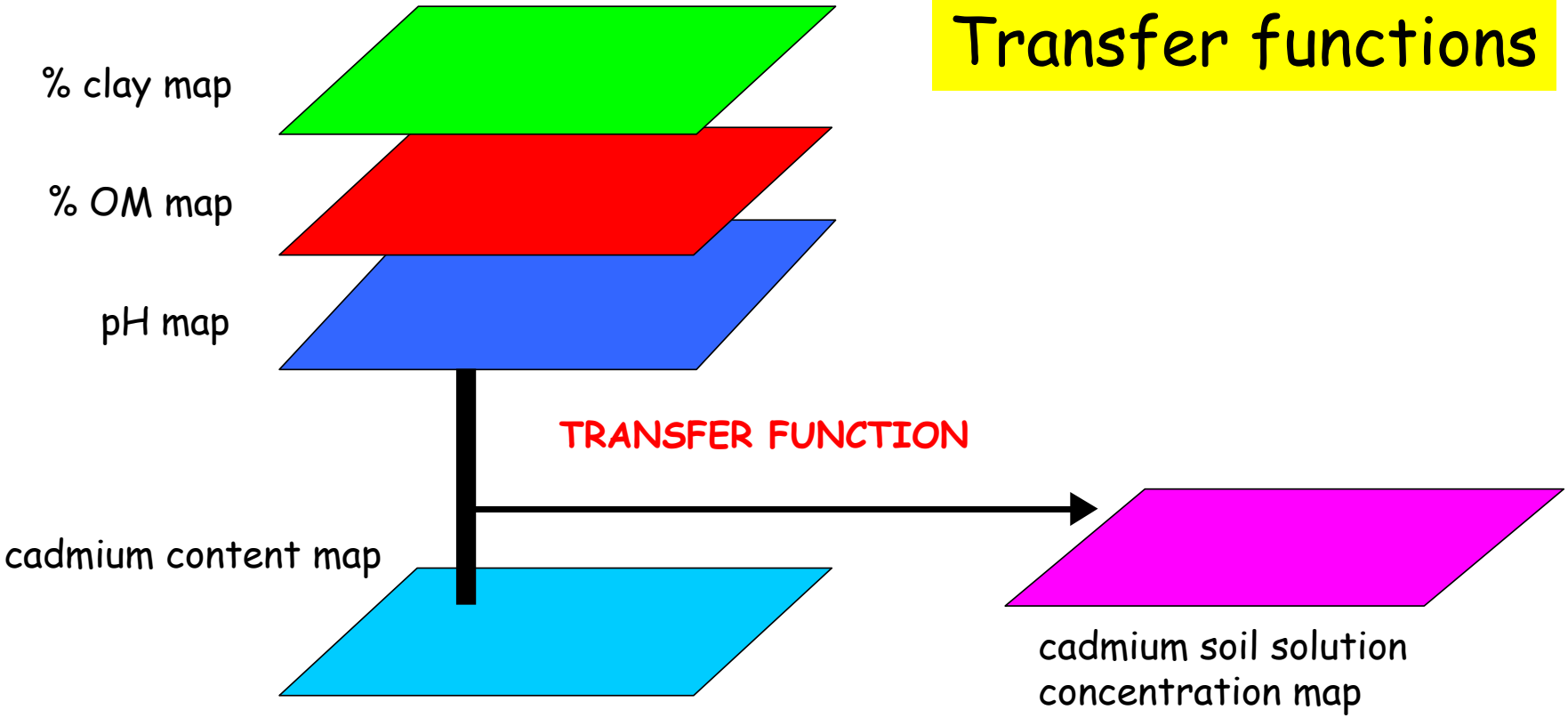
Transfer to soil solution dependent on:

- Soil pH
- Soil organic matter content
- Soil clay content
- Other adsorbing surfaces

Priority setting in soil remediation

$$\log[HM]_{soil\ solution} = a + b*\log [HM]_{soil} + c*\log(\%\ SOM) + d*\log (\%\ clay) + e*pH$$

Transfer functions



Priority setting in soil remediation

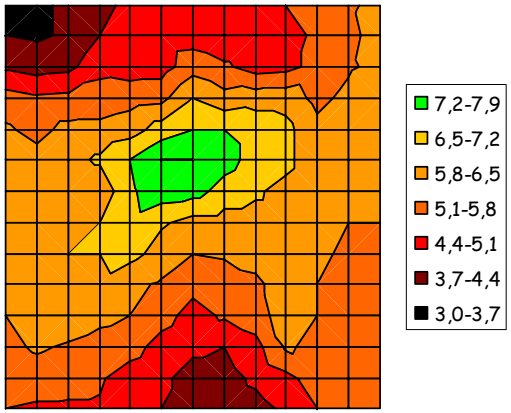
Transfer function (for cadmium)

$$\log[Cd]_{soil\ solution} = 5.05 + 1.26 * \log[Cd]_{soil} - 0.69 * \log(\%\ SOM) - 0.48 * \log(\%\ clay) - 0.40 * pH$$

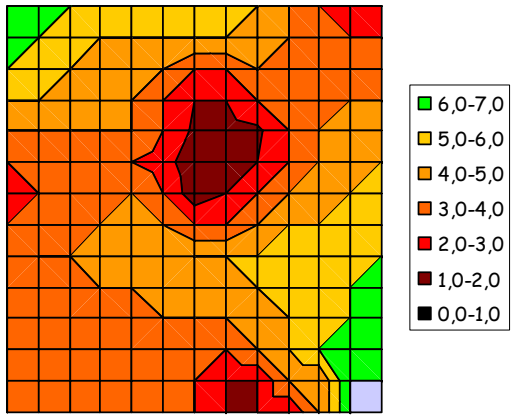
(to be used in example case)

Priority setting in soil remediation

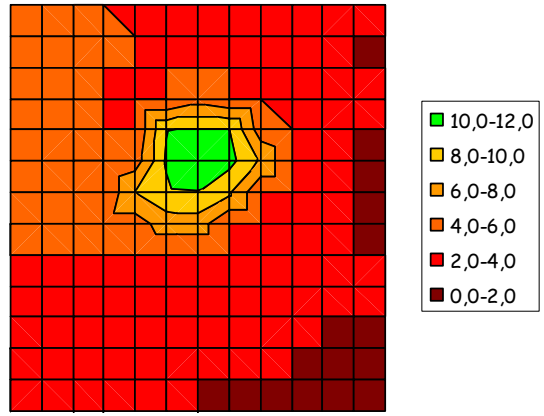
pH distribution over region



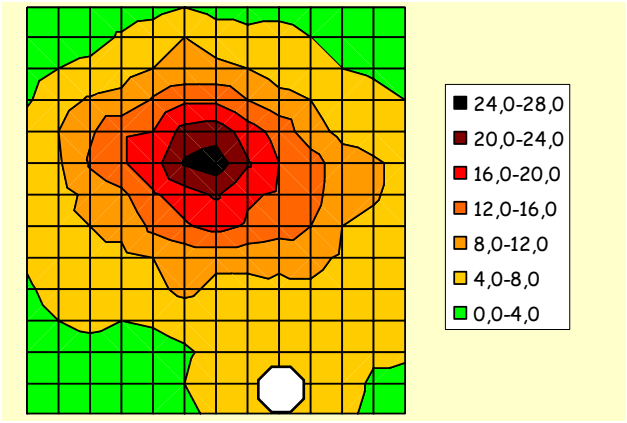
SOM distribution over region (%)



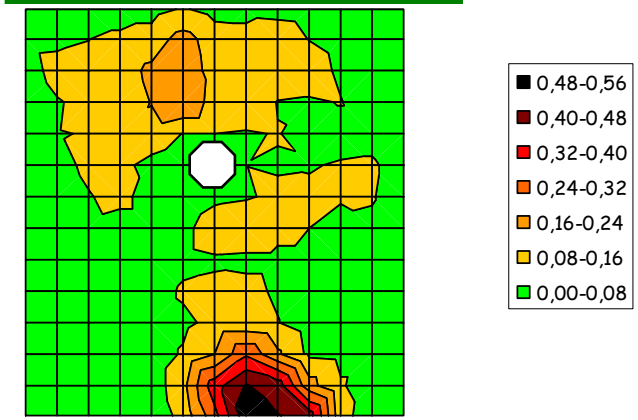
Clay distribution over region (%)



Adsorbed cadmium distribution over region (mg kg^{-1})

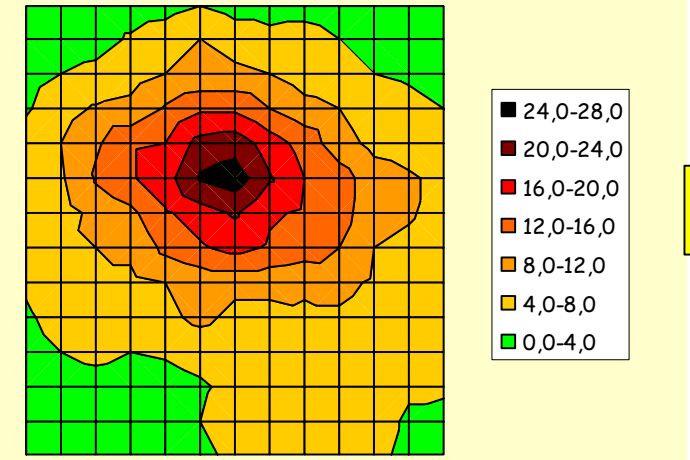


Cadmium soil solution (mg/L)



Priority setting in soil remediation

Adsorbed cadmium distribution over region (mg kg^{-1})



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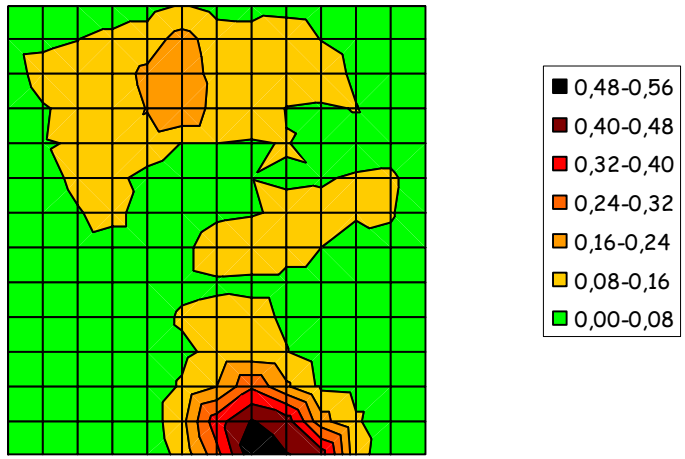
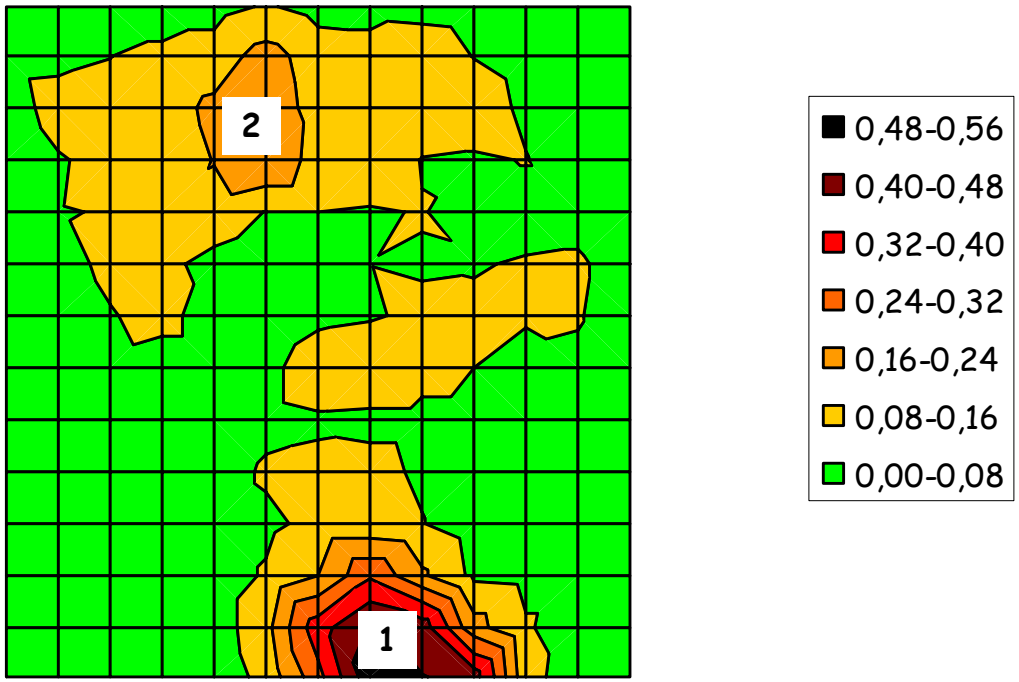


Potential risks exist in areas with no extremely high adsorbed cadmium contents in the soil !

and vice versa

Priority setting in soil remediation

Cadmium soil solution (mg/L)



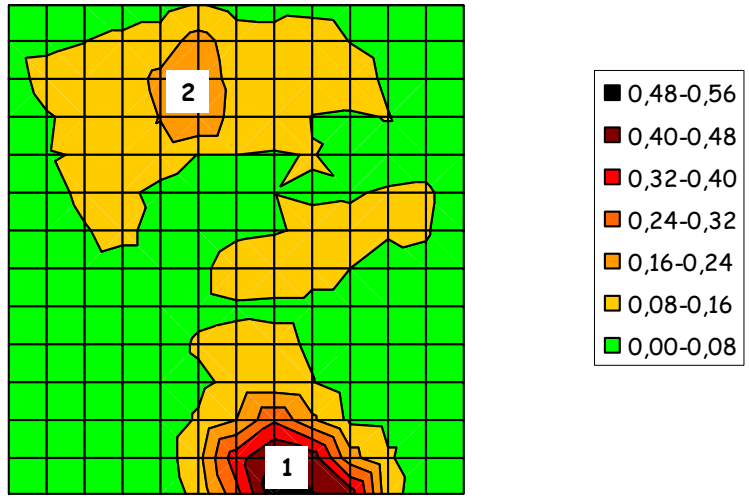
Priority areas for soil remediation ??

Priority setting in soil remediation

What to decide if:

site 1 is situated in a desert and site 2 is a residential area

Cadmium soil solution (mg/L)

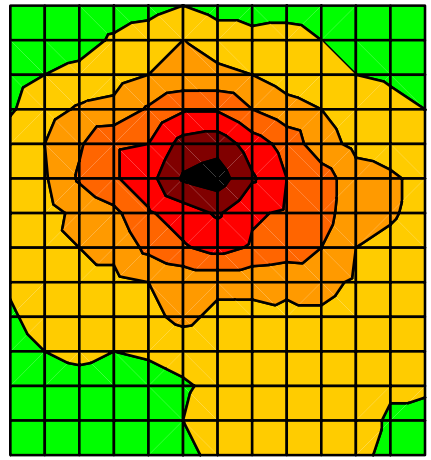


Further analysis necessary !

→ **land use options**

Priority setting in soil remediation

"**Source-Pathway-Receptor**"



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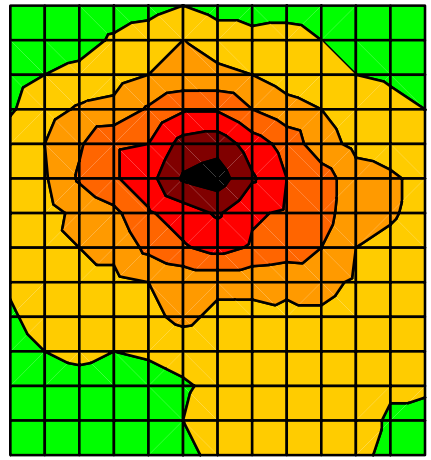
Pathway/Receptor:

dependent on **land use options**

Priority setting in soil remediation



"**Source-Pathway-Receptor**"

Pathway/Receptor:

dependent on **land use options**

Priority setting in soil remediation based on land/groundwater use options

Priority setting in soil remediation

Example
Drinking water obtained from groundwater

Combine the soil solution map with a map of groundwater table depth.

The example distinguishes between a "low" and a "high" groundwater table with its (hypothetical and arbitrary chosen) environmental quality standard for the soil solution.

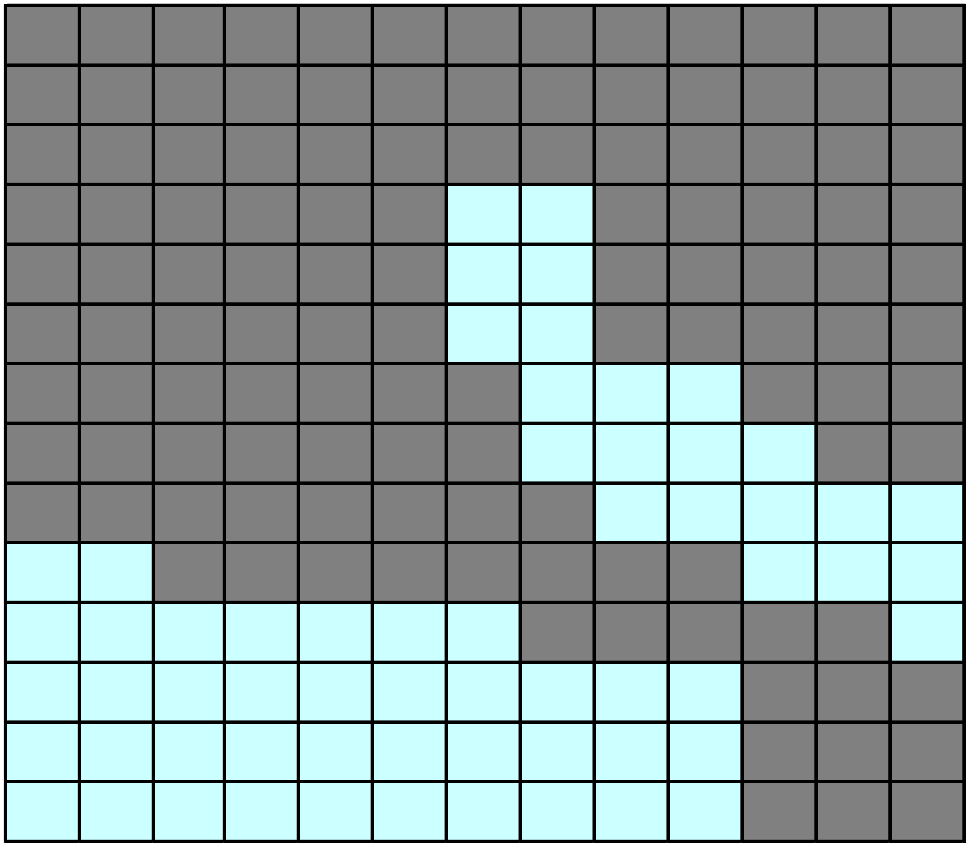
Deep groundwater table (low leaching risks)

0.2 mg L^{-1} in soil solution

Shallow groundwater table (high leaching risks)

1.0 mg L^{-1} in soil solution

Priority setting in soil remediation

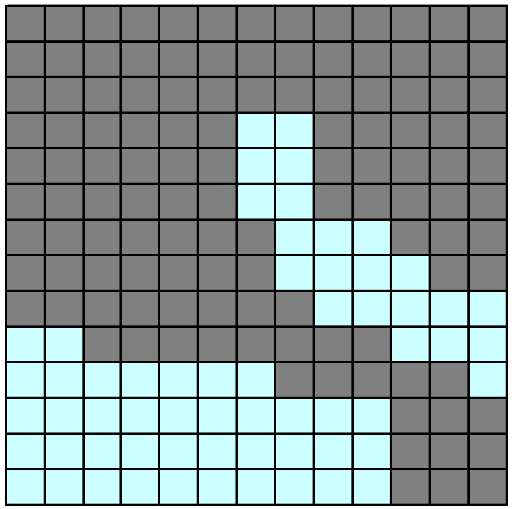


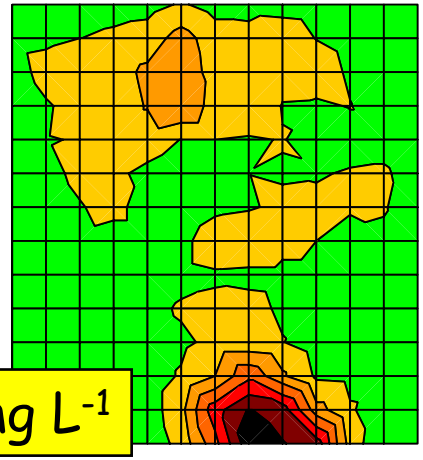
1,0 mg L^{-1}

0,2 mg L^{-1}

Map or the area with hypothetical threshold values for groundwater indicated

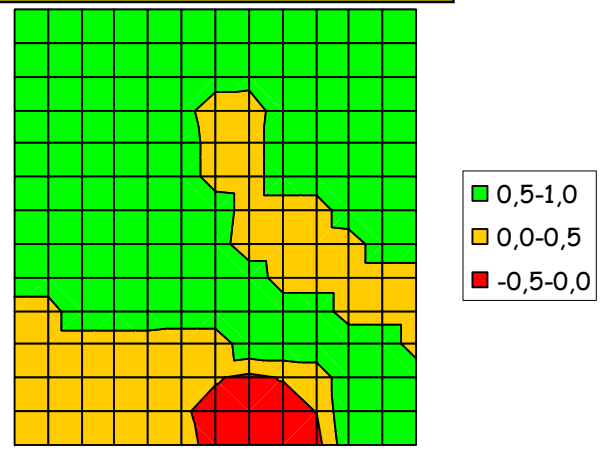
Priority setting in soil remediation





Cd soil solution mg L^{-1}

Exceedance "standard values" mg L^{-1}



Drinking water obtained from groundwater

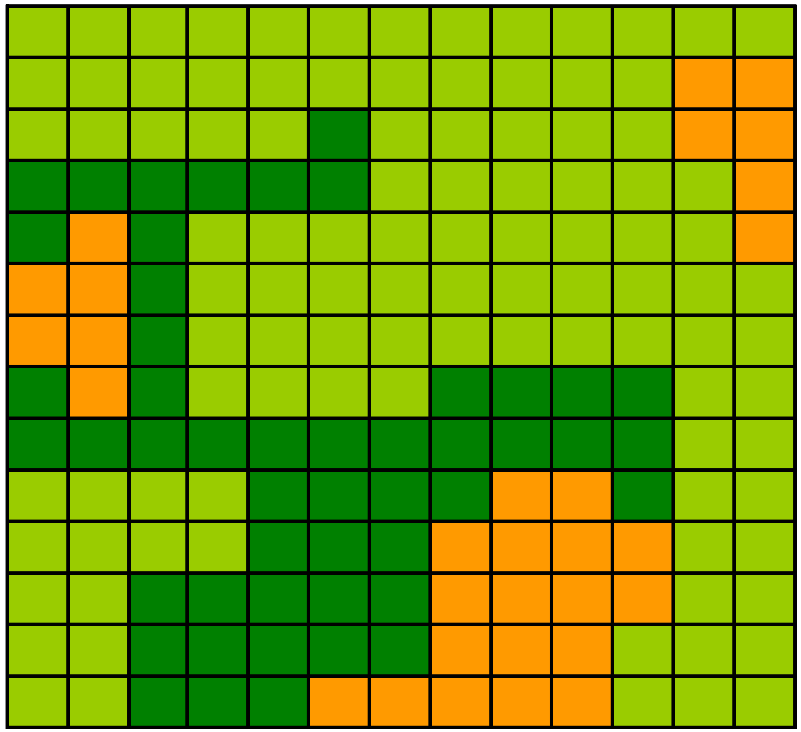
Example
Influence of land use

Combine the soil solution map with a map of local land use.

The example distinguishes between residential areas, agricultural areas and forest areas, each with its (hypothetical and arbitrary) environmental quality standard for the soil solution.

inhabited areas:	**10 mg kg^{-1} in soil**
agricultural areas:	**0.2 mg L^{-1} in soil solution**
forest areas:	**0.1 mg L^{-1} in soil solution**

Priority setting in soil remediation



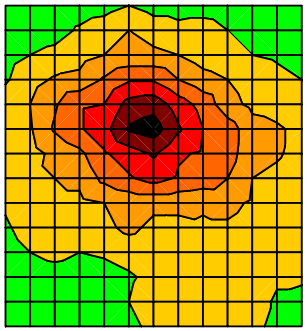
inhabited area = standard: 10 mg kg^{-1} in soil

agricultural area = standard: 0.2 mg L^{-1} in soil solution

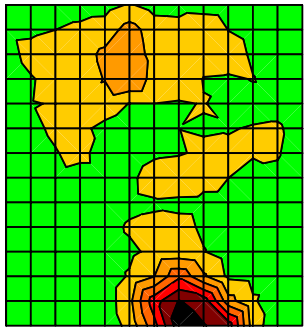
forest area = standard: 0.1 mg L^{-1} in soil solution

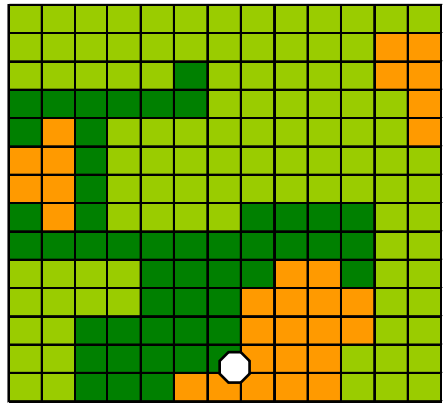
Priority setting in soil remediation

soil



soil solution





inhabited area = standard: 10 mg kg^{-1} in soil
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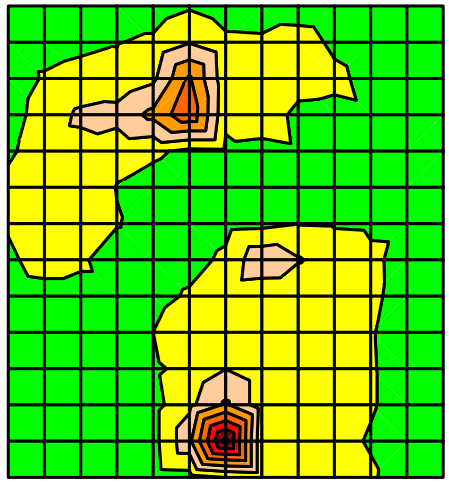
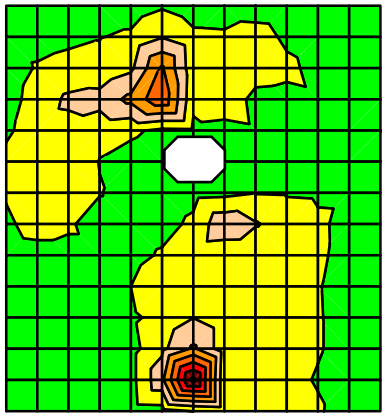
Land use influence



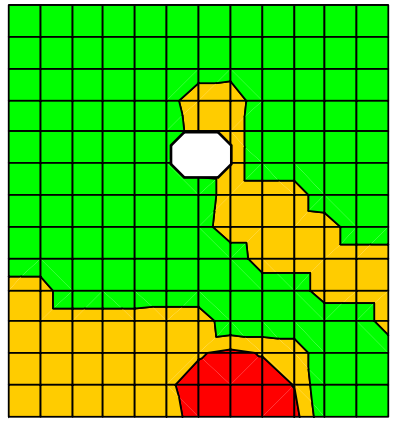
250-300% above
200-250% above
150-200% above
100-150% above
50-100% above
0-50% above
0-50% below
50-100% below

Priority setting in soil remediation - summary

Land use



Drinking water protection



Most polluted area

Using the soil solution concept, high adsorbed Cd contents in the soil do not necessarily lead to high remediation urgency

Priority setting in soil remediation - conclusion

Land use options and soil properties are important decision making factors.

Choice between:

- ✓ **Land use change** – towards less sensitive land use
- ✓ **Polluted land management** – to contain risks, e.g. regarding groundwater protection, crop safety
- ✓ **Physical removal of pollutant or "sealing"** – in cases of high pollution levels and limited size of the site