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PERSPECTIVES FOR THE PRACTICAL APPLICATION OF PHYTOREMEDIATION

FOCUS ON BULGARIA

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What is phytoremediation ?

The use of plants to reduce the risks of pollutants in soil, sediments and water

This can be achieved by:

- removing the pollutants
- otherwise reducing their effects on the environment



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This presentation focuses on phytoremediation of heavy metals in soils:

- **Phytoextraction**
- **Phytostabilisation (or revegetation,
ecological restoration)**



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PHYTOEXTRACTION OF HEAVY METALS

- Plants take up the heavy metals from the soil.
- Plant tissue is commercially used or treated as waste.
- Soil amendments can be applied to increase the availability of heavy metals for plant uptake.



PHYTOEXTRACTION OF HEAVY METALS

Critical success factors

- Availability of hyperaccumulators
- Phytoextraction duration & land value
- Leaching of heavy metals to the groundwater (also in relation to soil amendments)
- Food chain contamination
- Soil life interaction & ecological functioning of the soil
- Utilization of plant material (energy crops, non-food crops or even recuperation of heavy metal from ashes)

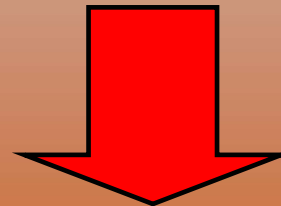


PHYTOEXTRACTION OF HEAVY METALS

Example of a succesful application

Use of a nickel hyperaccumulator (*Berkheya coddii*) near the Rustenburg smelter (South Africa):

- High yield (20 ton/ha)
- High nickel uptake (up to 2-3% nickel in dry matter)
- Ashes contain around 15% nickel and are fed back to the smelter.



RECYCLING OF HEAVY METAL



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PHYTOEXTRACTION OF HEAVY METALS

Example of a succesful application

(photograph Brett)



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PHYTOSTABILISATION OF HEAVY METALS

- Perennial vegetation is introduced on heavily polluted and non-vegetated sites to reduce leaching, surface run-off and wind erosion.
- Plant tissue is whenever possible commercially used.
- Soil amendments can be applied to decrease the availability of heavy metals for plant uptake, to decrease phytotoxicity and to stimulate plant growth.



PHYTOSTABILISATION OF HEAVY METALS

Critical success factors

- Vegetation cover & root density
- Rates of water and wind erosion
- Availability of perennial and strongly competing species
- Leaching of heavy metals to the groundwater (also in relation to soil amendments)
- Food chain contamination (low uptake species wanted)
- Soil life interaction & ecological functioning of the soil
- Utilization of plant material (energy crops, non-food crops or even recuperation of heavy metal from ashes)



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PHYTOSTABILISATION OF HEAVY METALS

Example of a successful application (1)

Use of a native non-hyperaccumulating perennial grass (*Deschampsia cespitosa*) near a former zinc smelter at Katowice (Poland). Combination with phosphates/lignite to immobilize heavy metals.

- 3-4% heavy metals (Pb, Zn, Cd,) in slightly alkaline "soil" with only marginal natural vegetation
- Nearby habitated area; high potential human health impact
- Dense root systems and good cover obtained
- Heavy metal uptake within acceptable limits



PHYTOSTABILISATION OF HEAVY METALS

Example of a successful application (1)



Dense root mat



Dense vegetation





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PHYTOSTABILISATION OF HEAVY METALS

Example of a successful application (2)

Brett: Boron story

PHYTOREMEDIATION OF HEAVY METALS



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Examples of application in Bulgaria





PHYTOREMEDIATION OF HEAVY METALS IN BULGARIA

Pirdop example

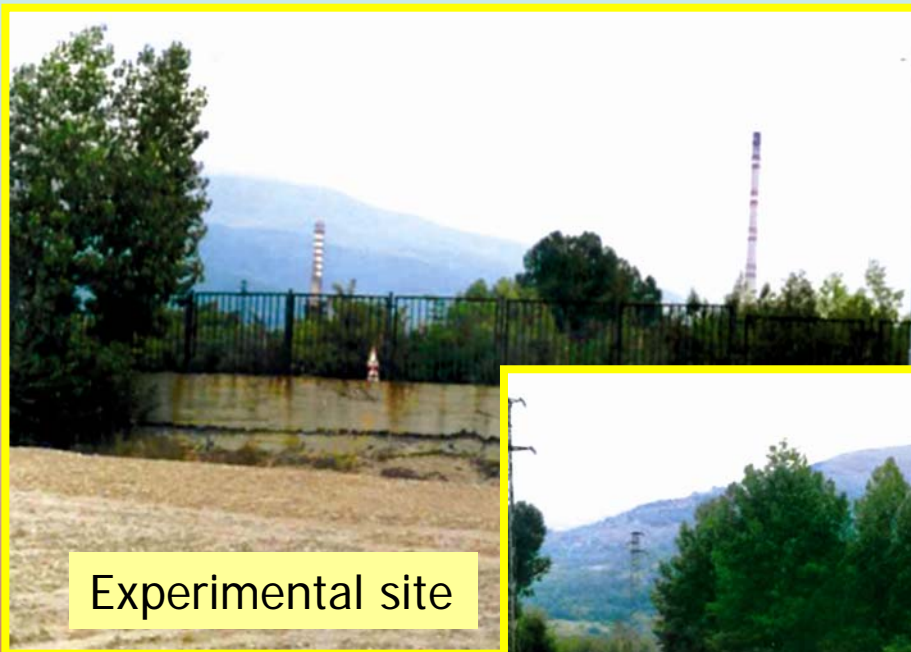
Use of a regular perennial grass mixture grass near a functioning copper smelter at Pirdop. Combination of revegetation with addition of peat, calcium oxide and ferric oxide to immobilize heavy metals and increase soil fertility.

- 1.5% copper in strongly acid (pH=4) delluvial soil with only marginal natural vegetation
- Nearby habitated area; high potential human health impact
- Good cover obtained after a few months
- Copper uptake within acceptable limits



PHYTOREMEDIATION OF HEAVY METALS

Pirdop example – situation before revegetation





PHYTOREMEDIATION OF HEAVY METALS

Pirdop example – situation during revegetation





PHYTOREMEDIATION OF HEAVY METALS

Pirdop example – situation during revegetation



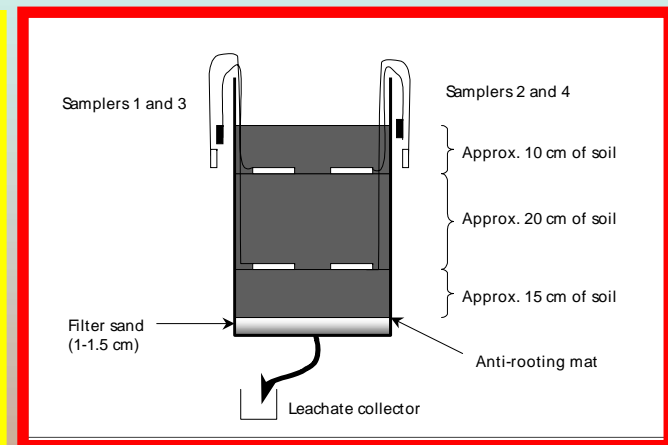


PHYTOREMEDIATION OF HEAVY METALS

How to select the most appropriate soil treatment ?



Lysimeter tests



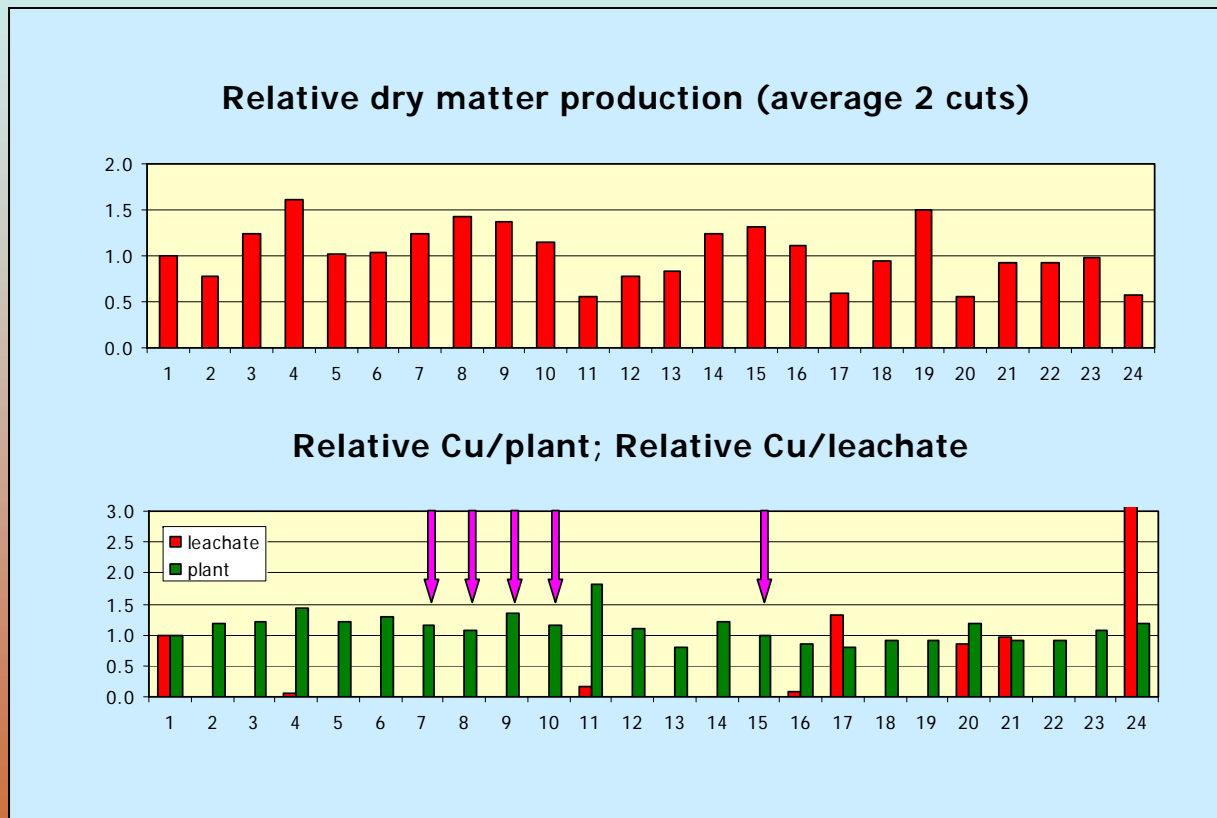
Different mixtures tested (24 combinations):

- Calcium oxide
- Peat,
- Coal powder
- Zeolites
- Ferric oxide
- Perlite



PHYTOREMEDIATION OF HEAVY METALS

How to select the most appropriate soil treatment ?



Arrows:

Selected for
field site

CaO (15 t/ha) + Fe₂O₃ (600 kg/ha) + peat (60 m³/ha)



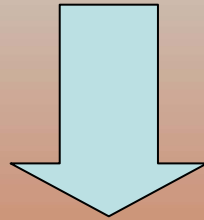
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POLLUTED SITE MANAGEMENT IN BULGARIA

Plovdiv example

- Soil pollution is caused by a non-ferrous metallurgical plant.
- Heavy metal levels in the soil greatly vary, up to 6000 mg/kg Pb and Zn & 100 mg/kg Cd.
- Some crops can be grown on certain areas and not on others.



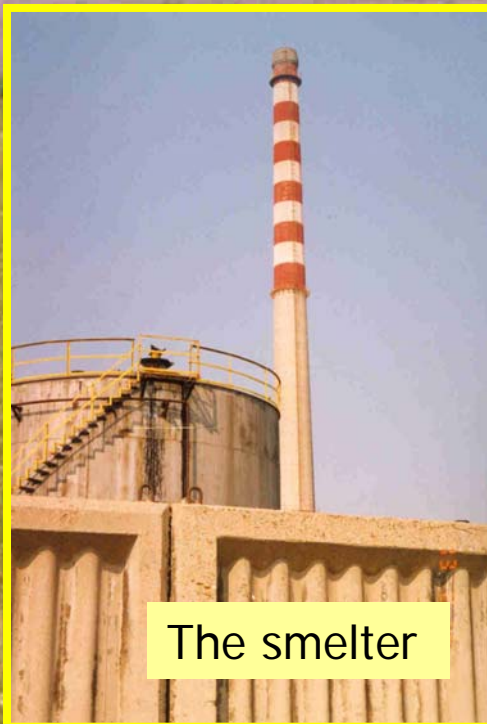
Approach:

- Select the right crop for each pollution level.
- Intensive monitoring of soil & crop quality
- Highest pollution level: etheric oils, trees
- Lower pollution level: traditional agriculture (vineyards, orchards)



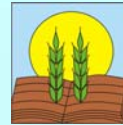
POLLUTED SITE MANAGEMENT IN BULGARIA

Plovdiv example



The smelter

Lavender production summer 2004



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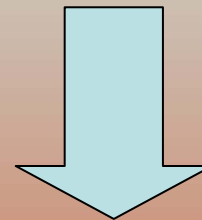
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POLLUTED SITE MANAGEMENT IN BULGARIA

Kardjali example

- Soil pollution is caused by a lead and zinc smelter
- Heavy metal levels in the soil greatly vary, up to 2400 mg/kg Zn, 2300 mg/kg Pb & 28 mg/kg Cd.
- Some crops can be grown on certain areas and not on others. Land use change.

Approach:



- Select the right crop for each pollution level.
- Intensive monitoring of soil & crop quality
- Highest pollution level: green belt (grass, bushes & trees)
- Lower pollution level: traditional agriculture (vineyards, orchards, no tobacco)



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POLLUTED SITE MANAGEMENT IN BULGARIA

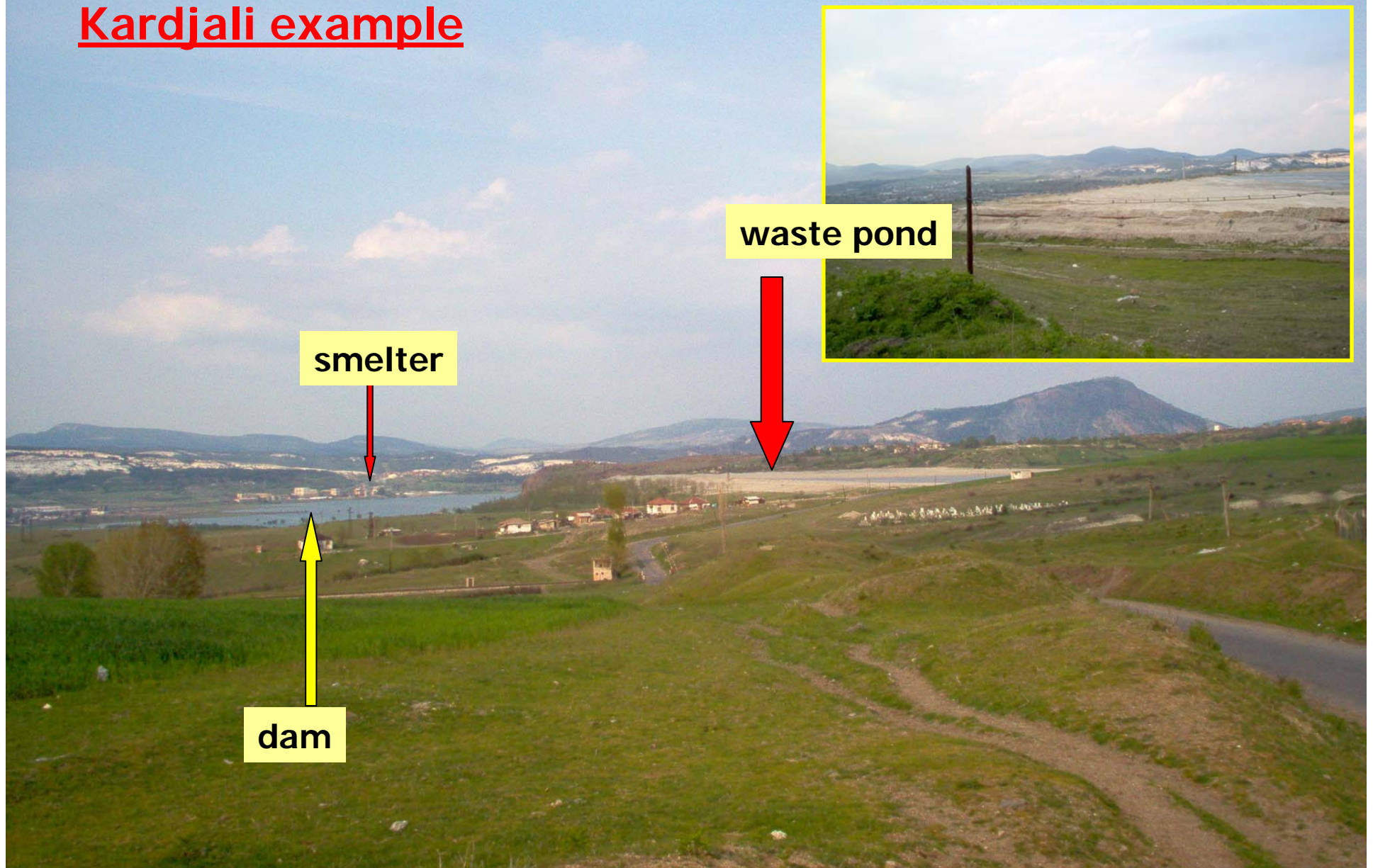
Kardjali example





POLLUTED SITE MANAGEMENT IN BULGARIA

Kardjali example





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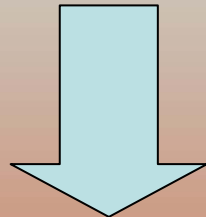
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POLLUTED SITE MANAGEMENT IN BULGARIA

Kremikovtzi example

- Soil pollution is caused by a steel factory
- Heavy metal levels in the soil greatly vary, up to 3000 mg/kg Pb and Zn & 15 mg/kg Cd.
- Some crops can be grown on certain areas and not on others.

Approach:



- Select the right crop for each pollution level.
- Intensive monitoring of soil & crop quality
- Highest pollution level: flowers, seed production
- Lower pollution level: traditional agriculture (potatoes, selected vegetables)



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POLLUTED SITE MANAGEMENT IN BULGARIA

Kremikovtzi example

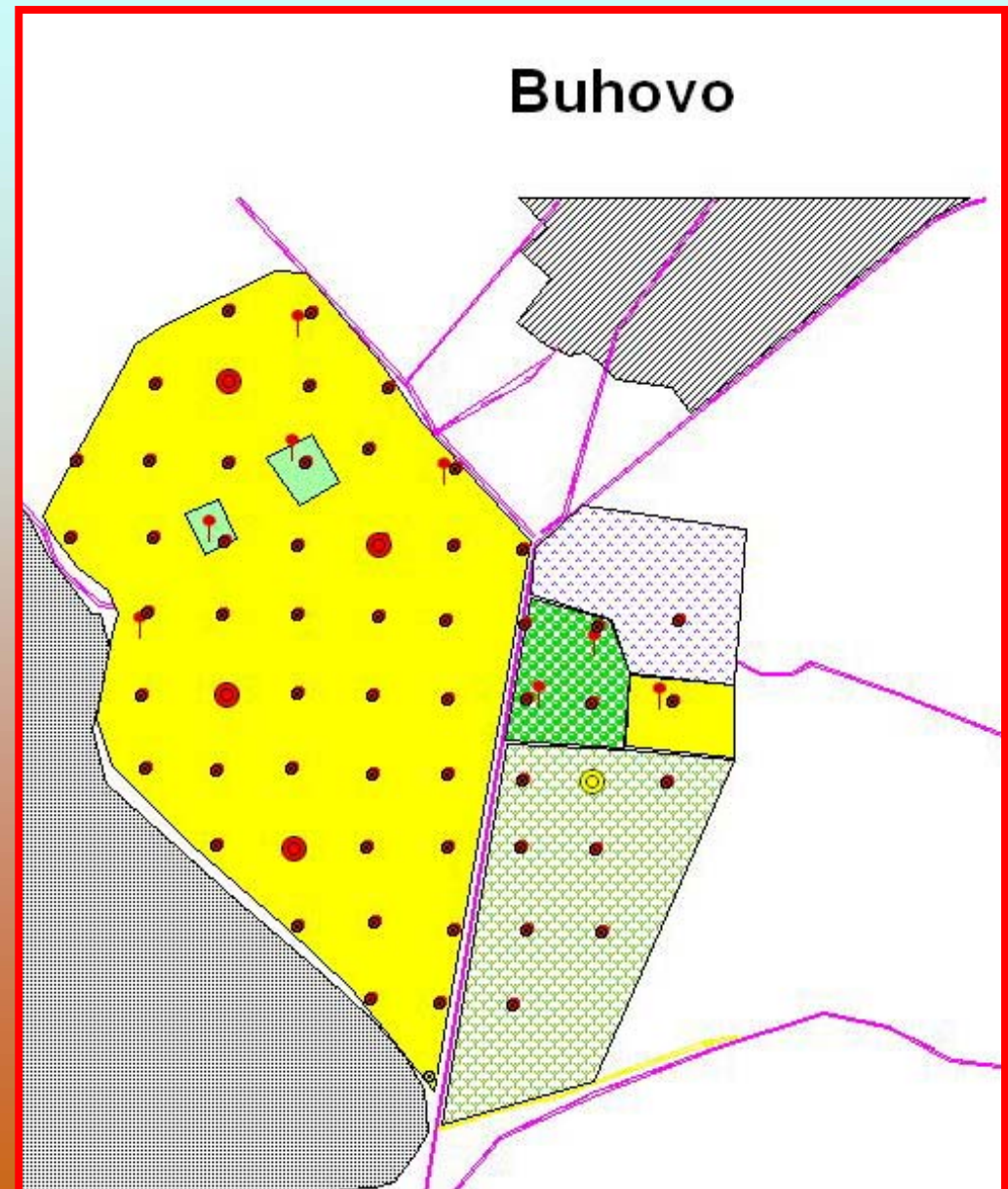
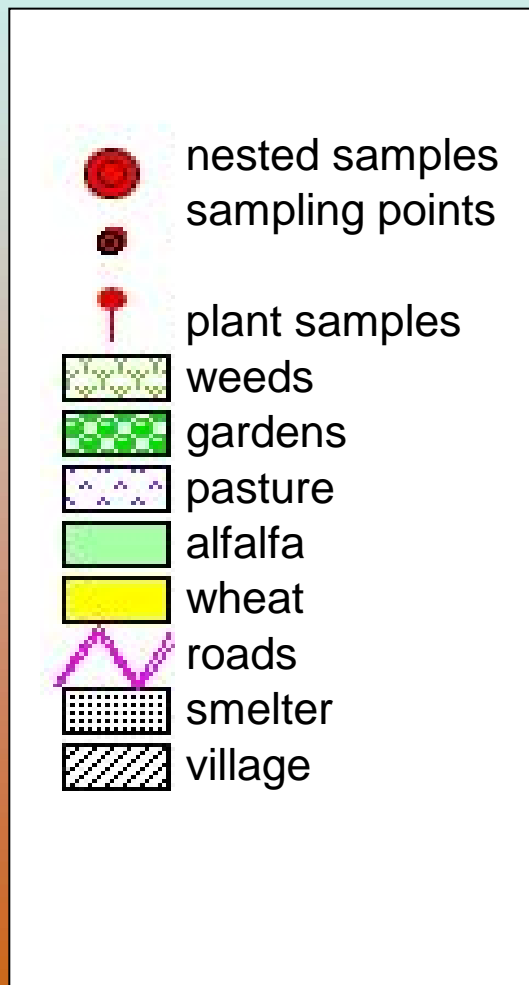


POLLUTED SITE MANAGEMENT IN BULGARIA

Kremikovtzi example



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POLLUTED SITE MANAGEMENT IN BULGARIA



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Conclusions

In Bulgaria the approach towards heavy metal polluted sites (hot spot areas around smelters, mines etc.) is a combination of:

- Tailor-made land use changes for risk control
- Revegetation and erosion control
- Intensive monitoring

POLLUTED SITE MANAGEMENT IN BULGARIA



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To improve the application of polluted soil management in Bulgaria, more intensive contacts are necessary with other (European) countries to exchange ideas.

This is also true for scientific contacts and joint research projects.

This helps Bulgaria to cope with European regulations and to harmonize its legislation regarding heavy metal polluted hot spots.