Complex regulation for sustainability in agriculture

Determination of the criteria of possible land use: forest, industrial plants, feed production, food production

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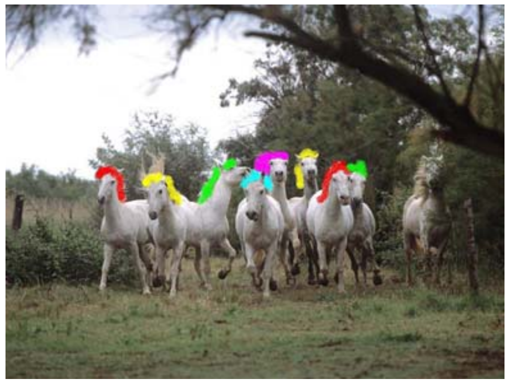
Dream:

1. Clear, well understandable, definite and simply regulation, which is defendable before the court if any disagreement occurs

2. Guideline level system for managing terrestrial food-chain: food, feed, soil by the end of EMRAS II.

Harmonisation ?



EUR 22805 EN - 2007

AVAILABLE:

- Several innovative decision support systems for handling emergency, they are perfect for the changing conditions of an emergency situation
- Regulation of caesium content of food and feed as follow up of the Chernobyl accident (EU)
- Regulation for content of several isotopes in food following an emergency (EU)
- CODEX guideline levels for radionuclides in foods contaminated following a nuclear or radiological emergency for use in international trade
- Drinking water: ^{3}H, indicative dose, ^{210}Po, ^{210}Pb, ^{222}Rn
- Basic safety rule: 1 mSv/year additional dose for public (ICRP, IAEA, EU)

LACK:

Derived guideline levels for foodchain for normal situation: concentration values in food, feed and soil which regarded healthy with very low risk (according to the current knowledge), use without any restriction

GOAL in the frame of EMRAS II:

Isotope specific guidelines levels for food, feed and soil derived from dose limits of inhabitants – use normal situation, achievable conditions for remediation work, prolonged emergency situation (longer than 1 year)

NON EMERGENCY SITUATION

Requirements:

- clear, definite regulation,
- measure or action taken quick and efficient,
- action should be defensible before the court
- assessment from the regulatory side: action taken based on the monitoring results,
  - imission (starting point not the emission, not the source term)
- isotopes: possible releases from nuclear installations (EC RadProt 129 and 143, EUR 19841),
  - long-lived nuclides (^{241}Am, ^{237}Np, ^{135}Cs, ^{129}I, ^{99}Tc, ^{94}Nb, ^{79}Se, ^{14}C)
  - natural radionuclides (terrestrial),
  - violence – not only $T_{1/2}$>> in case of food and feed
  - (do not group the isotopes – ^{131}I)
- system should ensure the possibility of active land-management

Tool : isotope-specific guideline level-system, derived from dose limits for inhabitants:

- radionuclide concentration in **FOOD, ready (300 isotopes):**
tolerance level derived from 0.1mSv/year
acceptable level derived from 1mSv/year

- radionuclide concentration in **FEED of ruminants, pigs, poultry, ready (178 isotopes):**
acceptable level derived from food acceptable level

- radionuclide concentration in **SOIL (for different land-use)**
deriving from: **food acceptable level**
feed acceptable level
for industrial use - exemption limit (?)
to be done in 2010

Food and feed production

Natural isotopes – root uptake

Available data: Pb, Po, Ra, Th, U

Food :

- cereals
- maize
- leafy vegetable
- non-leafy vegetable
- leguminous vegetable
- root crops
- tubers
- fruits
- herbs

Feed:

- grasses
- pasture
- fodder leguminous

Soil types (not every type for every product):

sand, clay, loam, organic

Generic values for TF:
- plant type: grass, fodder higher; tubers, cereals smaller
-soil type: organic, sand higher

Calculation to be done when only feed is produced

	acceptable level for adult, Bq/kg fresh	TF kg/kg	soil, Bq/kg	**acceptable level in soil, Bq/kg**
Pb-210	0,6	2,00E-02	30	**30**
Po-210	0,3	5,60E-03	54	**50**
Ra-226	1	4,00E-02	25	**20**
Th-228	6	3,40E-03	1765	**1700**
Th-230	2	3,40E-03	588	**500**
Th-232	1	3,40E-03	294	**200**
U-234	8	2,15E-02	372	**300**
U-238	9	2,15E-02	419	**400**

Same logic for artificial isotopes – to be done

Forest

Understorey: shrub layer (> 0.5m)
herb layer(< 0.5m)
moss layer

Critical use: consumption of wild food (might be target of restriction)

Available data for transfer from soil to edible mushroom :
^{137}Cs, ^{90}Sr, $^{239+240}$Pu, ^{234}U, ^{238}U, ^{228}Th, ^{230}Th, ^{232}Th, ^{226}Ra

	acceptable level for adult, Bq/kg fresh	**concentration in mushroom, Bq/kg dw**	**T_{ag}, m^2/kg dw**	**acceptable level in soil, Bq/m^2**	**acceptable level in soil, Bq/kg**
Sr-90	10	87	6.00E-03	1.45E+04	181
Cs-137	30	261	5.50E-02	4.74E+03	59
Ra-226	1	9	2.50E-02	-	348
Th-228	6	52	8.50E-02	-	614
Th-230	2	17	4.00E-02	-	435
Th-232	1	9	8.00E-02	-	109
U-234	8	70	0.1	-	696
U-238	9	78	0.095	-	824
Pu-239+240	2	17	0.0003	5.80E+04	725

Forest

Understorey: shrub layer (> 0.5m)
herb layer(< 0.5m)
moss layer

Available data for transfer of berries: mainly ^{137}Cs, *^{60}Co, ^{106}Ru, ^{125}Sb, ^{144}Ce, ^{154}Eu, ^{239}Pu – more study not in TECDOC*

Acceptable level for ^{137}Cs in soil
round down [min (mushroom, berries)]: 20Bq/kg
Effective half-life: 7.5 years (Ukraine)

^{137}Cs	concentration in berries, Bq/kg dw	T_{ag}, m^2/kg dw	acceptable level in soil, Bq/m^2	acceptable level in soil, Bq/kg
bilberry	227	5.00E-02	4.55E+03	57
cranberry	278	1.20E-01	2.31E+03	29
cloudberry	214	1.00E-01	2.14E+03	27
raspberry	173	3.00E-02	5.78E+03	72
blackberry	405	2.00E-02	2.03E+04	253
wild strawberry	195	4.00E-03	4.87E+04	609

	acceptable level in soil, Bq/kg
Sr-90	**100**
Cs-137	**20**
Ra-226	**300**
Th-228	**600**
Th-230	**400**
Th-232	**100**
U-234	**600**
U-238	**800**
Pu-239+240	**700**

Suggested acceptable level in soil of forest, without any restriction derived from acceptable level for adults

Forest

<u>Characteristics</u>: radionuclides can be efficiently trapped and recycled, long residence time

Influence of ecological factors governing **tree** contamination by radiocaesium

Influencing factor	**I (variability index)**	**T_{ag} (m^2/kg dw) hierarchy for trees**
Soil type	100 (10-200)	peat-gley > peat-podzolic > soddy-podzolic > podzolized chernozems
Moisture regime	10 (3-70)	central depression > terrace basement > terrace slope > slope upper part > watershed top
Stand composition	4 (5-10)	monospecific coniferous stand > mixed coniferous-deciduous forest
Stand age	4 (3-8)	0-30 > 30-60 > 60-90 > +90
Tree species	2 (2-3)	aspen > oak > birch > pine > lime > spruce

<u>Goal and management</u>:
- Remove contaminant from soil: aspen and semihydromorphic condition
- Keep contamination localised – decidous forest automorphic condition, willow

<u>Monitoring</u>: best indicative organs are leaves and 1 year-old needles

Steady state phase: quasi-equilibrium applicable after 5-10 years of deposition, available data Cs, Sr

Calculation to be done when just wood is used

Industrial plants

For industrial use - exemption limits

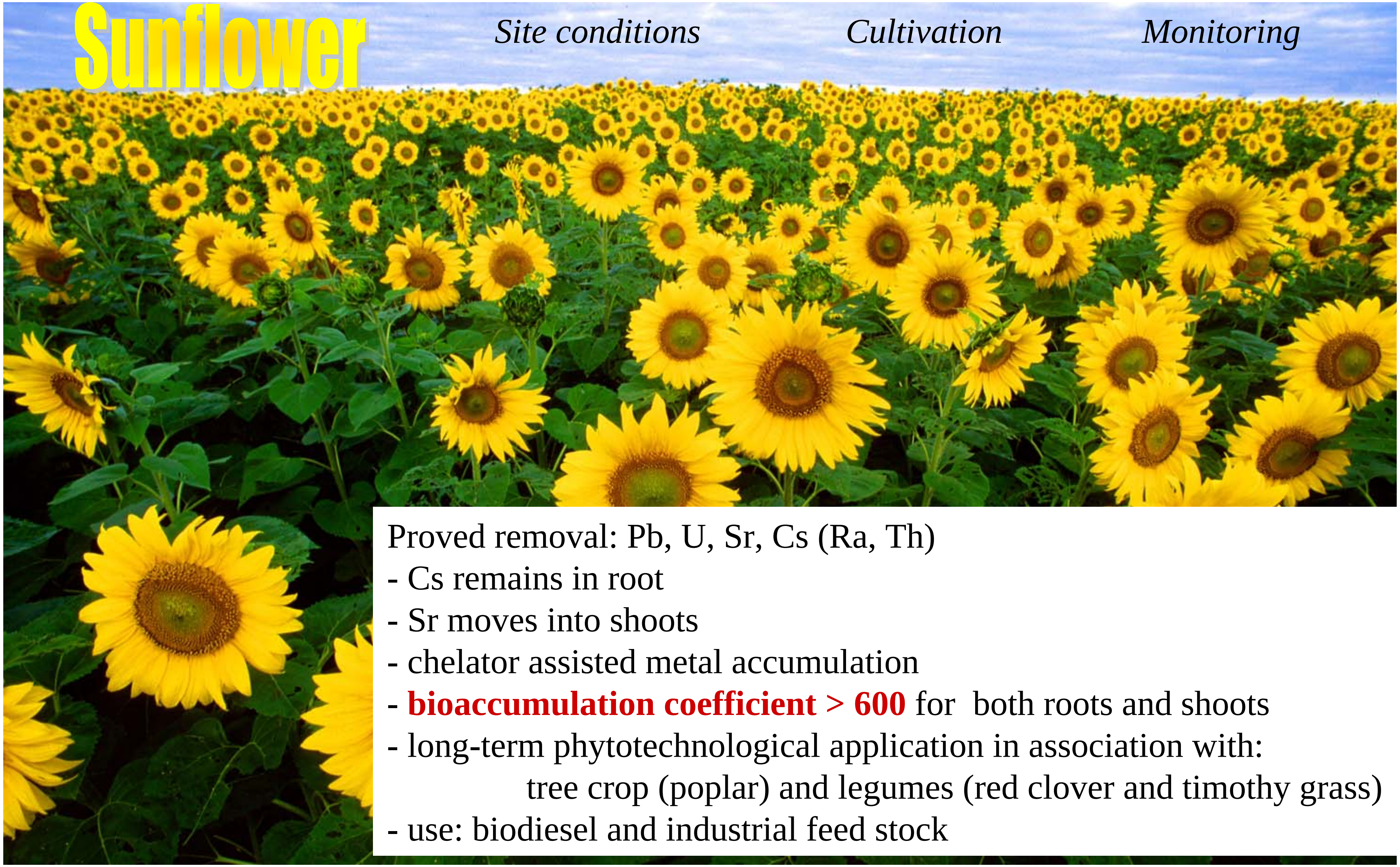
H. Vandenhove, M. Van Hees : Fibre crops as alternative land use for radioactively contaminated arable land*
Journal of Environmental Radioactivity 81 (2005) 131-141

Purpose of producing:
- cleaning of soil – sunflower (tobacco)
- get useful products even from a contaminated area – fibre crops, willow

Circumstances: sandy soil is the most vulnerable – high T_{ag} values

	flax		hemp	
^{137}Cs	**acceptable level in soil, Bq/m^2**	**acceptable level in soil, Bq/kg**	**acceptable level in soil, Bq/m^2**	**acceptable level in soil, Bq/kg**
Stem as biofuel	250 000	3125	1 050 000	13 125
Fibre as building material			1 850 000	23 125
Use of straw after retting / mechanically separated fibre as biofuel	free		740 000	9 250
Seed flour	1 000 000	12 500	160 000	2 000
Use of seeds for extraction of oil	free		600 000	7 500

Long-term phytotechnological applications of sunflower for the clean up of sewage sludge, heavy metals, radionuclides and organic contaminants and pollutants



Proved removal: Pb, U, Sr, Cs (Ra, Th)
- Cs remains in root
- Sr moves into shoots
- chelator assisted metal accumulation
- **bioaccumulation coefficient > 600** for both roots and shoots
- long-term phytotechnological application in association with:
  tree crop (poplar) and legumes (red clover and timothy grass)
- use: biodiesel and industrial feed stock

Industrial plants

Available data for sunflower, fibre crops (flax, hemp)

Clean up procedure by sunflower

Abundant biomass,
Trace element accumulation including radionuclides

↓

Soil amendment with chelators – enhanced metal uptake
HEDTA (hydroethylenediaminetriacetic acid)
NTA (nitrilotriacetic acid) and FYM (farm yard manure)

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Harvesting

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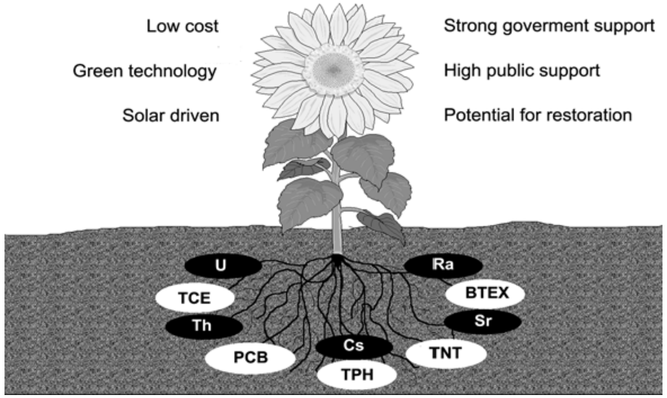
Biodiesel and industrial feed stock



Crop rotation system

sunflower → red clover → poplar → sunflower

Bioremediation technology is based on use of plants to cleanup metals, metalloid including radionuclides

Phytoremediation

technology

Vegetation cap: prevention of soil erosion by rain and storm

Foliar uptake of metals from aerosols (Ficus and Nerium)

Rhizofiltration: uptake of metals by plant roots from surface water (phytofiltration)

Phytoextraction: uptake and bioconcentration of metals in plant tissues from soil

Phytostimulation: rhizosphere exudates accelerate uptake of metals

Phytostabilisation: root exudates complex with metals,
thus bioavailability of metals decrease in soil/ground water

Phytoimmobilisation: fungi immobilize metals in rhizosphere

Phytovolatilisation: some elements (Se, Hg) in soil and ground water are removed by transpiration


Thank you for your attention!

Phytoremediation

Strategy

AVOIDE

Uptake exclusion

Biochemical changes on the root surface

Binding to cytosolic ligands

Extracellular deposition

Shedding of plant parts

Metal accumulation

Transport into vacuole

Phytochelatins, metallothioneins

Binding to cell wall

TOLERATE

Selection of plants:

- Growth rate and yield
- Depth of rootzone
- Bioaccumulation
- Rizospheric changes

Element	Conc of leaves, mg/g dw	No of plants
As	> 22	2
Cd	> 0.1	1
Co	> 1	28
Cu	> 1	37
Mn	> 10	9
Ni	> 1	317
Pb	> 1	14
Zn	> 10	11