Sustainable management of food production

Guideline levels

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EXPECTATION

MONITORING | **DECISION** | **REGULATION**

Need of the society,
economical possibilities

Radionuclide concentration in soil

Regulation for soil concentration for different land-use

Decision about land-use

Suggestion for the subsequent land-use

Plan for subsequent land-use (iterative steps)

Monitoring of soil and product from the field

Suggestion of the use of the crop

Decision about the use of the products (iterative steps)

Monitoring of food-chain and
different stages of food production

Regulation for radionuclide content of food and feed

Decision about the consumption of food or feed
or consumption form of them

AVAILABLE:

- Several innovative decision support systems
- 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 ALIMENTARIUSguideline 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:

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)

FOOD

Limits in force for radioactive isotopes in food

(after emergency for a given period, import rate)

Follow-up (Chernobyl)	For future event	Codex Alimentarius
737/90/EEC now: 733/2008/EC	3954/87/Euratom	CAC/GL 5-2006
616/2000/EC	2218/89/Euratom	
1609/2000/EC	2219/89/Euratom	
1635/2006/EC	944/89/Euratom	
2003/274/EC	770/90/Euratom	

Values in force: ^{137}Cs and ^{134}Cs together:
370Bq/kg – food for children younger than 6 months
370Bq/kg – milk, milk-products
600Bq/kg – other foodstuffs
10 times – minor foodstuff (spices)

2001/928/Euratom:
Limit: ^{222}Rn - 100Bq/l
^{210}Po – 0,1Bq/l
^{210}Pb – 0,2Bq/l

WHO Guidelines for drinking water quality (3rd edition) 2006:
Screening levels gross-α, gross-β, ^{222}Rn 100Bq/l

Guideline level is a specified quantity above which appropriate actions should be considered.

D-values:
In March 2002, the IAEA's Board of Governors approved a Safety Requirements publication entitled "Preparedness and Response for a Nuclear or Radiological Emergency". The Requirements define a dangerous source as one "that could, if not under control, give rise to exposure sufficient to cause severe deterministic effects".

Define the antithesis of D-values - Introduction of S-values:
S-values can describe the safe food, when it is consumed there is a small probability of the stochastic effect, for sure there is no need of any kind of control.

Might be the final goal of the environmental modelling

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):**
  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 (?)

Guidelines for food:

Background level (important to know for not to be too strict, but regulation should not based on the multiplication of background level)

Tolerance level (risk $5x10^{-6}$) :

- derivation of radionuclide concentration from 0.1mSv/year dose
- minimum(children below 1 year, adults)
- decision rule taking into account measurement uncertainty (Eurachem-CITAC guide)

Acceptable level for children below 1 year – from 1mSv dose (protection factor 5)

Acceptable level for adults – from 1mSv dose (protection factor 3)

Rounding rule – always down

In case of more isotope simultaneous presence:

sum of measured activity-concentration normalised by acceptable level < 1

Some values for the comparison -^{137}Cs

Regulation	***Food*** *Bq/kg*	***Effective dose***	
		Children < 1 year mSv/year	***Adults, mSv/year***
CAC/GL 5-2006	1000	0.42-4.2	0.72 -7.2
EU – follow up: children < 6 months	370	1.6	
EU – follow up: adult	600		4.3
EU –future: children < 6 months	400	0.4-1.7	
EU – future: adult	1250		2.2-8.9
Suggested for adult	30		0.3
Suggested for children below 1 year	30	0.2	
Suggested tolerance	9	0.06	0.09
Background (milkpowder included!)	0.15	0.0006	0.001

Feed – base of the derivation is the acceptable level for foodstuffs

Animal	***Method of the derivation***
Ruminants	Transfer to meat: minimum(concentration in feed of cow, sheep, goat) Transfer to milk: minimum(concentration in feed of cow, sheep, goat) Acceptable level: minimum concentration in feed (transfer to meat, transfer to milk) Decision limit = acceptable level – 2 x uncertainty of measured value (2.5% bad decision)
Pig	Acceptable level: Transfer to meat Decision limit = acceptable level – 2 x uncertainty of measured value (2.5% bad decision)
Poultry	Transfer to meat Transfer to egg Acceptable level: minimum concentration in feed (transfer to meat, transfer to egg) Decision limit = acceptable level – 2 x uncertainty of measured value (2.5% bad decision)

Feed

Commission Regulation (Euratom) No 770/90

Maximum permitted levels of radioactive contamination (caesium-134 and caesium-137) of feedingstuffs (as it is):

animal	Bq/kg
Pigs	1250
poultry, lambs, calves	2500
other	5000

Example: ^{137}Cs

FOOD - 30Bq/kg in meat

FEED – acceptable level ^{137}Cs: 70Bq/kg – 3.3mGy/year

in force: 5000Bq/kg – 249mGy/year

(1mGy/day: small probability of any effect for biota)

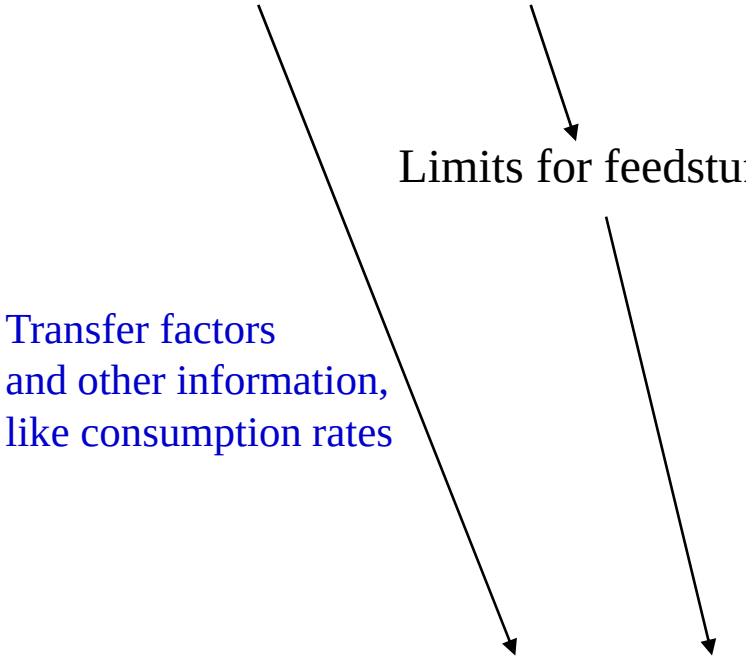
Protection of human being = protection of biota?!

Isotope	Suggested acceptance level		Suggested acceptance level for feedstuffs		
	child < 6 month	adult	ruminants	pork	poultry
^{3}H	5000	10000	-	-	-
^{14}C	400	700	-	-	-
^{32}P	20	100	200	900	2000
^{35}S	500	3000	1000	-	-
^{36}Cl	60	400	3000	-	-
^{51}Cr	1000	10000	30000	-	-
^{54}Mn	100	600	40000	40000	100000
^{55}Fe	80	1000	8000	-	10000
^{59}Fe	10	200	1000	-	2000
^{60}Co	10	100	6000	-	6000
^{65}Zn	10	100	70	200	800
^{75}Se	30	100	900	100	100
^{76}As	60	200	-	-	-
^{89}Sr	10	100	2000	10000	3000
^{90}Sr	2	10	200	1000	300
^{95}Nb	100	700	8000000	-	10000000
^{95}Zr	70	400	6000000	-	20000000
^{99}Mo	100	700	30000	-	10000
^{99}Tc	60	600	10000	-	1000

Isotope	Suggested acceptance level		Suggested acceptance level for feedstuffs		
	child < 6 month	adult	ruminants	pork	poultry
^{103}Ru	90	500	20000	90000	-
^{106}Ru	8	60	2000	-	-
^{110m}Ag	20	100	100000	-	-
^{124}Sb	20	100	10000	-	-
^{125}Sb	60	300	30000	-	-
^{129}I	3	3	8	200	10
^{131}I	3	10	20	700	50
^{134}Cs	20	20	40	40	100
^{137}Cs	30	30	70	60	100
^{140}Ba	20	100	1000	-	1000
^{141}Ce	80	600	100000	-	-
^{144}Ce	10	80	20000	-	-
^{154}Eu	20	200	-	-	-
^{192}Ir	50	300	-	-	-
^{210}Pb	0.08	0.6	10	-	-
^{210}Po	0.02	0.3	90	-	1
^{226}Ra	0.1	1	80	-	-
^{235}U	1	9	300	-	100
^{238}U	1	9	300	-	100
^{239}Pu	0.1	1	6000	-	-
^{241}Am	0.1	2	500	-	2000
^{244}Cm	0.2	3	-	-	-

DERIVATION OF GUIDELINE LEVELS

Starting with „end-user” or top of the food-chain – limits for foodstuffs – risk assessment



Limits for feedstuffs

Transfer factors
and other information,
like consumption rates

Goals

-Restricted use: forest

-Controlled use: energy plants, agricultural production (crops for fodder, pasture, fruit, cereals)

-Free use: green vegetables - small parcels

Limit for soil for different use
first(?): isotope-specific
concentration range
for 3 classified goal
or(?): for at least 7 possible use
at least for 4 main soil types

Lots of site-specific info -
or wide ranges with
high degree of conservatism

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

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

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

CHARACTERISATION:

Scale of contaminated area - survey
Likely radionuclides present, concentrations, distributions
Other contaminative processes and industries
Local background
Geology and hydrogeology
Soil types
Vegetation
Land-use
Population density
Living habits

Decision makers have to decide, from when and where sustainable management system is applied; deliberation of need, benefits and costs

NEED OF SOCIETY

RISK ASSESSMENT:

Source analysis
Environmental transport analysis
Dose and exposure analysis
Scenario analysis (likely)

SELECTION OF POSSIBLE MANAGEMENT OPTIONS
AGRICULTURE – LONG-TERM

Some important documents:

IAEA-TECDOC-1616: *Quantification of Radionuclide Transfer in Terrestrial and Freshwater Environments for Radiological Assessments, 2009*

ICRP publications : among them

Supporting guidance 5, 2007

Publication 103, 2007

Remediation of contaminated environment – edited by G. Voigt and S. Fesenko
Serie: Radioactivity in the environment, Volume 14, 2009

EC Radiation protection 122: Practical use of the concepts of clearance and exemption, Part I, 2000; Part II, 2001

Guidelines for soil description, FAO 2006, Rome

WHO – reference groups regarding the diet for the whole world


Thank you for your attention!