

IRSIN INSTITUT DE RADIOPROTECTION ET DE SÛRETÉ NUCLÉAIRE

Heterogenous distribution of radionuclides and external dosimetry

Faire avancer la sûreté nucléaire

Wildlife Dosimetry Workshop

Madrid 10-12 june 2014

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Context



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Exposure to soil/sediment

One of the simplifications applied in environmental dosimetry

1 single layer
=> homogeneous composition
=> homogeneous contamination





Description of media (soil/sediment) not realistic

Does it matter in terms of external exposure?



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How to deal with the question?

7 The example of the ERICA tool

- A given thickness for the soil/sediment layer, linked with...
- Two locations for the organism
 - At the surface
 - In the middle of the layer



7 Doesn't match with the reality

✓ Do we need for more flexible tools/approaches?





Assessors face such situations...

7 EMRAS II programme

STAR

U-238 activity (Bq/kg) 0.00E+00 5.00E+03 1.00E+04 1.50E+04 2.00E+04

Dubyna Lake Deep



Reaverlodge scenario » ideal to explore the effect on dose rates of a more realistic description of the exposure medium

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Scenarios under consideration



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The « Beaverlodge » scenario (1/3) ²³⁴Th profiles





Possibility to test the effect of the profile shape



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An increasing complexity

Organism on sediment



A : 1 single layer topped by a contaminated surface

Three locations for the organism:>On the sediment>In the sediment, at different depths

А







An increasing complexity



- A : 1 single layer topped by a contaminated surface
- B: 2 layers topped by a contaminated surface

Three locations for the organism:
>On the sediment
>In the sediment, at 2 different depths (in the middle of each layer)





An increasing complexity



Beaverlodge – Ace Bay

- A : 1 single layer topped by a contaminated surface
- B: 2 layers topped by a contaminated surface
- C: 7 layers, one for each measurement BAB







An increasing complexity



Beaverlodge – Ace Bay

- A : 1 single layer topped by a contaminated surface
- B: 2 layers topped by a contaminated surface
- C: 7 layers, one for each measurement BAB

Two organisms (different size and shape + lifestyle): >Insect larvae
>Benthic fish





An increasing complexity



- Possibility to test the organism effect (size and shape)
- Possibility to test the location effect / medium description
- \checkmark « Limitation » due to tool capacities (9 layers, EDEN V3)



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Other RN profiles

	Beaverlodge Ace Bay (BAB)					Dubyna Lake Deep (DLD)								
	²³⁸ U	²³⁴ Th ^a	²³⁴ U	²³⁰ Th	²²⁶ Ra	²¹⁰ Po	²¹⁰ Pb	²³⁸ U	²³⁴ Th ^a	²³⁴ U	²³⁰ Th	²²⁶ Ra	²¹⁰ Po	²¹⁰ Pb
				1150		1570	1570	47004	47004	46775			2980	3060
0-2 cm	6484	6484	6452	0	11500	0	0	1	1	7	1740	5480	0	0
	1741	1741	1732	3088		4216	4216						1134	1268
2-4 cm	4	4	9	6	30886	6	6	63010	63010	62704	1090	1840	0	0
	1377	1377	1370	2442		3334	3334							
4-6 cm	0	0	3	4	24424	4	4	18550	18550	18460	300	930	3600	5440
	1210	1210	1204	2146		2930	2930							
6-8 cm	3	3	4	7	21467	7	7							
8-10 cm	2631	2631	2618	4666	4666	6370	6370							
10-20 cm ^b	1662	1662	1653	2947	2947	4023	4023							
20-22 cm	692	692	688	1227	1227	1675	1675							
simplified description														
				1150		1570	1570	47004	47004	46775			2980	3060
Surface ^c	6484	6484	6452	0	11500	0	0	1	1	7	1740	5480	0	0
	1171	1171	1165	2077		2836	2836	47004	47004	46775			2980	3060
layer 1 ^d	2	2	5	3	20773	0	0	1	1	7	1740	5480	0	0
layer 2 ^e	1349	1349	1342	2392	2392	3266	3266	34188	34188	34022	572	1308	6389	8305

a: equilibrium with ^{234m}Pa /b: missing value estimated by the mean of adjacent layers/ c: 0-2 cm/ d: 2-8cm (BAB) 0-2 cm (DLD)/e: 8-22cm (BAB), 2-6 cm (DLD)

Possibility to test the RN effect (radiation nature, quantity)



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The soil scenario (1/2)

7 RN profiles

Srnick, M., Hrnecek, E., Steier, P., Wallner, A., Wallner, G., Bossew, P., 2008. Vertical distribution of 238Pu, 239(240)Pu, 241Am, 90Sr and 137Cs in Austrian soil profiles. Radioachim Acta 96, pp. 733-739.



- Possibility to test the effect of the profile shape
- Possibility to test the RN effect (radiation nature, quantity)





The soil scenario (2/2)

The same « extremum » concepts, applied to soil





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External dose rates



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Data set used for calculation

7 EDEN V3

Organisms

- Nature, shape and size: reference organisms ERICA/ RAPs ICRP
- Composition: FASSET/ERICA

Media

- Air, water, soil/sediment
- Composition: FASSET/ERICA
- Shape : semi-infinite layers

RNs

Nuclear data: JEF (OECD-NEA 1997)

Organism	Mass (kg)	X(cm)	Y(cm)	Z(cm)
Insect larva	1.77E-05	1.50E+00	1.50E-01	1.50E-01
Benthic fish	1.47E+00	5.00E+01	8.01E+00	7.01E+00
Bee	5.89E-04	2.00E+00	7.50E-01	7.50E-01
Rat	3.14E-01	2.00E+01	5.00E+00	6.00E+00
Earthworm	2.62E-02	1.00E+01	1.00E+00	1.00E+00





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Dose rates assessed for aquatic organisms



Dose rates assessed for aquatic organisms





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Dose rates assessed for terr. organisms







RN contribution / insect larva







RN contribution / insect larva

Site	ge Ace Bay	Dubyna Lake Deep			
Contamination	Heterogeneous	Homogeneous	Heterogeneous	Homogeneous	
On the sediment surface					
In the middle of the layer 1 In the middle of the layer 2	210Po	238U 234Th 234U 234U 230Th			





^{234m}Pa contribution / insect larva

	Site	Beaverlodg	Dubyna Lake Deep			
	Contamination	Heterogeneous	Homogeneous	Heterogeneous	Homogeneous	
	Without ²³⁴ mPa	210P0 238U 234Th 234U 234U 234U 230Th	210Pb			
<	With ²³⁴ mPa	234mPa				





Dose rate ratio heterogeneous vs homogeneous contamination





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Conclusions



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Some effects, but function of the case study?

A consistent set of observations

- Aquatic organisms
 - External dose rates impacted by sediment description (up to 10³)
 - Depends on sediment contamination (nature and location of RNs)
 - Depends on organism (size, shape and location)
- Terrestrial organisms
 - Less sensitive (due to case study?)
 - Depends on nature and location of RNs
 - Depends on organism characteristics





What to do about these effects?

In the context of the tiered ERA

- At the screening stage
 - Keep the usual simple approach, combined with the highest activity determined in the soil/sediment sample

For upper tiers

- A way to refine the assessment, toward a more realistic approach
- Need for adapted tools ...



