CASE STUDY

ENVIRONMENTAL RISK ASSESSMENT USING THE ERICA TOOL

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Problem based learning: Environmental risk assessment using the ERICA tool

BNEN – Advanced Course in Radiation Protection
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Examples for environmental risk assessment using the ERICA tool

(all data provided are example data and will only by chance reflect reality)

A river system is contaminated by a Nuclear Power Plant.
We have two series of data:

1. Predicted water concentrations downstream the discharge point for the period 1992 to 2007 (Table 1)
2. Measured environmental concentrations in river water, sediment and some biota for an upstream and downstream location for the year 2007 (Table 2)

We know hardly anything about the environment that may be affected. We know that the pH from river water is generally slightly alkaline. With respect to the affected ecosystems, the only information we have is that there are some protected fish species thriving in the river like Atlantic salmon (*Salmo solar* - pelagic fish), eel (*Anguilla angulla* – benthic fish) and bullhead (*Cottus gobio gobio* – benthic fish).

The terrestrial environment is unlikely to be affected but every ten years the river sediments are dredged and put on the river borders.
There are some natural reserves in the vicinity of the river where badge, the bird stonechat and the bat are protected species.

Tables 3a and 3b give some info about the characteristics of mentioned protected species.

What should you do?

1. Perform a Tier 1 impact assessment for the aquatic ecosystems based on the predicted environmental concentrations. Remember that in Tier 1 assumptions are conservative.
2. If required (it will be) perform a Tier 2 impact assessment for aquatic and terrestrial ecosystems based on the predicted environmental concentrations using as much as possible available information
3. Perform a Tier 2 impact assessment based on the measured environmental concentrations (Table 2). What sensible assessments could one make?
4. Make an assessment in 2007 for a natural reserve situated 500 m downstream from the river discharge point and on the same riverbank to that of the discharge point, using the ERICA river model. You will have to deduce the flow rate, and from the concentrations measured, the discharge rates for the relevant radionuclides.

Table 1: Water concentrations predicted (Bq/m³)

	Water concentrations, Bq/m³																Bq/m³
Year	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**	**2001**	**2002**	**2003**	**2004**	**2005**	**2006**	**2007**	**Average**
Ag-110m	0.0	18.7	15.5	16.4	24.0	16.6	14.1	8.3	11.4	26.6	22.2	19.0	18.5	11.5	10.7	8.5	15
Am241	0.2	0.4	5.0	1.0	0.3	3.5	0.1	0.2	0.1	0.4	0.1	0.5	1.5	2.5	10.0	7.5	2
Co60	23.2	16.8	11.4	8.8	42.5	10.5	7.7	6.4	6.3	8.8	9.6	8.5	13.9	8.7	17.0	10.2	13
Cs134	8.0	7.0	5.2	0.8	3.6	2.1	1.2	0.5	0.3	0.5	1.6	5.9	10.4	3.9	5.3	2.8	4
Cs137	11.5	9.7	7.2	2.5	6.2	3.8	5.2	1.4	1.7	2.1	2.9	5.7	10.5	6.3	10.1	5.1	6
Fe55	0.00	0.42	0.28	0.22	1.06	0.26	0.19	0.16	0.16	0.22	0.24	0.21	0.35	0.22	0.42	0.25	0.31
H3	59333	58733	64291	68743	74558	78814	54816	111026	55095	68416	99333	72500	75833	76667	73500	95167	74177
Nb95	5.0	12.1	3.4	5.5	21.0	5.1	3.3	3.6	4.7	18.8	8.3	6.4	9.3	5.3	4.2	12.2	8
Sr89	0.0	3.9	2.9	1.0	2.5	1.5	2.1	0.6	0.7	0.8	1.2	2.3	4.2	2.5	4.1	2.0	2
Sr90	0.0	1.9	1.4	0.5	1.2	0.8	1.1	0.3	0.3	0.4	0.6	1.2	2.1	1.3	2.0	1.0	1

Table 2: Environmental concentrations (measured)

	UPSTREAM				DOWNSTREAM		
	sediment Bq kg^{-1}	**mosses** Bq kg^{-1} FW	**waterplant** Bq kg^{-1} FW	**Dreissena** Bq kg^{-1}	**sediment** Bq kg^{-1}	**mosses** Bq kg^{-1} FW	**waterplant** Bq kg^{-1} FW
Ag-110m	10				51	5	
I-131	335				271		
Cs-137	23	10	0.83		42	4	
Ra-226	84	163	2.25	2.18	101	53	4.75
Ra-228	62	153	4.25	3.25	70	58	5.25
Th-228	48	23	0.90	0.90	62	14	3.50
Co-58					267	102	
Cs-134					24	2	

Table 3a: dimensions of the aquatic protected species

	Dimensions				Occupancy factor				
	M (kg)	A(cm)	B(cm)	C(cm)	Sediment In	Sediment On	Water In	Water On	
Bullhead	2.62E-04	2.00E+00	5.00E-01	5.00E-01		1			
Anguilla angulla	1.57E+01	1.00E+02	2.00E+01	1.5E+01		1			
Atlantic salmon	1.57E+01	1.00E+02	2.00E+01	1.5E+01			1		

Table 3a: dimensions of the terrestrial protected species

Reference organism – Terrestrial ecosystem	Dimensions				Occupancy factor			
	M (kg)	A(cm)	B(cm)	C(cm)	In air	On soil	In soil	
Badger	1.00E+01	4.70E+01	1.8E+01	1.8E+01		0.2	0.8	
Stonechat, sedge warbler (very small bird)	1.50E-02	6.0E+00	2.20E+00	1.80E+00	0.5	0.5		
Flying mammal (bat)	1.50E-02	6.0E+00	2.20E+00	1.80E+00	0.5	0.5		

Additional tables

Table A1: Water concentrations

	Water concentrations		
	Bq/m³	**Bq/l**	**Bq/l**
	Max	**Max**	**Average**
Ag-110m	27	0.027	0.015
Am241	10	0.010	0.002
Co60	43	0.043	0.013
Cs134	10	0.010	0.004
Cs137	10	0.010	0.006
Fe55	1.06	0.00106	0.0003
H3	111026	111.026	74.177
Nb95	21	0.021	0.008
Sr89	4	0.004	0.002
Sr90	2	0.002	0.001

Table A2: Sediment/soil concentrations

	Bq/kg sediment
	Average
Ag-110m	1.32E+03
Am241	1.76E+03
Co60	2.23E+03
Cs134	5.90E+01
Cs137	9.20E+01
Fe55	3.10E+02
H3	7.41E+01
Nb95	4.00E+00
Sr89	1.87E-01
Sr90	9.37E-02

Table A3: Kd values for slightly alkaline environments

	pH 7 - 8	
	Kdw(l/kg)	Kdw (m3/kg)
Co-60	1.70E+05	1.70E+02
Co-58	1.70E+05	1.70E+02
Sr-89	9.30E+01	9.30E-02
Sr-90	9.30E+01	9.30E-02
Nb-95	5.00E+02	5.00E-01
Cs-134	1.60E+04	1.60E+01
Cs-137	1.60E+04	1.60E+01
Fe55	1.00E+04	1.00E+01
Ag-110m	8.30E+04	8.30E+01
Am-241	8.50E+05	8.50E+02
H-3	1.00E+00	1.00E-03

Table A4: CR-values for Fe: own literature search

Fe-CR									
Reference	**Ecosysten**	**Species g**	**Species c**	**Latin nam**	**Organ**	**CF (Bq/kg**	**FW/Bq/L**	**AM**	**GM**
Poston an	Freshwate	Fish	FISH		muscle	100	ALL	951.8571	502.8765
Poston an	Freshwate	Fish	FISH		muscle	100	MUSCLE	261.1111	230.1963
Poston an	Freshwate	Fish	Yellow perch		muscle	190	WHOLE F	1966.667	1871.219
Poston an	Freshwate	Fish	piscivorous fish		muscle	250			
Poston an	Freshwate	Fish	Coho salmon		muscle	260			
Poston an	Freshwate	Fish	Lake trout		muscle	270			
Poston an	Freshwate	Fish	Brown trout		muscle	280			
Poston an	Freshwate	Fish	Whitefish		muscle	360			
Poston an	Freshwate	Fish	FISH		muscle	540			
Poston an	Freshwate	Fish	Spottail shiner		whole fish	1300			
Poston an	Freshwate	Fish	planktivorous fish		muscle	1600			
Poston an	Freshwate	Fish	Smelt		whole fish	1800			
Poston an	Freshwate	Fish	Alewife		whole fish	2800			
Coetzee, L	Freshwate	Fish			Gills	3476	took max value from Table 9; va		
						CF (Bq/kg dry weight / Bq/kg soil)			
IAEA TRS 472		Pasture			upper part	0.002			

Table A5: Origin of assigned concentration ratios (CR) for Fe for considered reference organisms in terrestrial ecosystems

Reference Organisms	**CR-Fe**	
Amphibian	0.00738	ERICA value for Co
Annelid	0.2665	ERICA value for Co
Arthropod-detritivorous	0.2665	ERICA value for Co
Bird	0.00337	ERICA value for Co
Flying insect	0.0737	ERICA value for Co
Grasses & Herbs	0.002	TRS 472
Lychen & briophytes	0.0801	ERICA value for Co
Mammal - large	0.0574	ERICA value for Co
Mammal - small burrowing	0.0574	ERICA value for Co
Mollusc - gastropod	0.2665	ERICA value for Co
Reptile	0.019	ERICA value for Co
Shrub	0.0136	ERICA value for Co
Mammal (Badger)	0.0574	ERICA value for Co
Mammal (Bat)	0.0574	ERICA value for Co
Very small bird (stonechat)	0.00337	ERICA value for Co

Table A6: Origin of assigned concentration ratios (CR) for Fe for considered reference organisms in aquatic ecosystems

Reference organism	**CR-Fe**	
Amphibian	210.0	ERICA 2.0 value for Co
Benthic fish	1870.0	own compilation
Bird	389.8	ERICA 2.0 value for Co
Crustacean	1875.0	ERICA 2.0 value for Co
Insect larvae	4685.0	ERICA 2.0 value for Co
Mammal	389.8	ERICA 2.0 value for Co
Mollusc - bivalve	4685.0	ERICA 2.0 value for Co
Mollusc - gastropod	4685.0	ERICA 2.0 value for Co
Pelagic fish	1870.0	own compilation
Phytoplankton	564.0	ERICA 2.0 value for Co
Reptile	11.73	ERICA 2.0 value for Co
Vascular plant	927.0	ERICA 2.0 value for Co
Zooplankton	4685.0	ERICA 2.0 value for Co

Note This table has been updated from previous years' courses due to update of ERICA to version 2.0, meaning that default values for Co gave slightly changed with the updating of the ERICA database.