IRSN
INSTITUT
DE RADIOPROTECTION
ET DE SÛRETÉ NUCLÉAIRE

Enhancing nuclear safety

Epistemological analysis of uncertainties in environmental assessment models

Uncertainties and decision-making in the early and intermediate phases of nuclear or radiological emergencies

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MEMBRE DE
ETSON
EUROPEAN TECHNICAL SAFETY ORGANISATIONS NETWORK

Models in radiological impact assessment

Modelling chain

- Source-term
- Radionuclide dispersion
- Radionuclide transfer
- Exposure / dose
- Impact and risk

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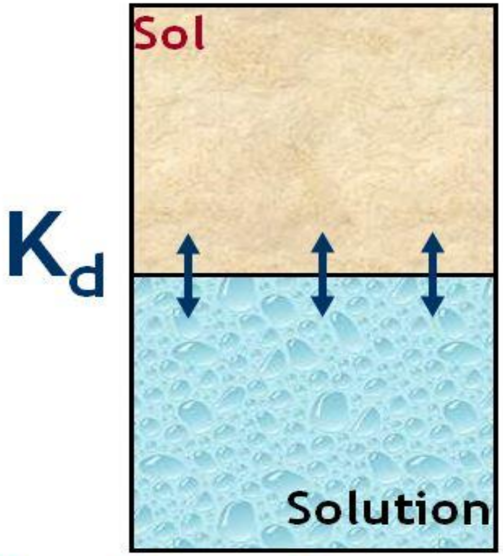
Models in radiological impact assessment

Distribution coefficient K_d

- A key-parameter easy to use
- Macroscopic phenomenological coefficient
- Values in databases (IAEA)
- Variation range : 6 orders of magnitude
- **Main source of uncertainty**



$K_d = C_{solide} / C_{solution}$

Models in radiological impact assessment

TABLE IX. PARTITION COEFFICIENT K_D OF RADIONUCLIDES IN SOILS (L/Kg) [37]

Nuclide	Soil type							
	Sand		Loam		Clay		Organic	
	Expected	Range	Expected	Range	Expected	Range	Expected	Range
Ac	4.5×10^2		1.5×10^3		2.4×10^3		5.4×10^3	
Ag	9.0×10^1	$2.5\times10^0 - 3.3\times10^3$	1.2×10^2	$1.3\times10^1 - 1.1\times10^3$	1.8×10^2	$8.1\times10^1 - 4.0\times10^2$	1.5×10^4	$2.4\times10^3 - 8.9\times10^4$
Am	2.0×10^3	$1.1\times10^1 - 2.6\times10^5$	9.9×10^2	$6.0\times10^2 - 1.6\times10^5$	8.1×10^3	$4.5\times10^1 - 1.5\times10^6$	1.1×10^5	$3.6\times10^3 - 3.3\times10^6$
Be	2.4×10^2		8.1×10^2		1.3×10^3		3.0×10^3	
Bi	1.2×10^2		4.0×10^2		6.7×10^2		1.5×10^3	
Br	1.5×10^1		4.9×10^1		7.4×10^1		1.8×10^2	
Ca	9.0×10^0		3.0×10^1		4.9×10^1		1.1×10^2	
Cd	7.4×10^1	$3.7\times10^0 - 1.5\times10^3$	4.0×10^1	$1.6\times10^0 - 9.9\times10^2$	5.4×10^2	$9.0\times10^1 - 3.3\times10^3$	8.1×10^2	$8.2\times10^0 - 8.1\times10^4$
Ce	4.9×10^2	$2.0\times10^1 - 1.2\times10^4$	8.1×10^3	$4.0\times10^2 - 1.6\times10^5$	2.0×10^4	$7.3\times10^3 - 5.4\times10^4$	3.0×10^3	
Cm	4.0×10^3		1.8×10^4	$4.4\times10^3 - 7.3\times10^4$	5.4×10^3		1.2×10^4	
Co	6.0×10^1	$2.2\times10^{-1} - 1.6\times10^4$	1.3×10^3	$9.9\times10^1 - 1.8\times10^4$	5.4×10^2	$1.5\times10^1 - 2.0\times10^4$	9.9×10^2	$4.9\times10^1 - 2.0\times10^4$
Cr	6.7×10^1	$1.0\times10^0 - 4.4\times10^3$	3.0×10^1	$9.1\times10^{-2} - 9.9\times10^3$	1.5×10^3		2.7×10^2	$1.2\times10^0 - 6.0\times10^4$
Cs	2.7×10^2	$1.8\times10^0 - 4.0\times10^4$	4.4×10^3	$3.3\times10^2 - 6.0\times10^4$	1.8×10^3	$7.4\times10^1 - 4.4\times10^4$	2.7×10^2	$2.0\times10^{-1} - 3.6\times10^5$
Fe	2.2×10^2	$1.2\times10^0 - 4.0\times10^4$	8.1×10^2	$2.0\times10^2 - 3.3\times10^3$	1.6×10^2	$6.7\times10^0 - 4.0\times10^3$	4.9×10^3	
Hf	4.5×10^2		1.5×10^3		2.4×10^3		5.4×10^3	
Ho	2.4×10^2		8.1×10^2		1.3×10^3		3.0×10^3	
I	1.0×10^0	$1.3\times10^{-2} - 8.5\times10^1$	4.5×10^0	$8.2\times10^{-2} - 2.4\times10^2$	1.8×10^2	$8.2\times10^{-2} - 3.3\times10^1$	2.7×10^1	$5.0\times10^{-1} - 1.5\times10^3$
Mn	4.9×10^1	$3.0\times10^0 - 8.1\times10^2$	7.2×10^2	$4.1\times10^0 - 1.3\times10^5$	1.8×10^2	$3.3\times10^0 - 9.9\times10^3$	4.9×10^2	
Mo	7.4×10^0	$8.2\times10^{-1} - 6.7\times10^1$	1.3×10^2		9.0×10^1	$8.2\times10^0 - 9.9\times10^2$	2.7×10^1	$1.0\times10^1 - 7.4\times10^1$
Nb	1.6×10^2		5.4×10^2		9.0×10^2		2.0×10^3	
Ni	4.0×10^2	$2.0\times10^1 - 8.1\times10^3$	3.0×10^2		6.7×10^2	$1.6\times10^2 - 2.7\times10^3$	1.1×10^3	$1.8\times10^2 - 6.6\times10^3$
Np	4.1×10^0	$1.4\times10^{-1} - 1.2\times10^2$	2.5×10^1	$2.2\times10^0 - 2.7\times10^2$	5.5×10^1	$2.7\times10^{-2} - 1.1\times10^5$	1.2×10^3	$5.4\times10^2 - 2.7\times10^3$

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➚ However, the K_d approach remains dominant

Why is the K_d approach the dominant one?

Practical and social legitimacy

- Weak computational cost and easy-to-use
- Already existing infrastructures
- Political and technical influence of the IAEA
- Consensus among the vast users community

Why is the K_d approach the dominant one?

Functions and usages of a model

- First developped as decision models
- Then used for research activities
- Confusion in the epistemic status of the K_d, leading to tensions
- Conceptual drift

Why is the K_d approach the dominant one?

↗ Models, science and representation of the world

- Divergence on a metaphysical level
- Instrumentalism (Dewey)
- Antirealism (Duhem)
- Scientific realism

Level of analysis

Functions and usages of a model	**Practical and social legitiacy**	**Different worldviews**
Conceptual history of the development and use of models	Political and institutionnal context	Role of the modelling agents