Dose Assessments Uncertainties for NORM Management in Conventional Hazardous Waste Disposals

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Introduction:

- ***Almost every industrial process produces wastes.***

- **Gaseous and liquid wastes are out of the scope of this work.**

- According to Spanish regulation a **characterization of physical and chemical properties of solid materials must be carried out**.

- A **minimization** of those wastes by recycling or other techniques as incineration should be regarded.

- **Categorization of solid wastes** according to their content in organic or inorganic toxics must be carried out.

- Industrial solid waste can be disposed in **two kind of landfills** according to the content in toxics **(NORM were not considered):**
  - **Hazardous**
  - **Non hazardous**

What if they areNORM wastes?

- ***Characterization of wastes should include radioactivity.***

- **Below Exemption levels** → minimization by recycling or other should be considered

- After minimization, categorization of wastes according to the content in organic toxics, inorganic toxics **or radioactivity** should be carried out.

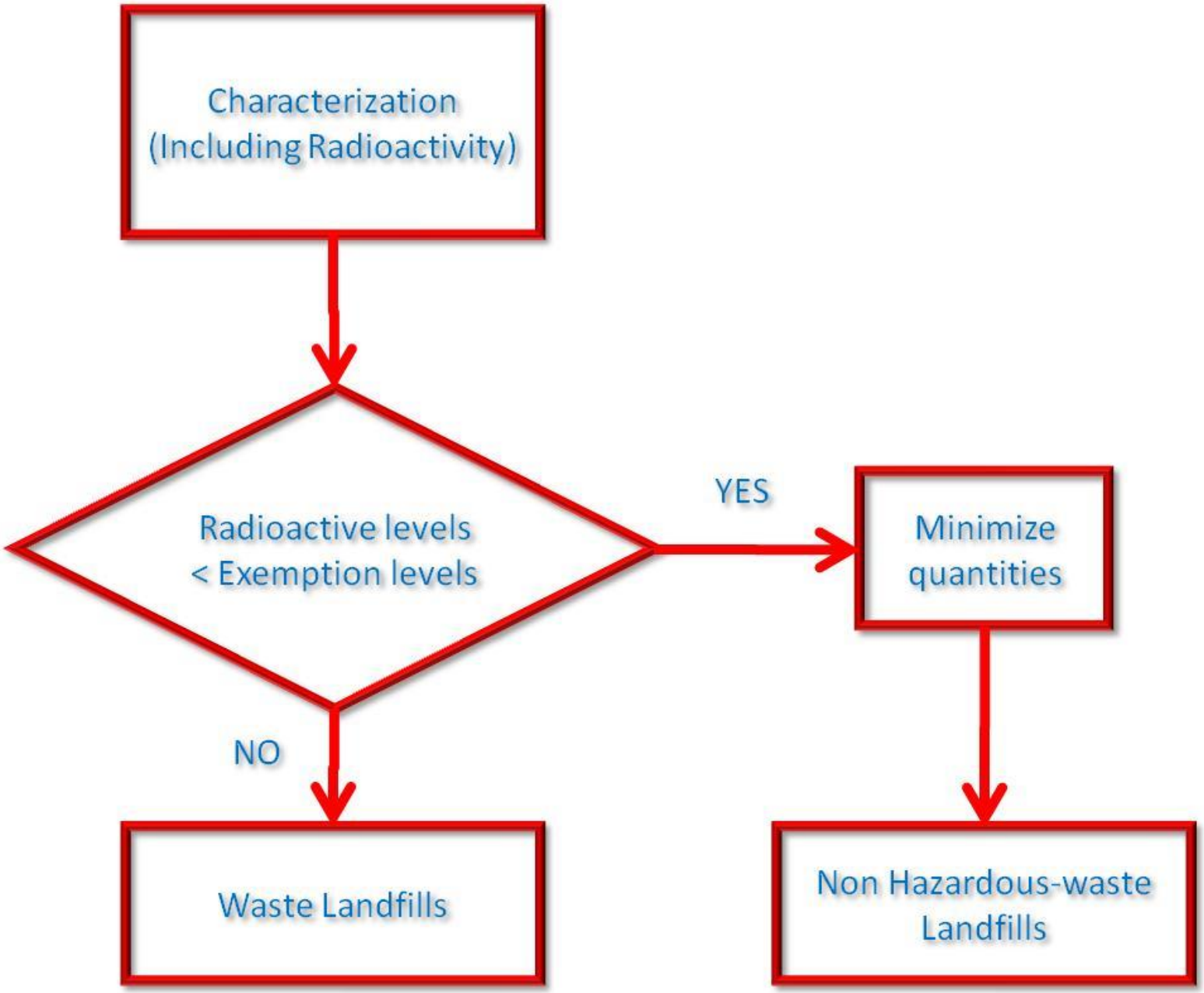
- What level of radioactivity define whether a waste should be considered **toxic** or not? → > 10 Bq g-1 (?)

- What level of radioactivity define whether a waste should be considered **"more than toxic"** or just toxic? → > 50 Bq g-1 (rad-was-surf-disp?)

- Other studies[1,2] support this categorization. But: What are the **quantities** to be managed in each type of disposal?

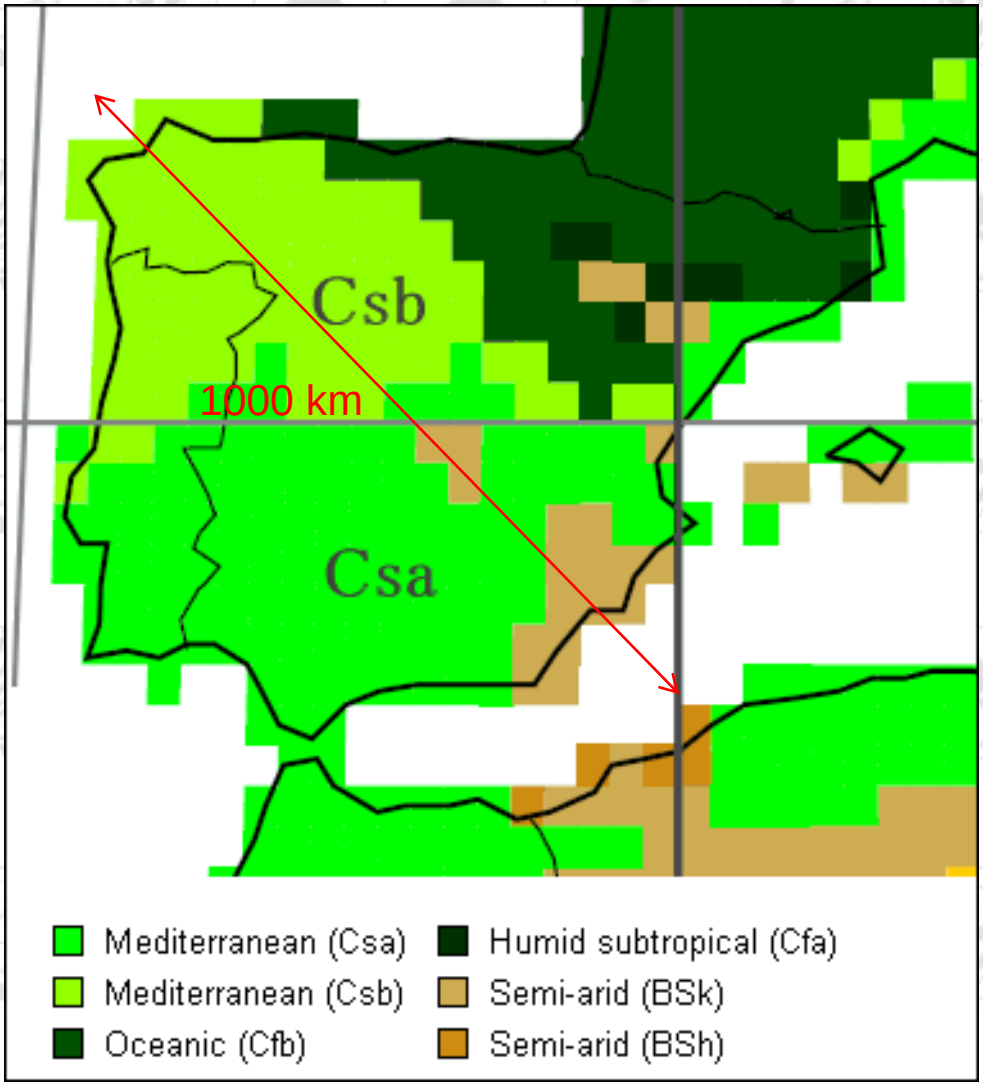
1- T. Anderson & S. Mobbs, HPA-CRCE-001. 2010

2- S. Pepin et. al, 4th EAN-NORM Workshop. 2011,


Characterization
(Including Radioactivity)
Radioactive levels
< Exemption levels
YES
Minimize
quantities
NO
Waste Landfills
Non Hazardous-waste
Landfills

Hypothesis of the study:

- ***Generic study (it should cover all the Spanish conditions)***



Precipitation rate

Temperature

Irrigation rate

Occupancy factors

Hypothesis of the study:

- **Limit is established with the more enriched radioisotope. The rest assumed to be in the same concentration as that one.**

Ref.	Process material	Radionuclide activity concentration (Bq/g)							
		U-238 series					Th-232 series		
		U-238	Th-230	Ra-226	Pb-210	Po-210	Th-232	Ra-228	Th-228
[51, 78, 82]	Baddeleyite feedstock	7		7	7	7	0.3	6	2
	Zirconia product	7		7	7	7	0.3	6	2
[51, 78, 82]	Furnace DCF	3		3	200	600	0.5	8	3
[79]	Baddeleyite feedstock	9.5	1.3	10	10	3.7	0.3	2	0.4
[79]	Zirconia product	8	1	10	10	3.0	0.3	2	0.5
[79]	Furnace DCF	16	2.5	30	200	600	1.8	11	3.6

3- IAEA. SRS-51. Radiation protection and norm residue management in the zircon and zirconia industries. 2007.

Hypothesis of the study:

- **No isotopic separation or previous treatment** is assumed. Proportion U238:Th232:U235:K40 = 1:1:0.05:10
- Design of landfills defined in Spanish regulation

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Layer #	Non-Hazardous waste		Hazardous waste	
	W (m)	K (m s^{-1})	W (m)	K (m s^{-1})
1	> 1	-	> 1	-
2	-	-	-	-
3	> 0.3	-	> 0.3	-
4	High-density polyethylene (HDPE) or Polypropylene (PP)			
5	Non used		> 1	< 10^{-9}
6	> 0.5	-	> 1	-
7	Waste (width fixed in this study)			
8	> 0.5	-	> 0.5	-
9	High-density polyethylene (HDPE) or Polypropylene (PP)			
10	> 0.5	< 10^{-9}	> 0.5	< 10^{-9}
11	> 1	< 10^{-9}	> 5	< 10^{-9}

- Homogeneity in characteristic of the waste

Dose assessment:

- Exposure scenarios maximized:
  - **Workers** in the landfill (60 y)
  - **Residential on** the landfill (1000-1500 y)
- Radon excluded
- RESRAD (onsite)
- Pathways: external, immersion, inhalation and ingestion of soil and vegetables.
- Dose constraint for public and workers → 1 mSv a-1. (additionally 6 mSv a-1 was considered for workers).
- Distribution for each parameter and distributions from bibliography[4] and local values.

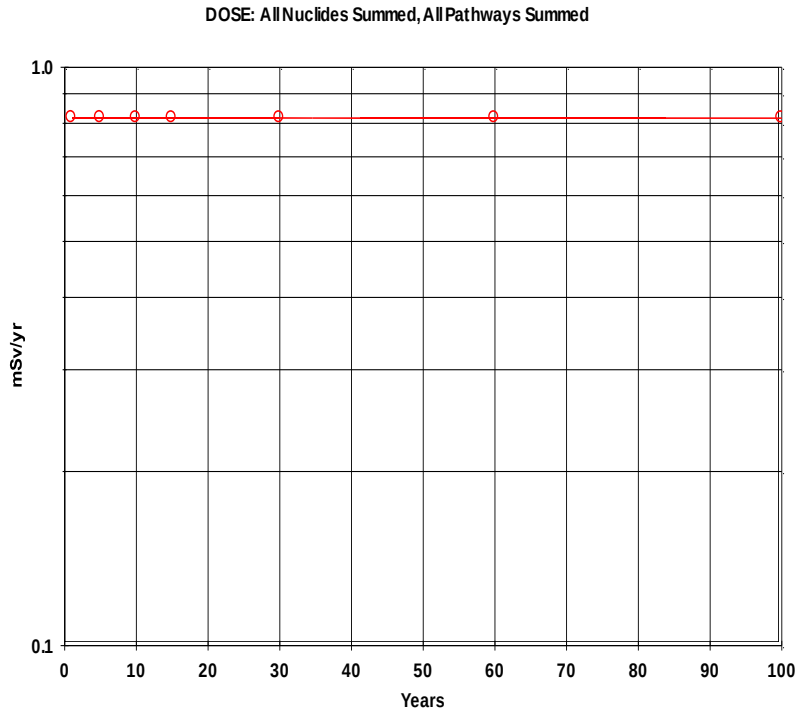
4- NUREG/CR-6692, ANL/EAD/TM-91. USNRC. 2000.

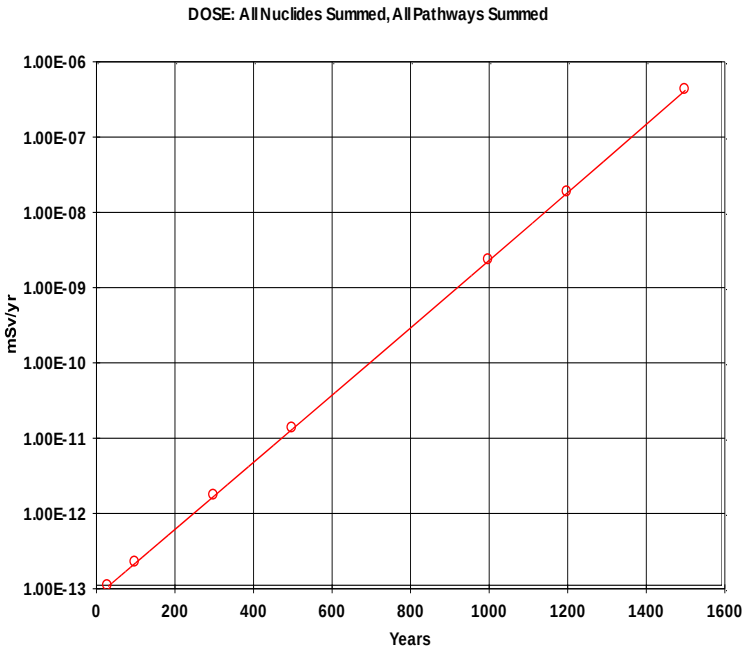
Parameter	Deterministic	Minimum	Maximum	Distribution
Soil ingestion (w) g a-1	73	-	-	-
Soil ingestion (p) g a-1	3.65	0.37	110	Lognorm
Dust loading mg m-3	0.1	0.001	12	Lognorm
Precipitation m a-1	0.222	0.222	2.86	Unif
Wind velocity m s-1	1	1	2	Lognorm
Evapotranspiration m a-1	1.16	0.5	1	Unif
Irrigation m a-1	1	0	1	Unif
Soil density g cm-3	1.62	1.1	1.6	Normal
Waste density g cm-3	3.3	1.1	3.3	Normal
Erosion rate (p) m a-1	3.1E-4	-	-	-
Erosion rate (w) m a-1	0	-	-	-
Runoff coefficient	0.2	0.2	0.4	Unif
Hydraulic cond. waste m a-1	1000	10	1000	Lognorm
Occup. Time (w)	0.05	-	-	-
Occup. Time (p) outdoor	0.2	0.2	0.7	Unif
Shielding (w) mm	2	0	5	Unif
Waste width m	2.5	0	2.5	Normal

Mass to be disposed:

Results:

- ***Effective doses for the workers and the public.***





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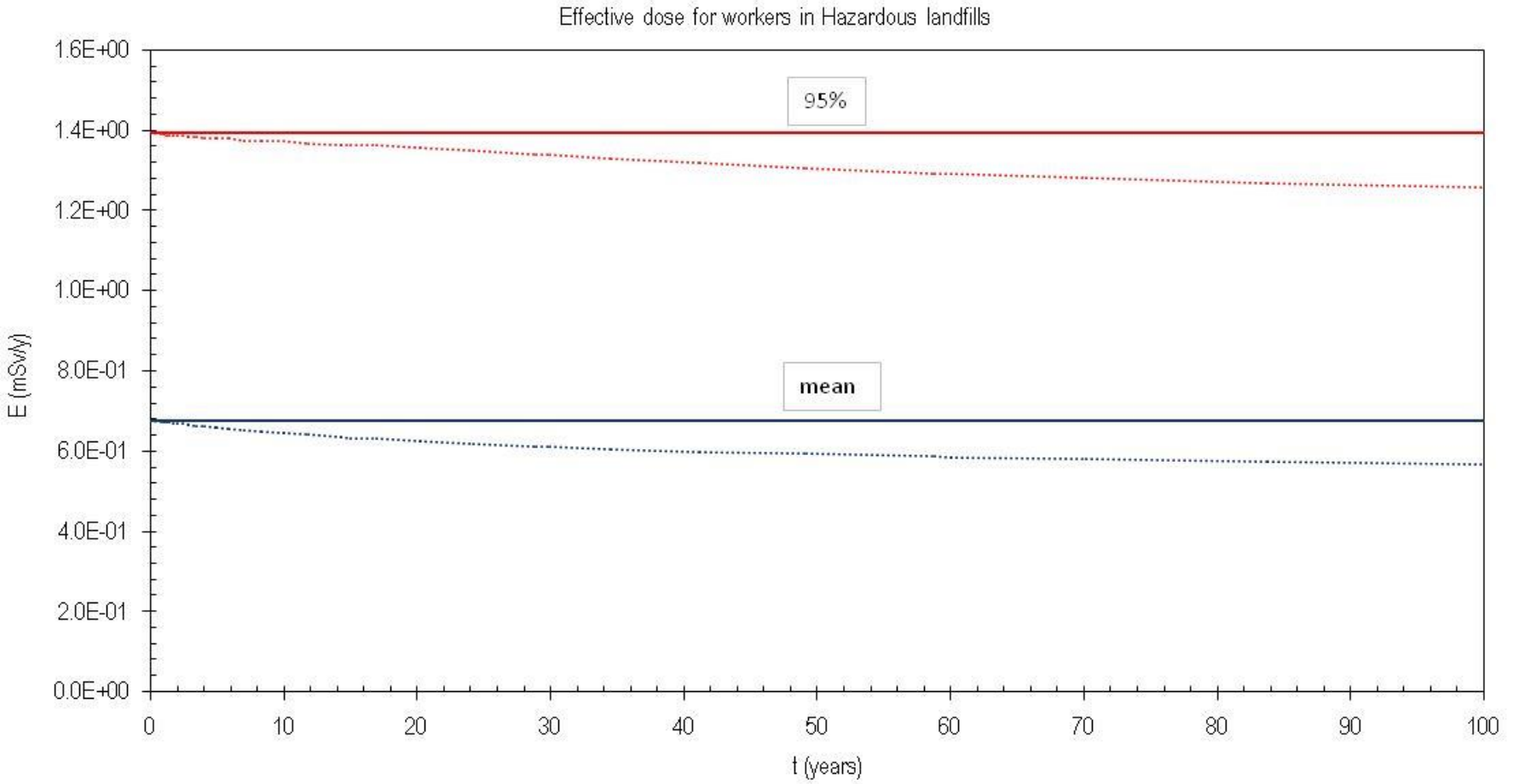

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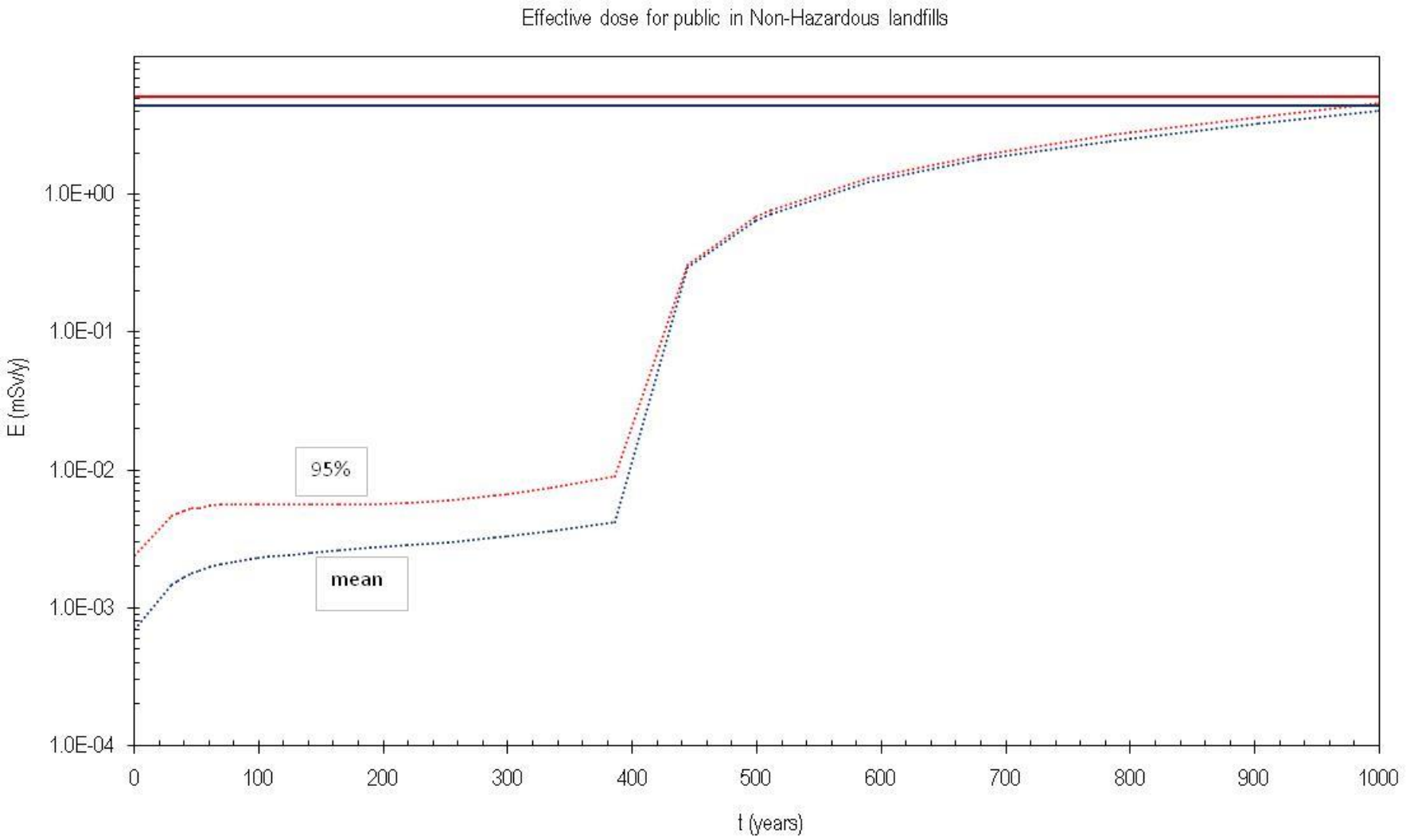

Sensitivity of the parameters (workers scenario)

RESRAD Regression and Correlation output

Variable
Mass loading for inhalation
Cover depth
Wind Speed
Thickness of contaminated zone
Precipitation
Evapotranspiration coefficient
Contaminated zone hydraulic conductivity
Density of contaminated zone
Irrigation

Sensitivity of the parameters (public scenario)

RESRAD Regression and Correlation output

Variable
Density of cover material
Density of contaminated zone
Contaminated zone erosion rate
Contaminated zone hydraulic conductivity
Evapotranspiration coefficient
Wind Speed
Precipitation
Irrigation
Runoff coefficient
Mass loading for inhalation
Indoor time fraction
Outdoor time fraction
Soil ingestion

Results:

- ***Masses to be disposed in the landfills.***

Hazardous wastes landfill				
	(20 m)		(55 m)	
	Allowed dose for the workers			
	1 mSv a^{-1}	6 mSv a^{-1}	1 mSv a^{-1}	6 mSv a^{-1}
10 Bq g^{-1}	7.2×10^{4}	4.3×10^{5}	2.0×10^{5}	1.2×10^{6}
50 Bq g^{-1}	1.5×10^{4}	9.0×10^{4}	4.0×10^{4}	2.4×10^{5}

Results:

- ***Masses to be disposed in the landfills.***

Non-hazardous waste landfills		
	(20 m)	(55 m)
	Residential scenario (1 mSv a^{-1})	
10 Bq g^{-1}	1.4×10^{4}	3.8×10^{4}
50 Bq g^{-1}	2.7×10^{3}	7.7×10^{3}

Conclusions:

- Results cover possible situations in Spain and offer solidity among them and with other studies.
- Uncertainty calculation shows possible variations in the results not greater than a factor of:
  - 1.7 in the case of workers (Hazardous disposals)
  - 1.2 in the case of public (non-hazardous disposals)
- More accuracy can be achieved in this calculation however.
- More sensitive parameters were:
  - mass loading for workers.
  - density of materials for public.
- Erosion factor alters greatly the validity of the model in the case of non-hazardous waste disposals.
- Case by case studies would raise the quantities to be disposed.

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Thank you!

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