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Clearance of surface-contaminated objects from the controlled area of a nuclear facility:

Application of the SUDOQU methodology

BEL V

National Institute for Public Health and the Environment
Ministry of Health, Welfare and Sport

EUROSAFE 2017

Outline

- Introduction
- Objectives and methodology
- Results
- Benchmarking study
- Conclusions

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Introduction – *Context*

- March, 2011: Fukushima nuclear accident
  - Possibly surface-contaminated consumer goods imported in Europe
  - Need for rapid screening and surface-contamination level assessment

Note: the picture is just for illustration purposes, and does not represent a ship concerned in the investigation

- Lack of robust dose-assessment models for members of the public
- RIVM develops the SUDOQU methodology

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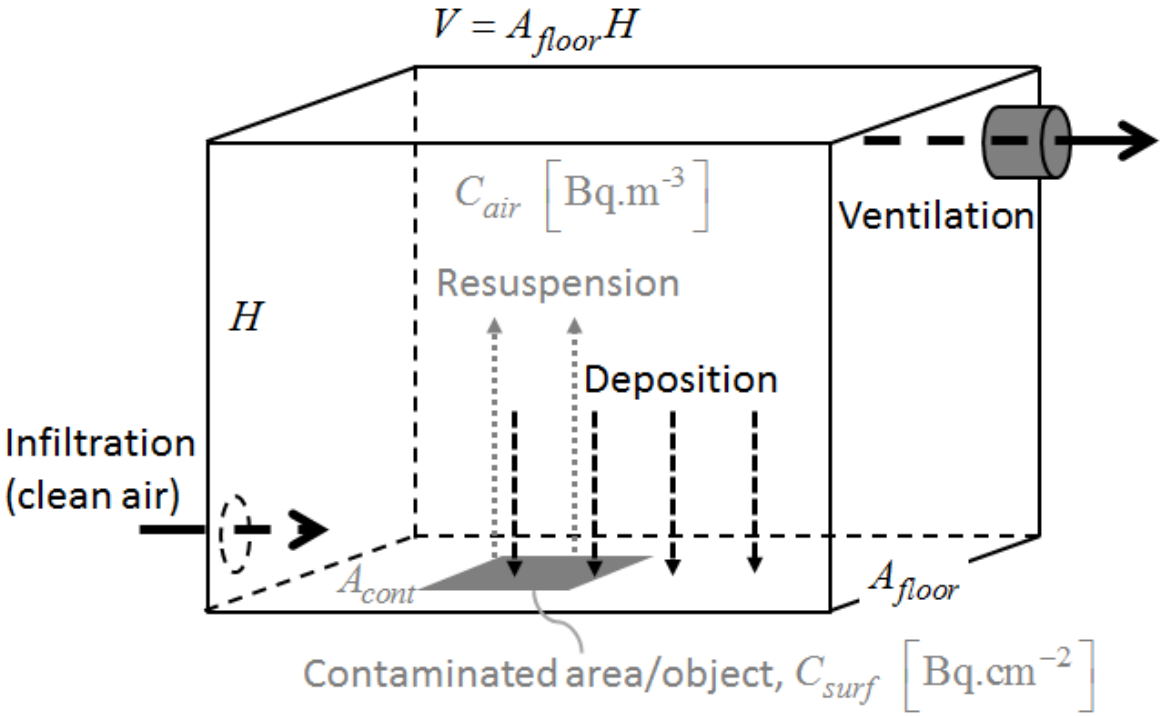
Introduction – *SUDOQU methodology*

S	U	D
R	Q	O
I	V	M

Based on the assumption of a non-constant surface activity, influenced by removal (radioactive decay, resuspension, wipe-off) and deposition mechanisms



Source: Presentation RIVM

Introduction – *Collaboration Bel V-RIVM*

- Belgian Regulation: Lack of surface clearance levels
- Commonly used levels:
  - 0.4 Bq/cm^2 / 1 Bq/cm^2 (β-γ)
  - 0.04 Bq/cm^2 / 0.1 Bq/cm^2 (α)

- Objective of the collaboration
  - Use of SUDOQU for the derivation of nuclide-specific surface-clearance levels based on conservative scenarios for a Belgian context

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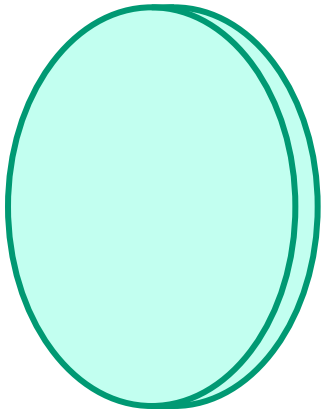
Objectives and methodology

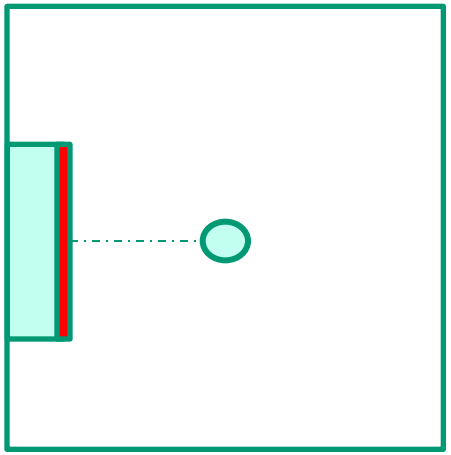
- Evaluation of the SUDOQU applicability for clearance calculations
- Deterministic dose calculations for exposure to a surface-contaminated office item: Bookcase

Geometry: *Circular shape*
Dimensions: *6 m²*
Contamination: *1 Bq/cm² (only front panel)*
Receptor: *Office worker (5 d/w, 8 h/d)*



Objectives and methodology – *Scenarios*

- Reference scenario
  - External irradiation:
    - *Distance = 3 m*
  - Inhalation:
    - *Air exchange rate = 0.5 h^{-1}*
    - *Resuspension rate = 1E-04 h^{-1}*
  - Skin dose (wipe off):
    - *Area of the hands = 400 cm^2*
    - *Wipe-off efficiency (f_{oth}) = 0.2*
    - *Wipe off-frequency (ϕ) = 0.313 h^{-1}*
    - *Area of the face = 100 cm^2*
  - Ingestion:
    - *Ingestion frequency = Wipe-off frequency*
    - *Ingestion fraction (f_{ing}) = 0.01*
    - *Fraction hands to mouth (f_{htm}) = 1*



Objectives and methodology – *Scenarios*

- Alternative scenarios

Scenario #	Varied parameter (wrt ref. Scenario 1)
01	*Reference scenario*
02	*Distance* ↗
03	*Wipe frequency* ↗
04	*Wipe Efficiency* ↘
05	*Wipe Efficiency* ↘↘
06	*Time* ↘

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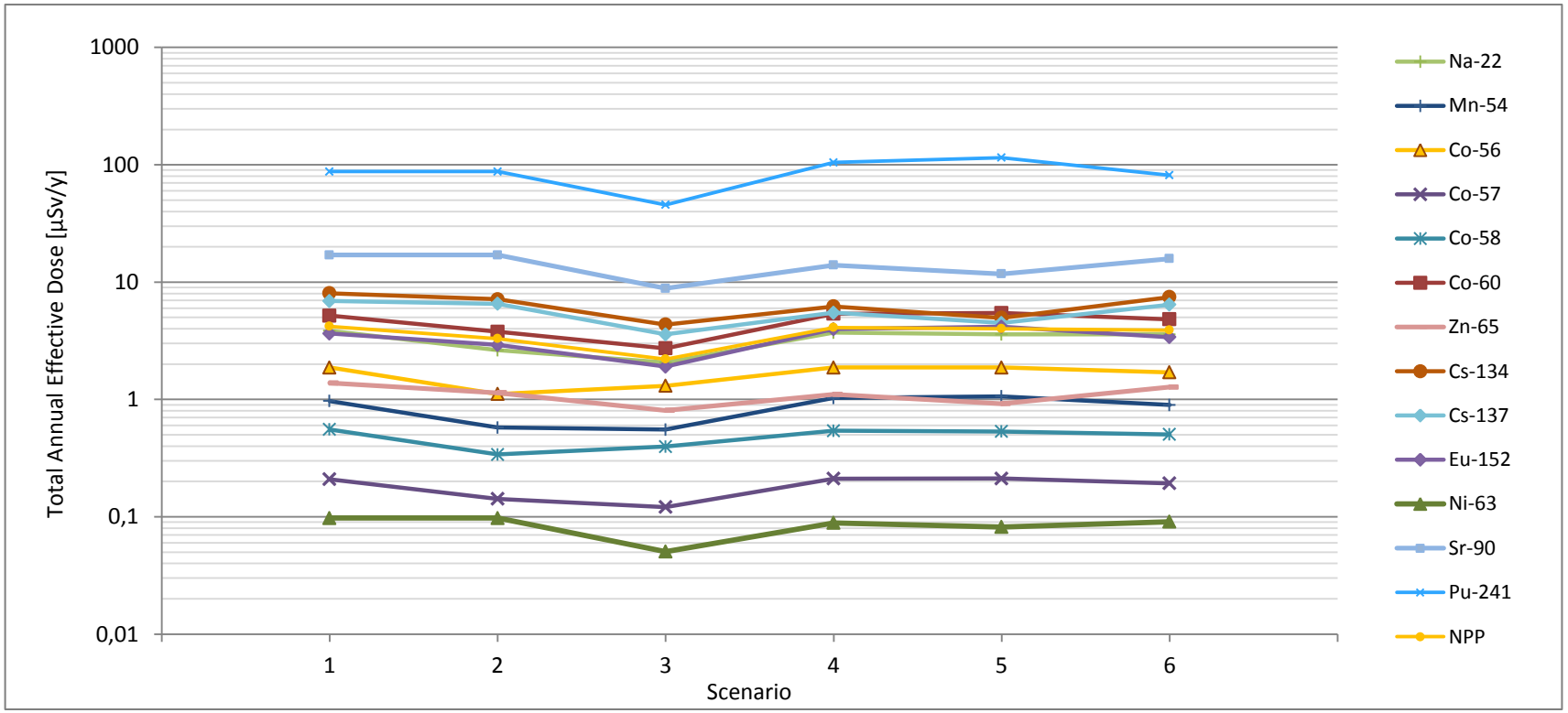
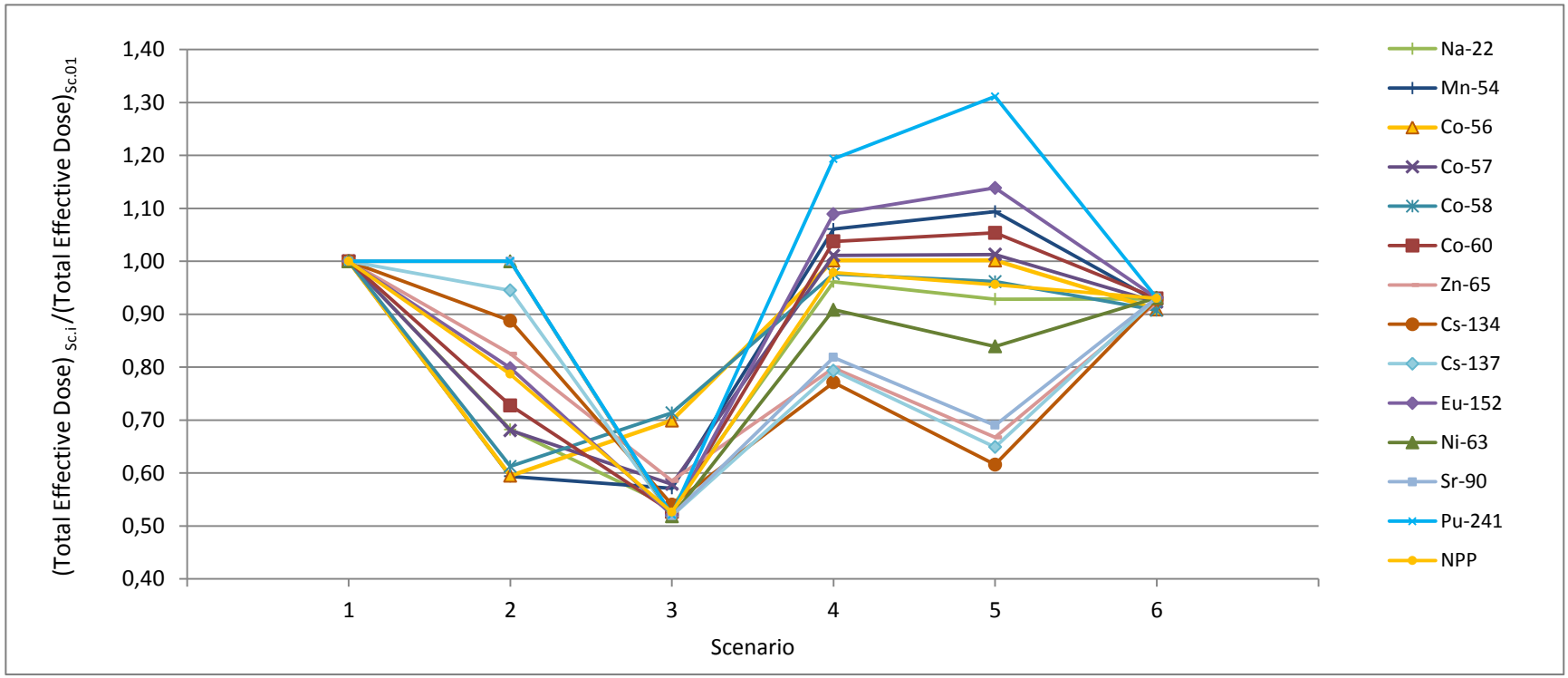
Results – *Absolute dose values*



- Absolute dose values are isotope-specific
- Pu-241 and Sr-90 exceed the 10-µSv/y value
- Results are specific for the bookcase

Results – *Dose variation w.r.t. reference scenario 1*



- Rather heterogeneous behaviour
- Variation of a parameter causes different (sometimes opposite) effects on the considered dose contributions
- The net outcome depends on which effect is dominant, which in turn is isotope-specific

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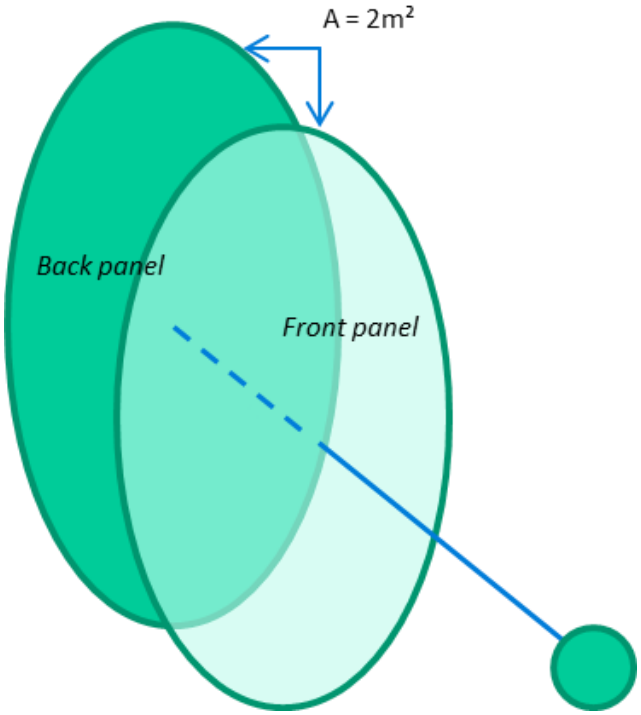
Benchmarking study

- Results were benchmarked against RP101

  Geometrical and time-parameters in SUDOQU set equal to RP101

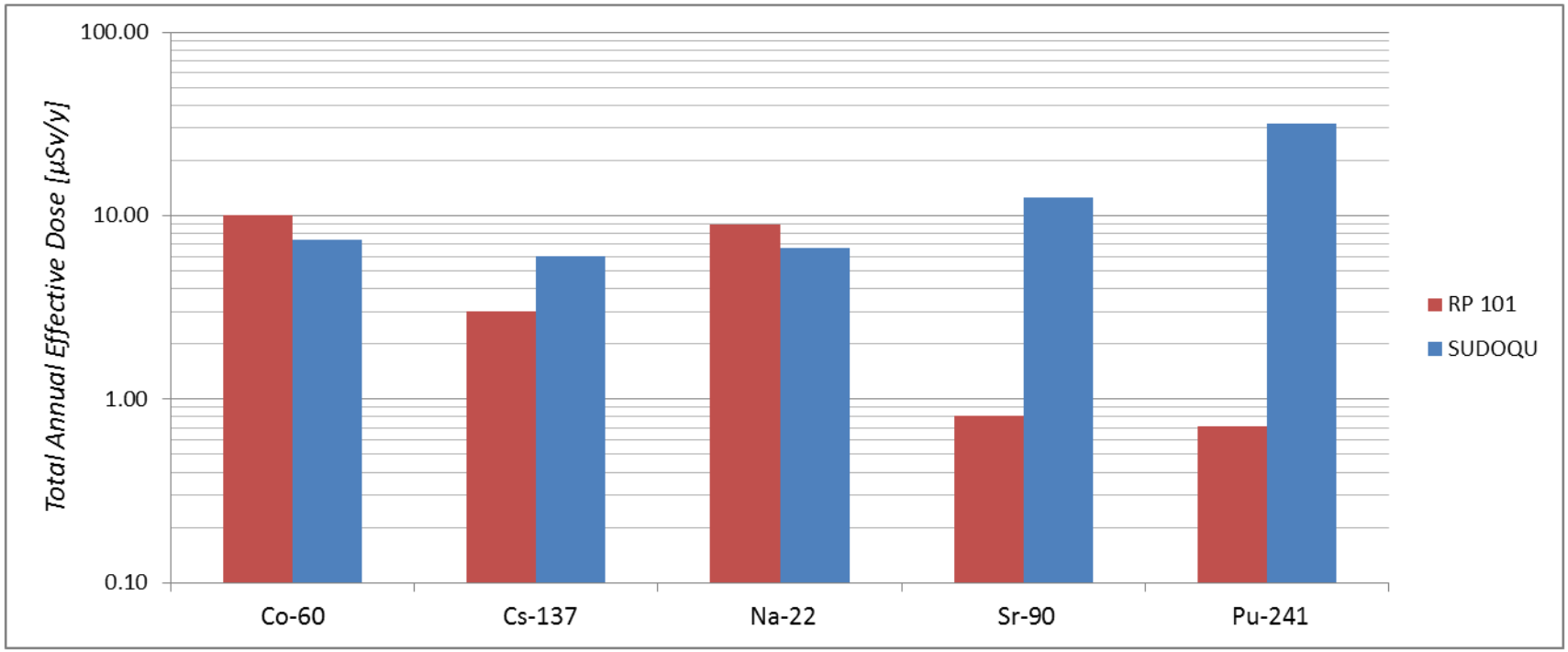


Benchmarking study

- Main assumption differences

	RP101	SUDOQU
Activity	Non-constant	Non-constant
Mechanisms affecting activity	Radioactive decay	Radioactive decay, wipe-off, resuspension, deposition
Removable fraction	10%	100%
Wipe-off efficiency	10%	20%

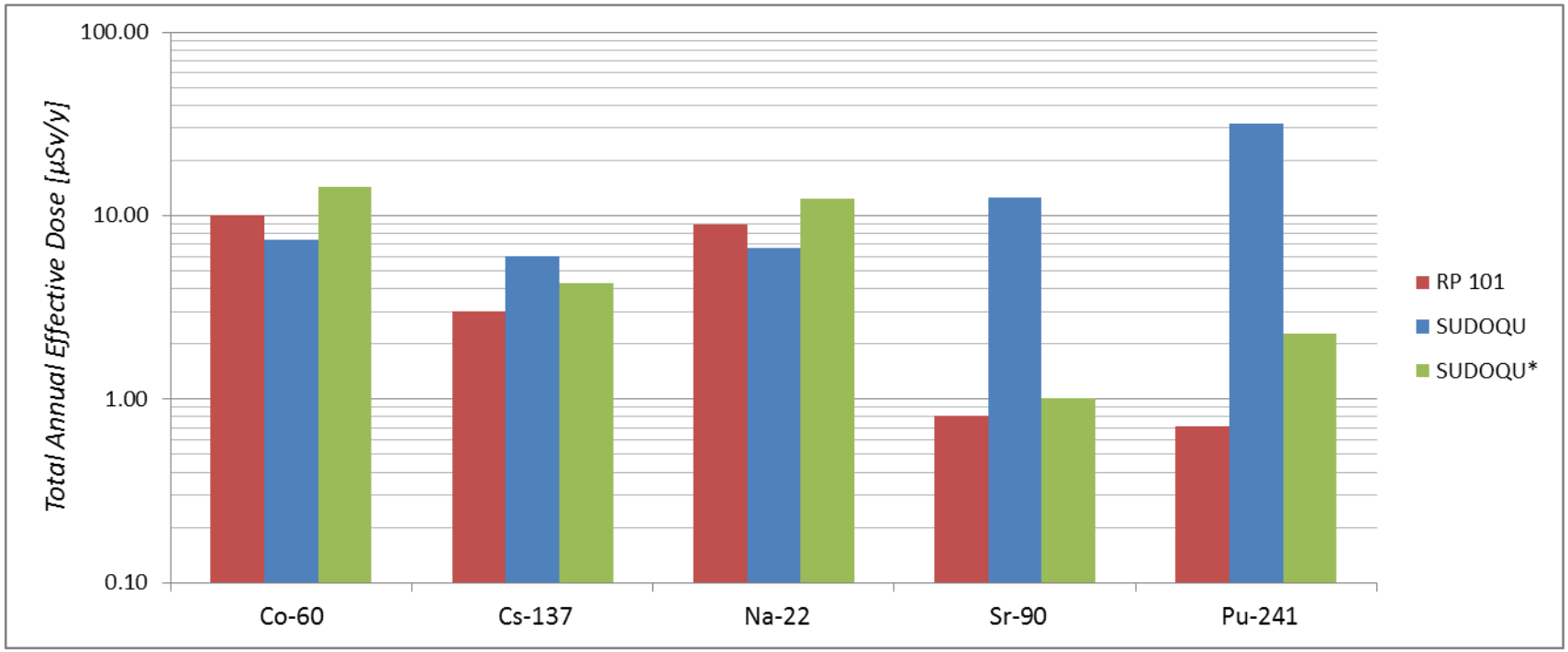
Benchmarking study



First comparison: all SUDOQU assumptions left unvaried

- External-irradiation contribution lower in SUDOQU (in RP101 more activity remains fixed on the surface) → effect visible for Co-60, Na-22
- Skin and ingestion dose higher in SUDOQU (larger removable fraction, more efficient wipe-off process) → effect visible for Cs-137, Sr-90+, Pu-241

Benchmarking study



Second comparison: SUDOQU assumptions adapted to RP101

- External-irradiation contribution increases → SUDOQU results for Co-60, Na-22 increase
- Skin and ingestion dose decrease → SUDOQU results for Cs-137, Sr-90+, Pu-241 decrease (but remain conservative)

Results in SUDOQU are conservative, and globally in good agreement

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Conclusion and future steps

- In SUDOQU, time-evolution of activity is influenced by several mechanisms (resuspension, wipe-off, radioactive decay, deposition)
- The variation of one parameter has different impacts on the involved phenomena. The outcome on the total dose depends on which effect is dominant, which is isotope-specific.

Difficulty to predict beforehand the effect
(and the conservatism) of a given assumption

- Next steps:
  - Detailed sensitivity analysis to identify the most relevant parameters
  - Performance of statistical calculations to identify more general trends and dependencies, and to develop probabilistic and conservative dose assessments

Thank you for your attention.

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