Task 1.1

Status and method of work for determining fallout radionuclides of importance to radiation doses

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Other participants: BfS, KIT, DEMA, DSA, DTU, NMBU, RIVM, UKHSA, UKMO

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Objectives

- On the basis of a review of relevant literature and source term modelling tools
  - a ranked list facilitating selection of most dose-relevant nuclides will be identified
  - considering different time phases and dose pathways

- A review will also be made of a 'pseudo radionuclide' approach.
  - 'Pseudo radionuclides' are created to each mimic a range of radionuclides to reduce atmospheric-dispersion model run times.

Deliverables

- D1.1 Report defining important radionuclides at different time phases (Month 12-> February 2025)

- Supplementary material: detailed results supplied as excel spreadsheets

Selection of radionuclides

- Selection of radionuclides that could be expected in the fallout following a nuclear explosion, and that are expected to be important as contributors to radiation doses by various exposure pathways

- Sources:
  - fission products
  - activation products, or
  - unconsumed fuel residues

Methodology – fission products

- MAX activity per nuclide from 3 fission reactions:
  - ^{239}Pu (fission spectrum n),
  - ^{235}U (fission spectrum n), or
  - ^{238}U (high-energy n).
- Each reaction has 800-900 different nuclides shortly after explosion, many stable or insignificant activity

- Ranking for different exposure pathways:
  - External dose from ground,
  - Internal dose from inhalation,
  - Internal dose from ingestion.
- At different time intervals (~6h, ~6-24h, ~1-30d, ~30-365d, ~1-2 y)

1. Initial amounts of fission products

- The initial number of atoms, *N*, produced by kiloton, kt, of explosive yield is estimated:

$$N = \frac{4.12 \cdot 10^{12}\ [\mathrm{J/kt}]}{E \cdot 1.6 \cdot 1^{-13}[\ \mathrm{J/MeV}\ ]}$$

- where E is the energy per fission [MeV] for the fission reaction (U-235, U-238, or Pu-239).

- The activity, A_i [Bq], of nuclide *i* per kiloton of explosive yield is calculated:

$$A_i = N\, y_i\, \lambda_i$$

- where y_i is the fission yield and , λ_i, is the decay constant [1/s] of nuclide i.

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2. PREDICT "nuclide vector"

- Final composition containing max Bq/kt from the three fission reactions U-235, U-238, and Pu-239 after **10 min**
- Max vector 483 radionuclides
- Cutoff: 1 kBq/kt
- Remove all nuclides in the composition for which dosimetry data is not available in current ICRP system
- PREDICT vector 359 radionuclides

- Ranking:

  External ground dose
  Calculations were made using software **SSM DosCalc** with dose factors from ICRP 144

  Internal dose
  Calculations were made for simple "dose product" with dose coefficients from ICRP 119

Methodology – activation products

- From ground and other materials in the vicinity of the explosions
- From the weapon itself
- Scenario-specific!
- Instead a more generic approach is made based on "reasonable examples" of radionuclides present in the literature

- No ranking
- Instead a selection of nuclear test explosions to provide "reasonable examples" of activation products
- Also, for those "reasonable examples", estimated contribution to the ground dose (in percentage and in total) in different time intervals

Methodology – unconsumed fuel residues

- Un-fissioned plutonium
- Tritium
- Scenario-specific!
- Instead a more generic approach is made

- No ranking
- Instead, for plutonium isotopes, estimated TBq per kiloton of fission explosive yield
- For tritium, the amount is estimated from fusion explosive yield and, less efficient, from fission explosive yield

Thank you for your attention!
Questions?

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