Dosimetry for animals and plants

Contending biota diversity

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Dosimetry for environmental radiation protection…

What is specific if compared to human radiation protection dosimetry?

The answers are:

- **Endpoints**
- **Immense (bio)diversity**

This presentation has neither been approved nor endorsed by the Main Commission of ICRP

ICRP system of radiological protection: the goals

- **Radiological protection of human (P103 ICRP, 2007):**
  "(29) The Commission's system of radiological protection aims primarily to **protect human health**. Its health objectives are relatively straightforward: to manage and control exposures to ionising radiation so that **deterministic effects are prevented**, and the **risks of stochastic effects are reduced** to the extent reasonably achievable."
- **Radiological protection of animals and plants (P124 ICRP, 2014):**
  "(7) The Commission's environmental protection aims are to prevent or **reduce the frequency of deleterious radiation effects** on biota to a level where they would have a negligible impact on the maintenance of biological diversity, the conservation of species, or the health and status of natural habitats, communities, and ecosystems. The **biological endpoints** of most relevance are therefore those that could lead to **changes in population size or structure**."

ICRP system of environmental protection: endpoints

- **ICRP Publication 124 (ICRP 2014)**

  "(8) **The biological endpoints** of interest to individuals that could have a consequence at a **population level** are those of:
  - early mortality (leading to changes in age distribution, death rate, and population density);
  - some forms of morbidity (that could reduce "fitness" of the individuals, making it more difficult for them to survive in a natural environment);
  - impairment of reproductive capacity by either reduced fertility or fecundity (affecting birth rate, age distribution, number, and density); and
  - the induction of chromosomal damage."

Diversity of non-human biota

Expresses via variability of:

- **Environment**
- **Morphological properties**
- **Biological properties**
- **Behavior and life cycle**
- **Sensitivity to radiation**

The current ICRP approach…

… stands on two legs:

- Established points of reference, i.e. a set of the Reference Animals and Plants (RAPs)
- Use of simple albeit plausible and representative models to quantify exposures to environmental radiation sources

Dosimetry for non-human biota – main principles

- Conventional dosimetry (i.e. not micro- or nano-dosimetry)
- Absorbed dose averaged over the whole body
- Simplified representation of exposure geometry, body shape
- Biokinetic is not accounted for (full retention, intake is expressed via lumped equilibrium concentration ratios, CR)
- Idealised sources (homogeneous media, uniform distributions)
- Interpolation and (physically justified) extrapolations, including allometric scaling of biological properties
- Superposition principle: a complex exposure scenario can be split into a series of simpler ones resulting in the same integral effect

The dosimetric approach of ICRP…

… for non-human biota was introduced in the *Publication 108* (ICRP, 2008) and can be characterised as…

- **A major step forward**
- **DCC cover major environmental sources, biota types, radionuclides**

- **Popular critiques and/or inquires:**
  - ✓ 'Gaps', i.e. situations not addressed by the P108 (e.g. DCC for immersion into contaminated air)
  - ✓ Need DCC for a non-reference organism (e.g., cormorant, not duck)
  - ✓ Organisms exposed at the interface between media (e.g. 'flatfish on sediment')
  - ✓ DCC for a radionuclide missing in the printed tables of P108

Current activity of the TG74

Since appearance of the Publication 108, the Task Group 74 continued its work aiming at:

- **Improving the existed dosimetric framework**
- **Extending the dosimetric framework**
- **Addressing concerns of the community**

Now, the new draft report of Task Group 74 is on its way to finalisation

The draft report of TG74 – what's new?

- **Improved DCC for external exposure of terrestrial organisms are:**
  - substantially and systematically extended (new sources, heights),
  - harmonised with aquatic (from 1 mg to 1 ton body mass),
  - revised (old sources are completely redone)
- **Transition to contemporary radionuclide database (P107) assuming completely revised DCC tables**
- **A DCC calculator complements the printed tables and provides fully flexible DCC ('fit-for-purpose' DCC) for any nuclide from P107**
- **Three alternative methods to account for effect of radioactive progeny allow for additional flexibility to address various exposure situations (emergency, planned, existing)**
- **Generalised allometric equations (help to plausibly interpolate biological parameters relevant to a dose assessment)**

The new tool to compute DCC

- The DCC calculator stems from its predecessors, the ERICA Tool and *Publication 108*, significantly updating and exceeding those
- "Now, it is unlike before…" ☺
- The DCC are always 'fit-for-purpose', i.e. they can be derived for user-defined and assessment-specific: organism, source(s), time to integrate effect of radioactive progeny
- Simple, flexible, fast, web-based (planned as an open access software, thus to comply with the ICRP's main goal: "…works for public good")
- Accessed via the ICRP web-site or hosted there directly **(to be clarified)**

The new layout of the revised DCC Tables

- Allows quick and simple interpolations for non-reference organisms or non-standard sources/locations
- Demonstrate that inters-species and inter-sources variability of DCC among RAPs is generally low, so…
- … the DCC themselves are not among the major sources of uncertainty of an environmental dose assessment
- Priority should be shifted towards reducing uncertainty coming from…
  - Environmental transfer
  - Biology
  - Representativity of an organism

Open issues

- **RBE (RWF) for non-human biota:**
  conditional on biological endpoints, organism, exposure type
- **Probabilistic assessment (to take care on uncertainty, to quantify uncertainty, …)**
- **Risk following highly non-uniform dose distributions (e.g. bone-seeking actinides, lung exposure to alpha-emitters, skin exposure to alpha- and beta-emitters, exposure to hot particles, and etc)**
- **These may require for selected species and exposure scenarios to do modelling using advanced methods, e.g. CT-based and radiographic images, microdosimetric endpoints and cellular responses to radiation, realistic morphological (voxel phantoms) and biological (biokinetic) models.**

Dosimetry for environmental RP: What is different from that for human RP?

Human	Non-human
Absorbed dose (Gy)	Absorbed dose (Gy)
Averaging in organ	Averaging in the whole body
Endpoints: for individuals, mostly, stochastic (late) effects	Endpoints: for populations, mostly, deterministic (early) effects
RBE is defined at low doses and dose rates	RBE to be defined at higher doses and dose rates
RWF, w_R, is defined for protection and relevant to cancer, mostly	No recommended value of RWF (though, provisional values: 10-3-1)
Equivalent dose (Sv)	Weighted dose?
TWF, w_T, are derived from organ-specific cancer risks	?
Effective dose (Sv)	? DCRL? Weighted?

Thank you for attention!

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