Improved dosimetry for animals and plants

What does the new ICRP draft publication bring?

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- **A draft of the new ICRP Publication is on the ICRP web site on public consultation**
- **Deals with dosimetry for animals and plants**
- **Suggests significant methodological improvements and provides the revised data (DC)**
- **Offers a new online tool (aka DC calculator)**

Main points of the TG74 draft report

- The DC for external exposure of the terrestrial biota have been substantially revised and extended. The current DC are applicable to organisms with body masses in range from 10^{-6} to 10^{3} kg, at heights above the ground surface from 0.1 to 500 m, for five types of environmental sources in soil and in ambient air.
- Transition from radionuclide emission data of the ICRP *Publication 38* to *Publication 107*. The absorbed fractions and dose coefficients for photons and electrons have been extended to maximum energy 10 MeV to address radionuclide properties in the new database.
- The report is supplemented by the tables of the DC for the ICRP Reference Animals and Plants. The tables, being compatible to the previously published ones, are completely recalculated with the new radionuclide emission data and presented in the new radionuclide-based layout, which highlights inter-species and inter-sources variability of the DC, thus facilitating reasonable interpolation of the DC in practical dose assessments.

Main points of the TG74 draft report (cont'd)

- The report discusses alternative methods of accounting for contribution of radioactive progeny in the DC. A method, which uses ratio of time-integrated activities of the parent nuclide and its radioactive progeny, is shown as 'fit for purpose' for practical dose assessment tasks.
- The report introduces the software tool BiotaDC, which is designed to allow assessment of the DC for user-defined types of biota exposed to any radionuclide from the current database and its progeny. The tool provides various possibilities to account for contribution of radioactive progeny.
- The report introduces some allometric equations for mammals formulated using generalised approach, which takes into account curvatures in the observed allometric relationships as well as quantifies their uncertainties.

Dosimetry for non-human biota — overview

biota	aquatic		internal exposure (in water)		infinite uniform volumic
			external exposure (in water)		infinite uniform volumic
	terrestrial	fauna	internal exposure (via aquatic module)		
			external exposure	in-soil	50-cm volume
				on- and above soil	planar, 10-cm volume, infinite volume, sub-mersion in air
		flora	internal exposure (via aquatic module)		
			external exposure	in-soil (like fauna, 50-cm volume)	
				on- and above soil	planar, 10-cm volume

Masses and shapes covered

$$\lim_{M\to 0} D^{\text{int}} = 0, \quad \lim_{M\to 0} D^{\text{ext}} = D_\infty$$

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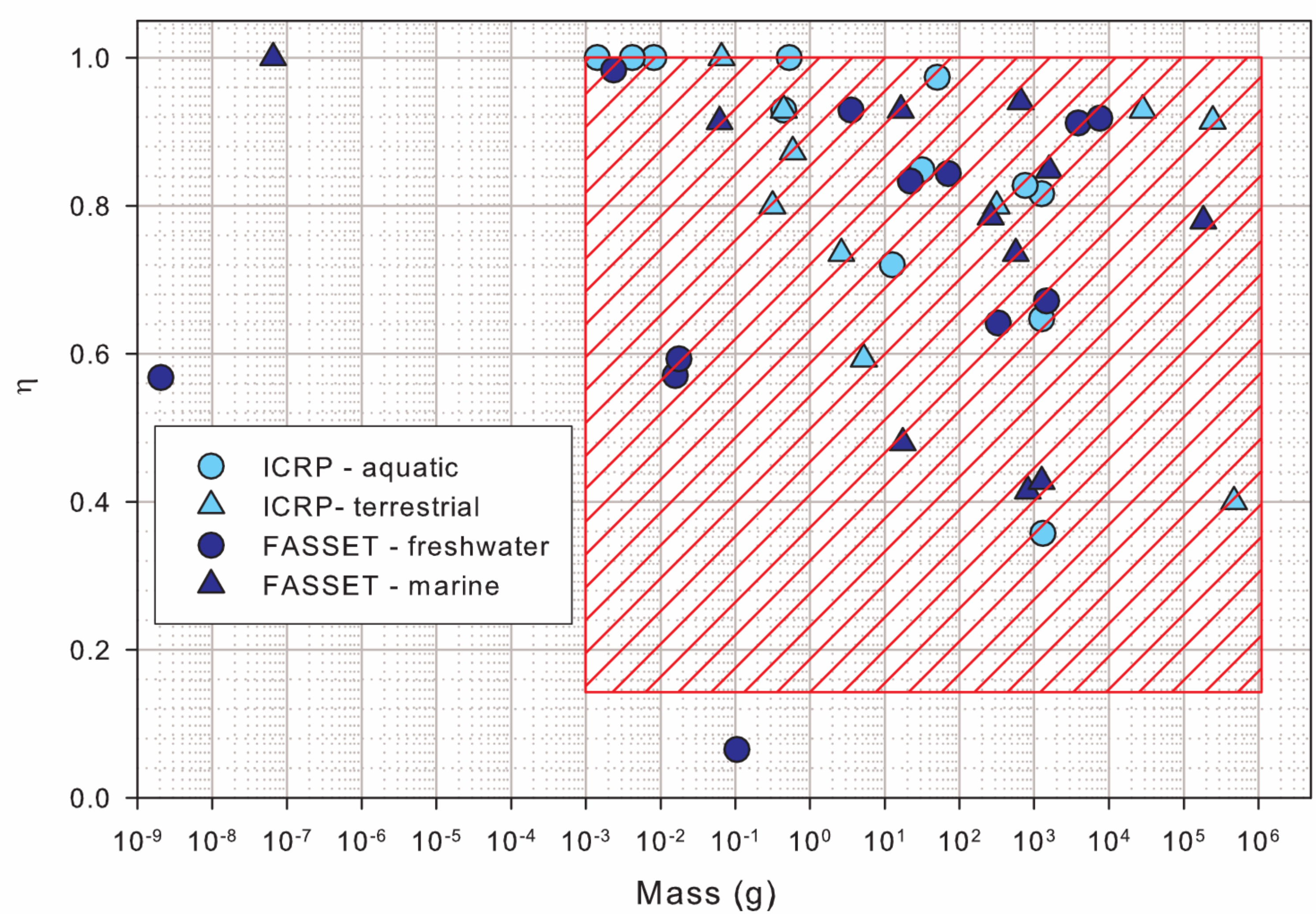
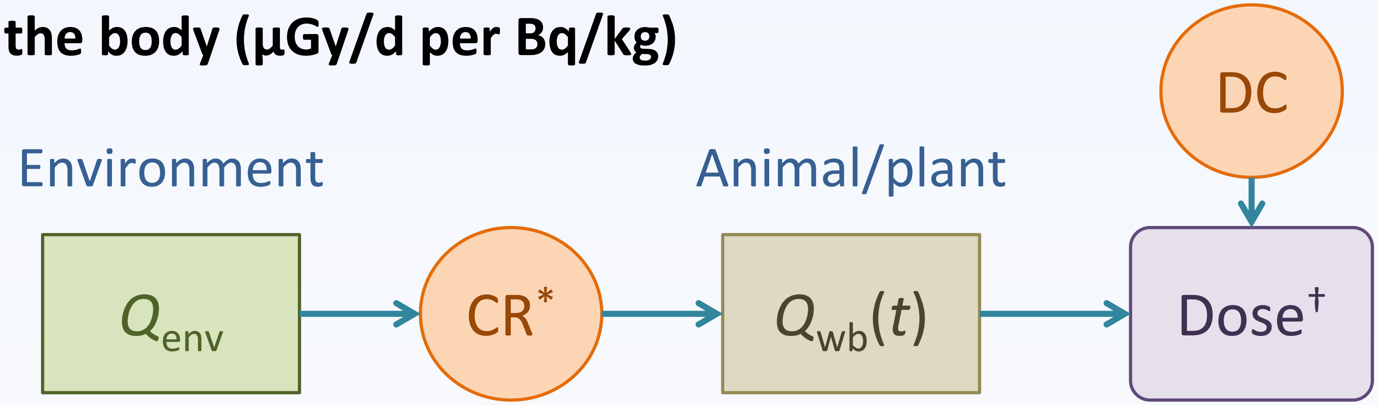


Internal dose assessment – biota vs. human

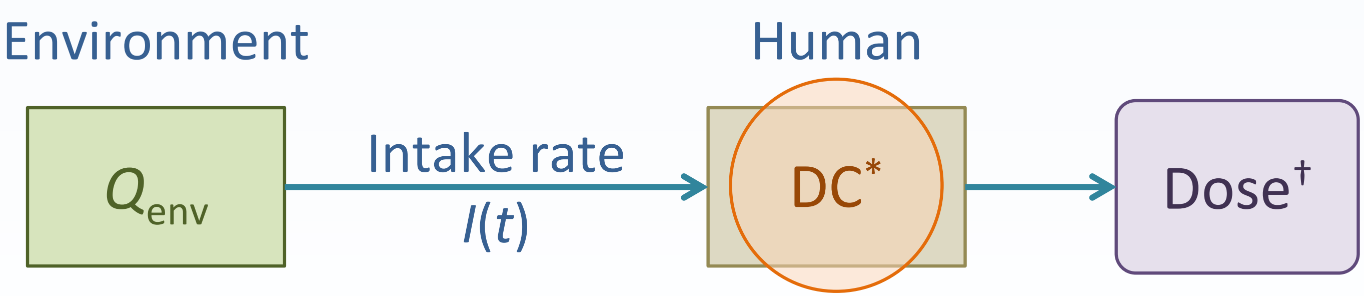
- **Biota:**
  DC – dose rate per unit concentration in the body (µGy/d per Bq/kg)



* Ecological transfer, biokinetic and decay included

† user integrates over time-dependent dose-rates

- **Human:**
  DC – committed (integral) dose per unit intake (Sv/Bq)



* biokinetic and decay included

† user integrates over time-dependent intake

External exposure of terrestrial animals (1)

External exposure of terrestrial organisms is modeled differently than that for aquatic organisms:

$$D(E_0,H,M) = \sum_i \tilde{K}_i(E_0,H)\bar{R}_i(M)$$

where

$$\tilde{K}_i(E_0,H) = \int_{\Delta_i} \frac{\mu_{tr}}{\rho}(E)\,E\,\frac{d\Phi}{dE}(E_0,H,E)\,dE$$

the differential air kerma is computed by Monte Carlo directly and

$$\bar{R}_i(M) = \frac{1}{\Delta_i}\int_{\Delta_i} R(E,M)\,dE$$

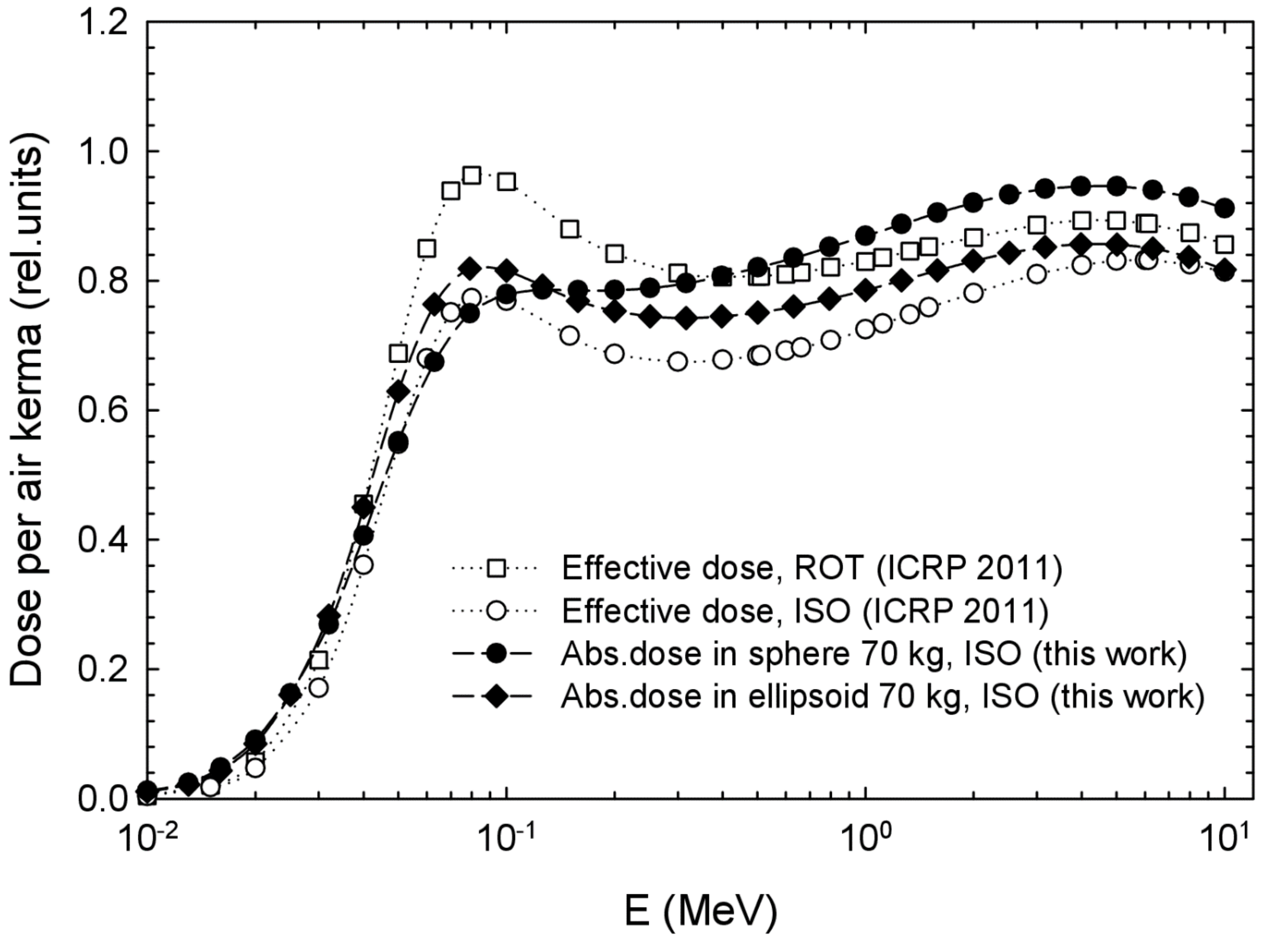
dose-per-kerma ratio is computed by integration of the values independently obtained by Monte Carlo method.

External exposure of terrestrial animals (2)

- As a result, the current method allows to compute DC of external exposure for terrestrial animals and plants:
  - for organism's body masses ranging from 10^{-6} to 10^{3} kg, thus closing the existing 'gap' in the current ICRP dosimetric approaches for terrestrial biota;
  - for four environmental sources: 'effective' plane source at depth 0.5 g cm^{-2}, volume 'aged' source uniformly distributed in the upper 10 cm of soil, volume infinitely deep uniform source in soil suitable for NORM, and submersion in contaminated air;
  - for heights above ground interface from 0.1 to 500 m;
  - for energies of source photons ranging from 10 keV to 10 MeV, thus matching the range of photon energies of all nuclides included in the contemporary ICRP Publication 107 (ICRP 2008)
- Also considered are:
  - 50-cm-deep uniform volume source in soil (for 'in-soil' exposure, only)

Dose-per-kerma for simple shapes and human phantom

- **Effective dose** (weighted sum of organ equivalent doses) for adult human (ICRP P116, 2011)
- **Absorbed dose** (averaged in the whole body) for 70 kg sphere and ellipsoid



Radionuclides considered

- The new version of the dosimetric tool works with database of the ICRP Publication 107 (ICRP, 2008) with emission data for 1252 radionuclides
- Current ICRP approach traditionally assumes only short-lived ($T_{½}$<10 d) progeny in equilibrium with parent nuclide, thus following approach of FASSET and ERICA projects
- Such truncation of decay chains may become inappropriate for certain exposure scenarios
- For some radionuclides, the DCs may change in time when no equilibrium exist between parent and daughters
- The new (proposed) approach assumes accounting for contribution of radioactive progeny using scenario-specific time

DC for biota:

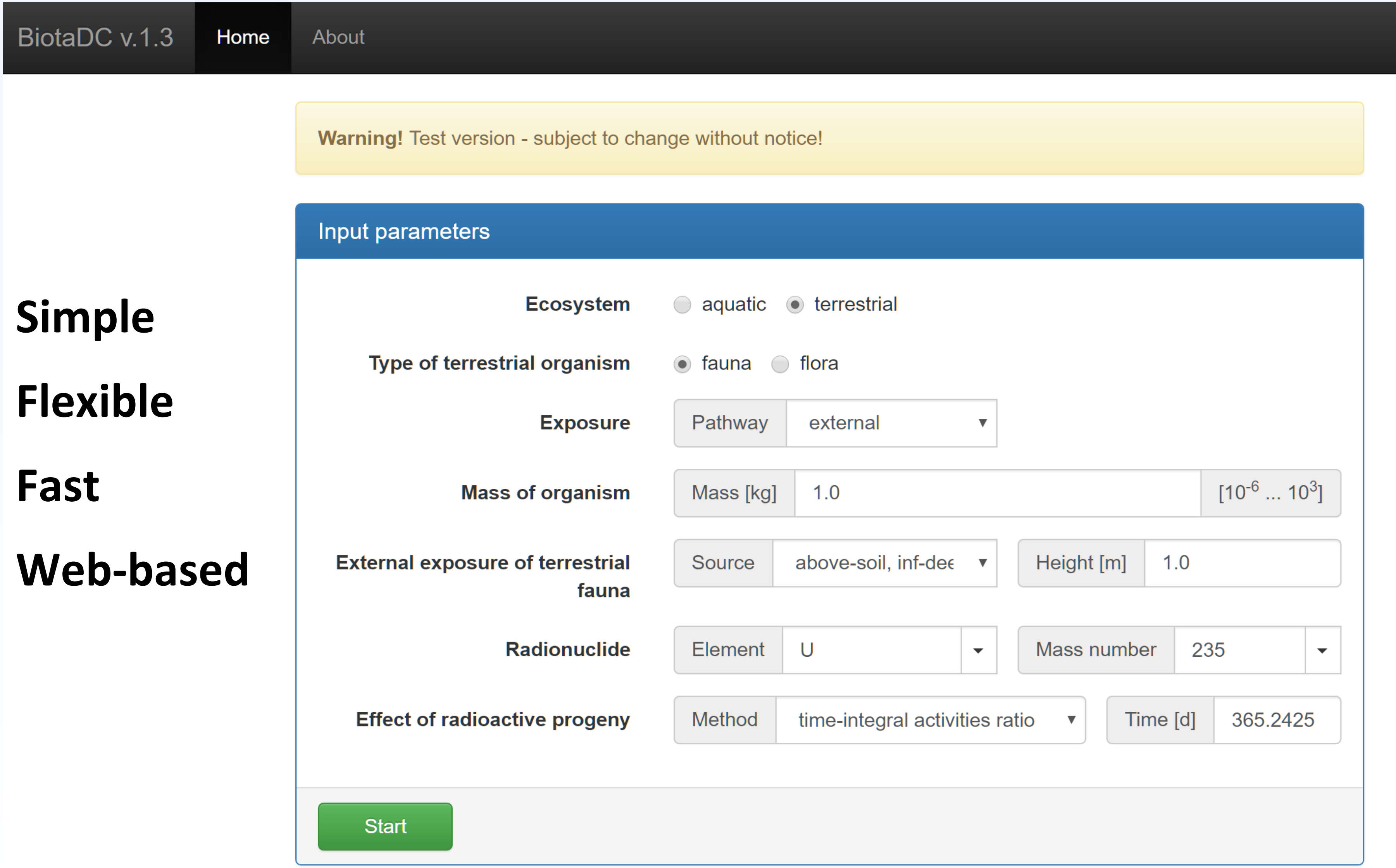
inter-species and inter-sources variability is low

(tables from the draft report of the ICRP/TG74)

Organism	Internal exposure (μGy h^{-1} Bq^{-1} kg)	f_0	f_1	f_2	f_3	External exposure: aquatic (μGy h^{-1} Bq^{-1} L)	in-soil (μGy h^{-1} Bq^{-1} kg)	on-ground (μGy h^{-1} Bq^{-1} kg)	above-ground (μGy h^{-1} Bq^{-1} kg)	immersion in air (μGy h^{-1} Bq^{-1} m^3)
^{134}Cs (progeny included: none)										
bee	9.7×10^{-5}	0.000	0.000	0.003	0.997	–	–	3.4×10^{-4}	3.3×10^{-4}	4.2×10^{-4}
wild grass (spike)	1.1×10^{-4}	0.000	0.000	0.003	0.997	8.9×10^{-4}	–	3.1×10^{-4}	–	4.2×10^{-4}
earthworm	1.1×10^{-4}	0.000	0.000	0.003	0.997	–	8.3×10^{-4}	3.5×10^{-4}	–	4.2×10^{-4}
frog	1.3×10^{-4}	0.000	0.000	0.002	0.998	8.6×10^{-4}	8.2×10^{-4}	3.5×10^{-4}	–	4.2×10^{-4}
rat	1.7×10^{-4}	0.000	0.000	0.002	0.998	–	7.8×10^{-4}	3.5×10^{-4}	–	4.1×10^{-4}
duck	2.2×10^{-4}	0.000	0.000	0.001	0.999	7.7×10^{-4}	–	3.4×10^{-4}	3.1×10^{-4}	4.4×10^{-4}
deer	6.3×10^{-4}	0.000	0.000	0.000	1.000	–	–	2.2×10^{-4}	–	2.6×10^{-4}
pine tree (trunk)	5.8×10^{-4}	0.000	0.000	0.001	0.999	–	–	2.5×10^{-4}	–	–
brown seaweed	1.6×10^{-4}	0.000	0.000	0.002	0.998	8.3×10^{-4}	–	–	–	–
crab	2.0×10^{-4}	0.000	0.000	0.002	0.998	7.9×10^{-4}	–	–	–	–
trout	2.0×10^{-4}	0.000	0.000	0.001	0.999	7.9×10^{-4}	–	–	–	–
flatfish	1.7×10^{-4}	0.000	0.000	0.002	0.998	8.2×10^{-4}	–	–	–	–
^{137}Cs (progeny included: ^{137m}Ba)										
bee	1.3×10^{-4}	0.000	0.000	0.003	0.997	–	–	1.4×10^{-4}	1.3×10^{-4}	1.6×10^{-4}
wild grass (spike)	1.4×10^{-4}	0.000	0.000	0.003	0.997	3.3×10^{-4}	–	1.1×10^{-4}	–	1.6×10^{-4}
earthworm	1.4×10^{-4}	0.000	0.000	0.003	0.997	–	3.0×10^{-4}	1.4×10^{-4}	–	1.6×10^{-4}
frog	1.5×10^{-4}	0.000	0.000	0.002	0.998	3.2×10^{-4}	3.0×10^{-4}	1.4×10^{-4}	–	1.6×10^{-4}
rat	1.7×10^{-4}	0.000	0.000	0.002	0.998	–	2.8×10^{-4}	1.4×10^{-4}	–	1.6×10^{-4}
duck	1.9×10^{-4}	0.000	0.000	0.002	0.998	2.8×10^{-4}	–	1.3×10^{-4}	1.2×10^{-4}	1.7×10^{-4}
deer	3.4×10^{-4}	0.000	0.000	0.001	0.999	–	–	8.4×10^{-5}	–	9.9×10^{-5}
pine tree (trunk)	3.2×10^{-4}	0.000	0.000	0.001	0.999	–	–	9.0×10^{-5}	–	–
brown seaweed	1.7×10^{-4}	0.000	0.000	0.002	0.998	3.0×10^{-4}	–	–	–	–
crab	1.8×10^{-4}	0.000	0.000	0.002	0.998	2.9×10^{-4}	–	–	–	–
trout	1.8×10^{-4}	0.000	0.000	0.002	0.998	2.8×10^{-4}	–	–	–	–
flatfish	1.7×10^{-4}	0.000	0.000	0.002	0.998	3.0×10^{-4}	–	–	–	–

Software tool BiotaDC

(Test version available at: http://biotadc.icrp.org)



- **Simple**
- **Flexible**
- **Fast**
- **Web-based**

Thank you for attention!