K-BIOTA approach to Beaverlodge lake scenario

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Dong-Kwon Keum
Korea Atomic Energy Research Institute

Basic equation

1) The total whole body absorbed dose rate of radionuclide *i* for a specified organism in aquatic ecosystem

$$D_{tot,i} = [\underbrace{CR_i DCC_{int,i}}_{\text{internal}} + \underbrace{\{\gamma_w + 0.5\gamma_{ws}(1 + K_{d,i}) + \gamma_s K_{d,i}\} DCC_{ext,i}}_{\text{external}}]C_{w,i}$$

2) Input data

- C_w : Water activity
- CR: Concentration ratio of organism to water
- γ: Occupancy factor
  (*w*: water, *ws*: water-sediment interface, *s*: sediment)
- K_d : Equilibrium distribution coefficient of radionuclide *i*
- DCC: Dose conversion coefficients (*int*: internal, *ext*: external)

① Input data- Water activity

- The water activity for a lake whose value was not provided was calculated by using the Kd value if the sediment activity (q_w) for the lake would be known

$$C_{w,i} = \frac{q_{w,i}}{K_{d,i}}$$

② Input data - Kd values

- **If the site specific Kd value for a lake was not available, the arithmetic mean of Kd values that had been provided for studied sites in this exercise was used.**

R/N	The provided Kd for studied sites	Arithmetic mean Kd (l/kg)	ERICA tool
Pb210	2.64E5, 1.1467E4, 3.13E5	1.02E5	1.0E5
Po210	3.94E5, 4.67E5, 2.1E4	2.94E5	2.0E7
Ra226	2.99E4, 2.49E4, 3.04E4, 2.28E4, 5.59E4, 1.49E4	3.0E4	1.5E4
Th230, Th234	3.18E5, 3.6E4	1.77E5	1.8E7
U238, U234	2.7E4, 9.8E3, 6.45E2, 2.63E3, 7.52E3, 1.28E5, 5.88E4	3.3E4	5.0E1

③Input data - Concentration ratios (CR)

➢ References and assumptions for the CR value to water

	Pelagic fish	Large benthic fish	Small benthic fish	Chironomus	Pisidium sp.	Caddisfly
Pb210	Swanson (1983)	Swanson (1983)	Swanson (1983)	ERICA tool insect larvae	ERICA tool bibalve mollusc	ERICA tool insect larvae
Po210	ERICA tool Pelagic fish	ERICA tool Benthic fish	ERICA tool Benthic fish	ERICA tool insect larvae	ERICA tool bibalve mollusc	ERICA tool insect larvae
Ra226	Swanson (1983)	Swanson (1983)	Swanson (1983)	ERICA tool insect larvae	ERICA tool bibalve mollusc	ERICA tool insect larvae
Th230, Th234	Assumed to be the same as that for the large benthic fish	Pyle and Clulow (1998)	Assumed to be the same as that for the large benthic fish	ERICA tool insect larvae	ERICA tool bibalve mollusc	ERICA tool insect larvae
U238, U234	Swanson (1983)	Swanson (1983)	Swanson (1983)	ERICA tool insect larvae	ERICA tool bibalve mollusc	ERICA tool insect larvae

➢ Used CR values to water (Bq/kg biota per Bq/kg water)

	Pelagic fish	Large benthic fish	Small benthic fish	Chironomus	Pisidium sp.	Caddisfly
Pb210	72	440	200	10,000	1,700	10,000
Po210	240	240	240	9,900	38,000	9,900
Ra226	13	280	187	1,500	1,500	1,500
Th230,234	200	200*	200	100	100	100
U238,234	4	13	2	500	180	500

*** Th230 CR (fresh) for large benthic fish was derived from the average value of the dry-based bone Th230 CR for male, female and immature White Sucker (Pyle and Clulow, 1998) and the dry-to-wet weight conversion factor of 0.57 (Clulow et al., 1998)**

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④ Input data - Dose conversion coefficients

- **Uniform isotropic model (Ulanovsky and Pröhl, 2006)**
- **Radiation weighting factor for internal DCC**

Radiation	value
α	10
low β	3
high β and γ	1

- **Daughter radionuclides considered in the calculation of DCC**

	Daughter radionuclides
Pb210	Bi210
Po210	
Ra226	At218, Po218, Bi214, Pb214, Rn222, Po214
Th230	
Th234	Pa234, Pa234m
U238	
U234	

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⑤ Input data - Occupancy factor (provided)

Organism	Water	Water-sediment interface	Sediment
Pelagic	0.75	0.25	
Benthic fish-large	0.3	0.7	
Benthic fish-small	0.8	0.2	
Chironomus		1.0	
Pisidium sp.		1.0	
Caddisfly		0.75	0.25

⑥ Input data – Activity of U234 and Th234

- The activity of Th234 and U234 were estimated from the U238 decay chain reaction by using the ratios of Ra226/U238 which could be obtained from the water input data.

- If the activity ratio of Ra226/U238 was greater than 1, the ratio was assumed to be 1 (there are 5 cases).

Site	Water input data			Calculated activity concentration of Th234 and U234 in water	
	Ra226 (Bq/kg)	U238 (Bq.kg)	Ra226/U238	Th234/U238 (Th234)	U234/U238 (U234)
Dubyna Lake	9.5e-2	6.45	0.0147	1 (6.45)	1.03e-1 (0.664)
Hanson Bay	3.89e-2	1.87	0.02	1 (1.87)	1.21e-1 (0.226)
Beaverlodge lake	5.33e-2	2.05	0.026	1 (2.05)	1.37e-1 (0.28)
Keddy Bay	1.00e-2	1.83	5.46e-3	1 (1.83)	6.52e-2 (0.12)
Millikan Lake	N/A	8.55e-3	N/A	N/A	N/A
Island Lake	5.28e-3	2.5	2.11e-3	1 (2.5)	4.24e-2 (0.106)
Sandy Lake	6.25e-3	2.87e-3	**2.18**	1 (2.87e-3)	1 (assumed) (2.87e-3)
Back Bay	7.9e-1	1.34e-1	**5.89**	1 (1.34e-1)	1(assumed) (1.34e-1)
St. Mary's Channel	7.e-3	7.33e-3	0.95	1 (7.33e-3)	1 (7.33e-3)
Delta Lake	3.83e-3	4.36e-3	0.88	1 (4.36e-3)	3.53e-1 (1.54e-3)
David Lake	2.84e-3	6.82e-4	**4.16**	1 (6.82e-4)	1(assumed) (6.82e-4)
Vulture Lake	3.37e-3	4.15e-3	0.81	1 (4.15e-3)	2.43e-1 (1.e-3)
Kewen Lake	1.16e-3	4.15e-4	**2.8**	1 (4.15e-4)	1(assumed) (4.15e-4)
Upper Link Lake	1.45	8.56e-1	**1.69**	1 (8.56e-1)	1(assumed) (8.56e-1)
Pow Bay	2.9e-3	1.58e-2	0.18	1 (1.58e-2)	3.98e-2 (6.3e-4)