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Contamination of the Baltic sea with radionuclides and potential risk to aquatic biota

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Data on long-lived radionuclide concentrations in water and sediments obtained during various projects performed by SRI CPST (Institute of Physics) as well as from HELCOM-MORS database have been analysed in order of better understanding transport, redistribution and accumulation of radionuclides during 1986-2015. In addition, the assessment of biota exposure was performed for the Baltic Sea (Lithuanian economic zone). Average activity concentrations of ¹³⁷Cs, ⁴⁰K, ⁹⁰Sr and ^{239, 240}Pu in surface water, sediments and biota for period of 2011-2015 from EPA and SRI CPST database were used for modelling. The species considered for this part of the sea included seaweed (*Cladophora glomerata*, *Flucelloria lumricalis* and *Fucus vesiculosus*) and fish species such as plaice (*Pleuronectes platessa*), Baltic herring (*Clupea harengus membras*), and bream (*Abramis brama*). ERICA Assessment Tool was used for evaluation of dose rates for biota. The screening value 10 microGy/h proposed in ERICA tool was used for evaluation of the risk. The total (including internal and external) estimated dose rates were compared directly to the selected screening dose rate to enable the assessment of the risk to biota.

¹³⁷Cs activity concentrations were measured with HPGe detectors (GEM40P4-76, efficiency 40%, resolution 1.85 keV (FWHM) at 1.33 MeV and GX4018, resolution 1.8 keV/1.33 MeV and efficiency 42 %). All dried samples were ashed, and Pu isotopes were separated from the matrix as well as from interfering radionuclides using the extraction chromatography method. ²⁴²Pu was used as a tracer for the chemical yield determination. Plutonium was extracted with TOPO/cyclohexane solution and TEVA and TRU resins were applied for the final cleaning (Lujanienė, 2013). Then plutonium isotopes were electrodeposited on the stainless steel discs. ^{239,240}Pu activity activities were measured by means of alpha spectrometry.

Wide variations of ¹³⁷Cs and ^{239,240}Pu activity concentrations in bottom sediments of the Lithuanian waters (Southern Baltic Proper) of the Baltic Sea were observed in 2011-2015. Average ¹³⁷Cs activity concentrations varied from 7.6±0.5Bq/kg to 200±10Bq/kg dry weight (d. wt.), while in the Curonian Lagoon activities ranged from 1.24±0.07Bq/kg to 10.4±0.5Bq/kg d. wt. The highest ¹³⁷Cs activity concentrations in the Baltic Sea in bottom sediments were reported for the Gulf of Finland and the Bothnian Sea (HELCOM-MORS database).

^{239,240}Pu activity concentrations in seaweed ranged from 0.48±0.04 mBq/kg to 17.6±1.5 mBq/kg, d. wt. The lowest activities were found in the *Cladophora glomerata* collected in the Curonian Lagoon, while the highest ones in the *Fucus vesiculosus* from the Baltic Sea.

Activity concentrations of ^{239,240}Pu in the fish species varied from 0.3 mBq/kg to 1.3 mBq/kg, wet weight (w. wt.). Low plutonium activity concentrations were measured in the *Abramis brama* from the Curonian Lagoon, whereas higher activities were characteristic of the *Clupea harengus membras* and *Pleuronectes platessa* species collected in the Baltic Sea.

Dose rate evaluation has shown that main contribution to dose rate in the Southern Baltic Proper was from naturally occurring ^{40}K , similar results were obtained for the Gulf of Finland and the Bothnian Sea where the doses to biota were mainly dominated by the natural radionuclides ^{210}Po and ^{40}K (Outola et al., 2011). ^{137}Cs was the main contributor to the dose rate from all studied artificial radionuclides. The lowest dose rates resulted to pelagic fish and the highest to seaweed. Higher activities of ^{137}Cs in bottom sediments is the reason for this difference, as the lowest dose rates resulted to fish and the highest to sediment-associated organisms. The contribution from the other artificial radionuclides evaluated (^{90}Sr , 239 , ^{240}Pu) to the total dose were negligible.

References

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