Transport of aerosol particles from the Fukushima accident

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Measurements of activity concentrations of 131I, 129mTe, 135Te, 134Cs, 137Cs in aerosol were carried out in daily samples after the Fukushima accident during the period of March – April, 2011 in Vilnius.

The ground level air samples were collected on the outskirts of Vilnius (54°42’N, 25°30’E). FPP-15 filters made of chlorinated polyvinyl chloride (~ 1 m² surface) were exposed at the height of 1 m above the ground. High volume samplers with flow rates (2400 m³ h⁻¹ - 6000 m³ h⁻¹) were operated. The sampling was carried out continuously. The activity concentrations of gamma-emitters were measured in 12 or 24 h samples by gamma-ray spectrometry using a HPGe detector (relative efficiency of 42 %, resolution of 1.9 keV at 1.33 MeV). The combined uncertainty of measurements by gamma-spectrometry was better than ±7 % (k = 2).

The radiochemical analyses of Am and Pu were performed on monthly samples (total volume ~ 2.0x10⁶ m³) of aerosol ashes (~ 30 g). The applied radioanalytical procedures are described in detail by Lujanienė (2011). The measurements of Pu and Am isotopes deposited on stainless-steel discs were carried out with the Alphaquattro (Silena) spectrometer. Accuracy and precision of analysis were tested using reference materials IAEA-135, NIST SRM No 4350B and 4357, as well as in intercomparison exercises, organized by the Risø National Laboratory (Denmark), and the National Physical Laboratory (UK). The precision of Pu and Am measurements was better than ±8 % and ±10%, respectively (k = 2).

Three-dimensional 13-day backward trajectories of air masses that reached Vilnius at 850 hPa and 700 hPa height were calculated employing the Hybrid Single-Particle Lagrangian Integrated Trajectory (Draxler & Rolph, 2011). A meso-scale chemical transport model system (EURAD, http://www.eurad.uni-koeln.de) was used to evaluate the wet and dry deposition of particulate 137Cs, and a potential dispersion of the radioactive cloud after a nuclear accident for three levels.

The measured activity concentrations at the site of investigation resulted from a long-range air mass transport and arrival time following downward air mass transport and meteorology (Lujanienė et al., 2012). The activity concentrations of 131I and 137Cs ranged from 2 µBq m⁻³ to 3800 µBq m⁻³ and from 0.2 µBq m⁻³ to 1070 µBq m⁻³, respectively. In addition to 131I, 134Cs and 137Cs 135I, 135Te, 136Cs, 132Te and 136Cs were detected in the aerosol filters as well. Variations in activity ratios of 131I/137Cs, 132Te/137Cs, 134Cs/137Cs and 135Cs/137Cs were observed. They were mainly due to the decay of the short-lived isotopes (e.g. 129mTe, 131I, 138Cs) while an increase in 134Cs/137Cs was explained by the presence of the Chernobyl-derived 137Cs in the environment. An increase in the activity ratio was observed whereas the highest activity ratio (1 ± 0.05) was found in the most active sample collected on 4 April. Contrary to the 134Cs/137Cs ratio the maxima of 131I/137Cs ratios did not coincide with 137Cs or 131I activities. It was found that different behavior of highly volatile 131I and 137Cs resulted in enrichment of ground level aerosol particles by 131I with respect to 137Cs. Simulated activity concentrations of 137Cs attached to aerosol particles for the Vilnius site reasonably agreed with measured activities in aerosol samples during the Fukushima accident (Lujanienė et al., 2013).

Figure 1. Backward trajectories of air-mass transport ending on 23 March, 2011 in Vilnius.

The activity concentration of actinides measured in the integrated sample collected in March–April, 2011 showed a small contribution of Pu with unusual activity and atom ratios indicating the presence of the spent fuel of different origin than that of the Chernobyl accident (Lujanienė et al., 2012).


