Novel method to quantify radioactive cesium-rich microparticles in the environment from the Fukushima Daiichi Nuclear Power Plant

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Highly radioactive cesium-rich microparticles (CsMPs) were released from the Fukushima Daiichi Nuclear Power Plant (FDNPP) to the surrounding environment at an early stage of the nuclear disaster in March 2011; however, the quantity of released CsMPs remains undetermined. Here we report a novel method to quantify the number of CsMPs in surface soils at or around Fukushima, and the fraction of radioactivity they contribute, which we call "quantification of CsMPs (QCP)" and is based on autoradiography. Here, photo-stimulated luminescence (PSL) is linearly correlated to the radioactivity of various microparticles, with a regression coefficient of 0.0523 Bq/PSL/h. In soil collected from Nagadoro, Fukushima, Japan, CsMPs were detected in soil sieved with a 114-μm mesh. There was no overlap between the radioactivities of CsMPs and clay particles adsorbing Cs. Based on the distribution of radioactivity of CsMPs, the threshold radioactivity of CsMPs in the size fraction <114 μm was determined to be 0.06 Bq. Based on this method, the number and radioactivity fraction of CsMPs in four surface soils collected from the vicinity of the FDNPP were determined to be 48–318 particles/g and 8.53–31.8%, respectively. The QCP method is applicable to soils with a total radioactivity as high as ~10^6 Bq/kg. This novel method is critically important and can be used to quantitatively understand the distribution and migration of the highly radioactive CsMPs in near-surface environments surrounding Fukushima.