Application of isotopic approach to assess the quasi-equilibrium levels of ^{137}Cs in Fukushima forests

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Radionuclides from atmospheric fallout are intercepted by aboveground forest biomass and then transported to the forest floor with litterfall, throughfall, and stemflow, which leads to a decrease in radionuclide inventories in biomass during an early stage after deposition. Accordingly, a well-studied dominant trend in Fukushima forests during that period was the fast decrease in radiocesium inventories in the aboveground tree biomass. After the early stage, depending on the local conditions and form of fallout, radionuclide inventories and concentrations in tree biomass may show different trends, including both increase and decrease, until reaching a quasi-equilibrium level.

In this study, we applied an isotopic approach to assess the quasi-equilibrium of Fukushima-derived radiocesium (^{137}Cs) in a typical mature Japanese cedar forest. The concentrations of radiocesium in the aboveground biomass compartments as of 2020 correlated well with the equilibrium concentrations of the naturally occurring stable isotope of cesium (^{133}Cs) entering the aboveground biomass from the soil, indicating that the quasi-equilibrium distribution of radiocesium had been achieved after a period of removal of the initially intercepted radiocesium from the biomass compartments. The isotope concentration ratio ^{137}Cs/^{133}Cs in the biomass as of 2020 is estimated as $3.6 \cdot 10^{-5}$ ($\mu g\ kg^{-1}$) ($\mu g\ kg^{-1}$)$^{-1}$ (95% CI: $1.6 \cdot 10^{-5}$ - $5.6 \cdot 10^{-5}$). The isotope inventory ratio ^{137}Cs/^{133}Cs in the 5-cm topsoil was slightly lower, $(2.52 \pm 2.39) \cdot 10^{-5}$ ($\mu g\ kg^{-1}$) ($\mu g\ kg^{-1}$)$^{-1}$, indicating the presence of some amounts of radiocesium intercepted from the atmospheric fallout in March 2011 in the biomass compartments. The total radiocesium inventory in aboveground biomass stabilized between 2017 and 2020 at the level of (3.1+1.7) % of its total inventory in the ecosystem.