Temperature Dependence of Dissolved ^{137}Cs Concentration in River Water: Differences among Forested River, Agricultural River, and Dam Discharge Water

*Hideki Tsuji[1], Tatsuhiro Nishikiori[2], Shoko Ito[1], Hirokazu Ozaki[1], Seiji Hayashi[1]

1. National Institute for Environmental Studies, 2. Tohoku Agriculture Research Center

In many rivers, the concentration of dissolved ^{137}Cs varies seasonally as a function of water temperature. Recent studies have suggested that this dependence indicates a shift in the thermodynamic equilibrium of ^{137}Cs between the solid and aqueous phases in response to temperature change. However, the thermodynamic behavior of ^{137}Cs has only been studied for a limited number of rivers, and the essential mechanism of the formation of the dissolved ^{137}Cs concentration with temperature has not yet been elucidated. In this study, we investigated the relationship between dissolved ^{137}Cs concentration and water temperature for agricultural rivers (flowing through agricultural areas), forested rivers and dam discharge waters based on monthly observations in the Fukushima Daiichi nuclear power plant accident affected area in 2014–2019.
When ^{137}Cs can be considered to be in equilibrium between the solid and aqueous phases, the distribution coefficient of ^{137}Cs and temperature follow the van't Hoff equation. If the ratio of the concentration of ^{137}Cs in suspended solids to the dissolved form is taken as the distribution coefficient of ^{137}Cs, the van't Hoff plots (logarithm of the distribution coefficient and the reciprocal of the absolute temperature on both axes) in two agricultural rivers were well approximated by the van't Hoff equation line. The standard enthalpies of the reaction derived from the regression equation were close to previously reported values (-19 kJ mol^{-1}). On the other hand, the van't Hoff plots in two forested rivers and two dam discharges were poorly approximated by the linear regression equation. The high proportion of organic matter in the suspended solids in these waters suggests that dissolved ^{137}Cs concentrations in forested rivers and dam discharge waters are not determined by ion exchange between suspended solids and the aqueous phases, but by other mechanisms such as microbial decomposition of litter and microbial growth within the dam lake.

Keywords: dissolved 137Cs, river water, dam discharge water

