Plot-scale wash-off of Cesium-137 and Strontium-90 after three decades since the Chernobyl accident

Yoshifumi Wakiyama¹, Yasunori Igarashi¹, Yuichi Onda², Dmitry Samoilov³, Hlib Lisovy⁴, Volodymyr Demianovych³, Gennady Laptev⁴, Alexei Konoplev¹, Kenji Nanba¹,⁵, and Serhii Kirieiev³

¹Fukushima University, Institute of Environmental Radioactivity, Fukushima, Japan (wakiyama@ipc.fukushima-u.ac.jp)
²Center for Research in Isotopes and Environmental Dynamics, University of Tsukuba, Japan
³Chernobyl Ecocentre, State Agency of Ukraine on Exclusion Zone Management, Ukraine
⁴Ukrainian Hydrometeorological Institute, Ukraine
⁵Faculty of Symbiotic Systems Science, Fukushima University, Japan

Long-term behaviors of Cesium-137 (¹³⁷Cs) and Strontium-90 (⁹⁰Sr) have been of great interest in Chernobyl and its downstream area. This study presents plot-scale observations of ¹³⁷Cs and ⁹⁰Sr wash-off in the Chernobyl exclusion zone since 2018 to date. Runoff plots were established on a pine forest in the Kopachi area (PF-KP), an abandoned farmland in the Korogod area (AF-KR) and a post wild fire territory in the Red Forest (WF-RF) in December 2017. Each runoff plot consists of eroding surface of 22.13 m length and 5 m width, a 30° V-notch weir with water level sensor for monitoring surface runoff and tanks for collecting runoff water and sediments. Since February 2018, runoff water and sediment samples trapped in the weir and tanks have been collected after rainfall events and analyzed for particulate ¹³⁷Cs concentration, dissolved ¹³⁷Cs concentration, and dissolved ⁹⁰Sr concentration. Analyses of samples in 2, 4, and 3 wash-off events were completed for PF-KP, AF-KR, and WF-RF, respectively. The ash/litter on soil surface, soil of 0-1 cm depth, soil of 1-2 cm depth, and soil of 2-3 cm depth were sampled with a scraper plate and subject to measurements of ¹³⁷Cs and ⁹⁰Sr concentrations. Total volume of surface runoff from PF-KP, AF-KR, and WF-RF were 0.97, 0.73, and 3.2 mm, respectively. Total sediment discharge from PF-KP, AF-KR, and WF-RF were 0.29, 0.015, 1.7 g m⁻², respectively. The runoff and sediment discharge from PF-KP and WF-RF were mainly observed in summer and attributed to severe water repellency of the surface soils. Total particulate ¹³⁷Cs wash-off from PF-KP, AF-KR, and WF-RF were 51, 0.082, 270 Bq m⁻², respectively. Total dissolved ¹³⁷Cs wash-off from PF-KP, AF-KR, and WF-RF were 7.4, 0.024, 9.8 Bq m⁻², respectively. Total dissolved ⁹⁰Sr wash-off from PF-KP, AF-KR, and WF-RF were 55, 0.31, 230 Bq m⁻², respectively. These results indicate that wild fire enhances surface runoff and sediment yield and result in greater wash-off of ¹³⁷Cs and ⁹⁰Sr. In comparisons between PF-KP and WF-RF, apparent Kd value for ¹³⁷Cs at WF-RF was higher than at PF-KP. Ratio of dissolved ¹³⁷Cs and ⁹⁰Sr concentration to those in ash/litter layer at PF-KP was lower than those of WF-RF. The dissolution of these radionuclides into runoff water appeared to be restrained in the post wild-fire site.