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Mobility and bioavailability of the Chernobyl origin radiocaesium and radiostrontium in the unsaturated zone

A. Konoplev
Science & Production Association “Typhoon”

Presented are the results of twenty years post-Chernobyl theoretical and experimental researches on radiocaesium and radiostrontium behaviour in the “soil-water” system.

Conceptual model of transformation of radiocaesium and radiostrontium speciation in soils and water bodies is proposed. The model considers processes of radionuclide leaching from fuel particles, sorption-desorption due to ion exchange, fixation and remobilisation. Steady state ratio between exchangeable and nonexchangeable forms of radionuclide (and therefore their mobility and bioavailability) is determined by initial ratio of radionuclide forms in deposition and rates of radionuclide leaching, fixation and remobilisation processes.

Characteristics of radionuclide washoff by surface runoff are presented for ^{134}Ñs; ^{137}Cs; ^{103}Ru; ^{106}Ru; ^{144}Ce and ^{90}Sr of Chernobyl origin in solution and on suspended matter. Method to parameterise washoff coefficients through hydrological characteristics is proposed. The method allows using the parameterisation in prediction of water pollution by surface runoff from contaminated watersheds. Presence of fuel particles in the Chernobyl deposition caused significantly lower values of wash-off coefficients in the first years after the accident as compare to nuclear weapon testing fallout. It is shown that radiocaesium and radiostrontium concentrations in surface runoff correspond to ion exchange mechanism between runoff and top soil layer of several mm depth. Method is proposed to predict radiocaesium and radiostrontium concentrations in surface runoff on the basis of using effective selectivity coefficients in the system “top soil layer – runoff”.

The model of radiocaesium and radiostrontium soil-plant transfer is proposed. The

model takes into consideration speciation of radionuclide and its transformation, sorption-desorption in the system “soil-soil solution” processes of speciation including selective sorption for radiocaesium, ion exchange between soil solution and root exchange complex and transfer through cell wall free space. On the basis of the model bioavailability factors for radiocaesium and radiostrontium were defined as functions of physical and chemical soil characteristics. Application of proposed parameterisation for soil-plant transfer factor allows to reduce substantially uncertainty of its assessment and prediction.