Modeling of downward percolation and prediction of concentration of the radionuclide in soil by ADE

OKA, Hiroki[1]* ; HATANO, Yuko[1] ; YAMAMOTO, Masahiro[2]

[1]Faculty of Systems and Information Engineering, University of Tsukuba, [2]Graduate School of Mathematical Sciences, the University of Tokyo

By the accident at the Fukushima First Nuclear Power Plant on March 11, 2011, the damage that surrounding environment was polluted by radioactive materials occurred. Cs-137 stuck in a ground surface soaks into soil and percolates downward. The underground migration of the radionuclide keeps being studied. The advection diffusion equation (ADE) is proposed as one of the models of downward percolation of the radionuclide in soil by Walling and He. This model has been used most, because it is simpler than other ones. However, There is also the report that we cannot express migration in porous medium such as soil by ADE. This is caused by the fact that differences in soil properties of each land have an influence on the downward percolation of the radionuclide. However, it takes considerable amounts of labor to propose the model included all complicated processes of such various environmental factors. In this study, by having a viewpoint different from such a model, we propose a more versatile model by improving the ADE model that used most.

For this ADE model, Robin boundary condition is used. Robin boundary condition is that the inflow and outflow of the radionuclide on a boundary surface does not happen. So, it is the downward percolation model while keeping the total volume of the concentration fixedly. However, it is difficult to think that the inflow and outflow in a ground surface do not happen at all. So in this study, by aiming at Robin boundary condition, we improve the ADE model. We derive the analysis solution when we use ADE as governing equation and Robin boundary condition that was generalized as condition at a boundary surface. From this, we propose the new ADE model including the case that the inflow and outflow happen in a ground surface. Here, we compare our model with the data of concentration of Cs-137 in Fukushima soil to inspect the validity of this new model. Then, we get the result that our model follow the date well.

Keywords: Advection Diffusion Equation, Downward percolation in soil, The accident at the Fukushima First Nuclear Power Plant, Radioactive Cesium