学　位　論　文　要　旨

Development and validation of a pollutant runoff module in SPEC model
SPEC モデルにおける汚染物質流出モジュールの開発と検証

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The existing SPEC model (Predicted Environmental Concentrations in agricultural Soils) was developed and validated for predicting pesticides in bare soil upland field. However, it could not predict pesticide concentration in more than 2 layers of soil as well as runoff simulation was not developed accurately. The objectives of the study were to (1) develop a pollutant runoff module in SPEC for simulating runoff water, sediment concentration and yield in runoff water, and pesticide concentrations in runoff water and in the sediment s; (2) improve SPEC model for simulating pesticide fate and transport in multiple soil layer; and (3) calibrate and validate the model with experimental runoff data using an artificial rainfall simulator for assessing pesticide runoff.

The improvements were made for the existing SPEC model for increasing the accuracy in simulating pesticide fate and transport at multiple soil layers and for developing a new module to simulate the pollutant runoff. The sediment simulation which was added in the runoff module allows simulating the sediment in runoff water as well as the pesticide concentration in runoff sediment. The improvements allow users to simulate runoff as well as pesticide in soil not only in single events but also continuous simulations. The shorter time steps of input and output enable the model to simulate the pollutant runoff in single rainfall events. The additional codes integrated in the SPEC model include statistical indexes and Monte Carlo simulation supporting the users in evaluating the model performance, sensitivity analysis, calibration and validation, as well as uncertainty analysis.

The improved SPEC model was tested for three applications. The first case study applied to simulate the pollutant runoff for two types of pesticides (clothianidin and imidacloprid) under artificial rainfall events in Sakeacho field on upland bare soil in Tokyo, Japan conducted on October 02, 2017. The second case study was conducted to simulate the fate and transport of imidacloprid and clothianidin in 4 layers of soils in Sakaecho upland bare soil (Tokyo, Japan) in 65 days from September 26 to November 29, 2017. The third simulation was applied for the case study of Sakaecho with two types of pesticides (atrazine and metolachlor) in 329 days from June 10, 2013 to May 04, 2014, under two options which were 2 and 3 soil layers simulations.

The calibration and validation for the pollutant runoff module under artificial rainfall condition were done for the Sakaecho upland field (Tokyo, Japan) on October 02, 2017 for two types of pesticides, imidacloprid and clothianidin. The simulated results of runoff rate using CN method and Green-Ampt method matched the observed data at a satisfactory level. The simulated results of cumulative runoff using CN method and Green-Ampt method performed a very good agreement with the observed data. The simulated time to first runoff performed well with the observed data. The results of sediment yield also performed a very good agreement with the observed data. The results of clothianidin concentrations in sediment and runoff water indicated a satisfactory model performance. The results of imidacloprid concentrations in sediment performed a very good agreement with the observed data.

The second case study for simulating pesticide concentrations in multiple soil layers was performed for imidacloprid and clothianidin in Sakaecho upland field in 65 days. The performance of simulated pesticides in multiple soil layers was not good because of the imprecise observation data. However, the simulated pesticides in the first soil layer (0-1cm) indicated the potential of the model to predict the pesticide concentrations in multiple soil layers.

The third case study for simulating pesticides in multiple soil layers was applied for Sakaecho upland field for atrazine and metolachlor in 329 days. The simulations for the same soil depth of 10cm, but classified in to 2 and 3 layers were conducted. It was found that the simulated results from 3 layers simulation performed better than those in 2 layers simulation for both types of studied pesticides. The results of 2 types of pesticides simulated by 3 layers scenario indicated a better model performance in the improved SPEC model as compared to those in the previous study.

The improvements of SPEC model were tested for runoff pollutant as well as for pesticide concentrations in multiple soil layers case studies. The results implied the potential capability of the improved SPEC model to predict pesticide fate and transport in multiple layers of soil as well as runoff pollutant in upland field.