Application of PCPF-1@SWAT model to simulate fate and transport of three rice herbicides in Sakura river basin

PCPF-1@SWAT を用いた桜川流域での３水稲用除草剤の動態シミュレーション

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1. Introduction

A PCPF-1@SWAT model, which was developed based on SWAT model, has been used to simulate pesticide concentrations in the Sakura river basin, Japan (Boulange et al., 2014). The PCPF-1@SWAT model consists of the algorithms regarding the water balance calculation in rice paddy areas and the algorithms to calculate the fate of pesticides used in paddy fields and their transport from the paddy fields to channel network (Boulange, Watanabe et al. 2014) (Figure 1). The aim of this study is to simulate the fate and transport of three herbicides applied to rice paddy fields in the Sakura river basin.

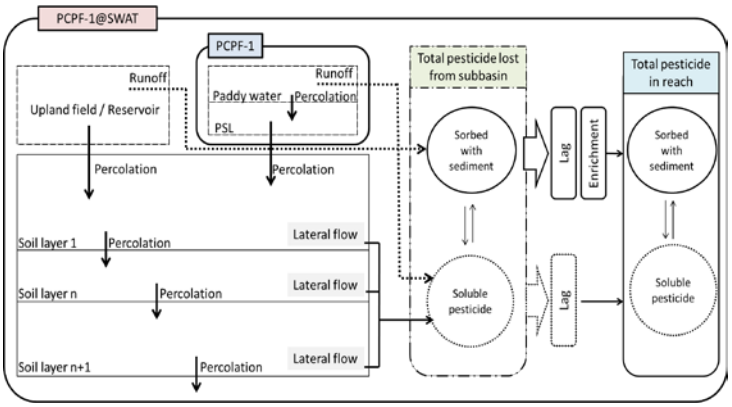

Figure 1. Water and pesticide routing from rice paddy in the PCPF-1@SWAT model (Boulange, Watanabe et al. 2014).

2. Material and method

The target compounds for these simulations are herbicides namely Pretilachlor (PTC), Bensulfuron Methyl (BSM) and Imazosulfuron (IMS). Since other herbicide, Mefenacet (MF) has been validated previously by Boulange et al. (2014), the same modeling procedure was used for simulating above three herbicides. Pesticide data for this study were extracted from the shipment data of pesticides collected in Ibaraki Prefecture in 2008 for the MF, PTC, BSM and IMS in order to determine the herbicide treated area and application rates. Digital Elevation Model (DEM) with a 10 m resolution, a land use map and stream network maps were obtained from the National Land Numerical Information (Ministry of Land, Infrastructure and Transport, 2015). Digital cultivated soil map data for Ibaraki Prefecture were obtained from National Institute for Agro-Environmental Sciences (NIAES). Meteorological daily observed data including precipitation, minimum and maximum temperatures, average wind speed, average relative humidity and average solar radiation were collected from Radar-AMeDAS-Analysis data base (Japan

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Keywords: PCPF-1@SWAT, rice paddy, agricultural chemical, pesticide transport simulation.

Meteorological Agency). Observed daily water flow data at the outlet of the Sakura river basin were obtained from the Water Information System (MLIT, 2015).

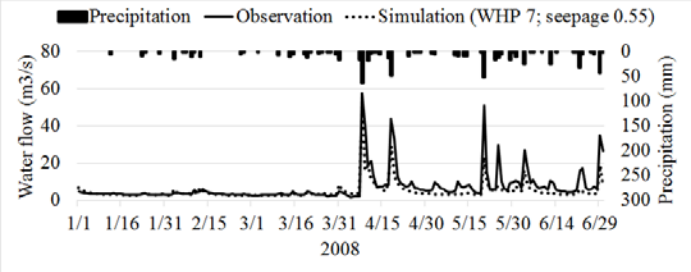

Figure 2. Observed and simulated water flow at the outlet of Sakura river

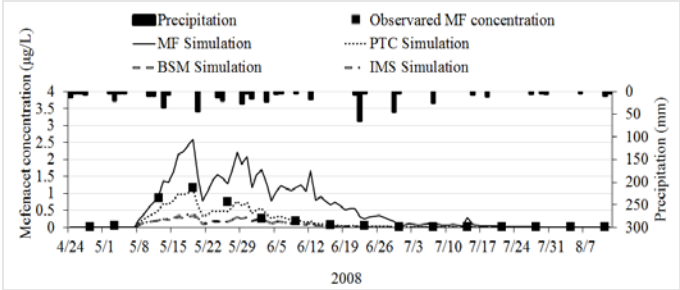

Figure 3. Simulated pesticide concentration at the outlet of Sakura river for Observed MF concentration, and simulated concentrations of MF, PTC, BSM and IMS.

3. Results and discussion

According to the pesticide shipment data, the area treated with PTC, BSM, and IMS was found to be 33.9% (23.05 km^2), 33.8% (22.98 km^2) and 20.7% (14.05 km^2) of the rice-copping area in Sakura watershed, respectively, and the application rates of PTC, BSM, and IMS were 0.404, 0.044 and 0.087 kg ha^{-1}, respectively. Boulange et al. (2014) reported that the rice area treated with MF in Sakura river basin was 8.1% (5.51 km^2) of the rice-copping area and the application rates of MF was 1.05 kg ha^{-1}. These pesticides are usually applied under flooded conditions from 1-2 weeks after rice transplanting for weed controll.

Simulation results showed that the observed and simulated streamflow rates agree reasonably well on daily basis during the ponding period (from April to October) and very well on daily basis during the non-ponding period (from November to March). The R^2 and E_{NS} statistics were 0.74 and 0.71, respectively, throughout the first six months in 2008 (Figure 2). Simulated pesticide concentrations in river water gradually increased from the beginning of rice transplanting and reached to the peak from 1 to 2 weeks after rice transplanting (Mid-May) and then rapidly decreased in early June. The simulation concentrations rose to maximum values of, 1.1, 0.34 and 0.4 µg.L^{-1} for PTC, BSM, and IMS respectively (Figure 3).

4. Conclusion

The simulated streamflow rates in the Sakura river had acceptable accuracy. Based upon the simulate flow rates, the concentrations of PTC, BSM and IMS in the stream water were simulated by PCPF-1@SWAT model. Simulated concentrations ranged within the simulated levels of validated compound of MF. However, further study needs to be conducted assess the accuracy of simulating herbicides concentrations in streamflow.

Reference: Boulange, J., H. Watanabe, K. Inao, T. Iwafune, M. Zhang, Y. Luo and J. Arnold (2014). "Development and validation of a basin scale model PCPF-1@SWAT for simulating fate and transport of rice pesticides." Journal of Hydrology **517**: 146-156; MLIT (2015). Ministry of Land, Infrastructure and Transport, Japan: http://nlftp.mlit.go.jp/ksj-e/jpgis/jpgis_datalist.html.