Application of the PCPF-1@SWAT2012 model for predicting rice herbicides transport in the Sakura River watershed

PCPF-1@SWAT2012 モデルの桜川流域での水稲用除草剤の流出予測への適用について

Le Hoang Tu[1], Julien Boulange[2] and Hirozumi Watanabe[1]
レ・ホアン・トゥ [1], ジュリアン・ブランジェ [2],渡邊裕純 [1]

1. Introduction

The Sakura River watershed is an agricultural watershed with 82% of the geographical area under agriculture, which is located in Ibaraki prefecture, Japan (Iwafune et al., 2010). Previous monitorings reported that more than 39 kinds of pesticides were detected in the watershed (Vu et al., 2006; Iwafune et al., 2010). Therefore, in order to evaluate for the aquatic environmental risk in the watershed, the fate and transport of rice pesticides need to be investigated. Along with the development of rice pesticide models, the PCPF-1@SWAT2012 model was developed. This model is able to simulate pesticide fate and transport from paddy field to aquatic environments in watershed scale. The objective of the study is to apply the model for simulating transport of four rice herbicides including mefenacet ($C_{16}H_{14}N_2O_2S$), pretilachlor ($C_{17}H_{26}ClNO_2$), bensulfuron-methyl ($C_{16}H_{18}N_4O_7S$), and imazosulfuron ($C_{14}H_{13}ClN_6O_5S$) in the watershed.

2. Material and method

The study collected the model input data including topography, land use, soil, weather, applied herbicides, observed water flow rate and monitored herbicides concentration of the Sakura River watershed. Among these data, the herbicides data are most important which include herbicides properties (e.g. solubility, first order dissolution rate constant, first order desorption rate constant etc.) and herbicides application data (application time, rate, area and water holding period). The herbicides properties and applied information were referred from the available literatures. Then, the herbicides transport was predicted by using the PCPF-1@SWAT2012 model. The simulations were run in daily time step for the period 2007-2009. Finally, the model parameters which related to the prediction of the water flow rate and the herbicides concentration were calibrated in 2007 period and validated in 2008-2009 period.

3. Results and discussion

Figure 1 shows the predicted water flow rate and observed data in validation period. Although RMSE (6.78 m^3/s) was beyond the optimal index value (RMSE = 0), NSE value was equal to 0.73, suggesting satisfactory performance of model. The predicted water flow rate showed well response to precipitation. For herbicides simulations, the calibration and validation also followed the same period as predicted water flow rate. Table 1 shows calculated values of RMSE and NSE of four predicted herbicides during the calibration and validation period. These statistical indices showed satisfactory predictions. Figure 2 shows the predicted and observed concentrations of the four herbicides in the Sakura River watershed during the monitoring period (2008 – 2009).

所属：[1] 東京農工大学，[2] 国立環境研究所；Affiliation：[1]Tokyo University of Agriculture and Technology, [2]National Institute for Environmental Science
Key words：The PCPF-1@SWAT2012 model, pesticide fate and transport, rice paddy

Results indicated that the concentrations of the predicted herbicides increased in early of May, reached the peak in the second and third weeks of May, and then decreased gradually. The aforementioned predicted trend for these herbicides was repeated in 2008 and 2009. The predicted concentrations of the herbicides well responded to precipitation events. During May 20-24, 2008, the predicted concentration of herbicides sharply increased after a precipitation event and then decreased due to dilution effects. A sharp decline in the concentration of all herbicides was further observed upon the precipitation events on June 3, 2008. The initial sharp increases and declines of herbicides upon the major precipitations were also observed during prediction period of 2009. The maximum predicted and monitored concentration were 1.88-1.50 µg/L, 0.98-1.40 µg/L, 1.65-1.17 µg/L and 0.56-0.62 µg/L in 2008; and 2.48-1.50 µg/L, 0.85-1.70 µg/L, 1.67-1.0 µg/L and 0.59-1.07 µg/L in 2009 for pretilachlor, imazosulfuron, mefenacet, and bensulfuron-methyl, respectively.

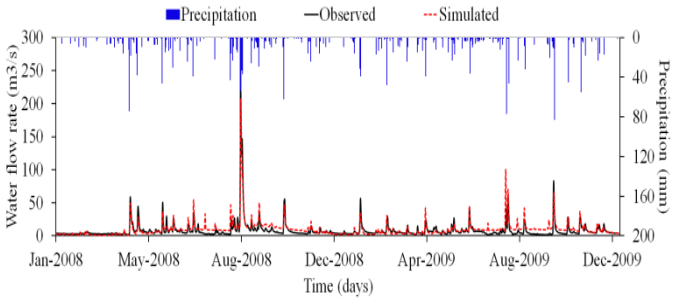

Fig 1. The Simulated water flow rate at the outlet of the Sakura River watershed during the period 2008-2009.

Table 1. NSE and RMSE for the simulated herbicides in calibration and validation periods.

Herbicide name	Calibration		Validation	
	NSE	RMSE (µg/L)	NSE	RMSE (µg/L)
Mefenacet	0.91	0.11	0.69	0.18
Pretilachlor	0.52	0.27	0.86	0.18
Bensulfuron-methyl	0.73	0.13	0.46	0.21
Imazosulfuron	0.70	0.41	0.64	0.28

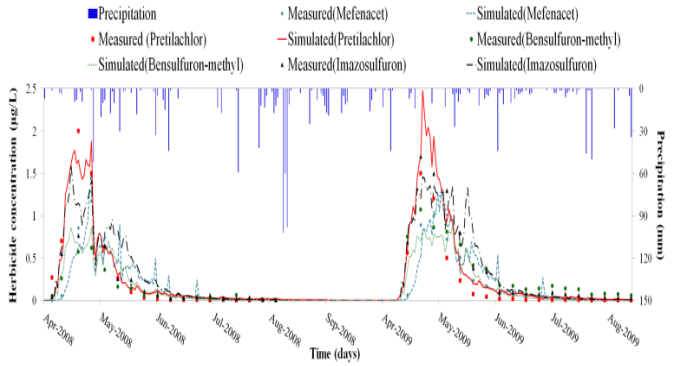

Fig 2. The simulated and observed concentration of the herbicides in the watershed during monitoring period in 2008 - 2009.

4. Conclusions

The PCPF-1@SWAT2012 model was applied for predicting transport of four herbicides in the Sakura River watershed during period 2007-2009. The model simulated the observed data with acceptable tendency. However, the model needs to be verified with other pesticides in this watershed as well as in other watersheds. Furthermore, to improve the model accuracy, detailed information regarding water management and pesticide use in the watershed are required. Beside, additional calibration and validations with monitoring data of pesticides in sediment are needed for the model accuracy evaluation.

References: Iwafune, T., INao, K., Horio, T., Iwasaki, N., Yokoyama, A., Nagai, T., "Behavior of paddy pesticides and major metabolites in the Sakura River, Ibaraki, Japan", *Pestic Sci* **35(2)**:114–123 (2010); Vu, S.H., Ishihara, S., Watanabe, H., 2006, "Exposure risk assessment and evaluation of the best management practice for controlling pesticide runoff from paddy fields", *Pest Manag Sci* **62**:1193–1206 (2006).