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Modeling of fate and transport of rice pesticide in river basin a case study for the Chikugo River basin

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Pesticide runoff from paddy field is one of the major causes on non-point source pollution in aquatic environment. It may induce the adverse effects on the aquatic life via pesticide exposure. Various monitoring studies have reported that rice pesticides were detected at public water area during rice cultivation season so far. Meanwhile, verification of monitoring results using a mathematical model based on the field data have hardly conducted. Therefore, this study aims to develop a mathematical model to assess the pesticide exposure in paddy watershed.

An integrated model, named the PCPW model, was developed in this study. The model consists of three sections; river section, paddy block section, and non-paddy section. In the river section, while solving Saint-Venant equations were solved numerically with the Preissmann implicit scheme for unsteady flow simulation, one-dimensional advection dispersion equation was solved with the modified finite element method to predict pesticide concentrations. In the paddy block section, a compartment model, named PCPF-B model, was used to simulate water balance and pesticide fate and transport in multiple paddy plots simultaneously. As for the non-paddy section, rainfall-runoff processes for city, upland and forest were estimated using a modified tank model. Numerical solutions of the PCPW model were coded with Visual Basic for Applications in Microsoft ExcelR.

The PCPW model was verified by comparing simulated results with rice herbicides concentrations collected in Kose river basin located Fukuoka Prefecture, Japan. Hydrologic and soil data in Kose River basin were imported from Geographical Information System (GIS). The target basin was divided into sub-basin. The extracted numerical data such as elevation, area of individual land uses and physicochemical properties of paddy soil were assigned as the input parameters of each sub-basin. The observed data of discharge at reservoir and estimated values from the tank model for forest were imposed as the upstream boundary condition for unsteady flow simulation. Information regarding applied herbicide, such as application date and usage ratio, physicochemical properties, and recommended water management were prepared from literatures. The two rice herbicides, pretalachlor and mefenacet were selected as the target compounds. Simulation was conducted from June to July in 2009. Simulated herbicide concentrations at up-, mid- and downstream of Kose River were evaluated with observed concentrations.

Results showed that river flow rates were predicted satisfactory. The simulated herbicide breakthrough curves show two distinct shapes; broad and sharp ones. Judging from rainfall data and applied water management scenario, it was considered that the former was due to water management and the latter was due to intensive rainfall events. Aforementioned results indicated that the PCPW model was potentially applicable for advanced assessment tool of pesticide exposure in river basin.

Keywords: rice herbicide, simulation model, river basin, GIS