Simulation of agricultural non-point source pollution in Xichuan by using SWAT model

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Abstract. This paper evaluated the applicability of using SWAT to access agricultural non-point source pollution in Xichuan area. In order to build the model, DEM, soil sort and land use map, climate monitoring data were collected as basic database. The SWAT model was calibrated and validated for the SWAT was carried out using streamflow, suspended solids, total phosphorus and total nitrogen records from 2009 to 2011. Errors, coefficient of determination and Nash-Sutcliffe coefficient were considered to evaluate the applicability. The coefficient of determination were 0.96, 0.66, 0.55 and 0.66 for streamflow, SS, TN, and TP, respectively. Nash-Sutcliffe coefficient were 0.93, 0.5, 0.52 and 0.63, respectively. The results all meet the requirements. It suggested that the SWAT model can simulate the study area.

1. Introduction

Soil and Water Assessment Tool (SWAT) is a widely used model to assess non-point source pollution. The recent study was mainly focused on the calibration and validation, modifying the algorithm, and the applicability of the model, in order to fit in various areas and time step. However, few people was concerning for the simulation of pesticide in China, due to lack of data and complex model parameters. And the use of SWAT can provide evaluation for improving the agricultural non-point source pollution programs.

The purpose of this study is to build the SWAT model for Xichuan area in Henan. Evaluate the applicability of this model by analysis two statistical metrics, coefficient of determination (R^2) and the Nash-Sutcliffe efficiency index (Ens). Streamflow, soil erosion, total nitrogen (TN) and total phosphorus (TP) are the mainly parameters simulated.

2. Materials and methods

2.1. Study area description

A 110 km^2 Xichuan watershed was adoped as the research area. Laoguan River is running through the whole city, and it directly linked to Danjiangkou reservoir. The reservoir plays an important role in the South to North Water Diversion. The protection of agricultural non-point source pollution should be concerned. Fig. 1 shows the study area.

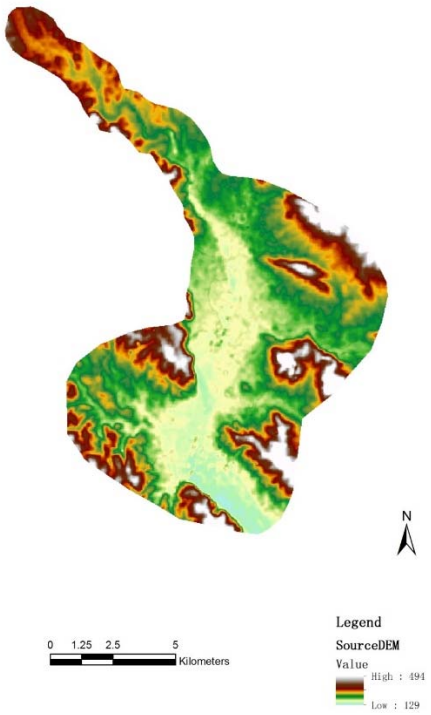

Fig.1 DEM image map of the research area

2.2. Input data prepared for the SWAT model setup

DEM, soil sort and land use map, climate monitoring data were collected as basic database. The streamflow, SS, TN and TP were considered for the calibration and validation. Although SS is not the main pollutant of agricultural non-point source pollution, but because nitrogen and phosphorus and other pollutants can be attached to the sediment, and then enter the water body as the loss of sediment. Thus, the calibration and validation of SS is significance for the model simulation. For the streamflow, the error between simulated and observed monthly values should be less than 20%, R^2> 0.6 and Ens> 0.5. For SS, nitrogen and phosphorus pollutions, Re<30%, R^2> 0.6 and Ens> 0.5[3].

3. Results and discussion

3.1. Calibration and validation of SWAT model

Coefficient of determination (R^2) and Nash-Sutcliffe coefficient (Ens) are the two important metrics for the model calibration and validation. For the study area, the SWAT model was calibrated and validated for 3 years from 2009 to 2011. Data of streamflow and SS from 2009 to 2010 were using for modelling calibration. Data from 2011 were chosen for modelling validation.

Table 1. Calibration and validation of Streamflow and SS

	Streamflow		SS	
	Calibration	Validation	Calibration	Validation
Re（%）	20.8	3.05	-15.6	-6.9
R^2	0.96	0.74	0.66	0.63
Ens	0.93	0.89	0.5	0.5

For the streamflow, the value of R^2 were 0.96 and 0.74 for calibration and validation, Ens were 0.93 and 0.89, respectively. As for the calibration and validation of SS, the value of R^2 were 0.66 and

0.63, Ens were 0.66 and 0.63, respectively. It indicated that the simulated and observed values were well correlated.

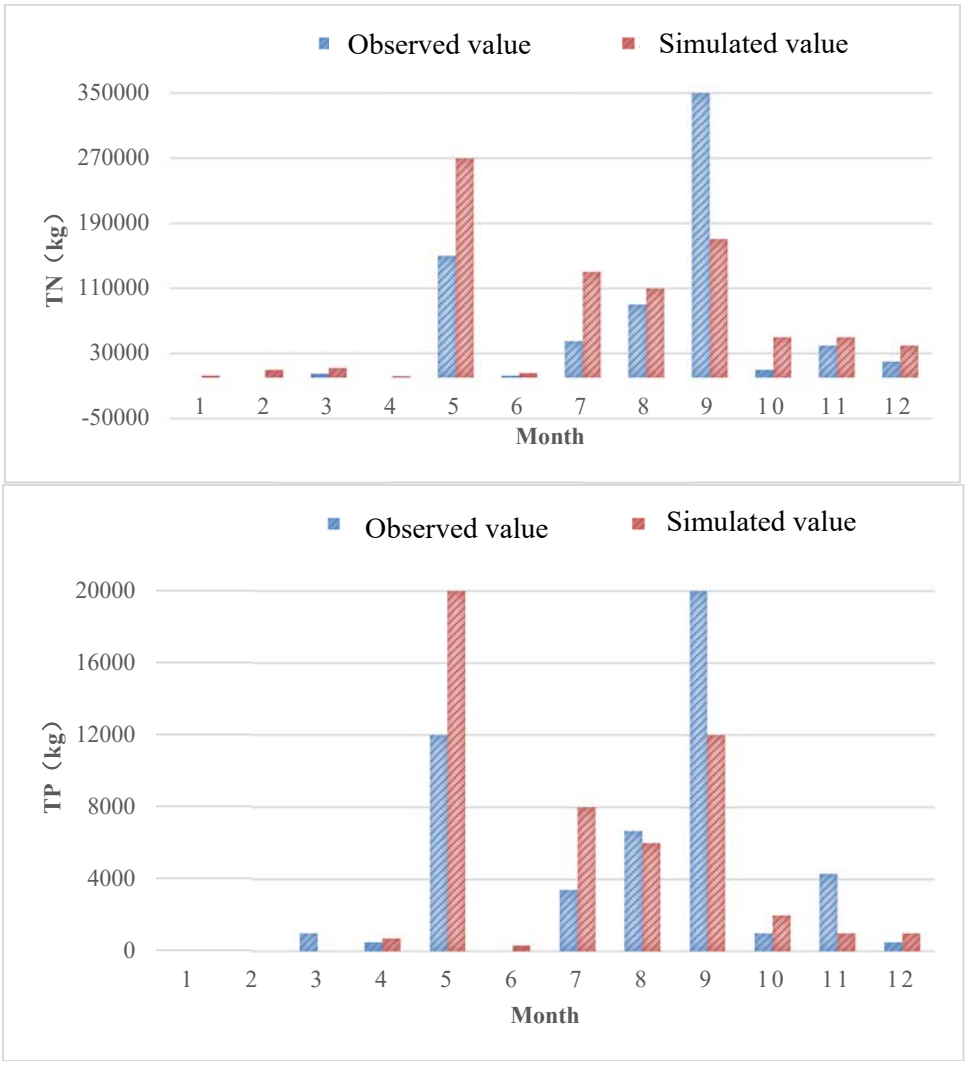

Fig. 2 Simulated and observed values of TN and TP in 2011

Simulated and observed values of TN and TP are compared in Fig.2. It can be seen that they both have the same trends, although there are some fluctuates. It may be caused by the accuracy of the database and the different definition of the soil character. The errors between simulated TN and observed TN values were 22.7%, R^2 was 0.55 and Ens was 0.52. As for TP, Re, R^2 and Ens was -1.2%、0.66、0.63, respectively.

4. Conclusion

In this study, the SWAT model was built to access the agricultural non-point source pollution in Xichuan. The calibration and validation for the model were using both observed (from 2009 to 2011) and simulated data. The result shows that the values of errors, coefficient of determination and Nash-Sutcliffe coefficient for streamflow, SS, TN, and TP meet the criteria values well. It can be concluded that the model can be used for further study of this area. Based on this research, influence of control measures on agricultural non-point source pollution in the study area can be evaluated.

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