Study on Erosion Status of Typical Small Watershed in Yanghe River Basin

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Abstract. A typical small-scale watershed in the Yanghe River Basin is selected as the research area, and the regional digital elevation model map (DEM) is studied by using the aerial photography of the drone. Based on the arcgis10.4 platform, the SWAT model was used to extract the water system and determine the boundary of the study area. The meteorological data of the SWAT model comes from the automatic weather station at the study area center. The physicochemical properties of soil surface samples and soil profiles were determined in the study area in July each year. The results were used as parameters of the SWAT soil model, and determine other parameters of the SWAT model by Sensitivity analysis. The soil erosion status of the study area was obtained, and the soil erosion in the study area was studied. It is more serious and the erosion channel has a tendency to expand further. According to the erosion status and development trend simulated by the SWAT model, it provides reference for soil and water conservation control measures.

Keywords. SWAT, small-scale basin, ocean basin, soil erosion.

1. Introduction

Soil erosion and its caused land degradation and other environmental problems are one of the important areas of concern for scholars at home and abroad. Soil erosion will cause nutrients such as nitrogen and phosphorus in the soil to be washed away, land productivity will decline, soil structure will be destroyed, and human production and life will be seriously affected. Small watershed is the most basic unit of occurrence and development of soil erosion, and reasonable and accurate prediction of soil erosion plays an important role in soil erosion in the study area [1], a time-based step developed by the US Department of Agriculture (USDA) with a strong physical mechanism. And a distributed watershed scale hydrological model with continuous long-term simulation.

The SWAT (soil and water assessment tool) model is based on the early sequence model and the subsequent SWRRB model [2], which is a distributed watershed-scale hydrological model with daily time steps, continuous long-term simulation, strong physical mechanism and developed by the United States Department of Agriculture (USDA). The distributed model divides the watershed into several grids or representative basic units as the calculation unit, and assigns the calculation unit to reflect the differences of various factors affecting soil erosion in the basin [3], which can simulate the hydrological process of the basin. Changes in soil erosion, chemical processes, etc., and can predict the impact of human activities on the above processes under different climatic conditions, soil conditions, land use/coversing and management measures [4].

Zhang Xuesong et al. carried out simulations of runoff and sediment yield in the upper basin of the
Luohe hydrological station in the Xiaohua area of the lower Yellow River in the lower reaches of the Yellow River. It is believed that the SWAT model can simulate the long-term continuous sediment load in the basin [5]. Using the SWAT model to simulate the status of soil erosion in the region can help to provide a reference for how to take measures to reduce soil erosion. Based on the SWAT model, this paper studies and analyzes the soil erosion status of typical small watersheds in the Yanghe River Basin.

2. Materials and Methods

2.1. Research Area Overview
The study area is located in the middle reaches of the Yanghe River (40.61° N and 114.95°E), which is a typical small watershed formed by the erosion in the Yanghe River Basin with a drainage area of 0.39km². The overall elevation of the southwestern part is relatively high, relatively, the elevation in the northeast is lower. The overall terrain on the slope is relatively flat, with gentle slopes as the main slope. However, the large erosion pit formed by years of heavy rain is more than 30m deep and up to 10m wide. Most of the watershed is covered by dimeric loess, with a loose surface and low vegetation coverage. Soil surface is seriously eroded by water flow.

2.2. Acquisition of Digital Elevation Model Data and Meteorological Data
Using a drone to perform aerial photography on the watershed terrain, a digital elevation model (DEM) with an accuracy of 0.2 m*0.2 m is obtained. The watershed map is obtained by calculating the DEM based on the arcgis10.4 platform. An unattended automatic weather station is set up in the middle of the river to obtain meteorological data such as temperature, rainfall, solar radiation and wind in the basin.

2.3. Soil Sampling Points and Sampling Methods
Following the principle of combining comprehensive investigation with key monitoring, periodic investigation and dynamic observation, and source-upstream-midstream-downstream-watershed export system, comprehensive consideration of natural geographical features, land use types and hydrology characteristics in the basin, the export section, the tributary points, the different land use types, the upstream and downstream key points are arranged. The first soil sampling point is arranged at the downstream slope of the channel. The second soil sampling point is laid on the midstream slope, and the groove head erosion slope. The third soil sampling point is arranged on the upper part, and the fourth soil sampling point is arranged at the intermediate branch channel branch point. Soil surface samples and soil profiles were collected periodically every quarter to determine soil physicochemical properties such as permeability, moisture content, and nitrogen and phosphorus content (figures 1 and 2).

Figure 1. Digital elevation model (DEM) of the typical watershed.
Figure 2. Soil permeability measurement experiment.

From 2008 to 2016, there are 13 of heavy rain days with a single day rainfall greater than 25 mm, accounting for 4.7% of the total rainfall days. The total amount of heavy rainfall is 466 mm, which accounts for 17.2% of the total rainfall (figure 3).

Figure 3. Annual average rainfall in the basin.

3. Soil Erosion Modulus
Accroding to the acquired DEM of 0.2 m precision, soil and climate data, combined with SWAT model calculation, some parameters are shown in table 1. As shown in figure 4 of the soil erosion modulus, the average erosion modulus in the study plot is 5,017 t/(km²*a), and the channel erosion is the most serious, which exceeds as high as 10,000 t/(km²*a). According to the classification standard of soil erosion classification of the People’s Republic of China for water industry, SL 190-2007, the intensity of hydraulic erosion is strong, and soil erosion is highly prone to occur.
Table 1. List of sensitive parameters calibrated based on global sensitivity analysis.

| Parameter   | Value |
|-------------|-------|
| ALPHA_BF    | 0.65  |
| SNDCO       | 0.2   |
| CDN         | 0.2   |
| ESCO        | 0.75  |
| GW_REVAP    | 0.18  |
| GWQMN       | 20    |

Figure 4. Soil erosion modulus map.

4. Conclusions
The typical small watershed in the Yanghe River Basin has loose soil structure, and the rainfall is concentrated in the summer. The rainfall intensity is high, which is very likely to cause soil erosion. Through the analysis of soil erosion, it is found that the soil erosion in the study area is serious, and the erosion intensity of the erosion channel is higher than that of the expansion, destroying the local grassland and cultivated land, causing local animal husbandry and agricultural production loss. Therefore, appropriate engineering measures are needed to mitigate soil erosion. For example, planting plants on the erosion slope to improve the soil physical structure and chemical properties of the topsoil [6] reduce soil erodibility and increase soil infiltration capacity. Returning sloping farmland to forests and grasslands, restoring vegetation, strengthening ecological construction, and controlling soil erosion from the source. On the abandoned farmland of barren hills and slopes, the combination of arbor and irrigation is carried out to form a multi-level, high-density shelterbelt system [7] to protect the local ecological environment.

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