THE SIMULATION OF AGRICULTURAL NON-POINT SOURCE POLLUTION IN SHUANGYANG RIVER WATERSHED

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Abstract: At present, agricultural non-point source pollution has become an important factor of the water environment deterioration and the lake eutrophication in China. With the Shuangyang River watershed for research object, using GIS and other soft wares establishing the database and the thematic maps of the Shuangyang River watershed, and using AnnAGNPS model simulated agricultural non-point source pollution of the watershed. The results showed that the total pollutant loading time distribution and spatial distribution of Shuangyang River Watershed sources of agricultural nitrogen, phosphorus and sediments. The Application can provide references for theoretical study of the non-point source pollution control and management, as well as practice for this area or domestic other regions.

Keywords: Shuangyang River Watershed, Agricultural non-point source pollution, AnnAGNPS model

1. INTRODUCTION

With people's attention to point source pollution, the point source pollution has been better controlled and managed, rather than non-point source pollution is becoming or has become the main pollution form of impacting water quality (Yang Ailing et al., 1998).Agricultural activities are the main reason caused by non-point source pollution. The soil particles, nitrogen, phosphorus, pesticide and other organic or inorganic contaminants in farmland soil, in the course of precipitation or irrigation, through agricultural surface runoff and farmland drainage and underground leakage, flow into the water and lead to water environmental pollution, namely, agricultural non-point source pollution (Liu Jihui et al.,2007). The results showed that, China's chemical fertilizer utilization ratio is not too high, nitrogen utilization of 30% ~ 35%, Phosphorus (P) 10% ~ 20%, Potassium (K) 35% ~ 50%. Even according to the highest utilization ratio to estimate, only in 1995, the loss of nitrogen, phosphorus, potassium respectively reached 13.145 million tons, 5.06 million tons and 13.43 million tons respectively (Peng Kui et al., 2001). Through runoff, eluviations, denitrification, adsorption and erosion unemployed the nutrient flowed into the environment, resulted in water and atmospheric pollution. Therefore, quantitative research on non-point source pollution load not only has an important significance for comprehensive management and systematic research of water environment pollution, but also has significantly environmental and social benefits in our country (Bao Quansheng et al., 1996; Li Guibao et al., 2001).

Shuangyang River originated from Xinyu Village Xinsheng Township Baiquan County of Heilongjiang Province, from east to west crossed Baiquan and flowed into Yi'an County. The segment flowing through Baiquan is the middle reaches of Shuangyang River. The average slope of the river is 0.1%. The watershed located in the open surface of Songnen Plain of the Midwest of Heilongjiang Province, which is the transition zone between extension of Xiaoxinganling mountain and Songnen Plain. It located in 47 ° 12 'N to 47 ° 43'N, 125 ° 32 'E to 126 ° 00'E. The terrain is high on the periphery and low in the middle of the watershed. The surface erosion and gully erosion is developed, so formed interlaced gullies, and showed severe erosion. The earth is highly uneven, the highest altitude is 301.1m, the lowest is 207.1m, and relative difference is 104m in height. The watershed is the severe soil and water erosion area.

2. APPLICATION OF ANNAGNPS MODEL

2.1 Model summary

AnnAGNPS is explored by Agricultural Research Service of USDA, to study the agricultural non-point source pollution load of the watershed. It is a continuous simulation model, compiled by ANSI Fortran95. The model considers day-to-day weather influence, so not only maintains simplicity of single-event model, also enhances ability of continuous simulation. Based on the digital elevation map (DEM), the AnnAGNPS model automatically defines each cell, the cell in accordance with the water collection region division, so could be arbitrary shape. According to this method to divide unit cell, the characteristics of the watershed itself is completely embodied.

The AnnAGNPS model is mainly composed three components (Darden et al., 2001): (1) Input Data Preparation Model; (2) Pollutant Loading Model and (3) Output Processor Model. The data preparation is the most main step of the model application, the Input Data Preparation Model composed by four modules: Flownet Generator, AGNPS-to-AnnAGNPS Converter, Input Editor, and GEM(Generation of weather Elements for Multiple applications) . The model used the runoff curve equation to calculate surface runoff, the modified universal soil loss equation (RUSLE) to calculate the surface sediment erosion, and the same formula with the CREAMS model to calculate dissolved and particulate concentration of nitrogen and phosphorus.

2.2 The collection of the database

The basic data included graphical, various statistics and experimental data. Graphic data included 1:25000 Watershed DEM map, 1:25000 land utilization map, and 1:250000 soil map which provided by the Earth System Science data sharing network, Heilongjiang Province Bureau of Surveying and Mapping. Statistics data mainly collected rainfall data, population density of the watershed, soil properties included: mechanical composition, organic matter, total nitrogen and phosphorus content, and the other statistical data within the watershed.

2.3 AnnAGNPS parameters selection

AnnAGNPS model system includes 32 classes of factor, about 500 parameters (Cronshey et al., 1998). All the parameters in a unified management by Input Data Preparation Model are stored in data files of AnnAGNPS. For different watersheds, it is not essential to input all parameters, such as livestock point sources, fertilizer and pesticides parameters, and the model also provides a typical value or default value to partial parameters. The main variables and parameters for Model are shown in Table 1.

The model will begin to operate after inputting the parameters in the Input Editor interface of AnnAGNPS model. The operation of AnnAGNPS needs two documents that are AnnAGNPS.inp and Dayclm.inp. Firstly, the two documents should be placed in the current directory, then run "Execute AnnAGNPS". The model will detect the database, if the detection has error, would display error; if the detection is normal, the model would generate incident files that are AnnAGNPS.evn, AnnAGNPS.acc and AnnAGNPS_AA.dat. The AnnAGNPS.evn file includes the amount of runoff, soil erosion, sediment, nitrogen, phosphorus and organic carbon in the outlet after each rainstorm incident. The AnnAGNPS_AA.dat file includes the annual mount of runoff, soil erosion, sediment, nitrogen, phosphorus and organic carbon in each unit cell. By imported AnnAGNPS_AA.dat, the model generates various *. dbf format files. According to practical need, the output dates of the model can generate the required pollution distribution map.

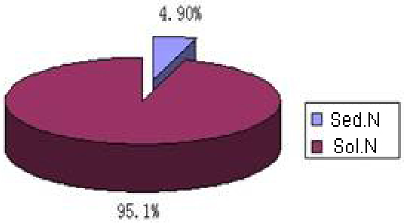
Table 1. Source of variables and parameters for AnnAGNPS model

Parameter	Source
Geographic parameter	Digital elevation model（DEM）
Soil parameter	《Heilongjiang Soil》
Crop parameter	Guidebook AH-703
Crop cover factor C	Universal Soil Loss Equation
Soil keeping factor P	Consulted data
Runoff curve CN	Data provided by model self :TR55
Climate parameter	Generation by GEM model and correction by climate dates of research region
Manning roughness coefficient and surface conditions	Land utilization situation and Model Guidebook

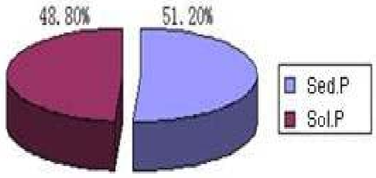
3. RESULTS AND DISCUSSION

3.1 The total pollution load

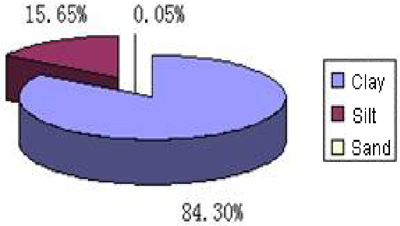
The AnnAGNPS model simulation obtained that the Shuangyang River Watershed produced total Nitrogen was 2319.71 tons/year, of which adsorbed nitrogen (Sed. N) 113.67 tons/year, dissolved nitrogen (Sol. N) 2206.04 tons/year, TP for 154.61 tons/year, of which adsorbed phosphorus (Sed P) 79.16 tons/year, dissolved phosphorus (Sol. P) 75.45 tons/year, for the sediment 120893.15 tons/year, including clay 101912.93 tons/year, Silt 18919.78 tons/year, and sand 60.45 tons/year. Its various morphology pollution ratio were shown in Figure 1.



(a) Nitrogen



(b) Phosphorus

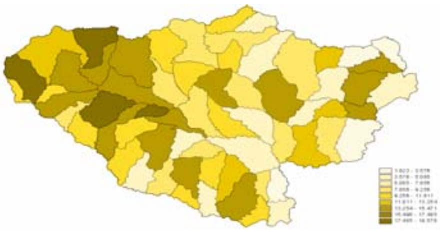


(c) Sediment

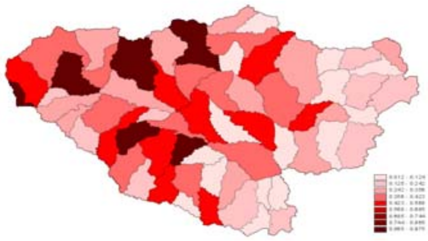
Fig. 1. The proportion of pollution load

3.2 The spatial distribution of non-point source pollution

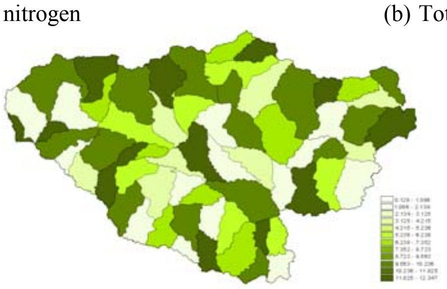
By means of the output data of the model can generate the pollution load graph. The spatial distributions of total nitrogen, total phosphorus, and sediment were shown in Figure 2.



(a) Total nitrogen



(b) Total phosphorus

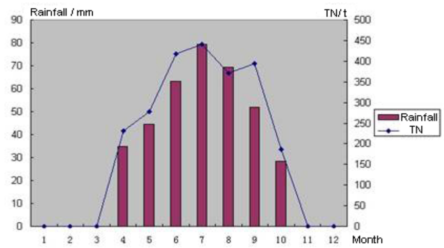


(c) Sediment

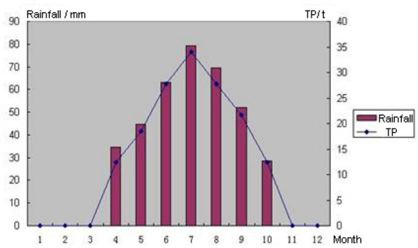
Fig.2. The spatial distribution of non-point source pollution

In the view of the spatial distribution of pollutants, the distributed location of nitrogen, phosphorus and sediment generated from non-point source pollutants is approximate. The pollution in the watershed upstream was relatively serious. Through analyzing topographic map and land utilization map, these areas were slope farmland with steep slope, and forest land cover relatively less, the effect of runoff scouring erosion comparatively significantly, so that basis pollution load will be much more than the normal. In addition, by scouring and leaching of rainfall, sloped farmland more easily separate the soil and nutrients in the soil, resulting in the loss of nutrient and non-point source pollution.

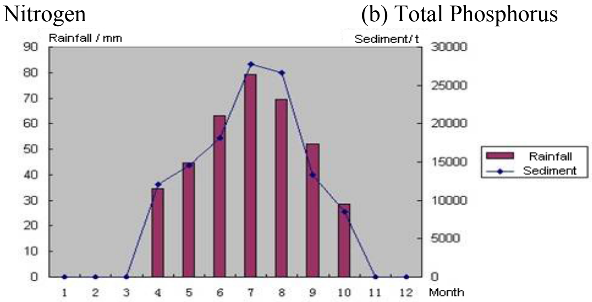
3.3 The time distribution of non-point source pollution



(a) Total Nitrogen



(b) Total Phosphorus



(c) The sediment

Fig 3: The time distribution of non-point source pollution

Simulating pollution status in one year, the model selected the output amount of total nitrogen, total phosphorus and sediment for index. The simulation results by monthly statistics obtained time distribution of nitrogen, phosphorus and sediment pollution, as shown in figure3.

From the figures, the non-point source pollution is almost no contribution in 1,2,3,11,12 months. In the north area, the rainfall and agricultural activities are rarely in these months. Pollution mainly concentrated on the relatively abundant rainfall summer. The pollution load mainly concentrated in six to eight months, in these three months, the load of nitrogen accounted for 53% of annual load, P accounted for 58% of annual load, and the sediment accounted for 60% of annual load. Because the local farmers began to apply base fertilizer in May, the fertilizer exposed to the surface, once rainfall occurrence, nutrients will be washing and leaching by rain, along the surface runoff into the river channel. In 9, 10 month non-point source pollution load slightly decreased. Shows that, by strong rainstorm runoff process in the flood season, the nutrient content in the soil has been greatly reduced. But there would still be some nitrogen, phosphorus loss, because from late September to early October, the crop harvest will start in succession, although this period precipitation was less than normal. Owing to the surface vegetation clearly changed, caused soil erosion and nutrient loss. In a word, agricultural non-point source pollution load not only closely related to rainfall, but also to fertilizer application and the surface situation.

3.4 Model Verification

The monitoring points of the N, P pollutants concentration in the river were installed in the outlet of the watershed (Meng Dan, 2006). The AnnAGNPS model was verified by the monitoring data. The verification results are showed in table 2.

Table 2 the table of comparison pollution concentration

	TN（mg/L）	error（%）	TP（mg/L）	error（%）
Observation value	2.8561	6.25	0.5913	16.34
Simulation value	3.0347		0.6879	

The results show that AnnAGNPS model for simulations of total nitrogen, total phosphorus load were closed to the measured values, error keeping in the permissible range, and the simulation for the total phosphorus was inferior to the total nitrogen. However, in general, AnnAGNPS model can be applied to evaluate the agricultural non-point source pollution of the Shuangyang River Watershed, and provide valuable reference for making various watershed environmental planning schemes.

3.5 Controlled measures evaluation

According to the non-point source status of Shuangyang River Watershed, put forward three different land management measures preventing pollution, and evaluate three measures applicability by AnnAGNPS model.

1. Land management measure I- permanent vegetation cover strips

In the watershed main channel boundary set permanent vegetation cover strips (vegetative filter strips), used to intercept sediment and filter chemicals of agricultural surface runoff. When the model simulated this measure, to adjusted AGNPS part of the input parameters including Manning roughness coefficient, surface conditions constant, C factor of USLE equation and size of the grid unit, reflected changes of 20 meters wide vegetation filter.

2. Land management measure Ⅱ- grassland buffer zone

In watershed all crops area established grassland buffer zone along contour line. These buffer zones had similar function with the last measures filter strips. The difference is not setting in the water boundary. By adjusted C, P factor of USLE equation, the surface conditions constant, Manning roughness coefficient solved the simulation of this measure.

3. Land management measure Ⅲ- combined method

The method combined vegetative filter strip with contour grassland buffer zone was applied to prevent pollution. The model made suitable adjustment to related input parameters.

By the three land management measures simulation, the results showed that in the watershed outlet reduced percentage of nitrogen output: 28% for measure Ⅰ, 22% for measure Ⅱ, 42% for measure Ⅲ;to reduce the percentage of phosphorus output: 35% for measure Ⅰ, 25% for measure Ⅱ, 53% for measure Ⅲ; to reduce the percentage of sediment output: 48% for measure Ⅰ, 42% for measure Ⅱ, 72% for measureⅢ. Upon those show that the measure Ⅲ is best effect. The results show that the simulation result is not satisfactory which only setting permanent vegetation cover strips along the river boundary or setting grassland buffer zone along the contour. This conclusion is in accordance with the results which evaluated vegetative filter strips and the grassland buffer zone in conventional methods.

4. CONCLUSION

With the research methods combined with GIS and AnnAGNPS model, forecasted agricultural non-point source pollution of the Shuangyang River Watershed in the Songnen Plain, simulated the effects of the non-point source pollutants production when using different land management measures, and verified the model with measured data. The results show that: the pollution in Shuangyang river watershed upstream was relatively serious. The method combined permanent vegetation cover strips with contour grassland buffer zone can effectively control non-point source pollution in the watershed. The result predicted is acceptable within error range for measured values. The simulation ability for the total nitrogen is stronger than the total phosphorus. The AnnAGNPS model realized agricultural non-point source pollution load quantitatively estimation. The model simulation results can provide the basis for non-point source pollution controlled and managed.

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