CHINESE GEOGRAPHICAL SCIENCE
Volume 13, Number 3, pp. 238–241, 2003
Science Press, Beijing, China

QUANTITATIVE STUDY OF SOIL EROSION AND ELEMENT RUN-OFF IN THE SONGHUA LAKE VALLEY

WANG Ning[1], ZHU Yan-ming[2], WANG Hui-lian[1]
(*1. Department of Environmental Science, Northeast Normal University, Changchun 130024, P. R. China; 2. Northeast Institute of Geography and Agricultural Ecology, Chinese Academy of Sciences, Changchun 130012, P. R. China*)

ABSTRACT: Under the condition of different precipitation intensities, different gradients, different land-use types and different vegetation coverage, the soil erosion and transference of element (or pollutant) are studied by simulating and analyzing the surface run-off of experimental plots in the catchment area of Songhua Lake, with an area of about 43 370.8km^2. And the influencing factors that produce the spatial difference are analyzed and assessed. It is put forward that the irrational land utilization is the reason of soil erosion and pollutant run-off. The gradient of farmland, the growing season of vegetation and the vegetation coverage are chiefly restricting factors that lead to the soil erosion and pollutant run-off. This study can provide the fundamental data for comprehensive planning and harnessing of the non-point source pollution in the valley.

KEY WORDS: soil erosion; pollutant run-off; land-use type; vegetation coverage

CLC number: X14 Document code: A Article ID: 1002-0063(2003)03-0238-04

1 INTRODUCTION

Soil erosion and pollutant run-off are the main origin of water pollution in the Songhua Lake valley. So far many scholars have studied the run-off producing course of rainfall, soil and water loss, the influencing factors and rules of the pollutant movement (HOU, 1987; JACKSON *et al.*, 1973; LAL, 1990; YANG, 1999). And they have developed such academic and practical models as chemical pollutant run-off model (YANG, 1989). But restrained by the research means, the study on academic and practical models of soil erosion and pollutant run-off under complicated conditions is yet to be further approached. This article studies the influencing factors and transference rules of the pollutant and calculates the nutrient elements run-off under the condition of different precipitation intensities, different gradients, different land-use types and different vegetation coverage by simulating and analyzing the surface run-off in the experimental plots of the catchment area in the Songhua Lake valley. According to the conclusion we can define the soil erosion and element run-off zones, such providing scientific basis for comprehensively controlling the soil and water loss in the valley.

2 STUDY AREA AND METHODS

2.1 Study Area

Songhua Lake lies in the east semi-mountain area of Jilin Province (41°40′–43°48′N, 125°41′–128°48′E). The lake is strait, long and curving along the valley. Its water area is 550km^2, the total capability is 10.8×10^{9}m^3 and the total catchment area is 43 370.8km^2 (Fig.1). The drainage water is controlled by the power plant. Songhua Lake is the biggest man-made lake in Jilin Province and has such functions as providing drinking water, breeding aquatics, generating electricity, irrigation, shipping, and tourism.

Songhua Lake is a typical hill-lake.The southeast is high and the northwest is low in the valley. The landform types are complicated, which include mountain, hill, platform, plain and so on, so it is also described as "seven-mountain, two-hill and one-plain". In the past decades, the land-use types changed greatly and

Received date: 2003-01-13
Foundation item: Under the auspices of Chinese Academy of Sciences (KZ952-S1-201)
Biography: WANG Ning (1953–), female, a native of Beijing, associate professor, Ph. D., specialized in environment geography and the control and management of water pollution

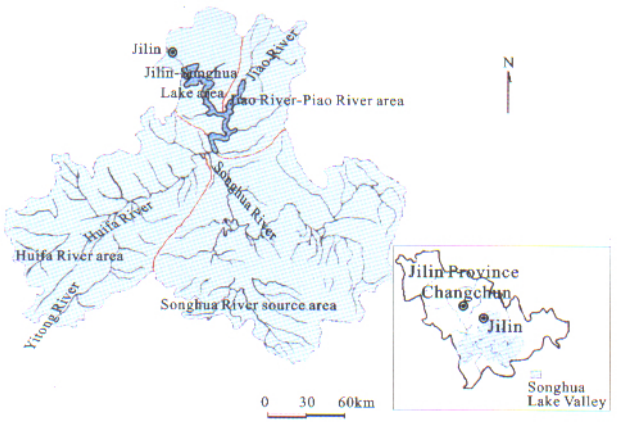

Fig. 1 The location map of the study area

soil erosion was very serious because of the increasing of population and the development of industry and agriculture. The water quality of Songhua Lake became worse year by year and it is an eutrophic lake now (WANG *et al*., 1999).

2.2 Methods

In different land-use types, we conducted semi-positioning measurement in order to study the rules and influencing factors of soil erosion and pollutant run-off in the valley. According to the measurement results, we analyzed the effects of different rainfalls, different gradients, different land-use types and different vegetation coverage on soil erosion and pollutant run-off.

According to the new aerial photos, we simulated such physical geography factors as the terrain gradient, soil type, land-use type and vegetation coverage by GIS, and calculated the quantity of soil erosion by current soil erosion equation under different rainfalls. We built up 10 experimental plots including dry land, paddy field, woodland, grassland, residential area, bare land, bottomland and so on in different gradients, with the areas of 2m×2m−5m×5m. Under the condition of rainfall<20mm/h and >50mm/h, we collected the run-off samples in different experimental plots and filtrated the run-off water by 0.45μm film, then we analyzed N and P concentrations under the different conditions and calculated the pollutant run-off modulus and run-off quantity.

3 RESULTS AND DISCUSSION

3.1 Effect of Rainfall Intensity

It is a hydrographic circulation course from rainfall to run-off producing. The run-off producing is affected by such factors as rainfall intensity, rainfall amount, land-use type and so on. In the different types of experimental plots with the same gradient, we collected the runoff samples and analyzed N, P concentrations in the condition of different rainfalls (Table 1).

Table 1 The pollutant concentration of surfac run-off in the condition of different rainfalls and different land-use types

Land-use type	<20mm/h		>50mm/h	
	Total N (mg/L)	Total P (mg/L)	Total N (mg/L)	Total P (mg/L)
Dry land	4.83	0.71	6.56	2.60
Woodland	2.22	0.44	6.54	1.68
Paddy field	2.67	0.26	5.20	1.91
Residential area	3.21	0.65	5.04	0.79

It was revealed from Table 1 that the effects of rainfall intensity on the soil erosion and pollutant run-off are obvious and regular. The higher the rainfall intensity is, the more serious the soil erosion and the higher the pollutant concentration.

3.2 Effect of Gradient

The landform characteristics of the valley (elevation, gradient, dissection degree) affect the rainfall run-off. The greater the gradient and the dissection degree are, the greater the rainfall confluence velocity. Under the condition of the same rainfall, the pollutant run-off changes greatly in different gradients (Table 2).

Table 2 The pollutant concentration of surface run-off in the condition of different gradients

Gradient	<20mm/h		>50mm/h	
	Total N (mg/L)	Total P (mg/L)	Total N (mg/L)	Total P (mg/L)
<17.5° dry land	4.83	0.71	6.56	2.60
>17.5° dry land	7.42	3.14	9.73	8.14

3.3 Effect of Land-use Type

The influence of the land-use type on soil erosion and pollutant run-off shows the influence of the human activities. The soil structure of cultivated land is different from that of grassland and woodland. The long-term cultivation made the soil hardened, destroyed the granule structure and reduced the water holding capacity. The soil pollutant in cultivated land is also different from that of grassland and woodland because of using fertilizer and pesticide.

It was revealed from Table 1 that the pollutant con-

centrations in dry land and residential area correspond to the results by other studies in China (ZHANG *et al.*, 1997). The pollutant run-off modulus in dry land is 1.5–2.5 times that in woodland and 0.5–1.5 times that in grassland. A great deal of N and P fertilizer was applied into dry land, but only 20%–30% of them were absorbed by crops, and mass of them moved away with rain; N and P in woodland and grassland mainly come from dead vegetation, so the N and P run-off was only a little if humus horizon was thinner (ZHANG *et al.*, 2000).

3.4 Effect of Vegetation Coverage

The influence of vegetation coverage on run-off producing is decided by the water-intercepting and water-keeping abilities of vegetation.The intercepted rainfall by plant evaporated and didn't form run-off. The dried leaves and grass can change the soil structure and make the land rough, so the rainfall can seep into the soil.

Under the condition of different growing seasons in dry land and the different vegetation coverage in woodland, the pollutant concentrations in the Songhua Lake valley are shown in Table 3.

Table 3 Pollutant concentration of surface run-off in condition of different vegetation coverage

Pollutant	Dry land(corn)		Woodland(arbor and shrub)	
	Growing season	Mature season	Coverage <25%	Coverage >50%
Total N(mg/L)	5.86	4.83	2.20	0.12
Total P(mg/L)	0.58	0.393	0.44	0.18

The results show obviously that the vegetation coverage is an important factor controlling the pollutant run-off under the condition of the same rainfall, the same gradient and the same land-use type. The effect of vegetation coverage on surface run-off is obvious in woodland. The concentration and run-off of N and P in low-coverage woodland are both higher than those in high-coverage woodland, especially in the shrubs with a height of more than 2m. The soil erosion and pollutant run-off are complicated in cropland, which are related to vegetation coverage, growing season, fertilizing period, farming method and crop type(SUN *et al.*,1999).

4 CALCULATION OF N, P RUN-OFF AND SOIL EROSION

According to the satellite photographs, we defined the areas of different land-use types and calculated the soil erosion quantity and N and P run-off. The results were shown in Table 4.

The results in Table 4 show that the annual soil erosion quantity is about 105×10^6t/a and the erosion modulus is 2406t/(km^2·a) in the Songhua Lake valley. Compared with other areas in China, it is middle-degree erosion type. From the calculation of the soil erosion quantity and the distribution map of the soil loss by GIS, we can see that the soil erosion is very serious (erosion modulus>5000t/km^2·a) in the central, northern and southeastern parts of the Songhua Lake valley, i.e. the two sides of the Jiaohe River, the mouth of the Huifa River and the upper reaches of the Yitong River; it belongs to middle degree in the dry land in the Songhua River source area (except Baitou Mountain) (erosion modulus is 2500–5000t/km^2·a); and it belongs to light degree in the upper reaches of the Huifa River and the centeral woodland of the Songhua River source area (erosion modulus is 600–2500t/km^2·a) (Fig. 2)(WANG *et al.*, 2002).

Table 4 The soil erosion quantitiy and N and P run-off in different land-use types

Item	Woodland	Grassland	Dry land	Paddy land	Residential area	Bare rock	Average	Total
Soil erosion quantity(10^6t/a)	42.260	4.046	52.474	1.113	4.491	0.579		104.964
Erosion modulus (t/km^2·a)	1291.2	3894.1	8219.6	433.4	5668.3	2011.8	2406	
N loss(t/a)	656.7	153.9	2394.2	46.5	157.0	10.9		3420.3
N loss modulus (kg/km^2·a)	0.020	0.148	0.375	0.018	0.198	0.038	0.08	
P loss (t/a)	105.10	16.87	315.65	16.38	25.90	1.45		481.9
P loss modulus (kg/km^2·a)	0.003	0.016	0.049	0.0064	0.033	0.005	0.011	

We can define the pollution areas according to the calculation results and the distribution map of N and P run-off. Human activities are the main reasons of soil erosion and pollutant run-off besides great gradient and small vegetation coverage. For example, the gradient is small and the soil erosion is middle degree in upper reaches of the Huifa River and the Songhua River source area, however the N and P run-off is very serious (loss modulus ▮ 5000g/km^2·a). The result shows that the effects of agriculture activities are strong and the using of fertilizer and pesticide causes the N and P run-off. While the terrain gradient is great

and the soil erosion is serious in the two sides of the confluent of Songhua Lake and the Jiaohe River, but the N and P run-off is lower. The results are caused by less farmland and few human activities (Fig. 3).

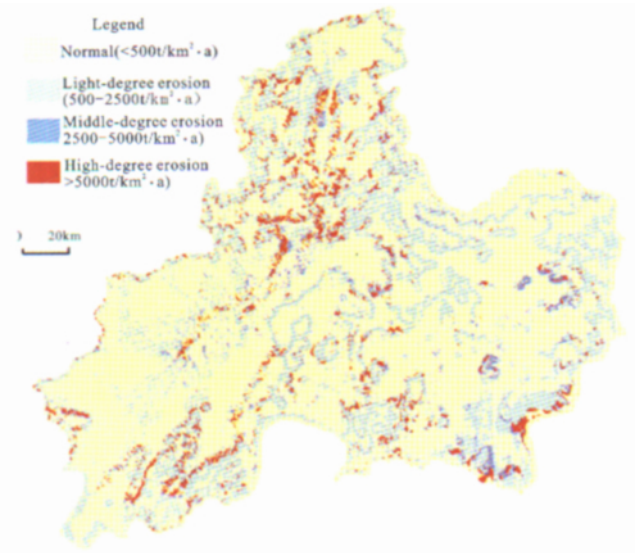

Fig. 2 Distribution map of soil erosion in the Songhua Lake valley

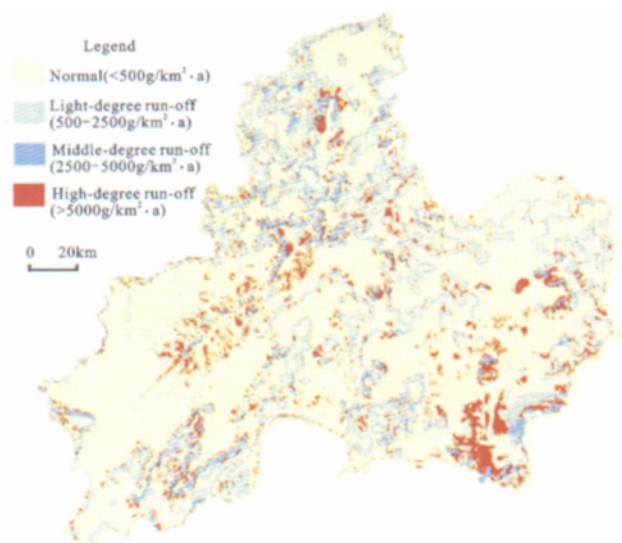

Fig. 3 Distribution map of N run-off in the Songhua Lake valley

5 CONCLUSIONS

(1) The change of land-use type is the main reason of soil erosion and pollutant run-off. So rational planning of land-use type and structure is very important for controlling soil erosion and pollutant run-off.

(2) The N and P run-off is related to the terrain gradient and growing season in farmland. The pollutant run-off is very serious when monsoon come before the mature season. The effect of gradient on soil erosion in farmland is also obvious. So returning the grain plots to forestry in steep slope and the successful field-management of crops are the main methods to control soil erosion.

(3) The vegetation coverage is the main factor influencing soil erosion and pollutant run-off in the condition of natural vegetation. And the type of vegetation also affects the soil erosion indirectly. So the protection of vegetation is very important.

(4) The non-point source pollution caused by N and P run-off is the main reason of the increasing of nourishment and the eutrophication of Songhua Lake. So the non-point source pollution must be prevented in Songhua Lake valley.

REFERENCES

HOU Yu-guang,1987. The non-point water pollution of strong rain [J]. *Water Resources Protection*, (4):49-58 (in Chinese)

JACKSON W A, ASMUSSEN R J, ELLIS D F, 1973. Nitrate in surface and subsurface flow from a small agricultural watershed [J]. *J. Environ. Qual.*, 2: 480-482.

LAL R, 1990. Research and development priorities in soil degradation [J]. *Advances in Soil Science*, (2): 331-336.

SUN Hui, TANG Ya, CHEN Ke-ming *et al*., 1999, The influence of nitrogen fixation plants on sloping-plowland erosion [J]. *Bulletin of Soil and Water Conservation*, 19(6):1-4.(in Chinese)

WANG Ning, ZHU Yan-ming, LI Shun, 1999. The dynamic change and formation analysis of elements in Songhua Lake [J]. *Research of Environmental Sciences*, 12(5):27-30.(in Chinese)

WANG Ning, ZHU Yan-ming, XU Chong-gang, 2002, The quantity study of rainfall pollutant in valley by GIS [J]. *Journal of Northeast Normal University*, 34(2): 92-98. (in Chinese)

YANG Zhi-sheng, 1999. The study on soil erosion equation of sloping-plowland in Northeast Yunnan Province [J]. *Bulletin of Soil and Water Conservation*, 19(1):1-9,(in Chinese)

YONG R A,ONSTAD C A,ANDERSON W P,1989. AGNPS:A nonpoint-source pollution model for evaluating agricultural watersheds[J]. *J. of Soil and Water Conservation*, 44(2): 168-173.

ZHANG Da-di, ZHANG Xiao-hong, DAI Yu-min, 1997. The investment and assessment of the four surface runoff pollutants in Shanghai suburb [J]. *Shanghai Environmental Sciences*. 16(9):7-11.(in Chinese)

ZHANG Xing-chang, LIU Guo-bin, FU Hui-fang, 2000. The influence of different vegetation coverage on N element runoff in valley [J]. *Environmental Science*, 21(6):16-19.(in Chinese)