

Study on soil erosion factors in Shanxi Province, China

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1. Abstract

Soil erosion in the province is closely related to rainfall intensity, plant cover, slope, soil quality and so on. Storms are the main factor influencing water loss and soil erosion, with raindrops reaching 4 to 5 mm in diameters, with falling speed 9 meters per second, and rainfall intensity of 2 mm/min. In some cases, slope and soil erosion are significantly positively correlated. In general, the greater the vegetation cover, the smaller the water loss and soil erosion. Meanwhile, to eliminate the hardened land surface crust can effectively increase water seeping into soil, promote crop growth, and reduce water loss and soil erosion.

Keywords: vegetation, runoff, soil crust, gully slope

2. Introduction

Shanxi Province is located on the Loess Plateau, North China. It covers a total area of 156 thousand square kilometers, with a population of 32 million. In the whole area, average annual precipitation is about 509 mm, average annual temperature is about 3 to 14⁰c, and soil erosion and water loss is quite serious. Average annual suspended load transport from the province is 456 million tons or 3000 ton/km², and in most serious areas, it could reach over 20,000 ton/km². Soil erosion has considerably limited the economic development and social progress in the region. In order to curb soil erosion and improve ecological environment and properly use our precious water and soil resources, people working in the field of soil and water conservation, especially the scientists and researchers, have made relentless efforts to understand soil erosion causes and mechanism, and obtained tremendous progress in the matter.

3. Rainfall Intensity

Most areas in the province are influenced by rain storms. Storm is the main factor for water loss and soil erosion, usually with raindrops reaching 4 to 5 mm in diameters, falling speed 9 meters per second, and the rainfall intensity of 2 mm/min. These raindrops have a big driving force, and, when hitting the ground with sloped surface and lack of vegetation cover, they will severely damage soil crumb structure and easily result in soil erosion. Soil erosion amount by rain storms can account for a predominant proportion of the soil erosion in the province. According to the analysis of precipitation information from 1957 to 1998 by Shanxi Provincial Water and Soil Conservation Institute (SPWSCI), average annual precipitation in Lishi Wangjiagou watershed was 506.5 mm, of which, precipitation between January and April was 46.2mm, accounting for 9.2%; precipitation 406 mm between May and September, accounting for 80.1%; precipitation 54.3 mm between October and December, accounting for 10.7%; but precipitation 238.6 mm only from July to August, accounting for 47.1%. According to the observation on the un-treated Yangdaogou watershed, Lishi County, each year on average had 8 times of eroded raining, with rainfall 177.5 mm accounting for 35% of average annual precipitation. The features of the eroded rainfalls are 1) short duration (4 to 6 hours) with rainfall from 40 to 100

mm; 2) high intensity of rainfall (10 to 20 mm/hour); 3) basic eroded rainfall intensity is 8.1 mm/hour; 4) soil erosion amount by rain storms accounts for over 90% of total eroded.

4. Slope degrees and slope length

On sloped farmland or barren hillsides with 5 to 40 degrees, soil erosion amount increases while slope degree and length increase, appearing significant positive correlation. Land surface erosion is the principal form of soil erosion on the sloped land, and its erosion amount can account for over 70% of the total eroded. According to the experimental data from SPWSCI, the relationships of different land slopes to water loss and soil erosion are shown as the following table 1 and table 2.

Table 1 The relation between different slopes and water loss and soil erosion

Land use type	Slope degrees	Run-off (m ³ /ha)	Eroded soil (ton/ha)
Arable land on weir-mound tops	1~5	102.0	3.75
Arable land on weir-mound slope	6~20	124.5	28.2
Arable land near gully edges	21~30	208.5	147.0
Deserted gully slope	40~60	310.2	273.0

Table 2 Relationship between slope length and soil loss

Land slope (c)	Slope length (m)	Soil eroded amount	
		(ton/ha)	Ratio (%)
12~29	7	52.5	100
	14	149.4	297
26~31	12~25	153.3	100
	24~36	217.7	142
	37~75	242.4	158

In reality, water loss and soil erosion are heavenly influenced by the combined impacts of both slope degrees and slope length. In the loess hilly areas, from weir-mound top to gully slope, the slope degrees and slope length become bigger and bigger, collected run-off becomes more and more, therefore, the eroded force stronger and stronger. Based on the observation data from 1963 to 1998 by SPWSCI, the soil erosion intensity on different position is: 575 ton/km² on weir-mound tops, 2820 ton/km² on weir-mound slope, 14700 ton/km² on near gully edges, and 27300 ton/km² on deserted gully slopes.

In the loess hilly area, slope farmland has been the principal land use type of soil erosion. The slope compositions of several typical watersheds are shown in the following table.

Table 3 Slope compositions of typical watersheds in western Shanxi Province

Watersheds	Land use type	Proportion of different slopes (%)				
		0~5 ⁰	6~15 ⁰	16~25 ⁰	26~35 ⁰	over 36 ⁰
Zhongyang County	Whole area	3.98	22.84	27.87	20.26	25.05
Gaojiagou	Farmland	5.60	32.11	37.65	19.96	4.68
Lish County	Whole area	2.02	17.67	23.38	16.12	40.81
Wangjiagou	Farmland	4.20	32.00	45.30	10.40	8.10
Hequ Nanqugou	Whole area	15.1	9.02	13.0	23.32	38.96

5. Vegetation

Standing trees, shrubs or grass can intercept rainfall, preventing raindrops from hitting ground directly and increasing water soaking into ground. Vegetation residuals can cover ground, protect soil, improve soil structure, increase soil erosion resistance, and, therefore, reduce runoff and eroded sediment. The bigger the vegetation coverage is, the smaller the water loss and soil erosion is. According to the investigation in Sanchuan River watershed, the relationship between forest coverage and annual soil loss is as the following table.

Table 4 Relationship between forest coverage and annual soil loss

Canopy density (%)	Annual soil loss (ton/km ²)
4.1	14984
13.2	7813
38.3	2412
80.0	223

According to observation data of Wangjiagou watershed by SPWSCI, compared with 30 degree sloped farmland, locust tree plantation on 31 degree sloped land can reduce annual runoff by 47.9% on average, sediment by 90.6%.

6. Soil crust

81.56% of the total land in the province is covered with loess soil. According to observation, average annual runoff on the deserted loess hillside could be 260 m³/ha, and the eroded sediment 248 ton/ha. In addition, according to artificial rainfall simulation tests, under a storm, the loess is quite easy to form a hardened soil crust due to lack of organic matter. Under a same condition of rainfall, the slope runoff and eroded sediment on the farmland with hardened surface crust increased 6 to 50 times by comparison with the same land without hardened surface crust. Therefore, any measures to eliminate the hardened crust can effectively increase water seeping into soil, promote crop growth, and reduce water loss and soil erosion.

7. Conclusion

Based on investigation, observation and research in Shanxi Province, soil erosion is closely related to natural conditions and human activities, such as rainfall intensity, plant cover, slopes, soil texture and quality and so on. Preserving soils and water has been seen as the biggest challenge in ensuring sustainable agriculture for years to come. Various soil conservation activities, such as terracing, afforestation, conservation tillage, etc, should be carried out to alleviate the problem. It is essential to preserve the limited land base and water resource while producing abundant high quality food.