GULLY EROSION IN MOUNTAIN AREA OF SW-CHINA, ASSESSED USING ^{137}CS AND ^{210}PBEX TRACERS AND GPS SURVEY

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1. Introduction

Gullies are extensively distributed in the Upper Yangtze River Basin, SW-China. But the impact of these gullies on total sediment output is still not clear because there is no reliable technique for quantifying this issue. The target areas of our research are the dry-valleys located in the upper Yangtze River Basin, SW-China. Our study objectives are to: a) quantify gully erosion rates as affected by land use change over the last 100 years, and b) to assess relative importance of different erosion types including gully and rill or sheet erosion in sediment production in selected gully catchments.

2. Study area and methods

Our investigations were carried out in the Anning Warm-Dry Valley of southern Sichuan in the territory of Xichang. We selected Changshanling catchment for our objectives. We measured the gully system using RTK-GPS and established Digital Elevation Mode (DEM) of the gully catchment, and proposed a method for extract the active gully system from the established DEM in frame of GIS (See Fig. 1). Sediment production by gully was estimated from DEMs based on RTK-GPS survey data. By establishing a sediment chronology within the gully systems using 137Cs and 210Pb dating we intended to develop a relationship between gully development and the history of gully catchment land use. Sediment production by rill or sheet erosion on slope of the catchment was estimated by the combined use of fallout ^{137}Cs and ^{210}Pb measurements.

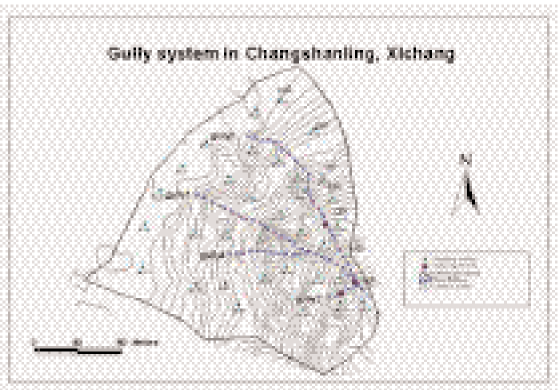

Fig. 1. Field sampling map in Changshanling of SW-China.

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3. Results and conclusions

Reference values of ^{137}Cs and ^{210}Pbex inventories were calculated to 802±49 Bq/m2 and 7823±1382 Bq/m^2, respectively, for the Majiasongpo catchment, and 916±75 Bq /m^2 and 6642±1303 Bq/ m^2, respectively, for the Changshanling catchment (Figs. 4-5). The coefficients of variation (CV, %) for 25 sampling sites were in range of 23-33% for ^{137}Cs and 21-25 for 210Pbex in the upper Yangtze River Basin, SW-China. The depth-incremental profiles of both fallout ^{137}Cs and ^{210}Pbex in reference sites shows a typical exponential decrease with soil depth, and majority of the 137Cs and 210Pbex is concentrated within the top layers of 0-10 cm.

Our results from caesium-137 and unsupported lead-210 dating provide direct evidence that gully initiation occurred in 1920's, which consistent with extensive deforestation by fire in the study area. Caesium-137 and only existed only in top 5 cm soils and ^{210}Pbex only in topsoil of 15 cm measured in the hillslopes suggested that the study gully catchment have not been cultivated over the last 200 years. The accelerated gully erosion may therefore arise from intensive grazing activities. This finding is opposite of the assumptions made by Bork et al (2001). Bork et al (2001) proposed that the grazed hill slopes were replaced by agricultural terraces in 1965. Evidently, fallout radionuclide dating may provide an independent tool for identification of past land uses. Local culture and history records were also analyzed, interviewing senior experts and farmersto givea more detailed reconstruction of land use history.

Results indicated that the gully density in Changshanling was 46.7m/hm^2, and annual sediment production by gully erosion ranged from 6 to 110 t/ha, averaging 61 t/ha/yr. Average sediment yield by sheet erosion was 26.42 t/ha/yr, nearly three times lower than gully erosion in the study catchment Gully erosion with 12% of total area represented 87% of total sediment yield whereas sheet erosion with 87% of total area accounted for 13% of the total soil loss in the study catchments (Tables 1-2). Our results suggested that gully erosion is the major sediment sources and the dominant water erosion process in the Upper Yangtze River Basin, SW-China.

The following conclusions could be drawn from our investigation: a) Stable gullies widely distributed in Changshanling mountain areas of .SW-China occurred in the years between 1930 and 1950, b) Gullies presented 80-90% of total sediment production, suggesting the dominance of water erosion processes in contributing sediment for SW-China, c) The active gullies on the planted forestland without understorey primarily result from intensive grazing and water buffalo trampling in the last 50 years, and d) Topographic threshold conditions for gully initiation in forest and grassland can be described using the following relation of a critical upslope drainage area (A) and a the critical slope gradients (S): $S\ A^{0.4145} > 0.1585$. These results provide reliable data on the long-term impacts of land use on soil erosion in western China, and add a new issue for global change studies.

Table 1. Gully parameters of Cahngshanling gully catchment estimated from ^{137}Cs and excess ^{210}Pb dating and RTK-GPS survey.

Gully Parameters	Unit	Gully 1	Gully 2	Gully 3	Gully 4	Total
Volume	m^3	5841	327	4560	844	11572
Gully area	ha	0.26	0.04	0.23	0.07	0.60
Length	m	212	36.3	137	51	436
Average depth	m	2.44	1.24	3.43	1.49	--------
Max. depth	m	11	4.1	22.1	6.53	--------
Average width	m	12	11	17	14	--------
Max. width	m	26	19	27	18	--------
Catchment area	ha	0.72	0.53	1.1	1.15	3.5
Average slope	degree	37.62	21.21	24.71	36.56	-------
Max. slope	degree	72.4	30.1	47.54	57.6	--------
Sediment yield	t	7709	432	6019	1114	15275
Eroded time	yr	70	70	50	50	
Gully erosion	t/ha-yr	110.14	6.17	109.44	19.38	60.76

Note: An average bulk density of 1.32 g cm^{-3} from measurements was used for calculation of sediment yields and gully erosion rate, and small gullies were not included in this calculation.

Table 2. Relative contribution of gully erosion derived from ^{137}Cs and excess ^{210}Pb dating and GPS-survey for Cahngshanling gully catchment

		Area ha	Contribution to total area (%)	Contribution to total sediment (%)
Gully		0.6	11.90	87.02
Sheet erosion	Loss	2.65	52.58	12.98
	Gain	1.79	35.52	

Note: Several major gullies in Changshanling catchment were not included in this calculation for gully erosion.

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References

Bork, H.R., Li, Y. Zhao,Y. 2001. Land use changes and gully development in the Upper Yangtze River Basin, SW-China. Journal of Mountain Science, 19: 97-103.

Cheng, H., Wu,Y.Q., Zou,. X.Y. Study of ephemeral gully erosion in a small upland catchment on the Inner-Mongolian Plateau. Soil & Tillage Research 90 (2006) 184–193.

Desmet, P.J.J., Poesen, J., Govers, G.. and Vandaele, K., 1999. Importance of slope gradient and contributing area for optimal prediction of the initiation and trajectory of ephemeral gullies. Catena, 37:377-392.

Fu, B., Chen, L., Ma, K., Zhou, H., Wang, J., 2000. The relationships between land use and soil conditions in the hilly area of the loess plateau in northern Shaanxi, China. Catena 39, 69 –78.

Li. Y., Poesen, J., Valentin, C. (eds.) 2004. Gully Erosion Under Global Chang .Sichuan Science Technology Press, Chengu ,China .354 pp.

Li, Y., Zhang, Q. W., Reicosky, D. C., Lindstrom, M. J., Bai, L. Y,.and Li L. 2007. Changes in soil organic carbon induced by tillage and water erosion on a steep cultivated hillslope in the Chinese Loess Plateau from 1898–1954 and 1954–1998, J. Geophys.Res., 112, G01021, doi:10.1029/2005JG000107.

Li, Y., Poesen, J., Yang, J. C., Fu, B., and Zhang, J. H. 2003. Evaluating gully erosion using 137Cs and $^{210}Pb/^{137}Cs$ ratio in a reservoir catchment, Soil Tillage Res. 69, 107– 115.

Nachtergaele, J. & Poesen, J. 1999. Assessment of soil losses by ephemeral gully erosion using high altitude (stereo) aerial photographs. Earth Surface Processes and Landforms, 24:693-706.

Poesen, J., Nachtergaele, J., Verstraeten, G. & Valentin, C. 2003. Gully erosion and environmental change: importance and research needs. Catena 50 (2-4):91-133.

Poesen, J.W.A. & Hooke, J.M. 1997. Erosion, flooding and channel management in Mediterranean Environments of southern Europe. Progress in Physical Geography 21 (2):157-199.

Ritchie, J.C. and J.R. McHenry. 1990. Application of radioactive fallout 137Cs for measuring soil erosion and sediment deposition rates and patterns: A review. J. Environ. Qual. 19: 215-233.

Valentin, C. J. Poesen and Y. Li. (Eds.) Gully erosion: A Global Issue. Catena 63 (2005) 129–330. (Special Issue)