Comparison of Detachment Rates from Purple and Loess Soil Rills

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Rills are commonly found on sloping farms in both the loess and purple soil regions of China. Rill erosion is an important component of slope water erosion, and sediments from rill erosion are the main sediment source in small catchments here. A comparative study about rill erosion processes on the two soils is important to exchange research applications and experiences between the two soils.

The data used in this study were obtained from rill erosion experiments on loess and purple soils, which included a series of laboratory experiments with the volume replacement method (Figure 1). The experimental design involved a combination of five slope gradients (5°, 10°, 15°, 20° and 25°) and three flow rates (2, 4 and 8 L min^{-1}), and produced sediment concentration distribution processes along the rill at positions of 0.5, 1, 2, 3,..., 8, 10 and 12 m from the rill outlet. The sediment distribution data was plotted along the rill distances, which were used for numerical estimation of rill detachment rates. The sediment distribution data were also fitted with rill length by an exponential function, which were used for analytical determination of rill detachment rates. With the experimental data and their fitted functions, numerical and analytical methods were proposed to compute rill detachment rates. In the numerical method, the increasing rate of the experimentally measured sediment concentration over each rill segment was computed as the numerical detachment rate. In the analytical method, the sediment-distance function was differentiated with respect to rill distance to analytically determine the rill detachment rate as a continuous function. This detachment function can be presented as either a function of rill length or as a function of sediment concentration in the rill water flow.

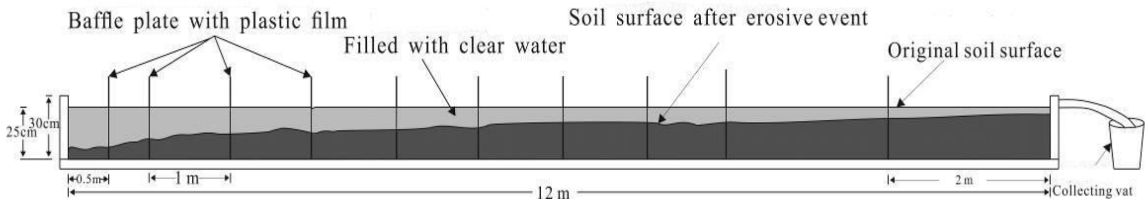

Figure 1. Sketch of the volume replacement method.

The results showed that rill detachment rates on the two soils decreased exponentially with rill length and linearly with sediment concentration, as computed with the two methods. These two relationships indicated that sediment detachment rate was negatively and linearly related to sediment concentration in the water flow (Table 1). With an increase of sediments in the water flow, the detachment rate was proportionally decreased. The detachment rate was also proportional when the sediment deficit tended towards the transport capacity. Therefore, when sediment concentration increased exponentially with rill length, the deficit was reduced exponentially and the detachment rate was reduced exponentially with rill length. High coefficients of determination for both the exponential and linear functions indicated high

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significances of the functions to relate detachment rate with rill length and sediment concentration, respectively. The results were good for both the purple and loess soil rills.

However there were important differences in the rill detachment rates between the two soils. The purple soil was a clay loam with higher clay content and more aggregates, while the loess soil was a sandy loam with much less clay and almost no aggregates. The purple soil was initially detached at relatively higher applied erosive forces than the loess soil, indicating greater resistance to water erosion by the purple soil. The maximum detachment rate in the purple soil rills was significantly less (approximately 88%) than that in the loess soil under the same flow rate and slope gradient (Figure 2). The rate of increase of the purple soil detachment rate was 4% faster than that of the loess soil, indicating that the rill flow in the purple soil may reach the sediment transport capacity more rapidly than the rill flow in the loess soil (Figure 3). The detachment rates estimated through the numerical method agreed well with those calculated using the analytic method, indicating that both computational methods were rational and equally applicable. The results from this study indicated that the research methods and experiences on rill erosion can be inter-exchanged between the loess and purple soils.

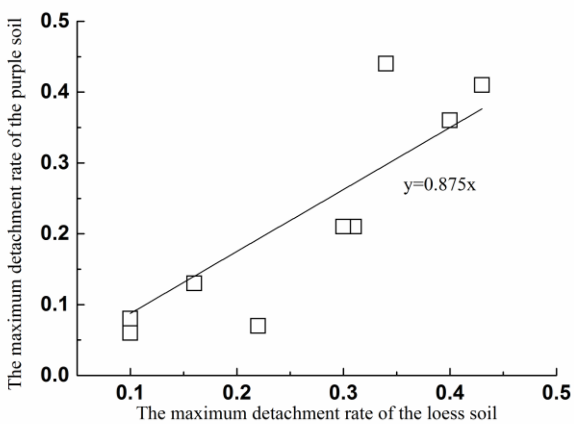

Figure 2. Comparison of maximum detachment rates.

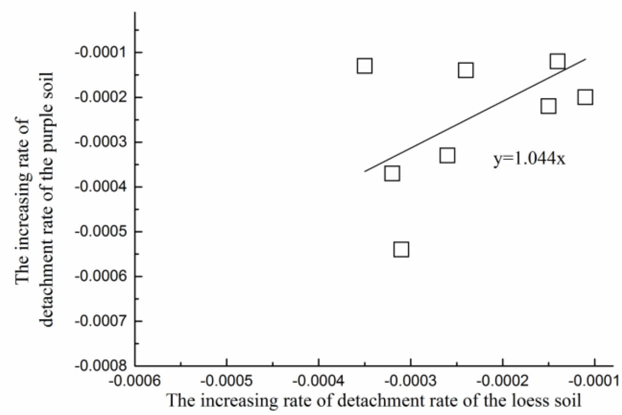

Figure 3. Comparison of increasing rates.

Table 1. Regression parameters of numerical method.

Slope (°)	**Flow rate (L min^{-1})**	**Regression Parameters**					
		f_l	f_p	g_l	g_p	$Prob>F_l$	$Prob>F_p$
10	4	0.24	0.04	-0.00035	-0.00013	2.29×10^{-3}	2.29×10^{-3}
	8	0.36	0.09	-0.00049	-0.00022	1.01×10^{-3}	3.63×10^{-3}
15	2	0.10	0.06	-0.00014	-0.00012	5.46×10^{-2}	3.09×10^{-4}
	4	0.16	0.13	-0.00015	-0.00022	9.59×10^{-2}	1.62×10^{-3}
	8	0.34	0.44	-0.00023	-0.00069	3.90×10^{-2}	3.31×10^{-3}
20	2	0.10	0.08	-0.00011	-0.00020	1.48×10^{-2}	6.64×10^{-3}
	4	0.31	0.21	-0.00032	-0.00037	4.91×10^{-2}	3.39×10^{-3}
	8	0.40	0.36	-0.00031	-0.00054	1.63×10^{-2}	5.13×10^{-5}
25	2	0.22	0.07	-0.00024	-0.00014	7.36×10^{-2}	1.20×10^{-3}
	4	0.30	0.21	-0.00026	-0.00033	3.09×10^{-2}	1.93×10^{-3}
	8	0.43	0.41	-0.00025	-0.00071	7.71×10^{-2}	8.91×10^{-3}

Notes: f_l – loess soil, f_p – purple soil, g_l –loess soil, g_p – purple soil, $Prob>F_l$ – loess soil, $Prob>F_p$ – purple soil.