Simulating Rill Erosion of Unfrozen Soil by Meltwater Flow

Ban Y Y[1], Lei T W[1, 2], Chen C[1], Liu Z Q[1]

1. College of Water Resources and Civil Engineering, China Agricultural University, Beijing, 100083, P.R. China

2. State Key Laboratory of Soil Erosion and Dryland Farming on the Loess Plateau, Institute of Soil and Water Conservation, Chinese Academy of Science and Ministry of Water Resources, Yangling, Shaanxi Province, 712100, P.R. China.

Abstract

Erosion caused by snowmelt can be particularly challenging, and there is a need for experimental data to improve our understanding and modeling of the phenomenon. Laboratory experiments were conducted to assess the impacts of slope gradient and flow rate on erosion by meltwater flow over unfrozen soil surface. Soil materials were collected from a watershed deposited sediments at altitude of 3682 m, 36°21.823′ N and 101°26.833′ E, at Qinghai-Tibetan Plateau of China. The soil contents were 27.99% of sand, 64.24% of silt and 7.77% of clay particles. Fumes of 6 m long by 0.1 m wide and 0.12 m deep were filled with the soil materials to a depth of 10 cm before being saturated and put into freezer storage of about 38 m^3 to freeze the flumes for more than 12 hrs. After the soil were completely frozen, the flumes were taken out and put in experimental hall with room temperature about 20 degrees to unfreeze the soil for a sufficient long period till all the soil materials were unfrozen. Meltwater was simulated with a tank filled with ice cubes to supply water flow at a temperature between 0~1 C°. The erosion experiments involved 4 slope gradients of 5°, 10°, 15°, and 20°, 3 flow rates of 1, 2, and 4 L/min, and 7 rill lengths of 0.5, 1, 2… 6 m. Four sediment-laden water samples were taken from the flume outlet, before the sediment concentrations were measured with oven-dried method. The sediment concentration along the rill were regressed with a mathematic model, $c = A(1-e^{-\beta x})$. Sediment concentrations increased exponentially with rill length to approach a limiting value. The sediment concentrations were positively correlated with flow rate and slope gradient. However, the effect of flow rate on sediment concentration was not as great

as slope gradient. The impact of flow rate on sediment concentration declined with increasing slope gradient. Results from these experiments will be useful for estimating erosion model parameters and predicting erosion from meltwater.

Keywords: Melt-water flow, Erosion process, Rill erosion, Sediment process, Laboratory experiment