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EXPERIMENTAL INVESTIGATION OF SOIL DETACHMENT BY RAINDROP IMPACTS

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INTRODUCTION

Soil detachment due to raindrop impact is an important part of the soil erosion process in upland areas. Consequently, the mechanisms of raindrop impact in dislodging and transporting of soil particles should be studied independently and analyzed in combination in order to understand water erosion (1).

A rainfall simulator (rotadisk rainulator) developed at the University of Arizona and Purdue University was used to study detachment of soil particles by raindrop impact. The rotadisk simulator produces artificial rainfall with median drop size, drop velocity, and kinetic energy comparable to natural rainfall (2). This study involved the following objectives:

(1) To determine soil detachment and transport by raindrop impact using a rainfall simulator.

(2) To relate detachment rates to vegetative cover, soil land slope, and rainfall intensity.

(3) To determine the influence of erosion pavement on soil detachment rates.

Experimental Procedure

Six study sites were selected considering soil particle size in the land surface and slope steepness. A site was located at the University of Arizona Water Resources Laboratory which has almost flat silt loam soils. Three sites were located at Atterbury Experimental Watershed, where the soils are sandy loam with gravel in the surface, and the amount of gravel increases with slope steepness. Montijo Flat and Lucky Hills sites were located at Walnut Gulch Experimental Watershed, where the soils are sandy loam with 2 percent slope, and erosion pavement (gravelly soil) with 11 percent slope, respectively.

Since the rotadisk rainulator covers uniformly a 1.3 x 1.3 m plot, an

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apparatus was constructed and attached to the frame of the simulator to limit the applied rainfall to a 10 x 70 cm source area. The remainder of the plot was left as a target area for the detached soil particles. The target area was covered with 10 x 170 cm or 10 x 75 cm paper strips in horizontal and vertical configuration related to the source area to record the amount of soil deposited on each strip. The procedure was to make three 5-min applications of rainfall in 44, 86, and 118 mm/hr bursts in each site, and then to collect the paper strips with deposited soil. These paper strips were oven-dried to obtain the amount of soil deposited on each strip. At Lucky Hills, a plot with extensive erosion pavement, the gravel was removed, and the same 5-min application of rainfall were made.

Results and Discussion

The amount of soil detachment at different distances from the source area of each site are shown in Table 1. The amount and rate of soil detached

Table 1.--Measurements of soil detached at different sites using horizontal paper strips.

Site	Intensity mm/hr	Distance From Source Area (cm)							
		10	20	30	40	50	60	70	Total
Lucky Hills	44	0.63	0.22	0.16	0.04	0.00	0.00	0.00	1.05
	86	0.695	0.355	0.185	0.080	0.085	0.050	0.075	1.53
	118	0.815	0.350	0.160	0.110	0.095	0.060	0.080	1.67
Lucky Hills (disturbed)	44	1.665	0.695	0.335	0.185	0.155	0.105	0.080	3.22
	86	1.555	0.740	0.445	0.260	0.155	0.120	0.135	3.41
	118	2.740	1.415	0.785	0.485	0.260	0.170	0.145	6.00
Montijo	44	0.620	0.265	0.130	0.120	0.070	0.045	0.055	1.305
	86	1.850	0.665	0.365	0.155	0.110	0.065	0.075	3.285
	118	3.900	1.475	0.555	0.325	0.185	0.130	0.090	6.660
Prince Road	44	2.265	1.00	0.59	0.34	0.27	0.11	0.18	4.755
	68	2.725	1.445	0.66	0.41	0.22	0.16	0.08	5.700
	86	4.835	2.225	1.235	0.72	0.385	0.24	0.18	9.820
	118	5.19	2.31	1.29	0.83	0.595	0.44	0.375	11.030
Atterbury 1	44	1.805	0.54	0.195	0.105	0.065	0.010	0.000	2.72
	68	3.815	1.055	0.335	0.235	0.090	0.070	0.095	5.695
	86	4.82	1.52	0.655	0.375	0.338	0.315	0.378	14.096
	118	4.99	2.045	0.865	0.385	0.185	0.130	0.220	8.820
Atterbury 3	44	1.13	0.405	0.165	0.130	0.080	0.035	0.045	1.990
	68	2.135	1.090	0.590	0.380	0.265	0.160	0.145	4.765
	86	3.065	1.030	0.735	0.605	0.260	0.175	0.220	6.090
	118	3.735	1.555	0.630	0.415	0.295	0.125	0.030	6.785
Atterbury 5	44	0.865	0.445	0.205	0.175	0.095	0.09	0.080	1.955
	68	0.900	0.380	0.265	0.140	0.105	0.080	0.065	1.935
	86	1.10	0.735	0.390	0.245	0.175	0.125	0.090	2.860
	118	2.025	1.085	0.395	0.315	0.160	0.125	0.075	4.180

increased with increasing rainfall intensity. However, for the Lucky Hills plot with extensive erosion pavement, the influence of rainfall intensity was slight. When the surface pavement was removed, the influence of intensity was magnified (Lucky Hills disturbed site). The maximum amount and rate of soil detached was found for silt loam soils at Prince Road Site, and it was observed that soil detachment decreased with increasing amount and increasing median particle size of the erosion pavements. These results show an agreement with those reported by Farmer (3) where he pointed out that maximum detachability of soil particles is between diameters of .3 to .1 mm, and that when the size of soil particle increases, there is a reduction in detachability due to increasing particle mass.

It was found that an exponential decay function explains the variation of amount of soil with distance from the source area. The same decay function was obtained from the data presented by Palmer and Van Haveren (4). This indicates that when a raindrop strikes soil surface, the material splashed is distributed exponentially around the impacting point.

SUMMARY

A simple procedure was developed to measure soil detachment and transport by raindrop impact, and we have determined relationship between plot characteristics, rainfall intensities, and soil detachment/transport rate. Rainfall simulators appear to be a useful tool in investigations of erosion by raindrop impact.

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