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Particle Size Distribution of Surface-Eroded Soil in Different Rainfall Intensities and Slope Gradients

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Introduction: Soil water erosion on the slope lands involves detachment, transport and deposition of soil materials due to erosive forces of raindrops and surface runoff. Surface runoff can produce relatively high soil loss and is often the dominant hillslope erosion process. The rate of surface runoff which controls surface erosion on the uniform areas in the hillsolpes, is dependent on rainfall intensity and slope steepness. In various studies, the relationships between rainfall characteristics and surface runoff were well known. Many studies have been performed on the relationship between runoff and rainfall characteristics and soil loss.The effects of slope steepness on the surface runoff and soil loss were also investigated by many researchers. In a few studies, the transportation of soil particles has been studied. For examples, some studies showed that the soil particles have different susceptibility to transport by surface flow . However, limited information is available on the effects of rainfall intensity and slope steepness on the transportability of soil particles by surface runoff in the semi-arid areas. Therefore, the objective of this study was to investigate the effects of rainfall intensity and slope steepness on the transport rate of soil particles by surface runoff in a medium soil texture in semi-arid region.

Materials and Methods: A clay loam soil with similar particle size distribution (33.15% sand, 33.22% silt and 33.63% clay) was provided to study the detachability of soil particles by surface runoff. Soil loss and particle size distribution of eroded material were determined in the soil under zero, 10%, 20%, 30% and 40% slope steepness using simulated rainfall with 10, 20, 30, 40, 50, 60, 70, 80 and 90 mm h^{-1} in intensity. Soil samples were filled to 32 cm × 50 cm flumes with 7 cm depth and exposed to simulated rainfalls. Surface runoff, surface soil erosion and particle size distribution (PSD) of eroded material were determined in the slopes under simulated rainfalls. A total of 135 trials were carried out on 45 soil samples using the factorial completely randomized
design with three replications. Data of surface soil erosion and transportation of soil particles were compared using the Duncan's test among the rainfall intensities and slope steepness.

Results and Discussion: No surface runoff and surface soil erosion were observed in 10 mm h^{-1} rainfall intensity. Rainfall intensity of 20 mm h^{-1} appeared to be the threshold rainfall intensity to make surface runoff and surface soil erosion. Based on the results, surface runoff, surface erosion and kind of eroded soil particles were significantly affected by rainfall intensity ($P< 0.001$). Significant relationships were found between rainfall intensity and surface runoff ($R^2= 0.98$) and surface erosion ($R^2= 0.99$). Surface runoff increased strongly with increasing rainfall intensity. Increases in the rainfall intensity caused more runoff production as well as more detachment of soil surface particles . Surface runoff and surface erosion were affected strongly by the slope steepness. With an increase in the slope steepness, more surface runoff was produced and in consequence, surface soil erosion was considerably increased. Significant differences were found in the PSD of eroded material among the diffrent rainfall intensities ($P< 0.001$) and the slope steepness ($P< 0.001$). Silt showed to be the sensitive soil particles to surface erosion in rainfall intensities and slope steepness. Silt included about 66% and 74% of eroded soil particles in the rainfall intensities and the slope steepness, respectively. Sand fractions (very coarse sand, coarse sand, medium sand, fine sand, very fine sand) were the resistant soil particles to surface erosion in the rainfall intensities and the surface slopes. In higher rainfall intensities and slope steepness, more surface soil erosion was produced which was associated with the more transport of silt.

Conclusion: Rainfall intensity was the more important factor than the slope steepness in the soil loss and transportation rate of soil particles by surface runoff. Silt was the most susceptible soil particle to erosion by surface runoff in the rainfall intensities and the slope steepness. The transportation of very coarse sand and clay didn't appear significant differences for both the rainfall intensities and the slope steepness. Protection of soil surface from raindrop impact is essential for prevention of runoff and soil loss in steep slopes especially for intensive rainfalls.

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