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PARTICLE SIZE DISTRIBUTION OF ERODED SOIL UNDER SIMULATED RAINFALL CONDITION

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ABSTRACT

A study was conducted in vertisols to determine variation in runoff, soil loss and particle size distribution of eroded material with different Antecedent Moisture Condition (AMC) under simulated rainfall condition. The runoff and soil loss increased as AMC increased. However the particle size distribution in the eroded sediment was not affected by either antecedent moisture condition or by total runoff. But the amount of each particle size varied with increasing AMC.

Land is one of the most precious natural resources. It is degraded by many ways. Among these, soil erosion particularly by water is the most serious problem (45.3 per cent) in the Indian sub continent (Sehgal, 1996). Due to this erosion, 5334 mt of top soil (16.4 t ha^{-1} yr^{-1}) are being eroded every year (Dhruvanarayana and Rambabu, 1983). The particles size distribution of eroded sediment is a major component in erosion/ sedimentation (Knisel, 1980) because sediment size is a primary factor determining displacement of sediment particles detached from soil surfaces by rainfall. The amount of primary particles and clay present in sediment is influenced by physical and chemical properties of the soil. Thus the size of eroded soil particle is highly related with productivity.

The particle size distribution of the sediment eroded from a given soil is usually determined by applying simulated rainfall on field plots and collecting the runoff (Mayer *et al.*, 1980). Although field experiments by natural rainfall provide valuable information, they are both time consuming and expensive. Rainfall simulator provides many advantages, so that this experiment was conducted in vertisol of Bellary district, Karnataka by using rainfall simulator to study runoff, soil loss and the particle size distribution of the erosive sediment with different antecedent moisture condition (AMC).

The rainfall simulator provides an option of creating rainstorms at any time and place, in accordance with the requirements of an erosion study. Due to their portability, rainfall simulator can be carried to almost any location and studies made on different kind of soils, cropping and management practices existing in the field.

Development of rainfall simulator: Initially a hemispherical sprinkler type of rainfall simulator with manual oscillation was developed following the one used at IIT Kharagpur (Gulati, 1964; Prasad, 1969). The tests conducted revealed that distribution of simulated rain was not uniform over the soil tray and the intensity of the rain could not be varied. Apart from the above, the drop size was also not uniform both with respect to space and time. Considering various types of simulators available, efforts were therefore made to correct the above deficiencies and develop an indigenous rainfall simulator (Plate 1) by introducing a V-jet nozzle for uniform drop size connected to an automatic oscillation system (between 15 and 30 oscillations per minute) fitted with a solenoid valve attached to a timer for intermittent spraying to effect changes in the intensity of simulated rainfall (Meyer, 1960). The clean water is pumped using a reciprocating pump having a facility to deliver the water at a constant pressure which can be varied from 2 PSI to 10 PSI (Adhikari

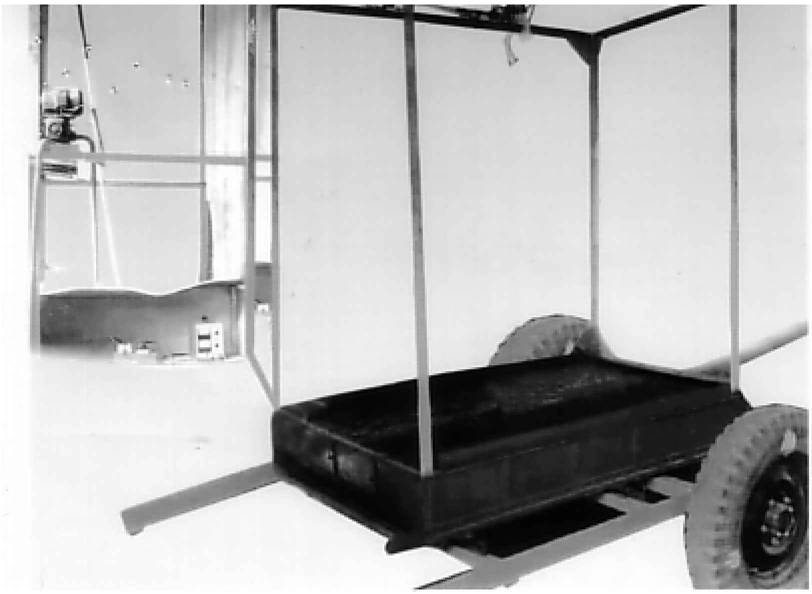

Plate 1. A view of rainfall simulator

et al., 2002).

Determination of uniformity coefficient: The simulator as described above was fabricated and put to test to determine the evenness of rainfall distribution over the plot area. The uniformity coefficient (CU) was calculated by using Christian's formula (Thomas, 1989):

$$CU=100\ (1 - \sum K/Mn)$$

Where, CU is the per cent uniformity coefficient, M is mean value of simulated rainfall, n is number of observations, and K is deviation of observations from mean. The CU was observed nearly 100 per cent suggesting validity of plot size.

Black soils were collected and filled in the tray size of 1.5 m x 1.0 m x 0.23 m having 1 per cent slope. The initial characteristics of the the soil such as bulk density, particle density, and pore space percentage were determined by using Keen-Raczkowski method (Keen and Raczkowski, 1921) and the particle size distribution was determined by international pipette method (Piper, 1966). Simulated rainfall intensity of 93-95 mm hr^{-1} was allowed over the soil tray over a time period of 20 min for continuous 5 days. The first rainfall application (initial run) occurred at existing soil water conditions while the wet run was conducted approximately after 24 hours. During that period, observations such as runoff, soil loss were recorded by using standard procedure after initial calibration of the rainfall simulator. Particle size distribution also worked out.

The initial characteristics of the soil determined were Bulk density 1.33 g cc^{-1}, particle density 2.04 g cc^{-1}, pore space 34 per cent, hydraulic conductivity 0.8 mm hr^{-1}, clay 545.5 g kg^{-1}, sand 232.7 g kg^{-1} and silt 211.50 g kg^{-1}.

During the 5 days observation period, the moisture percentage varied from 2.5 to 31.29 per cent. The runoff and soil loss increased as antecedent moisture condition

Table 1. Effect of Antecedent Moisture Condition on runoff and soil loss

Rainfall (mm)	AMC (mm)	Runoff (mm)	Soil loss (t ha^{-1})
31.60	0.00	3.30	0.20
31.32	31.60	7.40	0.37
31.80	62.92	10.11	0.41
31.60	94.72	18.12	0.95
31.58	126.32	18.18	0.97

increased. The increase was highly significant for first 4 days and there was no significant difference between 4th and 5th day (Table 1). It might be due to the saturation of the soil. Variation in runoff rates and associated water depth and velocity may affect soil detachment, deposition and sediment transport. The eroded soil was fine textured than the soil surface irrespective of the amount of aggregation and the particle size distributions of the eroded material were analyzed to detect any changes with the time of sampling throughout a given storm.

The particle size distribution in the sediment was not affected by either AMC or by total runoff and soil loss. It was corroborated with the findings of Swanson *et al*. (1965). But the amount (g kg^{-1}) of each particle size varied with the increasing AMC and soil loss (Fig. 1). At the end of the experiment, among the particle sizes, clay content in the eroded sediment was more as it required less energy to transport and another reason might be the fine texture of (high amount of clay content) the initial soil sample It was supported by Swanson *et al*. (1965). This clay distribution in the eroded sediment reflected the decrease in the productivity of the soil. It showed the importance of soil conservation measures in black soil to prevent the loss of eroded material and to sustain the fertility of the soil.

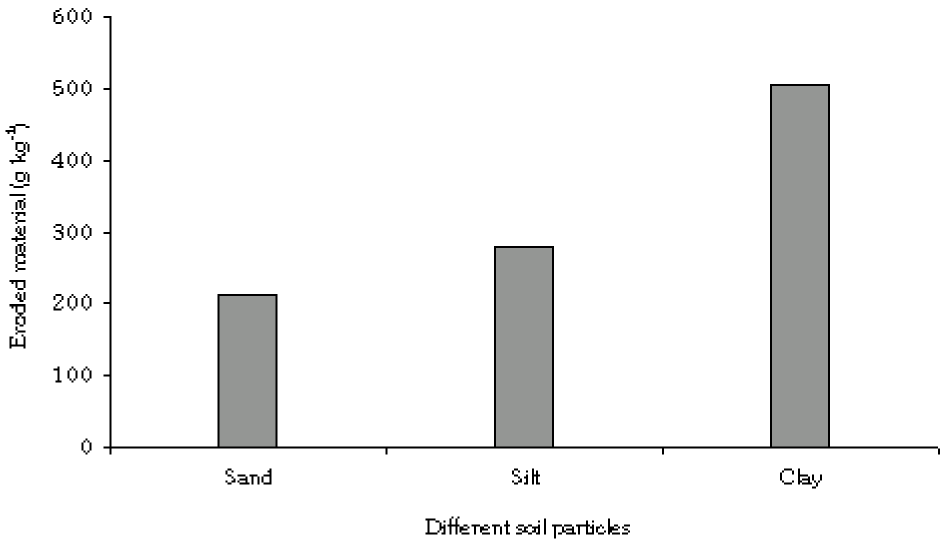

Fig. 1. Particle size distribution of eroded sediment

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