Particle Size Distribution of Eroded Spoil Materials

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Determinations were made of the particle-size distribution of the soil surface prior to runoff and of the eroded material under conditions of tillage and no tillage. Evaluations were made of changes in particle-size distribution in runoff samples collected during the course of a storm.

Erosion has been studied extensively in the United States during the past 50 years, focusing primarily on soil losses from cropped lands. These investigations have led to the adoption of cultural practices to reduce sediment production and maintain agricultural productivity at a high level.

Concern recently has grown over the magnitude of sediment yields resulting from construction activities. Reports indicate that serious erosion problems sometimes occur from highway, housing and business developments (1, 5). Similar difficulties could result from massive land displacement caused by surface mining. However, little detailed information is presently available on sediment losses from surface mined sites and of the physical nature of the eroded material.

Runoff and erosion studies were conducted on shaped mine spoil, (a) to determine and compare the particle-size distribution of the eroded material with the plot surface prior to rainfall, (b) to evaluate the effects of tillage on the particle-size distribution of the eroded material, and (c) to determine whether the particle-size distribution of the sediment in the runoff changed during the course of the rainfall event.

Procedure

The study was conducted at the North American Coal Corporation Indian Head mine near Zap, North Dakota. The site was mined in 1971 and shaped in 1973. Tilled and nontilled treatments were imposed on bare spoil of sandy loam, clay loam and silty clay loam texture. The sodium adsorption ratio (SAR) of each of the sites was considered to be high (Table 1). The tilled plots were roto-tilled with a small garden tractor to a depth of 2 to 3 inches immediately preceding testing.

Metal borders were installed on the nontilled plots in November, 1974, and on the tilled plots in July, 1975. The sparse vegetative growth on the nontilled plots was clipped prior to testing in August and September, 1975. Plots were 13.3 feet across the slope by 72.6 feet long, separated by a 6.7-foot border area.

A portable rainfall simulator, or rainulator, which combines features of standard runoff plot size, rainfall drop characteristics, minimized wind distortion and complete portability was used to apply artificial rainfall (4). Rainfall applications were run simultaneously on the tilled and non-tilled plots. Standard procedures were used to measure rainfall intensity, runoff and soil loss (4). An initial rainfall application was applied for one hour at a constant intensity of 2.5 inches per hour. A second, or wet run, was conducted approximately 24 hours later. Runoff samples were collected at three-minute intervals until a quart sample was obtained, or after three minutes, whichever was sooner. Sediment samples collected in quart jars from a given treatment were combined to obtain a sample large enough for particle-size analysis. Particle-size distribution of the spoil material was determined by the method described by Day (2). Silt separates ranged from .05 to .002 mm, with separates greater than .05 and less than .002 mm defined as sand and clay, respectively.

Gilley was research associate, Department of Agricultural Engineering; Dr. Gee was research scientist and Dr. Bauer was professor, Department of Soils.

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Table 1. Spoil characteristics.

Texture*	Slope, %	SAR**	Bulk density g/cm^3***	Per cent sand	Per cent silt	Per cent clay
scl	5	41	1.3	58	25	17
cl	10	31	1.3	31	38	31
sicl	13	33	1.2	12	49	39

**scl - sandy clay loam, cl - clay loam, sicl - silty clay loam*

***When concentrations are expressed in milliequivalents per liter,* $SAR = NA/\left[\frac{Ca + Mg}{2}\right]^{\frac{1}{2}}$

****Bulk density measurements were taken from the 0 to 6-inch depth.*

Results and Discussion

Data on runoff and erosion are presented in Table 2 (3).

Table 2. Erosion and runoff for rainulator study of shaped spoil materials*.

Texture**	Surface treatment	Soil loss ton/acre***	Runoff, inches
scl	nontilled	8.1	3.0
	tilled	4.1	2.9
cl	nontilled	3.9	3.9
	tilled	3.7	3.7
sicl	nontilled	3.9	3.9
	tilled	2.5	2.5

Plots were 13.3 feet by 72.6 feet.
**scl - sandy clay loam, cl - clay loam, sicl - silty clay loam*
***Average of initial + wet runs.*

Table 3 lists information on the particle-size distribution of both the plot surface prior to rainfall and of the eroded materials. Only minor variations occurred between the per cent composition of eroded soil separates from the nontilled plots and those of the plot surface. However, substantial variations occurred due to tillage. The per cent sand separate was much less in sediment from the tilled plots for each of the three textures examined. This reduction in per cent of sand separate from the tilled plots was accompanied by a substantial increase in clay separate in the sediment.

Table 3. Particle size distribution of spoil materials on plots prior to rainfall and of sediment from the spoil.

Spoil texture*	Spoil material	Per cent sand	silt	clay
scl	plot	58	25	17
cl	plot	31	38	31
sicl	plot	12	49	39
scl	sediment - nontilled	62	15	23
	sediment - tilled	3	20	77
cl	sediment - nontilled	26	43	31
	sediment - tilled	5	44	51
sicl	sediment - nontilled	16	55	39
	sediment - tilled	3	43	54

scl - sandy clay loam, cl - clay loam, sicl - silty clay loam. Average for plots prior to rainfall.

The change in particle-size distribution in sediment during the course of a rainfall event is described in data presented in Table 4. Results obtained on the clay loam site are representative of the sandy clay loam and silty clay loam material. It does not appear that particle-size distribution changed significantly in successive runoff samples. Of particular interest is the small variation in separate size present on the tilled plots. The effect of tillage did not appear to diminish through the end of the second rainulator run. The circumstances which must be met for the tilled plots to return to nontilled conditions is not known.

Summary

The particle-size distribution of eroded spoil materials from nontilled plots corresponded closely to surface conditions preceding rainfall. However, substantial changes in particle-size distribution of eroded material resulted from tillage. The particle-size distribution of sediment did not change significantly in successive samples collected during a storm.

References

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Table 4. Particle size distribution of eroded clay loam spoil.

Nontilled Time, min.	Per cent sand	silt	clay	Tilled Time, min.	Per cent sand	silt	clay
Run no. 1				Run no. 1			
2-11	14	50	36	7-16	5	38	57
11-20	23	47	30	16-25	2	44	54
20-29	34	37	29	25-34	2	48	50
29-38	29	43	28	34-43	3	49	48
38-47	28	42	30	43-52	6	51	43
47-56	26	41	33	52-61	7	49	44
Run no. 2				Run no. 2			
1-10	25	45	30	4-13	3	42	55
10-19	30	41	29	13-22	3	43	54
19-28	28	42	30	22-31	5	42	53
28-37	28	41	31	31-40	6	43	51
37-46	28	39	33	40-49	8	44	48
46-55	26	38	36	49-58	10	40	50