DIVISION S-6—SOIL AND WATER MANAGEMENT AND CONSERVATION

Relation of Soil Properties to its Erodibility[1]

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ABSTRACT

A soil's inherent erodibility, which is a major factor in erosion prediction and land-use planning, is a complex property dependent both on its infiltration capacity and on its capacity to resist detachment and transport by rainfall and runoff. The relations of these capacities to soil physical and chemical properties were investigated in a 5-year field, laboratory, and statistical study including 55 selected Corn Belt soils. Properties that contributed significantly to soil-loss variance included percentages of sand, silt, clay, and organic matter; pH, structure and bulk density of plow layer and subsoil; steepness and concavity or convexity of slope; pore space filled by air; residual effects of sod crops; aggregation; parent material; and various interactions of these variables. An empirical equation was derived for calculating the universal soil-loss equation's erodibility factor K for specific soils. Tests of the equation against soils of the older erosion-research stations, for which the erodibility factor is known, substantiated its general applicability over a broad range of medium-textured soils.

Additional Key Words for Indexing: soil-loss prediction, runoff, soil detachment, organic matter, texture.

RESEARCH data show that long-time average soil losses may vary more than 30-fold just due to basic soil differences (6). Variations such as illustrated in Fig. 1 are obviously a major factor in estimating and controlling erosion from farm fields, urban developments and roadbanks (17).

Numerous studies of factors related to water infiltration into soils have been reported (9). However, studies combining this information with the particle detachment and transport elements of soil erodibility have been much more limited. In 1932, Middleton et al. (5) grouped soils of the original 10 erosion stations according to soil properties believed to influence erodibility. The principal criteria were the dispersion ratio and a property designated as the erosion ratio. Other criteria included organic-matter content, the silica-sesquioxide ratio, and the total exchangeable bases. Voznesensky and Artsruui (12) developed a formula for an index of erodibility based on dispersion, aggregation and capacity to retain water. O'Neal (8) attempted to develop a key for evaluating soil permeability on the basis of certain field conditions. Peele et al. (10) modified Middleton's criteria in an analysis of four major soils of South Carolina. These developments led to a dimensionless soil-erodibility factor whose value could be expressed only relative to some benchmark soil serving as a common base.

The soil-erodibility factor K of the universal soil-loss equation (15) is a dimensional factor that can be directly determined from soil-loss data. This factor had its origin in the finding (14) that, for any given soil and area, individual-storm erosion losses are proportional to the rainfall parameter EI[3] and that the amount of eroded soil per EI unit differs substantially between soils. For a standard *unit*

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[3] EI is the erosion-potential index for a specific rainstorm. It was originally defined in the English system as the product: total rainfall energy of the storm in foot-tons/acre, times its maximum 30-min intensity in inches/hour, times 10^{-2} (14). In this system, its value is between 0 and 100 for nearly any natural rainstorm. A logical counterpart in metric units would be the product, storm energy in metric-ton meters per hectare times maximum 30-min intensity in cm/hour. The magnitude of this product would be 1.735 times that of the EI as defined in English units.

The rainfall-energy equation is: $E = 210.3 + 89 \log_{10} I$, where E is kinetic energy in metric-ton meters per hectare per centimeter of rain, and I is rainfall intensity in cm/hour. To convert foot-tons per acre-inch to metric-ton meters per hectare centimeter, multiply by 0.269.

Fig. 1—Some soils erode much more rapidly than others even when slope, rainfall, and management are identical. [Rossmoyne sil (*left*) and Morley cl (*right*), photographed on 9% slope after applying 12.7-cm rainstorms. Soil losses, in metric tons per hectare: *left*, 112; *right*, 22.]

plot,[4] the slope of the computed least-squares regression line of soil loss on storm *EI* values is the value of the factor *K* for a particular soil (16).

Thus, *K* is a measure of the total effect of a particular combination of soil properties. Some of these properties influence the soil's capacity to infiltrate rain, and therefore help determine amount and rate of runoff; some influence its capacity to resist detachment and transport by the erosive forces of falling raindrops and flowing water, and thereby determine the soil content of the runoff. The interrelations of these variables are highly complex.

Direct measurement of the erodibility factor is both costly and time consuming and has been feasible only for a few major soil types. Moreover, knowledge of basic interrelations of relevant soil parameters has not been sufficient to enable soil scientists to determine the relative erodibilities of the hundreds of other soils by analogy or computation.

To achieve a better understanding of how and to what extent each of the various properties of a soil affects its erodibility, a comprehensive interregional study was initiated in 1961. A second objective of the study was a general soil-erodibility equation that would enable computation of the universal erosion equation's factor *K* for any soil.

The study included the use of rainulators (4) in several states, to obtain comparative runoff and soil-loss measurements on numerous soils; indoor-laboratory investigations of specific phenomena; and operation of fallow plots under natural rain, to check the validity of estimates of *K* based on one-time tests under artificial rain. Field testing of soils under simulated rainstorms began in Indiana in 1961, Georgia in 1962, and Minnesota in 1964. Initial erodibility estimates were reported by Olson et al. (7) for several Indiana soils and by Barnett et al. (1) for Georgia and South Carolina soils. Barnett and Rogers (2) derived an erodibility equation based on their data for soils of Southern Piedmont and Coastal Plains, which are generally high in sand content. The following is a report of the Corn Belt study and deals primarily with differences in the erodibilities of medium-textured soils. A general erodibility equation for soils in this class is presented.

[4] A *unit plot* is 22.13 m (72.6 ft) long, with a uniform lengthwise slope of 9%, in continuous fallow, tilled up and down the slope (17).

MATERIALS AND METHODS

Fifty-five widely differing Corn Belt soils were selected for intensive field, laboratory, and statistical analysis. They included 5 sandy loams, 10 loams, 35 silt loams, 2 clay loams, 2 silty clay loams and a silty clay. Table 1 gives the variability in some of the common soil parameters. The particle-size, organic-matter, aggregation and suspension-percentage data shown apply to the plow layer. Laboratory techniques used are given in the table footnotes.

Research on soils similar to the 55 studied (13) indicates that the predominate clay mineral in the plow layer is a 2:1

Table 1—Variability in some properties of the 55 soils analyzed for the erodibility study

Variable	Range in values		Mean value
	Least	Greatest	
Sand content (> .05 mm), percent*	5.0	64.0	22.3
Silt content (.05-.002 mm), percent*	24.3	81.0	58.0
Clay ratio†	8	71	25.2
Organic-matter content, percent‡	0.9	5.5	2.2
Aggregation index ξ	.1	1.1	0.4
Suspension percentage, initial π	2.7	17.2	8.5
Suspension percentage, after 30 min rain	3.1	17.6	10.3
Soil moisture, 0-13 cm, % by weight	9.5	30.1	18.1
Bulk density, 0-5 cm (g/cc)	1.0	1.5	1.2
Bulk density, B horizon	1.0	1.7	1.4
Percent slope	3.2	14.5	8.3
Surface soil pH, coded	1	5	4.1
Soil structure, plow layer, coded	1	4	2.5
Thickness of granular material, inches	0	13	7.3
Runoff, initial 6.4-cm rain, cm	.4	4.5	2.7
Runoff, initial + wet run, 9.7-cm rain	1.6	6.6	4.7
Runoff, total, 12.7-cm rain	3.3	9.3	7.0
Soil loss, initial, metric tons/ha	.8	49.4	17.5
Soil loss, initial + wet	5.0	72.5	29.5
Soil loss, total	10.7	98.1	43.0

* Mechanical analyses by sieving and pipette method. † Percent clay/(% sand + % silt). ‡ By modified Walkley-Black method. The values are roughly 1.7 times % C. ξ By wet-sieving method. π Percent of the < 22-micron soil particles that remain in suspension after shaking or agitating for 4.5 min.

vermiculite-like, partially expanding lattice type but includes small amounts of illite (2:1, nonexpanding type), montmorillonite (2:1, expanding type), and kaolinite (1:1, nonexpanding type). The natural drainages of the soils range from moderately well drained to excessively drained. One somewhat poorly drained soil was included.

Topographic and surface-condition variables were measured, and a soil profile description was made at each test site. Standard laboratory techniques were used to determine physical and chemical properties of the soils. When detailed surveys showed the slope of a plot to lack complete uniformity, a slope-shape factor was assigned which is the ratio of the average gradient for the lower third of the plot to that for the middle third. Thus, the shape factor for a uniform slope is one, while that for a concave slope is less than one and a convex slope greater than one. Runoff, erosion, and related data were obtained by applying identical simulated rainstorms on two 4- by 10.7-m plots on each of the 55 soils.

Since the test sites were on privately-owned farm fields, it was not feasible to maintain them in continuous fallow for 3 or 4 years. With only a few exceptions, however, the selected fields had been in row crop in the last 3 years preceding the tests. All vegetation was clipped close to the surface and removed before spring plowing and disking. Plots received two additional diskings in late June and two more just before the tests.

Each test consisted of an initial rainulator run of 60 min followed about 24 hours later by two 30-min runs on the wet soil (7). All applications were at an intensity of about 6.4 cm/hour. Each series of applied storms provided runoff and soil-loss data for: 3.2- and 6.4-cm continuous rains, a 9.5-cm rain period with one interruption of not more than 24 hours, and a 12.7-cm rain within about a 24-hour period. The *EI* values of the four rain periods were 25, 50, 75, and 100. The rainulator technique eliminated rainfall differences and subsurface flow above the test plots.

The merits of various soil properties as indicators of erodibility were explored by multiple-regression techniques. Interaction terms were included in the regression models to study effects of interrelations of influential variables. Thus the effects of each soil parameter were studied with the levels of other parameters allowed to vary freely over their natural ranges. The computer was programmed to delete from the model each term whose contribution to the total information was not significant at the 75% probability level.

To achieve a better understanding of how particular properties of a soil affect its erodibility, we first explored the merits of the various parameters as estimators of the following dependent variables: (i) energy of rainfall required to start runoff, (ii) final infiltration rates, (iii) total runoff for each storm size, and (iv) soil concentration in the runoff.

Parameters that affect the first two of these directly influence the third and indirectly the fourth, because of their relation to velocity and depth of runoff. The analyses identified 16 soil and surface-condition parameters that contributed significantly to the observed differences in runoff and accounted for 90% of the total runoff variance for the 60-min rains. Seventeen parameters were identified which, combined in a multiple regression model, accounted for 96.5% of the total variance in soil-concentration in runoff from 300 rainulator runs. Details regarding the relations of the various soil properties to runoff rates and soil concentration, individually, will be presented in another report. Their principal relevance here is that they provided the basis for our selection of factors and interaction terms to test in a general erodibility equation.

Some of the variables that added significantly to an accounting for the variance in soil losses measured on the 110 plots (55 soils, replicated) can not be considered a part of the soil factor *K* in the universal soil-loss equation. For instance, not all soils can be found on a uniform 9% slope. Effects of slope steepness and slope shape interact significantly with several soil properties. In the concept of the soil-loss equation, however, these interactions result in varying the slope factor rather than *K*. Also, effects of variates such as plow date or variations in antecedent moisture tend to balance out over time under natural field conditions. In one-time rainulator measurements, unavoidable deviations of such variables from their expected mean or mode may not be permitted to bias the estimate of *K*. These problems were handled statistically. When regression equations had been derived which accounted for more than 95% of the plot-to-plot variance in soil loss for each storm size, the equations were solved for each test plot after substituting *unit plot* specifications for slope steepness and shape and expected average values of time-dependent variates. Thus, the necessary adjustments were accomplished on the basis of relationships in the data under analysis and by regression equations with relatively small standard errors of estimate. The soil losses thus computed for each of the four storm sizes were used to determine *K* for each of the 55 soils included in the study.

RESULTS

Table 2 shows the correlation coefficients obtained in simple linear regressions of final infiltration rate, runoff, soil content of runoff, and total soil loss on various soil properties. No single parameter or interaction term proved capable of predicting a soil's resistance to erosion by rainfall and runoff. When effects on infiltration and on soil content of runoff were combined in multiple-regression analysis of total soil loss from the 6.4-cm rainstorms, 22 soil and surface-condition parameters were needed to account for 95% of the variance. Similar equations fitted to the soil-loss data for the storms having EI values of 25, 75, and 100 accounted for 83%, 95%, and 96% of the respective variances. Standard errors of estimate were 15% and 11%, respectively, of the mean soil losses from the 50-*EI* and 100-*EI* storms.

The significant variables in these equations included primary and interaction effects of percent sand, percent silt, clay ratio, organic matter content, aggregation index, antecedent soil moisture, bulk density, percent slope, square of percent slope, pH of surface and subsoil, soil structure (coded from profile description), thickness of soil layer described as granular, land-use in preceding 3-year period, volume of pore space filled by air, slope shape, presence or absence of loessial mantle, and clay skins on ped surfaces.

Table 2—Coefficients of simple correlation

	Dependent variable			
Independent variable	Soil loss	Soil concentration	Runoff	Final infiltration rate
Suspension percentage	.49	*	.59	*
Organic-matter content	-.48	-.40	-.49	.48
Percent silt	.44	.35	.40	-.38
Percent slope	.32	.41	-.01	.07
Percent sand	-.30	-.26	-.25	.32
Clay ratio	-.31	-.17	-.35	.07
Aggregation index	-.24	-.14	-.34	*
Acidity increase below plow layer	.23	.29	.12	-.06
Soil structure	.23	.26	.01	.02
Slope shape	-.23	-.23	-.10	.18
Phosphorus content	-.21	*	*	*
Cropping, past 3 years	-.19	-.06	-.26	.25
Reaction (pH coded)	-.15	.00	-.26	.29
Plow date	-.13	.05	-.18	.17
Thickness of granular material	-.12	-.09	-.08	.06
Potassium content	-.10	*	*	*
Bulk density, 5-10 cm	.08	.05	.10	-.13
Depth to "firm"	-.05	-.04	-.04	-.06

* Not evaluated.

A Soil-Erodibility Equation

The adjusted data for the four storm sizes provided, for each of the 55 plot sites, four points on a soil loss-*EI* curve. These were fitted by least squares technique to the linear model $Y = a + m\ EI$.

The magnitude of a in the resulting equation for each soil reflected water intake by the soil before runoff began and, therefore, was primarily a function of initial infiltration rate and surface detention. Hence, observed values of a for a series of natural rainstorms on any soil would be expected to vary according to differences in antecedent moisture and surface conditions, which are time-dependent variables. In fallow-plot studies under natural rain, computed values of the negative Y-intercept have usually been small enough to be negligible. In the rainulator study, however, all soils were freshly disked and fairly dry at the beginning of testing, and absolute values of the negative intercepts were in the general range of 10 times the slope m. This pointed out the need to consider also the expected intercept value when estimating specific-storm soil losses on the basis of *EI*.

The slope m in the linear equation for a given soil is a function of sustained infiltration rates and the soil's ability to resist particle detachment and transport by rainfall and runoff. It is a function of physical and chemical properties of the soil. If determined under conditions defined for the *unit plot*, the slope m ($\Delta Y/\Delta EI$) is the erodibility factor K as defined for the universal erosion equation.

The next step was to derive an equation that would describe the relation of the 55 observed values of m to the physical and chemical properties of the respective soils. A multiple-regression equation that combines the effects of the primary and interaction terms listed in Table 3 accounts for about 98% of the total variance in the 55 observed values of the parameter m. When all coefficients in this equation are multiplied by the factor 0.013, the solutions are in the dimensions defined for the soil-loss equation's factor K (17). The equation's standard error of estimate is then 0.02, on 28 degrees of freedom. Neglecting errors in the aforementioned adjustments of the data, this would imply, at the point of means, 90% confidence limits of ± .03 and 95% confidence limits of ± .04 on estimates of K.

The complete equation is:

$$K = 0.013[18.82 + .62X_1 + .043X_2 - .07X_3 + .0082X_4 - .10X_5 - .214X_6 + 1.73X_7 - .0062X_8 - .26X_9 - 2.42X_{10} + .30X_{11} - .024X_{12} - 21.5X_{13} - .18X_{14} + 1.0X_{15} + 5.4X_{16} + 4.4X_{17} + .65X_{18} - .39X_{19} + .043X_{20} - 2.82X_{21} + 3.3X_{22} + 3.29X_{23} - 1.38X_{24}]$$

where the X terms are defined as in Table 3.

This equation seems cumbersome, but we shall show later that it can have considerable practical value.

Table 3—Variables in the soil-erodibility equation

		r	F ratio
X_1	% silt × 1/% organic matter	0.66	48.0
X_2	% silt × Reaction*	.53	13.0
X_3	% silt × structure strength*	.06	5.9
X_4	% silt × % sand	-.22	29.3
X_5	% sand × % organic matter	-.63	38.0
X_6	% sand × aggregation index	-.54	6.2
X_7	Clay ratio	-.37	24.7
X_8	Clay ratio × % silt	.0006	2.4
X_9	Clay ratio × % organic matter	-.46	34.2
X_{10}	Clay ratio × 1/% organic matter	.002	88.3
X_{11}	Clay ratio × aggregation index	-.44	4.3
X_{12}	Clay ratio × 1/aggregation index	.15	7.4
X_{13}	Aggregation index	-.37	17.5
X_{14}	Antecedent soil moisture	-.02	2.8
X_{15}	Increase in acidity below plow zone*	.52	18.2
X_{16}	Structure*	.05	19.9
X_{17}	Structure strength	-.03	6.9
X_{18}	Structure change below plow layer*	.13	12.7
X_{19}	Thickness of "granular" material	.13	6.7
X_{20}	Depth from "friable" to "firm"	.05	1.8
X_{21}	Loess = 1; other = 0	.36	14.3
X_{22}	Over calcareous base = 1; other = 0	-.30	21.6
X_{23}	% organic matter × aggregation index	-.49	6.7
X_{24}	Reaction × structure	.05	22.6

* Numerically coded from profile descriptions.

Testing the Equation

The list of parameters included in this study was quite comprehensive. Only those interaction terms whose significance or nonsignificance seemed to have a clear technical meaning were used in the model. Because of possible interrelations with extraneous variables not considered, however, correlation coefficients are not always reliable indicators of cause-and effect relationships. A better test of the equation's technical accuracy was provided by a check against known K values for soils that were not included in the data used to derive it.

More than 30 years ago, Middleton (5) published detailed analyses of physical and chemical properties of the soils on which the original 10 erosion stations were located. Using his published soil-property information, the equation was tested against the seven soils on which the old plot studies under natural rain had been most amenable to accurate evaluation of K. Four other soils, on which current fallow-plot measurements have exceeded 5 years, were also included in the test. The results, shown in Table 4, lend considerable confidence to the technical accuracy of the equation over a broad range of medium-textured soils. The fact that several of these soils contained more montmorillonite in the surface layer than the 55 soils in our sample does not appear to have had any profound effect on the relation of their erodibility to the predictive parameters in the equation.

Table 4—*K*-values computed by the new erodibility equation compared with previously established values for 11 benchmark soils

		Value of K*	
Soil type and texture	Location	Previously established	By new equation
Shelby l	Bethany, Mo.	.41	.39
Marshall sicl	Clarinda, Ia.	.33	.33
Houston c	Temple, Tex.	.29	.24†
Cecil scl	Statesville, N.C.	.36	.29‡
Fayette sil	LaCrosse, Wis.	.38	.38
Keene sil	Zanesville, Ohio	.48	.46
Zaneis fsl	Guthrie, Okla.	.22	.25
Caribou l	Presque Isle, Me.	.21	.23
Lexington sicl	Holly Springs, Miss.	.37	.40
Tifton ls	Tifton, Ga.	.10	.07
Mexico sil	McCredie, Mo.	.28	.31

* Δ soil loss/Δ EI. † The Houston on the Temple plots was about 60% clay, which is beyond the range of our data. ‡ The Cecil at Statesville, described by Middleton (5), is higher in both organic matter and clay fraction than the cecil sandy clay loam rated 0.36 at Watkinsville, and therefore less erodible.

DISCUSSION

A soil's erodibility is a function of complex interactions of a substantial number of its physical and chemical properties. Those that affect surface-seal and crust formation are of course highly important, but our study showed that characteristics of the soil beneath this thin surface layer are also relevant to erodibility.

The erodibility equation presented appears to provide an empirical model for investigation of how a change in any soil property will effect erodibility in a given situation.

It must be remembered that the variables in the erodibility equation are highly interrelated and that the coefficient of a single term taken out of context may not be assumed to reflect the overall relation of one parameter to erodibility. In nonorthogonal multiple regression equations, the coefficient of one term may include some of the effect of another variable with which it is highly correlated. Or, compensatory credit may be given in related terms. Nevertheless, helpful conclusions regarding the relation of the numerical erodibility factor K to a specific soil property can be drawn from the study of particular components of the overall equation if all terms that involve that property are considered together as a single entity. Some of these are discussed below.

Relation of Erodibility to Soil Texture

Generally speaking, soils that are high in silt, low in clay, and low in organic matter are the most erodible. Usually a soil type becomes less erodible with decrease in silt fraction, regardless of whether the corresponding increase is in the sand fraction or the clay fraction. However, percentages of silt, clay, and sand must be considered in relation to existing levels of other physical and chemical properties. The study showed that when this is done, erodibility is often so sensitive to small changes in particle-size distribution that conventional texture classifications are much too broad to serve as a reliable guide to a soil's capacity to resist erosion by rainfall and runoff. The range in erodibilities of silt loams, for example, seems to include about three-fourths of the range for all soils.

Combining all terms in the equation that directly involve percent silt, gives the relationship

$$K \propto (.043\ R + 0.62/OM + .0082\ s - .0062\ c)\ \%\ \text{si}$$

where K is erodibility, R (reaction) is directly proportional to pH, s is percent sand, and c is clay ratio. For most medium-textured soils, this four-term coefficient of the percent-silt variable assumes a positive value of appreciable magnitude. However, the expression shows that the magnitude of the increase in K with each additional increment of silt fraction becomes less as organic matter increases or the sand/silt ratio decreases. Increased organic matter improves the permeability of surface seals. When clay content becomes extremely high, small changes in organic-matter level or sand/silt ratio lose practical significance. (The effect of pH is discussed later.)

The equation's complete clay-ratio term is

$$K \propto (1.73 - .26\ OM - 2.42/OM + 0.3\ \text{agg.} - .024/\text{agg.} - .0062\ \text{si})\ \text{clay ratio}.$$

This expression usually has a negative value, indicating that erodibility decreases as the clay fraction becomes larger. Most of this effect is probably attributable to the increased cohesiveness. The magnitude of the negative coefficient of clay-ratio, however, declines with higher organic-matter content, higher aggregation index or higher sand/silt ratio.

The study indicates that the arbitrary demarcation between silt and sand in the standardized USDA system (11) is not the most logical one from the viewpoint of erodibility. The "very fine sand" (0.05 to 0.10 mm) particles seem to behave more like silt than like other sand particles.

Surface-Soil pH

The complete equation indicates that the relation of pH to erodibility depends on soil structure and silt content. For a high-silt soil, increased pH increases erodibility if the structure is very fine or fine granular. This is probably due to an effect on surface crusting. If the structure is medium or coarse granular, subangular, or angular, erodibility decreases with increased pH.

Organic Matter and Aggregation

Overall, organic-matter content ranked next to particle-size distribution as an indicator of erodibility. Both the rainfall energy needed to start runoff and the final infiltration rates increased directly with organic-matter increases, while soil content of the runoff was inversely related to organic-matter content. Nevertheless, these relationships did not hold for all the soils studied. The analyses showed an important but very complex interrelation between organic matter and clay. On silts, silt loams, loams and sandy loams, the inverse relation of erodibility to both aggregation index and organic-matter level was strong, but it significantly declined as the clay fraction became larger, and it may become insignificant on clay soils. For a high-clay soil with 4% organic matter, for instance, the inverse relation of erodibility to aggregation index appears to hold only so long as the sand fraction exceeds about 35%. For a 2% organic-matter level this critical sand level drops to about 10%. With clay content high and sand content appreciably less than these percentages, the relationship reverses. This suggests that aggregates comprised largely of clay particles are more susceptible to erosion in aggregated forms.

In our sample of 55 soils, the general inverse relation of erodibility and water-stable aggregation accounted for only 6% of the total variance in erodibility of the soils. Organic matter in high-silt soils is important also for reasons other than its effect on aggregation.

Other Relationships

In laboratory tests of samples from the 55 sites included in our study, the permeability of surface seals decreased as organic matter content, percent sand, aggregation index, bulk density or lime requirement decreased and as silt, clay ratio, suspension percentage, moisture equivalent, pH or modulus of rupture increased. On some soils, surface sealing, which decreases infiltration, also decreases particle detachment and therefore soil-content of the runoff.

Even though Middleton's "suspension percentage" appeared to be the single variable most closely correlated with erodibility (Table 2), the computer deleted it from our multiple-regression models as insignificant. Further analysis showed that suspension percentage was itself a function of other variables in the equation which, in the overall combination, had greater capacity to decrease the equation's error of estimate.

Standard profile descriptions usually describe structure as weak, moderate or strong. The effect of this variable was also related to silt content. The study showed erodibility inversely related to structure strength when the silt fraction exceeded about 60%.

Soils that went from fine or medium granular in the plow layer to subangular or blocky in the next horizon tended to be slightly more erodible than those with no change.

Indications of decreases in final infiltration rates and increases in soil content of runoff with increased bulk density of the surface soil were observed, but neither of the correlations was significant at the 95% level.

An inverse relation between soil loss from the 1-hour rains and phosphorous content of the plow layer was significant. Overall, the relation between soil loss and potassium content also appeared to be inverse, but it was not significant at the 5% level.

In general, plots plowed later in the season had higher final infiltration rates and less runoff than plots plowed in April or early May, but soil content of the runoff was not significantly related to plow date.

Field Application

The extreme sensitivity of the equation to small changes in organic-matter level or in particle-size distribution is a fact borne out by the large number of field measurements. It poses a problem for field technicians because of the inherent variability often apparent within a given soil type over a relatively small area. Nevertheless, guidelines provided by the equation can be quite helpful to them.

For example, field measurements on four Russell silt loams in Indiana gave K values of .38, .44, .52, and .52. The four soils had a common organic-matter level of about 2%, but their clay contents were inversely proportional to the measured K values. Solutions of the erodibility equation suggest that if soil properties other than particle-size distribution are assumed constant for all Russell silt loams at the levels measured in our four samples, then the erodibility index for this general soil type could vary as follows:

silt loam approaching silt	0.64
silt loam approaching sandy loam	0.55
silt loam approaching midpoint	0.50
silt loam approaching loam	0.44
silt loam approaching silty clay loam	0.35
silt loam approaching clay loam	0.31

An organic-matter level higher than 2% would lower all of these values.

Standard soil-profile descriptions usually provide all the information needed for the erodibility model except specific data on particle-size distribution, organic-matter content and aggregation in the plow layer. Where accurate erodibility information is needed for a small specific area such as an urban development or small-reservoir drainage area, the required soils information could be obtained in detail. For general use by field technicians, either midpoint values or ranges for specific soil types could be tabulated. Using the equation as a basis, an electronic computer could quickly derive a table of K values for a very large number of combinations of particle size, organic-matter level and other pertinent soil properties. Field selection of the appropriate value would then become a matching process.

From several tests, the equation appears to predict with good accuracy the numerical erodibility index for any specific soil in the silt, silt loam, loam or sandy loam texture groups. These are the most erodible soils and involve large agricultural areas. The sampling of soils containing more than 65% sand or more than 35% clay was too limited to provide the desired confidence in use of the equation on sands or clay until some of the complex interrelations involved are better understood.

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