

Analysis of the Present Research Situation and Trend of Soil Erodibility

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Abstract: According to the summarizing and reviewing of the studies on the present research situation of soil erodibility, this paper analyzes the main evaluation indexes and methods of the present studies of soil erodibility, and brings forward the main problems of present studies and applications on soil erodibility, especially when soil erosion refer to kinds of forces, there are shortages of non-standard and simplification of analysis mechanism by evaluating soil erodibility with single re-erosion indexes. Basing on this, it suggests that setting up comprehensive indexes system of soil erodibility is the important basis of defining mechanism of soil erosion, knowing about character of erodibility, evaluating soil erodibility, and reasonable lay-out for soil productivity, and that in the future the trend of the study on indexes system of soil erodibility is inducing more related conceptions, theories and techniques of multi-subjects, especially the applications of important technique and methods about the theory of big-system, computer technology, erosion dynamic model and so on, which will make multi-factors evaluation possible.

Keywords: soil erodibility; the system of evaluation indexes

Soil erosion is a main reason of land degradation and land collapse. For natural and social factors soil erosion in red soil craggy terrain regions in south China has become an obvious sign of ecological environment degradation and a serious restriction of economic and social development. A long-termed study and harness practice show that knowing about and evaluating the characteristics, distribution and its influence factors of soil erodibility are an important basis for reasonably utilizing and managing land resources, and also a main foundation for selecting countermeasures of water conservation and guarding against land degradation.

1 Summaries of analysis on erodibility

1.1 Soil erosions and erodibility

Soil erosion is a natural phenomenon, which generally occurs on the surface of dry land. Different from sequence of inside forces of earth, soil erosion is a "leveling process" to the surface of dry land under the function of outside forces such as water force, wind force and gravitational force. While the dimensions of human being's behaviors are more strengthened and engendered to evidently influence on the key elements of soil, new connotations have been continuously endowed to the phenomena.

N. W. Hudson, an English penologist, defined soil erosion in his monograph *Soil Conservation* as "soil erosion is the transshipping, roll or running off of soil and rock grains with the function of gravitational force. Wind and water are the main forces which loose and fragmentize the grains."^[1]

The Soil Preserving Bureau of American Ministry of Agriculture explained soil erosion in 1971 as "abrasion of soil surface, or dispersing and shifting of soil or rock trifles owing to the forces such as wind, water, frost and gravity etc."

The item about soil erosion in *New Encyclopedia Britannica* of American expounds that the wind blows and rain are the main reasons of soil erosion.

The definition of soil erosion in the volume of water conservancy of the *Encyclopedia Chinese* is that soil erosion is the process of destroying, eroding, moving and sediment of soil and its parent material due to the function of outside forces as water, wind, freezing and thawing or gravitational force.^[2]

All definitions of soil erosion above emphasize the diversity of outside forces and the process of function. Obviously, it is not comprehensive to describe and evaluate only one outside force or one segment of the function process.

In our country, the word “water and soil loss” is extensively used in scientific paper and everyday interflowing as a synonym of “soil erosion”. In the volume of water conservancy of the Encyclopedia Chinese, water and soil loss is defined as “destroying and losing of soil and water resources and land productive force owing to the function of outside forces such as water and wind”. Contrasting the intention of these two concepts, we can find out that soil erosion emphasizes the description of process while water and erosion emphasize the sequence. But they both express the common intention of mutual action between the outside forces and the resistance of active object that are the matter on land surface involving the soil.

The study about eroding force and resistance indicate that, the sequences of different outside forces acting on the same soil are different, and the sequence of the same outside force acting on different soils is different too. With the same water eroding, some soils are easy to be eroding, but others are more difficult. People describe the degree of difficulty of soil eroding process under the action of resistance as soil edibility. N. W. Hudson described soil edibility as “the sensitivity to soil erosion, it is the reciprocal of erodibility”. Raymond W. Miller and Roy L. Donahue defined soil edibility as the degree of difficulty of soil erosion.^[3]

1.2 The research progress of soil erodibility

German soil specialist Willon from 1877 to 1895 carried out the earliest experiment on soil erosion. In 1917, the American Professor M.F built runoff treatments to study the influence on runoff and erosion from soil, slope and crop.^[2] According to physical and chemical analysis and contrast to a great deal of data from experimental spots, Middleton H.E. and colleagues (1930, 1932) studied soil erodibility factors on soil aggregate, structure stability and permeability, etc. Zingg set up the relationship between the amount of soil erosion and slope, its length by studying the correlation between the amount of soil erosion and terrain factors in 1940. From then on, Browning (1947) had made the relation system by introducing soil erodibility factor perfect. Wischmeier and Smith brought forward the estimating equation based on sheet wash and rannel erosion in farmland in 1965. In 1971, Wischmeier, Johnson and Cross developed the methods that soil erodibility was estimated with four soil characteristic values (texture, organism content, soil structure and soil permeability),^[4,5] which were developed as widely-used universal soil losses equation finally (USLE). In this equation, what the soil erodibility index indicated is the rate of the amount of soil erosion produced by agent of erosion per unit between all kinds of soils and bareground (standard block). For several years, many experts made great progress on the soil resistance study, and richened tremendously the application to soil erosion valuation and technology system. R.M Bajracharya and R Lal found that soil erodibility factors (K) varied significantly in different seasons and years according to the study on soil erodibility’s seasonal variation in Miami silty clay. Its trend is that K value varied from low to moderate level in summer and autumn, but from moderate to high level in winter and spring. This result was consistent with many other research ones, which was caused by lower permeability and soil intensity because of too much water in soil in winter and spring. In this period, negative correlation existed between soil shear strength and water content in soil. Soil aggregate stability decreased because of frost’s negative effect.^[6] V. Rasiah etc. studied the relationship between soil water content and structure stability on ten rotation experimental lands. The results showed that there are several linear relationships between two soil stability parameters-Wet aggregate stability (WAS), dispersible clay (DC) and water content as follows: WAS decreased with the increasing water content, and DC increased with it.^[7-12]

Systematical research on soil erodibility in China began in 1950s. The study was emphasized on soil scouring resistance and erodibility. The former was defined as the capacity of resisting raindrop’s hit and runoff’s dispersing and suspending. The latter was defined as the soil resistance to runoff’s mechanic destructures force and lapse force. Among them, index of dispersion, erosion and dispersion coefficient, disparity were regarded as its index respectively^[13,14]. Based on experiment analysis, Zhou peihua etc thought eroding experiment was characteristic of strictly representative and accuracy in measuring soil

scouring resistance^[15]. Yan yusheng thought that index of dispersion and aggregate situation can reflect the function of red soil erodibility based on 17 variables' measuring and PCA category^[16]. Yan wenyuan etc measured and analyzed relation between purple soil's scouring resistance and runoff intensity, time variation in Sichuan by homemade scour channel and runoff treatments^[17]. Jiang dingsheng etc divided scouring resistance plot in Loess Plateau by improved scour channel and measuring results. There are many other studies on anti-erodibility that looked on scouring resistance as main contents^[18,19]. Recently, some researchers undertake national nature sciences foundation and 973 projects to study erodibility, in distribution, it was mainly in Loess Plateau, while the study on red soil is still few.

After American universal loss equation and its forecasting technology were introduced to China, many researchers make other probes on anti-erodibility of various soils and have made many achievements^[20, 21, 22, 23].

2 Problem analysis on soil erodibility study

2.1 Non-standard of soil erodibility eigenvalue

Based on reviewing and inspecting above survey and problems in soil erodibility, it is obvious that the studies on erodibility have many difference in whether theory, methods or experimental device, evaluating indexes. There is not still relative consistent measuring and evaluating standard. For example, many difference exist in different region and department in measuring methods of scouring resistance.^[18,19,10] Some researchers adopted Gussak scour channel, Willans dripping apparatus etc to measure soil scouring resistance. Other researchers make use of improved and self-designed methods to analyze soil scouring resistance. In addition, calculating methods have many differences in quantification of index value. Thus, there are many achievements on soil scouring resistance, but they can not be applied to different regions, soil and eroding type so that they can not instruct the comparison, evaluation of soil anti-erodibility, land resources management, sustainable development.

2.2 Simplification of factors analysis mechanism

Actual quantification value of soil erodibility in USLE was expressed according to soil terrain, structure, organism contents and permeability. But influence and contribution on Soil erosion of the four factors had not proper proportion and definition. At the same time, the four factors were special in total influence on soil because other soil physical and chemical feature had not been taken into account.

In USLE, the value of all kinds of factors is the ratio of different blocks' total soil erosion to standard ones'. The amount of soil erosion that those blocks measured is the total of splash erosion and sheetwash in a certain area. When treatment has stronger representative and enough blocks, the forecast erosion by statistical analysis has good correlation and important application value. But we must emphasize that ground feature in experiment blocks is limited, especially with the extent of limited slope length, that flow rate and flow velocity is not enough to produce gully erosion. Therefore, above amount of soil erosion is difficult to illustrate and evaluate the mechanism about actual gully erosion and larger-scale erosion effectively. In fact, the process of gully erosion and other soil erosion were caused by raindrop and surface runoff completely, and combined action was accompanied by hydraulic power, gravity etc, Such as debris flow in hilly region, devolution erosion in southern red soil region and breakup in river and lake region. Therefore, when evaluating erosion intensity level and potential intimidation, we could not make a correct conclusion by simple assembly with those impact resistance and soil erodibility.

Because of the limitation of the index of soil impact resistance and erosion resistance, some researchers have carried out soil mechanical studies on soil shear resistance and expansibility according to specific situation in southern red soil region.^[24, 25, 26, 27, 28] And have developed new research method on soil erosion resistance.

The research's continuations on soil erosion resistance make those researchers engaged in soil erosion realize that original research which defined soil erosion resistance based on dispersancy, suspension force and lapse force, only aimed at partial erosion resistance features. And it did not include gravity, wind power and heat power.

3 Improvement and trend analysis on soil erodibility

3.1 Constituent of index system of soil erodibility

The soil in a certain region may produce different erosion results due to different exogenic force, such as water force, gravity, and wind power and freeze-thaw action. Soil resistance is different corresponding to different exogenic forces. For instance, soil resistance index corresponding to wind power erosion may be comprehensively evaluated with soil texture, structure, water content, organism content and aggregate feature. To raindrop hitting and surface runoff sheet wash, soil texture, structure, organism content, permeability, the rate of secondary clay mineral, secondary lime, aggregate stability, commutatively action and free lime carbonate may be adopted to evaluate.^[4] When surface runoff have the potential possibility for producing gully erosion, the features' variance and distribution become more important in soil vertical section. If we will describe those features of mass erosion, the mechanics features of soil texture, structure, shear resistance, dilatation and soil's own feature of crevice, parent rock joint, soft plane distribution will come within the salient status. And once evaluating to certain area's soil erodibility, the difference of all kinds of erosion and factors must be sectionalized. Soil may suffer different agent of erosion in different time. We could adopt a certain factors of a specific exogenesis force as the index of soil anticorrosion. But the process of erosion was the results of more than two agent of erosions' coefficient, and cannot get the correct result only with an indicator. For example, collapse erosion in South China was the coefficient of waterpower and gravity in the same time range. This process was from surface erosion to gully erosion and disintegration. Obviously, this process was not described by a simple anticorrosion index like USLE. Because it was an erosion, which has a long duration, many factors and in a large scale. Therefore, establishing a soil erodibility index system, which combined with all kinds of agents of erosion, is more important to us. For that, we can realize the erosion mechanism, erodibility feature and soil vulnerability evaluation for a better layout to productivity.

3.2 Hot spot and trend of soil erodibility

(1) Because the original researches of soil erodibility remained a certain limitation, deviation may be produced in realizing the mechanism of soil erodibility. In order to reveal the law of soil erosion and retrogression efficiently, the posterior researches would be the more comprehensive and deep going researches. Those studies with comprehensive index system of soil erodibility will replace the original way that was with simple indicator. Soil erodibility index system will introduce more conception and theories about soil mechanic, soil geography, soil chemistry, soil physics and soil biochemistry.

(2) For the demands of soil erodibility index system, more of study's methods and means of all kinds of subdisciplines will be introduced to soil erodibility researches.

(3) The theories and technology's development of related discipline will be the base of methodology in setting up the index system of soil erodibility. Especially the technologies and methods' application of big-system theory, computer technology and erosion dynamic model will make it possible for multifactor evaluation.

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