

Study on the standard of soil erosion gradation based on erosive daily rainfall

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Abstract. This paper took Yuyao city as the research area. the daily rainfall data of 30-year was collected from the typical rainfall station. And the daily rainfall power function model was used to calculate the rainfall erosivity. The weight that the rainfall erosivity of the rainfall less than 30mm accounted for the total annual rainfall erosivity was calculated and analyzed. A method for soil erosion intensity gradation based on daily rainfall was proposed. At the same time, according to People's Republic of China water conservancy industry standard "the standards for classification and gradation of soil erosion", the weight value was used to establish the gradation standard of soil erosion intensity. The daily soil loss tolerance was 7 t/km² calculated by this method.

1. Introduction

The soil erosion intensity was displacement amount of the earth's crust surface soil in the unit area and unit time, under the comprehensive effect of natural force (water, wind, gravity and freeze-thaw etc.) or human activities [1]. Determining the soil erosion intensity in one area was one of the basic tasks of national and regional soil erosion surveys and soil degradation assessments. However, there were many factors, such as natural conditions and human conditions, had a significant impact on soil erosion. Therefore, it was very difficult to formulate a reasonable grading standard. that was why there had been controversy about the gradation standard of soil erosion intensity. In China, some academicians, such as Zhu Xianmo and Huang Bingwei, as well as some experts of the United States, the former Soviet Union and other countries, had put forward some indicators in terms of soil erosion gradation [2-5]. The Ministry of water resources of People's Republic of China formulated the grading index of soil erosion intensity for two times in 1988 and 1997. However, there were still many problems in practical application. Yuan [6] had discussed the rationality of the reference index of vegetation coverage in the standard by using the existing research results. Chen [7] and Yang [8] had discussed the tolerance soil loss amount from the factors affecting soil erosion, respectively. Ruan [9] studied the grading index of soil erosion intensity of granite in Southern China by using the measured data of soil erosion, and the reference index of soil erosion intensity of granite natural sloping land was set up in.

The determination of soil erosion gradation was an important problem in soil and water conservation work, which was an indispensable data for soil erosion severity and soil and water conservation planning and design. It was also an important content of soil erosion theory research. In planning, soil erosion intensity gradation was mainly judged by means of investigation and selection of ground characteristic indexes. Although there were strict mathematical calculations, some areas did not collect soil erosion



data, which made it difficult for soil erosion intensity gradation [10]. Moreover, the results based on different soil erosion survey methods were difficult to compare and use uniformly. At present, the standards for classification and gradation of soil erosion was main suitable for soil erosion gradation of macroscopic scale. There did not establish appropriate standards for soil erosion gradation of microcosmic scale. For example, the water conservancy and flood control departments, they are usually concerned with the amount of flood erosion produced by the daily rainfall. So, how do you determine that how much the daily rainfall can produce how extent erosion? Therefore, it was important to guide the establishment of soil erosion intensity classification standards from daily rainfall.

2. Materials and Methods

The gradation of soil erosion in the standard was graded by annual mean soil loss. Its application was restricted in many areas. For example, in the soil erosion forecasting of flood insurance or slope collapsing, it was necessary to grade the risk of soil erosion under a certain rainfall condition. In those areas with high risk, it was necessary to strengthen soil erosion monitoring and do a good job in soil erosion prevention and control. Therefore, it was necessary to establish a standard for soil erosion gradation based on conventional rainfall data. In the standards for classification and gradation of soil erosion (SL190-2007), the tolerance soil loss and soil erosion intensity gradation standards in different erosion types areas were shown in Table 1 and Table 2.

Table 1. Tolerance soil loss of different erosion type areas

Type areas	Tolerance soil loss $t \cdot km^{-2} \cdot a^{-1}$	Type areas	Tolerance soil loss $t \cdot km^{-2} \cdot a^{-1}$
Northwest Loess Plateau Region	1000	Hilly Red Soil Region of Southern China	500
Black Soil Region of Northeast China	200	Rocky Mountain Area in Southwest China	500
Rocky Mountain Area in North China	200		

Table 2. Hydraulic erosion intensity gradation

Gradation	Annual mean erosion modulus $t \cdot km^{-2} \cdot a^{-1}$	Mean soil loss thickness $mm \cdot a^{-1}$
Non-apparently eroded	<200, <500, <1000	<0.15, <0.37, <0.74
Slightly eroded	200, 500, 1000 ~ 2500	0.15, 0.37, 0.74 ~ 1.90
Moderately eroded	2500 ~ 5000	1.90 ~ 3.70
Severely eroded	5000 ~ 8000	3.70 ~ 5.90
Very severely eroded	8000 ~ 15000	5.90 ~ 11.10
Extremely eroded	>15000	>11.1

Note: The mean soil loss thickness was calculated by soil dry density $1.35g \cdot cm^{-3}$.

The daily rainfall was the most widely and frequently-used data in hydrological information. So, the establishment of soil erosion gradation standard based on daily rainfall had a wide range of applicability. Rainfall erosivity was a comprehensive index of potential ability of rainfall to soil erosion. The annual soil erosion amount was accumulated by daily soil erosion which produced by daily rainfall. According to study results of erosive rainfall standard by Xie [12] and Wang [13], the daily rainfall less than 12.0 mm did not produce erosion. the daily rainfall of 30.3 mm produced the upper limit value of non-apparently eroded. This study was based on the previous research results. The daily rainfall of 30 mm was regarded as the upper limit for the non-apparently eroded. The weight of rainfall erosivity of 12.0 ~ 30.0 mm was used as the weight of different erosion intensity gradation of the standard SL190-2007, in order to obtain the daily rainfall soil erosion intensity gradation standard.

The standard formula of different soil erosion intensity gradation for daily rainfall as following:

$$A_i = w \times B_i \quad (1)$$

Where A_i was the daily standard value of different erosion intensity grades. B_i was the standard value of annual soil erosion intensity grades stipulated in Table 2. The w was the weight of rainfall erosivity of 12.0 ~ 30.0 mm.

The weight w was calculated by the followed equation:

$$w = \frac{1}{N} \sum_{i=1}^N \left(\frac{1}{n_i} \times \frac{R_i p_{30}}{R_i} \right) \quad (2)$$

Where R_i was annual rainfall erosivity. R_{ip30} was the rainfall erosivity of daily rainfall of 12.0 ~ 30.0 mm. N_i was the days of daily rainfall between 12.0 ~ 30.0 mm. The i was ordinal number, 1, 2, ..., N . the N was the annual rainfall sequence length.

3. Results and Analysis

3.1 The change analysis of weight w

According to the daily rainfall data of Yuyao rainfall station for 30 years, the daily rainfall erosivity of the station was calculated. The rainfall erosivity and the days of 12.0 ~ 30.0 mm rainfall were counted. On this basis, the weight was calculated by formula 2. The change of the w was shown in Figure 1.

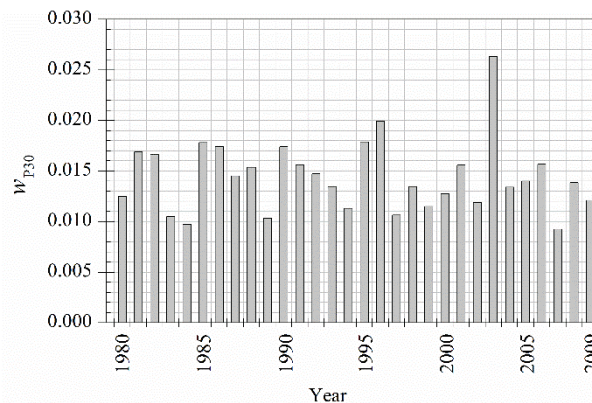


Figure 1. The yearly change trend of the w

It can be seen from Figure 1 that the interannual change of the w was obvious. The 30-year mean value was 0.0144. There were certain periodic change features in the long sequence. Especially at 1997 ago, there were 3-5 years of periodic change of peaks and valleys. Then there was a period of low volatility (1997-2002). In 2003, the mutation became apparent and the maximum (0.0263) occurred. In 2004-2009, the w returned to average fluctuant levels. Although there were some fluctuant changes. But through the Man-Kendall test ($z = -0.57$), it did not found there was obvious trend of change.

3.2 Daily tolerance soil loss and erosion intensity gradation

Based on the daily rainfall data and its calculation of typical rainfall station in Yuyao City, A soil erosion intensity gradation standard was established in Table 3.

Table 3. Hydraulic erosion intensity gradation

Gradation	Annual mean erosion modulus $t \cdot km^{-2} \cdot a^{-1}$	Mean soil loss thickness $mm \cdot a^{-1}$
Non-apparently eroded	<200, <500, <1000	<0.15, <0.37, <0.74
Slightly eroded	200, 500, 1000 ~ 2500	0.15, 0.37, 0.74 ~ 1.90
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Note: The mean soil loss thickness was calculated by soil dry density $1.35g \cdot cm^{-3}$.

Among the factors that affect the formation and evolution of ecosystems, climate factors and

hydrological factors were the long-term and slow drivers for the formation of ecosystems. Geological and geomorphic factors were the carrier and material basis for the existence and development of ecosystems. In the red soil region of South China, the soil formation rate was very slow. And in some areas the average soil layer was only tens of centimeters thick. In the absence of vegetation protection, a few heavy rains may lead soil depleted, forming rocky desertification. When we correctly understood and evaluate the soil erosion hazards in red soil region of South China at daily rainfall scale. It was not reasonable to use the annual mean soil erosion intensity standard. The standard of small time scale must be established according to the actual situation.

4. Conclusions

The proportion of hilly areas in Zhejiang province was very large. The external force of soil erosion was mainly hydraulic erosion, and the intensity of erosion was closely related to rainfall. With the rapid development of society, the rapid expansion of city, large-scale land development and frequent human activities, these inevitably disturbed the soil, destroy the original surface soil structure, and reduce the original soil erosion resistance, resulting in a large number of soil erosion. In order to prevent soil erosion, it was necessary to establish reasonable soil erosion graduation standard in order to plan soil and water conservation. In this paper, the typical study area in Yuyao City, according to the People's Republic of China water conservancy industry standard "the standard for classification and gradation of soil erosion " (SL190-2007), A new method was put forward for graduation of soil erosion based on daily rainfall erosivity. At the same time, the standard for gradation of soil erosion in Yuyao was established. the daily tolerance soil loss in the standard was $7.0 \text{ t} \cdot \text{km}^{-2} \cdot \text{d}^{-1}$.

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