

Raindrop Characteristics Analysis by Laser Raindrop Spectrometer

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Abstract: Raindrop characteristics, including speed and size of raindrops, in Zhengzhou city of Yellow River basin were analyzed through a natural rainfall on the loess slope. Results showed that the process of natural rainfall belonged to a parabola and counts, size and terminal velocity would increase with the rainfall intensity rising. Besides, the size and terminal velocity of natural raindrops were relatively scattered; In the process of individual rainfall, the terminal velocity and its peak value were mainly focused between 1~4.2m/s and 1.4-3.4m/s, respectively. Size of raindrops were mainly consisted of 0.125-0.5mm, The final velocity of 0.125mm is mainly between 1-3.4m/s, and the final velocity of the raindrops with 0.25mm particle size is mainly concentrated on the range of 1-4.2m/s, 0.375mm diameter of the raindrops mainly concentrated on the 1-3.4m/s, the 0.5mm diameter of the raindrops mainly concentrated on the 3.4-4.2m/s.

1. Introduction

Loess Plateau, the region with extremely serious problem of loss of water and soil among the world, has been the main source of sediments in Yellow River and its management is the critical factor to curb sediments^[1-2]. However, due to the complexity of soil and water loss and the limitations of observational methods and content^[3], some research fields, for example, law of watershed soil and water loss and the mechanism of erosion and sediment yield haven't had a breakthrough, especially the lack of practical soil and water loss model in Loess Plateau^[9], even though there being some advances around the world^[4-8]. All the limitations restrict the development of soil and water loss management in depth and breadth directly^[10]. To have a further study of natural rainfall distribution^[11] by combining the field observation and laboratory test were the research focus to explore the mechanism of soil and water loss law, develop optimized model and establish mathematical model of soil and water loss on the Loess Plateau.



In order to establish such models, it's imperative to analyze the scale transformation and rainfall similarity and finally the raindrops characteristics in the soil erosion experiments must be solved^[12-15]. This study aims to analyze the terminal velocity and grading of raindrops, combined with the sediment results in different rainfall conditions and offer a technology support for dynamic rainfall simulation.

2. Experiment design and data acquisition

2.1 Experiment design of runoff plots

The experiment was carried out at the Zhengzhou test base of model Yellow River of Yellow River Institute of Hydraulic Research. The length, width, depth and slope of runoff plots are 5m, 1m, 60cm and 20°, respectively. Structure of plots is brick-concrete and there is a water channel at the outlet in each plots. Soil landfilled in each plots is surface loessal soil from the Mangshan Mountain in Zhengzhou, with the proportion of particle size of 0.05 ~ 0.01 mm, 0.02 ~ 0.05 mm being 43.4% and 35.45% respectively. And soil bulk density is 1.2g/cm³.

2.2 Test method

The 5m long slope was divided into five fractural surface from top to bottom. The LPM laser raindrop spectrometer was used here to collect the information about characteristics of raindrops, including intensity, size, terminal velocity and number under the same terminal velocity. Slope velocity radar gun and steel rule were used to record hydraulics parameters, including speed, width and depth of runoff. Sediments were collected by 1 minute after producing runoff and analyzed the parameters mentioned above. Erosion amounts and sediment concentration were calculated by the method of substitution or oven drying and calculated the parameters like infiltration of runoff according to rainfall and runoff yield.

3. Results and analysis

In this paper, five typical rainfall time points in natural rainfall on August 30, 2015 (hereinafter referred to as 20150830) were selected. The length of each time point was 1min. The particle size of raindrops in the min length, the speed of raindrops, and the number of raindrops with the same raindrops were collected by LPM laser raindrop spectrometer. The raindrops characteristics were also analyzed. The results are as follows.

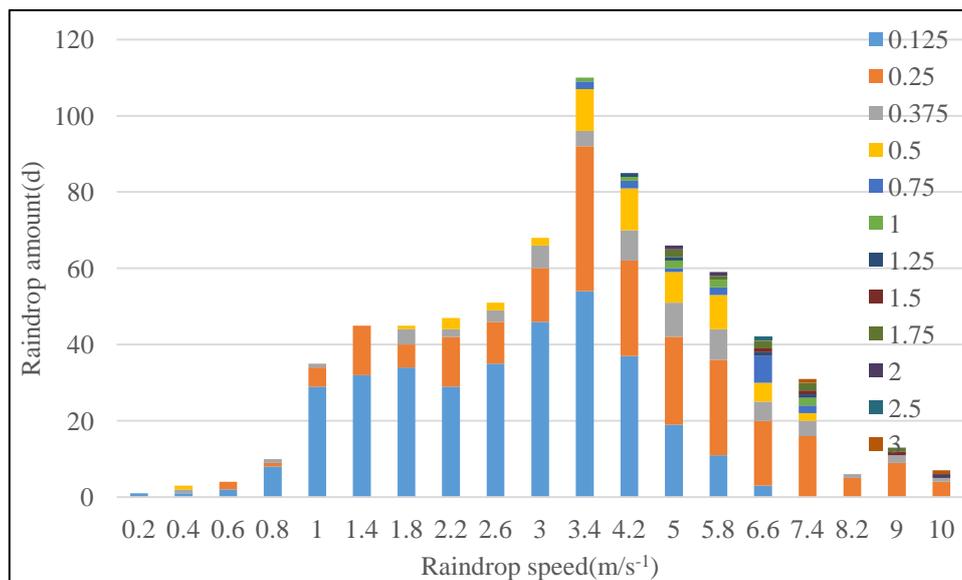


Figure 1: In the first minute during the natural rainfall on 20150830

The distribution of the particle size and the final velocity of the raindrops in the first 1 minute during the natural rainfall on 20150830 is shown in Fig.1. It can be seen from the figure that the final velocity of the raindrops in the first 1min of the rainfall is mainly concentrated between 0.8-7.4m/s and the peak velocity is 3.4m/s, and the number of raindrops with the final velocity of the raindrop is about 110, accounting for about 15%; The rainfall is mainly composed of raindrops with particle size of 0.125-0.5mm. The final velocity of 0.125mm is mainly between 0.8-5.8m/s, and the final velocity of the raindrops with 0.25mm particle size is mainly concentrated on the range of 1-9m/s, 0.375mm diameter of the raindrops mainly concentrated on the 1.8-7.4m/s, the 0.5mm diameter of the raindrops mainly concentrated on the 3.4-6.6m/s.

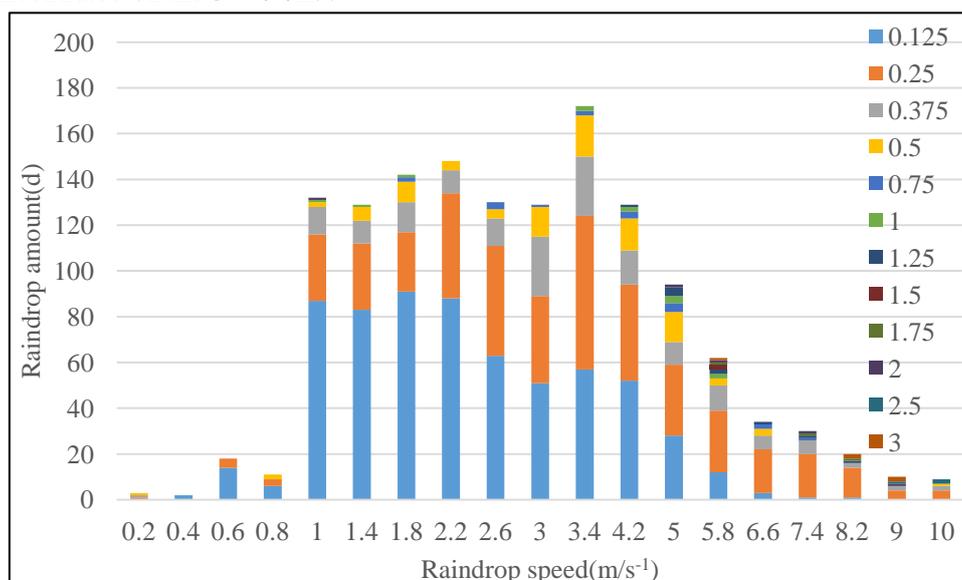


Figure 2: In the second minute during the natural rainfall on 20150830

According to the distribution of the raindrops and the final velocity of the raindrops in the second minute during the natural rainfall process (Figure 2), the final velocity of the raindrops in the second

minute of the rainfall is mainly concentrated between 0.6-8.2m/s and the peak velocity is 3.4m/s, with the number of raindrops at the end of the raindrops is about 170, accounting for about 15%; We can also see the rainfall is mainly composed of 0.125-0.5mm diameter raindrops, the final velocity of 0.125mm particle size is mainly concentrated on the 1-5.8m/s, the final velocity of 0.25mm size is mainly concentrated in the 1-8.2m/s, the final velocity of 0.375mm particle size is mainly concentrated in the 1-5.8m/s, the final velocity of 0.5mm particle size is mainly concentrated in the 1.4-5m/s.

Fig.3 shows the distribution of the particle size and the final velocity of the raindrops in the third minute during the natural rainfall in 20150830, it can be seen from the figure that the final velocity of the rains in the third minute of the rainfall is mainly concentrated in the range of 0.6-7.4m/s, and the velocity of the raindrops in the third minute of the natural rainfall is analyzed. At the same time, the final velocity and the peak velocity was formed, the value is 1.4m/s and 3.4m/s respectively. That is, most of the raindrop speed is 1.4m/s and 3.4m/s or so, with the number of raindrops about 100 and 85 or so, accounting for about 30% or so; We can also see the rainfall is mainly composed of 0.125-0.5mm diameter raindrops, of which 0.125mm particle size of the end of the rain mainly concentrated in the 0.6-4.2m/s, 0.25mm diameter of the raindrops mainly concentrated in the 1-5.8m/s, the 0.375mm diameter of the raindrops mainly concentrated in the 1.4-4.2m/s, the 0.5mm diameter raindrops is mainly between 1.8-5.8m/s.

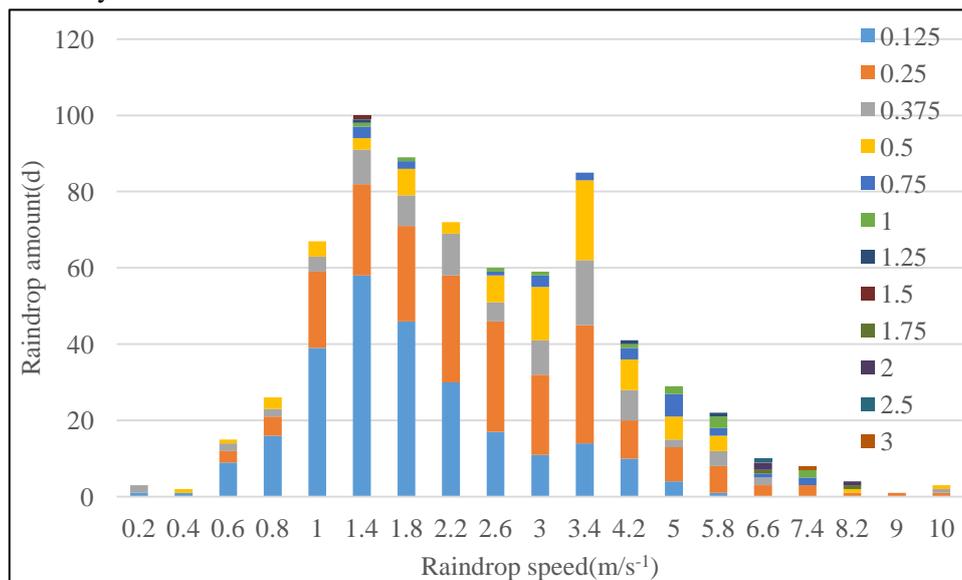


Figure 3: In the third minute during the natural rainfall on 20150830

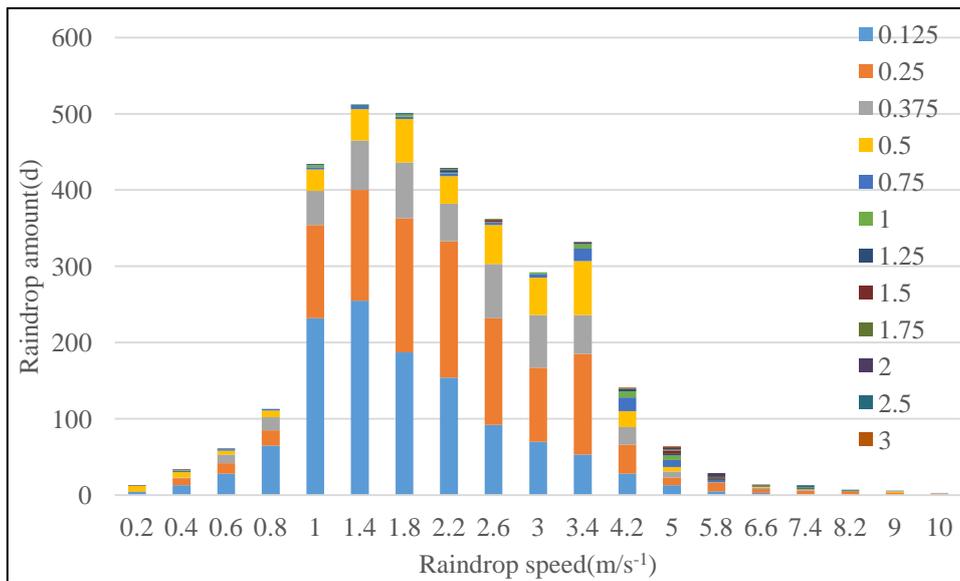


Figure 4: In the fourth minute during the natural rainfall on 20150830

Fig.4 shows the distribution of the particle size and the final velocity of the raindrops in the fourth minute during the natural rainfall in 20150830. It can be seen that final velocity of the raindrops in the fourth minute of the rainfall is mainly concentrated between 0.4-5.8m/s, forming two final velocity peaks, namely 1.4m/s and 3.4m/s respectively, that is, most of the raindrops is mainly 1.4m/s and 3.4m/s or so, with the number of raindrops is 505 and 320 or so, accounting for about 35%; We can also see the particle size of rainfall is mainly 0.125-0.5 mm raindrops. Of which 0.125, 0.25, 0.375, 0.5 mm particle size of the rain speed is mainly concentrated in 0.6-4.2, 1-4.2, 1-3.4, 1-3.4m/s.

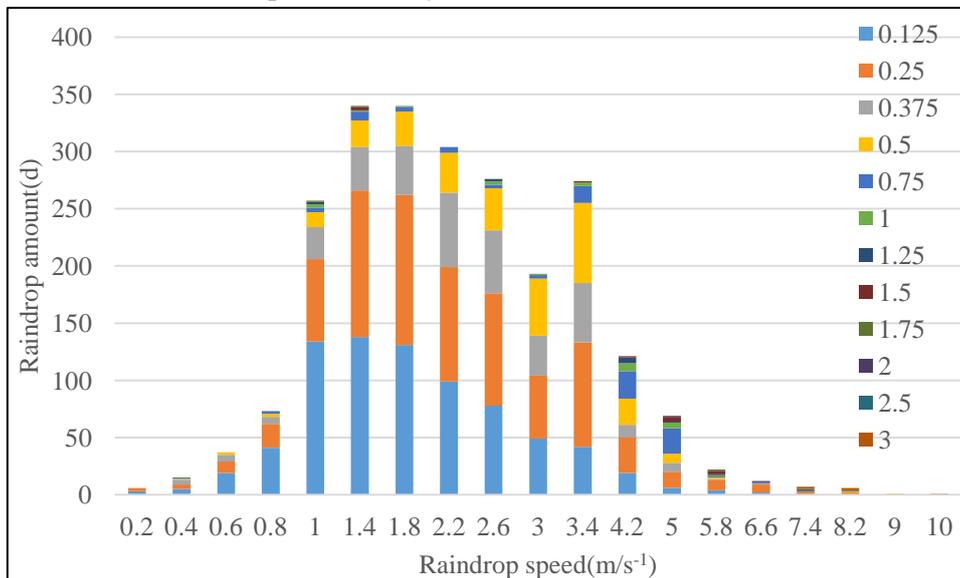


Figure 5: In the fifth minute during the natural rainfall on 20150830

Fig.5 shows the distribution of the particle size and the final velocity of the raindrops in the 5th minute during the natural rainfall, we can see that the final velocity of the raindrops in the first 5min of the rainfall is mainly concentrated between 0.6-5.8m /s, and the velocity of the raindrops in the 5th minute during the natural rainfall is analyzed. Forming a final velocity peak is 1.4m/s, that is, most of

the raindrop speed is 1.4m/s, with the raindrop speed of the number of raindrops for about 340, accounting for about 15%; We can also see the rainfall is mainly composed of 0.125-0.5mm diameter raindrops, of which 0.125,0.25,0.375,0.5mm diameter of the raindrops mainly concentrated in 0.6-4.2,0.8-4.2,1-3.4,1.4-3.4 m/s.

4. Conclusions

Through the analysis of natural raindrops, the following aspects have been obtained:

3.1 The natural rainfall process is a process of rainfall intensity parabolic changes, and with the increase of rain intensity, the number of raindrops per unit time, particle size, the final velocity will be a corresponding increase. Natural rainfall raindrops and raindrops are relatively scattered, from small to large are distributed.

3.2 During the process of this rainfall, the final velocity of the rain is mainly concentrated between 1-4.2m/s, the peak of the final velocity is generally 1.4-3.4m/s; rainfall is mainly composed of the particle size of 0.125- 1.25mm raindrops. The velocity of the raindrops of 0.125mm diameter is mainly between 1-3.4m/s, the final velocity of the raindrops of 0.25mm particle size is mainly concentrated between 1-4.2m/s, 0.375mm concentrated in the 1-3.4m/s, the 0.5mm particle size of the raindrops mainly concentrated in the 3.4-4.2m/s.

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