

Analysis of raindrop characteristics in Zhengzhou based on sample of August 26, 2015

Zhenzhou Shen, Wenyi Yao ^a, Peiqing Xiao, Mian Li, Pan Zhang and Hui Liu

Key Laboratory of Soil and Water Loss Process and Control on the Loess Plateau of the MWR, Yellow River Institute of Hydraulic Research, Zhengzhou, 450003, Henan

^awyyao@yrihr.com.cn

Abstract. Raindrop characteristics, including velocity and size of raindrops, in Zhengzhou city of Yellow River basin were analysed through a natural rainfall on the loess slope. Results showed that the process of natural rainfall and counts, size and terminal velocity would increase with rising rainfall intensities. 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 0.8-4.2 m/s, respectively. Sizes of raindrop were found to be between 0.125-0.5 mm. The terminal velocity of raindrops with sizes of 0.125 mm, 0.25 mm, 0.375 mm and 0.5 mm were primarily 0.8-2.2 m/s, 1.0-1.8 m/s, 1.4-1.8 m/s and 1.0-2.2 m/s, respectively.

1. Introduction

Loess Plateau, a region with serious problems of water loss and soils in the world, has been the main source of outflow sediments in Yellow River. Management of the sediments is the critical factor to curb sediment hazard^[1-2]. However, observation methods and procedures^[3] for field research are still limited due to complexity of soil and water loss. For example, mechanism of soil and water loss, and erosion and sediment yield in watershed is still unknown. There are still lack of practical soil and water loss models for Loess Plateau^[4] around the world^[4-8]. These limitation restrict the comprehensive development of soil and water loss management^[9-10].

Study of natural rainfall distribution^[11] by combining the field observation and laboratory test are the focus of this research to explore the mechanism of soil and water loss. Such mechanism is useful for developing an optimized model and for establishing a mathematical model of soil and water loss on the Loess Plateau. Therefore, it is imperative to analyze the natural raindrops characteristics in the soil erosion experiments^[12-15]. This study aims to analyze the terminal velocity and gradation (sizes) of raindrops,

2. Experimental program

2.1. Experiment design of runoff plots

The experiment was carried out at the Zhengzhou test base of model Yellow River (34°45'36"N 113°40'27"E) of Yellow River Institute of Hydraulic Research. The length, width, depth and slope of runoff plots are 5.0 m, 1.0 m, 0.6 m and 20°, respectively. Structure of plots is brick-concrete and a water channel is attached at the outlet of each plot. Soil filled in each plot is surface loessal soil from the Mangshan Mountain in Zhengzhou, with the proportion of particle sizes of 0.05-0.01 mm and 0.02-0.05 mm (43.4% and 35.45%, respectively). Soil bulk density is 1.20 g/cm³.



2.2. Test methods

The 5 m long slope was divided into five fractural surface from top to bottom (figure 1). The laser optical disdrometer was used here to collect the information about characteristics of raindrops (figure 2), including intensity, size, terminal velocity and number under the same terminal velocity. Slope velocity radar gun and steel rule were used to record hydrological parameters, including speed, width and depth of runoff. Sediments were collected by 1.0 minute after producing runoff and the parameters mentioned above were analyzed.



Figure 1. Soil erosion model.



Figure 2. The laser optical disdrometer.

3. Results and discussion

In this paper, five typical rainfall time points in natural rainfall on August 26, 2015 (hereinafter referred to as 20150826) were selected. The length of each time point was 1.0 minute. The particle size of raindrops in the minimum length, the speed of raindrops, and the number of raindrops with the same raindrops were collected by LPM laser raindrop spectrometer (the disdrometer). The raindrops characteristics were also analyzed.

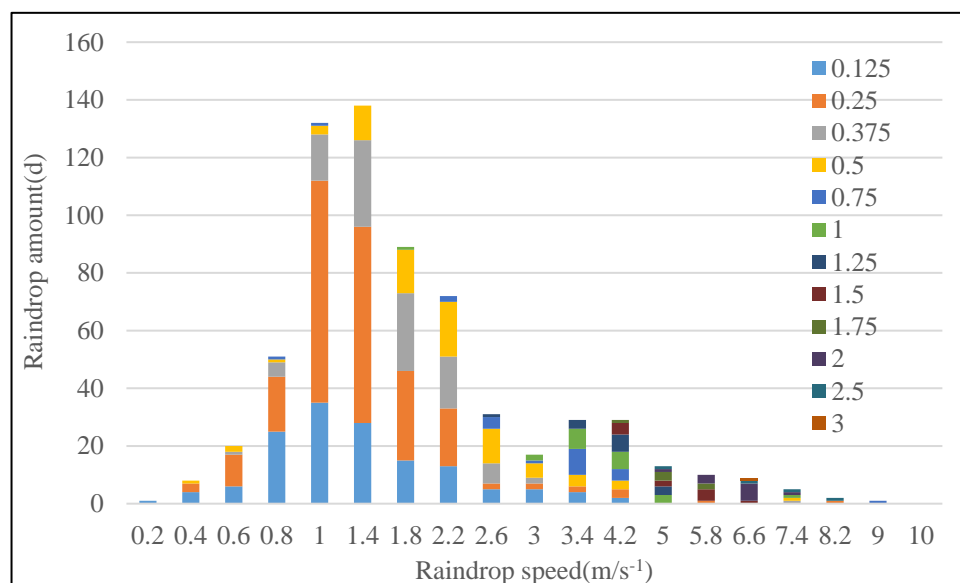


Figure 3. In the first minute during the natural rainfall on 20150826.

The distribution of the particle size and the terminal velocity of the raindrops in the first 1.0 minute during the natural rainfall on 20150826 is shown in figure 3. It can be seen from the figure that the final velocity of the raindrops in the first 1.0 minute of the rainfall was mainly concentrated between

0.8-4.2 m/s and the peak velocity was 1.4 m/s. The number of raindrops with the terminal velocity of the raindrop was about 138, accounting for about 25% of the total number of raindrops. The rainfall was mainly composed of raindrops with particle sizes of 0.125-0.5 mm. Velocities of raindrop with particle sizes of 0.125, 0.25, 0.375, 0.5, 0.75, 1.0 mm were mainly concentrated in 0.8-2.2, 0.6-2.2, 1.0-2.2, 1.4-2.6, 2.6-3.4, and 3.4-4.2 m/s, respectively.

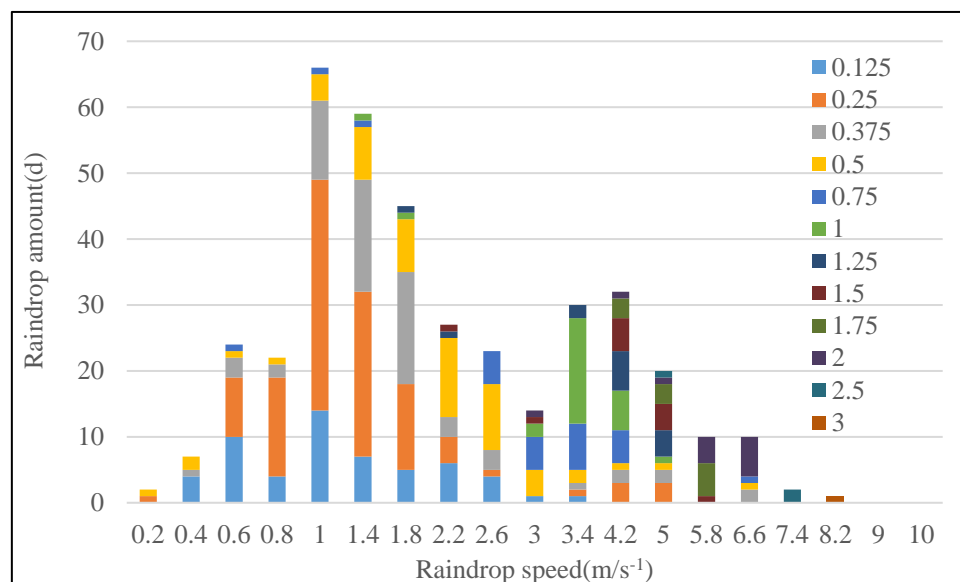


Figure 4. In the second minute during the natural rainfall on 20150826.

According to the distribution of the raindrops and the terminal velocity of the raindrops in the second minute during the natural rainfall process (figure 4), the terminal velocity of the raindrops in the second minute of the rainfall was mainly concentrated between 0.4-6.6 m/s and the peak velocity was 1.0 m/s, with the number of raindrops at the end of the raindrops was about 66, accounting for about 20%. The rainfall was mainly composed of 0.125-0.5 mm diameter raindrops. The terminal velocity of 0.125 mm particle size was mainly concentrated on the 0.4-2.6 m/s, the terminal velocity of 0.25 mm size is mainly concentrated in the 0.6-2.2 m/s, the final velocity of 0.375 mm particle size is mainly concentrated in the 1-1.8 m/s, the terminal velocity of 0.5 mm particle size was mainly concentrated in the 1.0-3.0 m/s, the terminal velocity of 0.75 mm particle size was mainly in the 2.6-4.2 m/s, and the 1.0 mm particle size of the rain drop was mainly between 3.4-4.2 m/s.

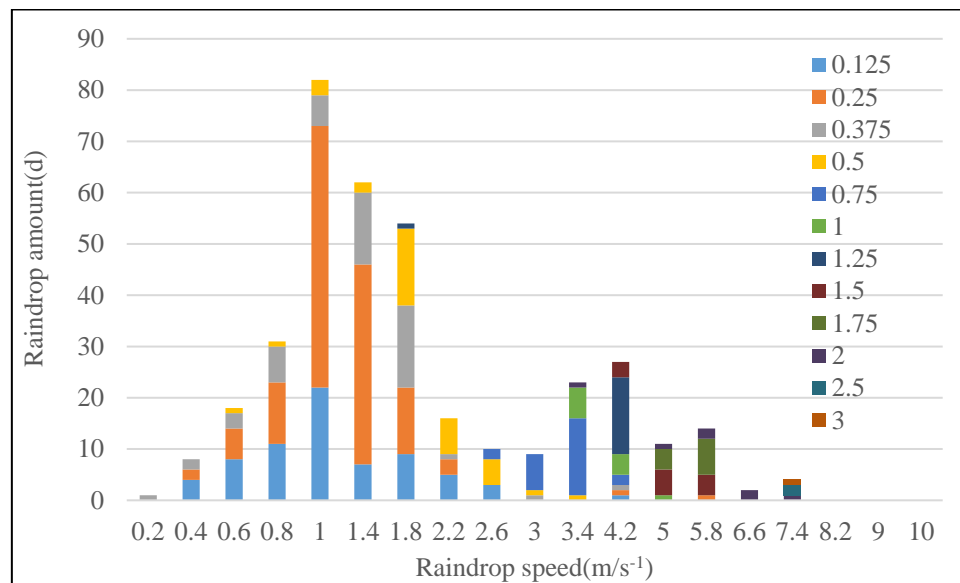


Figure 5. In the third minute during the natural rainfall on 20150826.

Figure 5 shows the distribution of the particle size and the terminal velocity of the raindrops in the third minute during the natural rainfall in 20150826. In figure 5, the final velocity of the rains in the third minute of the rainfall was mainly concentrated in the range of 0.4-5.8 m/s. The velocity of the raindrops in the third day of the natural rainfall was analyzed. At the same time, the terminal velocity and the peak velocity were 1.0 m/s with the number of raindrops about 82, accounting for about 20% or so; the rainfall was mainly composed of 0.125-0.5 mm diameter raindrops, of which 0.125 mm particle size of the end of the rain mainly concentrated in the 0.4-2.6 m/s, 0.25mm diameter of the raindrops mainly concentrated in the 0.6-1.8 m/s, the 0.375 mm diameter of the raindrops mainly concentrated in the 0.8-1.8 m/s, the 0.5mm diameter raindrops was mainly between 1.8-2.6 m/s, the 0.75 mm particle size of the raindrops mainly concentrated in the 3.0-3.4 m/s, the 1mm particle size of the rain speed is mainly between 3.4-4.2 m/s.

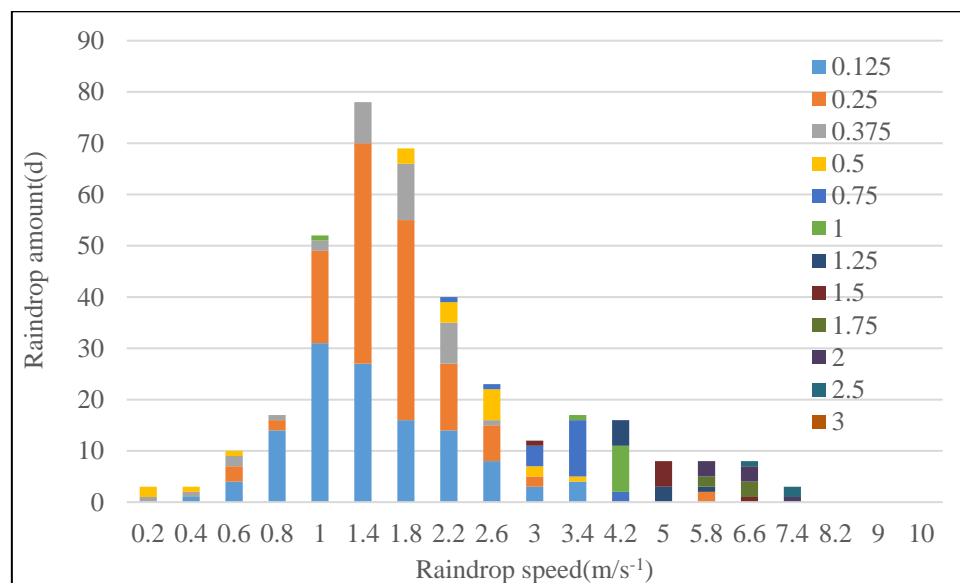


Figure 6. In the fourth minute during the natural rainfall on 20150826.

Figure 6 shows the distribution of the particle size and the terminal velocity of the raindrops in the fourth minute during the natural rainfall in 20150826. It can be seen that the terminal velocity of the

raindrops in the fourth minute of the rainfall was mainly concentrated between 0.6-6.6 m/s, most of the raindrops is mainly 1.4 m/s, with the number of raindrops is 78, accounting for about 25%. The particle size of rainfall is mainly 0.125-0.5 mm raindrops. Velocities of 0.125, 0.25, 0.375, 0.5, 0.75, 1.0 mm particle sizes were mainly concentrated in 0.6-2.6, 1.0-2.6, 1.4-2.2, 1.8-3.4, 3.0-3.4, and 4.2 m/s.

Figure 7 shows the distribution of the particle size and the terminal velocity of the raindrops in the 5th minute during the natural rainfall, the terminal velocity of the raindrops in the first 5.0 minute of the rainfall was mainly concentrated between 0.8-5 m/s, and the velocity of the raindrops in the 5th minute during the natural rainfall was analyzed. Forming a terminal velocity peak is 1.4 m/s, that is, most of the raindrop speed was 1.4 m/s, with the raindrop speed of the number of raindrops for about 62, accounting for about 20%. The rainfall was mainly composed of 0.125-0.5 mm diameter raindrops, of which 0.125, 0.25, 0.375, 0.5, 0.75, and 1.0 mm diameter of the raindrops were mainly concentrated in 0.4-3.4, 1.0-2.6, 1.4-2.2, 1.4-2.2, 3.0-3.4, and 3.4 m/s.

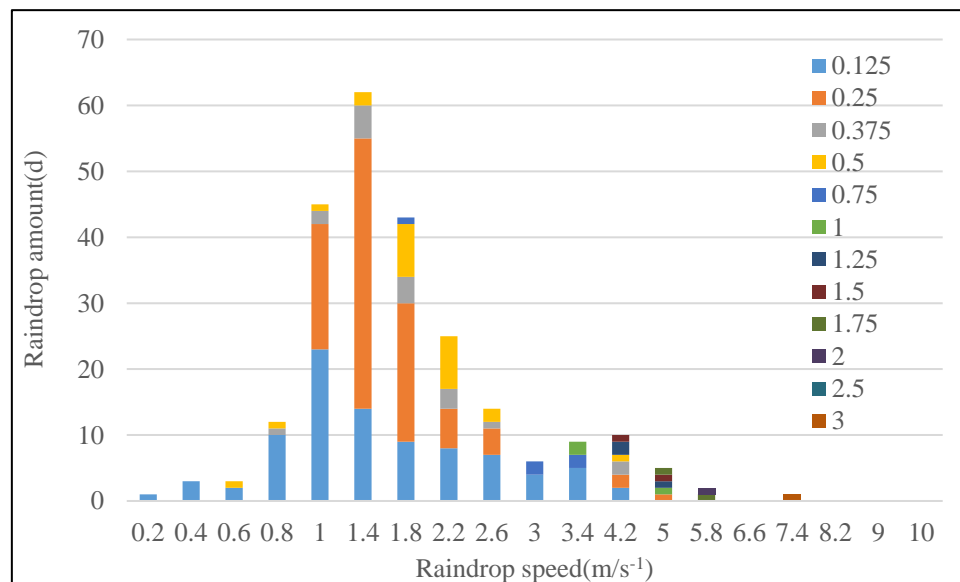


Figure 7. In the fifth minute during the natural rainfall on 20150826.

4. Conclusions

Through the analysis of natural raindrops in this study, the following aspects were obtained:

(1) The terminal velocity of the rain is mainly concentrated between 1.0-4.2m/s, the peak of the final velocity is generally between 1.4 -3.4 m/s; rainfall is mainly composed of the particle size of 0.125- 0.5mm raindrops.

(2) The velocity of the raindrops of 0.125mm diameter is mainly between 0.8-2.2m/s, the final velocity of the raindrops of 0.25mm particle size is mainly concentrated between 1-1.8m/s, 0.375mm concentrated in the 1.4-1.8 m/s, the 0.5 mm particle size of the raindrops mainly concentrated in the 1-2.2m/s.

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