The Fractal Characteristics of the River Network Based on Horton Law in the Landslides Area

Zhiwang Wang, Fangfang Zhou and Hao Cao

ABSTRACT

This paper applies Horton law to study the fractal characteristics of 17 sub-watersheds in the study area from Badong county to Zigui county in TGP reservoir region. The results indicate that the small watersheds have obvious fractal characteristics. There is a clear correlation between the fractal dimension of river network and spatial distribution of landslide and that the area with large fractal dimension is conducive to the formation and development of landslides. The results show that the fractal model provides powerful tools for quantitative description of the river network and the relationship between the river network and the landslides.1

INTRODUCTION

River basin system is one of the most classic fractal problem for its self-similarity, irregularity. Therefore, Mandelbrot first introduced fractal theory into hydrology. Nowadays fractal research has also been widely used in water system. This paper uses Horton law to calculate the fractal dimensions of the river network in the landslides area. The results show that Horton law is a powerful tool for quantitative description of the river network and the relationship between the river network and the landslides.

The study area is located in Hubei Province from Zigui to Badong counties. There are many landslides which are usually located in the section with “hard” rock

1Zhiwang Wang, Fangfang Zhou, Hao Cao, Changjiang River Scientific Research Institute, Wuhan, China; Research Center on Water Engineering Safety and Disaster Prevention of the Ministry of Water Resources, Wuhan, China; Research Center on National Dam Safety Engineering Technology, Wuhan, China.
and “soft” rock jointly and along the bank of the river. The main data for this study is the 1:50,000 scale digitized geological map and DEM, from which the river network and the sub-basins were obtained.

METHOD

According to Horton law (Horton, 1945), let RB be the furcation ratio of two adjacent watercourses in the river network, RL be the river length ratio of adjacent two watercourses, then the river network fractal dimension DN is:

\[ D_N = \frac{\log R_B}{\log R_L} \]  

(1)

Figure 1. DEM and the sub-basins of the study area.

RESULTS AND DISCUSSION

The Horton law was used to calculate and analyze the water system in 17 small watersheds in the study area. Figure 2 shows the furcation ratio of water system in 17 small watersheds in the study area. Figure 3 shows the length ratio of water system. According to equation 1, we can calculate the river network fractal dimension DN in 17 small watersheds in the study area (Figure 4). The result shows that there is a clear correlation between DN of river network and spatial distribution of landslide. Generally speaking, the larger the DN of river network is, the more landslides there are. It shows that the area with large DN is conducive to the formation and development of landslides.
Figure 2. The furcation ratio of small watershed in study area.
Figure 3. The river area ratio of small watershed in the study area.

Figure 4. The fractal dimension $D_N$ in 17 small watersheds in the study area.
CONCLUDING REMARKS

Horton law can be used to characterize the fractal characteristics of the river network in the landslides area. The results show that the fractal model provides powerful tools for quantitative description of the river network and the relationship between the river network and the landslides.

ACKNOWLEDGEMENT

This research was financially supported by the National Natural Science Foundation of China (No.51379023), and the Public Welfare Research Project sponsored by Ministry of Water Resources of China (201501033-3).

REFERENCES