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Analysis of Geological Hazard Types and Distribution Pattern in Xindu District

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Abstract: In order to correctly understand the characteristics and distribution law of geological hazards in Xindu District, the types of geological hazards are analyzed according to the geological environmental conditions and the development characteristics of geological hazards. In this paper, four types of geological hazards, landslide, collapse, mudslide and ground collapse are analyzed and the characteristics and distribution rules of geological hazards are studied, and it is concluded that the density of geological hazards in the plain area and the middle mountainous area is small, and the distribution density of geological hazards in the low mountainous area is the largest. Human engineering activities are the main triggering factors for the formation of geological hazards, and rainfall is the aggravating factor for geological hazards.

1. Introduction

In the flood season from June to September every year, geological disasters such as collapse, landslide and mudflow occur from time to time in the western mountainous area of Xingtai under the influence of rainfall, and the harm becoming more and more serious, which seriously restricts the development of the national economy in the mountainous area and threatens the safety of people's lives and property. It is of great significance to study the mechanism of disaster formation for disaster prevention [1]. The occurrence of geological disasters will inevitably be controlled by certain internal and external causes [2,3]. More studies have been done on the formation mechanism of geological disasters [4-16]. However, there is little analysis of the geological disaster formation mechanism.

Xindu District of Xingtai City is located at the eastern foot of Taihang Mountains, with intensive human engineering activities and a variety of terrain types, many common geological hazards often occur under the direct and indirect effects of various factors, posing a certain threat to the lives and property safety of local residents. In order to correctly understand the development law of geological disasters, improve the pertinence and effectiveness of prevention and control, based on the investigation of geological disasters, the development characteristics of geological disasters were analyzed, and the distribution law of geological disasters in Xindu District was obtained.

2. Geographic Environment

Xindu District is located in the west side of Xingtai City, Hebei Province, at the eastern foot of Taihang Mountain, which is connected with Shanxi Province through the mountain range on its west side, Xiangdu District of Xingtai City on its east side, adjacent to Shahe City of Hebei Province on its south side, and Neqiu County of Xingtai City on its north side. The total area of the territory is 1,941 square kilometers, accounting for 15.6% of the total area of Xingtai City. There are 25 townships and street offices in Xindu District, as shown in Figure 1.

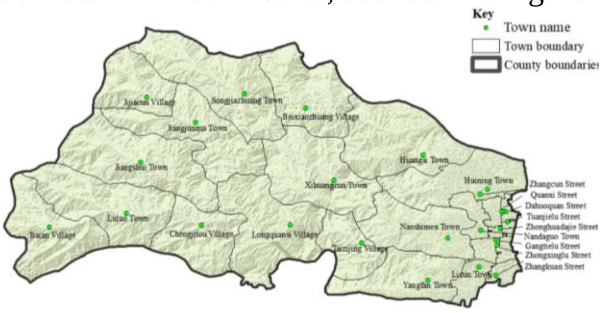

Figure 1: Administrative map of Xindou District

Xindu District of Xingtai City is located in the west of Xingtai City and the east of Taihang Mountains, because its western part is adjacent to Taihang Mountains, so its terrain is high in the west and low in the east, and the types of landforms are mountainous, hilly and plain from west to east in order of distribution. The highest elevation of Xindu District is 1752 m, the lowest elevation is 61 m, and the average elevation is 906.5 m. The terrain is roughly divided into four categories: plains, hills, low mountains and middle mountains. The main human engineering activities that affect the development of geological hazards are engineering construction, mineral development, land reclamation and cultivation, and the development of tourism.

3. Type of Geological Hazards in Xindu District

Figure 2: Geological hazard sites in Xindou District.

Table 1: Statistics on the types and number of geological hazards.

Types of Geological Hazards	Quantity	Type
landslide	102	50.49 %
collapse	84	41.58%
mudslide	5	2.48%
ground collapse	11	5.45%

After the field investigation and collection of geological hazards, there are 202 geological hazards distributed, whose types are landslide, collapse, mudslide and ground collapse, potentially threatening property of 82,774,500 yuan, threatening 2,166 people and 6,742 houses, and the field research shooting of geological hazards is shown in Figure 2. Among them, there are 102 landslide hazard types, accounting for 50.50% of the total number of geological hazards. The types and numbers of geological hazards are shown in Table 1 and Figure 3.

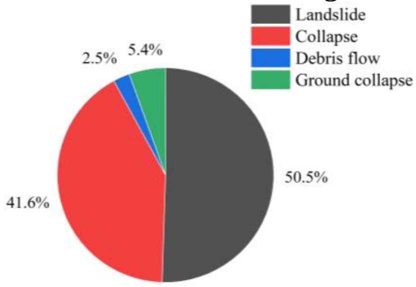

Figure 3: Statistical Map of Geological Hazards in Xindu District.

3.1. Landslide

Landslides are one of the main types of geological disasters in Xindu District. According to survey data, there are a total of 102 landslide geological disaster points. The classification is based on the slope type and disaster scale level of landslides, as shown in Table 2.

Table 2: Statistical table of landslide types.

Classification Basis	Type	Quantity	Proportion
slope type	soil slope	75	73.53%
	rocky slope	27	26.47%
diaster scale	small	97	95.10%
	medium	4	3.92%
	large	1	0.98%

Landslide is the phenomenon of the earth and rock mass on the surface of a slope sliding along a weak surface or zone under the influence of natural factors or human activities. Soil landslides account for 73.53% of the total number of landslides investigated, with a total of 75. The scale of landslide hazards is mainly small-scale, with relatively few medium-scale landslide development types, and there is only one large-scale landslide in the region. The stability of loess landslide is influenced by both human factors and natural factors. The human factor is mainly in the construction of houses and roads, the need to excavate the foot of the slope, affecting the original force situation of the slope, resulting in the occurrence of slope instability phenomenon. Under the action of natural factors such as rainfall and earthquakes, the structure between the geotechnical bodies will be damaged and become loose, leading to the occurrence of landslide disasters.

There are 27 rocky landslides accounting for 27% of the total number of landslides, and the scale of their disasters is the same as that of soil slopes, which are mainly of small scale, with fewer types of medium-scale landslide disasters developed and no large-scale landslides found. The stability of slopes is mainly affected by rainfall, weathering and road construction.

3.2. Collapse

Collapse is also one of the main types of geological disasters. According to statistics, there are 84 collapse geological disasters, threatening a total of 12.8859 million yuan in property. Classified according to the material composition, scale, stability, danger level, mode of collapse, and causes of collapse disasters, as shown in Table 3.

Table 3: Statistical table of collapse types.

Classification Basis	Type	Quantity	Proportion
slope type	soil slope	1	1.19 %
	rocky slope	83	98.81 %
diaster scale	small	81	96.43 %
	medium	2	2.38 %
	large	1	1.19 %

Most of the collapses are small rocky collapses, formed by villagers cutting slopes to build houses, with inconspicuous joint development, weathered surface, and a nearly upright steep cliff with a height of about 15m, which is prone to small collapse falling blocks in the rainy season, which may threaten the houses at the foot of the slope and the lives of villagers.

Rocky slope collapse is mainly formed by man-made factors such as cutting slopes for road construction and building houses, and another reason is formed by natural factors. Most of the towering cliffs formed by these natural factors are located in and around various scenic spots, and only very few are located on the side of the highway, and the slopes where these collapsed bodies are located are generally more than 75 degrees, and most of them are vertical. Under the effect of rainfall, weathering, earthquake, unloading and blasting vibration, the landslide may change the stress of the internal structure of the slope, thus causing the debris and rocks to suddenly leave the slope and fall, threatening the safety of tourists, roads and traffic in the scenic spot.

3.3. Mudslide

Table 4: Statistical table of mudslide types.

Classification Basis	Type	Quantity	Proportion
composition	water	0	0
	mud	5	100%
water source	rainstorm	5	100%
	burst	0	0
	groundwater	0	0
	glacier	0	0
diaster scale	small-scale	3	60%
	medium-sized	1	20%
	large	0	0
	extra large	1	20%

The main reason for the formation of debris flow is that the vegetation coverage of the slopes on both sides of the channel is low, and the slopes are exposed. Under the washing of water formed by rain or melting snow, the loose materials on the slopes of both sides of the channel, including sediment, stones, rock debris, etc., are mixed with water and gathered in the channel, thus forming debris flow. As shown in Table 4, there are 5 debris flows, all of which are rainstorm type. One of them is an extremely large one, with a debris flow volume of $200m^3$, another is medium-sized, and the other three areas are all small. After field investigation, monitoring and treatment, the project activities of returning farmland to forests and planting trees have been carried out. The extremely large debris flow has entered a recession period and has been listed as a low-risk point. However, in case of rainstorm or earthquake, there is still the possibility of debris flow.

3.4. Ground Collapse

There are 11 ground collapses in Xindu District, posing a threat to property totaling 27.97 million yuan, all of which are caused by roof collapse. The scale of 11 ground collapses is all small, and they have been treated and group measurement and prevention points have been established.

4. Characteristics and Distribution Patterns of Geological Hazards

4.1. Development Characteristics of Geological Hazards

4.1.1. Type Diversity

There are many types of terrain and landforms in Sindhu District, the terrain is more complex, geological tectonic activities are more obvious, and the intensity of human engineering activities is high, which not only leads to various types of geological hazards in Sindhu District in the study area, but also makes the same geological hazard manifest in different forms. Among the 202 geological hazards developed in Xindu District, there are four types of geological hazards: landslides, avalanches, debris flows and ground subsidence.

4.1.2. Suddenness

The topography of Xindu District is complicated, the rock is crushed, the weathering layer is obvious, the strength of the rock is low, the alluvium is thick and thin, the rainfall is concentrated, and the intensity of heavy rainfall is high. Therefore, the suddenness of geological hazards is obvious. The first is that geological hazards are generated in a short period of time, and the deformation is fast when the disaster comes, and the time between the intensification of the deformation and the occurrence of the disaster is very short. The second is that heavy rainfall is the main factor causing geological hazards, and in areas with complex topography, the climate change will also be large, and the time and intensity of the occurrence of heavy rainfall generally cannot be predicted and analyzed, and the geological hazards caused by heavy rainfall cannot be accurately predicted and analyzed.

4.1.3. Concentration

The concentration of geological hazards in Xindu District is mainly reflected in two aspects: space and time. The spatial concentration is mainly in the middle and low mountainous areas in the central and western part of the district. The temporal concentration is mainly because geological hazards are mostly manifested in years and months when heavy rainfall and continuous rains occur, and in the same year, especially in the rainy season every year, which is more likely to lead to the occurrence of geological hazards.

4.2. Distribution Pattern of Geological Hazards

Xindu District is located in a mountainous area, and there are four types of landforms developed, namely, plains, hills, low mountainous areas, and mid-mountainous areas, and there are distribution of disaster points in each landform type, as shown in Figure 4.

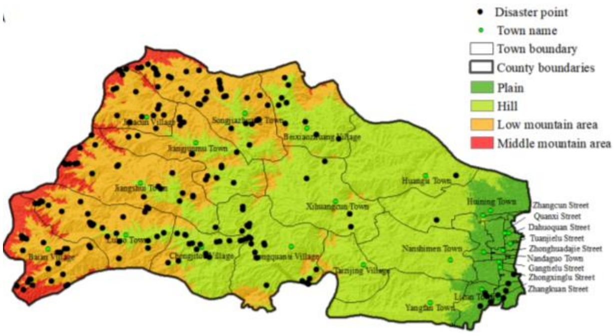

Figure 4: Relationship between landform type and geological hazard location

And the statistics related to the relationship between geomorphological types and geological hazards were conducted, as shown in Table 5 and Figure 5.

Table 5: Statistical table of the relationship between landform types and geological hazards.

Landform type	**Area**	**Number of disaster site**	**Area of the disaster site**
plain	142.7 km^2	9	0.063 /km^2
hill	1022.4 km^2	73	0.071 /km^2
Low mountain	654.1 km^2	112	0.17 /km^2
Mid mountain	121.8 km^2	8	0.06 /km^2

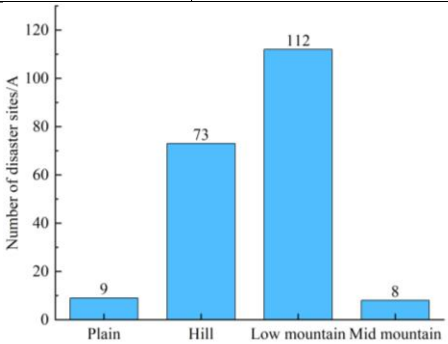

Figure 5: Map of the relationship between landform types and geological hazards in Xindou District

The following conclusions can be drawn from the Figure 4-5 and Table 5:

(1) The density of geological hazards in the plains and the middle mountainous areas is small.

The plain area is low in elevation and suitable for human living, but the slope of the mountain is not too steep and the height of the slope is relatively low, so it is not easy for geological disasters such as landslide and collapse to occur, and the geological disasters that occur are basically ground collapse caused by mining. Therefore, the density of geological hazards in this area is small, which is 0.063/km^2.

The high altitude, low temperature and relatively inconvenient transportation in the mid mountainou area are not suitable for human survival and production life, and human engineering activities are also very few. Therefore, the density of geohazard sites in this area is the smallest, which is 0.06/km^2.

(2) The distribution density of geological hazards is the greatest in low mountainous areas.

The low mountainous area is an area with more human habitation and more intensive human engineering activities. The geological structure of this area is more complex, and the possibility of geological disasters is higher compared with other areas, and the density distribution of disaster points is the largest, which is 0.17/km^2.

5. Conclusion

From the above analysis, the conclusion is as follows:

(1) A total of 202 geological hazard sites were found in Xindu District through detailed field work, with four types, mainly collapse and landslide. Among them, there are 84 landslides and 102 landslides.

(2) Developmental characteristics of geological hazard is diversity of hazard types, suddenness and concentration of hazards.

(3) Xindu District is located in a mountainous area and has four types of landforms: plains, hills, low mountainous areas and mid-mountainous areas. The density of geological hazards in plains and mid-mountain areas is small, and the distribution density of geological hazards in low-mountain areas is the largest.

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