Study and analysis on karst immersion waterlogging disaster

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Karst immersion-waterlogging disaster is the unique natural disasters in karst area. It has the characteristics of periodicity and sudden. Generally, it mainly distributed in peak cluster depression, peak forest valley and Butte plain area. The main Influence factors including Rainfall condition, Karst hydrogeological conditions and Human factors. This paper take Bailongtan reservoir area as an example; summarizes the present situation of waterlogging disaster; analyzes the causes of disasters ;pointed out the influence on the construction of karst waterlogging after the reservoir was building. At the end of the last, the corresponding countermeasures are put forward, including water conservancy engineering measures and environmental protection measures and so on.

Keywords: Karst; Immersion Waterlogging Disaster; Bailongtan Reservoir

1. Introduction

Karst immersion waterlogging disaster is a especial disaster type in the karst area with subtropical humid climate, it is closely related to karst ecological environment and human activities [1]. In south and southwest of China, peak cluster depression, peak forest valley and Butte plain area developed many Karst pipeline and underground rivers. The waterlogging disaster is mainly related with the karst groundwater, therefore, it is called "karst immersion waterlogging disaster". At present, the research on karst immersion waterlogging disasters mainly include its causes, characteristics and preventive measures etc.. Such as Guang Yaohua [2,3] take the Red River Yantan Hydropower Station Reservoir Area as an example, and analysis the karst immersion waterlogging disasters surrounding the reservoir; Jia Yun[4] analysis the causes of karst immersion waterlogging that in Yudongxia reservoir, and put forward the corresponding control measures. Karst immersion waterlogging is broadly distribution in karst area, its high frequency make a great threat to human beings, so it is necessary to strengthen the research and analysis for the disaster, and prevent and mitigation its effect.

2. The Research of Karst Immersion Waterlogging Disaster

It is different that the loose soil by increased capillary action make pore water immersion phenomenon, the karst immersion waterlogging disaster is a peculiar kind of geological disaster in the karst area, it has differences between periodism and burstiness, it widely distributed in fengcong depression, fenglin valley and butte plain areas, and it is strongly influenced by artificial factors.

2.1. *Periodism and burstiness of waterlogging*

The karst immersion waterlogging disasters generally distribute in the closed or half closed karst depression or valley, it has the characteristics of periodic and burst on time. The periodic refers that when the rainfall reached flood rainfall, the waterlogging disaster is easily happened in the karst immersion waterlogging disaster areas, it generally occurred in flood season from May to August. The burst refers that the place that never or rarely happened immersion waterlogging area in history suddenly occurred waterlogging disasters; the reason may be that the migration, development of karst conduit, collapse, congestion lead to the change of the pipe cross section, which affect the drainage of groundwater system, caused the waterlogging disasters.

2.2. *Distribution characteristics of waterlogging*

The karst piping general develops at fengcong depression, fenglin valley and butte plain areas, so these areas also occurred the karst immersion waterlogging disasters in general.

(1) Fengcong depression: The Fengcong depression is surrounded by tall mountains, the closed in it is flatter lowlands, the natural rainfall will be collected by the surrounding hillsides to depression, depression of aven, then funnel into the underground. The ground water level in the Fengcong depression is relatively great, waterlogging disasters generally are less occurred, but if part of the underground river water has bottleneck section, or sink, skylights, etc these cross sections are small, in case of heavy rain, the underground river system of drainage ability is limited, it will cause the waterlogging disasters [5, 6].

(2) Fenglin (fengcong) valley: The reason that many waterlogging disasters occured is there are many avens in the fenglin (fengcong) valley, In the flood season, the valley itself overland flow will inflow into the sink;at the same time the underground river system upstream inflow in a quick speed, forcing the groundwater from the sink, skylight poured out of the earth's surface, so the valley is flooded[7].

(3) Butte plain: The Karst plain have a flat terrain, hydraulic grade is small. Although the surface stream is developed, but there are many continuous or

discontinuous low tower fenglin surrounded them, so it will form undercurrent. When the earth's crust rose, the early wide karst water pipe are upraise to the mountain top, the new karst pipe is narrow, and the upstream plain have a large rainwater harvesting space, so it often form diffuse streaming waterlogging disasters[8].

3. Typical Case

3.1. *The profile of waterlogging disaster in bailongtan hydropower station*

Bailongtan reservoir is the 7th grade in red river cascade hydropower station; on the left bank of the reservoir about 6.5km is Disu underground river system. It including three closed or semi closed karst valley. Which are Nanjiang (containing Banqin), Zhenxing and Fengxiang. The waterlogging disasters would occur in different degree in these valley every year, the general waterlogging area is 300~450hm. After Bailongtan Reservoir impound, the underground rivers exit's (Qingshui) level elevation 11.5m, cause waterlogging water level and inundation area increased, duration extension, flood rainfall decreases, then the disaster aggravated.

3.2. *Waterlogging reason analysis*

3.2.1. *Karst hydrogeological conditions*

Bailongtan reservoir is located in Disu karst underground river system; the outlet is located in Qingshui. The mainly supply source of Disu karst underground river system is atmospheric precipitation, effective precipitation infiltration coefficient can reach 0.5~0.8. According to the difference of the landform and hydrological conditions, the rainfall supply can be divided into two modes, as shown in Figure 1. A model is that in peak cluster depressions and peak forest swamp areas, precipitation through the ground infiltration recharge, and also form surface runoff gather in the depressions, then recharge in a concentrated point by sinkhole, funnel or ponor. Another model is that in Karst Valley area, in addition to the precipitation infiltration, there also are several injection recharges like sinkholes and ponor. The hydraulic gradient in the Disu karst subterranean streams is gradually get slow from upstream to downstream, and the velocity decreases. But in the narrow or drop area exist the phenomenon of local enlargement.

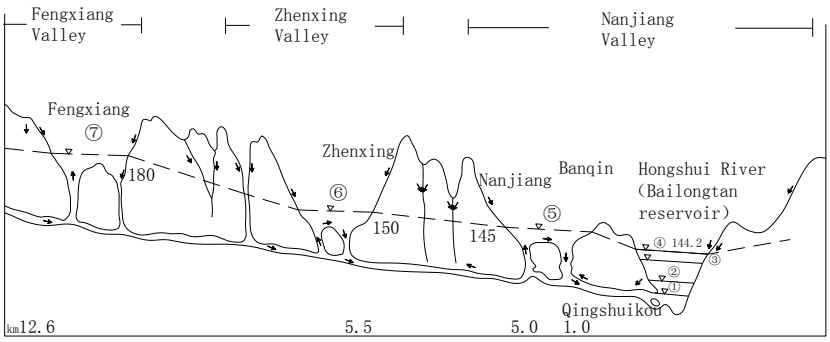
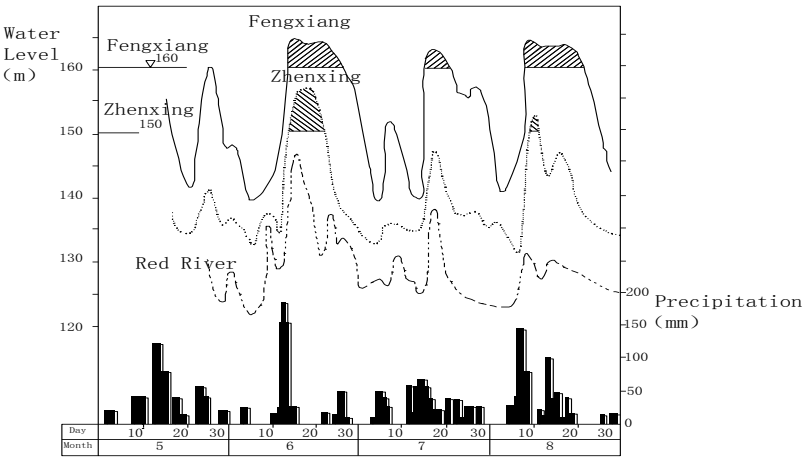


Fig. 1. Karst immersion section schematic diagram of Bailongtanreservoir in Hongshui River
Note: ①the low water level of Hongshui river is 108m; ②the normal water level of Bailongtan reservoir is 126m; ③Before impound P=0.5, level is 143.65m; ④After impound P=0.5, level is 144.20m; ⑤Nanjiang waterlogging level is 151.25m(1996); ⑥Zhenxing waterlogging level is 152.52m(1996); ⑦Fengxiang waterlogging level is 163.97m(1996).

3.2.2. *Rainfall condition*

The annual average rainfall of Bailongtan reservoir is 1726mm. The rainfall is almost concentrated in summer from May to September, accounted for 68.3% of annual rainfall. Figure 2 is the water level hydrograph waterlogging of Fengxiang - Zhenxing, from the figure we can see that the rainfall intensity and duration direct impact the water level and delay of waterlogging, the peak of waterlogging water level tend to lag behind in rainfall peak 1~3d, it can be said that the rainfall is the direct factors that causing waterlogging.



Note: The shaded range represents the waterlogging depth and delay
Fig. 2. Fengxiang - Zhenxing area waterlogging water level line (1994)

3.2.3. *Reservoir storage condition*

The check water level of Bailongtan reservoir is 159.2m, design flood level is 153.9m, normal water level is 126m, and dead water level is 125m [9]. In 1998, Nanjiang, The waterlogging level of Nanjiang, Zhenxinghe and Fengxiang respectively reached 165.48m, 154.57m and 151.94m, submerged area reached 124.9 hm^2, 133.5 hm^2, and 306.1 hm^2. Waterlogging level of Nanjiang is higher 14.04m, and the Fengxiang submerged area is larger 233.12hm^2 than before the reservoir construction. Therefore, the storage situation of reservoir also has a great influence on waterlogging disaster.

4. Karst Immersion Waterlogging Treatment Measures

The causes of karst waterlogging disasters are complex, and it have many influencing factors. Appropriate measures should be taken to the karst immersion waterlogging disasters control and management.

(1) Water conservancy engineering measures. Water conservancy engineering measures include expanding ponor entrance; broaden the water-carrying section being karst underground river system, channel flow in open channel excavation and drainage tunnel, etc. Karst valley or depressions dolina is usually presented under the small form, vulnerable to debris, straw, such as congestion, using artificial excavation methods such as expanding the water hole entrance and the "bottleneck" of water section helps to increase capacity.

(2) Environmental protection measures. Environmental protection measures include strengthening soil and water conservation, afforestation, prevent debris blocking aven, skylight, karst pipeline, etc. To prevent debris blocking sink, or at a skylight building block masonry dam, around to prevent debris blocking underground river system, and it is forbidden to sink garbage dumping.

(3) In the reservoir area limit the reservoir water level of flood season. If the occurrence and size of waterlogging has close relationship with reservoir storage level, it can reduce the water level of reservoir during flood season, the karst immersion waterlogging calamity in reservoir area could reduce losses, after the flood, the reservoir water level again returned to normal levels.

5. Conclusion

Karst immersion waterlogging disaster has seriously impact on the production and safety of our society, the economy suffered huge losses. The management of karst immersion waterlogging disaster should adhere to the principle of prevention first, and combining the prevention and control. From a macro perspective, it’s imperative to protect the karst ecological environmental, that is not only an important measure to improve waterlogging disaster, but also has

important significance to realize the sustainable utilization of land. Therefore, we must strengthen the understanding of karst immersion waterlogging disasters, and combined with the advanced technology to explore the strategies and measures for disaster prevention, improving the ability of human society to resist the disaster.

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