Evaluation of growth in gypsum sinkholes and resulting hazards

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چکیده[English]

Introduction

Mainly containing thin gypsum units, evaporite formations cover 8% of the Earth's surface and 25% of the Earth's continental surface (Ford and Williams, 2007). The term karst refers to a set of geological processes and the phenomena resulting from the dissolution of carbonate rocks. Decomposing the structure of the rocks forms a unique hydrological regime, leading to the development of special landforms (Ministry of Power, TAMAB, 1994). In general, the eight elements needed to develop a karst are: precipitation, relief, lithology, thickness of carbonate layers, carbon, low temperature, pressure, and tectonic rocks (White, 1988). Sinkholes are the enclosed depressions that are known as the characteristic of carbonate and evaporite karst landscapes. In recent years, several genetic classifications have been published for sinkholes (Gutierrez et al., 2008).

Materials and methods

To conduct this research, a 160,000-m^2 area of the Gachsaran formation in Maroon plain with a high density of sinkhole was examined and visited. The exact geographical location and specifications of 51 sinkholes were surveyed, and it was found that the sinkholes totally account for 25% of the surveyed area. Table 1 lists the specifications of the sinkholes. Also, in another field visit conducted in this study area, a sub-basin with an area of 6.2 hectares, average slope of 28%, and length of 2301.7 m was selected for the surface runoff sampling during the precipitation, which also included a number of previously surveyed sinkholes. The surface runoff samples taken included the first moment of runoff onset, which began 3 hours and 27 minutes after the start of precipitation. Then, 5:19, 5:45, 8:10, 9, and 9:20 after the start of precipitation, other samples of surface runoff were taken again to monitor the changes in the ions dissolved in the runoff in the spatial and temporal intervals. The minimum height of this sub-basin is 520 m, and its maximum height is 888 m above sea level. Also, in this regard, to estimate the average long-term rainfall of the region from the 20-year rainfall data of the meteorological stations in the study area, the daily rainfall data of the Maroon meteorological station in the vicinity of the study area, 1:100,000 geological map of Behbahan sheet, 1:50,000 topography, and 10-m DEM of the study area were used as the research data.

Results and Discussion

The obtained results showed that a total of 25% of the surveyed area is covered with the surface and visible sinkholes. It should also be noted that the dissolution in the Gachsaran formation is not

the only erosion process that is taking place. In addition to the dissolution of gypsum, the marls of this formation are eroded by the surface runoff due to the precipitation and leave the basin as a suspended load, which accelerates the formation of sinkholes. Therefore, it can be stated that the time interval estimated in this study can be shorter, because the effect of the accelerating factor of the suspended load was not calculated, which requires the investigation and study to calculate the suspended load. Directing the runoff by sinkholes to downstream areas is likely to lead to the same expansion of the underground karst and tunnel, which is not visible. Also, it is not clear how many cavities and tunnels formed in the subsurface of this area, but this is not expected to be low based on the obtained results. There are roads, agricultural lands and, more importantly, residential areas on the gypsum zones, at least 25% of which are visible sinkholes, and the subsurface tunnels that are expanding every year at this dissolution rate. In addition to the effective rainfall, the presence of agricultural lands requiring continuous irrigation and intensifying the dissolution rate can lead to surface collapses and expansion of sinkholes, which ultimately threatens the life and financial security of the inhabitants in these areas.

Conclusion

Based on the field observations and the conducted studies, the sinkholes in the stream course have a generally elongated form and often have several ponors. Given that the sinkholes do not retain the aggregated runoff inside the sinkhole and the runoff exits through the same ponors, such diversity in the number of ponors results in a number of sinkholes in the stream course, which are connected together through a subsurface path. Unlike calcareous sinkholes that can direct the runoff current to karst aquifers, water is rapidly saturated due to the high solubility of gypsum. The dissolution is mainly limited to the opening area of the sinkhole, and less runoff finds the opportunity to expand the sinkhole in depth. It should be noted that based on the results, to increase the safety factor and reduce the risk of gypsum dissolution, it is necessary to monitor and study the subsurface area and to examine the subsurface cavities and tunnels that have formed so far. Finally, to reduce the risks of the dissolution rate, some arrangements such as sinkhole risk zoning should be made. This is because the cavities in the gypsum layers with the high dissolution rate can easily expand and prepare the conditions for the sudden collapse so that the whole plain suffers the collapse, incurring human and financial losses.

Key Words: Sinkhole. Gachsaran formation, Gypsum karst, Maroon plain, TDS

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