

Study of effective factors in the formation of sinkholes in south of Poldokhtar, Iran

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1-Introduction

Sinkholes are a depression on the ground surface formed due to the sudden collapse of the caves' ceilings in the karstic areas or quaternary cemented sediments. These features, like a basin, drain the runoffs in that area toward themselves (Waltham et al., 2005; Gutierrez et al., 2008). Sinkholes have large dimensions in plains and flat areas and cause damage to industrial buildings and residential areas. Various remote sensing (RS) and geophysical methods and geological engineering studies can largely determine the areas susceptible to this phenomenon. Soluble bedrock, groundwater flow, and climate are of the most critical factors causing the sinkhole formation. Among these factors, soluble bedrock is a significant one. In the plain of Kabudarahang in Hamadan province in western Iran, numerous sinkholes have been created. These sinkholes threaten the infrastructure of the region, including the Hamadan power plant in western Iran. Using the AHP method, the susceptibility map of the region for sinkhole formation is provided, which indicates that with increasing the time intervals between the formation of sinkholes, their diameter is increased as well (Taheri et al., 2015). Studies in the Ebro River valley in the west of Zaragoza city in Spain show that about 70% of the sinkholes have been formed along with the main joint systems (Gutierrez et al., 2009). With the worldwide occurrence of the most massive rock avalanche in arid and non-volcanic areas along with Seymareh landslide in the southwest of Poldokhtar city in Lorestan Province in western Iran, three natural lakes were formed: Seymareh on the Seymareh River, Jaydar on the Kashkan River, and Gori Balmak on the Mirabad seasonal River. Presently, Seymareh and Jaydar lakes are dried, but a part of the Gory Balmak Lake is refilled during the seasonal floods to the level of the channel constructed in its western part. The sedimentary deposits of these lakes have characteristics of freshwater sediments. Moreover, they are over-consolidated because of their geological history. The bedrock of these sediments consists of soluble and evaporative Gachsaran Formation. The city of Poldokhtar, eight villages, a part of the main roads, and the oil and gas pipelines, and the industrial and agricultural centers of the region are located on the remnants of the old sediments of Jaydar and Gory Balmak lakes. Due to the presence of field evidence of karst forms such as sinkholes, caves, and galleries, geological engineering studies have been carried out to understand the causes of the formation of sinkholes.

2. Methodology

This study was conducted in three phases including desktop, field, and laboratory studies.

A. Desktop studies: IRS-P5 satellite imagery processing, DEM preparation with a resolution of 2.5 m, preparation of required maps, hydrogeology map, and the distribution of sinkholes.

B. Field studies: Geological surveys, measuring the joint system's specifications, preparing in-situ bedrock core samples using the Honda GX35 portable device, sampling of filler material and Gachsaran Formation marls. for conducting dispersion tests, sampling of lake sediments for collapsibility test, measuring underground water level changes using active zone piezometers, and field surveying to identify sinkholes, caves, and dissolution tunnels; in this study, the results of ground penetration radar (GPR) geophysical and electrical resistivity tomography (ERT) methods used to determine the depth of the bedrock. In subsidence studies in the southern regions of Poldokhtar city, these methods have been used.

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C. Laboratory studies: Microscopic study of thin sections of bedrock, measurement of physical and mechanical indices of bedrock, chemical dispersion test, Crumb and double hydrometer tests, double consolidation test for determination of collapsibility index and XRD test.

3. Results and discussion

Sinkholes are the representative of the Karst area (Galloway et al., 1999). Factors such as the type and depth of the bedrock, the type and thickness of bedrock coverings, water acidity, groundwater table and its long-run fluctuations, and groundwater rotational flow play an important role in the formation of the sinkhole (Heidari et al., 2011). In the present work, factors affecting the formation of the sinkholes in the south of the Poldokhtar city including the geological characteristics of the bedrock and its sediments, as well as underground water conditions were investigated. As mentioned in the geological section, the bedrock of the region is the Gachsaran evaporative Formation. In the study area, the depth of the bedrock increases from east to west. In the east of the region, at the site of Gory Balmak Lake, and in the Jaydar Lake, the bedrock levels are 800, 750, and 640 m.a.s.l, respectively. The rock mass discontinuities are filled with dispersive soils, which are easily washed out and removed from the environment. Also, the amount of sulfate in the bedrock is high. Therefore, bedrock is susceptible to solubility and the formation of karstic forms. In more than 49% of the area, the bedrock is covered by the landslide lake sediments of Gory Balmak and Jaydar.

Geophysical investigations show that the average depth of bedrock in the Jaydar Plain and Gory Balmak Lake site is 70 and less than 10 m above the ground, respectively. Lake sediments and marl soils resulted from weathering of the marl section of the Gachsaran Formation filling the joints. Filler materials are often classified as moderate and severe dispersive soils, according to laboratory results. The field surveys in the study area have resulted in the identification of at least 32 sinkholes (Fig.1). The sinkholes in the catchment basin of the Gory Balmak Lake are of a cover-collapse type and have a depth of more than 5 m. Also, they are often group-shaped and in the same direction as the fault. Around the Jaydar Plain, the sinkholes are of a cover-subsidence type, with a diameter of more than 10 m and an apparent depth of less than 5 m. Horizontal tunnel galleries connect the floor of some sinkholes. These galleries transfer water from the top to bottom levels. The results of the double consolidation test indicate the high collapsibility potential of bedrock covering sediments. In the southern part of the Gori Balmak Lake and the center of the Jaydar Plain, there is no visible sinkhole evidence on the ground surface due to the high thickness of the crater sediments. Therefore, the roughness of these areas is due to the ground subsidence at the top of the sinkhole crater.

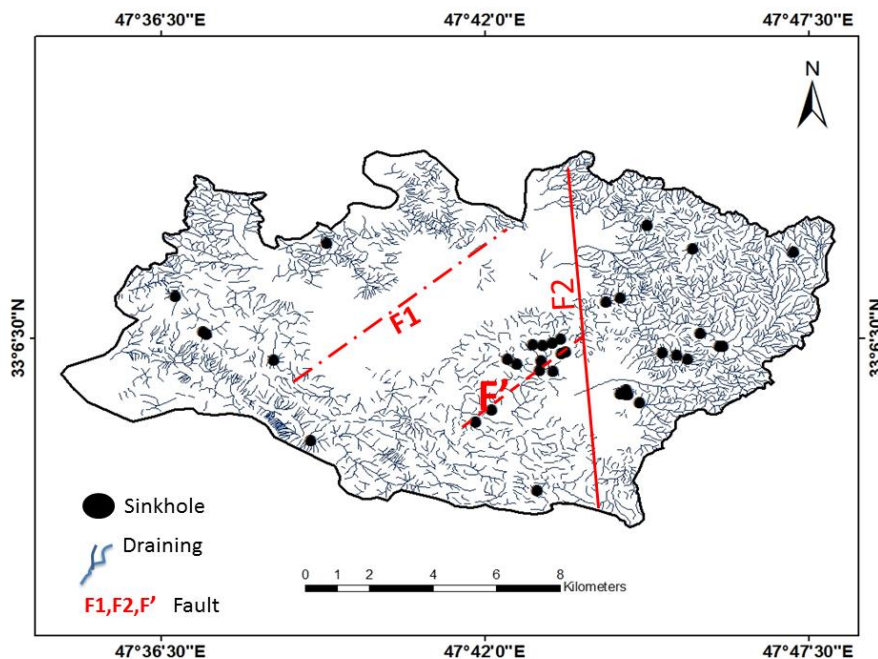


Fig 1. Type of sinkholes map in the study area.

4. Conclusion

The results of this study indicate that the soluble bedrock, the dispersion of the filler materials, and the collapsibility of bedrock covering sediments are practical factors in the study area in the formation of the sinkhole. Also, due to the difference in the geological age of sediments covering the bedrock, the presence of old and buried sinkholes in the area, especially in the Jaydar Plain, can create a severe threat to the centralized and linear structures in the region. Failure to manage the water resources of the region and the drop in the water table in the future can be useful in increasing the phenomenon of the sinkhole formation in the southern regions of Poldokhtar, especially in the Jaydar Plain.

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