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# THE EFFECT OF SINKHOLES ON LEAKAGE OF WATER FROM THE SARABCHENAR DAM, SOUTHWEST IRAN

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*The study area is situated in the south of the village of Sarabchenar in southwest Iran. The earth dam with a height of 15 meters and an area of 20 hectares was constructed to control floods and store water for irrigation. After the construction of the dam, several sinkholes appeared on the lake created by the dam. The sinkholes are oriented along a fault at the contact of the Amiran conglomerate and the highly weathered reef limestone. The main fault extends from west to east. The shape of the sinkholes varies from oval to elliptical. The largest diameter is 12 meters in the eastern part of the lake. In spite of a mean annual precipitation of only 550 millimeters, a small portion of rainfall is stored and the rest of water is released through the sinkholes immediately after rainfall stops. The effect of water leakage has been observed in the Hezar Many River which is about 15 kilometers away from the dam. Due to the instability of formations such as the Kashkan Formation (conglomerate, sandstone, and red marl) in the northern part of the dam, sedimentation will soon fill the lake.*

## INTRODUCTION

The study area is a part of the Zagros folded zone and is situated in the northwest of Lorestan Province, Iran. The mean annual rainfall is 550 mm. Figure 1 shows the location of the study area.

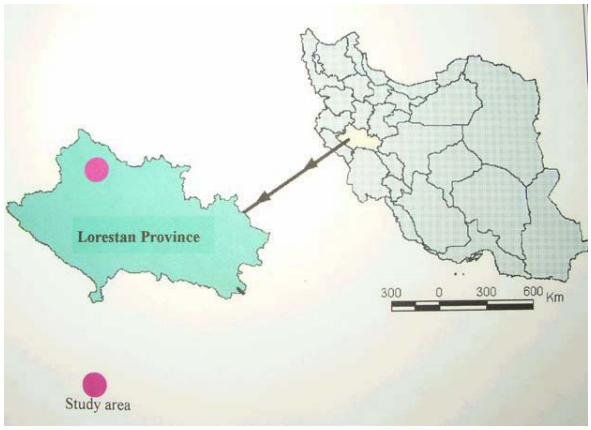


Figure 1. Location of the study area.

The earth dam was constructed in 1997 in order to control floods for the city of Khoramabad (the capital of Lorestan province) and irrigation of the lands of Sarabchenar village. The height and the total area of the dam and its lake are 15 meters and 22 hectares respectively. The dam was designed to store 1600000 cubic meters, but soon after the construction several sinkholes developed along the lake of the dam, and water storage never reached the estimated design level. Due to the inflow of sediments and mass wasting, the dam is gradually being filled, and at present it is not used for the intended purposes. Figure 2 shows a general view of the dam during high rainfall. Injection of uranine was carried out in two of the sinkholes, and the effect of leakage was observed in Peyazeh spring and the Q spring.


Figure 2. General view of the dam.

## GEOLOGY OF THE AREA

In general the geology of the area consists of the Asmari-Shahbazan (white limestone) of Oligocene age, Kashkan (reddish conglomerate, marl and sandstone) of Eocene age, Tal-e-zang (fine grained and fossiliferous limestone) of upper Cretaceous-Paleocene age and Amiran (gray conglomerate with interbedded red sandstone) of upper Cretaceous-Paleocene age (Figure 3). The Tal-e-zang is seen as small mounds in contact with Amiran formation.

The general geology and the cross-section(along AA') of the study area are shown in Figures 4 and 5 respectively. Other formations designated with symbols as K2 and K1 are marly blue and bedded limestones of upper and lower Cretaceous age around the study area.

Figure 3. Amiran formation (conglomerate with interbedded sandstone).

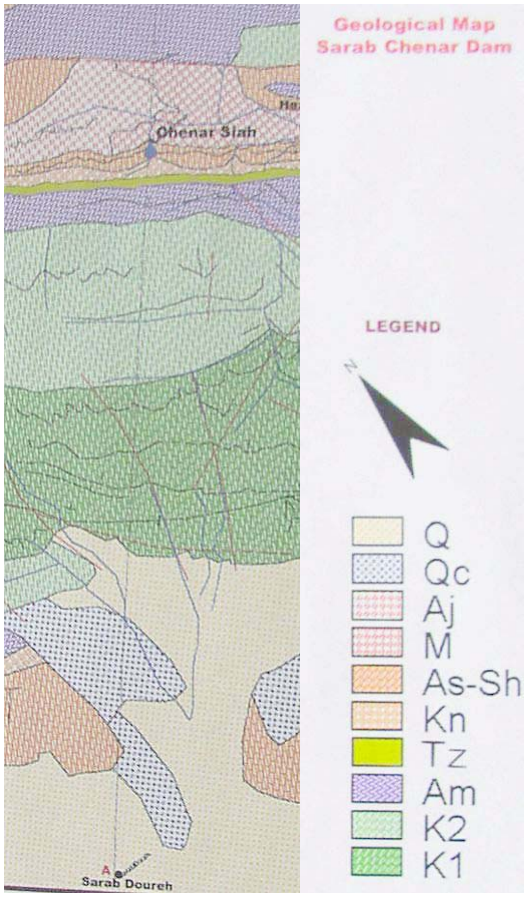


Figure 4. Geology of the area.

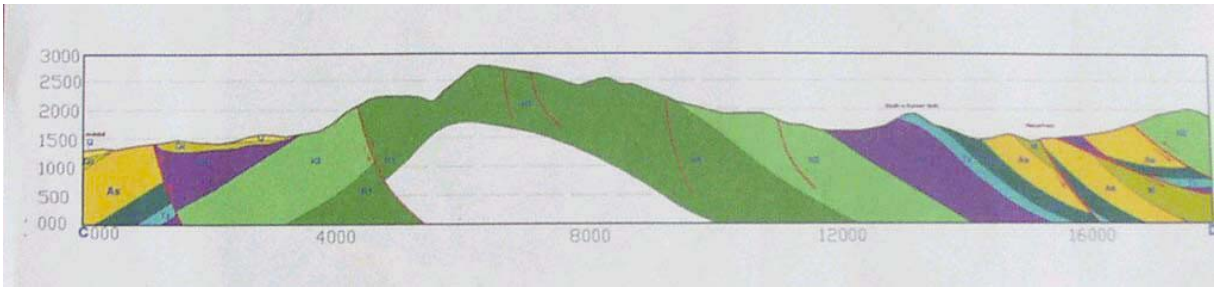


Figure 5. Cross section along the line A-A'.

The Amiran formation surrounds the study area in the southern part. The highest point is at an elevation of 1700 meters above the sea level.

## SINKHOLES

At the contact of Amiran and Tal-e-zang (some authors believe it as Tarbur formation) several sinkholes (ponors) with different diameters and a depth of about 2 meters have developed. The largest sinkhole has an elliptical (saucer) shape with a diameter of 12 meters in the eastern part of the dam. Figure 6 shows two of the sinkholes. Solution, jointing and collapse features are seen on the fine grained limestone at the foot of the Amiran Formation (Figure 7). The bottom of the sinkholes consist of conglomerate, sand and clay. The alignment of the sinkholes and collapse of the limestone may indicate a thrust fault. The collapse of sinkholes may be caused by increase in actual or effective loading.


Figure 6. Two of the sinkholes.

Figure 7. Development of joints and solution in Tal-e-zang.

## WATER RESOURCES

The water resources in the study area include the runoff, and the springs which originate from the Amiran Formation and recharge the Dam. The runoff recharges the lake of the dam in the western and the eastern part. The total discharge of the runoff during high rainfall is 20 liters per second. The streams become completely dry during periods of no rainfall.

## THE PEYAZEH SPRING

At a distance of about 5 kilometers east of the dam with the same stratigraphic succession in the Valley of Hezar Many, there are several springs which originate from the Amiran Formation. The discharge of these springs varies between 0.25 to 1 liter/second but the exception is the Peyazeh spring (1492 msl) which is like an artesian spring and emerges at the contact of Amiran and Tal-e-Zang formation. The discharge of the spring during high rainfall is 35 l/s. Figures 8 and 9 show the Peyazeh and a spring that emerges from conglomerate respectively.

Figure 8. Peyazeh spring

Figure 9. Spring from conglomerate

The discharge of the Peyazeh spring varies rapidly with the fluctuation of the water level of the dam. During the summer, the spring becomes dry when the dam has no water. Chemical analyses of the spring and the dam show a high concentration of total dissolved solids and turbidity (67 g/l and 86 n.t.u). The similarity of chemical analyses may indicate that the Peyazeh spring is one of the outlets of the dam. The chemical analyses of the runoff and the springs around the dam and the Peyazeh do not show turbidity.

## THE SARABDUREH SPRING

This spring is situated southwest of the dam at a distance of about 18 kilometers. The spring discharges from the Asmari(limestone) formation. The mean annual discharge is 220 l/s. During the rainy season the spring shows turbidity.

## THE Q SPRING

The spring is situated southeast of the dam at a distance of about 28 kilometers and emerges from the marly limestone of lower Cretaceous age (K2). In the local language Q means blue. When the water level of the Khoramabad River is high, the spring discharge is also high. As soon as the water level of the river drops, the discharge of the spring drops also. The Khoramabad River receives a part of its water from the temporary streams in the Sarabchenar Dam and Hezar Many Valley(east of Sarabchenar). An artificial lake has been constructed at the Q spring. Unfortunately

in spite of high investment the lake becomes dry in summer. Figure 10 shows the constructed lake. The average depth of the lake is 7.5 meters.

Figure 10. The constructed lake in the Q spring.

## URANINE INJECTION

In order to trace the effect of leakage from the sinkholes to the springs of Peyazeh (5 kilometers east of the dam), Sarabdoureh (18 kilometers from the dam) and the Q spring (23 kilometers from the dam) eight kilograms of uranine was injected in two of the sinkholes after two days of heavy rainfall in October 2004 through a pvc pipe of 4 inches in diameter. The location of the sampling points and the procedure of injection are shown in Figures 11 and 12 respectively.

Figure 11. Location of the sampling points.

Figure 12. Injection of uranine in the largest sinkhole.

Samples were taken at different hours and analyzed by the Kharad Pajoh Company. The effect of uranine was observed after 5 hours in the Peyazeh spring and 2 days later in the Q spring. The average maximum concentration of uranine in the Peyazeh and Q springs were 41 and 12 ppb respectively. The low concentrations of tracer are the result of dilution due to large quantities of groundwater flow and absorption by clay materials in the sinkholes. The absorption of uranine by the sinkholes can be seen as a red spot in Figure 13.

Figure 13. Absorption of uranine by clay materials in the largest sinkholes.

## CONCLUSION

Sinkholes are formed at the contact of the Amiran and the Tal-e-zang formations. Due to the solubility of the Tal-e-zang and the development of joints and collapse of limestone, sinkholes have been formed. Sinkholes are the main avenues for water loss from the dam and there is a direct connection between the sinkholes and the Peyazeh spring. The Q spring is recharged by the Khoramabad river and it is due to this reason that uranine is seen in the spring.

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