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Research Paper

An Investigation of Effective Factors on Groundwater Level Fluctuations in Western Anomalies of Sangan Iron Ore Mine

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Abstract: In order to design an appropriate dewatering system in an open pit mine, it is necessary to know the hydrogeological conditions and factors affecting the condition of groundwater in the mining area. One of the important factors for investigating the hydrogeological conditions of a mining site is to know the status of the catchment area, temporal and spatial changes of the piezometric levels and the range of disturbances caused by mining activities, climate conditions and the tectonic state of the mining area. The hydrological and hydrogeological conditions of Sangan iron mine are also affected by climate factors such as precipitation and tectonic factors including the number of faults and their trends, their distances and their relationship with each other. Therefore, in this study, the influence of various factors including precipitation, distance from waterways, tectonic status and faults, and the pit development during the exploitation period on the fluctuation of groundwater were investigated. By examining the fluctuations of the piezometric levels caused by these factors in the period from March 2011 to March 2014 and statistical analysis of the results, it was found that among the affecting factors, the Cn-pit expansion has the greatest effect on the groundwater level fluctuation of the western anomalies of Sangan mine. By drawing the ccorrelation diagram between the distance from Cn-Pit and the groundwater level drop of observation piezometers of the nearby areas of the Cn-pit, and obtaining a coefficient of determination equal to 0.94 (R^2=0.94), it was found that the radius of the influence of the Cn-pit expansion on the changes in the groundwater level of the adjacent areas is about 700 meters. In addition, it was found that the amount of precipitation and the distance from the waterways do not have a significant effect on the groundwater level fluctuations in the study area.

Keywords: Pit development, Tectonics and faults, Mining activities, Catchment area, Sangan iron mine.

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INTRODUCTION

The purpose of this study was to investigate the factors affecting groundwater level fluctuation in the western anomalies of the Sangan iron mine in order to control groundwater inflow into the pit. When the floor of an open pit is excavated below the water table, groundwater enters the pit through seepage faces that form on the pit walls and as upward flow at the pit floor. Groundwater seepage into an open pit initiates a transient hydraulic response in the surrounding bedrock and surficial units that is similar in a number of respects to radial flow toward a pumping well [1]. Where the surrounding bedrock has high hydraulic conductivity, inflow rates will be large, and water management is difficult. This results in many problems and dangers in the mining pit face, which in turn can reduce the efficiency of the operation in the best case, and in the worst case, cause many problems such as disruption to mine operation or geotechnical instability of pit walls and damage to mining equipment and in some cases, loss of reserves [2-5]. On the other hand, it is very important to investigate the groundwater level fluctuations, identify the influencing factors of the groundwater level fluctuations, quantify the groundwater drawdown and develop a monitoring network for the effective management of groundwater resources. In addition, due to the fact that controling and monitoring the changes in the groundwater level play an important role in the design of the dewatering system for open pit mines and due to the fact that such a study has not been carried out in Sangan iron mine previously, this study was to find out the factors affecting the groundwater level changes. In this research, the effect of factors such as rainfall, distance from waterways, faults, and the pit development on the fluctuations of the groundwater level was investigated and the influencing factor was identified. This investigation can be considered as an important innovation in the current research.

METHODS

In this study, the factors affecting groundwater level fluctuation in the western anomalies of the Sangan mine were investigated. To achieve this goal, hydraulic head data and precipitation data were collected from piezometers in the Sangan mine and meteorological stations close to the mine area, respectively, in order to prepare hydrographs during the study period and groundwater contour maps. There were 39 piezometers in the study area, and data collection was conducted only in the period of March 2011 to March 2014. From these piezometers, only 8 piezometers had been recorded monthly. Therefore, the data of 8 piezometers were used to investigate the groundwater level fluctuation. For investigating the effect of waterways, the map of waterways was extracted from digital elevation models (DEM) of the area. Other factors that control the distribution of groundwater resources were prepared from various sources, including satellite images, hydrogeological data, geological and topographic data. Finally, Excel software was used to analyze statistical parameters and Arc GIS software was employed to draw maps.

FINDINGS AND ARGUMENT

In this study, the effect of various factors, including precipitation, distance from waterways, tectonic status and faults, and the pit expansion on the groundwater level fluctuation were investigated as follows and the influencing factors were identified.

- To investigate the relationship between precipitation and groundwater level in the western anomalies of Sangan mine, the graph of month-to-month changes in precipitation and groundwater level in the period of March 2011 to March 2014 was drawn. Then, the coefficient of determination between these two factors was calculated for each of the piezometers in the mentioned time period (Table 1). It was found that there is a very low coefficient of determination between precipitation and groundwater level changes. The lowest coefficient of determination is related to piezometer A-55 with R^2=0.01 and the highest coefficient of determination is related to piezometer Cs-71 with R^2=0.0423. By examining the coefficient

Table 1. Correlation between average monthly groundwater levels and precipitation for piezometers (Mar-2011 to Mar-2014)

Piezometer	Cs-9	Cs -71	Cs -57	Cs -41	Cs -38	Cs -12	A-55	A-45
Coefficient of determination (R^2)	0.0417	0.0423	0.0359	0.0142	0.0023	0.0236	0.0001	0.0079

of determination, it can be concluded that there is no significant relationship between the precipitation changes and the groundwater level in the study area.

- To investigate the relationship between distance from waterways in the catchment area of the Sangan mine and groundwater level fluctuations, correlation curve between the distance from waterways and groundwater level drop of observation piezometers (Mar-2011 - Mar-2014) was drawn (Figure 1). It was determined that there is no significant relationship between these two factors (R^2=0.0035) in the study area.

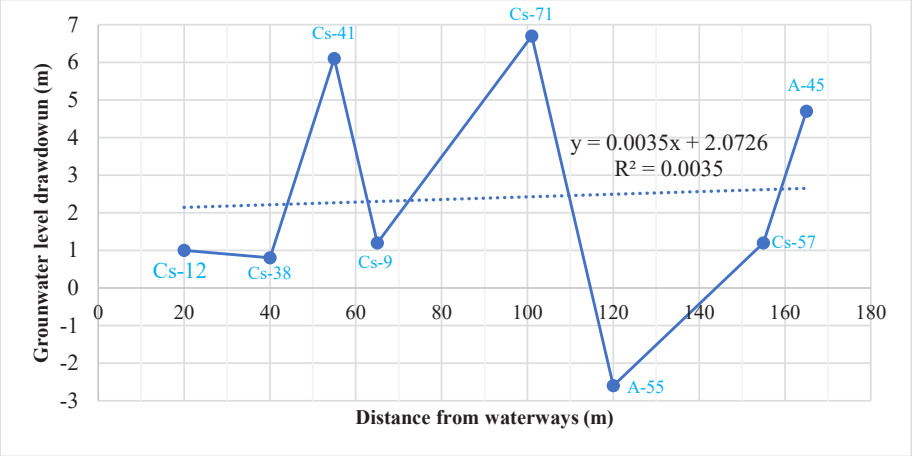

Figure 1. Correlation curve between the distance from waterways and groundwater level drop of observation piezometers (Mar-2011 to Mar-2014)

- To investigate the effect of fault and tectonic events on groundwater level fluctuations, the diagram of the groundwater level changes in each of the piezometers existed during the period of March 2011 to March 2014 was drawn. By examining this diagram and faults map of the study area, it was found that the sub-fault between the anomalies C and B behave as barrier with respect to groundwater flow between the anomaly C and other anomalies. This has caused the pit expansion in anomaly Cn to have no effect on the groundwater level of piezometers A-45 and A-55, which are located on the left side of the mentioned fault.

- In order to investigate the effect of pit expansion on the groundwater level of the nearby areas, the diagram of groundwater level drop of observation piezometers and the distance from Cn-Pit was drawn using the piezometer data (Figure 2). According to this diagram, it was found that up to a distance of 700 meters from the Cn-pit, with increasing distance from the pit, the amount of change in the groundwater level decreases. By increasing the distance from 700 meters to 3300 meters, the amount of change in the groundwater level increased and finally, at a distance of 3500 meters from the Cn-pit, instead of a drop in the groundwater level, an increase in the height of the groundwater up to 2.6 meters occurred in the study time period.

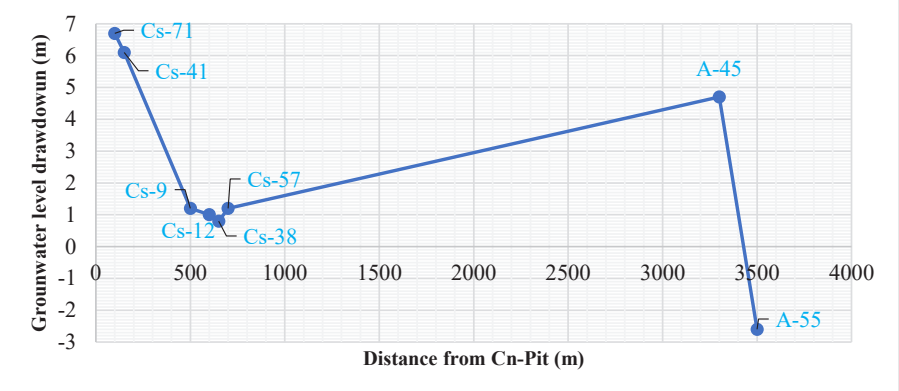

Figure 2. Diagram of groundwater level drop of observation piezometers and distance from Cn-Pit

- By drawing the correlation diagram between the distance from Cn-Pit and the groundwater level drop of observation piezometers of the nearby areas up to a distance of 700 meters from the Cn-pit, and obtaining a coefficient of determination equal to 0.94 (R^2=0.94),, it was determined that the radius of influence of the development of this pit on the groundwater level change of the nearby areas is about 700 meters. It indicates that waterways during pit expansion is an important factor affecting groundwater resources. The closer to the mining pit, the greater the amount of groundwater drawdown, and the greater the fluctuation. The waterways effect of mining pit has different degrees of influence on groundwater resources in different distribution areas, and the magnitude of this influence is inversely proportional to the distance from the Cn-pit mining area, that is, the closer to the Cn-pit, the greater the influence of mining on groundwater fluctuation.

CONCLUSIONS

By increasing the depth of the excavation of western anomaly of the Sangan iron mine, Cn-pit floor has reached below the groundwater level, and it has faced the problem of groundwater inflow into the pit through seepage faces that form on the pit walls and as upward flow at the pit floor. Therefore, in order to determine the appropriate dewatering system, it is important to identify the influencing factors on the groundwater level fluctuations in the mining area. To achieve the goal, the affecting factors on the groundwater level, including precipitation, distance from waterways, faults, tectonics and structural events and the pit in the western anomaly of Sangan mine were studied. By examining the fluctuations of the groundwater level caused by these factors in the period from March 2011 to March 2014 and analyzing the graphs and maps, it was found that the amount of precipitation and the distance from the waterways do not have a significant effect on the groundwater level fluctuations in the study area. However, the expansion of Cn-pit has an effect on the groundwater level drawdown to a distance of about 700 meters from the pit, and this effect gradually decreases with the increase of the distance from the pit. In the areas further than 700 meters to the west of the study area, due to the existence of a fault, the hydraulic connection of the groundwater with the Cn-pit has been interrupted, which causes the expansion of this pit to have little effect on the groundwater level in the western part of the study area. Of course, with the pit expansion and the deepening of the mine, the fault may have a different effect on the flow of groundwater towards the pit.

By knowing this information, it is possible to make the right decision to determine an appropriate dewatering system and to determine the location of pumping wells in the study area.

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