WATER QUALITY PROBLEMS OF KHASH AQUIFER IN SISTAN-BALUCHESTAN,(IRAN), A CASE STUDY

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ABSTRACT
The Khash aquifer is used in city of Khash in Sistan-Baluchestan (Iran) as the only source of water supplying approximately 100 MCM/yr of water from deep wells for domestic use as well as for agricultural and industrial activities. Groundwater from this basin has been extensively utilized since the last two decades. The aquifer comprises of coarse alluvial sediments, which can absorbs most of runoffs. Due to vicinity of the aquifer to Taftan volcanic mountain, the nature of water is acidic and corrosive. In recent years due to substantial utilization from the aquifer, cause gradual draw-down in groundwater table, also intensified the acidic problem. In this study, we look to make a diagnosis of the acidic pollution source and the physical and chemical heterogeneity of this groundwater reserve. During one year field study program a sampling scheme was carried out on 45 water wells in the area. Taking 200 samples during one month field study, and measured pH, hardness, Fe, Mn, CO_2 ,H_2S concentration and water temperature. Studies showed that groundwater contains high concentration of soluble gases; e.g. carbon dioxide and hydrogen sulfide, causing to maintain the pH of water in acidic range (5.36-7.12). We studied the relationship between the agricultural practices, industrial and urban development. On changing the quality of the aquifer, we detected the main causes of groundwater acidity and evaluate the spatial risk of water quality deterioration in the region. The risk factors are volcanic activities of Taftan mountain, urban concentration with using high quantities of water in the region.

Keywords: aquifer, groundwater, acidity, water quality, volcanic activity.

INTRODUCTION
Khash is a city located at Sistan-Baluchestan in Iran. It is approximately at 28 14’ N, 61 12’ E, and has around 130,000 people [1]. Precipitation over the Khash basin occurs in winter and spring with a mean annual of about 154 mm. Both diurnal and seasonal temperature variations are extreme reaching to as high as 44 degrees Celsius in summers and as low as –18.4 degrees Celsius in winters. Measurements of evaporation has been made from class A pans in Khash basin to determine evaporation potential an overall rate of 3600 mm per year. Due to rainfall shortage, the area is naturally accounted as a dry region with limited water resources. According to the collected data by the regional water and wasetwater authority, groundwter quality becmes worst during every summer. Therefore a wide examination study program was proposed on 48 wells during June-July 2001, aiming determination of spatial water quality chaning through the aquifer. As mentioned before Khash aquifer is the major water resource of this region which is influenced by the neighboring Taftan volcano. Therefore, the water is acidic and sour. The water balance calculation of the aquifer shows a decrease in water storage, due to consumption increase arising from development and population growth. This decrease in water quantity led to intensify the acidity of water in recent years [2].

KHASH AQUIFER
Characteristics
Relatively little detailed information is available concerning the nature of the aquifer within the sediments underlying the Khash area. A continuous water table aquifer, composed of poorly sorted gravel and marl beds intermixed with sands, silts and clays. It varies in thickness from about 10m to over 80m. Groundwater flow is generally from the north west towards south-east. The available pumping test data indicate a range of transmissivity (T)from 400 square meters per day to over 2100 square meters per day[2]. As far as the coefficient of storage (S) is concerned, pumping tests data indicate a range of values from 0.03 percent to 0.09 percent [2,3].

Water balance
Khash watershed has an area of 2400 square kilometers, comprises of 1450 square kilometers mountain area and 950 square kilometers alluvial plain. Elevation of Khash basin ranges from 1450 meters in plain area to 3941m at Taftan volcano peak. Most of precipitations occur in mountain area (150 mm/year), while the average precipitation in plain estimated about 120mm/year [2]. The basin does not have any prenium river, but most of the precipitation cause flushy flood flow, with a mean duration of 2 to3 days, due to coarse material of the alluvium plain at the north, huge amount of flood flow infiltrates and recharges the aquifer. Based on a mean annual precipitation figure for an average year, the total inflow from direct precipitation over the basin would be in order of 16.5 million cubic meters (Q_p). According to local water authority estimation, the area of the aquifer is about 342 square kilometers. Q_l, the annual returned water from irrigated land is estimated about 6.6 MCM.
The municipal wastewater which injected to the aquifer is about 2 MCM.(Q_{ds}) The total inflow to the aquifer is estimated about24.17 MCM.(Q_{igw}) The total outflow from underground storage is estimated to be in the order of 0.219MCM(Q_{ogw}). Total water consumption by wells, qanats and springs is estimated about 67.5MCM. Total evaporation from the basin is estimated about 0.37 MCM. Consequently total inflow to the aquifer is: 48.25 MCM. And total outflow from the aquifer

is 68.09; therefore, the deficit is –19.82 MCM. Considering the storage coefficient of the aquifer 0.06 percent, the average lowering of the water table should be about 0.966 meter per year [2,3].

WATER QUALITY PROBLEMS AND METHOD OF STUDY

As mentioned before the groundwater is acidic and sour, therefore water users in the region are encountered with many problems, e.g. corrosion of pipe and pump, also environmental and health problems. To study the problem, summer time was chosen as critical time as reported by the authorities. Forty eight (48) deep and semi -deep wells were chosen in the Northern part of the aquifer. In the field study program, pH and water temperature were measured directly. Moreover two separate samples (1.5 liter) were chosen from the wells for further laboratory analyses. Their pH was measured in the laboratory as well. The measured pH of the aquifer was used to produce pH iso-contours of the aquifer. See Figure 1. According to Figure 1 the pH of Khash aquifer, in view of wide alterations in the Northern part, has generally been low. The maximum PH is 7.12 related to Kalchat region and the minimum PH is 5.36 in Mohamadabad village. According to various standards, drinkable water pH should be between 6.5-8.5 [4], but in most parts of this aquifer, water PH is lower than 6.5.

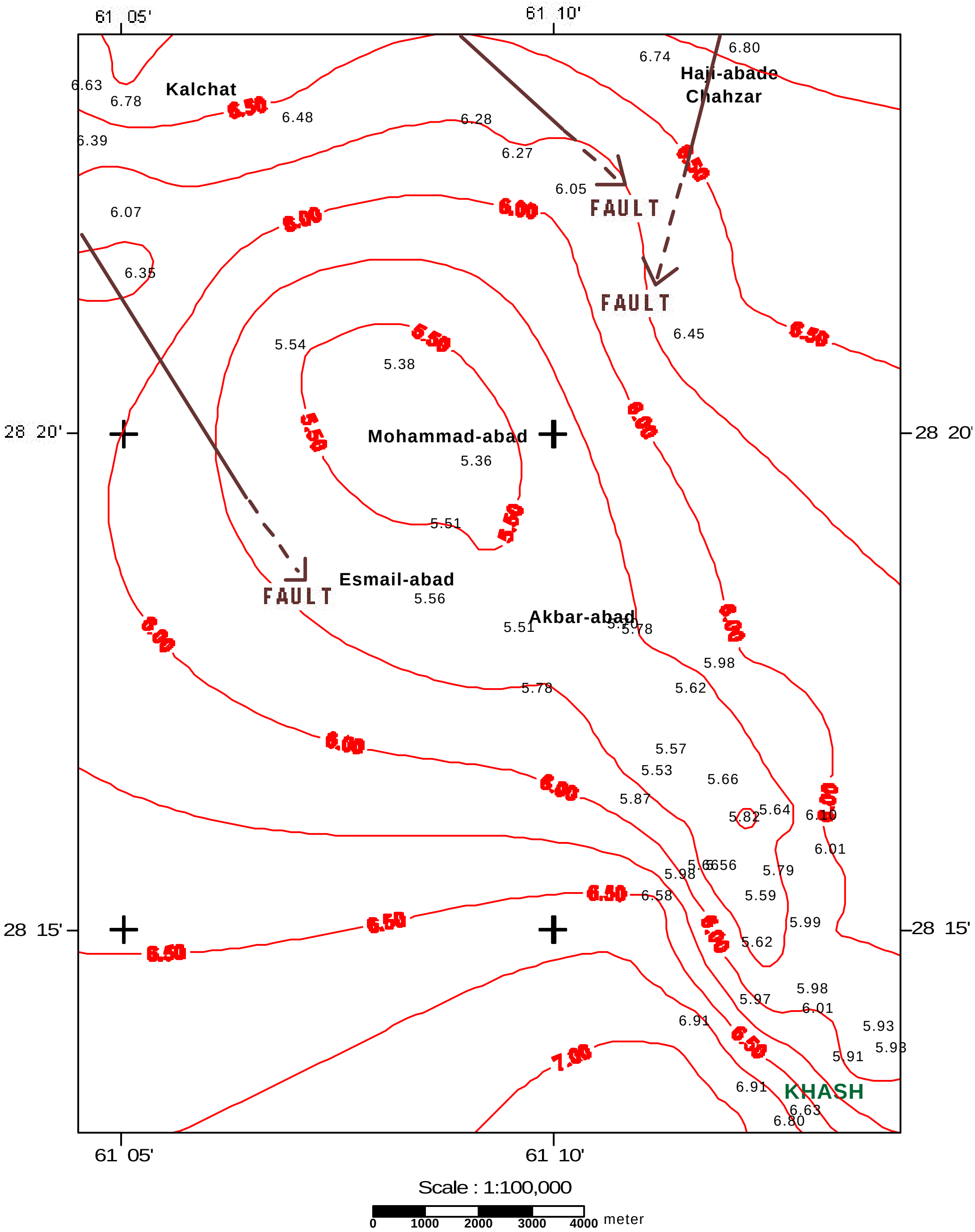

Figure 1. pH iso-contours of the aquifer and known faults location

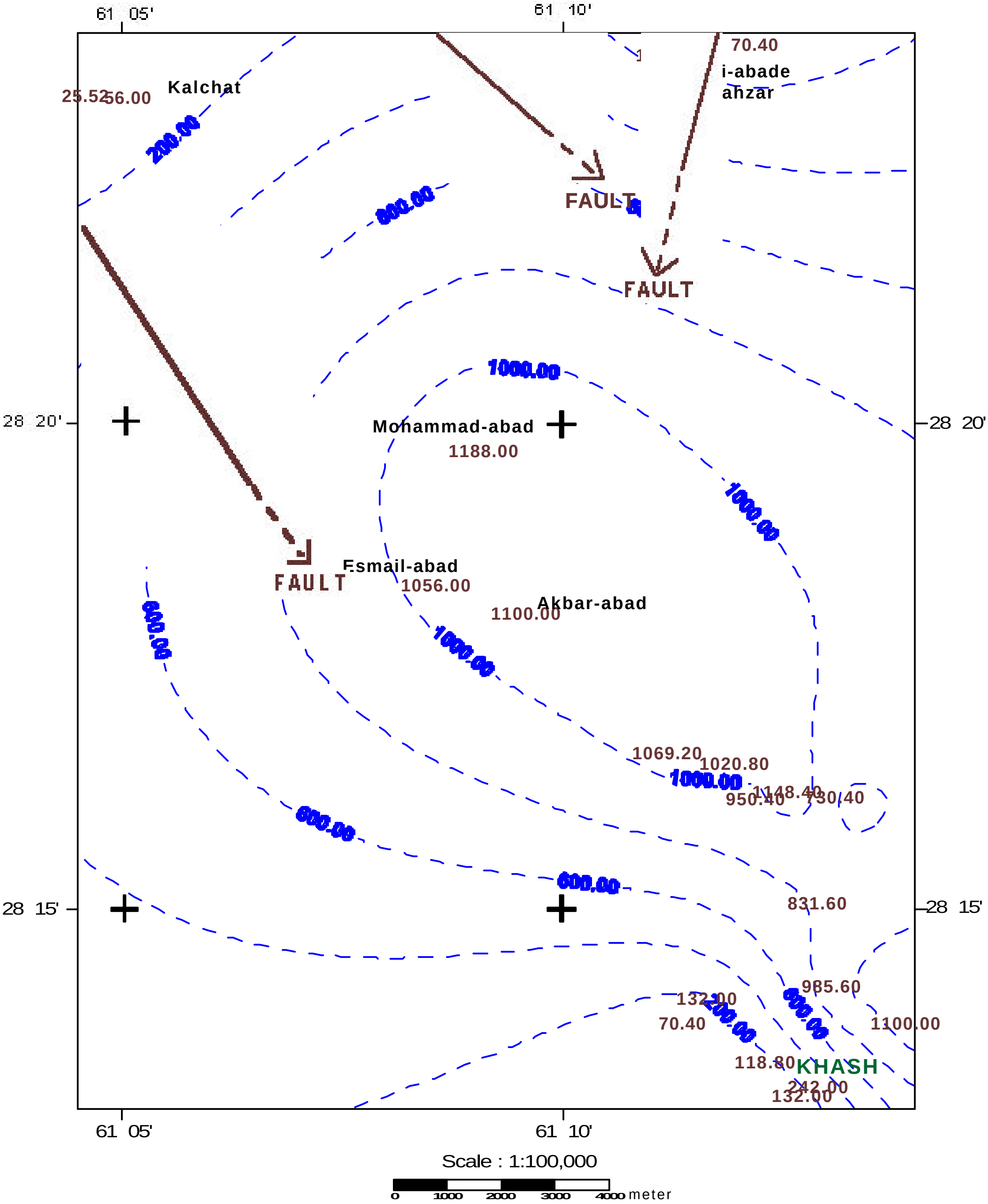

Figure 2. CO_2 concentration iso-contours and known faults location

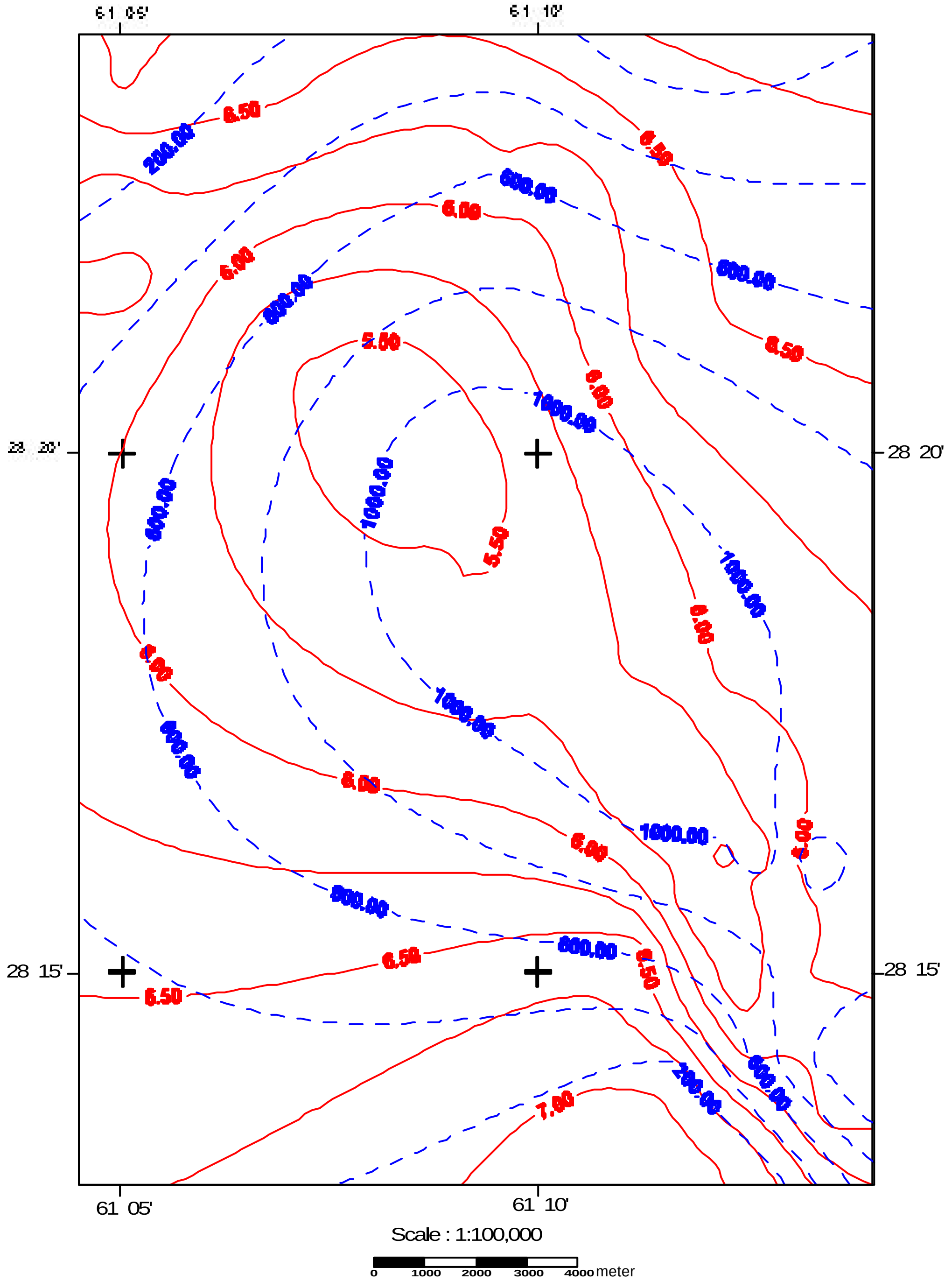

Figure 3. pH and CO_2 concentration iso-contours

Free CO_2

It is evident that free CO_2 reacts with water to form H_2CO_3, a week acid. A simple field test on flowing water in a canal, showed that pH of water, significantly increased with the traveling distance, indicates the presence of such volatile gas in the water. According to official reports [2,3], investigation about free CO_2 in Khash aquifer was considered in the research. Also, the main reason of low water pH rooted in Taftan volcano activities. Because the field determination of Co_2 was impractical, sampling techniques were used according to Standard Methods [5].

As mentioned before, the samples belong to all 48 wells on the aquifer timetable (two 1.5 ltr. Samples from each well). Due to some loss in free CO_2 can be expected in storage and transit, the sample bottles are filled completely and their caps were tightened by parafilm bands to prevent air influence. Also, the samples are kept at a temperature lower than that at which the water was collected[5]. Each sample was tested several times and its free CO_2 was measured by titration method. Therefore, the most careful free amount within water was identified. The measured values of CO_2 were used to produce iso-contours of CO_2 concentration for the aquifer. See Figure 2. According to Figure 2, the central part of the aquifer contains the most free CO_2 in comparison with other parts. To compare amount of free CO_2 in the water and pH values of the aquifer, Figure 1 and 2 were matched together, the outcome is Figure 3. According to Figure 3, the central part of the aquifer contains the maximum free CO_2 and the minimum water pH. There are some approximate differences between the CO_2 and pH iso-contours. It seems this discrepancy in some points may be due to interface of Ferrous ions concentration on titrimetric method, where concentration of iron is different through the aquifer. The studies showed iron concentration ranges between 0.019 to 0.234 mg/L[6], (for accurate results it should not exceed 1.0mg/L).

Hydrogen Sulfide

Hydrogen sulfide is determined by its special odor in water of some water wells in the area. H_2S is among the gases which form weak acid in water. It is found in sewages and mineral warm springs originated from volcanoes. H_2S is identified by its (rotten egg) odor at concentration of less than 1.0mg/L [5]. The threshold density of this gas in water is 0.025 micro gr./L [4]. Laboratory and field measurements did not show any amount of this gas. And the other references reported nil value for this gas[2,3]. According to threshold density of this gas, it was concluded that this parameter does not play a meaningful role in altering water pH [3]. To combat the acidity problem of the groundwater, a series of experiments were done in the field on pilots, using a pilot model of cascade and stepped aeration methods. Results were successful and showed both aeration methods are efficient with adjustment of pH at the beginning of aeration process [3,6].

Geophysical Survey Results

According to geophysical studies which performed in the area in 1972 and 1991[2,3,6], there are many geophysical logs, giving a clear view about thickness of the alluvium plain, bedrock depth and existence of significant faults in the bedrock beneath the aquifer, which located in northern part of the aquifer, see Figures 1 and 2.

CONCLUSIONS

1- Comparison between pH field measurements and laboratory CO_2 results through the area approves the theory that dissolved and free gases (especially CO_2) are the main reasons for the acidity of the aquifer.
2- Laboratory measurements of hydrogen sulfide did not show significant amount of this gas; therefore, hydrogen sulfate does not have a significant role in acidifying the groundwater.
3- Presence of faults in bedrocks beneath the aquifer can be the main reason of Taftan volcano activities on the aquifer.
4- Aeration methods are effective procedure to improve the quality of the groundwater, with adjustment of pH at the beginning of aeration process.

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