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[Research]

Modeling of karst and alluvial springs discharge in the central Alborz highlands and on the Caspian southern coasts

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ABSTRACT

Springs are the important water resources, which thier study is necessary in terms of their management and exploitation. In northern Iran, the karst springs locate in the central Alborz highlands and alluvial springs on the Caspian southern coasts.The Karst and alluvial springs discharge is variable because of different conditions in terms of aquifer, topography and precipitation .This study has been done to simulate the karst and alluvial springs discharge and to compare their hydrologic conditions. So, 80 karst springs and 82 alluvial springs were investigated in central Alborz and on the Caspian southern coasts. Two models were presented to simulate the karst and alluvial springs discharge using Multivariate Regression analysis (SPSS software).Then, their efficiency was considered. Finally, the models and the results of regression analyses were compared. The results showed that the most important factors of the karst springs discharge are aquifer formation (its porosity) and site elevation, but about the alluvial springs, the hydraulic conductivity of aquifer formation and aquifer depth are the most important factors.

Keywords: Discharge, Karst and alluvial springs, Central Alborz, Caspian coasts.

INTODUCTION

Springs are one of the most important water resources that provide a part of human required water. There are a lot of alluvial springs on the Quarternary sediment in the Caspian southern coasts. And, a lot of karst springs in the central Alborz highlands (karst areas). The discharge study of the Springs and their simulation is very important for water resources protection and planning. The hydrologic conditions of karst aquifer are different from alluvial aquifer. In the karst aquifer, formation porosity charges from water, but alluvial aquifer is saturated from water. Karst springs discharge is influenced limestone porosity. Porosity is dependent on texture and lithology characteristics. Karstification is highly influenced by precipitation and terrain, which can cause large differences in the karst springs flow between different regions (Yonghong and Chyi, 2006). One of the important factors in the discharge of the springs is precipitation values (Rimmer, 2006; Han *et al*., 1993; Ma *et al*., 2004). Different models have been developed to study the influence of climate changes on groundwater. Studies have shown that the impacts of climate changes on groundwater are site-specific. (Brouye`re *et al.,* 2004). Alvis *et al*., (2006) investigated the alluvial aquifer and its changes in the south Dakota. Their results showed that water table depth and discharge values differ in different places. Aukenthaler (2005) presented a linear model to simulate the discharge of the karst springs in Switzerland and the results showed the effect of aquifer formation and its hydraulic conductivity (K) on it. Worthi-ngton (1991) studied karst areas hydrology and the results showed that the porosity volume of aquifer formation is an impor-tant factor on the karst areas' hydrologic conditions. Prohaska and Stevanovic (1993); Zhang *et al*., (1996) and Dimitrov *et al*., (1997) presented some models to simulatethe discharge of the karst sprin-gsusing different methods, results showed the effects of these factors: kind of aquifer formation (such as K), rainfall and water resources such as rivers on springs discharge. The present research has been done to investigate the effective factors on the discharge of karst and alluvial springs and to simulate the discharge of the springs in the Caspian southern coasts and in the central Alborz highlands (Mazandaran Province, northern Iran)

MATERIALS AND METHODS

Mazandaran province located in northern Iran includes Caspian southern coasts and the central Alborz highlands. The present research has been done on the surface of the central Alborz highlands (karst areas) and the Caspian southern coasts (Quarternary alluvial sediment). The study area is located in eastern longitude 50˚30´ to 53˚50´ and northern latitude 35˚45´ to 36˚45´. The location of the study area, karst and alluvial springs are presented in figure 1.The Caspian southern coasts include the plains made of Quarternary sediment, but in central Alborz, different geologic formations and elevation and slope changes are observed. Elevation maximum is 5670m in Damavand peak. The Karst springs locate in the central Alborz highlands (karst areas) and the alluvial springs on the Caspian southern coasts (alluvial sediments). In this research, 82 alluvial springs on the Caspian southern coasts and 80 karst springs in the central Alborz highlands were studied. Multivariate Regression method was applied to present a linear model using SPSS Software the discharge of the Karst and alluvial springs was selected qua dependent variable. For the karst springs the factors are: aquifer formation porosity (%), aquifer depth, site elevation, annual precipitation and distance from water resources (lakes and rivers) which studied qua independent variables. For the alluvial springs these factors were studied qua independent variables: hydraulic conductivity (k) of aquifer formation, aquifer depth, water table depth, annual preci-pitation, site elevation and distance from water resources. Evaporation was rendered because of the lack of notable changes, dense of evaporimetery stations and the lack of significant relation between evaporation and the discharge of the springs. Quant-itative data of hydraulic conductivity (k), aquifer formation porosity (%), precipitation, water table and aquifer depth were provided by TAMAB (Water Resources Researches Organization of Iran). Regression analyses were done to present two linear models for estimating the discharge of the karst and alluvial springs. Multivariate regression analysis was done using SPSS software and Stepwise methods. In the next step, the efficiency of the presented linear models to simulate the discharge of the springs was investigated separately. In this step, the presented models were applied which were not used for presenting the models. Finally, the presented models and the results of regression analyses were compared to investigate the effective factors in the discharge of the karst and alluvial springs.

RESULTS

As pointed out before, extensive data were collected from TAMAB, Surveying and Climatology Organizations. Multivariate regression method was used to present two linear models for simulating the average discharge of the springs. The presented linear models for karst and alluvial springs were significant (table 1) and their R values are 0.73 and 0.7 (R2=0.53 and 0.502) respectively. Correlation between the discharge factors of each springs and the average discharge of the springs are presented in table 2. Regression analysis presented a linear model to simulate the discharge of the karst springs, which model is given below:

$$Q^{(½)}_{spring} = 4.09\ P^{(½)} - 0.0758634\ H^{(½)} + 4.361$$

where Q_{spring} is spring average discharge (lit/s), P is aquifer formation porosity (%) and H is site elevation (m).

Also, regression analysis presented a linear model to simulate the discharge of the alluvial springs which model is given below:

$$Q^{(½)}_{spring} = 0.258\ K^{(½)} + 0.295\ hq^{(½)} - 7.485$$

where Q_{spring} is spring average discharge (lit/s), K is hydraulic conductivity of aquifer formation (m^2/day) and hq is aquifer average depth (m). The presented linear models were applied to investigate their efficiency in simulating the discharge of springs separately. Thus, the models were used to simulate the discharge of the karst and alluvial springs were not used for presenting the models (the uniform distribution of springs in study area).Also, the evaluated results of the efficiency of the models have been given in fig2 and 3. Comparison between the estimated values of the models and recorded values by TAMAB confirmed the efficiency of the linear models for simulating the average dischargeof the karst and alluvial springsin the central Alborz highlands and on the Caspian southern coasts.

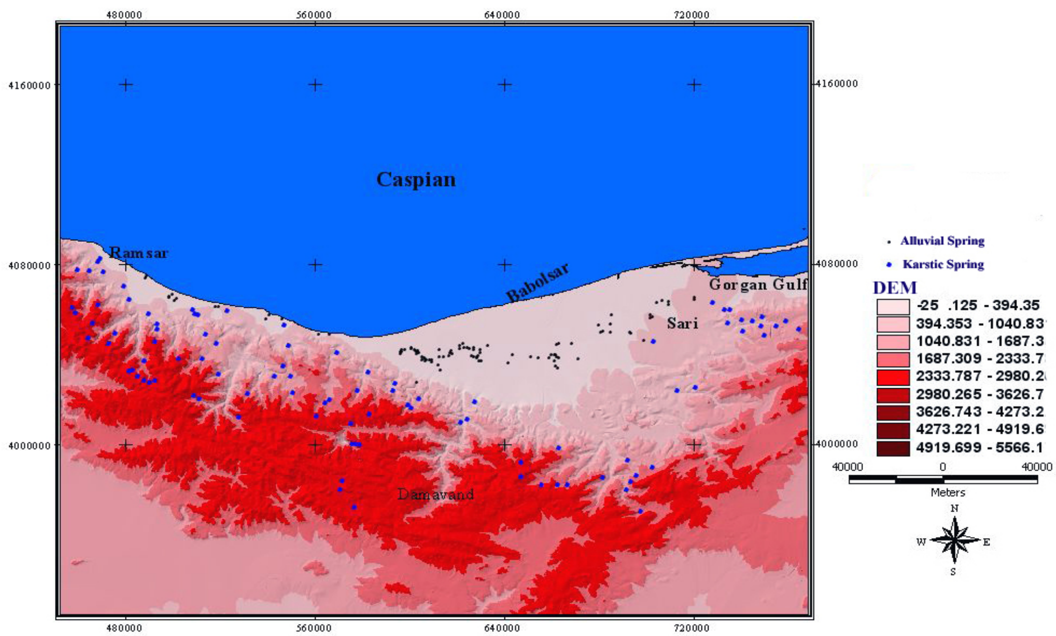

Fig 1. Study area and the location of the karst and alluvial springs in the central Alborz highlands and on the Caspian southern coasts.

Table 1. The results of Regression analyses (SPSS Software)

Model Karst Spring	Sum of Squares	df	Mean Square	F	Sig.
Regression	278.7953	5	55.791	10.517	<0.01
Residual	233.409	44	5.305		
Total	362.512	49			
Model Alluvial Spring	**Sum of Squares**	**df**	**Mean Square**	**F**	**Sig.**
Regression	217.652	2	108.826	25.71	<0.01
Residual	215.854	51	4.232		
Total	433.506	53			

Table 2. Correlation between the average discharge of the springs and their effective factors.

	Elevation	Precipitation	Porosity (aquifer formation)	Aquifer Depth	Distance from water resources
Karst spring discharge	-0.376	0.019	0.686	-0.2	0.259
	Elevation	Precipitation	Hydraulic conductivity of aquifer formation (K)	Aquifer Depth	Distance from water resources
Alluvial spring discharge	-0.156	-0.07	0.665	0.622	0.177

Also, correlation between alluvial springs discharge and water table depth is -0.234.

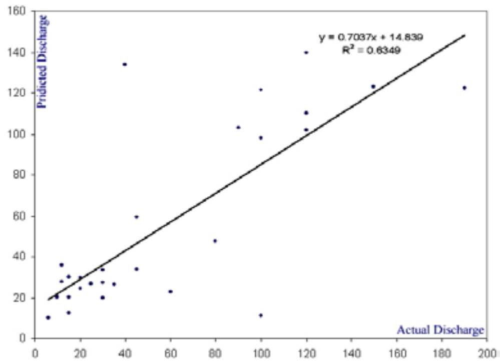

Fig 2. Comparison between the estimated discharges of the karst springs using the linear model with actual discharge (the karst springs were not used for presenting linear model).

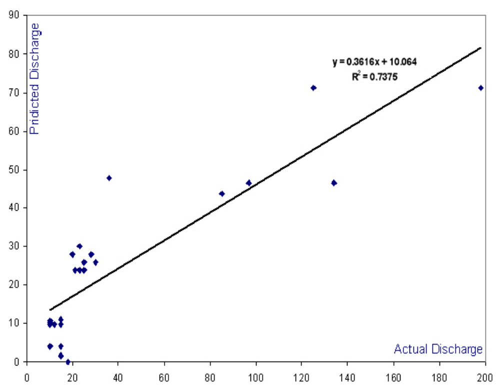

Fig 3. Comparison between estimated discharges of the alluvial springs using linear model with actual discharge (the alluvail springs were not used for presenting the linear model).

CONCLUSIONS

This research was done using extensive data about aquifer characteristics, climatology, elevation and so on. The purpose of this study was presenting two models for simulating the discharge of the karst and alluvial springs and to compare their hydrologic conditions. The karst aquifer is effective on surface flow through springs. Hydraulic conductivity (K) is an important factor on the karst aquifer discharge (William, 2003). Hydraulic conductivity (K) is depend on texture and lithology characteristics. The results of this study showed that aquifer formation porosity (%) has the most correlation with the discharge of the karst springs. In the presented model for karst springs the factors are: aquifer formation porosity (%) and elevation have significant relation with the discharge of the springs. But the elevation factor of the alluvial springs is not important and has not significant relation with the discharge of the springs. In the presented model for the discharge of the alluvial springs the factors are: hydraulic conductivity (K) of aquifer formation and aquifer depth,which have significant relation with the discharge of the springs and they are the most important factors in the discharge of the alluvial springs . The saturate of the alluvial aquifers from water and their discharge is depend on precipitation. Also, aquifer depth is depend on precipitation. In karst areas, formation porosity charge from water. Thus, water flows in this porosity. The results of this study showed that karst aquifer depth has not significant relation with aquifer discharge. As a matter of fact, the most important factor in the discharge of the karst springs and aquifer is formation porosity. This study presented two models for simulating the discharge of the karst and alluvial springs that can be applied to manage springs in the central Alborz highlands and on the Caspian southern coasts. According to TAMAB reports, there are about 800 springs in this region that most of them were not studied (there are not any data about their discharge). Thus, the presented linear models can be applied to simulate average discharge for the springs have not studied yet.

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