

# Assessment of Meymeh Plain Aquifer Vulnerability in Esfahan Using Comparative Method AVI, GODS, DRASTIC

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## Introduction

One of the most vulnerable water resources against contamination is ground water table. These resources are exposed to contamination in various forms. Identifying and controlling contamination in these resources are more difficult and costly than surface waters. Also because of the persistence of contamination in these resources, the best way to prevent their contamination is to identify contaminant sources and vulnerable media, providing vulnerability zoning maps and adopting perfect managerial policies. Providing the maps that characterize the vulnerable or sensitive zones to contamination is the best way to manage ground water. For the first time, the concept of "ground water vulnerability" was put forward, in late 1960 in France, to warn about water contamination.

The need for the maps of aquifer vulnerability against contamination increase each day, .because ground water is the main resource of drinking water supply on one hand, and on the other, it is the main resource for human and economic activities, such as industrial, agricultural, household, as the main or potential factors affecting ground water contamination.

Assessment of ground water vulnerability is carried out in various methods. In all methods, the aquifer vulnerability is estimated according to the transferring rate of contamination from an earth surface to an aquifer. The differences between these methods are the number of parameters used in evaluating the contamination potentials and privileges of each one.

In south Spain assessment of ground water vulnerability was carried out by four AVI, GODS, DRASTIC, and COP methods. The comparison of results indicates that the vulnerability zonings of DRASTIC and GODS methods are very close to each other. Assessment of aquifer vulnerability in south of Italy was carried out by GODS, DRASTIC, EPIK and SINTACS methods. In DRASTIC method, the range has low and mainly moderate vulnerability zonings. In GODS method, all zones are located in the range of low vulnerability. In south of Jordan, the ground water of the zone was evaluated by DRASTIC index, in combination with chemical analysis and leaching tests, resulting from the ashes caused by the burning of oil wells.

Accordingly, most of the zones are located in the range of moderate vulnerability. Researchers have carried out a research based on the aquifer vulnerability zoning of Juin plain in Iran by DRASTIC and GODS methods. Comparison of the results indicates that vulnerability is located in low and moderate groups in both methods. The comparison of these two methods indicates that DRASTIC method estimates aquifer vulnerability less than GODS method. Researchers evaluated the contamination potential of Baghmalek plain by AVI, GODS, and DRASTIC methods.

In this research, the results of the three mentioned methods are compared with each other, and defined that DRASTIC method precisely characterized the various ranges of contamination potential.

Researchers evaluated ground water of Zayandehrod drainage basin based on DRASTIC method, and presented the maps of vulnerability index. In this survey, the net recharge is considered in three states of minimum, maximum and average.

50% of the basin has been located in low vulnerability range. Also, west of the basin is the most sensitive zone to net recharge parameter, while east and center of the basin is free of great changes in vulnerability index, versus recharge parameter.

The goal of this study is to present the groundwater vulnerability map in Meymeh aquifer by the three methods of DRASTIC, GODS and AVI methods, comparing the results and choose the best method.

Considering the importance of groundwater resources, in the zone under study, which is used for drinking, agriculture and industrial activities, better management of groundwater resources, is of great importance.

## Materials and methods

Meymeh aquifer is located in the northern zone 39 and the range of latitudes of 3718051.059 and 3675650.104 and longitudes of 503201.963 and 534775.334. Meymeh is the northernmost zone of Esfahan province and is located at the distance of 85 kilometers from country town and next to the Esfahan-Tehran highway. It is known to be the highest plateau plain in Esfahan province. DRASTIC method is a numerical classification model presented for the first time in 1987, by (USPEA) and (AWWA), to evaluate groundwater vulnerability potential of the United States.

This method is based on the concept of hydrological state. This model is a combination of seven measurable hydrologic and effective parameters in transferring contamination to ground water, including depth of water, net recharge, aquifer media, soil media, topography, unsaturated zone and hydraulic conductivity. These seven parameters appear as seven layers in GIS software media, and essential analyses have been applied on them. A weight, from one to ten, is considered for each factor to determine the relative importance of each factor. The weight represents the relative effect of each parameter on the contamination transferring rate in ground water.

Also, a rate from one to ten is considered for intervals of each parameter in this model and allows the user to unify it with the zone under study. Finally, for providing the vulnerability map, after collecting and digitizing the information of these seven parameters, they are combined with each other and form a new layer called DRASTIC index, based on Equation (1):

$$\text{DRASTIC index} = DrDw + RrRw + ArAw + SrSw + TrTw + Irlw + CrCw$$
 (1) In this Equation, D, R, A, S, T, I and C are effective parameters in the model, and r and w, respectively are the rating and weight of each parameter. So, the intrinsic vulnerability index is formed by weight product of each parameter in its rating.

Some researchers believe that they can achieve results equivalent to DRASTIC model, using less number of parameter, more accuracy and less cost. In respect to this view, GODS method was presented. This model is a very simple, practical and empirical method for fast evaluating contamination potentials. In the method, there exist three parameters including groundwater confinement, overlying strata and depth of water. The primary method of GODS has not considered the soil layer, which is one of the most important factors for reduction and elimination of contaminants. Thus, GODS method was presented by considering parameters (presenting the sensitivity of soil leaching). In this method, the value of various classes of parameters changes from zero to one, and is considered to be of the same weight for all the parameters. The vulnerability index of GODS method is formed by the parameters product, according to Equation (2):

$$\text{GODS index} = G.O.D.S$$
 (2) In this Equation, G is the rating of the aquifer type, O is the lithology rating of zone on the aquifer, D is the rating of water table depth and S is the rating of soil covering type.

In the method for groundwater vulnerability index (AVI), two parameters are used to measure the vulnerability rate. These two parameters are the thickness of each deposit on the aquifer and the estimated hydraulic conductivity of each layer. The value of the aquifer hydraulic conductivity is calculated according to Equation (3): (3) In this Equation, c is the aquifer hydraulic conductivity, di is the thickness of layers on the aquifer per m, and Ki is the estimated hydraulic conductivity per m/d. The hydraulic conductivity parameter has a time dimension which indicates the time duration of groundwater movement through the porosity of the upper surface of saturation part to the lower layers.

## Discussion of Results

The results of DRASTIC method indicate that Meymeh aquifer is exposed to two ranges of low and moderate vulnerability, that are respectively 44.76%, 55.24%. The results of GODS model indicate that Meymeh aquifer is exposed to two low and moderate vulnerability classes that are respectively 71.58% and 28.42%. The results of AVI indicate that 54.32% of aquifer has low and 45.68% of it has moderate contamination potential.

## Conclusion

The results of DRASTIC model indicate that southern, northern and central zones of the aquifer have moderate vulnerability. The reason of vulnerability increase in these zones can be found in the unsaturated zones within these ranges that are less than alluvium with coarse sand. Also, the moderate to high permeability of these ranges increase the net recharge. It should be mentioned that the minimal slope of the central zone of aquifer is also an effective factor in increasing the vulnerability potential of

these zones. The results of the GODS model indicate that central, northern and western zones have low, and the edges of the aquifer have moderate vulnerability. Comparing the three methods, one can say that Meymeh plain aquifer is located in two groups of low and moderate vulnerability zones, but the expanding limit of vulnerability ranges in these zones are different. In GODS and DRASTIC methods, the vulnerability zones are more in accordance with each other, but the ranges of vulnerability in DRASTIC method are decreased, and it can estimate the aquifer vulnerability better than GODS method. In DRASTIC and AVI methods, the moderate vulnerability zonings in south of the aquifer are well in accordance with each other. In comparing DRASTIC method with the two other ones, more percentage of the aquifer is located in the moderate vulnerability zone. DRASTIC model precisely characterized various vulnerability ranges. The reason is that there are more parameters and different weights of parameters, based on their role in determining the contamination. The effect of uncertainty of some parameters is neutralized because too many parameters exist in this method.

Thus, in DRASTIC method, if uncertainty is increased in one of the parameters, its effect will be covered by the other ones, while in the two other methods, the uncertainty in each one changes the result of zoning. But vulnerability zoning in DRASTIC method is more time-consuming and costly than the two other ones, because of the existence of many parameters. Specially, in Iran, there is a lack of initial statistics and information. Providing the required information for evaluating vulnerability in GODS method is easier and cheaper than that of the other ones. GODS method doesn't mention the rate of surface recharge, and that is the main deficiency of this method, because the rate of surface recharge of the aquifer is very effective in determining the vulnerability.

There are just two parameters in AVI method. Thus, this method has less accuracy than the two other ones, and can present a general evaluation of contamination potential. Since the insaturated zone and depth to water table are just the same in all three methods, these two are the most important and effective parameters in evaluating the contamination.

Keywords: Aquifer, DRASTIC method, Groundwater, Meymeh plain in Esfahan