Computational Research Progress in Applied Science & Engineering

ISSN 2423-4591

CRPASE Vol. 02(01), 17-22, January 2016

Assessment of Aquifer Vulnerability using the DRASTIC Model; A Case Study of the Dezful- Andimeshk Aquifer

Leila Goodarzi [*], Saman Javadi

Department of Irrigation and drainage, College of Aburaihan, University of Tehran,Tehran, Iran.

Keywords

Groundwater,
Aquifer Vulnerability,
DRASTIC,
Dezful- Andimeshk Plain.

Abstract

Aquifer pollution is one of the main environmental problem caused by human activities, especially those related to agriculture. Therefore, identification of the highly vulnerable areas and land use management are effective to prevent groundwater pollution. The aim of this study is to assess the aquifer vulnerability using the DRASTIC method, based on a Geographic Information System (GIS) in the Dezful- Andimeshk aquifer. The DRASTIC model uses seven environmental parameters (depth of groundwater (D), recharge (R), aquifer environment (A), soil type (S), topography (T), the effect of the unsaturated region (I) and hydraulic conductivity (C)) to evaluate the aquifer vulnerability. An aquifer vulnerability map was prepared using overlay analysis in GIS environment. According to this map, potential vulnerability was divided into three classes. It was concluded that central regions of the aquifer were highly vulnerable. This map can be used for future land use planning and groundwater management in the study area.

1. Introduction

The major portion of the water consumption, especially drinking water, is supplied from groundwater in Iran. Therefore, protection of groundwater is the important issue in the area of human and environmental health. Decontamination of groundwater is costly and time consuming and normally after the time that the removal of the contaminant in the aquifer becomes almost impossible, the pollution is detected. Vulnerability index is the main tool for groundwater conservation and land use management [1]. The vulnerability of groundwater is defined as the potential of penetration and diffusion of contaminants in the groundwater resources. This index represents the amount of contaminant that can penetrate and distribute from the surface of ground to the groundwater resources. Vulnerability is a relative, nonmeasurable and dimensionless parameter that depends on the aquifer environment, geological features, hydrogeological environment, topography, recharge and etc. different methods were presented to evaluate the potential of vulnerability. This methods can be divided into three classes of processing, overlapping and statistical methods [2].

Many studies were conducted to assess the aquifer vulnerability in the world. Al-Fawwaz [3] examined the geological structures to assess the effects of human activities on the vulnerability of aquifer. Ferreira and Oliveira [4] compared the different vulnerability methods in an aquifer located at Portugal. They used six methods including AVI (Aquifer Vulnerability Index) , GOD, DRASTIC, SI (Susceptibility Index), EPPNA and SINTACS. The results of this research showed that the AVI method is not a suitable method to represent the groundwater vulnerability of the study area. Yahia and Bouabid [5] studied the aquifer vulnerability of an aquifer in Yemen. They concluded that 6.4% of the study area was highly vulnerable. They recommended to using urgent pollution preventions measures for human activities in this aquifer. Azizian and Merufinia [2] studied the vulnerability of Karaj plain aquifer located in Iran using the DRASTIC model.

In this study, the DRASTIC method is used to identify the vulnerable areas of Dezful-Andimeshk aquifer.

2. Material and Methods

2.1 Study Area

Dezful- Andimeshk is the widest plain of the Karun basin and has an area about 6288 km^2 which is located in the southwest of the basin. The area of 2496 km^2 of the basin is consist of the plain and the remaining area of 3792 km^2 is the altitudes. Figure 1 shows the location of the study area.

* Corresponding Author:
E-mail address: Goodarzi.1988@gmail.com – Tel, (+98) 9355290165

Received: 17 November 2015; Accepted: 30 December 2015

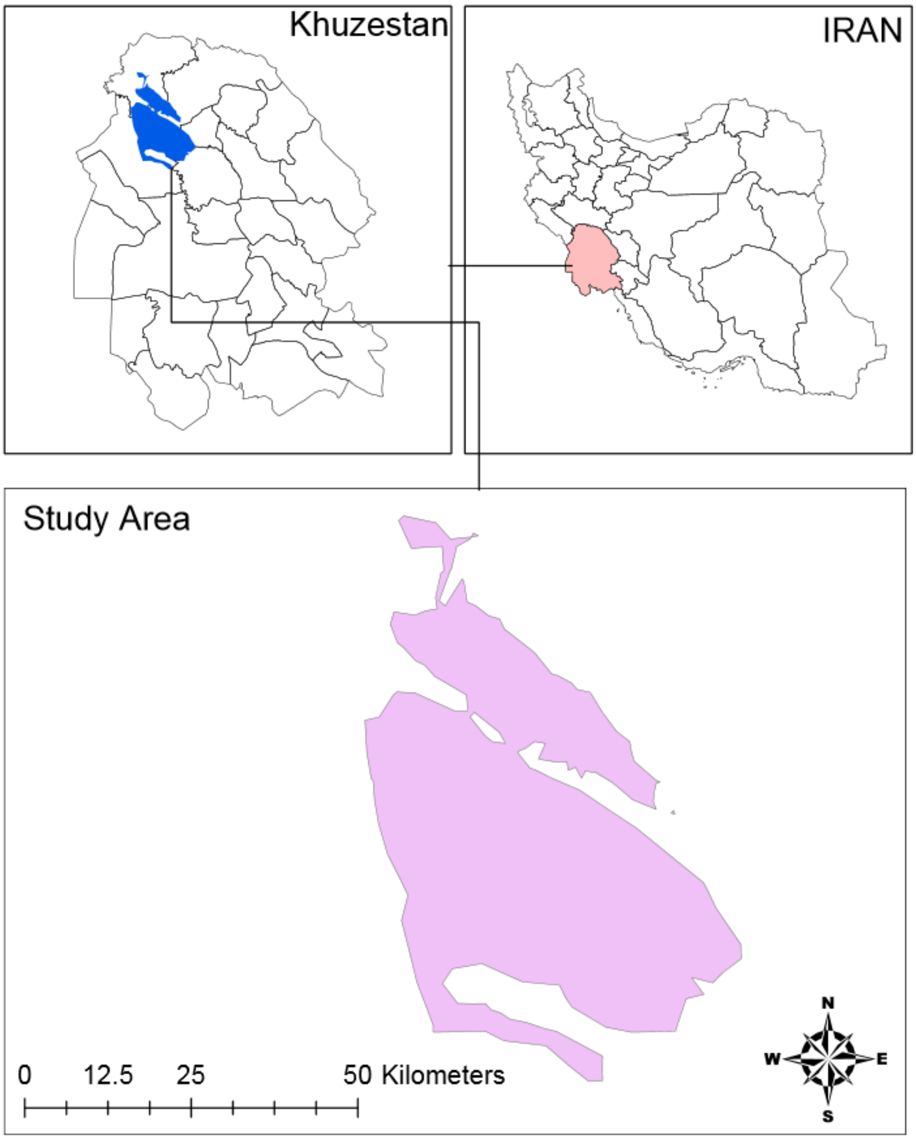

Figure 1. The location of the study area

2.2 DRASTIC Method

DRASTIC method uses seven effective parameters including as

- Depth of groundwater (D): The depth of groundwater determines the vertical distance that contaminants penetrate to reach the water table.

- Net recharge (R): The net recharge is the amount of water that penetrates from the surface of ground to the groundwater resources.

- Aquifer environment (A): Aquifer environment shows the characteristics and texture of aquifer media.

- Soil type (S): Soil media is the upper layer of the earth, with the average thickness of 0.5 to 2 m.

- Topography (T): Topography refers to the slope of the ground surface.

- Unsaturated zone (I): Unsaturated zone or the vadose zone is the zone above the water table.

- Hydraulic conductivity (C): This parameter refers to the rate at which water flows horizontally through an aquifer.

According to the importance of these parameters in groundwater vulnerability, the weight between 1 to 5 is assigned to each parameter (See Table 1). The most important parameter will get five and the parameter which has the lesser importance, was assigned the value of one and the rating between 1 to 10 is assigned to each classification parameter (See Table 2). Vulnerability index is calculated as

$$index = DrDw + RrRw + ArAw + SrSw + TrTw + IrIw + CrCw \quad (1)$$

In this Equation r and w are respectively the rating and the weight of each parameter [2].

Table 1. DRASTIC assigned weights [6]

Parameter	DRASTIC weights
Depth of water	5
Net recharge	4
Aquifer media	3
Soil media	2
Slope	1
Impact of vadose zone	5
Hydraulic conductivity	3

Table 2. Attributed rating for parameters of DRASTIC model [7]

Class D (m)	Note	Class A	Note	Class S	Note	Class C (m/d)	Note
0 - 1.5	10	Massive shale	2	Thin or absent	10	0.4 - 4.1	1
1.5 - 4.6	9	Métamorphic	6	Gravels	10	4.1 - 12.3	2
4.6 – 9.1	7	Altered - sandstone		Sands	9	12.3 – 28.7	4
9.1 - 15.2	5	Massive limestone	8	Sandy silts	6	28.7 - 41	6
15.2 – 22.8	3	Massif Sandsone	6	Silty loam	3	41- 82	8
22.8 – 30.4	2	Sand and gravel	8	Shales	1	> 82	10
>30.4	1	Karstic limestone	10				
Class R (mm)	Note	Class T (%)	Note	Class I			Note
0 – 50.8	1	0 - 2	10	Silt and shales			3
50.8 – 101.6	3	2 - 6	9	Shale			3
101.6 – 177.8	6	6 - 12	5	Limestones			3
177.8 - 254	8	12 - 18	3	Sandstones			6
>254	9	> 18	1	Sand and gravels with passage silt and shale			6
				Sand and gravels			8

3. Results and Discussion

As discussed earlier, DRASTIC metohod uses seven layers to assess the aquifer vulnerability. A raster form map for these layers was perepared in GIS software and then the raster layers were integrated and the aquifer vulnerability map was prepared. Below, the DRASTIC layers were discussed in the study area.

The net recharge was calculated using growndwater balance equtions in the study area. This parameter was higher in the southern parts of the plain and decreased toward the northern parts, see Figure 2. Whatever the net recharge is greater, the vulnerability potential in the aquifer is higher.

The raster layer for depth of groundwater was calculated by computer subtraction of water level elevation in observaton wells from land surface elevation. In the study area, the depth of groundwater was increased with movement from the center toward the sides of the plain (Figure 3) .

The texture of aqifer environment was determined using the exploration well logs. As shown in Figure 4, the study area comprises three classes in terms of aquifer environment that their importance in aquifer vulnerability is decreased from the northern towards the southern parts of the plain. Whatever the grain size is smaller, the potential of penetration is lower.

Classification of soil type (Figure 5) shows that the study area was classified into five classes that their importance in aquifer vulnerability was decreased from the northern toward the southern parts of the plain as what was mentioned about the aquifer environment.

Topographic slope was calculated using Digital Elevation Model (DEM) in the study area. Figure 6 shows that the major parts of the study area had the gentle slope (less than 2 percent). Low slope causes the slow movement of the contaminants and thus the potential of penetration is increased. Therefore, the gentle slope creates a greater potential of aquifer contamination.

The texture of unsaturated zone was determined using the exploration well logs. The classification of this parameter is shown in Figure 7. The study area was classified into 3 classes. The effect of this criterion was increased from the southern toward the northern parts of the plain. The ratings for the unsaturated zone are generally the same as the aquifer environment.

Hydraulic conductivity is estimated based on the texture of the aquifer sediments. As shown in Figure 8, the central and southern parts of the study area had higher hydraulic conductivity. Hydraulic conductivity was decreased toward the northern parts. Whatever the hydraulic conductivity is greater, the aquifer vulnerability is higher.

After preparing the raster form map for effective parameters, DRASTIC vulnerability index was computed using weighted sum of the effective parameters in GIS environment. Finally, the vulnerability map was classified into 3 different classes related to vulnerability degrees. The result of the aquifer vulnerability map created with DRASTIC method is shown in Figure 9. As shown in this figure, The major parts of the study area was the averagly vulnerable and the highly vulnerable areas were located mainly in the central parts of the aquifer due to high recharge, low groundwater depth and high hydraulic conductivity that they are observed in Figures 2, 3 and 8 respectively. It is concluded that 15% of the aquifer area is highly vulnerable, 71% is averagely vulnerable and 14% of the aquifer area is lowly vulnerable. Vulnerability map can be used for future land use planning and groundwater management in the study area. It is recommended to use urgent pollution preventions measures in the central parts of the aquifer and in these areas. The policy maker should prevent the application of high risk activities.

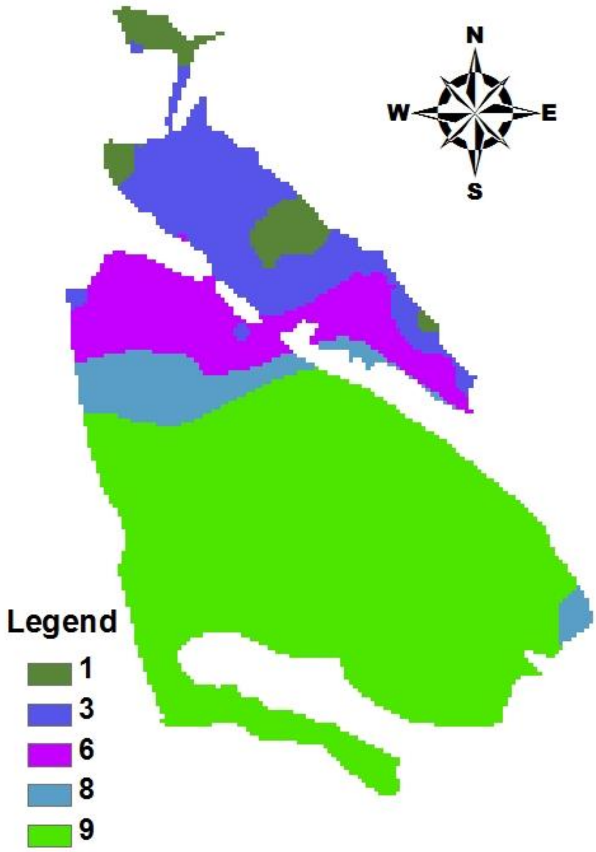

Figure 2. Classification and ranking of net recharge

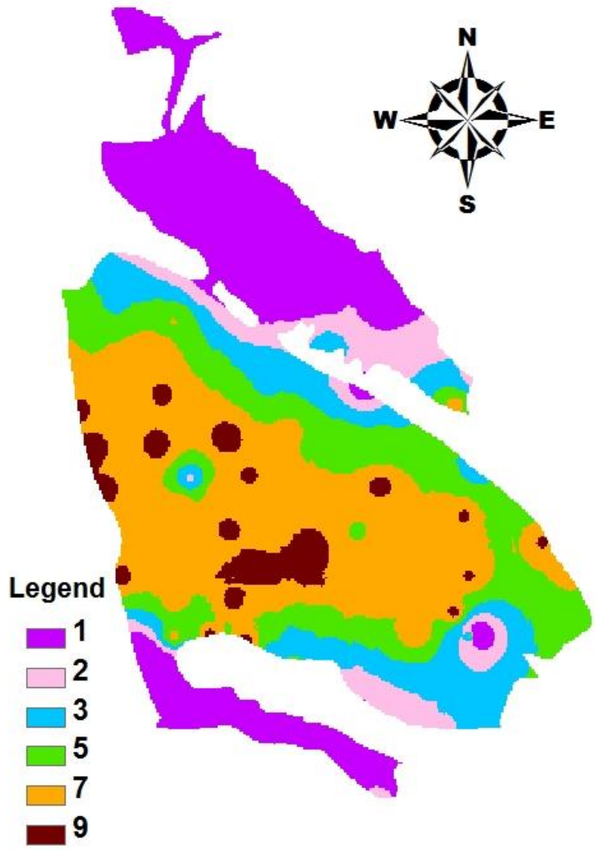

Figure 3. Classification and ranking of depth of groundwater

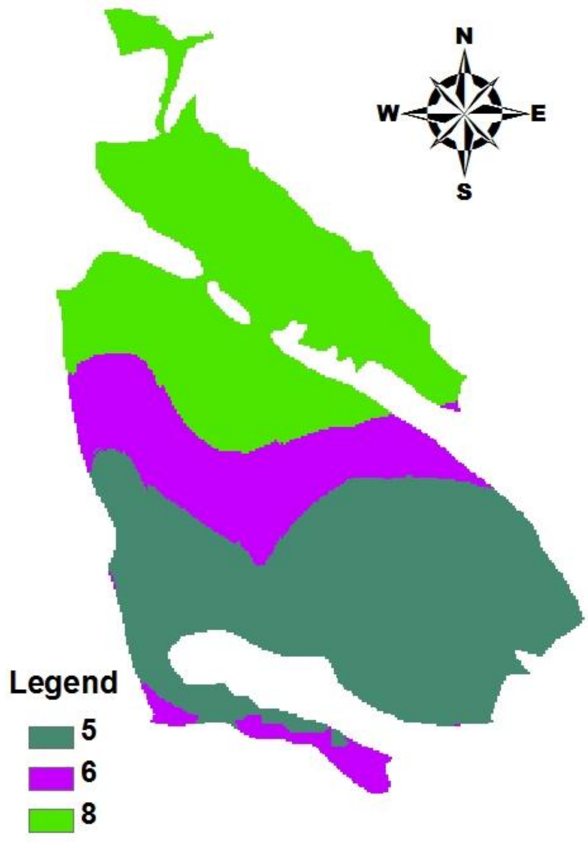

Figure 4. Classification and ranking of aquifer environment

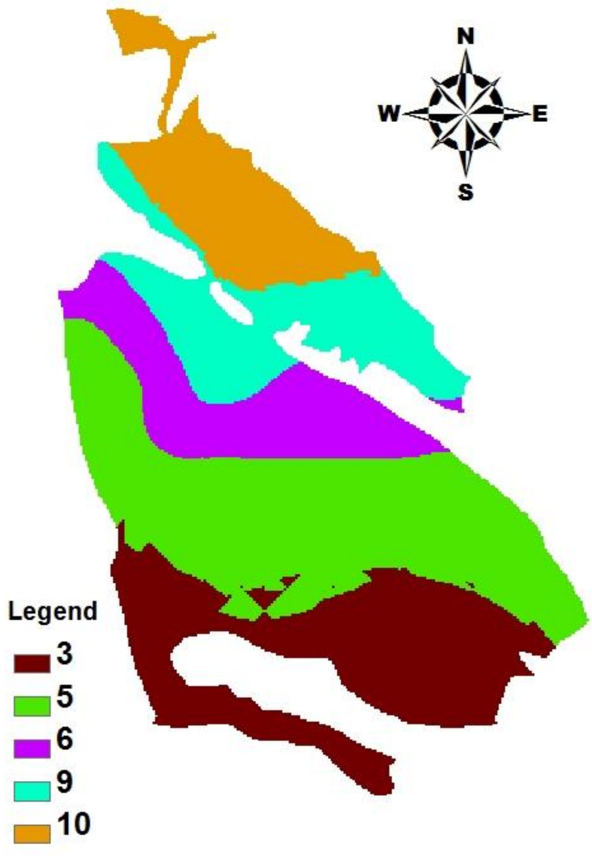

Figure 5. Classification and ranking of Soil type

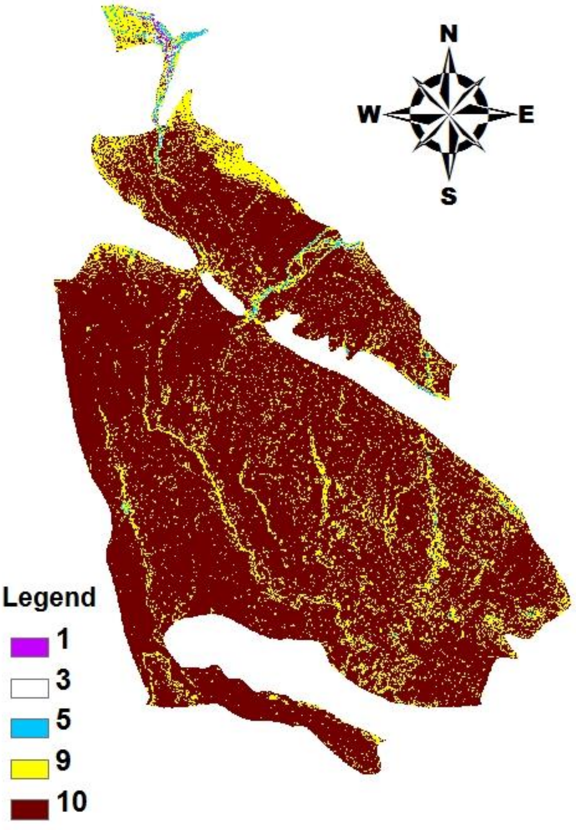

Figure 6. Classification and ranking of topography

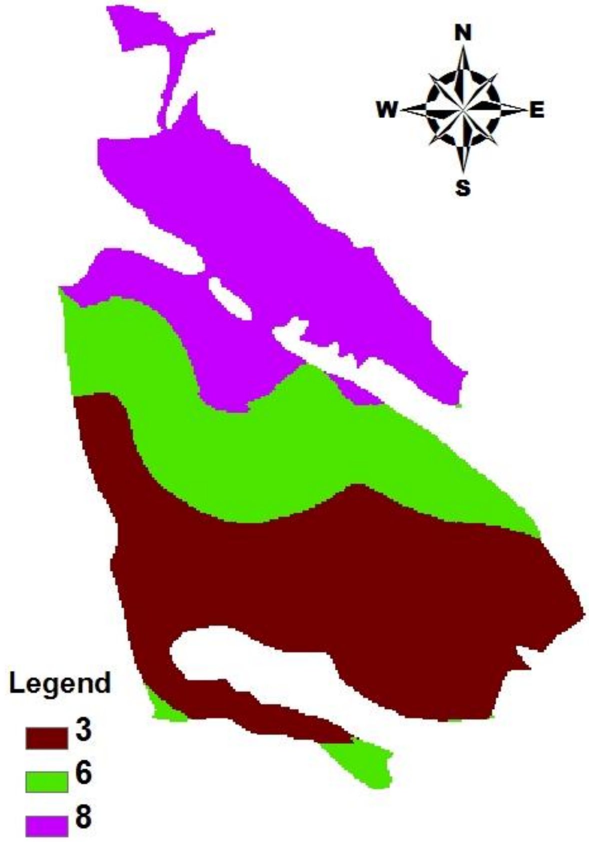

Figure 7. Classification and ranking of unsaturated region

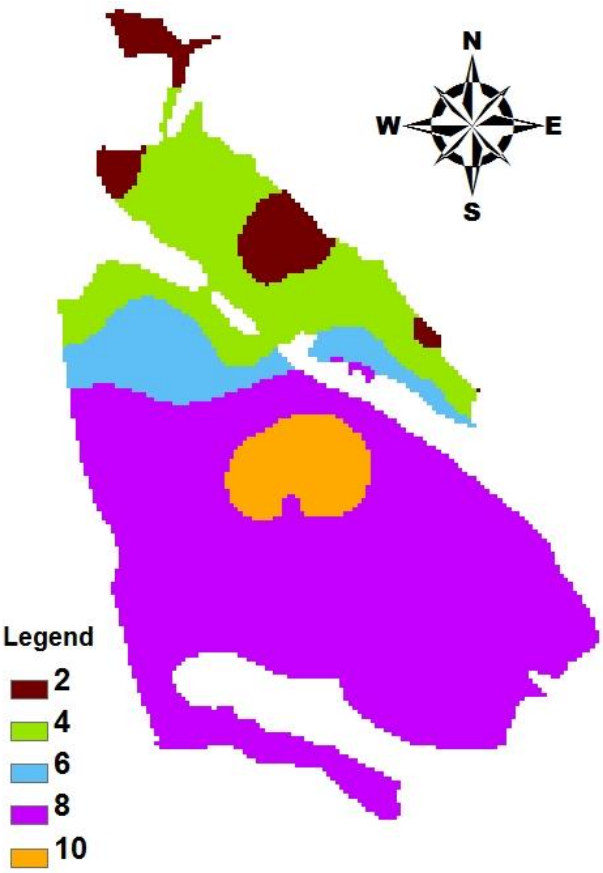

Figure 8. Classification and ranking of hydraulic conductivity

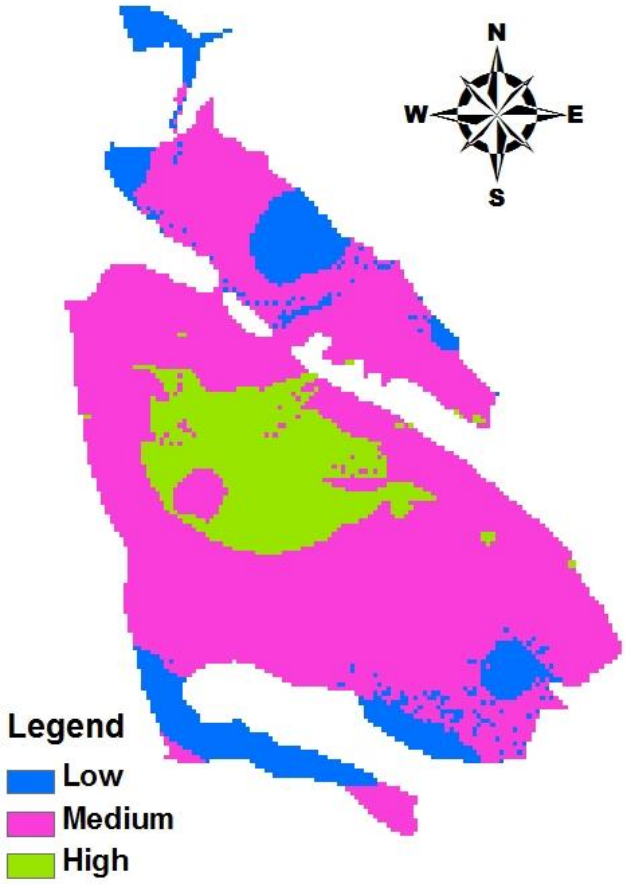

Figure 9. Aquifer Vulnerability by DRASTIC

4. Conclusions

In this study, the area of the aquifer with the high vulnerability potential was identified. The remaining parts of the area were classified into low and middle risk of the vulnerability as well. The results of this study can be used for future land use planning and groundwater management in the study area. To reach the results with the further accuracy, it is recommended to use the other methods (such as SINTACAS, GOD, AVI, etc.) in future studies and compare them with the present and previous researches.

References

[1] J. M. Vias, B. Andreo, M.J. Perles, F. Carrasco, A comparative study of four schemes for groundwater vulnerability mapping in a diffuse flow carbonate aquifer under Mediterranean climatic conditions, Environmental Geology, 47(2005) 586–595.

[2] H. Azizian, E. Merufinia, Studying and Assessment of Vulnerability and local changes of Quality of Karaj plain Aquifer with DRASTIC Method, Biological Forum, 7 (2015) 244.

[3] M. Al-Fawwaz, Role of the Geologic Structures on the Aquifers Vulnerability in Arid Areas: Case Study from Swaqa-Ghabawi/Jordan, Jordan Journal of Civil Engineering, 4 (2010) 132.

[4] J.L. Ferreira, M. Oliveira, Groundwater vulnerability assessment in Portugal, Geofísica internacional, 43 (2004) 541–550.

[5] Y. Alwathaf, B. El Mansouri, Assessment of aquifer vulnerability based on GIS and ARCGIS methods: A case study of the Sana'a Basin (Yemen), Journal of Water Resource and Protection 3 (2011) 845–855.

[6] G.K. Anornu, A.T. Kabo-Bah, Evaluation of AVI and DRASTIC Methods for Groundwater Vulnerability Mapping, Journal of Environment and Ecology, 4 (2013) 126–135.

[7] S. Javadi, N. Kavehkar, M.H. Mousavizadeh, K. Mohammadi, Modification of DRASTIC model to map groundwater vulnerability to pollution using nitrate measurements in agricultural areas, Journal of Agricultural Science and Technology 13 (2010) 239–249.

[8] B. Abdelmadjid, S. Omar, Assessment of groundwater pollution by nitrates using intrinsic vulnerability methods: A case study of the Nil valley groundwater (Jijel, North-East Algeria), African Journal of Environmental Science and Technology, 7 (2013) 949–960.