Research Journal of Earth Sciences 4 (1): 01-04, 2012
ISSN 1995-9044

DOI: 10.5829/idosi.rjes.2012.4.1.1105

Evaluation of the Groundwater Vulnerability to the Pollution at the Middle Atlas Plateau (El Hajeb-Ifrane Region) Based on Drastic Model and GIS

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Abstract: The study of the vulnerability in areas susceptible to pollution of various kinds is a very important element in the management of water resources. Our study aims to map this phenomenon using GIS and modeling approach (e.g. DRASTIC) at the middle atlas (region of El Hajeb – Ifrane). This region occupies an important place in Moroccan territory, as well as its geographical location and its potential agricultural and water. The first data were acquired from different sources and converted to thematic maps through the use of GIS, because of the substantial mass of data needed for this treatment. The initial diagnostic reveals that it is a medium with a low topography and a karst lithology favourable to the development of high permeability may seriously affect the quality of groundwater.

Key words: GIS · Groundwater · Vulnerability · Pollution · DRASTIC · El Hajeb-Ifrane plateau

INTRODUCTION

Groundwater is an important renewable resource in the northern Middle Atlas. It is used essentially for drinking water supplies and agriculture. The gradual urbanization of the territory, the development of areas managed for agriculture, livestock and many other human activities threat the water quality without any supervision.

This study aims to assess the vulnerability of the groundwater in the plateau of El Hajeb – Ifrane to pollution using Geographic Information Systems. The study area is located in the plateau of middle Atlas, limited on the north by the plain of Sais, to the west by the sudden interruption of the plateau, to the south by the important line accident of Tizi-N'Tretten and to the east by the plateau of Immouzer. This plateau is characterized by the carbonate deposits of the Lower and Middle Lias. (Fig. 1a & 1b)

MATERIALS AND METHODS

The study of the vulnerability of groundwater to pollution consists of a compilation of data from several disciplines such as topography, geology, hydrology, hydrogeology, climatology. So many maps have been used as: topographic maps of El Hajeb, Ifrane and Azrou at 1:50,000, geological map of El Hajeb at 1:100,000, the piezometric map, in addition to the use of the Digital Elevation Model (DEM) of the study area.

The method for evaluating the vulnerability of groundwater is to assess the different parameters involved in the vertical transfer of the pollution from the surface [1] including:

Groundwater recharge (from precipitation, watercourse, infiltration of irrigation water, etc.);

Nature and Soil Depth: Characteristics of the unsaturated zone (lithology, permeability, etc.);

Water Depth Relative to the Ground: The method adopted in our study is the DRASTIC method. This is the standard most commonly used. This is a general method used in the first analysis, because it allows the mapping of large areas. The parameters considered by this method for the establishment of a vulnerability map are seven:

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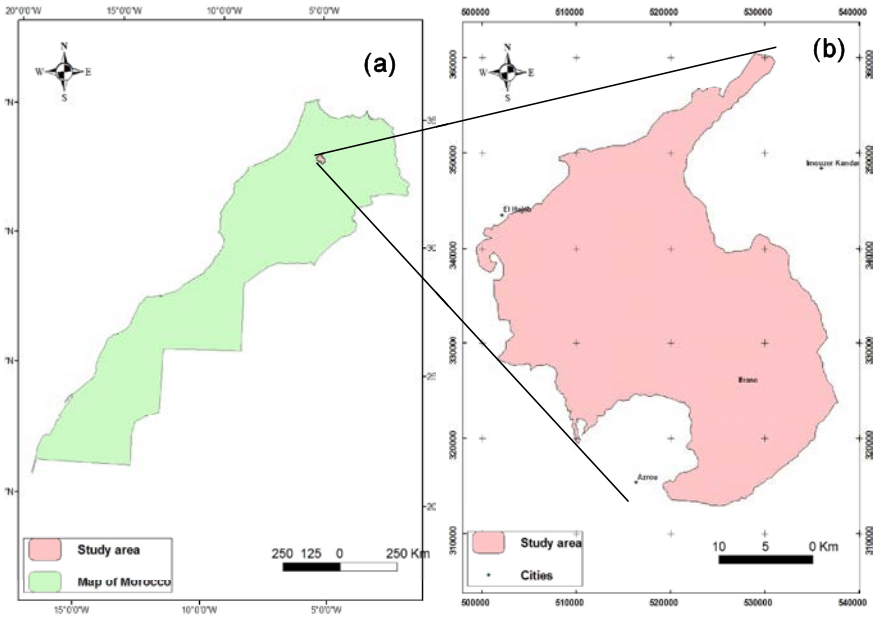

Fig. 1: (a) The location of the study area on the map of Morocco and (b) the map of the study area.

The depth of grounwater (D),
The recharge (R),
The aquifer nature (A),
The soil texture (S),
The topography/slope (T),
The nature of the vadose zone (I),
The permeability (C).

This method is to assign a note from 1 to 10 and weight from 1 to 5 for each parameter. The desired final vulnerability index (ID), is obtained by summing the products of the ratings of seven settings by their respective weights:

$$IV = D_n * D_w + R_n * R_w + A_n * A_w + S_n * S_w + T_n * T_w + I_n * I_w + C_n * C_w$$

(Where D, R, A, S, T, I, C the seven DRASTIC parameters, n is the note of the parameter, w its weight).

RESULTS AND DISCUSSION

In order to develop the vulnerability map, several thematic maps have been drawn:

The depth map of groundwater has been established by subtraction between the piezometric map [2, 3] and the DEM map. This map shows the levels of shallow (less than 20 m), especially in the outskirts of the plateau, moderately high (up to 80 m) in the centre. This parameter alone can provide information on the vulnerability of the aquifer.

It was developed by performing a water balance of the study area. The aquifer is recharged mainly by direct infiltration up to 10-15 mm of rain. Based on the total area of the zone, the amount of infiltrated water is estimated at 10.96 million m3 per year.

Nature of the Aquifer: Considering the hydrogeology, the plateau of El Hajeb – Ifrane is formed by a karstic aquifer, consists of dolomite and dolomitic calcareous of the Lower and Middle Lias. The movement of infiltrated water depth is at the origin of the outcrop surface sources at the flexures.

Nature of the Soil: Soils in the study area are dominated by alternating layers of type isohumic, magnesium and limestone very favourable for agricultural activities with a high average depth. In the upstream direction, soils become low quality with a variable depth.

The slope is an important indicator to runoff or infiltration of precipitation. It was developed from the DEM of the study area. In general, except along of Tizguite river, where the slope exceed 10% in some cases, the other lands are low slope (less than 2%).

Lithology of the Aquifer: The study area is located on a platform dominated by tabular Liassic carbonate structures. The stratigraphic distribution is essentially characterized by the transition from Paleozoic to the Middle Lias with the outcrop Miocene on the northern fringes of the plateau [2].

Depth map (Fig. 2)

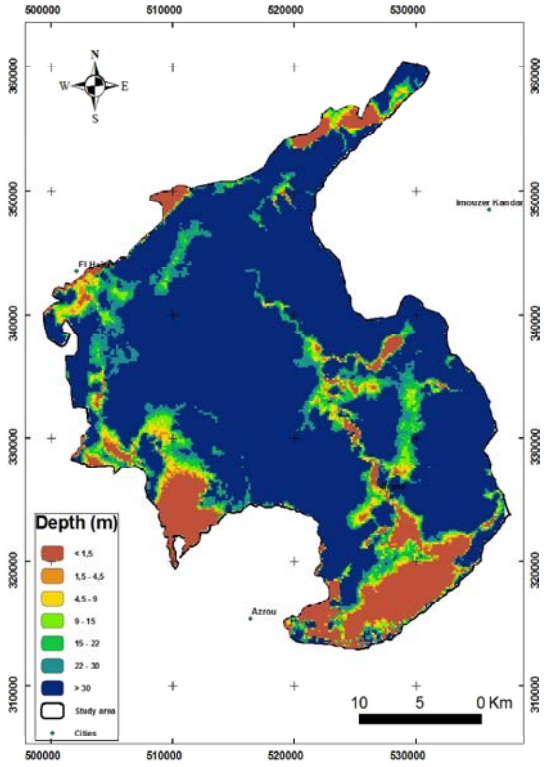

Fig. 2: The depth map.

Recharge map (Fig. 3):

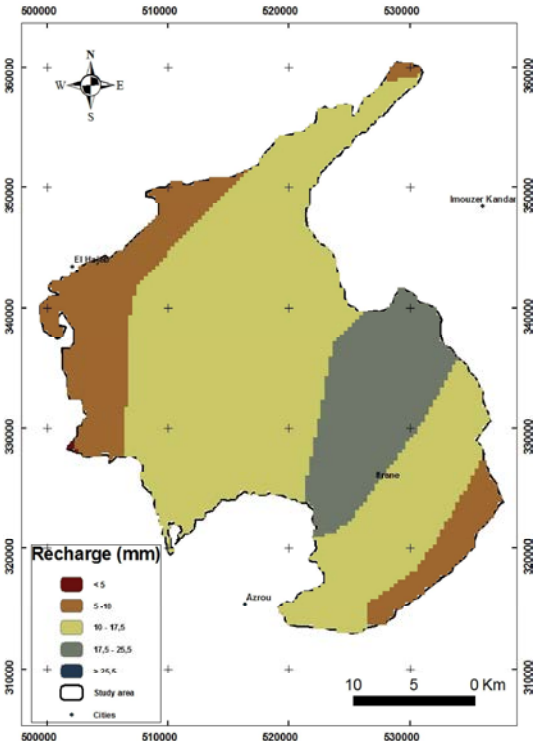

Fig. 3: The recharge map

Topography (Fig. 4)

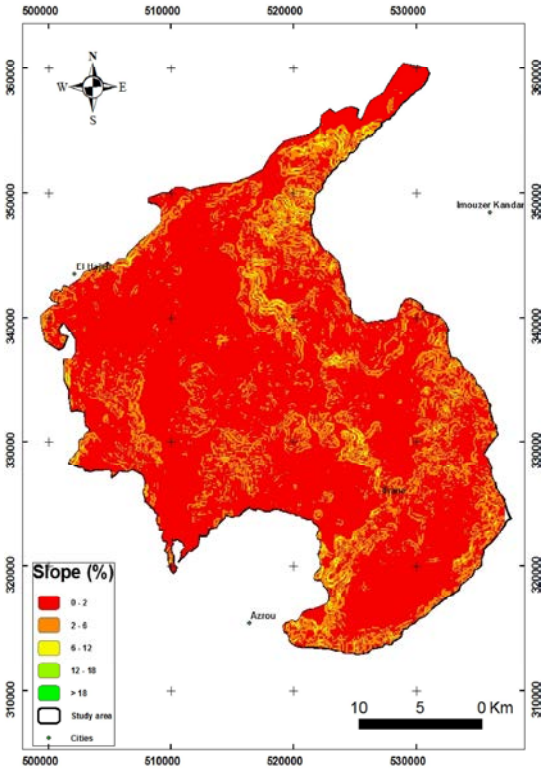

Fig. 4: The slope map.

3-7 Permeability (Fig. 5):

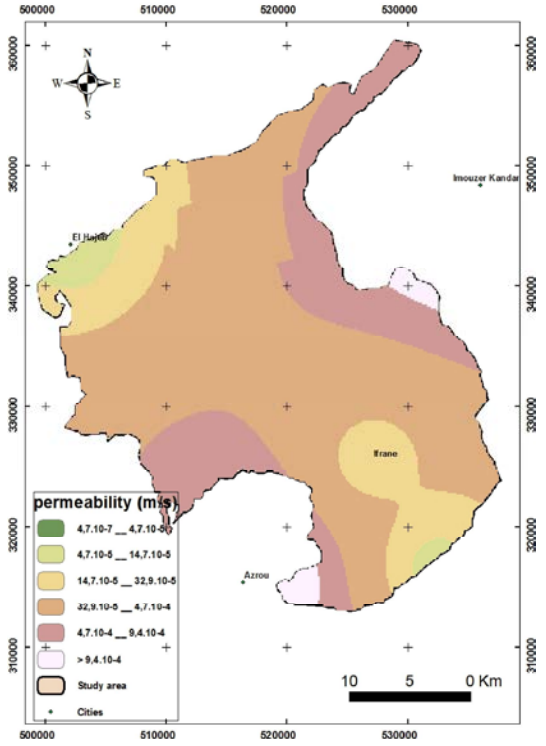

Fig. 5: The map of permeability.

It expresses the ability of the geological formations to transmit water with potential pollutant at the saturated zone under the effect of a hydraulic gradient. Through the existing drilling data in the region (lithology), it appears that areas with the highest permeabilities are located on the SW-NE diagonal axis which coincides with the direction of the major group of fracturing dominant and which is part of the accident Tizi N 'Tretten located at the southern limit of our study area.

CONCLUSION

This study allowed mapping spatially the parameters for assessing the vulnerability of groundwater. Based on the elements identified above, an initial analysis of the situation of the causse of El Hajeb – Ifrane inferred that vulnerability to pollution of groundwater is more important in the south where the majority of parameters are favorable (low slope, karstified and fractured aquifer, high permeability,...).

The completion of the study by the development of the vulnerability map of the groundwater in the region will be a very important tool for the diagnosis of water quality through the mapping of the affected areas and / or at risk of pollution. The resulting maps are an important tool to help protect the aquifer and also for the proper management of water resources and soil of the region.

ACKNOWLEDGMENTS

We would like to thank the Hydraulic Basin Agency of Sebou (ABHS) cooperation and have at our disposal the database necessary for the completion of this work. We also want to thank our reviewers, who took the time to carefully read what we wrote and make corrections, additions, suggestions and improvements to our original work.

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