NEW APPROACH TO ESTIMATE GROUNDWATER RECHARGE IN SEMI-ARID AREA: CASE STUDY OF DJELFA

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Abstract

Groundwater recharge (GWR) is the most solicited resources to satisfy the different needs it used to supply population daily needs in water, and for Agricultural and industrial activities. Estimation of this GWR is very necessary to an actionable management plane of water resources; serval factors are control Groundwater recharge phenomena (B. R. Scanlon et al, 2006); Geological and soil characteristics of the study Area, Slope and topographical parameters of the area, Hydro climatic conditions (Precipitation, Surface runoff and Evapotranspiration)

In this paper; a new model was proposed for groundwater assessment in semi-arid area. This model is based on three parameters (temperature, precipitation, and geological factor); this model was tested in semi-arid area in the region of Djelfa (Algeria).

Keywords: Groundwater Recharge, new model, groundwater management, semi-arid area, temperature, Precipitation, geological factor;

I. Introduction

The insufficient surface water resources make the exploitation of underground water the most requested operation in semi-arid area, to meet the water needs for drinking water supply, irrigation, and also for the industry. One of the real problems in hydrogeology is the quantitative assessment of groundwater recharge (J. V. BONTA et al, 1999) which becomes a real concern for groundwater resources management.

Several investigations are launched to establish a reliable and efficient method for fast and robust assessment of water reserves in geological formations that can be hydrogeological aquifer (B. R. Scanlon et al, 2011).

Several techniques are applied in the world for estimating groundwater recharge, includes hydrological methods, chemical, isotopic methods, hydrogeological modeling (Kinzelbach et al, 2002); the Use of only one of these techniques it is not sufficient to give an approach estimation of Groundwater recharge. We try in this paper to estimate GWR by using new method to establish an action plan for management of water reserves.

The impact of changing weather patterns on water resources is high, it is observed in irregular rainfall, increasing air temperatures, and thus the increase in evapotranspiration which decreases recharge in the aquifers above or geology does not promote rapid infiltration cases majorities of aquifer in semiarid climate zone (B.J.M.Goes, 1999).

II. Material and methods:

The principle of this study based on simulation of the hydro-climatic parameters (temperature and precipitation) to establish a mathematical model of two variables in the annual time scale. This model was calibrated by coefficients which depend on litho-logy and geology of area.

1- **Formulation of the model**

The model used is derived from the water balance, it takes into account two hydro-climatic parameters (temperature and precipitation), and lithological parameters depends on the lithology of the studied field.

The general equation of this model is given as follows:

$$\mathrm{GWR} = \left(\frac{\mathrm{T}^{0,2} \times \mathrm{P}}{\varphi}\right)^{0,478} \text{ (eq.2)}$$

With GWR: groundwater recharge given in mm; P: annual rainfall; φ geological factor depend to geological morphology.

φ was determined approximately using the following equation:

$$\varphi = 10.136 \times e^{-0.402 \times Cp} \text{ (eq.3)}$$

With

φ: Coefficient dépend de la lithologie.

Cp: Infiltration coefficient given in %; depend to the geological structure.

The different value of Cp are given in % for different type of Rocks given by G.Castany, 1982; and modified by Banton, 1997

Table-1: Coefficient of Infiltration given in % for some type of Rocks (Banton, 1997 & Castany, 1982).

TYPE OF ROCK	COEFFICIENT OF INFILTRATION %	INFILTRATION
Gravels;Alluvium	6	HIGH
Sandstone ;Sand ;Sandy Loam ; Silt ; Clay Loam ; Clayey Sand ;Marl ;Sandy Clays	4	MEDIUM
Limestone; Crusting; Dolomite	2	LOW
Gypsum ;Clays ; Silt ; Soil Of Sebkhas	1	VERY LOW

2- **Study Area**

Geographically the area of study was located at 300 km from the capital of Algeria (Fig.1) , 2° and 5° East longitude and between 33° and 35° North latitude; it was characterized by a moderate rainfall (less than 400 mm in general), an average annual temperature (less than 16°C).

Geologically The Djelfa are formed with different geological deposits, from the geological cross section and the geological maps; our study area are composed from the Barremian essentially consisting by an alternating sandstones and Sandy clays intensely cracked, the Barremian form the major aquifer capacity, it thick from 1500 to 2000 meters. The lower Albian consisting primarily of continental sandstones with a dense cracking there is the place of the emergence of multiple sources. Its thickness is about 400 meters, it is one of the aquifers most important. The Turonian is limestone majority with marls alternations in its uppermost part. The density of these limestones fractures indicates that the aquifer is Karst type.

Its thickness is 450 meters. The Mio-plio-Quaternary mainly sandy, silty and conglomeratic is surmounted by a calcareous crust ; due to it is low permeability, the Mio-plio Quaternary is operated by small wells, its thickness is variable (250-300 m). (B.Chibane et, al, 2015).

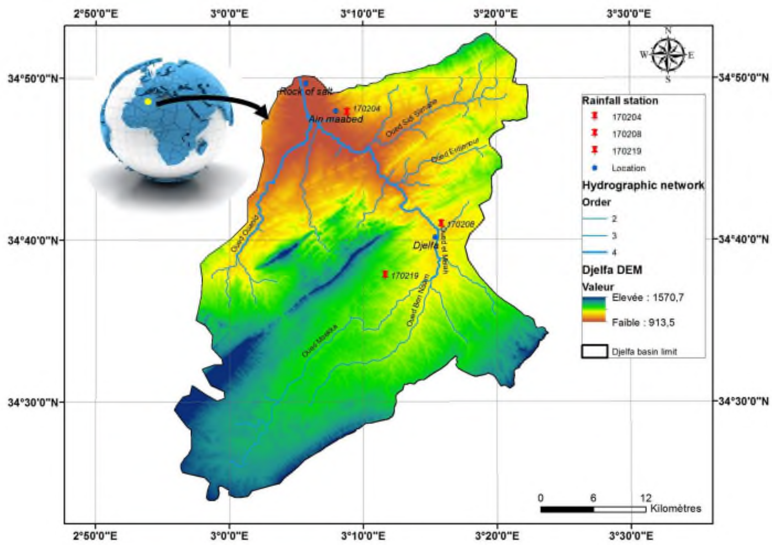

Fig.1 study area

III. Results and discussion

Initially the application of this model in the study area let us to quantify approximately the average annual recharge rate. The variation of GWR in function of rainfall and the geological coefficient are given in the graphic in Fig.2.

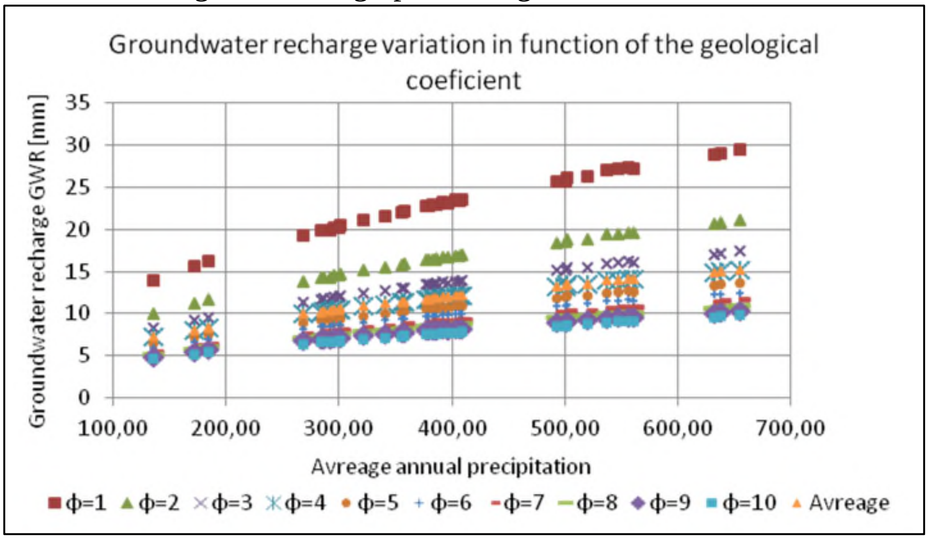

Fig.2 variations of GWR in function of precipitation for (φ vary from 1 to 10).

Analysis of the curve obtained by application of this model let us to appreciate that the variation of GWR in function of rainfall; follow a power fit model with a very good fitness coefficient.

The recharge capacity vary from low to high recharge, this capacity is depend to the geological characteristics of the area. We have formulated the geological characteristics by using the infiltration coefficient, given by Castany, 1982 and modified by Banton in 1997.

In this work we have developed also a relationship between the Infiltration coefficient and the geologic factor φ; this relation is described by the equation (eq.3).

Presentation of the annual variation of GWR in function of Rainfall and average annual temperature let us to trace a 2D contour map; to give a clear visualization of the game of Recharge in semi-arid area . The 2 D contour map are showed in the Fig.3

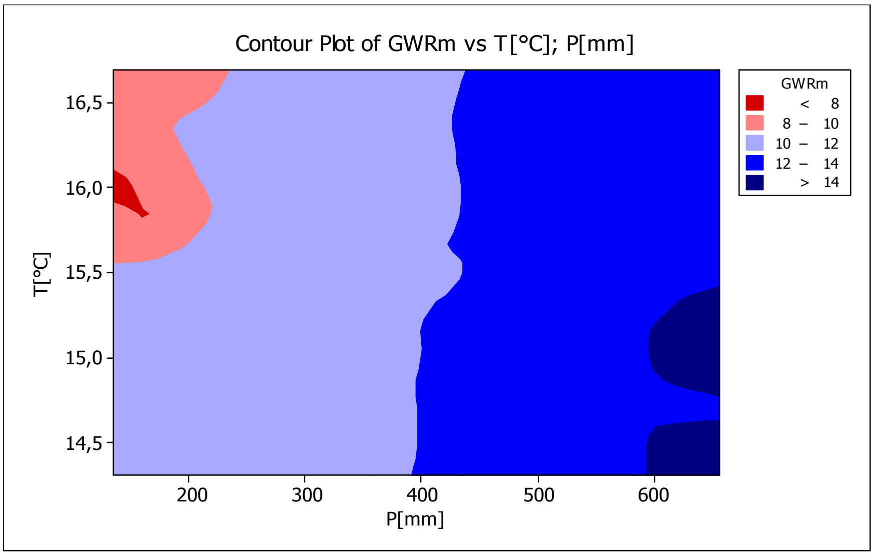

Fig.3 GWR variations in function of precipitation and temperature

According to the 2D contour map, we can distinguish clearly the kind of recharge type in function of rainfall and temperature variation. Three major class can be extracted from the map in Fig.3; the first class correspond to the low recharge (GWR < 10 mm), the second class correspond to the medium recharge (GWR <14mm), the third class correspond to high recharge where (GWR>14). The groundwater recharge is controlled by the rainfall intensity and duration, the soil capacity (Infiltration coefficient) and the temperature amplitude.

IV. Conclusion

In this research, a new model was developed and tested to evaluate the groundwater recharge in semi-arid area; this model is depend to three parameters; hydro- climatic parameters (Rainfall and temperature), and geologic characteristic factor. The average annual recharge estimated for the region in Djelfa with a mean annual rainfall (398 mm) and annual temperature (15.5 °C) is about 11.88 mm/y. This region is characterized by medium recharge, application of the strategic management of groundwater resources is very recommended in this area, where the rate of annual groundwater recharge can't be sufficient to satisfy the increased water demand.

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