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Hydrogeological and Hydro Chemical Evaluation of Groundwater in Karbala Region Using Geographic Information System (GIS)

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K E Y W O R D S

Groundwater, GMS, Dibdiba Formation.

A B S T R A C T

The study area is located in the holy governorate of Karbala, Iraq; the research studied a predictive mathematical model of groundwater within Dibdiba Formation and by fifty (50) wells distributed randomly within the boundaries of the study area, all of them fall within the unconfined aquifer. Likewise, there is no component to direct the activity of these wells, where a mathematical model for the study area has been developed using the groundwater system modeling program (GMS v.10). The area was divided into a grid where the dimensions of a single cell ranged from 250m×250m. The model of the steady flow state was adjusted utilizing pressure driven conductivity extending from 9 to 15 m/day with a 0.15 storage coefficient to match the groundwater levels measured with the calculated groundwater table. The model was run for unsteady flow condition in the first scenario with fifty (50) wells and five (5) years. The drawdown in the groundwater tables ranged between (0.05-1.05) m. In the second scenario, the model was run after adding thirty-six (36) wells for five (5) years, groundwater limits 0.15-1.15 meters. The drawdown values are concentrated near wells sites, and the drawdown decline as we move away from the sites of these wells and this reflects the nature of the water reservoir located in the study area, which is characterized by high production where compensation resulting from the operation of the wells decline rapidly by the reservoir. Therefore, the values of the drawdown in elevations appeared very low. The study also showed the possibility of drilling additional wells in this area depending on this model to benefit from them in the future for different uses.

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1. Introduction

Groundwater, which assumes the first job in local water assets, is utilized for various purposes, for example, modern, rural, and household purposes. The board of this asset is imperative to satisfy the expanding need for water. Nowadays, with expanding populace and life gauges, there is a developing requirement for the usage of groundwater assets. In any case, because of some human-centric causes, for example, impromptu urbanization and industrialization, the number of groundwater assets keep on diminishing [1]. Along these lines, practical administration procedures ought to be created by chiefs to use the groundwater assets ideally. The study area is essential because it has significant storage of groundwater evidenced by many flowing wells [2]. The groundwater is mainly utilized for industrial purposes due to the existence of several factories for the production of washed sand and fractionalizing gravel. Besides, the agricultural activities where there are many farms as well as the presence of artificial lakes for fish breeding, which supply its water from groundwater by the drilled wells in the area. The groundwater modeling is the management tool for deciding to provide information about the groundwater system concerned and the future response of the system due to management decisions. Generally, a model is a valuable predictive tool designed to represent a simplified version of reality if it is properly constructed. The more detailed and complex the model is, the better it may represent the real situation. It is, however practically impossible to correctly represent all-natural processes included, and consequently, all groundwater models are simplifications of real situations [3].

2. Desecration of the Study Area

The study area located in Karbala governorate, bounded by Al- Razzaza Lake northwest and the AL Euphrates River northeast, a scarp called Tar Al-Sayyed west, Al-Najaf city south and by Karbala city east as shown in Figure 1 [4]. The study area of 1773.5km2 is considered one of the crucial parts of the city of Karbala because there are many industrial and agricultural investment projects [5].

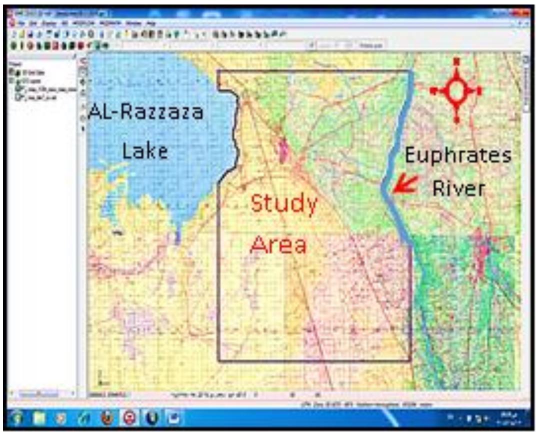

Figure 1: Model boundaries and grid design

3. Material and Methodology

The methodology of work can be divided into two categories: Firstly: The data of the investigated area was provided by the General Administration of groundwater in Karbala governorate, which includes climate data, topographic maps, hydrological data for fifty (50) existing wells, and general information about the area [4]. Secondly: State the suitable software for building up the study model such as Groundwater Modeling System (GMS) software. The GMS is used to simulate the steady and unsteady states of flow based on two-dimensional finite difference techniques [1].

4. Use of Numerical Model

The numerical model of the investigation zone was planned as a matrix comprising of 186 lines and 157columns. The total quantities of cells are 29202 incorporates the dynamic 28376 and latent cells 826. The extent of the model was picked to cover 1773.5 km2, and the thickness of the layer is around 60 m, and for this was taken one layer. The scientific model of the investigation zone was structured as a lattice comprising of 186 lines and 157 segments. The cell region is (0.063) km2, as appeared in Figure 2. A few elements were considered in this structure: the nature of the change in water-driven properties, the pressure-driven inclination, and the circulation of wells in the zone and the accessibility of data on groundwater levels at explicit focuses.

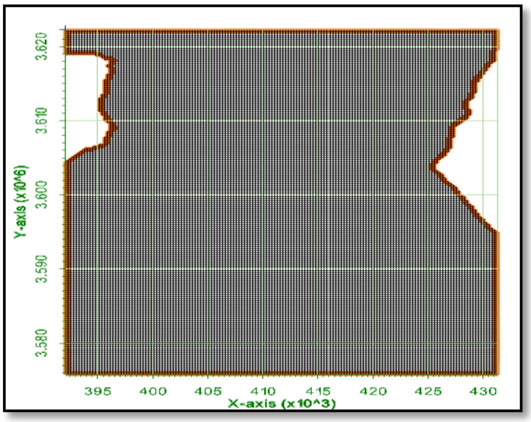

Figure 2: Grid design study area

I. Steps to implement the GMS model

The GMS programming is executed all through the following situations :
Situation one: This situation is running for the regular state of the groundwater without existing any well.

1) Steady-state (without wells) an unfaltering state stream is the initial phase in recognizing the conduct of the framework under typical conditions. This process helps to calibrate the model by comparing the results of the study state with the natural groundwater map in the region to achieve the closest match between the two maps.
2) Unsteady-state (with pumping wells) the operation results of steady-state are used as the initial condition for the unsteady-state in which existing wells (50). The models were operated for five years and take a reading every six months and determine the amount of drawdown in groundwater during that period
3) Scenario two: Unsteady state (with suggested pumping wells)

Based on the results of the drawdown in groundwater levels from the first scenario, the areas that have been reduced a little in the groundwater levels were used underground water through the drilling of additional wells where 36 additional wells have been proposed that have been distributed in these areas.

II. Initial and boundary conditions

Contingent upon the provincial groundwater stream example of the unconfined spring and the field estimations of the groundwater head in the wells of the new current town of Karbala city according to [6], the outskirt zone of unfaltering territory limit conditions were picked far enough from the well field impact to be consistent heads. These active headers ranged from 45 m in the center, and their values ranged outward to reach 25 m at the outer boundaries of the area in Figure 3.

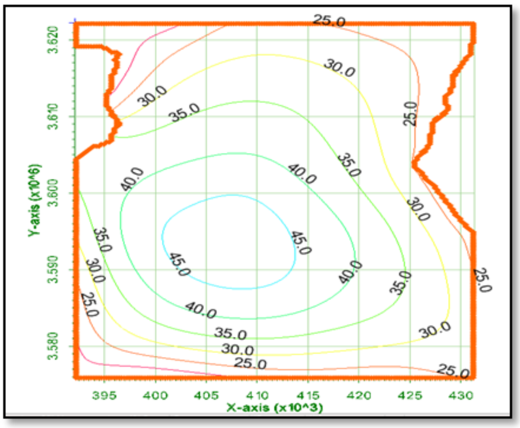

Figure 3: Initial groundwater levels in the study area (m.a.s.l) (according to [8])

5. Input Parameters

A few info parameters were essential to be given as starting qualities to use for the reproduction of consistent and precarious state stream conditions. Water driven properties of the spring frameworks were input parameters that were necessary to be provided as initial values in order to use for simulation of steady and unsteady state flow conditions. Hydraulic properties of the aquifer systems were estimated using pumping tests analysis and lithology of the aquifer system, as follows:

I. Hydraulic conductivity

Initial values of aquifer hydraulic conductivity for confined aquifer were evaluated from pumping test results of wells within the studied area. These values were utilized as initial parameter values of the model. The values were altered later during the calibration stage through trial and error, which has been accomplished by hydraulic conductivity, preparing contour maps for the values, as shown in Figure 4 [1].

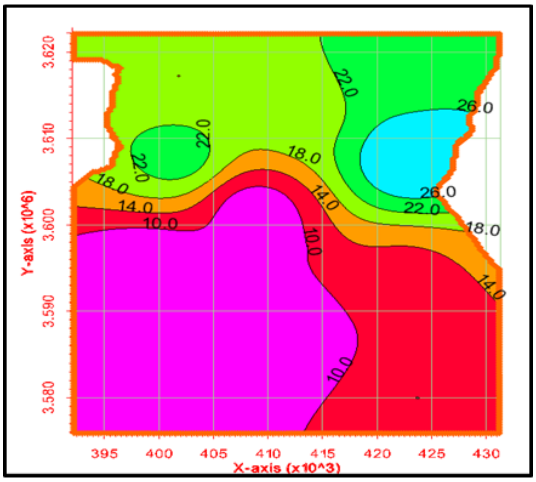

Figure 4: Hydraulic conductivity contour map (m.a.s.l.)

II. Storage coefficient

The unsteady simulation requires an initial evaluation for the storage coefficients in the confined aquifer. Contour map of the storage coefficient values, Figure 5, was drawn in surfer software and used as input data for GMS. [1]

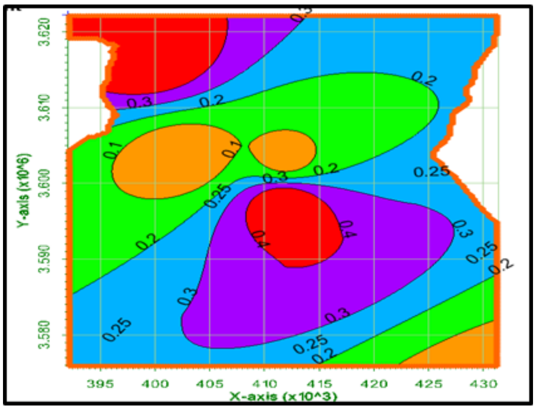

Figure 5: Storage coefficients contour map (m.a.s.l)

6. Steady State Flow Simulation

A consistent state stream is the initial phase in distinguishing the conduct of the framework under ordinary conditions, and utilization the aftereffects of this condition as primer contributions to the insecure state stream, which is the reason for the long-haul spring conduct with different siphoning tasks.

After the establishment of all things considered and contributions of the numerical model, the model was kept running under stable stream conditions up to the field levels enlisted in the investigation territory, and the levels got from the model to the most elevated amount of conformance. This procedure regularly requires changes in the estimations of the pressure-driven conductivity or network, the measure of water entering the model limit is the perfect bolstering of the layers of the spring and up to the levels to the match Figure 6 demonstrates a guide of the comparability of the field springs with the inferred numerical model for relentless state. It is noticed that there is a decent broad accord for these levels mirroring the general pattern of stream. Note that it is hard to get an ideal match between the fields and determined because the model depends on numerous hypothetical suppositions. It is additionally hard to have a porous media with similar qualities on which the model is based and similar presumptions apply.

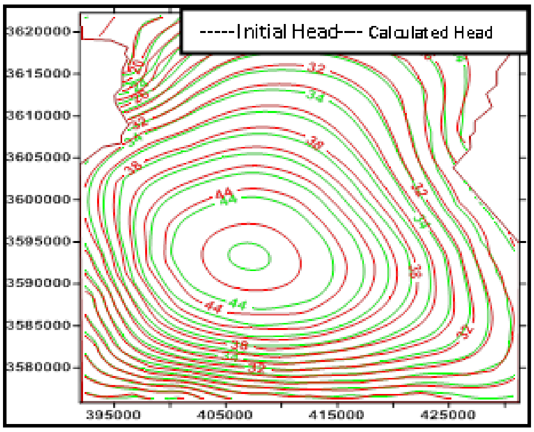

Figure 6: Initial and calculated head in the area of study for steady state simulation

7. Unsteady State Simulation (with pumping wells)

The unsteady state simulation is the most significant advance in communicating the conduct of the spring because of its effect on siphoning tasks as it gives a long-haul impression of this conduct.

The estimations of the subsequent leaders of the standard model for the constant stream state were utilized as essential contributions to speak to the flimsy stream, and the wells in the demonstrated region Figure 7 were worked. Concerning the limit conditions, the external limits of the model were picked as a steady head. The utilization of these limits to speak to the temperamental stream state is just if the contemplated framework is a piece of a bigger spring, gave that the limits are picked away from the impact in the seepage territories, when the outside of the spring matches any water body, for example, an ocean or lake and the remainder of the phones were viewed as factor [6]

Because of no intermittent readings information of the field springs during the activity of dove wells in the zone and for extensive stretches of time we were not be able align the model under this case yet the model has worked with the (50) siphoning wells for a long time. The operating results of the model showed that the value of the drawdown in groundwater levels during the period of operation ranged between 0.05-1.05m where it was obtained in areas where the presence of wells is concentrated while the other areas of the study area showed a very low drop in ground water levels as shown in Figure 8.

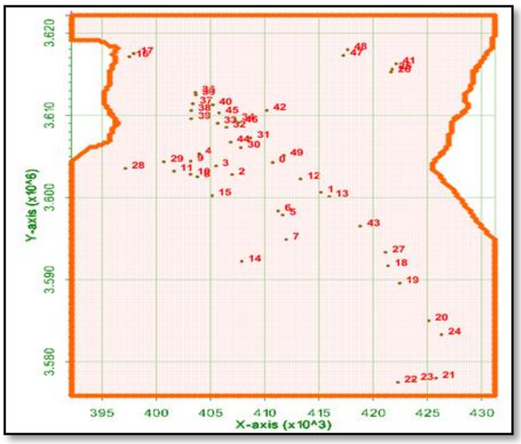

Figure 7: Pumping wells locations in steady area

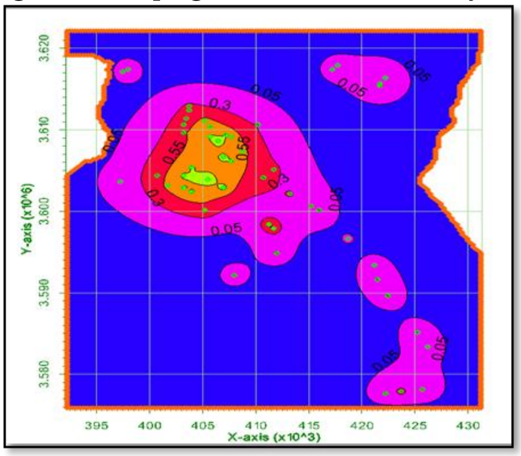

Figure 8: The drawdown of groundwater level after 5years of pumping

8. Unsteady State Simulation (with suggested pumping wells)

Based on the results of the drawdown of groundwater from the previously unsteady state, areas that decreased slightly in groundwater levels were used for groundwater use by drilling additional wells, with 36 additional wells being distributed in this area as show in Figure 9. This model was run for five years, and the extent of withdrawal was observed in the study area. The expansion of the area of the reduction area was observed near the area where the wells were concentrated, and the estimated decrease in groundwater was between (0.15-1.15) m, as shown in Figure 10.

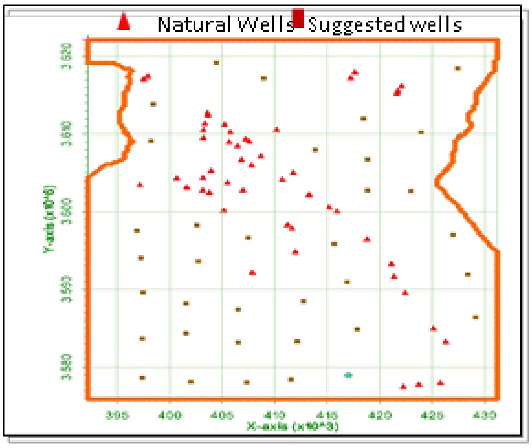

Figure 9: Natural and suggested pumping wells location

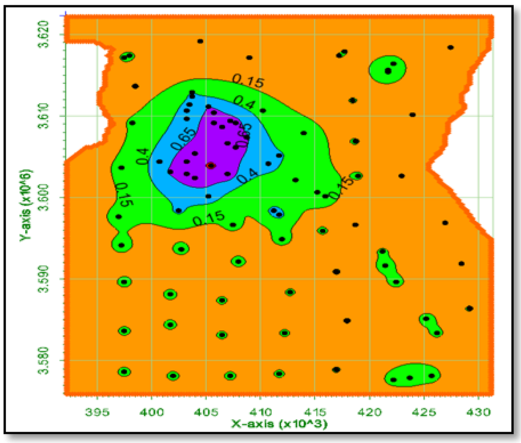

Figure 10: Drawdown of groundwater level after 5 years with suggested wells

9. Conclusions and Recommendations

The main conclusions of the theoretical work of this study can be summarized as follows:

1. The operational results of the model showed that the value of drawdown in groundwater levels during the five-years ranged between 0.05 - 1.05m for the first scenario with 50 wells obtained in areas where wells are concentrated contrasted with different zones of the investigation territory.
2. The operating results of the model showed that the value of drawdown in groundwater levels during the 5 years ranged between 0.15 - 1.15m for the second scenario after adding 36 wells to the wells in the region of 50 wells.

Some recommendations for future research are proposed to continue the research on the topic undertaken in this study. The suggestions are as follows:

1. Due to the shortage of field data, several pumping tests are needed for proper measurements of field transmissivity and storage coefficient.
2. It is recommended to conduct a study to define a proper distance between one well and another to achieve water balance and to avoid drought.
3. Flow-Transport model can be developed to simulate flow and solute transport in the area of study.

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