IASJ
المجلات الاكاديمية العراقية

Tikrit Journal of Pure Science
ISSN: 1813 – 1662 (Print) --- E-ISSN: 2415 – 1726 (Online)

Journal Homepage: http://tjps.tu.edu.iq/index.php/j

Applying a mathematical model to simulate the ground water reservoir in Al-Alam area /Northeast Tikrit city/Iraq

Yasir Ahmed khudhair, Sabbar Abdullah Salih , Ghazi Atiya Zarraq

Applied Geology Department, College of Science, Tikrit University, Tikrit, Iraq

https://doi.org/10.25130/tjps.v26i3.143

ARTICLEINFO.

Article history:

-Received: 1 / 11 / 2020

-Accepted: 26 / 12 / 2020

-Available online: / / 2021

Keywords: groundwater, AL-Alam region, Groundwater simulation, Hydrology

Corresponding Author:

Name: Yasir Ahmed khudhair

E-mail:

Tel:

ABSTRACT

In this study, the water table in reservoirs in the Al-Alam area was studied for the year 2019. The water table was taken for 104 wells that covered the study area, except for the region near the Hemrin anticline, because it was impossible to reach for safety reasons. It was found that the higher water table North Study area near the Hemrin anticline and the levels decreased towards Al-Shari playa. A simulation of the aquifer was made after the introduction of the water table, the hydraulic properties of the area, and the depth of the reservoir. Three hypotheses were made to simulate the aquifer within one year by placing several virtual wells with constant drainage and the number of fixed operating hours during the year. to know the amount of water that leads to the depletion of the aquifer and the safe drilling distance of the aquifer. For the aquifer not to reach the stage of over-pumping and depletion, as several hypothetical wells have been placed in a manner that approximates the reality of the study area, Through a questionnaire on the number of working wells and relied upon in the study area, they were from about (250-350) wells. (200 wells, 300 wells, 400 wells) with constant discharge and operating hours during the year. As the well was operated according to the policies set by the Ministry of Agriculture with a discharge of (7 liters/second) for a period of (8 hours/day) for a period of (22.5 days/month), which is equivalent to (270 days/year) that is, at the disposal of (54432 m3 / year) for each A presumed well, to know the impact of the reservoir, and It was found that drilling 200 wells with a distance of 1 km2 between one well and another is considered safe and that drilling 300 wells or 400 wells in the study area leads to the depletion of the aquifer.

Introduction

More than a third of the water percent that humans use around the world comes from groundwater. In rural areas, the percentage is higher than that. Half of the world's drinking water is from groundwater[1].The scarcity of surface water resources is the main reason for exploiting groundwater and maintaining the strategic storage of this resource[2] . The purpose of the mathematical model is to simulate the water aquifer and to develop several hypotheses to know the position of the reservoir and the quantities of safe water discharged from inside the aquifer [3]. Our Major problem is not only in the limited natural resources of water but rather in its. In mismanagement and estimation of their available quantities. This is why we gave special priority to studying the mathematical model in the study area.

The location of the study area

The study area is located in Salah Al-Din Governorate, northeast of Tikrit (Al-Alam region) It lies between latitude (35°01'03"- 34°36'21")North and longitudes (43°31'35"- 44°01'41") East.The area bounded on the north and east side by the Hemrin anticline. On the western side, it is bounded by the Tigris River, and the total area of the study area is about (1400) km2. As in the Figure(1).

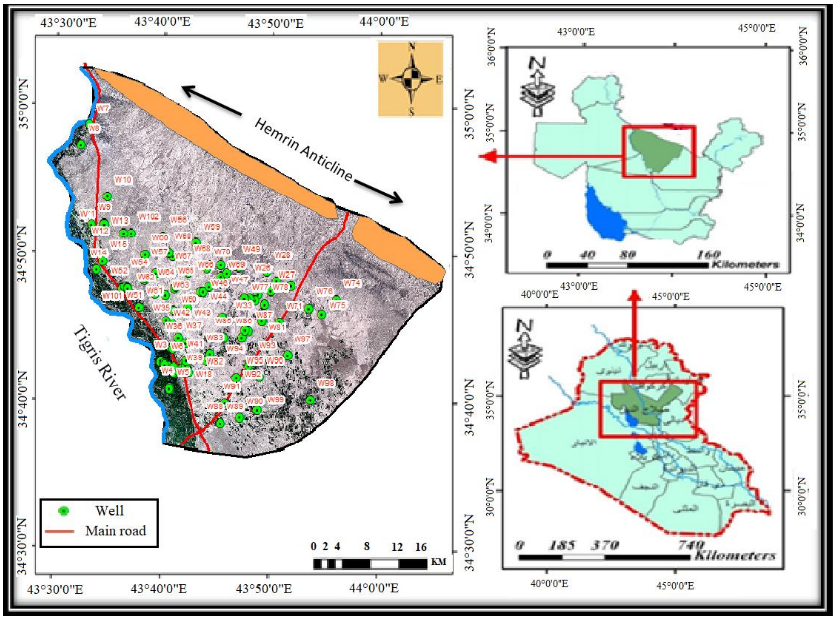

Fig. 1: Location map of the study area, with selected water wells

Geology of the study area

Fatha Formation (Middle Miocene):

Fatha Formation has Exposed on the surface near the Hemrin anticline consists of two members. The lower member represents a succession of marls, limestone, and gypsum layers that reflecting a shallow marine environment to the lagoon. The upper member consists of a sequence of mudstone, gypsum, and limestone that denotes a shallow marine environment to a semi-enclosed marine environment[4].

Injana Formation (Upper Miocene) :

Injana Formation is exposed on the surface near the Hemrin anticline contains the largest part of the aquifer in the study area and consists of a succession of sediments represented by sandstone, claystone. The environment of formation is continental except the lower part is a lagoon to continental[5].

Al-Muqdadiyah Formation (Upper Miocene)

Al-Muqdadiyah formation is exposed in the study area above Al-Al-Maibdi Village near the Hemrin anticline, Muqdadiyah formation consists of a sedimentation cycle of gravel sandstone, siltstone, and mudstone, The environment of sedimentation is a riverine [5].

Quaternary Sediments :

These sediments cover most of the study area is composed of sediments of gravel, alluvial fans, and gypsiferous soil, besides there are deposits of a flood plain. The quaternary age deposits form the aquifer adjacent to the Tigris river [5].

Field Work

The fieldwork is the Major aspect of the study, through which data was collect for depths using a water table detector, as the depths are subtracted from the height relative to the sea level to extract water table, then a map of the water table is made, where water table of 104 is collected. Wells distribute over the study area, except for the area near Hamrin anticline it was impossible to reach it.

Ground water levels

The water table were measured in (104) wells in the study area the location of each well was determined by GPS device, and the ground surface height (well head) from sea level was measured using (DEM) (Digital Elevation Model) using the global mapper As shown in Table 1.Water table in the wells ranged from (25.42 - 101.69) meters above sea level as in the figure(2) .

Table 1: Wells locations, water table and depths

No.	x	y	Depth	ELV.	W.T	No.	x	y	Depth	ELV.	W.T
W1	381102	3840330	8.33	88	79.67	W27	394440	3850984	76.91	120.75	43.84
W2	380386	3841294	7.1	87.3	80.2	W28	393869	3853516	67.83	126.56	58.73
W3	379256	3841834	4.71	87	82.29	W29	392624	3850537	67.23	117.97	50.74
W4	380452	3838551	5.84	88	82.16	W30	392171	3849812	65.32	111.63	46.31
W5	380475	3838419	6.58	86.2	79.62	W31	391580	3850057	67.7	112.23	44.53
W6	379647	3841674	5.32	88	82.68	W32	391145	3849758	65.21	117.32	52.11
W7	369471	3872517	10.61	112.3	101.69	W33	390801	3850024	63.25	115.47	52.22
W8	368232	3869944	10.57	108.4	97.83	W34	387805	3847569	60.3	108.24	47.94
W9	369765	3859663	11.53	101	89.47	W35	380901	3846778	53.72	109.73	56.01
W10	372025	3863286	35	130	95	W36	382693	3844158	38.32	104.09	65.77
W11	370290	3858745	10.77	91.4	80.63	W37	381671	3844938	38.3	107.85	69.55
W12	371524	3859710	18.83	113.2	94.37	W38	384867	3850898	54.22	111.42	57.2
W13	371508	3859609	18.79	113	94.21	W39	381843	3840617	9.71	98.13	88.42
W14	370511	3853816	5.53	93.4	87.87	W40	382628	3841470	27.07	104.01	76.94
W15	371342	3854899	17.74	95	77.26	W41	382745	3841925	33.2	107.51	74.31
W16	382016	3840533	11.69	95.3	83.61	W42	380016	3847143	31.34	115.1	83.76
W17	382269	3840507	14.42	103	88.58	W43	382953	3848877	35.21	106.2	70.99
W18	383194	3840532	30.45	108	77.55	W44	385177	3850873	46.12	115.7	69.58
W19	385740	3841996	31.26	107.5	76.24	W45	386020	3851473	44.7	115.2	70.5
W20	380696	3843538	6.74	94.7	87.96	W46	387638	3852829	54.3	117.7	63.4
W21	380915	3843604	7.81	92.32	84.51	W47	388524	3853327	62.3	124	61.7
W22	380957	3843459	11.3	98.34	87.04	W48	390097	3854080	70.3	124.2	53.9
W23	382381	3841456	19.21	105.38	86.17	W49	389691	3854197	69.76	130.4	60.64
W24	382104	3841058	14.3	101.53	87.23	W50	381114	3848500	30.31	114.3	83.99
W25	397156	3851603	79.95	120.93	40.98	W51	373960	3851331	9.25	98.8	89.55
W26	395193	3852195	71.8	123.29	51.49	W52	374391	3851466	11.22	95.7	84.48
W57	380989	3855530	54.32	117.2	62.88	W87	391324	3845809	68.89	106.89	38
W58	380442	3855953	47.23	111.8	64.57	W88	387517	3833800	42.68	92.54	49.86
W59	384282	3857238	60.42	118.1	57.68	W89	387521	3833814	42.67	92.56	49.89
W60	377106	3855709	42.45	120	77.55	W90	390123	3834518	52.92	90.94	38.02
W61	376326	3848903	7.35	96.3	88.95	W91	388185	3836492	49.09	99.86	50.77
W62	378519	3850630	30.05	115.6	85.55	W92	389717	3839735	52.34	96.42	44.08
W63	379922	3850463	31.04	113.7	82.66	W93	391812	3841731	56.4	103.51	47.11
W64	381140	3851316	32.62	111.8	79.18	W94	391315	3841367	60.03	96.09	36.06
W65	381398	3851524	32.15	112.1	79.95	W95	392870	3839835	59.98	93.2	33.22
W66	383426	3853601	47.65	118.3	70.65	W96	392868	3839855	59.95	93.13	33.18
W67	383075	3853373	34.43	103.5	69.07	W97	396686	3842643	70.08	92.15	22.07
W68	386304	3854358	56.56	116.7	60.14	W98	399930	3836929	58.71	86.38	27.67
W69	387623	3854329	62.52	115	52.48	W81	393167	3847037	70.03	109.48	39.45
W70	385732	3853974	48.32	115.2	66.88	W82	386136	3842777	39.89	108.82	68.93
W71	395599	3846959	72.31	107.36	35.05	W83	386199	3842829	40.02	108.08	68.06
W72	403561	3849356	82.1	125.32	43.22	W84	381104	3841210	3.47	85.91	82.44
W73	403579	3849111	94.28	121.11	26.83	W85	388064	3844932	62.56	108.43	45.87
W74	403548	3849820	94.32	126.34	32.02	W99	392950	3834801	56.61	90.15	33.54
W75	401513	3847965	85.52	106.94	21.42	W100	374766	3851362	11.28	99.46	88.18
W76	399672	3848780	62.32	118.6	56.28	W101	374686	3851281	11.36	101.92	90.56
W77	393602	3849269	67.18	112.83	45.65	W102	375288	3858526	49.64	126.04	76.4
W78	393567	3849230	67.13	112.11	44.98	W103	374153	3858477	54.79	122.03	67.24
W79	379760	3841482	5.35	87.72	82.37	W104	390916	3845911	36.8	106.46	69.66
W80	393242	3847064	69.9	109.46	39.56	W104	390916	3845911	36.8	106.46	69.66

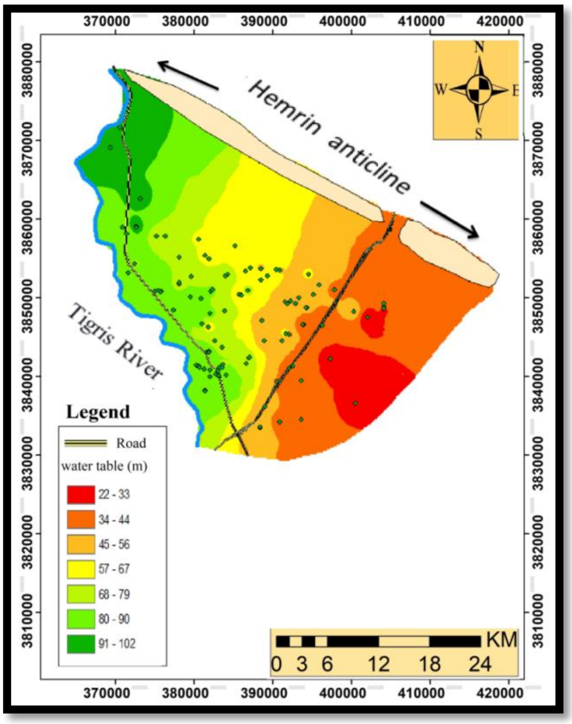

Fig. 2: The ground water level in the area study

The mathematical model

A model means as an approximate representation of or a real system or process. Through the mathematical model, it is possible to estimate the changes in the groundwater system in the event that one or more parameters change with time, which saves great financial efforts and costs, gives an opportunity to estimate future changes and allows for a more reliable comprehensive strategic plan. [6].

Modeling stages and information required to build a mathematical model

1- Preparing a base map
2- Determining the type of reservoir in terms of being confined, unconfined, or semi-confined [7].
3- Determination of hydrogeological and hydraulic properties.
4- Underground water levels.
5- Wells sites used.
6- Aquifer feeding.
7- Boundary conditions and giving each border a fixed value[8].

Mathematical model grid and Definition of Border circumstances for study area

The mathematical model grids were designed to correspond to the dimensions of the study area, the study area is Prepare sub-regional. A regular grid designed for the mathematical model for the study area is composed of (2805) square-shaped distributed over (51) columns and (55) rows, with dimensions of (1000 * 1000 meters (because of the area study large. Not all of these cells participate in the mathematical model, as some cells are outside the natural boundaries represented in the model. The natural boundaries of the region are represented by the Tigris River from the west and the Hamrin anticline from the north and east. And cells outside the study area were neglected The boundary conditions of the region have defined as each cell is represented by a fixed value, so a positive value (1) is known as the active cell (in which water table calculated), while a negative value (-1) defines the cell with a fixed level (as in lakes and rivers.), And value (0) identifies the inactive cell (that does not pass water). as in figure (3).

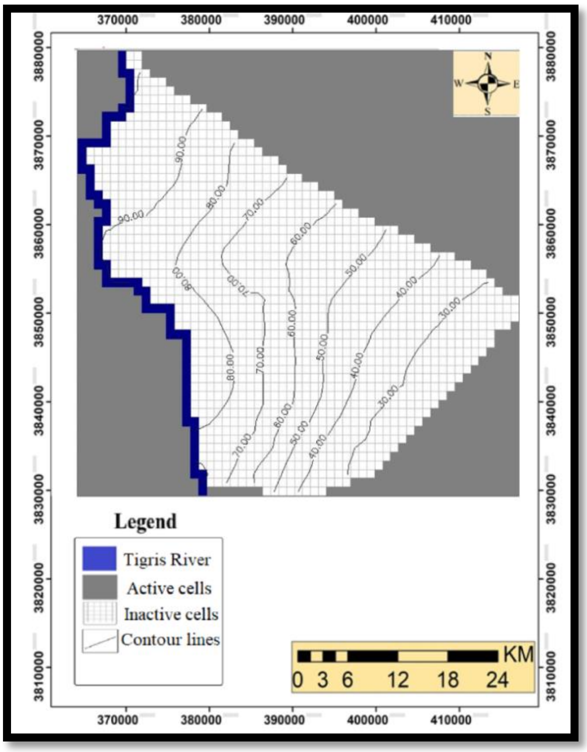

Fig. 3: The boundary conditions of the study area

Calibration and confirmation of the mathematical model of the study area

The main goal of calibrating the mathematical model is to improve the model to reach a real value very close to the field measured values. The model is calibrated by knowing the input parameters to which the model is sensitive, for example, groundwater models are calibrated with input parameters such as hydraulic conductivity and storage factor [9]. In this study, the model was run for about 240 times until a calibration of 98% was reached, which is considered an excellent percentage because the study area is large and 100% difficult to reach calibration.

Predicting and simulating the aquifer

This case is important to predict the status of the water reservoir and the quantities of water present in the aquifer at present using the data obtained during the conduct of the study, such as the water table that was received and making a level map as well as the values of hydraulic properties (conductivity, storage factor, hydraulic conductivity The height above sea level, reservoir depth, in addition to the levels of the Tigris River natural. Several hypotheses have been developed to simulate an underground water reservoir within one year, that is, for 12 months, to find out the amount of water that leads to the depletion of the reservoir and the safe drilling distance of the reservoir so that the reservoir does not reach the stage of over-pumping and depletion, as several hypothetical wells have been placed in a converging fashion. The number of invested wells in the study area reached (250-350) wells, through a questionnaire that was submitted to farmers. Therefore, Three hypotheses were developed with (200 wells, 300 wells, 400 wells) with a fixed discharge and the number of fixed operating hours during the year. A program of running the wells was set up according to the orders by the Ministry of Agriculture. That with discharge (7 liters/second) for a period of (8 hours/day) for a period of (22.5 days/month), equivalent to (270 days/year) that is, with (54432 m3 / discharge) One year (for each well it is assumed to know the impact of the aquifer, As in table (2). The assumptions are as follows.

Table 2: shows the amount of cubic meters that are drained from the reservoir for a certain number of wells

Discharge (year)	Volume (m3)
(1) well	54432
(200) wells	10886400
(300) wells	16329600
(400) wells	21772800

The first hypothesis (200 wells)

In this hypothesis, hypothetical wells distributed over the study area were placed close to the reality, at a distance of (1 km) between one well and another, and that one well represents an area of (1 km). As the well was operated with a discharge of (7 liters/second) for a period of (8 hours/day) for a period of (22.5 days/month), equivalent to (270 days/year), that is, with a discharge of (54432 m3/year) for each supposed well, as (200 A well) distributed over the study area, which is equivalent to the annual amount of discharge from the aquifer of the study area (10886400 m3 / year). As in Figure (4) and Figure(5).

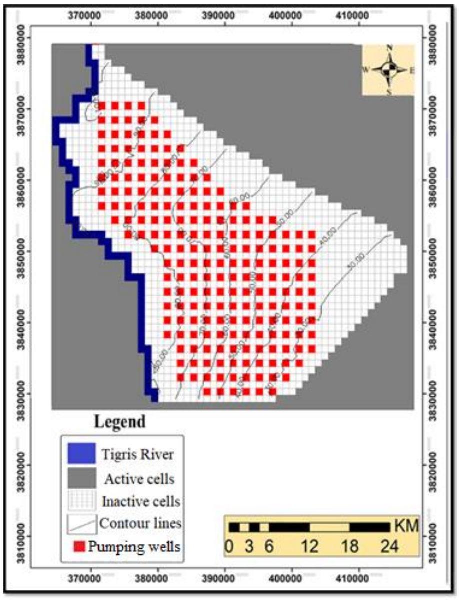

Fig. 4: Water table when drilling 200 meter wells and pumping (54432 m^3 / year) for each well

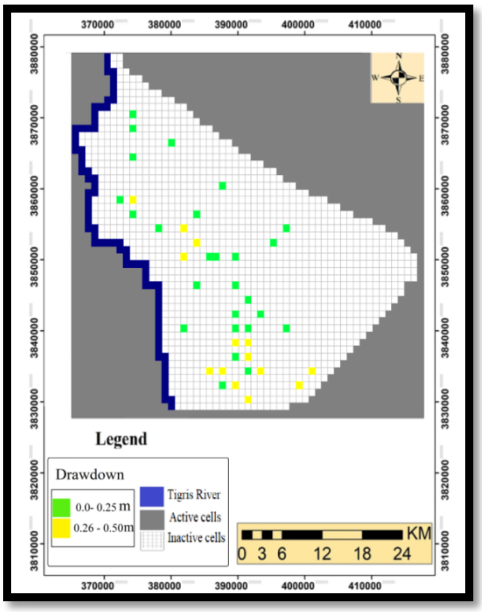

Fig. 5: the decrease in water table when drilling 200 wells and pumping (54432 m3 / year) per well

The second hypothesis (300 wells)

In this hypothesis, the cells in the middle of the area were minimized so that each cell occupies an area (500 square meters) to increase and density the number of wells, while others occupy (1 km^2) as in the first hypothesis, as the well was operated with a discharge of (7 liters/second) for (8 hours / per day) and for (22.5 days/month) equal to (270 days/year) that is, the discharge of (54432 m^3 / year) for each supposed well, as 300 wells were distributed over the study area, equal to the annual amount of drainage from the reservoir of the study area (16329600 m^3 / year) as by mapping the levels of groundwater. As in Figure (6). And drawing a map of the decrease shows that pumping with this explanation of water occurs in a decrease in the reservoir in some areas, with a decrease of (1-2.5) meters, as in Figure (7), and that this decrease is a drain on the reservoir if it continues with these quantities, i.e. the withdrawn quantities should be less so.

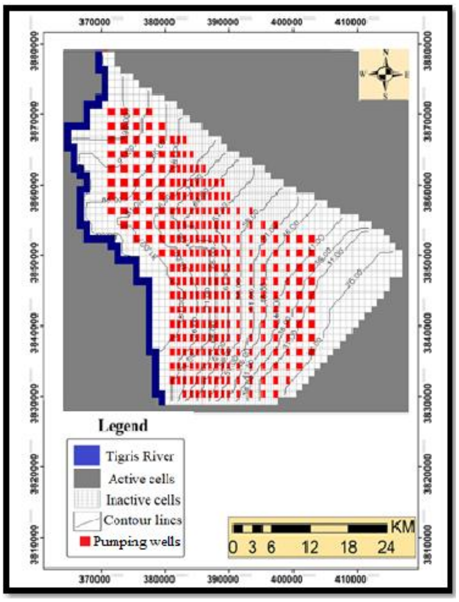

Fig. 6: Water table when drilling 300 meter wells and pumping (54432 m3 / year) for each well

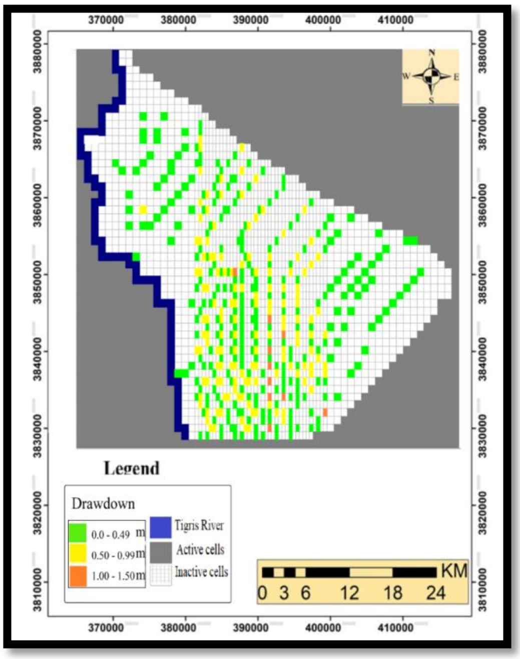

Fig. 7: the decrease in water table when drilling 300 wells and pumping (54432 m3 / year) per well

The third hypothesis (400 wells)

In this hypothesis, the cells in the center of the area were reduced more than the previous hypothesis. So that each cell occupies an area of (500 m^2) to increase and intensify the number of wells and some others occupy (1 km^2), as the well was operated with drainage of (7 liters/second) for (8 hours / per day) and for (22.5 days/month) equal to (270 days/year) that is, the drainage of (54432 m^3 / year) for each assumed well, as (400) wells were distributed over the study area, equal to the annual amount of drainage from the reservoir of the study area (21772800 m^3 / year). as by drawing a map of groundwater levels as in figure (8), it was found that there is depletion in the aquifer and a significant decrease in many areas within one year, the change in the water table is considered significant. As in the form (9).

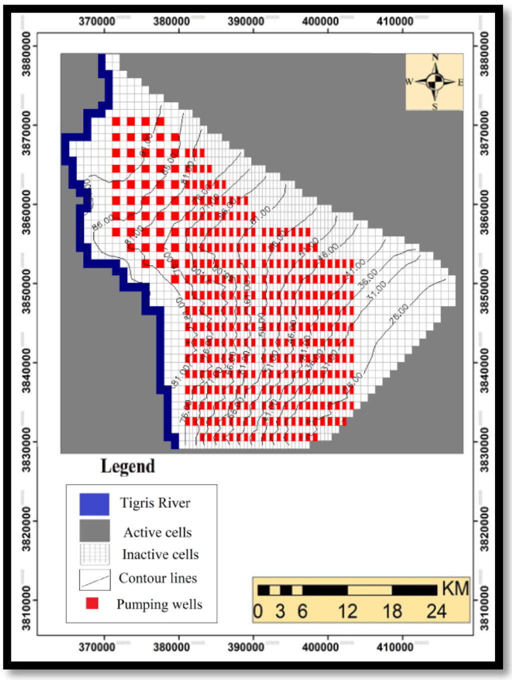

Fig. 8: Water table when drilling 400 wells and pumping (54432 m3 / year) for each well

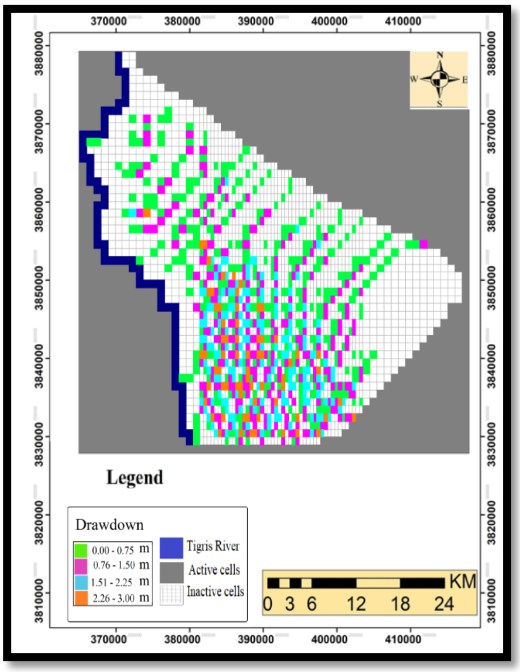

Fig. 9: The decrease in water table when drilling 400 wells and pumping (54432 m3 / year) per well

Conclusions

By drawing a map of water table, and applying the mathematical model. It was found the higher water table north study area near the Hemrin anticline, and the levels decreased towards Al-Shari playa. It was found that drilling 200 wells with a distance of 1 km^2 between one well and another is considered safe and that drilling 300 wells or 400 wells leads to the depletion of the aquifer.

References

[1] Harter T (2015) Basic concepts of groundwater hydrology. ANRPublication 8083, FWQP Reference Sheet 11.1،University ofCalifornia

[2] Al-Sudani HIZ (2017) Hydrogeological study of Khan Al-Baghdadi area in Anbar Governorate—West of Iraq. Diyala J Pure Sci13(2):192–207.

[3] Al-Fatlawi, A.N., (2010):Hydrogeological Study for Ummerradhuma Aquifer - West of Iraq, M.S.C. thesis, univ. of Baghdad (unpubl), 162 P.

[4] GEOSURV.(2017). Evaluation of groundwater in the area between Tigris and Diyala rivers, Report, No. 3646.

[5] Jassim, S.Z., and Goff, J.C., 2006. Geology of Iraq, Published bu Dolin, prague and Musem, Brno Czech Republic, 2006, 337p.

[6] Delleur, J. W, (2007). The hand book of GROUNDWATER ENGINEERING.

[7] McCarthy, J.M. and Yeh, W.G., (1990): Optimal Pumping Test Design for Parameter Estimation and Prediction in Groundwater Hydrology. Water Reso, Rese, Vol. 26, No.4, PP. 779-791.

[8] Bear, J. and Verruijt, A., (1989): Modeling Groundwater Flow and Pollution. Theory and Application of Transport in Porous Media, D. Reider Pub. Go., Holland , 414 P.

[9] Ra'i, Kinan Jamal, (2015): A mathematical model to simulate the hydrogeological conditions of water carriers in the area between the North Kabir and the Pine rivers and assess their available resources, Department of Geology, College of Science, Tishreen University, PhD thesis (unpublished), 182 p.(In Arabic).

[10] Wang, J.F. and Anderson, M.P. (1982) (reprinted, 1995): Introduction to Groundwater Modeling, Academic Press, San Diego, CA. 237p .

تطبيق موديل رياضي لمحاكاة خزان المياه الجوفية في منطقة شرق العلم – شمال شرق مدينة تكريت/ العراق

ياسر احمد خضير، صبار عبدالله صالح، غازي عطية زراك

قسم علوم الارض التطبيقية ، كلية العلوم ، جامعة تكريت ، تكريت ، العراق

الملخص

تم دراسة مناسيب المياه الجوفية في منطقة شرق العلم لعام 2019 حيث تم تحديدها في 104 بئر، موزعة على منطقة الدراسة عدا المناطق القريبة من طية حمرين حيث تعذر الوصول اليها بسبب الاوضاع الامنية، حيث تبين بان المناسيب الاعلى في شمال منطقة الدراسة بالقرب من طية حمرين وتقل المناسيب باتجاه بحرية الشاري. تم عمل محاكاة للخزان بعد ادخال مناسيب المياه الجوفية والخواص الهيدروليكية للمنطقة وعمق الخزان حيث تم عمل 3 فرضيات لمحاكاة الخزان خلال سنة واحدة وذلك بوضع عدة ابار افتراضية بتصريف ثابت وعدد ساعات تشغيل ثابتة خلال السنة وذلك لمعرفة كمية المياه التي تؤدي إلى استنزاف الخزان ومسافة الحفر الامنة للخزان لكي لا يصل الخزان إلى مرحلة الضخ الجائر واستنزافه إذ تم وضع عدة ابار افتراضية موزعة بصورة مقاربة لواقع منطقة الدراسة حيث من خلال الاستبيان عن عدد الابار الشغالة والتي يعتمد عليها في منطقة الدراسة كانت من حوالي (250–350) بئر لذلك تم وضع 3 فرضيات بواقع(200 بئر , 300بئر, 400 بئر) بتصريف ثابت وعدد ساعات تشغيل ثابتة خلال السنة. إذ تم تشغيل البئر حسب السياسات الموضوعة من قبل وزارة الزراعة بتصريف (7 لتر/ثانية) ولمدة (8 ساعات/ يوميا) ولمدة (22.5 ايام /شهريا) اي ما يعادل (270 يوم/ سنوياً) اي بتصريف (54432 م^3/سنة) لكل بئر مفترض, لمعرفة تأثر الخزان وتبين بأن حفر 200 بئر وبمسافة 1 كم^2 بين بئر واخر تعتبر امنة. وان حفر 300 بئر او 400 بئر في منطقة الدراسة يؤدي الى استنزاف الخزان.