

Effects of recharge area and drainage system on ground water quality of Telkaif area/ north of Iraq

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Abstract:

Drainage system and recharge area of the catchment area plays important role in recharging ground water aquifer, through infiltration of rain and runoff water to the ground water depending on the type of sediments cover, intensity of rainfall, slope and intensity of runoff. This study discuss the drainage system recharge and its effect on the concentration of the chemical constituents of ground samples, through the analysis of chemical and physical parameters of ground water samples of the studied area for two periods during the year 2007. The first period of sampling is on April 2007 where the ground water table is on the highest level, while the second period is on November 2007 where the ground water table is on the lowest level. The chemical parameters analyzed were pH, TDS, EC, TH, Ca, Mg, Na, K, HCO₃, SO₄, Cl and NO₃. Chemical parameters such as sodium percentage (Na%), Sodium adsorption ratio (SAR), Permeability Index (PI) and saturation index with respect to calcite and gypsum (SI) were calculated, based on the major cation and anions analysis of ground water samples. A notable variation in the chemical composition of ground water samples between the two analyses has attracted attention of the authors. An attempts is made to interpret the variation in the chemical composition of ground water and the cause of the variation by the interaction of ground water and host rocks in one hand and drainage system recharge and dissolution of surface pollutants during infiltration and percolation of rainwater in the other hand. The abundance of the major ions of the ground water samples (1, 2, 3, 4) is in the following order: Na > Ca > Mg > K = HCO₃ > SO₄ > Cl > NO₃, while the abundance of the major ions of the rest samples is in the following order: Ca > Na > Mg > K = SO₄ > HCO₃ > Cl > NO₃

Key words: Chemical and physical parameters, drainage system, ground water.

Introduction:

Drainage system recharge has a significant role in the chemical composition of ground water due to the mixing of surface pollutants during infiltration and percolation of rainwater and interaction between ground water flow and hostrocks.

In recent time, there has been a tremendous increase in demand for ground water in the studied area due to the population grow and intense agricultural activities.

Very useful hydrogeological data, such as lithological units of deep well, water level depth and geological prospecting, were obtained.

Geological and agricultural consumers are supplied with water from aquifers, 120 to 180 meter deep. These aquifers consist of Injana and Al-Fatha Formations and forms the only sources of ground water in the area.

The quality of ground water is not uniform and differs from season to another due to the

difference in rainfall quantity, recharge, fluctuation change of water level and dissolution between ground water and gypsum.

Rainfall is the main sources of recharging the ground water of the studied area. Different factors affect recharge precipitation, among of these are elevation, time, type and intensity of rainfall. The amount of precipitation increase with altitude. Short and heavy rainfalls are directly affect the recharge in the area due to the high permeable soil covered.

The depth to the ground water level of deep wells in the studied area range between 6-10 meter during rainy season, while in dry season range between 10-14 meter.

People in the studied area abstracted water from deep wells to meet their needs and domestic purposes. It is not an exaggeration that the number of wells drilled during the last five years is more than the number of

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wells drilled in the studied area since its existence.

In order to know the effects of drainage system recharge on ground water quality; a study of quality variation of the ground water in the studied area were carried out through the analysis of (10) samples from deep wells of the studied area, for two periods during the year 2007. The data were used to determine water quality and as an information for assesment of the drainage system recharge and water bearing rock influence on the chemical constituents of the abstracted water.

The authors have referred several aspects of chemical data and discussed the principle characteristics of ground water quality classifications for domestics and irrigation purposes.

Material and Methods:

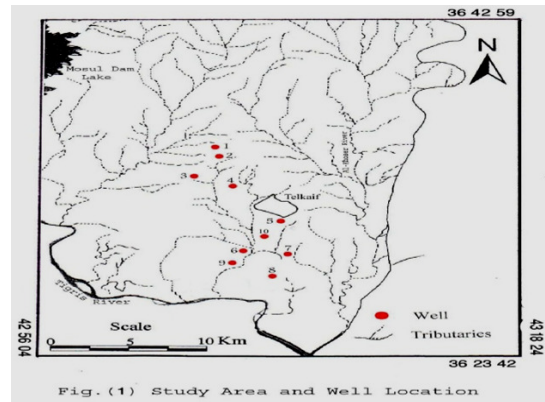
Location and description of study area:

The study area is situated in the Northern part of Mosul city covering an area of about 140 Km² and lacated approximately between latitudes (36 23 42 – 36 38 16) and longitudes (42 44 19 – 43 18 24) Fig. (1). The average elevation for the study area is 380 m. Above sea level. The climate is considered to be semi-arid and the annual precipitation being approximately between (320-400) mm. 90% of the total rainfall occurs from Oct.- April. The area is characterized by well-developed dendritic type of drainage system. Tributaries are consider to be non-perennial, as it carries water during rainy season and rainfall of high intensity and long duration. Coarse textured patterns noticed in the plains indicating high rainfall infiltration. The regional slope of the studied area is towards the south where the Tigris River. The most important activity of the area is agriculture, and the cheif crops are wheat, barley, lentil and chick-pea.

Samples collection:

Water for chemical analysis was sampled directly from the suction pipe of (10) Wells for water supply. The first period collection of ground water samples are during April 2007 whenever the ground water table is of high level, while the second period of samples collection are during Nov. 2007 whenever the ground water table is of low level. Ground water samples for both

periods were analyzed in the laboratories of the Dept. Of geology and Environmental Research Center of Mosul university, for the major ion chemistry employing standards methods (Hem, 1985). The total dissolved solid (TDS) Estimated by residue on evaporation method. The pH and Ec were



measured using pH an Ec meters. Ca and Mg were determined titrimetrically using standard EDTA. Chloride (Cl) was determined by standard AgNO₃ titration. Carbonate (CO₃) and Bicarbonate (HCO₃) were determined by titration with HCl. Na and K were measured by flame photometer. SO₄ and NO₃ were determined by spectrophotometric techniques. The major ion concentration, physical properties and chemical parameters indices for ground water samples of the study area of both periods of the year 2007 are listed in table (1a and b) and (2a and b).

Results and Discussion:

Drainage system:

A map of the drainage system for the studied area has been prepared Fig. (2). The drainage system, which develops in an area is strictly dependent on the slope, the nature and attitude of bedrock and on the regional and local fractures pattern. Drainage system can be described in terms of pattern types and texture or density of dissection.

The studied area is charcterised by well-developed dendritic type of drainage system. Dendritic type is found in homogeneous rock such as soft sedimentary. Drainage system can also be described in terms of texture, and on this basis three types can be recognized:

- 1- Fine, which is expressive of high run off and impervious bedrock.
- 2- Medioum, which can be correlative to a medium and mixed lithology.

- 3- Coarse, which is available in the studied area. This type is characterized by little run off and coarse permeable soil materials.
- 4- Structure and lithology seems to be dominant factors in the development of the drainage system which can be of great value for ground water resources.

Geology setting:

Stratigraphically, the area under research is dominated by geological formations ranging from Middle Miocene to Quaternary as shown in Fig. (3), and as follows:

- 1- Al Fatha Formation of Middle Miocene:-

This formation is cropped out at the southern part of the studied area and composed of gypsum, anhydrite, marl, clay,

green marl and lime stone (Buday and Jassim, 1984; Mohi addin, *et al.*, 1977). The thickness average about (50-75) m.

- 2- Injana Formation of Upper Miocene:-

This formation crop out at the North East of the study area, composed of sand stone, marl, lime stone and thick beds of red to brown sand stone (Buday and Jassim, 1984).

- 3- Quaternary sediments:-

The Quaternary sediments are mostly covering the total area under study. This sediments include residual soil (sandy and loamy soil) and flood plain deposits which consist of sand, silt and clay, and slope deposits which consist of rock fragments, sand and silt which is slightly cemented. The thickness varies greatly from less than 2 m. to over 5 m.

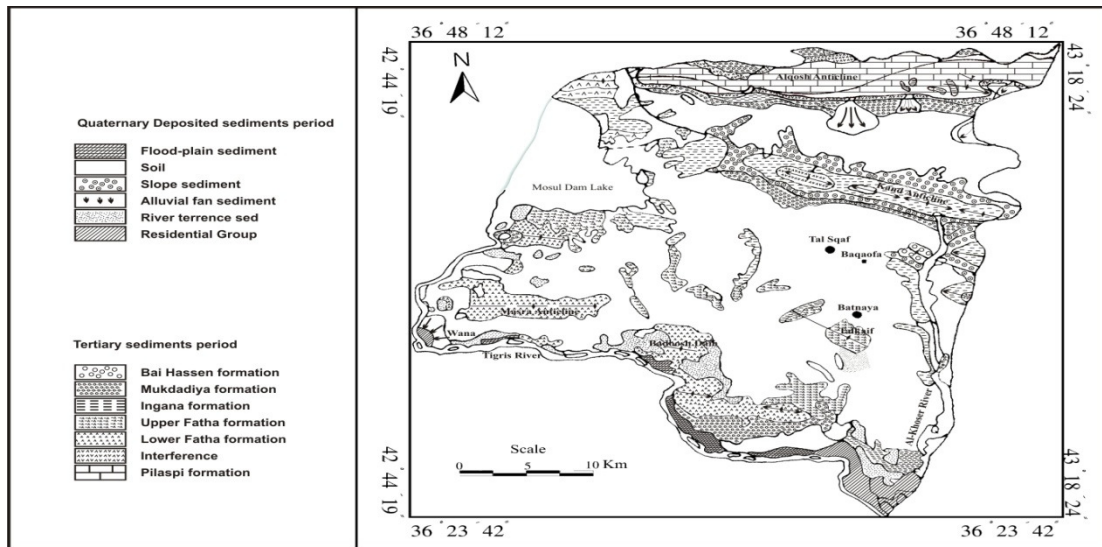


Fig. (2) Geology of the study area

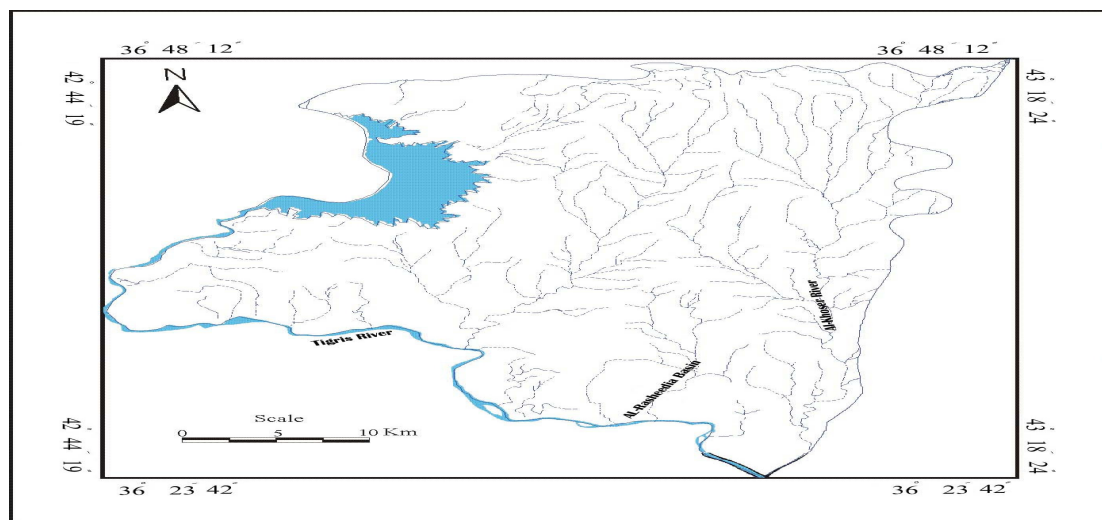


Fig. (3) Drainage System of The Study Area.

Well No.	Na	K	Ca	Mg	HCO ₃	SO ₄	Cl	NO ₃	pH	EC	TDS
1	110.3	3.1	100.7	92.5	448.0	206.5	88	43	7.7	1365	1270
2	108.2	2.8	99.6	97.3	470.0	223.4	69	38	7.5	1415	1300
3	112.0	2.1	110.6	95.4	442.8	210.4	74	40	7.6	1390	1275
4	124.8	2.0	115.5	108.0	492.2	236.6	76	42	7.8	1425	1320
5	82.0	3.6	258.5	125.7	420.7	1040.0	85	39	7.5	2425	2235
6	95.0	3.2	288.7	130.8	540.3	980.0	92	36	7.8	2480	2350
7	107.0	2.9	276.4	148.2	390.5	1120.0	80	34	7.4	2515	2480
8	87.0	3.4	320.6	163.4	425.0	1180.0	78	38	7.5	2500	2485
9	93.0	3.8	238.2	172.0	475.1	850.0	90	45	7.8	2275	2150
10	88.0	3.8	340.1	152.3	365.4	1260.0	98	43	7.4	2580	2520

Table (1a) Concentration Of Chemical Constituents Of Ground Water Samples (ppm) of the period April 2007.

Well No.	TH	Na%	SAR	PI	SI Ca	SI SO ₄
1	632.0	27.9	1.91	44.2	1.34	0.24
2	649.1	27.0	1.85	43.8	1.05	0.31
3	668.7	26.9	1.88	44.0	1.36	0.28
4	732.8	27.3	2.00	44.6	1.27	0.29
5	1162.7	12.9	1.01	25.1	0.45	1.40
6	1259.1	14.4	1.16	26.3	0.32	1.63
7	1300.0	15.4	1.29	25.4	0.64	1.75
8	1472.9	11.6	0.98	22.8	0.37	1.38
9	1302.5	9.4	0.72	24.5	0.26	1.64
10	1475.9	8.7	0.99	23.0	0.18	1.42

Table (1b) Chemical Parameters of Ground Water Samples of the period April 2007.

Well No.	Na	K	Ca	Mg	HCO ₃	SO ₄	Cl	NO ₃	pH	EC	TDS
1	97.3	2.9	92.4	88.3	435	198.0	76	40	7.25	1265	1120
2	100.5	2.8	92.2	94.6	462	212.0	65	32	7.38	1310	1200
3	98.6	2.1	98.2	88.0	428	198.5	68	36	7.18	1280	1180
4	102.3	2.0	100.6	98.2	478	218.0	71	38	7.26	1350	1220
5	78.7	3.4	228.7	119.4	408	990.0	79	35	7.45	2250	2125
6	82.4	3.2	253.2	122.0	532	930.0	84	30	7.30	2280	2200
7	91.2	2.7	238.3	136.7	378	1035.0	73	29	7.55	2240	2175
8	76.8	3.2	286.4	147.6	418	1120.0	71	32	7.45	2340	2280
9	81.5	3.7	214.5	164.8	476	775.0	82	38	7.35	2175	2010
10	82.4	3.6	275.7	138.6	355	1195.0	88	36	7.24	2380	2275

Table (2a) Concentration Of Chemical Constituents Of Ground Water Samples (ppm) of the period Nov. 2007.

Well No.	TH	Na%	SAR	PI	SI Ca	SI SO ₄
1	632.0	27.9	1.91	42.8	1.26	0.32
2	649.1	27.0	1.85	42.6	1.15	0.34
3	668.7	26.9	1.88	41.8	1.28	0.37
4	732.8	27.3	2.00	41.4	1.16	0.27
5	1162.7	12.9	1.01	23.9	0.39	1.39
6	1259.1	14.4	1.16	24.9	0.28	1.58
7	1300.0	15.4	1.29	23.8	0.54	1.78
8	1472.9	11.6	0.98	20.3	0.32	1.42
9	1302.5	9.4	0.72	22.8	0.21	1.68
10	1475.9	8.7	0.99	20.9	0.13	1.62

Table (2b) Chemical Parameters of Ground Water Samples of the period Nov. 2007.

Hydrogeology Setting:

According to the geological formation, two types of aquifers are of particular importance in the study area:

- 1- Unconfined aquifer, mainly in the Quaternary sediments which has wide geographical distribution and of thickness ranges from 3 to 6 m. This aquifer is underlined by the Pliocene clay which act as a confining bed. The main source of recharge to this aquifer takes place from direct rainfall and wadis runoff.
- 2- Injana and Al-Fatha formations are considered to be a semiconfined aquifers. Bore hole lithology records as shown in fig. (5) reveal that both formations are separated from Quaternary sediments by an aquiclude of clay sediments in some places, and are hydraulically connected with Quaternary sediments in others. These aquifers consist mainly of variable lithological units of permeable and impermeable beds and receives its water mainly by underflow and leakage from upper regional aquifer. These aquifers are well jointed and fissured and in local scale exhibits solution channels.

Rainfall is the main source of aquifer recharge. It occurs along Quaternary sediments. In addition, infiltration from intermittent tributaries that drain water during period of heavy precipitation.

Hydrochemistry:

The dissimilar composition of ground water type result from numerous hydro chemical processes, among of these processes is the interaction between ground water and host rocks. The concentration of dissolved ions in ground water samples are generally governed by lithology, velocity and quantity of ground water flow, nature of geochemical reactions, solubility of salts and human activities (Karanth, 1997; Bhatt and Saklani, 1996).

The total dissolved solids (TDS) of ground water analysis is found on the higher side level by comparing with the specification of (TDS) values set up by the WHO (1984). The excess of TDS in the analysis is caused by mixing of surface pollutants during the infiltration and percolation of rainwater downward and the interaction between the ground water and host rocks, and leaching back of salts withhold in the pores of sediments, while ground water evaporated, to the ground water during the rainy period.

The electrical conductivity (EC) make a sign of the amount of salts dissolved in water and its value of ground water samples range from 1930 μmhos to 4320 μmhos.

The pH value of ground water samples in the study area fluctuate within the narrow limits between 7.4 and 7.8. for April 2007 and between 7.18 and 7.55 for the period Nov. 2007.

Sodium Adsorption Ratio (SAR):

SAR is an important parameter for determining the suitability of ground water for irrigation because it is a measure of alkali/sodium hazard to crops. The SAR can be estimated by the formula:

$$SAR = \frac{Na^+}{(Ca^{2+} + Mg^{2+})^{1/2} / 2}$$

Where all ionic concentration expressed in epm.

The SAR value of ground water samples range from 2.88 to 6.82 which is fell in the low sodium class. This implies that no alkali hazard to the crops (Saleh *et al.*, 1999).

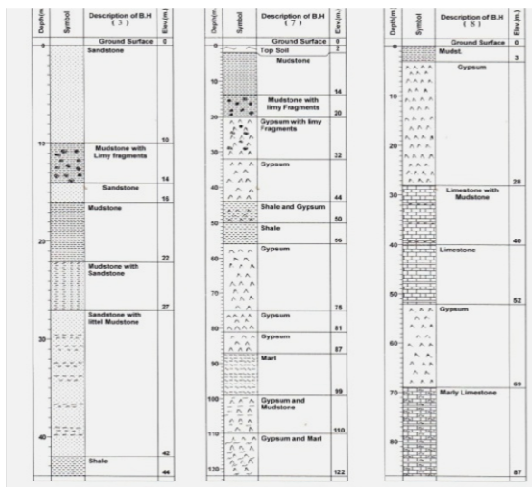


Fig.4 Bore hole lithological unit

Sodium percentage (Na%):

Sodium concentration is important in classifying irrigation water because sodium reacts with soil to reduce its permeability. Sodium content is usually expressed in terms of percent sodium (Na%). The Na% values of ground water samples range from 29.37 to 46.07. The sodium percentage (Na%) is calculated using the following formula:

$$Na\% = \frac{(Na^+ + K^+)}{(Ca^{2+} + Mg^{2+} + Na^+ + K^+)} * 100$$

Where all the concentration are expressed in meq/l.

The Na% of samples (2, 3, 4, 5, 9, 10) indicates that the ground water is good for irrigation while samples (1, 6, 7, 8) are permissible (Ragunath, 1987).

Residual Sodium Carbonate (RSC):

The excess sum of carbonate and bicarbonate in ground water over the sum of calcium and magnesium also influence the unsuitability of ground water for irrigation. This is denoted residual sodium carbonate (RSC), which is determined by the formula (Ragunath, 1987):

$$RSC = (HCO_3 + CO_3) - (Ca + Mg)$$

Where the concentration of cations and anions are expressed in epm.

From the residual sodium carbonate value of the ground water samples of the study area, it is observed that all samples are safe for irrigation according to the US Salinity Laboratory Diagram (1954), which is proposed that water containing less than 1.25 meq/l is safe for irrigation.

Permeability Index (PI):

The soil permeability is influenced by Na, Ca, Mg and HCO₃ contents of the soil and affected by long term use of irrigation water. It is defined as follows (Ragunath 1987):

$$PI = (Na + \text{sqrt } HCO_3) * 100 / (Ca + Mg + Na)$$

Where the concentration of cations and anions are expressed in epm.

The value of PI of ground water samples of the study area range 32.3 to 46.7 which comes under class II (25-75%) of Doneen chart (Domenico and Schwartz, 1990). therefore the ground water sample in the study area is in general suitable for irrigation purposes on the basis of US Salinity Diagram (1954).

Hydro chemical Facies:

Ground water quality is defined by the chemical constituents in the water and the chemical analysis data are helpful for determining the usefulness of ground water as a potable resource.

Rock Work, 2006 Software has been employed to calculate and plot the concentration of chemical constituents of ground water samples of both period using Piper and Stiff Diagrams. Piper Diagram, (Hem, 1985) is used to illustrate the major ions composition of ground water samples for both periods as shown in Figs. (5, 6). This diagram is particularly useful for detecting changes or trends in ground water chemistry across an area or through time (Sanders, 1998). Piper diagram shows that most samples are of mixed cations- SO₄ type and samples 1, 2, 3 and 4 of Ca- HCO₃ type. Stiff Diagrams illustrates the water chemistry and shows similarities of shapes of samples 1, 2, 3, and 4. see Figs. (7, 8) This similarities indicates similar composition. Samples 5, 6, 7, 8, 9, and 10 also shows similarities of shape and in composition of mixed cations - SO₄

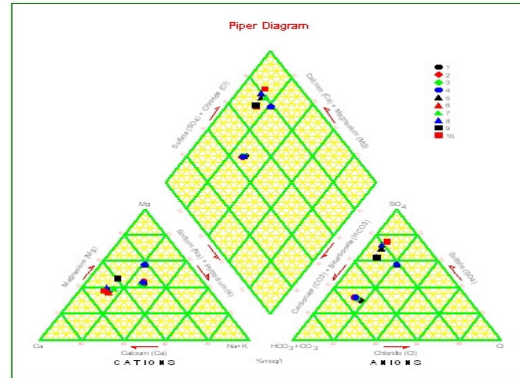


Fig. (5) Piper diagram for the period April 2007.

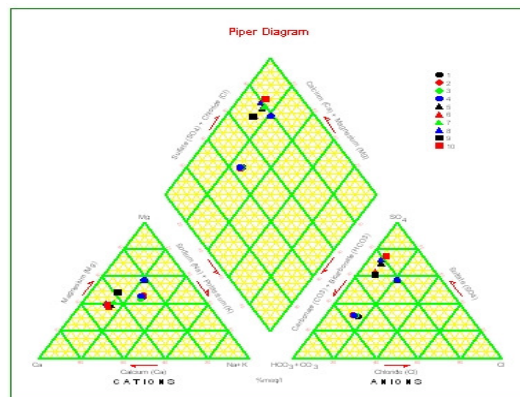


Fig. (6) Piper diagram for the period Nov. 2007.

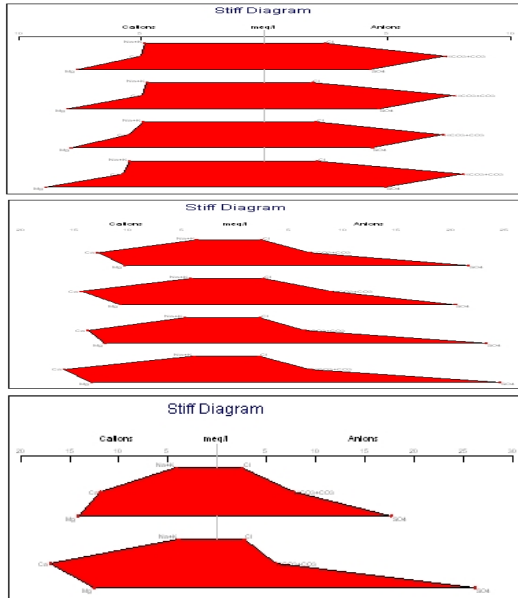


Fig. (7) Stiff Diagrams for the period April 2007

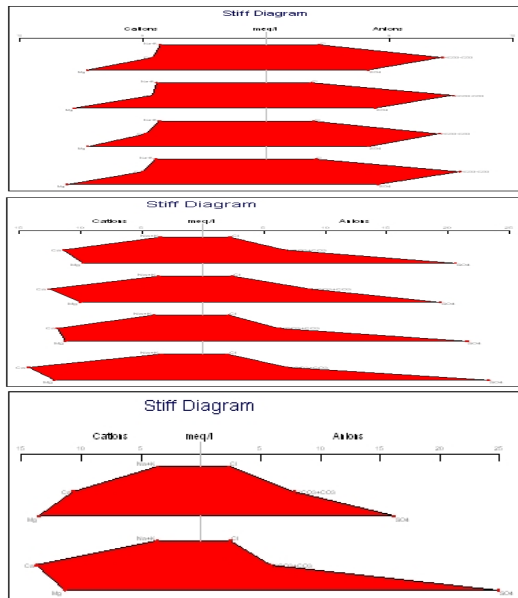


Fig. (8) Stiff Diagrams for the period Nov. 2007

Conclusion

This paper presents general guide lines for the variations in the chemical composition of ground water of the two periods of chemical analysis of groundwater samples and the suitability of ground water for domestic and agricultural purposes.

The chemical analysis of ground water reveals that the ground water is hard, fresh to saline and alkaline in nature. The pH value range between (7.1-7.63). The Ec value range from 1500 μ mohs to 2659 μ mohs. Total hardness value range from 757.1 – 1388.6 mg/l and shows that the majority of ground water samples fall in the hard water

category. TDS values range from 1450 mg/l to 3000 mg/l.

Chemical parameters such as sodium percentage (Na%), Sodium adsorption ratio (SAR), Permeability Index (PI) and saturation index with respect to calcite and gypsum (SI) were calculated, based on the major cation and anions analysis of ground water samples. The SAR value of ground water samples range from 2.88 to 6.82 which is fell in the low sodium class. This implies that no alkali hazard to the crops The Na% values of ground water samples range from 29.37 to 46.07. The Na% of samples (2, 3, 4, 5, 9, 10) indicates that the ground water is good for irrigation while samples (1, 6, 7, 8) are permissible. From the residual sodium carbonate value of the ground water samples of the study area, it is observed that all samples are safe for irrigation. The value of PI of ground water samples of the study area range 32.3 to 46.7. Therefore the ground water sample in the study area is in general suitable for irrigation purposes.

Piper and Stiff Diagrams also applied in this study using Rock Work 2006 software to show the trend of groundwater chemistry and chemical composition of groundwater samples of the study area.

High to very high salinity hazard shows that ground water in the south part of the study area can be used for plants having good salt tolerance and also restricts its suitability for irrigation.

The concentration of dissolved ions in ground water samples are generally governed by lithology, velocity and quantity of ground water flow, nature of geochemical reactions, solubility of salts and human activities. It is also shows slightly difference in concentration in cations and anions between the two periods of analysis due to the fluctuation change of water level along the groundwater column of the well and drainage system replenished groundwater.

Therefore the variations in the chemical composition of ground water of the two periods were caused by the interaction of ground water and host rocks in one hand and drainage system recharge and dissolution of surface pollutants during infiltrations and percolation of rainwater in the other hand.

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الملخص العربي

تأثير مناطق التغذية و نظام التصريف على نوعية المياه الجوفية لمنطقة تلييف شمال العراق

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نظام التصريف لأي حوض يلعب دورا مهما في تغذية خزان المياه الجوفية من خلال ترشيح مياه الأمطار و الجريان السطحي إلى المياه الجوفية و إن شدة التغذية تعتمد على نوع الترسبات التي تغطي المنطقة، شدة الأمطار، الميل وشدة الجريان السطحي. تم في هذه الدراسة البحث في تغذية نظام التصريف و تأثيره على تركيز المكونات الكيميائية للمياه الجوفية من خلال تحليل العوامل الفيزيائية و الكيميائية لنماذج المياه الجوفية لمنطقة الدراسة لفترتين خلال العام (2007) وكانت الفترة الأولى في شهر نيسان عندما يكون مستوى الماء الجوفي أعلى ما يمكن بينما الفترة الثانية كانت في شهر تشرين الثاني (2007) حيث يكون مستوى الماء الجوفي في أوطأ مستوى بسبب قلة الساقط المطري. العوامل الكيميائية و الفيزيائية التي تم تحليلها هي الأملاح الذائبة الكلية، الألس الهيدروجيني، التوصيلية الكهربائية، الأيونات الموجبة الرئيسية مثل الكالسيوم، البوتاسيوم، الصوديوم، و المغنيسيوم والأيونات السالبة الرئيسية مثل ألييكاربونات، الكبريتات، الكلورايد و النترات. كما تم حساب العوامل الكيميائية مثل نسبة الصوديوم، نسبة امتزاز الصوديوم، و معامل النفاذية، و معامل التشبع بالكالسيوم و الكبريتات اعتمادا على الأيونات الموجبة والسالبة و ذلك لغرض تقييم نوعية المياه لأغراض الري. لقد تبين أن هناك تغير ملحوظ في المكونات الكيميائية لنماذج المياه الجوفية خلال الغترتين والتي جلبت انتباه الباحث و جعلت تفسيرها على أساس التفاعلات ما بين المياه الجوفية و الصخور المضيفة من جهة و دور نظام التصريف في التغذية و عملية الأذابة للمذبات السطحية خلال عملية الترشيح من جهة أخرى. أن وجود و توفر الأيونات الرئيسية للنماذج (1, 2, 3, 4) كانت حسب الترتيب التالي:



بينما بقية النماذج الأخرى كانت حسب الترتيب التالي:

