STUDY AND SOFTENING OF TIKRIT UNIVERSITY GROUNDWATER

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ABSTRACT

The purpose of this study is to evaluate ground water quality and to identify the temporal and spatial variation of ground water contamination at Tikrit City, University site. Groundwater samples were collected from September 2007 till august 2008, and investigate its characteristics and a suitable treatment method. Test of ground water sample, showing the proportion of pH, temperature, total dissolved solids, electrical conductivity, calcium and magnesium ions concentration, chloride, sulphates and nitrates ions, and the alkalinity, total hardness, dissolved oxygen and the turbidity is performed during this work.
Data shows moderate to great variation for most of the above characteristics and most of them lies above Iraqi standards for drinking water. For this reason an attempt is made to treat the water to brink it within Iraqi standards using laboratory scale apparatus by an ion exchange. The result of treatment show that it is able to treat this water by ion exchange.
The variation in water contents is according to complicated reaction processes in the study area, reaction between ground water and geological materials contamination due to agricultural activities and rains intrusion.

Key Words
Groundwater, Groundwater Quality, Softening, Ion exchange.

INTRODUCTION

Ground water is the source of about 40% of the water used for public supply. It provides drinking water for more than 97 % of the rural population who do not have access to public water-supply systems. Between 30 and 40 % of the water used for agriculture comes from ground water. Withdrawals of ground water are expected to rise in the coming century as the population increases and available sites for surface reservoirs become more limited, and surface water is much more easily contaminated than ground water due to filtration through the soil which helps to clean ground water. Also ground water usually contains no suspended matter, very rarely contains pathogenic bacteria; generally it contains microbes native to the formation, unless contaminated by human activity and ground water is clear and colorless unless tainted with humid material[5].
Water is one of the basic and fundamental requirements for the survival of human beings. Nearly 80% of all the diseases arise as a result of using unsafe and contaminated water. Groundwater (GW) contamination has long been a deep concern to environmentalists due to its harmful effects on human health. The presence of different effluents in groundwater should be known as accurately as possible so that necessary arrangements can be made to provide treatment to this contaminated water[12].

Groundwater is in aquifers below the surface of the earth, is among the nation's most important natural resources., therefore it is one of the most useful water sources[2]. There are plenty of reasons to be concerned about groundwater quality, the sources of drinkable groundwater can vary from shallow sand and gravel adjacent to a river to deep sandstone layers over 2,000 feet below the land surface. Groundwater is usually more protected from contamination than surface water[6].

The earth's temperature or chemical reaction affects the usefulness of water for many purposes. Most users desire water of uniformly low temperature. In general, temperatures of shallow ground water show some seasonal fluctuation whereas temperatures of ground water from moderate depths remain near or slightly above the mean annual air temperature of the area[8].

The concentration of sulphate in groundwater highly depends on the nature of the natural ground; in gypsum areas, groundwater may be saturated (1.45g of sulphate per liter) and in this case the addition of gypsum will not change the sulphate concentration. The sulphate ion (SO_4^{2-}) has no adverse effect on health, even at concentrations corresponding to a saturation of $CaSO_4$ (app. 1500mg/l). Several studies failed to find any association between exposure to high levels of sulphates in concentrations mostly up to 1200 mg/l, sometimes up to 2000 and more mg/l) caused diarrhoea or other adverse health[6], but if sulfate in water exceeds 250 mg/L, a bitter or medicinal taste may render the water unpleasant to drink. High sulfate levels may also corrode plumbing, particularly copper piping.

Hardness is primarily a measure of calcium and magnesium content, so Atteh and Leeson examined the effect of adding these to broiler drinking water. They found that up to 100 ppm magnesium significantly improved feed efficiency but increased the incidence of swollen hocks and shortened tibia. Up to 100 ppm of calcium had no effect.

The temperature of groundwater is generally equal to the main air temperature above the land surface, it is usually stays within a narrow range year- round. Ground water temperature data is necessary for the proper deployment of heat pumps. It is helpful to know the temperature of the ground water to be used in order to select the proper equipment and configuration for the installation ,the potential impact on the aquifer needs to be assessed to avoid overexploitation and excessive change in aquifer temperature. This is especially important in regions where either heating or cooling will predominate[8].

Acharya , Hathi, Asha and Parmar present the results of physicochemical study of water samples from thirteen bore wells in Bhiloda Taluka in India, the water quality parameters such as; pH, electrical conductivity (EC), total dissolved salts (TDS), calcium and magnesium, sodium, potassium, carbonate, bicarbonate, chloride, sulphate, fluoride, sodium adsorption ratio, residual sodium carbonate and soluble sodium percentage were assessed and estimated[2].

In upland sub-watersheds of Meenachil river, parts of Western Ghats, Kottayam, Kerala, India was used to assess the quality of groundwater for determining its

suitability for drinking and agricultural purposes. Many water samples were collected from different wells and analysed for major chemical constituents to determine the quality variation. Parameters of groundwater such as pH, dissolved oxygen, total hardness, chloride, nitrate and phosphate were determined. it showed that the high and low regions of water quality varied spatially during the study period. The influence of lithology over the quality of groundwater is negligible in this region because majority of the area comes under single lithology and it was found that the extensive use of fertilizers and pesticides in the rubber, tea and other agricultural practices influenced the groundwater quality of the region[9].

In Tamil Nadu Surface water become scares in pre monsoon, concentration greater than their permissible limits in drinking water have been linked to health problems, especially in infants, tannery is one of the major industries in this area leading to water quality problems. The diseases were classified and they were arranged according to ward wise in the study area. So in order to elucidate the status of groundwater quality in Tamil Nadu, a geochemical seasonal variation of groundwater have been investigated and the result was that the groundwater is the only alternative source for drinking water[13].

The present study assesses by Ravisankar and Poongothai the source, degree, extent and nature of groundwater contamination in the Sirkazhi coastal region. Samples of groundwater were collected from eleven wells in this area and analyzed chemically to determine the extent of contamination. The results showed significant variations in water quality parameters in the study area and helped understand the longer-term adverse impacts that tsunami inundation can have upon groundwater resources[17].

Ahmed and Sulaiman described the groundwater quality at Seri Petaling Landfill located in the state of Selangor, Malaysia, they concluded that the total dissolved solids (TDS) represented by Na^+, K^+, Ca^{++}, Mg^{++}, Cl^-, SO_4^{--}, and NO^-_3 ions were estimated to be more than 4000 μS/cm at a depth of about 16 m and a distance of 190 m along the resistivity survey line. The groundwater was determined as unfit for domestic purposes[3].

Pajunen & etc investigated one of the more interesting innovations in ion exchange technology over the past few decades has been the Recoflo short bed ion exchange to be an effective method for the metal finishers to minimize waste, ensure effluent compliance, provide water recycle[1].

A new ion exchange softening flow-sheet that uses brine regeneration has been developed by Brown and Sheedy based upon the Recoflo short-bed ion exchange process. Recoflo makes it possible to use extremely high service flow rates through very short resin beds, while achieving low hardness leakage[16].

Recently, inexpensive technologies for drinking water supply in small communities are highly considered in developing countries. One of these technologies is the application of ceramic filters that are usually made of diatomaceous earth or clay soil., the results showed that the clay filters had not the potential to remove hardness, EC, TDS and nitrate of water[4].

Many industrial water treatment facilities use lime softening to reduce hardness, Jerry and etc developed

package plant combines solids contact reaction and sludge thickening in a single tank[14].
Ground water was treated by reverse osmosis by Belkacem, Bekhti & Bensadok to eliminate the water solutes, the obtained results showed that the reverse osmosis process is well adapted for this treatment[10].
Polk, Murray, Onewokae, Tolbert, Togna, Guarini, Frisch, and M. Del Vecchio treated groundwater in certain areas at Longhorn Army Ammunition Plant (LHAAP) (Texas) with a biological fluid bed reactor (FBR) to remove the perchlorate[17].
In Pasadena, Texas, unique packed-bed ion exchange trains in a new demineralized water treatment system at the OxyVinyls, managed multi-plant site have keyed a dramatic gain in treatment efficiency for both boiler feed and process water[19].

MATERIALS AND METHOD

Water quality parameters which were studied taken from a well of about 65meters depth that excavated in 2003 are as follows: temperature, pH, electrical conductivity alkalinity, dissolved oxygen, turbidity, nitrate, Sulfate, magnesium and calcium ions, total dissolved solids (TDS) and hardness. The affected parameters are the hardness and total dissolved solids, therefore we try to treated and softening this GW to be used for potable and agriculture uses.
A laboratory apparatus of packed bed system consist of glass column with a 25 mm diameter and bed depth of (250mm) of (0.3–1.2mm) bead diameter at the bottom of the column that act as an adequate collection system with a valve connection and a screw clamp on the tubing used as an on/off valve and to control the flow rate fig.(1).
The resin that used in our process was a strong acid cation SAC exchange resin in the hydrogen form (C100-H) gel polystyrene cross linked with divinylbenzene which is used as spherical beads that vary in diameter as the standard bead distribution, these beads allow a maximum amount of surface area for facilitating the ion exchange process to remove or reduce the higher rate of hardness and total dissolved solid of GW as indicated in tab(1). During the softening process, calcium and magnesium that are present in the water supply are exchanged on to the ion exchange resin beads as the water flows past a bed of the resin placed in the column and the total dissolved solids TDS also removed fig.(3.a).
After (1.2min) of laboratory softening process the efficiency of the resin decreased, that leads to regenerate it. The simplest method of regeneration is co-flow (co-current) where the regenerate passes down flow through the resin in the same direction as the service flow, the bed is settled then regenerated with 10% sodium chloride solution as shown in for (12 min) fig.(3.b). In this process, regeneration of a softener is normally done with 100 gm/L of sodium chloride solution. As the TDS of the water to be softened increases, the amount of salt has to be increased also in order to reduce the amount of hardness left in the lower part of the bed. Therefore, dosages of 100 to 150 gm/ L may be required to achieve low hardness leakage when softening higher hardness water and TDS.
To provide a university city of about 1000 person of 400,000L/day of softening water, a scale up for laboratory apparatus was made of four packed softening units each one of 1m^3 volume.

RESULTS AND DISSCUSION

According to this study and investigation for the wells water of site of Tikrit University, we concludes that the temperature of ground water is relatively constant and is equivalent to, or greater than, the mean air temperature above the land surface, as shown in tab.(1).

Although water does not have to be strongly basic (high pH) to have high alkalinity, bicarbonate (HCO_3^-) and carbonate ($CO_3^=$) produce an alkaline environment which is generated by the action of carbon dioxide in water on carbonate rocks such as limestone and dolomite here was slightly.

Chlorides (Cl^-) which are dissolved from rocks and soils in groundwater, exist in small quantities which have little effect on the use of water according to ISP 417, and this water is free from noticeable turbidity that mean not containing enough iron for appreciable precipitation on exposure to air[8].

Nitrate in water encourages growth of algae and other organisms that cause undesirable tastes and odors. In the university site the nitrate contamination is not significant, its concentrations increase slightly and becomes more as in march, September and October. This variation shows that the main origin of nitrate is chemical fertilizer, but it agrees comparatively with the allowable range of Iraqi Standard Properties for Drinking Water 417.

High concentrations of TDS can lead to objectionable taste, problems with scaly buildup in pipes, and reduced efficiency in hot water heaters. Due to the problems associated with high TDS, a recommended maximum level of 500 mg/l has been set by the Environmental Protection Agency (EPA). Tab.(1) show TDS values can range from 1570 to over 2,200 mg/l; the highest values are located in the spring season of Tikrit University.

As water moves through soil and rock formations that contain sulfate minerals, some of the sulfate dissolves into the groundwater. Minerals that contain sulfate include magnesium sulfate (Epsom salt), sodium sulfate (Glauber's salt), and calcium sulfate (gypsum). The level of sulfate in most groundwater in occurs at higher levels, which sometimes can exceed 1000 mg/L, in certain areas of the city (sulfate in well water). Sulfate SO_4^{-2} is a concern with drinking water due to its objectionable taste, smell, and laxative effects. The Iraqi Standard Properties-417 has determined a recommended maximum level of 400 mg/l for sulfate in drinking water. Tab.(1) shows concentrations of sulfate in Tikrit University. of values range from less than700to 1,300mg/l.

Water hardness in most groundwater is naturally occurring from weathering of limestone, sedimentary rock and calcium bearing minerals shows the variation of Ca^{+2} and Mg^{+} in ground water. Hardness can also occur locally in groundwater from chemical and mining industry effluent or excessive application of lime to the soil in agricultural areas. In some agricultural areas where lime and fertilizers are applied to the land, excessive hardness may indicate the presence of other chemicals. The results of groundwater samples analyzed had a hardness of over than 1400mg/L , and less than 3400 mg/L. Notice that soft water tended to be found in areas with mainly igneous rock formations, while areas with mainly sedimentary rock tended to have greater water hardness as our site.

In general, the longer groundwater remains in contact with soluble

materials, the greater the concentrations of dissolved materials in the water. The quality of groundwater also can change as a result of the mixing of waters from different aquifers. In aquifers affected by human activity, the quality of water can be directly affected by the infiltration of anthropogenic compounds or indirectly affected by alteration of flow paths or geochemical conditions.

So, water quality in the Tikrit University tends to be rich with most water quality as the TDS, sulfate, and hardness which are consistently over than (Iraqi Standard Properties-417) SIP. The major factor influencing TDS and hardness concentration appears to be the depth of the aquifer, the nature of well rocks and anthropogenic compounds. However many communities still use the aquifer water, since water from the groundwater can be easily treated[4].

Softening Process

Softening process mainly depended on ion exchange bed volume. The best flow rate of raw water in our process was taken to be 4600 ml/hr, leads to have a contact time of removing total hardness about 1.6 minutes as shown in tab.(2) and fig.(4), which shows different values of time for different flow rates of the same bed volume, to produce about 1.75 L/hr of softening water of no hardness and 30 mg/L of TDS, fig(5).

There are many factors controlling how well a softener works, one is the water composition, the higher the Ca^{++} and Mg^{+} of the raw water, the fewer milliliters a system will produce when regenerations (cleanings).

Typically, about 35,000 liter/hr of one cubic meter unit regenerated by 62.5gm of salt will produce 100,000 liters per day of treated water of 100 mg/L hardness and 35 mg/l TDS as shown in fig(5).

Regeneration Process

As the brine is fed down-flow, to the resin bed, the sodium will displace the calcium and magnesium gradually lower and lower through the bed until forced out[9], with a flow rate of 625 ml/hr of 10% sodium chloride solution along the time of regeneration that equal to 12 min.

In regeneration process hardness gradually, more and more is pushed down through and out of bed, at the end of such co-current regeneration, the upper section of the resin bed is highly regenerated while the lower section, which only saw spent brine, will still contain some hardness. The amount of hardness left in the bottom of the bed will be directly related to the amount of brine fed to the resin bed. And as the TDS of the water to be softened increases, the amount of salt has to be increased also in order to reduce the amount of hardness left in the lower part of the bed. Therefore, about 62.5 gm of salt may be required to remove hardness and softening higher TDS water[13].

Rinse process

The bed is then rinsed with a flow rate of 1250 ml/hr for 6 min total time to have an activated ion exchange bed to returned to service, and the wastewater is discharged to the sewer or septic system.

Material Balance

To produce a volumetric flow rate of softening water of 100 L/hr , we made the material balance as shown in the block diagram fig.(2) that explaining the flow rates and the hardness concentration as the main parameter of all streams in the system.

$$Q_f = 2500 ml/hr = 2.5 L/hr = Q_f$$

$Q_P = Q_t + Q_r$, $2.5 = Q_t + Q_r$

$c_p Q_p = c_t Q_t + c_r Q_r$

$100 * 2.5 = 0 * c_t Q_t + 2000 * Q_r$

$Q_r = 0.125 L/hr = 125 ml/hr$

$Q_t = 2.375 L/hr$

$Q_t = Q_f = 2.375 L/hr$

$Q_{\acute{f}} = Q_f + Q_r = 2.5 L/hr$

According to this material balance, we have a softening water of flow rate equal to 2.5L/hr of a hardness concentration of 100 mg/L and a 30mg/L TDS.

Scale up

A scale up of the laboratory apparatus plant was made to be one cubic meter bed volume to provide about 100,000 L/day therefore, we need four units of the packed bed system volume (ion exchange) to provided about 400,000 L/day of drinking water or for potable uses water for a small city of about 1000 person.

CONCLUSION

1. The appropriate time to remove total hardness from ground water is 1.6 minutes at a flow of raw water of 4.6 L/hr to have softening water.

2. Strong acid cation in the form of H is the suitable ion exchange to remove water hardness and total dissolved solid.

3. Brine solution is the most suitable regenerate solution to replace the calcium and magnesium ion with sodium ions to returned to service.

4. Since the resin has a higher selectivity for calcium and magnesium than for sodium, the only way to displace the calcium and magnesium off the resin, with sodium, is by feeding the sodium at a sufficiently high concentration, normally 10 to 12% brine is used for regeneration.

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Tab.(1) Tikrit University GW Properties and the Min. & Max. Values & The Standard Iraqi Properties -417

Property / Date	T °C	pH	TDS mg/l	EC	Ca^{++} mg/l	Cl^{-} mg/l	Mg^{++} mg/l	Hardness mg/l	Alk mg/l	SO_4^{-2} mg/l	NO_3^{-} mg/l	D.O mg/l	Turbidity NTU
20/1	14.5	8.6	1570	3210	544	280	89	1760	80	700	22	3.7	5
20/2	14	7.0	2200	3420	640	258	89	2610	260	1000	31	4	3
20/3	13	7.3	2260	3320	593	267	143	2125	160	960	40	4.5	5
20/4	14	7.1	1970	3400	620	298	223	3400	180	800	18	3.5	3
20/5	15	7.3	2100	3700	621	250	45	1500	60	1100	20	1.5	5
20/6	16	7.6	2200	3400	500	300	70	1700	70	1200	32	2	2
20/7	18	7.8	2270	3430	550	298	70	1720	80	1200	38	2.5	2
20/8	17	7.5	2200	3350	530	285	75	1670	89	1100	40	2.5	2
20/9	15	7.7	2100	3300	450	280	60	1500	80	1300	42	2.5	2
20/10	15	7.8	2200	3350	400	250	80	1600	100	1200	40	1.5	3
20/11	16	8.1	2300	3900	500	230	87	1700	90	1000	35	2.5	3
20/12	14	7.6	1735	3470	520	200	92	1400	80	900	32	4	5
Min.	13	7.0	1570	3210	450	200	45	1400	60	700	18	1.5	2
Max.	16	8.6	2300	3900	640	300	223	3400	260	1300	45	4.5	5
Average	14	7.5	2017	3402	561	267	101	2000	121	1133	30	3.2	3.8
Acceptabl Range	4-10	7-8.5	500	40	75	200	50	80-150	5-125	200	0.01-0.05	4	0.1-5
Max. Accept	15	6.5-9.2	1500	370	200	600	150	500	200	400	40	7	25
Softening water	15	7.5	30	28	23	15	12	100	78	34	9	3	2

Tab.(2). The Operating Condition in the System

Operating Conditions (Co-Current softening of GW)				
Operation	**Flow Rate (ml/hr)**	**Solution**	**Amount (gm)**	**Contact Time (min)**
Service	4600	Raw water	-------	1.6
Regeneration	625	Brine solution	62.5	12
Rinse	1250	Water	------	6

Tab.(3) Material Balance Over the System

Stream No/Symbol	**1/f**	**$2/f^{-}$**	**3/r**	**4/t**	**5/p**
Flow rate L/hr	2.5	2.375	0.125	2.375	2.5
Hardness conc. mg/L	2000	2000	2000	0.0	100

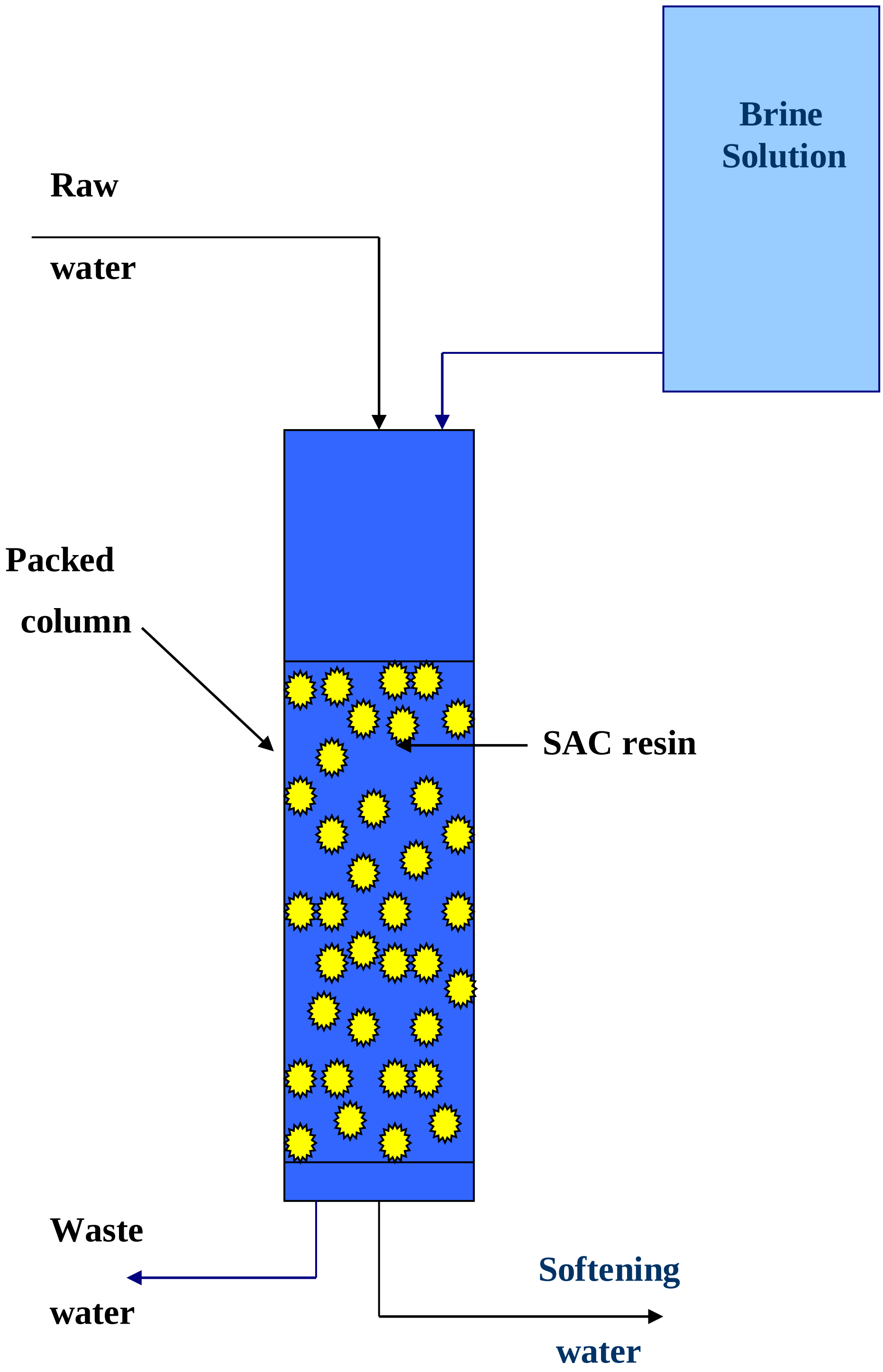
Brine
Solution
Raw
water
Packed
column
SAC resin
Waste
water
Softening
water

Fig. (1). Schematic Diagram of Packed Bed Plant.

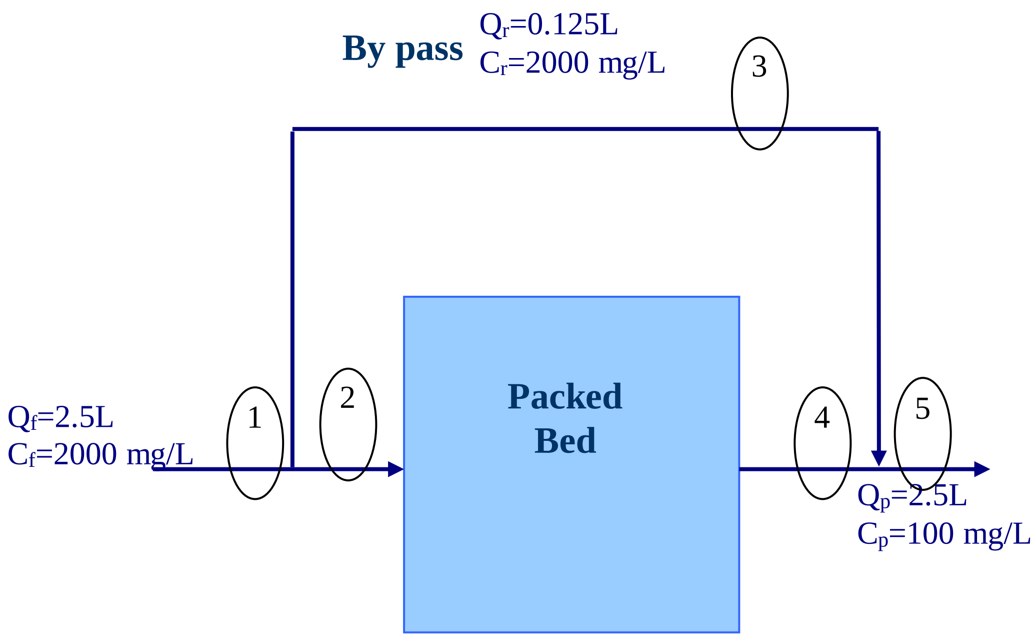

Fig. (2) block diagram of the packed bed system.

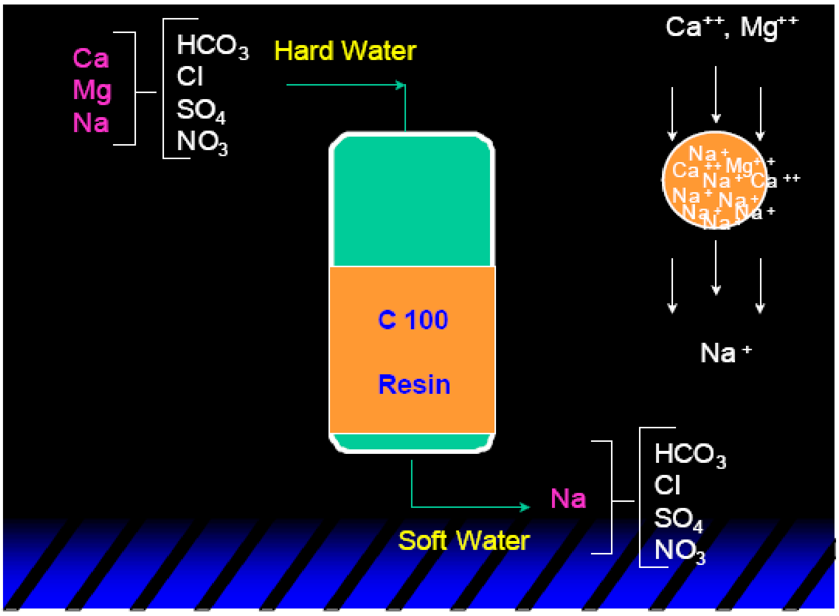

Fig. (3-a).Softening & Regeneration Process.

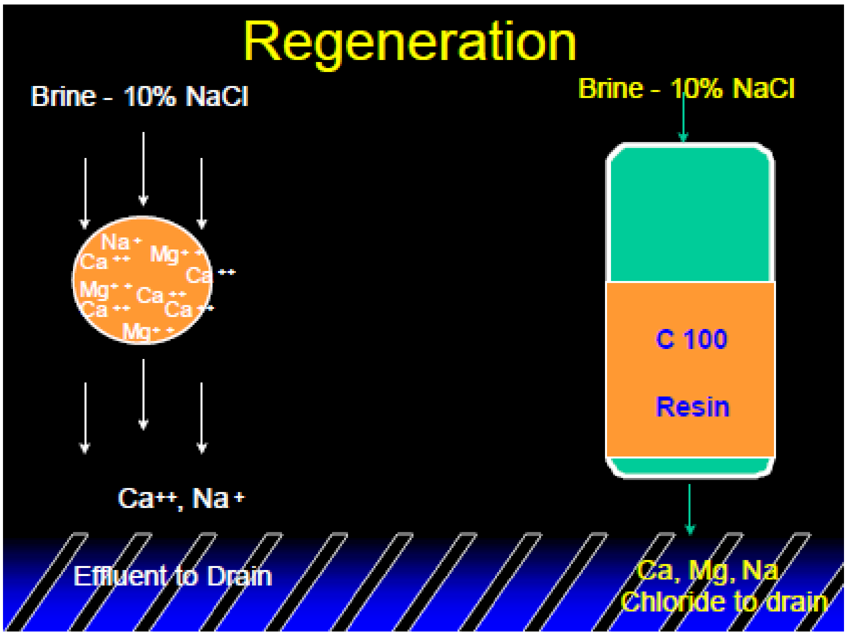

Fig. (3-b).Softening & Regeneration Process

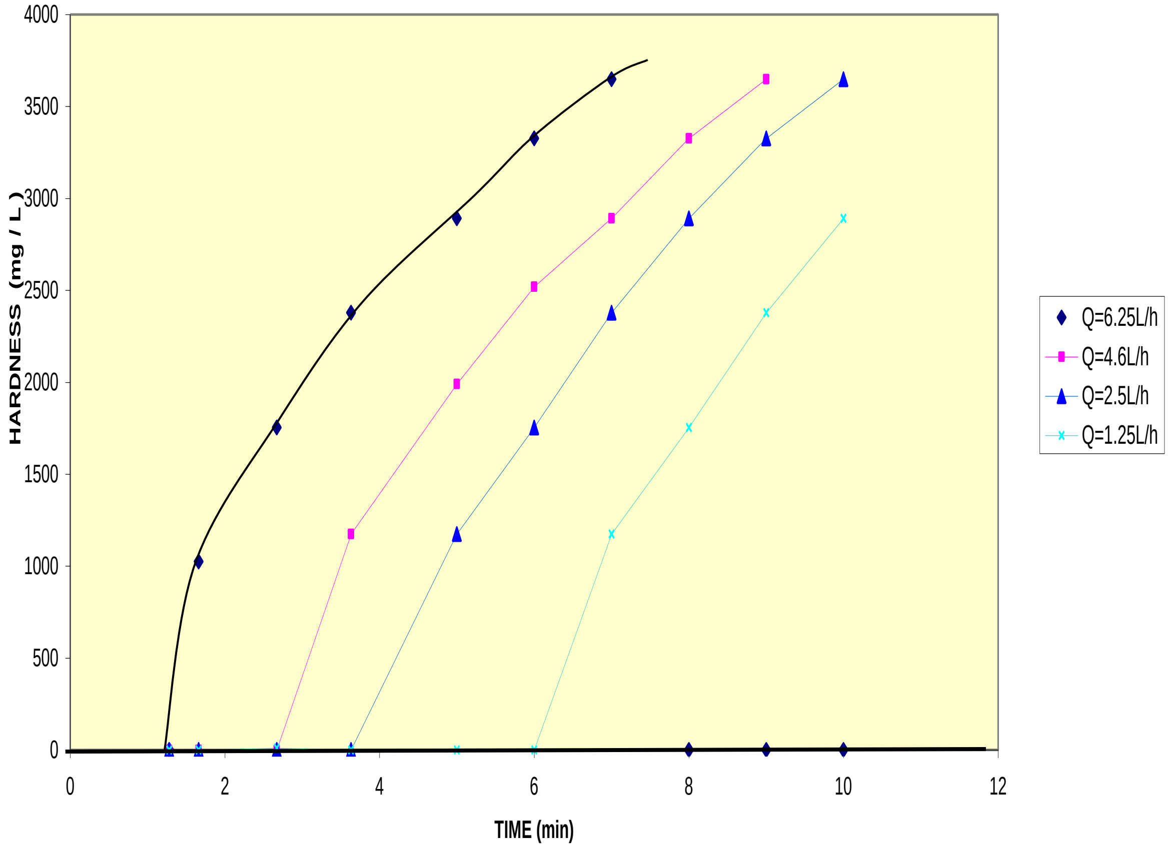

Fig.(4). Relation of Hardness removal with Contact Time at Different Flow rates.

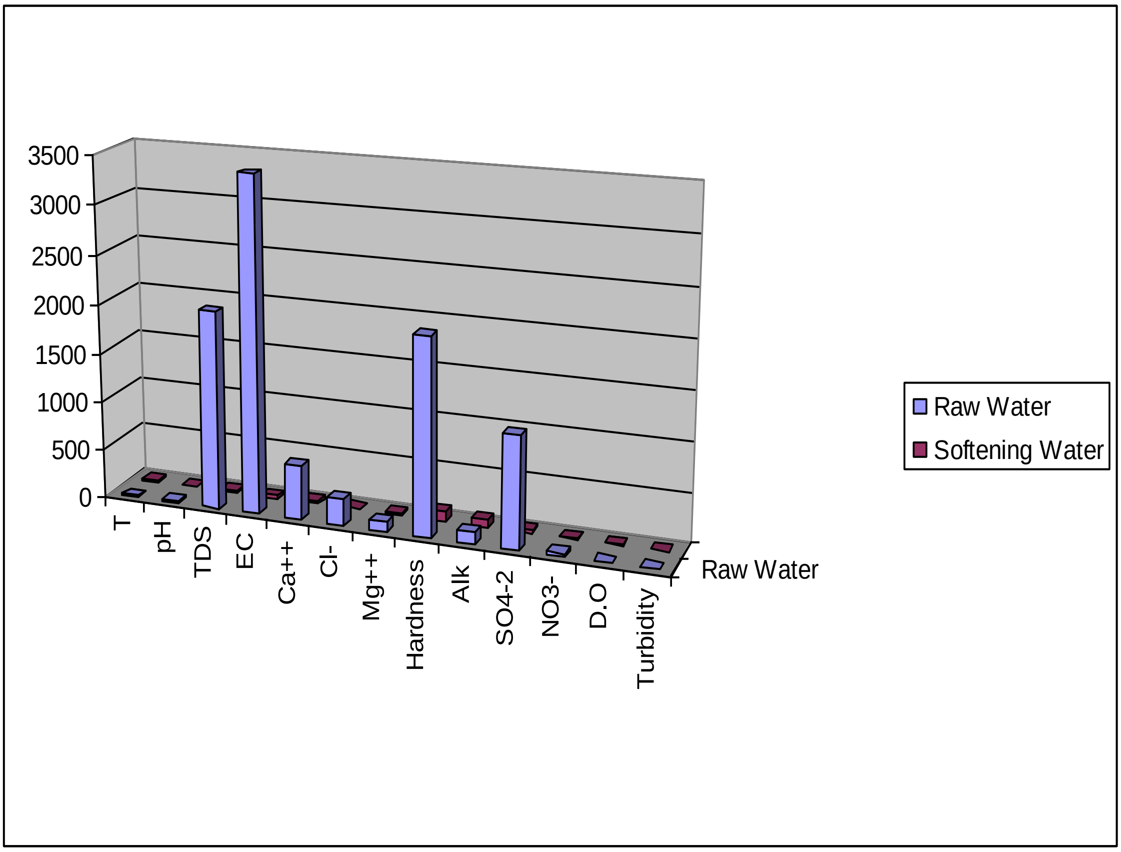

Fig. (5). Variation of properties in Raw and Softening Ground Water.

دراسة وتقييم ومعالجة المياه الجوفية في جامعة تكريت

مها إبراهيم صالح

مدرس مساعد

قسم الهندسة الكيمياوية

جامعة تكريت

الخلاصة

الهدف من هذا البحث هو دراسة ومعرفة التغيرات الزمنية والمكانية على الخواص الكيمياوية والفيزياوية للمياه الجوفية في جامعة تكريت في محافظة صلاح الدين ومن ثم معالجة هذه المياه بما يجعلها مياه صالحة للشرب والاستخدام البشري.

حيث تم أخذ نماذج مختلفة من بعض الآبار الموجودة في جامعة تكريت وعلى مديات زمنية مختلفة خلال السنة ابتداءا من شهر أيلول لسنة 2007 ولغاية شهر آب لسنة 2008. وقد أجريت الاختبارات القياسية المختلفة لنماذج المياه الجوفية في الموقع المذكور آنفا والتي كانت مقياس الحامضية , درجة الحرارة, كمية الأملاح المذابة, التوصيلية الكهربائية, تراكيز ايونات الكالسيوم والمغنسيوم وتراكيز الكلوريدات والكبريتيدات والنترات وكذلك مقياس القاعدية ومقدار العكورة إضافة إلى مقدار العسرة الكلية وكمية الأوكسجين المنحل.

وقد تبين من خلال نتائج هذه القياسات أعلاه وجود اختلاف في خواص المياه و تراكيز الايونات فيها يتجاوز المديات العراقية القياسية المسموح بها لمياه الشرب, وهذا يعود إلى التفاعل بين المكونات الجيولوجية للأرض مع المياه الجوفية بسبب الزراعة والمبيدات أو التدخل البشري عموما أو تداخل الأمطار بين الصخور الجوفية وتأثير الرياح على الصخور, , لهذا تمت معالجة وتحلية هذه المياه الجوفية بطريقة المبادل الأيوني كطريقة مناسبة لتوفير مياه صالحة للشرب.

الكلمات الدالة: المياه الجوفية, نوعية المياه الجوفية, التحلية, المبادل الأيوني.