# EVALUATION OF GROUND WATER QUALITY FOR SELECTED AREAS OF IRAQ[+]

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## Abstract

**The present study is concerned with evaluating the quality of the ground water in the selected areas of Iraq [Kut (8 wells), Bedra (8 wells), Mussayab (10 wells), Shatra (5wells)]. Thirty – one wells were selected for this purpose. Quality parameters testssuch as total dissolved solids, total hardness, conductivity, concentration of some anions and cations were all conducted on each sample. The results are compared with criteria and standards issused by international agencies interested in this field. Most of parameters investigated appear to exceed the recommended limit set by standards.**

**The evaluation parameters in this study are temprature, pH, Ec, TDS, $Ca^+$, $Mg^+$, $K^+$, $Na^+$, $Cl^-$, $SO_4^-$, TH, BoD, SAR, Na, Table (1). Generally all tested samples were not suitable for domestic and potable purposes . But also the results show the suitability of water for irrigation, building, some industrial and animals uses.**

## المستخلص

**اهتمت هذه الدراسة بتقييم نوعية المياه الجوفية في المنطقة الوسطى من العراق (والممثلة بمناطق الكوت،بدرة ،المسيب،الشطرة ). وقد اختير (٣١) بئرا لهذا الغرض. اجريت العديد من الفحوصات النوعية مثل المواد الذائبة ،العسرة الكلية ،التوصيل الكهربائي فضلا عن تحديد تراكيز بعض الايونات السالبة والموجبة لجميع النماذج الماخوذة من هذه الآبار. وتم مقارنة نتائج هذه الفحوصات مع المعايير الموضوعة من قبل هيئات عالمية ذات علاقة بالموضوع اظهرت النتائج تجاوز تراكيز المعايير المطلوبة للقيم المسموح بها في المواصفات . العناصر التي تم تقييمها في هذه الدراسة هي درجة الحرارة، pH، Ec، TDS، $Ca^+$، $Mg^+$، $K^+$، $Na^+$، $Cl^-$، $SO_4^-$، TH، BoD، SAR، Na, جدول رقم (١).**

**وبصورة عامة يمكن القول ان جميع النماذج المفحوصة غير ملائمة للاستخدام المنزلي والشرب، لكن ايضا اوضحت الفحوصات صلاحية المياه لاغراض الري والبناء وبعض الفعاليات الصناعية واستخدامات الحيوانات.**


## Introduction

Ground water is considered a good water resources for drinking, irrigation, spraying and other domestic use, these resources constitute the major portion of the total world fresh water avialable [1].

In rural areas there is often a serious problem of adequate year – round supply of water in both quantity and quality [2].

Ground water in Iraq is not fully used and efforts have been made to develop these waters which represent the most valuable water resource [3].

Ground water plays very important pent in places with water shortage [4]. Also ground water has two advantages over surface supplies - first ground water is less polluted and second it is not a source of loss as it is the case in streams, lakes and reservoirs [5]. A major problem with ground water is the possibility of chemical pollution [6].

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This research is intended to classify and evaluate the quality of the ground water, used for different uses in the middle area of Iraq.

## Ground water samples

In sampling water for analysis of its quality, the water should be collected in one – half glass bottles. After rinsing the bottle with the water being sampled, the sample is stored in a cool place and transferred promptly to a laboratory for analysis. Samples should be taken from a well only after it has been pumped for some time [1] .

## Experimental work

Before sampling water was pumped for 2 hrs. A sample was then taken for measurement of physical and chemical characteristics, samples were collected from 6 wells within Shatra area, 10 wells within Mussayab area, 9 wells within Bedra area, and 6 wells within Kut area .

The examination procedures were performed using American standard method for the examination of water and waste water [2].

## Measures of water quality

The quality required of a ground water supply depends upon its purpose, thus the needs for drinking water, industrial water, and irrigation water vary widely .

In specifying the quality characteristics of water, a complete statement requires chemical, sanitary, and biological analyses. For ground water, however, the chemical, physical, are most important, the others being pertinent only for unusual situations of a local character .

A complete chemical analysis of a sample of ground water includes the determination of the concentrations of all the inorganic constituents present. Dissolved salts in ground water occur, as dissociated ions, in addition, other minor constituents are present and reported in elemental form only. The analysis also includes measurements of PH and specific electric conductance. Depending upon the purpose of the water quality investigations, a partial analysis of any particular constituents will sometimes suffice .

Properties of ground water evaluated in a physical analysis include temperature, color, turbidity, odor, and taste [1].

### 1- Temperature :

The temperature of ground water is usually the mean atmospheric temperature of the locality and tends to increase at greater depth. Ground water temperature remains fairly uniform throughout the year. No significant differences occurred between the four sites of studied areas.

### 2- % Na (Sodium percent):

usually this content is expressed by :

$$\% \, Na = \frac{(Na + K) \times 100}{Ca + Mg + Na + K}$$

Based on percent of Sodium, the quality of water is classified as good for irrigation purposes Table(2)

TABLE 1: RANGES AND MEANS OF GROUND WATER QUALITY OF STUDIED

| Parameters | Shatra | Bedra | Mussayab | Kut |
|---|---|---|---|---|
| Temprature $C^0$ | 18-25 | 15-24 | 17-23 | 17-27 |
| Mean | 21 | 20 | 20 | 21 |
| PH | 7.4-8.1 | 7.1-7.2 | 7.09-8.15 | 7.15-7.75 |
| Mean | 7.75 | 7.15 | 7.8 | 7.45 |
| $Ec*10^6$ | 1780-9500 | 4100-13500 | 1380-7450 | 3200-11250 |
| Mean | 5640 | 8800 | 4415 | 7225 |
| TDS | 630-1070 | 645-2315 | 750-1150 | 440-1440 |
| Mean | 850 | 1480 | 950 | 940 |
| $Ca^+$ | 170-710 | 625-940 | 105-520 | 190-690 |
| Mean | 440 | 782 | 312 | 440 |
| $Mg^+$ | 64-410 | 155-570 | 180-700 | 80-625 |
| Mean | 115 | 240 | 240 | 220 |
| $K^+$ | 8.5-25 | 1.6-7.3 | 9.5-30 | 11.5-25 |
| Mean | 17 | 3 | 31.5 | 20.1 |
| $Na^+$ | 115-620 | 280-850 | 185-1410 | 240-1310 |
| Mean | 230 | 430 | 650 | 500 |
| $Cl^-$ | 200-1550 | 340-2800 | 260-2350 | 410-2150 |
| Mane | 700 | 800 | 945 | 920 |
| $So4^-$ | 1800-2350 | 696-6300 | 210-3900 | 810-3200 |
| Mean | 2210 | 3115 | 1600 | 2250 |
| TH | 700-3200 | 2100-4880 | 1330-5115 | 1630-4200 |
| Mean | 2035 | 4100 | 3200 | 3650 |
| BOD | 0-8 | 0-10 | 0-8 | 0-9 |
| Mean | 4 | 5 | 4 | 2 |
| SAR | 1.7-5 | 3-12 | 3-13 | 2-25 |
| Mean | 3.5 | 6 | 10 | 11 |
| % Na | 20-37 | 19-48.1 | 17.1-59 | 27-60.9 |
| Mean | 27 | 35 | 31 | 34.5 |

**Table (2) :** Quality of water for irrigation (after wilcox).[1]

| Water Class | Percent Sodium | $Ec*10^6$ At $25C^0$ | Boron , ppm | | |
|---|---|---|---|---|---|
| | | | Sensitive crops | Simitolerant Crops | Tolerant Crops |
| Excellent | <20 | <250 | <0.33 | <0.67 | <1.00 |
| Good | 20-40 | 250-750 | 0.33-0.67 | 0.67-1.33 | 1.00-2.00 |
| Permissible | 40-60 | 750-2000 | 0.67-1.00 | 1.33-2.00 | 2.00-3.00 |
| Doubtful | 60-80 | 2000-3000 | 1.8-1.25 | 2.00-2.50 | 3.00-3.75 |
| Unsuitable | >80 | >3000 | >1.25 | >2.5 | >3.75 |

## 3-SAR (Sodium Adsorption Ratio):

It is defined by:

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

According to Rechared classification table (3) waters of the studied area are regarded as excellent for irrigation purposes for low group plant.

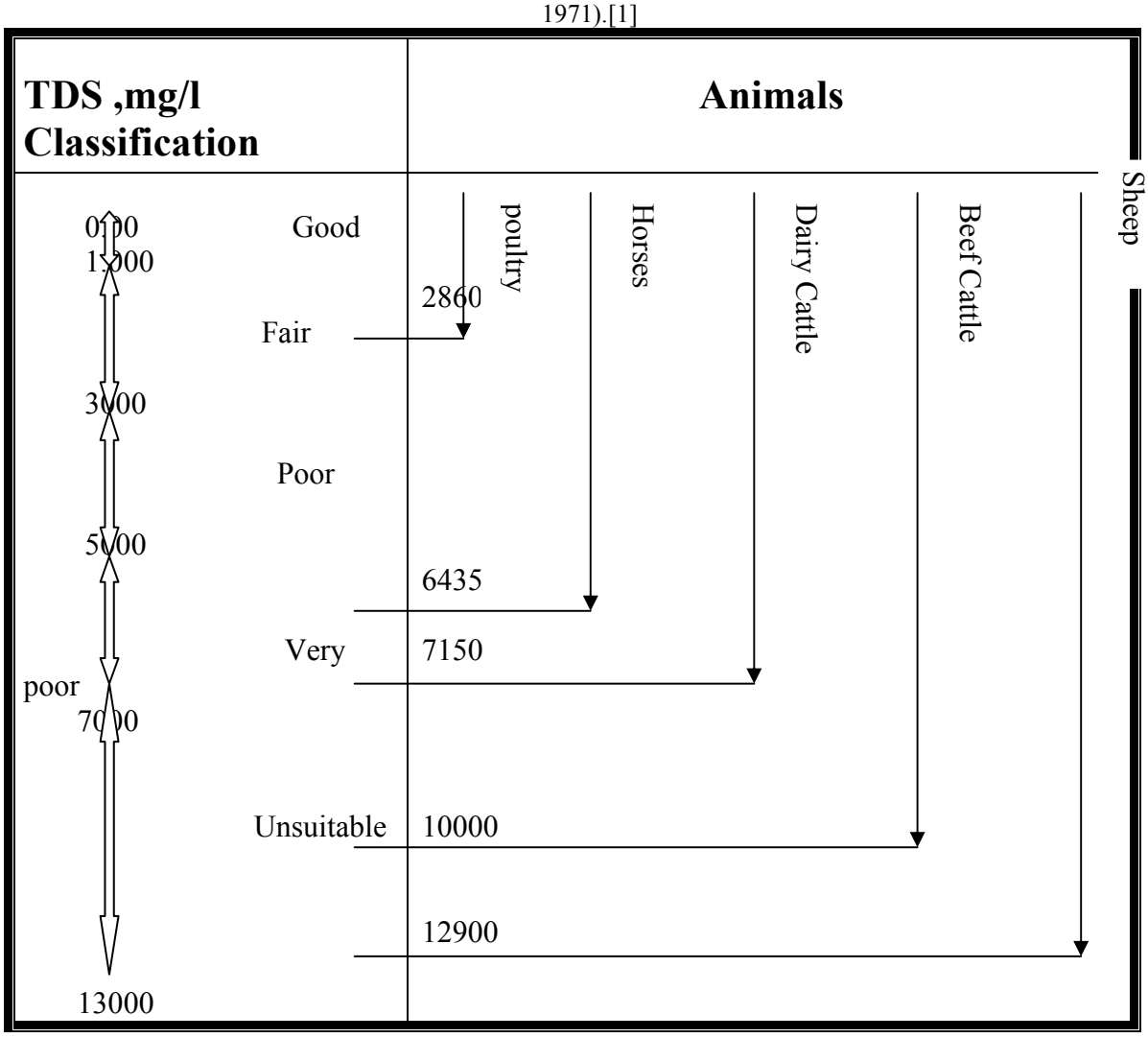
**Table 3:** Rechared classification for water uses of irrigation purposes.[1]

| Ec*106 | SAR | Water Class | Group |
|---|---|---|---|
| 100-250 | 10 | Excellent | Low |
| 250-750 | 10-18 | Good | Medium |
| 750-2250 | 18-26 | Fair | High |
| 2250 | 26 | Poor | V.High |

## 4- TDS and EC (Total dissolved solids and electrical conductivity)

Total dissolved solids ranged from 850 to 1480 mg/l. No similarities were also observed for electrical conductivity measurements as well. According to Wilcox Table(2) and recharged Table(3) these waters are classified as unsuitable and poor for irrigation uses. But they are good to fair for animal drinking purposes according to Crest, Lowery, Lowen and king classification Table(4).

**Table 4:** Classification of water for animal drinking purposes (crist and lowry , 1972 , lowen and king , 1971).[1]




## 5- PH (hydrog concentration)

There is a significant difference between the average PH of Bedra site (7.15)and the PH of Mussyab, Kut and Shatra (7.8 , 7.45 , 7.75) respectively. This suggests that water dissolution of soil calcium carbonate increased the PH of the percolating solution, offsetting the production of hydrogen ions from nitrification and organic acid formation. So all these waters represent low alkaline waters, and are recommended for some industrial purpose Table(5)such as canning food chemical, cement, refinery, and paper industry .

**Table 5:** Recommended limits for some industrial water purposes (salvato , 1982) .[1]

| Industry | PH | TH Mg/l | Cr Meq/l | So4 Meq/l | $Ca^+$ *Meq/l* | $Mg^+$ *Meq/l* |
|---|---|---|---|---|---|---|
| Canning Food | 6.5-8.5 | 310 | 8.462 | 5.205 | 5.988 | 8.226 |
| Chemical Industry | 6-9 | 1000 | 14.103 | 17.697 | 9.980 | * |
| Cement | 6.5-8.5 | * | 7.052 | 5.205 | * | * |
| Refinery | 6-9 | 900 | 45.13 | 11.867 | 10.978 | 6.992 |
| paper | 6-9 | 475 | 5.641 | * | 0.998 | 0.987 |

*** Not available**

## 6-Major Anions:

Chloride and sulfate are the major anions, Chloride are widely distributed in nature. They are present in mineral deposits, in sea and brackish water, in ocean vapors and spray carried inland by wind, in human excreta. The chloride content is not affected by normal passage of water over the ground or through it. The chloride levels measured in Mussayab averaged (945)mg/l. Thus ,chloride appears to be moving freely through the soil profile. This observation is consistent with the generally held finding the chloride reacts minimally with the soil profile .

High sulfate concentrations in Mussayab were less than that in Shatra and Bedra water wells, thus, sulfate contamination resulting from waste water application has occurred. Concentrations of chloride and Sulfate are with in the limits recommended by Salvato for some industrial purposes Table(5) .

## 7- Exchangeable cations:

Concentration of Sodium and potassium in the Mussayab and Kut (31,31.5), (34.5,20.1)mg/l respactively, were indistinguishable from equivalent concentration in Shatra and Bedra areas. This indicates that the soil exchange capacity for these constituents has been exhausted and that both sodium and potassium were entering the ground water unimpeded. Based on calcium concentration only ground water of Mussayab area is recommended for building purpose Table (6), while that of the other areas is not. Also the concentrations of magnesium, potassium and sodium are within the limits recommended for building purposes by Altoviski, Table(6).

**Table 6:** Rrecommended limits of water for building purposes (altoviski ,1962)[1]

| *Cation* | **Concentration ,ppm** | **Anions** | **Concentration ,ppm** |
|---|---|---|---|
| $Na^+$ | 1160 | $Cl^-$ | 2187 |
| $Ca^+$ | 437 | $SO4^-$ | 1460 |
| $Mg^+$ | 271 | HCO3 | 150 |

## 8- TH (Total Hardness):

The total hardness (TH) is a measure of the Calcium and Magnesium content and is cutomarily expressed as the equivalent of calcium carbonate. Hardness in water is due to carbonates, bicarbonates, chloride and sulfate of calcium and magnesium dissolved in it. It causes more consumption of soap without foaming later.

According to Sawyer and Mccarty, Table (7), water of the studied area is classified as a very hard water, and out of water of limits recommended by Salvato for industrial purposes Table (5) .

**Table 7:** Water classification according to hardness (after sawyer and mc carty , 1976)

| WATER CLASS | HARDNESS |
|---|---|
| SOFT | 0-75 |
| MODERATELY HARD | 75-150 |
| HARD | 150-300 |
| VERY HARD | OVER 300 |

## Conclusions

The results of the study may be summarized as follows :

1. All water types represent low alkaline water, it is recommended for some industrial purposes such as canning food, chemical, cement, refinery and paper industry.
2. Based on total dissolved solids these water types are classified as unsuitable and poor for irrigation uses, but they are good to fair for animal drinking purposes .
3. Based on calcium concentration only ground water of Mussayab area is recommended for building purposes .
4. According to Altoviski classification, water of studied area is recommended for building purposes .
5. Based on percent of sodium, adsorption ratio, the quality of water is classified as good to excellent for irrigation purposes .
6. Water of studied area is classified as very hard water .
7. This study may be considerd generalised for all selected areas.

The above results are shown in Table (8).

**Table 8 :** Ground water suita bility of this studied area for drinking , irrigation and industrial purposes

| Parameter | Site | Field data | | Ground water quality | | |
|---|---|---|---|---|---|---|
| | | Min. | Max. | Drinking | Irrigation | Industrial |
| PH | Shatra | 7.4 | 8.1 | | | Poor water according to Rechard classification and unsuitable according to Wilcox . |
| | Bedra | 7.1 | 7.2 | | | |
| | Mussayab | 7.9 | 8.15 | | | |
| | kut | 7.15 | 7.75 | | | |
| **Ec Mmhos** | Shatra | 1780 | 9500 | | | Acceptable according to salvato 1982 |
| | Bedra | 4100 | 13500 | | | |
| | Mussayab | 1380 | 7450 | | | |
| | kut | 3200 | 11250 | | | |
| **TDS Mg/l** | Shatra | 630 | 1070 | Fair for animals according to crist and Lowry 1962,Lowen and King 1971 | | |
| | Bedra | 645 | 2315 | Fair to poor for all animals according to crist and Lowry 1962,Lowen and King 1971 | | |
| | Mussayab | 750 | 1150 | Fair for all animals according to crist and Lowry 1962, Lowen and king1971 | | |
| | kut | 440 | 1440 | | | |
| **Exchangea -ble cations (Ca Mg) Mg/l** | Shatra | 170 , 64 | 710 , 410 | | | Recommended for canning food , chemical ,cement , refinery , and paper industry purposes limited by salvato 1982 |
| | Bedra | 625 , 155 | 940 , 570 | | | |
| | Mussayab | 105 , 580 | 180 , 700 | | | |
| | kut | 190 , 80 | 690 , 625 | | | |
| **Major anions ($Cl^-$** | Shatra | 200 , 1800 | 1550 , 2350 | | | Recommended for canning food , chemical cement , refinery , and paper |
| | Bedra | 340 , 696 | 2800 , 6300 | | | |

| | | | | | | |
|---|---|---|---|---|---|---|
| **, SO4 ) Mg/l** | Mussayab | 260 , 210 | 2350 , 3900 | | | industry purposes limited by salvato ,1982 |
| | kut | 410 , 810 | 2150 , 3200 | | | |
| *SAR* | Shatra | 1.7 | 5 | | Excellent for irrigation purposes for low ground according to Rechard classification . | |
| | Bedra | 3 | 12 | | | |
| | Mussayab | 3 | 13 | | | |
| | kut | 2 | 25 | | | |
| **% Na** | Shatra | 20 | 37 | | Good according to Wilcox . | |
| | Bedra | 19 | 48.1 | | | |
| | Mussayab | 17.1 | 59 | | | |
| | kut | 27 | 60.9 | | | |
| **TH Mg/l** | Shatra | 700 | 3200 | Very hard water according to sawyer and Mccarty ,1967 . | | Not recommended for industrial purposes according to Rechared classification . |
| | Bedra | 2100 | 4880 | | | |
| | Mussayab | 1330 | 5115 | | | |
| | kut | 1630 | 4200 | | | |

## REFERENCES


1. Todd , D. K., "*Ground Water Hydrology*" John Wiley Sons . Inc,1980.
2. Catterjee A.K. , "*Water Supply And Sanitary Engineering*" Khanna Publishers –Delhi, 1983.

٣. الهيأة العامة لتشغيل وصيانة النهر الثالث، مشروع تخفيض المياه الجوفية لمدينة الحلة، ١٩٩٩.
٤. الهيتي، بيان محي حسين، "*دراسة نوعية المياه الجوفية لمدينة بغداد*"، اطروحة ماجستير، كلية العلوم، جامعة بغداد، ١٩٨٥.
٥. الشكر،عبد الحسن خضير،" *دراسة صلاحية المياه الجوفية في مدينة الحلة للاستخدامات المختلفة*"، مجلة جامعة بابل، العلوم الهندسية ، المجلد ٥، العدد ٥ ،٢٠٠٠.
٦. البديري، نجاح كاظم،" *دراسة الخواص الكيمياوية للمياه الجوفية في مدينة الحلة ومعرفة مصادرها*"، مجلة جامعة بابل، العلوم الهندسية، المجلد ٥، العدد ٥، ٢٠٠٠.