A comparison of Two Methods of the Environmental Treatment for Water Wells: Case Study in Kufa City -Iraq

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Abstract. Water wells are considered one of the important sources for drinking and agricultural needs. To improve the quality of water wells, ten samples were taken from water wells, which are located in various places from Kufa city /Najaf. Wells are used for multi purposes: irrigation, drinking, cooking and other household uses. Two methods were adopted to achieve the essential requirement; one is ion exchange, while the other is activated carbon method. Study results show the unsafe of some water wells used for drinking purposes because some ions concentrations have exceeded the allowable limits of sulfate SO₄⁻, chlorides Cl⁻, and also water hardness. All these parameters exceeded the limits for drinking uses. However, they were within the allowable magnitudes for agricultural uses. Water wells can classify into two classes, one for irrigation water with high salinity valid to irrigate some crops, which withstand a certain percentage of salinity in soils. The second was classified as water with very high salinity, which have used in case of irrigating crops that resist high levels of salinity. Study concluded that the method of activated charcoal was improved the water quality better than method of ion exchange.

1. Introduction

Human beings can live without water is impossible. Continues of life on the planet with a suitable quantity of water is inevitable. Water looks like a fuel cooling device in the human body, which has important role in its operations and vital, as water comes from two main sources, either free surface water or groundwater. Surface water comes from rivers, lakes, dams and reservoirs on the surface of the ground, it may exposed to various types of agricultural pollutants, while containing a small percentage of salt in comparison with groundwater, which contains a high content of salts (1). Therefore, water surface has low hardness in comparison with ground water. Generally, processing operations are designed to remove suspended solids, which cause an increasing in turbidity magnitude, and change in taste and color. Treatment unit is limited to physical properties, which include sedimentation, filtration and disinfection. While wells clean source reliably in many communities in the world, but the deep wells produce water to processors need either physical or chemical treatments or some advanced engineering method to be safe for drinking. To remove dissolved gases such as, hydrogen sulfide, carbon dioxide and others, or remove some dissolved minerals such as: iron, zinc, manganese and other minerals, which cause water hardness. The hardness composed of calcium and magnesium compounds dissolved in water. In Iraq 75% from total well numbers 2454 is used for drinking but only 38% of these wells are suitable for drinking and domestic uses (2). In case of using water well for agricultural uses, its quality will affect the productivity of agricultural crops, in addition to their direct impact on the growth of agricultural crops by the direct effect on physical and chemical
characteristics of the soil. In general, water wells contain varying proportions of soluble salts. On this base, studying the quality of water wells are very essential to explore the issues that may emerged from the study. Additionally, quality of groundwater was affected by rocks and salts that pass through it to the soles of the Earth's crust (3).

It is also affected by the quality of surface water from oceans, seas, lakes and rivers. Many previous studies were show that the quality of water wells in eastern region of Tigris river varied in its classification from normal salty water few alkaline effect to high salty water and high alkaline effect, while water wells in western region of Tigris river was classified from normal salty water few alkaline effect to high salty water and few alkaline effect (4).

In this study, 10 different samples from water wells were tested according to standard international method for analytical water in order to ensure that is water suitable and safe for different uses (drinking or irrigation) or not, After that, introducing suggestions for a simple treatment of water wells.

2. Study area

Figure 1, shows the area of study in Al-Najaf Al-Ashref governorate.

![Wells distribution in the site](image)

**Figure 1.** Wells distribution in the site.

3. Chemicals and equipment used in the study

3.1 Chemicals

All chemicals used in the research of high-purity (A.R grade).

3.2 instrument used

1. Single beam UV-visible spectrophotometric Sp300 (Japan).
2. The pH meter, WTW-720 Inolab (Germany).
3. Digital conductivity meter – WT-720 Inolab (Germany).
4. Flame atomic absorption spectrophotometer (Pyunicom).
4. Methodology

A field survey was done to collect ten samples from wells within Kufa area in Al-Najaf governorate. These samples were chose in two different seasons (July and January). Different seasons will give us the effect of temperature and rainfall on the properties of water wells. The selection of wells was done according to its locations and distance between them. It is found that almost these wells are used in irrigation and drinking unless the last one which is used for irrigation only. These wells have operated by farmers who live there. Depths of these wells were ranged from (6-23) m. Samples were collected in glass bottles with a constant volume, temperature and pH were recorded in the site. All the remaining tests were done in the laboratory according to study requirements and standard methods to analyze water samples (5).

4.1 Analytical Measurements

Analytical measurements were done to analyze the properties of samples water, which collected from field and determine the present of each element by using two methods below:

1. Simple analytical method (traditional): using complex titration (Loose one interaction and the existence of a known concentration detector, in order to know the concentration of the unknown solution). This method used to estimate the concentrations of ions through using Othlee diaminesolution Quad-acetic acid EDTA concentration of (10-3M) and precipitation titration, also used through method of Volhard to estimate chloride ion cl⁻ by using the Silver nitrate (AgNO₃) concentration of (10-3M) using Potassium chromate as evidence (6).

2. Instrumental Methods of Analysis: This method was used for estimating flame spectroscopy analysis of sodium and potassium ions (Na⁺, K⁺) by using a combination of standard solutions of sodium chloride and potassium chloride concentration ranging between (20 ppm, 50 ppm) respectively. Also the measured of molar conductivity of the water samples using the device molar connectivity or Electrical Conductivity EC.

5. Results and discussion

Temperatures and pH values were measured in the site but electrical conductivity EC was measured before treatment process. The results show that all water samples have pH values more than 8, which mean that water can be classify as Alkaline water. Ions of (Cl⁻,SO₄²⁻, Na⁺,K⁺,Mg²⁺ and T.H) were calculated to know its values before treatment. All concentrations of these elements were high in all water samples. After first measurement of elements concentration in water samples, we can classify water as moderate salty irrigation water and increase salty irrigation water. This classification was made according to suggested regime depending on irrigations water and problems appear to the plants directly or the surrounding area (7). According to pH and EC results, we obtain for these samples a simple classification to classify these water samples to small alkaline high salty irrigation water and small alkaline very high salty irrigation water. All the results show below in table 1.
Table 1. Chemical measurement for water wells before treatment

| Well number | pH value | EC µs/cm | Cl⁻ mg/l | SO₄²⁻ mg/l | Na⁺ mg/l | K⁺ mg/l | Ca²⁺ mg/l | Mg²⁺ mg/l | Total hardness |
|-------------|----------|----------|----------|------------|----------|---------|-----------|-----------|----------------|
| 1           | 8.4      | 1122     | 930      | 1030       | 189      | 4.5     | 367       | 121       | 1288           |
| 2           | 8.3      | 987      | 1078     | 1206       | 218      | 3.2     | 192       | 166       | 1408           |
| 3           | 8.6      | 1203     | 886      | 966        | 178      | 2.22    | 211       | 142       | 1166           |
| 4           | 8.7      | 1423     | 1272     | 1311       | 333      | 5.62    | 278       | 129       | 1566           |
| 5           | 8.4      | 3360     | 2216     | 3620       | 377      | 5.2     | 667       | 292       | 2982           |
| 6           | 8.6      | 4380     | 1926     | 4677       | 463      | 7.8     | 509       | 572       | 5666           |
| 7           | 8.1      | 3891     | 3720     | 5122       | 608      | 11.7    | 960       | 618       | 4293           |
| 8           | 8.1      | 4010     | 2988     | 3772       | 762      | 9.8     | 766       | 408       | 3932           |
| 9           | 8.8      | 3525     | 2960     | 3280       | 434      | 8.61    | 567       | 399       | 3862           |
| 10          | 8.7      | 3898     | 3650     | 4920       | 311      | 8.51    | 488       | 444       | 5692           |

Note: Above results shows high values of elements present in water wells and this lead to eliminate its use to limited type of agriculture that can resist these high concentration values of elements with good drain systems.

Table 1 in Appendix A shows classification of irrigation water according to its use in agriculture (8). Through the results of the current tests, we can see the effect of high salinity in some wells water and its impact on the crops, and soil which is irrigated by these water. Table 2-Appendix A shows classification of Cofield American laboratory for salinity water according to EC values (9). The process of using water wells for drinking and domestic uses without treatment and without disinfection process. In addition, the magnitude of some chemical indexes were higher than the limits of international for drinking which shown in Table 3-Appendix A (10). Therefore, these wells are not suitable for drinking or domestic use without treatments.

5.1 Engineering treatment methods

When exposed to the subject of groundwater treatment and make it fit for consumption, there are many well-known and modern engineering methods that can be used for the purpose of purifying and sterilizing water wells, and make them safe sources for drinking and rely choose one of these methods to the cost of treatment and the type of contaminants in the groundwater (11). Here are some of the most common ways:

1. Reverse Osmosis method: a common and effective ways in dealing with large amount of salt water problems like sea water.
2. Activated Carbon method: from the simplest and cheapest kind of good treatment which improves the quality of the water passing through the center of the coal which is based adsorption of salts and turbid color and some chemicals suitable for moderate salinity water.

3. Ion exchange method: it is one of the simple ways through which lead water on the surface of the resin material of positive and negative ions to obtain an exchange of ions dissolved substances in the water by adsorption.

4. Distillation: one of the oldest means of purification and high efficiency, but high consume energy and low productivity.

5. Sand Filter: a means of liquidation of old but need extra water sterilization process.

6. Water Softener: chemicals added to the water to remove the brackish water and smoothing properties.

7. Air bar stripper: modern techniques that blends in which water and air to get some types of processors.

8. Iron filters: it’s a sand filter consist of layer of green sand consist of almost treated Manganese.

9. Nanotechnology process: new define technology that benefits from application of nano- scales tubes as media to filter out contamination.

10. Biological treatment: used for bacteria remove from water.

Table 2 Shows treatments choice for some kind of environmental problems that complies with wells water. The selection of each type of treatment depend on the required properties and its final use either for drinking water or for domestic use.

| Type of contamination | Treatment choices |
|-----------------------|-------------------|
| Bacteria              | Biological treatments |
| Chloride              | Reverse Osmosis, RO and Distillation |
| Cloudy/ turbid        | Sand Filter, activated charcoal |
| Color                 | Activated charcoal distillation and RO |
| Fluoride              | Distillation and RO |
| The total hardness    | Distillation |
| Solvent iron and Manganese | Iron filters |
| Znej                  | Activated charcoal distillation and RO |
| The volatile organic chemicals | Air bar stripper Activated charcoal |

In this study, Ion exchange method was introduced using negative ion exchanges (weak base) and positive type (strong acid). The conducted preparation process for ion exchanges was done by putting the ion exchange in distilled water for 48 hours with all what required to achieve Ion exchange (7). Also, activated charcoal was used based on its simple and effective method to improve water quality.
5.2 Chemical measurements after treatment
All the previous elements were examined again after treated with ion exchange and activated charcoal. When using ion exchange (both negative and positive), the values of EC for all water samples decreased because of the reducing of concentration of elements ions after absorbed by exchanger. The results of ion exchange treatments are shown in Table 3. By using activated charcoal as media, water passed through, EC magnitudes are highly reduced through the absorption process. The treated water using activated charcoal (Table 4).

Table 3. Chemical measurements for water wells ion exchange treatment

| Well number | pH value | EC µs/cm | cl⁻ mg/l | SO₄²⁻ mg/l | Na⁺ mg/l | K⁺ mg/l | Ca²⁺ mg/l | Mg²⁺ mg/l | Total hardness |
|-------------|----------|----------|----------|------------|----------|---------|-----------|-----------|----------------|
| 1           | 7.5      | 432      | 743      | 833        | 112      | 2.9     | 201       | 98        | 1022           |
| 2           | 7.4      | 355      | 821      | 1001       | 141      | 2.1     | 173       | 113       | 1132           |
| 3           | 7.8      | 833      | 675      | 1022       | 103      | 1.61    | 175       | 113       | 989            |
| 4           | 7.6      | 902      | 737      | 925        | 261      | 3.21    | 182       | 98        | 1251           |
| 5           | 7.3      | 2327     | 1621     | 2226       | 210      | 3.7     | 391       | 163       | 1923           |
| 6           | 7.5      | 2667     | 1621     | 2920       | 311      | 5.2     | 371       | 319       | 2653           |
| 7           | 7.4      | 1933     | 2162     | 3716       | 418      | 7.6     | 507       | 307       | 3336           |
| 8           | 7.2      | 2020     | 1668     | 2003       | 489      | 5.3     | 413       | 272       | 2775           |
| 9           | 7.6      | 2655     | 2006     | 2819       | 189      | 4.33    | 220       | 283       | 2855           |
| 10          | 7.5      | 2771     | 2890     | 2810       | 172      | 4.41    | 387       | 292       | 3672           |

The percentage of removal depending on EC values and Total Hardness range below for ion exchange:
1. For EC values ranges from 24% at well 9 to about 64% at well 2.
2. For T.H values ranges from 15% at well 3 to about 53% at well 6.
3. Average percentage of removal for EC is 41% and TH is 27%.

The original values and the final values of ions test and the effect of treatment are shown in figures 2 to 5 which are fixed in attachment.
Figure 2. Percent of removal for Electrical Conductivity EC

Figure 3. Percent of removal for Total Hardness TH
Figure 4. Original and treated values of EC by two methods.

Figure 5. Original and treated values of TH by two methods.
Table 4. Chemical measurements for water wells activated charcoal treatment

| Well number | pH value | EC µs/cm | Cl⁻ mg/l | SO₄²⁻ mg/l | Na⁺ mg/l | K⁺ mg/l | Ca²⁺ mg/l | Mg²⁺ mg/l | Total hardness |
|-------------|----------|----------|----------|------------|----------|---------|-----------|-----------|---------------|
| 1           | 7.3      | 327      | 631      | 577        | 97       | 1.60    | 173       | 78        | 968           |
| 2           | 7.1      | 269      | 702      | 962        | 121      | 1.50    | 121       | 93        | 971           |
| 3           | 7.4      | 762      | 431      | 902        | 93       | 1.1     | 135       | 78        | 822           |
| 4           | 7.2      | 621      | 551      | 702        | 181      | 2.31    | 153       | 67        | 862           |
| 5           | 6.9      | 1023     | 1316     | 1721       | 106      | 2.30    | 262       | 136       | 1211          |
| 6           | 7.1      | 1039     | 1409     | 1630       | 211      | 2.67    | 291       | 110       | 1721          |
| 7           | 6.8      | 1321     | 1505     | 1966       | 197      | 4.02    | 437       | 167       | 2305          |
| 8           | 6.7      | 1621     | 1432     | 1337       | 268      | 3.03    | 271       | 167       | 1667          |
| 9           | 7.2      | 1443     | 1656     | 1710       | 76       | 2.10    | 105       | 142       | 2274          |
| 10          | 7.4      | 1069     | 1620     | 1700       | 95       | 1.88    | 167       | 182       | 2034          |

The percentage of removal depending on EC values and Total Hardness range below:
1. For EC values ranges from 36% at well 3 to about 73% at well 2.
2. For T.H values ranges from 25% at well 1 to about 70% at well 6.
3. Average percentage of removal for EC is 63% and TH is 46%.

6. Conclusions

From the results, water wells in the study region with high hardness exceed allowable limits, as well as the increasing in concentrations of chloride, Calcium, magnesium and sulfate, which were recorded magnitudes higher than the allowable limits before treatment process, and this is important evidence that these wells are not suitable for drinking and domestic uses.

In agricultural side, water wells in this area were classified into two parts: one, with moderate salinity suitable for some crops, which can bear this amount of salinity, and the other types of water have high salinity values, which not suitable for all crops unless that can resist high salinity with condition of improving drainage system(12).

Treatment methods, which includes both ion exchange and activated charcoal proved that the ability of these methods to perform water quality and for distinguish between these two methods. Study concluded that it is better to use activated charcoal instead of ion exchange method. The reason is this method simple and effective in removing contaminations. After this treatment process, water can be used for irrigation for wide types of crops and for domestic only and it is not suitable for drinking.
7. Recommendations

The two types of treatment can be used respectively to improve the quality of water by treating the water first in ion exchange and treating it again with activated charcoal. For ensuring we can get almost potable water for drinking we can use these two methods with a third method of removing contaminations like mixing the treated water with bentonite which have good ability of adsorption.

8. References

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### Appendix - A

#### Table 5. Irrigation water classification

| Irrigation water type | Suitability for irrigation | Agriculture use |
|-----------------------|----------------------------|-----------------|
| Irrigation water with an alkaline effect and relatively moderate salinity | Used to irrigate some crops which resist relatively salinity in soils with good drainage system | the cultivation wheat and barley, corn, rice tomato olive and pomegranate |
| Irrigation water with an a few alkaline effect and relatively high salinity | Used for irrigate some crops which resist high salinity with condition of bathing soil and good drainage system | The cultivation cotton Palm and sugar beet |

#### Table 6. American salinity laboratory

| Irrigation water type | Classification | Values of EC µs/cm |
|-----------------------|----------------|--------------------|
| Excellent             | Low salinity   | < 250              |
| good                  | Moderate salinity | 250-750          |
| Allowable             | Relatively high salinity | 750-2000         |
| Not suitable          | Very high salinity | >2000             |

#### Table 7. International standard according to WHO (mg/l)

| Chemical index | Allowable limit | Highest limit |
|----------------|-----------------|---------------|
| pH             | 7.0-8.5         | 6.5-9.2       |
| Ca<sup>2+</sup> | 75              | 200           |
| Cl<sup>-</sup>  | 200             | 650           |
| So<sub>4</sub><sup>-2</sup> | 200 | 400 |
| Mg<sup>2+</sup>  | 50              | 150           |
| T.H             | 100             | 500           |