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# ENVIRONMENTAL ASSESSMENT OF GROUNDWATER IN NAJAF GOVERNORATE (IRAQ) FOR IRRIGATION PURPOSES

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## ABSTRACT

Middle East has suffered from drought since many decades because of climate changes; therefore, surface water has become scarce in many countries such as Iraq. It seems, in general that groundwater is the alternative best solution to cover the lack in water requirements of domestic, agriculture, and industry. In this study, environmental assessment was carried out for 29 wells in Najaf Governorate to evaluate their water suitability for irrigation use. This bases on comparison between 8 water quality parameters with their limitations at Food and Agriculture Organization guideline (FAO) beside British Colombia guideline (BC), the parameters are: nickel, chromium, lead, zinc, cadmium, sulfates, hydrogen power (pH), and total dissolved solids. The study outcome clarifies that there are only 4 wells have suitable water for irrigation use, the others have at least one parameter not applicable with the international guidelines of FAO and BC, which are probably not appropriate for irrigation.

## KEYWORDS

Groundwater; FAO guideline; British Colombia guideline; Irrigation water.

## 1. INTRODUCTION

In Iraq, there is a scarcity of surface water because of climate changes in addition to other economic and political reasons, which have caused a lack of surface water where is flowing from spring countries (Turkey, Syria, and Iran) and fall on Iraqi rivers (Alkhafaji, 2018; IAU et al, 2012; Al-Askari, 2012; Chulov, 2009; UN Iraq, 2013). Therefore, groundwater has become one of the essential sources for irrigation and other purposes in recent years (Al-Jawad et al, 2018; Al-Mussawi, 2014; Al-Sudani, 2018; Al-Muqdadi, 2012).

Najaf Governorate (Fig. 1) locates south - west Iraq 160 km southern Capital Baghdad, its area is 28,824 km with a population greater than million people, its climate is hot-dry in summer and cold-rainy in winter, most of its landscape consists of desert (NGO, 2018).

Despite there is a main river passes through its lands, Euphrates River. However, its water is not enough to cover the requirements of its towns. Therefore, the local government, factories, and farmers have begun to drill wells to use groundwater in agriculture basically and other civilian and industrial requirements.

The Municipal Office of Najaf Province drilled many wells so as to cover the demand for water for domestic use and plants irrigation in public parks inside its towns. Because the office didn't depend on remote sensing technology (Al-Bahrani, 2018) to detect the quality of groundwater before drilling the wells, therefore; most of these wells have not been applicable with standards of international organizations such as FAO (Ayers & Westcort, 1994) and BC (BC, 2018) guidelines.

This paper aims to assess environmentally the irrigation water of different wells that are drilled by Najaf Municipal Office according to different international guidelines such as Food and Agriculture Organization (FAO) and British Colombia (BC).


**Fig. 1. Najaf profile.**

## 2. MATERIALS AND METHODS

Twenty-nine wells were drilled by Najaf Municipal Office in different places along with Najaf Governorate, the depth of these wells was (30 – 35) m. They were drilled along the main roads and parks so as to use for domestic and irrigation purposes. This office also measured eight environmental parameters for each well.

In this study, the location of these 29 wells is located on the satellite image according to their coordinates as shown in Fig. 2. Moreover, eight water quality parameters for each well are illustrated statistically. These parameters are nickel (Ni), chromium (Cr), cadmium (Cd), zinc (Zn), lead (Pb), sulfates ($SO_4^{-2}$), total dissolved solids (TDS), and hydrogen power (pH). The values of these parameters are compared with the criteria of water that is used for irrigation such as FAO and BC guidelines. The aim of this comparison is determining the environmentally suitability of these wells for irrigation purpose according to their acceptability with these guidelines.

Irrigation water should be acceptable with limitations and standards that have been recorded in national and international guidelines. There are many limitations for irrigation water, some of them are agreed with international guidelines while the others are not. Table 1 represents the determinants of water quality for irrigation use according to guidelines of Food and Agriculture Organization (FAO) (Ayers & Westcort, 1994) and British Colombia (BC) (BC, 2018).

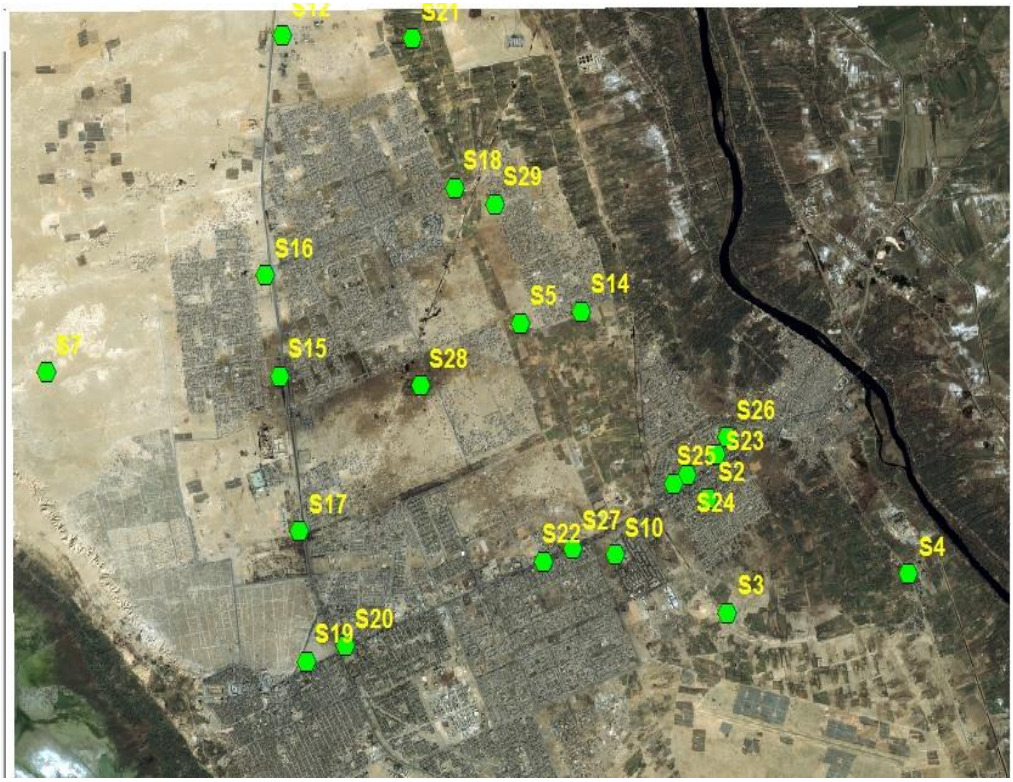


**Fig. 2. Locations of wells on satellite image of Najaf.**

**Table 1. Determinants of irrigation water quality according to FAO and BC.**

| Determinants | Guideline | Determinants | Guideline |
|---|---|---|---|
| Conductivity (EC) or total dissolved solids (TDS) | FAO | Mercury (Hg) | BC |
| Sodium adsorption ratio (SAR) | FAO | Polychlorinated biphenyls (PCBs) | BC |
| Nitrogen ($NO_3$ – N) | FAO | Sulfolane (C4H8O2S) | BC |
| Bicarbonate ($HCO_3$) | FAO | Temperature | BC |
| pH | FAO& BC | turbidity and total suspended solids | BC |
| Sodium (Na) | FAO | Manganese (Mn) | FAO |
| Chloride ($Cl^-$) | FAO & BC | Molybdenum (Mo) | FAO & BC |
| Boron (B) | FAO & BC | Nickel (Ni) | FAO |
| Aluminum (Al) | FAO & BC | Lead (Pb) | FAO & BC |
| Arsenic (As) | FAO & BC | Selenium (Se) | FAO & BC |
| Beryllium (Be) | FAO | Tin (Sn) | FAO |
| Cadmium (Cd) | FAO & BC | Titanium (Ti) | FAO |
| Cobalt (Co) | FAO | Tungsten (W) | FAO |
| Chromium (Cr) | FAO | Vanadium (V) | FAO |
| Copper (Cu) | FAO & BC | Zinc (Zn) | FAO & BC |
| Fluoride ($F^-$) | FAO & BC | Chlorine (Cl) | BC |
| Iron (Fe) | FAO | Diisopropanolamine (DIPA) | BC |
| Lithium (Li) | FAO | Manganese (Mn) | FAO |

## 3. RESULTS, DISCUSSION AND RECOMMENDATIONS

The values of the eight water quality parameters (Ni, Cr, Pb, $SO_4^{-2}$, pH, TDS, Cd, and Zn) of the 29 wells will be illustrated using line chart method, comparing them with their limitations

at guidelines of FAO and BC. The results will be discussed so as to know the irrigation water quality of these wells via the quality of these parameters.

Fig. 3 represents the line chart of nickel, chromium, and lead concentrations in addition to their guidelines according to FAO and BC for water samples of the 29 wells in Najaf Province. It is seen that all values of these three parameters are less than their limitations. The recommended maximum concentration of Ni according to FAO guideline is 0.2 mg/L, it is toxic trace element for all plants but its toxicity reduces at neutral or alkaline pH (Ayers & Westcort, 1994). Cr is toxic trace element too and isn't essential for plant growth, its permissible value shouldn't exceed 0.1 mg/L (Ayers & Westcort, 1994). Pb is also toxic trace element, its total value shouldn't exceed 0.4 mg/L at alkaline fine-textured agriculture earths, while for all other soils, its limit reduces to 0.2 mg/L (BC, 2018& BC, 1987).

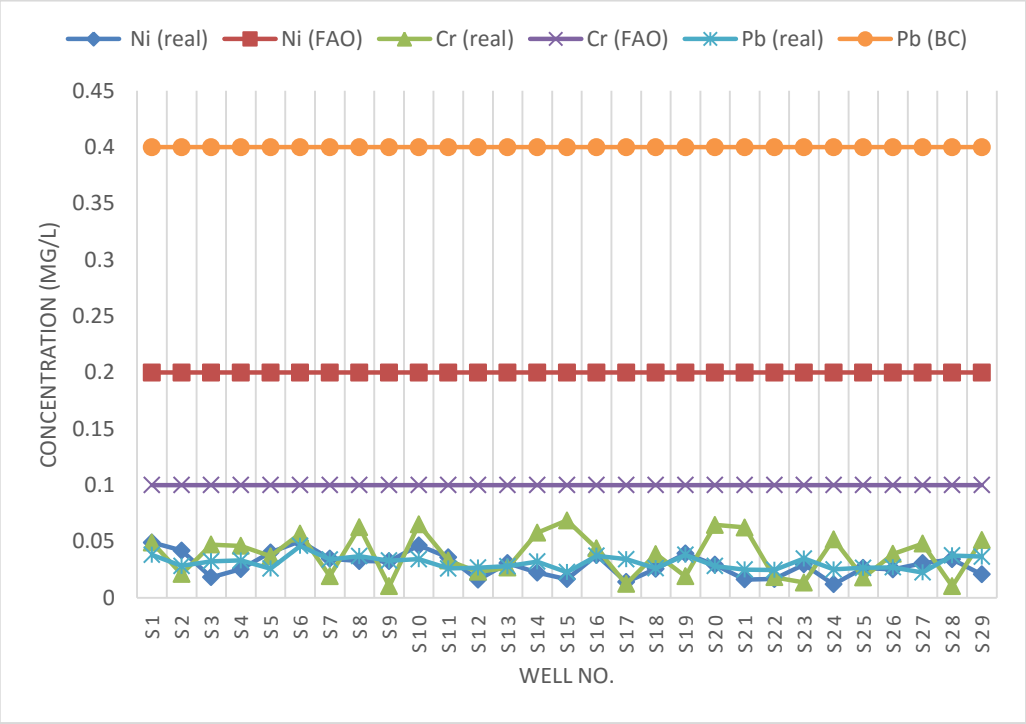


**Fig. 3.Concentrations of nickel, chromium, and lead with their limitations according to FAO and BC guidelines.**

Cadmium (Cd) has been known as a toxic metal to beans, beets, and turnips, also it has the ability to accumulate in plants and soils to values that may be harmful to human, its recommended maximum concentration for irrigation water is 0.01 mg/L according to FAO Guideline (Ayers & Westcort, 1994), while the allowable limit of Cd according to BC Guideline is 0.0051 mg/L depending on hardness of water, which is a primary factor in enhancing cadmium toxicity (Sinclair et al 2015). This heavy toxic metal is available in batteries, pigments, coating, plating, PVC stabilizers and alloys industry, also it enters the

environment and combines with water or soil causing toxicity to plants and animals (Sharma et al, 2015). Fig. 4 illustrates the concentrations of Cd for water samples of the 29 wells, it is seen that all the samples are less than the limitation of FAO, but there are 15 wells have water not applicable to BC Guideline. These wells are S1, S5, S6, S11, S13, S15, S16, S17, S19, S20, S23, S24, S25, S26, and S29, they are drilled in commercial and industrial places; therefore, there is possibility for mixing between ground water of these wells with cadmium-contaminated subsurface water.

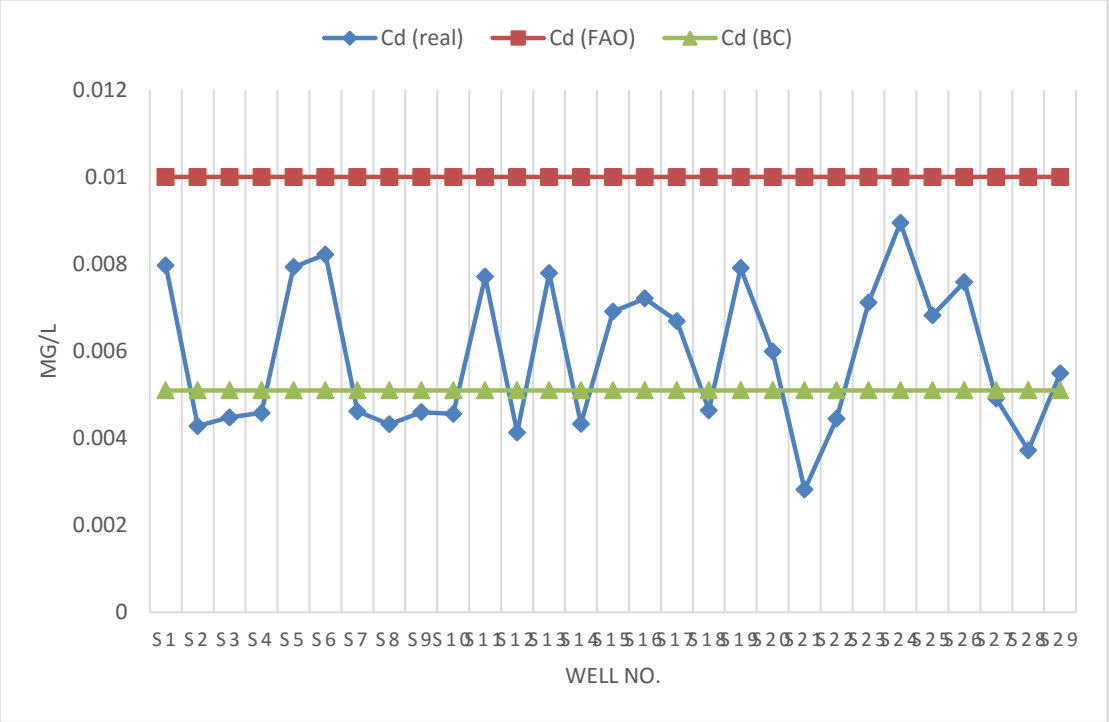


**Fig. 4. Cadmium and its criteria according to FAO and BC guidelines.**

Sulfates ($SO_4^-$) is hardly harmful to plants, the guidelines of FAO and BC don't put criteria for sulfates in irrigation water, however, total sulfates shouldn't exceed 1000 mg/L to protect livestock via BC Guideline (Fig. 5), however, as seen in the figure, the concentrations of sulfates for all wells are acceptable.

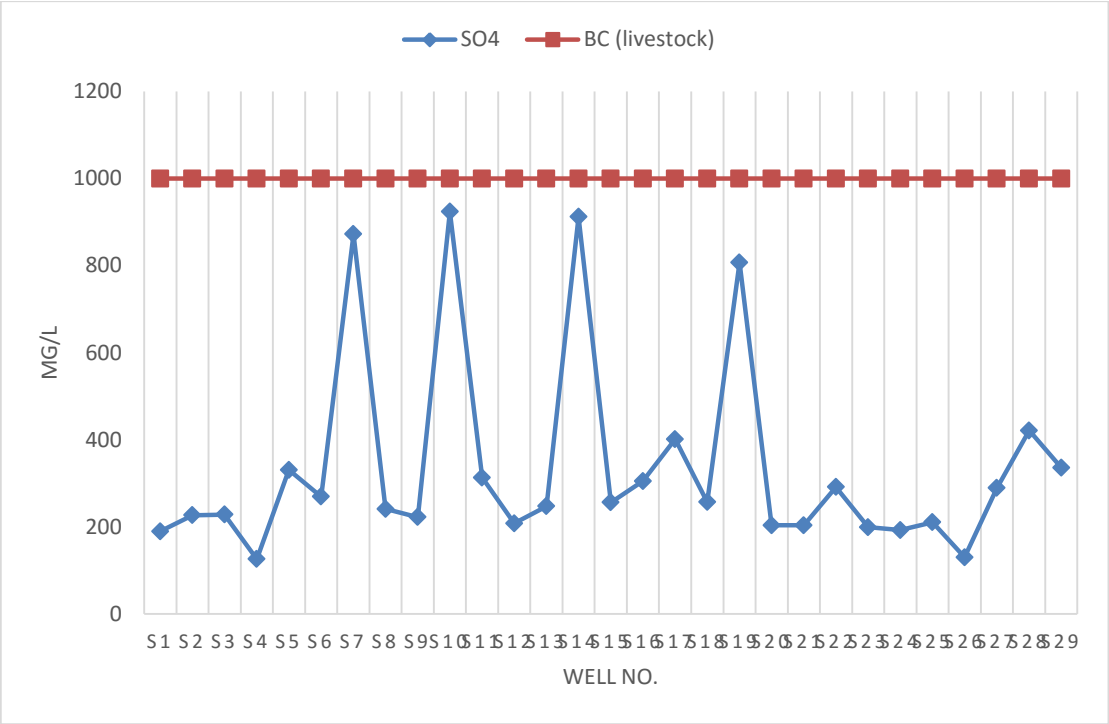


**Fig. 5. Sulphates concentrations and its BC limitation.**

Fig. 6 shows the concentrations of TDS for the 29 wells. According to FAO Guideline (Ayers & Westcort, 1994), irrigation water is suitable to sensitive plants if its concentration is below 450 mg/l, while it can use to irrigate moderately restricted crops if its value is between 450 and 2000 mg/L, however, it is appropriate for severely restricted plants when its concentration is above 2000 mg/L. the American Salt Laboratory (Al-Bahrani, 2014) has found that water is unsuitable for irrigation when its concentration exceeds 3200 mg/L. It is clarified from Fig. 6 that most wells have water can be used to irrigate moderately restricted plants, while there are only 12 wells (S2, S5, S7, S8, S9, S11, S13, S16, S18, S20, S22, and S27) can irrigate sensitive plants.

Fig. 7 illustrates the values of pH, according to FAO, the normal range for irrigation water is (6.5 – 8.4). It is seen from the figure, that wells S4, S20, and S23 have acidy water where their pH are 5.6, 6.4, and 6.2 respectively, while wells S8 and S17 have alkaline water, their values are 8.9 and 8.7, these wells locates in different locations along Najaf Governorate and most of them have critical concentrations of cadmium.

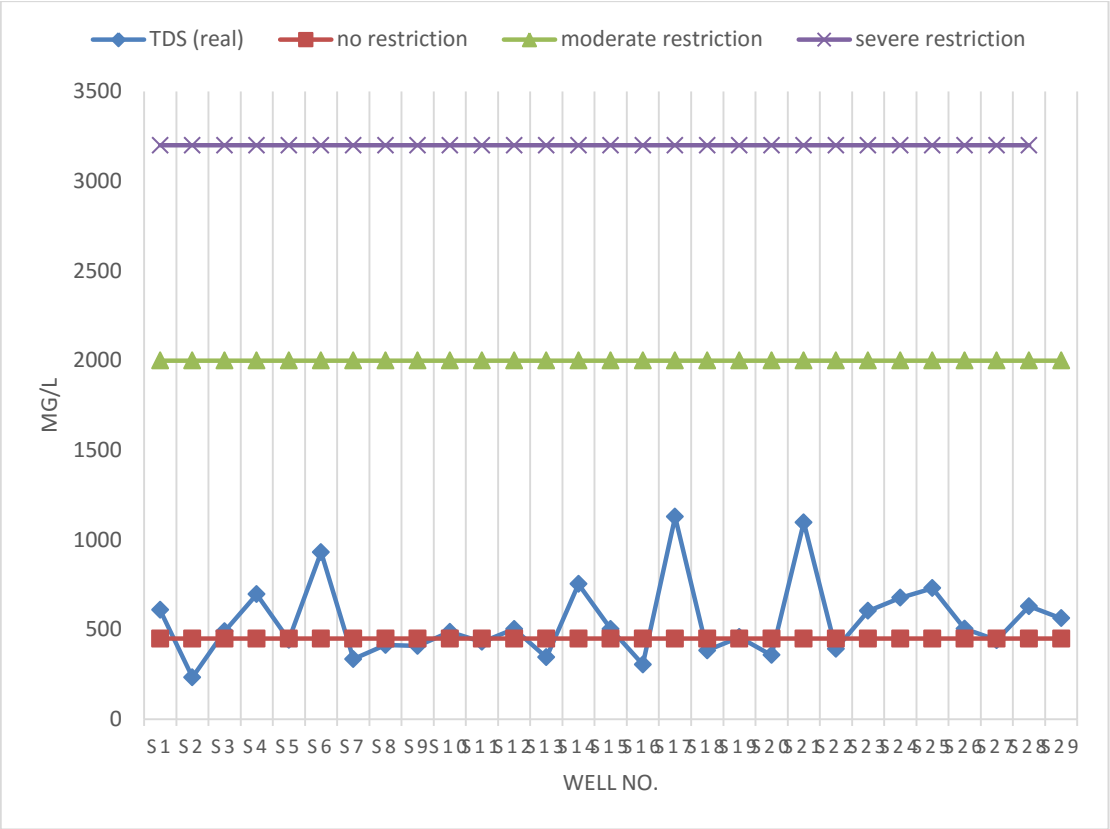


**Fig. 6. Total dissolved solids (TDS) and its limitations via FAO and American Salt Laboratory.**

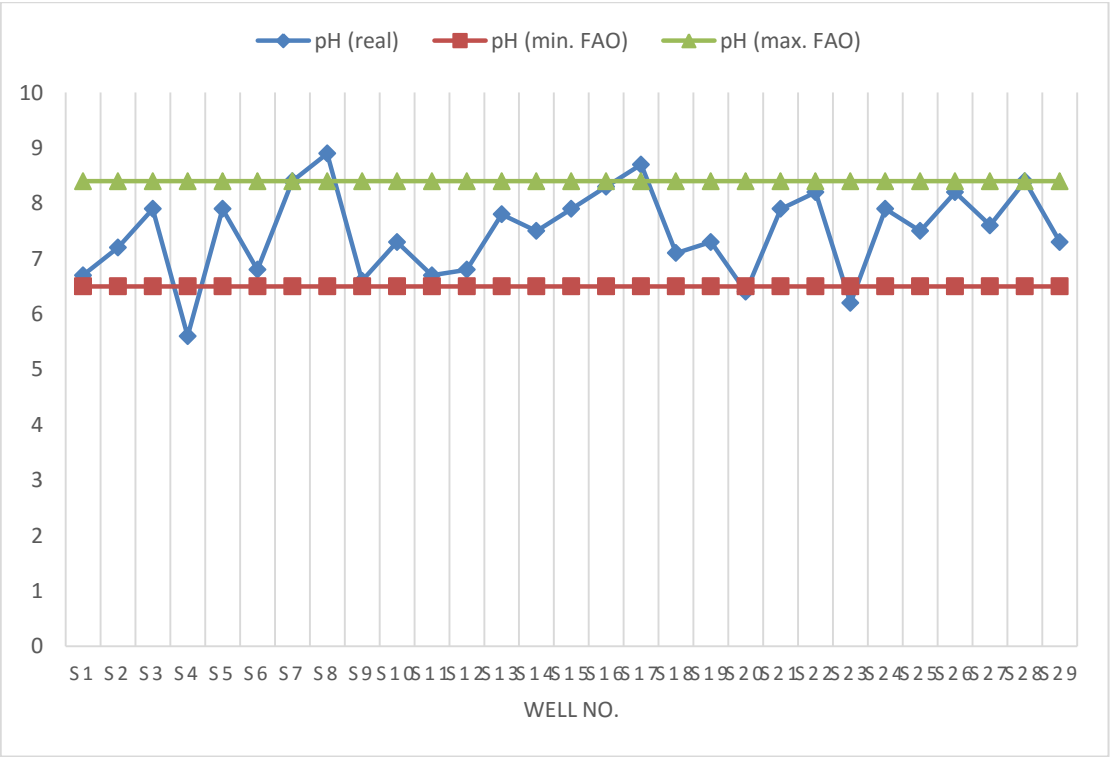


**Fig. 7. pH values and their limitations according FAO Guideline.**

The concentrations of zinc (Zn) for groundwater of the 29 wells are demonstrated in Fig.8. FAO Guideline considers Zn as toxic trace element for many plants, its criteria is 2.0 mg/L, but its toxicity decreases when soil pH exceeds 6.0 and at fine textured or loams (Ayers & Westcort, 1994). According to British Colombia Guideline (BC), concentration of Zn for irrigation water should be less than 1 mg/L if soil pH is less than 6, and less than 2 mg/L if (7 > soil pH > = 6), however, it should be less than 5 mg/L if soil pH equals or exceeds 7 (BC, 1999). The soil in Najaf Governorate and other lands on the Euphrates Basin have alkaline soil, its pH exceeds 7 (Jaradat, 2002); therefore, the 5 mg/L is the appropriate criteria for zinc. Fig. 8 clarifies that there are eight wells that their water have high concentrations of Zn and they are not suitable for irrigation purpose, these wells are S3, S8, S13, S16, S24, S25, S26, and S28.

Fig. 9 illustrates the pollution rank of these 29 wells that were drilled in Najaf Governorate by Municipal Najaf Office. This chart is designed in this study by giving score 1 to inapplicable parameters with FAO and BC guidelines and score 0 to applicable ones. Summing these scores for the eight parameters gives the pollution rank to each well for the sake of determining the suitability of water-well for irrigation. According to this chart the wells that have the least pollution rank are the suitable wells for irrigation. It can be seen from the figure that only four wells have suitable water for irrigation use, these wells are S9, S18, S22, and S27, the others have at least one parameter does not applicable with the international guidelines of FAO and BC, this means they are probably not appropriate for irrigation of all kind of plants.

Drilling wells is costly operation; therefore, it is recommended to use remote sensing technology for the sake of detecting the locations and depths of high water quality wells. Also it is recommended to treat the pollution in these wells before use their water in irrigation and other purposes by using magnetic treatment (Al-Bahrani, 2018).

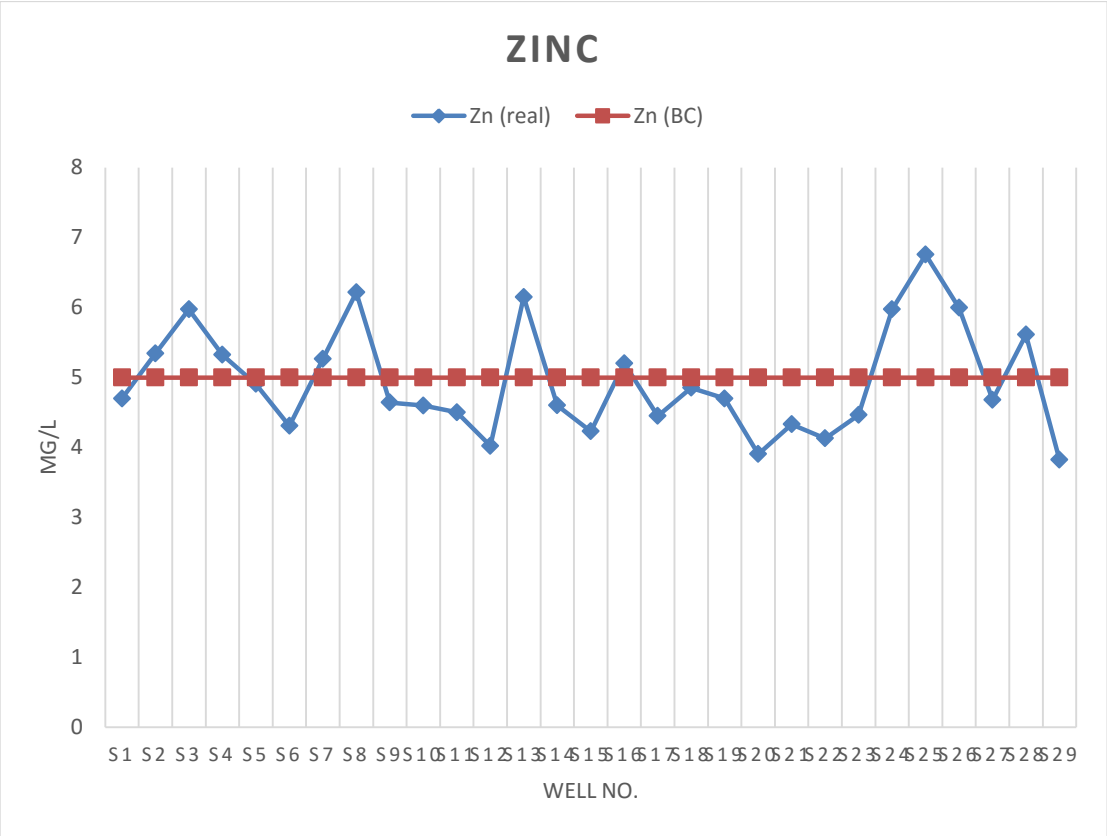


**Fig. 8. Zinc concentrations and their limitations according to BC Guideline.**

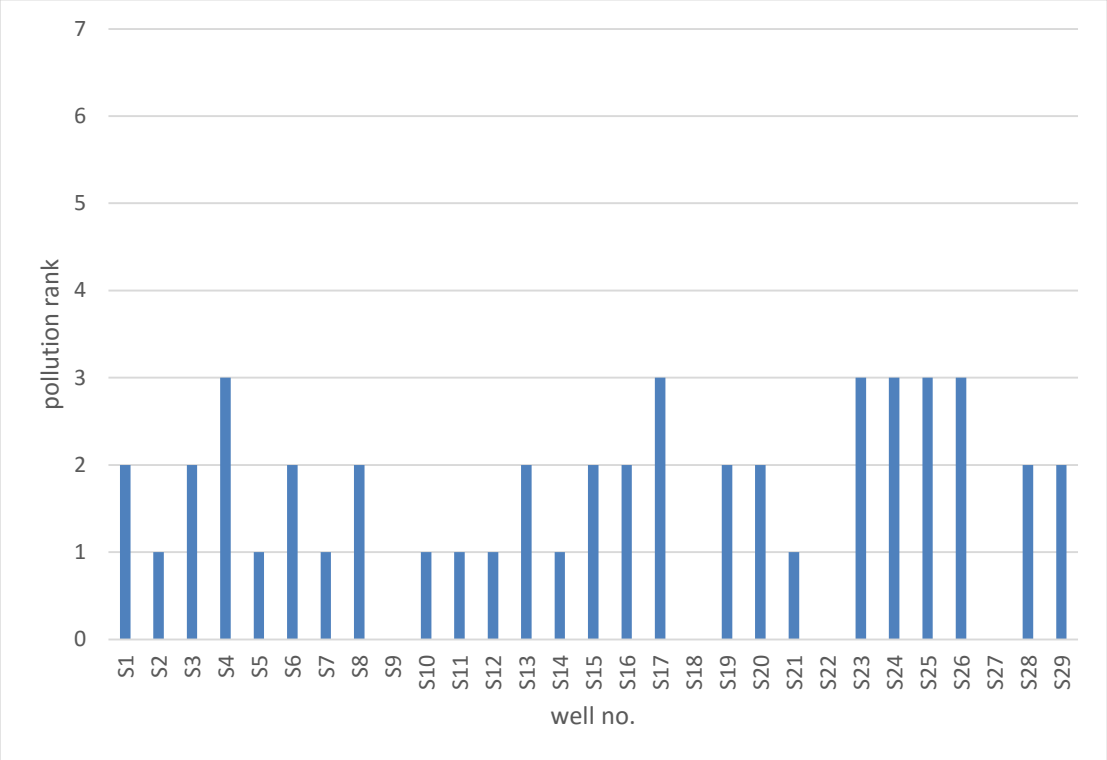


**Fig. 9. Pollution rank of wells.**

## 4. CONCUSIONS

This research studied the quality of water for 29 wells which were drilled by Municipal Najaf Office for irrigation use. It is concluded from this manuscript that only 4 wells have high quality groundwater. The others have at least one parameter not applicable with the international standards FAO and BC. However, from 8 parameters compared with these international standards, the highest inapplicable parameters are only 3. This means the groundwater of these wells could be only used to irrigate some insensitive plants.

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