Pak. j. sci. ind. res. Ser. A: phys. sci. 2023 **66A**(1) 95-102

# Evaluation of Water Quality in Household Water Treatment Systems (Filters) used in Kalar City, Sulaimaniyah, Iraq

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(received December 6, 2021; revised Feburary 2, 2022; accepted March 28, 2022)

**Abstract.** A number of water quality data is available from local water corporation. However, people do not know the quality of the water that is coming out of their taps. Our drinking water, whether it comes from the mains supply is likely to be contaminated. Lots of water filter manufacturers are posting incorrect advertisements about water quality to promote their products. This is what drives people to use water filters. The objective of this research was to assess the quality of household water treatment systems (filters) which are being used in Kalar for the removal of cations and anions. A number of brands of home water treatment devices used in Kalar were selected, with one device chosen from each brand for study. The results of this study indicated that the average removal of calcium, magnesium, sodium, potassium and fluoride were (97.35%), (96.06%), (89%), (89.09%) and (77.9%) respectively. However, many residents of the study area are suffering from tooth decay due to a lack of fluoride in the water, especially in children and young adults. So, the use of water treatment devices is not necessary and it's not recommended to drink this type of water especially for children. Also, the general quality of water before treatment with the filters considered as good quality; therefore, it's not recommended to use these devices in households.

**Keywords:** evaluation, drinking water quality, household water treatment systems, Kalar, Iraq

## Introduction

Generally speaking, amount of drinking water a day is required to maintain good human health. So, that tap water should contain some minerals such as calcium, magnesium, sodium, potassium and fluoride in reasonable proportions. Some pollutants may be introduced in drinking water even in small amounts could be dangerous to human health. So, increased people awareness of the consequences of pollutants in drinking water and human desire to avoid those pollutants has led to use household water treatment systems which provide higher quality water (Mwabi *et al*., 2011). Also, various types of household water treatment systems have become widely available in the market as a result of the propaganda of water filter manufacturers regarding poor water quality. Although, the use and purchase of bottled water is also fashioned through out of the world but also have many concerns regarding substandard quality of water (Mohsin *et al*., 2019a). Alarmingly, poor quality of water leads to various health problems such as tooth decay, kidney disease and other issues. Therefore, it is significant to develop water treatment in order to get rid of those diseases. Minerals including calcium, magnesium, sodium, fluoride and potassium are very important for human health (Aydin, 2019; Hammer and Hammer, 2007). However, according to some studies conducted, water treatment systems have high ability to remove some minerals, such as magnesium, fluoride, potassium and calcium (Miranzadeh and Rabbani, 2010). According to a number of research conducted, household water treatment systems have a huge ability to remove most of the minerals, such as magnesium, copper, chromium, fluoride, zinc, iron, selenium, manganese, phosphorus, potassium and calcium (Miranzadeh and Rabbani, 2010; Yari *et al*., 2007). Also, a study conducted in Kerman, Iran found that the average efficiencies of household water treatment systems for the removal of ($Na^+$, $Ca^{2+}$ and $Mg^{2+}$) were 80.23, 61.20, 78.97% respectively (Malakootian *et al*., 2017). Another study which was conducted in China found that the pH values of purified water were significantly increased compared to raw water, however, the other parameters were significantly decreased (Zhang *et al*., 2020). This study was designed to evaluate the quality of household water treatment systems used in Kalar city, Sulaimaniyah, Iraq to remove some minerals from drinking water and determine the suitability of using household water filter

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system for drinking purpose basis of the quality indices and WHO standards.

## Materials and Methods

**Study area.** A number of devices have been selected randomly from many brands of household water treatment systems in Kalar. The cases in which the devices were used extensively, samples were selected with filters that had been changed in proper time, based on the devices' operational instructions. The samples were selected from homes in the center of Kalar and outwards the four geographical directions of the city (Fig. 1). Kalar City is a part of the Kurdistan region of Iraq and represents the center of the Garmian administration (a semi-independent administration from the Sulaymaniyah Governorate). The city is located between latitudes 34° 38′ to 34° 35′ degrees north and longitudes 45° 15′ to 45° 21′ degrees east. Also, it is 300-355 m above sea level. It has an area of 32 km$^2$ and is located on the southeastern side of Kirkuk governorate, 150 km away and on the south of Sulaymaniyah governorate, 140 km away and north of Baghdad, 180 km away and close to the western border of Iran, 35 km away (Sarhat, 2013). Sirwan river is the main source of drinking water in Kalar city, and the water is treated well in the Kalar water treatment plant.

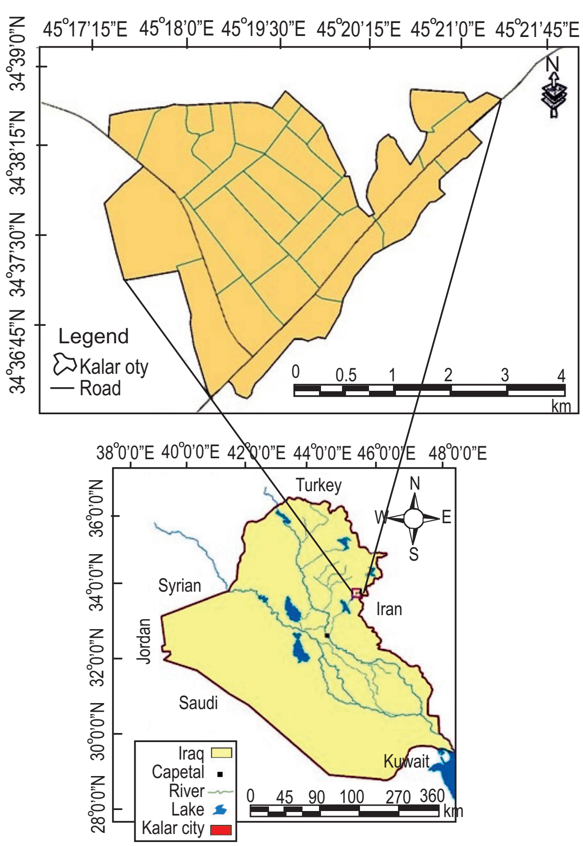


**Fig. 1.** Map of the study area.

**Water samples acquisition.** Water samples were taken for analysis with the high precaution of care and 48 samples of water were taken from household in July 2021. Each sample was conducted of input and output of each device water treatment systems. Each sample was collected in a 2 L container. A one inch space for air was left under the cover. The water taken were immediately covered, labeled and sent to the laboratory due notice being previously given in order that they may be dealt with without delay. The collected samples were transferred to the laboratory in a cooled water container. These water quality parameters were analyzed: pH, total dissolved solids (TDS), sulphate ($SO4^-$), chloride (Cl), calcium (Ca), sodium (Na), magnesium (Mg), potassium (K) and fluoride (F).

**Analysis of water samples.** After collection of the samples, few physical property parameters include pH, TDS and EC were measured directly in sites without physically removing the samples. Other chemical properties consist of essential elements (Ca, Mg, K and Na) were measured by means of inductively coupled plasma optical emission spectroscopy (ICPOES). Some anions (Cl, $SO^4$ and F) were quantified by using ion selective electrodes (ISE) with different electrode for each specific parameter comprises sulphate, chloride electrodes (APHA*,* 1998). The output and input values of each parameter were statistically tested using paired t-test (with respect to the effect of filters types or made) in R. also, the removal percentage Rp (%) of each element or parameter was calculated as the following:

$$P = P1 - P2$$

$$Rp = (P1/P) * 100$$

where:

P is the subtraction and P1 (value of input water – before treatment by filter) and P2 is (value of output water – after treatment). Rp is Removal percentage (%)

## Results and Discussion

The results are shown in Table 1, 2 and 3. Also the results compared to World Health Orgnization (WHO) standard for drinking water.

**pH.** The pH is a representative of acidic or alkaline of water and it is an important parameter regarding water quality. The pH value can sensitively indicate variations in water quality and is affected by dissolved substances (WHO, 2006). The maximum and minimum pH values of input water samples are 7.25 and 8.37, however, all those values were decreased and observed 6.5 and 7.6 for all the output water samples. This indicates that all the water samples are slightly moderate and found within the WHO limits for drinking purposes.

**Table 1.** Physical properties of input and output water samples

| Filters brand | pH input | pH output | EC input | EC output | Removal percentage (%) | TDS input | TDS output | Removal percentage (%) |
|---|---|---|---|---|---|---|---|---|
| A | 7.76 | 7.06 | 588 | 54 | 90.8 | 588 | 0.048 | 99.99 |
| | 7.98 | 6.7 | 567 | 53.7 | 90.5 | 592 | 0.142 | 99.98 |
| | 7.77 | 6.5 | 528 | 6.1 | 98.8 | 595 | 0.062 | 99.99 |
| | 7.87 | 6.7 | 584 | 30.5 | 94.8 | 588 | 0.081 | 99.99 |
| | 7.65 | 6.8 | 564 | 25.8 | 95.4 | 587 | 0.052 | 99.99 |
| | 8.35 | 6.9 | 543 | 43.1 | 92.1 | 597 | 0.06 | 99.99 |
| B | 7.67 | 6.7 | 589 | 46.8 | 92.1 | 592 | 0.049 | 99.99 |
| | 7.8 | 6.8 | 591 | 75.5 | 87.2 | 595 | 0.047 | 99.99 |
| | 7.69 | 6.6 | 599 | 74.6 | 87.5 | 606 | 0.045 | 99.99 |
| | 7.98 | 6.5 | 548 | 19.4 | 96.5 | 583 | 0.034 | 99.99 |
| | 7.6 | 6.6 | 528 | 8.55 | 98.4 | 582 | 0.065 | 99.99 |
| | 7.68 | 6.7 | 587 | 20.7 | 96.5 | 581 | 0.058 | 99.99 |
| C | 7.53 | 6.8 | 564 | 38.7 | 93.1 | 583 | 0.045 | 99.99 |
| | 8.37 | 6.7 | 508 | 18.2 | 96.4 | 584 | 0.043 | 99.99 |
| | 7.8 | 7 | 569 | 11.7 | 97.9 | 583 | 0.05 | 99.99 |
| | 7.25 | 7.1 | 578 | 25.5 | 95.6 | 583 | 0.064 | 99.99 |
| | 7.57 | 6.7 | 600 | 21.4 | 96.4 | 591 | 0.057 | 99.99 |
| | 7.48 | 7.2 | 609 | 43.3 | 92.9 | 583 | 0.04 | 99.99 |
| D | 7.7 | 7 | 563 | 30.8 | 94.5 | 581 | 0.06 | 99.99 |
| | 7.36 | 6.9 | 512 | 12.2 | 97.6 | 583 | 0.096 | 99.98 |
| | 7.5 | 6.8 | 544 | 27 | 95.0 | 584 | 0.075 | 99.99 |
| | 7.85 | 6.6 | 578 | 61.8 | 89.3 | 582 | 0.048 | 99.99 |
| | 7.59 | 6.6 | 598 | 47.7 | 92.0 | 588 | 0.043 | 99.99 |
| | 7.9 | 6.6 | 532 | 19.9 | 96.3 | 584 | 0.046 | 99.99 |
| E | 7.7 | 6.7 | 555 | 91.2 | 83.6 | 581 | 0.038 | 99.99 |
| | 7.76 | 6.6 | 564 | 59.6 | 89.4 | 584 | 0.073 | 99.99 |
| | 7.8 | 6.9 | 567 | 32.4 | 94.3 | 597 | 0.084 | 99.99 |
| | 7.9 | 6.9 | 589 | 22.8 | 96.1 | 595 | 0.074 | 99.99 |
| | 7.46 | 7 | 500 | 44.8 | 91.0 | 583 | 0.05 | 99.99 |
| | 7.67 | 6.7 | 509 | 29.5 | 94.2 | 583 | 0.116 | 99.98 |
| F | 7.49 | 6.7 | 605 | 90.7 | 85.0 | 593 | 0.071 | 99.99 |
| | 7.85 | 6.8 | 577 | 27.1 | 95.3 | 588 | 0.096 | 99.98 |
| | 7.9 | 6.8 | 564 | 69.5 | 87.7 | 584 | 0.055 | 99.99 |
| | 7.54 | 6.8 | 588 | 23 | 96.1 | 581 | 0.084 | 99.99 |
| | 7.77 | 6.7 | 578 | 30.8 | 94.7 | 584 | 0.176 | 99.97 |
| | 7.5 | 7.1 | 598 | 22.5 | 96.2 | 597 | 0.088 | 99.99 |
| G | 7.7 | 7.3 | 576 | 15.1 | 97.4 | 595 | 0.058 | 99.99 |
| | 7.87 | 6.8 | 578 | 12.6 | 97.8 | 589 | 0.066 | 99.99 |
| | 7.86 | 6.8 | 608 | 40.1 | 93.4 | 590 | 0.069 | 99.99 |
| | 7.79 | 6.9 | 600 | 47.7 | 92.1 | 586 | 0.09 | 99.98 |
| | 8 | 7.2 | 543 | 18.6 | 96.6 | 588 | 0.075 | 99.99 |
| | 8.15 | 7.6 | 590 | 32.9 | 94.4 | 614 | 0.061 | 99.99 |
| Average | 7.25 | 6.5 | 590 | 32.9 | 93.64 | 588.26 | 0.07 | 99.99 |
| Minimum | 8.37 | 7.6 | 500 | 6.1 | 83.57 | 581 | 0.034 | 99.97 |
| Maximum | 7.75 | 6.83 | 609 | 91.2 | 98.84 | 614 | 0.176 | 99.99 |
| WHO | 6.5 - 8.5 | | 600 | | | 500 | | |

**Electric conductivity (EC).** It represents the ability to conduct electric current, and is measure of the inorganic dissolved solids, ions which are carrying positive and negative charges (Reaffirmed, 2009). It is also regarded as an effective indicator to classify water into good, medium, and bad categories. The EC of all input water samples are varied between 500 to 609 µ mho/cm. However, the EC of all output water samples are varied between 6.1 to 91.2 µ mho/cm comparing to the acceptable values of conductivity. According to WHO

**Table 2:** Input and output values for different chemical parameters used in this study. The table includes the average, minimum, maximum and WHO range limit (bold) values.

| Filters brand | Ca input | Ca output | Mg input | Mg output | Na input | Na output | $SO^4$ input | $SO^4$ output | K input | K output | F input | F output | Cl input | Cl output |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| A | 15.98 | 0.361 | 4.39 | 0.14 | 19.81 | 2.052 | 141.4 | 10.1 | 2.55 | 0.325 | 0.7 | 0.048 | 161 | 18.2 |
| | 14.78 | 0.379 | 4.51 | 0.146 | 19.77 | 1.81 | 144 | 12.5 | 5.67 | 0.263 | 0.6 | 0.142 | 167 | 19.3 |
| | 15.09 | 0.588 | 4.31 | 0.222 | 19.57 | 2.458 | 167 | 16.1 | 4.43 | 0.325 | 0.64 | 0.062 | 121.3 | 14.4 |
| | 15.7 | 0.159 | 4.45 | 0.03 | 19.63 | 0.447 | 155.9 | 12.8 | 2.65 | 0.111 | 0.45 | 0.081 | 185.4 | 16.3 |
| | 15.88 | 0.181 | 4.35 | 0.083 | 19.37 | 1.213 | 154.7 | 13.4 | 2.87 | 0.187 | 0.55 | 0.052 | 175.1 | 19.2 |
| | 13.89 | 0.068 | 4.41 | 0.059 | 19.78 | 1.703 | 143 | 11 | 2.87 | 0.178 | 0.6 | 0.06 | 185.6 | 15.22 |
| B | 12.11 | 0.307 | 4 | 0.153 | 20.04 | 1.891 | 150.3 | 16.4 | 2.588 | 0.205 | 0.75 | 0.049 | 156.4 | 17.8 |
| | 1.18 | 0.382 | 4 | 0.15 | 19.58 | 2.11 | 153.8 | 13.2 | 3.262 | 0.191 | 0.69 | 0.047 | 174.8 | 16 |
| | 13.8 | 0.779 | 4.39 | 0.306 | 19.51 | 3.56 | 157.8 | 11.9 | 2.54 | 0.259 | 0.54 | 0.045 | 151.9 | 15.4 |
| | 19.83 | 1 | 4.51 | 0.227 | 20.78 | 3.39 | 159 | 14.2 | 3.85 | 0.34 | 0.47 | 0.034 | 150 | 16 |
| | 15 | 0.01 | 4.31 | 0.059 | 20.8 | 1.21 | 158 | 11.8 | 2.83 | 0.03 | 0.53 | 0.065 | 121.7 | 15.5 |
| | 14.96 | 0.02 | 4.35 | 0.05 | 20.6 | 1.52 | 157.4 | 17.1 | 1.9 | 0.13 | 0.55 | 0.058 | 180.1 | 15.5 |
| C | 12.38 | 0.023 | 4.41 | 0.06 | 19.7 | 3.78 | 160 | 14.33 | 1.7 | 0.33 | 0.37 | 0.045 | 177.3 | 13.8 |
| | 11.56 | 0.076 | 4.23 | 0.04 | 19.9 | 1.76 | 160 | 12.2 | 3.89 | 0.15 | 0.29 | 0.043 | 173.9 | 17.1 |
| | 12.88 | 0.62 | 4.4 | 0.09 | 19.54 | 1.29 | 167.5 | 13 | 2.02 | 0.15 | 0.21 | 0.05 | 122.5 | 15.6 |
| | 13.67 | 0.012 | 4.48 | 0.71 | 20.35 | 2.17 | 159.5 | 14 | 6.05 | 0.27 | 0.23 | 0.064 | 182.3 | 16.55 |
| | 15.16 | 0.023 | 4.31 | 0.05 | 21.75 | 1.81 | 159.6 | 16.1 | 1.85 | 0.19 | 0.34 | 0.057 | 174.9 | 13.4 |
| | 13.44 | 0.37 | 4.45 | 0.12 | 20.04 | 2.25 | 155.6 | 17.5 | 1.69 | 0.21 | 0.33 | 0.04 | 166.4 | 14.9 |
| D | 18.55 | 0.005 | 4.35 | 0.24 | 19.58 | 1.67 | 153.2 | 12.3 | 1.79 | 0.27 | 0.31 | 0.06 | 183.4 | 19.6 |
| | 16.45 | 0.017 | 4.41 | 0.05 | 19.51 | 0.84 | 156.5 | 14.8 | 1.73 | 0.14 | 0.32 | 0.096 | 163.4 | 18.7 |
| | 14.98 | 0.11 | 4.23 | 0.08 | 19.69 | 1.59 | 154.2 | 11.34 | 1.81 | 0.22 | 0.27 | 0.075 | 181 | 21 |
| | 12.76 | 0.6 | 4.4 | 0.26 | 19.54 | 3.17 | 143.7 | 10.22 | 1.77 | 0.27 | 0.25 | 0.048 | 174 | 15.9 |
| | 13 | 0.42 | 4.47 | 0.16 | 19.54 | 2.55 | 148.4 | 11.5 | 2.04 | 0.23 | 0.47 | 0.043 | 179.4 | 10.55 |
| | 13.98 | 0.011 | 4.83 | 0.06 | 20.54 | 1.48 | 160 | 10.78 | 1.79 | 0.14 | 0.5 | 0.046 | 199 | 18.7 |
| E | 12.77 | 0.87 | 5.02 | 0.34 | 19.35 | 3.91 | 167 | 17.4 | 2.01 | 0.28 | 0.55 | 0.038 | 170.3 | 18.4 |
| | 13.56 | 0.004 | 4.99 | 0.2 | 19.58 | 3.17 | 163 | 14.2 | 2.95 | 0.28 | 0.37 | 0.073 | 188 | 16.3 |
| | 13.89 | 0.088 | 4.39 | 0.08 | 19.51 | 2.93 | 151.6 | 10.4 | 1.85 | 0.2 | 0.26 | 0.084 | 162 | 14.76 |
| | 14.87 | 0.02 | 4.37 | 0.08 | 19.69 | 2.15 | 166.2 | 15.8 | 1.76 | 0.23 | 0.35 | 0.074 | 153 | 13.9 |
| | 18.5 | 0.395 | 4.47 | 0.23 | 19.54 | 2.43 | 140.5 | 11.4 | 1.76 | 0.28 | 0.28 | 0.05 | 166 | 11.89 |
| | 13.98 | 0.24 | 4.57 | 0.18 | 19.54 | 2.04 | 166 | 10.9 | 2.8 | 0.28 | 0.22 | 0.116 | 177.6 | 22.1 |
| F | 13.67 | 1.095 | 4.76 | 0.55 | 20.54 | 3.36 | 159 | 13.5 | 269 | 0.34 | 0.25 | 0.071 | 172.1 | 15.76 |
| | 13.29 | 0.057 | 4.51 | 0.08 | 19.35 | 2.67 | 168.3 | 16.4 | 2.8 | 0.35 | 0.19 | 0.096 | 174.9 | 12.65 |
| | 12.37 | 0.85 | 4.47 | 0.4 | 19.52 | 3.1 | 177 | 11 | 1.7 | 0.32 | 0.22 | 0.055 | 173 | 18.4 |
| | 12.8 | 0.024 | 4.83 | 0.1 | 19.5 | 2 | 155.9 | 12.3 | 1.8 | 0.27 | 0.23 | 0.084 | 173.9 | 22 |
| | 13 | 0.12 | 4.76 | 0.13 | 19.44 | 2.89 | 164 | 10.44 | 1.89 | 0.49 | 0.22 | 0.176 | 174.6 | 17.33 |
| | 13.8 | 0.047 | 4.51 | 0.11 | 19.99 | 1.43 | 143 | 16.34 | 3.2 | 0.24 | 0.25 | 0.088 | 169.7 | 15.4 |
| G | 13.56 | 0.042 | 4.56 | 0.06 | 19.57 | 1.04 | 149 | 12.5 | 2.87 | 0.32 | 0.25 | 0.058 | 171 | 14.9 |
| | 14.53 | 0.087 | 4.9 | 0.05 | 19.71 | 1.03 | 158.5 | 12.76 | 2.3 | 0.34 | 0.21 | 0.066 | 171.7 | 17.8 |
| | 13.5 | 0.32 | 4.98 | 0.16 | 19.59 | 2.61 | 159.8 | 11 | 1.79 | 0.43 | 0.21 | 0.069 | 173.5 | 13.3 |
| | 13.94 | 0.48 | 5.8 | 0.1 | 19.71 | 3.18 | 159.4 | 17.1 | 2.01 | 0.57 | 0.23 | 0.09 | 168.3 | 12.1 |
| | 14 | 0.05 | 4.47 | 0.98 | 20.67 | 1.31 | 167 | 13 | 3.2 | 0.31 | 0.23 | 0.075 | 166 | 14.8 |
| | 13.65 | 0.2 | 4.83 | 0.14 | 20.73 | 2.64 | 162.2 | 12.89 | 5.9 | 0.42 | 0.56 | 0.061 | 183.0 | 14.6 |
| Average | 13.97 | 0.27 | 4.53 | 0.18 | 19.87 | 2.18 | 157.09 | 13.28 | 8.99 | 0.26 | 0.38 | 0.07 | 168.96 | 16.21 |
| Minimum | 1.18 | 0.004 | 4 | 0.03 | 19.35 | 0.447 | 140.5 | 10.1 | 1.69 | 0.03 | 0.19 | 0.034 | 121.3 | 10.55 |
| Maximum | 19.83 | 1.095 | 5.8 | 0.98 | 21.75 | 3.91 | 177 | 17.5 | 269 | 0.57 | 0.75 | 0.176 | 199 | 22.1 |
| WHO | 200-300 | | 100-300 | | 200 | | 250 | | 75 | | 1-1.5 | | 200-300 | |

standards the permissible value for (EC) is 600µ mho/cm (WHO, 2011). The average efficiencies of household water treatment filters studied for the decreasing of electric conductivity (EC) of drinking water was 93.64%.

**Total dissolved solids (TDS).** Total dissolved solids (TDS) are formed as a result of water ability to dissolve salts and minerals; then, these minerals produce undesirable taste in water (Mohsin *et al*., 2019b; Mohsin *et al*., 2013). The WHO and Iraqi standard values for TDS is 500 ppm (WHO, 2009). Results show that value of conductivity and concentration of total dissolved solids changes. The TDS concentrations of input water

**Table 3.** Removal percentage (Rp) of elements in the water samples

| Filters brand | Rp (%) of Ca | Rp (%) of Mg | Rp (%) of Na | Rp (%) of $SO^4$ | Rp (%) of K | Rp (%) of F | Rp (%) of Cl |
|---|---|---|---|---|---|---|---|
| A | 97.7 | 96.8 | 89.6 | 92.9 | 87.3 | 93.1 | 88.7 |
| | 97.4 | 96.8 | 90.8 | 91.3 | 95.4 | 76.3 | 88.4 |
| | 96.1 | 94.8 | 87.4 | 90.4 | 92.7 | 90.3 | 88.1 |
| | 99.0 | 99.3 | 97.7 | 91.8 | 95.8 | 82.0 | 91.2 |
| | 98.9 | 98.1 | 93.7 | 91.3 | 93.5 | 90.5 | 89.0 |
| | 99.5 | 98.7 | 91.4 | 92.3 | 93.8 | 90.0 | 91.8 |
| B | 97.5 | 96.5 | 90.6 | 89.1 | 92.1 | 93.5 | 88.6 |
| | 67.6 | 96.4 | 89.2 | 91.4 | 94.1 | 93.2 | 90.8 |
| | 94.4 | 93.0 | 81.8 | 92.5 | 89.8 | 91.7 | 89.9 |
| | 95.0 | 95.0 | 83.7 | 91.1 | 91.2 | 92.8 | 89.3 |
| | 99.9 | 98.6 | 94.2 | 92.5 | 98.9 | 87.7 | 87.3 |
| | 99.9 | 98.9 | 92.6 | 89.1 | 93.1 | 89.5 | 91.4 |
| C | 99.8 | 98.6 | 80.8 | 91.0 | 80.6 | 87.8 | 92.2 |
| | 99.3 | 99.1 | 91.2 | 92.4 | 96.1 | 85.2 | 90.2 |
| | 95.2 | 98.0 | 93.4 | 92.2 | 92.6 | 76.2 | 87.3 |
| | 99.9 | 84.2 | 89.3 | 91.2 | 95.5 | 72.2 | 90.9 |
| | 99.8 | 98.8 | 91.7 | 89.9 | 89.7 | 83.2 | 92.3 |
| | 97.2 | 97.3 | 88.8 | 88.8 | 87.6 | 87.9 | 91.0 |
| D | 100.0 | 94.5 | 91.5 | 92.0 | 84.9 | 80.6 | 89.3 |
| | 99.9 | 98.9 | 95.7 | 90.5 | 91.9 | 70.0 | 88.6 |
| | 99.3 | 98.1 | 91.9 | 92.6 | 87.8 | 72.2 | 88.4 |
| | 95.3 | 94.1 | 83.8 | 92.9 | 84.8 | 80.8 | 90.9 |
| | 96.8 | 96.4 | 86.9 | 92.3 | 88.7 | 90.9 | 94.1 |
| | 99.9 | 98.8 | 92.8 | 93.3 | 92.2 | 90.8 | 90.6 |
| E | 93.2 | 93.2 | 79.8 | 89.6 | 86.1 | 93.1 | 89.2 |
| | 100.0 | 96.0 | 83.8 | 91.3 | 90.5 | 80.3 | 91.3 |
| | 99.4 | 98.2 | 85.0 | 93.1 | 89.2 | 67.7 | 90.9 |
| | 99.9 | 98.2 | 89.1 | 90.5 | 86.9 | 78.9 | 90.9 |
| | 97.9 | 94.9 | 87.6 | 91.9 | 84.1 | 82.1 | 92.8 |
| | 98.3 | 96.1 | 89.6 | 93.4 | 90.0 | 47.3 | 87.6 |
| F | 92.0 | 88.4 | 83.6 | 91.5 | 99.9 | 71.6 | 90.8 |
| | 99.6 | 98.2 | 86.2 | 90.3 | 87.5 | 49.5 | 92.8 |
| | 93.1 | 91.1 | 84.1 | 93.8 | 81.2 | 75.0 | 89.4 |
| | 99.8 | 97.9 | 89.7 | 92.1 | 85.0 | 63.5 | 87.3 |
| | 99.1 | 97.3 | 85.1 | 93.6 | 74.1 | 20.0 | 90.1 |
| | 99.7 | 97.6 | 92.8 | 88.6 | 92.5 | 64.8 | 90.9 |
| G | 99.7 | 98.7 | 94.7 | 91.6 | 88.8 | 76.8 | 91.3 |
| | 99.4 | 99.0 | 94.8 | 91.9 | 85.2 | 68.6 | 89.6 |
| | 97.6 | 96.8 | 86.7 | 93.1 | 76.0 | 67.1 | 92.3 |
| | 96.6 | 98.3 | 83.9 | 89.3 | 71.6 | 60.9 | 92.8 |
| | 99.6 | 78.1 | 93.7 | 92.2 | 90.3 | 67.4 | 91.1 |
| | 98.5 | 97.1 | 87.3 | 92.1 | 92.9 | 89.1 | 92.0 |
| Average | 97.35 | 96.06 | 89.00 | 91.54 | 89.09 | 77.90 | 90.32 |
| Minimum | 99.97 | 78.1 | 79.8 | 88.6 | 71.6 | 20.0 | 87.3 |
| Maximum | 67.6 | 99.33 | 97.72 | 93.79 | 99.87 | 93.47 | 94.12 |

samples are ranged between 581-614 mg/L. On the other hand, the concentration of TDS had decreased in the output of water treatment systems and ranged between 6-91 mg/L. The average removal efficiencies of household water treatment systems for TDS were 99.99%.

**Calcium and magnesium.** Both calcium and magnesium are essential to human health. In general, water gains hardness because presence of calcium and magnesium and these elements enter water body as a result of leaching limestone, magnesia, dolomite and others (Gupta, 2009). The average removal efficiencies and concentrations of input and output ions of calcium and magnesium of household water treatment systems are shown in Table 4. Household water treatment systems remove useful ions (calcium and magnesium); this is regarded as one of the disadvantages of home water treatment devices. The average removal efficiencies of household water treatment systems for calcium and magnesium were 97.35% and 96.06% respectively.

**Sodium and potassium.** The human body needs sodium in order to maintain blood pressure. Potassium is a co-factor for many enzymes and is required for the secretion of insulin. The great decreasing in the sodium and potassium amount through household water treatment systems may lead to cause other problems in drinking water. The removal (%) for sodium and potassium ions removal was 89% and 89.09% respectively. This indicates a high ability of these devices to remove sodium and potassium from Kalar water household. The decreasing sodium element is only useful for renal disease patients (WHO, 2006). On the other hand, potassium concentrations vary between 0.032 to 3.25 mg/L.

**Sulphate and chloride.** Sulphate ($SO_4^{2-}$) and chloride ($Cl^-$) ions naturally exist in surface water. The analysis of input water treatment systems samples observed sulphate concentrations to be within permissible limit 200 mg/L. The concentration of chlorine and sulphate ions had decreased significantly in the output of water treatment systems. The average efficiencies of household water treatment filters for removing $SO_4^{2-}$ and $Cl^-$ were 90.32% and 91.54% respectively. The removal of chloride ions in the devices lead to cause growth of bacteria and algal.

**Fluorides.** Fluoride plays a significant role in the development of tooth enamel in children and possibly in strengthening the bone matrix through out life. Fluoride is used to combat dental caries (tooth decay), particularly in areas of high sugar intake. It is recommended that the optimal fluoridation of water has to be at least (1) mg/L (WHO, 2011). The input samples were less than minimum permissible limit. Water sample analysis observed that the average removal efficiencies of household water treatment systems for fluoride were (77.9% in Table 5). For the mentioned reason and due to the already shortage of fluoride in Kalar's water; so, the use of water treatment devices are not necessary and it's not recommended to drink this type of water especially for children.

Overall, there were significant decreasing ($P< 0.05$) in all output parameters in comparison with input one (Fig. 2 and 3).

The use of household water treatment systems (filters) causes great reduction in the proportion of useful ions such as (sodium, calcium, magnesium, chloride and sulphate), which significantly leads to cause some other issues in drinking water. The ability of household water treatment systems (filter) to remove sodium ions was 89%. This indicates a high ability of those devices to remove sodium from water in Kalar City. Although, reducing sodium is important for patients who suffered from renal disease (WHO, 2006). However, the presence of appropriate proportions of sodium in the drinking water is of great importance. Malakootian *et al*. (2017) in a study conducted in Kerman (Iran) found that the sodium ions concentration in output of home water treatment systems' was significantly reduced. This corresponds to the results of this study.

Also, the ability of household water treatment systems (filters) tested in removing sulphate ions at 90.32%. Furthermore, they showed high ability in removing calcium and magnesium ions at 97.35% and 96.06% respectively. Sadigh *et al*. (2015) in a study conducted in Ardebil (Iran) and Zhang *et al*. (2020) in rural southwest China showed that the concentration of calcium and magnesium ions in output of household water treatment systems' were significantly reduced, which is corresponds to the results of this study. The deficiency of magnesium in drinking water leads to increase the risk of cardio-vascular disease and stroke (Morrisa *et al*., 2008). Calcium and magnesium in drinking water can significantly contribute to reduced cardiovascular disease. However, intakes of Inadequate calcium is associated with increased the risks of osteoporosis, colourectal cancer, nephro-lithiasis, hypertension and stroke, coronary artery disease and obesity (WHO, 2009).

Although the water resources in Kalar contains insufficient amounts of fluoride, however, the average removal efficiencies of household water treatment systems for

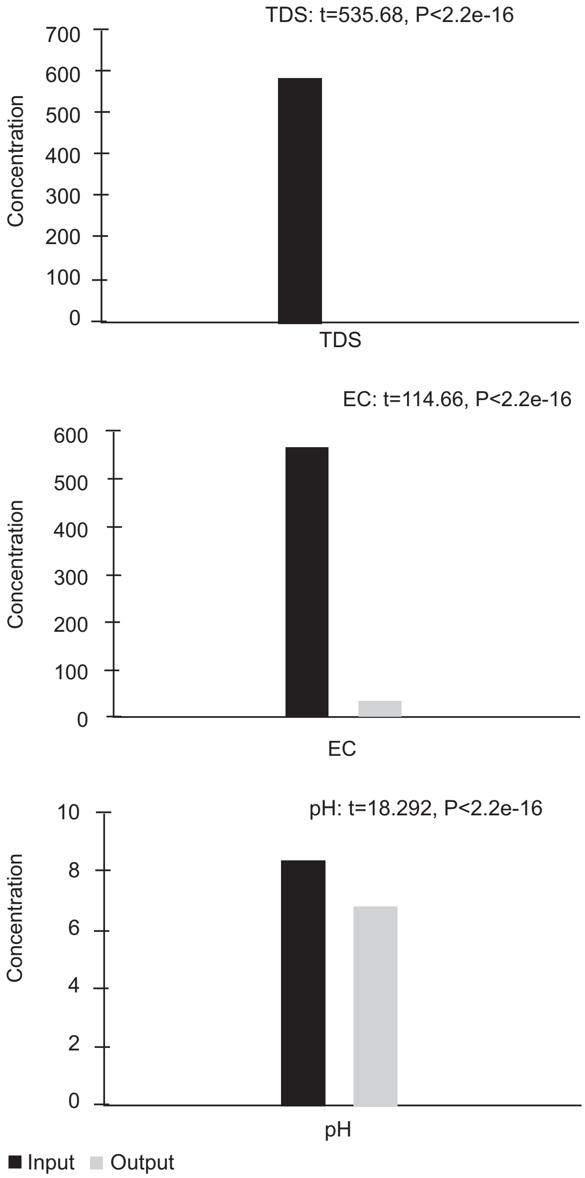


**Fig. 2.** The differences between input and output values of TDS, EC and pH.

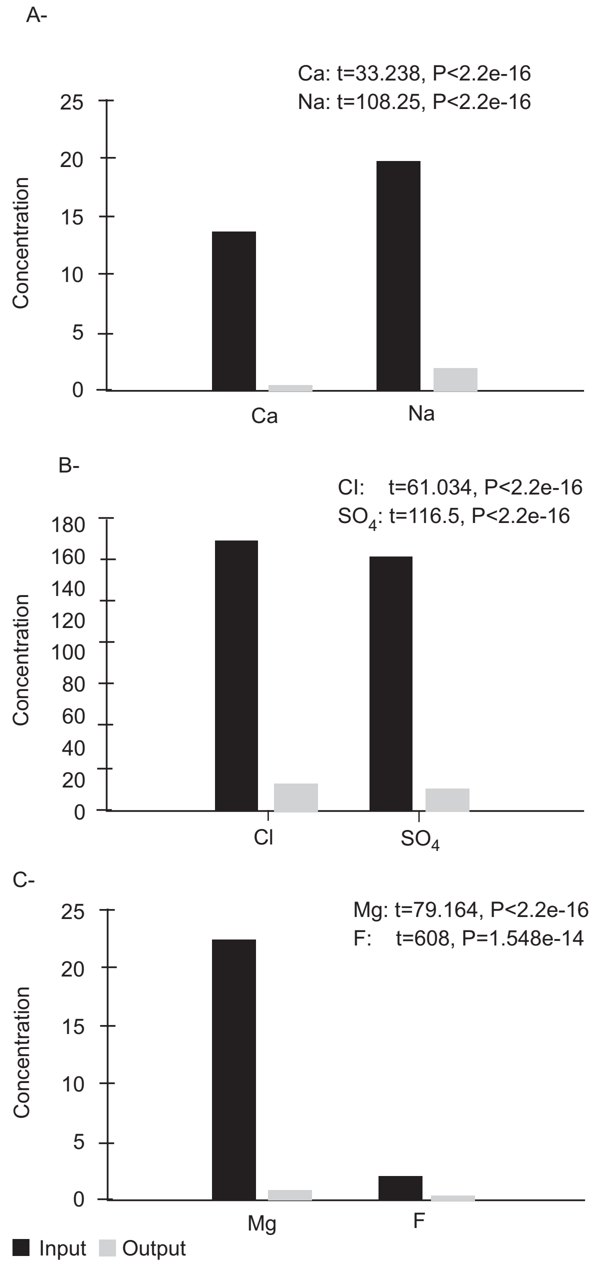


**Fig. 3.** The differences between input and output values of: (A) Ca and Na. (B) Cl and $SO_4$ (C) Mg and F.

fluoride were (77.9%). This result is corresponding to other studies conducted in 2010 in Kashan (Iran) and in 2007 in Qom (Iran) (Miranzadeh and Rabbani, 2010; Yari *et al*., 2007). With long term use of treated water from water treatment systems will lead to cause an increased incidence of bone complications (Osteoporosis) as a result of lack of some (Morrisa *et al*., 2008). Also, removing a number of minerals causes an undesirable bitter taste of output water from these devices and may cause a disturbance in the ion balance (Sauvant and Pepin, 2002). Therefore, due to the reasons above mentioned, water treatment devices are not necessary to be used and it's not recommended to drink this type of water especially for children.

## Conclusion

Different types of household water treatment systems have been used widely in Kurdistan Region especially in Kalar city. This study conducted to assess the household water treatment systems used in Kalar city to remove minerals from drinking water. The results indicate that the certain chemical minerals such as calcium, magnesium, potassium and fluoride were significantly removed. Therefore, the use of such devices for a long time and due to the removing of significant elements in water will negatively affect human health. The average removal of calcium, magnesium, sodium, potassium and fluoride were 97.35, 96.06, 89, 89.09 and 77.9%, respectively. Therefore, the use of these devices is not recommended as the quality of water in the study area considered as good quality.

**Conflict of Interest.** The authors declare they have no conflict of interest.

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