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Assess the efficiency of drinking water filters that use in houses in Erbil city- Iraq

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ABSTRACT

Many people in Erbil city started more than two decades to put special treatment units in their houses to purify water to become safer for drinking uses. One way of classifying water quality is by means of indices, in which a series of parameters analyzed are joined a single value, facilitating the interpretation of extensive lists classification of water quality. The aim of this study was to determine the efficiency of six water treatment units established in houses. Water samples were collected twice, one before and the other after the treatment unit. Each sample was collected with three replications during November and December 2021. Analyzed for Major cations concentration (calcium, magnesium, sodium, and potassium), anions concentration (nitrate and chloride) and hydrogen ion concentration (pH), electrical conductivity (EC), total dissolved solids (TDS), alkalinity, and total hardness by using standard methods. The water quality index values for all raw water sample before and after treatment was good and excellent respectively for drinking purposes. The efficiency of water treatment units ranges from16.25% to 39.78%. Values for major cations, anions, and others chemicals characteristics in the water samples after treatment became lower concentrations than before treatment, likely an indication that these were removed by treatment. According to the guidelines of the world health organization, all of the variables before treatment are safe and suitable for drinking purposes.

Keywords: efficiency; drinking water; filter; WQI.

1. INTRODUCTION

Water is important for the transport of substances; organisms need it to move things around in their bodies (and to move substances in and out of cells). Water is significant for maintaining body temperatures. Finally, it plays a major role in chemical activity in cells. It is essential for the survival of all known forms of life (Al-Ansari, 2013). Water, a prime natural resource and precious national asset form the chief constituent of the ecosystem. Water sources may be mainly in the form of rivers, lakes, glaciers, rainwater, groundwater, etc. Besides the need for water for drinking, water resources play a vital role in various sectors of the economy such as agriculture, livestock production, forestry, industrial activities, hydropower generation, fisheries, and other creative activities. The availability and quality of water either surface or ground, have been deteriorated due to some important factors like increasing population, industrialization, urbanization, etc. (WHO, 2012). Man's utmost concern since the beginning of civilization has been the search for good quality domestic water. One of the world's most challenging environmental problems resulting in the increasing demand for domestic water is the scarcity and search for clean freshwater (Bustanmante *et al.,* 2004). Most of the water is used for drinking, irrigation, and industries, not supporting habitat for natural flora and fauna, but also needs treatment to become suitable for drinking and other purposes (Salem, 2010).

Water quality of any specific area or specific source can be assessed using physical, chemical, and biological parameters. The values of these parameters are harmful to human health if they occurred more than defined limits (WHO, 2012). Therefore, the suitability of water sources for human consumption has been described in terms of the water quality index (WQI), which is one of the most effective ways to describe the quality of water. WQI utilizes the water quality data and helps in the modification of the policies, which are formulated by various environmental monitoring agencies. It has been realized that the use of individual water quality variables to describe the water quality for the common public is not easily understandable (Bharti and Katyal, 2011; Akoteyon *et al.,* 2011). That's why, WQI can reduce the bulk of the information into a single value to express the data in a simplified and logical form (Babaei Semiromi *et al*., 2011). It takes information from several sources and combines them to develop an overall status of a water system (Karbassi *et al*., 2011; Chowdhury *et al.*, 2012). They increase the understanding ability of highlighted water quality issues by the policymakers as well as for the general public as users of the water resources (Nasirian, 2007). The water quality index (WQI) is one of the most effective tools to communicate information on the quality of water to concerned citizens and policymakers. It, thus, becomes an important parameter for the assessment and management of surface water. WQI is calculated from the point of view of the suitability of surface water for human consumption (Atulegwu and Njoku, 2004). WQI is defined as a rating reflecting the composite influence of different water quality parameters. WQI is calculated from the point of view of the suitability of surface water for human consumption (Jadoon *et al*., 2014). The quality of water sources deteriorates due to point source and non-point source pollution. Point source pollution includes industrial effluents and discharges from municipal wastewater treatment plants while non-point source pollution includes agricultural runoff, seepage of septic tank effluents into groundwater, indiscriminate dumping of wastes into streams, and rivers among others (Deepika, 2015).

Water is essential for maintaining, an adequate food supply and a productive environment for the human population, animals, plants, and microbes worldwide (Cunningham and Saigo, 2001). Population and economics grow, accompanied by increased water use, will not only severely reduce water availability per person but also create stress biodiversity in the entire global ecosystem (Graham *et al*., 2006). Rivers are used as sites for the disposal of refuse, human sewage, and wastewaters from kitchens, abattoirs, and industries. Streams and rivers running through areas of significant human influence such as farms, cities, and industrial locations are therefore prone to pollution (Adewoye, 2010).

Drinking water supplies have a long history of being infected by a wide spectrum of microbes. Therefore, the primary goal of water quality management from a health perspective is to ensure that consumers are not exposed to pathogens that cause disease. Protection of water sources and treatment of water supplies have greatly reduced the incidence of these diseases in developed countries. Therefore, testing the source of water is necessary, especially when there is no water treatment. This is useful as a result of the failure of the treatment process or as a part of an investigation of a serious water-borne disease outbreak (WHO, 2003). This study aims to calculate the WQI for tap and filtered water and determine the efficiency of six drinking water filters present in houses in Erbil city.

2. MATERIALS AND METHODS

2.1. Description of the Studied Area

Erbil is the capital of the Kurdistan region of Iraq it is situated almost at the center of the region. Erbil covers about 18170 square kilometers. Its boundaries extended from longitude 43° 15¯ E to 45° 14¯ E and from latitude 35° 27¯ N to 37° 24¯ N. and they are a large hydrological basin, this area bordered by the Great Zab River in the northwest side and Lesser Zab River in the southeast side, which formed from melting of snow in the winter season and spring sources in the summer season. The aquifer underneath Erbil city is recharged by an excess of rainfall and recently Erbil city is undergone heavy groundwater draft (Guest, 1966). The climate is most closely to Irano–Turanian type and the annual rainfall may exceed 1000 mm while the average rainfall in Erbil city is 440 mm. Erbil city is currently served by two types of water resources (Barznii and Ganjo, 2014). The figure below shows the locations of the studied waters.

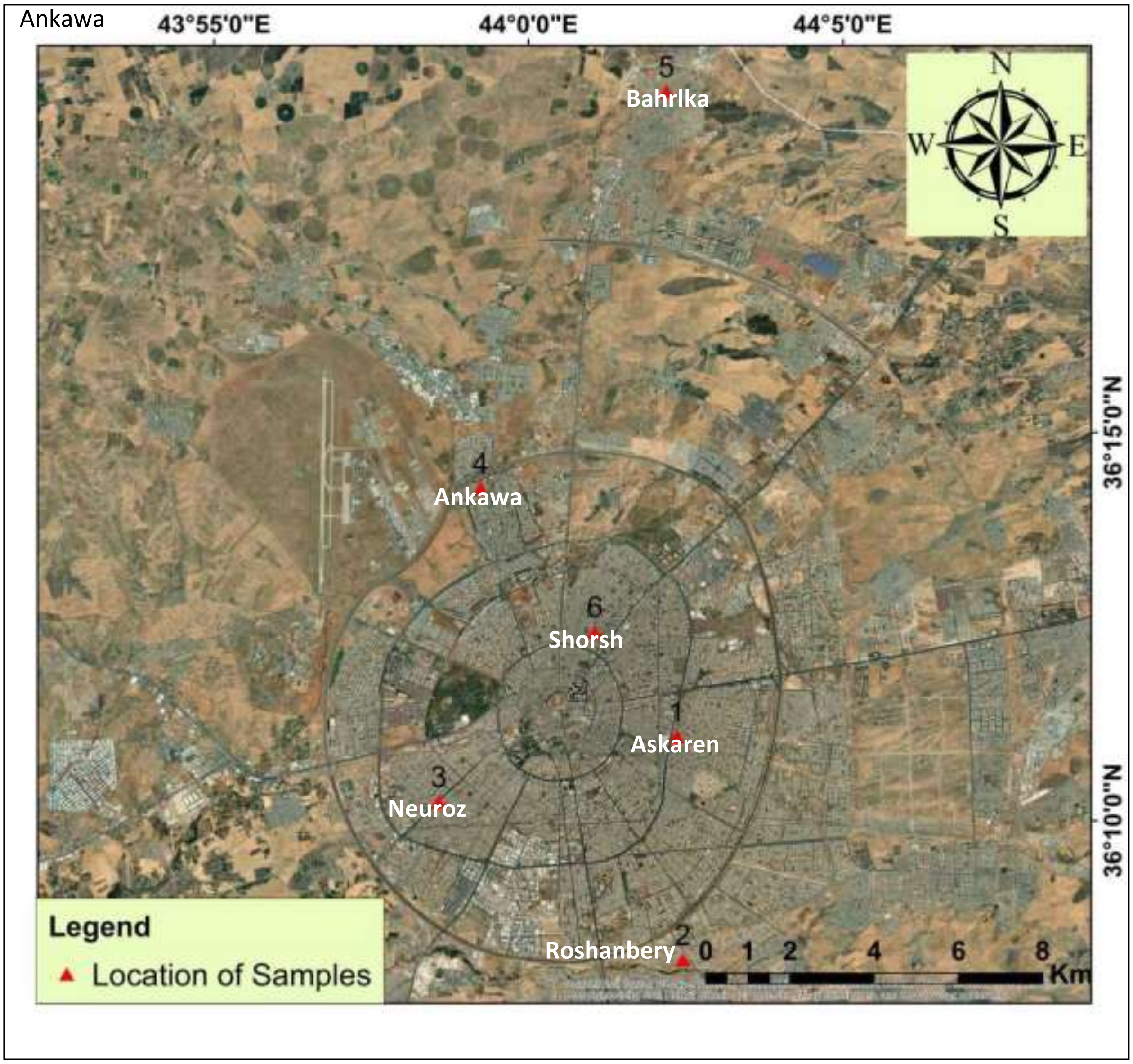

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Figure 1: Map of studied sites (Google earth, 2021).

2.2. Sample collection and analytical methods

Water samples from six houses located at Erbil city were collected once for physical and chemical analysis during November and December 2021. From each house, the sample of tap water and filtered water (R O Water Purifier) was collected with three replications during the period of the study. The following water quality parameters were determined which were chosen as the major indicators namely Potential of Hydrogen Ion (pH), Electrical Conductivity (EC), Total Dissolved Solids (TDS), total alkalinity, total hardness, calcium, magnesium, sodium, potassium, chloride, and nitrate. The water samples were analyzed following methods outlined in the Standard Method for Examination of Water and Wastewater (APHA, 2012).

2.3. Water Quality Index

For the calculation of the water quality index, eleven important parameters were chosen. The calculation and formulation of WQI involved the following steps (Table 1):

1- In the first step, each of the eleven parameters has been assigned a weight (AWS) ranging from 1 to 5 depending on (Yogendra andtaiah, 2008).

2- In the second step, the relative weight (Rw) was calculated by using the equation below:

$$\boldsymbol{Rw = \frac{AWi}{\sum_{i-1}^{n} AWi}}$$

Where:

Rw =is the relative weight

AWS =the assigned weight of each parameter

n= the number of parameters

3- In the third step, a quality rating scale (Qi) for all the parameters except pH and DO was assigned.

$$\boldsymbol{Qi = \frac{Ci}{Si} \times 100}$$

While, the quality rating for pH or DO ($Q_{, DO}$) was calculated based on,

$$\boldsymbol{Q\ pH, DO = \frac{Ci-Vi}{Si-Vi} \times 100}$$

Where:

Qi =the quality rating

Ci = value of the water quality parameter obtained from the laboratory analysis

Si = value of the water quality parameter obtained from recommended WHO (2003)

Vi = the ideal value which is considered as 7 for pH and 14.6 for DO (Table 1).

The sub-indices (SI) were first calculated for each parameter, and then used to compute the WQI as in the following equations:

$$SI = Q_i \times W_i$$

$$WQI = \Sigma SI$$

Finally, the overall Water Quality Index was calculated by aggregating the quality rating with the relative weight linearly. The waters were classified according to Raakthe rishnaiah, *et al.* (2009) (Table 2).

Table 1: Calculation of WQI for drinking purposes at the studied sites.

Parameters	**Unit**	**WQS**	**Wi**	**RW**	**Qi**
pH	mg/L	6.5-8.5	4	AWi/∑AWi	(Ci-Vi)/(Si-Vi)×100
EC	µS/cm	1000	3	AWi/∑AWi	Ci/Si×100
TDS	mg/L	500	3	AWS/∑AWS	Ci/Si×100
Alkalinity	mgCaCO3/L	200	1	AWi/∑AWi	Ci/Si×100
T. hardness	mgCaCO3/L	200	2	AWi/∑AWi	Ci/Si×100
Calcium	mg/L	100	2	AWi/∑AWi	Ci/Si×100
Magnesium	mg/L	30	2	AWi/∑AWi	Ci/Si×100
Sodium	mg/L	200	1	AWi/∑AWi	Ci/Si×100
Potassium	mg/L	10	1	AWi/∑AWi	Ci/Si×100
Chloride	mg/L	250	2	AWi/∑AWi	Ci/Si×100
Nitrate	mg/L	50	5	AWi/∑AWi	Ci/Si×100

Table 2: WQI range and type of water can be classified according to Ramakrishnaiah *et al.* (2009).

Range	Type of water
< 50	Excellent water
50.1 – 100	Good water
100.1 – 200	Poor water
200.1 – 300	Very poor water
> 300	Water unsuitable for drinking purposes

2.4. Efficiency (E%)

Efficiency (E%) of the filters situated at tap water was calculated by determining the WQI of the before and after treated water supplied by using the formula given below (Toma and Hanna, 2017):

$$E\% = \frac{WQI\ of\ tap\ watert - WQI\ of\ filtered\ water}{WQI\ of\ tap\ water} \times 100$$

3. RESULTS AND DISCUSSION

The mean values of the physicochemical parameters of the various drinking water samples are presented in Table 3. The mean pH values of the different drinking water samples ranged from 7.28 to 8.46 in. These mean values of the water samples fall within the standard maximum permissible limit set by (WHO,2011). The lowest values were recorded after treatment, Although, the highest values were measured in raw water. Electrical conductivity varied between 27.66 µS/cm in treated water to 706.66 µS/cm in tap water, variations throughout this survey depend on the climate, soil, geological origin, and the content of ionic salts (Ezzat *et al.*, 2012) The maximum acceptable level of conductivity as indicate by (WHO,2011) is 1000µs/cm, and accordingly all studied wells were in the permissible range. According to (WHO, 2011) water containing TDS below 1000mg/L is usually acceptable to consumers, this has coincided with the present studied area. Since during this study higher value of total dissolved solids was 452.26mg/l observed in raw water and the lowest value was 17.79 mg/l recorded after treatment units. Most of the observed values of alkalinity in tap water were above the permissible level recommended by the (WHO,2011) for drinking water. However, after treatment, the water fell within the acceptable range. The mean values recorded for total hardness, calcium, and magnesium ions ranged from 13.33 mg$CaCO_3$/l in treated water to 80.00 mg$CaCO_3$/l in raw water, 0.01 mg/l to 13.33 mg/l and 1.08 mg/l to 13.26 mg/l respectively. The values for these parameters fell below the WHO specifications. These parameters reflect the nature of the geographical characteristic of the study area. Water with low magnesium can cause morbidity and mortality for cardiovascular disease, high risk of motor neuronal disease, pregnancy disorders, and pre-eclampsia while water with low calcium may be associated with a higher risk of fracture in children (Balan *et al.,* 2012). The concentrations of sodium and potassium range from 5.06 to 35.45 mg/l for sodium and 0.62 to 1.40 mg/l for potassium. These differences of values of cations in different sites are possibly related to the rocks and soil characteristics of catchments area within Erbil Province (Al- Sahaf, 1976). However, water treatments will directly or indirectly cause the removal of the cations such as calcium, magnesium, potassium, and sodium to a certain degree. The values for calcium, magnesium, potassium, and sodium of raw water are consistently higher than other treatment water samples, this may be due to the efficiency of treatment units to reduce the concentrations of cations (IBWA, 2000). All the studied water brands have major anions levels falling within the WHO standard for drinking purposes (WHO,2011). Nitrate concentration levels ranged from 5.19 to 59.79 mg/L in water samples. The guidelines standards value for nitrate in drinking water were respected in all of the tested waters within the recommended value of 50 mg/l. Chloride levels varied between 2.00 to 58.33 mg/l recorded in treated waters. The desirable guideline value of chloride concentration in drinking water is 250mg/l (WHO,2011), therefore the studied sites are located within desirable levels of chloride for drinking purposes.

The water quality index is critical for displaying information about water quality and providing a warning alarm so that pollution control measures can be taken. This study might be considered a first attempt at determining water quality indices in some water treatment units installed in some homes in Erbil city, as well as Erbil in general. WQI levels are heavily influenced by the value of several physical and chemical features of water. The water quality is categorized from good to excellent using the WQI (Ramakrishnaiah *et al.,* 2009). Applying the former equations on the results of water analysis data of water (tap and filtered) have been described in (Table 4). In this study, the computed grads of WQI values were categorized into five types for human consumption according to (Ramakrishnaiah *et al.,* 2009), as they were revealed in (Table 2). The results showed that, for raw water, the samples are coming under good and excellent categories. However, after treatment, all waters fall within the excellent category and acceptable quality for human consumption. In this paper the application of the water quality index approach to water samples from tap water and six treatment units that were established in some houses in Erbil city, Kurdistan region of Iraq. Had the purpose of providing a simple, valid method for expressing the results of several parameters in order to assess the water quality. Assembling different parameters into one single number leads to an easy interpretation of the index, thus providing an important tool for management purposes (AL-Hayani, 2009).

Figure (2) represents the efficiency of the water treatment unit situated in some houses in Erbil City, it has been concluded that the tap water was good and after treatment was excellent quality throughout the study, as the efficiency of water treatment units ranges from16.25% to 39.78%. This means the efficiency of the water treatment unit varied, this may be due to reducing the ability of treatment units to treat the water from different physical and chemicals variables after a period of establishing the unity on the tap water. Strict measures and monitors should be applied in order to known the efficiency of each of water treatment that putted of some houses to treat water to become more suitable for drinking purposes (Ramakrishnaiah *et al.,* 2009).

Table 3: Physical and chemical variables were recorded in six water treatment units during November and December 2021.

Variables	No. of time	House 1	House 2	House 3	House 4	House 5	House 6
pH	Tap	8.01	7.99	7.80	7.42	7.45	7.39
	Filtered	8.46	8.31	8.05	7.28	7.84	7.79
EC	Tap	414.66	433.00	706.66	679.00	532.00	438.00
	Filtered	76.33	27.66	246.00	502.00	80.00	43.33
TDS	Tap	265.38	277.12	452.26	264.33	339.00	218.00
	Filtered	49.22	17.79	158.21	250.33	41.00	26.66
Alkalinity	Tap	212.50	177.50	256.66	202.50	203.33	195.83
	Filtered	29.50	25.00	70.83	200.83	35.00	34.16
T. hardness	Tap	41.66	40.00	64.00	70.00	80.00	66.66
	Filtered	25	26.66	33.33	56.66	13.33	16.66
Calcium	Tap	6.66	5.86	3.49	13.33	10.66	10.66
	Filtered	6.13	2.13	3.73	6.66	0.01	0.10
Magnesium	Tap	6.00	6.08	13.26	4.40	6.40	4.80
	Filtered	1.08	5.12	5.76	4.80	1.6	2.00
Sodium	Tap	14.68	35.45	22.92	12.62	32.87	20.34
	Filtered	5.06	6.78	14.33	11.93	22.75	5.41
Potassium	Tap	1.04	1.14	1.30	1.40	1.11	0.98
	Filtered	0.75	0.62	0.88	1.33	0.85	0.62
Chloride	Tap	2.66	4.66	6.00	18.33	13.33	16.66
	Filtered	2.00	2.66	4.00	23.33	58.33	21.66
Nitrate	Tap	39.62	25.52	54.00	6.50	59.79	48.56
	Filtered	23.69	5.19	44.48	9.37	23.10	5.50

Table 4: Water Quality Index for six water treatment units during the studied period.

No. of time	House 1	House 2	House 3	House 4	House 5	House 6
Tap	51.79 (Good)	47.19 (Excellent)	60.01 (Good)	31.08 (Excellent)	48.63 (Excellent)	39.73 (Excellent)
Filtered	46.31 (Excellent)	36.61 (Excellent)	48.10 (Excellent)	26.02 (Excellent)	32.11 (Excellent)	23.92 (Excellent)

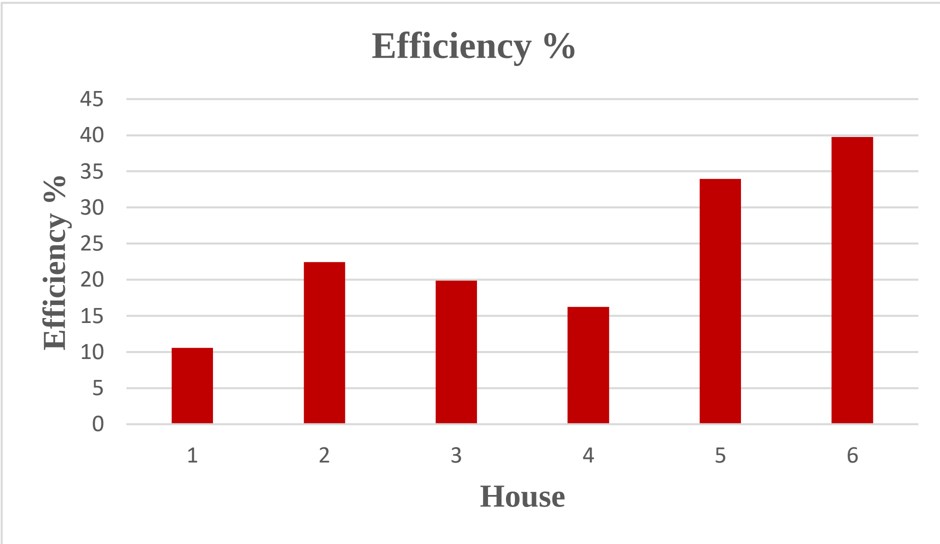

Figure 2: Efficiency of the water treatment units.

4. CONCLUSION

The objective of using WQI is to give a single value to the water quality of a particular source and reduce the number of different parameters into a simple expression. The results of this study revealed that all tap and filtered water in the study area was of good and excellent quality and is fit for human consumption. The efficiency of each water treatment unit differs from others and this is related to the period of establishing the unity of the tap water.

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