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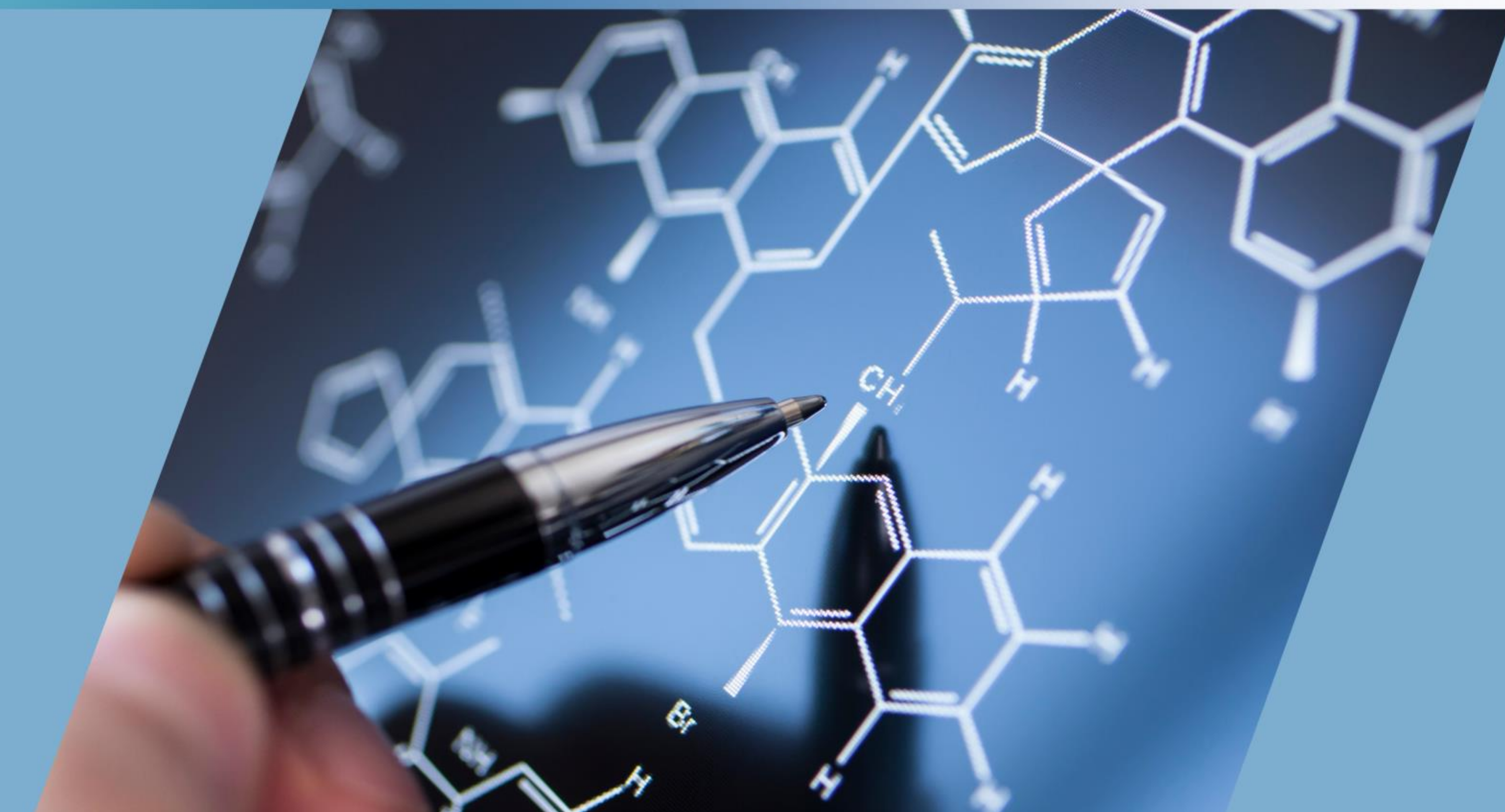

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Assessing the Drinking Water Quality, and its Commercial Purification Units Efficiency Distributed in Alassaba Municipality- Libya

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A B S T R A C T

The demand for drinking water is increasing daily due to the rising world population, alongside the leakage of water, overuse of groundwater, and occurrence of several pollution issues that led to reducing the quality of groundwater. Consequently, in most countries purifying water technologies have been used to obtain drinkable water. Nationally, Libyans use the purified water extensively in their daily needs. Accordingly, to ensure that our citizen utilize harmless water, the quality of the used water and the efficiency of purification units was assessed by analyzing several physical and chemical characteristics of purified water and raw water supplied to the purification units from some local wells and man-made river (MMR) using recommended standard methods. The study results showed that the quality of purified water is excellent, and the purification process reduced the pH, electro conductivity and the concentration of studied chemical properties significantly to values less than the optimum levels (OL) suggested by the World Health Organization (WHO) and Libyan standards (LS) for drinking water. As a conclusion, the studied purified water may use in the daily needs of human with continuously analytical monitoring.

1 Introduction

Even though, approximately over than 75% of our planet's surface is covered by water, only more less than 1% of this amount is accessible to use by humankind in their daily needs, and with increasing the world population led to raise the demand for drinking water which cause water depletion in some regains and decline the water quality in others (Ighalo et al., 2021). The quality of drinking water is the most important aim that World Health Organization (WHO) emphasised on during the last decades due to appearing of several pollution phenomena such as changing the pH, increasing the levels of some pollutants and other chemical substances in water over than their permissible concentrations, consequently WHO has issued several criteria to adjust drinking water quality. Nowadays, to meet the growing demand of clean drinking water and realise WHO standards many solutions used to encounter this such as sea water distillation or purifying the low-quality fresh water particularly ground water by using various treatment units privately or commercially (Aboraye and Aboraye, 2017; Gabbasa et al., 2020) . These unites may use different technologies to treat drinking water such as reverse osmosis system, boiling, chlorination and solar disinfection (Malan and Sharma , 2023).

In Libya, groundwater is the main source of drinking water but with unfair use of this source for agriculture, industrial, and municipal activities led to reduce the quality of water, particularly drinking water which

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directed to the use of water purifying technologies to obtain palatable water to drink (Ali and Salman, 2021). The used techniques may be beneficial to produce drinking water with high quality if the machine under use has optimal technical characteristics and its filters are replaced in proper time, but if the used system with low manufacture criteria and/or the filters are overused, then the resulted water may be not purified well make it unfavorable for drinking by humankind (Abogussa and Madi, 2012). Unfortunately, people unconcern about the minerals content of purified water and focus only on the taste of water, thus the water quality should be monitored regularly (Ali and Salman, 2021).

Ighalo and Adeniyi, (2020) stated that water quality may be monitored by evaluating some physiochemical and biological characteristics. In this context, several studies investigated the quality of bottled drinking water nationally such as (Al-Keylany et al., 2020; Gabbasa et al., 2020 and Owen and Kamoka, 2019) by estimating several parameters, and to our knowledge there is no study examined the efficiency of the commercial purifying units used to purify water sourced from some local groundwater wells over our country and particularly in Alassaba city, therefore to ensure that the used technologies produce proper drinking water and our nation obtain drinking water with high quality this research aimed at assessing the efficiency of purifying water units by evaluating several physiochemical parameters of water before and after purify it by commercial units distributed in Alassaba Municipality and investigating the quality of drinking purified water by calculating the water quality index (WQI).

2 Methodology

2.1 Sample collection

Fifteenth water samples with triplicates in the volume of 0.5L were collected from several purifying units (10 units) and groundwater wells (5 wells) as sources of raw water to these units, the investigated units and wells distributed in Alassaba Municipality (32.036 N, 12.847 E). Also, one water sample was collected from the man-made river, making a total of 16 samples (48 replicates). These samples were collected on the same day (14 November 2022) and stored in polyethylene bottles, labeled, covered with multi-layered black plastic bags, and kept in a cold place to diminish the effect of environmental conditions till the time of analysis.

2.2 Sample analyses

Rahmanian et al. (2015) reported that several parameters may affect the quality of drinking water that must be determined to justify the water's drinkability including pH, turbidity, electroconductivity (EC), total dissolved solids (TDS), alkalinity, and the levels of Calcium (Ca^{2+}), Chloride (Cl^-), Magnesium (Mg^{2+}), Sulphate (SO_4^{2-}), Potassium (K^+), Ferric (Fe^{3+}) ions and total hardness (TH), and other several characteristics. Accordingly, the mentioned features were evaluated in the studied samples. The pH was measured by using a pH meter (HANA, model HI 98130), the same machine was used to determine the EC and the turbidity was measured using a turbidity meter (HACH, model 2100P (Gabbasa et al., 2020**)** and the other characteristics stated above were determined following the methods reported by APHA, (1995) in the Ras Lanuf oil and gas processing Company's Laboratories.

2.3 Calculating the water quality index (WQI)

According to Verma et al. (2020), WQI has been used to identify the effect of physiochemical parameters individually on the drinking water quality. In this study, the WQI was evaluated following the method described by Oko et al. (2014) and Dhakad et al. (2008) using the equations below.

$$Q = \sum \left(\frac{Ap-Ip}{S-Ip}\right) \times 100 \quad (1)$$

$$WQI = \frac{\sum Qp\ Wp}{\sum Wp} \quad (2)$$

Where Q is the quality of parameters, Ap is the value of the estimated parameter in this study, S is the LS for drinking water, Ip is the ideal value of the determined parameter which is equal to zero for all investigated characteristics except that for pH = 7, and the unit weight (W) was calculated by taking the reciprocal value of S to any studied parameter, separately (Dhakad et al., 2008). As the inhabitants of Alassaba Municipality use the purified water only for drinking and cooking, therefore WQI calculated only for the resulting water from studied units to justify the results and stop on the quality of the used water. The results are presented in Tables 2-10 (look the supplementary data). The resulting data for WQI will justify the used water flowing the instructions that are: if WQI ranged from 0 – 25 the quality of investigated water is excellent, if WQI showed values from 26 – 50 than the water quality is god, and if WQI recorded values from 51 to 75 the quality of examined water is bad, if WQI ranged between 76 – 100 the examined water quality is very bad and if WQI over than 100 thus the studied water is undrinkable (Oko et al., 2014).

2.4 Statistical Analyses

SPSS software version 26 was used to analyse the obtained data and the resulting statistics presented in Table (1) as a mean of 3 replicates ± stander error. To identify if there are differences between the parameter value before and after the purification process for the same sample the independent-sample T-test was run at ($P< 0.05$) after the data tested for normal distribution as the Shapiro-Wilk test confirmed.

3 Results and discussion

The obtained results illustrated in the table (1) and discussed separately as follows:

3.1 pH: The pH value of the purified water ranged between 6.50 ± 0.09 to 7.5 ± 0.17 this means that these waters are weak acid-alkaline water, but the pHs of raw water obtained from studied wells show alkaline characteristics as the pHs recorded 7.60 ± 0.12 to 8.0 ± 0.12 and 7.77 ± 0.09 for MMR water. The purification process reduced the pHs of all investigated samples significantly ($P < 0.05$) related to the input water separately, except the pH of resulted water from U1. The pH reduction of the purified water may be related to the chlorination of row water during the purification process (Gabbasa et al., 2020). Even though, all the pHs of studied water samples were within the recommended value of pH set by WHO and LS for drinking water.

3.2 TDS: The TDS of row water ranged between 755 ± 10 to 1173 ± 15.70 mg L^{1-} as a result, all water samples recorded levels of TDS higher than OL (500 mg L^{1-}) of TDS in drinking water recommended by WHO and LS. The height levels of TDS in water can affect people who suffer from heart and kidney diseases (Memon et al., 2011). On the other hand, the purification process decreased the levels of TDS of resulted in water significantly ($P < 0.05$) in contrast to the TDS of input water as it measured concentrations ranged from 15.73 ± 0.55 to 95.23 ± 3.03 mg L^{1-} which may classify the output of studied units as a super freshwater (Ighalo et al., 2021).

3.3 EC: The ECs of output water showed values ranged from 24.10 ± 1.10 to 193.3 ± 3.90 µS/cm, however the EC of raw water (wells water) ranged between 1110 ± 14.7 to 1725 ± 23.1 µS/cm, and 1610 ± 11 µS/cm in MMR's water. The EC of all purified water except that obtained from U1 and U5 may be classified as a very low saline water, but the U1 and U5 water can be categorised as low saline water. However, Wells and MMR samples are high saline water (Abderahman, 2021). The height values of groundwater EC can be ascribed to the occurrence of several chemical ions that may inter the water from the aquifer's geological compositions (Ali and Salman, 2021) as to the researcher's knowledge, the study cite did not record any pollution phenomenon before. All the analysed water samples recorded ECs lower than the optimum EC in drinking water (1400 and 1500 µS/cm) recommended by LS and WHO, respectively. Except that for water samples collected from W3 and MMR, though, all the wells water samples may be classified as a high saline water (Abderahman, 2021). The purification process reduced the EC of all purified water samples significantly ($P < 0.05$) related to the input water, separately.

3.4 TH: The TH of wells water ranged from 350 ± 10.70 to 720 ± 15.3 mg L^{1-} and were significantly higher ($P < 0.05$) than the TH of units output water that recoded levels between 9.83 ± 0.44 to 30 ± 1.73 mg L^{1-}. All the results of the TH concentrations were lower than the permissible levels of TH recommended by LS and WHO except the samples of water obtained from W3. Even though, the water of Wells and MMR can be classified as very hard water as the levels of TH of them more than 180 mg L^{1-}, while the water purified by unites is soft (Abderahman, 2021).

3.5 Ca^{2+}: The concentration of Ca^{+2} varied in the resulted water from 0.98 ± 0.07 mg L^{-1} to 10.23 ± 0.56 mg L^{-1} which is significantly lower ($P < 0.05$) than the levels of Ca^{+2} in the raw water that recorded levels ranged from 127.7 ± 5.49 mg L^{1-} to 253 ± 18.0 mg L^{-1}. The levels of Ca^{2+} in all studied samples excluding in the water of W3 were lower than its concentration recommended by LS and WHO, but in the resulted water were much lower by approximately more than 10-folds than OL suggested by LS and WHO (72 mg L^{-1}) in drinking water which is critical health issue specially for children by recanting the bone and teeth development (Huaug et al., 2017).

Table (1) The parameters was evaluated for studied samples illustrated as Mean of 3 replicates ± standard error.

Group	Sample Source	Parameters											
		pH	EC	TDS	TH	Ca^{+2}	Cl^{-}	K^{+}	SO_4^{-2}	Alkalinity	Fe^{+3}	Turbidity	Mg^{+2}
		Value	**μS/cm**	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	mg/L	**NTU**	**mg/L**
G1	U1	**7.5 ± 0.17a**	**138 ± 4.36a**	**95.23± 3.03 a**	**30 ± 1.73a**	**4.0 ± 0.23a**	**28.27 ± 0.98a**	**1.20± 0.06a**	**11.2 ± 0.52a**	**50.3 ± 3.17a**	**< 0.02**	**< 5**	**4.83 ± 0.43a**
	W1	**7.8 ± 0.12a**	**1110 ± 14.7b**	**755 ± 10b**	**350± 10.70b**	**132 ± 4.04b**	**153 ± 4.91b**	**2.53 ± 0.26b**	**120 ± 4.33b**	**170 ± 6.06b**	**< 0.02**	**< 5**	**0.10 ± 0.01b**
G2	U2	**6.5 ± 0.12a**	**32.57± 2.28a**	**22.1 ± 1.53a**	**19.93± 1.68a**	**3.99 ± 0.34a**	**21.3 ± 0.69a**	**1.03 ± 0.20a**	**2.57± 0.20a**	**43.0 ± 2.52a**	**< 0.02**	**< 5**	**2.43 ± 0.26a**
	W1	**7.8 ± 0.12b**	**1110 ± 14.7b**	**755 ± 10b**	**350± 10.70b**	**132 ± 4.04b**	**153 ± 4.91b**	**2.53 ± 0.26b**	**120 ± 4.33b**	**170 ± 6.06b**	**< 0.02**	**< 5**	**0.10 ± 0.01b**
G3	U3	**6.5 ± 0.06a**	**26.6 ± 0.98 a**	**18.0 ± 0.69a**	**10.0 ± 0.58a**	**1.60 ± 0.09a**	**1.63 ± 0.09a**	**< 1.0**	**< 2.0**	**19.67 ±1.45a**	**< 0.02**	**< 5**	**1.49 ± 0.30a**
	W1	**7.8 ± 0.12b**	**1110 ± 14.7b**	**755 ± 10b**	**350± 10.70b**	**132 ± 4.04b**	**153 ± 4.91b**	**2.53 ± 0.26**	**120 ± 4.33**	**170 ± 6.06b**	**< 0.02**	**< 5**	**0.10 ± 0.01b**
G4	U4	**6.5 ± 0.15a**	**23.1 ±0.78a**	**15.73 ± 0.55a**	**9.83 ±0.73a**	**0.98± 0.07a**	**14.2± 0.21**	**1.10 ± 0.06a**	**< 2.0**	**10.3± 0.88a**	**< 0.02**	**< 5**	**1.78 ± 0.21a**
	W1	**7.8 ± 0.12b**	**1110 ± 14.7b**	**755 ± 10b**	**350± 10.70b**	**132 ± 4.04b**	**153 ± 4.91b**	**2.53 ± 0.26b**	**120 ± 4.33**	**170 ± 6.06b**	**< 0.02**	**< 5**	**0.10 ± 0.01b**
G5	U5	**7.0 ± 0.12a**	**193.3± 3.90 a**	**94.60 ± 2.66a**	**19.83 ± 1.0a**	**7.93 ± 0.41a**	**28.37 ± 2.51a**	**1.23 ± 0.09a**	**12.13± 0.26a**	**20.33 ±2.03a**	**< 0.02**	**< 5**	**0.01± 0.001a**
	W2	**8.0 ± 0.06b**	**1152± 25.4b**	**782 ± 17.30b**	**360 ± 16.2b**	**127.7± 5.49b**	**185.7 ± 7.04b**	**2.10 ± 0.17b**	**110.7 ± 6.06b**	**200 ± 8.37b**	**< 0.02**	**< 5**	**9.47 ± 0.93b**
G6	U6	**7.46± 0.09a**	**55.1 ± 3.72a**	**37.37± 2.51a**	**9.83 ± 0.44a**	**3.97 ± 0.15a**	**14.23 ± 0.43a**	**< 1.0**	**22.03 ± 0.61a**	**20.1± 0.73a**	**< 0.02**	**< 5**	**0.01 ± 0.002a**
	W2	**8.0 ± 0.06b**	**1152± 25.4b**	**782 ± 17.30b**	**360 ± 16.2b**	**127.7± 5.49b**	**185.7 ± 7.04b**	**2.10 ± 0.17**	**110.7 ± 6.06b**	**200 ± 8.37b**	**< 0.02**	**< 5**	**9.47 ± 0.93b**
G7	U7	**6.67 ± 0.09a**	**33.60 ± 2.60a**	**22.80 ± 1.80a**	**10.17± 0.73a**	**4.10 ± 0.26a**	**14.17 ± 0.37a**	**< 1.0**	**2.87 ± 0.20a**	**19.70 ±1.40a**	**< 0.02**	**< 5**	**0.02 ± 0.001a**
	W3	**8.03 ±0.15b**	**1725± 23.1b**	**1173 ± 15.70b**	**720 ± 15.3 b**	**253 ± 18.0b**	**185 ± 3.75b**	**3.80 ± 0.17**	**587± 13.6b**	**170 ± 6.64b**	**< 0.02**	**< 5**	**29.27 ± 1.53b**
G8	U8	**6.50 ± 0.09a**	**24.13 ± 1.70a**	**16.40 ± 1.15a**	**10 ± 0.87a**	**2.50 ± 0.22a**	**21.43 ± 0.38a**	**< 1.0**	**< 2.0**	**20.3 ± 1.45a**	**< 0.02**	**< 5**	**0.94 ± 0.14a**
	W4	**7.60 ± 0.12b**	**1186 ± 21.93b**	**805 ± 14.90b**	**370 ± 8.37b**	**136 ± 3.18b**	**157 ± 6.10b**	**1.70 ± 0.17**	**153 ± 6.06**	**190 ± 6.64b**	**< 0.02**	**< 5**	**7.33 ± 0.54b**
G9	U9	**6.80 ± 0.06a**	**24.10 ± 1.10a**	**16.30 ± 0.75a**	**9.83 ± 0.44a**	**2.16 ± 0.095a**	**10.27 ± 0.15a**	**< 1.0**	**2.47 ± 0.20a**	**10.0 ± 0.58a**	**< 0.02**	**< 5**	**0.94 ± 0.09a**
	W5	**8.0 ± 0.12b**	**1143 ± 14.0b**	**778 ± 9.41b**	**360± 10.68b**	**140 ± 4.19 b**	**163 ± 3.70b**	**2.50 ± 0.17**	**166 ± 7.22b**	**180 ± 6.64b**	**< 0.02**	**< 5**	**7.27 ± 0.61b**
G10	U10	**6.70 ± 0.12a**	**88.20 ± 2.48a**	**60.0 ± 1.67a**	**16.33± 0.88a**	**10.23± 0.56a**	**14.57 ± 0.32a**	**< 1.0**	**5.93 ± 0.64a**	**29.67 ±2.60a**	**< 0.02**	**< 5**	**2.17 ± 0.03a**
	MMR	**7.77± 0.09b**	**1610 ± 11b**	**1096 ± 7.45b**	**374± 6.64b**	**138 ± 3.79b**	**288 ± 7.22b**	**9.37 ± 0.46**	**250 ± 6.64b**	**150 ± 2.61b**	**< 0.02**	**< 5**	**10.73 ± 0.66b**
LS	RL	**6.5-8.5**	**2500**	**1000**	**500**	**200**	**250**	**40**	**400**	**200**	**1.0**	**< 5**	**150**
	OL	**6.5-8.5**	**-**	**500**	**-**	**75**	**150**	**12**	**200**	**-**	**0.03**	**< 5**	**30**
WHO	RL	**6.5-8.5**	**2800**	**1500**	**500**	**200**	**600**	**40**	**400**	**-**	**1.0**	**< 5**	**150**
	OL	**6.5-8.5**	**1500**	**500**		**50**	**200**	**15**	**200**	**-**	**0.3**	**< 5**	**50**

W= well, U= unit, MMR= man-made revie, G= group. LS= Libyan standard, OL= Optimum levels and RL= Recommended levels set by WHO and LS.
The values with different lowercase letters in the same group for each parameter separately are significantly different from each other at P < 0.05.

3.6 Cl^-*:* The levels of chloride ion in the output water ranged from 1.60 ± 0.09 mg L^{-1} to 28.37 ± 2.51 mg L^{1-} which is lower significantly ($P < 0.05$) than chloride levels in the input wells water ranged between 153 ± 4.91 mg L^{1-} to 288 ± 7.22 mg L^{1-}. All the levels of Cl^- in the studied samples except that in MMR (288 ± 7.22 mg L^{1-}) were lower than that suggested by LS and WHO. Even though, the concentrations of Cl^- in the raw water higher than the OL level set by LS and WHO, but was much lower than OL in the resulted water from purification procedure which may affect human body growth due to long-time use of this water as the human body needs Cl^- in the osmotic activity in the external cells and the chloride deficiency may lead to increase blood pH and cause metabolic alkalosis (Tello, 2021).

3.7 K^+: Potassium ion levels were undetectable in resulted water from U3, U6-10 and ranged between 1.03 ± 0.20 mg L^{1-} to 1.20 ± 0.06 mg L^{1-} in resulted water from other units, additionally, in the wells water before purification steps K^+ levels were higher significantly ($P < 0.05$) ranged from 1.70 ± 0.17 mg L^{1-} to 9.37 ± 0.46 mg L^{1-}, as a result showed that all the samples recorded levels of K^+ lower than the acceptable and OL level set by LS and WHO in drinking water.

3.8 $SO_4{}^{2}$: The concentration of sulphate ion were undetectable in the samples collected from U3, U4 and U9, on the other hand, its levels in the rest of the samples taken from the rest units ranged from 2.47 ± 0.20 mg L^{1-} to 22.03 ± 0.61 mg L^{1-}. But, in the raw water were significantly higher ($P < 0.05$) than its level in purified water recording levels ranged between 110.7 ± 6.06 mg L^{1-} to 587± 13.6 mg L^{1-}. Only one well (W3) showed levels of $SO_4{}^{2-}$ higher than that set by LS and WHO (400 mg L^{1-}). The very low levels of sulphate ion in drinking water is a critical health issue as it may decrease the efficiency of immune system and lungs inflammation (Gabbasa et al., 2020).

3.9. Alkalinity: The alkalinity of all studied samples was lower than that set by LS, however, the alkalinity of purified water resulting from all investigated units was significantly ($P < 0.05$) lower than that of water obtained from studied wells and MMR.

3.10 Fe^{3+}: The iron (III) concentrations were undetectable (lower than 0.02 mg L^{1-}) in all collected samples. The presence of Fe^{3+} in water can increase the turbidity and undesirable water test (Gabbasa et al., 2020), the absence of Fe^{3+} in the studied water here may ascribe the low turbidity of all studied samples.

3.11 Mg^{2+}: The purification process reduced the concentrations of Mg^{2+} significantly related to row water except the samples of units 1, 2, 3 and 4 which increased the resulted water content of Mg^{2+} significantly, but to levels much lower than the OL suggested by LS and WHO. The levels of Mg^{2+} in the purified water resulted from U1, U2, U3 and U4 higher than Mg^{2+} concentrations in raw water, this can be ascribed to the filters containing of this metal.

3.12 Turbidity: All the studied water samples recorded turbidity lower than 5 NTU which is lower than that set by LS and WHO, this may be related to the absence of Fe^{3+} in studied samples (Gabbasa et al., 2020).

Generally, the purification process reduced the levels of most investigated parameters in water significantly ($P < 0.05$) to levels greatly less than the acceptable values recommended by WHO and LS. The results of the current study is in line with the results of several national studies that confirmed that the levels of physiochemical properties in the majority of bottled water sold in Libyan markets were in the range of that set by WHO and LS (Al-Keylany et al., 2020; Gabbasa et al., 2020 and Owen and Kamoka, 2019).

The values of WQI of purified drinking water collected from all units (U1-U10) were 11.85, 6.08, 5.97, 6.00, 8.93, 11.50, 6.95, 6.00, 7.69, and 7.18, respectively. This suggests that the quality of purified water is excellent according to the rules stated by Oko et al. (2014). On the other hand, it should be noted that the concentrations of most investigated parameters in purified water are less than the OL set by both WHO and LS which may suggest that the resulting water contains low levels of essential elements to human health, therefore utilizing this water for prolonged may lead to reduce the supply of several nutrients to humans affecting people is health by occurring several health risks such as osteopenia, dental caries and reduce bone development in children (Huang et al., 2018; Huang et al., 2019). Conversely, the water supplied from most studied wells may be used to drink for a short period and under any urgent circumstance as the values of investigated parameters were slightly lower than the higher recommended levels set by LS and WHO, and most of examined characteristics higher than OL. However, the raw water obtained from W3 and MMR must not be used for drinking by inhabitants under any circumstance as the values of some physiochemical parameters exceeded the higher recommended limits set by WHO and LS.

4 Conclusions

The purification procedures reduced the values of pH, EC and the levels of studied chemical parameters to values and levels much lower than the allowable values set by WHO and LS and also to levels less than the OL of these characteristics in drinking water, which highly suggest advising and convince the owners of the purification units in the area of study to select the proper machines and filters with high quality to produce water contain levels of minerals close to OL to ensure that our citizen utilizes water to contain the required concentrations of essential minerals for human body development, furthermore, the purified water quality must be monitored frequently for the water chemical and biological contains.

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Conflict of Interest: The authors declare that there are no conflicts of interest.

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Supplementary data

Table (2) Water quality index of water collected from U_1

Parameter	Mean	LS	Iv	W	Q	QW
pH	7.5	8.5	7	0.1176	33.33	3.92
EC	138	2500	0	0.0004	5.52	0.0022
TDS	95.23	1000	0	0.001	9.523	0.0095
TH	30	500	0	0.002	6	0.012
Ca^{2+}	4	200	0	0.005	2	0.01
Cl^{-}	28.7	250	0	0.004	11.48	0.046
K^{+}	1.2	40	0	0.025	3	0.075
SO_4^{2-}	11.2	400	0	0.0025	2.8	0.007
Alkalinity	50.3	200	0	0.005	25.15	0.126
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	4.83	150	0	0.0067	3.22	0.022
∑				1.3692		16.228975
WQI	11.85288855					

Table (3) Water quality index of water collected from U2

Parameter	Mean	LS	Iv	W	Q	QW
pH	6.5	8.5	7	0.1176	-33.33	-3.92
EC	32.57	2500	0	0.0004	1.30	0.00052
TDS	22.1	1000	0	0.001	2.21	0.0022
TH	19.93	500	0	0.002	3.99	0.0080
Ca^{2+}	3.99	200	0	0.005	1.995	0.010
Cl^{-}	21.3	250	0	0.004	8.52	0.034
K^{+}	1.03	40	0	0.025	2.575	0.0644
SO_4^{2-}	2.57	400	0	0.0025	0.643	0.0016
Alkalinity	43	200	0	0.005	21.5	0.108
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	2.43	150	0	0.0067	1.62	0.011
∑				1.369		8.31909
WQI	6.075878885					

Table (4) Water quality index of water collected from U3

Parameter	Mean	LS	Iv	W	Q	QW
pH	6.5	8.5	7	0.118	-33.33	-3.92
EC	26.6	2500	0	0.0004	1.064	0.00043
TDS	18	1000	0	0.001	1.8	0.0018
TH	10	500	0	0.002	2	0.004
Ca^{2+}	1.6	200	0	0.005	0.8	0.004
Cl^{-}	1.63	250	0	0.004	0.652	0.0026
K^{+}	0.5	40	0	0.025	1.25	0.0313
SO_4^{2-}	1	400	0	0.0025	0.25	0.00063
Alkalinity	19.7	200	0	0.005	9.84	0.049
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	1.49	150	0	0.0067	0.993	0.0067
∑				1.369		8.180538
WQI	5.974685169					

Table (5) Water quality index of water collected from U4

Parameter	Mean	LS	Iv	W	Q	QW
pH	6.5	8.5	7	0.1176	-33.33	-3.92
EC	23.1	2500	0	0.0004	0.924	0.00037
TDS	15.73	1000	0	0.001	1.573	0.0016
TH	9.83	500	0	0.002	1.966	0.0039
Ca^{2+}	0.98	200	0	0.005	0.49	0.0025
Cl^{-}	14.2	250	0	0.004	5.68	0.023
K^{+}	1.1	40	0	0.025	2.75	0.070
SO_4^{2-}	1	400	0	0.0025	0.25	0.00063
Alkalinity	10.3	200	0	0.005	5.15	0.026
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	1.78	150	0	0.0067	1.187	0.0080
∑				1.3692		8.2141267
WQI	5.999211					

Table (6) Water quality index of water collected from U5

Parameter	Mean	LS	Iv	W	Q	QW
pH	7	8.5	7	0.1176	0	0
EC	193.3	2500	0	0.0004	7.73	0.0031
TDS	94.6	1000	0	0.001	9.46	0.0095
TH	19.83	500	0	0.002	3.97	0.0079
Ca^{2+}	7.73	200	0	0.005	3.87	0.019
Cl^-	28.37	250	0	0.004	11.35	0.045
K^+	1.23	40	0	0.025	3.075	0.077
SO_4^{2-}	12.13	400	0	0.0025	3.033	0.0076
Alkalinity	20.33	200	0	0.005	10.17	0.051
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	0.01	150	0	0.0067	0.0067	4.47×10^{-5}
$\sum$				1.3692		12.2205
WQI	8.925305081					

Table (7) Water quality index of water collected from U6

Parameter	Mean	LS	Iv	W	Q	QW
pH	7.46	8.5	7	0.1176	30.667	3.606
EC	55.1	2500	0	0.0004	2.204	0.00088
TDS	37.37	1000	0	0.001	3.737	0.0037
TH	9.83	500	0	0.002	1.966	0.0039
Ca^{2+}	3.97	200	0	0.005	1.985	0.0099
Cl^-	14.23	250	0	0.004	5.692	0.0228
K^+	0.5	40	0	0.025	1.25	0.0313
SO_4^{2-}	22.03	400	0	0.0025	5.5075	0.0138
Alkalinity	20.1	200	0	0.005	10.05	0.05025
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	0.01	150	0	0.0067	0.0067	4.47×10^{-5}
$\sum$				1.3692		15.74295702
WQI	11.49792362					

Table (8) Water quality index of water collected from U7

Parameter	Mean	LS	Iv	W	Q	QW
pH	6.67	8.5	7	0.1176	-22	-2.5872
EC	33.6	2500	0	0.0004	1.344	0.00054
TDS	22.8	1000	0	0.001	2.28	0.0023
TH	10.17	500	0	0.002	2.034	0.0041
Ca^{2+}	4.1	200	0	0.005	2.05	0.0103
Cl^-	14.17	250	0	0.004	5.668	0.023
K^+	0.1	40	0	0.025	0.25	0.00625
SO_4^{2-}	2.87	400	0	0.0025	0.7175	0.0018
Alkalinity	19.7	200	0	0.005	9.85	0.0493
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	0.02	150	0	0.0067	0.0133	8.93×10^{-5}
$\sum$				1.3692		9.509990683
WQI	6.945654896					

Table (9) Water quality index of water collected from U8

Parameter	Mean	LS	Iv	W	Q	QW
pH	6.5	8.5	7	0.1176	-33.3	-3.92
EC	24.13	2500	0	0.0004	0.965	0.00039
TDS	16.4	1000	0	0.001	1.64	0.00164
TH	10	500	0	0.002	2	0.004
Ca^{2+}	2.5	200	0	0.005	1.25	0.00625
Cl^-	21.43	250	0	0.004	8.572	0.0343
K^+	0.5	40	0	0.025	1.25	0.03125
SO_4^{2-}	1	400	0	0.0025	0.25	0.000625
Alkalinity	20.3	200	0	0.005	10.15	0.05075
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	0.94	150	0	0.0067	0.627	0.0042
$\sum$				1.3692		8.213387747
WQI	5.998676414					

Table (10) Water quality index of water collected from U9

Parameter	Mean	LS	Iv	W	Q	QW
pH	6.8	8.5	7	0.1176	-13.33	-1.568
EC	24.1	2500	0	0.0004	0.964	0.00039
TDS	16.3	1000	0	0.001	1.63	0.00163
TH	9.83	500	0	0.002	1.966	0.0039
Ca^{2+}	2.16	200	0	0.005	1.08	0.0054
Cl^-	10.27	250	0	0.004	4.108	0.0164
K^+	0.5	40	0	0.025	1.25	0.0313
SO_4^{2-}	2.47	400	0	0.0025	0.6175	0.0015
Alkalinity	10	200	0	0.005	5	0.025
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	0.94	150	0	0.0067	0.6267	0.0042
$\sum$				1.3692		10.521772
WQI	7.684612925					

Table (11) Water quality index of water collected from U10

Parameter	Mean	LS	Iv	W	Q	QW
pH	6.7	8.5	7	0.1176	-20	-2.352
EC	88.2	2500	0	0.0004	3.528	0.0014
TDS	60	1000	0	0.001	6	0.006
TH	16.33	500	0	0.002	3.266	0.0065
Ca^{2+}	10.23	200	0	0.005	5.115	0.0256
Cl^{-}	14.57	250	0	0.004	5.828	0.023
K^{+}	0.5	40	0	0.025	1.25	0.0313
SO_4^{2-}	5.93	400	0	0.0025	1.483	0.0037
Alkalinity	29.67	200	0	0.005	14.84	0.074
Fe^{3+}	0.02	1.0	0	1	2	2
Turbidity	2.5	5	0	0.2	50	10
Mg^{2+}	2.17	150	0	0.0067	1.4467	0.0097
∑				1.3692		9.829654117
WQI	7.18					