Libyan Journal of Ecological & Environmental Sciences and Technology

(LJEEST)

LJEEST

ISSN: 2710-5237

www.srcest.org.ly/jou

http://aif-doi.org/LJEEST/050101

ASSESSMENT OF THE QUALITY OF DRINKING WATER TRANSPORTED BY PIPES FROM A MICROBIAL AND CHEMICAL POINT OF VIEW IN THE CITY OF TOBRUK

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ARTICLE INFO

Vol. 5 No. 1 June, 2023

Pages (1- 7)

Article history:

Revised form 02 January 2023

Accepted 09 April 2023

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Keywords:

drinking water quality assessment, physico-chemical and microbial parameters

ABSTRACT

In a study to conduct an assessment of the drinking water quality in 4 different regions (Shaabiat Al-Jaish, Buildings Al-Hurriya, Al-Mukhtar, and Al-Khaleej) in Tobruk city, Libya, through collection 5 samples from each region, physical, chemical, and microbial parameters analysis were performed for all samples and compared to the source water, which is a seawater desalination plant (Tobruk desalination plant), as well as comparing with quality specifications and standards according to the World Health Organization. Although there is a difference in the results of the analysis between the four regions, the results obtained from the physico-chemical analysis of water samples were within Libyan specifications and standards, and WHO guidelines. For example, Electrical conductivity varied between 160 µS cm^{-1} and 368 µS cm^{-1} but it did not exceed the permissible limits according to the World Health Organization, which are 400 µS cm^{-1}. Also, the results of the analysis of total dissolved salts in the four regions, concentrations were found to be 107 ppm, 120 ppm, 246 ppm, and 223 ppm. As well as pH values in all the collected drinking water samples did not exceed the permissible limits according to WHO, which ranged from (7.1 to 7.4) in the four study regions. Na concentrations obtained from the water samples in the four analyzed regions ranged (15.28 mgl^{-1},17.17 mgl^{-1}, 38.48 mgl^{-1}, and 31.89 mgl^{-1}. As for the bacterial analysis, the results showed that there is microbial contamination in the first and second regions, which may be due to contamination due to the overlapping of sewage water.

تقييم جودة مياه الشرب المنقولة بواسطة الأنابيب من الناحية الميكروبية والكيميائية في مدينة طبرق

Ʉǵ ÛǿǺ 4 Ž ãÀÎ 5 ϶P Ž Ǭǵ Û - (ǰ) ... 368µS/cm ş 160 ... 246 ş 120 ş 107 ... pH ... 223 ş ... 31.89 ş 38.48 ... 17.17 ... 15.28) ...

INTRODUCTION

Water is one of the most important needs of life, where is extremely important for the continuation of life, as about 0.3% of the world's water resources are usable. Despite the numerous sources and resources of freshwater such as rivers, groundwater, as well as rainwater, the world is constantly facing water shortages and scarcity. Globally about 30 % of the population still has no access to safe drinking water according to WHO 2017, and in the African continent, about 320 million (Bazié , 2014). As there is an urgent need to provide suitable water for various human activities, as water resources are decreasing as a result of the increase in the population and unconscious use, which exposes water sources to deterioration as well as pollution (WHO, 2012). The negative effects of global population increase, climate change impacts, and lifestyle changes are exerting growing pressures upon our vital water resources leading to widespread water stress in many countries. As a result, there is growing realization of the urgent need to conserve water. Water is essential to life because it heavily influences public health and living standard. However, water is unequally distributed throughout the world.

Libya, like other countries in the developing world, is located within the arid and semi-arid regions, which are the regions most exposed to the acute shortage of water suitable for human consumption (WHO 2006), so there was a motive to compensate for the shortage of fresh water. Therefore, the trend was to compensate for this shortfall by using seawater desalination technology as one of the most important global ways to compensate for this shortfall and to provide other sources of fresh water.

Where desalinated seawater is the third source of water in Libya after groundwater, which provides nearly 95% of the country's needs; as well as surface water (Wheida, and Verhoeven, 2007; Hamad *et al.,* 2021). In light of these global conditions, it was necessary to set some controls and standards that must be preserved and achieved in the water consumed by humans, whether directly (drinking water) or indirectly (agriculture and other activities), which the state sets, and agree with the World Health Organization accordance, entrusted with preserving on human health worldwide. Where the primary purpose of the Guidelines for drinking-water quality is the protection of public health. The Guidelines provide the recommendations of the World Health Organization (WHO) for managing the risk from hazards that may compromise the safety of drinking-water.

Providing safe drinking water requires the development of management plans to achieve comprehensive monitoring of the microbial and chemical quality of drinking water and process control to ensure that the number of pathogens and concentrations of chemicals do not pose a threat to public health and that it is acceptable for human consumption (WHO, 2011). According to Hussain *et al.,* 2021, Water contaminants are primarily from geological conditions, and industrial and agricultural activities. According to Malan & Sharma, 2023, reverse osmosis (RO) followed by boiling is the best method for drinking water treatment at home which removes most of the microbes as well as EC and TDS to a large extent, However, chlorination is also effective in removing contaminants. In the study conducted by Din *et al*., 2023 for the assessment of drinking and irrigation water quality, results illustrate that most of the physicochemical parameters were found within WHO guidelines set for drinking water, except nitrate ($NO3^-$), sodium (Na^+), magnesium (Mg^{+2}), fluoride (F^-), chloride (Cl^-), ($SO4^{-2}$), and sulfate. Finally, water was suitable except for 5% of the sampling sites under study, where that water quality mainly showed rock weathering dominance, according to Piper’s and Gibb’s plot models.

MATERIALS AND METHODS

Study Area:

The study was conducted in 4 different sectors (Shaabiat Al-Jaish, Buildings Al-Hurriya, Al-Mukhtar, and Al-Khaleej) in Tobruk city, which located on Libya's eastern Mediterranean coast.

Water Samples:

In 2021 five samples were taken from each sector, in addition to another sample from the desalination water plant (Tobruk desalination plant), in order to compare the physico-chemical and microbial properties of water samples from the different sites with the properties main water source, as well as a comparison between the four regions under study. The result was also compared with the Libyan specifications and standards, and WHO guidelines.

The five water samples were collected in addition to the sixth sample (from the source water, Tobruk desalination plant) at the same time for each region in conjunction with the water pumping to it. Where water is pumped to each region from the desalination plant in different periods of time, which may range from two months

Laboratory analyses:
Table 1. Water quality parameters and analytical methods for samples water evaluation

Parameters	Methods
pH	"pH meter 720"
Conductivity (E.C)	"Milwaukee"
Total Dissolved Salts (TDS)	"T.G.W" TDS meter
Total Hardness (T.H)	EDTA titrimetric
Total Alkalinity (T.A)	According to standard methods for acidity or alkalinity of water, 1982
Chloride	Titration method
Nitrite, Nitrate, and Phosphate	Spectrophotometer according to Gaith G. *et al.*, 2018, method
Sulfate	Spectrophotometer according to American Public Health Association. 1998.
Carbonate, Bicarbonate	According to standard methods for acidity or alkalinity of water, 1982
Calcium, Magnesium	Titration according to Betz, J. B., and C. A. NOLL, 1950
Sodium, Potassium	CARELYTE electrolyte analyzer according to Shibata Y. *et al.*, 1992

STATISTICAL ANALYSIS:

ALL DATA WAS ANALYZED STATISTICALLY BY USING STATISTICAL PACKAGE FOR SOCIAL SCIENCES (SPSS 20), AN ANALYSIS OF VARIANCE WAS PERFORMED (ANOVA) MEANS WERE COMPARED USING THE LEAST SIGNIFICANCE DIFFERENCE (LSD) TEST AT 0.05 ACCORDING TO GOMEZ AND GOMEZ,1984.

RESULTS AND DISCUSSION

Electrical conductivity (EC) The electrical conductivity is directly proportional to its dissolved mineral matter content. It varied between 160 µS cm^{-1} in the first region and 368 µS cm^{-1} in the third, although it did not exceed the permissible limits according to the World Health Organization, which are 400 µS cm^{-1}. This variation may be due to the difference in the concentration of total dissolved salts in different water sources (Table 2, and Fig.1).

Total Dissolved Salts (TDS**)** Results illustrate there were clearly significant differences in the amounts of dissolved salts in the water between the four regions, concentrations were found to be 107 ppm for (R1) Shaabiat Al-Jaish site, 120 ppm for (R2) Building Al-Hurriya, 246 ppm for (R3) Al-Mukhtar, and 223 ppm for (R4) Al-Khaleej. Whereas the WHO standards set a maximum of 1,000 ppm for total dissolved salts in water. The palatability of drinking water was classified into 4 different levels with respect to the level of TDS which was rated by panels of tasters as follows: Excellent, if less than 300 ppm; good, between 300 ppm to 600 ppm; fair, between 600 ppm to 900 ppm; and unacceptable, if more than 1000 ppm. Thus, through the data presented in Table 2, and Fig. 1, we find that the quality of drinking water in the four study areas is within the first level of this rating (excellent).

pH (potential hydrogen) refers to the activity of the hydrogen ion, and is considered a factor that shows the state of the acid and alkaline balance of water as well as an important indicator of the degree of water pollution if its concentration exceeding the permissible limits according to the World Health Organization, which ranges between (6.5-8.5). In the present study, the results showed that the pH values in all the collected drinking water samples range from (7.1 to 7.4) in the four study regions, however, it always exceeded the pH value of the source water.

Total alkalinity (TA), of water, is due to the presence of mineral salts, primarily carbonate and bicarbonate ions (Hussain 1987), low alkalinity can cause corrosion in the water supply pipes, which can increase the chance of many heavy metals being deposited (Jingxi Ma, *et al.*, 2020). The permissible value of alkalinity as recommended by the standards of the World Health Organization is (75 mgl^{-1}). The results recorded the lowest total alkalinity in the first region (R1) (8.7 mgl-[1]), and the highest values were in the samples of the third region (R3), and it recorded (20.1 mgl-[1]), and it reached (9.2 mgl^{-1}), (18.2 mgl^{-1}) for the second and fourth regions, respectively (Tab. 2, Fig. 2). This may be due to the difference between the concentrations of both carbonates and bicarbonates in the four regions under study, as well as the difference in their concentrations in the water source stations. We also notice a high concentration of carbonates in the four regions compared to the permissible limits according to the World Health Organization.

Total hardness (TH) is a parameter of drinking water quality, which is used to describe the effect of dissolved minerals (mostly Ca and Mg), which are considered the principal natural sources of hardness in water, and to determine the suitability of water for domestic, industrial and drinking purposes. As a result of this relative correlation between the hardness of water and the extent to which it contains calcium and magnesium cations.

Calcium (Ca), and Magnesium (Mg)

Calcium is very important for human cell physiology and bones, high calcium deficiency may cause rickets, poor blood clotting, bones fracture, etc., and the exceeding limit of concentration of calcium, increase cardiovascular diseases. Magnesium is a natural constituent of water, and it is essential for the functioning of living organisms. The human body contains about 25 g of magnesium (60 % in bones and 40 % in muscles and tissues).

Where the calcium and magnesium concentrations were in the range from (16.04 to 36.96 mgl^{-1}) and (3.01 - 6.93 mgl^{-1}), respectively. These rates did not exceed the standards of the World Health Organization, which recorded (30 and 100 mgl^{-1}), respectively (Tab. 2, Fig. 2).

Sodium is one of the mineral elements that are found in limited quantities in water, as its presence in an appropriate amount in the human body is necessary to protect against many deadly diseases, according to its report in 2017 by WHO, determined that the sodium concentration in drinking water must not exceed (50 mgl^{-1}). On the other hand, the concentrations of Na obtained from the samples in the four analyzed areas ranged from (15.28 mgl^{-1}) in the first site, with an increase of (0.54 mgl^{-1}) from the source of water. and (17.17 mgl^{-1}) in the second site, with an increase of (1.26 mgl^{-1}) from the source of water, but In the third region, the concentration of Na decreased by (3.28 mgl^{-1}) compared with the source of water which recorded (38.48 mgl^{-1}), and the concentration of sodium in the fourth region increased from the source water by (0.8 mgl^{-1}) where reached (31.89 mgl^{-1}). In general, the concentration of sodium did not exceed the standards of the World Health Organization (Table 2, Fig 3).

Hydrochloric acid as table salt (NaCl), is the main source of chloride. But high chloride concentration in water damages metal pipes, as well as harms growing plants when used in agriculture. However, it has fundamental importance to the human body's metabolic activity and other major physiological processes. According to WHO standards in 2017 the concentration of chloride should not exceed (200 mgl^{-1}). Data in table 3, and Fig 3., showed that the averages of chloride value ranges in the study regions from (8.84 mgl^{-1} in R1) to (31.98 mgl^{-1} in R3). However, the average concentration of chloride in the four regions differed with their water source for each of them, where the highest concentration of chloride in the source of water (desalination plant) in the third region reached (35.78 mgl^{-1}).

Table 2. Descriptive statistics of physico-chemical properties of the water drinking samples of 4 Regions in Tobruk city, Libya 2021

Locations A	Locations B	(E.C) µS/cm	(TDS) ppm	(pH)	(T.A) mg/L	(T.H) mg/L	(Ca) mg/L	(Mg) mg/L	(Na) mg/L
Shaabiat Al-Jaish	Shaabiat Al-Jaish	160	107	7.4	19.1	8.7	16.04	3.01	15.28
	Source	154	103	7.2	18.4	8.4	15.48	2.90	14.74
Buildings Al-Humya	Buildings Al-Humya	179	120	7.2	21.4	9.8	18.03	3.38	17.17
	Source	162	109	7.0	19.3	8.9	16.28	3.05	15.51
Al-Mukhtar	Al-Mukhtar	368	246	7.1	43.9	20.1	36.96	6.93	35.20
	Source	402	269	7.0	48.0	22.0	40.40	7.58	38.48
Al-Khaleej	Al-Khaleej	333	223	7.2	39.8	18.2	33.49	6.28	31.89
	Source	325	218	7.1	38.8	17.8	32.66	6.12	31.11
Standard	WHO 2017	400	<1000	6.5-8.5	250-500	75	100	30	50
	Libyan	**	<1000	6.5-8.5	500	**	200	150	200
$LSD_{0.05}$	(A)	21.37	14.15	0.056	2.55	2.55	1.13	2.14	0.4
	(B)	9.33	5.73	0.2	1.58	1.21	0.69	0.38	1.33
		17.17	12.66	0.21	2.02	1.65	1.97	0.49	2.16
		44.37	29.88	0.16	5.2	2.12	4.21	0.49	3.5
		19.19	8.86	0.15	1.87	1.21	1.48	0.27	1.1

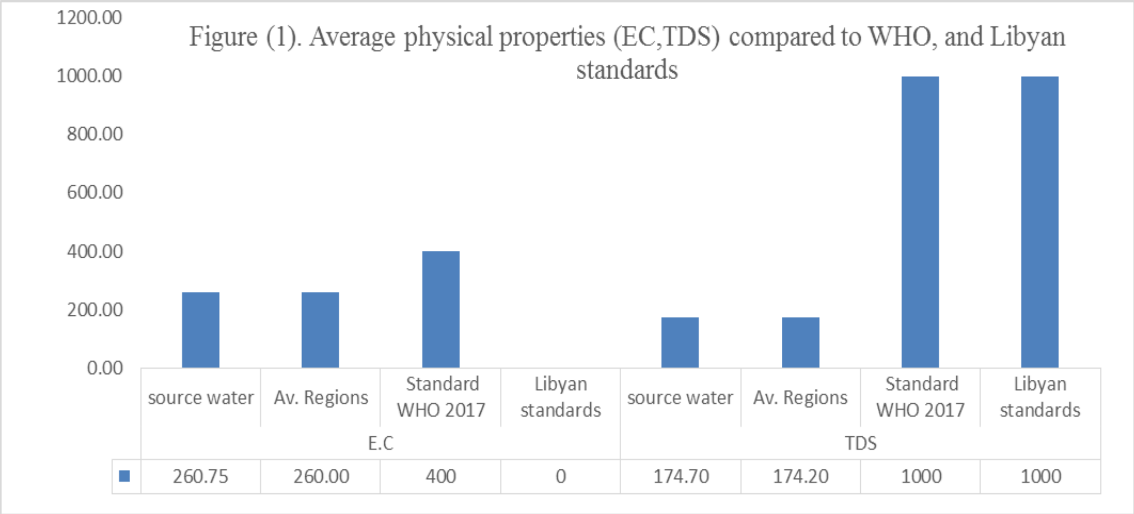

Figure:1 Average physical properties (EC,TDS) compared to WHO and Libyan standards

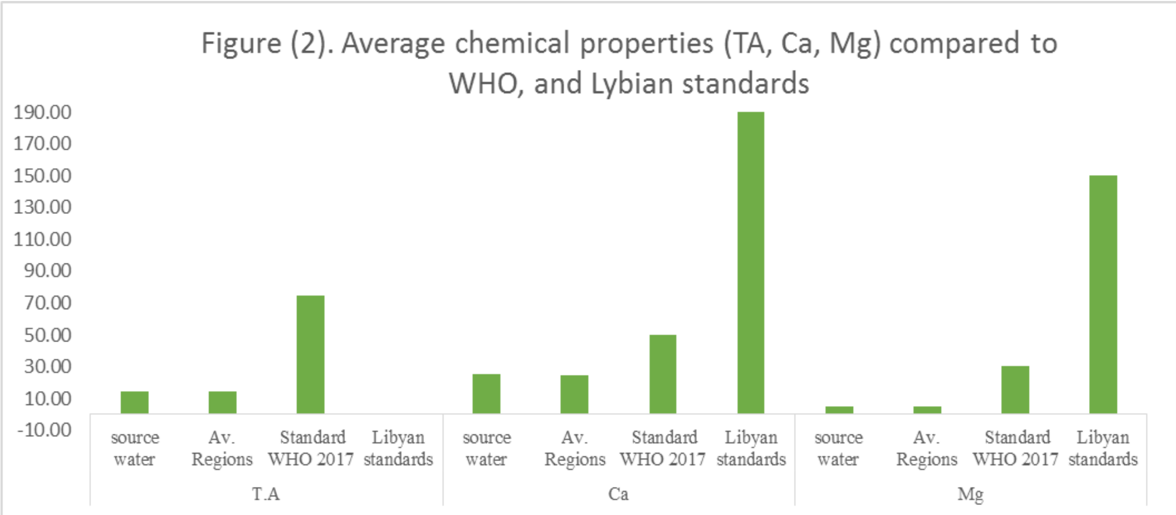

Figure:2 Average chemical properties (TA,Ca,Mg) compared to WHO and Libyan standards

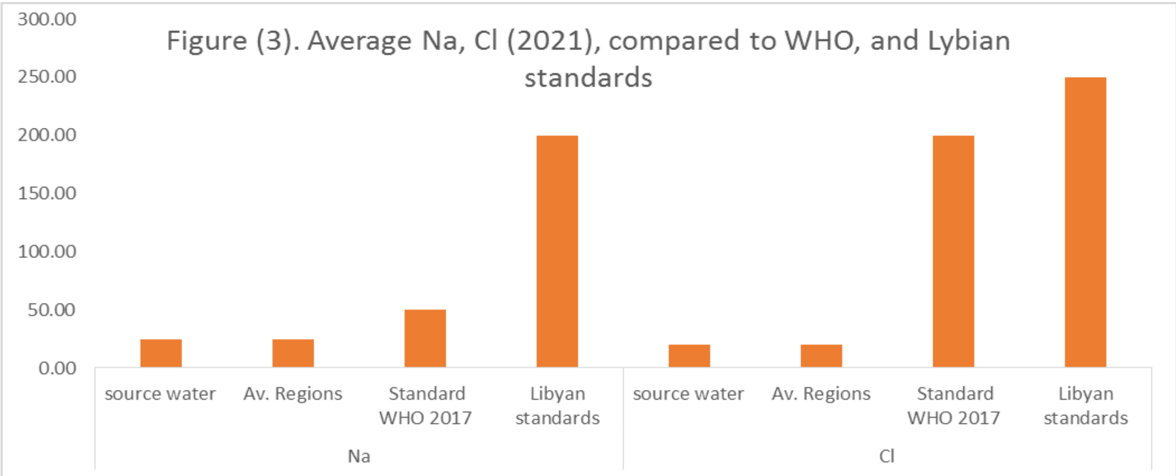

Figure:3 Na, Cl (2021) compared to WHO and Libyan standards

Table 3 Chemical parameters of the drinking water of 4 Regions in Tobruk city, Libya 2021

Locations A	Locations B	(Cl) mg/L	(NO_2) mg/L	(NO_3) mg/L	(SO_4) mg/L	(PO_4) mg/L	(CO_3) mg/L	(HCO_3) mg/L	(K) mg/L
Shaabiat Al-Jaish	Shaabiat Al-Jaish	8.84	0.37	4.11	63.65	0.21	0.18	8.55	1.09
	Source	8.22	0.35	3.88	63.37	0.17	0.17	8.25	1.05
Building Al-Hurriya	Building Al-Hurriya	11.04	0.45	4.94	64.65	0.35	0.20	9.62	1.23
	Source	9.11	0.38	4.21	63.77	0.23	0.18	8.68	1.11
Al-Mukhtar	Al-Mukhtar	31.98	1.17	12.86	74.21	1.67	0.42	19.71	2.51
	Source	35.78	1.30	14.30	75.95	1.91	0.46	21.55	2.75
Al-Khaleej	Al-Khaleej	28.13	1.04	11.41	72.46	1.43	0.38	17.86	2.28
	Source	27.22	1.01	11.06	72.04	1.37	0.37	17.42	2.22
Standard	WHO 2017	200	0.01	50	250	0.4	00	120	10
	Libyan	250	0.01-0.03	45	400	0.4	**	150	40
LSD 0.05	(A)	1.17	0.08	2.38	0.92	1.07	0.01	0.02	2.04
	(B)	0.9	0.08	0.37	0.41	0.07	0.02	0.41	0.07
		1.8	0.08	0.81	0.71	0.17	0.03	1.01	0.12
		3.71	0.21	2.1	0.97	0.38	0.06	1.95	0.41
		1.1	0.03	0.4	0.06	0.22	0.21	0.63	0.33

Nitrite (NO_2), and Nitrate (NO_3) , As for nitrites and nitrates, the World Health Organization has allowed their presence in drinking water within the limits that do not cause any harm to human health, so that they do not exceed (0.01 mgl^{-1}, and 50 mgl^{-1}), respectively. Nitrateis one of the most important parameters of water quality, which is one of the causes of diseases, especially blue baby syndrome in infants if its concentration exceeds the standards of the WHO. The results presented in Table 3 show negative results, where the recorded increase in the concentration of nitrites in all water samples than the standards of the WHO. On the other hand, nitrate concentrations in all water samples did not exceed the standards of the WHO for 2017. Sulfate (SO_4), and Phosphate (PO_4), The concentration of sulfate in the source water ranged from 63.6 to 73.5 mgl^{-1}, while this concentration increased in the first, second and fourth regions compared to the source water, but it slightly increased by (0.28, 0.88, and 0.42 mgl^{-1}), respectively, but the sulfate concentration decreased in the third region by 3.49 mgl^{-1}, compared to the source water. In general, the proportion of sulfates in drinking water did not exceed the standards of the WHO, which amount to 250 mgl^{-1}. Results show that the concentration of Phosphate in study regions ranges (0.21, and 0.35 mgl^{-1}) in the first and second regions and did not exceed the WHO standards, which reached 0.4 mgl^{-1}, on the other hand in the third and fourth regions ranges (1.67, and 1.43 mgl^{-1}), but these results did not meet the WHO standards, which leads to deterioration of water quality in these regions.

Carbonate (CO_3), and Bicarbonate (HCO_3), the presence of carbonates and bicarbonates generally in water conjunction with Ca and Mg. The WHO (2017), and the United States Environmental Protection Agency (US EPA) (US EPA 2002), sets a guideline value for the alkalinity of drinking water directive of 120 mgl^{-1} not to be exceeded for HCO3. Concentrations of HCO3 ranged from (8.55, 9.62, 19.17, and 17.86 mgl-1), respectively, and CO3 ranged from (0.18, 0.20, 0.42, and 0.38 mgl-1), respectively for the four study regions. which is due to the difference between the concentrations of both carbonates and bicarbonates in the difference in their concentrations in the water source stations. also, this may be due to the corrosion of the water conveying pipes, which causes the accumulation of those salts of carbonates and bicarbonates in drinking water.

Potassium is necessary for living organism functioning hence found in all human and animal. In human body the total potassium amount lies between 110 and 140 g. which it is consider vital for a lot of human body functions. According to WHO standards the permissible limit of potassium is 10 $mg1^{-1}$. Results show that the concentration of potassium in study regions ranges from 1.09 to 2.51 $mg1^{-1}$.

Bacteriological quality assessment, according to the results of the bacteriological analysis, showed that although the source water was not contaminated for the four study regions, there was bacterial contamination with bacterial colonies in the first and second regions with numbers exceeding the standards of the WHO.

On the other hand, in the third and fourth regions, there was no pollution, which makes the presence of an urgent need and further investigation to find out the source of that pollution. This may be due to the deterioration of the infrastructure in these regions and the mixing of sewage with drinking water, as there have been no maintenance works in these two regions (Shaabiat Al-Jaish, and Building

Al-Hurriya) for more than 40 years, which led to damage.

CONCLUSION

Through the results that were discussed with the aim of evaluating the quality of drinking water in some regions of the Tobruk city in Libya, as well as studying the efficiency of seawater desalination plants in providing drinking water in accordance with international standards of the World Health Organization as well as the Libyan specifications and standards. By results analyze we can be certain that the quality of drinking water is fully compatible to international and local specifications and standards. However, we may need other studies to find out the cause of contamination of some regions with E. coli bacteria, despite the absence of that pollution in the water source, which may need the attention of the government to know the reasons for this and overcome it in order to preserve the health of the Libyan citizen.

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