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Original Article

Assessment of the Physicochemical and Microbiological Groundwater Quality in the Jennawen, Shakshouk, and Jadu Agricultural Project Areas, Jadu City, Libya.

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ABSTRACT

Background In arid regions such as Jennawen, Libya, groundwater is the primary source for drinking and irrigation, yet it is highly vulnerable to geogenic and anthropogenic contamination. This study aimed to assess the chemical and microbiological quality of 26 groundwater samples from wells and springs, including desalinated water. **Material and Methods** Physicochemical parameters (e.g., pH, salinity, major ions) and microbiological indicators (total coliforms, E. coli, total bacterial counts) were analyzed according to established guidelines. **Results** revealed that most untreated groundwater samples exceeded the permissible limits for salinity, hardness, and sodium. Furthermore, widespread bacterial contamination was identified, posing significant health risks. While desalinated water was free from microbiological contaminants, it was severely deficient in essential minerals. **Conclusion**: the groundwater in the Jennawen region requires urgent attention. Balanced water management strategies are critically needed to address both chemical and microbial contamination while maintaining an optimal mineral balance in potable water.

Keywords: Groundwater quality, Jennawen, Libya, E. coli, Water standards.

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INTRODUCTION:

In arid and semi-arid areas groundwater is the main source for drinking, irrigation and other purposes uses. Generally, the quality and quantity of groundwater mainly depends on the geochemistry of soils and rocks. Groundwater chemistry of a region is usually not homogeneous and it is driven by flow, geochemical processes, evaporation andvapotranspiration, and possible sources of pollution.[1] Water is the first biological liquid. It facilitates the reactions of turning food into energy. It is also the means of transporting pollutants due to the large number of pollutants that reach it in different ways and cause many serious diseases that affect the health of living organisms, especially humans.[2] Groundwater recharge, surface water quality, precipitation, and subsurface hydrochemical processes are factors affecting groundwater quality.[3]Water pollution not only affects water quality but also threatens human health, economic development, and social prosperity.[4] Thus, analysis of water forphysical, biological and chemical properties including trace element contents are very important for public health studies. Human activities can change the natural composition of ground water through the disposal of chemicals and mining activities, at the land surface and into soils, or through injection of wastes directly into ground water.[5] Contaminated water is generated from many different sources involving petroleum refineries, dyes, drugs, paper, textile dye, detergents, surfactants, pesticides, herbicides, insecticides and pharmaceutical manufacturers.[6] Majority of microbes in water are from faeces from human and other mammals. Pathogens can enter waters either from a point source, non-point sources or both. Rainwater surface run-offs, storm sewer spillages or over flow cause non-point microbial pollution of waters, while point-source pollution comes from discharge of untreated or partially treated effluents from wastewater treatment plants.[7] The coliform bacteria (Escherichia coli, E. coli) were enumerated for the assessment of the fecal contamination of groundwater from three major aquifers of the region viz., Quaternary Alluvium, Tertiary and Cretaceous sedimentary formations in the Pondicherry region. In addition, assays of total microbial loads (total viable counts - TVC) in different aquifers, the distribution of E. coli and TVC laterally and vertically, and correlations with dissolved oxygen and total organic carbon were also carried out.[8] The analysis of groundwater microorganisms has not routinely been included in previous wet-tropics groundwater research, but a growing interest in the ecological significance of these organisms and their influence on groundwater chemistry has started to emerge in recent years.[9] With the increasing pollution of groundwater, it is essential to analyze the chemical characteristics of groundwater and evaluate its quality for water supply purposes. In this regard, methods like thegroundwater quality index (GWQI), the fuzzy comprehensive method, and the health risk weight method (HRWM) have been widely used by researchers. Among these methods, the water quality index (WQI) has been more commonly used by international researchers due to its simple calculation, practicality, and versatile applications.[10] Jasmine Shahina et al (2019) studied Bacteriological Quality Assessment of Groundwater and Surface Water in Chennai, and a total of 11 different bacterial species were identified from both ground and surface water samples [7].Elyaagubi et al. (2019). Their study was Assessment of Groundwater Pollution in Different Locations of Al-khums City, Libya, and the results detected that the ground water was not proper for drinking as well as domestic purposes due to significant variation of most of the results from the standard permissible limit whichwas high in water samples collected from nearby coastal areas such as Suk-Al-Khuamis (Sk) and Al-Khums [5]. Ben Sera et al. (2021) assessed groundwater and determined its suitability for drinking and irrigation purposes from two major aquifers in thenorth and south of the Azintan area and found that the groundwater in many places is dominated by higher concentrations of Cl-, SO42-, and HCO3-. Two water types were recognized in this region are Cl-SO4-Na-Ca and Cl-SO4-Na [11]. Abeish and Said (2020) investigated the physical and chemical quality of the Libyan Assabaa groundwater and the degree of its contamination, and the results showed that the groundwater of theAssabaa area was within the limitations of WHO Standards. However, some samples had a bit high concentrations for TDS and Total Hardness [6]. Siham Ali et al. (2024) studied Chemical and Microbial Analysis of Commercial Bottled Drinking Water Available in Surman City Markets, and the Microbial analysis revealed that none of the samples showed significant microbial activity, indicating the absence of microbial contamination. The chemical analyses showed compliance with Libyan standards, particularly in terms of pH levels and trace element concentrations, which were close to the acceptable limits [12].

Despite the importance of aquifers to the population, no studies in the Jennawen region have focused on groundwater resources. Thus, the objectives of this study were to evaluate the quality of groundwater according to theassessment of physicochemical properties and microbiological measurements.
The study area is located in the Nafusa Mountains of northwestern Libya, specifically between Jadu and Shakshuk, as shown in Fig. 1. It is considered part of the city of Jadu and ischaracterized by mountainous terrain and valleys.

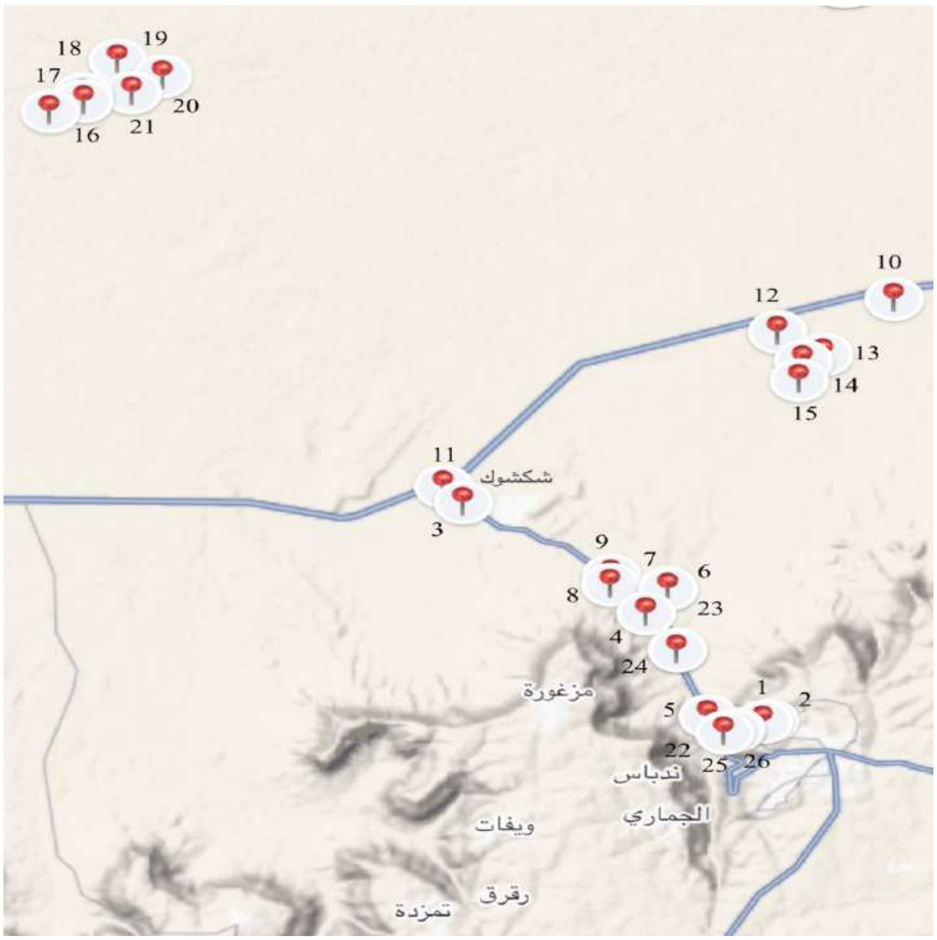

Figure 1: The location of the study area

Table 1: Sources of water samples

Sample Number	Water source	Sample Number	Water source
1	Algattar spring	14	Yakhlef Lashhab 1well
2	Atmogatt spring	15	Ahmed Lashhab well
3	Shakshouk spring	16	Yakhlef Lashhab 2 well
4	Omar Al-Qallal well 1	17	Musa Hakeem well
5	Jennawen well	18	Ahmed Gojeel well
6	Alaa Al-Qallal well	19	Khaled Zikri well
7	Gleza well	20	Yaagob Rshada well
8	Fouad EL-Alawy well	21	Omar Al-Qallal well 2
9	Salem Abukhrais well	22	Jennawen Mosque2 water desalination
10	Omar Abuhanik well	23	Alaa Al-Qallal well water desalination
11	The well of Shakshouk Mosque	24	Omar Al-Qallal well water desalination
12	Fathy Abuhanik well	25	Jennawen Funeral home water desalination
13	Ali Omer well	26	Abo-Obyda Mosque water desalination

MATERIAL AND METHODS:

Sample Collection

The study was conducted to evaluate some physical, chemical, and microbiological properties of 26 groundwater samples. These samples were collected from different wells and springs located in Jennawen, Shakshuk, and the Jado Agricultural Project region in Jadu City. All fresh samples were obtained directly from the wellheads as the water flowed out. The investigations were carried out in the laboratory within 24 hours.

All analyses were carried out in the Advanced Libyan Center of Chemical Analysis.

Physiochemical analysis

The physical and chemical investigations of groundwater samples were performed according to different laboratory methods. The concentration of hydrogen ions (pH) was measured using a pH meter, and the conductivity was determined with a Conductivity Meter at 25 °C, from which the total dissolved solids (TDS) were calculated during sampling. Sodium and potassium concentrations were measured using a Flame Photometer, while sulfate and nitrate ions were quantified using a Spectrophotometer. Calcium, magnesium, and total hardness were determined by titration with 0.01 M EDTA solution, using Murexide and Eriochrome Black T as indicators. Chloride ion concentration was estimated via titration with silver nitrate solution using potassium chromate as an indicator [12].

Microbiological analysis

Several microbiological estimations were conducted in this study, including the total colony counts, total coliform group, and E. coli. The total numbers of colonies were determined by thenutrient agar method; however, the coliform group and E. coli were determined by theColilert (defined substrate) method as described by Al-Barakah. Et al (2017).[13]

RESULT:

Physicochemical Analysis

The physicochemical analysis of the samples is presented in Table 2. pH: The values ranged from 6.62 to 7.88 in all samples except No. 22 and No. 24, which decreased to 6.43–6.29 after desalination. These values generally fall within the WHO and Libyan standards (6.5–8.5).

Electrical Conductivity (EC): Values ranged from 29.4 µS/cm (sample 23) to 6170 µS/cm (sample 19). All untreated groundwater samples exceeded the WHO permissible limits (500–1500 µS/cm), while desalinated samples were below the minimum standard.

Total Dissolved Solids (TDS): Ranged from 22.7 mg/L (sample 23) to 4060 mg/L (sample 19). Most untreated samples exceeded the WHO limits (500–1000 mg/L), while desalinated water contained extremely low TDS values.

Total Hardness (TH): Ranged from 0 mg/L (samples 25, 26) to 5524.9 mg/L (sample 18). Almost all untreated samples exceeded the permissible limit (100–500 mg/3.6. Chloride (Cl^-): Values ranged from 21.08 to 1013.8 mg/L. About 42% of samples exceeded the permissible range (200–600 mg/L), 39% were within, and 19% (desalinated samples) were below.

Sodium (Na^+): Concentrations ranged from 0 to 560 mg/L. Most untreated samples exceeded the permissible range (20–200 mg/L), while desalinated samples were below the limit.

Potassium (K^+): Values ranged from 1.35 to 55.05 mg/L. All samples were below WHO limits (40–200 mg/L), except four that were close to the minimum threshold. Magnesium (Mg^{2+}): Concentrations ranged from 0 to 417.9 mg/L. About 46% of samples were within WHO standards (30–150 mg/L), 27% were above, and 27% (mainly desalinated) were below. Calcium (Ca^{2+}): Ranged from 0 to 2115.9 mg/L. Most samples exceeded WHO limits (75–200 mg/L), while desalinated samples showed very low concentrations. Sulfate (SO_4^{2-}): Values ranged from 0 to 900 mg/L. Only four samples were within theWHO and Libyan permissible limits (200–400 mg/L).Bicarbonate (HCO_3^-): Ranged from 12.2 to 610 mg/L. About 73% of samples exceeded the permissible limit (200 mg/L.Nitrate (NO_3^-): Ranged from 1.1 to 116.2 mg/L. Only two samples (No. 1 and 2) exceeded theWHO limits (45–50 mg/L). Calcium Hardness (Ca-H): Ranged from 0 to 5284.7 mg/L. Most samples exceeded WHO standards, except fordesalinated water.

Microbiological Analysis

The microbiological results are presented in Table 3. Total Coliforms: Ranged from 0/100 ml (desalinated water) to 470/100 ml (sample 12). Most samples exceeded WHO limits (zero detectable coliforms).E. coli: Values ranged from 0 to 78 cfu/100 ml. About 77% of samples were within WHO limits (≤2.2 cfu), while 23% exceeded the limit.

Total Bacterial Count: Ranged from 0 cfu/ml (desalinated samples) to 150 cfu/ml (sample 12). Most untreated samples exceeded theWHO permissible levels

Table.2: physicochemical analysis

Sample Number	PH	EC	TDS	TH	Ca^{+2}	Ca^{+2} Hardness	Mg^{+2}	Na^{+}	K^{+}	Cl^{-}	NO_3	HCO3	SO_4^{-2}
1	7.88	2330	1745	852.76	312.5	180.70	17.010	451	38.58	404.16	116.2	274.5	**120**
2	7.22	2158	1602	670.603	224.4	560.504	26.73	388	7.59	421.74	54.4	152.5	**127**
3	7.34	3920	2620	2041.8	400.7	1000.9	252.7	376.6	55.05	506.9	10.8	610	**600**
4	7.50	3110	2300	1201.08	296.5	740.66	111.7	518.6	14.12	562.32	2.7	305	**100**
5	7.48	4150	3090	1501.35	216.4	540.48	233.2	265.7	8.46	773.19	38.0	305	**290**
6	7.56	2012	1492	700.63	156.2	390.35	75.33	201.4	17.74	351.45	2.2	305	**390**
7	7.40	2960	2186	1000.9	200.38	500.45	121.50	394	13.29	527.17	4.0	610	**470**
8	7.25	4230	2830	2201.9	480.9	1201.08	242.9	504.9	18.55	651	8.1	366	**900**
9	7.40	2360	1571	820.7	160.3	400.36	102.05	172	14.34	362.1	8.7	488	**200**
10	7.43	2760	2041	1020.91	280.53	700.36	77.76	265.8	33.07	492.03	15.9	244	**700**
11	7.74	3420	2550	1721.5	625.18	1561.40	38.96	242.4	53.61	351.45	2.2	122	**119**
12	6.62	4310	2860	1401.26	416.7	1040.94	87.48	388.4	29.54	506.94	5.4	244	**114**
13	6.89	4003	2650	1401.26	384.7	960.8	106.9	405	31.34	651.78	11.5	488	**580**
14	7.05	4910	3230	2762.4	577.05	1441.2	320.7	410.2	41.65	724.2	9.2	366	**480**
15	7.17	4870	3107	2682.4	545.02	1361.2	320.7	500.2	47.39	811	3.5	366	**490**
16	7.08	5110	3320	2882.5	1106.06	2762.4	29.13	397.9	33.04	724.2	5.5	366	**440**
17	7.10	5310	3480	3122.8	1122.1	2802.5	77.76	271.4	30.64	621.7	10.0	366	**740**
18	7.29	4990	3207	5524.9	2115.9	5284.7	58.32	420.5	34.42	651.78	5.6	610	**550**
19	7.31	6170	4060	3603.2	1360.5	3403.06	48.59	543	38.13	941.4	11.9	366	**280**
20	7.29	6040	3940	3443.09	881.6	2201.9	301.36	560	37.62	1013.8	7.6	366	**620**
21	7.33	5260	3410	3122.8	561.06	1401.26	417.9	453	36.11	724	9.9	244	**490**
22	6.43	107.8	83.8	20.018	4.808	12.01	1.94	17.29	2.83	28.11	12.1	12.2	**11**
23	7.2	29.4	22.7	2.0018					1.35	21.08	2.2	24.4	
24	6.26	121.3	93.8	36.03	8.01	20.01	3.88	17.34	7.97	35.14	1.1	12.2	**13**
25	7.55	112.9	73.8			0		21.76	2.27	36.21	7.2	61	**0**
26	7.42	172.9	113.1			0		36.26	3.43	72.42	9.3	91.5	**4**

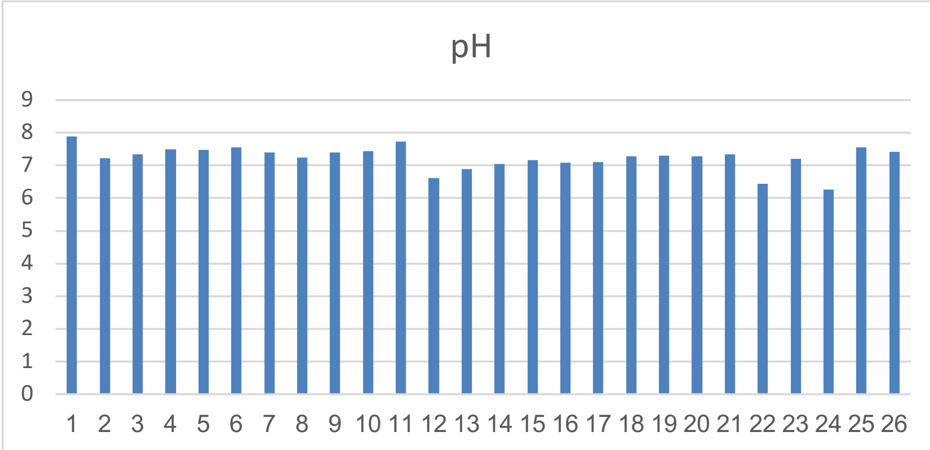

Figure 2: Results of pH concentration values

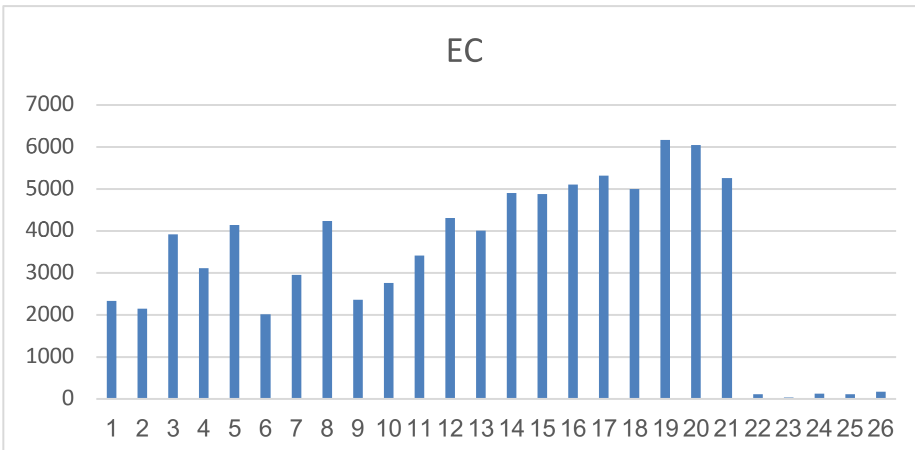

Figure 3: for electrical conductivity

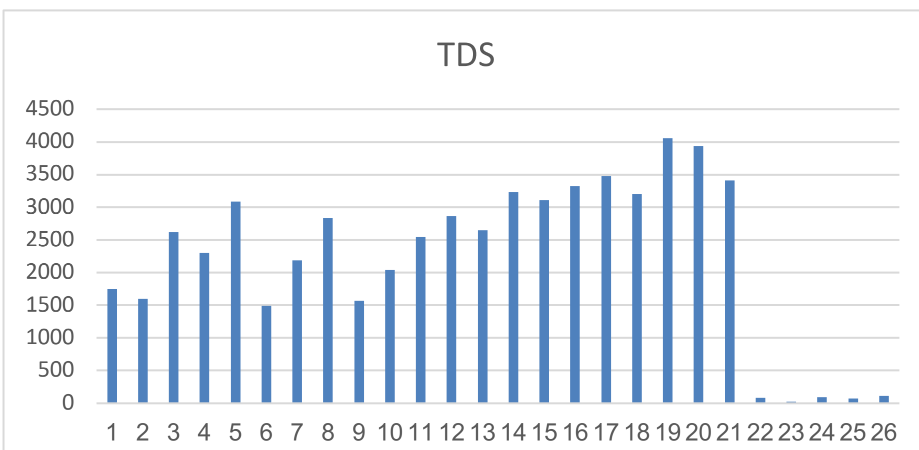

Figure 4: Results of TDS concentration values

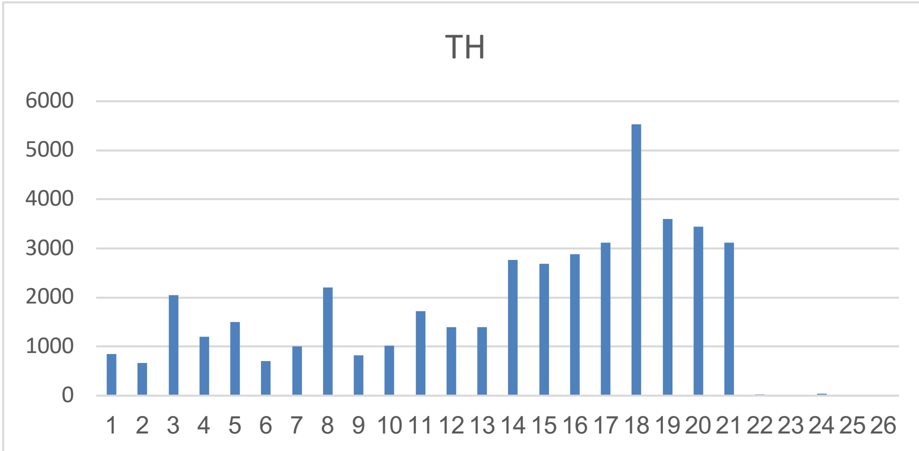

Figure 5: Total Hardness values

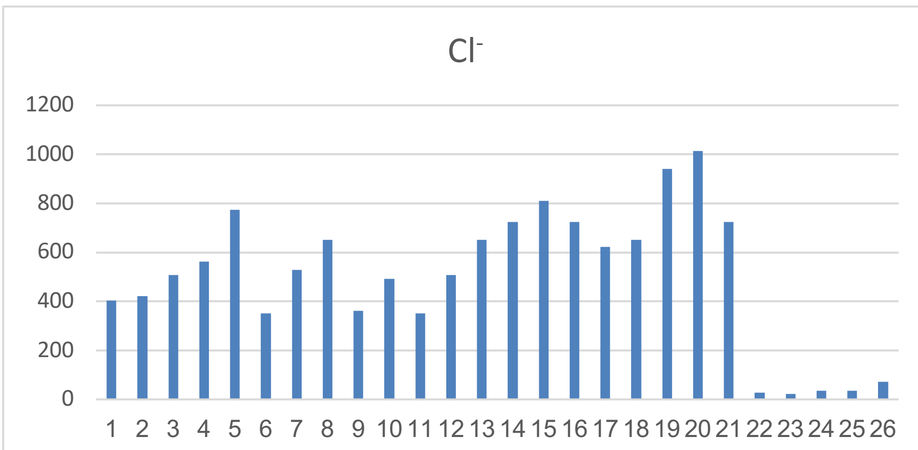

Figure 6: Chloride Concentration values

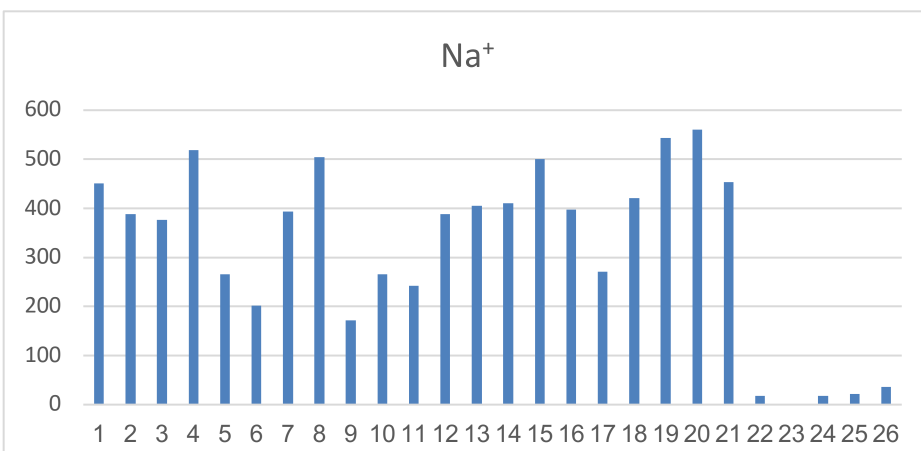

Figure 7: Sodium Concentration values

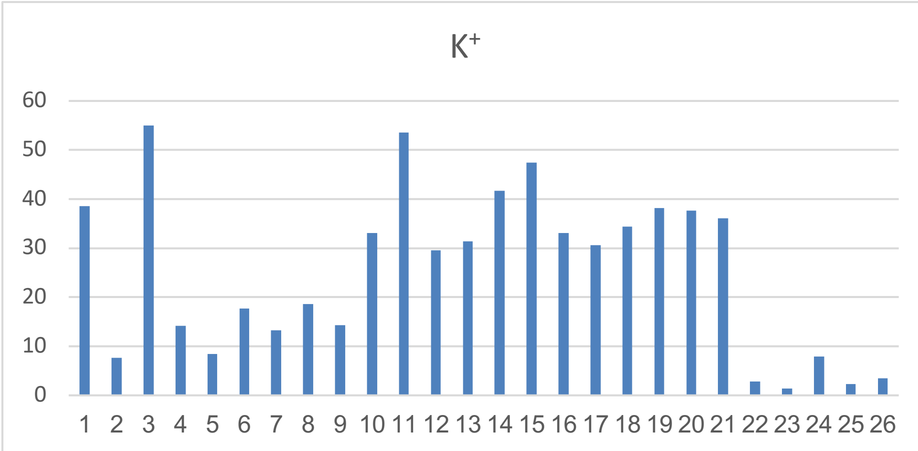

Figure 8: Potassium Concentration values

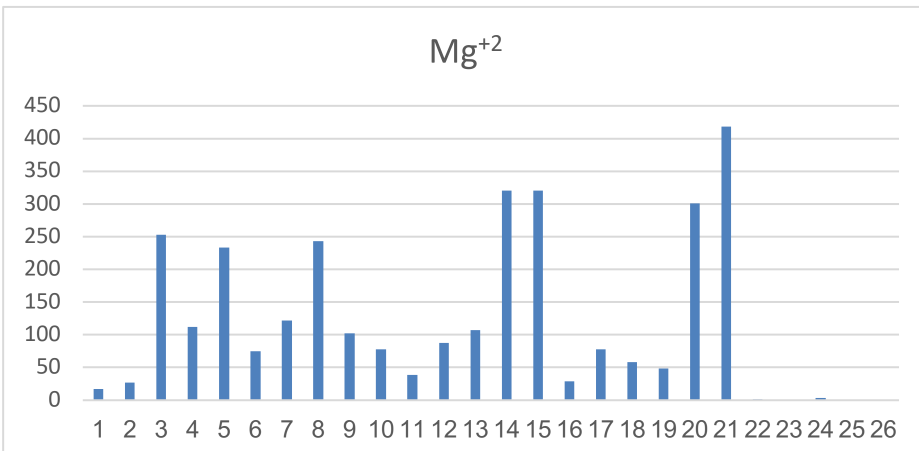

Figure 9: Magnesium Concentration values

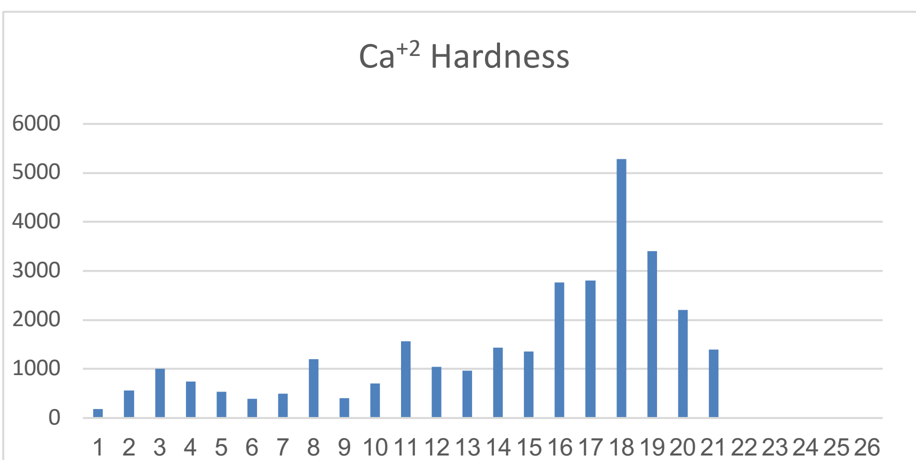

Figure 10: Calcium Concentration values

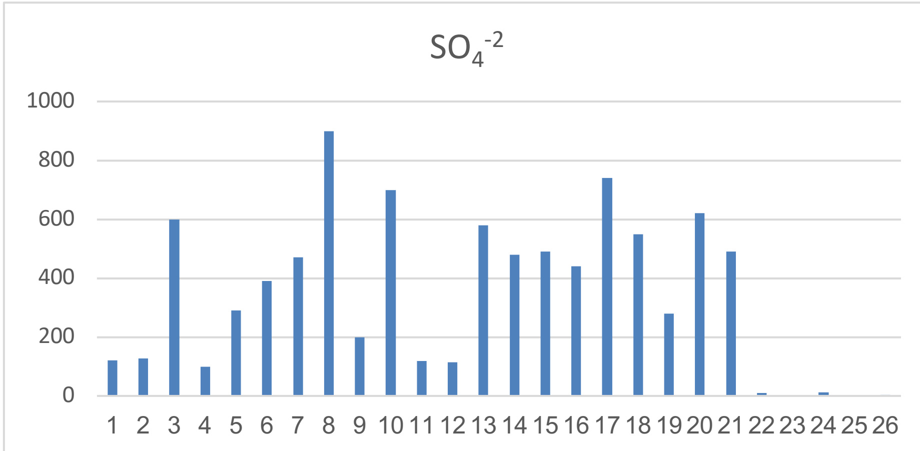

Figure 11: Sulfate Concentration values

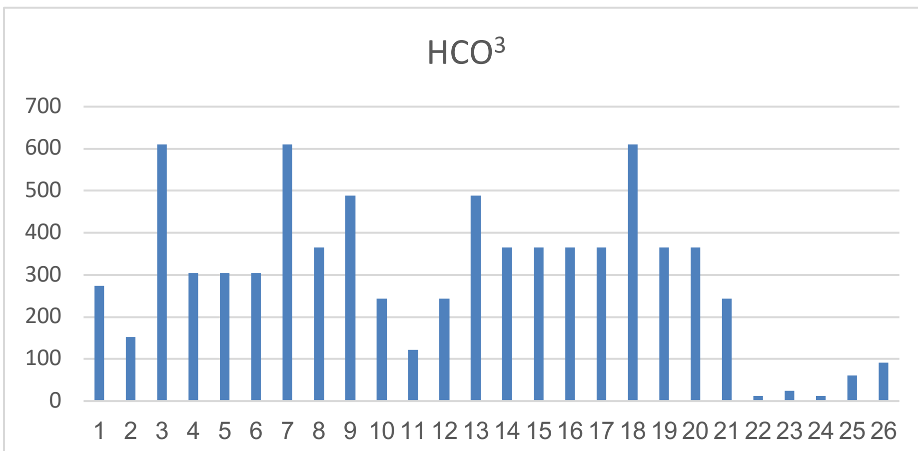

Figure 12: Bicarbonate Concentration values

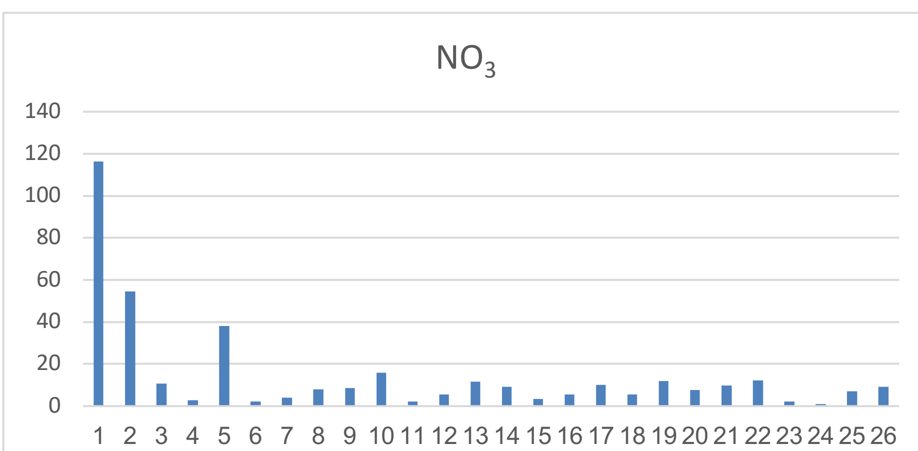

Figure 14: Calcium hardness values

Table (3): Results of Biological Tests

Sample Number	Total coliform	Total bacterial count	E.COLI	Sample Number	Total coliform	Total bacterial count	E.COLI
1	4	0	0	14	200	3	**0**
2	190	50	40	15	350	24	**0**
3	213	28	Nill	16	95	2	**0**
4	2	0	0	17	1	1	**0**
5	0	0	0	18	1	1	**0**
6	60	7	1	19	368	19	**1**
7	250	20	17	20	292	16	**3**
8	330	70	3	21	2	1	**Nill**
9	35	99	78	22	0	0	**0**
10	22	2	17	23	0	0	**0**
11	30	10	0	24	0	0	**0**
12	470	150	1	25	Nill	0	**0**
13	120	6	2	26	Nill	Nill	**Nill**

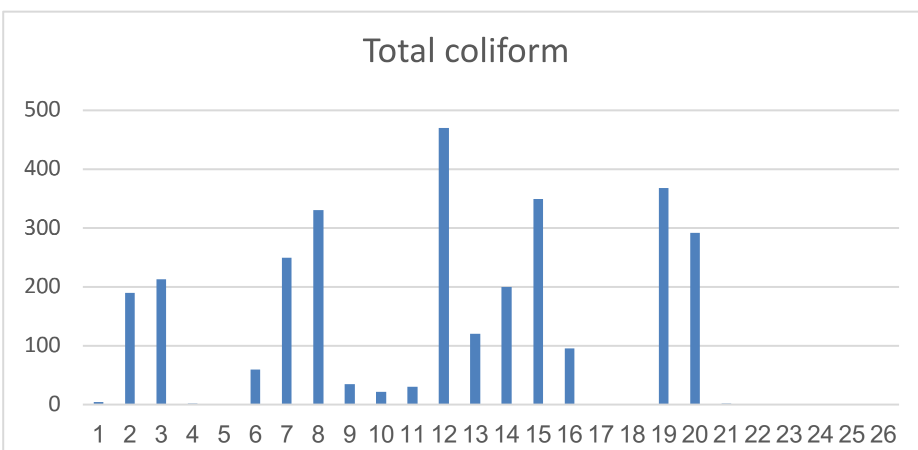

Figure 15. T.Coliforms

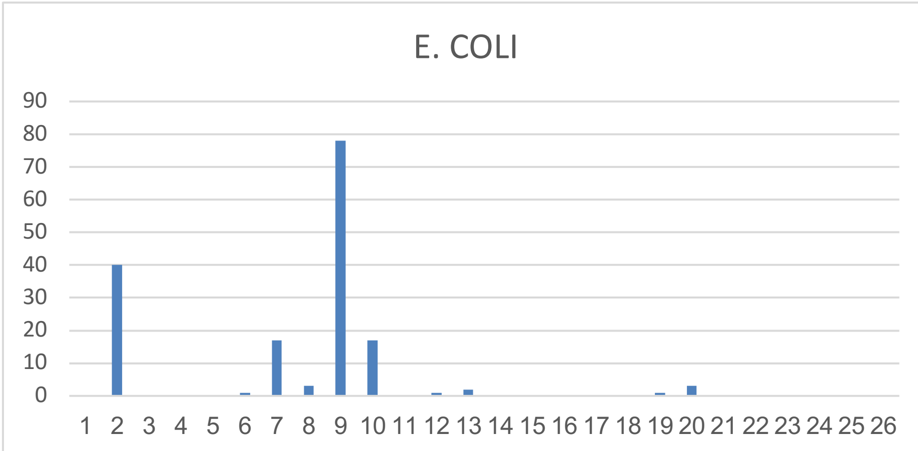

Figure 16. E. coli

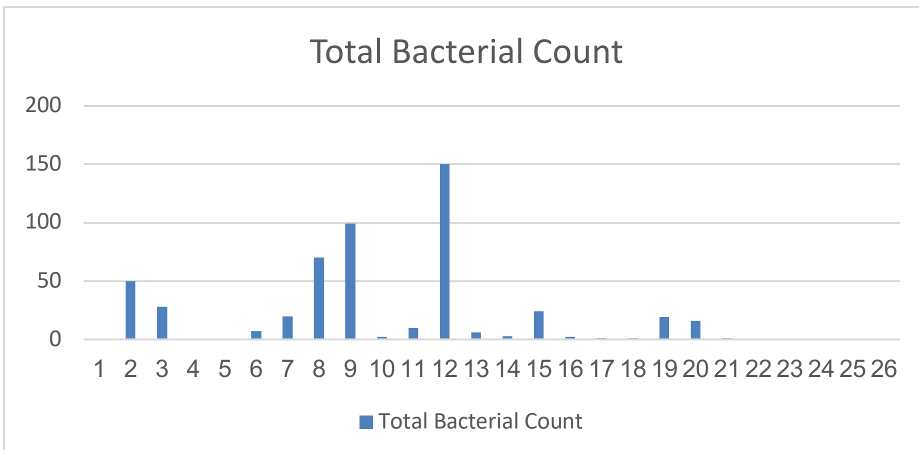

Figure 17. Total bacterial count

DISCUSSION:

In this study, the results showed a significant difference between the physicochemical variables of groundwater before and after desalination. Water of samples (9,10, and 11) isare same water of wells (4,5, and 3), respectively, but after desalination.

All results achieved were validated using World Health Organization (WHO) Standards and Libyan standard specifications. The concentration of hydrogen ions in a solution determines its pH level. From the results shown in Figure 2, the pH values of the samples (except samples No.22 and No.24) ranged from 6.62 to 7.88, which fall within the permissible limits of 6.5 to 8.5, as specified by the Libyan standards and WHO [14]. This indicates that none of the water samples showed excessive acidity or alkalinity. Samples No.22 and No.24, which have slightly decreased after desalination since it was in the range of (7.48-7.50) and became (6.43-6.29), that is less than the permissible limits. This is due to the removal of elements. From the results shown in Figure (3) for electrical conductivity EC), it was found that the electrical conductivity values in the samples at 25ºC ranged from 29.4µS/cm to 6170µS/cm. The lowest electrical conductivity is 29.4 in the sample No.23 and the highest electrical conductivity is 6170 in the sample No.19. According to this study, with exception of desalinated water samples (sample No.22,23,24,25 and26), all water samples have excessed the permissible limits of WHO (500 - 1500 μS/cm) [15], that means the need of the desalination processes. Desalinated water samples were much lower than the minimum limit in the WHO international specifications. This reflects that the desalination process produces unbalanced water because these values areless than the recommended standards. Also, this means that there is a need for a uniform standard for all the desalination plants. Also, there is a big difference between the values of EC before and after the desalination process, which reflects high efficiency of desalination plants. The US Salinity Laboratory (1954) classified groundwater on the basis of EC. According to this classification, all studied groundwater samples, which arewithout desalination belong to the poor category [16]. From the results shown in Figure 4), the values of TDS in the studied samples range from 22.7 to 4060 mg/l. The lowest total dissolved salts are 22.7 mg/l in the sample No.23 and the highest total dissolved salts is 4060 mg/l in the sample No.23. Based on WHO standard values for TDS (500-1000mg/l) [17], all samples have unacceptable values except desalinated water samples (sample No.22,23,24,25 and26), which shows TDS values less than the minimum limit of international specifications WHO,therefore this water is similar to distilled water that does not contain salts, and drinking this water does not benefit the human body except for quenching and refreshing apparently. Therefore, with the abundance of drinking this water, it will harm the human being and cause them heart disease, stroke, and premature aging [2]. Total hardness is the property of water that prevents the formation with soap and increases the boiling point of water. In groundwater, hardness is mainly due to carbonates, bicarbonates, sulphates, and chlorides of Ca and Mg. In the studied samples, TH, as shown in Figure 5) ranges from 0 to 5524.9 mg/l. The lowest total hardness is 0 mg/l in the samples No.25 and 26, and the highest total hardness is 5524.9 mg/l in the sample No.18. According to WHO recommendations, the permissible limits of total hardness are (100-500 mg/L) [18]. In this study, with theexception of desalinated water samples (sample No.22,23,24,25 and 26), all other samples exceeded the permissible limits. Chloride serves as a valuable indicator for identifying the source of contamination resulting from anthropogenic activities. The results of thechloride concentration are shown in Figure 6). The chloride present in the samples ranges from 21.08 to 1013.8 mg/l. The permissible limit according to WHO standards for soluble chloride is (200- 600 mg/l) [17]. In this study, about 42% of thestudied samples exceeded the permissible limits, 39% were found to be within the permissible limit, and 19% (desalinated water samples) were less than the minimum limit of the international specifications set by WHO. The results of thesodium concentration are shown in Figure 7). The concentration of Na in the studied water samples ranges from 0 to 560 mg/l. The permissible limits of sodium concentration are (20-200 mg/l) based on (WHO, 2011; LNCSM 1992) [19].In this study, the Na content in almost all samples without desalination was above the permissible limits, while it was below the safe limit in the desalinated water samples. The high sodium content is attributed to the weathering of minerals that make up the rocks, such as Halite, in addition to human sources, such as domestic and industrial waste and animal waste [19]. The potassium concentration isshown in Figure 8). The concentration of K in the studied water samples ranges from 1.35 to 55.05 mg/liter. The permissible limits of potassium concentration are (40- 200 mg/l) based on (WHO, 2011; LNCSM 1992) [19], and it was found that all studied samples were below these limits, with the exception of only four samples, which were almost at the minimum limit. Desalinated water samples had very low concentrations of potassium. The main quantity of potassium (K^+) in groundwater enters from theweathering of rocks. However, the quantities increase in water increase as a result of thedisposal of wastewater [5]. Magnesium concentration is shown in Figure 9. The concentration of Mg in the studied water samples ranges from 0 to 417.9 mg/liter. The lowest concentration of magnesium (0mg/l) was found in desalinated water samples, while the highest one (417.9mg/l) was found in the sample No.21. According to WHO, the permissible limit of Mg concentration of drinking water is 30-150 mg/l [17,19]. Approximately 46% of the samples fell within this limit. The remaining samples were split: 27% were above the limit, and 27% were below it. The samples below the limit included springs and desalinated water. Magnesium is the most common element found in the Earth’s crust, and all available sources contribute to the hardness of water. A high concentration of this ion makes the water unpalatable [20]. Calcium concentration is shown in Figure 10. It was found that the Ca concentration in the studied samples ranged from 0 to 2115.9 mg/L. The lowest calcium concentration (0 mg/L) was found in desalinated water samples, and the highest concentration (2115.9 mg/L) was found in sample No.18. The calcium concentration in most of the studied samples exceeded the permissible limit for drinking water (75 - 200 mg/l) [17,19]. An exception was the desalinated water samples, which were below the minimum permissible limit and showed a very low calcium concentration. Therefore, samples with high Ca concentrations were not suitable due to their hardness. The main sources of calcium are gypsum and calcite found in sedimentary rocks, as well as rock–water interactions and contamination from industrial and domestic wastes [20].The concentration of sulfates is shown in Figure 11. In the studied samples, the SO4 values range from 0 to 900 mg/L. The lowest sulfate concentration is 0 mg/L in samples No. 23 and 25, and the highest one is 900 mg/L in sample No. 8. The recommended levels set by the World Health Organization and the Libyan Standards Centre for sulfate are (200-400 mg/L) [2,17,19,22]. Consequently, only 4 samples were within the permissible limits, 10 samples (including 5 desalinated water samples, which had very low concentrations) were below these limits, and 12 samples were above. The high sulfate concentration in water can cause diarrhea, leading to severe dehydration over the long term [21].The concentration of bicarbonate is shown in Figure 12. It was found that the bicarbonate (HCO_3) values for the samples range from 12.2 to 610 mg/l. The lowest bicarbonate concentration is 12.2 in samples No.22 and 24, and the highest concentration is 610 in samples No. 3, 7, and 18. The permissible limit of bicarbonate concentration according to Libyan standards [23] and WHO, 2011 [19] is 200 mg/L. It was found that 27% of the studied samples were below this limit (most of which were desalinated water samples), while 73% of the samples exceeded the permissible limit. The main source of bicarbonate is the disintegration of carbonate minerals or, as a result, the dissociation of carbon dioxide through the biological decomposition of organic materials from human sources such as domestic and industrial wastewater and buried waste [19]. The high bicarbonate concentration may be attributed to local calcareous water-bearing sediments [16].The Nitrate concentration is shown in Figure 13. In the studied samples, the NO_3 values range from 1.1 to 116.2 mg/L. The lowest nitrate concentration is 1.1 in sample No.24, and the highest one is 116.2 in sample No.1. The permissible limits of nitrate concentration according to Libyan standards are 45 mg/L [23] and 50 mg/L based on WHO, 2011 [19]. The nitrate concentration in most of the studied samples was within the permissible limits; however, only two samples (samples No.1 and 2) exceeded the permissible limits. High nitrate concentrations may be attributed to the oxidation of nitrogenous and biological substances resulting from wastewater or industrial waste [19]. The Calcium hardness is shown in Figure 14. The permissible limits of Calcium hardness concentration according to WHO standards are (75-200) mg/L. Calcium hardness (Ca-H) of the studied samples ranged from 0 to 5284.7 mg/L. The lowest calcium hardness was found to be 0 mg/L in desalinated water samples, and the highest one is 5284.7 mg/L in the sample No.18. Approximately all samples exceeded the permissible limits and showed very high concentrations of calcium hardness, with the exception of desalinated water samples, which had very low concentrations. Total coliforms have been selected as important indicators for the presence of pathogenic microorganisms in drinking water. This is an important indication of the adequacy of drinking water. If a large number of coliforms are found in the water, other pathogenic bacteria or organisms are more likely to be present. The WHO guidelines require that there be no detectable coliforms in the supply of public drinking water [25]. In this study, total coliform levels as shown in Fig. 15 ranged from 0/100 ml in desalinated water samples and 470/100 ml in sample No. 12. In general, most of the samples contain very high undesirable values of T.coliforms, with the exception of desalinated water samples.

The main sources of fecal coliform in freshwater are effluents from wastewater treatment plants, inefficient septic tank systems, and animal manure. Diseases and conditions that can be caused by high fecal coliform count in water include typhoid fever, hepatitis, gastrointestinal infections, dysentery, and ear infections. Escherichia coli is present in the intestines of humans and warm-blooded animals. The presence of E. coli in drinking water samples usually indicates recent fecal contamination. This means that there is a higher risk of pathogens. The permissible limit of E. coli is 2.2 cfu. The values of E. coli in the studied samples, as shown in Figure 16, ranged from 0 to 78 cfu. About 77% of the studied samples (including desalinated water samples) lie within the permissible limit of theWHO, while 23% exceed this limit.

The presence of E. coli in these samples may be due to the location of its basins near the wastewater discharges. E. coli can cause meningitis, sepsis, urinary tract infections, and other diseases.

Total bacterial count is shown in Fig. No.17. The highest average total viable bacterial count in the studied samples was 150 cfu/ml, obtained from sample No. 12, which also had the highest values of T. Coliform. The lowest average total viable bacterial count was 0 cfu/ml, found in desalinated water samples. Except desalinated water samples, most of the studied samples contained high bacterial counts that exceeded the permissible limits of the WHO. The presence of different bacterial genera in the groundwater may be due to direct contamination caused by human activities and indirect effects caused by ecological disturbances [24].

CONCLUSION:

The study area included three regions: Jennawen(samples 1-9), Shakshuk(samples 10-15), and Jado Agricultural Project(samples 16-21) in Jado city.

The results did not show clear differences between the springs samples and wells samples, except for nitrate concentration, which was high in the springs water compared to the wells water, and this may be due to its location near wastewater basins. While the differences between the well water and its desalination were significant and clear, as it was found high decrease in the concentration of salts and minerals after desalination, which reflects the efficiency of desalination plants, on the other hand, very low salt and minerals concentrations below the permissible limits mean that these desalination plants may produce unbalanced water. In general, the region´s it was found that all samples have exceeded the permissible limits of TDS, EC, TH, Na, Ca, and Ca-H. High EC values reflect high TDS values as is clearly evident in sample No.19. High Ca concentration were followed by increase of Ca-H and T-H as it shown in sample No.18.Given that the study included three regions (Jennawen, Shakshuk and Jado Agricultural Project), a clear difference was observed in salinity, hardness and electrical conductivity which had higher levels in Jado Agricultural Project. In terms of microbiology, with the exception of desalinated water samples, many samples contained high concentrations of T. coli, E. coli, and total bacterial count.

Conflict of interest

There are no conflicts of interest and no financial support and nosponsorship

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