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Validity assessment of some spring water in Akra District, Kurdistan region, Northern Iraq as a safe drinking water

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ABSTRACT

In this study, lasted for six months from October 2016 to April 2017 in the Akra district of Duhok governorate, we found out the validity of the spring water of the area to be used as drinking water. Indeed, the aim of this study was to assess the validity of the water of spring of the Akra area for human consumption as potable water. The results showed us after the analysis and laboratory examinations (i.e., electrical conductivity (EC), total alkalinity (TA), total dissolved solids (TDS), pH, total hardness (TH), magnesium (Mg^{2+}), Calcium (Ca^{2+}), Dissolved oxygen (DO), and Chloride (CL^{-})) of all springs water of the region in terms of physical and chemical properties are safe to drink and can be identified as a good source of human consumption. Although there is a difference in some physical and chemical properties in some springs of water in that area, it did not exceed the limits and international standards for drinking water. Therefore, the people of this region can use the water of those springs to drink without fear of any health effects.

1. Introduction

Springs are the principal source of domestic water supply for rural communities in the Kurdistan region. The quality of the spring water is highly related to the local environmental and geological conditions. The regular withdrawal and hence changes the groundwater table of a source. There are many water springs in many countries vary in physical and chemical properties depending on the geology of the region where some of them are characterized by high temperature and increase in the proportion of sulfur salts and the lack of potable water to drink as the area of Bath Alalil in the province of Nineveh in Iraq as well as in the city of Aachen in Germany Federal and similar institutions in the State of Iceland and the quality of groundwater also changes (Tamilarasi et al., 2015). To provide safe drinking water especially to rural population, groundwater has been sought as the source in many developing and undermined by both natural processes, (Dissolution and precipitation of minerals, groundwater velocity, quality of recharge waters and interaction with other types of water aquifers) and anthropogenic activities (Devic et al., 2014). If water is suitable for drinking, it can also be safe for all other purposes. Usually, groundwater is safer than surface water in normal conditions, as it is naturally protected from the contamination caused by the infiltration of recharge water through soil cover. However, soils can be contaminated as a result of human activities. On the other hand, toxicity of minerals present in soils and rocks can also be caused by groundwater contamination following geochemical processes. Thus, fresh infiltrating recharge water can affect the quality of pure groundwater (Rao, 2008). This spring serves as a water source for the inhabitants of the area who utilize the water for their daily activities. Hence there arose the need to assess the quality of this spring to make recommendations where necessary. The present study was carried out to assess the spring water quality around Akra District.

1.1. Geology of the study area

The geological formations of the area consist of deposits of the Eocene age represented by following formation 1-Kolosh: represented by an alteration of clay marl, dolomite marl, and clay limestone polemicist. 2-Gecus: represented by an alteration of dolomite marl and siltstone with some gypsum rocks. 3- Fragmental Detritus: represented by small rocks fragments. The quaternary is represented by

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alluvial and diluvia deposit. 4-pelaspi limestone: represented by slightly dolomite limestone and dolomite. An important here is the mineral spring water which appears on the limit between the Eocene and chalk deposit in the tail of reservoir. Their discharge is not constant and decreases considerably during the dry summer period (Ameen and Karim, 2009).

2. Materials and methods

Nine springs were collected from Akra district, Kurdistan region, Iraq (Fig. 1). Monthly samples were collected from the springs during the period October 2016 to April 2017. The samples, electrical conductivity (EC), pH, total dissolved solids (TDS), total alkalinity (TA), total hardness (TH) magnesium (Mg^{2+}) and Calcium (Ca^{2+}). Were brought to laboratory and analyzed for the selected parameters using the standards methods (White, 1988). The pH, temperature and electrical conductivity parameters of the samples were determined in the field at the point of collection of the samples with appropriate instruments of measurement. The collected data were statistically analyzed to compare between the spring water quality using ANOVA and Duncan multiple range test.

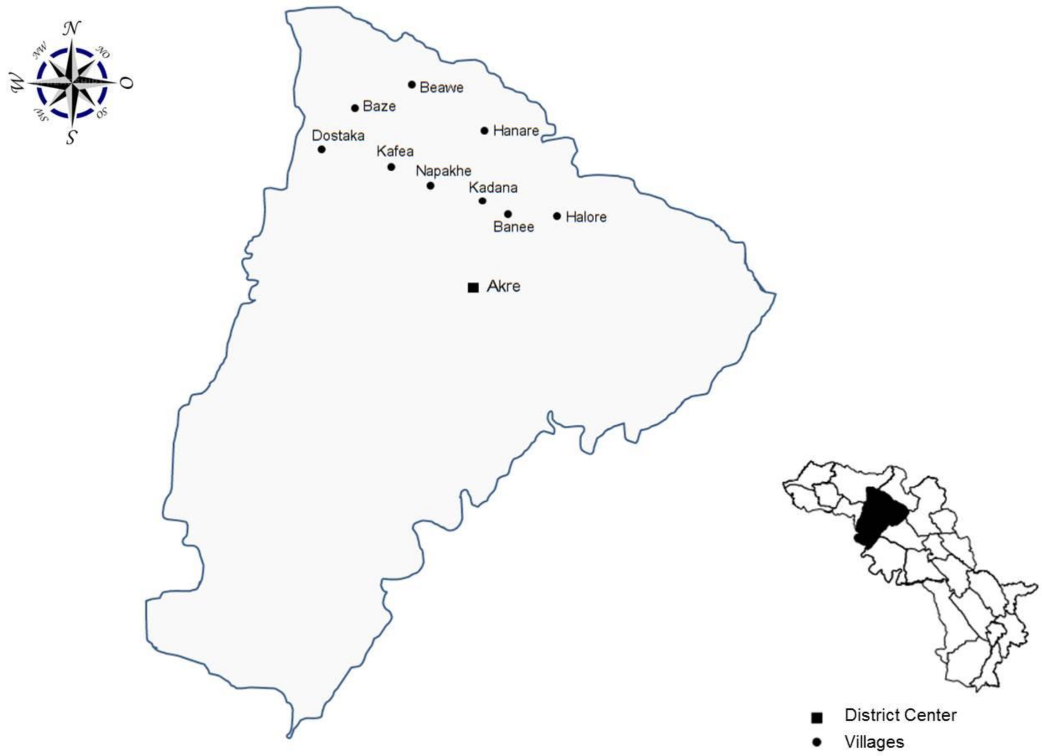

Fig. 1: Map of spring sampling sites in Akra district

3. Results and discussion

In the present study, the temperature value of all water samples ranged from 8.2 to 18.2°C. As shown in Fig. 2 from Table 1, there was significant variation in water temperature between the studied springs. The mode of variation was different with a month. This reflects the variation of the nearby feeding source. Table 1 shows that the temperature of the spring's water varies throughout the study period, dropping in winter and rising in summer in all the studied springs. This indicates that these springs are of conduit type, which is affected by the runoff in winter and spring which does not allow them to come in chemical equilibrium due to the low residence time and short path length because of the mountainous topographic nature of the area. This will lead to the monthly variation in the water quality of these springs (APHA, 1999).

Table 1: Temperature (◦C) variation between selected springs for the study period

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	14.28	15.30	14.28	12.11	13.85	12.20	14.60
Baze	18.23	17.35	11.76	11.48	12.42	15.22	16.37
Deawe	15.36	15.72	8.32	9.03	11.80	13.60	16.37
Kafea	16.77	17.32	15.18	8.73	10.38	14.95	15.60
Napakhe	17.83	16.77	11.33	9.37	12.17	14.87	15.47
Kadane	12.27	15.32	8.75	10.90	11.64	15.18	16.85
Banee	20.32	17.80	10.27	8.29	11.03	14.37	16.85
Halora	15.80	17.32	8.27	11.53	11.65	13.82	15.81
Hanare	14.35	15.20	10.30	10.70	12.67	14.17	16.31

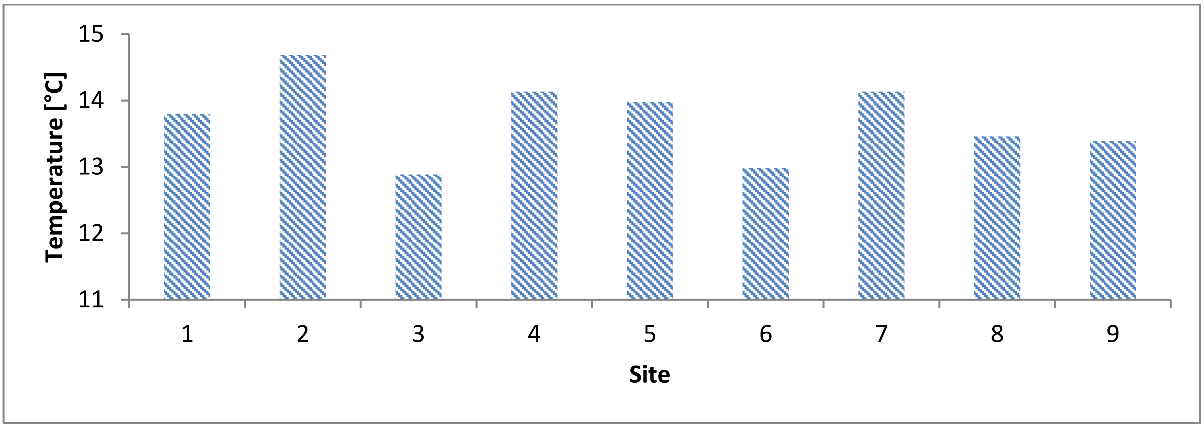

Fig. 2: The average water temperature of wells study area

In the present study, the concentration of electrical conductivity (EC) in all sampling points were ranged from 480.7 to 1322.7 µs/cm as shown in Fig. 3. Significant variation of electrical conductivity was recorded among the studied springs (Table 2). Kadane, Dostaka and Hanare springs have the lowest electrical conductivity along the studied period. On the other hand, Banee spring water has the highest electrical conductivity among the studied springs during the studied period. The conductivity is produced by the erosion of the natural deposits and the dissolution of minerals from the media which the water passes through. In this study are significantly higher than those reported by Asadi et al. (2007).

Table 2: EC µs/cm variation between selected springs for the study period

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	526.7	536	530.7	532.3	525.7	579.3	526
Baze	928.7	908.7	806	841.7	932.7	816.3	809.3
Deawe	698.3	681.3	820.3	681.7	653.3	705	646.3
Kafea	637.7	777.7	531.7	646	573.7	652.3	652.3
Napakhe	839	852.7	855.7	970.3	872.3	861	804.3
Kadane	528.7	519.7	506.7	517.7	541	480.7	501
Banee	1231	1322.7	1313	1280	1242.7	1175	1095.3
Halora	776	786	770.7	700	689.3	597.7	660
Hanare	577.7	577	577	555.3	537.7	579	516

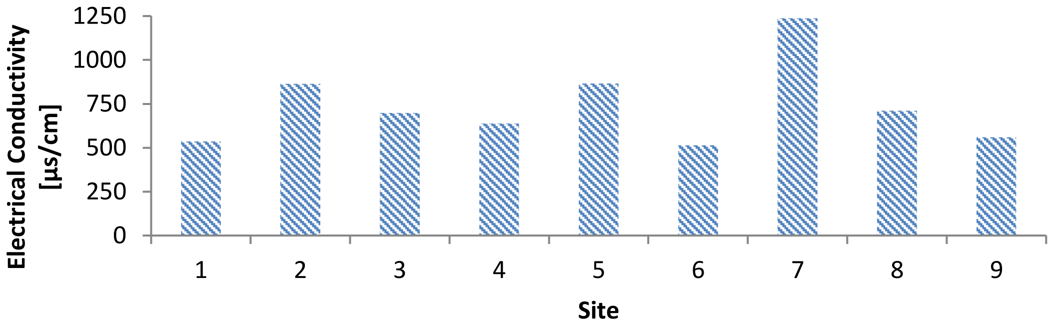

Fig. 3: The average electrical conductivity of wells study area

In the present study, the concentrations of TDS in all sampling sites were ranged from 341.7 to 859.7 mg/l as shown in Fig. 4 for total dissolved solids (TDS). Table 3 shows a significant variation between the studied springs. As it has strong relationship with conductivity, TDS demonstrate the same mode of variation between springs. Kadane, Hanare and Dostaka springs have the lowest TDS with a significant difference from the others. In construct Banee spring water has the highest TDS along the study period. According to WHO (2009) and EPA (2006) classification of water for drinking, TDS of this spring was above the recommended level (500 mg/l). In this study are significantly higher than those reported by Zidi et al. (2017).

The pH of all water samples ranged from (7.17 to 8.84). As shown in Fig. 5 from Table 4, all the results of spring's pH values were on the alkaline side of neutrality. This is probably due to the increase of runoff in this season and accordingly the dissolution of carbonates. Also, they are within the range of UK Regulation (5.5 to 9.5) of drinking water (Twort et al., 2001). In this study are significantly higher than those reported by Lebrahimi et al. (2018).

High dissolved oxygen concentration was recorded in the studied springs between 7.13 to 10.53 mg/l in the water springs. As shown in Fig. 6

from Table 5. This indicates the absence of any organic pollution in these springs and the shallow feeding sources of these springs. The highest dissolved oxygen values were distributed between Hanare spring five times and once for each Kadane and Baze spring. In this study are significantly higher than those reported by Gawai and Nandre (2017).

Table 3: TDS mg/l variation between selected springs for the study period

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	342.3	348.4	344.93	346.02	341.7	376.6	341.9
Baze	603.6	590.6	523.9	547.08	606.2	530.6	526.1
Deawe	453.9	442.9	533.22	443.08	424.7	458.3	420.1
Kafea	414.5	414.5	345.58	419.9	372.88	424	424
Napakhe	454.4	545.4	556.18	630.72	567.02	559.7	522.8
Kadane	343.6	337.8	329.33	336.48	351.65	312.4	325.7
Banee	800.2	859.7	853.45	832	8.7.7	763.8	712
Halora	504.4	510.9	500.93	455	448.1	388.5	429
Hanare	357.5	370.1	357.05	360.97	349.5	376.4	335.4

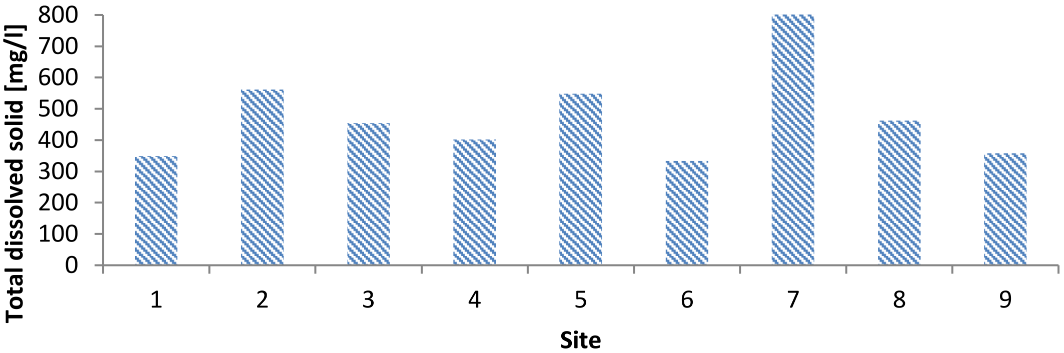

Fig. 4: The average total dissolved solid of wells study area

Table 4: pH variation between selected springs for the study period

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	7.81	7.59	7.27	7.79	7.73	7.61	7.77
Baze	7.33	7.17	7.32	8.18	8.18	7.24	7.49
Deawe	7.43	7.57	7.4	8.1	7.92	7.75	7.59.
Kafea	7.31	7.36	7.61	8.14	7.87	7.78	7.43
Napakhe	7.48	7.66	8.51	8.38	8.09	8.52	8.31
Kadane	8.05	7.73	7.88	7.74	8.84	8.2	7.97
Banee	7.72	8.11	7.77	8.79	8.19	7.39	7.27
Halora	7.22	7.22	8.62	8.84	7.9	8.13	7.89
Hanare	7.96	7.69	8.31	7.71	7.37	8.15	7.99

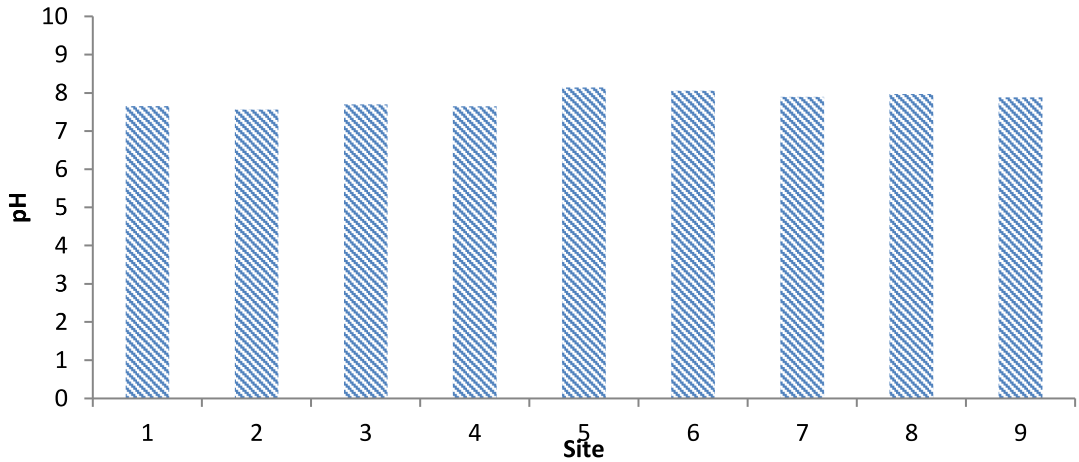

Fig. 5: The average PH of wells study area

For total hardness, it ranged from 286.33 to 604.33 mg/l as shown in Fig. 7 from Table 6. These values were very far from the hardness of the springs of bottled water (more than10mg/l). Little variation was recorded between springs. Halora and Baze have more hardness than the others, at about all the studied months. According to the classification of WEDC (1997) all the springs produce very hard water. On the other hand and according to WHO (2009), most of the springs were lower than the recommended level of hardness 500mg/l, except Halora, Banee, Dostaka, and Baze.

The carbonaceous nature of the geological formation of Akra District especially limestone and dolomite contribute to hardness increase as the water pass through them. In this study are significantly higher than those reported by Toure et al. (2017).

Table 5: DO (mg/l) variation between selected springs for the study period

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	8.83	8.23	8.47	8.51	9.08	9.25	9.34
Baze	9.57	9.6	9.93	10.87	10.38	10.73	10.78
Deawe	9.23	9.02	8.93	8.1	9.6	9.19	9.47
Kafea	7.42	7.33	7.14	8.01	7.27	8	7.67
Napakhe	7.13	7.42	7.99	7.77	8.37	7.97	8.41
Kadane	8.6	10.39	7.36	8.43	8.27	9.14	9.5
Banee	7.32	7.56	8.83	8.25	9.11	8.26	8.77
Halora	7.55	7.49	7.47	7.8	7.82	8.47	8.35
Hanare	9.73	9.53	10.22	9.53	10.53	10.12	10.24

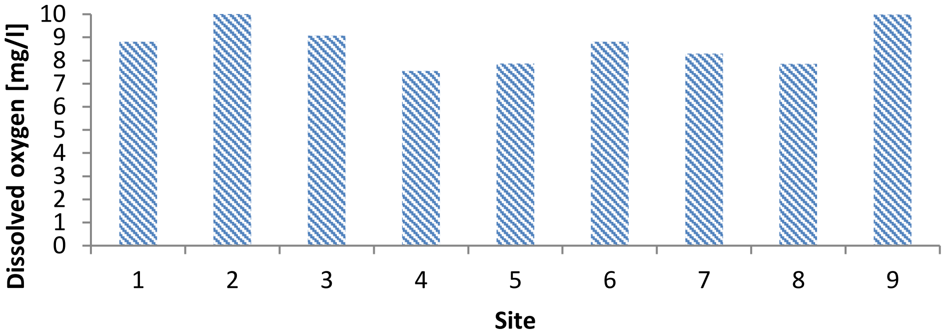

Fig. 6: The average dissolved oxygen of wells study area

Table 6: Total hardness between selected springs for the study period

Sites	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	286.33	341	354	425.33	446.7	359	343
Baze	493.7	492.6	465.3	554	511	497	473.33
Deawe	326.33	399.3	529	543.3	596.3	454.67	435.33
Kafea	415.33	450	381.3	466	466.3	437.67	435.33
Napakhe	437.67	414.7	444.33	460.3	441	406.69	248
Kadane	351.33	321.3	361.3	408.3	435.6	395.33	374.6
Banee	584.67	367.2	422.3	523.7	546.7	462.33	441.67
Halora	506.33	525.7	604.3	600.7	529.7	532.33	518.67
Hanare	343	332.3	391	413.7	372.7	316.33	345.33

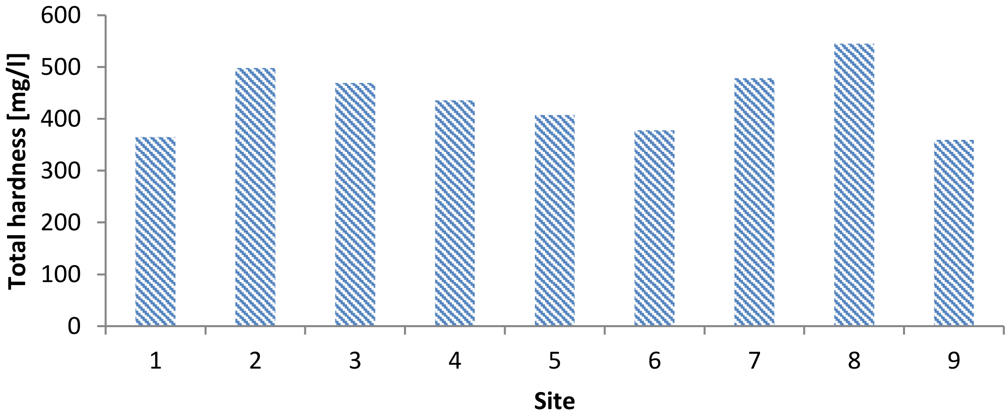

Fig. 7: The average total hardness of wells study area

Calcium hardness is part of the total hardness. The results in Fig. 8 from Table 7 show little variation in calcium hardness among the studied springs. The variation in calcium hardness was convenient with that of the total hardness. Halora and Banee springs have the highest values along the study period. It represents the major part of hardness. Table 7 shows a significant difference in calcium hardness along the study period except in Napakhe spring. The nearby feeding source and the seasonal variation in them contribute to this variation. Similar results reported by Kilwake et al. (2017).

Table 7: Calcium hardness variation between selected springs for the study period

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	281	256.7	241	370	336.33	280	274.67
Baze	367.7	392	313	472	394.67	387.33	400
Deawe	223.3	229	393	451	483.67	360	355
Kafea	248	385.3	240.33	495	380	377.33	369.67
Napakhe	394	323	369.33	376.13	368.67	388	352.33
Kadane	242	279	279.2	455	379	351.67	338
Banee	531.3	276	292	429.33	495	415.67	401
Halora	400.7	439	579	558.67	446.33	479.9	485.67
Hanare	332	269.67	382.33	385	340.1	279.33	288.67

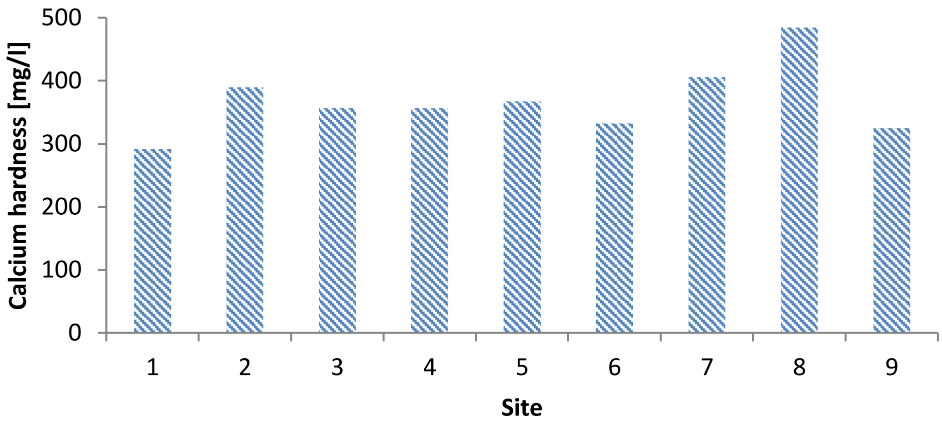

Fig. 8: The average calcium hardness of wells

The principal source of magnesium hardness in the springs in the studied area is dolomite. Magnesium hardness ranged from 6.2 to 61.9 mg/l as CaCo3. As shown in Fig. 9 from Table 8, Hanare springs have the lowest magnesium hardness along the study period. On the other hand, Napakhe, Kafea, Deawe, baze, and Dostaka springs have the highest magnesium hardness. The values of magnesium hardness were very low in comparison with calcium hardness. Which reflects the geological formation of the study area. Similar results reported by Gawai and Nandre (2017).

Table 8: Magnesium hardness variation between selected springs for the study period

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	14.3	29.8	37.9	15.97	31.43	22.33	25.63
Baze	31.97	33.21	51.3	30.97	38.01.	38.53	22.77
Deawe	41.9	61.9	48.63	32.93	39.53	17.8	27.1
Kafea	53.1	22.17	43	26.2	25.1	24.2	19.4
Napakhe	22.21	28.9	25.5	23.9	26.47	26.83	28.27
Kadane	24	16.1	24.1	14.7	15.07	22.43	13.1
Banee	25.8	32.28	42.1	26.2	18.73	12.1	17.13
Halora	29.17	27.4	26.5	16.5	27	20.47	10.7
Hanare	6.4	15.01	6.2	8.23	12.7	9.4	19.17

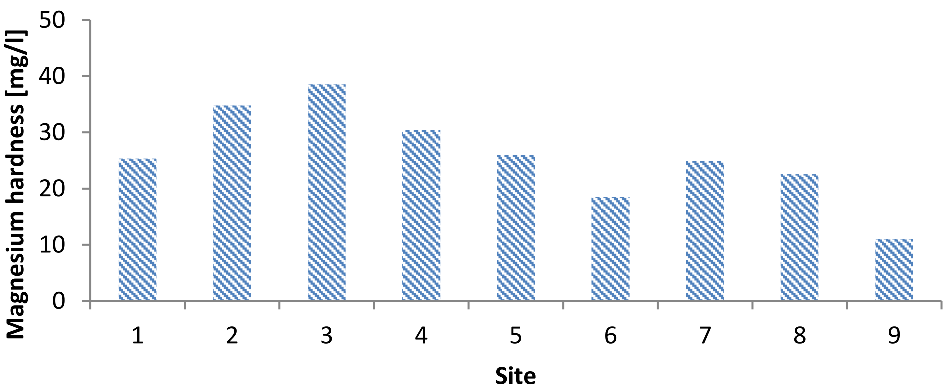

Fig. 9: The average magnesium hardness of wells study area

Chloride ion concentrations ranged between 11.63 to 49.6 mg/l. As shown in Fig. 10 from Table 9 the lowest values were recorded in Hanare, and Banee along the study period and in Dostaka spring at January to April. All the values were lower than the recommended values by EPA of 250 mg/l. Table

9 shows that Napakhe and Deawe springs have the highest seasonal variation in chloride. This is probably due to the variation in the feeding source flow rate and level. In this study are significantly lower than those reported by Zidi et al. (2017).

Table 9: Chloride ion variation between selected springs for the study period

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	17.5	22.13	22.5	15.5	15.6	13.3	13.73
Baze	37.5	36.6	40.1	42.43	41.43	37.3	35.17
Deawe	14.9	32.6	34.03	21.87	24.9	23.03	23.78
Kafea	19.3	23.77	22.8	24.57	25	17.8	17.47
Napakhe	33.75	34.67	21.6	49.6	42.9	27.8	36.13
Kadane	17.13	23.4	22.83	26.92	25.37	20.5	18.57
Banee	7.27	13.7	11.9	15.2	14.93	11.9	11.63
Halora	18.1	20.83	27.3	22.4	22	18.4	18.6
Hanare	12.6	13.94	13.3	12.81	12.63	15.23	15.87

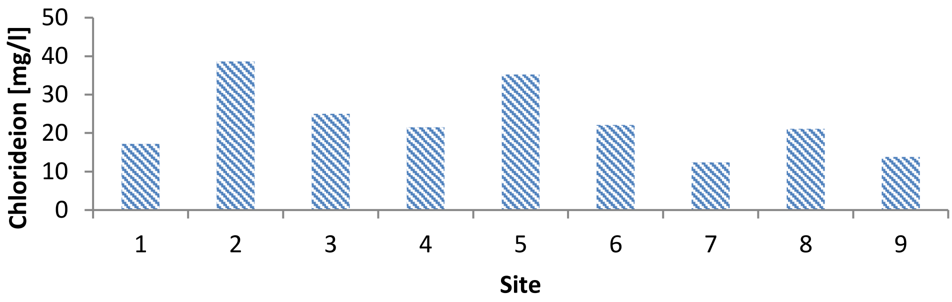

Fig. 10: The average chloride ion of wells area

The alkalinity of water comprises the sum of bicarbonate and carbonate of Calcium, Magnesium, Sodium, and Potassium. It provides the buffering effect of PH. The lowest alkalinity values were recorded in Banee spring with a minimum value of 161.33 mg/l in November, while the highest values were recorded in Nabakhe and Deawe spring with the highest value of 426.33mg/l in Deawe spring. As shown in Fig. 11 from Table 10. All the springs exhibit seasonal variation in Alkalinity, except Kadane spring. In this study are significantly lower than those reported by Batool et al. (2018).

Table 10: Alkalinity variation between selected springs for the study period

	Oct.	Nov.	Dec.	Jan.	Feb.	Mar.	Apr.
Dostaka	223	225.67	264.67	258.67	299.3	264.33	283
Baze	250.33	266	238	279	258.33	213.67	170
Deawe	320.33	335	368.67	354	418.67	407	426.33
Kafea	248.67	262	251.33	280.67	251	201.67	181.13
Napakhe	326.67	323	360	338.33	375	315.33	328.33
Kadane	191.67	190.33	164.67	182.67	196.7	201.33	191
Banee	170	161.33	192	179.33	220	173.67	202
Halora	319	344.67	299	361.67	364.33	344.67	282.67
Hanare	254.33	249.33	268	240.33	293	262	283.77

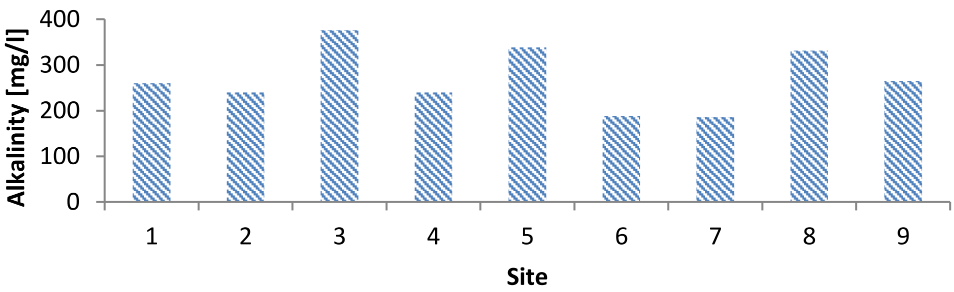

Fig. 11: The average alkalinity of wells study area

4. Conclusion

- The water quality of the studied Akra district springs was not so fresh but it is acceptable for drinking for the studied parameters.
- Akra springs within the studied area were of conduit type as they exhibit monthly variation in temperature and water quality.
- Akra springs within the studied area have very hard water due to the geological formation.

- The water of Akra springs within the studied area cannot be utilized for the bottled water without treatment.

Compliance with ethical standards

Conflict of interest

The authors declare that they have no conflict of interest.

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