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Groundwater quality in some areas of Sirte City, Libya

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A B S T R A C T

This study investigates groundwater quality in various areas of Sirte City, located in northern Libya, focusing on identifying the most prevalent pollutants. The research specifically examines pH levels and other key pollution indicators, including total dissolved solids (TDS), salinity, and electrical conductivity (EC) of the water. The study is centered on assessing the physicochemical parameters of groundwater in the Sirte City area. A total of twenty-eight surface water samples were collected from different directions (west, east, and south) around Sirte City during the Winter season, from January to March 2016. The overall findings revealed mean to all directions of water quality parameters as follows: pH 7.37, TDS 7419.9 mg/L, salinity 8.91 mg/L, EC 10.2 µS/cm, Na 225 mg/L, K 30.0 mg/L, and total hardness (TH) 11.4 mg/L. The results are shown for each direction separately, TDS 3324 mg/L in the south, 13663 mg/L in the west, and 5272 mg/L in the east. Similarly, the average salinity values ranged from 3.70 mg/L in the south, 16.2 mg/L in the west, to 6.80 mg/L in the east. The results further indicated that the average pH, conductivity, and metal concentrations were highest in the western wells of Sirte City compared to the eastern and southern wells. The average TH values were 6.57 mg/L in the south, 13.5 mg/L in the west, and 14.1 mg/L in the east. Additionally, the concentrations of heavy metals in the studied samples were below the detection limits of the measurement devices used. Notably, the lowest concentrations of heavy metals were found in the southern and middle-western regions, while the highest concentrations were observed in the eastern region. Furthermore, it was observed that the water samples from the western direction were the most saline, whereas those from the eastern and southern directions were less saline.The all results above were increasing than permissible limit According to World Health Organization specifications .

The results of this study suggest that all collected surface water samples from the Sirte region are natural and acceptable for livestock and agricultural use, as well as for cleaning purposes. However, simple treatment is necessary to make the water suitable for human consumption, particularly when compared to WHO and Libyan water quality standards.

1-Introduction

Water is one of the most vital resources for all living organisms, including humans, and thus stands as one of the most precious substances on Earth [1],[2]. Recently, there has been a marked increase in the demand for water across its various uses, including drinking and other essential purposes. Despite its crucial role in sustaining life and human survival, many countries face significant challenges in accessing adequate supplies of safe drinking water and sufficient resources to maintain basic hygiene [2]. Although approximately 71% of the Earth's surface is covered by water [3], potable fresh water is primarily found as groundwater within aquifers. The distribution of water across different resources—oceans, ice caps, glaciers, groundwater, lakes, and rivers—is approximately 98.93%, 1.05%, 0.009%, and 0.0001%, respectively [4].

The presence of potentially harmful heavy metals (PHMs) in drinking groundwater sources is frequently reported as a critical environmental issue [5]. Common PHMs, including arsenic (As), zinc (Zn), lead (Pb), mercury (Hg), manganese (Mn), iron (Fe), copper (Cu), and nickel (Ni) [6], are released into groundwater through both natural processes and human activities [7],[8]. These metals can have detrimental effects on human health, contributing to various diseases such as cancer, hyperkeratosis, pigmentation disorders, peripheral vascular disease, lung disease, and hypertension, with health impacts ranging from acute to chronic [9],[10].

Groundwater serves as a crucial source of drinking water in arid and semi-arid regions. However, in recent periods, the quantity and quality of groundwater have faced increasing challenges, particularly related to the loss of freshwater sources and the degradation of water quality [11],[12]. The quality of groundwater is influenced by multiple factors, including recharge sources, lithology, hydrodynamic conditions, water extraction processes, water-rock interactions such as mineral dissolution, ion exchange, and redox reactions, as well as anthropogenic activities [13],[14].

This study provides a comprehensive definition of water and its essential properties, with a particular focus on groundwater. It examines the extent of pollution by various ions and heavy elements in the vicinity of Sirte City, highlighting the environmental and health implications of such contamination

2.Materials and Methods

2.1. Collection the samples:

A total of 24 samples were collected from regions west, east, and south of Sirte City,in winter sesone with each sample taken at approximately 500-meter intervals within a 15-kilometer radius from the city center The depth of the wells ranges from 80 to 140, in the winter season as depicted in Figure 2.1. The samples were collected in polyethylene bottles immediately after measuring the pH and electrical conductivity (EC) on-site using field instruments. Three drops of nitric acid (HNO_3) were added to each sample for preservation, and the samples were stored at a temperature below 4°C until further analysis. All samples were kept refrigerated below 4°C post-collection to ensure the integrity of the measurements. electrical conductivity (EC) were measured directly at the sample sites using handheld analyzers. Sodium (Na) and potassium (K) concentrations were determined using flame photometry at the Ras Al-Anof Gas and Oil Company laboratories. All measurements and analyses in this study were conducted following established scientific methodologies and using the specified instruments to determine ion concentrations in water samples collected from different directions relative to the Sirte station.

Figure (1.1) Map of sampling sites ,sirte city, libay.

2.1.Chemicals

The names of the chemicals that were used in this research are as follows. pH calibration solution, EC device solution, buffer solution pH = 10, EDTA standard solution 0.01N, Eriochrome black T, nitric acid 0.1N

2.2.. Instruments

The name of the devices used in this research is as follows: pH meter and electrical conductivity meter (EC). Sensitive balance, water bath, atomic absorption spectrometer -Thermo AAS, electric oven

3. Results and discussion

3.1. pH meter

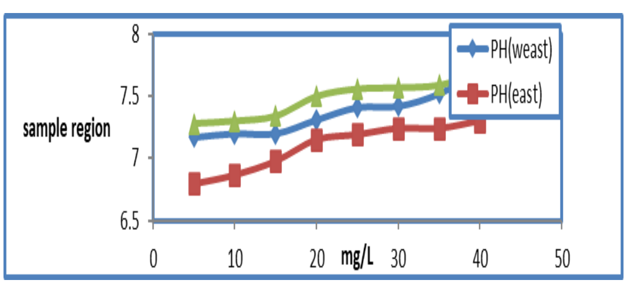

Figure 3.1 pH of water samples from all direction around Sirte City

As shown in Figure 3.1 and Table 3.3, the pH values of the samples across all regions around Sirte City ranged from 7.17 to 7.60 in the west, 6.9 to 7.5 in the east, and 7.3 to 7.8 in the south. A comparison of these pH results indicates no significant variation between the samples, with all pH values falling within the normal range as specified by both Libyan standards and World Health Organization (WHO) guidelines for drinking water, which recommend a pH range of 6.5 to 8.5. The pH levels were observed to follow the order: South > West > East.

3.2. Total Hardness:

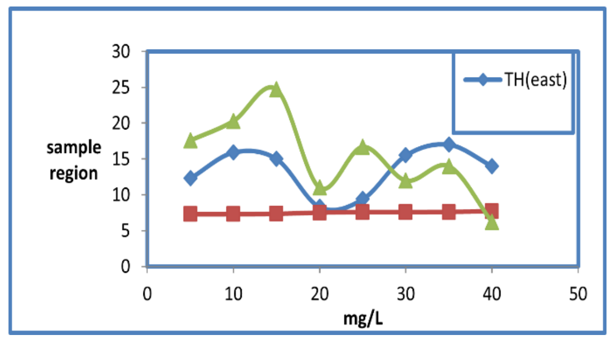

Figure (3.2) Mean TH of water samples from all directions around Sirte City

Hardness, which indicates the concentration of magnesium and calcium in water, was analyzed across all regions around Sirte City. According to Figure 3.2, total hardness was observed to range from 2.5 to 24.7 mg/L in the west, 8.3 to 15.9 mg/L in the east, and 9.1 mg/L in the south. The results presented in Table 3.3 and Figure 3.2 indicate that the hardness values in the study area are within the permissible limits for drinking water and groundwater, as established by Libyan standards and World Health Organization (WHO) guidelines. All recorded values are well below the Libyan standard specification limit of 200 mg/L. The hardness levels followed a regional gradient, with the west region showing the highest concentrations, followed by the east and then the south.

3.3. Total dissolved solids (TDS):

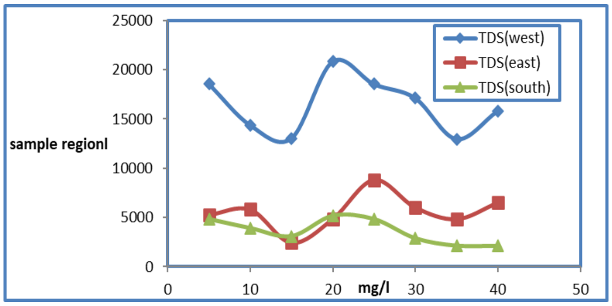

Figure (3. 3) TDS of water samples from all direction around of Sirte City

Total dissolved salts (TDS) were analyzed and compared across different regions, as presented in Table 3.3 and Figure 3.3. The results indicate that samples from West Sirte exhibited a TDS range from 5818 to 18,562 mg/L. In comparison, samples from East Sirte ranged from 2128 to 8830 mg/L, while those from South Sirte ranged from 2108 to 5165 mg/L. When these results are compared with Libyan standards, it is evident that the TDS levels in the majority of the samples exceeded the permissible limits. The TDS concentrations followed a regional gradient, with the highest levels observed in the west, followed by the east, and then the south.

3.4. Degrees of salinity (Soil Salinity):

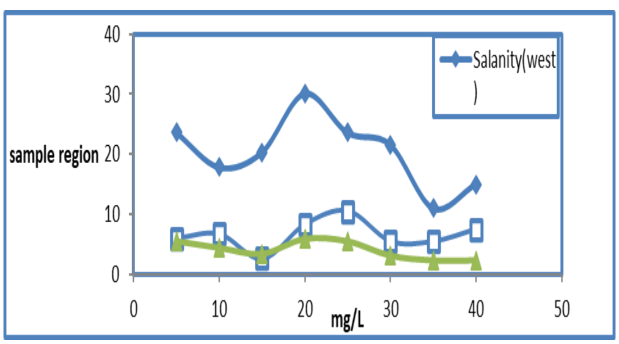

Figure 3.4 Salinity values of water samples all direction around of Sirte City.

Salinity levels were analyzed and compared across different regions, as shown in Figure 3.4 and Table 3.3. The results indicate that salinity in the West Sirte region ranged from 2.3 to 32.67 mg/L. In the East Sirte region, salinity levels ranged from 2.6 to 10.5 mg/L, while in the South Sirte region, values ranged from 2.3 to 5.9 mg/L. The salinity levels followed a regional gradient, with the highest concentrations observed in the west, followed by the east, and then the south.

3.5. Electrical conductivity:

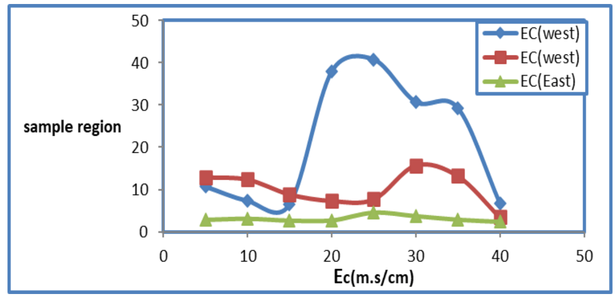

Figure 3.5 Conductivity values for water samples all direction around of Sirte City

The conductivity was studied and compared with each other according to Table 3.3.and Fig 4. 4 The results showed that West Sirte samples had range from 17.9 to 40.8 ms / cm.and the samples of East Sirte had a total range from 3.47 to 15.7 ms / c m.The results showed that South Sirte samples had a total range from 2.83 to 4.6 ms / cm. By comparing the results of the electrical conductivity of the study samples with the Libyan specifications, which are supposed to not exceed 1500 microspun/cm and the World Health Organization specifications. per liter of drinking water, which is supposed to not exceed 400 µM/cm. Therefore, all samples exceeded the permissible limit according to World Health Organization specifications. However, 8 were below the upper limit of Libyan specifications (Figure 3.4). value graduated as its West >East >south.

3.6.Concentration of sodium (Na+).

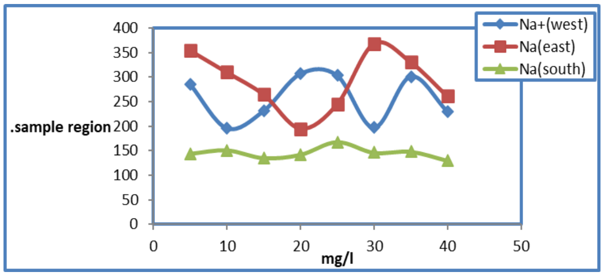

Figure (3.6) Sodium concentration of water samples from all direction around of Sirte City

The concentration of sodium in the samples was analyzed and compared, as detailed in Table 3.3 and Figure 3.5. The results showed that the West Sirte samples had a concentration range from 130.4 to 303.3 mg/L, the East Sirte samples ranged from 94.9 to 354.5 mg/L, and the South Sirte samples exhibited a range from 129.9 to 246.2 mg/L.According to [15], sodium (Na) can be produced through the dissolution and weathering of sodium-bearing minerals (e.g., halite and sodium plagioclase), as well as from anthropogenic sources, including industrial, domestic, and animal wastes. The mean sodium concentrations followed a descending order: West region > East region > South region, surrounding Sirte City.

3.7. Potassium concentration (K^+):

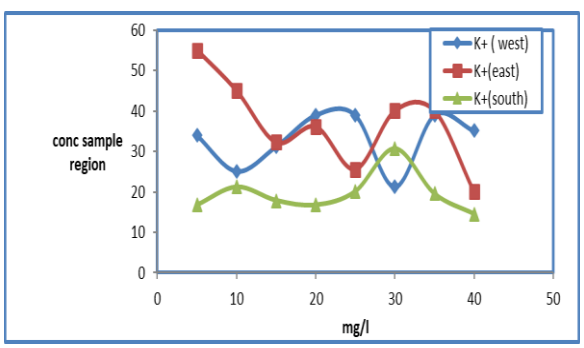

Figure 3. 7 Values of potassium concentration of water samples from all direction around of Sirte City

The potassium concentration in the samples was analyzed and compared, as shown in Table 3.3 and Figure 3.7. The results indicated that the West Sirte samples had a concentration range from 21.2 to 39 mg/L, the East Sirte samples ranged from 25.6 to 45.1 mg/L, and the South Sirte samples exhibited a range from 16.7 to 30.7 mg/Potassium (K^+) primarily originates from K-bearing minerals, such as those found in rainwater and clay minerals, as well as from agricultural fertilizers and domestic wastes [16]. The mean potassium concentrations followed a descending order: West > East > South.

3.8. Heavy elements:

The concentrations of certain heavy metals, including Pb^{2+} and Cu^{2+}, were measured, and all were found to be below the detection limits of the instrument, with levels recorded at less than 0.05 ppm. These results indicate that the concentrations of these elements were either non-existent or very low, in compliance with Libyan standard specifications. Consequently, these elements do not contribute to groundwater pollution in the study area, likely due to the absence of heavy industries in the region.

3.9. Electrical Resistivity:

all measured values of electrical resistance were between 0.0001-0.0002 m.c.cm.

Table 3.3 Results of water samples from different areas direction of Sir

area	K^+	Na^+	Ω.c	Salinity ppt	TH	TDS	EC	PH	No
Twila farm	36.222	94.958	0.0001	5.5	8.3	4835	7.33	7.15	1

er									
Al-\ Qardabiyah	18.44	159.125	0.0001	5.5	2.3	4835	3.40	7.87	2
Al-Zaid - 1	16.778	142.042	0.0002	2.3	7.7	2128	2699	7.5	3
Abu Hadi 3	16.778	144.125	0.0002	2.3	7.3	2128	2832	7.34	4
Sultan Project-4	55.111	354.542	0.0001	8.1	14. 4	6947	12.9	7.24	5
3 Haniwa	45.111	309.958	0.0001	6.9	13.1	6031	12.39	7.19	6
-2 Al-Zaid	19.556	148.292	0.0001	5.9	5.7	5165	2889	7.84	7
Al-Zaid -3	14.556	129.958	0.0002	3.4	2.5	3101	2365	7.59	8
Al-Zaid -4	23.444	171.625	0.0001	4.4	9.1	3915	3.77	7.69	9
1 Sawawa	20.111	160.792	0.0002	2.6	14	2438	3.47	7.31	10
2 alasile	34.	285.	0.0001	6.7	20.3	5818	10.7	7.2	11
Sawawa 2	37.889	296.208	0.0001	6.7	12.3	5818	11.14	7.59	12
2 Haniwa	25.667	244.542	0.0001	5.5	9.4	4843	7.68	7.24	13
Sultan Project-2	32.33	264.542	0.0001	7.5	15.5	6496	8.8	6.9	14
Sultan Project-1	40.111	368.292	0.0001	10.5	31.5	8830	15.70	6.8	15
3 Haniwa	40.111	330.792	0.0001	8.3	17	7108	13.20	6.87	16
algharbiaat 1	21.222	197.042	0.0001	3.3	4.1	3037	4.76	7.42	17
Sawawa 3	34.000	286.708	0.0001	6.0	15.9	5267	8.86	7.41	18
Abu Hadi 5	21.22	151.208	0.0002	2.3	.94	2142	3.1	7.5	19
Abu Hadi 2	17.889	135.375	0.0002	2.3	17.8	2108	2656	7.3	20
Abu Hadi 1	20.111	167.875	0.0002	3.3	7.5	2886	4.60	7.28	21
Abu Hadi 4	30.667	246.208	0.0001	5.5	0.9	4835	3.76	7.56	22
2 alasile	25.111	196.208	0.0002	3.2	17.6	2959	7.33	7.17	23

700 housing units 1	31.22	231.208	0.0001	21.6	8.3	1713	6.4	7.2	24
Al-Arbaeen, east of Sirte	35.111	130.375	0.001	23.6	2.5	1856	1797	7.7	25
700 housin	39.00	306.625	0.0001	23.6	24.7	1856	1314	7.31	26
algharbiaat 2	39.00	303.292	0.002	30.1	16.7	2886	9.14	7.41	27
algharbiaat 2	39.00	301.208	0.000	17.8	14	1436	9.25	7.52	28
Sawawa 1	18.44	118.292	0.004	10.1	4	1104	1406	7.3	29

Conclusion

The results indicate that groundwater contamination is present in all areas surrounding the city of Sirte—extending towards the west, north, and south—up to approximately 15 kilometers from the city center. High concentrations of several measured elements were observed, along with physical properties that fall outside the permissible limits both locally and internationally. The quality of this water resembles that of surface water, tending towards salinity, and is currently used for irrigating certain agricultural crops and for livestock.

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الملخص العربي

تمت هذه الدراسة إلى مناطق حول مدينة سرت شمال ليبيا ، حيث تتدرس الملوثات الأكثر شيوعًا في المياه الجوفية، منها الأس الهيدروجيني ومؤشرات التلوث الأخرى مثل المواد الصلبة السائلة والملوحة والتوصيل الكهربائي للمياه. ركزت على تقييم البارامترات الفيزيائية الكيميائية للمياه الجوفية في منطقة مدينة سرت. تم أخذ 28 عينة مختلفة من المياه السطحية من اتجاهات مختلفة من مدينة سرت الغرب و الشرق و الجنوب) ، العينات التي تم جمعها في أشهر يناير إلى مارس 2016 خلال موسم الأمطار.

أظهرت النتائج أن بارامترات جودة المياه مع المتوسط كانت على النحو التالي: pH 7.37 ، TDS 7419.9 ملغم/لتر، EC 10.2 ~ s/cm ، الملوحة 8.91 ملغم/لتر، Na^+ 225 mg/L ، K^+ 30.0 mg/L و TH 11.4 mg/L. وكانت متوسط قيم TDS جنوب 3324 وغرب 13663 وشرق 5272 ملغم/لتر، واضهرت النتائج أن متوسط قيم الملوحة تراوح جنوبًا 3.70 و 16.2 غربا . و 6.80 شرقا ملغم/لتر.و أظهرت النتائج أن متوسط قيم الأس الهيدروجيني والموصلية وتركيزات المعادن في غرب مدينة سرت كانت أعلى من القيم شرق وجنوب المدينة، وتراوحت متوسط قيم TH جنوبًا 6,57 والغرب 13.5 والشرق 14 ملجم/لتر .

كما أن تركيزات المعادن الثقيلة للعينات المدروسة كانت أقل من حدود الكشف للأجهزة المستخدمة للقياس. وكانت اقل

تركيزًا في الجنوب والاتجاه الغربي والأكبر كانت في الشرق، وبحسب ملاحظتنا بشكل عام، لاحظنا أن عينات الاتجاه الغربي كانت أكثر المياه مملحة بينما كانت العينات أقل ملوحة في الاتجاه الشرقي والجنوبي. كما أظهرت نتائج هذا العمل أن جميع عينات المياه التي تم جمعها من المياه السطحية في منطقة سرت طبيعية ومقبولة للاستخدام الزراعى والثروة الحيواني ، لذلك تحتاج إلى معالجة بسيطة حتى تصبح قابلة للاستخدام البشري، مقارنة مع معايير المياه فالصادرة من منظمة الصحة العالمية.

الكلمات المفتاحية : المياه الجوفية، نوعية المياه، المعادن الثقيلة، البارامترات الفيزيائية الكيميائية، ليبيا، مدينة سرت.