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Article

Hydro-chemical Quality of Well Water in Ghadames Area in Northwestern Libya

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Abstract: Aim of this research was to investigate the suitability of well water for the human consumption in the Ghadames area of northwestern Libya. Having in mind that water is valuable natural resources and limiting factor for the life and that the fresh water plays vital role to sustain the international economic, and thus that well water recorded over the years extreme high salinity, this research was very necessary. Beside high salinity pollution of well water has become serious problem in the arid zones which should be addressed. For this study total of thirty different well water samples were collected during April 2016. The hydro-chemical parameters such as pH, electrical conductivity (EC), total dissolved solids (TDS), total hardiness (TH),calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), chloride (Cl), sulfate (SO4), bicarbonate (HCO3), fluoride (F), nitrate (NO3) and iron (Fe) were analyzed. Obtain results were compared with WHO and Libyan water standards. In this study, the most of the parameters of the water samples were beyond the permissible limits and analyzed water was not suitable for drinking.

Keywords: water; quality; chemical; physical; analyses;

1. Introduction

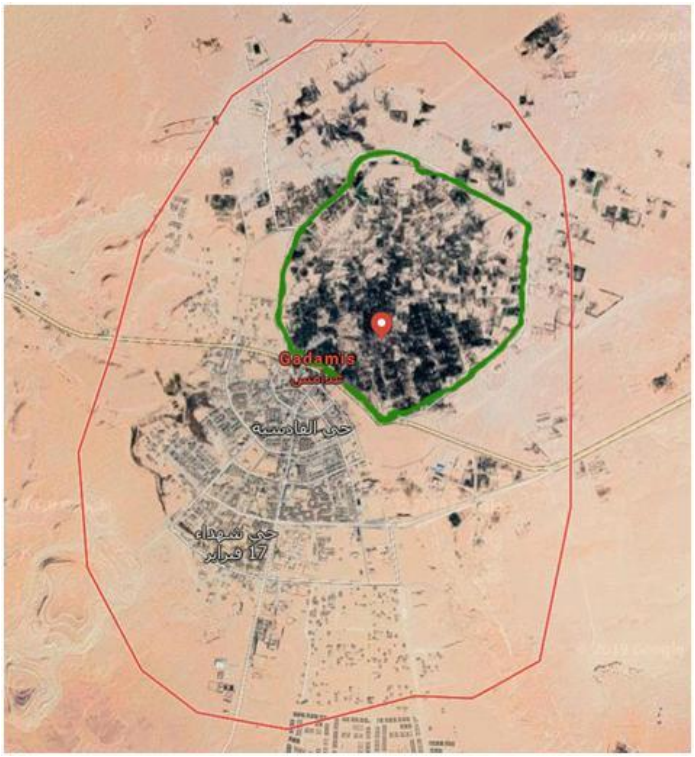
Water is a valuable natural resource and essential factor for sustainability. Well water resource is one key factor that play important role in sustaining the socio economic standards [1]. It supports various phases of development, including agriculture and industry. In arid and semi-arid regions, well water quality is considered a critical issue. The shortage of precipitation, unsustainable human activities and environmental pollution, are few examples of the challenges faced in Ghadames area in northwestern Libya [2, 3, 4]. Beside well water, the ground water of the northwestern part of Libya is the major water supply for all daily applications. Specifically, the groundwater in the Jiffarah Plain Basin in this part of the Libyan geography, has been under heavily use over decades by the rapidly expanding development. This development has affected adversely the quality of the well and groundwater, in terms of chemical, physical and biological aspects. Characterizing the properties of well water for specific application by its industrial or human consumption is considered vital for deciding the feasibility of the resource and its safeness for the public health and the environment. For human consumption, the chemical parameters of well and ground water should comply with the drinking water needs [5]. If these parameters exceeded the recommended values, the resource is considered unsafe. In many countries, different studies have been carried out to assess the suitability of ground and well water for human consumption. For examples, ground water quality in north east Jabal Alhasawnah was evaluated for its composition and suitability for drinking [6]. Nagwa et al. [7] carried out chemical and biological analysis to evaluate ground water quality in Shebna region,

Benghazi of Libya. Ground water quality for human consumption was assessed in Alshati district of Libya [8]. Shubhra et al. [9] studied the ground water quality and its suitability for human consumption in some parts of India. Hydro-chemical study was conducted in Birbhnm district, west Bengal to evaluate the suitability of groundwater for drinking purposes [10]. Ground water quality and its suitability for domestic purposes were assessed in district of Andra Pradesh by Hussainan and Rao [3]. Other researchers [4] studied the distribution of some chemical elements in ground water in Derna area, Libya, while chemical and biological properties of ground water were determined by Mabrouk and Saad [11]. Chemistry of ground water was assessed for drinking and agricultural purposes in Lahore, Pakistan, while Salehi and Zeinivand [1] studied the chemical and physical properties of ground water in Kuhdasht region, Iran. Different elements of cations and anions were measured to assess the ground water and its suitability for different purposes like, crop irrigation and human consumption in Yinchuan area, China [12]. However, in Libya, including the northwestern region, the data similar to such studies are not made on a major scale in the country. Therefore, the present study investigates the hydro-chemical qualities of well water in the northwestern region, particularly Ghadames area for drinking water purposes. The described area is known as "the pearl of the desert", stands in an oasis area that the society largely depends on.

2. Materials and Methods

Sample collection

The study area is situated in Ghadames (30°8′N 9°30′E), roughly 462 km to the southwest of Tripoli, near the borders with Algeria and Tunisia (Picture 1).



Picture 1. Target area of water sampling in Ghadames (30°8′N 9°30′E)

The maximum temperature is about 41°C in July, the hottest month of the year as well as short, warm winters with an average annual rainfall of 33 mm. Ground water is considered the main source of water supply in the study area. The dominant soils are sandy and sandy loam. The agriculture is considered one of the main activities in the area where barley, wheat, lattice, sparsely, carrots and fodder crops are grown. The current study has been carried out to assess the suitability of well water quality for the human consumption. A total of 30 well water samples were collected during April 2016 from Ghadames area. Water samples (Table 1) were collected from public and private wells

(W1), water sources in the health centers (W2), and schools (W3). First, the water was left to run for 10 minutes from the wells to pump out the standing water before taking the final samples. Each sample was immediately filtered using 0.45 μm filters of acetate cellulose and was transferred into 100 ml polyethylene bottles.

Table 1. Experimental design and water sampling.

Sample	Number of samples	Source of water sample
W1	10	Water from public and private wells
W2	10	Water from the health centres
W3	10	Water from the schools

Sample analyses

The samples were acidified, bringing down the pH to <2 by the addition of Merck™ ultrapure nitric acid (5 ml 6 N HNO3), and were used for cations analysis. Samples for anions analysis were collected into 250 cm3 polyethylene bottles without preservatives and were stored in an ice chest at a temperature of <4°C and later transferred to the laboratory of the Department of Engineering Management in Biotechnology, Faculty of Economics and Engineering management and stored in a refrigerator at a temperature of <4°C until analyzed. Immediately after sampling, parameters like pH, electrical conductivity (EC) fluoride (F) and iron (Fe) were measured in the field using a multi-parameter WTW (P3 MultiLine pH/LF-SET) field kits. Subsequently, the samples were analyzed in the laboratory for their chemical constituents such as calcium (Ca), magnesium (Mg), potassium (K), sulphate (SO4), chloride (Cl), sodium (Na), bicarbonate(HCO3) and nitrate (NO3) using standard methods as suggested by the American Public Health Association [13, 14, 15]. Concentrations of Ca and Mg were estimated titrimetrically using 0.05 and 0.01 N EDTA and those of HCO3 and Cl by H2SO4 and AgNO3 titration, respectively. Concentrations of Na and K were measured using a flame photometer (Model: Systronics Flame Photometer 128) and those of sulfates SO4 by turbidimetric method [16]. Nitrates, NO3, were analyzed by colorimeter with a UV–vis spectrophotometer [17]. Standard solutions for the above analyses were prepared from the respective salts of analytical reagents grades.

Statistical analyses

Standard statistical procedure such as ANOVA, mean (χ) and standard deviations (SD) within statistical software STATISTICA 13 was used. The results were compared with WHO and Libyan water standards for drinking water.

3. Results

The results of this research are presented in Tables 2, 3, and 4, while the summarized results of three water collection sites as an overall picture of water quality is given in Figure 1.

From the presented results it can be seen that the average pH value of water samples is 7.28 and that the values are in accordance with values given by WHO and Libyan water standards for drinking water. pH is a measure of how acidic or basic water is. The range goes from 0 - 14, with 7 being neutral. pHs of less than 7 indicate acidity, whereas a pH of greater than 7 indicates a base. pH is really a measure of the relative amount of free hydrogen and hydroxyl ions in the water. Water that has more free hydrogen ions is acidic, whereas water that has more free hydroxyl ions is basic. Since pH can be affected by chemicals in the water, pH is an important indicator of water that is changing chemically [18].

Table 2. Hydro-chemical well water quality from public and private wells.

Parameter	Average mean	SD	WHO	Libyan
pH	6.99	0.21	6.5-8.8	6.5-8.5
EC	3675.84	1501.22	-	-
TDS	2687.73	998.13	1500.00	1000.00
TH	1855.46	1200.13	500.00	500.00
Ca	412.03	145.17	75.00	200.00
Mg	305.42	288.51	50.00	150.00
Na	513.25	393.11	100.00	200.00
K	24.28	30.02	10.00	20.00
Cl	695.91	574.67	250.00	250.00
SO_4	1662.09	327.13	200.00	400.00
HCO_3	399.51	75.71	-	150.00
F	3.01	0.12	1.50	1.50
NO_3	127.81	38.67	45.00	45.00
Fe	0.31	0.09	0.30	0.30

Table 3. Hydro-chemical well water quality from the health centers.

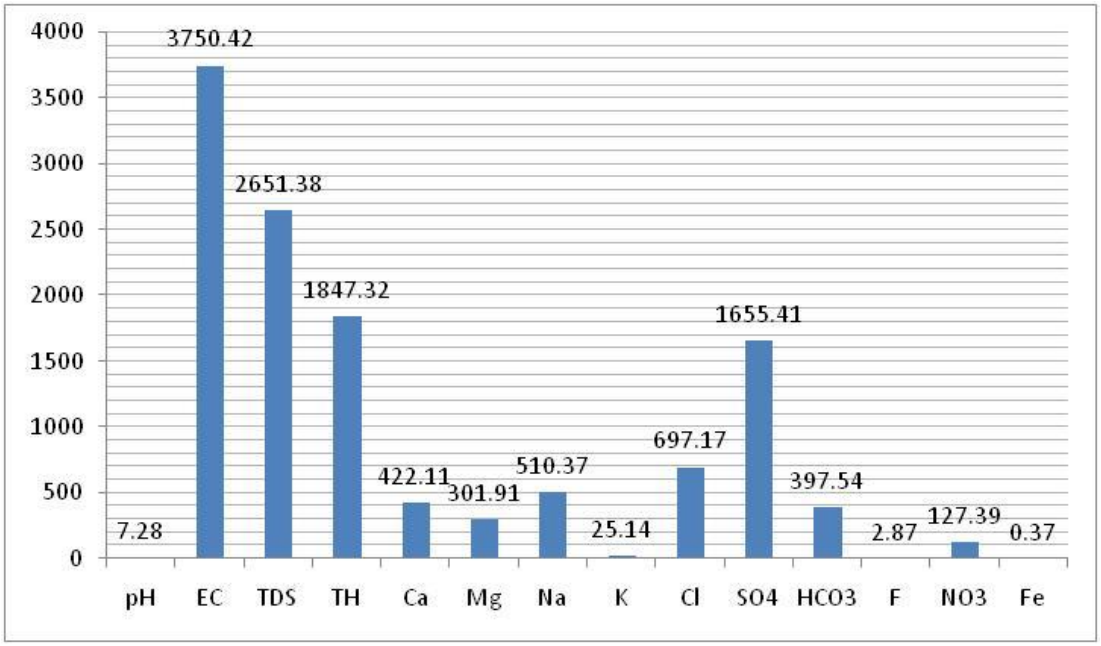
Parameter	Average mean	SD	WHO	Libyan
pH	7.6	1.47	6.5-8.8	6.5-8.5
EC	3764.36	856.27	-	-
TDS	2656.9	1287.33	1500.00	1000.00
TH	1837.22	754.74	500.00	500.00
Ca	435	220.04	75.00	200.00
Mg	275.91	145.91	50.00	150.00
Na	507.88	218.00	100.00	200.00
K	26.12	13.08	10.00	20.00
Cl	727.34	512.77	250.00	250.00
SO_4	1648.02	522.89	200.00	400.00
HCO_3	402.01	105.73	-	150.00
F	2.73	0.69	1.50	1.50
NO_3	129.16	28.05	45.00	45.00
Fe	0.42	0.19	0.30	0.30

Table 4. Hydro-chemical well water quality from the schools.

Parameter	Average mean	SD	WHO	Libyan
pH	7.25	0.11	6.5-8.8	6.5-8.5
EC	3811.05	1545.15	-	-
TDS	2609.52	1012.00	1500.00	1000.00
TH	1849.28	1368.05	500.00	500.00
Ca	419.3	132.09	75.00	200.00
Mg	324.39	311.04	50.00	150.00
Na	509.97	289.66	100.00	200.00
K	25.02	26.75	10.00	20.00
Cl	668.26	322.97	250.00	250.00
SO_4	1656.11	588.14	200.00	400.00
HCO_3	391.11	101.91	-	150.00
F	2.87	0.57	1.50	1.50
NO_3	125.2	37.25	45.00	45.00
Fe	0.37	0.13	0.30	0.30

While electrical conductivity (EC) isn't defined neither by WHO or Libyan standards, our results showed that the average EC from well water is 3750.42, where the similar results were obtained from Elmabrok [2] in his research. Total dissolved solids (TDS) found in well water samples in our research was highly increased (2651.38) compared those ones regulated by WHO and Libyan standards. The similar results were obtained by Nair et al. [19] with indication that water is excessively polluted and are unsuitable for drinking.

Figure 1. Summarized results of hydro-chemical well water quality from three collections sites.



4. Discussion

Our results regarding the total hardiness (TH) of well water are in accordance with the research of Attaf and Omara [20], which recorded values excided, those ones, recommended by WHO and Libyan water standards. Average values for Ca, Mg, Na, K and Cl obtained in our research are even for 50% higher from those values recommended by WHO and Libyan water standards for drinking water. The same higher values for these elements were reported by other researchers [21, 22, 23]. Sulphate (SO4) occurs naturally in most groundwater and well water, while in at high levels, sulphate can give water a bitter or astringent taste and can have laxative effects [24]. If sulphate in water exceeds 250 mg/L, a bitter of medicinal taste may render the water unpleasant to drink [25,26]. In our study results shows that the levels of SO4 is much higher then allowed limits which makes this water unsuitable for drinking, how in human as well in animals. In this research concentration of anions (CO3, HCO3, Cl, SO4 and NO3) as well as trace elements (Fe) overcomes all allowed limits which make well water in Ghadames area in northwestern Libya undrinkable. Our results are in accordance with other authors as well [27, 6, 12].

5. Conclusions

The study classifies the waters according to the utility and chemistry of well water in the Ghadames area in northwestern Libya. The major ion concentration suggests that predominant samples belong to the unsuitable category for drinking based on WHO and Libyan standards for drinking water quality. Based on the obtained results in can be concluded that the well water of Ghadames area is polluted and unsafe for drinking and cooking purposes. People should be advised to use small techniques to purify the water and to minimize the levels of the pollutants and also is essential to be educated and to have awareness on importance of health and water quality.

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Conflicts of Interest: The authors declare no conflict of interest.

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