Quality Assay Measurements of Groundwater in Wadijarif-Sirte-Libya

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Abstract

Sirte is a city that lies on the coast of the Mediterranean Sea being overwhelmed by the arid or the semi-arid climate. Across the extension of this city, there are several valleys descending from south to the north to be pouring into marshes across the long coast. The collected samples are subjected to different analyses, in order to conduct hydrochemical and bacteriological study of the study area, Chemical analyses have been conducted on those wells samples in terms of determining the concentration of main ions (Chloride Cl^-, potassium K^+, sodium Na^+, sulfate SO_4^{2-}, carbonate CO_3^{2-}, bicarbonate HCO_3^{--}, Silicon Si^{4+}, manganese Mn^{2+}, Barium Ba^{2+}, magnesium Mg^{2+}, calcium Ca^{2+}, nıtrate NO_3^-, NH_4^+, Alkalinity, electrical conductivity, acidity, pH and total dissolved solids TDS) and bacteriological analysis .For drinking, this groundwater are classified as very poor and unsuitable, furthermore, all analyzed samples for bacteriological content classified as contaminated and classified as unsafe too. Results showed that the concentration of (TDS) has been higher in wells. The increase in (TDS) in wells extending from south to the north, since (TDS) concentration and other ions were increasing the more we are coming close to the sea being a result of the sea waters' invasion. The study has come to the results that these waters are not suitable for drinking before treatment, because the rate of the total dissolved solids and ions are critically high. The wells ones which is an outcome of seawater leakage.

Keywords: *Sirte, Wadijarif, Hydrogeology, Groundwater quality, assessment, chemical analysis, bacteriological analysis*

1. Introduction

Water is an essential commodity to mankind, and the largest available source of fresh water lies underground. As the world's population increases, the demand for fresh water has stimulated for the development of underground water supplies. Inevitably, progresses in the form of modernization and urbanization have magnified the problem of the search for fresh water supplies. Efforts have increased to solve these problems; methods for investigating the occurrence, patterns, and movement of groundwater have been improved, better means for extracting groundwater have been developed, principles of conservation have been established, and research of several types has contributed to a better understanding of the subject (Todd, 1963).

Groundwater is an essential part of life; it is a vital source of water for domestic, irrigation and industrial uses in both urban and rural areas. The physicochemical and chemical properties of the groundwater determine its quality and suitability for irrigation and human consumption. The potential of groundwater is largely influenced by the specific geologic settings of the area (Elango and Kannan, 2007; Manimaran, 2012; Parihar et al., 2012; Tmava et al., 2013).

Groundwater is generally polluted;the pollution of groundwater regime is not only due to sub-surface waste disposal, but is also attributable to the seepage of contaminants from impoundment of toxic waste on unlined surfaces such as indiscriminate spraying of insecticides, pesticides and excessive use of chemical fertilizers etc. (Edmunds, 2003; Thangarajan, 2007; Abdul Jameel et al., 2012; Mumtazuddin et al., 2013).

Arid regions have being featured with strong solar radiation, intensive evaporation, significant temperature variations and frequent sand storm, which result in vulnerable environment, particularly water environment due to the insufficiency and non-uniformity of precipitation. Therefore scientific and comprehensive insight into the water resources and environment in such a region is important for water sustainability (Sen, 2008).

The rate of population growth in Libya is considered a high rate and creates a demand for water at a great rate and one of the most important reasons that led to the emergence of the problem of water scarcity. This added to the great diversity in the water demand for the versatility that characterized recent decades, which covered all aspects of life (Mohamed, 2014).

Groundwater is an important water resource in both the urban and rural areas of Libya for domestic as well as for agriculture purposes (Kumar et al., 2014). Libya as many other regions under arid climates suffer from inadequate water resources to cover all the needs of this rapidly developing country (Elgzeli, 2010).

The Libyan coastal area, south of the Mediterranean Sea, is among one of the different types of water systems, which has a common and specific water characteristic (El-Ghawi, 2005). The intrusion of salt seawater is a groundwater pollution problem in many coastal cities and towns (Kumar et al., 2014).

2. Materials and Methods

All the samples brought from the field were subjected to chemical analysis, aimed to determine the concentration of the following ionized elements: Sodium (Na^+), Potassium (K^+),Calcium (Ca^{+2}), Magnesium(Mg^{+2}),Chloride (Cl), Bicarbonate(HCO_3^-), Carbonate (CO_3^{-2}), Sulphate (SO_4^{-2}), NO3, NH4 and others minor ions Sr, Mn, Si, Ba. In addition to the cation and anion determination, the electrical conductivity (EC), the total dissolved solids (TDS), pH and the Alkalinity ($CaCO_3$ mg/l**)** have been measured. Doubled check measurements of borehole depth (m), groundwater depth below ground (m), and converted groundwater elevation from the Sea Level (m) and water temperature *T* (°C) have also been taken at the site during field work

Chemical Analysis

The analyses of water samples were carried out according to the standard methods for examination of water and wastewater **[2].**

pH

The pH was measured using BOECO PT-370 pH/mv meter, Germany.

Electrical Conductivity (EC)

It is measured using ATC bench electric al conductivity meter, HANNA, model HI 8820. The standard unit of electrical conductivity is the reciprocal of the resistance in Ohms and is written in terms of microseimens per centimeter (μS/cm) at 25^0C.

Total Dissolved Solids (TDS)

Gravimetric method is being used to determine TDS. A well-mixed sample was filtered through a standard glass fiber filter. The filtrate was evaporated and dried to constant weight using the evaporating porcelain dishes and oven model HI-9321 at 103-105°C.

Alkalinity:

A) Total Alkalinity is expressed in terms of the number of milligram equivalent of carbonate and bicarbonate and hydroxyl groups.
B) Methyl orange was used as indication for total alkalinity determination.
C) Titrate with sulfuric acid 0.1N or HCl 0.1N until flectional point appear.

Hardness of water:

The hardness is expressed in terms of the number of milligram equivalents of soluble Ca^{++} and Mg^{++} per liter of water.

Anions analysis

Sulfate (SO_4^{--}): The sulfate was determined by spectrophotometer which detected the absorption at 540 nm **[3].**

Chloride (Cl^-): The chloride was determined by (MOHR) method which used silver nitrate solution and potassium chromate as indicator **[3].**

Nitrate (NO_3^-): The nitrate was determine by spectrophotometer at 220 nm.The presence in the ground water or surface water is good indicator for water contamination which product by chemical activity **[3].**

Bicarbonate (HCO_3^-): The bicarbonate was determined by titration with diluted hydrochloric acid and methyl orange indicator **[3]**

Cations analysis

The concentration of calcium, potassium, magnesium, manganese and sodium determined using Flame Atomic Absorption Spectrophotometer (GBC Scientific Equipment SAVANTAA) according to condition shown in the **Table (1)**

Heavy metals Analysis

Samples were filtered using filtration system through 0.45 µm-pore-diameter filter paper then analyzed for ions using atomic absorption spectrophotometer (iCE 3000 Series AA Spectrometer–Thermo Scientific)

Bacteriological Analysis of Groundwater Samples.

Sterile 250 ml plastic bottle was taken for sample collection. Carefully unscrew the cap and immediately hold the bottle under the water surface of the wells and fill. Membrane filters (MF) method described by **[8]** was strictly followed; 100 mls of each water sample was filtered through sterile membrane which retained the bacteria on its surface. The membrane was removed aseptically and placed on a MacConkey medium that was then incubated at 37°C for 24 hr. Coliform colonies (indicating faecal contamination) growing on the surface of the membrane were counted and recorded as Coliform density (total Coliform colonies per 100 mL) or colony forming unit (CFU).

3. Results and Discussion

The data have been handled and interpreted in the following to understand groundwater salinization, general hydro geochemical evolution of groundwater. **Table (2)**

In addition, the proportion of major ions in shallow groundwater is presented in **Figure 2.** From these two pie charts, it can be seen that Na^+ and Cl^- are the prevalent cation and anion. The relative abundance of the cations - is Na+ > Ca2+> Mg2+ > K+, and that of the anion is Cl-> SO42-> HCO3 for shallow-groundwater.

Total Dissolved Solid and Hydro Chemical Type of Groundwater:

Total dissolved solid (TDS):

Total Dissolved Solids (TDS) is a measure of the combined content of all inorganic and organic substances contained in a liquid in: molecular, ionized or micro-granular (colloidal solids) suspended form. The principal application of TDS is in the study of water quality, although TDS is not generally considered a primary pollutant it is used as an indication of aesthetic characteristics of drinking water and as an aggregate indicator of the presence of a broad array of chemical contaminants. According to TDS in water, groundwater is classified as fresh water (TDS<2.5g/L), slight saline water (2.5g/L<TDS<5g/L) and saline water (TDS>5g/L) in Groundwater Standard of Libya **[13].**

The TDS of sample groundwater in the study area ranges between the 3201 and 8369 mg/l, identified as salty water. From the TDS we can note that TDS increases dramatically from the WadiJarif upstream to downstream by 5500 mg/l.

Spatial Variation of Groundwater Chemical Composition:

Sample Groundwater:

Taking into account the nearly "linear"" distribution of the sample wells in the direction of groundwater flow, the spatial variation of hydro-chemical characteristics then can be analyzed along the groundwater flow, namely the direction from inland to the sea.
According to **Figure 3** variations off concentrations of Cl^-, Na^+, $So_4^{2--}$are in a good phase with that of TDS along the flow path. Generally, ion concentrations of groundwater in the south are much lower than that in the downstream of discharge region, and a dramatic fall occurs at the point of 70 km from the coast. TDS slumps from 7044 mg/L to 34991 mg/L and the concentration of Cl^- fells down to 2943 mg/L from 834 mg/L at that point. Similarly but not sharply ions of Ca^{2+} and Concentra Mg^{2+} decrease from 662 mg/L to 331 mg/L and 332 mg/L to 152 mg/L respectively **Figure 4**. Additionally, several minor components such as Mn^{2+}, Ba^{2+} and Si^{2+} fluctuated along the flow path with no obvious increase or decline **Figure 5.**

4. Bacteriological Contaminants

Groundwater also contains a broad spectrum of microbial types similar to those found in surface soils and waters. These microbes encompass bacteria, fungi and protozoa, and are representative of most physiological types. On occasion pathogenic viruses, bacteria and protozoans of gastrointestinal origin from domestic, agricultural and other anthropogenic activities, may infiltrate through soils, sediments and rocks to the underlying groundwater [10].
Faecal coliforms bacteria Maximum Acceptable Concentration for Drinking Water is none detectable per 100 mL **[7, 15].** Coliform bacteria are present in the environment and feces of all warm-blooded animals and Humans **[14].**The faecal coliforms bacteria form per 100 ml from 10 well isolated from the studied groundwater samples of WadiJarif(Table 3) are ranged from 20 to 140 CFU/100 mL.
The total count of coliforms bacteria Sources of Total and Fecal Coliform in groundwater can include:
•Agricultural runoff drainage water, effluent from septic systems or sewage discharges and Infiltration of domestic or wild animal fecal matter **[16].**
The total counts of coliform per 100 mL isolated from 10 well samples of Wadijarif (Table3) are ranged from 40 to 2400 CFU/100 mL.
Faecal Streptococci bacteria, the total estimate of the number of bacteria in the water gives a general idea of the degree of bacterial contamination of the water without reference to the types of bacteria in it**[1].**The faecal Streptococciform per 100 ml isolated from 10 well samples of WadiJarif are ranged from 20 to 500 CFU/100 mL., Table (3).

5. Conclusions and Recommendations

Conclusions

Geology and hydrogeology of the Wadijarif have been characterized based on limited previous information and much current collected data. A hydrogeological concept of the groundwater system was established. Hydro geochemistry was employed to characterize the hydrochemical processes for water origin and evolution in groundwater systems.

1- Generally the quality of the underground water of the investigation zone not suitable as a drinking water before treatment (must be treated).

2- All pH values in the normal range.

3- The observed water quality changes (e.g. TDS and ions) from southern to northern part of the area with a remarkable rise at around 70 km and 55 km off the coast for sample well groundwater respectively.

4- These indicate mixing process with ancient salt water in shallow groundwater, whilst modern seawater intrusion more likely is induced in deep water apart from mixing with saline or brackish water in paleo-processes as indicated from geochemical evolution.

5- Artificial abstraction has also induced mixing of modern water and local old saline groundwater.

6- Among different bacteriological parameters measured in the studied groundwater of WadiJarif, the fecal coliform bacteria form from 10 wells isolated from the studied groundwater samples of WadiJarif are ranged from 20 to 140 CFU/100 mL. The total count of E. coli form ranged from 40 to 2400 CFU/100 mL. The Fecal Streptococci form per 100 mL ranged from 20 to 500 CFU/mL. which revealed that this groundwater is classified as unsafe.

Recommendations

1. Putting a permanent monitoring program to observe groundwater quality and determine the annual and seasonal changes in order to put a proper strategy to protect and remediate the aquifer especially that the groundwater is the lonely water resource in WadiJarif area.

2. Control actions of private water well drilling companies by the related authority to limitation the random and unscientific wells drilling.

3. Conclusions about seawater intrusion will be much more reliable if a comprehensive isotopic analysis should be carried out with support of other trace elements such as Br and I to be introduced as markers for the seawater intrusion.

4. Design and construction of monitoring wells must be planned for better control of seawater intrusion.

5. Groundwater contamination from organics and heavy metals is not my scope in this study but this is an important area for future work in this part of Libya.

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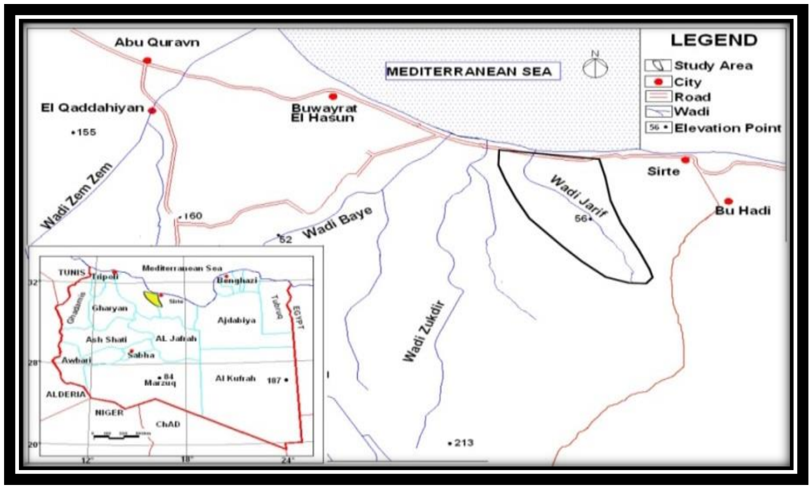

Figure 1. Location map of Sirte showing WadiJarif.

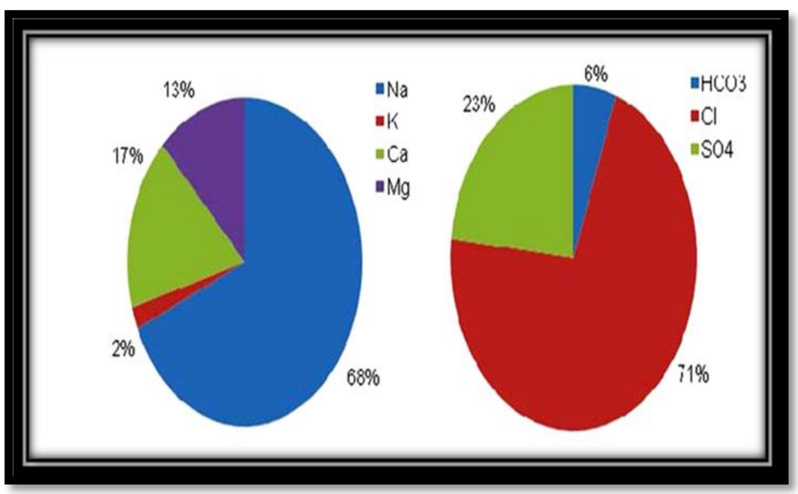

Figure 2. Proportions of Major Ions as mg/L in Groundwater

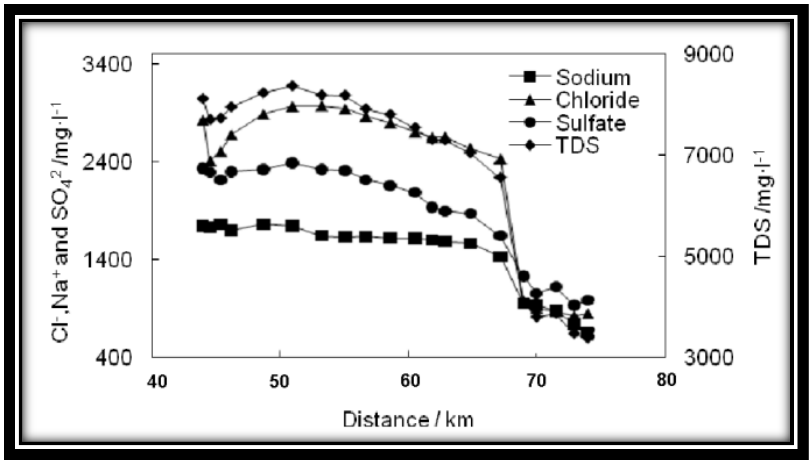

Figure 3. **Variation of TDS, Cl-, Na+ and $SO_4^{2-}$with Distance from the Sea**

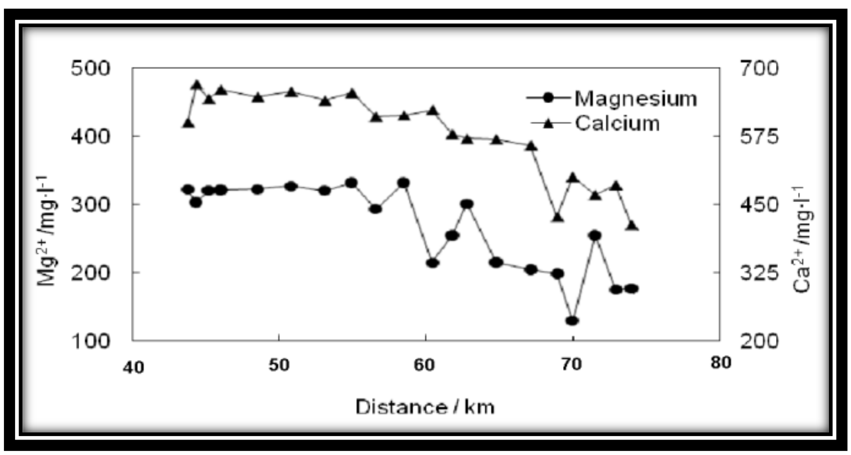

Figure 4. Variation of Ca^{2+} and M g^{2+} with Distance from the Sea

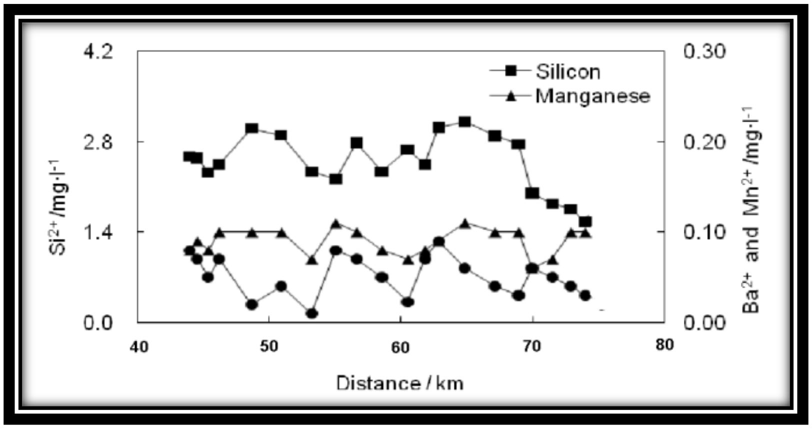

Figure 5. **Variation of Ba^{2+}, Mn^{2+} and, Si^{2+} with Distance from the Sea**

Table 1. Conditions of Flame atomic absorption spectrophotometer.

Element	Wave length (nm)	Slit width(nm)	Fuel	Oxidant	Measurement
Ca	422.7	0.5	C_2H_2	Air	Absorbance
K	766.5	0.2	C_2H_2	Air	Emission
Mg	285.2	0.5	C_2H_2	Air	Absorbance
Na	589.0	0.2	C_2H_2	Air	Emission

Table 2. Summary of groundwater hydrochemistry in WadiJarif_sirt

	Shallow groundwater		
	Maximum	**Minimum**	**Average**
Ph	7.69	7.05	7.23
TDS(mg/l)	8368.52	3209.49	5578.33
Hardness (mg $CaCO_3$/l)	3017.58	1300.41	2162.53
Na^+(mg/l)	1760.00	507.50	1154.23
K^+(mg/l)	72.00	53.00	63.53
Ca^{2+}(mg/l)	670.20	320.08	501.03
Mg^{+2}(mg/l)	331.95	115.25	218.39
HCO_3^-(mg/l)	331.95	214.70	244.42
Cl^-	2975.00	823.40	1802.06

Table 3. The total count of coliforms bacteria, Faecal coliforms and Faecal Streptococci isolated from the studied groundwater samples of WadiJarif.

Sample No.	Well Name	MPN/100ml		
		Total Coliform	Faecal Coliform	Faecal Streptococci
1	Ahmed	300	140	1<
2	Alkazan	110	80	80
3	Alfergania1	1<	1<	20
4	Alfergania2	40	1<	1<
5	Alnakos	170	1<	20
6	Almohageren	1<	1<	40
7	Alachren	1<	1<	130
8	Amgahed	1<	1<	80
9	Moaskarsetean	130	1<	130
10	Alsoada	2400	20	500
WHO limit		<1	<1	<1