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Quality of Water Resources in Kufra Basin, SE Libya

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Abstract: Kufra basin has a maximum thickness of 900 m, where located in the south-eastern part of Cyrenaica in Libya and covers of about 400,000.00 km^2. The sediments of the Kufra basin are mainly continental or marginally marine sandstones clays and shales, The large central part of the kufra basin was occupied by the Upper Cretaceous Nubian sandstone. The Nubian sandstone is one of the major sedimentary basins occur in eastern Libya. Information from water wells drilled in the Kufra basin indicates that Nubian sandstone consists mainly of unconsolidated sandstones interbedded with varying amounts of clays and shales. The main water resources studied in Kufra are derived from the ground water drilling wells are variable in depth where the total depths are ranging in meter from 140 m to 333 m. This paper focus on the parameters including pH values of 7.16 to 7.35, electrical conductivity (E.C) values of 104.8 to 1800 mg/l. The water quality is very fresh with dissolved solids (T.D.S) typically less than 162 mg/l, sodium (20.02 – 295 mg/l), potassium (4.48 – 23 mg/l), magnesium (9.15 –25.25 mg/l and calcium (15 –75 mg/l). The microbiological analysis showed that the ground water in Kufra is drinkable and free of any environmentally harmful pollutants. The available chemical analyses are in accordance with the Libyan and World Health Authority (WHO) would indicate an acceptable Drinking Water Standards.

1. Introduction

1.1 General Demand of fresh water in Libya

Libya is among the world's most water scare area it has been responded to specialized water institutions, with extensive investments in water infrastructures including ground water sources, dams, the Great Man

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Made River Project (GMMRP), and desalination plants [1]. Municipal water demand has increased markedly in the last 4 decades in response to high population growth rates and increased per capita requirements. Based on this fact the chemical and microbiological studies have been highly recommended for drinking water quality [2]. Quantitatively, a total volume of about 1.81 Mm^3/day was supplied in 2009, almost one Mm^3/day were supplied from GMMRP, O.53 Mm^3/day from local ground water aquifers and the desalination plants are supplying the remainder O.28 Mm^3/day. Off course Water quality continues to be one of the major concern globally and in Libya [3].

The demand for fresh water has increased significantly in Libya, due to the population growth rate, consequently, the public water supply has increased markedly, either in Urban area or rural town [4, 5]. Even though, it has been concluded that drinking water in urban and town area have no hazardous effects on human health. The analysis of water quality parameters must be identical or in the allowed international and national recognized specifications within the maximum permissible limit of WHO [6] and Libyan standards[7].

To satisfy these demands, Libya has installed large water supply systems, including water sources developments, water treatments, conveyance storage, and distribution systems. The main water resources in Al-kufra are derived from water drilling wells. Water well field has been established in eight different areas in Al-kufra, to match the municipal water supply and the rising demand.

The problem of water resources is most critical for the development in the area of eastern Sahara. in this area, the only available water resource is the Nubian sandstone aquifer, which consist of an immense sedimentary basin and holds an enormous water reserve [8]. The present study has conducting the main chemical analysis parameters such as pH, EC, TDS, Alkali and Alkali earth elements. The study was aimed to monitor the ground water quality of drilling wells in Al-Kufra area which located in south east part of Libya (Figure 1).

1.2 Geology and Stratigraphy

The Nubian Sandstone Aquifer System (NSAS), underlying 2.2 million square kilometers of North African desert, is vital to the survival of the Egyptians, Libyans, Sudanese, and Chadians living above it. The NSAS's "virtual water" the water used by farmers to grow crops and produce other goods reaches beyond the region. At 375,000 cubic meters in volume, the NSAS is one of the largest aquifers in the world [9]. Demand for NSAS water has grown rapidly over the past 30 to 40 years. As water levels dropped in the small coastal aquifers near Libya's population centers on the Mediterranean coast, salt water from the Mediterranean flowed into the aquifers. Soon, the water from these aquifers was too salty to use for drinking

and irrigation. Libya's coastal areas, which make up 1.5% of the area of the country but are home to 75% of its people, turned to the NSAS. The Great Man Made River Authority (GMMRPA), a decades-long project funded by the Libyan government, has been piping hundreds of millions of gallons of water from the NSAS north to the coast every day since the first pipeline was completed in 1993 [9].

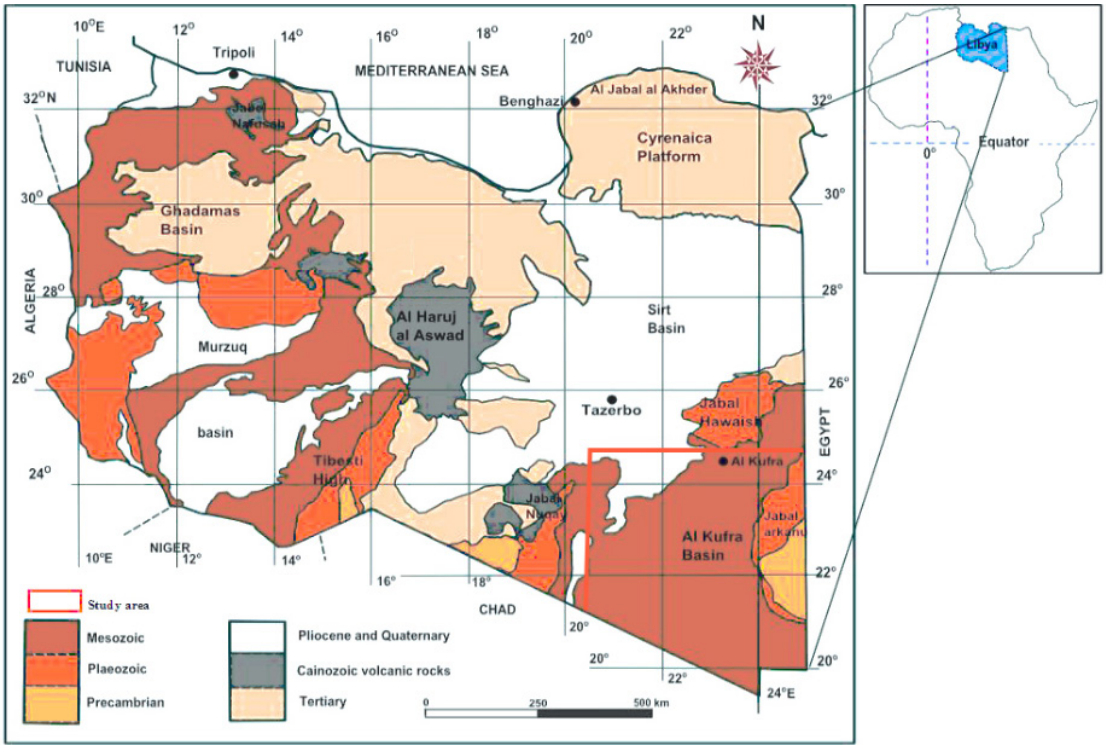

Figure 1. Location of the Kufra Basin, SE Libya

The term Kufra/Al Kufrah was introduced by Desio (1935) as general name to all sequences, the greater part being quartzitic sandstones, which form the area of Al Kufrah group or series [10]. The sediments of the Kufra basin are mainly continental cross bedded sandstone intercalated with argillaceous clays and shales [11]. It corresponds to the 'Nubian Sandstone" in the eastern part of Libya. The Cretaceous Nubian sandstone is one of the major sedimentary basins occur in eastern Libya. The Nubian sandstone of the Kufra basin has a maximum thickness of 900 m and includes mainly cross bedded sandstone, intercalated with clays and shales. The following table below shows a brief general stratigraphic geological successions of the Nubian Sandstones and the Kufra basin [12] (Table 1).

Table 1. General sedimentological succession of the Kufra basin

Age	Formations & approximate max. thickness (m)	Lithology & depositional environment
Recent/Pleistocene	100 m	Sandstone and Sabkhat deposits
Lower Creataceous	Nubian Sandstone (900 m)	x-bedded sandstone, shales and conglomerates
Carboniferous	800 m	Continental sanstones
Devonian	Tadrart Sandstones (100 m)	Massive, continental x-bedded sandstones with fossil plant marginal marine deposits
Silurian	TanezzuftShaes Acacus Sandstones (90 m)	Sandstones, marine with fossils. dark shales and silty with fossils
Ordovician	Gargaf Group (700 m)	x-bedded sandstoes with some silty shales (continental/marginal marine deposits
Pre-Cambrian	Basement	Folded metamorphic and granitic igneous rocks

2. Objectives

The aim of this paper as priority is to monitoring and investigating the chemical and microbiological analysis of ground water quality which use in water of Kufra municipal supplying system without any treatment. The geological information was used to support the water quality results which have been analyzed in this study.

3. Methodology

This paper is mainly concern to chemical analyses of ground water quality of kufra water drilling wells and supported with microbiological measurements, even though, there is no microbiological contamination is expected at depth range from 140 m to 333 m.

3.1 Sample Collection

Eight water samples were collected from the drilling wells directly, representing the main municipal supply of Kufra region.

3.2 pH measurement

The pH meter of the samples were determined by using WTW pH meter (type pH 315 i), the instrument was calibrated with buffer solutions of pH 4, 7, and 10.

3.3 Conductivity measurement

Electrical conductivity measurement was determined using calibrated WTW meter (type cond. 315 i).

3.4 Total dissolved solid (TDS) measurement

The total dissolved solid measurement (TDS) was determined with help of WTW meter (model TDS 315 i).

3.5 Alkali and Alkali Earth elements measurement

Na^+, K^+, Mg^{2+}, Ca^{2+} cations were determined using WTW spectrophotometer (model CR 2200).

4. Results

The study is mainly concern with the chemical and microbiological analysis measurements of the contamination of the eight ground water wells of the kufra basin, south east of Libya. Table (2) shows the chemical analyses of the Kufra ground water wells, where table (3) shows the microbiological analyses of the eight wells in Kufra area.

Table 2. Chemical analyses of Al-Kufra ground water compared to WHO and Libyan drinking water standards.

Ground water well	pH	E.C μ S/cm^{-1}	T.D.S mg/l	Na^{+} mg/l	K^{+} mg/l	Mg^{2+} mg/l	Ca^{2+} mg/l	Well depth m
Al-Manaya well	7.35	248	162	20.02	4.48	9.15	19.06	195
Abo-Naama well	7.16	418	278	55.12	6.10	9.50	27.18	250
West Jowf well	7.30	275	181	28.15	7.10	9.50	15.00	250
New Kufra well	7.30	295	200	27.20	6.15	9.50	25.00	249
Tobat well	7.30	385	252	36.10	6.25	9.50	29.00	188
Metrological station well	7.30	104.8	725	161	14.00	12.00	34.00	333
South Station Area well	7.26	1,800	1150	295	23.00	25.25	75.00	140
Green Houses Area well	7.32	250	215	32	6.24	11.02	28.00	259
WHO Standards	6.5-8.5	1,500 μS/cm^{-1}	1,200 mg/l	200 mg/l		150 mg/l	100 mg/l	
Libyan Standards	6.5-8.5	750-1,200 μS/cm^{-1}	500-1000 mg/l	20-200 mg/l	10-40 mg/l	30-150 mg/l	75-200 mg/l	

Table 3. Result for studies of microbiological water quality at source.

Ground water well	**Indicator Bacteria**		
	Residue chlorine mg/l	**Total count per 100 ml**	**Coliform per 100 ml**
Al-Manaya well	None	None	None
Abo-Naama well	None	None	None
West Jowf well	None	None	None
New Kufra well	None	None	None
Tobat well	None	None	None
Metrological station well	None	None	None
South Station Area well	None	None	None
Green Houses Area well	None	None	None

5. Discussion

The values of pH were found in the range of 7.16 -7.35, which are in the prescribed limit of both WHO and Libyan standards. The values of total dissolved solid were found in the range of 162-278 mg/l, except the values of Metrological station well, where the T.D.S is approximately 725 mg/l and South station area well of about 1150 mg/l. Both are a bit higher if compared with the previous results, but are still in the prescribed limit of both WHO and Libyan standards. These high values may be due to presence of dissolved salts of Mg^{2+} and Ca^{2+} in the sandstone reservoir aquifer. Dissolved solids can produce hard water, which leaves deposits and films on fixtures, also on the insides of hot water pipes and boilers [1]. The values of electrical conductivity were found in the range of 104.5 $\mu s/cm^{-1}$ to 418 $\mu s/cm^{-1}$, which are in the prescribed limit of both WHO and Libyan standards. Except the value of electrical conductivity of the south station where the higher value of electrical conductivity (1800 $\mu s/cm^{-1}$) is observed. It may due to presence of dissolved salts such as Mg^{2+} and Ca^{2+}. The values of alkali and alkali earth elements were found Na^{+} (20.02 – 36.11 mg/l), K^{+} (4.48 – 14.00 mg/l), Mg^{2+} (9.15 – 12.00 mg/l), and Ca^{2+} (15 – 34.0 mg/l). All well samples are in permissible limit of both WHO and Libyan standards, except the South Station well, where alkali and alkali earth cations is above the limit values due to the same reason mentioned in cases of E.C and T.D.S.

6. Conclusion

The ground water which were taken from various chosen places of drilling wells in Kufra region in Libya were chemically analyzed and investigated using the main water quality parameters as pH meter, E.C meter, T.D.S meter, spectrophotometer for alkali and alkali earth. The study and investigation concluded that all data lye within the maximum permissible limit prescribed by WHO and Libyan standards. The higher amounts of E.C, T.D.S, alkali and alkali earth values of south station well is supposed to be due to the dissolved salts in sandstone of reservoir aquifer, where the Mg^{2+} and Ca^{2+} are high. It has been also concluded that all the water wells in Kufra have no hazardous effects on human health.

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