

Physico-chemical Evaluation of Drinking Water Quality in Alshati District of Libya

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Abstract: *The quality of groundwater of fifty one wells for drinking water from Alshati district was assessed for its suitability for drinking. Water samples were collected and analyzed for various physico-chemical parameters such as pH, Temperature (°C), Electrical Conductivity (EC), Total Hardness (TH), Total Dissolved Solids (TDS), Alkalinity (Alk), Chloride (Cl⁻), Iron (Fe⁺⁺), Manganese (Mn⁺⁺), Calcium (Ca⁺⁺), Magnesium (Mg⁺⁺), Nitrate (NO₃⁻), Sodium (Na⁺), Potassium (K⁺), Sulphate (SO₄⁻) and Phosphate (PO₄⁻). The results revealed that some parameters of water samples were out of limit according to the WHO standards and Libyan standards for drinking water. The results shows rising of Fe⁺⁺ and Mn⁺⁺ in most of the wells studied, rising of Ca⁺⁺ in water samples of wells of Al-Mansura and Abu-gadgud, rising of SO₄⁻, TDS and EC in water samples of wells of Idri, and rising of Cl⁻ in water samples of Idri, Waanzarik, Taamasan, Al-Mansura and Al-kadra. NO₃⁻ was also rising in water samples of wells of Mahruga and Bergen.*

Keywords - *Groundwater, Alshati district, physico-chemical parameters, WHO standard*

I. Introduction

Ground water is the sole source of drinking water in Alshati district in Libya. It is the major source of water supply for domestic purposes in this area. The quality and purity of ground water has direct effect on human life. The problem of ground water quality is more acute and can be seen obviously in highly populated areas [1,2]. Shortage of drinking water worldwide is becoming very acute nowadays. A bout 2.5% of earth's water is fresh and potable for human use. The ground water represents 13% of this water. Ground water has been used for drinking for a long time due to its purity and has made it very important source for potable water widely. [3]. Heavy using of ground water in urbanization places along coastlines and estuaries will have a large impact on the quantity and the quality of aquifer water. [4]. In arid and semiarid regions, groundwater is the primary source of water. It has been estimated that at least one - fourth of the world's population obtain their water from underground aquifers. [5]. The world's largest aquifers are located in these regions and its limited recharge makes them highly susceptible to groundwater depletion. [6]. It has been believed that ground water is pure and safer than surface water. Although the presence of more than 200 chemical constituents has been documented in it, the source of these chemicals are both naturally or/and anthropogenic [7]. Ground water quality can be contaminated and become unsafe for drinking and domestic uses as a result of lack of proper amenities in many societies, which can lead to the contamination of ground water with different bacteria including pathogens, especially in the high-density residential areas where sewage disposal practices are not proper. [8, 9]. An excessive amount of arsenic, fluoride, nitrate, sulphate, salinity and heavy metals has been reported in different parts of India. [10]. Ground water in surrounding area of industries usually contains higher levels of heavy metals such as lead, copper and cadmium. Industrial effluents released on the land or dumped in the surface water which ultimately leaches to ground water leading to the contamination of water due to its accumulation in high concentration and cause a series of problems in living [11]. Contamination of ground water due to human activities can lead to adverse effects on the health of mankind and ecosystems. [12]. Once the ground water polluted at site, it may remain unusable or even hazardous for decades of centuries. Low velocity of ground water is a crucial factor for mixing or diluting of these contaminants, consequently a contaminant plume may maintain a high concentration as it slowly moves from points of recharge to zone of discharge [13]. Ground water can also be contaminated as a result of disposal of fluids through wells in lime stone terrains as well as (or) through sinkholes directly into aquifers. Infiltration of contaminated surface water has caused contamination of ground water in many places and raised the degree of contamination related to the hydrologic properties of the aquifer, type and amount of waste, climate and disposal method. An excessive of water pumping may lead to deterioration of ground water quality as a result of migration of more mineralized water from surrounding strata to the well [14 - 16]. In India, 77% of surface water resources and large number of ground water reserves are already contaminated by biological, organic and inorganic pollutants. [17, 18]. Urbanization, climate changes and increase of the world's populations are the main factors for the limiting of fresh water resources as a result of increasing of water demand and pollution of fresh water ecosystems [19, 20]. Ground water represents the main source of fresh water in Libya. Its availability and quality is vulnerable to climate changes and over-abstraction. Shortage resources of water in Libya reduce its ability to maintain its

quality especially if there are different sources of pollutants [21]. Ground water is the only source of water supply for drinking, agricultural and other purposes. 90% of water supply comes from underground water while the 10% comes from other sources [22]. Water unavailability, depletion of underground water as a result of overuse in agricultural developments cause salinity and sea-water penetration into the coastal aquifers are the major concerns in Libya.

II. Materials And Methods

Alshati district is located in Southern - West corner of Libya between North latitude 27° to 27.4° and East longitude 13° to 14.30°, its area is about 97160 Km², (fig. 1), and the population of it is about 80,000.

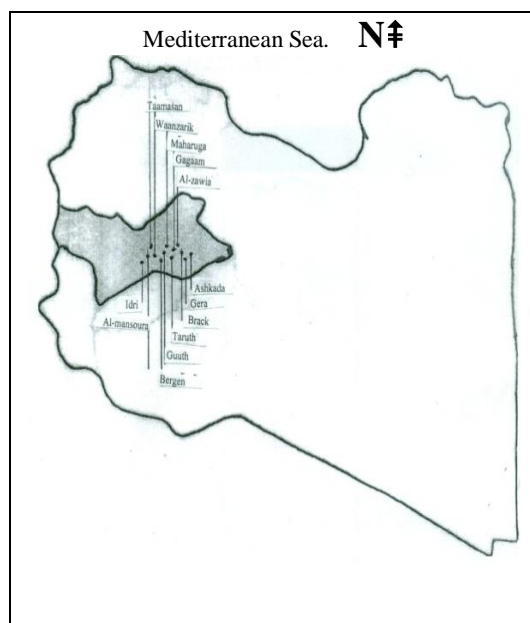


Fig. 1. Map of Libya showing Alshati district and the places from where the samples collected

The ground water samples were collected from fifty one wells of different places randomly in Alshati district these wells represented all drinking wells in Alshati. Water samples were collected in polythene bottles as per standard procedure in January 2009. Samples were analyzed for sixteen parameters including, pH, Temperature, Electrical Conductivity, Total Hardness, Total Dissolved Solids, Alkalinity, Chloride, Iron, Manganese, Calcium, Magnesium, Nitrate, Sodium, Potassium, Sulphate and Phosphate. Temperature, electrical conductivity and total dissolved solids were measured immediately on site after sampling using Hanna auto ranging microprocessor EC/TDS/°C while the pH measured by Beckman pH meter. Nitrate concentration was determined by spectrophotometer. Sodium and Potassium was analyzed using Flame photometer. The other physico-chemical parameters were analyzed in the laboratory using the standard methods. [23]

III. Results And Discussion

A comparison of the physico-chemical characteristics of the studied water samples of drinking water wells has been made with [24, 25] Table 1, Collected data revealed that there were considerable variations in physico - chemical properties of examined samples from the different localities. Temperature of water samples were ranging from 22.6 - 30.08°C. Biological activities and growth can be greatly affected by temperature, other parameters such as pH, EC, dissolving oxygen and water chemistry can also influenced by high temperature [3]. The pH of the water samples were varying from 6.32 to 7.67 which lies within the limits of WHO standards for drinking water quality. WHO (2000). The pH value of drinking water is an important index of acidity or alkalinity, pH of ground water influenced by geology of catchment area and buffering capacity of water [26]. EC of the water samples were ranging between (117 - 2214 $\mu\text{mhos.cm}^{-1}$) which revealed a large variation in EC. High EC were found in water samples of Taamasan, Al-Mansoura and in both the wells of Idri. The desirable limit set for natural water by WHO (2000). [27] should not exceed 1400 $\mu\text{mhos.cm}^{-1}$. It has been reported that EC is affected by the presence of TDS and Temperature, high value of EC is correlated with high TDS [28, 29]. EC is an important parameter in assessing water quality for drinking and irrigation purposes. EC is used as an indicator and classification of salinity. High values of EC in ground water are due to high dissolved solids. Therefore high EC means high degree of salinity and an index of the amount of dissolved substances in water [30]. The results show good positive correlation between EC, Cl⁻, Na⁺, TDS and SO₄²⁻. The correlation ($r = 0.877, 0.872, 0.956$ and 0.936) respectively. These results suggested that Cl⁻, Na⁺, TDS and SO₄²⁻ greatly

influenced the EC and agreed with the results reported by [7, 27]. Total dissolved solids (TDS) of collected water samples were ranging between 345 - 1411 mg.l⁻¹, all samples were under standard limits except Idri site which recorded more than 1400 mg.l⁻¹. According to Libyan standards for drinking water, TDS should not exceed 1000 mg.l⁻¹. TDS is one of the main characteristics that decide the quality of drinking water. The results showed positive correlation between TDS and EC, Cl⁻, Ca⁺⁺, Na⁺ and SO₄⁻ were the correlation (r = 0.956, 0.926, 0.4, 0.94 and 0.967) respectively. High levels of TDS might be due to contamination of ground water as result of discharge of waste waters into pits and pods [31]. These results were also consistent with the results by [7, 27]. The results show that total hardness of all water samples was varying from 88 - 309 mg.l⁻¹. These values were lay within the standard limit of WHO (2000) and Libyan standards for drinking water which permit any value less than 500 mg.l⁻¹. The results show positive correlation between TH and Ca⁺⁺ and Mg⁺⁺ (r = 0.535 and 0.514) respectively, which revealed the dependence of TH on Ca⁺⁺ and Mg⁺⁺, this is consistent with the results reported by [7, 32]. Total hardness is an important parameter of water quality to be used for any purpose. It had been reported that water hardness in most ground water is naturally occurring from weathering of limestone, sedimentary rock and calcium bearing minerals or as a result of an application of lime to the soils in agricultural areas [27]. Total alkalinity of studied water samples were ranged from 64 - 142 mg.l⁻¹. These values of alkalinity were lay within the permit values of Libyan standards for drinking water and WHO (2000) standard. Results show a correlation between Alk and Cl⁻, TH, Na⁺, TDS, and SO₄⁻ (r = 0.372, 0.314, 0.432, 0.342 and 0.422) respectively. Alkalinity in water gives an idea of natural salts present in it. High alkalinity is a result of dissolve of various ionic species such as bicarbonate, hydroxide, phosphate, borate, organic acids and natural processes taking place at any certain time. [33]. Slight increasing of alkalinity values is not harmful to human beings health. [34]. Also, the results show that Chloride varied from 143 - 649 mg.l⁻¹, the permissible limit for chloride in drinking water is up to 250 mg.l⁻¹ as reported by WHO (2000) and Libyan standards for drinking water. High concentration of chloride more than (250 mg.l⁻¹) were found in water samples from Waanzarik, Al-kadara, Taamasan, Al-Mansoura and Idri. These places are located close to each other (fig. 1). Results show positive correlation between Cl⁻ and EC, Na⁺, K⁺, TDS, Alk, SO₄⁻ and PO₄⁻. were r = 0.877, 0.963, 0.54, 0.925, 0.372, 0.891 and 0.53 respectively. High chloride value in ground water gives salt tastes to water and possibly due to minerals like apatite and mica or might be from liquid inclusions in the igneous rocks. [35]. These results were agree with the results reported by [7]. Sulphate content in ground water samples were ranged from 19 - 440 mg.l⁻¹. In some places, sulphate concentration exceeded the permissible limits of sulphate 250 mg.l⁻¹. WHO (2000). Libyan standard for sulphate is 400 mg.l⁻¹. Results show high positive correlation between SO₄⁻ and EC, Cl⁻, Na⁺ and TDS were r = 0.936, 0.891, 0.901 and 0.967 respectively. SO₄⁻ also correlated with Ca⁺⁺, Na⁺ and Alk were r = 0.41, 0.357 and 0.38 respectively. These are the same places where we found high values of chloride. Therefore we believe that there is a relationship between high concentration of chloride and sulphate. Sulphate may be present in sedimentary rocks and in minor quantities in igneous rocks; therefore concentration of sulphate may occur in wide range in nature [7]. These results were consistent in some extent with the results reported by [7, 27]. Sodium concentration in ground water samples collected was found in between 57.4 - 126.9 mg.l⁻¹. According to Libyan standards for drinking water, sodium concentration (< 200 mg.l⁻¹) is lay within the permissible limit for sodium. Whereas according to the WHO (2000) standards for sodium content in water samples should not exceed 50 mg.l⁻¹. The results show positive correlation between Na⁺ and EC, Cl⁻, TDS and SO₄⁻ were r = 0.872, 0.963, 0.94 and 0.901 respectively. These results were agreed with the results obtained by [7, 27]. According to WHO 2000 Sodium is high in all locations Sodium content has been found higher than permissible limit in all water samples. Sodium is a naturally occurring element and can be added to the ground water from industrial and domestic wastes. It is one of the major contributors to salinity of water. High sodium concentrations were found in ground water samples in Panipat city in India [7]. The results show that nitrate concentration in water samples were ranged between 0.01- 92 mg.l⁻¹, WHO (2000) recommended safe permissible limit for nitrate is up to 50 mg.l⁻¹. High content of nitrate 80.95 and 92 mg.l⁻¹ were observed in ground water samples from Bergin area and Mahruga respectively. Positive correlations were observed between NO₃⁻ and Ca⁺⁺ and Mg⁺⁺ were r = 0.33 and 0.514 respectively. It had been reported that NO₃⁻ is positively correlated with K⁺. This result differs with the results obtained by [27]. Nitrate is highly soluble element and had an anionic form. Therefore it can be easily leached into the water table. The most sources of nitrate contamination in ground water are atmospheric fallout, organic and sewage pollution and agriculture activities [36]. Potassium in all ground water samples were within the desirable limits set by Libyan standards for drinking water. It ranged between 10.3 - 34.3 mg.l⁻¹. The results shows correlation between K⁺ and EC, Cl⁻, Na⁺, TDS, SO₄⁻ and PO₄⁻, r = 0.434, 0.54, 0.431, 0.437, 0.357 and 0.355. Sources of potassium in natural ground water are due to weathering of rocks and disposal of waste water can also increase its concentrations in fresh water [3]. Manganese in ground water samples were ranged between 0.01 - 1.83 mg.l⁻¹. According to Libyan standard for drinking water and WHO 2000, the permissible limit of manganese is up to 0.1 and 0.5 mg.l⁻¹ respectively. The results show that 92% of the studied ground water samples contain more than the recommended value, where it recorded 1.83 mg.l⁻¹ in Brack area, whereas water samples from Al-zawia, Abu-

gadgud, Bergin and Al-Mansoura contains less than permissible limit, Mn^{++} was not significantly correlated with any of the analyzed parameters. This result is consistent with the results obtained by [7]. High concentration of Iron was recorded in 82.4% of studied ground water samples. Up to 6.94 mg.l^{-1} has been reported in Idri. Fe^{++} shows positive correlation with PO_4^{-} ($r = 0.48$). The permissible limits of Fe^{++} prescribed by Libyan standard for drinking water and WHO (2000) is up to 0.3 mg.l^{-1} [3]. We think the presence of high concentrations of Fe^{++} in the area referred to the geological criteria of Alshati area, where Iron is precipitated in the ground. High concentrations of Phosphate (PO_4^{-}) were also recorded in 88% of collected underground water samples, Up to 15 mg.l^{-1} were recorded in Idri. Permissible limit of phosphate in drinking water is up to 0.01 mg.l^{-1} as it has been mentioned by [3]. The results show positive correlation between PO_4^{-} and EC, Cl^{-} , Fe^{++} , Na^{+} , K^{+} , TDS and SO_4^{-} , the value of $r = 0.421, 0.53, 0.48, 0.46, 0.355, 0.433$ and 0.422 respectively. Calcium in water samples were ranged between $11.2 - 333 \text{ mg.l}^{-1}$. According to WHO (2000) permissible limit for Ca^{++} is up to 100 mg.l^{-1} . While it is 200 mg.l^{-1} in Libyan standards for drinking water, results show high concentration of Ca^{++} in Abu-gadgoud and Al-Mansoura were the concentration of Ca^{++} recorded 276 and 333 mg.l^{-1} respectively. Ca^{++} shows positive correlation with Mg^{++} , TH, SO_4^{-} and TDS were $r = 0.848, 0.535, 0.4$ and 0.4 respectively. There is some kind of correlation between Ca^{++} , NO_3^{-} and Na^{+} were $r = 0.33$, and 0.37 too. Ca^{++} is commonly present in all water bodies [3]. This result is consistent with the results reported by [27]. The results shows that Magnesium concentration is ranged between $3.36 - 57.6 \text{ mg.l}^{-1}$. The acceptable limit for Mg^{++} is up to 150 mg.l^{-1} as described by WHO (2000) and Libyan standards for drinking water. Ca^{++} and Mg^{++} are combined to form total hardness [27]. Mg^{++} shows positive correlation with Ca^{++} and TH were $r = 0.848$ and 0.514 respectively.

Table 1. MANIMIUM AND MAXIMIUM VALUES OF MEASURED PHYSICO - CHEMICAL PARAMETERS COMPARED TO WHO 2000 AND LIBYAN DRINKING WATER STANDARDS 1992

Parameter	standards of drinking water		Results	
	Libyan	WHO (2000)	Minimum	Maximum
PH	6.5 - 8.5	6.5 - 9.5	6.32	7.67
°C	*	*	19.4	30.8
EC $\mu\text{mhos.cm}^{-1}$	**	1400	117	2214
TDS mg.l^{-1}	Up to 1000	600	354	1411
$Fe^{++} \text{ mg.l}^{-1}$	0.3	0.3	0.01	6.94
$Mg^{++} \text{ mg.l}^{-1}$	150	150	3.36	57.6
$Na^{+} \text{ mg.l}^{-1}$	200	-	57.39	126.86
$K^{+} \text{ mg.l}^{-1}$	40	-	10.29	34.29
$SO_4^{-} \text{ mg.l}^{-1}$	400	250	19.12	440.12
$Ca^{++} \text{ mg.l}^{-1}$	200	100	11.2	332.8
$Cl^{-} \text{ mg.l}^{-1}$	250	250	143	648.9
TH mg.l^{-1}	500	500	88	309
$NO_3^{-} \text{ mg.l}^{-1}$	45	50	0.01	91.97
$Mn^{++} \text{ mg.l}^{-1}$	0.1	0.5	0.01	1.83
Alk mg.l^{-1}	200	-	64	142
$PO_4^{-} \text{ mg.l}^{-1}$	**	**	0.01	43.31

* There is no standard limit. ** Not mentioned, - not mentioned, Alk limit. Sherma (2004)

Table 2: Correlation matrix among sixteen water quality parameters of ground water of study area

	C	PH	EC	Cl^{-}	Fe^{+}	Mn^{++}	Ca^{++}	Mg^{+}	TH	NO_3^{-}	Na^{+}	K^{+}	TDS	Al k	SO_4^{-}	PO_4^{-}
C	1															
	0.40															
pH	5	1														
	0.10	0.21														
EC	3	6	1													
	-	-	0.87													
Cl^{-}	0.13	0.03	7*	1												
	-	-	-	0.19												
Fe^{++}	0.26	0.17	0.14	5	1											
	-	-	-	-	0.2											
Mn	0.36	0.33	0.19	0.05	1	1										

Ca ⁺	-			0.26	0.2														
+	0.19	0.00	0.38	8	5	-0.2	1												
Mg ⁺	-	-	0.10	0.03	0.1	0.2	0.84												
+	0.14	0.02	2	4	6	6	8*	1											
TH	-	-	0.16	0.21	0.1	-	0.53	0.51											
	0.29	0.16	9	9	3	0.1	5	4	1										
NO ₃	-	-	0.02	0.08	0.0	0.1													
-	-0.2	0.23	6	2	4	3	0.33	0.4	6	1									
Na ⁺	-	-	0.87	0.96	0.1	0.0													
	0.15	-0.1	2*	3*	5	9	0.37	0.15	5	8	1								
K ⁺	-	-	0.00	0.43		0.2	-	-	0.17	-	0.43								
	0.07	7	4	0.54	0.2	71	0.49	0.65	4	0.26	1	1							
TD	0.02	0.03	0.95	0.92	0.0	0.1			0.14	0.23	0.07	0.94	0.4						
S	9	1	6*	6*	2	4	0.4	2	3	2	*	37	1						
Alk	-	-		0.37	0.1	0.0	0.16	0.02	0.31	0.16	0.43	0.0	0.34						
	0.26	0.07	0.31	2	2	8	7	6	4	4	2	62	2	1					
SO ₄ ⁻	0.05	0.05	0.93	0.89	0.0	0.1													
-	5	1	6*	1*	2	7	0.4	0.14	6	3	1*	57	7*	38	1				
PO ₄ ⁻	0.14	0.25	0.42		0.4	0.1	-	-	0.03	-		0.3	0.43	0.	0.42				
-	4	8	1	0.53	8	8	0.15	0.17	9	0.09	0.46	55	3	15	2	1			

IV. Conclusion

The present study aimed to evaluate the suitability of underground water of Alshati area for drinking, on the basis of present physico-chemical analysis of samples of ground water of Alshati district. According to the findings, we come to the conclusion that the ground water quality of the district varies from place to place. High values of some chemical elements were observed in the west part of the district. The results show high concentrations of EC, TDS, Cl⁻, Fe⁺⁺, Mn⁺⁺, Ca⁺⁺, NO₃⁻, SO₄⁻ and PO₄⁻ at certain locations which indicate that the ground water of these specific locations is not suitable for drinking and needed primary treatment. High values of some chemical parameters are signs of the deterioration of the water quality.

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