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Assessment of Physico-chemical and Biological Properties of Ground Water of Khulais, Province, Kingdom of Saudi Arabia

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ABSTRACT

A study was carried out in Khulais Province, which is located in western area in kingdom of Saudi Arabia situated about 30 km at the eastern site of the red sea. Previously people were using Khulais valley for cultivation and its groundwater was used for drinking. The study aimed to assess the quality of sixteen ground water samples, these samples were taken, subjected to both physicochemical and microbial analysis, the parameters such as Temperature, pH, Electrical Conductivity (EC),Total Dissolved Solids (TDS), Total Alkalinity (TA), Total Hardness (TH), Calcium (Ca^{2+}), Magnesium (Mg^{2+}), Sodium (Na^{+}), Potassium (K^{+}), Iron (Fe^{2+}), Chloride (Cl^{-}), Nitrate (NO_3^{-}), Sulphate (SO_4^{2-}), Fluoride (F^{-}) and biological characteristics were analyzed. The results of physicochemical and microbial parameters were found to be higher than the permitted values when compared with standard values of (SASO), (GSC) and World Health Organization (WHO) guidelines, statistical tools were applied also for these groundwater characteristics.

1. INTRODUCTION

Water resources are limited and non-renewable in Saudi Arabia, which is an arid, and the largest country in the Middle East. Most of the people over the world using ground water for various purposes such as agriculture, industrial, household, recreational and environmental activities. In Saudi Arabia mainly using the treatment of water from the sea and saline water from different groundwater sources to meet, their daily need of drinking water (Khopkar, 1993). Water is the most important natural resource because it is renewable but not replaceable (CBD, 2010). Different sectors of the society use water for different purposes; water fulfills a wide range of human needs such as nutrition, drinking, improving sanitation and using energy (Gleickand Iwra, 1996). Healthy water is essential for the survival of the living organisms; it promotes optimal health and viability and facilitates all the biochemical mechanisms inside the human body. Water represents about 70% of the total body weight (CBD, 2010). Healthy water flushes out waste products, facilitates inhalation and digestion, transports absorbed food, regulates the body temperature, and optimizes the acid-base balance regime. Estimated that a daily water intake of 3.7 L for adult men and 2.7 L for adult women meets the needs of the vast majority of persons under normal conditions [Sawka *et al.* 2005). Polluted water has been reported to cause many health problems (WHO/UNICEF, 2000), (World Health Organization, 2004) and (Magram, 2009). Water–borne diseases have been documented in many environmental studies over the last few decades (Al Otaibi, 2009; Mara and Sleigh, 2010; Al Zahrani and Gherbawy, 2011; and Aly,Ali and El Badawy, 2013). Previous studies recorded a variety of pathogens such as bacteria, protozoans and parasites in the drinking water. The most common pathogens in the drinking water are Cryptosporidium spp., Giardia duodenalis, Coliform and Streptococcus spp. (Aly, Ali, and El Badawy, 2013 and Hogue, *et al.* 2002). These microorganisms were found to pose a considerable threat to the human health and are a major cause of diarrhea (Al Otaibi, 2009 and Al Mazroui, *et al.* 1995). Over the last two decades, a considerable research was made of the sources and quality of the drinking water in KSA (Aly *et al*. 2013; Al Redhaiman *et al*. 2002; Al Turki *et al*. 2003; Al Othman, *et al.* 2013; Moneer *et al.* 2013; Abderrahman, 2006; Abderrahman, *et al*. 1988; Al Sayari *et al.* 1978; Al-Bassam, 1998; Al-Bassam *et al.* 2003; Al-Bassam *et al.* 2003; Allael-Din, *et al*. 1993; Al-Sefry *et al.* 2006).

2. MATERIAL AND METHODS:

2.1. Study area:

The coordinates and the information of the ground water wells taken under this study are given in the table-1, and the geographical location of the ground water wells from northern and southern of Khulais Province are represented in Fig.-1, from Google map.

Table-1: Groundwater Sampling Locations at northern and southern site of Khulais province

S.No.	Sampling Number	Sampling Location	Depth of the groundwater well (in meter)
1	S#1	22°08'49.2"N 39°18'59.8"E	20 m
2	S#2	22°08'56.6"N 39°20'05.2"E	92 m
3	S#3	22°20'58.1"N 39°21'26.6"E	30 m
4	S#4	22°22'31.5"N 39°20'48.4"E	35 m
5	S#5	22°23'39.6"N 39°21'15.5"E	45 m
6	S#6	22°08'59.1"N 39°19'43.1"E	25 m
7	S#7	22°08'57.0"N 39°20'04.8"E	80 m
8	S#8	22°33'11.4"N 39°41'53.8"E	30 m
9	S#9	21°95'33.4"N 39°34'86.3"E	90 m
10	S#10	21°95'56.2"N 39°45'37.9"E	100 m
11	S#11	21°95'30.7"N 39°46'38.9"E	80 m
12	S#12	21°95'77.9"N 39°41'40.3"E	90 m
13	S#13	21°98'75.8"N 39°39'19.3"E	80 m
14	S#14	21°99'73.1"N 39°38'17.6"E	115 m
15	S#15	22°00'03.6"N 39°37'93.5"E	110 m
16	S#16	22°00'29.1"N 39°37'78.8"E	120 m

Fig.-1: Map location of ground water samples at the northern site of Khulais Province

2.2. Methodology:

Sixteen ground water well samples were collected from different area of Khulais Province using standard procedures (APHA, AWWA, WEF., 1998). The groundwater samples were collected in pre-cleaned polyethylene bottles and prior to collection, the samples bottles were rinsed thoroughly with the sample water. The water samples were taken through pumping so the sample will be a well representative and in order to avoid any contamination from the surface. The temperature of the samples was measured immediately during field study to these water samples, the bottles were air tighten and handed over to the laboratory of Al hada Water Company for analysis.

2.3. Physical and chemical analysis:

The pH is measured using Hanna pH meter, electrical conductivity (EC) using Vernier Labquest. The chemical analysis of the groundwater samples are carried out at the Al Hada Water Industry Laboratory, Hada Alsham, Western area, Kingdom of Saudi Arabia, where the sodium and potassium are analyzed using a flame photometer; the calcium and magnesium are determined with EDTA; while the titration with mercury nitrated are used to determine chloride. For bicarbonate, a titration with 0.01N sulfuric acid is used. Finally, a turbidity method is employed for the sulfate analysis.

2.4. Microbiological analysis:

The three-tube procedure using lactose broth (Difco) was used for estimating the most probable number (MPN) of coliform organisms. Tubes were incubated at 37˚C for 48 h and the MPN was obtained according to the standard Methods for the Examination of Water and

Wastewater (APHA, 1985; Geldreich, 975, Al Sabahi *et al.* 2009, Bakir *et al.* 2003). The confirmed coliform test was done by culturing positive tubes into brilliant green bile broth (Difco) and incubating at 37°C for 48 h.

2.5. Statistical Analysis:

Statistical analyses were performed using SPSS application program ver. 18. The means obtained for the various water quality parameter measured were evaluated according to the current USEPA (1976), SASO (1984), G.C.C.S (1993) and WHO (1993) and drinking water standards and guidelines.

3. RESULTS AND DISCUSSION

The data revealed that there were considerable variations in the examined ground water samples.The results of analysis of various physicochemical and biological parameters of ground water of Khulais was summarized in Table-2, Table-3 and Table-4. A comparison of physicochemical characteristics and microbial analysis Table-5, of the studied groundwater samples, has also been made with WHO standards (1993) and SASO standards (1984). In addition to that, a statistical analysis was done. These parameters are discussed below:

3.1. Temperature

Temperature is an important water quality parameter and is relatively easy to measure. Many aquatic organisms are sensitive to changes in water temperature. The temperature of ground water samples varied from 29°C to 39°C, Table-2, Fig.2, the lowest temperature was observed in S#1 at the northern side of Khulais.

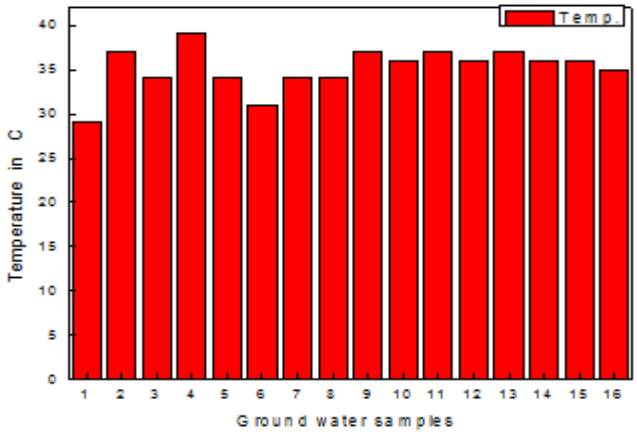

Fig.-2: Graphical representation of Temperature in ◦C for ground water samples in Khulais

3.2. Color, Odor and Taste analyses:

Drinking water should be aesthetically acceptable; it should be free from apparent turbidity, color, and odor and from any objectionable taste. Water meeting these conditions is termed as "Potable Water", which suits our health (Pontius, 1993). All the groundwater samples were found clear in appearance except the samples S# 7 and S#15. Similarly, direct inspection of the samples for odor and objectionable taste were done and found that samples were odorless and free from unobjectionable taste Table-2. According to European Union (EU), clarity and odor of water should be acceptable to consumers and there must not be abnormal changes in these characteristics of water.

3.3. Turbidity analysis:

Turbidity or Total Suspend Solids (TSS) is the material in water that affects the transparency or light scattering of the water. It is an important factor for characterization of water (Keith Bellingham). The measurement unit used to describe turbidity is Nephelometric Turbidity Unit (NTU). The range for natural water is 1 to 2000 NTU. Results of turbidity analyses of ground water samples are given in Table -2, Fig.-3; the mean value of turbidity was measured to be 0.16 NTU. For all the water samples, turbidity was in the range of 0.044 to 1.30 NTU. It indicates absence of suspended and colloidal matters like decomposed vegetation, sewage, sediments in the samples.

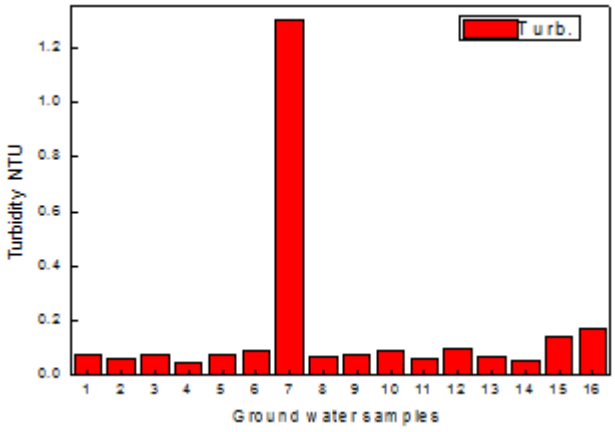

Fig.-3: Graphical representation of Turbidity (NTU) values for ground water samples in Khulais

Table-2: Physical properties of groundwater samples of Khulais Province

Sampling Number	Temperature°C	ODOUR	TASTE	APPEARANCE	TURBIDITY NTU
S#1	**29**	Un-Ob*.	--	Clear	**0.080**
S#2	**37**	Un-Ob*.	--	Clear	**0.060**
S#3	**34**	Un-Ob*.	--	Clear	**0.076**
S#4	**39**	Un-Ob*.	--	Clear	**0.044**
S#5	**34**	Un-Ob*.	--	Clear	**0.080**
S#6	**31**	Un-Ob*.	--	Clear	**0.090**
S#7	**34**	Un-Ob*.	--	**Slight muddy**	**1.300**
S#8	**34**	Un-Ob*.	--	Clear	**0.071**
S#9	**37**	Un-Ob*.	--	Clear	**0.076**
S#10	**36**	Un-Ob*.	--	Clear	**0.088**
S#11	**37**	Un-Ob*.	--	Clear	**0.062**
S#12	**36**	Un-Ob*.	--	Clear	**0.099**
S#13	**37**	Un-Ob*.	--	Clear	0.073
S#14	**36**	Un-Ob*.	--	Clear	0.054
S#15	**36**	Un-Ob*.	--	**Slight muddy**	0.146
S#16	**35**	Un-Ob*.	--	Clear	0.174

Un-Ob*. = Un-Objectionable

3.4. pH analysis:

The experimental results for pH analyses of ground water samples are depicted in (Table-3, Fig.-4). As well-known pH is a term used to express the acidity and alkalinity condition of a solution and the pH of natural water can provide important information about many chemical and biological processes and provides indirect correlations to a number of different impairments. In the case of groundwater samples ranging from 7.01 to 7.88 and were found to be within the limit prescribed (6.5–8.5) by WHO. The slight alkalinity of water due to presence of carbonates and bicarbonates.

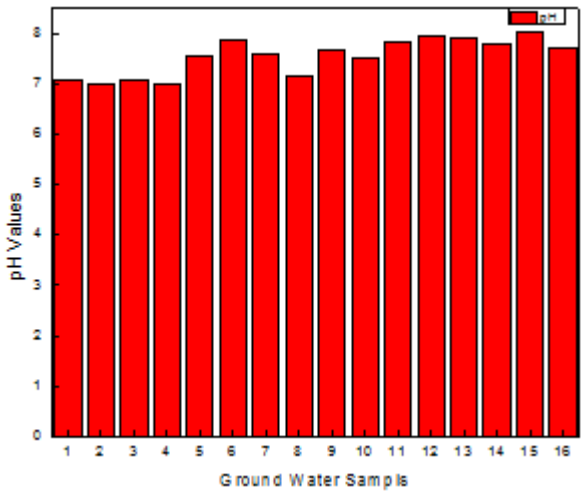

Fig.-4: Graphical representation of pH values for ground water samples in Khulais

3.5. Conductivity analysis (EC):

The experimental analysis for electrical conductivity (EC) was carried out for the ground water samples, the electrical conductivity (EC) can be defined as it is a measure of the water's ability to conduct electric current. Therefore, it signifies the amount of total dissolved salts (Sudhir Dahiya and Amarjeet, 1999). EC values were in the range of 1096 µS/cm to 27700 µS/cm (Table-3, Fig.-5), and they were not in agreement with conductivity range (160-1600 µS/cm) of the guidelines for drinking water as indicated by WHO, SASO and GCS. The mean value of conductivity was found to be 8256.6250 µS/cm. High conductivity values of all samples reflect the amount of total dissolved solids (TDS) in natural waters.

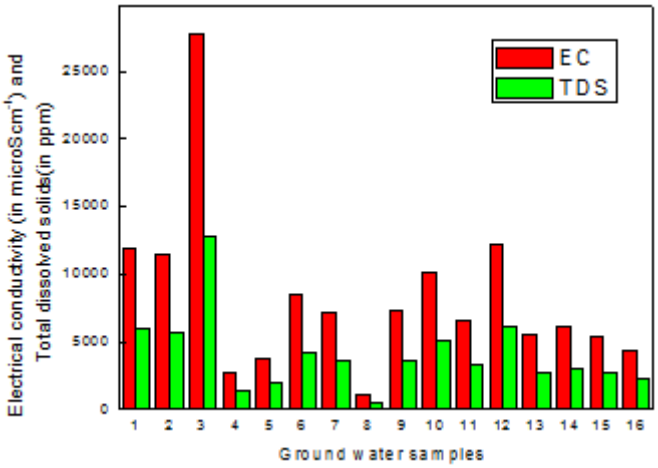

Fig.-5: Graphical representation of EC and TDS values for ground water samples in Khulais

3.6. Total Solid analysis:

Salinity refers to the presence of dissolved inorganic ions such as Mg^{++}, Ca^{++}, K^{+}, Na^{+}, Cl^{-}, SO_2^{4-}, HCO_3^{-} and CO_3^{2-} in the aqueous solution or soil matrix. The measure of salinity indicates the amount of total dissolved solids in water quality for drinking. Water containing more than 500 mg/l of TDS is not considered desirable for drinking water supplies, but in unavoidable cases 1500 mg/l is also allowed (Khan and Khan 1985). TDS values varied from 549 mg/l to 12860 mg/l (Table-3, Fig.-5). All sampling ground water showed higher TDS values when compared to the prescribed limit (100-1000 mg/l) given by WHO, SASO and GCS. Except for the S#8 which shows 549 mg/l.

3.7. Hardness analysis (TH):

Hardness is the property of water, which prevents the lather formation with soap and increases the boiling points of water (Shrinivasa Rao, and Venkateswaralu 2000). Hardness of water mainly depends upon the amount of calcium or magnesium salts or both. The total hardness values for ground water samples S#1 to S#8 shown the range from 200 mg/l to 7200 mg/l (Table-3, Fig.-6). All samples values were higher than the prescribed limit (500 mg/l) by WHO, SASO and GCS. Except for the samples, S#7 and S#8 showing values 200 and 400 respectively within the limit.

3.8. Total Alkalinity (TA) analysis:

Total alkalinity (TA) The alkalinity of the water is its ability to neutralize an acid, its concentration ranged from 90 mg/l to 170 mg/l for the ground water samples S#1 to S#16 (Table-3, Fig.-6). The presence of total alkalinity resulting from naturally occurring materials is not considered a health hazard in drinking water supplies. Maximum levels up to 400 mg/l. In general, the values of total alkalinity for all samples were found to be within the permissible limit of SASO and GCS.

3.9. Calcium analysis:

Calcium concentration ranged from 140.14 mg/l to 1361.36 mg/l for the ground water samples S#1 to S#16 (Table-3, Fig.-6). The presence of calcium related to hardness. In general, a higher value of calcium for all samples except for the S#4 and S#8 were found within the permissible limit of SASO and GCS.

3.10. Magnesium analysis:

Magnesium is directly related to hardness. Magnesium content in the investigated ground water samples S#1 to S#16 was ranging from 12.12 mg/l to 923.4 mg/l (Table-3, Fig.-6). As we observed only ground water samples S#4, S#5, S#8 and S#16 having values less than prescribed limit (30- 150 mg/l) given by SASO and GCS. While other samples have higher values for magnesium.

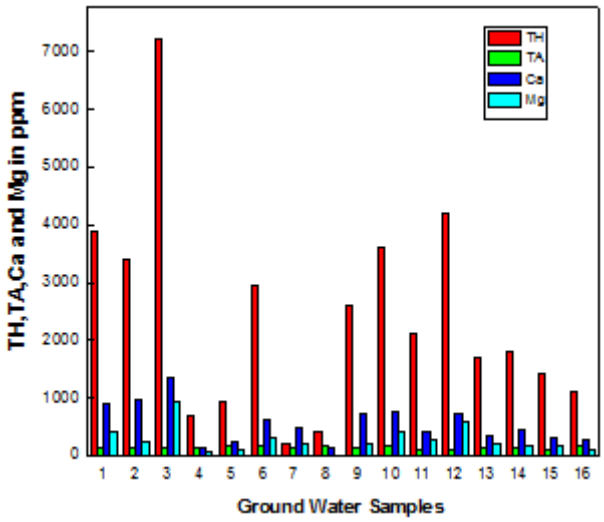

Fig.-6: Graphical representation of TH, TA, Ca & Mg values for ground water samples in Khulais

3.11. Sodium analysis:

Higher values for sodium concentrations were found for all samples S#1 to S#16 of the investigated ground water Table-3, than the prescribed limit (200 mg/l) by WHO, SASO and GCS.

3.12. Potassium analysis:

Potassium concentrations were found ranging from 2.7 mg/l to 11.36 mg/l (Table-3, Fig.-7). All Sampling plants showed lower potassium concentration than the prescribed limit by WHO, SASO and GCS.

3.13. Iron analysis:

Iron concentrations were found to be varied from 0.00 mg/l to 0.01 mg/l (Table-3, Fig.-7). All Sampling of ground water showed lower iron concentration than the prescribed limit (0.3 to 1.0 mg/l) by WHO, SASO and GCS.

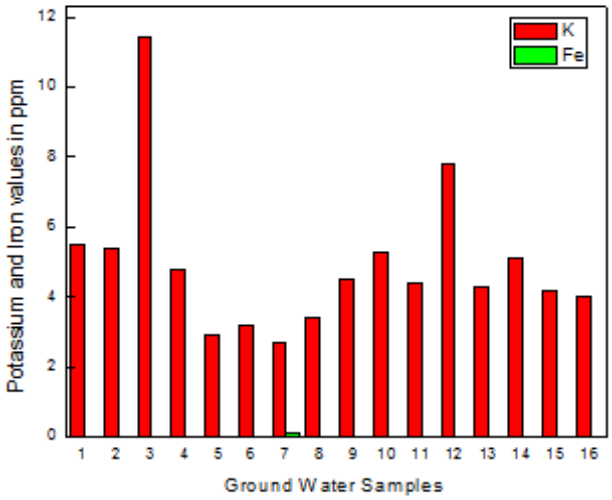

Fig.-7: Graphical representation of K & Fe values for ground water samples in Khulais

3.14. Bicarbonate analysis:

Bicarbonate concentration ranged from 146.4 mg/l to 207.4 mg/l for the ground water samples S#1 to S#16 (Table-3, Fig.-8). The presence of bicarbonate related to hardness. In general, a higher value of bicarbonate for all samples.

3.15. Sulfate analysis:

The sulfate concentration varied from 150.0 mg/l to 3350.0 mg/l, for the ground water samples S#1 to S#8 (Table-3, Fig.-8). While samples S#9 to S#16 shown very high values above the range that can be detected. It is well known that sulfate occurs naturally in water as a result of leaching from gypsum and other common minerals (APHA, 1989), and also discharge of industrial wastes and domestic sewage tends to increase its concentration. From the above results of analysis only the sample S#8 is found to be within the prescribed limit (400 mg/l) by WHO, SASO and GCS.

3.16. Nitrate analysis:

Nitrogen (N_2) is essential to life on Earth and is the most abundant element in Earth's atmosphere. Biological compounds such as proteins, amino acids, and nucleic acids contain nitrogen. In the environment, plants and microorganisms convert N_2 into different oxidation

states where it becomes part of the nitrogen cycle. The major inorganic oxidation states include nitrate ion (NO_3^-), nitrite ion (NO_2^-), ammonia (NH_3), and ammonium ion (NH_4^-). Nitrate ion (NO_3^-) is the common form of nitrogen in natural waters. Nitrite (NO_2^-) will oxidize into nitrate after entering an aerobic regime. The nitrate content in the study of groundwater samples varied from 4.84 mg/l to 338.6 mg/l (Table-3, Fig.-8) and only S#2, S#4, S#8, and S#16 were found to be within the prescribed limit (10-50 mg/l) by WHO, SASO and GCS. While other ground water samples have higher values.

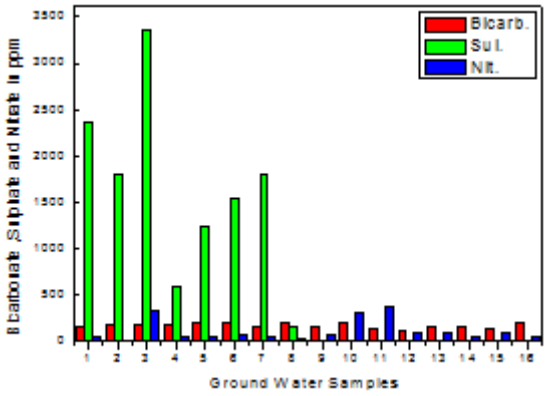

Fig.-8: Graphical representation of Bicarb., Sul. & Nit. values for ground water samples in Khulais

3.17. Chloride analysis:

The chloride content in the study of groundwater samples varied in the range 145.0 mg/l to 7890.0 mg/l. (Table-3, Fig.-9) the samples S#4, S#8, S#13 and S#15 were found to be within the prescribed limit (250- 600 mg/l) by WHO, SASO and GCS. While other ground water samples have higher values for chloride.

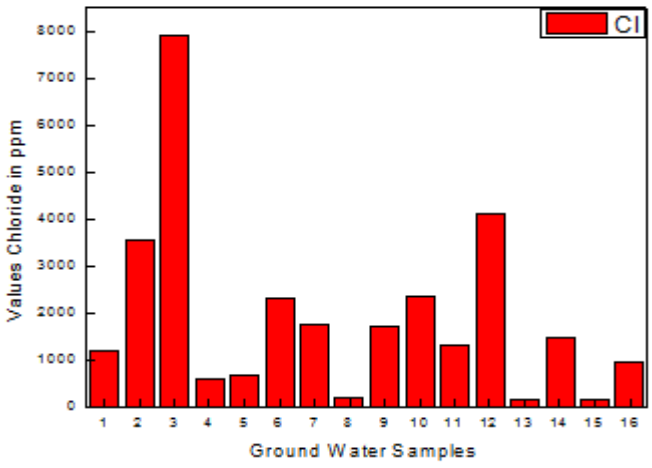

Fig.-9: Graphical representation of Chloride values for ground water samples in Khulais

3.18. Fluoride analysis:

The fluoride content in the study area varied in the range 0.45 mg/l to 1.69 mg/l. (Table-3, Fig.-10) the only sample S#8 shown lowest value compared to the prescribed limit (0.6- 1.70 mg/l) by WHO, SASO and GCS. While other ground water samples are found to be within the prescribed limit values.

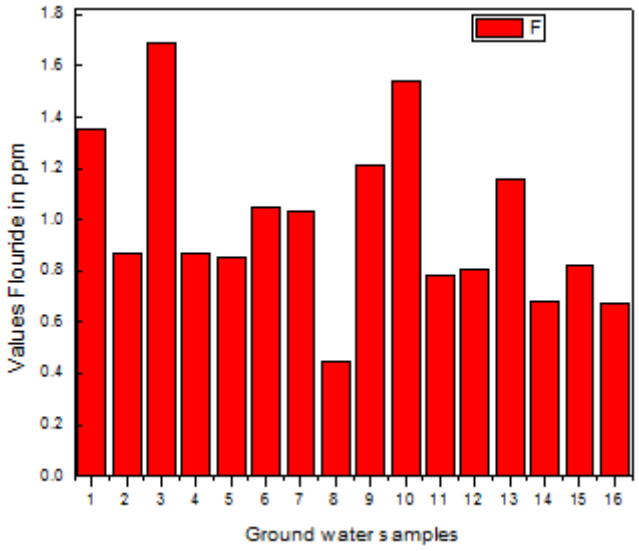

Fig.-10: Graphical representation of Fluoride values for ground water samples in Khulais

3.19. Biological Examinations:

In addition to the investigation of physical and chemical parameters, we also studied the effect of biological activities of water such as fecal coliform content in the water samples. Results of fecal coliform and other microbial activities analyses are shown in Table-4. The most notable result is that samples collected from different areas were showing coliform per 100 ml of the sample. This indicates that after treatment it was completely removed. Similar reports have been given for water treated and untreated (McNair &Lesher, 1963).

Table-3: Chemical properties of groundwater samples of Khulais Province (in mg/l)

Par.	pH	EC	TDS	TH	TA	Sil	Ca	Mg	Na	K	Fe	Bicar.	Sul.	Nit.	Cl	F
S#1	7.10	11930	5960	3900	130	--	900.9	401	--	5.5	0.01	159	2357	60.2	1180	1.35
S#2	7.01	11430	5710	3400	150	--	981.0	231	--	5.4	0.01	183	1800	4.48	3570	0.87
S#3	7.57	27700	12860	7200	155	31.9	1361	923	--	11.4	0.01	189	3350	338.8	7890	1.69
S#4	7.88	2740	1370	700	145	--	140	85	--	4.8	0.01	177	600	48.4	570	0.87
S#5	7.59	3800	1898	950	170	--	228	92	--	2.9	0.01	207	1250	59.4	680	0.85
S#6	7.14	8480	4250	2950	170	--	640	328	--	3.2	0.01	207	1550	79.2	2320	1.05
S#7	7.68	7110	3550	200	140	--	480	194	--	2.7	0.12	171	1800	50.6	1750	1.03
S#8	7.52	1096	549	400	165	--	140	12	--	3.4	0.01	201	150	40.5	170	0.45
S#9	7.85	7330	3660	2600	140	--	720.2	194.4	--	4.5	0.01	170.8	--	71.6	1720	1.21
S#10	7.95	10160	5080	3600	170	--	760.8	413.1	--	5.3	0.01	207.4	--	319	2350	1.54
S#11	7.92	6590	3290	2100	120	--	400.4	267.3	--	4.4	0.00	146.4	--	385	1300	0.78
S#12	7.78	12250	6120	4200	90	60	720.7	583.2	--	7.8	0.01	109.8	--	99	4100	0.81
S#13	8.03	5580	2790	1700	130	--	360.4	194.4	--	4.3	0.01	158.6	--	89.3	147	1.16
S#14	7.71	6160	3070	1800	130	--	456.5	160.4	--	5.1	0.01	158.6	--	57.2	1450	0.68
S#15	7.80	5380	2690	1440	120	--	320.3	155.2	--	4.2	0.01	146.4	--	92.8	145	0.82
S#16	7.97	4370	2240	1100	170	--	280.3	97.2	--	4.0	0.01	207.4	--	44	960	0.67

Table-4: Microbiological analysis of groundwater of Khulais Province

Sample No.	Total Count	Ps. Aerugonisa	Total Coliform	Fecal Coliform	F. Streptococcus	Yeast & Molds
S#1	TNTC	00	20	10	69	31
S#2	TNTC	23	03	00	00	00
S#3	TNTC	00	46	10	25	15
S#4	TNTC	22	08	04	98	00
S#5	TNTC	70	08	00	00	03
S#6	TNTC	00	30	00	66	27
S#7	TNTC	00	28	09	15	98
S#8	TNTC	00	20	08	TNTC	19
S#9	TNTC	32	TNTC	TNTC	25	TNTC
S#10	TNTC	20	97	00	00	03
S#11	TNTC	10	92	00	00	28
S#12	TNTC	38	74	TNTC	03	01
S#13	TNTC	30	70	TNTC	00	02
S#14	TNTC	25	98	00	00	02
S#15	TNTC	09	89	78	01	29
S#16	TNTC	37	TNTC	00	33	89

TNTC * Too Numerous To Count

Table-5: Comparative of chemical parameters with standard values

Parameters	collected samples			WHO	SASO	GCSC
	Minimum	Maximum	Mean			
pH	7.01	8.03	7.6562	6.0-8.5	6.5-8.5	6.5 – 8.5
T.D.S ppm	549	12860	4067.94	--	800-2300	160-1600
EC µS/cm	1096	27700	8256.63	1000	1500	100-1000
TEMP.^{0}C	29	39	--	--	--	--
TH mg/l	200	7200	2390.0	500	500	500
TA mg/l	90	170	143.43	--	--	--
TURB. NTU	0.044	1.30	--	--	--	--
Sil.mg/l	60	31.90	5.7438	--	--	--
Ca mg/l	140.14	1361.36	555.66	--	200	200
Mg mg/l	12.15	583.2	270.70	--	30-150	150
Na mg/l	>200	>200	>200	200	200	200
K mg/l	2.7	11.36	4.9312	--	150	150
Fe mg/l	0.00	0.12	0.016	0.3	1.0	0.3
Bicar. mg/l	109.8	207.4	174.96	--	--	--
Sul. mg/l	150	3350	803.56	400	400	400
Nit. mg/l	4.8	385	114.97	10	45	25(50)
Cl mg/l	145.0	7890	1893.88	250	600	250
F mg/l	0.45	1.69	0.99	1.5	0.6-1.0	0.6-1.70

Table-6: Classification of the water samples in the study area on the basis of TDS

S. no.	Classification of groundwater	Total dissolved solids (mg/l)	No. of samples
1	Non-saline	<1000	1
2	Slightly saline	1000-3000	5
3	Moderately saline	<10000	9
4	Very saline	> 10000 -	1

Table-7: Classification of the water samples in the study area based on TH. (Todd, 1980)

S. no.	Description	Hardness(mg/l)	No. of samples
1	Soft	0-75	Nil
2	Hard	75-150	Nil
3	Moderately Hard	150-300	1
4	Very Hard	Over 300	15

4. CONCLUSION

The analysis of sixteen groundwater samples in this study was taken from northern site and southern site of Khulais Province. Ground Water samples were analyzed for Electrical conductivity, pH, TDS, TH, TA, Ca, Mg, Na, K, Fe, Silica, HCO_3, Cl, SO_4, F, and NO_3 contents. The values of EC of groundwater were found to be from 2740.0 µs/cm to 27700.0 µs/cm. Calcium and Magnesium were the most abundant cation. Chloride was the most abundant anion followed by HCO_3 and SO_4 in groundwater of Khulais Province. The Fe concentration was found to be within the safe limits for drinking purpose according to WHO (2003) standards and SASO. As a result, the quality of water samples from sites (S#1 –S#16) showed poor water quality characteristics, highly polluted and unfit for drinking purpose and the need of some treatment for minimization of the parameters. The water should be treated properly before its usage as drinking water to avoid possible adverse effects. Therefore, public should be made aware of drinking water quality and careful management of precious natural resources. Water quality also should be monitored continuously for the welfare of the people. Investigations of the biological parameters shown that all ground water samples were polluted and unfit at all for human usage based on the guidelines of WHO (2003) standards and limits according to SASO.

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6. REFERENCES

1. Abderrahman, W.A.; Dabbagh, A.E.; Edgell, H.S.; Shahlam, A.B.(1988) Evaluation of groundwater resources in aquifer systems of three regions in Saudi Arabia; 6th IWRA World.Wat. Congr. On Wat. Resour., 1–11 Ottawa.
2. Abderrahman, W.A. (2006) Water management in Ar Riyadh; Int J Water, Resour. Dev., 22(2), 281.
3. Al Mazrou, Y.Y.; Khan, M.U.; Aziz, K.M.S.; Farid, S.M.(1995) Factors associated with Diarrhoea prevalence in Saudi Arabia. Journal of Family and Community Medicine, 2(1), 27–34.
4. Al Otaibi, E.L.Sh. (2009) Bacteriological assessment of urban water sources in KhamisMushait Governorate, southwestern Saudi Arabia; International Journal of Health Geographics, (8), 16.
5. Al Othman, A.M.; Al Othman, Z.A.; El-Desoky, G.E.;Aboul-Soud, M.A.M.; Habila, M.A.; Giesy, J.P. (2013) Lead in drinking water and human blood in Riyadh City, Saudi Arabia; Arabian Journal of Geosciences; 6(8), 3103-3109.
6. Al Redhaiman, K.N.; Abdel Magid,H.M. (2002) The applicability of the local and international water quality guidelines to AI–Qassim Region of central Saudi Arabia; Water, Air and Soil Pollution; 137, 235–246.

7. Al Sabahi, E.; Abdul Rahim, S.; Wan Zuhairi, W.Y.; Alshaebi, F.; Al Nozaily, F. (2009) Assessment of Groundwater and Surface Water Pollution at Mitm. Area, Ibb City, Yemen. American Journal of Applied Sciences, 6(4), 772–783.
8. Al Sayari, S.S.; Zötl, J.G. (1978) Quaternary period in Saudi Arabia; Springer:New York.
9. Al Turki,A.I.; Abdel Magid, H.M.(2003) Nitrate content of drinking and irrigation water in AI-Qassim Region -central Saudi Arabia; Mansura. J. Agric. Sci., 11(27), 7943–7950.
10. Al Zahrani,A.M.; Gherbawy,Y.A. (2011) Antibiotic resistance in Escherichia coli strains isolated from water springs in Al-Ahsa Region, African Journal of Microbiology Research , 5(2), 123–130.
11. Al-Bassam, A.M. (1998) Determination of hydrochemical processes and classification of hydrochemical facies for Sakakah aquifer, northeastern Saudi Arabia; J. Afr. Earth Sci., 27(1), 27–38.
12. Al-Bassam, A.M.; Al-Rumikhani, Y.A. (2003) Integrated hydrochemical method of water quality assessment for irrigation in arid areas, application to the Jilh aquifer, Saudi Arabia; J. Afr. Earth Sci.; 36,345–356.
13. Al-Bassam, A.M.; Hussein, M.T.; Sharaf, M.A. (2003) A real distribution of the dissolved major and minor ions in the Sakaka aquifer, Saudi Arabia; Ann. Geol. Surv. Egypt; 32,453–466.
14. Allael-Din M.N.; Madany I.M.; Al-Tayaran, A.; Al-Jubair, A.H.; Gomaa, A. (1993) Quality of water from some wells in Saudi Arabia ;Water, Air Soil Pollut.; 66(1–2),135–143.
15. Al-Sefry, S.A.; Sen, Z. (2006) Groundwater rise problem and risk evaluation in major cities of arid lands—Jeddah case in Kingdom of Saudi Arabia; Water Resour. Manag.,20,91–108.
16. Aly, N.S.M.; Ali, R.M.; El Badawy, H.A. (2013) Assessment of Drinking Water Quality;Life Science Journal;10 (1), 1795–1803.
17. APHA (1989) Standard Methods for the examination of water and wastewater; American Public Health Association, 17th Ed., Washington, DC.
18. APHA, AWWA, WEF.(1998)Standard Methods for the Examination of Water and Waste Water; 20th Ed , Washington DC.
19. APHA, (1985), (American Public Health Association) (1985). Standard Methods for the Examination of Water and Wastewater; 16th ed, New York, USA.
20. Bakir, B.; Tanyuksel, M.; Saylam, F.; Tanriverdi, S.; Araz, R. E.; Hacim, A.K.; Hasde, M. (2003) Investigation of Waterborne Parasites in Drinking Water Sources of Ankara, Turkey, The Journal of Microbiology,41 (2),148–151.
21. CBD (2010) The Convention on Biological Diversity, A good practice guide drinking water, Biodiversity and Development;
22. G.C.C.S (1993) (Gulf Cooperation Council Standards) Unbottled drinking water standards; Standardization and MetrologyOrganization for the Gulf Cooperation Council Countries # GS149/193, Riyadh, Saudi Arabia,
23. Geldreich, E.E., (1975) Handbook of Evaluating Water Bacteriological Laboratories; 2nd ed, Cincinnati. OH. U.S. Environmental Protection agency.
24. Gleick, P.H.; Iwra, M. (1996) Basic Water Requirements for Human Activities: Meeting Basic Needs. Water International, 21, 83–92.
25. Hogue, M.E.; Hope V.T.; Kjellstorm, T.; Scragg, R.; yee, R.I. (2002) Risk of giardiasis in Aucklanders, a case control study; Int. J. Infect. Dis.; 6,191.
26. Khan, I.A. and Khan, A.A.(1985) Physical and chemical condition in Seika Jheelat, Aligarh, Ecol., 3, 269-274.
27. Khopkar, S.M. ;(1993) Environmental Pollution Analysis; Wiley Eastern Ltd., New Delhi India, 86-87.
28. Keith Bellingham, Physicochemical Parameters of Natural Waters; Stevens Water Monitoring Systems, Inc. http://www.stevenswater.com
29. Magram, S.F. (2009) A Review on the Environmental Issues in Jeddah, Saudi Arabia with Special Focus on Water Pollution; Journal of Environmental Science and Technology; 2(3),120–132.
30. Mara,D.; Sleigh,A. (2010) Estimation of Ascaris infection risks in children under 15 from the consumption of wastewater-irrigated carrots; Journal of Water and Health,8 (1),35–38.
31. McNair, D.B. & Lesher, E.C.; (1963) Effect of ozone on survival and permeability of Escherichia coli. J. Bacteriol.85, 567–576.

32. Moneer, S.; Khashogji, S.; Magdy El Maghraby, M.S. (2013) Evaluation of groundwater resources for drinking and agricultural purposes, Abar Al Mashi area, south Al Madinah Al Munawarah City, Saudi Arabia, Arab J Geosci., 6,3929–3942.
33. Pontius, F.W. (1993) Federal of drinking water regulation update, Journal AWWA, 85, pp 42-51.
34. SASO (1984), (Saudi Arabian Standards Organization) (1984) Bottled and Unbott1ed Drinking Water; SSA 409/1984, 2nd ed., 1996-03-13, ISSN, 1319-2302, Available from: SASO Information Center, P.O.Box.3437, Riyadh, 11471, Saudi Arabia, pp. 1-8.
35. Sawka, M.N.; Cheuvront, S.N.; Carter, R. (2005) Human Water Needs. Nutrition Reviews, 63 (1), S1–S62.
36. Shrinivasa Rao, B. and Venkateswaralu, P. (2000) Physicochemical Analysis of Selected Groundwater Samples, Indian J Environ Prot., 20(3), 161.
37. SudhirDahiya, and Amarjeet Kaur, (1999) physico chemical characteristics of underground water in rural areas of Tosham subdivisions, Bhiwani district, Haryana, J. Environ Poll., 6(4), 281.
38. Todd D.K. (1980) Groundwater Hydrology; 2nd Ed., John Willey & Sons Inc., U.S.A.,pp. 535.
39. USEPA (1976), (United States Environmental Protection Agency) National interim Primary Drinking Water Regulations; Publication, EPA/S70/9-76-003. Washington, D.C, Government Printing Office.
40. WHO (1993), (World Health Organization), Guidelines for Drinking water Quality; Volume1. 1, Recommendations, 2nd (ed.), Geneva.
41. WHO/UNICEF (2000) Global water supply and sanitation assessment report; Number of pages: 87.
42. World Health Organization (2004) Guidelines for Drinking-water Quality; Volume 1. Recommendations, Third ed., World Health Organization, Geneva, Switzerland.