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ASSESSSMENT OF CHEMICAL PARAMETERS OF GROUND WATER IN HOLLY MAKKAH

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Abstract: Groundwater is a very important resource, particularly in arid regions. In Makkah, which is the religious capital of the kingdom, water supply is provided from the aquifers of many valleys inside and around it, including Al Hussineh and WadiNaman valley that considered tobe important groundwater sources . In this study, the chemical and physicalparameters of different resources of groundwater in Makkah were evaluated. The results of the chemical parameters were compared with the Saudi Arabian Standard Specifications in order to determine the suitability of these water resources for drinking and detect any possible contamination supplied from wells around Makkah through 20km latitude to water sources inside makkah.The results revealed that parameters of Sulfate, Chloride, magnesium and Sodium were respectively at 100.0% in E and W wells, at 83.3% in E and W, at 25.5% in NE and 50.0% in S wells, and 15.0% in which are higher than the standard limits. The fluoride concentration ranged from 0.04 to 2.31 ppm, where 25 %, 80.3% samples showed fluoride less and higher than permissible limit respectively. The NO3 concentration was increased than minimum and maximum permissible limits in all studied wells.

Keywords: Groundwater, Makkah, Water quality, Wells, chemical analysis; Water samples.

I.INTRODUCTION

Water is the most important substance in our daily life. Without it, life would not have been possible. Potable water is essential to humans and other life forms, as water is important to the mechanics of biological metabolisms in the body. Drinking water should be pure and free of contaminants to ensure proper health and wellness[1].

There are three main sources of water namely rain, surface and ground water. There are various types of drinking water available in Saudi Arabia; tap water, spring water, bottled and mineral water. The water from wells in Saudi Arabia is often high in mineral contents. Ground water is generally less expensive to develop for use, and usually provides a more certain supply. For these reasons, ground water is generally preferred as a source for municipal and industrial water supplies. Against these common advantages, it must be noted that ground water may be contaminated by toxic or hazardous materials leaking from landfills, waste treatment sites, or other sources (some natural), which may not be known to either the public or regulatory agencies[2] The sources of water particularly surface water is usually subjected to environmental pollution. However many of natural surface water is salty water. Ground water is the best choice in areas where there is no surface water body. In Makkah,which is the religious capital of the kingdom, water supply is provided from theaquifers of many valleys inside and around it and from the desalination plant inJeddah[3].

Ground water usually polluted with chemicals which originated from soil, run off water and waste water. There are very serious environmental, economic and social impacts relating to the groundwater contamination resulting by wastewater discharge[4]. In general, the measurements of chemicals and non-chemicals carried out both in the field and laboratories,

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might reflect a number of variables which together make up the groundwater chemistry. Such obtained variables could cause rather complexity and confusion for investigation to have a clear picture of the existing system[1].

II. MATERIALS AND METHODS

Study location:

The Holly Makkah was determined to be the study area for the importance of ZamZam well water over the Islamic world. So, our study included all regions around 20Kmswidth approximately for comparisons and studying the effect of urban activities on groundwater entering Makkah. Al-Houssina region was included in the study for its importance as a center of environmental pollution by drainage waste water. Also, we studied Naman valley as one of the important well water feeding source for Makkah.

Study stages:

The study was donein 2006 on Makkah area and surroundings as the following:

Wells inside Makkah between North and East (NE).
Wells inside Makkah between North and West (NW).
Wells inside Makkah between South and East (SE).
Wells inside Makkah between South and West (SW).
Wells outside Makkah in East (E).
Wells outside Makkah in West (W)
Wells oustideMakkah in North (N).
Wells outside Makkah in South (S).

Our study included 49 wells inside Makkah borders in addition to 69 wells outside Makkah borders.

Sample Collection:

Three samples were collected from wells inside Makkah , one sample form Naman valley , one sample from Al-Houssina area and one sample from outside Makkah borders. Samples collection was done according to Saudi Arabia standard (407/1989) and Gulf standard (111/1989).

Basic chemical parameters:

Cations:

Sodium (Na^+), Potassium(K^+), Magnesium(Mg^{+2}), Calcium (Ca^{+2}) and Iron (Fe^{+2}) were measured by using DR-4000 Hach USA and Atomic Absorption Spectrophotometer (AAS) Varian SpectrAA 110 USA.

Anions:

Chlorides (Cl^-), Sulfates ($SO4^{-2}$), Nitrates ($NO3^-$) and Nitrites ($NO2-^{2}$) were measured by using Ion Chromatography Metrohm USA.

Residual Chlorine:

Residual chlorine was detected by using manual chlorometer.

Statistical analysis was performed using the SPSS-15 package software Chi-Square test was used to compare the means of the different parameters between each two groups. The correlation between the studied clinical and biochemical parameters was calculated using Pearson's correlation coefficient.

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III. RESULTS

Table (1) The concentration range of chemical parametersin well water inside and outside Makkah Al-Mokarrama.

Parameter	NE	NW	SE	SW	E	W	N	S
$NO3^-$	50.35-210.60	73.50-788.25	94.23-522.35	12.60-462.74	31.22-522.34	38.02-526.50	40.40-420.40	314.10-1,649.00
$NO2^{-2}$	0.01-0.03	0.01-0.13	0.05-1.04	0.01-1.30	0.00-1.19	0.00-1.12	0.02-0.23	0.05-0.19
$SO4^{-2}$	126.00-1,316.30	105.00-1,051	120.41-840.80	84-1,070.00	68.32-867.05	78.98-579.15	551.77-1,471.40	732.90-1,361.10
Cl^-	93.45-511.76	93.18-510.79	144.49-498.37	28.35-561.75	62.09-458.26	62.65-772.90	72.51-1,042.59	405.19-831.32
Fe^{+2}	0.01-0.08	0.00-0.13	0.00-0.07	0.00-0.12	0.00-0.30	0.00-0.11	0.00-0.14	0.03-0.19
Cu^+	0.03-5.74	0.03-1.25	0.03-3.15	0.02-3.72	0.04-5.11	0.05-6.43	0.07-5.72	3.62-5.55
Ca^{+2}	50.54-252.72	33.50-588.56	71.20-201.02	11.55-268.80	42.04-201.79	33.70-484.38	0.00-625.34	184.27-418.80
Mg^{+2}	23.17-30.64	21.00-168.36	35.59-93.53	3.15-117.60	16.81-93.53	16.85-176.91	0.00-235.42	81.66-175.90
K^+	2.29-70.10	0.22-7.90	0.00-3.10	1.05-34.10	3.15-9.46	6.32-6.32	-	-
Na+	42.90-170.90	59.20-399.90	69.37-111.00	0.00-139.20	5.26-79.88	29.48-29.48	33.63-33.63	-
F	1.04-1.56	0.17-1.89	0.87-2.15	0.64-1.43	0.41-2.31	0.21-1.98	0.04-1.93	0.27-2.05

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Table (2):Proportion of wells exceeded Saudi Arabia standards inside and outside Makkah:

Chemical parameters	NE	NW	SE	SW	E	W	N	S
F^-	25	0	40	0	27.3	66.6	80.3	0
Na^+	0	15	0	0	0	0	0	0
K^+	25	0	0	0	0	0	0	0
Mg^{+2}	25	10	0	0	0	16.6	4.1	50
Ca^{+2}	50	15	20	35	0	50	16.6	66.6
Cu^{+2}	50	20	80	40	63.6	50	62.5	100
Fe^{+2}	0	0	0	0	0	0	0	0
Cl^-	50	40	80	40	51.5	83.3	66.6	100
SO_4^{-2}	25	40	80	30	60.6	100	0	100
NO_2^-	0	0	0	0	12.1	0	12.5	0
NO_3^-	100	100	100	85	96.9	83.3	100	100

The finding showed that the minimum concentration of NO_3^- was 12.60 mg/l in the South West (SW) region and maximum concentration was 1.649mg/l in the South region (S). The minimum concentration of NO_2^- was zero in different regions and maximum concentration was 1.3 mg/l in the South West (SW) region. The minimum concentration of SO_4^{-2} was 8.40 in the South West (SW) region and maximum concentration was 1.471.40 mg/l in the North region (N). The minimum concentration of Cl^- was 28.35 mg/l in the South West (SW) region and maximum concentration was 1.042.59mg/l in the North region (N). The minimum concentration of Fe^{+2} was zero in wells of different regions and maximum concentration was 0.30 mg/l in East region (E). The minimum concentration of Cu^{+2} was 0.02 mg/l in the South West (SW) region and maximum concentration was 6.43 mg/l in the West region (N). The minimum concentration of Ca^{+2} was zero mg/l in the North region (N) and maximum concentration was 625.34 mg/l in the same region. The minimum concentration of Mg^{+2} was zero in the North region (N) and maximum concentration was 235.42 mg/l in the North region (N) too. The minimum concentration of K^+ was zero in the South East region (N) and maximum concentration was 70.10 mg/l in the North East region (NE). The minimum concentration of Na^+ was zero in the South West region (SW) and maximum concentration was 399.90 mg/l in the North West region (NW). The minimum concentration of F^- was 0.04 mg/l in the North region (N) and maximum concentration was 2.931 mg/l in the East region (E).
An excessive amounts of Fluoride (F^-) in 80% of wells in North , Sodium (Na^+) in 15% of North west wells, Potassium (K^+) in 25% of north east wells, Magnesium (Mg^{+2}) in 50% of south wells, Calcium (Ca^{+2}) in 66.6% of south wells and all south wells recorded high levels of Copper (Cu^{+2}). In Almost wells levels of SO_4^{-2} and NO_3^- were high.

IV. DISSCUSSION

According to United Nation studies, the ground water represents 98% of fresh water throughout the world. About 70% of water demand in Saudi Arabia is obtained from ground water. This study is to assess the chemical parameters of well water

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inside and outside Holly Makkah which was divided into eight regionsNorth East (NE), North West (NW), South East (SE).South West (SW), East (E), West (W), North (N) and South (S). The chemical analysis includes the investigation of cations and anions.

Calcium (Ca^{+2}) and Sodium (Na^{+}):

The SAS states that the optimum value for calcium (Ca^{+2}) concentration is 75 mg/l and the maximum allowable value is 200 mg/l. Our study revealed that calcium (Ca^{+2}) concentration exceeded permissible limits of Saudi Arabian Standards (SAS) in 66% of the South wells.

Moreover, Na^{+} levels were increased in NW wells according to Saudi Arabian standards; however Na in drinking water normally presents no health risk [5].The SAS and USEPA state that the maximum allowable value of sodium (Na^{+}) is 200 mg/l. Therefore, all the samples were below the maximum allowable value of sodium for drinking water except wells in NW region.

Potassium (K^{+}) and Magnesium (Mg^{+2}):

Potassium is an essential element in humans. It may present in drinking water as a consequence of the use of potassium permanganate as an oxidant in water treatment [6]The SAS states that the optimum allowable value of the potassium (K^{+}) for drinking water is 30 mg/l and the maximum allowable value is 100 mg/l. All the water samples of all locations were below the optimum allowable value. The USEPA has no recommendation for potassium.

The SAS states that the optimum value for magnesium (Mg^{+2}) is 30 mg/l and the maximum allowable value is 150 mg/l. All the water samples were within the optimum allowable value except 25%, 10%, 16.6%, 4.1% and 50% of the water samples in NE, NW, W, N and S wells respectively.

Sulfate,Nitrate and ammonia:

The sulfate concentration (SO_4^{-2}) of water samples ranged from 68.32mg/l to 1,471.40 mg/l. The SAS states that the maximum allowable value of the sulfate concentration for drinking water is 400 mg/l. By using this standard, all samples were below the maximum allowable value. The USEPA states that the maximum allowable value for sulfate is 250 mg/l. By using the American standards, all the samples were below the maximum allowable value of sulfate concentration.

The minimum concentration of $NO3^{-}$ was 12.60 mg/l in the South West (SW) region and maximum concentration was 1.649 mg/l in the South region (S).The SAS and the USEPA state that the maximum allowable value for drinking waterin term of nitrates is (NO3-N) is 10 mg/l. All of the water samples significantlyexceeded the maximum allowable value of the total nitrate (NO3-N) using eitherstandards. This means that this watershould not be used for dirking purposes before treatment or dilution with water of lownitrate concentration. Higher Nitrate levels in water can cause methmoglubinemia or blue baby syndrome that readily convert nitrate into nitrite. So, infants are not allowed to drink water that exceeds 10 mg/L Nitrate. Nevertheless, all wells in this study exhibit high nitratelevels [7].

The SAS and the USEPA state that the maximum allowable value for drinking water in term of nitrates is (NO3-N) is 10 mg/l. All of the water samples significantly exceeded the maximum allowable value of the total nitrate (NO3-N)[8].

Chloride (Cl^{-}) and Fluoride (F^{-}):

The minimum concentration of Cl^{-} was 40 mg/l in the South West (SW) region and maximum concentration was 100 mg/l in the North region (N). The SAS states that the optimum value of the concentration of chloride for drinking water is 200 mg/l and the maximum allowable value is 600 mg/l. By using this standard, the water samples of all locations were within the maximum allowable value of the chloride. The USEPA states that the maximum allowable value of chloride is 250 mg/l. Using the American standard, all wells were belowthe acceptable value for chloride.

The results revealed that Fluoride (F^{-}) exceed permissible limits of Saudia Arabian Standards in NW, SW, E, W, N and S wells. An excessive amount of Fluoride (F^{-}) in 80% of wells in North.

Copper (Cu^{+2}):

Drinking water is an important source of Cu^{+2} for humans [9], although Cu^{+2} concentrations in surface and groundwater are generally low, long term cumulative intake of the mineral poses a threat to human health. Thus, the U.S. Environmental Protection Agency (EPA) set a maximum contaminant level (MCL) for Cu^{+2} of 1.3 mg/L in drinking water[10]. Our study assured that levels of Cu^{+2} were higher than permissible limits in NE, SE, SW, E, W, N and S wells.

V. CONCLUSION

- This study indicated that most of the chemical parameters such as Sulfate, Chloride, Sodium and Nitrate do not fall within the permissible limit. Therefore, currently the related government departments should focus on treatment of drinking water and regular monitoring of groundwater quality.
- The qualities of the well water samples were therefore not suitable for human consumption without adequate treatment. Regular monitoring of groundwater quality, abolishment of unhealthy waste disposal practices and introduction of modern techniques are recommended.
- Most of the water samples in the study area evidenced excess fluoride concentrations and were not meeting the water quality standards. Ground water samples in particular showed high fluoride concentrations. The excess fluoride concentration in the study area may be attributed to the geological formation of that particular area and rapid ground water depletion. The water in the study area is not suitable for domestic consumption without prior treatment.

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