Chemical Studies on the Water Quality in Tabuk City, Saudi Arabia

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Abstract— *The water quality was studied for selected samples from groundwater and network water-supply. The values of NH_3, NO_3^-, pH, TDS, alkalinity, hardness, Pb, Cd, Fe^{3+} and Mn^{2+} were estimated. Ammonia values ranged between 0.07-0.7 ppm. Nitrate values ranged between 2.4 and 0.35 ppm. The TDS was between 645 ppm and 480 ppm. For Fe^{3+} and Mn^{2+} the values are below the limits of WHO except for well 9; and manganese in wells 6-10. Several wells showed values of Cd above the Saudi STD. The network water-supply in Tabuk city was investigated. The TDS values for these samples were between 500-600 ppm. The hardness values exceed the Saudi STD limit. When ammonia was tested, only one sample showed high value. Chloride level was below 158 ppm, but sulfate values for most samples were 128-222 ppm. For iron only one sample (well no. 9) was above the permissible limit.*

Keywords— water quality, Tabuk city, groundwater, network water-supply, heavy metal levels.

I. INTRODUCTION

Kingdom of Saudi Arabia is considered as one of the most water scarce countries in the world. It depends on groundwater as well as desalination water as source of water supply. According to the last published report of Ministry of water, it is clear that aquifers shared with 46% of total water production in Saudi Arabia according to MOWE-report [1]. In Tabuk, groundwater production reached 30 million m^3 that year. Accordingly, it is of interest to evaluate the water quality in this region. Very little studies which directed to evaluation of water quality in Tabuk region (either groundwater or network water-supply) were recorded. The previous studies were concentrated on hydrology of Tabuk area as part of Saq aquifer by Al-Ahmadi [2]. The author evaluated only the major ions, but nothing was mentioned about the different minerals. The author recommended that the TDS value of aquifer water ranged between 630 and 420 ppm. This indicates that the groundwater is refreshed. Sharaf and Hussein [3] evaluated the groundwater in Saq region in Saudi Arabia. They were studying the water composition concerning chloride, sulfate, carbonate, and calcium. Al-Harby [4] put a simple management model for irregularly located wells is presented by considering interference between adjacent wells at a certain risk level and safe groundwater velocity which depends mainly on the hydraulic conductivity at individual well sites. Sen and Al-Somyien [5] put a simple management criterion for confined Saq aquifer in Tabuk region.

In the present study, evaluation of water quality of groundwater and network-water supply will be introduced for the first time according to the WHO [6] and Saudi STD [7]. In addition, the study included the evaluation of Pb and Cd levels for the first time. The selected wells were located inside the city. Most of them were the source of water-network supply for the city population. This study is considered as a role of the university towards community since there is no scientfic studies that record the variation in water quality in this area.

II. EXPERIMENTAL

2.1 Materials

Ethylendiamine tetra-acetic acid disodium salt (EDTA) (BDH Chemicals Co, England), Eriochrome Black-T (EBT) powder (Nice, India), ammonium chloride (Carlo Erba Reagent, France), ammonium hydroxide solution (Sigma-Aldrich, Germany), sodium chloride (panreac Chemicals Co, Spain), sodium hydroxide microgranular pure P.A. (Poch Sa, Poland), murexide (Surechem Products Ltd, England), methyl Orange (Blulux, India), sulphuric acid 96% (BDH, England), potassium chromate (Merck, Germany), silver nitrate (BDH Chemicals Co, England), acetic acid (Carl Roth, Germany), sodium carbonate (Panreac, Spain), barium chloride dihydrate (Merck, Germany), potassium nitrate (Aldrich Chemicals Co, USA), sodium acetate (Carlo Erba Reagent, France), hydrochloric acid 37% (Carlo Erba Reagent, France), oxalic acid (Merck, Germany), potassium permanganate (Winlab, UK), nitric acid 69.5% (Carlo Erba Reagent, France), phosphoric acid 85 % (Sigma-Aldrich, Germany), sodium acetate trihydrate (Merck, Germany), Nessler reagent (Fluka, Germany), ammonium solution

(Panreac, Spain), were used for performing the analytical methods. Deionized water was used for preparing different reagents.

2.2 Apparatus

Conductivity-meter (Jenway, UK), pH-meter (Jenway, UK), Hotplate & Stirrer (Jenway, UK), flow-injection spectrophotopmeter (UV1800-Shimadzu, Japan), Hotplate & Stirrer (LabTech Co.Ltd, Indonesia). Flame Atomic absorption spectrometer (Buck 205).

2.3 Location of wells

The chosen wells are located in Tabuk city. Table 1, shows the location of each well.

TABLE1
LOCATION OF THE SELECTED WELLS INSIDE TABUK CITY, SAUDI ARABIA

Sample	Location
Well 1	Al-Khmseen street- Al-Mahragan-A.
Well 2	King Abd Al-Aziz Street, Al-Akhwia
Well 3	King Abd Al-Allah Street- Al-Mahragan beside King Fahd Hospital
Well 4	Al-Worood- back of Tabuk Prison
Well 5	Al-Manshia.
Well 6	Madeeny Well, Kilo-1 Senaiah Road
Well 7	Prince Sultan Park, Al-Salhia
Well 8	Al-Attwy Farm, Kilo-2 Madinah Road
Well 9	Zaid Well, Kilo-2 Senaiah Road
Well 10	Al-Kahatany Kilo-2 Madinah Road
nwMahragan-A	Mohmed bin Matrooh St.
nwManshia	Zeid AlKheir St.
nwBeside Fahd-hospital	King Khlid St.
nwAkhwia	Mohmed bin Omar Altonisy St.
nwSalhia	Ali bi Ali Taleb St.
nwWrood	Al Segen St.
nw-college-1	Faculty of Science, University Campus, Diba Road

III. METHODS OF ANALYSIS

3.1 Determination of pH:

Transfer 50ml of the sample solution into the cell. Immerse the electrodes in the solution. Calibrate the pH-meter using buffers with pH 4 and 7. Check the pH with buffer 9. Then, measure the pH of the sample. Rinse several times before changing between the measured samples or buffers. Record the pH-reading as displayed. Repeat the reading three times then take the average.

3.2 Determination of TDS

Calibrate the conductometer by measuring STD KCl solution (0.01M) has a conductivity of 1412 µS at 25ºC. Transfer 50 ml of the sample solution into the cell. Immerse the electrodes in the solution. Record the reading in display.

3.3 Determination of total alkalinity

Place 50 ml of sample in a 250 ml flask, add 2 ml of methyl orange pH indicator. Titrate against 0.02 N H_2SO_4 until the color change from yellow to pink. Read the burette and record the volume reading of H_2SO_4 according to STD-methods [8].

3.4 Determination of total hardness

Place 50 ml of sample in a 250 ml flask, add 2 ml of ammonium buffer solution and add a speck of Eriochrome Black T indicator. Titrate against 0.01 M EDTA until the color change from wine red to blue. Read the burette and record the volume of EDTA as shown by STD-methods [8] and Barnard et al [9]**.**

3.5 Determination of chloride

Place 50 ml of sample in a 250 ml flask add 1 ml of potassium chromate indicator. Titrate a against 0.028 N silver nitrate until the color change from yellow to pinkish yellow. Record the volume of silver nitrate. Repeat three times; calculate the average reading as in STD-methods [8] and Kolthoff [10].

3.6 Determination of iron

Take 50 ml of sample add 2 ml HCl and add 1 ml NH_2OH-HCl. Boil the sample until it become 15-20 ml then cool. Transfer the solution to a volumetric flask. Add 10 ml ammonium acetate and 4 ml 1.10.phenanthroline to the exit solution and complete to 50 ml with distilled water. Wait 10 min until the color appears. Measure the sample in the apparatus by using Spectrophotometer as mentioned by STD-methods [8]; Ryan and Botham [11].

3.7 Determination of manganese

Place 100 ml of sample in a 250 ml flask, then add 5 ml of special reagent. Add 1 drop of peroxide H_2O_2 and 1 gm of persulphate. Boil for one minute and let it stand one minute after boiling then cool. Measure the sample in the apparatus by using spectrophotometer as mentioned in STD-methods [8] and by Nydahl [12]. Standard Mn solution (1ml = 0.1mg/Mn) by dissolve 3.287g of potassium permanganate in 100ml of distilled water. Acidify with sulfuric acid and heat to boiling. Slowly add a dilute solution of oxalic acid until the color is just discharged. Cool and dilute to 1 litre. Prepare series (0.2, 0.4, 0.6, 0.8, 1 and 1.5 ml) of visual standard manganous sulfate into 250ml Erlenmeyer flasks and adding 50ml of distilled water.

3.8 Determination of ammonia as N

STD NH_4Cl solution was prepared by dissolving 3.141g of the solid salt into 1 liter. Put 10 ml of this solution to 1 liter flask and dilute to the mark (1 ml of this solution contains 0.01mg NH_3). Prepare series of visual standards contains (0, 1, 2, 3, 4, 5 and 6 ml of NH_4Cl and dilute to 50ml. Add 2.0 ml Nessler reagent to either the sample or the standard and mix thoroughly. Let treated samples and standards stand for 10-15 min, and measure at wavelength 420 nm according to STD-methods [8].

3.9 Determination of nitrate as N

KNO_3 solution was prepared by dissolving 0.7218 g solid salt into 1 liter. This solution corresponds to (1 ml contains 0.1 mg N-NO_3. Then intermediate solution is prepared by diluting 100 ml of this solution to 1liter, the obtained solution is equivalent to (1ml contains 0.01 mg). Then, several dilutions were made to prepare series of standard nitrate solutions for preparing calibration curve. This is achieved by diluting 1, 2, 4, and 7 ml to 50ml by distilled water. Add 1 ml of 1N HCl to each STD solution, read the absorbance at 220nm as in STD-methods [8]. Repeat the same procedure for 50 ml of water samples**.**

3.10 Determination of sulfate by turbidimetric method

The procedure depends on STD-methods [8]. Transfer 100 ml of sample in a 250 ml flask adds 20 ml of buffer solution. Mix with magnetic stirrer at a constant speed, while stirring add spoonful of barium chloride crystals and begin timing immediately. Stir for 60 second, pour sample into turbid meter sample cell and leave it for 5 min. outside the turbidimeter, And after that measure the sample. Estimate the sulfate concentration of the sample by comparing the turbidity reading with calibration curve. To prepare a calibration curve by measuring the turbidity of known standards in 5 or 10 mg/L increments from 0 to 40 mg/L sulfate. Check the reliability of the calibration curve by running standard with every 3 or 4 samples. Standard sulfate solution (1ml = 0.1mg SO_4^{2-}).

3.11 Analysis of sodium, cadmium, and lead

All of them were analyzed by flame AAS using the corresponding lamp for each element and according to the instrument manual [13] and STD-methods [8].

IV. RESULTS

4.1 Analysis of groundwater in Tabuk City:

Ten wells were assigned inside Tabuk city. Most of them provide Tabuk with water for domestic uses rather than drinking. Their major parameters were analyzed. This includes pH, TDS, conductivity, alkalinity, hardness, chlorides, and sulfates. The parameters indicating contamination were assigned too (NH_3 and NO_3). Finally, iron and manganese as important cations were analyzed for all samples.

The pH values for the ten wells were ranged between 6.56 for well 2 to 7.91 for well 9. The TDS values were not exceed 645ppm, which was registered for well number 7. In the other hand, well number 4 exhibit the lowest TDS level. Well 8 was characterized by highest alkalinity among all of the studied wells. By observing the recorded values for the hardness, it can be reported that they were above 240 ppm for most wells. Only well 8 showed the lowest hardness value (230 ppm). Also, the highest value (288 ppm) of hardness was for well 10. Table 2 shows a summary of the obtained results.

TABLE 2
PHYSICAL PARAMETERS OF GROUNDWATER IN TABUK CITY, SAUDI ARABIA

Sample	Color	pH	TDS, ppm	Conductivity, µS	Alkalinity, ppm	Hardness, ppm
Well (1)	Nil	6.61	563.2	563	750	250
Well (2)	Nil	6.56	590.7	590.7	650	258
Well (3)	Nil	6.71	557.4	557.4	750	250
Well (4)	Nil	6.9	480	480.6	730	250
Well (5)	Nil	6.98	591.4	924	740	250
Well (6)	Nil	7.15	557.4	871	720	258
Well (7)	Nil	6.98	645.1	1008	750	250
Well (8)	Nil	7.72	565.8	884	1240	230
Well (9)	yellow	7.91	563.2	880	750	248
Well (10)	Nil	6.98	604.8	945	790	288

Due to the special condition of Tabuk city, it is important to study the contamination parameters (ammonia and nitrates). Table 3, shows the results for each well. In addition, chlorides and sulfates represent major anions for groundwater, thus evaluation of their levels was performed. It was found that the values of chloride varied between 39 and 170 ppm. Sulfates values of the tested samples were of lowest for wells 4 and 1, while it was largest for wells 9 and 10.

TABLE 3
VALUES OF NITRATES, AMMONIA, CHLORIDES AND SULFATES OF GROUNDWATER IN TABUK CITY, SAUDI ARABIA.

Sample	NO_3^-, ppm	NH_3, ppm	Cl^-, ppm	SO_4^{--}, ppm
Well (1)	2.4	0.27	134.9	133.7
Well (2)	2.4	0.23	163.5	161.6
Well (3)	2.4	0.44	142	169
Well (4)	1.9	0.70	106.5	118.1
Well (5)	2.2	0.21	149.1	148.5
Well (6)	2.3	0.07	138.5	150.7
Well (7)	2.4	0.20	170	185
Well (8)	0.35	0.081	39	183.3
Well (9)	2.2	0.49	134.9	253.3
Well (10)	1.8	0.23	71	331.1

Iron and manganese are metallic elements present in many types of rock. Concentrations of iron and manganese in groundwater are often higher than those measured in surface waters. The Aesthetic Objective (AO) for iron in drinking water is less than or equal to 0.3 milligrams per litre (mg/L) while the Aesthetic Objective for manganese in drinking water is less than or equal to 0.05 mg/L. The taste and smell of manganese or iron at concentrations above the drinking water guidelines may be noted by some water users. In well-water, iron concentrations below 0.3 mg/litre were characterized as unnoticeable. Staining of laundry and plumbing may occur at concentrations above 0.3 mg/litre [14,15]. Iron also promotes undesirable bacterial growth iron bacteria within a waterworks and distribution system, resulting in the deposition of a slimy coating on the piping.

Due to that the importance of evaluating the levels of iron, manganese, calcium and magnesium; all of the tested samples were analyzed to calculate the levels of these elements. The values of iron and manganese were ranged between 0.022 to 0.081 ppm, and 0.077 to 0.11 ppm; respectively. The values of calcium are the smallest (138 ppm) for well 4, and the highest (172 ppm) for well 3. Magnesium levels are different from well to another. Some were above 100 ppm , like wells 2, 5, 7, 8, and 10. Others were below 100 ppm like wells 1, 4, 6, and 9. Table (4) shows the obtained results.

TABLE 4
VALUES OF IRON AND MANGANESE OF GROUNDWATER IN TABUK CITY, SAUDI ARABIA.

Sample	Fe^{3+}	Mn^{2+}	Ca^{2+}	Mg^{2+}
Well (1)	0.05	0.077	152	98
Well (2)	0.06	0.079	154	104
Well (3)	0.022	0.079	172	78
Well (4)	0.022	0.079	138	92
Well (5)	0.081	0.097	156	105
Well (6)	0.0058	0.11	156	92
Well (7)	0.059	0.11	172	112
Well (8)	0.12	0.11	166	174
Well (9)	0.37	0.11	160	88
Well (10)	0.028	0.11	162	126

Table 5, shows the obtained results for analysis of Pb, Cd and Na for the the groundwater samples under study. The samples of all the wells are free from Pb. In case of Cd, the recorded values range was 0-0.474 ppm. Finally, sodium level range was 200-300 ppm for wells no 2-3. Only well 1 exhibited value of Na 42.96 ppm.

TABLE 5
VALUES OF SODIUM, CADMIUM, AND LEAD IN GROUNDWATER FOR TABUK CITY, SAUDI ARABIA

Sample	Pb^{2+}, ppm	Cd^{2+}, ppm	Na^{+}, ppm
Well (1)	0.002640	0	42.96
Well (2)	0	0.033	262.96
Well (3)	0	0.380	280.74
Well (4)	0	0.419	282.59
Well (5)	0.000190	0.020	311.48
Well (6)	0.000490	0.475	366.67
Well (7)	0	0	291.11
Well (8)	0	0	283.33
Well (9)	0	0.0077	349.26
Well (10)	0	0	238.89
Saudi STD	0.01	0.003	100

4.2 Analysis of water quality network-water supply of Tabuk City:

The major parameters were determined for assigning water quality in Tabuk network water-supply. It was found that the pH-value of all parts of the network did not exceed the 7.6. In addition, the TDS for the tested water-network samples showed values ranged between 494.08 and 638.72 ppm. The TDS-value for area no 3 showed the lowest value among the tested samples. The alkalinity value range between 666.4 and 733.04 ppm. The value of hardness recorded for the all samples was above 200 ppm. The smallest value was recorded for sample well-3 (230 ppm), while the highest value was 294 ppm for sample well-5. Table 6 shows the results of analysis of major physical parameters of network-water supply.

TABLE 6
PHYSICAL PARAMETERS OF NETWORK-WATER SUPPLY IN TABUK CITY, SAUDI ARABIA

No	Sample	Color	pH	TDS, ppm	Alkalinity, ppm	Hardness, ppm
1	**nwMah-A**	Nil	7.17	565.76	714	262
2	**nwMansh**	Nil	7.25	547.84	666.4	238
3	**nwFahd Hosp. site**	Nil	7.27	494.08	714	230
4	**nwAkhwia**	Nil	7.55	601.6	666.4	264
5	**nwSalh**	Nil	7.19	638.72	685.44	294
6	**nwWrood**	Nil	7.8	552.96	733.04	260
7	**nw-College site**	Nil	7.6	614.4	714	248

Chlorides, nitrates, and sulfates represent the major anions among water parameters. The water-network samples were analyzed for the mentioned anions. It was found that the values of chlorides ranged between 104.73 and 157.98 ppm. Sample well-3 had the lowest level, while sample well-5 had the highest level of chloride. The level of sulfate was found for samples (wells-1,3,6) below 200 ppm, while it was above 200 ppm for samples (wells 2,4,5 and 7).

It was found that the ammonia level for samples (wells 2, 5 and 7) were below 0.2 ppm, while other samples (wells 1, 4 and 6) exceeds 0.2 ppm. Table 7, shows the obtained results.

TABLE 7
VALUES OF NITRATES, AMMONIA, CHLORIDES AND SULFATES OF WATER-NETWORK IN TABUK CITY, SAUDI ARABIA.

Sample No.	Sample	NO_3^-, ppm	NH_3, ppm	Cl^-, ppm	SO_4^{--}, ppm
1	**nwMah-A**	2.411	0.206	133.13	141.23
2	**nwMansh**	1.884	0.159	118.93	203.50
3	**nwFahd Hosp. site**	1.892	0.308	104.73	128.05
4	**nwAkhwia**	2.313	0.233	154.43	204.86
5	**nwSalh**	2.402	0.199	157.98	222.14
6	**nwWrood**	2.060	0.295	122.48	139.41
7	**nw-College site**	2.16	0.098	133.13	591.23

Table 8, shows the values of iron in the tested samples showed large variety between 0.02 and 0.557 ppm.

TABLE 8
VALUES IRON AND MANGANESE OF NETWORK-WATER IN TABUK CITY, SAUDI ARABIA.

Sample No.	Sample	Fe^{3+}
1	**nwMah-A**	0.036
2	**nwMansh**	0.557
3	**nwFahd Hosp. site**	0.036
4	**nwAkhwia**	0.075
5	**nwSalh**	0.012
6	**nwWrood**	0.020
7	**nwCollege site**	0.038

V. DISCUSSION

5.1 Analysis of groundwater in Tabuk City:

The water quality studies are based on evaluating the water parameters relative to the WHO regulations. Standard methods [8] were applied throughout this work. It can be recorded that, none of the previous work studied the water quality in Tabuk city in a comprehensive way. Drinking water must be colorless, odorless and transparent with acceptable taste.

The pH of water is a measure of the acid–base equilibrium and in most natural waters, is controlled by the carbon dioxide–bicarbonate–carbonate equilibrium system. The pH of an aqueous sample is usually measured electrometrically with a glass electrode. The pH-value of the tested wells was in the permissible limit 6.5-8.5. Only wells 1, 2 and 3 showed values those are very close to the lower limits 6.6 to 6.7. This means that the water of these wells is considered acidic.

Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in water. The values of TDS reflect the quality of water. The world health organization [16] classified the palatability of drinking water according to the total solids levels as the following:

Excellent, where the TDS concentrations is (<300mg/l); good, where the TDS concentration is (300-600mg/l); fair, where the TDS concentration is (600-900mg/l); poor, where the TDS concentration is (900-1200mg/l); unacceptable, where the TDS concentration is (>1200mg/l).

The classification of water in Tabuk city can be introduced according to the above guidelines. The obtained TDS values of different wells were found above 500 ppm except well 4. According to the mentioned classification, most of the wells provide good to fair water quality. Well 7 exceed the 600 ppm value. Figure 1, shows the obtained results related to the WHO-guidelines. In this field, well 4 is the only well with values lower than the STD value. The values of the TDS are close to each other, indicating the similar water quality.

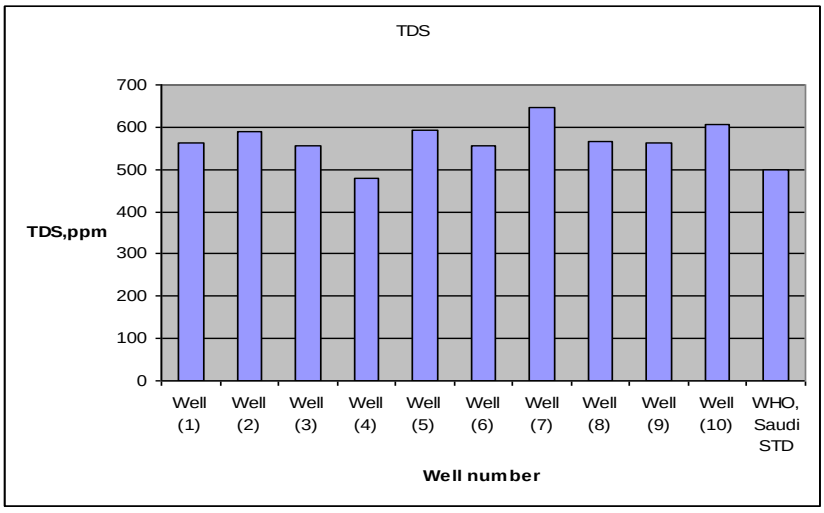

FIG. 1: CORRELATION OF TDS VALUES TO THE STD VALUE FOR GROUNDWATER IN TABUK CITY.

The presence of ammonia is an important indicator of fecal pollution according to International Organization for Standardization [17]. Most of wells contain ammonia levels below the permissible level (0.5 ppm) except well 4 (0.7 ppm). This is due to contamination from sewage water. Two wells (3 and 9) showed values (0.44 and 0.49 ppm) and approached the limit (0.5 ppm). Although other wells show smaller ammonia values, it is an indication for the contamination from sewage water inside the city. Figure 2, showed the relation between all wells and WHO regulation.

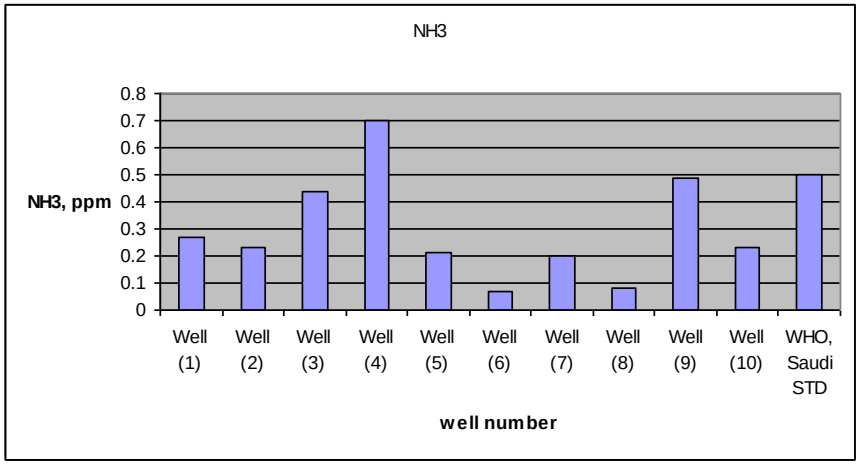

FIG 2: CORRELATION OF AMMONIA VALUES TO THE STD VALUE FOR GROUNDWATER IN TABUK CITY.

According to Greenwood and Earnshaw [18], **s**ulfates occur naturally in numerous minerals, including barite ($BaSO_4$), epsomite ($MgSO_4 \cdot 7H_2O$) and gypsum ($CaSO_4 \cdot 2H_2O$). Two wells (9 and 10) showed values (253 and 331 ppm) of sulfate exceeds the WHO permissible values (250 ppm). Other wells are in the safe limits of sulfate. The considerable amounts of sulfate agree with the type of geological layers of the aquifer which is almost sedimentary type. Figure 3 correlates the sulfate values for all wells to WHO limit.

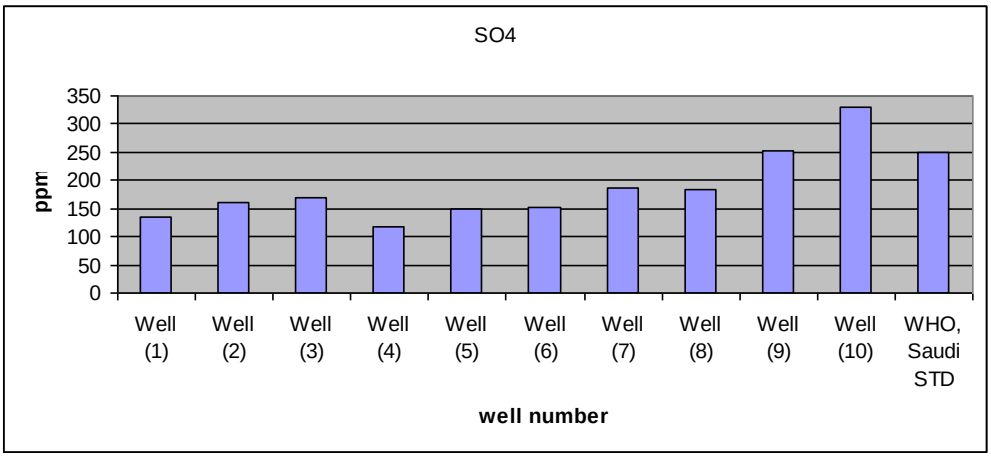

FIG 3: CORRELATION OF SULFATE VALUES TO THE STD VALUE FOR GROUNDWATER IN TABUK CITY.

Hardness is most commonly expressed as milligrams of calcium carbonate equivalent per liter. McGowan [19] classified water according to $CaCO_3$ content. When calcium carbonate at concentrations below 60 mg/l, it is generally considered as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and more than 180 mg/l, very hard. Although hardness is caused by cations, it may also be discussed in terms of carbonate (temporary) and non-carbonate (permanent) hardness. Here, most of the wells are considered very hard water, since they have hardness more than 200 ppm. The hardness is aroused from either magnesium or calcium soluble salts (Ca and Mg levels are shown in table 4). They are mostly sulfates, chlorides and bicarbonates. This agreed with the high levels of sulfates and chlorides found in most well samples. Figure 4 correlates the hardness values.

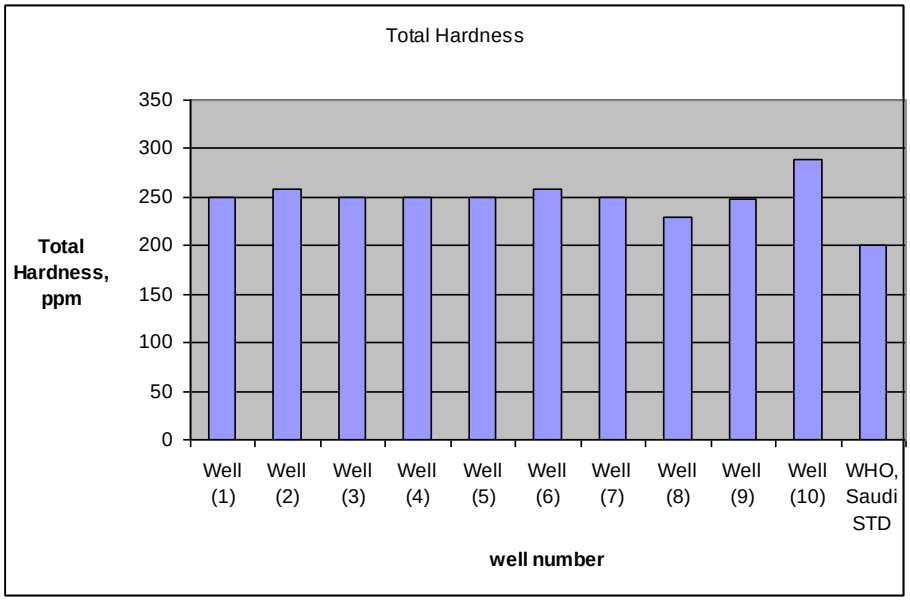

FIG 4: CORRELATION OF TOTAL HARDNESS VALUES TO THE STD VALUE FOR GROUNDWATER IN TABUK CITY.

Manganese occurs naturally in many surface water, groundwater sources and in soils that may erode into these waters. The level of manganese in the Saudi STD is different from the WHO. The permissible limit in Saudi STD is 0.1 ppm, while in WHO it is 0.5 ppm. Here, we will consider the Saudi limits. In this study, the values of manganese are very close to the limit. The range of the manganese values is between 0.07 to 0.11 ppm. Wells 6 to 10 showed value of manganese equal to 0.11 ppm. Table 4, showed the obtained results.

Iron and manganese usually are accompanying each other in water. Anaerobic groundwaters may contain iron (II) at concentrations up to several milligrams per liter without discoloration or turbidity in the water when directly pumped from a well. Taste is not usually noticeable at iron concentrations [20] below 0.3 mg/liter as WHO and Saudi STD recommended. Although turbidity and color may develop in piped systems at iron-levels above 0.05–0.1 mg/liter. In this study, iron was not exceeding the permissible limit for most of the test wells in Tabuk city except well 9 (0.37 ppm). The other wells showed very little iron values (0.022 to 0.08 ppm). Well 8 recoded an iron level out of this range 0.12 ppm. Table 4 gives the results of the iron analysis.

Some elements were analyzed only by AAS. Sodium, lead, and cadmium were chosen to perform this study. After comparing the obtained results with the Saudi STD (0.01ppm), it is found that almost the all wells have values of Pb lower values. This means that the wells are lead-free. In case of Cd, wells no 2,3,4,6, and 9 recorded values out of the Saudi STD limit (3 ppb)[7]. Other wells are in the safe range. For sodium, it was found that the wells 2-10 had levels above the Saudi STD (100 ppm). Only well no 1, showed the smallest value (42.96 ppm).

5.2 Analysis of water quality network-water supply of Tabuk City:

The water supply in Tabuk city mainly depends on groundwater. As shown in the first part the quality of this water was evaluated. To complete the interpretation, evaluation of the network-water supply should be evaluated too. This will allow the correlation between the water source and the final product water.

The TDS values of network-water supply inside Tabuk city were determined as it represents the major parameter in evaluation of the water quality. According to the Saudi STD most of the samples exceed the limit of drinking water quality (500 ppm). Sample well-3 is the only one that fits the mentioned limit, since it was 494.08 ppm. Other samples had TDS values range between 547.8-638.7 ppm, which is out of the permissible limit (Figure 5). Although these are accepted for domestic uses, they are not accepted for drinking.

The obtained values for water-network supply can be explained if we recall the groundwater results (figure 1). It was shown that the TDS values were also above 500 ppm and exceed 600 ppm by a small value.

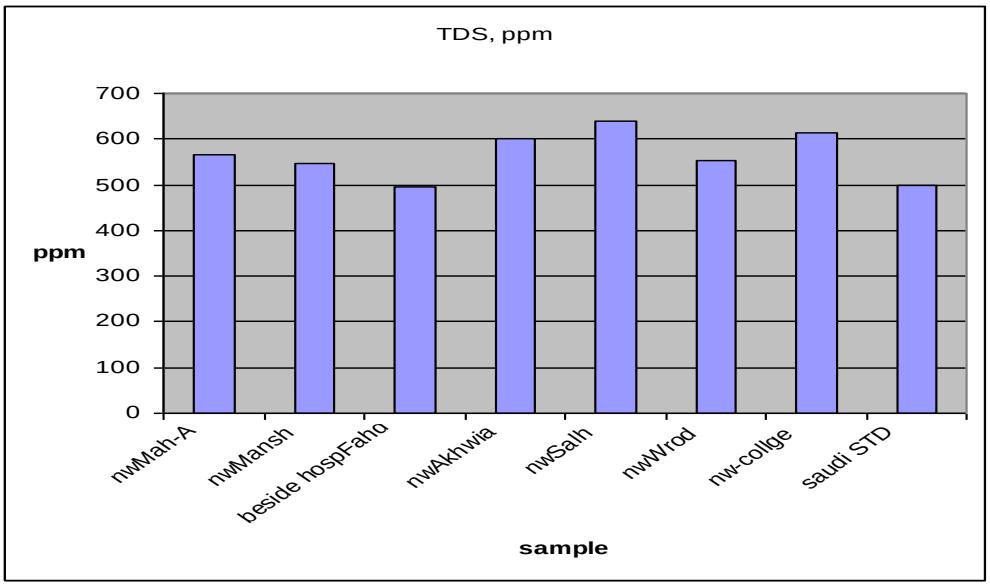

FIG 5: CORRELATION OF TDS VALUES TO THE STD VALUE FOR NETWORK-WATER IN TABUK CITY.

The hardness of all the tested samples exceeds 200 ppm (figure 6). This proves that the hardness values are out of the Saudi STD value. Figure 6 shows the obtained results. This agreed with the previously found values for ground water of Tabuk city (figure 4). So, it can be reported that no actual treatment for the water-network supply to overcome this property.

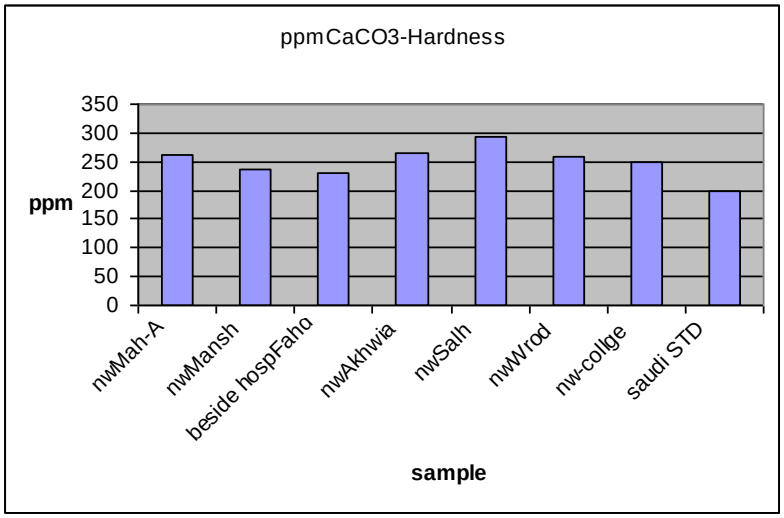

FIG 6: CORRELATION OF TOTAL HARDNESS VALUES TO THE STD VALUE FOR NETWORK-WATER IN TABUK CITY.

The sulfate values of the different samples of water-network supply were determined. It was found that only sample no 7 showed a value (591.2 ppm) more than the permissible limit according to the Saudi-STD (250 ppm). This site is the sample located in faculty of Science inside the Tabuk University campus.

Iron values were calculated for seven samples of water-network supply. Only well-2 showed high level of iron (0.557 ppm), which exceeds the permissible limit (0.3 ppm for Saudi-STD. So, no serious deviation from the Saudi-STD concerning the iron level.

VI. CONCLUSION

Quality studies is important for human need. It is associated with health and human safty. These studies is considered as a role of the university towards community, since there is no scientfic studies that record the variation in water quality in this area. Evaluation of major water-parameters in Tabuk city, Saudi Arabia was successfully intoduced. The relation between between groundwater quality and the network-water supply quality was predicted. Evaluation of Pb and Cd levels for the first

time in these area was pridected. No lead was recorded above limits, while Cd limits of most wells exceeds the Saudi STD limits. Other heavy metals need more studies to evaluate the water quality in Tabuk City, Saudi Arabia.

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