Evaluation of Water Quality in Parts of Wadi Fatimah, Western Saudi Arabia

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Abstract— *11 wells in Wadi Fatimah were chosen to perform this study. The studied area was classified into three regions namely Abo-Hassani, Al-Khief, and Allaf. In Abo-Hassani, the water quality agrees with the WHO standards. The TDS was between 175 and 339 ppm. The hardness was below 193 ppm. The sodium and the chloride were below 71 and 63 ppm, respectively. The water here suffers from the presence of E.Coli. In Al-Kheif region, the water suffers from the high TDS 1077 ppm and the presence of E. Coli. In Allaf region the TDS was high a little (487 ppm), but still within WHO standards for drinking water. In this region, the sulfate value and the total hardness were above 250 ppm, which exceeds the WHO standards.*

Keywords— Wadi Fatimah, Water quality, Western Saudi Arabia water quality.

I. INTRODUCTION

Wadi Fatimah is one of the important sources of groundwater in the western part of Saudi Arabia. It is located to the southeast of Jeddah. It is between latitudes 21° 15` and 22° N, and longitudes 39° and 40° 30` E (figure 1a,b). Although the main source of water in Jeddah city is the desalination plants on the Red Sea **[1,2]**, the natural groundwater worth to focus the interest. Early in 1972, according to Dekkart **[3]**, it was reported that Wadi Fatimah can produce 12 million gallon of water per day. Based on this report Ain Aziziah decided to construct the third line of water. His report recommended that there must be a compromise between the rate of withdraw water and the rate of recharging. It was reported that the precipitation rate was about 200 ml/year. This leads to that the amount of rainwater is between 100-600 million m^3. Hussein and Ibrahim **[4]** introduced a geological study of different valleys in the western part of Saudi Arabia. Their studies involved Wadi Fatimah.

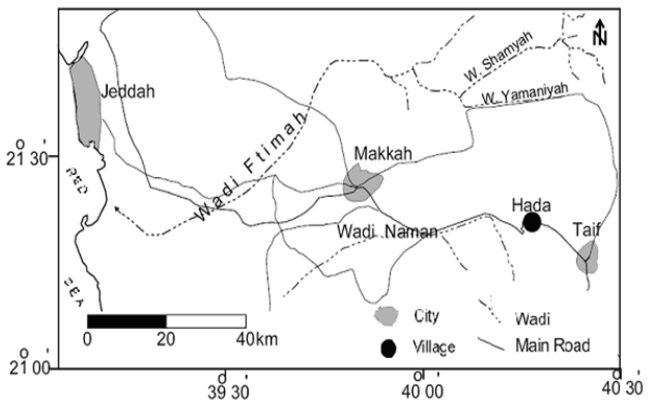

FIGURE 1A: LOCATION MAP OF THE AREA UNDER STUDY

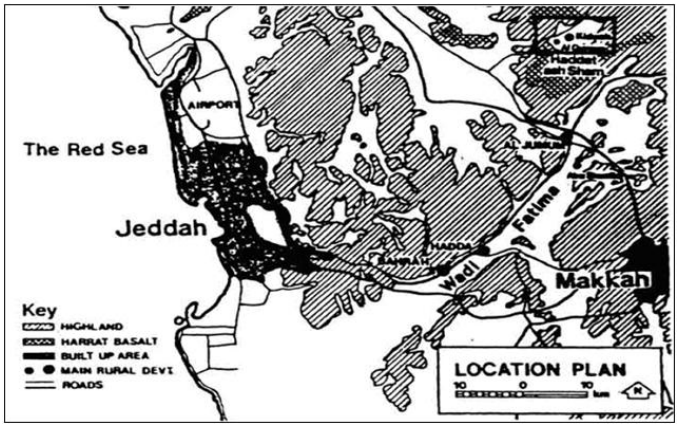

FIGURE 1B: TOPOGRAPHY OF THE LOCATION

Wadi Fatimah basin comprises the most important drainage system in the western province of Saudi Arabia. It is considered as the major important sources of groundwater to the cities of Makkah, Jeddah and the surrounding villages and towns. Trace elements were analyzed in each sample for a total of 17 water quality descriptors (variables) by Sharaf et al **[5]**. The studied elements were: As, Zn, P, Pb, Ba, B, Si, Al, Li, Cu, Fe, Hg, Mn, Cd, V, and Rb. AlYamani **[6]** investigated of the potential contamination of groundwater from on-site domestic wastewater systems blasted in weathered and fractured bedrock in the upper reaches of Wadi Fatimah basin, western Saudi Arabia. Groundwater in the shallow alluvial and fractured bedrocks aquifers of Wadi Fatimah, west central Arabian Shield, Saudi Arabia was investigated by Sharaf et al **[7]**. The impact of human activities and natural processes on groundwater quality is one of the major serious problems for sustainable development in this area. They investigated 80 well-representative groundwater samples for the total 17 water quality descriptors (variables) including toxic elements. This was not considered in traditional techniques for water quality assessments. Sharaf **[8]** described the chemical composition of the groundwater of Wadi Fatimah includes the variations of the groundwater salinity, the major and trace constituents.

Although many geological studies were found about Wadi Fatimah, none of the previous work concentrated on the water quality. In the present study we found it is useful to study the water quality the cited area in a systematic way, as a part of a general study of water quality in western area of Saudi Arabia. The number of the wells out of work is 15, this is due to the presence of the Abo-Hassani Dam which produce a change in the hydrology of the area. There is a thick layer of clay that was accumulated in front of the Dam. This layer closed the Dam's holes and prevent the motion of water down the valley in the direction of the wells.

II. EXPERIMENTAL

The spectrophotometric measurements were carried by a UV-VIS-spectrophotometer DR-4000 (HACH, USA). It was daily calibrated for Fe^{3+}, Cl^{-}, NH_3, SO_4^{--}, NO_3^{-}, and K^{+},....etc. The pH-measurements were holding using either portable-multiparameter model Sension-156 (HACH, USA), or bench top model Sension-4 (HACH, UAS). The TDS-measurement was applied using Sension-7 (HACH, USA). Sodium determination was applied by the sodium combination (no.51925, HACH, USA). All of the aforementioned instruments were loaded to a computer system through RS-232 connection, a channel selector and HACH-software. The results were recorded and signified via the mentioned computer program. Thus, the measurements can be followed up online. Also, direct evaluation of the data can be effected. The total hardness was estimated by the visual titrimetric method against EDTA in presence of EBT-indicator and ammonium buffer solution (pH 10).

The chemicals and standard solutions were analytical grade reagents. They were purchased either from HACH [USA] or prepared in Ain–Azizziah-laboratory. The applied methods for water analysis were based on the WHO recommended methods **[9]**.

Microbiological examinations were carried out by Sartoriuos kits (Germany) prepared media for the total Colony, E. Coli, and finally yeast and molds. The method was based on the membrane filter technique for separation of the required species. An incubator (Germany), stainless steel funnel with its cover (Sartorious, Germany), and air pump (Sartorious, Germany) were used to perform the separation of the mentioned species from water samples. So, the count of the different species was estimated.

III. RESULTS AND DISCUSSION

Wadi Fatimah comprises different areas, among them are Ab-Hassani, Al-Kheef, and Wadi Allaf. Samples from different areas were investigated. Eleven wells were chosen to perform this study. Figure 2 shows the location of the investigated wells.

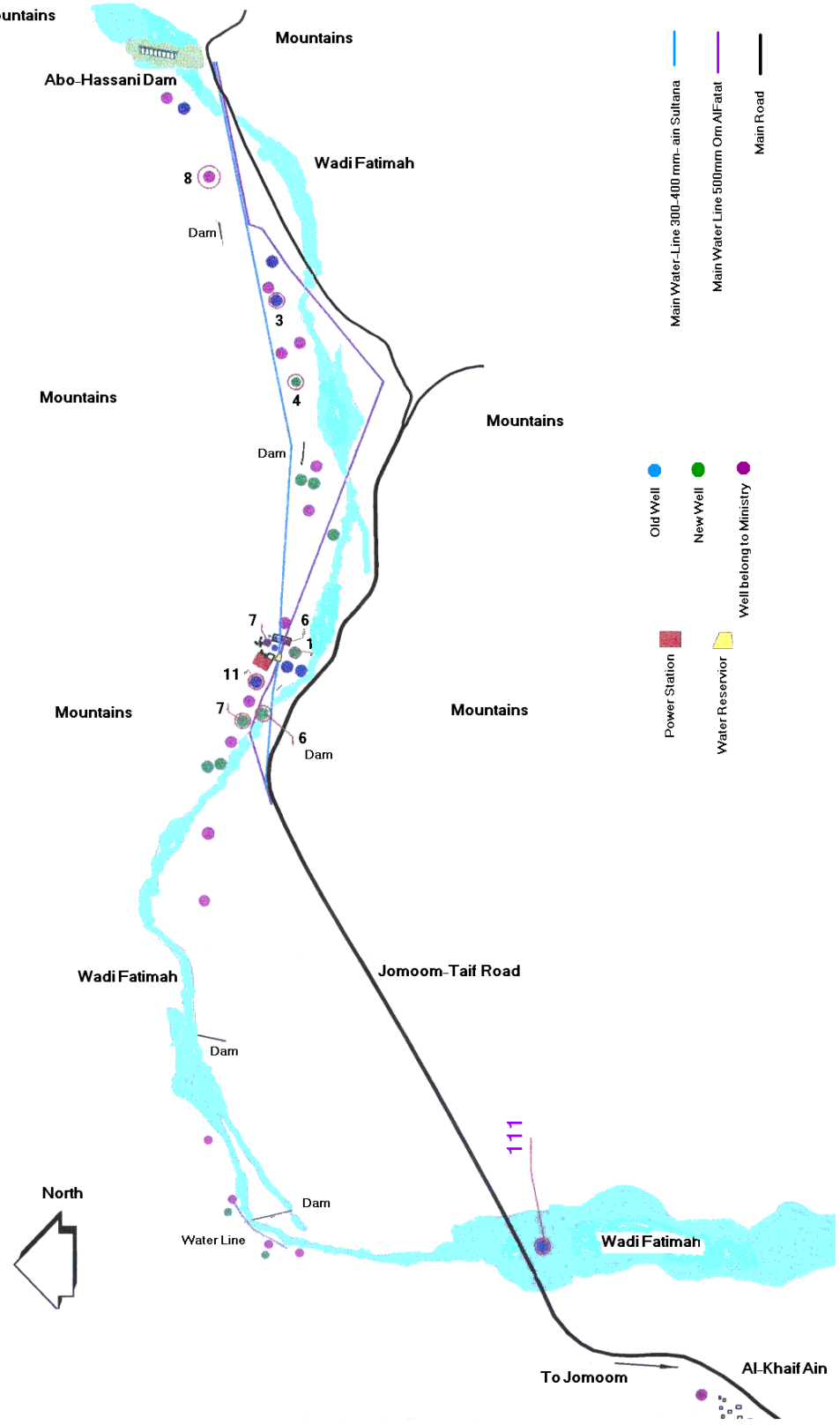

FIGURE 2: SCHEMATIC DIAGRAM OF THE LOCATION OF THE WELLS UNDER STUDY

3.1 Abo-Hassani

Samples from ten wells in (Abo-Hassani, in Wadi Fatima) were picked up and analyzed for the main parameters. Table 1 showed the main analytical results. Figures 3a-3c, represents the correlation between the WHO guidelines [10] and the recorded values for TDS, Cl^-, and SO_4^{--}.

TABLE 1
ANALYTICAL RESULTS OF DIFFERENT PARAMETERS FOR WADI FATIMAH WELLS

Property	1-AD57	4-AD58	7-AD59	7-AD60	6-AD61	8-AD62	3-AD63	6-AD64	11-AD65	111-AD66
pH	7.67	7.8	7.7	7.9	7.8	7.6	7.9	7.8	7.9	7.6
Hardness	163	108	171	133	190	167	191	177	193	630
Alkalinity	336	370	347	339	359	373	379	265	347	402
K^+	0.69	0.6	0.82	0.67	0.72	0.7	0.76	0.8	0.77	1.04
Na^+	55	47	63	46	58	64	71	30	64	219
Fe^{3+}	0	0.028	0	0	0.005	0	0.015	0.017	0.054	0.536
Cl^-	65	39	54	50	63	56	60	52	54	283
SO_4^{2-}	52	31	59	46	56	72	77	43	62	525
NO_3^-	13.3	4.4	2.2	9.7	6.6	0.22	2.7	2.2	9.3	2.2
Total colony	720	3600	660	4800	1020	1440	6480	1200	110	660
E.Coli	158	Obs.	274	Obs.	1980	278	6480	4800	2160	5940
TDS	267	176	282	224	290	300	339	233	302	1077

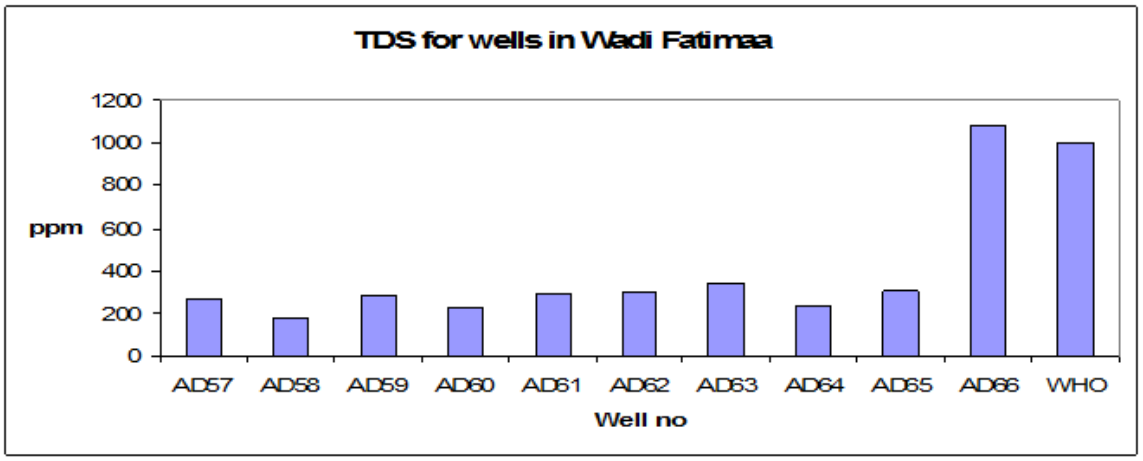

FIGURE 3A: VALUES OF TDS IN THE DIFFERENT WELLS

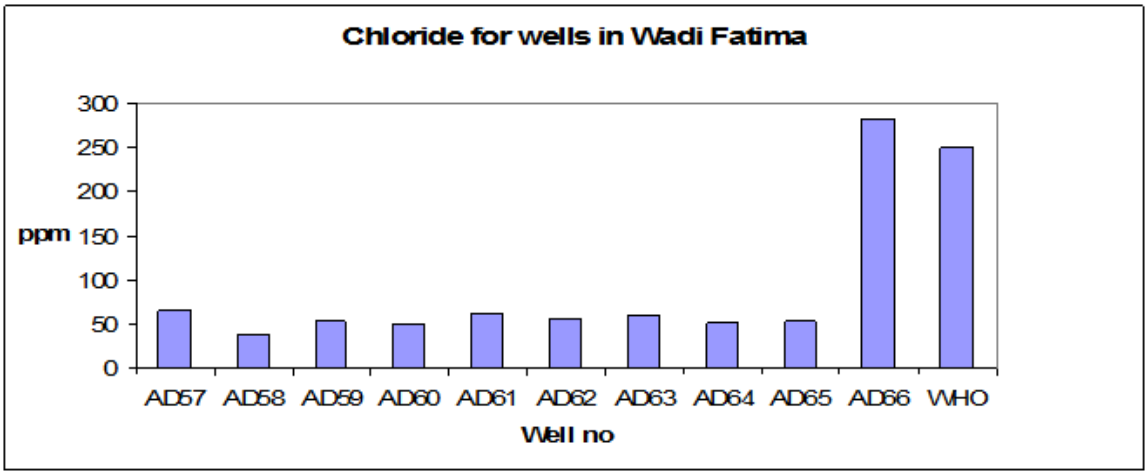

FIGURE 3B: CHLORIDE VALUES FOR THE DIFFERENT WELLS.

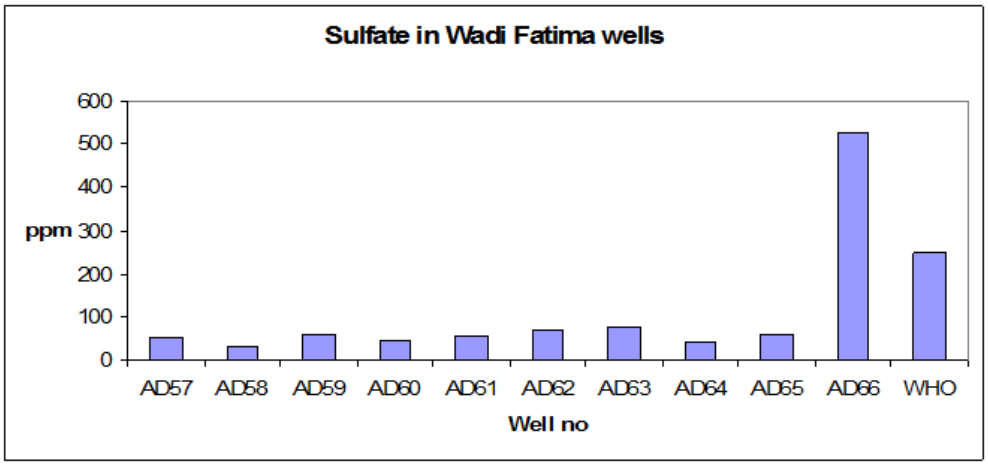

FIGURE 3C: SULFATE VALUES IN THE DIFFERENT WELLS

The investigation of the physical properties showed that the water was free from turbidity and odor. The recorded values for the turbidity were between 0.654 NTU and 0.061 NTU.

The chemical parameters for water were studied and evaluated for the chosen wells. The pH-value range was 7.91-7.58, which agreed with the WHO limits. The total dissolved salts TDS values were less than 500 ppm. Their range was between 175.9 and 339 ppm. One of the important chemical parameter is to decide the water quality is the range of nitrate and ammonia. For the tested samples, the highest level was 13.3 ppm NO_3^- and 0.084 ppm NH_3, which means that water was away from the contamination sources. The values of the total hardness were suitable for most samples (108.3-193.1 ppm). Sodium levels were between 71.1 and 30.5 ppm, which was below the WHO standard. The highest value for chloride was 63.7 ppm. In addition, sulfate level was between 77.5 and 31.6 ppm. The sulfide was tested, where the highest recorded value was 0.004 ppm.

The biological investigation showed that there were contamination of colony bacteria and E.Coli. The analysis showed that the total count of colony range was between 110 and 7200 per 100 ml, while the E. Coli was 158-6480 per 100ml. The yeast and mould count was 2-216 per 100 ml. Therefore, it is recommended to apply a disinfection procedure before use.

3.2 Al-Kheef

The well no AD66 was only available for the study. The water here was quite different from Abo-Hassani area. This was clear from the analytical data as below:

The physical properties of water in this well showed that high value of turbidity (7.72 NTU), which exceeded the standard values.

The TDS value was 1077 ppm, which was more than the WHO recommended value. High value (629.9 ppm) of the total hardness was recorded for this well. Sodium (219 ppm) and iron (0.536 ppm) values exceeded the WHO recommended values. The anionic species like chloride and sulfate showed high values 525 ppm and 283.7 ppm, respectively. The obtained value for the nitrate and ammonia were 2.2 ppm and 0.24 ppm, respectively. The presence of these species (NO_3^- and NH_3) reflected the contamination of water either by fertilizers or sewage in the close area.

The biological analysis for this water showed that the water suffered from high amount of colony = 660, E.Coli = 5940, and yeast and mould = 1740 per 100 ml. These results agreed with what was predicted in the chemical analysis concerning nitrate and ammonia.

The previous analysis, which was applied one year before for this well, showed similar results except for the nitrate value (it was 50.2 ppm).

The water from this well can be mixed with that from Abo-Hassani wells. The resultant water will have TDS value 349 ppm, total hardness 213 ppm, sodium 72 ppm, chloride 77 ppm, sulfate 103 ppm, and iron 0.066 ppm. All these values were within the WHO limits.

3.3 Wadi Allaf:

Four samples belong to Wadi Allaf were analysed. The samples were chosen carefully to represent the wells in this area. It was found that the water was free from turbidity and it was odourless.

The TDS values were varied between 408 and 487 ppm which was within the WHO limit. Only one well showed a value (541 ppm) that was beyond the WHO-guidlines for drinking water. The pH-value was between 7.49 and 7.56. The chloride value was not more than 99.8 ppm. The value of sodium was not more than 100 ppm. The sulfate, nitrate and ammonia values were within the WHO limits. This proved the good quality of water. Only one well showed value of sulfate higher than the WHO limits. The total hardness showed relatively high values 300, 316, and 344 ppm, though it is still within the guideline limits value of WHO for human uses.

IV. CONCLUSIONS

After the investigation of the water quality of Wadi Fatimah, it was found that:

1. Water from Wadi Abo-Hassani fitted the limits of either the WHO or the Saudi standards. The water suffers from contamination of E.Coli and Colony bacteria. Therefore, water should be treated by a disinfecting agent.
2. Water from Wadi Al-Kheef was so salty that it was not suitable for drinking. High amounts of sodium and chloride were observed. It is better to mix this water with that from other wells to a percent 1:1.
3. Water from Wadi Allaf agreed with the WHO standards.
4. Water from each of the Wadi areas should be collected in separate tanks. This will give a chance to eliminate and treat problems in each section alone. This will help to control the added percentage of each section.

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