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Some Aspects of Groundwater Quality in Najran Town, Kigdom of Saudi Arabia

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Abstract

This paper aims to determine the groundwater quality at Najran town and nearby villages, Kingdom of Saudi Arabia. Physical and chemical analyses have been carried out for seven groundwater samples collected from Najran area. This study indicates that the groundwater quality in the study area is fit for human purposes except at few localities which contain high amounts of total dissolved solids (TDS) and electrical conductivity (EC) above the permissible limits of the World Health Organization standards. The groundwater is also fit for irrigation purpose and agricultural use.

Keywords

Chemical Analysis, Groundwater, Najran Town, Saudi Arabia

Subject Areas: **Analytical Chemistry**

1. Introduction

Water is a ubiquitous chemical substance that is composed of hydrogen and oxygen and is vital for all known forms of life (UNOSIA, 2005) [1]. In typical usage, water refers only to its liquid form or state, but the substance also has a solid state, ice, and a gaseous state, water vapor or steam. Water covers 71% of the Earth's surface (FAO, 1997) [2].

Different contaminants make water unfit for different uses and purposes, especially drinking uses. Among these contaminants are nitrates, which are a hazardous contaminant, and have been frequently implicated in epidemiological studies concerning methaemoglobinaemia and cancer diseases. Cases of methaemoglobinaemia usually occur in rural areas, or in areas that rely on wells as primary source of drinking water. Nitrates contamination of water results in methaemoglobinaemia which affects infants less than six months of age when consume

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water containing more than 50 mg/l of nitrates in water, this was reported by WHO (1993) [3] and Grignon (1997) [4]. Infantile methaemoglobinaemia occurs when bacteria either from soil or in the immature infant gut, converts NO_3 to NO_2. Nitrite easily combines with foetal haemoglobine to form methaemoglobin, which can't carry oxygen around the body (USEPA, 2010) [5]. Among drinking water contaminants is also fluoride (F^-) which, to far extent, influenced by ambient temperature, alkalinity, calcium and magnesium contents of drinking water and it affects the human health positively or negatively (Singh *et al*., 1993) [6].

It has been reported that standards and guidelines for major cations and anions in drinking water were set on the based of taste considerations rather than the impact on human health (WHO, 1993) [3] and thus higher values can be tolerated. However, excessive concentrations of Na^+ in drinking groundwater can be a health risk factor for those individuals on a low-sodium diet as reported by USGS (2005) [7].

The aim of this study is to investigate the groundwater quality extracted from bore holes and dug wells in the area of Najran town. Groundwater samples will be collected from both bore holes and dug wells if available. Physical and chemical analysis will be conducted to investigate the groundwater characteristics and if there is any pollution. Radiochemical analysis should also be carried out. This will show us if there is any radioactive contamination and its possible source, since the area is surrounded by many outcrops of different geological formation and contains different minerals with wide chemical composition and crystal structures which mainly characterize the acidic igneous rocks such as feldspars, micas and quartz.

The final results of this work will show us the nature of groundwater in the area of Najran and may lead us for more investigations about the geology of the area, water quality and its extent of pollution.

2. Climate, Location and Geological Setting

The climate in Najran is desert climate. There is much less rainfall in winter than in summer. The driest month is June with 0 mm rainfall, and most precipitation falls in March with an average of 59 mm (**Figure 1**). About 133 mm of precipitation falls annually. The average annual temperature in Najran is 23.6˚C. The warmest month of the year is July with an average temperature of 29.9˚C. In January, the average temperature is 16.6˚C. It is the lowest average temperature of the whole year (http://www.climate.data.org) [8].

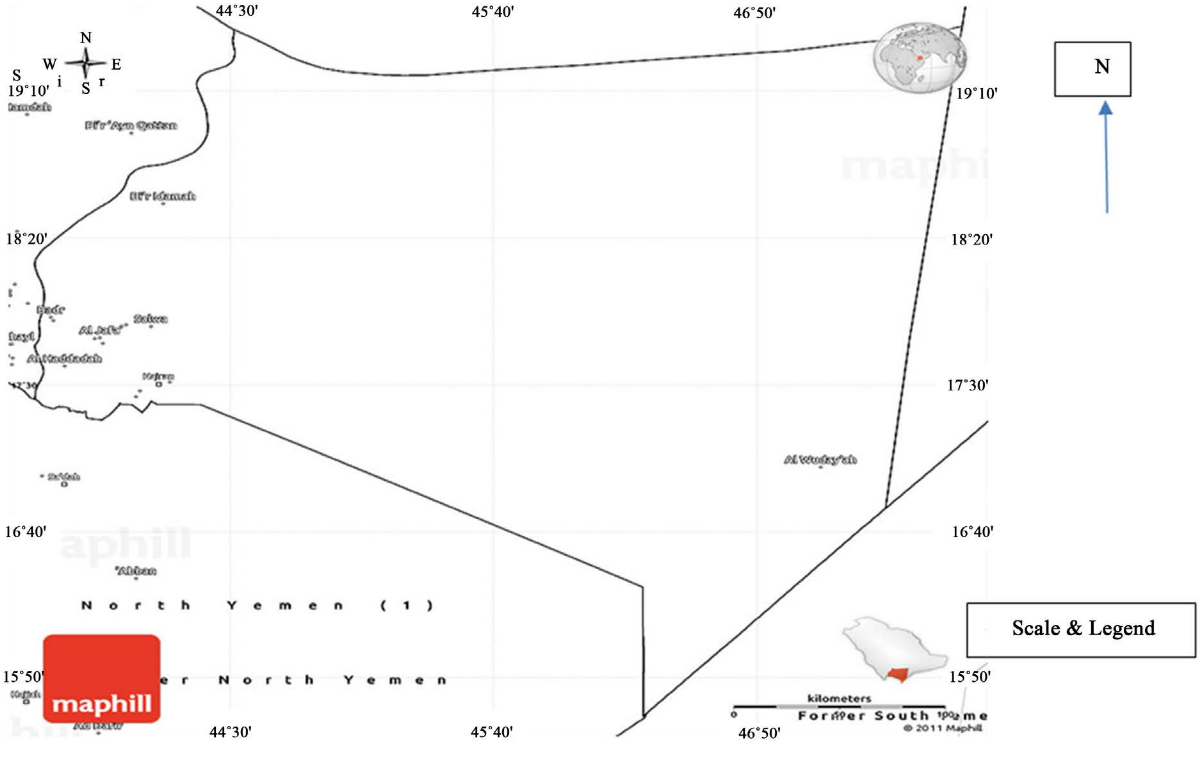

Figure 1. Map of Saudi Arabia with Najran Town Highlighted in red (seen on the right side above the scale).

Najran Town (the study area), lies in the southern part of the Kingdom of Saudi Arabia (**Figure 1**). The study area is surrounded by many outcrops of different geological formation and contains different minerals with wide chemical composition and crystal structures which mainly characterize the acidic igneous rocks such as feldspars, biotite, micas and quartz. They are mainly metamorphosed pre Cambrian igneous rocks.

Najran area which lies in the south western part of Saudi Arabia, lies within the area of the Great African Rift valley with its simple and complex fault zones which have different trends. The faults have trends north east to south west, or north west to south east.

Najran is located in Saudi Arabia, its geographical coordinates are 17˚30'20" North, 44˚11'3" East and its original name (with diacritics) is Najran.

Najran is located in the southwest corner of Saudi Arabia, close to the Yemini border. It is one of the Kingdom's most modern cities and is also the capital city of Najran province. Najran town is surrounded by orchards and trees, and encircled by outcrops of metamorphosed pre-cambrian rocks.

3. Materials and Methods

The groundwater samples were collected in 1-litre polyethylene plastic bottles from the different bore holes examined in the study area. The available productive bore holes in the study area were chosen.

The physical parameters contain the pH measured with HANA pH meter, model Hi 8424, turbidity was measured with Lovibond turbidity meter, electrical conductivity and total dissolved solids were measured using Conductivity-TDS-Salinity meter (850,038), and dissolved oxygen (DO) was measured using DO-meter 850,041.

Cations represented by Ca^{2+} (Calcium), Mg^{2+} (Magnesium), Na^{+} (Sodium), K^{+} (Potassium) have been analyzed using OPTIMA-spectrophotometer model SP-3000 plus. The anions were determined by titrimetric methods using the relevant reagent. Sulfate was carried out following turbidity method using spectrophotometer.

4. Results and Discussion

The results of physical and chemical parameters were shown in **Table 1(b)**, **Table 1(c)**, and **Table 2(a)**, while **Figures 2-4** show the distribution of total dissolved solids (TDS), nitrates NO_3^-) and sodium ions (Na^+) respectively. Physical parameters and major anions were presented in **Table 1(a)**, while the major cations were presented in **Table 2(a)**. **Table 1(b)** and **Table 1(c)** illustrate the max, min and mean values of physical parameters and major anions respectively, while **Table 2(b)** presents the max, min and mean values of major cations.

Among the physical parameters of the water samples collected from the study area it was found to be high in certain localities. The total dissolved solids were found to be high at the bore hole of Habona (1690 mg/l) exceeding even the acceptable levels set by the WHO (2004) standards for drinking water (**Table 1(a)**) and **Figure 3**. High values of electrical conductivity were recorded in the study area at Habona (3430 µS) (**Table 1(a)**). Ac-

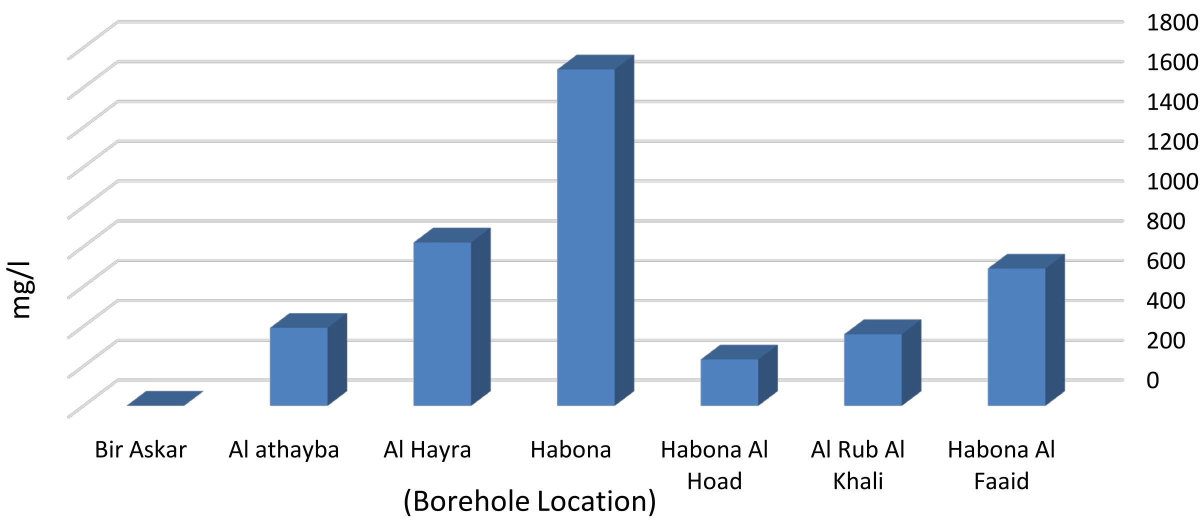

Figure 2. Distribution of TDS (mg/l) in the study area.

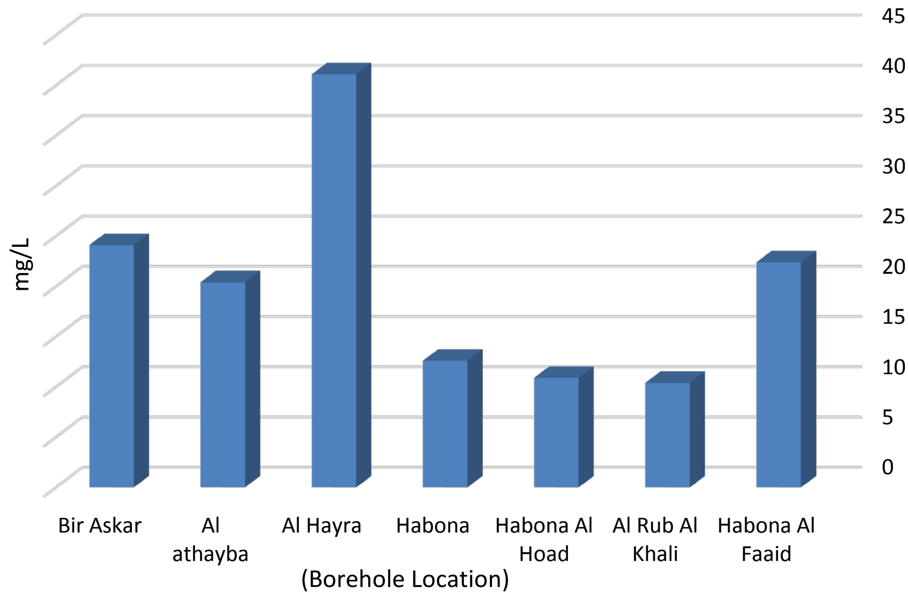

Figure 3. Distribution of Nitrates (NO_3) in the study area.

Table 1. Results of physical and chemical parameters (Major anions) of water samples from the study area.

(a)

	Locality	NH_3^-	NO_2	NO_3^-	SO_4^{2-}	F^-	Cl^-	TDS	EC	Taste	Color	pH	DO	Turbi.
1	Habona al Faid	-	0.04	22.2	134	3.5	-	358	718	Nil	Nil	7.10	0.0	4.44
2	Al Rub al Khali	-	0.01	10.4	97	2.1	-	360	717	-	-	8.0	0.01	0.67
3	Habona al Hoad	-	0.01	10.9	64	0.9	-	233	467	-	-	8.13	0.01	0.93
4	Habona	-	-	12.6	227	-	-	1690	3390	-	-	7.78	0.02	
5	Al Hayra	-	0.01	41.1	180	-	-	821	1638	-	-	7.87	0.25	0.25
6	Al althayba	-	0.03	20.4	146	0.7	-	392	784	-	-	8.0	0.37	0.37
7	Bir Askar	-	0.07	24.1	-	-	-	-	-	-	-	8.07	0.62	0.30

*All parameters in (mg/l) except for Taste, Color and pH.

(b)

Parameter	Max. value	Min. value	Mean	Range
TDS (mg/l)	1690	358	642.3	358 - 1690
EC µS/cm	3390	467	1285.6	467 - 3390
pH	8.13	7.10	7.85	7.1 - 8.13
DO (mg/l)	0.62	0.01	0.21	0.01 - 0.62
Turbidity (TU)	4.44	0.25	1.16	0.25 - 4.44

(c)

Parameter	Max. value	Min. value	Mean	Range
NO_2	0.07	0.01	0.03	0.01 - 0.07
NO_3	41.1	10.4	16.39	10.4 - 41.1
SO_4	227	64	119.67	64 - 227
F	3.5	0.7	1.8	0.7 - 3.5

*All parameters in (mg/l).

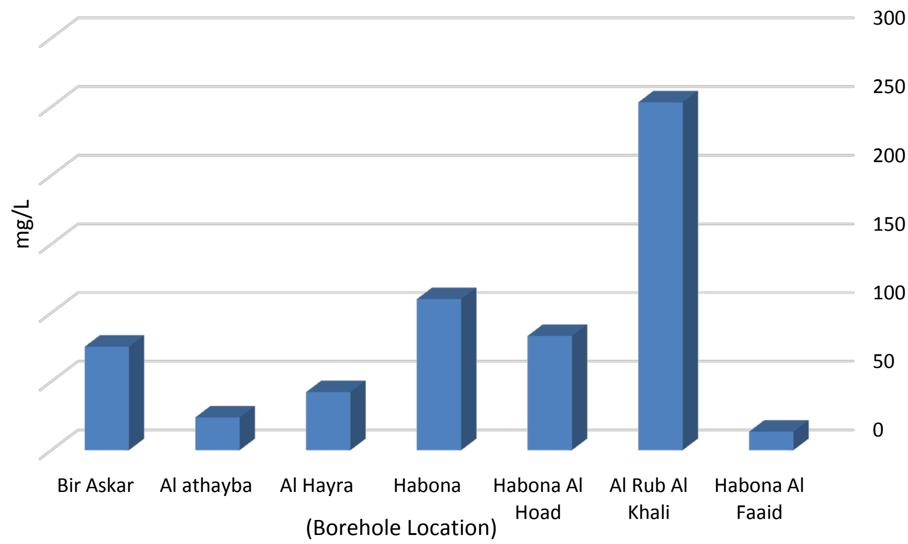

Figure 4. Distribution of Na ions (mg/l) in the study area.

Table 2. Results of chemical parameters (major cations) of water samples from the study area.

(a)

No.	Locality	Na^+	Mg^{+2}	K^+	Ca^{+2}
1	Habona El Faid	13.4	51.7	8.4	66.5
2	Al Rub al Khali	253.2	12.5	20.5	0.0
3	Habona Al Hoad	83.1	24.1	6.0	57.7
4	Habona	109.9	94.6	0.0	374.4
5	Al Haira	42.2	51.5	0.0	14.8
6	Al athayba	23.8	37.7	8.9	140.0
7	Bir Askar	75.2	19.2	0.0	162.1

*All values are in mg/l.

(b)

Parameter	Max. value	Min. value	Mean	Range
Na	253.2	13.4	85.82	13.04 - 253.2
K	20.5	8.4	12.6	8.4 - 20.5
Ca	374.4	14.8	135.92	14.8 - 374
Mg	94.6	12.5	41.61	12.5 - 94.6

*All values are in mg/l.

cording to Langenger (1990) [9], the importance of electrical conductivity is its measure of salinity, which greatly affects the taste and thus has a significant impact on the user's acceptance of the water as potable. According to Mallevialle and Suffer (1987) [10], the single most important class of consumer complaints with regard to water supplies is related to taste and odor problems. A look at **Table 1(b)** indicates that electrical conductivity values are below the WHO guidelines (1984) [11] of 1400 µS/cm, except at Habona (3390 µS/cm) and Al Hayra (1638 µS/cm) (**Table 1(a)**) and both localities possess high values of total dissolved solids (TDS).

The major anions analyzed in the groundwater collected from the study area show that they are detected in low concentrations and even absent in some localities.

Ammonia (NH^{4+}) and chlorides (Cl^{-}) are not detected in the groundwater. Nitrite $\left(NO_2^-\right)$ and Nitrates $\left(NO_3^{2-}\right)$ are found to be in low concentrations, where their maximum levels are 1.5 mg/l and 50 mg/l respectively according to the WHO standards (1984) [11] for drinking water. High nitrates levels are recorded at Al Hayra (41.1 mg/l) (**Table 2(a)** and **Figure 4**).

Among the major cations, it was clear that all cations were below the acceptable levels of the drinking water standards set by WHO (1984). Only sodium ions occur in concentrations exceeding the WHO guidelines for drinking water at bore hole No. 2 (Al Rub al Khali), where it reaches a concentration of 253.2 mg/l exceeding the WHO standards of 200 mg/l (**Table 2(a)**). This cation is possibly derived from the chemical weathering of the feldspars and micas which are some of the minerals characterizing the rocks of the area (Metamorphosed granitic rocks), where the original rocks are granites composed mainly from quartz, feldspar and micas beside other silicate minerals found in few amounts.

These ions are among the species which are constantly involved in cation exchange processes and interaction with aquifer materials (Mercado, 1985) [12].

5. Conclusion and Recommendations

On the basis of analytical results obtained from the groundwater geochemistry, the following can be concluded:

-The groundwater in the study area is potable and good for domestic and other uses except at certain localities.

-In all bore holes the groundwater pH is above 7.10 which indicates that the water is slightly alkaline and within the range of 6.5 – 8.5 set by the WHO (1984) standards for drinking water for pH.

It is recommended that more groundwater samples should be collected and analyzed to investigate a large number of samples and the area should be widely covered, especially Al Rub Al Khali area, where high concentrations of Na (Sodium) ions are detected, and no data is available before this quick study.

It may be recommended that bore holes with low grade and deteriorating drinking water quality may be abandoned or closed, regardless of the status of economic, social and water availability and scarcity.

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