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Determination of some Inorganic Constituents of Ground Water in Afif Area- Kingdom of Saudi Arabia

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Abstract:

Groundwater quality for three samples of well water collected from Afif area (Al-batin, Battahah, Khalidiya has been studied to the presence of several water quality parameters such as pH, electrical conductivity, total dissolved solids, total alkalinity, total hardness, bicarbonates, calcium, magnesium, sulphate, sodium and potassium.. Results obtained for Al-batin sample found to be in the permissible range reported by the WHO for pH, electrical conductivity, chloride, total alkalinity, Mg^{+2}, and K^{+} while TDS value and Ca^{+2} below the level permitted by the WHO, Al-batin sample classified as moderately hard. Battahah and Khalidiya samples show that pH., TDS value, total alkalinity, chloride , and K^{+} were in agreement with WHO standards while electrical conductivity for Battahah sample above the maximum permissible limit and Khalidiya sample within the permissible range reported by the WHO, the tow samples were classified as hard, Ca^{+2} and Mg^{+2} for Battahah sample within the permissible range reported by the WHO, while Khalidiya sample shown Ca^{+2} below the level permitted by the WHO and Mg^{+2} above the permissible range..

Na^{+} and sulphate of all water samples shows values above the permissible range reported by the WHO, it might be due to Sedimentary rocks that contain a high percentage of Sodium sulphate in the study area. It is inferred from the study that these water sources can be used for potable purpose only after prior treatment to reduce the concentrations of sulfate ion and sodium ion in order to be suitable for human and animal consumptions.

Keywords: drinking water, Afif Area, Kingdom of Saudi Arabia, WHO, Inorganic Constituents

1. INTRODUCTION

Water is an inorganic, transparent, tasteless, odorless, and nearly colorless chemical substance covers over 70% of Earth's surface. No known life can live without it. Lakes, oceans, seas, and rivers are made of water, which is the main constituent of Earth's hydrosphere and the fluids of all known living organisms [11].

Water is a unique, ubiquitous substance that is a major component of all living things. Without it neither animals nor plants life will exist. Water is essential in processes of digestion, circulation, elimination and the regulation of body temperature. Water used as a solvent for many substances ([10]).

It is anomalous in many of its physical and chemical properties. Its nature and properties have intrigued philosophers, naturalists and scientists since antiquity. Water continues to engage the attention of scientists today as it remains incompletely understood in spite of intense study over many years [13]. Water is one

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of the two official names for the chemical compound H_2O ([14]). It is also the liquid phase of H_2O[29], the other two common states of matter of water are the solid phase, ice, and the gaseous phase ([7]), its chemical formula is H_2O [29], meaning that each of its molecules contains one oxygen and two hydrogen atoms, connected by covalent bonds. Two hydrogen atoms attached to one oxygen atom at an angle of 104.45° ([11]).

Water is an essential resource for which there are no substitutes. The fact that water does not lend itself to international trade complicates the Water resource scarcity problem. Unlike metals, grain, timber, coal, or petroleum, cannot transported economically in large quantities, certainly not in the quantities necessary to satisfy the demands of even a small country. While there are schemes to divert major rivers, create long canals, tow icebergs, or desalinize water, such schemes have substantial economic and political costs. They appear to be sustainable solutions to water scarcity problems only in rare situations ([28]). The supply of fresh water limited by the hydrologic cycle and general climatic conditions, and demand for water as an agricultural, industrial, or urban resource is increasing exponentially with the rising global population **([12]).**

1.1 Objectives of the study:

The aim of this study was to determine quantitatively some Inorganic Constituents of Ground water samples in Afif area (Riyadh Region-Kingdom of Saudi Arabia) and compare the results with those recommended by the WHO.

2. MATERIALS AND METHODS

Study area:

All ground water samples for this study are located within Afif region. Afif is a city in central Saudi Arabia, in the Najd region. It is situated approximately halfway between Riyadh and Mecca. The modern town was established in the 1910s as a hijra, or "settlement", for the nomadic tribes of the area, particularly the tribe of 'Utaybah . The town was named after an old well in the area called Afif "alaud beer". People used to pass by this well in their way to Mecca while performing the Hajj or Omrah, in order to get water for the rest of the way. Eventually, during the month of Hajj, merchants began to congregate around this well to sell their goods to the pilgrims, which led to the first settlements being established. Thereafter, the people from small villages nearby the well started to recognize how profitable it was to live nearby this well, and houses started to be built there, which caused the city to develop over time. Its coordinates are 23°54′36″N 42°55′13″E [30]. The Geographic location of study area shown in Figure. (2.1)

Figure (2.1) show the Geographic of different sites under study.

2.1. Sampling:

The samples of the Ground water were collected from Afif area wells and sorted in plastic container at room temperature. Table (2.1) shows the locations of the samples, the dates and times collected.

Table (2.1): Locations of ground water samples, and date of collection.

Sample No.	Location	Date of collection
1	Khalidiya	27-6-1443
2	Battahah	27-6-1443
3	Al-batin	27-6-1443

2.2. Methods:

2.2.1. Determination of pH

The hydrogen ion concentration plays great importance in the chemistry of water [15]. PH is the negative common logarithm of the hydrogen ion activity ([22]) The pH of most raw water lies within the range 6.5–8.5 ([23]).

The pH meter calibrated by the standard solutions of p^H 4,7 and 9 at 25°C, and then the pH values for all water samples directly from the AL device. (PH) meter at 25 ° C.

2.2.2. Electrical conductivity (EC):

Electrical conductivity is the measure of the ability of water to conduct an electrical current) [(6), (18).]
The electrical conductivity values of water samples measured directly from the Conductivity meter at 25 ° C.

2.2.3. Determination of TDS:

Total dissolved solids (TDS) is the term used to describe the inorganic salts and small amounts of organic matter present in solution in water ([23]).
TDS values for all samples was measure directly using TDS meter in mg / l at 25 ° C.

2.2.4. Determination of Hardness:

Hardness is the most commonly expressed as milligrams of calcium carbonate equivalent per litre [(16).]
EDTA titrimetric method used as described in 1 ml ammonia buffer solution and about 30 mg of eirochrome black T indicator added to 50 ml water sample in a 250 ml conical flask, the solution was then titrated with 0.01 M EDTA solution until the color changes from wine red to blue end ([5]) ([2]).

Calculation:

$$\text{Hardness as } CaCO_3 \text{ mg / L} = \frac{A \text{ x } B \text{ x } 1000}{\text{mls of sample}} \quad \text{(general formula)}$$

Where:
A = mls of EDTA required for titration.
B = mg of $CaCO_3$ equivalent to 1 mole EDTA titrant.

$$\text{Hardness} = \frac{V \text{ x } 0.01 \text{ x } 100 \text{ x } 1000}{50}$$

Therefore, hardness = 20 V ppm
V = Volume of EDTA required for titration.

2.2.5. Determination of Sulphate:

US EPA 6010 ICP/AES, Samples digested by USEPA 3005 prior to analysis. The ICPAES technique ionizes the filtered sample atoms emitting a characteristic spectrum. This spectrum then compared against matrix-matched standards for quantification.

2.2.6. Determination of Chloride:

Chloride is the major anions in water, Chloride as sodium Chloride and to lesser extent as calcium and Magnesium Chlorides [(1).]
50 ml of each sample placed in a 250 ml conical flask, 1 ml of K_2CrO_4 indicator added, the solution then titrated with (0.014 M) $AgNO_3$ solution ($AgNO_3$ solution standardized by mohr method using standard KCl solution) until a pinkish yellow precipitate was produced. The distilled water being used as blank was treated in the same manner, ([21]) ([28]).

Calculation:

$$Cl^- \text{ mg / L} = \frac{(A - B) \text{ x } M \text{ x } 35.5 \text{ x } 1000}{V}$$

Where:
A = mls of Ag NO_3 required for the sample.
B = mls of the titrant for the black.
M = molarity of $AgNO_3$ solution.
V = mls of sample.

2.2.7. Determination of Carbonate and bicarbonate:

To a 50 ml of water sample few drops of phenolphthalein solution added, and the solution titrated with 0.05M HCl. The burette reading (say x) recorded. Few drops methyl orange indicator added to titration flask and the titration continued till the end point when the color changes from yellow to red (burette reading y) ([22]).

Calculation:

x = Volume of acid ≡ $^1/_2$ carbonate.
Therefore:
2x = Volume of acid required to titrate all the carbonate in 50 ml of Sample.
y = Volume of acid ≡ all carbonate + all bicarbonate.
Therefore:
y – 2 x = Volume of acid required to titrate all the bicarbonate in 50 ml sample.
The result expressed as mg/L.
Therefore:

$$CO_3^{-2} \text{ mg / L} = \frac{0.05 \text{ x } V \text{ x } 60 \text{ x } 1000}{50 \times 2}$$

Where:
V =Volume of acid – required to titrate all carbonate in 50 ml Sample.
60 = the molecular weight of the carbonate.

$$HCO_3^- \text{ mg / L} = \frac{0.05 \text{ x } (y - 2x) \times 61 \text{ x } 1000}{50}$$

61 = the molecular weight of the bicarbonate

2.2.8. Determination of Calcium:

100 ml of the water sample placed in 250 conical flasks; 0.5 ml NaOH solution added to get a p^H of (12 – 13) and the solution stirred. A one gm of the murexide indicator added, while stirring and 0.01 M EDTA solution added slowly until the end reached the color change from pink to purple, ([5]).

Calculation:

$$Ca^{2+}\ mg / L = \frac{A \times B \times M \times 40 \times 1000}{Ml\ of\ sample}$$

Where:

A = mls of titrant for the sample.

B = mg $CaCO_3$ equivalent to 1 mole EDTA titrant.

M = Molarity of EDTA.

40 = Calcium molecular weight.

2.2.9. Determination of Magnesium

The magnesium estimated mathematically by subtracting the water hardness of calcium from the total water hardness. The result of this process is the water hardness of the magnesium, which taken in milligrams / liter, ([5]).

2.2.10. Determination of Sodium:

From the stock solution (1000 ppm Na) 1ml , 2ml , 3ml , 4ml and 5ml were transferred to 50 ml flasks and diluted to the mark with distilled water to give : 10 , 20 , 30 , 40 and 50 ppm Na . The flame photometer then used to measure the emission intensities of the standards and the samples.
The calibration curve was then constructed and from which the concentration of Na^+ were determined ([22]).

2.2.11. Determination of Potassium:

From the stock solution, (1000 ppm K) 20 ml transferred to 100 ml flask, and diluted to the mark with, distilled water to give (200 ppm K) 2ml , 4ml, 6m,8ml, 10 ml. transferred to 100 ml flasks and diluted to the mark with distilled water to give 4 , 8 , 12 , 16 and 20 ppm K. The flame photometer then used to measure the emission intensities of the standards and the samples. The calibration curve was then constructed and from which the concentration of K^+ were determined [(22)].

3. RESULTS AND DISCUSSION

3.1 Chemical and Physical Analysis of Water Samples

The pH value is an important index of acidity or alkalinity and the concentration of hydrogen ion in the ground waters **Table (3.1) and figure (3.2)** show the pH, electrical conductivity, and total dissolved solids, the (pH) of the three samples in the range between (7.02 to 7.66), which indicates that all water samples fall in the equilibrium side, and (pH) values within the permissible level as reported by WHO standards (6.5 – 8.5) ([23]), ([8]).

The most influential water quality guideline on crop productivity is the water salinity hazard as measured by electrical conductivity (EC). The primary effect of high EC water on crop productivity is the inability of the plant to compete with ions in the soil solution for water (physiological drought). The higher the EC, the less water is available to plants.

The electrical conductivity for Al-batin and Khalidiya samples were in agreement with those values reported by WHO standards, while Battahah sample is in disagreement with values reported by WHO standards (0.05 to0.75) ([4]) ([8]).so it will be unsuitable for irrigation.

Also **Table (3.1) and figure (3.2)** shows that the values of total dissolved solids (TDS for all the samples as follows 138ppm (in Al-batin), 362 ppm (in Battahah), and 402 ppm (in Khalidiya), which indicates that Battahah and Khalidiya samples are acceptable for household and irrigation uses according to WHO while Al-batin sample shows very low of TDS which is considered unsuitable for drinking as it lacks essential minerals it could be used for irrigation [(23)].

Table (3.2) and figure (3.3) shows levels of Hardness, Carbonate and bicarbonate, Sulphate, and Chloride for water samples

The hardness is the property of water which increase the boiling point of water, all water samples shows values of harness in agreement with the recommended by WHO (60 to 500 ppm) [(17)] [(27)]

The alkalinity of ground water is primarily a function of carbonate, bicarbonate, hydroxide content and includes the contributions from borates, phosphates, silicates and other bases. Alkalinity is an important parameter because it measures the water's ability to resist acidification [(19)]. Carbonate and bicarbonate concentrations summarized in table (3.2) and figure (3.3) shows that all the samples within the permissible range reported by the WHO.

The results of sulphate concentration, which obtained and summarized in table (3.2) show that in, Khalidiya (1660 mg/l) and Bataha (1470 mg/l) out range of WHO standards (250 to 1000 mg/l) [25], this is mainly due to Sedimentary rocks that contain a high percentage of sulfate ions in the study area (Na_2SO_4),but in Al-batin sample (553 mg/l) within the permissible range reported by the WHO standards ([18]).

Chloride is one of the major inorganic anions in water and wastewater. The chloride content in all water samples ranged from (28 to 128 mg/l) Show that all samples within the permissible range reported by the WHO (from 25 to 250 mg/l) ([9]).

Table (3.3) and figure (3.4) show Calcium, Magnesium, Sodium, and Potassium concentrations

Calcium:

Calcium is the most abundant ions in fresh water and is important in shell construction, bone building and plant precipitation of lime.

Calcium concentrations for the study samples shows that Battahah sample within the permissible range reported by the WHO, while Khalidiya and Al-batin samples are less than the level permitted by the WHO ([2]). This can be due to the presence Haloxylon plant, which absorbs salinity from the soil.

Magnesium:

Magnesium is often associated with calcium in all kinds of waters, but its concentration remains generally lower than the calcium. Magnesium is essential for the Chlorophyll growth and acts as a limiting factor for the growth of Phytoplankton [20].

Magnesium concentrations shows that samples (Al-batin and Battahah) within the permissible range reported by the WHO, while Khalidiya sample is higher than permissible range reported by the WHO ([3]). This can be due to decrease of calcium.

Sodium:
From table (3.3) show that the concentration of Sodium cation (Na^+) of all water samples above the permissible range reported by the WHO, this is mainly due to Sedimentary rocks that contain a high percentage of Sodium ion in the study area (Na2SO4) [24]

Potassium:
Concentrations of Potassium cation (K^+) of all water samples within the permissible range reported by the WHO [26].

Table (3.1): pH, electrical conductivity (EC) and total dissolved solids (TDS) for Afif Area water samples.

International standards for drinking water according to WHO		Samples			
minimum	maximum	1	2	3	**Sample No**
		Al-batin	Battahah	Khalidiya	**Location**
6.5	8.5	7.66	7.23	7.02	**pH**
0.05	0.75	0.72	0.9	0.76	**E C/ µ s**
300	1000	138	362	402	**TDS/ppm**

Figure (3.1): The pH, electrical conductivity (EC) and total dissolved solids (TDS) for Afif Area water samples.

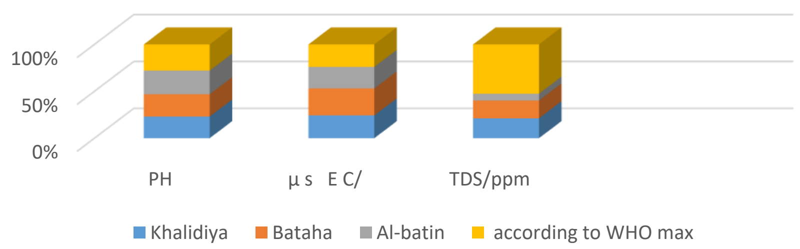

Table (3.2): Chloride, sulphate, carbonate, bicarbonate and hardness

International standards for drinking water according to WHO		**Samples**			
minimum	maximum	1	2	3	**Sample No**
		Al-batin	Battaha	Khalidiya	**Location**
60	500	140	220	252	**Hardness as $CaCO_3$mg/L**
60	250	213.5	219.6	225.7	**HCO_3^- mg/L**
60	180	108	108	180	**CO_3^{-2} mg/L**
250	1000	553	1470	1660	**SO_4^{-2} mg/L**
25	250	28	106	128	**Cl^- mg/L**

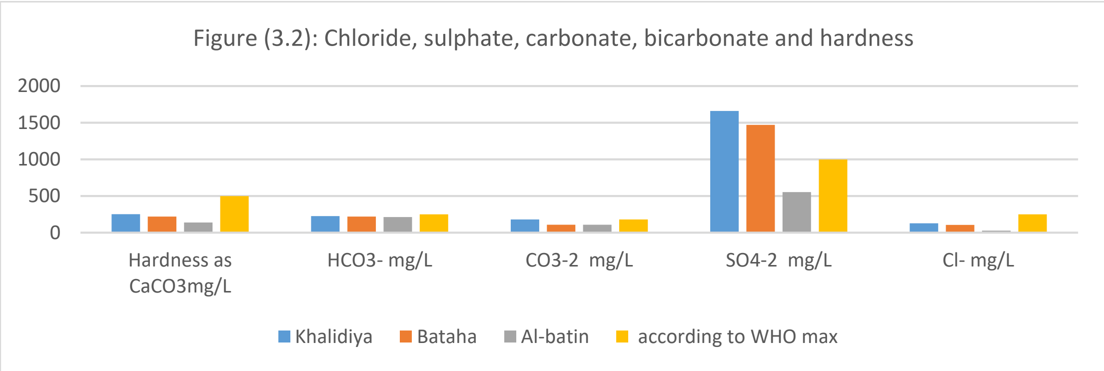

Figure (3.2): Chloride, sulphate, carbonate, bicarbonate and hardness

Table (3.3) results obtained for the listed cations Sodium, potassium, and calcium in ppm.

International standards for drinking water according to WHO		**Samples**			
minimum	**maximum**	**1**	**2**	**3**	**Sample No**
		Al-batin	Battahah	Khalidiya	**Location**
100	**200**	**23.2**	**134**	**46.4**	**Ca^{+2} mg/L**
50	**150**	**117**	**86**	**206**	**Mg^{+2} mg/l**
1	**8**	**3.8**	**3.6**	**5.7**	**K^+ mg/L**
20	**200**	**407**	**787**	**1210**	**Na^+ mg/L**

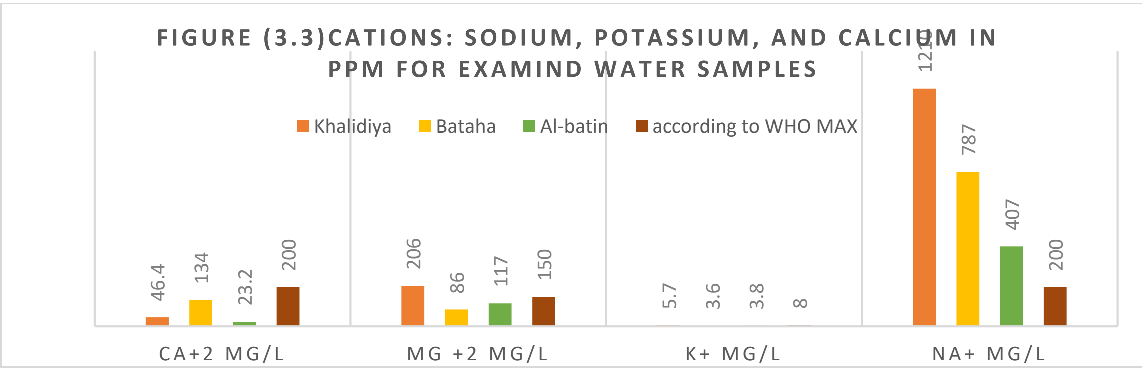

FIGURE (3.3)CATIONS: SODIUM, POTASSIUM, AND CALCIUM IN PPM FOR EXAMIND WATER SAMPLES

4. CONCLUSIONS:

From the previous results, all water samples showed different concentrations of inorganic ions. The concentration of chloride, carbonate, hydrogen carbonate, magnesium, calcium, and potassium ions for all water samples were within the range allowed by the WHO, while the the geological formation of the area is the basic cause of high concentrations of sulfate and sodium ions which were higher than the permitted range by WHO. Therefore, these samples need chemical treatments to reduce the high concentrations of sulfate and sodium in order to be suitable for human and animals uses.

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