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The Study of some Physicochemical and Microbiological Properties in Water Wells at Rabigh Governate, Saudi Arabia

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ABSTRACT

This study was conducted to analyze water wells in seven sites lie along a valley that discharges into the Red Sea at Rabigh province in the Western Region of Saudi Arabia. The analysis was conducted to evaluate and determine whether the water in the study area is suitable for drinking and agricultural uses. Nevertheless, the study included some of the physical, chemical, and microbiological characteristics. While the physical characteristic included odor, taste, and color, however, the chemical characteristics included the pH, Electric conductivity (EC), Turbidity, Total Hardness (TH), Total Dissolved Salts (Solids) (TDS), ammonium (NH_4-N), nitrates (NO_3-N), nitrites (NO_3-N), and bicarbonates (HCO_3). In addition to microbiological aspects like the water concentrations of Total Coliform Bacteria (TCB) and the Fecal Coliform Bacteria (FCB). However, in the present study, our results indicated clear variations in the levels of physical and chemical concentrations. It was found that the levels of ammonium (NH_4-N), nitrates (NO_3-N), nitrites (NO_3-N), and bicarbonates (HCO_3) at all sites have levels below the standards recommended by the international and local organizations. The only exception was found at Rabigh and Colia, in which the levels of these parameters exceeded the permissible limits recommended by these organizations. Regarding the concentrations of the Total Coliform Bacteria and Fecal Coliform Bacteria, the water wells at all sites are acceptable for both drinking and agricultural use due to their concentrations were below the recommended standards. In this paper, we recommended that the quality of drinking water must be checked at regular time intervals and further studies are needed in the future to monitor the pollution in the study area.

Keywords: Physiochemical, Total Dissolved Solids, Electric conductivity, Turbidity, Bacteria, Coliforms and Fecal.

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Introduction

Water is a versatile solvent that is fundamental to the existence of all living organisms and it is one of the most important and abundant compounds of virtually all biological ecosystems. Inadequate drinking water supply is still one of the major challenges in developing countries. Surface water is generally poor in quality and there has been a deliberate shift towards reliance on groundwater for domestic needs. The preference as a source of drinking water in a rural area is because of the relatively better quality than surface water [1]. The quality of groundwater is increasingly being affected by anthropogenic activities and various chemical constituents and their concentration [2], and any sort of pollution either physical or chemical will cause evidently changes and highly affected the receiving water body [3-5). The deterioration of drinking water quality arises from increased use of pesticides, fertilizers, industrial wastes, municipal solid wastes, and heavy metals. The adverse effects of contamination of drinking water by toxic doses of chemicals cause either acute or chronic health effects such as nausea, lung irritation, skin rash, vomiting, dizziness, and even death [6]. Also, the pollution of drinking water by harmful microorganisms causes water-borne diseases in developing countries manifested as incidents of diarrhea that occur annually [7, 8] The availability of good quality water helps in preventing the spread of gastrointestinal diseases and the transmission of infectious diseases that have caused serious illnesses and associated with mortality worldwide. Therefore, the quality of drinking water must be checked at regular time intervals [2].

Groundwater refers to all the water occupying the voids, pores, and fissures within geological formations, which originated from atmospheric precipitation either directly by rainfall infiltration or indirectly from rivers, lakes, or canals. Groundwater is a valued freshwater resource and constitutes about two-thirds of the freshwater reserves of the world [9]. A well is an excavation or structure created in the ground aquifers, where most hand-dug wells can vary greatly in depth and water volume, many wells are found to be critically polluted in terms of temperature, mineral contents, particles solute, organic matter, and bacterial concentration [10]. Many factors are known to affect the quality of water and could be amenable to contamination with different pollutants, especially liquid pollutants from sewage water that was discharged in valleys, oil wastes, workshop wastes, in addition to the garbage that was usually dumped inside the valleys.

The chemical, physical and bacterial characteristics of groundwater determine its usefulness for humans, animals, agriculture, and other various purposes. Drinking water should pass these rigorous entire tests for obtaining more and more standard quality in purity, however, all these criteria must be strictly monitored. The physical analysis of groundwater includes the determination of color, odor, taste, color, temperature, pH, hardness, and the degree of turbidity. These factors may affect water acceptability due to aesthetic considerations such as color and taste; produce toxicity reactions, unexpected physiological responses of a laxative effect, and objectionable effects during normal use such as curdy precipitates [11]. The water must be free of any detectable taste and odor when it is used for drinking, cooking, or bathing purposes. Taste and odor depend on the stimulation of the human receptor cells, which are located in the taste-buds for taste, whereas the nasal cavity for the test of odor [12]. Tastes and odors in water may be derived from a variety of conditions and sources which can be characterized as natural and man-made. The changes in the taste of water are due to organic and inorganic waste materials reaching the water including a variety of constituents like phenol, oil, fats, dissolved salts, and metals like Fe, Mn, chlorides [13]. Ca^{2+} and K^{+} are the most important components affecting the taste of water, while high concentrations of Na make the water taste salty [14]. The recommended dietary amounts for Mg^{2+} are 6 mg/kg per day, but excess Mg^{2+} makes water taste bitter [15]. The bad odor of groundwater is due to sewage water which remains a long time in their channels, thus releasing hydrogen sulphate gas, organic sulphate, amines, and ammonia [13]. The presence of phenol in the water at a rate of 0.01 part per million will give rise to a bad smell, so WHO recommended that phenol compounds in drinking water should not be more than 0.001 part per million [15]. Generally, the taste and odor of water are influenced by temperature and pH [9].

The degree of water turbidity is an expression of certain light scattering and light-absorbing properties of the water sample caused by the presence of clay, silt, suspended matter, colloidal particles, plankton, and other microorganisms [12]. It also affects other water quality parameters such as color, promotes the microbial proliferation, and chemical quality of drinking water. The color of the water is caused by the presence of colored organic substances that originated from the decay of vegetation [9]. An experiment to test well water quality from wells [16] found an increase in well water salinity in the Sallala region, Saudi Arabia. The microbial quality of water is considered to be the most important objective since water represents an obvious avenue of transmission of enteric diseases [17] According to [18], the greatest danger associated with drinking water is the contamination by sewage, human and animal excreta. Therefore, most of the mortality and morbidity associated with water-related diseases especially in the developing countries, correlated directly or indirectly to the infectious agents which infect man through ingesting pathogenic bacteria, viruses, or parasites (protozoans and helminths) in water polluted by human or animal faces or urine [19]. In another study [20] found a relationship between the degree of turbidity and the increase of coliform bacteria in drinking water in Sydney, Australia. This study was undertaken as a comparative examination of physicochemical and microbiological parameters of water sampled from different locations in Rabigh Province, Saudi Arabia.

Materials and Methods

The water samples were collected from 49 wells in 7 districts (Fig. 1), in dry clean tightly-closed polyethylene bottles, and all the required information was labeled on each bottle. The samples were taken directly to the laboratories of the Faculty of Sciences, King Abdul Aziz University, Jeddah for further physical and chemical tests. However, for the microbiological tests, one-liter glass bottles with covers were used. The bottles containing samples were then put in ice, and the first data recovery included the Total Coliform bacteria (TCB) and Fecal Coliform bacteria (FCB) tests at the same time. Eosin methylene blue (EMB) was added to the nutritional lactose agar, then poured into dishes and incubated at 37^{o} C for 24 hours for the examination of the fecal bacteria. The bacterial growth was examined according to its color. The Coliform bacteria (CB) filtration method was used using milli-pore Instrument according to the presumptive test which depends on the capability of the CB to ferment lactose sugar and then put in a petri dish, also of the media, according to the method used by American Public Health Association (APHA).

Watercolor was determined using Neslar tubes and compared with other standard colors, according to the Saudi Arabian Standard Organization [21]. The degree of turbidity was determined by the Turbid meter, and the pH using pH meter, the EC by the conductivity meter, and TDS by the TDS meter. Moreover, the determination of the TH volumetric calibration method was performed by using complex sodium salt with ethylene diamines tetra acetic acid (EDTA). To determine the basic chemical characteristic tests three instruments were used to test the anions and cations, and these were DR-400 from Hach Company, the Spectrometer Atomic Absorption (AAS), and the Metrohm Ion Chromatograph.

Fig. 1. Location map of the study site, Rabigh Governorate, West of Saudi Arabia

RESULT AND DISCUSSION

Physical and chemical*:*

The term physiochemical quality is used in this publication about the characteristics of water that may affect its acceptability due to aesthetic considerations such as odor, color, taste, production of toxicity reactions, caused unexpected physiological responses of a laxative effect, and objectionable effects during normal use including curdy precipitates [11]. It is crucially essential and important to test the water before it is used for drinking, domestic, agricultural, or industrial purposes. Water must be tested with different physiochemical parameters. The selection of parameters for testing solely depends upon the purposes for which water will be used and to what extent we needed its quality and purity achieved [2].

Water might contain different types of floating, dissolved, suspended, and microbiological impurities. Therefore, some physical tests should be performed for testing its physical appearance such as color, odor, pH, Turbidity, TDS... etc., while chemical tests should be performed on its NH_4, NO_3, NO_2, HCO_3, SO_4, TH, and other characteristics. Therefore, the physicochemical parameter analysis is very important in this context to get an exact idea about the quality of water.

In the present study, our results indicated clear variations in the levels of physical and chemical concentrations. However, values obtained from this study were presented in Tables 1 & 2 and as well as shown in Figs. 2 & Fig. 3. It revealed that most parameters tested were either above or below the international and national standards with the only exception of pH, which fell within the range of the [12] standards, whereas significant differences ($P \geq 0.01$) were reported concerning pH, EC, Turbidity, TH, and TDS.

Taste and odor: While odors are caused by volatile substances associated with organic matter and living organisms, however, tastes are caused by chloride, sulfates, foreign organisms, and industrial waste**.** It was found that 29 wells (59.2%) out of 49 have high-quality water, and these were found at Rabigh, El-Abwai, Kolia, and Mustoora. The remaining 20 wells (40.8%) have an acceptable quality of water taste such as those found at Hagr, Mugeniah, and El-Nowabi. In terms of odors, 12.2% of the wells have odors in their water (i.e. wells 4 & 2 at Mugniah and Kolia respectively), 87.7% have no odors. The taste and odor found in wells such as those at Rabigh, El-Abwa, Mustoora, and Kolia may be due to animals that recently gather around these wells.

pH scales: It is a well-known fact that pH influences the taste and odor of a solvent or solution significantly, especially when it controls the equilibrium concentration of the neutral and ionized forms of a substance in a solution. The test for pH of the water was carried out to determine whether it is acidic or alkaline.

However, the mean values obtained for 49 wells under this investigation (Table1 &Fig. 2) are within the range of 6.5-8.9 as recommended by WHO [22] for drinking water.

Although the values indicated that the well water samples are slightly basic, this is in agreement with what was reported early by other researchers in a similar study elsewhere [23].

Table 1 shows that all of the examined wells have pH > 7 (i.e. alkaline). It was found that 4 wells at Rabigh and only one well at Hagr have a pH of (8.27, 8.17, 7.96, 7.93, and 8.20 respectively). Thus, Rabigh district has more alkaline groundwater when compared to the remaining wells. Nevertheless, our findings, are in agreement with [21, 24] for drinking water.

Electric conductivity (EC): Table 1 shows that three wells at Mustoora have the highest EC (14972.80, 14450, and 12913.40 milm/cm), followed by 2 wells at Rabigh with EC (10920.80 and 9893 mlm/cm) and one at Kolia with EC (83640.40 mlm/cm).
Generally, Rabigh and Mustoora have higher EC when compared to the remaining wells, although Hagar wells have the least values (Table 1).

Our findings were much higher than those reported by [6], who found that EC mean values were (38.7 ± 0.30, 30.20 ± 0.56, and 38.8 ± 0.40 µs/cm for Dass, Kaltungo, and Langtang areas respectively). Also, they found that their results were within the [12] maximum permissible limits (8-10,000 µs/cm) for drinking water and in agreement with [21, 25] standards. We are results agree with those obtained by [26].

Turbidity: Turbidity as already defined in this text is an expression of certain light scattering and light-absorbing properties of the water sample caused by the presence of clay, silt, suspended matter, colloidal particles, plankton, and other microorganisms [12]. The turbidity of water depends on the quantity of solid matter present in the suspended state. It is a measure of the light-emitting properties of water and the test is used to indicate the quality of waste discharge concerning the colloidal matter. The turbidity should ideally be below 5 NTU since the appearance of water with a turbidity of less than this value is usually acceptable to consumers.

Table 1 illustrated the well water turbidity for the study areas. It was found that the most turbid water is that of Rabigh wells which reached in 4 of the study wells (0.376, 0.352, 0.320, and 0.302 nifilometer units), and there was a well at El-Abwai with (0.378 units), in addition to 2 wells at EL-Nowabi with (0.354 and0.320 units). Nevertheless, the present study revealed that El-Abwai and Hagr have the least turbidity (Table 1 & Fig. 2). The water turbidity of these wells is less than that found in other regions in Saudi Arabia, [27]. Also, our findings were lower than those reported by Al-Otaaibi and Zaki (2012).

Total Hardness (TH): This is simply the resistance of water in forming lather with soap due to Ca and Mg. Hard water thus requires a considerable amount of soap to produce lather. Groundwater is often harder than surface water and may have levels up to several thousand. Sources of hardness include sewage and run-off from soils particularly limestone formations, building materials containing calcium oxide, textile, and paper materials containing magnesium.

The TH in this investigation varies among the study sites (Table 1 & Fig. 2). It was found that Hagr and Mugneiah have the lowest levels when compared to the remaining sites, which is within the acceptable limit recommended by [12], while the other wells' levels were much higher than what was recommended by the WHO. Some of the wells of Mustora reached >3000 mg/l, followed by Kolia with 2093 mg/L. However, Rabigh the TH ranged between 1829 and 1250 mg/L. The mean values of the TH hardness for Hagr and Mugneih locations are within the WHO [12] specification limits for drinking water. Nevertheless, they are high enough to cause hardness of the water in the remaining locations.

Total dissolved solids (TDS): The total dissolved solids comprised of organic matter and inorganic salts, usually originate from sources such as sewage, effluent discharge, and urban run-off or natural bicarbonates, chlorides, sulphates, nitrates, sodium, potassium, calcium, and magnesium. The WHO [12] gave the palatability of drinking water according to its TDS level with a rating given by Bruvold as less than 500 mg/l excellent level and greater than 1700 mg/l as unacceptable.

In the present study Table, 1 and Fig. 2 demonstrated the total dissolved solids (TDS). It was found that wells with the highest TDS levels were found at Mustoora with average levels of (7486.20, 72223.8, and 6560.20 mg/l), followed by two wells at Rabigh with levels of (5467.80 and 4978 mg/L), then one well at Kolia with a level of 4179.40 mg/L. The WHO specification limits (1000 mg/L) for drinking water [23]. The value also differs from that reported by [5]. They reported a value of 1048.67 mg/L, which could be due to differences in organic matter that remains as a residue in the well water.

Table 1. Averages of pH, EC, Turbidity, TH, TDS at Rabigh Province in the Western Region of Saudi Arabia.

Region	Well no.	EC (millimose/ccm)	TDS (mg/L)	TH (mg/L)	Turbidity (Unit nifilometer)	pH
Hagr	1	565.23	283.08	189.80	0.216	7.76
, ,	2	607.40	304.00	209.50	0.262	7.73
, ,	3	517.87	318.60	178.91	0.116	7.69
, ,	4	668.74	334.40	204.94	0.260	7.78
, ,	5	670.08	338.10	216.00	0.128	7.66
, ,	6	653.30	338.40	204.20	0.142	8.20
, ,	7	593.40	299.40	161.20	0.112	7.85
Mugneiah	1	1270.40	639.00	377.20	0.236	7.78
, ,	2	1381.33	689.78	415.00	0.154	7.78
, ,	3	1458.25	728.84	458.50	0.182	7.60
, ,	4	1485.20	743.00	463.43	0.176	7.78
, ,	5	671.06	335.20	211.20	0.116	7.59
, ,	6	572.80	284.00	191.20	0.080	7.79
, ,	7	681.00	342.20	216.20	0.084	7.70
El – Nowbi	1	785.76	389.40	285.21	0.354	7.84
, ,	2	3426.40	1714.06	724.22	0.260	7.55
, ,	3	6627.37	3317.50	1100.86	0.320	7.64
, ,	4	760.04	378.69	223.80	0.202	7.72
, ,	5	1228.30	616.00	386.80	0.180	7.68
, ,	6	5209.20	2609.00	817.46	0.180	7.54
, ,	7	1947.70	972.36	514.60	0.172	7.62
Rabigh	1	6706.80	3355.82	1525.60	0.320	7.93
, ,	2	7237.00	3617.30	1621.40	0.226	7.73
, ,	3	10920.80	5467.80	1829.00	0.376	7.75
, ,	4	9893.00	4948.00	1758.80	0.352	7.96
, ,	5	3314.60	1657.00	778.60	0.302	7.85
, ,	6	6925.00	3461.40	1455.60	0.192	8.27
, ,	7	7915.80	3957.00	1250.60	0.204	8.19
El-Abwai	1	3558.40	1777.40	589.20	0.066	7.79
, ,	2	3523.98	1762.54	550.40	0.068	7.59
, ,	3	4139.70	2065.30	791.86	0.156	7.57
, ,	4	3854.80	1926.40	723.80	0.378	7.74
, ,	5	3644.20	1820.60	791.40	0.170	7.67
, ,	6	2737.60	1367.40	512.20	0.202	7.70
	7	1275.20	638.90	416.80	0.040	7.78
Mustora	1	12913.40	6560.20	3153.00	0.170	7.68
, ,	2	3131.20	6918.00	3131.20	0.118	7.73
, ,	3	3147.80	6816.60	3147.80	0.058	7.84
, ,	4	3042.80	6004.00	3042.80	0.170	7.68
, ,	5	4052.00	8018.40	4052.00	0.148	7.78
, ,	6	14972.80	7486.20	3878.40	0.140	7.76
, ,	7	14450.00	7223.80	3858.60	0.078	7.64
Kolia	1	6440.80	3220.00	1255.00	0.176	7.60
, ,	2	8364.40	4179.40	2093.00	0.154	7.30
, ,	3	1903.60	954.80	408.80	0.164	7.66
, ,	4	4503.20	2253.40	863.40	0.156	7.76
, ,	5	4373.80	2182.20	723.40	0.212	7.79
, ,	6	3155.20	1577.80	654.80	0.294	7.63
, ,	7	3017.80	1508.60	817.20	0.172	7.71
	LSD	82.06	27.75	8.0579	0.074	0.120

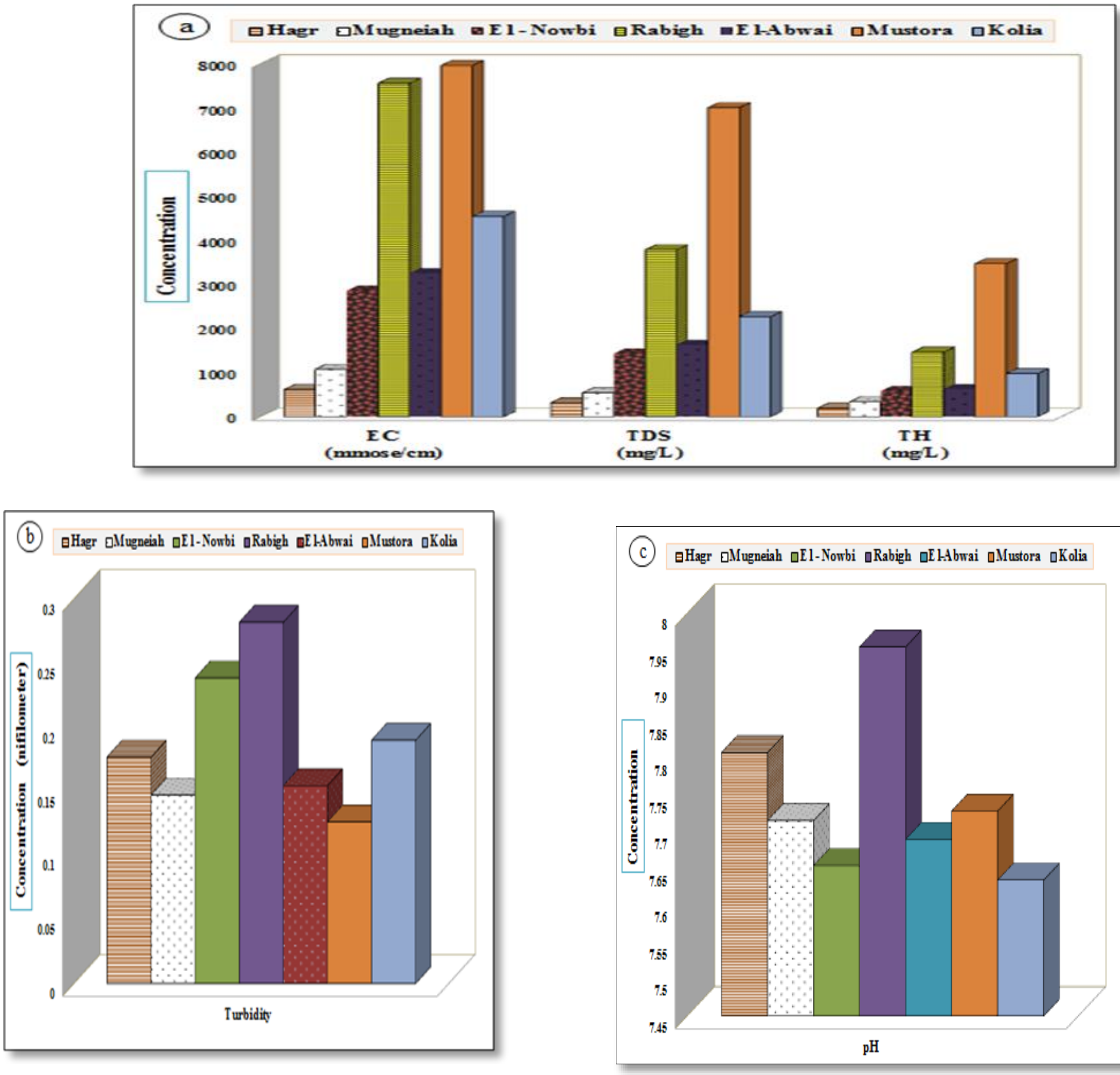

Fig. 2. (a, b, and c): Averages of pH, EC, Turbidity, TH, and TDS at different locations at Rabigh Province in the Western Region of Saudi Arabia.

Nitrates-NO_3-N: The presence of various nitrogen forms is an indication of the pollution history of the carrying water. Nitrates indicate the presence of fully oxidized organic matter. The mean values obtained from this investigation has resulted in a significant difference between all wells under investigation. Although in some places NO_3 concentrations were higher than that of WHO [12] limits (5mg/l), needless to mention, in other wells, the concentration was below that limit for drinking water (Table 2 & Fig. 3). The implication of this situation shows that the well water analyzed contains a high level of oxidized organic matter which appears in the form of soluble anions such as nitrates. Excess levels of nitrates can cause methemoglobinemia like a blue baby disease [6].

Although nitrates levels that affect infants do not pose a direct hazardous threat to older children and adults, they do indicate the possible presence of other more serious residential or agricultural contaminants such as bacteria or pesticides (Robert, 2006). The previous issue of nitrate pollution in groundwater from pit latrines, which has led to numerous cases of "blue baby syndrome" in children, notably in rural countries such as Romania, Bulgaria, and Somalia. Nitrate level above 10mg/L (10ppm) in groundwater can causes "blue baby syndrome". Our results show that there were significant differences ($P \geq 0.01$) between wells under this investigation (Table 2 & Fig. 3). There were clear variations in the level of **- NO_3.** It was found that the level of **NO_3** was predominantly at Kolia wells, thus, having the highest NO_3-N level compared to the remaining wells.

Five of the Kolia wells have levels of (47.54, 42.40, 28.84, 24.72, and 22.02 mg/L), which can cause the above-mentioned syndrome. Then, followed by El-Abwai which have levels ranged between 9.34 and 18 mg/L. The results obtained from our data in some wells were much higher than those obtained by others [33].

Nitrates –NO_2-N: Nitrates and nitrites concentrations obtained from this study are summarized in Table 2 and Fig. 3. High significant differences ($P \geq 0.01$) were obtained concerning the water content of NO_2-N between the investigated wells in the different sites. Although, El-Nowabi and Mugeniah revealed the highest NO_2-N concentrations in their water compared to the other sites, hence the concentration reached between 0.534 and 0.450 mg/L in 2 wells of El-Nowabi. Nevertheless, in Mugeniah wells it ranged between 0.526 and 0.502 mg/L (see Table 2, Fig. 3). However, the results obtained in this study also were much higher than those obtained by other researchers [33].

Both nitrates and nitrites are considered together because the conversion from one form to the other occurs in the environment and the health effects of nitrates are generally consequential of its ready conversion to nitrites in the body. The WHO [12] guideline for nitrates in drinking water is typically below 50 mg/l of nitrate-N levels, exceeding these are indicative of pollution.

Ammonium – NH_4-N: Usually ammonium is a natural component of many foods, but amounts of ammonium compound**s (<0.001-3.2%**) are also added to foods as acid regulators, stabilizers, flavoring substances, and acid fermentation processes**.** It is known that more than 90% of the nitrogen content in water is in the form of NH_4-N or one of its derivatives like ammonium, and the nitrogen compounds became environmentally important because they might cause health problems like toxicity to fish and other water organisms. Table 2 illustrates that no significant differences in water NH_4-N concentrations between the wells under this investigation. The level of NH_4-N varied and ranged between 0.02 and 0.11 mg/L, the only exception and significant result were found at El- Nowabi reaching up to 1.2508 mg/L. The results obtained in the present study are in agreement with those obtained by Al-Otaibi and Zaki (2012).

Sulphates – SO_4: It exists naturally in numerous minerals, including barite, and gypsum

(Greenwood & Earnshaw, 1984). These dissolved minerals contribute to the mineral content of many drinking drinks of water. The reported taste threshold concentration in drinking water is 250-500mg/l [28]. If the sulphates concentration in water is less than 10mg/l, it is an indication that the water sources are fresh and unpolluted. The higher levels of sulphates in any water source can be indicative of some form of pollution.

Table 2 shows that there were highly significant differences (P≥0.01) in SO_4 concentration among well water from different study sites. The highest being at Rabigh, Mustora, and Kolia, moreover the concentration of SO_4 in these investigated sites ranged between 380-1959 mg /L. The site with the least SO_4 concentration was Hagr reported concentration ranged between 37.16 and 66.48 mg /L, The one followed in term of least level of concentration at Magneia with concentration ranged between 88.68-166.17 mg /L, followed by El –Abwai with concentration ranged between 125- 790mg /L. Where an average of 326 mg /L was found at El – Nowbi. [6] found that the mean concentrations of sulphates at each of the three locations are within the limits set by WHO [12]. Our results were also in agreement with the findings of other workers in similar studies [5].

Bicarbonates - HCO_3: Table 2 and Fig. 3 illustrate highly significant differences (P≥0.01) in the HCO_3 concentration in the water wells under this study, and the highest being in wells at Rabigh with 263.46 mg/L and there were no significant differences between the 3 wells. Following these are another 3 wells at Mustoora with 254.22, 211.08, and 214.89 mg/L HCO_3 concentration, and the lowest HCO_3 concentration is in the wells at Hagr were reached between 73.1 and 106.21 mg/L.

Table 2. Averages of NH_4, HCO_3, SO_4, NO_3, NO_2 – N at Rabigh Province in the Western Region of Saudi Arabia.

Region	Well No	NH_4	HCO_3	SO_4	NO_3-N	NO_2 – N
Hagr	1	0.0232	73.10	44.02	6.62	0.014
, ,	2	0.0230	105.47	43.80	6.36	0.020
, ,	3	0.0340	85.30	37.58	5.60	0.020
, ,	4	0.0252	106.21	66.48	5.48	0.176
, ,	5	0.0330	93.52	55.52	3.54	0.140
, ,	6	0.0332	124.39	37.16	5.95	0.106
, ,	7	0.0334	94.95	47.64	5.68	0.020
Mugneiah	1	0.0722	120.30	159.22	7.90	0.394
, ,	2	0.0680	128.24	174.40	11.76	0.390
, ,	3	0.0540	167.17	164.20	10.06	0.502
, ,	4	0.0520	166.36	183.60	8.72	0.526
, ,	5	0.1044	86.88	74.48	5.78	0.370
, ,	6	0.1180	109.78	46.76	4.82	0.384
, ,	7	0.1180	118.00	58.08	5.70	0.388
El – Nowbi	1	0.0446	94.98	48.78	3.39	0.370
, ,	2	0.0732	145.93	377.80	7.90	0.402
, ,	3	1.2508	266.29	758.00	13.94	0.372
, ,	4	0.0808	83.37	47.26	3.65	0.534
, ,	5	0.0480	134.69	47.14	0.09	0.450
, ,	6	0.0406	193.60	1145.49	0.09	0.382
, ,	7	0.0240	184.02	124.92	9.22	0.424
Rabigh	1	0.0654	164.60	833.80	0.55	0.020
, ,	2	0.0152	194.84	775.40	0.49	0.012
, ,	3	0.0124	235.83	1381.80	0.48	0.018
, ,	4	0.0170	149.46	1948.60	46.28	0.462
, ,	5	0.0326	183.17	421.51	9.88	0.346
, ,	6	0.0148	263.46	725.70	0.65	0.012
	7	14.92	0.458	1157.00	0.0246	154.38
El - Abwai	1	0.0330	174.99	374.19	13.62	0.012
, ,	2	0.0238	178.90	361.24	18.00	0.120
, ,	3	0.0146	265.87	790.00	14.98	0.110
, ,	4	0.0124	171.50	205.60	16.06	0.016
, ,	5	0.0134	193.99	205.04	13.08	0.068
, ,	6	0.0250	73.55	212.54	12.08	0.084
, ,	7	0.0150	70.21	125.20	9.34	0.036
Mustora	1	0.0130	254.22	1959.00	0.49	0.042
, ,	2	0.0232	211.08	1571.00	0.43	0.050
, ,	3	0.0007	200.02	1512.34	0.43	0.046
, ,	4	0.0338	124.36	1357.60	0.42	0.042
, ,	5	0.0312	180.84	1424.00	0.45	0.040
, ,	6	0.0232	158.48	1326.40	0.41	0.050
, ,	7	0.0264	72.30	1373.60	0.52	0.050
Kolia	1	0.0244	191.26	807.14	28.84	0.258
, ,	2	0.0328	177.99	1189.70	42.40	0.528
, ,	3	0.0480	94.52	168.80	7.62	0.196
, ,	4	0.0242	214.89	530.22	24.72	0.282
	5	0.0236	197.68	469.20	14.78	0.026
, ,	6	0.0592	137.75	411.80	22.02	0.132
, ,	7	0.0470	83.40	380.00	47.54	0.226
LSD(0.05)		0.473	4.75	5.54	0.91	0.045

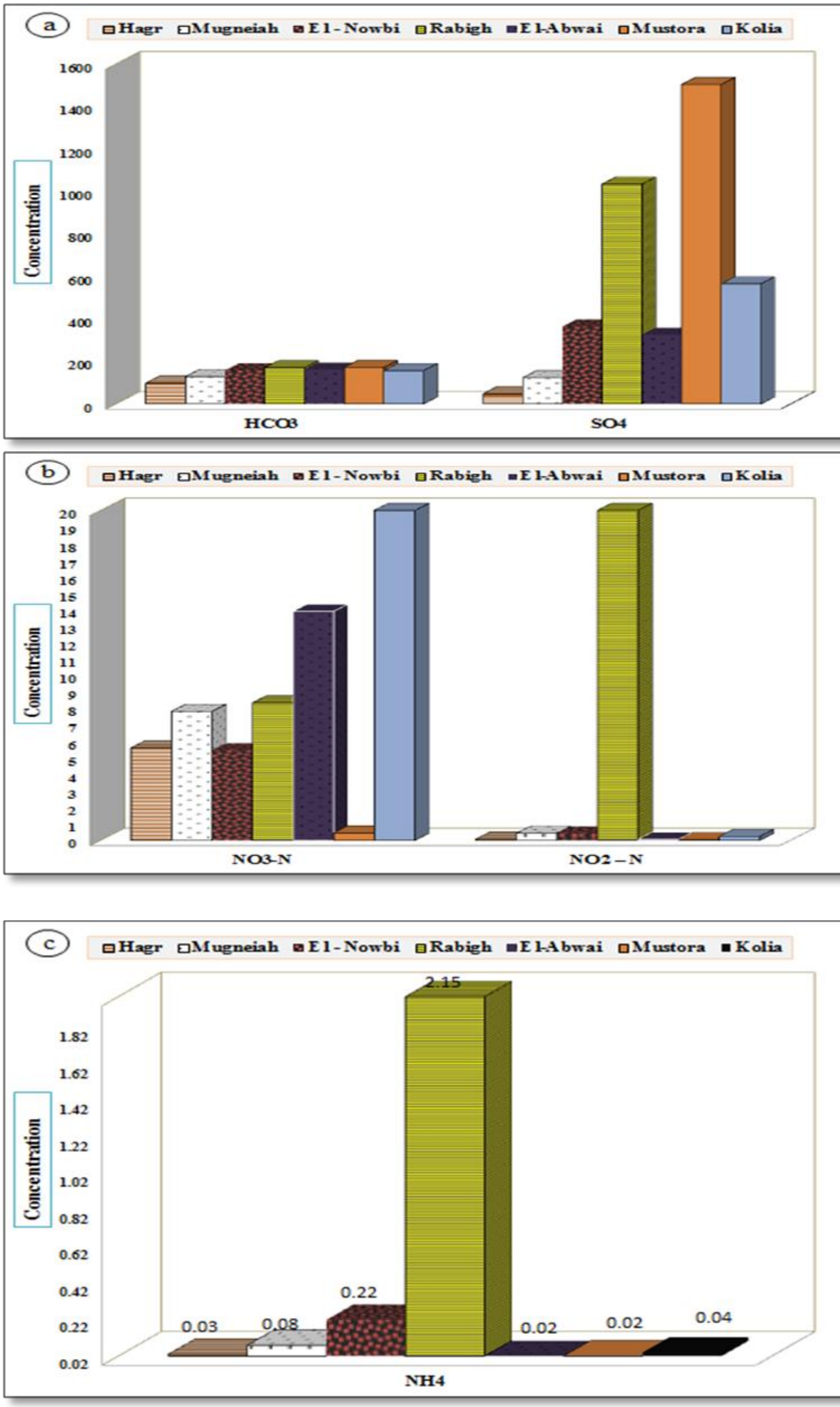

Fig. 3. (a,b &c): Averages of Biocarbonate, NO_3, NO_2, and NH_4 at Rabigh Province in the Western Region of Saudi Arabia.

Total Coliform bacteria (TCB): High significant differences (P≥0.01) between wells in their water concentrations of TCB. All wells of Rabigh, Hagr, El-Abwa, and Mustoorah have no TCB in their water (Table 2). TBC is present in the water of all wells of Mugenia (ranging from none to 480 colonies /100ml) and 3 wells of El-Nowabi (ranging between 240&480 colonies/100ml) and 2 wells of Kolia (130-1100 colonies/100ml. However, the permissible ratings of TCB concentration in drinking water suggested by [29, 30] were not exceeded in the water of all these wells. But the only exception was found in a well at Kolia. The concentrations of FCB were not exceeded in any of the remaining wells.

Fecal Coliform bacteria (FCB): There are highly significant differences (P≥0.01) between the wells in regards to their water content of FCB. This bacteria is found in all wells of Mugenia (30-2400 colonies/100ml), 3 wells of El-Nowabi (11-210 colonies /100ml), and one well in Kolia with 1100 colonies/100ml. Also, the permissible ratings of TCB concentration in drinking water suggested by [29, 30] were not exceeded in the water of all the study wells

CONCLUSION

Referring to what was indicated by [31, 32] that the EC in drinking water should not exceed 1400 and 1500 mlm/cm. Although all Rabigh, Mustoorah, El-Abwa, and Kolia wells have unacceptable water for drinking and agricultural use, however, all wells of Hagr and Mugenia and 3 wells in En-Nowabi can be used for drinking and agriculture. The results indicated that all wells of Hagr, Mugenia, and Rabigh and 4 wells in El-Nowabi have TH less than the prohibited limit (500 mg/L) by [31], so it can be used for drinking. The other district wells have high TH and are not unacceptable to be drink purposes. Wells of Rabigh, Mustoorah, Kolia, and 4 wells in El-Nowabi and one in El-Abwa have water with a high concentration of TDS and are unacceptable for drinking and agriculture according to the standards of [30, 31] which is not more than 2000 mg/L. Regarding concentrations of NO_3-N, NO_2-N, HCO_3, and NH_4-N all districts have wells with safe water for drinking with the only exception were that 2 wells (one in Rabigh and one in Kolia) with high concentrations of these substances**.**

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