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THE SEASONAL MICROBIOLOGICAL AND CHEMICAL CHANGES OF ABU-ARISH WATER WELL IN JAZAN REGION, KSA

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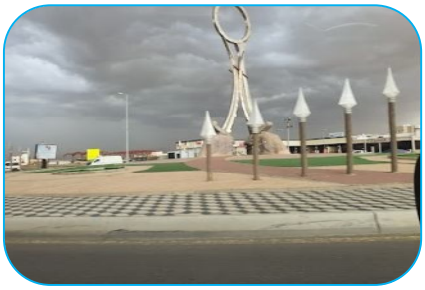
ABSTRACT:



There is no doubt that water is the source of life on earth. Water is a complicated subject, because it has a unique nature and multiple uses. Gulf Countries depend mainly on expensive methods like desalination of seawater followed by extraction of water from groundwater resources to meet their increasing demand from water due to absence of rivers. This investigation aims at testing the potability of groundwater at North Jazan region in KSA through a water well named Abu-Arish during the year's four seasons of 2020. Four samples of well water represent the four seasons were collected. The obtained results indicate that groundwater's pH ranged from 7.1 to 7.4 being the highest in Summer and the lowest in Winter. As to salinity content, it ranged from 450 to 500 mg/l where the highest values were found in Summer and Autumn while the lowest values were recorded in Winter and Spring with no significant difference between them (10%). Both values were less than the standard of WHO. The total dissolved oxygen (DO) recorded the lowest value in Spring season (4.23 mg/l) whilst the highest value was found in Autumn (5.26 mg/l). For total nitrogen content, it ranged from 8.26 to 11.70 being the highest in Summer and the lowest in Winter. The total microbial numbers ranged between 11.6 x 10^2 (CFU/ml) in Winter and 20 x 10^2 (CFU/ml) in Summer after 24h incubation period. The coliform group was detected in the well water due to its presence near the septic tanks of the city. The coliform numbers ranged from 9 cell/ml in Winter to 22 cell/ml in Autumn after 24h incubation period. All tested anions (chloride, nitrate, sulphate and phosphate) recoded amounts were less than the standard of WHO where chloride content ranged from 123.7 mg/l in Winter season to 168.8 mg/l Spring, nitrate content ranged from 0.64 mg/l in Spring to 0.86 mg/l in Autumn, sulphate content ranged from 8.5 to 11.2 mg/l being the lowest in Autumn and the highest in Summer and phosphate quantities ranged between 1.58 mg/l in Winter and 2.10 mg/l Spring. For various cations content of North Abu-Arish well water, it was found that each of calcium, sodium, magnesium and iron recorded amounts less than the standards of WHO during the four seasons of the year. Calcium quantities ranged from 33.8 to 36.8 mg/l against 100 mg/l for the standard of WHO, sodium values ranged between 24.5 and 30.6 mg/l in comparison with 50 mg/l the standard of WHO. Magnesium quantities ranged from 16.5 to 18.5 mg/l against 30 mg/l for the standard of WHO and the recorded amounts of iron were traces that ranged from 0.01 to 0.02 mg/l against 1.0 mg/l for the WHO standard. Potassium was the only cation that had quantities close to or a little bit exceeded - without clear differences – the standard of WHO where its quantities ranged from 12.71 to 14.67 mg/l against 12 mg/l for the WHO standard. It is worthy to mention that the ammonium content in North Abu-Arish well water was not detectable during the four seasons of the year.

KEY WORDS: *Groundwater, Abu-Arish Well, Microbiological & Chemical Pollution, Water Potability, North Jazan, KSA.*

INTRODUCTION

There is no doubt that water is the source of life on earth. Water is a complicated subject, because it has a unique nature and multiple uses (FAO, 2010). Generally, water obtained from two types of natural sources; the first is the surface water, *e.g.* lakes, ponds, rivers and water streams meanwhile the second source is the ground water (bore holes and wells). Water plays an essential role in domestic, industrial and irrigation all over the world (Ouda, 2013). All countries worldwide seeking renewable water resources especially gulf countries that suffer from arid environment, irregular/sparse rainfall and have low water index value. The annual average of water renewable sources per capita, in some countries, has already reached the so-called chronic water scarcity line, *i.e.* less than 500 m^3 per capita/y (Jiménez *et al.*, 2008). Gulf Countries depend mainly on expensive methods like desalination of seawater followed by extraction of water from groundwater resources to meet its demand from water (Al-Otaibi and Abdel-Jawad, 2007). Desalination process needs more oil and consequently burning of this fuel causes considerable ecological and health effects due to emissions, including greenhouse gases (Al-Shayji and Aleisa, 2018). Moreover, desalination of high salinity sea water, a high temperature is released and contains residual chlorine, heavy metals from corrosion, antiscalant and antifoaming agents (Abdulraheem, 2010). The Kingdom of Saudi Arabia is one of the hottest and driest subtropical desert countries on the earth with an average of 112 millimeters of precipitation per annum, most of the country falls within the standard definition of a desert (Mahmoud, 2014). Jazan region is an arid region located in the southwest of Saudi Arabia along the coast of the Red Sea. Groundwater in the Jazan region is the main and only source for agricultural and drinking uses, so it is always the subject of scientific and research concern (Alhababy and Al-Rajab, 2015). The present work aims at testing the potability of North Abu-Arish Well water via determining its microbiological and chemical properties.

MATERIALS AND METHODS

Regarding the study area, North Abu Arish well [16°58'54'' N 42°49'31'' E] situated in Abu-Arish city that located in the heart of Jazan region was selected due to its geographical importance and it's one of the important cities in southern of Saudi Arabia (Plate 1). It's considered as agriculture land which contain a lot of vegetable and fruit farms depending on groundwater irrigation.

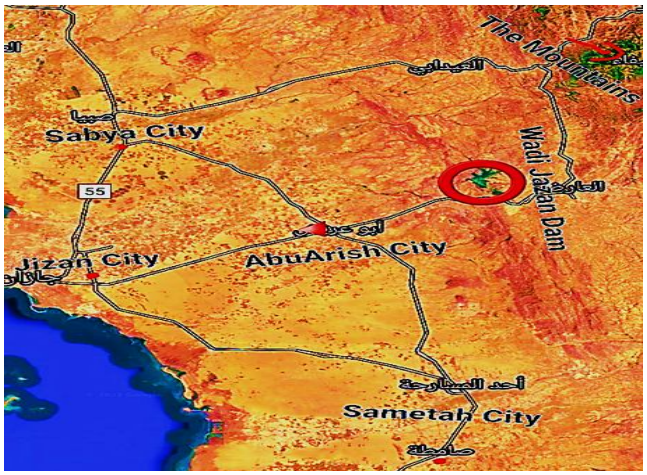


Plate 1: Abu-Arish city located in Jazan and includes North Abu-Arish Well near Wadi Jazan Dam.

Samples collection:

Groundwater samples collected from North Abu-Arish well in sterile bottles using standard sampling procedures (American Public Health Association (APHA), 2005 and International Standards Organization (ISO) (1993) during the seasons of 2020. Sampling bottles were rinsed well 2-3 times using groundwater to be sampled. Water samples were collected after pumping water from the well for at least 10 minutes.

MICROBIOLOGICAL ANALYSIS:

The serial dilution method and pour-plate method were used for total microbial count where nutrient agar medium (C.F Gomaa, 1989) was applied. The developed microbial colonies were counted after 1- and 5-days incubation periods at 30±2 °C. Moreover, Total coliform group was determined using MacConkey Broth medium and the most probable number (MPN) technique (Rijal, 2017) was followed. Inoculated test tubes containing MacConkey medium were incubated at 37 °C for 24 and 48 hr.

CHEMICAL DETERMINATIONS:

Anions such as Cl^-, NO_3^-, $SO_4^=$ and PO_3^{-3} & Cations such as NH^{+4}, Ca^{++}, K^+, Mg^{++}, Na^+, Fe^{++} in addition to total nitrogen and dissolved oxygen were analyzed using (ICP-AES) Inductively Coupled Plasma Atomic Emission Spectroscopy (Fan *et al.*, 2008).

RESULTS AND DISCUSSION

Table 1: Acidity, salinity, dissolved oxygen (DO) and total nitrogen of North Abu-Arish Well groundwater during the year's four seasons.

Year's Seasons / Parameters	North Abu-Arish Well			
	Winter	**Spring**	**Summer**	**Autumn**
pH	7.1	7.2	7.6	7.4
Total dissolved solids (mg/L)	450	450	500	500
Total Dissolved Oxygen (mg/L)	5.21	4.23	4.29	5.26
Total Nitrogen (mg/L)	8.26	8.27	11.7	8.9

Concerning the acidity of Abu-Arish well water, Table (1) indicates that it ranged from 7.1 to 7.4 being the highest in Summer and the lowest in Winter. In general, the pH of the well water approximately falls within the neutral range during the four seasons of the year. According to APHA (1989) the obtained pH degrees fall within the normal pH degrees of drinking water that ranging from 6.5 to 8.5. Besides, some studies had been conducted on the Jazan region water and indicated that the pH values ranged between 6.5 and 8.5 that fall within the normal standard of both WHO and SAS (Abada *et al.*, 2019 and Hassan, 2012). In addition, El Maghraby (2013) mentioned that the pH of studied groundwater ranged between 7.15 and 7.95.

Excess salinity in water poses a growing threat to food production, drinking water quality and public health. As to salinity content of North Abu-Arish well, Table (1) also shows that it ranged from 450 to 500 mg/l where the highest values were found in Summer and Autumn while the lowest values were recorded in Winter and Spring with no significant difference between them (10%). According to the Water Health Organization (WHO, 1984), the water containing <1000 (mg/l) TDS is considered as water of good quality.

Regarding the total dissolved oxygen (DO), the data presented in Table (1) indicate that the lowest DO value was recorded in Spring season (4.23 mg/l) whilst the highest value was found in Autumn season (5.26 mg/l). Despite there is no health-based guideline value is recommended, depletion of dissolved oxygen in water supplies can encourage the microbial reduction of nitrate to nitrite and sulfate to sulfide. It can also cause an increase in the concentration of ferrous iron in solution, with subsequent discoloration at the tap when the water is aerated. Nevertheless, very high

levels of dissolved oxygen may exacerbate corrosion of metal pipes (WHO, 2017). Mohamed Hanipha & Zahir Hussain, (2013) mentioned that the concentration rate of DO in the pure water ranges between 8-10 mg/l and increase or decrease of dissolved oxygen in water depends on presence of activities of living organisms and the surrounding environmental conditions such as waste, organic decomposition and high temperatures all of these factors lead to reduce the rate of oxygen in the water.
Furthermore, Table (1) Shows the content of Abu-Arish well water from total nitrogen. It was found that it ranged from 8.26 to 11.70 being the highest in Summer and the lowest in Winter. According to U.S. Environmental Protection Agency (2017), maximum contaminant level with nitrate is 10 mg/l in primary drinking water standards; so, the results within hand are approximately considered within the same level.

MICROBIOLOGICAL ANALYSES

Table (2) recorded the total microbial count and the coliform group count during the four seasons of the year in North Abu-Arish well water. For the total microbial count, it was found that there are no great differences between the two incubation periods (24 h and 5 days). The total number of microorganisms ranged between 11.6 x 10^2 (CFU/ml) in Winter and 20 x 10^2 (CFU/ml) in Summer after 24h incubation period. Meanwhile the same values recorded after 5-days incubation period ranged from 12.3 x 10^2 to 21.1 (CFU/ml) being the lowest Winter and the highest in Summer. It is well known that the high temperature of Summer season (35^0C, sometimes elevates to reach 41^0C) -According to Jazan Municipality, KSA (2022)- encourages microorganisms propagation while the low temperature of Winter (25^0C, sometimes decreased to reach 18^0C) inhibits microbial propagation. Concerning the coliform group count, Table (2) also shows that the North Abu-Arish Well contained numbers ranged from 9 cell/ml in Winter as the lowest number to 22 cell/ml in Autumn as the highest number after 24h incubation period. The coliform group numbers recorded after 48h was the same without any change in their numbers through the four seasons of the year. The presence of coliform group in the well water is owing to the location of the well close to septic tanks of the city that leakage their contents to the ground water around the well.

Table 2: Microbial analysis of the North Abu-Arish well water through the four seasons.

Parameters / Seasons	Total microbial count (CFU/mL) X (10^2)		Total Coliform (cell/mL)	
	24h	120h	24h	48h
Winter	11.6	12.3	9	9
Spring	19.0	19.8	14	14
Summer	20.0	21.1	17	17
Autumn	18.7	19.2	22	22

With regard to the well water content of Abu-Arish from chloride, nitrate, sulphate and phosphate, Table (3) indicates that chloride content ranged from 123.7 mg/l in Winter season to 168.8 mg/l Spring season. In comparison with the WHO (2008) standards of drinking water quality, the obtained results did not reach the standard of WHO (200 mg/l). Concerning nitrate content of North Abu-Arish Well during the four seasons of the year, Table (3) also indicates presence of unobjectable amounts of nitrate in comparison with the standards (45 mg/l) of WHO (2008). The nitrate content ranged from 0.64 mg/l in Spring to 0.86 mg/l in Autumn. The same trend was found with sulphate content that ranged from 8.5 to 11.2 mg/l being the lowest in Autumn and the highest in Summer whilst the recorded standard of WHO (2008) is 250 mg/l. On the same line, wide differences were recoded

between phosphate quantities in the well water (from 1.58 mg/l in Winter to 2.10 mg/l Spring) against 5 mg/l for the standard of WHO (2008).

Table 3: Content of certain anions of North Abu-Arish water well through the four seasons.

Seasons / Anions (mg/L)	Winter	Spring	Summer	Autumn	WHO (2008) standards (mg/L)
Chloride	123.7	168.8	141.4	144.8	**200**
Nitrate	0.69	0.64	0.83	0.86	**45**
Sulphate	9.6	9.5	11.2	8.5	**250**
Phosphate	1.58	2.09	1.93	2.1	**5**

Eventually, it could be observed from Table (3) that each of chloride, nitrate sulphate and phosphate content of North Abu-Arish well water are significantly lower than the standards of WHO (2008) and consequently they are not considered as pollutants.

Table 4: Changes in some macro elements of North Abu-Arish well during the four seasons.

Seasons / Cations (mg/L)	Winter	Spring	Summer	Autumn	WHO (2011) standard (mg/L)
Calcium	33.8	36.8	34.4	36.7	**100**
Sodium	24.5	28.5	30.6	24.9	**50**
Potassium	12.71	14.67	13.75	12.74	**12**
Magnesium	16.5	17.4	18.5	17.8	**30**
Iron	0.02	0.02	0.02	0.01	**1.0**
Ammonium	ND	ND	ND	ND	**0.5**

ND: Not detected

For various cations content of North Abu-Arish well water, Table (5) shows that each of calcium, sodium, magnesium and iron recorded amounts less than the standards of WHO (2011) during the four seasons of the year. As to calcium, its quantities ranged from 33.8 to 36.8 mg/l against 100 mg/l for the standard of WHO. For sodium, the quantities ranged between 24.5 and 30.6 mg/l in comparison with 50 mg/l the standard of WHO. The same recorded with magnesium where the quantities ranged from 16.5 to 18.5 mg/l against 30 mg/l for the standard of WHO. The recorded amounts of iron were traces that ranged from 0.01 to 0.02 mg/l against 1.0 mg/l for the WHO standard. Potassium was the only cation that had quantities close to or a little bit exceeded - without clear differences – the standard of WHO where its quantities ranged from 12.71 to 14.67 mg/l against 12 mg/l for the WHO standard. It is worthy to mention that the ammonium content in North Abu-Arish well water was not detectable during the four seasons of the year.

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