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# MICROBIOLOGICAL AND CHEMICAL SEASONAL FLUCTUATIONS IN HISTORICAL OTHMAN'S WELL AT AL-MADINAH AL-MUNAWARAH, KSA

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**ABSTRACT:**

*Saudi Arabia Kingdom (KSA) located in very harsh conditions region. As a subtropical desert country, it is regarded as one of the driest and hottest country on the earth. Saudi Arabia has no rivers or lakes and low average rainfall less than 100 mm/year. The kingdom relies largely on the desalination of seawater and groundwater for providing water requirements suitable for different anthropogenic activities such as drinking, irrigation and industrial purposes. In the future there will be a potential risk of water shortage due to the rapid change in climate as well as anthropogenic activities. This investigation was carried out to study the water potability of Othman's well. Othman's well located in Othman Farm at the north west of the holly city Al-Madinah Al-Munawarah. The obtained results indicate that there are no intrinsic changes between the four seasons in pH degrees that ranged from 7.2 to 7.4, i.e. approximately neutral. These pH degrees fall within the normal pH degrees of drinking water that range from 6.5 to 8.5. For salinity level, it ranged from 1.8 to 2.2 (g/l) being the highest in Summer and the lowest in Winter season. It is worthy to mention that the dissolved oxygen ranged between 4.04 and 4.65 mg/l where the highest level was recorded in Autumn while the lowest was in Spring. No significant differences were recorded between the four seasons where the difference among the highest value and lowest one reached 0.61 mg/l. In relation to the total nitrogen content of Othman's well water, the obtained data indicate that the values ranged from 10.7 to 17.2 mg/l where the highest value was recorded in Summer while the lowest value was in Winter. For total microorganisms, it was found that after 24 hr. they ranged from 6 to 12 (CFU/ml) being the lowest in Winter and the highest in Summer. The same trend was recorded after 5 days incubation period with a little increase in microbial numbers that ranged from 7 to13 (CFU/ml). The highest microbial number recorded in Summer season either after 24 hr. or 5 days incubation period could be attributed to the high temperature of Summer season which is suitable for mesophilic microorganisms' growth. Regarding the total coliform group after 24 hr. incubation period, the results indicate that the total number reached 9 (cell/ml) in Autumn as the lowest number and 11 (cell/ml) in Spring as the highest number. For the whole tested anions, i.e. chloride, nitrate, sulphate and phosphate, it was found that they recorded the highest values in Summer while the lowest values were found in Winter. Generally, the obtained results of all tested anions were less than the recorded standards of WHO. On the other hand, the highest variations between the studied cations values and the standard ones of WHO were recorded for calcium, sodium and potassium where the augments over the standard values reached 136%, 40.6% and 59.8% consecutively. So, it is recommended to use the Othman's well water mainly in irrigation of salt-tolerant plants.*

**KEY WORDS:** Historic Water Wells, Othman's Well, Water Pollution, groundwater Potability, Al-Madinah Al-Munawarah, KSA.

## INTRODUCTION

Many countries all over the world seek renewable water resources especially gulf countries that suffer from arid environment, irregular/sparse rainfall and have low water index value. Cisneros *et al.* (2008) stated that the mean annual per capita water renewable sources, "in some countries like Kuwait" have already reached the so-called chronic water scarcity line (< 500 $m^3$/capita/year). Therefore, countries like gulf ones rely mainly on the expensive desalination method of seawater followed by extraction of groundwater to satisfy its needs from water (Al-Otaibi and Abdel-Jawad, 2007).

Saudi Arabia Kingdom (KSA) is located in very harsh conditions region. As a subtropical desert country, it is regarded as one of the driest and hottest country on the earth. Saudi Arabia has no rivers or lakes and low average rainfall less than 100 mm/year (Al-Ibrahim, 1992 and FAO, 2009). The kingdom relies largely on the desalination of seawater and groundwater for providing water requirements suitable for different anthropogenic activities such as drinking, irrigation and industrial purposes (Saud and Abdullah, 2009). In the future there will be a potential risk of water shortage due to the rapid change in climate as well as anthropogenic activities (Fallatah, 2020).

Al- Madinah area is characterized historically by existence of several water wells that represent essential component of the Islamic heritage. Othman well is one of the most well-known wells where water has been flow since 1,400 year up to now. Nowadays, the farms and city extensions nearly surround this well and this situation may subject this well to natural humans' activities which may result in water pollution. Recently, water from this well is naturally used for household purposes, particularly as drinking water and irrigation too. Up to now, Othman well does not receive the required enough studies regarding its microbiological and/or chemical water content.

So, the work within hand aims at demonstrating the seasonal changes in microbial and chemical contents of the historical Othman water well and to investigating to how extent its water is safe for human and animal consumption.

## MATERIALS AND METHODS

### Samples collection

Plate (1) shows an aerial photograph of Othman well located in Othman Farm at the north west of Al-Madinah Al-Munawarah. Othman's farm is about 5 km away from the Prophet's Masjid (The Masjid Al-Nabawi) between latitudes 24° 29'40.6 N and longitudes 39° 34'42.8 E. Groundwater samples were collected from the Othman's well in sterile bottles using standard sampling procedures of American Public Health Association (APHA, 2005) and the International Standards Organization (ISO, 1993). Water samples were collected during the four seasons of 2020 after pumping water for 10 minutes. Moreover, before sampling sterile bottles were rinsed twice using the well groundwater. While Plate (2) indicates an overview of Othman well.

**Plate 1: Aerial photograph of Othman's water well located in Al-Madinah Al-Munawarah.**

**Plate 2: An overview of Othman's well.**

## 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) shows the pH and salinity concentration of Othman's Well groundwater. Despite pH usually has no direct effect on water consumers, it is considered one of the most important operational water quality parameters. Careful attention to pH control is necessary at all stages of water treatment to ensure satisfactory water clarification and disinfection. The obtained results reveal that there are no intrinsic changes between the four seasons in pH degrees that ranged from 7.2 to 7.4, *i.e.* approximately neutral. These pH degrees fall within the normal pH degrees of drinking water that range from 6.5 to 8.5 (APHA, 1989). Furthermore, Ayers and Westcot (1985) stated that the acceptable limits of water pH range between 6.5 and 8.4. Likewise, El Maghraby (2013) mentioned in his study that the pH of studied groundwater ranged between 7.15 and 7.95. Regarding salinity level, it ranged from 1.8 to 2.2 (g/l) being the highest in Summer and the lowest in Winter season. This is due to high temperature of summer season in KSA; where the high temperature is a key factor in salts solubility. According to the Water Health Organization (WHO, 1984), the water containing from 0.9 to 1.2 (g/l) salt concentration is regarded as water of poor quality while that contains more than 1.2 (g/l) salinity level is considered unacceptable. Saud and Abdullah (2009) mentioned that Saults accumulation in the groundwater is due to the lack of proper drainage system; they added, groundwater in Al-Madinah city, in general, used for agricultural purposes.

**Table 1: Acidity and salt concentration of Othman's Well groundwater during the year's four seasons.**

| **Parameters** | **pH** | | | | **Salinity (g/l)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Season** | Winter | Spring | Summer | Autumn | Winter | Spring | Summer | Autumn |
| **Value** | 7.4 | 7.3 | 7.2 | 7.2 | 1.8 | 1.9 | 2.2 | 2.1 |

**Table 2: The dissolved oxygen (DO) and total nitrogen of Othman's Well during the year's four seasons.**

| **Parameters** | **Dissolve oxygen (mg/L)** | | | | **Total Nitrogen (mg/L)** | | | |
|---|---|---|---|---|---|---|---|---|
| **Season** | Winter | Spring | Summer | Autumn | Winter | Spring | Summer | Autumn |
| **Values** | 4.45 | 4.04 | 4.43 | 4.65 | 10.7 | 11.4 | 17.2 | 15.7 |

Regarding the groundwater contents of Othman's Well of dissolved oxygen and total nitrogen content during the year's four season, the obtained data were illustrated in Table (2). It is known that rapidly moving water, such as in a mountain stream or large river, tends to contain a lot of dissolved oxygen, whereas stagnant water contains less. As to the dissolved oxygen parameter of Othman's Well, the obtained values indicate that no significant differences were recorded between the four seasons; where the difference among the highest value and lowest one reached 0.61 mg/l. It is worthy to mention that the dissolved oxygen ranged between 4.04 and 4.65 mg/l where the highest level was recorded in Autumn while the lowest was in Spring. As long as 100% air saturation in water = 8.915 mg/l (https://www.fondriest.com/environmental-measurements/parameters/water-quality/dissolved-oxygen/), the obtained results of DO are approximately half the standard 100% of air saturation in water. This could be attributed to some of the microbial content that reached 20 CFU/ml, as an average, regardless of the year's season.

In relation to the total nitrogen content of Othman's well water, Table (2) indicates that the values ranged from 10.7 to 17.2 mg/l where the highest value was recorded in Summer while the lowest value was in Winter. These values are a little bit surpassed the standards of U.S. Environmental Protection Agency (2017) that stated maximum contaminant level with nitrate is 10 mg/l in primary drinking water standards.

## MICROBIOLOGICAL ANALYSES

Microbiological pollution of water wells could be induced through groundwater, surface water run-off, cracked well parts, poor construction or leaking septic tanks. Total microbial and coliform group counts are considered the most important parameters indicating microbiological water pollution. Total microbial and coliform group counts after 24h and 120h incubation periods in Othman well during the four seasons were illustrated in Table (3). For total microorganisms, it was found that after 24h they ranged from 6 to 12 (CFU/ml) being the lowest in Winter and the highest in Summer. The same trend was recorded after 5 days incubation period with a little increase in microbial numbers that ranged from 7 to13 (CFU/ml). The highest microbial number recorded in Summer season either after 24h or 5 days incubation period could be attributed to the high temperature of Summer season which is suitable for mesophilic microorganisms' growth.

**Table 3: Microbiological analysis of Othman well during the various seasons of the year.**

| Parameters | Microbial contaminants | | | |
|---|---|---|---|---|
| | Total microorganisms (CFU/ml) | | Total coliform group (cell/ml) | |
| Season | **24h** | **120h** | **24h** | **120h** |
| Winter | 6 | 7 | 10 | 10 |
| Spring | 10 | 11 | 11 | 11 |
| Summer | 12 | 13 | 9 | 9 |
| Autumn | 9 | 10 | 9 | 9 |

Regarding the total coliform group after 24h incubation period, Table (3) also indicates that the total number reached 9 (cell/ml) in Autumn as the lowest number and 11 (cell/ml) in Spring as the highest number. It is worthy to mention that the same trend with the same numbers was recorded after 5 days incubation period. Despite the low numbers of microbial contaminants, either total microbial count or total coliform bacteria that presented in Table (3), application of this water should be used

with highly precaution procedures for irrigation of trees or must be treated to get rid of its microbial load before its application for human or animals. The presence of this microbial load in Othman's well might be owing to its close to sewer system of the city.

Table (4) illustrates contents of Othman's well water from certain anions, *i.e.* chloride, nitrate, sulphate and phosphate during the four seasons of the year. Concerning chloride anion, the obtained results indicate that the values ranged from 135.7 to 142.6 mg/l where the highest number was recorded in Summer while the lowest was found in Winter. These values of chloride content were less than mentioned in the standards of drinking water quality of WHO (1984) that reached 250 mg/l. Regarding Nitrate content, the obtained values ranged between 2.09 and 2.20 mg/l during the four seasons being the highest in Summer while the lowest value was found in Winter. In comparison with the U.S. Environmental Protection Agency (2017), that mentioned maximum contaminant level with nitrate is 10 mg/l in primary drinking water standards, the current results are significantly lower than the standard of U.S. Environmental Protection Agency (2017).

**Table 4: Certain anions concentration in groundwater of Othman's Well during the four seasons of the year.**

| Season / Anions (mg/L) | Winter | Spring | Summer | Autumn | WHO (2008) standards (mg/l) |
|---|---|---|---|---|---|
| **Chloride** | 135.7 | 135.9 | 142.6 | 137.3 | **200** |
| **Nitrate** | 2.09 | 2.11 | 2.20 | 2.14 | **45** |
| **Sulphate** | 10.72 | 10.78 | 11.29 | 10.98 | **250** |
| **Phosphate** | 2.83 | 2.87 | 2.98 | 2.85 | **5** |

As to sulphate content, it ranged from 10.72 to 11.29 mg/l during the four seasons of the year. Again, the highest value was found in Summer while the lowest one was recorded in Winter. For phosphate content, its values fall between 2.83 and 2.98 mg/l during the four seasons of the year. Once again, the highest number was found in Summer meanwhile the lowest one was recorded in Winter. In general, the recorded differences between the year's seasons for every studied anion were not remarkable and reached 6.9, 0.11, 0.57 and 0.15 mg/l consequently for chloride, nitrate, sulphate and phosphate. In comparison with the WHO standards of 2008, it was found that the whole values of Othman's well water content of the studied four anions were significantly less than the recorded WHO (2008) standards. The averages per year of the four investigated anions reached 137.88 mg/l for chloride, 2.14 mg/l for nitrate, 10.94 mg/l for sulphate and 2.88 mg/l for phosphate respectively against 200, 45, 250 and 5 mg/l standard values of WHO (2008).

**Table 5: Concentrations of some cations in groundwater of Othman's Well during the different four seasons of the year.**

| Season / Cations (mg/l) | Winter | Spring | Summer | Autumn | WHO (2011) standards (Mg/l) |
|---|---|---|---|---|---|
| **Calcium** | 209.0 | 232.0 | 261.0 | 242.0 | **100** |
| **Sodium** | 67.6 | 67.6 | 76.0 | 70.0 | **50** |
| **Potassium** | 18.4 | 18.4 | 20.6 | 19.3 | **12** |
| **Magnesium** | 33.2 | 33.3 | 37.3 | 35.1 | **30** |
| **Iron** | ND | ND | ND | ND | **1.0** |
| **Ammonium** | ND | ND | ND | ND | **0.5** |

ND: not detected

As for the studied cations, *i.e.* calcium, potassium, magnesium, sodium, iron and ammonium, the data presented in Table (5) show that except for iron and ammonium, the rest elements surpassed the standard values of WHO (2011). The highest variations between the studied elemental values and the standard ones were recorded for calcium, sodium and potassium where the augments over the standard values of WHO (2011) reached 136%, 40.6% and 59.8% consecutively. On the other hand, magnesium cation recoded the lowest difference (15.77%) when compared with the standard value of WHO (2011). Regarding the season effect on quantities of cations in Othman's well water, Table (5) also indicates that the highest recorded values were found in Summer for Ca, Na P and Mg that reached 261, 76, 20.6 and 37.3 mg/l respectively. On the other side, the lowest values of the whole studied cations were registered in Winter (209, 67.6, 18.4, 33.2 mg/l consecutively).

## REFERENCES


1. Al-Ibrahim, A.A. 1992. Excessive use of groundwater resources in Saudi Arabia: Impacts and policy options. AMBIO, 20: 34-37.
2. Al-Otaibi, A. and Abdel-Jawad, M. 2007. Water security for Kuwait. Desalination, 214(1-3): 299-305.
3. American Public Health Association (APHA) 1998. Standard methods for the examination of water and wastewater.17th ed. Washington, DC.
4. American Public Health Association (APHA), 2005. Standard Methods for the Examination of Water and Wastewater, 21st ed.; Washington, DC, USA, 1368p.
5. Ayers, R.S. and Westcot, D.W. 1985. Water quality for agriculture 29(Rev. 1); Food and Agriculture Organization of the United Nations Rome, 1985 © FAO, Rome, Italy.
6. Cisneros, B.E.J.; Jiménez, B. and Asano, T. 2008. Water reuse: an international survey of current practice, issues and needs (Vol. 20): IWA publisher.
7. El Maghraby, M.M.; El Nasr, A.K.O.A. and Hamouda, M.S. 2013. Quality assessment of groundwater at south Al Madinah Al Munawarah area, Saudi Arabia. Environmental earth sciences, 70(4): 1525-1538.
8. Fallatah, O.A. 2020. Groundwater Quality Patterns and Spatiotemporal Change in Depletion in the Regions of the Arabian Shield and Arabian Shelf. Arab. J. Sci. Eng. 45: 341-350.
9. Fan, Q.; He, J.; Xue, H.; Lü, C.; Sun, Y.; Shen, L. and Bai, S. 2008. Heavy metal pollution in the Baotou section of the Yellow River, China. Chemical Speciation & Bioavailability, 20(2): 65-76.
10. FAO, 2009. Irrigation in the Middle East region in figures. Food and Agriculture Organization of the United Nations. FAO Water Reports 34, Rome.
11. Gomaa, A.M. 1989. Biofertilizers & Increasing of crop production. M. Sc. Thesis, Faculty of Agriculture, Cairo University, Egypt.
12. International Standards Organization (ISO) 1993. Methods for the calibration of vibration and shock-pick ups -Part 12: Testing of transverse shock sensitivity.
13. Rijal, N. 2019. Most Probable Number (MPN) Test: Principle, Procedure and Result.
14. Saud, A.G. and Abdullah, S.A. 2009. Water Resources and Reuse in Al-Madinah. In: The International Conference on Water Conservation in Arid Regions (ICWCAR'09). Organized by Water Research Center, King Abdulaziz University, Jeddah, Saudi Arabia.
15. Water Health Organization (WHO), 1984. International standards for drinking water.
16. Water Health Organization (WHO), 2008. N-Nitrosodimethylamine in drinking-water. Background document for preparation of WHO Guidelines for drinking-water quality. Geneva, World Health Organization (WHO/HSE/AMR/08.03/8).
17. Water Health Organization (WHO), 2011. Guidelines for drinking-water quality. 4th ed.: 216: 303.
18. U.S. Environmental Protection Agency, 2017. Water-quality standards for drinking water. E-Reference:https://www.fondriest.com/environmentalmeasurements/parameters/water-quality/ dissolved-oxygen/