SINAI Journal of Applied Sciences 12 (3) 2023 399-412

Available online at www.sinjas.journals.ekb.eg

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SINAI Journal of Applied Sciences

Print ISSN 2314-6079
Online ISSN 2682-3527

ASSESSMENT OF GROUNDWATER QUALITY FOR DRINKING AND DOMESTIC USE: IMPLICATIONS FOR WATER SAFETY IN EL-ARISH CITY, NORTH SINAI, EGYPT

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ARTICLE INFO

Article history:
Received: 26/05/2023
Revised: 31/05/2023
Accepted: 02/06/2023

Keywords:
Groundwater quality;
E. coli;
Multi-elements;
Risk assessment.

ABSTRACT

The current study assesses groundwater quality and its appropriateness for drinking and domestic use using numerous microbiological and chemical characteristics for 55 waters well samples taken from various places in El-Arish region, North Sinai, Egypt based on residential districts *i.e.*, Abosakl, Elresh, Karam Abongellh, Elbahr, and City Center**.** The study compares the results of various water quality criteria and uses statistical analysis to find the source of pollution. This research aims to study the water characteristics and evaluates the acceptability of water samples which collected from the study region for human consumption. Microbiological examinations, including total bacterial counts and total coliform counts, were conducted to assess the microbial quality of the water. The results indicated that while some water samples exceeded standard specifications for total bacterial counts, they still fell within internationally permitted limits. Coliform bacteria indicate possible fecal contamination but remain within acceptable limits for most samples. The study also analyzes some chemical characteristics of the water such as pH and electrical conductivity (EC). The pH values are outside the permissible limits according to standard specifications. The electrical conductivity values indicate potential water quality issues but are within the recommended limits for most samples except Abosakl and the City Center districts. In addition, multi-element analyses reveal elevated elements such as ammonia, nitrate, boron, lead, and nickel in the groundwater samples. These elements may be attributed to various anthropogenic sources and require further investigation and remediation. The findings underscore the significance of monitoring and controlling water quality to guarantee that the population can access clean drinking water, particularly in border cities such as El-Arish, North Sinai, Egypt.

INTRODUCTION

Groundwater is a vital source in North Sinai, supporting various sectors, including domestic, agricultural, and industrial activities. However, the increasing prevalence of natural and anthropogenic contaminations necessitates carefully evaluating potential hazards **(Rodrigues and Cunha, 2017**). The global water shortage crisis, particularly in arid and semi-arid regions, has prompted countries to explore alternative water sources, such as groundwater, due to their availability **(Mirdashtvan *et al.*, 2021**). Unfortunately, groundwater contamination has emerged as a significant nationwide socioeconomic problem **(Kumar and Singh, 2007**), exacerbated by rapid urbanization, industrial and agricultural activities, and the impacts of global climate change **(Canora and Sdao, 2022; Zhang *et al.*, 2023**).

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https://doi.org/10.21608/sinjas.2023.213520.1211

To ensure sustainable planning and the preservation of uncontaminated groundwater resources, providing guidelines to planning authorities becomes paramount (**Haigh *et al.*, 2008**). Consequently, monitoring the water quality for consumption and residential use is a vital responsibility for any nation, providing local authorities and researchers with complete data for making educated decisions (**Cosgrove and Loucks, 2015**). Traditional approaches to water quality observation often prove unreliable due to limited sample sizes, labor-intensive procedures, time constraints, and the inability to provide a holistic understanding of water conditions, particularly in developing countries like Egypt (**Safford and Bischel, 2019**).

Among the many constituents found in groundwater, heavy metals, nitrate, and total coliform bacteria are the most health-related contaminants of particular concern (**Brenner and Hoekstra, 2012**). Nitrate poses a health risk, especially to infants, and can be fatal if consumed in high quantities. On the other hand, total coliform bacteria indicate the potential presence of pathogenic microorganisms, which can lead to severe illnesses and even fatalities. The threshold for total coliform in drinking water is thus set at zero to limit the risk of exposure to waterborne pathogens. Well water can get contaminated through two primary routes: firstly, when the aquifer from which the well draws water is contaminated, and secondly, when surface water carrying contaminants infiltrates the well due to compromised well structures (**Lapworth *et al.*, 2017a; Lapworth *et al.*, 2017b; Thomas-Possee, 2023**). In groundwater, most significant values found with total dissolved solids in Dakahlia Governorate, Egypt (**Afify *et al*., 2021**). Hence, the well's type, age, and depth are crucial when assessing water quality.

In this context, this study aims to establish baseline groundwater quality data for the El-Arish region by microbiological and chemical analyses. By doing so, we aim to address potential contamination sources, analyze the quality of well water for human use and any related health hazards. A carefully selected set of 55 well water samples representing different residential areas were subjected to rigorous analysis, focusing on chemical and biological parameters to achieve these goals.

MATERIALS AND METHODS

Sampling and Location Descriptions

On September 2022, 55 well water samples were taken from various places in El-Arish region, North Sinai, Egypt based on residential districts *i.e.*, Abosakl, Elresa, Karam Abongellh, Elbahr, and City Center**,** (Figure1). The city lies between longitudes 31° 02′ 11.6″ and 31° 10′ 18.5 ″ and latitudes 33° 44 ′ 16.7 ″ and 33° 53 ′ 24.1 ″. Two groups of samples from each well were obtained in separate dark-colored, sterile vials (200 ml) with three replicates from each sampling group. Different sample protocols were utilized for the various types of water analyses (chemical and biological analyses), and all safeguards were taken. The two well water sampling groups from each well were taken as follows: (i) The first group bottles were filled with unfiltered, non-acidified water for microbial, pH, and EC analyses, collected in an ice box, and stored at 4°C for analysis within 24 hours (ii) The second group bottles were filled with filtered water (Millipore < 0.2 µm syringe filter) from the same site and acidified to 2 percent (TAG) HNO_3 by adding approximately one drop of the concentrated acid (70%) to stop the microbial activities and preserve heavy metals (loids) in the solution phase for analysis. After being transported to the laboratory, acidified samples were immediately forwarded for multi-element analyses.

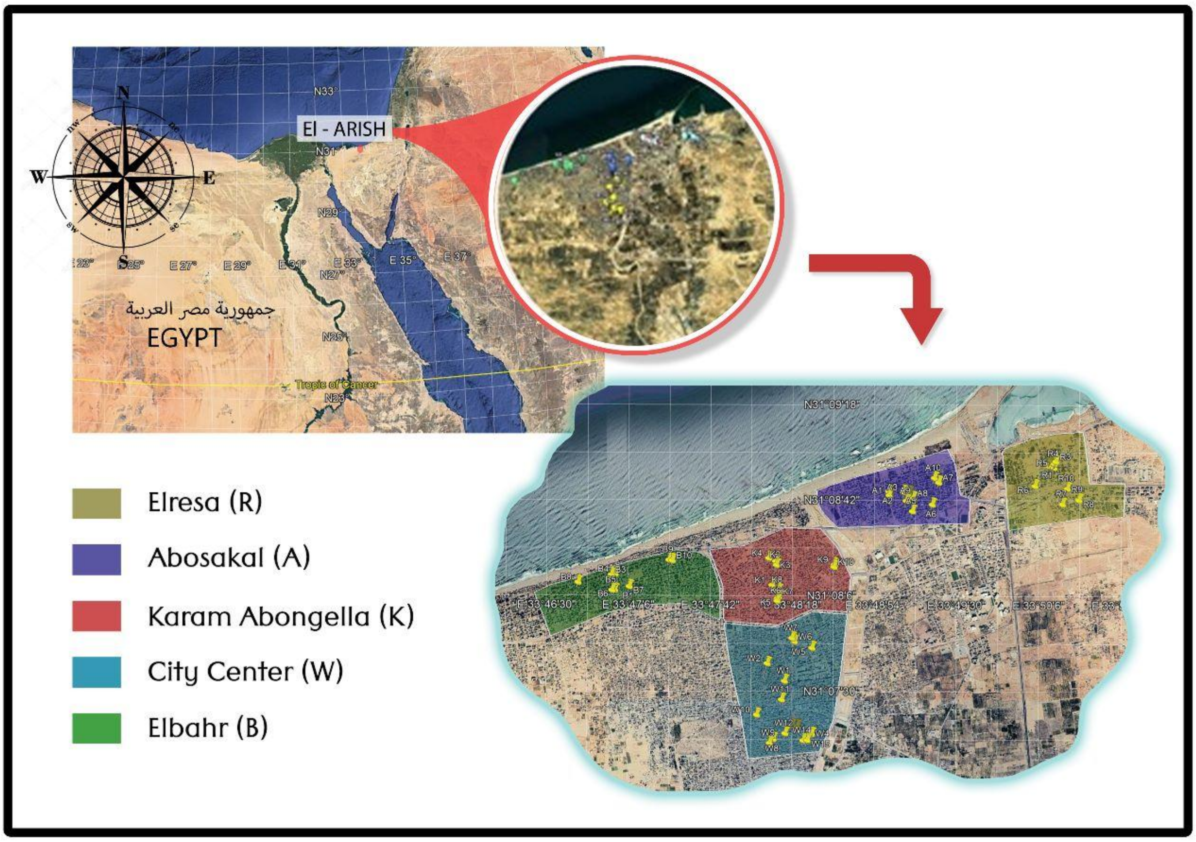

Fig. 1. Location map of the study area, El-Arish city, North Sinai, Egypt. Five districts were selected according to residential capacity: Abosakl (A, n=10), Elresa (R, n = 10), Karam Abongellh (K, n = 10), Elbahr (B, n = 10), and City Center (W, n = 15)

Microbiological Analyses

The Most Probable Number (MPN) technique and Total Bacterial Count (TBC) were employed for bacterial studies within 24 hours after sample collection, as prescribed elsewhere **(Gilcreas, 1967**). The process of analyzing the water sample for MPNs was carried out sterilely. The MPN procedure consisted of three stages: presumptive, confirmed, and completed tests **(Woodward, 1957; Pelczar, 1958**): (i) Presumptive Test (using the multiple-tube fermentation technique method and lactose broth media). A negative presumptive test indicates that the water supply is microbiologically safe. The series' hazardous sample shows acid and gas, indicating a positive response. (ii) The Confirmed Test (using sterile glass petri plates with 15 ml EMB' Eosin Methylene Blue Agar' medium); and (iii) The Completed Check Test (using microbiological growth medium, typically, Eosin Methylene Blue's and Endo's media, inoculated Petri dishes and tubes).

pH, EC and Multi-element Analyses

In order to eliminate polyatomic interferences and carry out multi-element investigations, the standard Agilent triple quadrupole ICP-MS (Model No. 8800, Tokyo, Japan) was utilized while operating in He gas mode as described in detail by **Marzouk (2012)**. Using a pH meter and a combination glass electrode (Ag/AgCl; PHE 1004; Model pH-211, PHE 1004, HANNA Instruments, Bedford, UK), the sample pH values were measured in 10 mL of filtered, unacidified water using the HANNA Instruments model pH-211. Using a conductivity meter, the electrical conductivity (EC) of 10 mL of filtered and unacidified water samples was determined using Model HI 9033 Multi-rang, Hanna instruments, Bedford, UK.

Statistical Analyses

Using the Minitab® 17.1.0 software **(Minitab, 2022**), cluster analyses of the multivariable are performed based on the data array of the pollutant concentrations of underground water to discriminate between the various forms of pollution.

RESULTS AND DISCUSSION

Several microbiological and chemical criteria were used to assess the groundwater's quality and appropriateness for drinking and other uses in the home. This was accomplished by contrasting the findings of the present research with those of other water quality standards and determining the origin of the contamination *via* statistical analysis. Various water characteristics were analyzed and determined whether or not the water samples taken from the location under investigation were suitable for human consumption.

Microbiological Examinations

Total bacterial counts

Table 1 shows the average total microbial count of water well samples from the different study areas. The highest total bacterial count values that were observed were in the Abosakl district (130±128 CFUs mL^{-1}) and Karam Abongella (130 ± 133 CFUs mL^{-1}), followed by Elresa (107± 64.5 CFUs mL^{-1}) neighborhoods. In comparison, the lowest values of the total number of bacteria were in the city center (86.1 ± 56.2 CFUs mL^{-1}), followed by Elbahr area (29.7 ± 619.9 CFUs mL^{-1}). Despite this disparity, all of the apparent counts stay within the internationally approved and acceptable levels for health, following the worldwide standard requirements stated by the World Health Organization (30 < CFUs mL^{-1} < 300) **(WHO, 2017**). However, according to the high-value standard deviation (SD) observed in Table 1 for the samples collected from Abosakl and Karam Abongella (128 and 133 CFUs mL^{-1}, respectively), three odd samples were exceeded standard specifications (A1=400, A4=300, and K2=400 CFUs mL^{-1}).

The elevated total bacterial count observed in the three water well samples collected from Abosakl and Karam Abongellh areas with high values may be attributed to inadequate planning and poorly equipped sewage systems prone to constant leakage due to uneven elevations in these areas (**Tortajada and Castelán, 2003**). However, overall, the average values of TBC fall within WHO permissible limits. However, it is important to consider the regions experiencing deterioration in the sanitation infrastructure when interpreting the results.

Total Counts of Coliform Bacteria

A bacteriological analysis was conducted to determine the total coliform count in water samples using the most probable number (MPN) method. The results of the presumptive coliform counts indicated the presence of recorded counts in all three dilutions. However, it should be noted that the absence of coliform bacteria can be inferred from the disappearance of the yellow color and the lack of gas formation in Durham's tubes for these samples **(Swelam *et al.*, 2022**). These findings align with the international standard specifications reported by various authors **(Sayre, 1988; WHO, 2011; Cook *et al.*, 2013; Da Silva *et al.*, 2018; WHO, 2021**). These results are consistent with the local Egyptian specifications **(Donia, 2007; Goher *et al.*, 2014; Abdel-Satar *et al.*, 2017; Abdelhafez *et al.*, 2021**). Drinking water quality assessment often relies on analyzing fecal indicator microorganisms. *Escherichia coli*,

Table 1. Total bacterial counts (mean ± SD) for different study locations

No.	Sample	Total bacterial count (CFUs mL^{-1})§
1	Abosakl	130± 128
2	Elresa	107± 64.5
3	Karam Abongella	130± 133
4	Elbahr	29.7± 19.9
5	City center	86.1± 56.2

§ Standard count by **WHO, 2017** (30 < CFUs mL^{-1} < 300).

in particular, is commonly used as it provides definitive evidence of recent fecal contamination from humans or animals, and its presence in drinking water is considered unacceptable. The microbial analysis of all water well samples in the El-Arish area consistently demonstrated variable results of bacterial indicators associated with fecal pollution. This signifies potential health hazards for the population and compliance with established water quality standards. Water contamination is widely used to evaluate the quality of microbiological status of drinking water and as a parameter for estimating water pollution by wastewater **(Afify *et al.*, 2023).**

According to the method of analyses to measure the extent of *E. coli* contamination, which were the presumptive, the confirmed, and the completed tests, the microbiological examinations for the presence of *E. coli* bacteria results are shown in Fig. 2.

From all the 55 wells tested for *E.coli* presence of; (i) 50, 30, 10, and 10%, (ii) 30, 10, 10, and 50 %, (iii) 20, 30, 10, 40 %, (iv) 0, 0, 20 and 80% and (v) 6.67, 13.3, 13.3 and 66.7 % from the total number of wells for Abosakl, Elresa, Karam Abongellh, Elbahr and City center in each group, respectively recorded the high, moderate, low and negative degree of contamination for each group. Regarding the presence of *E.coli* in water wells collected from Elbahr and City Center (Fig. 2), it was shown that no notable gas was produced from lactose fermentation at a frequency of 80% and 66.7%, respectively. It means that most wells in such areas were not contaminated due to the non-presence and detection of *E.coli* in most examination tests. The general finding in both locations sample is considered not significantly contaminated.

Even though coliform bacteria may not directly cause illness, their presence indicates that disease-causing organisms could be present **(Feng *et al.*, 2002**). As a result, water from a well is considered risk-free in the absence of coliform bacteria **(Gosselin *et al.*, 1997**). However, the frequency of *E. coli* was greater in Abosakl, Elresa, and karam Abongellh, as recorded from the amounts of gases produced during 24 hr of tests (Fig. 2). This indicates that surface water gets into the well, usually caused by insufficient construction. Coliform bacteria are associated with areas experiencing inadequate sanitation services and lower living standards **(Khan *et al.*, 2013**). The presence of *Escherichia coli* in water well samples from such areas may indicate inadequate sewage treatment and a higher likelihood of fecal contamination. This can be attributed to a lack of proper infrastructure for waste management, limited access to clean water sources, and poor living conditions. The absence of bacterial indicators of fecal pollution in the drinking water samples reflects compliance with established water quality standards and implies a lower risk to public health in regions with better sanitation

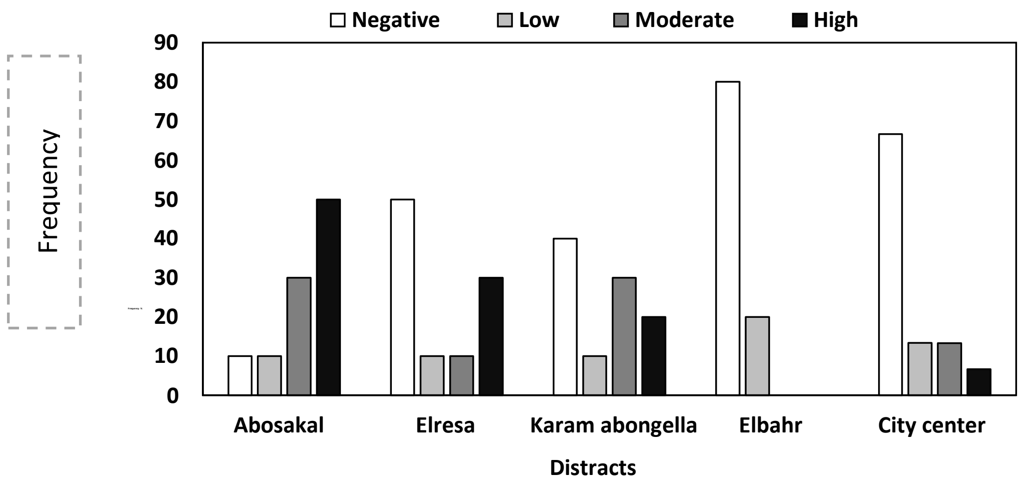

Fig. 2. Frequency appearance of *E. coli* measured by MPN methods in different districted areas. Two data values of moderate and high were zero

facilities and higher living standards (**Fennell *et al.*, 2021**). The presence of coliform bacteria might also suggest the likely presence of pathogens and other dangerous pollutants. Sewage contaminants, including pathogens, can be found in surface water, the worst conceivable scenario. Surface water can also include pathogens (**Khan and Gupta, 2020; Parija, 2023**).

Chemical Characteristics

Water pH

Water pH is a fundamental indicator to assess the acidity or alkalinity of water. It plays a crucial role in determining water quality and suitability for drinking. Although pH may not directly impact consumers, it significantly impacts overall water quality. World Health Organization (WHO), European Standards (EUs), and Egyptian Standards (EGs) reports emphasize the importance of considering pH as a key parameter in assessing water quality. These standards recognize that pH is essential in evaluating water's chemical characteristics and overall suitability for various applications. While pH may not directly impact consumers, it indirectly influences other water quality parameters and can affect the behavior and effectiveness of other treatment processes. For example, pH can influence the solubility of minerals, disinfectants' activity, and plumbing systems' corrosion. Therefore, monitoring and maintaining appropriate pH levels are essential for ensuring drinking water's overall quality and safety.

As shown in Table 2, the pH of the samples taken from the study areas was analyzed. It was found that the highest value was 8.90± 0.29 (mean±SD) in Elbahr, followed by Elresa district (8.80±0.52), while the lowest values were 8.40 in Abosakl and City center. The results revealed that the pH of the water samples did not fall below the acceptable range according to the standard standards accepted by the WHO (7.5) and EGs 7.5. This was the overall conclusion drawn from the findings. In line with the topic, **Moussavi *et al.* (2023**) conducted a study highlighting the significance of pH values in water quality. Their findings indicated that pH values exceeding 8 are unsuitable for effective disinfection.

On the other hand, pH values below 6.5 were observed to contribute to corrosion in water sources and plumbing systems. These results emphasize the importance of maintaining pH within an optimal range to ensure efficient disinfection and prevent detrimental effects on infrastructure. Proper

Table 2. pH and EC measurements (mean±SD) for all studied wells (n = 55)

District	pH	EC (dSm^{-1})
Abosakal	8.40±0.25	3900±1200
Elresa	8.80±0.52	1100±750
Karam Abongella	8.60±0.23	1200±1000
Elbahr	8.90±0.29	1600±900
City center	8.40±0.17	5300±1800
WHO standards [1]	7.5	1400
EUs standards [2]	8.5	2500
EGs standards [3]	7.6	2000

[1] **(WHO, 2021**), [2] **(Gray *et al.*, 2013**) and **(EUs, 1970**), [3] **(Badr *et al.*, 2013**)

monitoring and control of pH levels are essential in maintaining the desired water quality standards and safeguarding the integrity of water distribution systems. Our hypothesis agrees with pH parameter of **Afify *et al.* (2021)** who found that groundwater contains pH values 6.1 to 7.6. in Egypt.

Increase the frequency of pH monitoring to closely track any changes in the pH levels could help identify any fluctuations or deviations from the desired range and allow for immediate corrective actions. Moreover, maintain regular communication with the relevant authorities or officials responsible for addressing the issue. Keep them updated on the situation, share the findings regarding unsuitable pH samples, and request their assistance in resolving the problem at the earliest. By implementing these quick actions, it is possible to mitigate the impact of unsuitable pH samples and maintain effective disinfection until the issue is resolved by the officials.

Electrical conductivity (EC)

The assessment of water quality using the electrical conductivity (EC) method is widely acknowledged as a reliable and accepted approach. EC serves as a valuable indicator for monitoring water quality due to its ability to measure the conductivity of water, which is influenced by the presence and concentration of dissolved ions and minerals **(Pal, 2015**). According to **(Haydar *et al.*, 2009**), the electrical conductivity (EC) parameter, while not directly providing information about specific chemicals in water, serves as a valuable indicator of potential water quality issues. It is especially useful when monitored over time. Due to the report of **WHO (2005**), there is little direct health risk associated with this parameter, but high values are associated with poor taste, customer dissatisfaction, and complaints. The results of this investigation shown in Table 2 indicate that the EC values varied from 5,300 to 1,100 dSm^{-1}. Electrical conductivity levels should not be more than 1,400 to 2,500 dSm^{-1}, according to the worldwide reports of WHO and the standard requirements of EUs and EGs (WHO $\geq$ 1400, EUs $\geq$ 2500, and EGs $\geq$ 2000). Our findings were consistent with previous research **(Mohsin, 2013; Sehar *et al.*, 2013**).

The elevated salinity levels observed in the Abosakl and City center groundwater samples could be attributed to two main factors. Firstly, the proximity of Abosakl to the Mediterranean Sea, located along the coastline, contributes to the intrusion of saline water into the groundwater aquifers. This natural process leads to increased salinity levels in the groundwater. Secondly, the unregulated drilling of wells within the city center area, driven by population growth and the absence of governmental oversight, has resulted in a decline in groundwater quality. Uncontrolled drilling practices have led to groundwater contamination with saline water and increased salinity levels. Consequently, the high salinity levels make the groundwater unsuitable for direct consumption without undergoing desalination processes, such as reverse osmosis membranes. These membranes effectively remove the excess salts and impurities, improving the water quality and making it suitable for drinking.

The responsible authorities must address the issue by properly monitoring and regulating well-drilling activities. This will help safeguard the groundwater resources and ensure the provision of high-quality drinking water to meet the needs of the growing population.

Multi-element analyses

All water samples measured ten elements and compounds, including NH_3, NO_3, Fe, Pb, Zn, Cu, B, Cd, Mo, and Ni. The results are shown in Table 3.

The analysis results, compared to the values recommended by the World Health Organization (WHO), indicate that ammonia levels in the groundwater samples fall within the safe limits for human consumption, especially when drinking water from wells. However, the analysis results indicate elevated levels of certain elements, and it is important to explain these findings and explore potential reasons for the increased concentrations. Several factors can contribute to the higher values observed for these elements in the study areas. The elevated NO_3 levels in Abosakl and the City center areas could be attributed to agricultural activities, improper waste management, or using nitrogen-based fertilizers. These sources can lead to nitrate leaching into the groundwater, increasing concentrations. The potential risk of elevated nitrate levels, particularly for children, is well-documented **(Tanamal *et al.*, 2021**). The elevated levels of B and Pb may be linked to anthropogenic sources such as industrial activities or contaminated waste. These elements can leach into the groundwater from surrounding soil and geological formations. It is important to address the sources of contamination and implement remediation measures to reduce B and Pb levels in the water **(Dewan *et al.*, 2015; Derakhshan *et al.*, 2018**). The increased concentrations of Ni in the study areas, except for Abosakl, could be attributed to natural geological sources, such as Ni-rich rock formations or weathering of Ni-bearing minerals. However, further investigation is required to determine if any specific anthropogenic activities contribute to the elevated Ni levels in water wells **(ATSDR, 2019**). The elevated levels of Mo in both Abosakl and Elbahr areas could be associated with natural geological sources, as Mo is often present in certain types of rocks and minerals. It is important to assess the region's geology to understand the potential sources of Mo and its behaviour in the groundwater system **(USEPA, 2016**).

It is worth noting that interpreting these results and identifying potential causes require further investigation, including comprehensive site-specific studies and detailed analysis of local factors. These findings emphasize the importance of ongoing monitoring and management of water resources to ensure safe drinking water.

The raw dataset for each of the tested elements was subjected to cluster analysis to determine how strongly numerous elemental relationships were present. A dendrogram that reveals probable relationships is seen in Fig. 3. Within this dendrogram, it is feasible to distinguish between numerous different groupings clearly. Cluster (i) (B and Pb connected with NH_3) may (probably) indicate chemical fertilizer use or saltwater intrusion. Cluster (ii) consists of nickel and cadmium, and their strong

Table 3. Multi-elemental analyses for 55 well water samples collected from districted areas

	Districts					WHO,
	Abosakl	Elresa	Karam Abongella	Elbahr	City center	
	(mg L^{-1})					mg L^{-1}
NH_3	2.63	2.21	2.14	2.17	2.25	**5.0**
NO_3	56.2	31.4	40.9	48.3	57.4	**50.0**
Cd	nd	0.003	0.003	0.001	0.005	**0.003**
Zn	0.012	0.025	0.057	0.069	0.051	**≤3.0**
Fe	0.058	0.073	0.041	0.070	0.103	**0.30**
B	2.29	2.24	2.00	1.43	2.16	**0.5**
Cu	0.031	0.103	0.046	0.025	nd	**2.0**
Mo	0.143	0.022	0.048	0.084	0.071	**0.07**
Ni	0.057	0.188	0.179	0.123	0.092	**0.07**
Pb	**0.224**	0.179	0.263	0.141	0.101	**0.01**

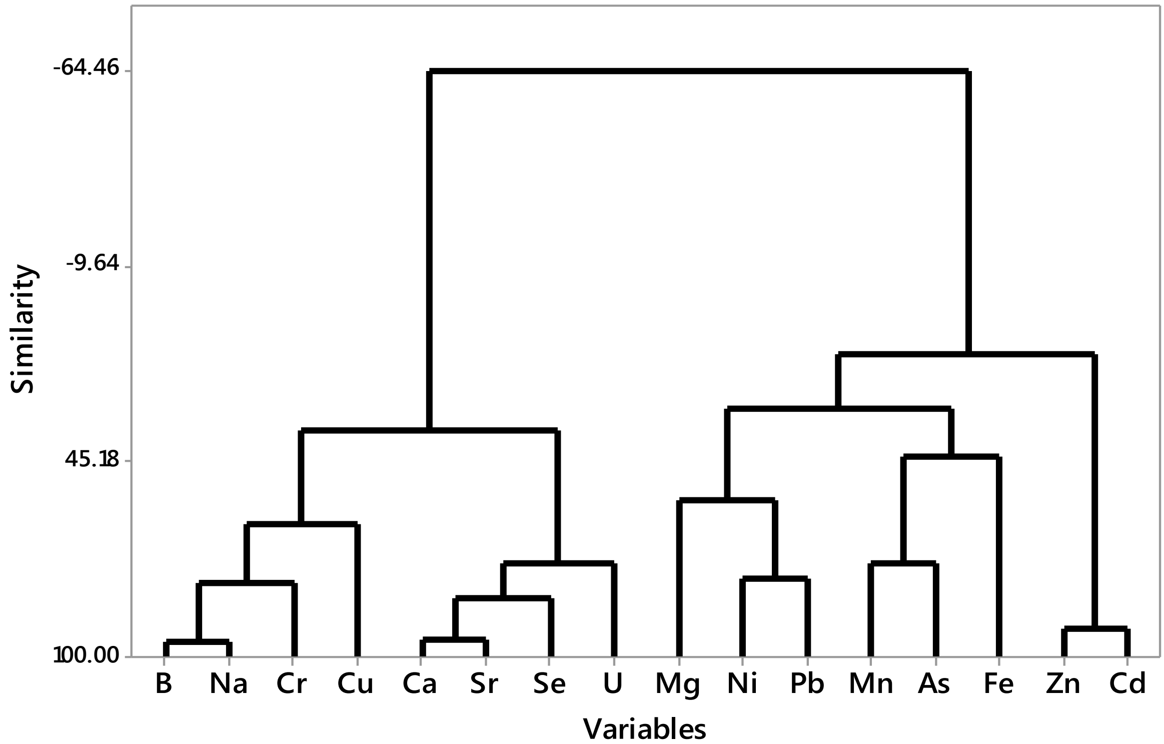

Fig. 3. Dendrogram showing the results of elemental testing performed on water from El-Arish area (n = 55 samples).

geochemical relationship points to a natural origin. Cluster (iii) (NO_3, Fe, Zn, MO) may be the result of human activity, and there is substantial evidence to imply a connection via oxide mineralogy (Fe) connected with the adsorption or replacement of certain elements.

Conclusion

In the end, the microbial and chemical parameters of the groundwater in the study areas differed. Microbiological tests showed that, with a few exceptions in Abosakl and Karam Abongella, the total number of bacteria was within the limits set by the WHO. Even though there was no high risk of coliform bacteria, the pH was higher than the recommended limit, and the electrical conductivity was higher than WHO standards. Also, high levels of some elements like NO_3, B, and Pb were found in some places. This is likely because of farming and poor waste management. These results show how important it is to improve infrastructure for sanitation, regulate well drilling, and deal with human-made sources of contamination. By doing this, the goal of providing safe drinking water could be met, which might protect public health and improve the population's well-being. For sustainable water management, constant monitoring and regular assessments must be needed to find new problems and come up with solutions. By improving the water quality and taking the right steps to clean it up, the study areas can try to give their communities access to clean, drinkable groundwater. Continued cooperation between government agencies, researchers, and local communities is important for putting these measures into place and raising awareness about how water quality affects human health directly.

The final recommendation for the areas with high levels of elements and unsuitable pH in groundwater is as follows:

1. Find alternative water sources for the affected population.
2. Implement comprehensive water treatment processes to remove or reduce contaminants.
3. Conduct health education campaigns to raise awareness about the risks and preventive measures.
4. Establish a regular monitoring and testing system for water quality.
5. Collaborate with authorities to develop long-term solutions and implement regulations.

These actions aim to prevent long-term health problems for the population by addressing the contamination issue and ensuring the provision of safe drinking water taken up from water wells.

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الملخص العربي

تقييم جودة المياه الجوفية للشرب والاستخدام المنزلي: تداعيات سلامة المياه في مدينة العريش، شمال سيناء، مصر

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تقوم الدراسة الحالية بتقييم جودة المياه الجوفية وملائمتها للشرب والاستخدام المنزلي باستخدام معايير ميكروبية وكيميائية متنوعة لـ 55 عينة من آبار المياه. تقارن الدراسة النتائج مع معايير المياه المختلفة وتتبع مصدر التلوث من خلال التحليل الإحصائي. تناقش الدراسة الحالية معايير المياه المختلفة وتقيم ملائمة عينات المياه من منطقة الدراسة بمدينة العريش – محافظة شمال سيناء لخمس مناطق وهي أبي صقل، الريسة، كرم أبو نجيلة، البحر بالإضافة الى وسط المدينة وذلك لأغراض الشرب. تم إجراء الفحوصات المكروبيولوجية، بما في ذلك عدد البكتيريا الكلية واختبارات الكشف عن بكتريا الكوليفورم الكلية، لتقييم الجودة الميكروبية للمياه. أظهرت النتائج أن بعض عينات المياه تتجاوز المواصفات القياسية لعدد البكتيريا الكلية، ومع ذلك فإنها تتوافق مع الحدود المسموح بها عالميًا. تشير وجود بكتيريا الكوليفورم إلى وجود تلوث محتمل بمخلفات الصرف الصحي ولكنه يبقى ضمن الحدود المقبولة لمعظم العينات. تحليل الخصائص الكيميائية للمياه أيضًا، بما في ذلك درجة الحموضة (pH) والتوصيل الكهربائي (EC). تبين أن قيم درجة الحموضة خارج الحدود المسموح بها وفقًا للمواصفات القياسية. تشير قيم التوصيل الكهربائي إلى وجود اخطار محتملة في جودة المياه ولكنها تتوافق مع الحدود الموصي بها لغالبية العينات باستثناء أبو صقل ومناطق وسط المدينة. توجد عناصر ومركبات كيميائية مرتفعة مثل الأمونيا والنيترات والبورون والرصاص والنيكل في عينات المياه الجوفية. يمكن أن يعزى ظهور هذه العناصر إلى مصادر بشرية مختلفة وتتطلب مزيدًا من التحقيق والتصحيح. تسلط النتائج الضوء على أهمية مراقبة وتنظيم جودة المياه لضمان توفير مياه الشرب الآمنة للسكان، وخاصة في المدن الحدودية مثل العريش في شمال سيناء بمصر.

الكلمات الإسترشادية: جودة المياه الجوفية، بكتريا القولون، العناصر المتعددة، تقييم المخاطر.

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