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Assessing of drinking water quality in Al-karak province in central Jordan; based on water saturation indices

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ABSTRACT

Jordan is renowned for having limited water resources. The demand for water will increasing rapidly as the country's population grows and the number of refugees increases. In order to maintain the highest water quality for consumers, the Ministry of Water and Irrigation and other governmental agencies are striving to manage Jordan's water resources through continuous monitoring. The main objective was to evaluate the drinking water quality at storage mixing tanks at Al-Karak province, besides, assessing its suitability for safe consumption. The investigation scheme was to monitor Al-Karak's drinking water system for three successive months. The fourteen principal storage tanks for the water distribution system in the area of investigation were sampled. The pH, electrical conductivity (EC), major cations, major anions, total dissolved solids (TDS), total hardness (TH), turbidity, total alkalinity (TA), and heavy metals were measured. The scaling and originality of the dissolved salt elements in the collected water samples and geochemical processes were examined using Piper and Durov diagrams. The indices used in all samples over the period of investigation, are Langelier Saturation Index (LSI), Ryznar Stability Index (RSI), Aggressive Index (AI), Puckorius Scaling Index (PSI), and Water Quality Index (WQI). The results showed that scale development is high in all storage tanks, as the water is calcium carbonate supersaturated, evident from LSI values that ranges 0.5–2. According to the range of RSI values (5.91–6.6), all water tanks are resistant to corrosion. Throughout the period of study (October–December), the estimated WQIs of all samples upon average were found to be less than 50, indicating excellent water quality. Finally, the collected water samples are analyzed and found to be within the acceptable levels of Jordan's drinking water standards.

1. Introduction

Water resources are the main driver of economic, industrial, agricultural, and societal growth in dry and semi-arid regions of the world, including Jordan. Jordan is a country with severe water shortage, and by 2025, it may not be able to meet its water needs [1,2].

Ground water is considered the main source of drinking water. The country's water distribution system typically consists of a

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network of wells that are connected to central receiving reservoir, where water is first mixed to guarantee that its quality is within the parameters set by Jordanian Department of Water Standard (JDWS) (Drinking Water Standards No. JS 286/2015). Therefore, it is crucial to monitor and evaluate groundwater quality on large scale, as this can act as a potent tool for improving management and development of valuable and limited groundwater resources.

General investigation, including physical (temperature, color, taste, odor, etc.), chemical (pH, turbidity, total solids, hardness, alkalinity, presence of metallic or non-metallic salts), and microbiological, were used to describe the water quality. No single criterion can be used for water quality assessment that would provide an accurate understanding of water quality [3,4]. The quality of water is determined by water composition, which is impacted by both industrial and agricultural activities. Meanwhile, there is now some knowledge of how the quality of water changes over time [5]. Application of a promising and economical tool is therefore required for comprehensive and accurate assessment of the quality of surface water and groundwater.

WHO organization approved the drinking water quality standards in 2004 [6]. The traditional method for evaluating the quality of drinking water resources involves comparing the levels of each water quality parameter to recommended values depending on the water use. This method of evaluation is straightforward and thorough, but it cannot give a comprehensive picture of drinking water quality, especially for managers and other decision-makers who need clear details about water bodies [7].

Various water quality indices have been developed to merge large number of water quality parameters into an integrated numerical score by mathematical instrument in order to address the challenges of analyzing such a large number of multiple water quality parameters for characterization and interpretation of water quality status [3,8–18].

Water saturation indices are frequently used to evaluate the water's corrosion potential (water dissolves calcium in coatings and tank linings) and scalability (water deposits calcium on pipelines, filters, valves, and pumps); as a result, they are helpful in corrosion control as they limit the development of calcium carbonate scale in pipes and equipment. The most frequent saturation indices are the Langelier Saturation Index (LSI), Ryznar Stability Index (RSI), Puckorius Scaling Index (PSI), and Aggressive Index (AI). LSI was constructed by W. F. Langelier in the year 1936. It is a qualitative measure of water's tendency to precipitate or dissolve calcium carbonate derived from the theoretical idea of saturation [19]. The LSI index was modified by John Ryznar in 1944. RSI is an empirical method for predicting scaling tendencies of water based on a study of operating results with water of various saturation Indices. In 1980, Paul Puckorius developed a new index (PSI) that based on the buffering capacity of water and the utmost amount of precipitation that can form when water is brought to equilibrium [20]. AI is derived from the parameters of calcium hardness, total alkalinity, and actual pH The aim of AI was to guarantee the structural integrity of water pipe systems and for monitoring water in asbestos-cement pipes particularly.

The Water Quality Index (WQI) is a statistical and mathematical technique that combines physical, chemical, and biological water parameters (sub-indices) into a numerical score, typically dimensionless, which meaningfully describes the overall water quality status at a specific location and time [8]. A study of surface water quality assessment methods using WQI models can also be used to determine whether water is suitable for a given purpose, such as domestic, agricultural, or industrial.

WQI was used in several research to assess the quality of ground water. For example [21], used drinking water quality index (DWQI) to assess the suitability of the groundwater for drinking and irrigation purposes in El Fayoum Depression, Egypt. They found that groundwater is unsuitable for drinking due to high mineralization processes caused by aquifer materials. Additionally, contamination from irrigation return flow through high application of agrochemical pesticides and seepage from irrigation drainage network contributed to the deterioration of water quality. Other study has been performed by Ref. [22] to evaluate groundwater quality of the Nubian Sandstone Aquifer (NSSA) using indexing approaches, such as the drinking water quality index (DWQI) supported with multivariate analysis, artificial neural network (ANN) models, and geographic information system (GIS) techniques in El Kharga Oasis, Egypt and has been observed most of the samples are not suitable for drinking (poor to very poor class), while some samples fell in the good water class. Similarly, groundwater quality in Makkah Al-Mukarramah Province, Saudi Arabia was assessed by drinking water quality index (DWQI), and it was discovered that the overall quality of groundwater samples in the studied areas varied greatly, from excellent to unfit for drinking [23]. [24] collected 27 samples from wells and boreholes located throughout Quaternary Aquifer in the Al-Jawf Basin, Yemen and the irrigation water quality index (IWQI) revealed moderate-to-severe restrictions in some samples. However, it has been stated that the integrating of physicochemical parameters, WQIs, and multivariate modeling with statistical analysis and GIS tools is a successful methodology that provides a comprehensive picture of groundwater quality and governing mechanisms [25].

Several researches highlighted central Jordan region's groundwater's vulnerability to contaminants. Leachability studies revealed a vulnerability of ground water toward heavy metals discharged as a result of the leachability process [26–31]. Heavy metals are found to be the major emerging pollutant that threats all environmental components (i.e. soil, water and plants) [32–41]. A variety of techniques, including biological ones, are used to remediate contaminated water sources [42–45].

The aim of current study is to evaluate the drinking water quality in Al-Karak province (Central Jordan) at the storage mixing tanks, which are an important part of the water network distribution system. Water saturated indices of Ryznar Stability Index (RSI), Langelier Saturation Index (LSI), Aggressive (AI), Puckorius Scaling index (PSI), and water quality Index (WQI) were used to investigate the tendency of calcium carbonate to precipitate and the corrosiveness of water body during its trip from mixing tanks to its final destination. The suitability of water at source for consumption was assessed using the Jordanian Department of Water Standard (JDWS) (Drinking Water Standards No. JS 286/2015).

This investigation should be considered in the context of the national Jordanian efforts being established by the governmental organizations to manage Jordan's water resources through a system of ongoing monitoring to ensure the highest possible quality of drinking water available to the citizens.

2. Materials and methods

2.1. Study area

With coordinates of Latitude 31.1853° North and Longitude 35.7048° East, the Al-Karak Governorate locates in southwest Jordan (Fig. 1). 10 municipalities made up the entire governorate, which has a total population of 350,000 people, with 65% of those living in urban areas and 35% in rural areas [46]. The primary source of water for Al-Karak Municipality is the groundwater resources.

The area's water distribution system consists of hundreds of kilometers of metallic and plastic pipes, storage tanks, mixing pumps, and pumps connecting to gather through various types of fittings, and valves to transport drinking water from sources that may be located far from the final end users. The collection and supply reservoirs of the water network system in the province of Al-Karak are dispersed in various areas to meet the demand for drinking water in the area (Fig. 2).

2.2. Climate

The study area has a semiarid Mediterranean climate, with cool wet winters and long hot dry summers. The average near surface air temperature during January varies from 4 C° to 9 C°, and the average in July ranges 21 C° to 26 C° [47,48]. The mean annual rainfall ranges from 300 mm west of the study area to around 100 mm east, it decreases gradually toward the east [49]. The average annual evaporation from Class A pan amount is found to be (13.3 mm/day) for Al-Hisa evaporation station. Generally, the maximum evaporation values are observed in July with monthly maximum (488 mm/day), and a minimum in January (103 mm/day) [33].

2.3. Aquifer

The aquifer system in the study area is known as B2/A7, its thickness reaches about 320 *m* and demonstrates various thicknesses in Central Jordan with a range from 100 to 320 *m* at different locations. According to the wells data obtained from the MWI and the data

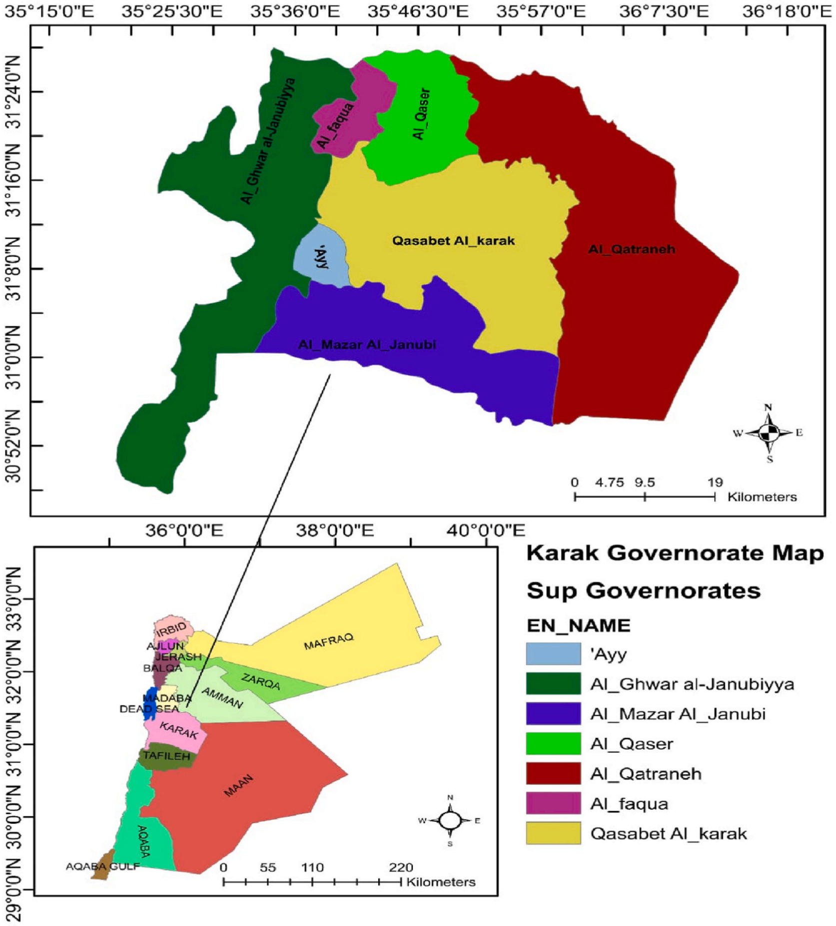

Fig. 1. Location of the study area (Al-Karak province area).

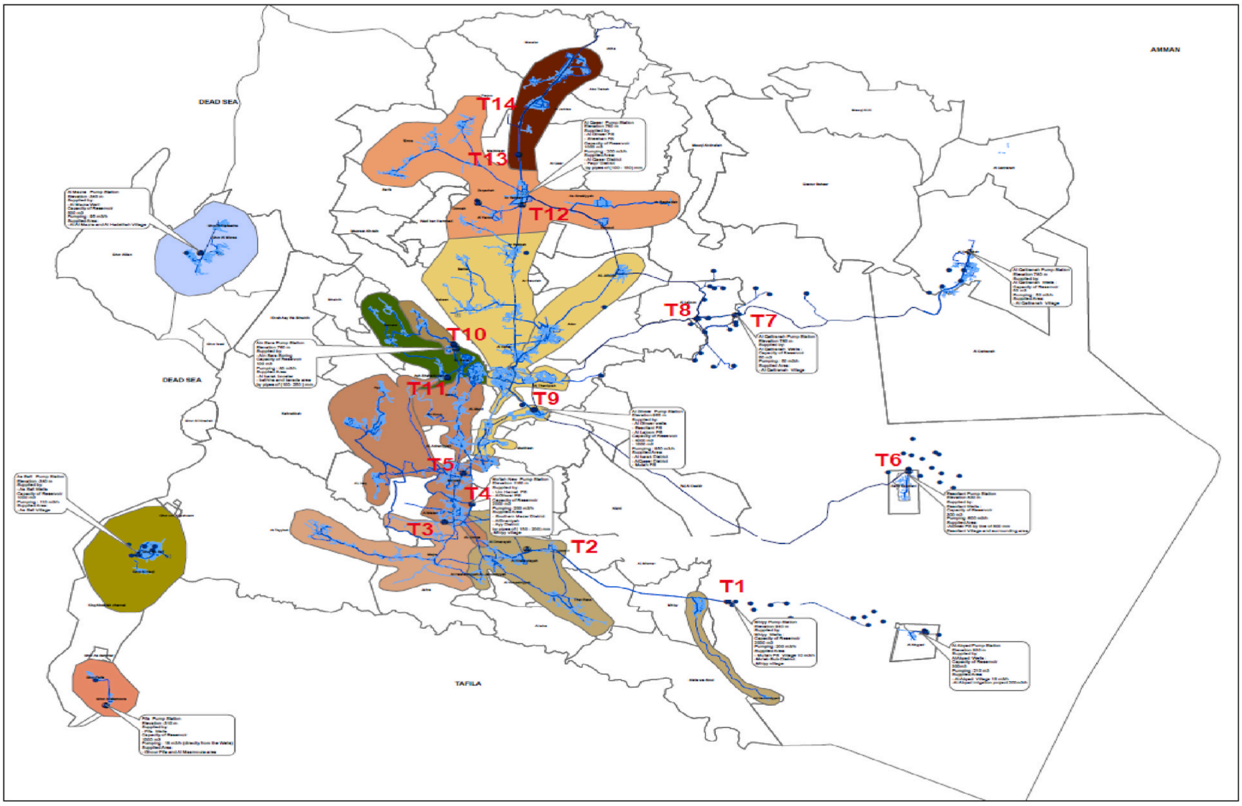

Fig. 2. Water distribution system in study area and sampling points.

of Jordanian Uranium Mining Company (JUMCO) camp at Siwaqa area, the thickness of B2/A7 aquifer ranges between 250 m and 300 *m*. The B2/A7 aquifer is related to upper Cretaceous fractured carbonate formation with karstic features; it is unconfined aquifer with phreatic conditions. The groundwater flow direction of B2/A7 in the study area is north-northeast. The depth of this aquifer ranges between 120 *m* and 300 *m* below surface [50].

2.4. Methodology

2.4.1. Sample collection

Three water samples with a 2 L volume were collected from each of the fourteen water collecting tanks in the Al-Karak water network (Table 1) with a one-month interval between each collection during the period of October to December 2022. All samples were labeled with the following locational symbols: T1, T2, . T14. According to Ref. [51], all samples were collected, stored and analyzed at Prince Faisal Center for Dead Sea, Environmental, and Energy Research (PFC-DSEER, Mutah University).

Table 1
Collection tanks locations.

Sample ID	Region	Name	Location
T1	AL-Mazar	Mhiyy	30°59′41.5″N 35°52′55.6″E
T2		Um-Hammat	31°02′13.6″N 35°44′56.4″E
T3		AL-Mazar	31°03′25.9″N 35°41′20.2″E
T4		Mutah New	31°04′19.9″N 35°42′29.2″E
T5		Mutah	31°05′44.6″N 35°42′07.5″E
T6	AL-Karak	Essoltani	31°05′54.8″N 36°00′24.4″E
T7		AL-Qatraneh	31°16′32.7″N 36°02′56.8″E
T8		AL-Lajjoon	31°12′57.9″N 35°51′46.3″E
T9		AL-Ghwer	31°08′41.6″N 35°45′02.5″E
T10		Ain-Sarah	31°11′49.0″N 35°41′44.0″E
T11		Ash-Shehabiyyeh	31°10′12.9″N 35°41′29.8″E
T12	AL-Qaser	AL-Rabah	31°18′17.4″N 35°44′34.6″E
T13		Majdoleen	31°20′38.1″N 35°44′28.9″E
T14		Shihan	31°22′32.4″N 35°44′03.2″E

2.4.2. *Water analysis*

According to Jordanian Department of Water Standard (JDWS) (Drinking Water Standards No. JS 286/2015), all collected samples were analyzed for different parameters required for monitoring drinking water quality.

2.4.2.1. Total dissolved solids (TDS), total suspended solids (TSS), total alkalinity (TA), pH, dissolved oxygen (DO), electrical conductivity (EC), turbidity, and total hardness (TH). The value of TDS, TSS, TA were measured according to the standard methods 2540C, 2540D, and 2320 B, respectively [52]. The pH, DO, and EC were measured in situ according to the standard methods 4500-H + B, 4500-O G, and 2510 B using the portable electrode meters (pH meter, Lovibond, SensoDirect 150, Germany; DO meter, Lovibond, SensoDirect 150, Germany; and EC meter Cond 31.5i), respectively. The turbidity was measured according to 2130 A standard method using turbidimeter (Turbidimeter, Jenway 6035, UK) and the TH according to the standard method 2340C [52].

2.4.2.2. Heavy metals. The water samples were collected in plastic vials, filtered using cellulose acetate syringe filter of 0.45 μm pore size, acidified and stored in a refrigerator until analysis. The water samples were analyzed for heavy metals (Cr, Cu, Pb, Fe, Mn, Zn, and Ni) according to the Standard Method 3111 B using Atomic absorption spectroscopy (AA-7000, Shimadzu Scientific Instruments, Japan) [52].

2.4.2.3. Major anions and cations. The water samples were collected in plastic vials, filtered using cellulose acetate syringe filter of 0.45 μm pore size, and stored in a refrigerator until analysis. The water samples were analyzed for anions (Cl, SO4, Br, NO3, PO4, and F) and cations (Li, Na, NH4, K, Ca, and Mg) using an Ion Chromatography Analyzer (Eco IC, Metrohm, Switzerland) [52].

2.5. *Quality control (QC) and quality assurance (QA)*

Three main activities were carried out in the current study to ensure the results, which were, analyzing 10% of all samples in duplicate distributed randomly, duplicate determination should be agreed with 5% of their average relative percentage duplicate (RPD), and the recovery of the QC sample must be within the range of 80–120% to be accepted.

2.6. *Precision and accuracy*

Only standard curves with R^2 0.9995–1 have been authorized for the analysis of heavy metals, anions, and cations that required the building of a standard curve. At the beginning, after every five samples, and at the end of each run of samples, a quality control (QC) sample with a known concentration was examined to ensure that all analyses and measurements were precise and accurate.

2.7. *Statistical analysis*

All samples were analyzed in triplicate. Data were analyzed by means of SPSS software. The results were expressed by means ± SD. The statistical significance of differences between groups were assessed by the p value, where $p < 0.05$ was considered significant.

2.8. *Assessment of drinking water using water quality index (WQI)*

The WQI ranges suggested by Ref. [53] were used to evaluate the drinking water quality (Table 2).

3. Results and discussion

3.1. *Water physio-chemical characteristics*

The physico-chemical characteristics of the analyzed water samples over three months (October, November, and December) are shown in Table 3. These characteristics included pH, electrical conductivity (EC), total dissolved solids (TDS), total hardness (TH), turbidity, total alkalinity (TA), and dissolved oxygen. For comparison, standard values from Jordanian Department of Water Standard (JDWS) (Drinking Water Standards No. JS 286/2015) [54] were added. Water tanks (T1-T14) over a three-month period complied with JDWS drinking water pH criteria (6.5–8.5). The EC values were (752–2168 μS/cm in October, 768–2250 in November, and

Table 2
The WQI range and categorization of water quality for drinking [53].

WQI Range	Type of water
<50	Excellent
50–100	Good
100.1–200	Poor
200.1–300	Very poor
>300	Unsuitable for drinking

Table 3

Physical Characteristics of all samples (T1-T14) (means ± SD, n = 3).

Month	Parameter	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	JDWS standard
Oct-22	pH	7.6 ± 0.4	7.9 ± 0.4	7.8 ± 0.4	7.9 ± 0.4	7.7 ± 0.4	7.8 ± 0.4	7.3 ± 0.4	7.7 ± 0.4	7.7 ± 0.4	7.8 ± 0.4	7.6 ± 0.4	7.7 ± 0.4	7.4 ± 0.4	7.6 ± 0.4	6.5–8.5
	EC μc\cm @ 25 C°	999 ± 50	1019 ± 50	1069 ± 53	983 ± 49	976 ± 48	1222 ± 60	1220 ± 60	1013 ± 51	1173 ± 58	752 ± 37	1185 ± 59	1405 ± 70	1567 ± 78	2168 ± 108	750–2300
	DO %	15.7 ± 0.8	16.4 ± 0.8	16.8 ± 0.8	18.4 ± 1	18.3 ± 1	15.5 ± 1	15.3 ± 0.8	14.4 ± 1	18 ± 1	17.6 ± 1	16.4 ± 0.8	16.8 ± 0.8	16.9 ± 0.8	17.3 ± 0.9	–
	D0 mg/l	6.5 ± 0.3	6.7 ± 0.3	6.9 ± 0.3	7.4 ± 0.4	7.3 ± 0.4	6 ± 0.3	6 ± 0.3	5 ± 0.3	7.4 ± 0.4	7.2 ± 0.4	6.7 ± 0.3	6.9 ± 0.3	6.9 ± 0.3	7.1 ± 0.4	–
	Turbidity (NTU)	6.2 ± 0.3	5.1 ± 0.3	1.9 ± 0.1	1 ± 0.05	1.6 ± 0.07	0.8 ± 0.03	0.3 ± 0.01	1.8 ± 0.1	2 ± 0.1	0.3 ± 0.01	0.2 ± 0.01	2.4 ± 0.1	0.3 ± 0.02	0.1 ± .01	5
	TSS (mg/L)	8 ± 0.4	4 ± 0.2	2 ± 0.1	1 ± 0.05	0	2 ± 0.1	4 ± 0.2	1 ± 0.05	3 ± 0.1	1 ± 0.04	2 ± 0.1	3 ± 0.2	1 ± 0.1	11 ± 1	–
	TDS (mg/L)	538 ± 27	508 ± 25	497 ± 25	561 ± 28	603 ± 30	626 ± 31	759 ± 38	552 ± 27	611 ± 30	436 ± 20	629 ± 31	810 ± 41	916 ± 46	1234 ± 62	1000
	TA (mg/L)	228 ± 11	205 ± 10	194 ± 9	226 ± 11	246 ± 12	214 ± 11	228 ± 11	242 ± 12	204 ± 10	166 ± 8	284 ± 14	163 ± 8	214 ± 11	162 ± 8	300
	TH (mg/L)	312 ± 16	311 ± 15	311 ± 16	309 ± 16	338 ± 16	331 ± 16	360 ± 18	294 ± 14	285 ± 15	242 ± 12	339 ± 17	310 ± 16	459 ± 23	513 ± 26	500
Nov-22	pH	7.6 ± 0.4	7.9 ± 0.4	7.9 ± 0.4	7.8 ± 0.4	7.8 ± 0.4	7.5 ± 0.4	7.6 ± 0.4	7.8 ± 0.4	7.7 ± 0.4	7.7 ± 0.4	7.7 ± 0.4	8.2 ± 0.4	8.0 ± 0.4	7.9 ± 0.4	6.5–8.5
	EC μc\cm @ 25 C°	998 ± 50	987 ± 50	1070 ± 54	1101 ± 55	1100 ± 53	1207 ± 58	1227 ± 60	974 ± 50	1117 ± 56	768 ± 37	1098 ± 55	1032 ± 52	1568 ± 78	2250 ± 113	750–2300
	DO %	22 ± 1	21 ± 1	21 ± 1	21 ± 1	21 ± 1	21 ± 1	21 ± 1	21 ± 1	20 ± 1	21 ± 1	21 ± 1	21 ± 1	21 ± 1	20 ± 1	–
	DO mg/l	8.5 ± 0.4	8.4 ± 0.4	8.4 ± 0.4	8.2 ± 0.4	8.2 ± 0.4	8 ± 0.4	8 ± 0.4	8 ± 0.4	7.9 ± 0.4	7.9 ± 0.4	8.2 ± 0.4	8.3 ± 0.4	8.2 ± 0.4	7.9 ± 0.4	–
	Turbidity (NTU)	2.4 ± 0.1	1 ± 0.1	0.4 ± 0.02	0.3 ± 0.01	0.8 ± 0.04	0.1 ± 0.006	0.1 ± 0.006	1.8 ± 0.1	2.5 ± 0.1	0.1 ± 0.006	0.8 ± 0.04	1 ± 0.1	0.7 ± 0.04	0.3 ± 0.02	5
	TSS (mg/L)	3 ± 0.2	8 ± 0.4	14 ± 1	4 ± 0.2	1 ± 0.05	10 ± 0.4	6 ± 0.3	10 ± 0.4	5 ± 0.2	2 ± 0.1	4 ± 0.2	6 ± 0.3	3 ± 0.2	2 ± 0.1	–
	TDS (mg/L)	640 ± 32	583 ± 29	670 ± 34	693 ± 34	680 ± 33	745 ± 38	799 ± 40	587 ± 30	789 ± 38	381 ± 19	699 ± 35	622 ± 31	1041 ± 52	1463 ± 73	1000
	TA (mg/L)	293 ± 15	276 ± 14	248 ± 13	277.6 ± 13	273 ± 13	278 ± 13	276 ± 14	255 ± 12	288 ± 14	225 ± 11	308 ± 15	141 ± 7	199 ± 10	205 ± 10	300
	TH (mg/L)	377 ± 19	382 ± 19	365 ± 18	360 ± 18	364 ± 18	394 ± 20	408 ± 20	307 ± 15	369 ± 18	301 ± 15	364 ± 18	288 ± 14	444 ± 22	556 ± 28	500
Dec-22	pH	7.5 ± 0.4	7.9 ± 0.4	7.9 ± 0.4	7.8 ± 0.4	7.8 ± 0.4	7.9 ± 0.4	7.6 ± 0.4	7.8 ± 0.4	7.7 ± 0.4	7.7 ± 0.4	7.9 ± 0.4	8.1 ± 0.4	8.0 ± 0.4	8.0 ± 0.4	6.5–8.5
	EC μc\cm @ 25 C°	976 ± 50	981 ± 50	990 ± 50	1122 ± 56	1113 ± 54	1190 ± 60	1243 ± 61	1013 ± 48	1142 ± 55	750 ± 37	1075 ± 54	1558 ± 78	1846 ± 92	2300 ± 115	750–2300
	DO %	21 ± 1	19.6 ± 1	20 ± 1	20 ± 1	20 ± 1	21 ± 1	20 ± 1	19 ± 1	20 ± 1	18 ± 1	20 ± 1	20 ± 1	20 ± 1	19 ± 1	–
	D0 mg/l	8.4 ± 0.4	8.6 ± 0.4	8.6 ± 0.4	8.6 ± 0.4	8.4 ± 0.4	8.7 ± 0.4	8.3 ± 0.4	8.5 ± 0.4	8.3 ± 0.4	8.0 ± 0.4	8.5 ± 0.4	8.4 ± 0.4	8.5 ± 0.4	8.0 ± 0.4	–
	Turbidity (NTU)	1.2 ± 0.1	1.2 ± 0.1	0.5 ± 0.02	0.2 ± 0.01	0.1 ± 0.006	0.6 ± 0.02	0.1 ± 0.004	0.3 ± 0.01	1.4 ± 0.1	0.1 ± 0.006	0.2 ± 0.01	1.7 ± 0.1	3.0 ± 0.2	0.3 ± 0.02	5
	TSS (mg/L)	3 ± 0.2	2 ± 0.1	9 ± 0.5	1 ± 0.05	1 ± 0.05	4 ± 0.2	3 ± 0.2	1 ± 0.05	2 ± 0.1	1 ± 0.05	1 ± 0.1	4 ± 0.2	3 ± 0.2	2 ± 0.1	–
	TDS (mg/L)	436 ± 22	390 ± 19	502 ± 25	593 ± 29	622 ± 30	649 ± 33	674 ± 33	525 ± 25	602 ± 28	382 ± 19	558 ± 28	882 ± 44	1075 ± 54	1339 ± 67	1000
	TA (mg/L)	270 ± 14	228 ± 11	225 ± 11	263 ± 13	259 ± 12	251 ± 12	275 ± 13	261 ± 12	273 ± 14	210 ± 10	270 ± 14	236 ± 12	233 ± 12	208 ± 10	300
	TH (mg/L)	354 ± 18	334 ± 17	343 ± 17	346 ± 17	351 ± 17	368 ± 18	408 ± 20	313 ± 15	355 ± 17	287 ± 14	326 ± 16	383 ± 19	479 ± 24	560 ± 28	500

Table 4

Chemical characteristics of all samples (T1-T14) (means ± SD, n = 3).

Month	Parameter	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	JDWS standard
October-2022	Na^+	67 ± 3	66 ± 3	77 ± 4	95 ± 5	95 ± 5	103 ± 5	102 ± 5	87 ± 4	97 ± 5	35 ± 2	95 ± 5	120 ± 6	128 ± 6	179 ± 9	200
	NH_4^+	0.03 ± 0.002	0.05 ± 0.003	0.03 ± 0.002	0.04 ± 0.002	0.03 ± 0.002	0.03 ± 0.002	0.03 ± 0.002	0.03 ± 0.002	0.04 ± 0.002	0.03 ± 0.002	0.05 ± 0.002	0.04 ± 0.002	0.05 ± 0.002	0.06 ± 0.003	0.5
	K^+	2.8 ± 0.1	3.3 ± 0.2	0.01 ± 0.001	3.8 ± 0.2	3.6 ± 0.2	3.1 ± 0.2	3.2 ± 0.2	3.9 ± 0.2	3.6 ± 0.2	11.9 ± 0.6	3.3 ± 0.2	6.6 ± 0.3	8.4 ± 0.4	16.2 ± 0.8	10
	Ca^{2+}	64 ± 3	61 ± 3	61 ± 3	63 ± 3	74 ± 4	65 ± 3	72 ± 4	60 ± 3	51 ± 3	66 ± 3	73 ± 4	64 ± 3	87 ± 4	114 ± 6	200
	Mg^{2+}	37 ± 2	39 ± 2	39 ± 2	37 ± 2	38 ± 2	41 ± 2	44 ± 2	35 ± 2	38 ± 2	19 ± 1	38 ± 2	37 ± 2	59 ± 3	56 ± 3	150
	F^-	0.01 ± 0.001	0.01 ± 0.001	0.01 ± 0.001	0.08 ± 0.004	0.11 ± 0.006	0.27 ± 0.014	0.3 ± 0.015	0.01 ± 0.001	0.09 ± 0.005	0.01 ± 0.001	0.14 ± 0.007	0.01 ± 0.001	0.01 ± 0.001	0.01 ± 0.001	2
	Cl^-	97 ± 5	100 ± 5	121 ± 6	154 ± 8	156±	176 ± 9	174 ± 9	131 ± 7	160 ± 8	67 ± 3	160 ± 8	454 ± 23	451 ± 23	911 ± 46	500
	NO_3^-	2.7 ± 0.1	2.9 ± 0.1	3.7 ± 0.2	4.1 ± 0.2	4.2 ± 0.2	3.0 ± 0.2	3.0 ± 0.2	2.3 ± 0.1	4.7 ± 0.2	46 ± 2.3	4.9 ± 0.2	2.1 ± 0.1	2.6 ± 0.1	2.8 ± 0.1	50
	SO_4^{2-}	90 ± 5	107 ± 5	106 ± 5	101 ± 5	101 ± 5	110 ± 5	123 ± 6	92 ± 5	103 ± 5	39 ± 2	102 ± 5	147 ± 7	403 ± 20	656 ± 33	500
	PO_4^{3-}	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	–
November-2022	Na^+	66 ± 3	66 ± 3	48 ± 2	91 ± 5	92 ± 5	99 ± 5	98 ± 5	83 ± 4	92 ± 5	37 ± 2	91 ± 5	91 ± 5	134 ± 7	234 ± 12	200
	NH_4^+	0.04 ± 0.002	0.04 ± 0.002	0.03 ± 0.002	0.06 ± 0.003	0.04 ± 0.002	0.03 ± 0.002	0.05 ± 0.003	0.04 ± 0.002	0.04 ± 0.002	0.04 ± 0.002	0.04 ± 0.002	0.03 ± 0.002	0.04 ± 0.002	0.04 ± 0.002	0.5
	K^+	0.01 ± 0.001	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	10
	Ca^{2+}	84 ± 4	85 ± 4	81 ± 4	81 ± 4	82 ± 4	89 ± 4	88 ± 4	69 ± 3	83 ± 4	88 ± 4	83 ± 4	58 ± 3	80 ± 4	126	200
	Mg^{2+}	41 ± 2	42 ± 2	40 ± 2	38 ± 2	39 ± 2	42 ± 2	46 ± 2	33 ± 2	39 ± 2	20 ± 1	38 ± 2	35 ± 2	59 ± 3	59 ± 3	150
	F^-	0.01 ± 0.001	0.01 ± 0.001	0.1 ± 0.005	0.1 ± 0.005	0.1 ± 0.005	0.3 ± 0.015	0.3 ± 0.015	0.01 ± 0.001	0.1 ± 0.005	0.01 ± 0.001	0.1 ± 0.005	0.01 ± 0.001	0.01 ± 0.001	0.01 ± 0.001	2
	Cl^-	97 ± 5	97 ± 5	133 ± 7	146 ± 7	149 ± 7	170 ± 9	168 ± 8	119 ± 6	151 ± 8	69 ± 3	147 ± 7	136 ± 7	312 ± 16	460 ± 23	500
	NO_3^-	2.4 ± 0.1	2.7 ± 0.1	3.4 ± 0.2	4 ± 0.2	4.1 ± 0.2	3.1 ± 0.2	2.8 ± 0.1	2.2 ± 0.1	4.2 ± 0.2	42.9 ± 2.1	4.9 ± 0.2	2.3 ± 0.1	2.5 ± 0.1	2.6 ± 0.1	50
	SO_4^{2-}	113 ± 6	115 ± 6	100 ± 5	93 ± 5	94 ± 5	104 ± 5	113 ± 6	82 ± 4	95 ± 5	39 ± 2	92 ± 5	92 ± 5	146 ± 7	333 ± 17	500
	PO_4^{3-}	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	–
December -2022	Na^+	63 ± 3	63 ± 3	65 ± 3	92 ± 5	92 ± 5	99 ± 5	101 ± 5	84 ± 4	94 ± 5	35 ± 2	86 ± 4	156 ± 8	180 ± 9	252 ± 13	200
	NH_4^+	0.06 ± 0.003	0.04 ± 0.002	0.03 ± 0.002	0.03 ± 0.002	0.03 ± 0.002	0.04 ± 0.002	0.04 ± 0.002	0.05 ± 0.003	0.04 ± 0.002	0.06 ± 0.003	0.06 ± 0.003	0.06 ± 0.003	0.05 ± 0.002	0.05 ± 0.003	0.5
	K^+	0.01 ± 0.001	3.12 ± 0.2	3.08 ± 0.2	3.11 ± 0.2	3.08 ± 0.2	3.1 ± 0.2	3.1 ± 0.2	3.09 ± 0.2	3.13 ± 0.2	3.12 ± 0.2	3.1 ± 0.2	3.08 ± 0.2	3.1 ± 0.2	3.11 ± 0.2	10
	Ca^{2+}	77 ± 4	70 ± 3	72 ± 4	75 ± 4	77 ± 4	79 ± 4	87 ± 4	69 ± 3	79 ± 4	83 ± 4	72 ± 4	79 ± 4	95 ± 4	127 ± 6	200
	Mg^{2+}	40 ± 2	39 ± 2	40 ± 2	39 ± 2	38 ± 2	42 ± 2	46 ± 2	34 ± 2	39 ± 2	19 ± 1	36 ± 2	45 ± 2	59 ± 3	59 ± 3	150
	F^-	0.9 ± 0.05	1.1 ± 0.06	1.2 ± 0.06	1.3 ± 0.07	1.3 ± 0.07	1.5 ± 0.08	1.5 ± 0.08	1.1 ± 0.06	1.3 ± 0.07	0.8 ± 0.04	1.2 ± 0.06	1.1 ± 0.06	0.8 ± 0.04	0.9 ± 0.05	2
	Cl^-	85 ± 4	86 ± 4	88 ± 4	132 ± 7	133 ± 7	153 ± 8	153 ± 8	111 ± 6	134 ± 7	61 ± 3	125 ± 6	170 ± 8	140 ± 7	398 ± 20	500
	NO_3^-	3 ± 0.1	3 ± 0.1	2.7 ± 0.1	3.9 ± 0.2	4.2 ± 0.2	3.2 ± 0.2	2.6 ± 0.1	1.8 ± 0.1	3.2 ± 0.2	42.7 ± 2.1	8.4 ± 0.4	1.9 ± 0.1	2.1 ± 0.1	2 ± 0.1	50
	SO_4^{2-}	101 ± 5	102 ± 5	106 ± 5	93 ± 5	93 ± 5	103 ± 5	119 ± 6	84 ± 4	94 ± 5	36 ± 2	86 ± 4	164 ± 8	273 ± 14	304 ± 15	500
	PO_4^{3-}	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	–

B.D: Below detection limit, which was 0.006 mg/L for the PO_4.

Table 5
Metal concentration in the water samples of study area (mg/L) (means ± SD, n = 3).

Month	Metal	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14	JDWS standard
October-2022	Ni	B.D	B.D	B.D	B.D	B.D	0.02 ± 0.001	B.D	B.D	0.024 ± 0.0012	B.D	0.023 ± 0.0011	B.D	B.D	B.D	0.07
	Cu	0.02 ± 0.001	0.02 ± 0.001	0.02 ± 0.001	0.02 ± 0.001	0.02 ± 0.001	0.02 ± 0.001	0.03 ± 0.001	0.03 ± 0.001	0.04 ± 0.002	0.03 ± 0.001	0.03 ± 0.001	0.03 ± 0.001	0.03 ± 0.001	0.03 ± 0.001	1
	Cr	0.07 ± 0.004	0.07 ± 0.004	0.08 ± 0.004	0.11 ± 0.005	0.11 ± 0.006	0.12 ± 0.006	0.13 ± 0.007	0.15 ± 0.007	0.15 ± 0.008	0.15 ± 0.008	0.16 ± 0.008	0.17 ± 0.008	0.16 ± 0.008	0.17 ± 0.009	0.05
	Fe	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	0.1838	B.D	B.D	B.D	B.D	B.D	1
	Mn	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	0.1
	Zn	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	4
	Pb	0.04 ± 0.002	0.03 ± 0.002	0.03 ± 0.001	0.03 ± 0.001	0.03 ± 0.001	0.03 ± 0.001	B.D	0.03 ± 0.001	0.04 ± 0.002	0.03 ± 0.001	B.D	0.03 ± 0.001	0.04 ± 0.002	0.04 ± 0.002	0.01
November-2022	Ni	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	0.07
	Cu	B.D	B.D	B.D	B.D	0.009 ± 0.0004	0.008 ± 0.0004	0.027 ± 0.0013	0.011 ± 0.0006	0.015 ± 0.0007	0.018 ± 0.0009	0.016 ± 0.0008	0.016 ± 0.0008	0.018 ± 0.0009	0.017 ± 0.0009	1
	Cr	0.02 ± 0.001	0.03 ± 0.001	0.02 ± 0.001	0.04 ± 0.002	0.04 ± 0.002	0.04 ± 0.002	0.05 ± 0.002	0.05 ± 0.002	0.05 ± 0.003	0.06 ± 0.003	0.06 ± 0.003	0.06 ± 0.003	0.07 ± 0.004	0.08 ± 0.004	0.05
	Fe	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	1
	Mn	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	0.1
	Zn	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	4
	Pb	0.05 ± 0.003	0.06 ± 0.003	0.07 ± 0.003	0.08 ± 0.004	0.09 ± 0.005	0.1 ± 0.005	0.1 ± 0.005	0.13 ± 0.006	0.13 ± 0.007	0.15 ± 0.007	0.16 ± 0.008	0.17 ± 0.009	0.18 ± 0.009	0.2 ± 0.01	0.01
December-2022	Ni	0.02 ± 0.001	0.02 ± 0.001	0.02 ± 0.001	0.03 ± 0.001	0.02 ± 0.001	0.03 ± 0.002	0.03 ± 0.001	0.02 ± 0.001	0.03 ± 0.001	0.02 ± 0.001	0.03 ± 0.001	0.02 ± 0.001	0.02 ± 0.001	0.02 ± 0.001	0.07
	Cu	0.03 ± 0.002	0.04 ± 0.002	0.04 ± 0.002	0.04 ± 0.002	0.04 ± 0.002	0.04 ± 0.002	0.05 ± 0.002	0.04 ± 0.002	0.05 ± 0.002	0.05 ± 0.002	0.05 ± 0.003	0.05 ± 0.003	0.05 ± 0.003	0.05 ± 0.003	1
	Cr	0.05 ± 0.003	0.06 ± 0.003	0.07 ± 0.003	0.08 ± 0.004	0.08 ± 0.004	0.1 ± 0.005	0.1 ± 0.005	0.11 ± 0.005	0.12 ± 0.006	0.13 ± 0.007	0.14 ± 0.007	0.14 ± 0.007	0.15 ± 0.008	0.16 ± 0.008	0.05
	Fe	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	1
	Mn	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	0.1
	Zn	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	B.D	4
	Pb	0.06 ± 0.003	0.06 ± 0.003	0.09 ± 0.004	0.12 ± 0.006	0.12 ± 0.006	0.15 ± 0.007	0.19 ± 0.009	0.22 ± 0.011	0.25 ± 0.013	0.28 ± 0.014	0.31 ± 0.015	0.34 ± 0.017	0.36 ± 0.018	0.39 ± 0.02	0.01

B.D: Below detection limit, which were; 0.02, 0.006, 0.005, 0.01, 0.006, 0.002, 0.03 mg/L for the Ni, Cu, Cr, Fe, Mn, Zn, and Pb, respectively.

750–2300 in December) are within JDWS. T10 had the lowest EC throughout three months, whereas T14 had the highest. It is clear that the increase in dissolved oxygen (mg/L) from October to December was caused by a drop in temperature.

With the exception of T1 and T2 in October, where turbidity exceeds 5, all turbidity measurements over the period of the three months are lower than the JDWS (500 NTU). The TSS lowest value was zero for T5 (October), T8, and T10 (December), while T3 (November) had the highest value. All tanks' TDS measurements were within JDWS, with the exception of T13 in October and T14 during the period of the three months. With the exception of T11 in November, all TA values were discovered within the JDWS during the period of three months. All tanks, with the exception of T14, had total hardness (TH) measurements below the JDWS maximum value (500 mg/L).

The main cations and anions detected in all water samples were listed in Table 4. With a few exceptions throughout the three months, such as the concentration of K^+ in T10 (October) and K^+, Cl^-, and SO_4^{2-} in T14, which exceeds the JDWS, all the measured ions (cations and anions) were found to meet the JDWS values. The presence of excessive sulfate in water can clog pipes and induce diarrhea in humans and excessive nitrate can lead to gastric cancer and methemoglobinemia (blue-baby syndrome) in infants [55]. Table 5 findings demonstrate that, with the exception of Cr and Pd, whose concentrations consistently above the JDWS over the period of three months in most tanks, all measured metal concentrations (Ni, Cu, Cr, Fe, Mn, Zn, and Pb) were within the JDWS's acceptable limits. Despite this, there are no significant differences between the groups in all previous analyzes, because the p value was >0.05.

By processing data of water chemical composition using (AQUACHEM 2014.2) software, Piper and Durov diagrams are created in this study in order to evaluate the originality of dissolved salts constituents in collected water samples and geochemical processes in the study area. Aquachem is a software program that analyzes and models water quality data using graphical and numerical methods. All water samples in the research region are classified as alkaline groundwater by Piper's classification with an increasing amount of alkali and a predominance of sulfates and chlorides (Fig. 3).

One geochemical process that might affect the genesis of water in the study area is revealed by Durov diagrams (Fig. 4). All samples were located in field 4 of the Durov diagram, indicating a predominance of calcium and sulfates. It frequently denotes recharged water in gypsum and lava formations. Increased nitrate content (NO^{-3}) in T10 (Ain-Sara) is frequently a sign of increased agricultural activity in the area because of the use of synthetic and natural fertilizers that contain soluble salts of nitrogen.

3.2. Water saturation indices

The indices of the Langelier Saturation Index (LSI), Ryznar Stability Index (RSI), Aggressive Index (AI), Puckorius Scaling Index (PSI), and water quality Index (WQI) were computed for all collected samples in order to evaluate the quality of the drinking water in the study area (Table 6).

3.2.1. Langelier Saturation Index (LSI)

A qualitative indicator of water's potential to dissolve or precipitate calcium carbonate is provided by the LSI equilibrium model, which is based on saturation. The solubility of calcium carbonate in water with a pH between 6.5 and 9.5 is affected by temperature, pH, calcium, dissolved solids, and total alkalinity, as shown by the LSI equation. Only water's corrosively to calcium carbonate scales or other structures is discussed in the LSI. Water is in equilibrium when LSI is zero and forms deposits when it is positive and dissolves when it is negative. At values above 1.5 or 1.7, scale formation will affect the water's chemistry and pipe flow. However, LSI values

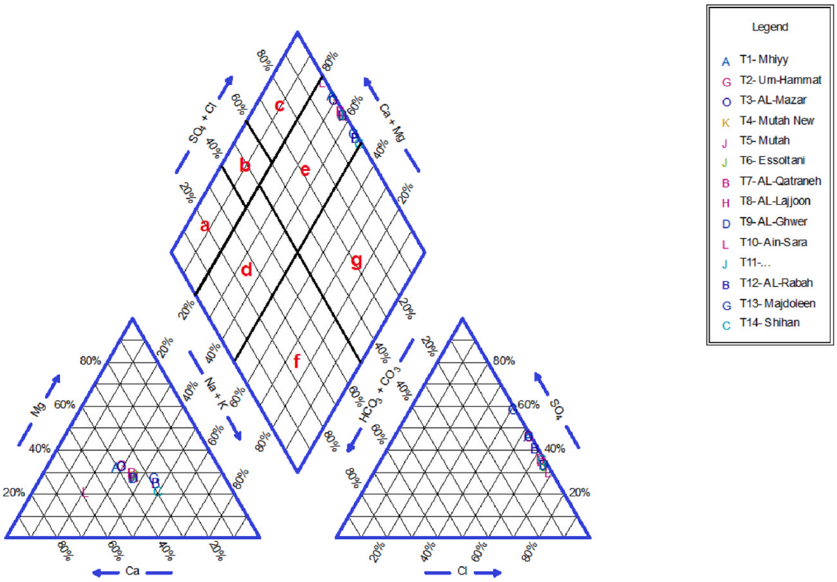

Fig. 3. Piper Trilinear diagram identifying the main hydrochemical facies in the study area's water samples.

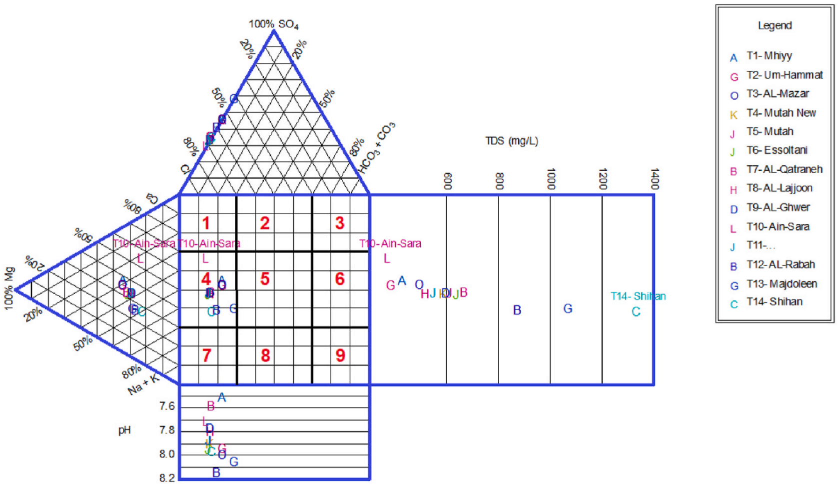

Fig. 4. Durov diagram showing the hydrochemical processes for the study area's water samples.

lower than −1.5 indicate aggressive water, which can harm and corrode pipes [56].

According to Ref. [19], the LSI was calculated in equation (1).

$$LSI = pH - pH_s \tag{1}$$

Where: pH is the actual pH value$pH_s = (9.3 + A + B) - (C + D)$

$$A = (Log_{10}\ [TDS] - 1)\ /\ 10$$

$$B = -13.12 * Log_{10}(^{\circ}C + 273) + 34.55$$

$$C = Log_{10}\left[Ca^{2+} + CaCO_3\right] - 0.4$$

$$D = Log_{10}[Alkalinity\ as\ CaCO_3]$$

Positive LSI values (Table 6) show that calcium carbonate is supersaturated in all of the tanks' water, which may lead to scale formation. On the other hand, T7, T10, T12, and T13 had LSI values in the range of 0–0.5 in October, showing mild Scaling without corrosion. It is notable that all tanks have water with LSI in the range of 0.5–2 during the three months (October, November, and December) indicating scale formation.

3.2.2. Ryznar Stability Index (RSI)

In order to precisely anticipate water's propensity for scaling or corrosion, RSI is commonly combined with LSI. According to Ref. [19], RSI was calculated in equation (2).

$$RSI = 2(pH_s) - pH \tag{2}$$

Heavy scale formation is indicated by RSI values below 5.5, some scale formation is possible between 5.5 and 6.2, neither scaling nor corrosion is present between 6.8 and 8.5, and highly corrosive water is present at RSI values above 8.4.

Table 6 demonstrates that all water tanks are resistant to scale and corrosion, with the exception of T10 and T11, whose water seems to be more corrosive in October and has RSIs of 6.9 and 6.82, respectively. No water tanks showed signs of scaling or corrosion in November, with the exception of T2, T3, T4, T5, T11, T13, and T14, whose water tends to produce some scale, where the RSI were 5.9, 6.09, 6.14, 6.11, 6.12, and 6.04, respectively. All water tanks in December show no signs of corrosion or scaling, with the exception of T3, T4, T5, T6, T11, T12, T13, and T14, which have a tendency for mild scaling and RSI values of 6.16, 6.12, 6.16, 6.07, 6.18, 5.92, 5.85, and 5.91, respectively.

3.2.3. Puckorius Scaling Index (PSI)

The buffering capacity of water is estimated using PSI. The PSI is a water index that identifies and quantifies the tendency of water to form scales (encrustation) on domestic and industrial systems based on the relationship between water's pH and alkalinity [57]. The description and numbering systems for the PSI and RSI are similar. PSI used the equilibrium pH rather than the actual pH and calculated according to Refs. [19,58] in equation (3).

$$PSI = 2pH_s - pH_{eq} \tag{3}$$

Where:$pH_{eq} = 1.465 + log(TA) + 4.54$

Table 6
The water Saturation Indices.

Month	Index	T1	T2	T3	T4	T5	T6	T7	T8	T9	T10	T11	T12	T13	T14
October-2022	LSI	0.50	0.80	0.63	0.83	0.63	0.63	0.27	0.59	0.54	0.45	0.66	0.46	0.45	0.51
	RSI	6.61	6.36	6.54	6.29	6.41	6.48	6.79	6.52	6.66	6.90	6.33	6.82	6.54	6.56
	AI	12.46	12.76	12.59	12.79	12.60	12.60	12.24	12.55	12.51	12.40	12.62	12.43	12.43	12.51
	PI	6.22	6.38	6.46	6.25	6.05	6.28	6.13	6.19	6.48	6.91	5.84	6.77	6.03	6.38
	WQI	71.7	69.1	32.4	35.4	35.6	22.3	17.8	37.9	40.1	46.7	22.4	50	32.5	50
November-2022	LSI	0.72	1.04	0.93	0.83	0.87	0.57	0.67	0.72	0.74	0.56	0.81	0.81	0.93	0.91
	RSI	6.20	5.90	6.09	6.14	6.11	6.36	6.25	6.35	6.21	6.55	6.11	6.54	6.12	6.04
	AI	12.69	13.00	12.90	12.80	12.84	12.55	12.65	12.68	12.72	12.51	12.78	12.78	12.92	12.92
	PI	5.85	5.93	6.09	5.94	5.89	5.89	5.84	6.11	5.96	6.45	5.71	6.98	6.14	6.02
	WQI	34.0	27.6	21.7	18.9	23.8	11.5	14.0	31.1	35.9	16.6	22.0	30.8	26.2	23.1
December -2022	LSI	0.53	0.86	0.91	0.88	0.85	0.94	0.65	0.73	0.78	0.53	0.84	1.10	1.10	1.03
	RSI	6.44	6.20	6.16	6.12	6.16	6.07	6.27	6.32	6.20	6.63	6.18	5.92	5.85	5.91
	AI	12.48	12.81	12.87	12.85	12.82	12.91	12.62	12.69	12.75	12.48	12.80	13.09	13.09	13.03
	PI	5.97	6.22	6.24	6.02	5.97	6.04	5.85	6.07	6.04	6.55	5.91	6.21	5.90	6.00
	WQI	34.0	34.2	28.3	25.5	30.4	18.2	20.6	37.7	42.5	23.2	28.7	37.4	32.8	29.8

$$[TA] = \left[HCO_3^-\right] + 2\left[CO_3^{-2}\right] + [\mathrm{OH}^-]$$

With the exception of T5, T7, T8, T11, and T13, whose water has a tendency to develop some scale with PSI values 6.05, 6.13, 6.19, 5.84, and 6.03, respectively, Table 6 data from October reveal that all water tanks are resistant to corrosion and scale. All tanks' water in November indicated a potential for some scaling, with the exception of T10, whose water has no tendency to scale or be corrosive with PSI value 6.45, and T12, whose water has a tendency to be corrosive with PSI value 6.98. In December, all water tanks revealed a possibility for modest scaling, with the exception of T2, T3, T10, and T12, whose water had neither a tendency to scale nor be corrosive with PSI values 6.22, 6.24, 6.55, and 6.77, respectively.

3.2.4. Aggressive Index (AI)

To examine the water in asbestos pipes, AI was developed. Due to its independence of temperature or dissolved solids, AI is simple to employ. The value of AI 10 is regarded as being quite aggressive, while $10 > AI > 12$ denotes a considerable inclination toward corrosion. If AI is greater than 12, water scales. The Aggressive Index (AI) was calculated according to Ref. [59] in equation (4).

$$AI = pH + log_{10}[(TA) * (H)] \tag{4}$$

Where:

TA: Total alkalinity in (mg/l as $CaCO_3$).

H: Calcium hardness (in mg/l $CaCO_3$).

The results from Table 6 illustrate that water in all tanks has the tendency to be scaling ($AI > 12$) throughout the three months.

3.2.5. Water quality index

WQI determines the water's quality and whether it is suitable for human consumption. The determination of water characteristics is the initial stage in determining WQI. The availability of the data and the importance of a water quality parameter to the environment were typically among the numerous factors that went into selecting the parameters [60]. The WQI was measured according to Ref. [61] in equation (5).

$$WQI = \frac{\sum(q_i/W_i)}{\sum W_i} \tag{5}$$

$$W_i = \frac{1}{S_i}$$

$$q_i = \frac{C_i}{S_i} \times 100$$

where q_i is the quality rating scaleC_i is the concentration of the i parameterS_i is the standard value of i parameterW_i is the relative weight of parameter i.

Due to their regular detection in drinking water, the 12th parameters of pH, EC, TDS, TH, turbidity, and concentrations of Na^+, K^+, Ca^{2+}, Mg^{2+}, Cl^-, NO_3^-, and SO_4^{2-} were chosen for this investigation. Regarding the 2015 JDWS, the weighted arithmetic approach was used to calculate the WQI. WQI 50 indicates very good water quality, and 50–100 indicates good water. When the WQI is between 100 and 200, the water quality is poor. WQI scores between 200 and 300 indicate extremely poor water quality. And water with a WQI of 300 or higher should not be consumed [53] (Ibrahim, 2019). Based on the findings in Tables 6 and it can be concluded that, with the exception of October T1 and T2 (50–100), where the water is good, all tanks had excellent water quality during the period of the three months.

The results of the LSI, RSI, AI, PI, and WQI indices clearly show a significant association, indicating that the water in the studied tanks is excellent and typically neither corrosive nor scaling. Finding of current research would be useful to the inhabitants, agriculturalists, industrialists, water distributors/managers and policymakers in the effective and sustainable planning and management of water resources in the study area.

4. Conclusions

This study evaluated the drinking water quality in Al-Karak province (central Jordan). Water samples were collected from storage mixing tanks at 14 locations throughout the main water network distribution system and subjected through a physio-chemical analysis. Three months are included in the studied timeframe. Almost all of the water samples examined using chemical and physical analysis were determined to meet established Jordanian drinking water standards. Based on a variety of water indices, including the Langelier Saturation Index (LSI), calcium carbonate, and RSI, the potential of calcium carbonate to precipitate and the corrosiveness of water body were investigated. Positive LSI values mean that scale formation is possible since the water in all tanks is supersaturated with calcium carbonate. According to LSI results, all water tanks are found to be resistant to corrosion. According to the calculated Aggressive index for pumping water in asbestos pipe, water in all tanks has a tendency to scale ($AI>12$) over period of the study. The performed in this study WQI indicated an excellent drinking water quality in all located pointed of water distribution system of the study area. Finally, the water quality assessment is essential to sustainable water management and the general welfare of society. The results of this study will be beneficial for the authorities in protecting public health, preserving ecosystems, supporting economic activities, ensuring safe drinking water, enforcing regulations, and promoting community engagement.

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Author contribution statement

Conceived and designed the experiments; Adnan Al-Harahsheh and Amjad Al-Tarawneh.

Performed the experiments; Adnan Al-Harahsheh, Amjad Al-Tarawneh, and Sadam Ramadeen.

Analyzed and interpreted the data; Adnan Al-Harahsheh, Amjad Al-Tarawneh, Alaa Al-Ma'abreh, and Tayel El-Hasan.

Contributed reagents, materials, analysis tools or data; Adnan Al-Harahsheh, Amjad Al-Tarawneh, Tayel El-Hasan, and Mutaz M. Al-Alawi.

Wrote the paper. Adnan Al-Harahsheh, Amjad Al-Tarawneh, Alaa Al-Ma'abreh, Sadam Ramadeen, Tayel El-Hasan, Mutaz M. Al-Alawi.

Data availability statement

The data that has been used is confidential.

Declaration of competing interest

The authors declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

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