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ORIGINAL PAPER

Qualitative spring water management in the central western catchment of the West Bank from hydrochemical and environmental isotopes approaches

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Abstract This study assesses spring water quality data connected to groundwater pollution indicators for building a qualitative groundwater management system in the central western catchment of the West Bank. It characterizes the major ion chemistry and trace elements for the mountainous spring water in terms of their suitability for irrigation and domestic purposes. The results increase community awareness about qualitative access to available and reliable water resources in central catchments. The cation–anion orders indicate calcium–hydrogen carbonate spring water type, useful for determining the parameters of risk. EC-TDS relations classified the water as fresh and within the allowable limits of the WHO guidelines. The fact that the majority of these springs are located within densely populated areas explains the higher counts of total and fecal coliforms. The environment of recharge is determined through the stable isotopic compositions of deuterium and oxygen—18 of a north–south profile analysis. The study shows that the isotopic composition, ranging from −5.06 to −5.89 ‰ for $\delta^{18}O$ and from −20.28 to −24.44 ‰ for δ^2H. The δ^2H–$\delta^{18}O$ relationship is used to define the local meteoric water line (LMWL), according to the equation: $\delta^2H = 4.7\ \delta^{18}O + 3.6$. The plotted isotopic content of the analyzed water samples on the Mediterranean meteoric water line signifies water recharge from recent precipitation.

Keywords Hydrochemistry · Environmental isotopes · Spring water · West Bank

Introduction

Groundwater is the main source of drinking water for over 80 % of the Palestinian population. In Palestine, sustainable qualitative groundwater resource evaluation and management are limited (Jebreen and Ghanem 2014). The increasing contamination of Palestinian aquifers is caused by the lack of adequate infrastructure to manage wastewater treatment. The main sources of pollution are domestic wastewater, hazardous chemicals from agriculture and industry, and uncontrolled and illegal dumping of solid wastes. The karstic nature of the Palestinian aquifers, with flow infiltrating the ground mainly through open fissures and cracks, leaves them especially vulnerable to pollution. Hotspots of groundwater contamination related to particular localities including Palestinian towns, Israeli settlements, and industrial zones have developed as a result of these pollution sources (SUSMAQ 2004). High quality drinking water has significant health and economic benefits (WHO 2006; Todd 2007). Thus, there is a need for groundwater quality surveys that will provide qualitative benefits for Palestinian society. Short-term seasonal variations in groundwater quality assessment can result from changes in quantity and quality of recharge and groundwater flow patterns (Stoessell 1995). The Central Western Catchment contains most of the important springs in the West Bank, which are the dominant water sources for domestic and agricultural purposes.

In the West Bank, a series of problems are evident, including point and nonpoint pollution sources affecting the

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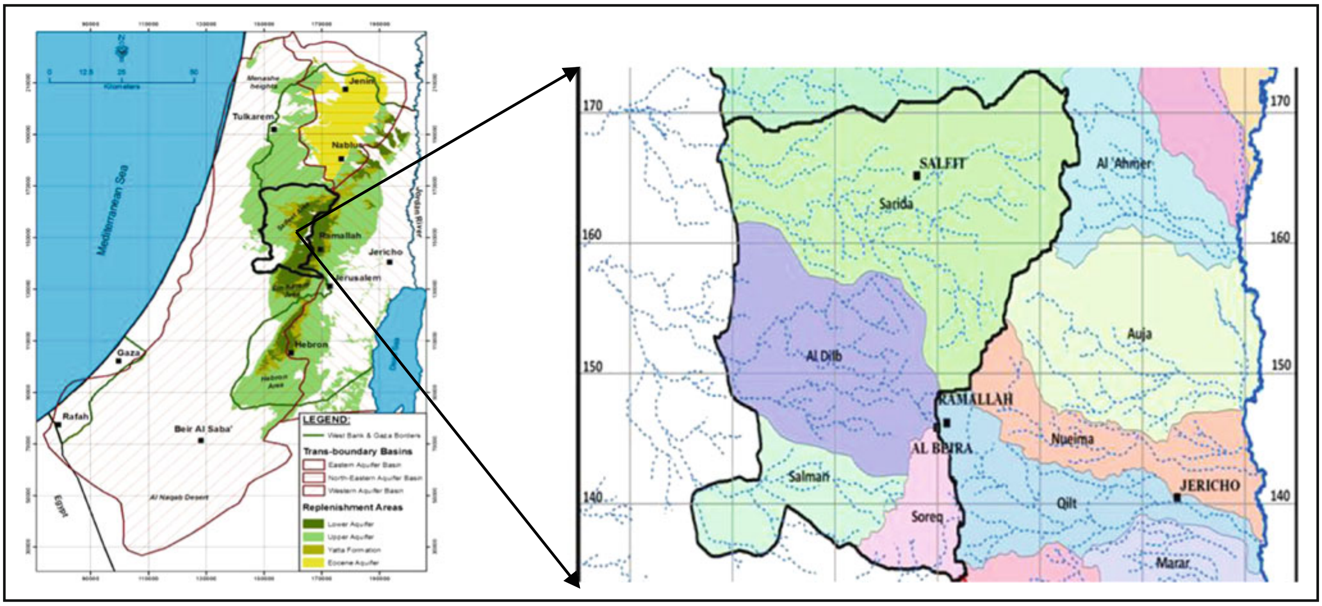


Fig. 1 Location map of the study area

vulnerable karstic areas of the mountainous aquifers. These pollution sources affect water quality in abstraction wells and groundwater discharges (Abdul-Jaber et al. 1999). In light of the increasing population and the high water demand that will follow, seasonal studies on groundwater quality, hydrochemical controls, and groundwater recharge are essential for water management (Zheng and Bennett 2002). Only a few recent groundwater investigations have been carried out in the central western catchment. Among these studies are Rofe and Raffety (1965), Applied Research Institute Jerusalem (Arij) (1995), Arad and Michaeli (1967), Avisar et al. (2003), Bakalowicz et al. (2008), Palestinian Water Authority (PWA) (2006), Wolfer (1998), Palestinian Hydrology Group (PHG) (2004) and SUSMAQ (2004). The present study integrates major ions, trace elements, and stable isotope data from the Central Western Catchment in order to (1) determine the effect of seasonal variation on spring water chemistry, (2) identify hydrochemical processes, (3) evaluate groundwater quality and its suitability for drinking, and (4) evaluate the spring environmental recharge process. The findings will contribute to the desired information for groundwater management in the area.

The study area

Location

The study area is located in Central Western Aquifer Basin, which is the most productive aquifer basin (Shalash and Ghanem 2008) yielding the highest quality water in the West Bank. The selected catchment area lies within 35° 00 and 35° 15 longitude and 31° 80 and 32° 10 latitude (Fig. 1). The catchment stretches from the West Bank mountaintops in the east, down to the western slopes to the Coastal Plain and to the Mediterranean Sea in the west (Abed and Wishahi 1999). The catchment is bounded by the Jerusalem district to the south, Nablus district to the north, and the Jericho district to the east. The Western Aquifer Basin covers a total area between 9000 and 14,167 km^2 (Abu Saada and Sauter 2013).

Table 1 Litho-stratigraphy column of the Western Aquifer Basin

Age	Formation			Lithology		Hydrostratigraphy	
Senonian	Abu Dees			Chalk, chert, marl		Aquitard	
Turonian	Daliya		Jerusalem	Chalky marl4	Limestone	Aquitard	Upper aquifer
Cenomanian	Undifferentiated	Talme Yafe	Bethlehem		Dolomite, Limestone, Marl, chalk		Aquitard
Albian			Hebron		Chalk, marl, limestone		Lower aquifer
			Yatta		Dolomite, limestone, marl		Aquitard
			Beit Kahel Qattana		Marl, clay		

Climate

The Western Aquifer Basin is characterized by a semiarid climate. The West Bank mountains cause orographic lifting, which results in precipitation from moisture-laden clouds drifting in from the Mediterranean Sea. Average annual precipitation comes to between 550 and 700 mm, with rain and snowfall occurring mainly between October and March. On the Coastal Plain, average annual precipitation ranges from around 600 mm in the north to 250 mm in the south, in contrast with the arid Sinai Peninsula, which receives no more than 50 mm. The Central Western Catchment (CWC) is characterized by a Mediterranean climate, with long, hot, dry summers and short, cool, rainy winters. In general, the distribution of rainfall in the area is heavily influenced by the topography, with higher rainfall in the hills and mountains. Rainfall also shows considerable inter-seasonal variation. The rainy days are estimated between 40 and 70 days per year. The monthly

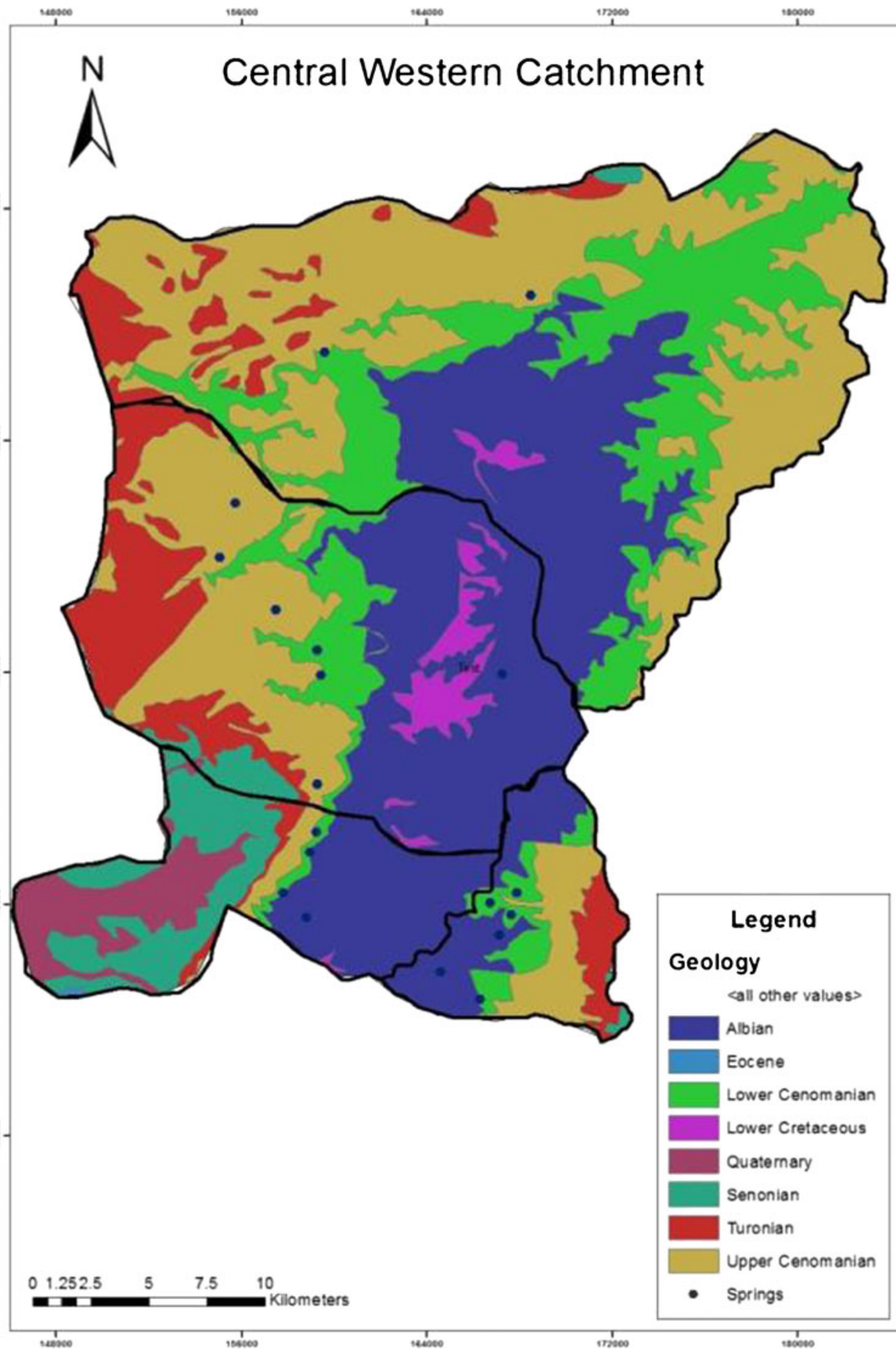


Fig. 2 The Geology map of the Central Western Catchment aquifer including the spring locations. The *arrow* shows the cross section of the aquifer system

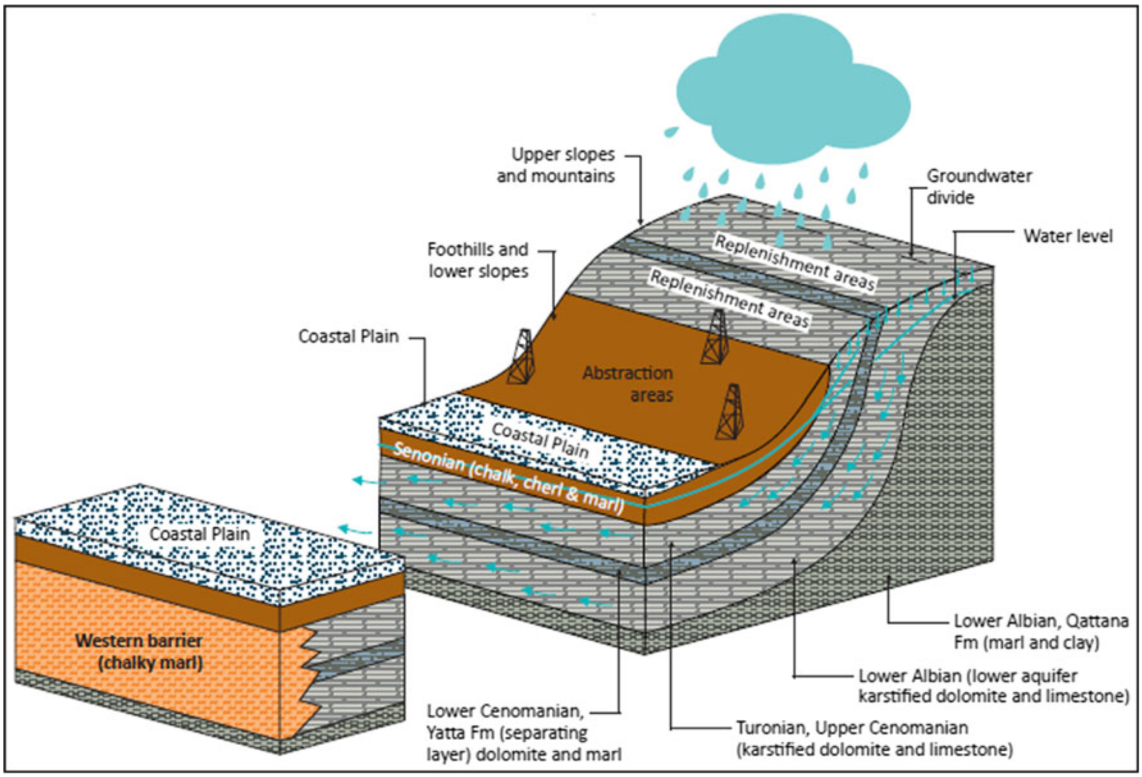


Fig. 3 The hydrogeological setting of the WAB aquifer (Abu Saada and Sauter 2013)

average temperature ranges from 7.5 to 10 °C in winter to 22 °C in the summer. The minimum temperature is −3 °C in January and the maximum is 40 °C in August (Ghanem 1999).

Geology

The geology of the Central Western Catchment consists mainly of a group of karstified limestone and dolomite of Late Albian to Turonian origin (Table 1 and Fig. 2). The lithology of the group's formations is comprised of limestone, dolomite, marl, chalk, chert, and alluvium. The exposed rocks of the Senonian Formation date from between the Eocene and Senonian ages; it consists of chalk as well as chert founding some places, which classifies it as an aquiclude. The Turonian Formation is also known as the Jerusalem Formation, formed from hard white creamy limestone. It is highly karstified and thus has high hydraulic conductivity. The upper Cenomanian Formation, known as the Bethlehem Formation, is formed from chalky limestone and chalk, which also forms an aquifer. The lower Cenomanian Formation is characterized by

Table 2 Physicochemical of spring water in Soreq catchment

Spring (Ein) Name	Dry season					Wet season				
	Date	pH	TDS (mg/L)	T (in °C)	EC (μS/cm)	Date	pH	TDS (mg/L)	T (in °C)	EC (μS/cm)
Ajab	01 November 2013	8	198	20.2	393	11 March 2014	7.8	274	21	552
Katana	01 November 2013	7.5	185	20.3	370	11 March 2014	7.1	510	22	1016
Biet Soreq	01 November 2013	7.6	561	19.7	1200	11 March 2014	7.3	690	21.4	1385
Al-Shami	01 November 2013	7.8	397	23.4	792	11 March 2014	7.6	340	19	680
Salman	01 November 2013	7.9	421	21.4	844	11 March 2014	7.8	435	20.3	870
Jefna	02 November 2013	7.7	236	22.9	469	11 March 2014	8	236	20	472
Al-Balad	02 November 2013	8	430	15.6	912	11 March 2014	7.8	763	19.1	1530
Qebleya	02 November 2013	7.9	379	19.5	759	11 March 2014	8	372	20	734
Abu Zaher	02 November 2013	8.2	224	19.8	446	11 March 2014	8.4	210	20.2	421
Aziz	02 November 2013	7.5	415	20	832	11 March 2014	7.5	310	20	623

Table 3 The anion and cation of the spring water in Soreq catchment in dry periods in milligrams per liter

Spring name	Date	Na^+	K^+	Mg^{2+}	Ca^{2+}	Cl^-	SO_4^{2-}	HCO_3^-	NO_3^-
Ajab	01 November 2013	15.62	0.34	20.17	79.06	31.91	18	244.08	18
Katana	01 November 2013	48.68	3.75	47.08	123.34	184.34	52	488.16	31
Beit Soreq	01 November 2013	44.58	23.48	57.48	145.61	95.72	98	366.12	44
Al-Shami	01 November 2013	46.67	0.98	41.75	112.16	127.62	88	305.1	36
Salman	01 November 2013	36.77	1.8	44.13	106.01	81.54	39	488.16	39
Jefna	02 November 2013	13.18	0.4	19.91	76.2	39	22	366.12	26
Al-Balad	02 November 2013	49.84	17.71	52.45	115.22	219.79	110	427.14	33
Qebleya	02 November 2013	34.33	30.01	34.45	81.07	120.53	32	366.12	48
Abu Zaher	02 November 2013	15.91	2.07	18.73	58.77	46.09	36	183.06	16
Aziz	02 November 2013	28.64	0.96	15.17	145.47	106.35	84	305.1	49

sequences of hard rocks of limestone and dolomite. This formation can function as a good aquifer with a good permeability because of the conduits and karstic systems. The Yatta Formation is formed from marl layers with some layers of limestone in between, which makes it a good aquiclude. The Albian Formation consists of layers of limestone with marl layers in between. The presence of marl and chalk in this formation also makes it an aquiclude.

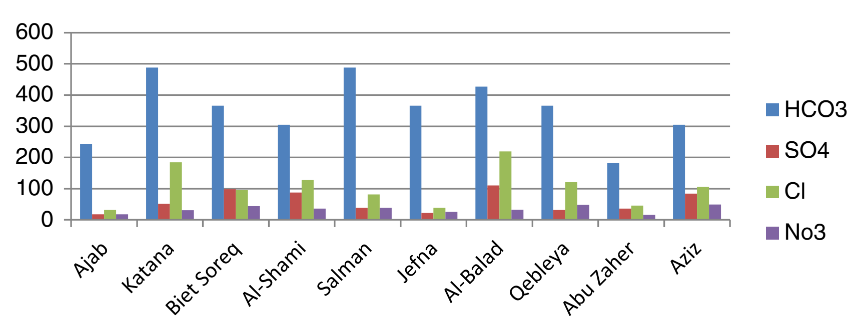
Hydrogeology

The CWC is recharged mainly from precipitation falling on the mountains of West Bank, as well as from direct infiltration along the karstified outcrops in the mountainous and sloped areas in the eastern part of the aquifer system (Fig. 3). The springs are the natural outlets of the aquifer in the study area. Around 73 % of recharge of the western basin takes place in the mountainous areas. This is concentrated especially in the northern part of the basin, due to the karstified nature of the limestone and dolomite outcroppings there. A wide range of values for annual recharge have been reported, from as low as 318 MCM to as high as 430 MCM (SUSMAQ 2004), depending on precipitation and other meteorological factors. Other smaller sources of recharge to the aquifer system include network losses, agricultural and wastewater return flows, and infiltration from Wadis.

Methodology

The samples used in this study were collected from springs directly as they discharged under natural pressure, in a 1-L high-density polyethylene bottles. They were stabilized with ultrapure nitric acid (0.5 % HNO_3) after filtration, preserved in a cool place (about 4 °C). Temperature, pH, electrical conductivity, and total dissolved solids were measured onsite, using Hanna Field Multimode Meter. The meter was calibrated before and during the field campaign using buffer solutions recommended by the manufacturer. Major anions (NO_3^-, SO_4^{2-}, and Cl^-) were analyzed using HP liquid chromatography. Concentrations of the major cations (Ca^{2+}, Mg^{2+}, Na^+, and K^+) were determined by ICP-MS. HCO_3^- analysis was measured onsite by titration. Trace elements were analyzed by ICP/MS, and each sample was prepared by dilution of 1.0 mL of the water samples to 10.0 mL with 0.3 % ultrapure nitric acid after filtration. Each sample was analyzed three times, and the results are expressed as mean ± standard deviation (SD). Relative standard deviation (RSD) of the three results has been calculated and found to be less than 5 % for all samples for all metals analyzed in this study, reflecting the precision of the method for the analysis of these trace elements (Malassa 2014). All chemical analyses were carried out at the Environmental Research Lab at Al-Quds University—Abu Dis. For total coliform and fecal coliform tests, samples were

Fig. 4 The cation concentrations of water samples of the study area in milligrams per liter



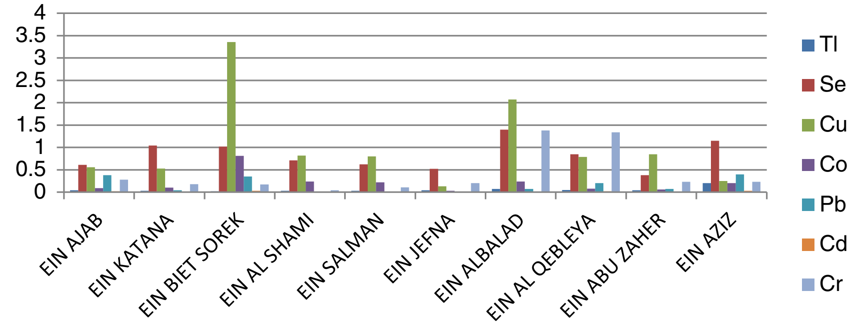


Fig. 5 The concentration of trace elements in spring–dry period in milligrams per liter

collected in sterile 100-ml glass bottles, then cooled in an ice box, and transferred to the laboratory on the same day for biological tests. The spring water samples were analyzed at the laboratory of Birzeit University in Ramallah. A 12-spring water samples were taken from three catchments, Soreq, Natuf, and Sarida catchments, and their isotopic ^{18}O as well as of the deuterium ^{2}H was analyzed at the isotopic labs of Freiburg University in Germany. The isotopic ratio D/H and 18O/16O in water samples was expressed as per mille deviation (%) relative to Vienna-Standard Mean Ocean Water (V-SMOW) (Gat 1996; Gat 2010; Clark and Fritz 1997).

Results and discussions

Hydrochemistry

The results of the physicochemical analysis of spring water samples are represented in Table 1. The results of cations and anions are represented in Tables 2 and 3. The spring water quality has been assessed through the analysis of physiochemical parameters (pH, EC, T, TDS) and major cations (Ca^{2+}, K^{+}, Na^{+}, Mg^{2+}), major anions (Cl^{-}, SO_4^{-}, HCO_3^{-}, NO_3^{-}), and trace elements (Zn, Mn, Pb, Cd, Fe, B, As, Be, Se, Ba, Ti , Cr, Al, V, Co, Cu, Ni, Sr, Bi, Mo, Ag, Li).

The spring water in the study area is generally of low alkalinity with (pH) average ranging between 7.8 for dry period and 7.7 for the wet period. The maximum TDS value in March was 763 recorded in Ein Al-Balad and the minimum TDS value at that time was 210 ppm, recorded in Ein Abu Zaher. The maximum TDS value in November was 561 ppm, recorded in November in Ein Beit Soreq, and the minimum at that time was 185 ppm recorded in Ein Katana. EC and TDS averages in the wet period are higher than in the dry period due to dilution process. Taking into consideration TDS values for both periods, the spring water in the area has been classified as fresh water. The relationship between EC and TDS in the spring water of the study area is strong and lead to the equation: $TDS = 0.5\ EC + 0.65$. The concentration of Ca^{2+} is higher than the other major cations, and HCO_3^{-} concentration is higher than the other major anions in both seasons (Fig. 4).

EC values are higher in the Ein Beit Soreq as a result of fertilizer uses in the recharge areas, in addition to agricultural and human activities. Concentrations of cations and anions in the wet period were greater than in the dry period due to the dilution process except hydrogen carbonate (HCO_3^{-}) which is lower in the wet period due to the recharge process, where the carbonate is associated with water converted to HCO_3^{-} (Tables 2 and 3). The NO_3^{-} has a mean of 32 mg/L for the samples; nitrate concentration in dry period is greater due to

Table 4 The anion and cation of the spring water in Soreq catchment in wet periods in milligrams per liter

Spring name	Date	Na^{+}	K^{+}	Mg^{2+}	Ca^{2+}	Cl^{-}	SO_4^{2-}	HCO_3^{-}	NO_3^{-}
Ajab	11 March 2014	12.4	0.29	19.8	82	88.63	18	251.95	8.85
Katana	11 March 2014	43.6	5.5	48.1	132.6	106.35	78	430.15	20.87
Biet Soreq	11 March 2014	57.9	51.8	59.3	148.1	230.43	112	497.75	39.51
Al-Shami	11 March 2014	43.9	1.0	34.1	84.4	106.35	90	288.82	24.02
Salman	11 March 2014	41.1	2.2	42.5	127.2	88.63	56	359.48	23.18
Jefna	11 March 2014	11.6	0.3	18.3	79.5	88.63	35	245.8	2.52
Al-Balad	11 March 2014	48.8	52.02	54.4	131	301.33	102	337.98	22.05
Qebleya	11 March 2014	33.4	27.7	35.4	91.5	88.63	32	285.74	17.16
Abu Zaher	11 March 2014	15.8	1.8	19.6	59.2	88.63	40	187.42	3.95
Aziz	11 March 2014	20.09	0.7	14.2	131.1	88.63	76	251.95	12.08

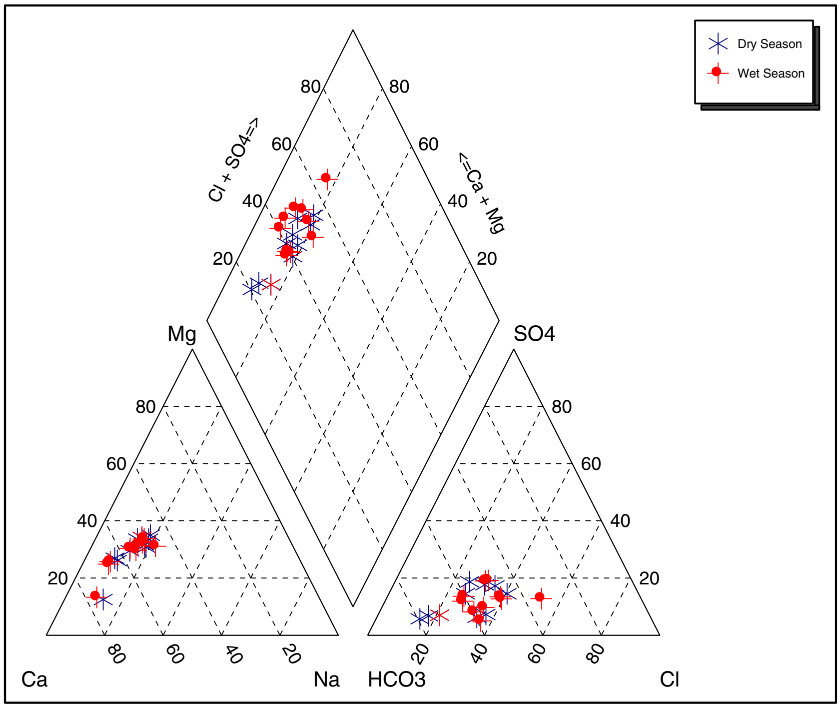


Fig. 6 The piper diagram of the spring water in the Soreq catchment

agricultural activities and sewage effect, especially in springs located in the effect of the populated areas.

The analysis of trace elements in the groundwater of the study area confirms that spring water contains higher values of Co, Ni, Cd, Pb, As, Zn, Cr, V, Mn, B, Se, Al, Ti, and Ba (Fig. 5 and Table 4) than the permissible limits according to World Health Organization (WHO) (2007) and Palestinian Water Authority (PWA) (2001) standards as a result of the use of fertilizers and human activities.

The hydrochemical formula shows that most springs of study area have a water type of Ca-Mg-HCO_3, while the other springs have a Ca -HCO_3 for the two periods. The spatial distribution of water quality in the study area for both dry and wet periods shows difference in water quality between

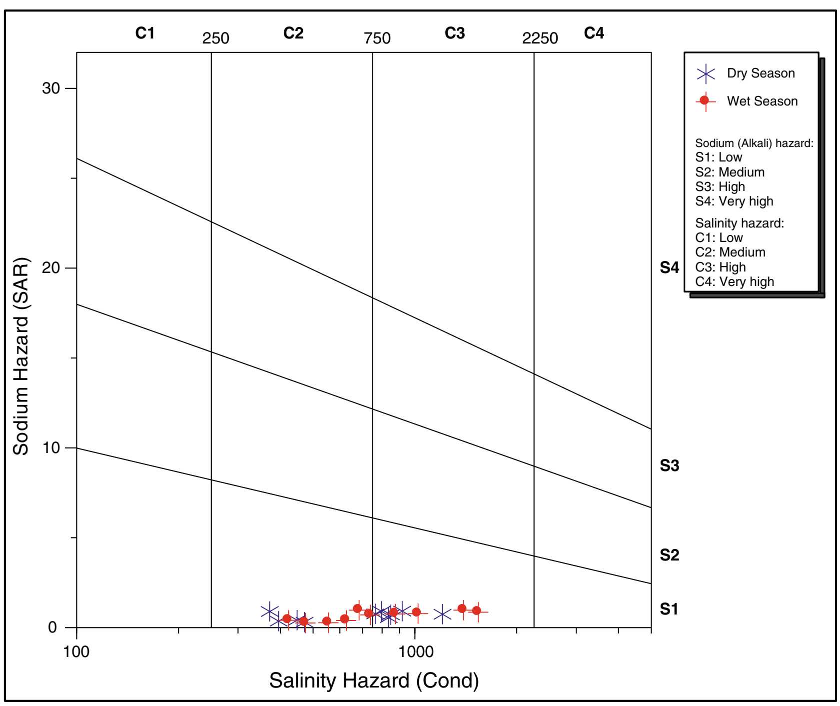


Fig. 7 The relationship between SAR and EC characterizing the irrigation quality of spring water

Table 5 Trace elements (ppm) of the springs water in Soreq catchment

Spring name	Zn	Cd	Mn	Pb	B	As	Fe	Co	Ni	Cu	Se	Ba	Tl	Al	Cr	V
Ajab	2.8	0.02	0.01	0.38	30.4	0.2	31.3	0.09	0.33	0.56	0.61	11.57	0.04	4.19	0.28	1.88
Katana	3.2	0.01	1.26	0.04	35.9	0.3	1.8	0.1	0.82	0.53	1.04	30.07	0.03	4.17	0.18	2.54
Biet Soreq	3.2	0.03	0.65	0.35	133.8	2.1	16.5	0.81	5.87	3.36	1.02	63.77	0.02	21.57	0.17	6.69
Al-Shami	1.3	0	0.16	0	50.3	0.4	0.7	0.24	1.35	0.82	0.71	29.26	0.03	3.11	0.04	2.5
Salman	0	0.01	0	0	53.9	0.6	1.1	0.22	1.95	0.8	0.62	23.22	0.03	1.08	0.11	2.97
Jefna	0	0	0	0	29.2	0.3	0	0.03	0.13	0.13	0.52	12.58	0.04	0.06	0.2	2.69
Al-Balad	12.2	0.01	0.5	0.07	159.2	11.2	11.5	0.24	1.09	2.07	1.4	30.4	0.07	17.01	1.38	31.49
Qebleya	7.3	0.02	1.69	0.2	93.7	7.9	28.4	0.08	0.57	0.79	0.85	17.7	0.05	23.09	1.34	29.59
Abu Zaher	0.6	0	0.47	0.07	36.7	2.8	5.5	0.06	0.54	0.85	0.38	8.02	0.04	12.15	0.23	10.6
Aziz	22.7	0.03	15.79	0.4	35.5	0.3	101.9	0.2	1.03	0.25	1.15	22.87	0.2	18.23	0.23	0.79

both periods as a result of recharge and dilution processes in the wet period. Piper classification showed that the type of spring water in the study area for both periods is located between the areas of normal earth alkaline water with prevailing hydrogen carbonate and chloride for the two periods (Fig. 6).

Water quality parameters

The spring water samples are plotted in the Wilcox (1955) diagram, which represents SAR against the conductivity in microsiemens per centimeter and shows most samples falling within the field of S1, C2 (Fig. 7). This means that they are in the zones of medium salinity to low SAR, which is good for agriculture. The other springs fall within the field of S1, C3, which means that they are in the zones of high salinity to low SAR, which is permissible for agriculture. According to EC and Na% values for the spring water, the springs are good for irrigation in the two periods.

Microbiological analysis

Water is an excellent medium for microorganisms. Groundwater and surface water may contain bacteria, viruses, fungus, and algae, which make water objectionable for domestic purposes and threatening to health (WHO 2007). The results obtained from microbiological analysis show that Ein Al-Balad, Ein Ajab, Ein Biet Soreq, and Ein Salman contain uncountable colonies of FC and TC. This reveals contamination from wastewater from sewerage system near Ein Al-Balad and cesspits near Ein Ajab, Ein Biet Soreq, and Ein Salman. Ein Katana, Ein Abu Zaher, and Ein Al-Shami springs show uncountable TC, attributed to herds of livestock such as sheep and manure piles near the spring outlet. This is especially true for Ein Katana spring, which is located near cow farms. This study concludes that all the springs are contaminated with coliform bacteria and therefore not suitable for drinking unless they are treated first. Boiling, sun disinfection, and chlorination of the water are all possible treatment techniques.

Stable isotopes

The isotopic composition ^{2}H and ^{18}O of spring water are listed in (Table 5). The highest and lowest deuterium values were found in the Soreq catchment, ranging

Fig. 8 The relationship of δ^{18}O and δD in the spring water samples in comparison with LMWL

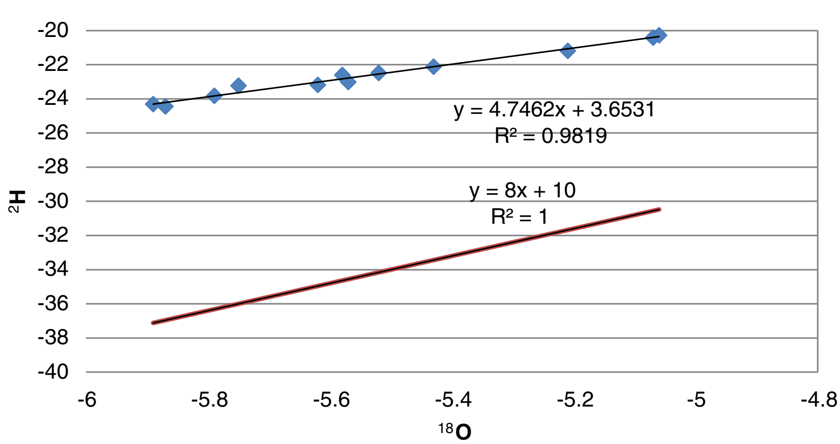


Table 6 Environmental isotopes data of selected, springs for the study area

Name	Date	Location	$\delta^{18}O$	$\delta^{2}H$	Catchment
EinAjab	29 November 2013	Beit Anan	−5.06	−20.28	Soreq
EinKatanah	29 November 2013	Katanah	−5.07	−20.42	Soreq
Ein Salman	29 November 2013	Beit Duqqo	−5.87	−24.44	Soreq
EinJariot	29 November 2013	Batounia	−5.75	−23.23	Natuf
EinArik–Alfuqa	29 November 2013	Ein Arik	−5.57	−23.02	Natuf
EinArik–Altehta	29 November 2013	Ein Arik	−5.62	−23.18	Natuf
Ein Al-Zarqa–Aboud	29 November 2013	Aboud	−5.58	−22.6	Natuf
Ein Al-Zarqa–Beitillu	29 November 2013	Beitillu	−5.89	−24.31	Natuf
Ein Qinia	29 November 2013	Ein Qinia	−5.21	−21.2	Natuf
Ein Bobbin	29 November 2013	Deir Ibzi	−5.79	−23.83	Natuf
Ein Al-Fawwar	29 November 2013	Kafr ad-Dik	−5.43	−22.12	Sarida
Ein Al-Matwi	29 November 2013	Salfit	−5.52	−22.49	Sarida

between −24.44 and −20.28 ‰ with a mean of −21.71 ‰, whereas the mean for all catchment spring is −22.59 ‰. Delta ^{18}O values in the study are varied between −5.87 and −5.06 ‰ in the Soreq catchment with a mean of −5.3 ‰. The Natuf catchment has a range of −5.89 to −5.21 ‰ with a mean of −5.63 ‰. The Sarida catchment has a range of −5.52 to −5.43 ‰ with a mean of −5.47 ‰. The mean is −5.53 ‰ for all spring water with small variation in Deuterium. The stable isotopes are good tracers for determining the recharge of spring water in hilly areas. The sample of Natuf and Sarida catchment shows high $\delta^{2}H$ and $\delta^{18}O$ compared with the Soerq catchment, due to the combined effect of rainwater and accompanying flood flows (Table 5). This reflects all spring's recharge comes from rainfall directly.

Delta ^{2}H with ^{18}O could be used to identify water bodies that are affected by rapid evaporation. A linear relationship is found, after plotting $\delta^{2}H$ as a function of ^{18}O for the water in continental precipitation (Mayo, Muller and Ralston 1985): $\delta^{2}H = 8\delta^{18}O + 10$ ‰ (meteoric water line MWL) where d is constant and the results are given in terms of permils deviation form SMOW (δ ‰) (Craig 1961). Deviation from the MWL is caused by precipitation that occurred during warmer and colder climates than at present or by subsurface changes. The equation for the whole catchment area was found to be: $\delta^{2}H = 4.7\ \delta^{18}O + 3.6$ ‰. The slope between $\delta^{2}H$ and $\delta^{18}O$ is 4.7, which is directly related to the winter runoff (Craig 1961). These values lie on the local meteoric water line (Fig. 8). Deviation from the MWL (Craig 1961) is well-known and documented for this area (Gat and Carmi 1970; Gat and Dansgaard 1972). Measured $\delta^{2}H$ values of the entire catchment plot parallel to, but higher than, the MWT. The most depleted isotope content was found in springs, such as Ein Al-Zarqa, which has ^{18}O of −5.89 ‰ and ^{2}H of −24.31 ‰.

Conclusion

The seasonal variation in spring water chemistry, hydrochemical controls, drinking quality, and recharge in the central western catchment were investigated using physico-chemical and stable isotope data from two surveys in the dry and rainy seasons (Table 6). There is a negligible seasonal effect on spring water chemistry and order of ionic abundance. The results of hydrochemical formula show that most springs in the study area have water type of Ca-Mg-HCO_3^- and Ca-HCO_3^- for the two periods. The spring water is considered fresh and suitable for human consumption based on TDS and major ion concentrations. This was the first study on the stable isotope composition in the Central Western Catchment in Palestine. The relationship between $\delta^{2}H$ and $\delta^{18}O$ contents in spring water samples was used to define the local meteoric water line (LMWL), according to the equation: $\delta^{2}H = 4.74\ \delta^{18}O + 3.65$. The isotopic content of the analyzed water samples plots on to the Mediterranean meteoric water line, signifying recharge from recent precipitation.

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