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Quality Assessment of Underground Water Resources in the Northeast of Sabzevar

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ABSTRACT

Introduction. In semi- arid and arid countries in which groundwaters are the main supplier of water, monitoring of water quality is of vital significance. To better manage water resources, therefore, investigation of water quality utilized for drinking, agricultural and industrial purposes sounds compulsory.

The purpose of article. The aim of this study was to investigation the factors in fluencing the evolutionary process of groundwater resources and hydrogeochemical characteristics of groundwater resources in the northeast of Sabzevar.

The research methods. Given the geological formation, water yield and condition of the region's water resources, a total of 10 underground water resources were surveyed in respect of quality. In this regard, physical parameters e.g. PH, Electric Conductivity (EC) and Total Dissolved Solids (TDS) were measured in the sampled solution by multimeter. The hydrochemical analysis of data was implemented in laboratory and by inductive Plasma method and by statistical analysis and the modeling process were conducted by the SPSS, Chemistry and AqQA suites.

The results of research. According to Scholler diagram, that most of water samples are categorized in good and acceptable class. According to the drawn Wilcox diagram, the samples are in C_2S_2, C_2S_4, C_3S_2 and C_3S_4 classes. Most samples agriculturally unsuitable with high salinity. According to the water quality index (GQI)), the water resources of the study area are in poor to acceptable category. Spatial study showed that the catchment area of water resources located in volcanic rocks, conglomerates and gravels, due to the lower impact of these rocks on water salinity, has caused the outflow of water of appropriate quality from these areas. In the western part of the region, due to the presence of marl and evaporation -detrital deposits, the value of this index is low and water is of poor quality. In other parts of the region, the water quality index (GQI), increases and water has a better quality.

The type of geological formation around the basin is one of the important factors in the evolution of water resources. Chemical weathering of different rocks with natural waters produces different cations and anions. The water-rock reaction and weathering of minerals, is the main factor in changing the quality of groundwater chemistry in the region. Chemical analysis of water entering the aquifer of region showed that the sources of ions entering the region were affected by the lithology of rocks and sediments that were exposed to weathering for a long time, hence, as the region water, due to the passage of the detrital evaporation formation of the third period and marl, have dissolved them and increased the ratio of $Cl+SO_4>HCO_3$. The results showed that the presence of rocks and minerals of carbonate such as limestone, dolomite and calcite, sandstone and silicate such as volcanic rocks in the water passage has caused the scenarios of $Ca>CO_3$ and $Ca + Mg>CO_3$.

Conclusions. Results revealed that drinking water resources are decent in most of the sites, exclusive of the resources that place in detrital-evaporate deposits. Meanwhile, the water is hypersaline and indecent for agricultural purpose. To the east, however, salinity plummets and is decent for agricultural purpose. The concentration of bicarbonate as the most abundant onion in the entire resources is higher than the global health standard and dissolution of carbonate rocks like limestones and dolomites play a role in this manner. The concentration of nitrate in the entire resources is lower than the global standard. Their concentration in the area is owing to agricultural activities and circulated water. Water resources emplaced in volcanics, conglomerate and gravels are of less concentration in respect of salts content and quality of water is higher. The young detrital-evaporate deposits in the west have augmented the concentration of ions as per the Ground Quality Index (GQI) and zonation maps, and where upon, water quality in this portion is poor.

Keywords*: Sabzevar, Northeast of Iran, Geological formation, Water quality, Binalood zone.*

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Introduction

In semi-arid and arid countries in which groundwaters are the main supplier of water, monitoring of water quality is of vital significance (Sener et al., 2017; Kawo and Karuppannan, 2018, Khanoranga and Khalid, 2018). Burgeoning population globally, on the other hand, has given rise to a greater demand for water for household, agricultural and industrial sectors, leading to over-exploitation of water resources (Heydari et al., 2012).

To better manage water resources, therefore, investigation of water quality utilised for drinking, agricultural and industrial purposes sounds compulsory. One of the major resources are springs and qanats which outline differing discharge rates given geological formations and precipitation (Javadi et al., 2019). The water resources are formed through the discharge of aquifer into impervious layers in a ridge-and-ravine topography, emerging in permeable sediments like gravels, sandstones and conglomerates which overlie the impermeable sedimentary formations. The severe reduction in rainfall have rendered not only the quality, but also the quantity of water vulnerable by anthropogenic activities. Nowadays, groundwater in rural areas have been known as the main and reliable source of potable water supply, whilst some problems in quality have tarnished the reliability reputation of the sources. Variation in water quality could be owing to interaction between rocks and water, evaporation and fluctuations in concentration considering the amount of precipitation and presence of anthropogenic controls like agricultural activities and industrial effluent.

Groundwater reacts chemically with a variety of solid phases e.g. sediments and aquifer's bedrock en route from recharge to discharge zone. Such reactions are invariable as per the chemical character of water, geological formations and settlement duration of water (Sarkar et al., 2007).

Monitoring of chemical composition of water could help forefend imminent dangers jeopardising human's health and maintain societies' hygiene. Numerous workers have engaged international criteria like those by the WHO, base diagrams like that of Scholler's (Scholler, 1955) and a wide assortment of quality indices as tools to categorise potable water (Ketata-Rpkbani et al., 2011, Jerome and Piuse, 2010; Kishore and Hanumantharao, 2010) in their collected works.

Extensive studies have, by far, been undertaken on this issue in domestic and international scales, from which we can refer to those fundamental ones that have perceptibly assisted us to learn about this trend. The most outstanding of the studies are: Investigation of evaporite precipitations (Hardie, 1968), Convulsion of brines in enclosed basins (Hardie and Eugster, 1970), Sedimentologic and geochemical properties and hydrogeochemical provenance of brines (Spenser et al., 1990), Upheaval of important groundwaters at playas (Rosen, 1994; Erfanian Kaseb et al., 2020), Heydrogeochemical investigations of water in Dasht-e-Jajarm (Javanbakht et al., 2020), Ardak region in Mashhad (Fazel valipour et al., 2021), Siahoo Basin in Bandar Abbas (Gholamdokht Bandari et al., 2018), Karstic springs in Ajabshir (Saraei Tabrizi et al., 2021).

To project qualitative variation in water resources, other phenomena in the target area shall be statistically investigated (Rabah et al., 2011). Besides the cited matters, the quality of water resources in a region hinges upon the existing ions which their number is commonly reduced by lithology and their own evolutionary cycle (Jones and Decampo, 2014).

The early chemical properties of waters being delivered to enclosed basins is affected by the lithology and the sediments being weathered and by the duration over which groundwaters remain inside the rocks of basin (Hardie and Eugster, 1970; Jones and Decampo, 2014). Familiarity with enclosed basins is indispensable in assimilating the chemistry of waters. Surface and underground waters supply the ions that precipitate as salts at basin. Acidic waters would cause chemical weathering of surface rocks of the watershed. The chemical weathering of variant rocks by natural waters would generate a vaudeville of anions and cations (Erfanian Kaseb et al., 2020).

Given the fact that water of the aquifer in Sabzevar's north is used for drinking, agricultural and industrial purposes, the environmental characteristics of water and the effect of lithology on water quality have been taken into account on this study.

Geology of the study area

The studied groundwaters are located in a mountainous area of equitable to semi-arid climate, coordinating 58°- 58° 30ˈ E and 36° 30ˈ -37°N in the NE of Sabzevar township in Khorasan-e-Razavi Province. The Sabzevar-Quchan trunk road is amongst the most important means of transportation in this region. The annual precipitation amounts to 276mm. The highest elevation is 2529m and the lowest 1150m above sea level. Winters are fairly cold and summers are equitable to warm (Fig. 1).

Structurally speaking, it is a portion of the Binalood Zone, and lithologically, however, the geological formations are variegated. Most of the exposed rocks are the Cenozoic volcanics of Miocene age which are predominantly of pyroclastic lava variety. Within them lie volcanic rocks of Plio-Quaternary age as domes and dykes. Deposits of shallow marine facies also exist that transform into continental sediments which are of the Cenozoic age and belong with E_2 and E_3 series. The series consist of shale, sandstone, conglomerate, limestone, dolomite, marly shale and chalk. The youngest sediments are detrital evaporites that have formed adjacent to the Kaalshur River. The limestone outcrops of Lower Cretaceous of Mesozoic Era are witnessed as dislocated huge boulders in the NE of the area. Such formations have, somehow, cropped out overlying the Plio- Quaternary pyroclastic sediments and also underlying them unconformably which is an indicator to post Plio- Quaternary tectonism (Fig. 2).

Methodology

Some 10 samples were grabbed from the springs, wells and qanats so as to investigate the groundwater quality in 2020 (Fig. 2). Over the sam-

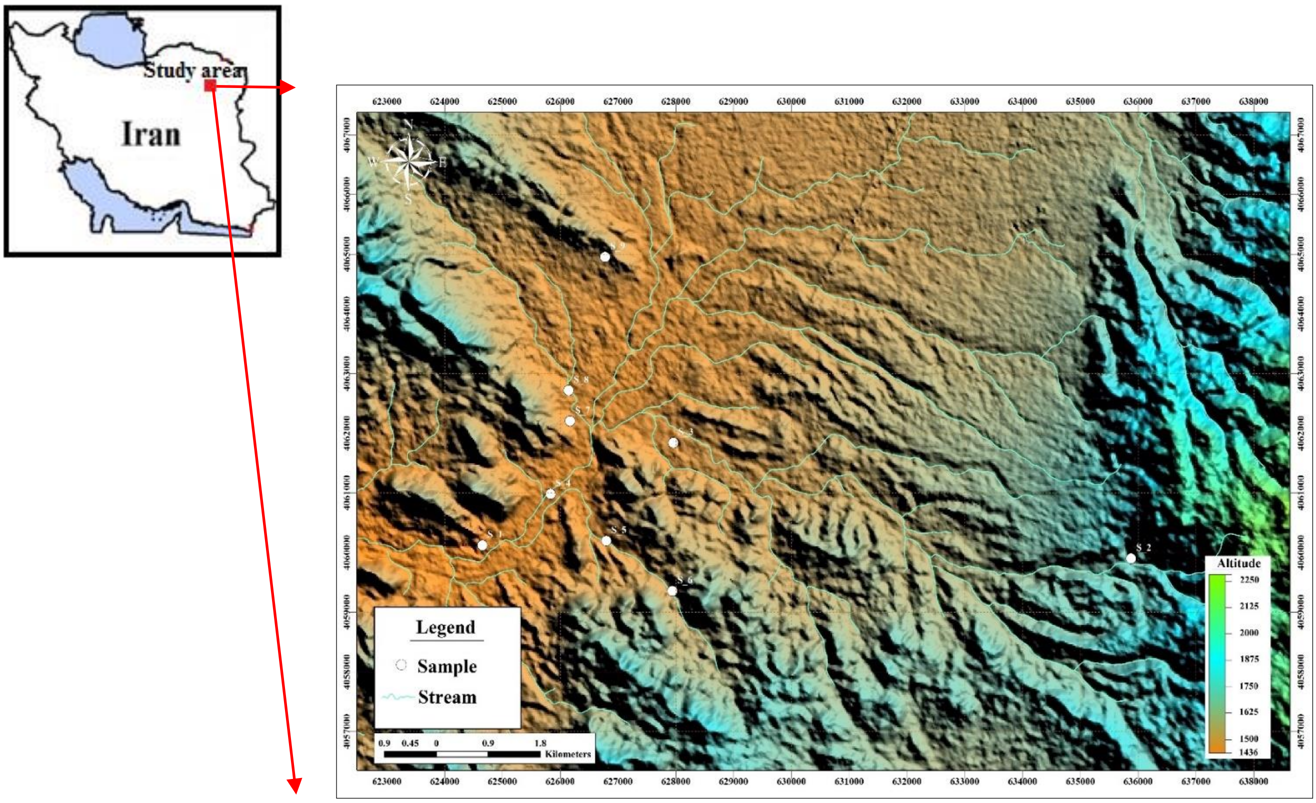


Fig. 1. The location of study area

pling process, the sampling bottles were thoroughly washed and one sample was grabbed from each site. Physical parameters like PH, EC and TDS were measured by an Extech multimetre at the sampling site. To forefend any settlement of heavy metals, the pH value of samples was reduced to 2 by adding thick HNO_3. The samples were then transferred to the chemical laboratory of Mashad Azad University at a temperature of 4°C where the hardness and alkalinity of water samples were measured by means of the Titration technique using the EDTA (di amine tetra acetic acid). The samples were subsequently transferred to the IMPRC to undertake the inductive Plasma Analysis. The statistical analyses were conducted on the Chemistry, SPSS22 and AqQA suites. To study the quality of potable water, Scholler's diagram and for agricultural purposes, the Wilcox's were engaged. The qualitative classification was, ultimately, implemented utilising the GQI and effective parameters were analysed. The index entails weighing and combining of 10 qualitative parameters for potable water i.e. Cl, Na, Ca, Hardness, Acidity, Bicarbonate, Sulphate, Nitrate, Mg and the TDS. This approach encompasses the spatial variation of measurings, and multi-stage conversions of groundwater quality data as ranking of groundwater quality index by means of generating concentration maps for each parameter of point data and through the interpolation method. The data are subsequently calculated utilising the normalised difference index as follows:

$$C=(X` - X)/(X`+X) \qquad (1)$$

Where the X" is the calculated concentration in each cell on the primary map and X is its optimum standard (WHO). The calculation procedure is conducted through the measuring of the contamination index (the ratio between the measured concentration of contaminant and maximum acceptable amount of contaminant) ranging from 1 through -1 for each cell and, ultimately, through the conversion of contamination index to a ranking map ranging between 1-10 (rank 1 connotes the least and 10 the highest level of groundwater effect).

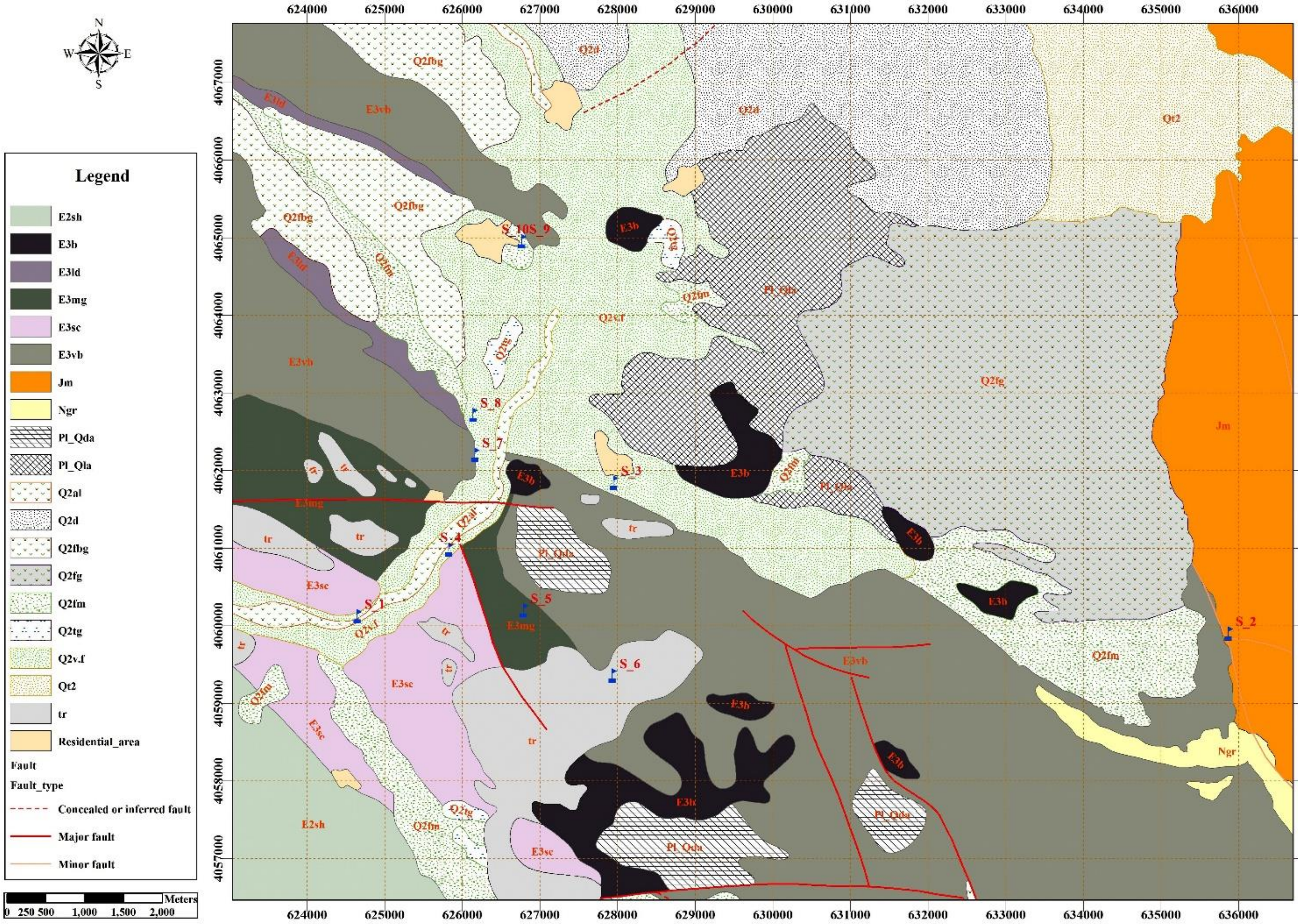
To rank the concentration of cited elements from 1-10, the formula below is applied (Babiker et al., 2007)

$$r=0.5\,C^2+4.5\,C+5 \qquad (2)$$

Where C represents the concentration index for each cell and r shows the related rank. The GQI is obtained by formula 03:

$$GQI = 100 – (r_1w_1+r_2w_2+\ldots+r_nw_n/\ N) \qquad (3)$$

Where r is the value/ amount of ranking map of range 1-10, W is the relative weight of the parameters and N is the total number of utilised parameters on the analyses (Alexander et al., 2017). Table-01 demonstrates the categories of potable water quality as per the represented quality index (Babiker et al., 2007).



GEO_UNIT	First_DESCRIPTION
E2sh	Dark gray to violet shale with sandstone at the base
E3b	Dark gray olivin trachybasalt, pyroxen basalt. andesitic basalt as lava flows or dikes
E3ld	Light gray cherty limestone and dolomite
E3mg	Light green gypsiferous silty, marly shale with intercalations of gypsum, sandstone, tuffite and limestone
E3sc	Red alternations of sandstone and shale with conglomerate and tuff intercalations
E3vb	Dark greenish to reddish gray vesiculated spilitic basalti
Jm	Dolomite, limestone, partly dolomitized, cream, gray
Ngr	Marl, sandy marl, sandstone and conglomerate, consoidate, partly gypsiferous, light red_orange
Pl_Qda	Light gray dacitic andesite, quartz trachyandesite as domes and thick lava
Pl_Qla	Light gray lahar, volcanic conglomerate with acidic pyroclastics
Q2al	Recent alluvium
Q2d	Silt and sand with lenses of gravel forms alluvial plane (dasht)
Q2fbg	Cabble_bulder gravel, unconsolidated and uplifted, forms highest (oldest) level fans
Q2fg	Gravel unconsolidated and uplifted, forms intermediated level fans
Q2fm	Mud, silt and sand, forms lowest(youngest)level fans
Q2tg	Gravel unconsolidated and uplifted, forms intermediated terraces
Q2v.f	Silty clay, silt and sand, with gravel packets forms filled valley
Qt2	Terraces and young gravel fans
Residential_area	
tr	Gray quartz trachyandesitic to trachyandesitic dikes

Fig. 2. Geological map and selected groundwater resources in the region

Results and discussion

Given the physio-chemical and geological conditions governing the groundwaters, numerous variables play role in the quality of groundwater, all of which may not usually be analysed (Lucassen, 2004; Kumar and Dua, 2009). Juxtaposing the anions and cations in the samples, the most frequent ones were distinguished and compared with the world standards (Table 2). The dominant onion in the whole samples were bicarbonate, whilst the least abundant was nitrate ion. The dominant cations were Na in most of the samples and the least was K.

Table 1

The classification of drinking water quality based on quality index (Babiker et al., 2007)

GQI	Quality
91-100	Suitable
71-90	Acceptable
51-70	Medium
26-50	Poor
0-25	Low

Table 2

The analysis and physical parameters of groundwater resources in the region (mg/L)

Station	X	Y	TDS (mg/L)	PH	EC	Alkal	TH	Na	Ca	Mg	K	HCO_3	SO_4	Cl	NO_3
S1	58 25 42	36 40 43	1083	8.09	1602	80	16	113	59.7	21.4	2.17	235	115	81	30
S2	58 31 14	36 40 30	321	7.66	482	90	270	51	49.7	16.4	2.59	175	70	33	30
S3	58 25 56	36 41 37	666	7.83	953	96	233	36	47.9	12.3	1.76	165	62	21	19
S4	58 24 30	36 41 10	191	8.07	273	350	469	1376	254	141.5	36.16	400	790	1950	31
S5	58 25 08	36 40 44	994	8.21	1150	72	410	184	59.6	30.1	3.84	330	180	168	25
S6	58 25 54	36 40 16	470	8.31	679	54	310	118	48.3	20.7	1.72	240	182	62	28
S7	58 24 44	36 41 50	298	7.70	479	70	116	108	14.6	6.4	2.72	170	60	44	25
S8	58 24 43	36 42 06	342	7.75	480	320	410	1218	203.7	123.1	7.43	380	1070	1400	41
S9	58 25 10	36 43 19	750	7.77	548	96	233	114	20.8	7.3	1.89	190	78	30	26
S10	58 24 57	46 43 23	306	7.5	448	92	300	200	18.2	7.4	2.33	195	76	36	25
WHO			500	7-8.5			150	200	75	50	12	150	250	250	50

Table 3

The classification of water quality for agricultural

SAR	Water quality for agriculture	Water class	Station
17.75	High salinity-inapproperiate	C3S4	S1
8.87	Low salinity-approperiate	C2S2	S2
6.56	Salinity-acceptable	C3S2	S3
97.85	High salinity-inapproperiate	C2S4	S4
27.47	High salinity-inapproperiate	C3S4	S5
20.09	High salinity-inapproperiate	C2S4	S6
33.33	High salinity-inapproperiate	C2S4	S7
95.28	High salinity-inapproperiate	C2S4	S8
30.41	High salinity-inapproperiate	C2S4	S9
32.70	**High salinity-inapproperiate**	**C2S4**	**S10**

Quality of water resources. To assess the present quality of gr resources used to supply potable water, the Scholler's diagram (Scholler, 1955) was adopted. This is a semi-logarithm illustrating the concentration of major ions in mg/L. The diagram also categories Na, Cl, sulphate, TDS and hardness as per chemical parameters as good, acceptable, average, inappropriate, totally unpleasant and indecent for drinking (Asgharimoghadam et al., 2015). Hence, given the qualitative samplings as per Figure. 3, it can be concluded that the quality of water in the area ranks good to acceptable, exclusive of samples 4 and8 whose quality is totally unpleasant owing to being extracted from evaporate-detrital facies adjacent to the Kaal River.

The Wilcox diagram was applied to assess the quality of water used in agricultural purposes (Wilcox, 1995). It studies the classification of water usage as per the EC or Electric conductivity and the SAR or Sodium Adsorption and can be applied to categorise the water rate at the study area up to 16 differing ranks. The finest quality is C1S1 and the worst is C4S4 whose application is in agricultural and irrigation (Asadzadeh et al., 2017). Table. 3 illustrates the classification of water used in agriculture. Assessing the results obtained from the local resources connotes average to high salinity and alkalinity. This could be construed as presence of evaporite formations. Because of the remarkable difference in Na concentra-tions in a number of samples, they are absent on the Wilcox diagram. Hence, 10% of the samples fall into C2S2, 60% into C2S4, 10% into C2S2 and 20% into C2S4 class. Consequently, the entire samples are pondered inappropriate for agricultural except for and S2 and S3 (Fig. 4).

The achieved analyses and depiction of zonation maps (Fig. 5) revealed that the concentration of Ca, Mg, Na, sulphate, Cl and TDS indicate a decreased concentration of these ions everywhere in the area exclusive of the western portion, and water quality is good. Presence of dolomite and limestone formations, of young detrital-evaporite deposits whose presence has given rise to the concentration of TDS, of marly shales and density of joints and fissures whose presence has boosted dissolution and vulnerability of formations in the western portion all would help augment ions' concentration and deteriorate the quality of water as a result. Propagation of volcanic rocks like basalt, andesite and dacite, and trachy-andesite dykes in the area's south and south-east, a conglomerate formations in the south-west and presence of gravel within the deposits of the northern portion have all lessened the concentration of ions, boosting water quality.

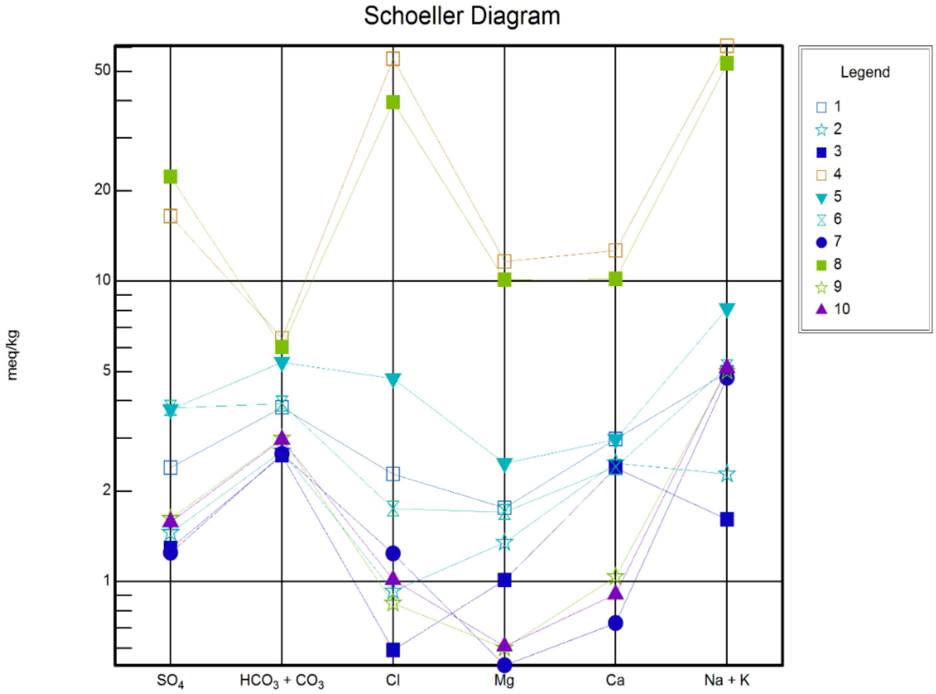


Fig. 3. The analysis of the exploitation situation based on Schoeller diagram

The quality of the study area's resources ranks poor to acceptable as per the GQI (Table 1). Spatially investigating, it was revealed that the watershed of water resources which has been hosted by volcanic and conglomerate rocks and by coarse-grained gravels has helped release of water of good quality all owing to the insignificant influence of these formations on the salinity of water. The GQI is low in the west, however, owing to the presence of limestone, dolomite, marl and detrital-evaporite deposits and, consequently, water quality is poor and the index is low. Notwithstanding, the GQI shows rise in the rest of the area and the water has a better quality (Fig. 6).

Effect of lithology on water resources. Combination of water resources with the rocks in the periphery of the basin hinges upon their reaction with water and water characteristics s and (Decampo, 2014).

The rock type of geological formations surrounding the basin is one of the significant factors in the quality of water resources. Chemical weathering of different rocks due to reaction with inflowing waters would generate variable onions and cations which disturbs the primary $HCO_3/Ca+Mg$ in solution (Fig. 7).

Geological data (Fig. 2) revealed that the quality of water resources corresponds with the lithology which consists silicates, carbonates and sulphates. Hydrogeochemical studies demonstrate that bicarbonates, as onions, are dominant and exceed the global standard in the entire samples. Dissolution of limestones and dolomites play an elemental role in the abundance of bicarbonate ion in water. Dissolution within the gypsum beds and young detrital-evaporite deposits in the west of Abdullah-e-Giv Village has released the sulphate onion into water. Given the fact that the origin of Cl onion in ground-

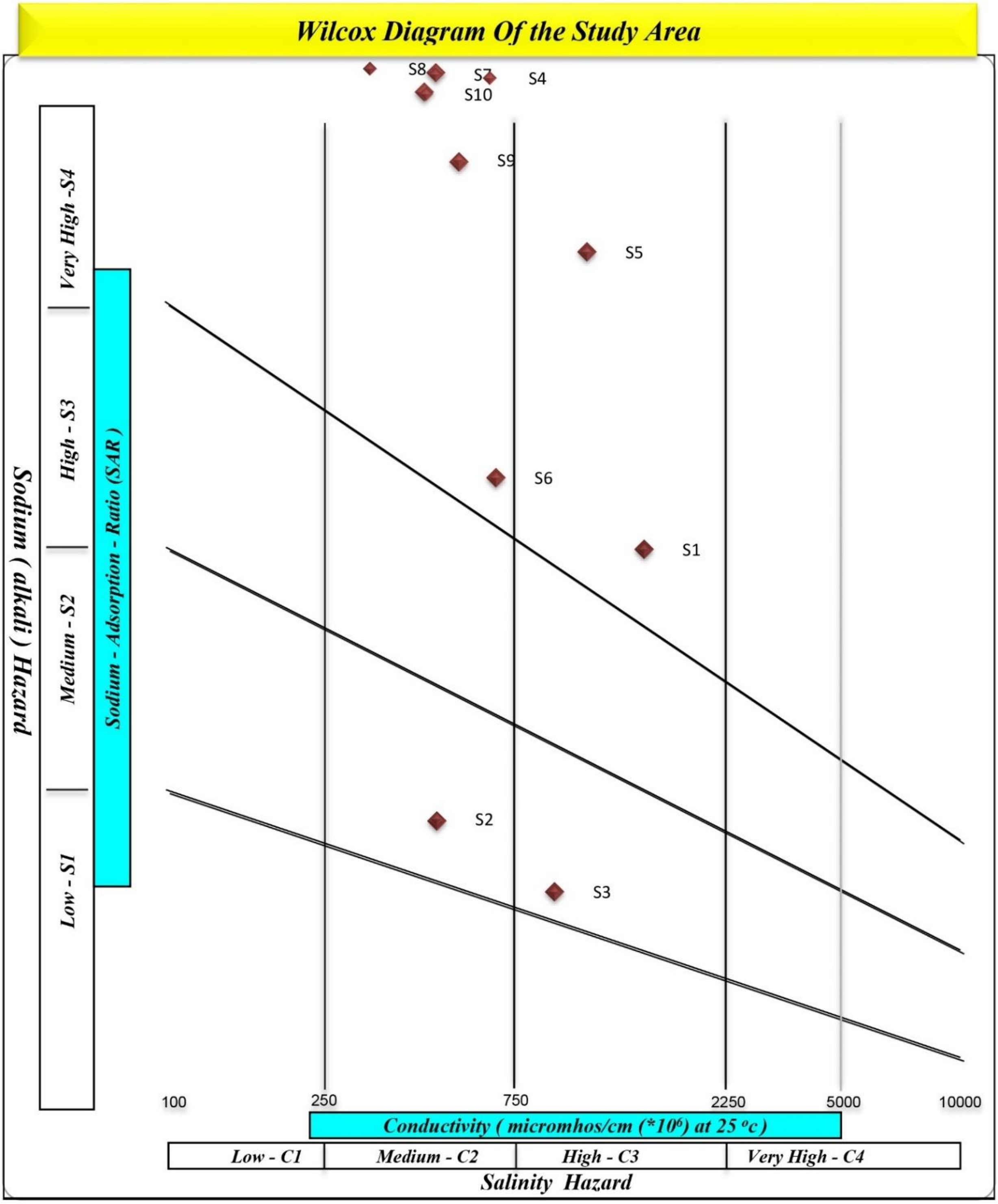


Fig. 4. The analysis of the exploitation situation based on Wilcox

water resources is atmosphere and it's concentration is highly diluted with the lost water, hence, the assessment of its concentration is pivotal. The Cl in waters has resulted from the dissolution of evaporite deposits and weathering of shale formations (Anonymous, 2010). Nitrate is known as one of the most significant anions of water and its presence maybe as a result of leaching/ washing by streams, breakdown of organic material and anthropogenic activities e.g. municipal effluent and usage of chemical and natural fertilisers. The minimum and maximum concentration of nitrate is 19 and 41 mg/L, respecti-

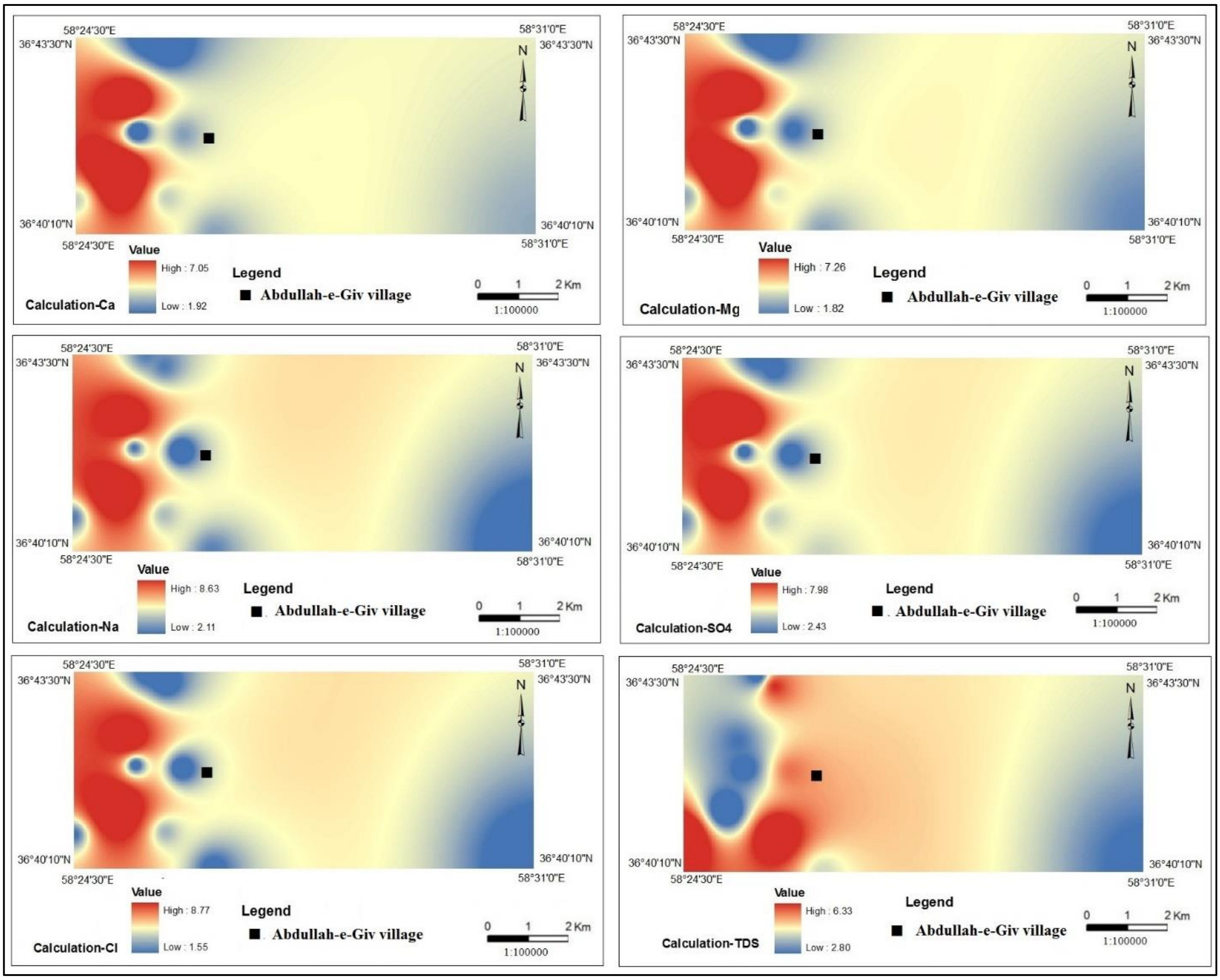


Fig. 5. The distribution of ion concentrations and TDS of groundwater sources in region

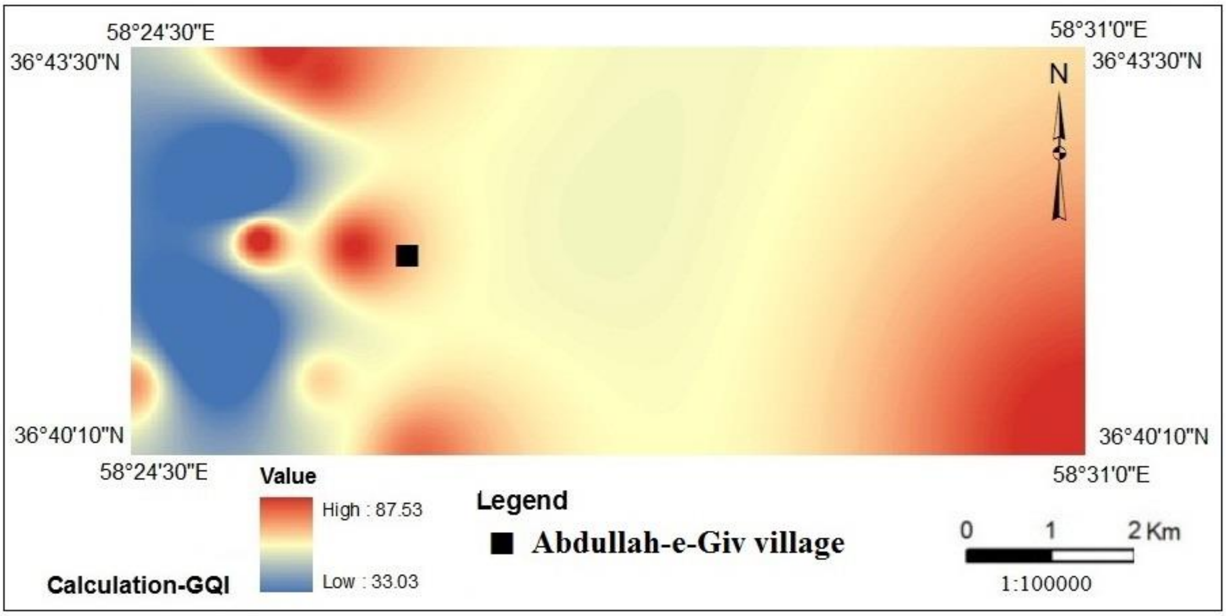


Fig. 6. Zoning map of GQI of groundwater in region

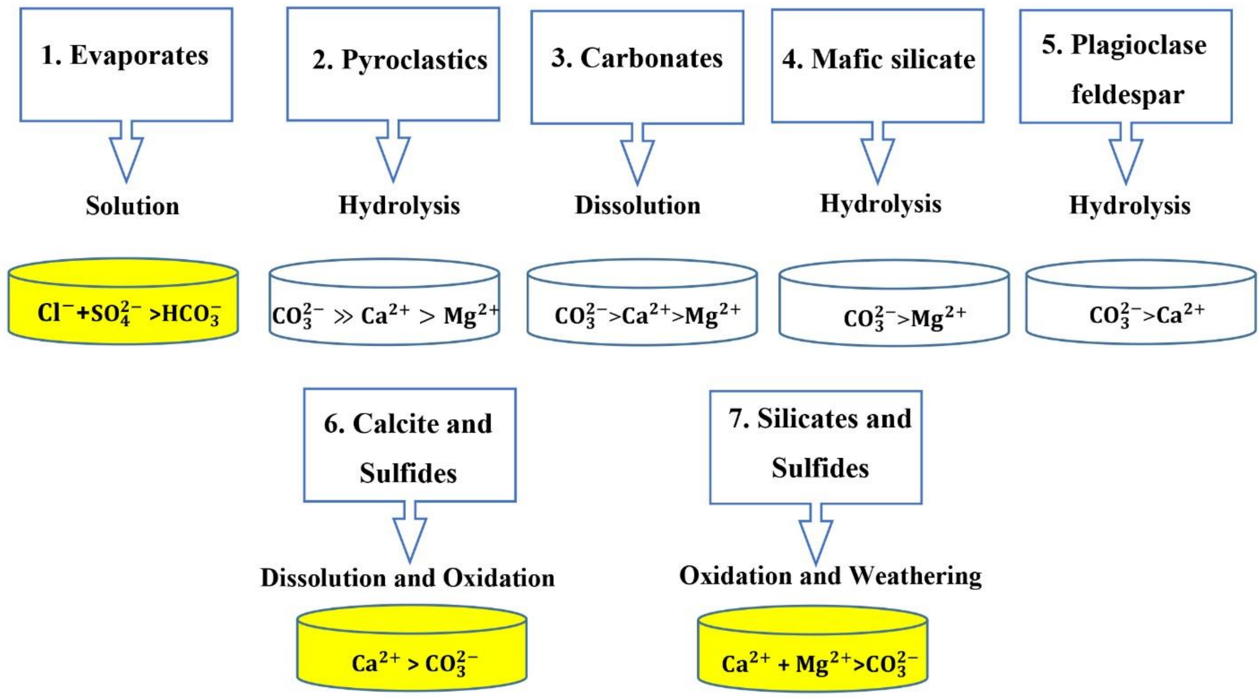


Fig. 7. The relationship between the origin and composition (Jones and Decampo, 2014)

vely. Given the fact that the concentration of nitrate ion is below the global standard in the entire samples, however, the major reason behind the rise in nitrate concentration in water resources lying in the downstream of farmlands and homesteads could be leaching of nitrate. In other sense, the aquifer is fed by the nitrate-bearing waters circulated from the agricultural use.

Na shows the highest concentration amongst the cations in water resources. Apart from halite (NaCl), the main origins of Na are seawater, rainfall, hydrothermal springs, brines, Na-bearing silicates (albite), nepheline and rare Na-bearing minerals such as sodium carbonate Al – (Khashmon et al. 2017). The shale formations in the area may convert clay minerals to each another, releasing variety of ions like Na. Furthermore, presence of Na-bearing silicates (albite) in volcanic rocks has played a role in releasing Na. The most perceptible origins for Ca and Mg cations in groundwaters, are limestones and dolomites, Ca-bearing silicates as well as groundwater of great salinity (TDS> 500 mg/lit) through which these ions have entered the water resources. The water is in close contact with limestones of high Ca content and low SiO_2 (Cohen, 2003; White and Drake, 1993). Their pH is commonly alkaline (Duarte et al., 2020). The waters that are in contact with dolomite are analogous to calcerous waters, whilst their content of Ca and Mg is the same in molar values. Release of Ca from Ca-bearing silicates in basalts and also dissolution of non-carbonate formations like gypsum beds have played a role in the liberation of Ca.

Conclusion

Groundwaters are one of the most important resources of water. The quality of groundwater resources in Abdullah-e-Giv area in the SW of Guchan township was studied. Given the lithology and water abstraction statues, a total of 10 groundwater resources of decent position were opted and assessed. Results revealed that drinking water resources are decent in most of the sites, exclusive of the resources that place in detrital-evaporite deposits. Meanwhile, the water is hypersaline and indecent for agricultural purpose. To the east, however, salinity plummets and is decent for agricultural purpose.

The dissolution of calcerous and dolomite factors has played the most pivotal role in the release of Ca and Mg cations in water, with Na as the most abundant cation in the water originated from shaly formations.

The concentration of bicarbonate as the most abundant onion in the entire resources is higher than the global health standard and dissolution of carbonate rocks like limestones and dolomites play a role in this manner. The dissolution of interbedded gypsum is influential in the release of sulphate ion, and dissolution of young evaporite and detrital deposits, and shale formations have had a role in the release of Cl. Water resources emplaced in volcanics, conglomerates and gravels are of less concentration in respect of salts content and quality of water is higher.

The concentration of nitrate in the entire resources is lower than the global standard. Their concentration in the area is owing to agricultural activities and circulated water.

The young detrital-evaporite deposits in the west have augmented the concentration of ions as per the GQI and zonation maps, and whereupon, water quality in this portion is poor.

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Оценка качества подземных водных ресурсов на северо-востоке Сабзевара

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Введение. В полузасушливых и засушливых странах, в которых подземные воды являются основным поставщиком воды, мониторинг качества воды имеет жизненно важное значение. Таким образом, для лучшего управления водными ресурсами исследование качества воды, используемой для питьевых, сельскохозяйственных и промышленных целей, является обязательным.

Цель статьи. Целью данного исследования было изучение факторов, влияющих на процесс эволюции ресурсов подземных вод и гидрогеохимические характеристики ресурсов подземных вод на северо-востоке Сабзевара.

Методы исследования. С учетом геологического строения, водоотдачи и состояния водных ресурсов области, было обследовано на предмет качества 10 видов запасов подземных вод. В связи с этим физические параметры, например, Ph, электропроводность (EC) и общее количество растворенных твердых веществ (TDS) измеряли в отобранном растворе с помощью мультиметра. Гидрохимический анализ данных осуществлялся в лабораторных условиях методом индукционной плазмы и методом статистического анализа, а также моделирования в пакетах SPSS, Chemistry и AqQA.

Результаты исследования. Согласно диаграмме Шоллера, большинство проб воды относятся к хорошему и приемлемому классу. Согласно нарисованной диаграмме Уилкокса, образцы относятся к классам C2S2, C2S4, C3S2 и C3S4. Большинство образцов агрономически непригодны из-за высокого засоления. По индексу качества воды (ИКВ) водные ресурсы исследуемой территории находятся в категории от плохого до приемлемого. Пространственное исследование показало, что водосбор водных ресурсов, расположенных в вулканических породах, конгломератах и галечниках, в силу меньшего влияния этих пород на минерализацию воды, обусловил отток воды соответствующего качества с этих территорий. В западной части области из-за наличия мергелевых и эвапорито-обломочных отложений значение этого показателя низкое, а вода плохого качества. В других частях региона индекс качества воды (ИКВ) увеличивается, и вода имеет лучшее качество.

Тип геологической формации вокруг бассейна является одним из важных факторов эволюции водных ресурсов. Химическое выветривание различных горных пород природными водами приводит к образованию различных катионов и анионов. Реакция вода-порода и выветривание минералов являются основным фактором изменения качества химического состава подземных вод в регионе. Химический анализ воды, поступающей в водоносный горизонт района, показал, что на источники поступления ионов в регион повлияла литология горных пород и отложений, которые длительное время подвергались выветриванию. Следовательно, воды региона при прохождения обломочных эвапоритовых образований третичного периода и мергелей, растворили их и повысили соотношение $Cl+SO_4>HCO_3$. Результаты показали, что наличие горных пород и карбонатных минералов, таких как известняк, доломит и кальцит, песчаник и силикаты, вулканических пород, в водотоке вызвало сценарии $Ca>CO_3$ и $Ca + Mg>CO_3$.

Выводы. Результаты показали, что ресурсы питьевой воды на большинстве участков приличные, за исключением ресурсов, находящихся в обломочно-эвапоритовых отложениях. Поэтому вода очень соленая и непригодна для сельскохозяйственных нужд. Однако к востоку соленость резко падает и подходит для сельскохозяйственных целей. Концентрация бикарбоната, как наиболее распространенного компонента, во всех ресурсах выше, чем глобальный санитарный стандарт, и растворение карбонатных пород, таких как известняки и доломиты, играет роль в этом. Концентрация нитратов во всех ресурсах ниже мирового стандарта. Их концентрация в районе связана с сельскохозяйственной деятельностью и оборотным водоснабжением. Водные ресурсы, заложенные в вулканитах, конгломератах и гравиях, имеют меньшую концентрацию по содержанию солей и более высокое качество воды. Молодые детритно-эвапоритовые отложения на западе имеют повышенную концентрацию ионов по индексу качества грунта (GQI) и картам районирования, при этом качество воды в этой части оставляет желать лучшего.

Ключевые слова: *Сабзевар, северо-восток Ирана, геологическое образование, качество воды, Биналудская зона.*

Оцінка якості підземних водних ресурсів на північному сході Сабзевару

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Вступ. У напівзасушливих та посушливих країнах, в яких підземні води є основним постачальником води, моніторинг якості води має життєво важливе значення. Таким чином, для кращого управління водними ресурсами дослідження якості води, що використовується для питних, сільськогосподарських та промислових цілей, є обов'язковим.

Мета статті. Метою даного дослідження було вивчення факторів, що впливають на процес еволюції ресурсів підземних вод та гідрогеохімічні характеристики ресурсів підземних вод на північному сході Сабзе-вара.

Методи дослідження. З урахуванням геологічної будови, водовіддачі та стану водних ресурсів області, було обстежено щодо якості 10 видів запасів підземних вод. У зв'язку з цим фізичні параметри, наприклад, Ph, електропровідність (EC) і загальна кількість розчинених твердих речовин (TDS) вимірювали у відібраному розчині за допомогою мультиметра. Гідрохімічний аналіз даних здійснювався в лабораторних умовах методом індукційної плазми та методом статистичного аналізу, а також моделювання у пакетах SPSS, Chemistry та AqQA.

Результати дослідження. Згідно з діаграмою Шолера, більшість проб води відносяться до хорошого та прийнятного класу. Згідно з намальованою діаграмою Вілкокса, зразки відносяться до класів C2S2, C2S4, C3S2 та C3S4. Більшість зразків агрономічно непридатні через високе засолення. За індексом якості води (ІКВ) водні ресурси досліджуваної території перебувають у категорії від поганого до прийнятного. Просторове дослідження показало, що водозбір водних ресурсів, розташованих у вулканічних породах, конгломератах і галечниках, через менший вплив цих порід на мінералізацію води, зумовив відтік води відповідної якості з цих територій. У західній частині області через наявність мергелевих та евапорито-уламкових відкладень значення цього показника низьке, а вода – поганої якості. В інших частинах регіону індекс якості води (ІКВ) збільшується, і вода має кращу якість.

Тип геологічної формації навколо басейну є одним з важливих факторів еволюції водних ресурсів. Хімічне вивітрювання різних гірських порід природними водами призводить до утворення різних катіонів та аніонів. Реакція вода-порода та вивітрювання мінералів є основним фактором зміни якості хімічного складу підземних вод у регіоні. Хімічний аналіз води, що надходить у водоносний горизонт району, показав, що на джерела надходження іонів у регіон вплинула літологія гірських порід та відкладень, які тривалий час зазнавали вивітрювання. Отже, води регіону під час проходження уламкових евапоритових утворень третинного періоду та мергелів, розчинили їх і підвищили співвідношення Cl+SO4>HCO3. Результати показали, що наявність гірських порід та карбонатних мінералів, таких як вапняк, доломіт та кальцит, піщаник та силікати, вулканічних порід, у водотоку викликало сценарії Ca>CO3 та Ca+Mg>CO3.

Висновки. Результати показали, що ресурси питної води на більшості ділянок пристойні, за винятком ресурсів, що знаходяться в уламково-евапоритових відкладеннях. Тому вода дуже солона та непридатна для сільськогосподарських потреб. Однак на схід солоність різко падає і підходить для сільськогосподарських цілей. Концентрація бікарбонату, як найбільш поширеного компонента, у всіх ресурсах вища, ніж глобальний санітарний стандарт, і розчинення карбонатних порід, таких як вапняки та доломіти, відіграє роль у цьому. Концентрація нітратів у всіх ресурсах нижча за світовий стандарт. Їх концентрація в районі пов'язана з сільськогосподарською діяльністю та оборотним водопостачанням. Водні ресурси, закладені в вулканітах, конгломератах і гравій, мають меншу концентрацію за вмістом солей і більш високу якість води. Молоді детритно-евапоритові відкладення на заході мають підвищену концентрацію іонів за індексом якості ґрунту (GQI) та картами районування, при цьому якість води в цій частині залишає бажати кращого.

Ключові слова: *Сабзевар, північний схід Ірану, геологічне утворення, якість води, Біналудська зона.*

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