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RESEARCH PAPER

Groundwater quality assessment of Domiz refugee camp in Duhok governorate, Kurdistan region, Iraq.

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ABSTRACT:

Groundwater is considered the fundamental source of drinking uses in Domiz refugee camp, Duhok governorate. Water quality investigation is critical component for determining water consumption. A field assessment was performed on August 2019 in order to examine the groundwater quality used for the refugees in Domiz camp. Groundwater samples were collected from 8 observation wells, 5 wells inside the camp and 3 wells outside the camp limits, and water samples investigated for basic physico-chemical parameters, major elements, as well as certain toxic metals to find out the suitability of groundwater sources for drinking purposes. The analytical out comes display high concentrations of TDS, EC, TH, SO_4, and NO_3 ions which refers to signs of contamination. Groundwater facies via piper diagram in the study area was primarily of Ca-Mg-Na-HCO_3 water type. Heavy metals show high concentration levels in some groundwater samples above drinking water permissible standard prescribed by World Health Organization. These high contents of major elements beside heavy metals in groundwater were probably due to the seepage of unprocessed waste waters from the camp. WQI method were performed to assess the current condition of groundwater samples, then the result revealed variation in water quality classes ranging from very poor to excellent water class.

KEYWORDS: Domiz camp, groundwater, water pollution, heavy metals, WQI.
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1. INTRODUCTION

Water is considered the most significant element that profound life (Gorde and Jadhav, 2013). Groundwater resources have been utilized for industrial and domestic water supply as well as irrigation aims around the world. Though, there are several aspects influencing the quality of groundwater, such as agricultural flow out, industrial and domestic waste, geological formation, land use practices, rate of infiltration and patterns of rainfall (Federation and American Public Health Association, 2005). In the past, the demand on the fresh water has been formidable increase due to industrial acceleration and rapid population growth (Dohare *et al.*, 2014). WHO organization reported that, around 80% of human diseases are came from water (Kavitha and Elangovan, 2010). Tripathi, *et al.*, (2013) highlighted that, around 3% of the world fresh water is enough for human requirements for millions years. The water quality is declining via the pollution caused by human activities. The safest type of water sources is groundwater for both domestic and drinking purposes (Suresh and Kottureshwara, 2009).

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Kurdistan region of Iraq display a large spatial and temporal dissimilarity in terms of water resources. The growing population, expansion of economic arrangements, and increase in internally displaced person (IDPs) and Syrian refugees certainly leads to rising request of water usage for different practices (BRHA, 2017). Groundwater resources in Iraqi Kurdistan have further more experienced of notable tension regarding the quantity of water affected by several reasons for example the global climatic changes, the regional variations of the yearly precipitation rates and unsuitable arrangement of water utilization (Trondalen, 2009; Mohammed, 2019). Hence, investigating water quality is very crucial to be accomplished so as toretain the consciousness and understanding of water resources.

Water quality index become unique and vital method aimed at the management and assessment of groundwater (Srinivas and Huggi, 2011). The soluble minerals in sedimentary rocks and soils are the main part of the soluble components in groundwater, including sulfate ions, sodium, calcium and bicarbonate, chloride, (Dohare *et al*., 2014). Weathering of the rocks for example dolomite, limestone and calcite are the common sources of the magnesium and calcium in the ground water (Marque *et al*., 2003). Greater nitrate contents in water resources may affect the health of human especially pregnant women and infants and become a source of water contamination (Bukowski *et al*., 2001). Heavy metals can also deteriorate the quality of water if they present in high concentrations. Therefore, the main aim of the current investigation is to evaluate the quality of groundwater resources that are used mainly for drinking purposes in Domiz refugee camp via using physico-chemical, major ions, heavy metals, and water quality index computing method in order to better understand and manage groundwater resources in the area of interest.

2. MATERIALS AND METHODS

2.1. Study Area:

This investigation implemented at Domiz1camp (Refugee camp of Syrian) – Duhok Governorate (Latitude: 36^o 78’ 29 N) and (Longitude: 42^o 88’ 61 E) (Figure 1) with altitude of 425m. This camp has been established 2012 in the response to the refugees’ influx from Syria especially from the North, which has turned now quickly to a residential city (Mizzouri *et al*., 2017). Refugees’ population is estimated to be around 33,000 and the total area of the camp is around 1,142,500m^2 (BRHA, 2017). The camp is located such 15 km from the south of Duhok city and 54 km from the north of Mosul city. Moreover, the average air temperature for the year 2018 – 2019 was 26°C, while rainfall amount was about 995mm fallen between October and may (Youssef *et al*., 2019). The main source of drinking and domestic purposes of Domiz camp inhabitants is from groundwater boreholes. To assess water quality of these resources, a total of eight groundwater boreholes were selected in and outside the camp which are principally used for consumption uses for the Syrian refugees in Domiz camp (Table 1).

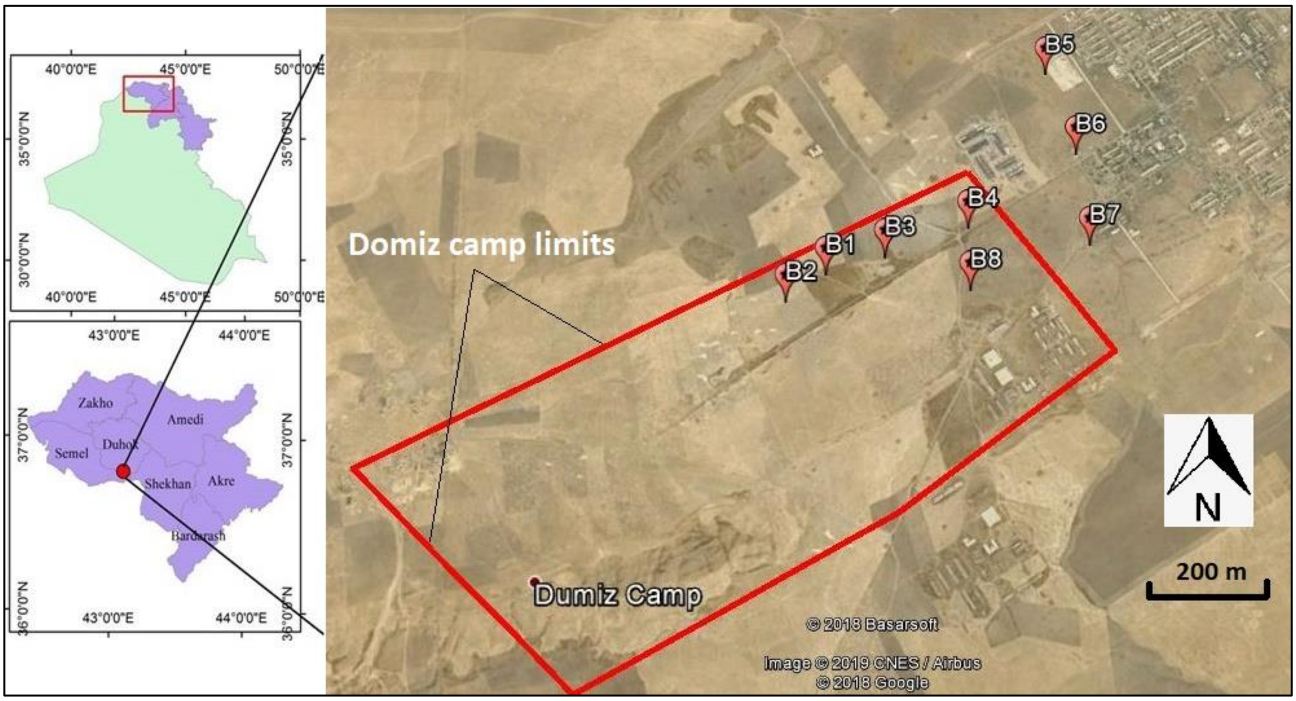

Figure 1. Study Area Map showing groundwater sampling points and Domiz camp limits (border).

Table 1. Geographical coordinates (WGS84) of the groundwater samples.

No	Sample ID		Location	Coordination	
				N	E
1	Boreholes 1	B1	Domiz 1 Refugees Camp	36° 47’ 7”	42° 52’ 53”
2	Boreholes 2	B2	Domiz 1 Refugees Camp	36° 47’ 6”	42° 52’ 45”
3	Boreholes 3	B3	Domiz 1 Refugees Camp	36° 47’ 6”	42° 52’ 1”
4	Boreholes 4	B4	Domiz 1 Refugees Camp	36° 47’ 5”	42° 52’ 14”
5	Boreholes 5	B5	Outside Domiz 1 Refugees Camp	36° 47’ 28”	42° 52’ 34”
6	Boreholes 6	B6	Outside Domiz 1 Refugees Camp	36° 47’ 8”	42° 52’ 34”
7	Boreholes 7	B7	Outside Domiz 1 Refugees Camp	36° 46’ 57”	42° 52’ 29”
8	Boreholes 8	B8	Domiz 1 Refugees Camp	36° 46’ 58”	42° 52’ 10”

2.2. Data collection and analytical methods:

Eight groundwater samples were brought from eight groundwater boreholes during August 2019 to investigate the groundwater quality for drinking purposes. The sterilized 1L polyethylene bottle was used for collected water, to avoid contamination the bottles rinsed twice with the sampled water and then saved under condition of 4°C and transported to the laboratory of the Duhok Environmental Directorate for immediate analyzes. The groundwater samples examined for 24 various parameters including: turbidity (TUR), pH, electrical conductivity (EC), total dissolved solids (TDS), total alkalinity (TA), total hardness (TH), calcium (Ca), magnesium (Mg), sodium (Na), potassium (K), bicarbonate (HCO_3), sulfate (SO_4), chloride (Cl), nitrate (NO_3), chromium (Cr), manganese (Mn), iron (Fe), copper (Cu), zinc (Zn), arsenic (As), selenium (Se), silver (Ag), barium (Ba), and lead (Pb). Total dissolved solids, electrical conductivity, and pH were measured independently in the field by a transportable multi-meters (Trans ISO 9002). All other water quality parameters were analyzed in the laboratory following standard protocols. Total alkalinity and bicarbonate were determined using titration with sulfuric acid. Other chemical and heavy metals analyses were performed by spectrophotometer and flame atomic absorption spectrometer.

Water Quality Index (WQI) was computed by utilizing the Weighted Arithmetic Index technique as defined by Cude (2001) as follows:

$Qi = [(V_{actual} - V_{ideal}) / (V_{standard} - V_{ideal})] * 100$…….. (1)

Where,
Qi = Quality rating of *i* parameter for a total of *n* water quality parameters
V_{actual}: Actual value of the water quality parameter gained from laboratory analysis
V_{ideal}: Ideal value of the water quality parameter in pure water.
V_{ideal} for pH = 7, while for other parameters is equivalent to zero in pure water.
$V_{standard}$: prescribed WHO standard of the water quality parameter.

$Wi = 1/ Si$ ……… (2)

Where,
Wi = Relative (unit) weight for nth parameter
Si= Standard permissible value for *n* parameter
I = Proportionality constant.
Lastly, the total WQI was obtained by combining the quality rating with the unit weight linearly via following equation:

$WQi = \sum QiWi / \sum Wi$ ……… (3)

Where,
Qi = Quality rating
Wi = Relative weight
In this study, the WQI was measured for human drinking purposes and uses with the maximum allowable WQI for the drinking water was set as 100.

3. RESULTS AND DISCUSSION:

3.1. Physico-chemical parameters

The physico-chemical, chemical and heavy metals results of all examined groundwater boreholes are given in Table 2 and illustrated in Figure 2c. The pH measurement of water is vital since it controls many of the geochemical reactions or solubility calculations within groundwater aquifer. The pH value of current study is ranged between 7.0 and 7.6 which considered being neutral to slightly weak alkaline and measured as normal condition since in the pH of the region's groundwater categorized by alteration toward the alkaline caused mainly by geological makeup of the study site which principally comprised of limestone (Nabi, 2005). The recorded values in all boreholes were suitable for drinking uses between 6.5 – 8.5 set by WHO and Iraqi guideline (WHO, 2008). Salinity of water is specified via determining the capability of water to conduct an electrical current and is generally expressed by either electrical conductivity (EC) or total dissolved solids (TDS), which are determining the suitability of water for particular purposes. The concentration of EC varied from 663.2 µS/cm to 1183 µS/cm with an average concentration of 984.3 µS/cm, and TDS value ranged between 424.5 and 757.1 mg/l and the water is classified as high saline water (Kadhem, 2013). The allowable level of EC for consumption purposes is value less than 1500 µS/cm and no water samples surpassed this concentration, however all samples (except one sample B5) exceeded the desirable limits of TDS for drinking water value of 500 mg/l set by WHO (2008). This could be connected to availability of elevated dissolved ions, organic material from the study area, large mineral salts content from the soil dissolved minerals, and semi-arid type of climatic condition (Shekha, 2008; Al-Mezori and Harami, 2013; Shekha *et al.*, 2017; Mohammed and Bamarni, 2019). The occurrence of elevated amount of dissolved solids in groundwater could change its taste. Water hardness is such a crucial parameter for domestic uses of water and is the record of how water react with the soap, for instance, hard water requests noticeably additional soap to produce lather. Water comprising hardness content lower than 60 mg/l is usually categorized as soft; 60–120 mg/l, moderately hard; 120–180 mg/l, hard; and greater than 180 mg/l is considered very hard (Mc Gowan, 2000). The results of this study show that water samples are listed as very hard water since the total hardness values vary from 240 to 476 mg/l with the average of 319.5 mg/l. High concentration of hardness in water is unwanted typically for aesthetic and economic aims (WHO, 2011). Groundwater hardness results primarily from the presence of alkaline earth metals calcium and magnesium.

Table 2. Physico-chemical, major ions and heavy metals of analyzed groundwater samples from Domiz refugee camp.

Parameters	**Unites**	**Sample ID**								**AV**	**SD**
		B1	**B2**	**B3**	**B4**	**B5**	**B6**	**B7**	**B8**		
TUR	NTU	0.4	0.4	0.5	0.6	0.6	0.8	0.3	0.5	0.51	0.16
pH		7.1	7	7.3	7.4	7.3	7.6	7.1	7	7.23	0.21
EC	µS/cm	905.6	1001.6	1052.1	1053.2	663.2	906.7	1183	1109.3	984.34	160.39
TDS	mg/l	579.6	641	673.4	674.1	424.5	580.3	757.1	710	630.00	102.64
TA	mg/l	322	264	214	232	222	230	384	390	282.25	73.11
TH	mg/l	296	284	296	248	240	316	476	400	319.50	79.98
Ca^{2+}	mg/l	81.6	72	57.6	57.6	40	118.4	72	67.2	70.80	22.98
Mg^{2+}	mg/l	22.4	25.4	37.1	25.4	34.2	49	72.2	56.6	40.29	17.61
Na^{+}	mg/l	50.7	70.3	84.6	88.6	40.1	67.6	75.4	77.2	69.31	16.51
K^{+}	mg/l	0.8	1.2	1.2	1.3	0.8	1.2	1.1	0.9	1.06	0.20
HCO_3^{-}	mg/l	392.84	322.08	261.08	283.04	270.84	280.6	468.48	475.8	344.35	89.20
SO_4^{2-}	mg/l	68.5	128.2	184.9	202	53.3	137.5	104.3	98.3	122.13	52.22
Cl^{-}	mg/l	60	46	56	60	38	100	26	48	54.25	21.82
NO_3^{-}	mg/l	24.3	21.9	25.2	25.2	26.5	30.2	34.2	24.5	26.50	3.90
Cr	mg/l	0.324	0.03	0.046	0.048	0.03	0.038	0.006	0.005	0.066	0.11
Mn	mg/l	0.311	0.004	0.002	0.003	0.002	0.003	0.005	0.001	0.041	0.11
Fe	mg/l	0.291	0.045	0.016	0.01	0.011	N.D	0.017	0.023	0.059	0.10
Cu	mg/l	0.302	0.008	0.014	0.009	0.009	0.002	N.D	N.D	0.057	0.12
Zn	mg/l	0.029	0.113	0.019	0.003	0.004	0.001	0.015	0.033	0.027	0.04
As	mg/l	0.027	0.033	0.028	0.012	0.003	0.016	0.009	N.D	0.018	0.01
Se	mg/l	0.023	N.D	0.011	N.D	N.D	N.D	0.014	N.D	0.016	0.01
Ag	mg/l	0.36	0.029	0.027	0.016	0.018	0.005	0.023	0.017	0.062	0.12
Ba	mg/l	0.391	0.076	0.045	0.035	0.055	0.037	0.082	0.081	0.100	0.12
Pb	mg/l	0.007	0.01	0.005	0.002	N.D	0.005	0.005	0.003	0.005	0.00

(NTU= Nephelometric turbidity unit, AV= average value, SD= standard deviation, N.D= Not detected)

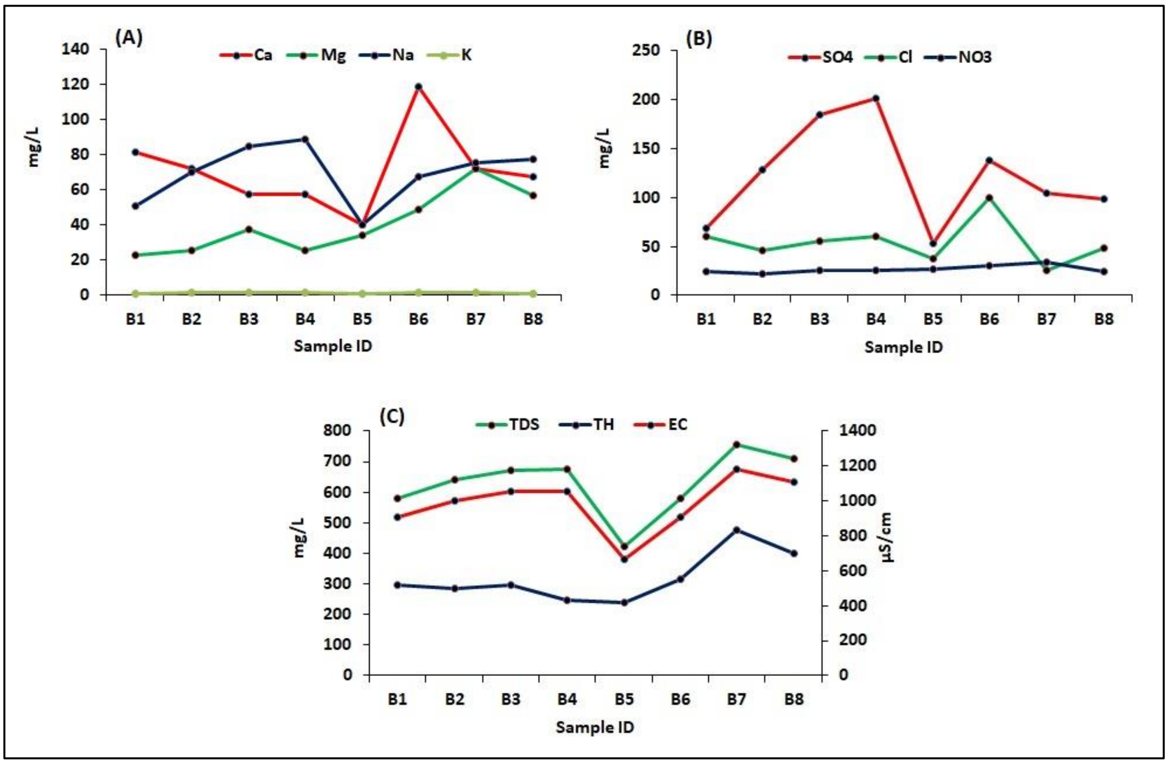

Figure 2. Physico-chemical and major ion concentration in groundwater samples.

3.2. Major ions

In all groundwater samples, no particular cation (Ca^{2+}, Mg^{2+}, Na^{+}, and K^{+}) shows a clear dominance. The major ions concentration is given in Table 2 and showed in Figure 2a and 2b. The concentration of calcium (Ca^{2+}) was fluctuated between 40 and 118.4 mg/l with the mean value of 70.8 mg/l. The magnesium contents in groundwater samples fluctuated from 22.4 to 72.2 mg/l with the mean value of 40.29 mg/l. The outcomes point out that all samples (except B5) exceeded the concentration of calcium and only two samples (B7 and B8) exceeded the concentration of magnesium for their drinking desirable limits of 50 mg/l as per Iraqi standards (MOE, 1998). High levels of $Ca^{2+}$and Mg^{2+}in water resources results in water hardness problem. The main sources of calcium and magnesium in groundwater are largely the geochemistry of the rock types. The value of sodium (Na^{+}) fluctuate from 40.1 to 88.6 mg/l with the mean value of 69.31 mg/l. The sodium contents in all groundwater samples were well below the prescribed concentration of WHO (2008) as 200 mg/l for drinking purposes. The concentration of potassium (K^{+}) were very low in groundwater samples and ranged between 0.8 and 1.3 mg/l. Parts of potassium enter clay structure and thus its concentrations get lowered in water (Kannan and Joseph, 2010).

Bicarbonate (HCO_3^{-}) was the most dominate anion measured in groundwater samples. The content of HCO_3^{-} in the investigated groundwater boreholes ranged between 261.1 and 475.8 mg/l with the mean amount of 344.3 mg/l. Entire groundwater samples contained levels that exceeded the standard concentration for drinking purposes (250 mg/l) agreed by WHO (2008). The availability of carbonate rocks like calcite and dolomite in the sediments defines the high bicarbonate contents in the aquifer (Mizzouri, 2007). Sulfate ion (SO_4^{-2}) is one of the major anions widely found in fresh water resources. The SO_4^{-2}content in groundwater samples ranged from 53.3 to 202 mg/l with the mean value of 122.1 mg/l. These were below the maximum permissible limit of 250 mg/l set by WHO (2008) for drinking purposes. Sulfate is not negatively influences the health below the standard amount for drinking purposes, never the less, it may have a laxative consequence at higher concentration, which can lead to intestinal anxiety and subsequently dehydration (WHO, 2011a). The chloride concentration in groundwater samples was fluctuated between 26 and 100 mg/l which were far lower than the acceptable limit of 200 mg/l for drinking purposes set by WHO (2008). In natural groundwater, the likely sources of chloride is the discharge of chloride-bearing minerals such as apatite, inland salinity, and the discharge of agricultural, industrial and domestic waste water (Abbasi, 1998). The nitrate (NO_3^-) content varied between 21.9 and 34.2 mg/l with the mean value of 26.5 mg/l. Despite the high concentration of nitrate in groundwater samples, none of the samples surpassed the allowable limit for drinking purposes of 50 mg/l (WHO, 2008).The wide spread use of agricultural fertilizers is considered to be a key cause of the nitrate that percolates to groundwater (Postma *et al*., 1991; Chowdary *et al*., 2005). Moreover, point sources of nitrogen for instance septic systems are revealed to consider the nitrate contamination of groundwater (Mac Quarrie *et al*., 2001). Higher nitrate content in drinking water can bring methemoglobinemia to infants and stomach cancer in adults (Lee, 1992; Wolfe and Patz, 2002).

3.3. Groundwater classification

The hydrochemical evolution of water samples could be revealed via plotting the major cations (Ca^{2+}, Mg^{2+}, Na^+, and K^+) and major anions ($HCO_3^{–}$, $SO_4^{2–}$, $Cl^–$, , $NO_3^–$) present in water resources. Figure 3 displays the Piper diagram which is a graphical illustration grouping water rely on the prevailing cations and anions and has extensive application to find out water facies, for the obtained data of this study (Piper, 1944). Two chemical water facies of groundwater recognized; (i) Calcium-Magnesium-Sodium-Bicarbonate facies (Ca^{2+}-Mg^{2+}-Na^+-HCO_3^-), and (ii) Calcium-Magnesium-Sodium-Bicarbonate-Sulfate facies (Ca^{2+}-Mg^{2+}-Na^+-$HCO_3^–$-$SO_4^{2–}$). There is no major cation dominant in groundwater and bicarbonate by far was the most dominant anion in groundwater followed by sulfate ion. These water types could be as a consequence of the geological influences of the aquifer bed rock mainly of limestone carbonate (Mohammed and Bamarni, 2019). The geological formation of an aquifer can significantly influences the concentration of dissolved ions since the mineral-water interaction is important and hence determine the dominate ions (Panno and Hackley, 2010).

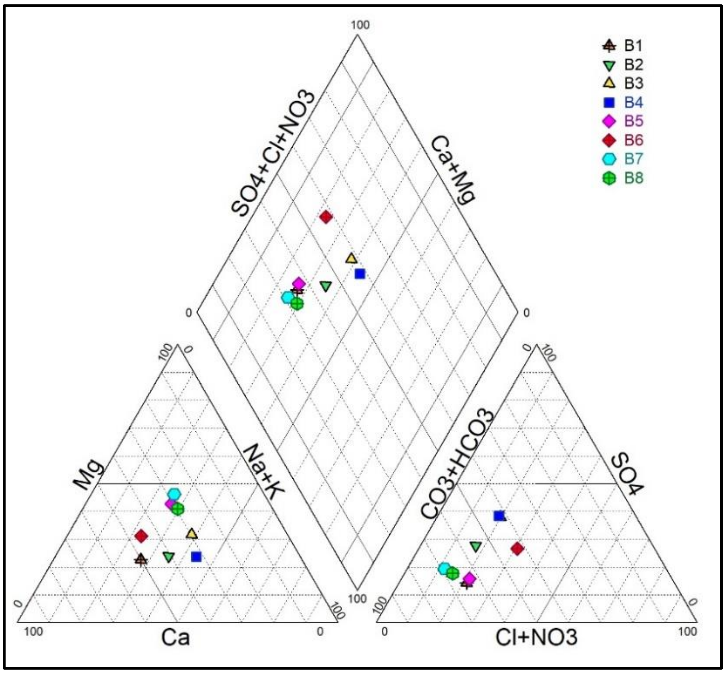

Figure 3. Piper trilinear diagram showing the groundwater chemical facies of the studied samples.

3.4. Heavy metals

The concentration, mean and standard deviation of ten dissolved heavy metals (Cr, Mn, Fe, Cu, Zn, As, Se, Ag, Ba, and Pb) in groundwater samples are presented in Table 2 and displayed in Figure 4a and 4b. The analytical results did indicate high levels of some heavy metals in few water samples. The lowest and highest concentration of Chromium (Cr) obtained from the groundwater samples at 8 different boreholes varied from 0.005 to 0.324 mg/l with the mean value of 0.066 mg/l.

The acceptable level set by WHO (2011) for Cr in water for drinking purposes is 0.05 mg/l, the lower value of Cr ions were recorded in every collected samples excluding water sample from B1 which had concentration above the WHO set, this could be mainly due to the adjacent of B1to the waste water outlet. The use of water with excessive concentration of Cr for drinking and domestic uses can cause cancer (Jarup, 2003). The concentration of Manganese (Mn) obtained from the groundwater varied from 0.001 to 0.311 mg/l with the mean value of 0.041 mg/l. The maximum allowable amount of Mn in water resources used for drinking purposes recommended by WHO is 0.4 mg/l and none of samples exceeded this limit. The results show that the maximum concentration for Mn ion was recorded in borehole B1 which was close the limit value for drinking purposes. Manganese ion is frequently detected in drinking water but is having important human health concern at lower levels (Keen and Zidenberg-Cherr, 1994). The source of Mn in groundwater may be naturally from rock and soil weathering (such as manganese carbonate and rhodonite) and anthropogenic from agricultural activities (Mohammed, 2019). The high content of manganese recorded in the water resources can cause neurological disorder; it can also stain clothes (Jarup, 2003). The minimum and maximum concentrations of Iron, Copper, and Zinc in the groundwater samples were 0.01 – 0.291 mg/l, 0.002 – 0.302 mg/l, and 0.001 – 0.113 mg/l, respectively. The WHO guideline maximum for Fe, Cu, and Zn for drinking water are 1.0, 2.0, and 4 mg/l, therefore, no water samples exceeded these levels.

The minimum and maximum concentration of Arsenic (As) obtained from the groundwater samples varying from 0.003 to 0.033 mg/l with average concentration of 0.018 mg/l. Arsenic ion was not detected in only one groundwater sample (B8). The maximum permissible limit of As in drinking water is 0.01 mg/l which is prescribed by WHO (2011). The recorded values of five boreholes (B1, B2, B3, B4, and B6) were observed to be beyond the allowable level for drinking purposes. The main sources of Arsenic in groundwater is natural from geological formation (such as arsenopyrite and arsenic sulfides) and could also be from the agricultural activities mainly pesticides and insecticides containing arsenic (Momot and Synzynys, 2005; Pirsaheb *et al.*, 2015). Human exposure to high amounts of arsenic may inspire severe toxic health consequences such as gastrointestinal indications (poor appetite, vomiting, diarrhea, etc.), disruption of cardiovascular and the functions of nervous system or even death (Abernathy and Morgan, 2001). The minimum and maximum concentration of Silver (Ag) recorded from the groundwater samples ranged from 0.005 to 0.360 mg/l. The maximum allowable limit of Ag in drinking water is 0.1 mg/l set by WHO (2008). Lower concentration of Ag ion were measured in all the samples collected except for sample from B1 which had concentration to be above the maximum allowable limit set by WHO. Geological makeup could be the source of Ag in the studied groundwater samples, however, wastewater is believed to be the main source of Ag in groundwater sample of B1. The use of water with high content of Ag for drinking purposes may cause aesthetic discolorations of the skin, hair and various organs (WHO, 2003). Low concentrations of Barium (Ba) ion were detected in groundwater samples and varied from 0.035 to 0.391 mg/l which were far below the maximum permissible limit of 0.7 mg/l for drinking purposes set by WHO (2004). Lead ion (Pb) is a highly toxic metal which should normally be available in very low concentration in drinking water. The minimum and maximum concentration of Lead recorded from the groundwater samples varied from 0.002 to 0.010 mg/l. The maximum allowable limit for drinking water is 0.01 mg/l prescribed by WHO (2008), and all the water samples were below this set excluding B2 which recorded the same value.

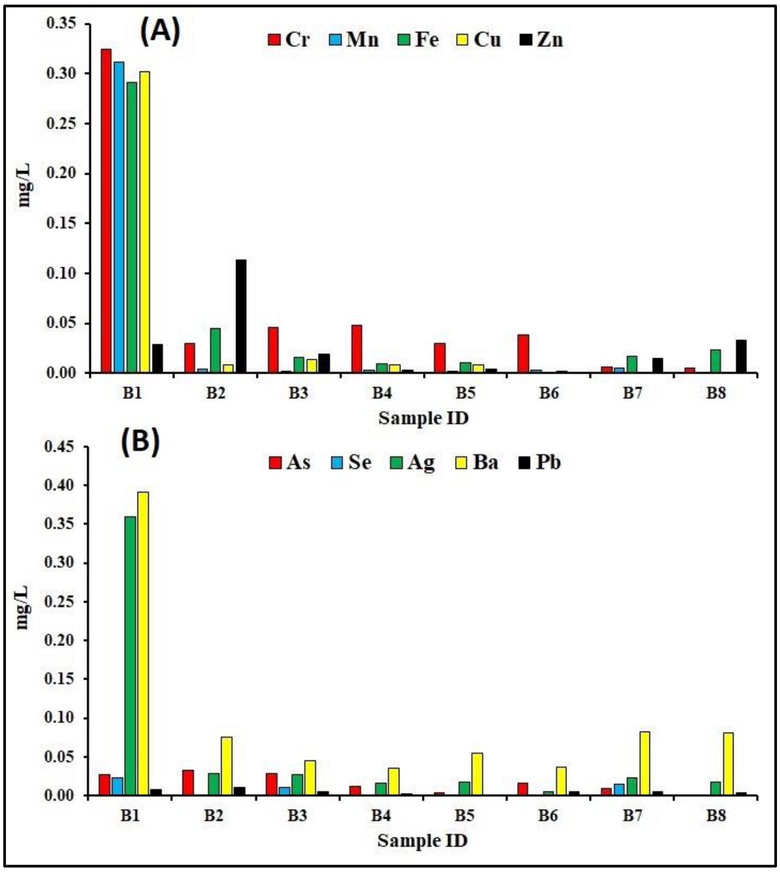

Figure 4. Concentration of the heavy metal for the groundwater samples.

3.5. Water quality index (WQI)

Water quality index is such a suitable technique for evaluating the quality of water resources as a whole (Ketata *et al.*, 2011). This method decreases the great amount of data into only one meaningful number and simplifies understanding of the results. WQI is applied in water resources to identify their drinking suitability (Gibrilla *et al.*, 2011; Khwakaram *et al.*, 2012). Table 3 presents the results of WQI of the groundwater B1 and it was 217.3 as an example of calculation. The calculated values of WQI were classified into five sorts''as revealed in Table 4 (Ramakrishniah *et al.*, 2009). The results of WQI values in the study area are demonstrated in Table 5. The computed WQI values varied from 25.43 (B8) to 217.32 (B1). Accordingly, the quality of studied groundwater samples is in the ''Excellent'' to ''Very poor water '' for drinking range. Table 4 revealed that out of eight groundwater samples, two boreholes are categorized in the ''Excellent water'' class, three as ''Good water'' class, two as ''Poor water'' class, and one as a ''Very poor water'' class. Very poor water class has been observed in the borehole B1, this may be due to anthropogenic activities surrounding the borehole mainly sewer waste water and there could be a leakage of wastewater. Thus, the results reflect the presence of anthropogenic pollution sources within the study area (Refugee camp).

Table 3: An example calculation of WQI for the groundwater sample B1.

Parameters	Actual measured values	Water quality standards	Relative weight (wi)	Quality rating (Qi)	Weighted values (Wi * Qi)
TUR	0.4	5	0.2	8	1.6
pH	7.1	8.5	0.12	6.67	0.8

EC	905.6	1000	0.001	90.56	0.09
TDS	579.6	500	0.002	115.92	0.23184
TA	322	100	0.01	322	3.22
TH	296	100	0.01	296	2.96
Ca	81.6	75	0.013	108.8	1.46
Mg	22.4	30	0.03	74.67	2.49
Na	50.7	200	0.005	25.35	0.127
SO4	68.5	250	0.004	27.4	0.109
Cl	60	250	0.004	24	0.096
NO3	24.3	50	0.02	48.6	0.972
Cr	0.324	0.05	20	648	12960
Mn	0.311	0.4	2.5	77.75	194.375
Cu	0.302	2	0.5	15.1	7.55
Zn	0.029	4	0.25	0.725	0.18125
Ag	0.36	0.1	10	360	3600
As	0.027	0.01	100	270	27000
Pb	0.007	0.01	100	70	7000
			∑Wi 233.669		**∑Wi*Qi 50776.262**

Table 4. Water Quality Index values with their status.

Water Quality Index levels	Description
<50	Excellent
50 – 100	Good water
100 – 200	Poor water
200 – 300	Very poor (bad) water
>300	Unsuitable for drinking

Table 5. Results of Water Quality Index of Domiz refugee camp groundwater for drinking water purposes.

Sample ID	WQI	Water type
B1	217.3	Very poor water
B2	190.5	Poor water
B3	150.4	Poor water
B4	68.9	Good water
B5	32.95	Excellent
B6	79.6	Good water
B7	75.07	Good water
B8	25.43	Excellent

3. CONCLUSION:

Groundwater have been evaluated in the Domiz Refugee camp for its suitability for drinking purpose. In overall, 24 different hydrochemical parameters, including physico-chemical, major elements and heavy metals, were examined from eight groundwater boreholes. The results discovered that the water was in alkaline nature and having high content of total dissolved solids above recommended set prescribed by WHO. Elevated levels of nitrate also recorded in all water samples indicating the agricultural and wastewater from sewer contamination in the area.

Moderately low levels of studied heavy metals measured in groundwater and, interestingly, elevated concentration of arsenic ion recorded in almost all samples that exceed permissible limit for drinking water. Moreover, Water Quality Index technique were used to evaluating the overall groundwater quality of the study area and the results displayed four different categories: Excellent water class; Good water class; Poor water class; and Very poor class. The water quality assessment evidently exhibited that the status of some groundwater in Domiz camp was degraded and it was also concluded that discharging of domestic effluents and other human actions were the key reasons of polluting groundwater resources predominantly boreholes B1 and B2. Nevertheless, regular seasonal observing of groundwater quality, in terms of biology, to detect variation of water quality parameters over time and to manage water resources is highly recommended.

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