Evaluation of Groundwater Quality Index for drinking purpose from some villages around Darbandikhan district, Kurdistan Region -Iraq

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Abstract: *This study was conducted over seven villages near Darbandikhan district including (2) wells and (5) springs. It covers more than 60 km², to assess the suitability of ground water quality for drinking purpose using water quality index through investigating of different wells and springs; this technique is very useful tool for quick assessment for any water system. This was done by subjecting the seven water resources in the mentioned area under investigation, where drinking water samples are not treated before consumption. For calculating Water Quality Index, fourteen parameters such as (pH, TDS, EC, Turbidity, Total Hardness as $CaCO_3$, Calcium, Magnesium, Sulphate, Chloride, Nitrate (NO_3-N), Nitrite (NO_2-N), Phosphate (PO_4-P), Sodium and Potassium) have been considered. The study spread over two seasons namely fall and spring. The observed values of these physicochemical parameters were compared with World Health Organization standards. The results indicated that water quality of springs and wells varied from excellent water quality (A) to good water quality (B).*

Key words: *Water Quality Index, Assessment, Physical-chemical Parameters, Suitability for Drinking, Ground Water.*

I. Introduction

Water quality index (WQI) is valuable and unique rating to depict the overall water quality status in a single term that is helpful for selecting appropriate treatment technique to meet the concerned issues. Whereas, water quality index depicts the composite influence of different water quality parameters and communicates water quality information to the public and legislative decision makers. Recent research conducted by (Yisa and Jimoh, 2010) showed that there was an increase in the demand for freshwater due to rapid population growth as well as the accelerated pace of industrialization in the last few decades. Ground water is a gift of nature, its quality about 210 billion m³ including recharge through infiltration seepage and evaporation. Ground water is the main source of drinking water. Today human activities are constantly adding industrial, domestic and agricultural waste to ground water reservoirs at an alarming rate (Panda and Sinha, 1991). With growing industrial sectors, urban areas also developed near the industrial areas. So, the consumption of fresh water is increased also. Disposal of industrial effluent and sewage into fresh water cause ground water pollution (Panigrahi et al., 2012). The quality of ground water may also vary with depth of water table, seasonal changes and composition of dissolved salts depending upon sources of the salt and sub surface environment (Gebrehiwot et al., 2011). The present study focus on the water qualities of some villages near Darbandikhan district. The physicochemical properties of springs and wells were determined and compared with international of WHO together with recommended water guidelines for drinking water and domestic uses based on water quality index. This was derived by weighted arithmetic method. It is one of the most effective ways to communicate information on water quality trends to policy makers to shape strong public policy and implement the water quality programs (Kalavathy et at., 2011). The WQI was first developed by Horton in early 1970s based on weighted arithmetical calculation, a number of researchers all over the world developed WQI models based on weighing and rating of different water quality parameters (UNEP GEMS, 2007, Kavitha and Elangovan, 2010 and Alobaidy et al., 2010). The water quality index is a dimensionless number with values ranking between 0 and 100. The higher index value represents a good water quality (Cude, 2001, Pandey and Sundaram, 2002). This numerical index can use as a management tool in water quality assessment. In Iraq, many researchers and projects have been conducted to measure surface water quality index but in Kurdistan region of Iraq, few studies have been done conducted on water quality index (Shekha, 2008) applied water quality index for both Erbil wastewater channel and great Zab river. (Alobaidy et al., 2010) formulated application of water quality index for assessment of Dokan Lake ecosystem. Determination of Water Quality Index for Qalyasan Stream in Sulaimani City (Khwakaram et al., 2012) and (HamaSalh, 2014) Water Quality Index (WQI) of some Wells located in the region of Kani Goma and Kanasura in Sulaimani governorate. Evaluation of ground water quality and its suitability for drinking is the objective of the present study by comparing the results against drinking water

quality standards laid down by world Health organization. The suitability of ground water for domestic use has been based on water quality index.

II. Materials And Methods

Study area: Darbandikhan district is located at northeast of Iraq 531 m altitude and 65 km far from Sulaimani City. The ground water samples were collected from seven different villages (2) wells and (5) springs (Miradee, Ahmad brnda, China rah, Azaban, Siyara, Birke and Qashti) near Darbandikhan district, it is far about 15 km from the Darbandikhan and it is a rural area composed of 2000 residents which are the only main sources of water for the community. The study area is located in the northeast of Darbandikhan and it is under investigation lies approximately between North latitudes 35^0 08' 73" to 35^0 14' 27" and East longitudes 45^0 41' 32" to 45^0 44' 49" as show in Figure (1).

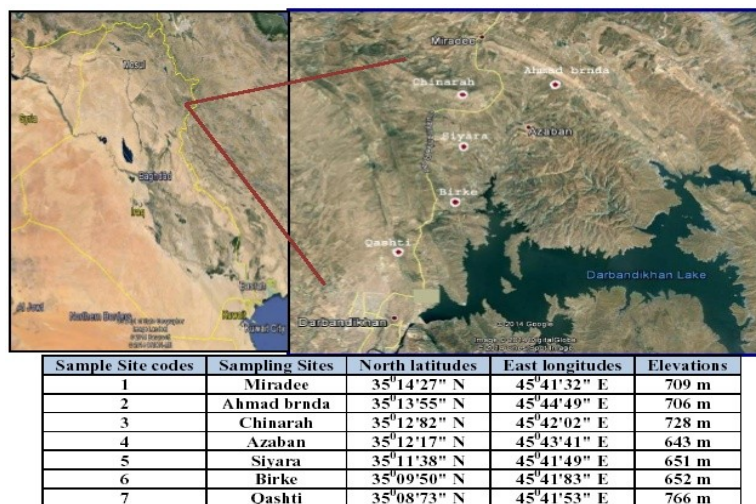| Sample Site codes	Sampling Sites	North latitudes	East longitudes	Elevations
1	Miradee	$35^0$14'27" N	$45^0$41'32" E	709 m
2	Ahmad brnda	$35^0$13'55" N	$45^0$44'49" E	706 m
3	Chinarah	$35^0$12'82" N	$45^0$42'02" E	728 m
4	Azaban	$35^0$12'17" N	$45^0$43'41" E	643 m
5	Siyara	$35^0$11'38" N	$45^0$41'49" E	651 m
6	Birke	$35^0$09'50" N	$45^0$41'83" E	652 m
7	Qashti	$35^0$08'73" N	$45^0$41'53" E	766 m

Figure 1: Satellite image of the study area showing the sampling sites according to Lat. N, Long. E and elevations

Analytical methods: Water samplings were done two times at two different sampling periods. Samples were collected in (November; 2013 and February; 2014) using acid washed 0.5 liter polypropylene (PET) bottles to avoid unpredictable changes in characteristic of water according to standard procedures (APHA et al., 1998). The physiochemical properties of water samples were determined and performed on the same day of sampling, and analyzed for 14 physicochemical parameters using following procedures. The water samples were analyzed for most parameters using a photo Lab spectral model (82362 Weilheim) WTW company-Germany according to (A.P.H.A., 1989), except Na^+ and K^+ which were determined using flame photometer model (JENWAY PF P7), as described in (A.P.H.A., 1989). The pH, electrical conductivity (EC) and Turbidity were analyzed using pH-meter, model (Microprocessor pH meter, Hanna pH 211), according to (Jackson, 1958), a portable (EC) meter (LF318/SET, WTW Company-Germany), according to (Wilcox, 1950) and turbidity meter (Photo Flex/Photo Flex Turb.WTW Company-Germany), as recommended by (APHA et al., 1998) respectively.

III. Calculation of Water Quality Index (WQI)

The water quality index was calculated depending on fourteen parameters. The WQI has been calculated using the drinking water quality standard recommended by the World Health Organization (WHO, 2011). The weighted arithmetic index method (Brown, 1972) used for the calculating WQI of the water body in following steps:

a. Calculation of Sub Index of Quality Rating (q_n)

Let there be **n** water quality parameters, where the quality rating or sub index (**qn**) corresponding to the nth parameters is a number reflecting the relative value of these parameters in the polluted water with respect to its standard permissible value. The value of q_n is calculated using the following expression.

$q_n = 100 [V_n-V_{io}]/[S_n-V_{io}]$ (1)

Where,

q_n = Quality rating for the nth water quality parameters

V_n = Estimated value of the nth parameter at a given sampling station.

S_n = Standard permissible value of the nth parameters

V_{io} = Ideal value of nth parameter in pure water. *(i.e., 0 for all other parameters except the parameter pH and dissolved oxygen (7.0 and 14.6 mg l^{-1} respectively)* (Tripaty and Sahu, 2005).

b. Calculation of Quality Rating for pH

For pH the ideal value is 7.0 (for natural water) and a permissible value is 8.5 (for polluted water). Therefore, the quality rating for pH is calculated from the following relation:

q_{pH} = 100 [(V_{pH} -7.0)/(8.5 -7.0)]   **(2)**

Where,

V_{pH} = observed value of pH during the study period.

If quality rating q_n = 0 means complete absence of pollutants,

While $0 < q_n < 100$ implies that, the pollutants are within the prescribed standard.

When $q_n > 100$ implies that, the pollutants are above the standards.

c. Calculation of Unit Weight (Wn)

Calculation of unit weight (Wn) for various water quality parameters are inversely proportional to the recommended standards value Sn of the corresponding parameters.

Wn = K/Sn **(3)**

Where,

Wn = Unit weight for the nth parameters.

Sn = Standard value for n^{th} parameters.

K = Proportional constant, this value considered (1) here, also can calculate using the following equation:

$K = 1/\Sigma (1/Sn)$ **(4)**

The overall Water Quality Index was calculated by aggregating the quality rating with the unit weight linearly.

If water quality index (WQI) is less than 50 such water is slightly polluted and fit for human consumption, WQI between (51 - 80) moderately polluted, WQI between (50 -100) excessively polluted and WQI-Severely polluted (Sinha et at., 2004).

$$WQI = \sum_{n=1}^{n} q_n \, Wn \, / \, \sum_{n-1}^{n} Wn \qquad \textbf{(5)}$$

Table 1: Water Quality Index (WQI) and status of water quality
[Chaterjee and Raziuddin, 2002]

Water Quality Index Level	Water quality status	Grading
0-25	Excellent water quality	A
26-50	Good water quality	B
51-75	Poor water quality	C
76-100	Very poor water quality	D
>100	Unsuitable for drinking	E

IV.   Results And Discussion

Water quality index of the ground water samples are established on important various physiochemical parameters for seven sites, from several villages around Darbandikhan district. Various physiochemical parameters were calculated for water quality index Table (2). The WQI for all the samples taken were calculated according to the procedure explained previously in materials and methods. WQI indicates the quality of water in terms of index number which represents overall quality of water for any intended uses. On the basis of the WQI, the water quality index obtained for ground water samples in different sites in (November; 2013 and February; 2014) are 32.82, 13.51, 18.86, 24.43, 13.42, 11.77 and 14.75 respectively Table (3, 4, 5, 6, 7, 8 and 9).

The WQI results obtained for the different sampling sites were found to fall under the class from excellent water quality (0- 25) class at the sample sites (2-Ahmad brnda, 3-China rah, 4-Azaban, 5-Siyara, 6-Birke and 7-Qashti) to Good water quality (25 - 50) class at the sample site (1-Miradee), Table (1). Those index values revealed that the status of the ground water samples were suitable for drinking at all sampling locations according to WHO guideline standards (WHO, 2011).

The pH of the aquatic systems is an important indicator for the water quality assessment and extent pollution in the watershed areas. Results obtained for pH varied between (7.23 and 7.68). The pH values of the studied waters were ranging between the minimum value of 7.23 at site (1) while, the maximum value was 7.68 at site (2) Table (2). pH measurement is very important as an indication of water quality due to the sensitivity of organisms to the pH of their environment. pH is also important in assessing the suitability of water for drinking (WHO, 2004). However, the pH concentration in the study area is within allowable standard permissible limits of (World Health Organization) (WHO, 2011).

The EC values for the investigated periods ranged between (342.50 to 796.50) μS cm^{-1} at sites (2 and 7) respectively. Table (2) which were lower than the suggested level (1500 μS cm^{-1}) by WHO (WHO, 2011). The results showed those waters were suitable for dinking depending on WHO (1000 mg l^{-1}). The TDS values

ranged from the minimum value of TDS was 219.20 mg l^{-1} at site (2) and maximum value was 509.76 mg l^{-1} at site (7). Primary sources for TDS in receiving waters are agricultural and residential runoff, leaching of soil contamination and point source water pollution discharge from industrial or sewage treatment plants (Boyd, 2000). Turbidity is widely concerned as an important parameter for drinking water. However, the observed values were within permissible level recommended by WHO (5 NTU) for all sites. The minimum value (< 0.01 NTU) recorded from sites (2, 5, and 7) and maximum value (4.94 NTU) recorded at site (1).

The result of Calcium was higher than the permissible level recommended by the WHO (75 mg l^{-1}) for drinking water of all sites. The Calcium enters water by leaching from minerals within an aquifer. Common calcium-containing minerals are calcite and gypsum, also some human activities involved in increasing calcium concentration of carbon dioxide which form the carbonic acid that eventually lead to dissolve the bituminous lime rocks (Boyd, 2000). The concentrations of Magnesium in studied waters were ranged between (61.30 to 92.15) mg l^{-1} at sites (1 and 7) respectively Table (2) and the result of Magnesium was lower than the permissible level recommended by WHO (100 mg l^{-1}). Total Hardness varies from (598.21 to 760.17) mg l^{-1} as CaCO$_3$. The hardness values for the study waters are found to be high for all locations and determined to fall above the desirable limit of WHO specification (500 mg l^{-1}). Total hardness mainly a reflect the major ions, e.g., Ca^{2+}, Mg^{2+}, CO$_3^{2-}$ and HCO$_3^{-}$, being present in the water. These ions enter the ground water by leaching from minerals like Calcite, gypsum and Dolomite.

Chloride is one of the most important parameter in assessing water quality. In the present study the concentration of chloride fluctuated between (19.50 to 29.50) mg l^{-1}. Thus the water for all study sites considered as fresh water because they were containing low levels of chloride, therefore it is within permissible level recommended by the WHO (250 mg l^{-1}), for drinking water.

The sulfate concentrations of studied waters were ranged from (43 to131) mg l^{-1}. Generally, Iraqi Kurdistan region inland waters usually contain significant amount of sulfate. While the dissolution of gypsum from sedimentary rocks required a period of time for contacting with ground water, so shallow aquifers containing low concentration of sulfate (Rasheed, 1994), due to the rocks formation of the area is rich in gypsum. There for, their values were higher than in other parts of the world (WHO, 1996). These results are in agreement with those results of previous worker in Kurdistan (Zeywayee, 2011 and Ganjo, 1997). In this study, sulfate concentration values relatively were high but within the permissible level recommended by the WHO (250 mg l^{-1}), for drinking water.

The phosphate values obtained were without the tolerable limits and within permissible limit (5 mg l^{-1}). The minimum and maximum values were (0.20 and 0.45) mg l^{-1} for sites (5 and 6) respectively, which suggest that phosphorus is rarely found in high concentrations in waters as it is actively taken up by plants. The values of sodium were found to be always higher than potassium and much less than that of calcium. The differences between sodium and potassium values at the waters possibly are related to the soil formation within the study area. The sodium and potassium concentrations were ranged (5.40 to 28.30 and 0.20 to 2.26) mg l^{-1} were within permissible level recommended by WHO (250 and 12) mg l^{-1} respectively, for drinking water.

Nitrate and Nitrite are naturally ions that are part of nitrogen cycle. Nitrate ion in water is undesirable. Because it causes methaemoglobinaemia in infants less than 6 months old (Egereonu and Nwachukwu, 2005), however, the nitrate value varies from (1.50-8.50) mg l^{-1}. Although all the samples exceed the permissible limit which could be due to leaching from waste disposal, sanitary landfills, over application of inorganic nitrate fertilizer or improper manure management practice (Chapman, 1996).

Table 2: The mean of physiochemical parameters for all studied groundwater sites.

Sampling Sites	Miradee (dug well)	Ahmad brnda spring)	Chinarah (dug well)	Azaban (Spring)	Siyara (Spring)	Birke (Spring)	Qashti (Spring)
Sample Site codes	1	2	3	4	5	6	7
pH	7.23	7.68	7.44	7.59	7.43	7.47	7.40
Electrical Conductivity (EC) µS cm^{-1}	584.50	342.50	527.50	345.50	459.00	704.00	796.50
Total Dissolved Solid (TDS) mg l^{-1}	374.08	219.20	337.60	221.12	293.76	450.56	509.76
Turbidity NTU	4.94	< 0.01	1.67	2.28	< 0.01	< 0.01	0.27
Calcium (Ca^{2+}) mg l^{-1}	138.50	140.50	152.50	151.50	137.50	136.50	152.50
Magnesium (Mg^{2+})mg l^{-1}	61.30	67.75	75.55	63.30	68.30	82.30	92.15
Total Hardness as CaCO$_3$ TH mg^{-1}	598.21	629.76	680.40	650.34	625.15	679.67	760.17
Chloride (Cl^{-}) mg l^{-1}	27.00	19.50	25.00	20.00	20.00	29.50	26.00
Sulphate (SO$_4^{2-}$) mg l^{-1}	91.00	49.50	53.50	58.50	43.00	131.00	126.00
Phosphate (PO$_4$-P) mg l^{-1}	0.25	0.35	0.30	0.35	0.20	0.45	0.30
Sodium (Na^{+}) mg l^{-1}	10.81	5.40	11.75	6.49	8.35	19.29	28.30
Potassium (K^{+}) mg l^{-1}	0.37	0.43	0.28	0.33	0.20	2.26	1.78
Nitrate (NO$_3$-N) mg^{-1}	8.50	3.70	4.50	6.90	6.25	1.50	4.60
Nitrite (NO$_2$-N) mg l^{-1}	0.02	0.01	0.02	0.01	0.02	0.01	0.02

Table 3: Calculation of water quality index in site (1)

Parameters	Observed Value (V_n)	Standard Value (S_n)	Unit weight (Wn)	Quality rating (q_n)	q_nW_n
pH	7.23	6.5-8.5	0.1176	15.333	1.80
Electrical Conductivity (EC) µS cm^{-1}	584.50	1500	0.0007	38.9667	0.03
Total Dissolved Solid (TDS) mg l^{-1}	374.08	1000	0.0010	37.4080	0.04
Turbidity NTU	4.94	5	0.2000	98.8000	19.76
Calcium (Ca^{2+}) mg l^{-1}	138.50	75	0.0133	184.6667	2.46
Magnesium (Mg^{2+}) mg l^{-1}	61.30	100	0.0100	61.3000	0.61
Total Hardness as CaCO$_3$ TH mg l^{-1}	598.21	500	0.0020	119.6412	0.24
Chloride (Cl$^-$) mg l^{-1}	27.00	250	0.0040	10.8000	0.04
Sulphate (SO$_4^{2-}$) mg l^{-1}	91.00	250	0.0040	36.4000	0.15
Phosphate (PO$_4$-P) mg l^{-1}	0.25	5	0.2000	5.0000	1.00
Sodium (Na$^+$) mg l^{-1}	10.81	250	0.0040	4.3252	0.02
Potassium (K$^+$) mg l^{-1}	0.37	12	0.0833	3.1000	0.26
Nitrate (NO$_3$-N) mg $^{-1}$	8.50	10	0.1000	85.0000	8.50
Nitrite (NO$_2$-N) mg l^{-1}	0.02	3	0.3333	0.6667	0.22
			$\Sigma\ Wn$ = **1.07**	$\Sigma\ q_n$ = **701.41**	$\Sigma\ q_nW_n$ = **35.12**
Overall Water Quality Index = *WQI* =Σ *qn Wn* / Σ *Wn* = **32.82**					

Table 4: Calculation of water quality index in site (2)

Parameters	Observed Value (V_n)	Standard Value (S_n)	Unit weight (Wn)	Quality rating (q_n)	q_nW_n
pH	7.68	6.5-8.5	0.1176	45.3333	5.33
Electrical Conductivity (EC) µS cm^{-1}	342.50	1500	0.0007	22.8333	0.02
Total Dissolved Solid (TDS) mg l^{-1}	219.20	1000	0.0010	21.9200	0.02
Turbidity NTU	< 0.01	5	0.2000	0.2000	0.04
Calcium (Ca^{2+}) mg l^{-1}	140.50	75	0.0133	187.3333	2.49
Magnesium (Mg^{2+}) mg l^{-1}	67.75	100	0.0100	67.7500	0.68
Total Hardness as CaCO$_3$ TH mg l^{-1}	629.76	500	0.0020	125.9510	0.25
Chloride (Cl$^-$) mg l^{-1}	19.50	250	0.0040	7.8000	0.03
Sulphate (SO$_4^{2-}$) mg l^{-1}	49.50	250	0.0040	19.8000	0.08
Phosphate (PO$_4$-P) mg l^{-1}	0.35	5	0.2000	7.0000	1.40
Sodium (Na$^+$) mg l^{-1}	5.40	250	0.0040	2.1584	0.01
Potassium (K$^+$) mg l^{-1}	0.43	12	0.0833	3.6167	0.30
Nitrate (NO$_3$-N) mg $^{-1}$	3.70	10	0.1000	37.0000	3.70
Nitrite (NO$_2$-N) mg l^{-1}	0.01	3	0.3333	0.3333	0.11
			$\Sigma\ Wn$ = **1.07**	$\Sigma\ q_n$ = **549.03**	$\Sigma\ q_nW_n$ = **14.46**
Overall Water Quality Index = *WQI* =Σ *qn Wn* / Σ *Wn* = **13.51**					

Table 5: Calculation of water quality index in site (3)

Parameters	Observed Value (V_n)	Standard Value (S_n)	Unit weight (Wn)	Quality rating (q_n)	q_nW_n
pH	7.44	6.5-8.5	0.1176	29.3333	3.45
Electrical Conductivity (EC) µS cm^{-1}	527.50	1500	0.0007	35.1667	0.02
Total Dissolved Solid (TDS) mg l^{-1}	337.60	1000	0.0010	33.7600	0.03
Turbidity NTU	1.67	5	0.2000	33.4000	6.68
Calcium (Ca^{2+}) mg l^{-1}	152.50	75	0.0133	203.3333	2.70
Magnesium (Mg^{2+}) mg l^{-1}	75.55	100	0.0100	75.5500	0.76
Total Hardness as CaCO$_3$ TH mg l^{-1}	680.40	500	0.0020	136.0796	0.27
Chloride (Cl$^-$) mg l^{-1}	25.00	250	0.0040	10.0000	0.04
Sulphate (SO$_4^{2-}$) mg l^{-1}	53.50	250	0.0040	21.4000	0.09
Phosphate (PO$_4$-P) mg l^{-1}	0.30	5	0.2000	6.0000	1.20
Sodium (Na$^+$) mg l^{-1}	11.75	250	0.0040	4.7016	0.02
Potassium (K$^+$) mg l^{-1}	0.28	12	0.0833	2.3333	0.19
Nitrate (NO$_3$-N) mg $^{-1}$	4.50	10	0.1000	45.0000	4.50
Nitrite (NO$_2$-N) mg l^{-1}	0.02	3	0.3333	0.6667	0.22
			$\Sigma\ Wn$ = **1.07**	$\Sigma\ q_n$ = **636.72**	$\Sigma\ q_nW_n$ = **20.18**
Overall Water Quality Index = *WQI* =Σ *qn Wn* / Σ *Wn* = **18.86**					

Table 6: Calculation of water quality index in site (4)

Parameters	Observed Value (V_n)	Standard Value (S_n)	Unit weight (Wn)	Quality rating (q_n)	q_nW_n
pH	7.59	6.5-8.5	0.1176	39.3333	4.63
Electrical Conductivity (EC) µS cm^{-1}	345.50	1500	0.0007	23.0333	0.02
Total Dissolved Solid (TDS) mg l^{-1}	221.12	1000	0.0010	22.1120	0.02
Turbidity NTU	2.28	5	0.2000	45.6000	9.12
Calcium (Ca^{2+}) mg l^{-1}	151.50	75	0.0133	202.0000	2.69
Magnesium (Mg^{2+}) mg l^{-1}	63.30	100	0.0100	63.3000	0.63
Total Hardness as CaCO$_3$ TH mg l^{-1}	650.34	500	0.0020	130.0670	0.26
Chloride (Cl$^-$) mg l^{-1}	20.00	250	0.0040	8.0000	0.03
Sulphate (SO$_4$$^{2-}$) mg l^{-1}	58.50	250	0.0040	23.4000	0.09
Phosphate (PO$_4$-P) mg l^{-1}	0.35	5	0.2000	7.0000	1.40
Sodium (Na$^+$) mg l^{-1}	6.49	250	0.0040	2.5972	0.01
Potassium (K$^+$) mg l^{-1}	0.33	12	0.0833	2.7500	0.23
Nitrate (NO$_3$-N) mg l^{-1}	6.90	10	0.1000	69.0000	6.90
Nitrite (NO$_2$-N) mg l^{-1}	0.01	3	0.3333	0.3333	0.11
			ΣWn = **1.07**	Σq_n = **638.53**	Σq_nW_n = **26.14**
Overall Water Quality Index = $WQI = \Sigma qn\ Wn / \Sigma Wn$ = 24.43					

Table 7: Calculation of water quality index in site (5)

Parameters	Observed Value (V_n)	Standard Value (S_n)	Unit weight (Wn)	Quality rating (q_n)	q_nW_n
pH	7.43	6.5-8.5	0.1176	28.6667	3.37
Electrical Conductivity (EC) µS cm^{-1}	459.00	1500	0.0007	30.6000	0.02
Total Dissolved Solid (TDS) mg l^{-1}	293.76	1000	0.0010	29.3760	0.03
Turbidity NTU	< 0.01	5	0.2000	0.2000	0.04
Calcium (Ca^{2+}) mg l^{-1}	137.50	75	0.0133	183.3333	2.44
Magnesium (Mg^{2+}) mg l^{-1}	68.30	100	0.0100	68.3000	0.68
Total Hardness as CaCO$_3$ TH mg l^{-1}	625.15	500	0.0020	125.0292	0.25
Chloride (Cl$^-$) mg l^{-1}	20.00	250	0.0040	8.0000	0.03
Sulphate (SO$_4$$^{2-}$) mg l^{-1}	43.00	250	0.0040	17.2000	0.07
Phosphate (PO$_4$-P) mg l^{-1}	0.20	5	0.2000	4.0000	0.80
Sodium (Na$^+$) mg l^{-1}	8.35	250	0.0040	3.3404	0.01
Potassium (K$^+$) mg l^{-1}	0.20	12	0.0833	1.6833	0.14
Nitrate (NO$_3$-N) mg l^{-1}	6.25	10	0.1000	62.5000	6.25
Nitrite (NO$_2$-N) mg l^{-1}	0.02	3	0.3333	0.6667	0.22
			ΣWn = **1.07**	Σq_n = **562.90**	Σq_nW_n = **14.36**
Overall Water Quality Index = $WQI = \Sigma qn\ Wn / \Sigma Wn$ = 13.42					

Table 8: Calculation of water quality index in site (6)

Parameters	Observed Value (V_n)	Standard Value (S_n)	Unit weight (Wn)	Quality rating (q_n)	q_nW_n
pH	7.47	6.5-8.5	0.1176	31.3333	3.68
Electrical Conductivity (EC) µS cm^{-1}	704.00	1500	0.0007	46.9333	0.03
Total Dissolved Solid (TDS) mg l^{-1}	450.56	1000	0.0010	45.0560	0.05
Turbidity NTU	< 0.01	5	0.2000	0.2000	0.04
Calcium (Ca^{2+}) mg l^{-1}	136.50	75	0.0133	182.0000	2.42
Magnesium (Mg^{2+}) mg l^{-1}	82.30	100	0.0100	82.3000	0.82
Total Hardness as CaCO$_3$ TH mg l^{-1}	679.67	500	0.0020	135.9338	0.27
Chloride (Cl$^-$) mg l^{-1}	29.50	250	0.0040	11.8000	0.05
Sulphate (SO$_4$$^{2-}$) mg l^{-1}	131.00	250	0.0040	52.4000	0.21
Phosphate (PO$_4$-P) mg l^{-1}	0.45	5	0.2000	9.0000	1.80
Sodium (Na$^+$) mg l^{-1}	19.29	250	0.0040	7.7172	0.03
Potassium (K$^+$) mg l^{-1}	2.26	12	0.0833	18.8250	1.57
Nitrate (NO$_3$-N) mg l^{-1}	1.50	10	0.1000	15.0000	1.50
Nitrite (NO$_2$-N) mg l^{-1}	0.01	3	0.3333	0.3333	0.11
			ΣWn = **1.07**	Σq_n = **638.83**	Σq_nW_n = **12.59**
Overall Water Quality Index = $WQI = \Sigma qn\ Wn / \Sigma Wn$ = 11.77					

Table 9: Calculation of water quality index in site (7)

Parameters	Observed Value (V_n)	Standard Value (S_n)	Unit weight (Wn)	Quality rating (q_n)	q_nW_n
pH	7.40	6.5-8.5	0.1176	26.6667	3.14
Electrical Conductivity (EC) µS cm^{-1}	796.50	1500	0.0007	53.1000	0.04
Total Dissolved Solid (TDS) mg l^{-1}	509.76	1000	0.0010	50.9760	0.05
Turbidity NTU	0.27	5	0.2000	5.4000	1.08
Calcium (Ca^{2+}) mg l^{-1}	152.50	75	0.0133	203.3333	2.70
Magnesium (Mg^{2+}) mg l^{-1}	92.15	100	0.0100	92.1500	0.92
Total Hardness as CaCO$_3$ TH mg l^{-1}	760.17	500	0.0020	152.0348	0.30
Chloride (Cl$^-$) mg l^{-1}	26.00	250	0.0040	10.4000	0.04
Sulphate (SO$_4^{2-}$) mg l^{-1}	126.00	250	0.0040	50.4000	0.20
Phosphate (PO$_4$-P) mg l^{-1}	0.30	5	0.2000	6.0000	1.20
Sodium (Na$^+$) mg l^{-1}	28.30	250	0.0040	11.3196	0.05
Potassium (K$^+$) mg l^{-1}	1.78	12	0.0833	14.8583	1.24
Nitrate (NO$_3$-N) mg l^{-1}	4.60	10	0.1000	46.0000	4.60
Nitrite (NO$_2$-N) mg l^{-1}	0.02	3	0.3333	0.6667	0.22
			Σ Wn = **1.07**	Σ q_n = **723.31**	Σ q_nW_n = **15.78**
Overall Water Quality Index = *WQI =Σ qn Wn / Σ Wn* = **14.75**					

V.   Conclusions

The drinking water quality results of the villages Miradee, Ahmad brnda, China rah, Azaban, Siyara, Birke and Qashti, show that the highest water quality was recorded at the site (1) Miradee (WQI = 32.82) due to the increases in the human population, agricultural activities and it was very close to septic system, whereas the lowest quality found at site (6) Birke (WQI = 11.77). These water samples were fit for drinking without proper treatment according to standard WHO.

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