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Study of qualitative analysis of groundwater resources Silakhor plain's, Lorestan province, Iran

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ABSTRACT

The pollutants of ground water resources are divided in to two groups, natural and human factors. The purpose of this research is to study Silakhor plain hydrochemically and its pollutants. Silakhor plain is about 1100 square kilometer located in the west of Iran and north east of Lorestan province. In this research, the quality of surface and ground waters of Silakhor plain and also the effective factors on the quality of this water have been studied. In order to do this, in two dry season. (October, 2014) and wet season (May, 2015) 32 and 20 samples of Silakhors' underground and surface waters were taken. Parameters such as electronic conductivity (EC) and acidity (PH) were measured in their own taken places. Then, in order to study the effect of geological factors on the quality of the regions' waters, the density of the main anions and cations of the plains' water resources were studied and the results were compared with the universal standards world's amounts. After that, in order to study the effect of agricultural activities, the density of nitrate and phosphate and to study the effect of industrial activities the density of heavy elements was studied. The result of this research shows that just concentration of Boron in three samples was higher than the universal standards and it is due to the adjacency of these places to stonecutting workplaces. It seems that it is these stone cuttings which have caused an increase in concentration of Boron in the samples.

Keywords: Quality water, Pollution, Ground water aquifers, Silakhor.

INTRODUCTION

One of the main pollutants in ground waters is due to the lithology and mineralogy characteristics of the stones which are in the water stream and the mines in the regions' stones has mainly caused high concentration of constitutive elements of these stores [1] Agricultural activities are probably the largest source of man–made nitrate which enters ground waters.

Nitrogen is essential for growing of plants and increases the quantity of agricultural products, however, if it used in a great deal, it enters through ground water in form of Nitrate. Nitrate in ground waters has a high mobility and it is absorbed less [2]. However, the amount of nitrate in ground waters depends on that regions' geological condition. The amount of nitrate in wells of infirm and non-condensed formations is more than the other wells [3]. Silakhor plain is about 1100 square kilometer and located in the west of Iran and north east of Lorestan between longitude of 48^o and 30 minutes to 49^o and 10 minutes of eastern latitude from 38^o and 48 minutes to 34^o and 10 minute of northern.

Its highest point from sea level is Garrin mountain whose height is 3645 meters and its lowest point is south of which has a height of 1450 meters from the sea level. Thus the difference from the highest point to the lowest point is about 2150 meters. Generally, the slope of basin in head spring of aquifer is more than flat places (Figure1).

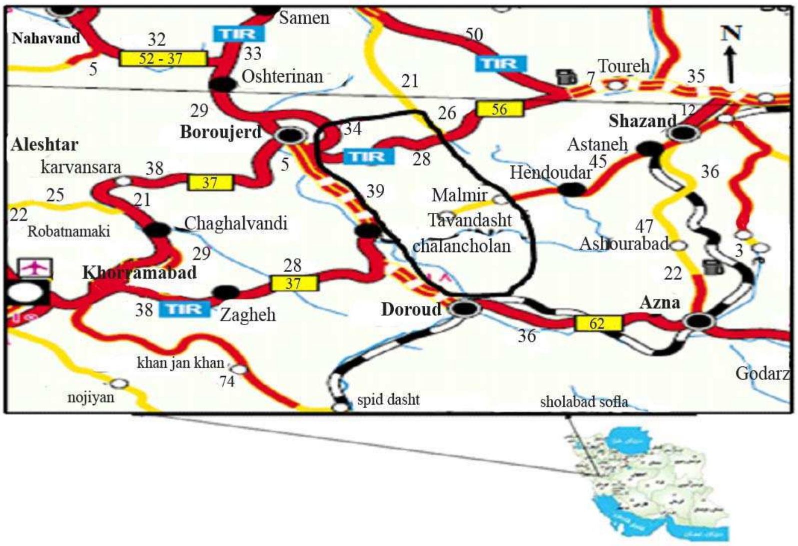

Figure 1- The geographical situation of the under-study region (taken from Iran's roadways map)

There has been a comprehensive study about the characteristics of this region's hydro geological and hydro chemical ground water sources and its pollutants so far , and the main purpose of this research is to do such a study in the area between Boroujerd and Doroud on a space about 200 square kilometers.

The hydrologic aquifer of Silakhor plain is composed of two main substances: lime and Trans formed–igneous. The main formations of the region in its west and North West are lime and Carbonate formation with lots of cracks and Slits, while on the eastern and south eastern of this aquifer granite and gneiss and Trans formed, igneous formation more could be found (Figure 2).

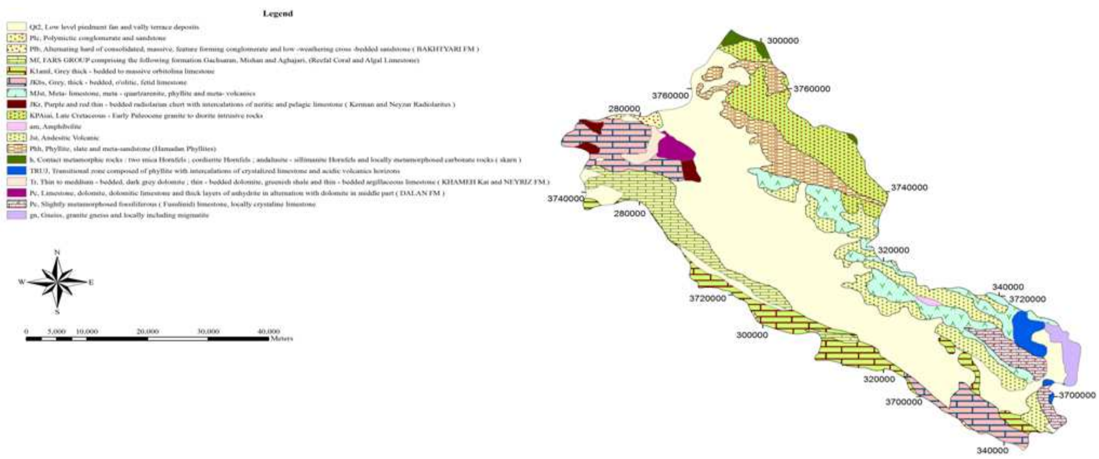

Figure 2- Geology map of Silakhor plain

EXPERIMENTAL SECTION

To evaluate the effects of human activities and geology factors (specially agricultural and industrial activities) in the quality of Silakhor plain's ground water, the following tasks have been done.

1- Collecting the information and maps of the region.
2- Field activities and measuring the parameters needed in field.
3- Lab studies.
4- Statistics work done with soft wares.

Taking samples of underground and surface waters of the basin of Silakhor was done in two dry and wet seasons. In the first sample, 32 samples of underground and surface sample were taken from this basin, and they were sent to laboratory for chemical analyzing (to determine the amounts of cation, anion, nitrate, phosphate and heavy metals).

Theses soft wares have been used in this research: Are GIS, Rock work, surfer, RHREEQC, Aqua, and chemistry. The multi variable analyzing is a quantitative and independent approach which categorizes the sources of the ground water based on adhesion among chemical parameters.

The use of different multi variable analyses such as principal component analysis (PCA) and correspondence analysis (CA) causes a better understanding of the alteration in the quality of water and a better comparison of samples with each other [4, 5]. Data standardizing decreases the effect of variables with high variance and increases the effect of variables with low variance. Furthermore, standardizing with deleting different parameters can have a better explanation of their relations. To analyze multi variables statistics, first of all the data should be standardized. Standardizing is calculated from the following formula:

$Z = (x = \mu) / \sigma$
X = shows the primary amount of the measured parameter.
μ = the average of the measured parameters in all sample, and
σ = the standard deviation of that parameter [6].

Linear correlation among different variables is determined with coefficients between +1 and -1. When the numerical coefficient correlation is close to +1 or -1, the relation of two parameters has a significant value. Positive correlation reveals common characteristics between two different items like common–evolutionary pattern form up stream to downstream; negative correlation reveals the alterations of one of the parameters from up streams to downstream be against of the other parameter.

RESULTS AND DISCUSSION

In this research, the correlation matrix has drown based on Pearson's method (because of the abundance of the sample) and with the software 'spss19' which has been showed in table 5. As you see in this table, Sodium, Sulphate, Chlorine, TDS, and EC have a high correlation with each other. Because of this fact and also because the maps with the same consistency taken from the software 'surfer', it could be explained that the density of the mentioned parameters increases from the upstream of the basin toward the downstream. On the other hand bicarbonate has a very negative relation with Calcium and acidity and based on the changes in its density it can be said from upstream toward downstream its amount would be increased. The cations of calcium and Magnesium just have a positive correlation with each other, this fact shows that there are lots of chemical and behavioral similarities between these two elements from upstream toward downstream and also their origins are the same (table1).

Table 1 – Pearson's coefficient correlation in different physiochemical parameters in Silakhor plain's waters

	pH	EC	TDS	TH	Ca	Mg	Na	K	TA	HCO_3	Cl	SO_4
pH	1.000	-0.092	-0.096	-0.328	-0.313	-0.104	0.131	0.003	-0.069	-0.069	-0.089	0.095
EC	-0.092	1.000	**1.000****	**0.653****	0.296	**0.766****	**0.835****	**0.768****	**0.715****	**0.715****	**0.873****	**0.785****
TDS	-0.096	**1.000****	1.000	**0.653****	0.292	**0.768****	**0.834****	**0.769****	**0.717****	**0.717****	**0.869****	**0.785****
TH	-0.328	**0.653****	**0.653****	1.000	**0.785****	**0.726****	0.154	0.242	**0.489****	**0.489****	**0.556****	0.258
Ca	-0.313	0.296	0.292	**0.785****	1.000	0.213	-0.171	0.019	-0.024	-0.024	**0.412****	-0.004
Mg	-0.104	**0.766****	**0.768****	**0.726****	0.213	1.000	**0.502****	**0.411***	**0.869****	**0.869****	**0.457****	**0.465****
Na	0.131	**0.835****	**0.834****	0.154	-0.171	**0.502****	1.000	**0.854****	**0.630****	**0.630****	**0.750****	**0.821****
K	0.003	**0.768****	**0.769****	0.242	0.019	**0.411***	**0.854****	1.000	**0.506****	**0.506****	**0.706****	**0.850****
TA	-0.069	**0.715****	**0.717****	**0.489****	-0.024	**0.869****	**0.630****	**0.506****	1.000	**1.000****	0.346	**0.459****
HCO_3	-0.069	**0.715****	**0.717****	**0.489****	-0.024	**0.869****	**0.630****	**0.506****	1.000	1.000	0.346	**0.459****
Cl	-0.089	**0.873****	**0.869****	**0.556****	**0.412***	**0.457****	**0.750****	**0.706****	0.346	0.346	1.000	**0.666****
SO_4	0.095	**0.785****	**0.785****	0.258	-0.004	**0.465****	**0.821****	**0.850****	**0.459****	**0.459****	**0.666****	1.000

The analysis of the main component was done to better explain the relation between physiochemical parameters in ground water sources and decreasing in variables. A certain amount and a specific vector from the matrix of covariance variables were taken in this method.

Each of the principal components is a collection of independent variables, which through the multiplication of dependent variable in each other, is show with a special vector. The special amount of each of the principal component is a unit of cumulative variance and the presence of the primary variables in the principal components is determined through number loading and monitoring the changes of each of the variables which generally is called ranking. First, the variables with high correlation are arranged and determined. In order to evaluate the eligibility, GrowitBartletr test on the correlation matrix of the data will be done. According to cattle & Jasper's standards, the principal components which their specific amount are more than 1 (Eigen value>1) they are remained and the rest will be omitted [5, 6]. In table two the principal components of physicochemical parameters are given.

Table 2 – The amount of principal components of physiochemical parameter existing in Silakhor plain's waters

	component			
	1	**2**	**3**	**4**
pH	-0.053	-0.591	-0.033	-0.370
EC	**0.980**	0.100	0.107	-0.029
TDS	**0.980**	0.101	0.102	-0.022
TH	**0.591**	**0.757**	-0.032	-0.200
Ca	0.187	**0.820**	0.335	-0.340
Mg	**0.798**	0.272	-0.458	-0.069
Na	**0.877**	-0.425	0.123	0.076
K	**0.812**	-0.239	0.300	0.211
TA	**0.797**	0.035	-0.576	0.108
HCO_3	**0.797**	0.035	-0.576	0.108
Cl	**0.812**	0.087	0.491	-0.169
SO_4	**0.802**	-0.250	0.295	0.156

As it can be seen in the above table, the first component has most of the above parameters. This pact shows that these parameters are in one group based on geochemical characteristics. Two parameters – calcium and the hardness of water–have a little difference with the other parameters.

However, all of these parameters act, more or less, in the same way. The above explanations could be clearly seen in Figure 3 which relates to the analysis of the principal component.

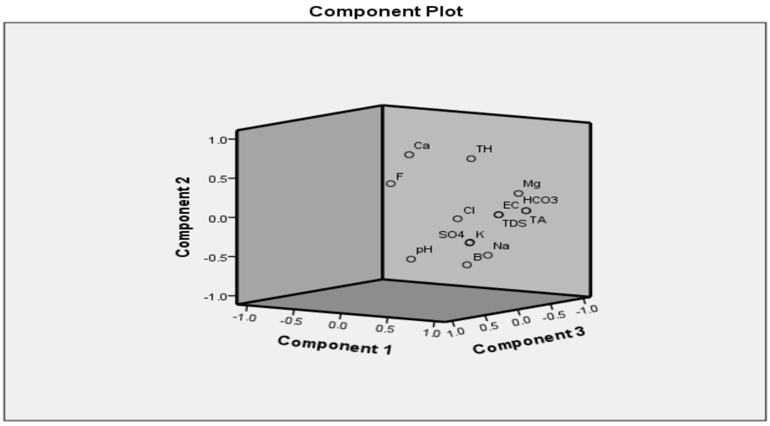

Figure 3 – The diagram of the analysis of the analysis of principal component

In this research and because of the usage of cluster analysis, agglomerative hierarchical clustering based on ward's linkage method, cluster algorithm, and Euclidian distance was done to determine the amount of similarities.

It should be said that, this method is a popular method, considering the variance of the data, evaluates the distance between clusters. Euclidian distance is a geometrical distance in a multidimensional space. The result of this analysis is a diagram which is called dendogram. In Figure 4, the dendogram of water resources for a dry season is showed.

According to this diagram which is drawn with SPSS 19 soft were, the plain's upstream points, downstream points and the interval points could be seen clearly.

That is, the water resources can be divided in to four main groups. These four groups are shown in Figure 5. Group 1 (which is mainly springs) includes the upstream points (the disembarkation point of the secondary feeding stream is also located in this group), the fourth group includes the down–stream points and the second and third groups are also located between these two groups.

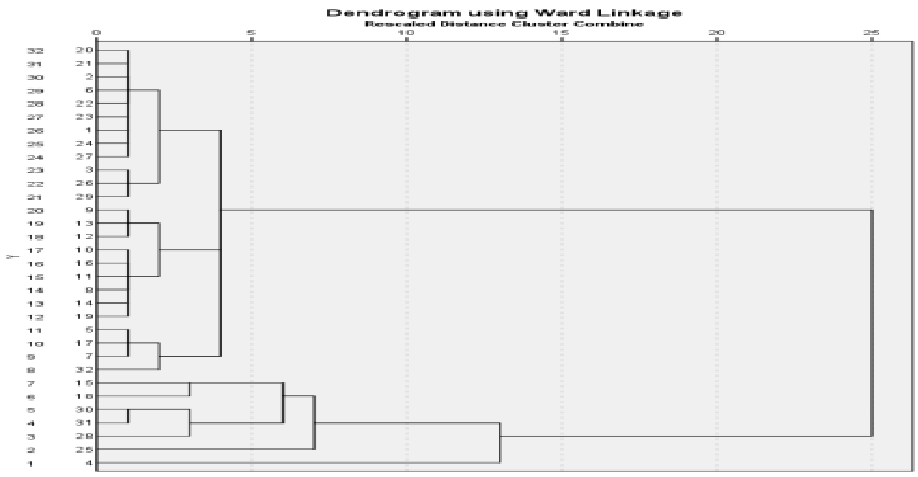

Figure 4- The dendogram of Silakhor plain's water resources (by the use of ward's linkage method and the square of Euclidian distances)

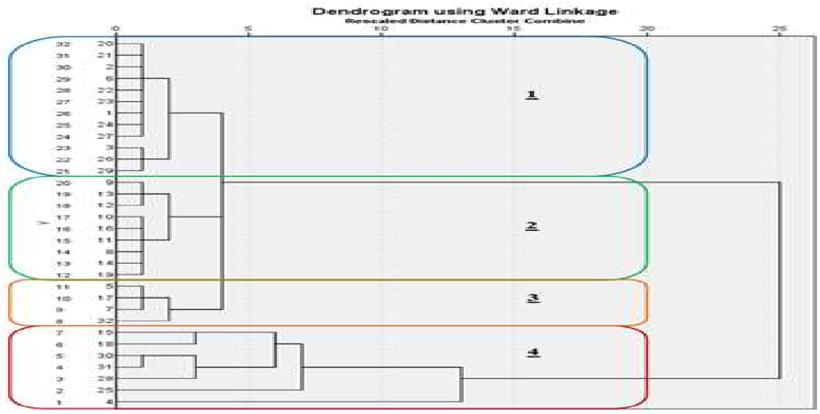

Figure 5- Zoning the points of Silakhor plain with dendogram

In Figure 6 the tree diagram of water resources in wet season is shown.

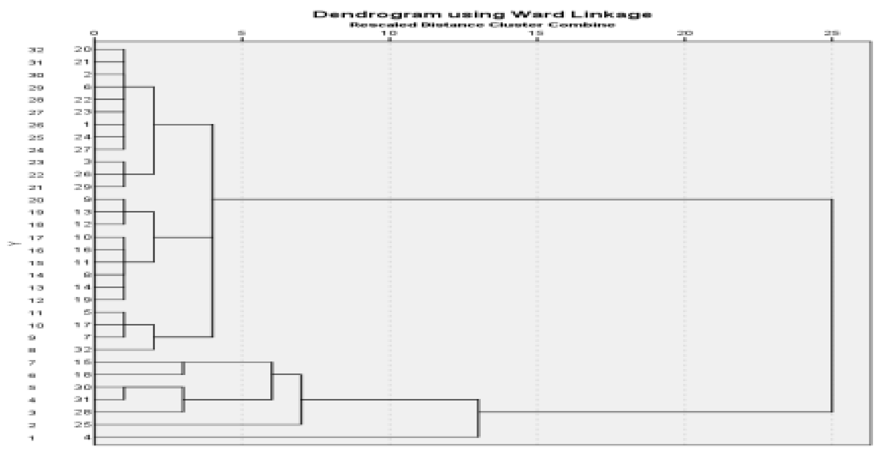

Figure 6- The tree diagram of Silakhor plain's water resources (by the use of ward's linkage method and the square of Euclidian distances)

According to this diagram which is drawn with SPSS 19 software, the plain's upstream points, downstream points and the interval points can be seen clearly. That is, the water resources can be divided in to four main groups. These four groups are shown in Figure 7. The first group, which is mainly springs, includes the upstream points (the disembarkation point of the secondary feeding stream is also located in this group), the fourth group includes the downstream points and the second and third groups are also located between these two groups–the first and the fourth.

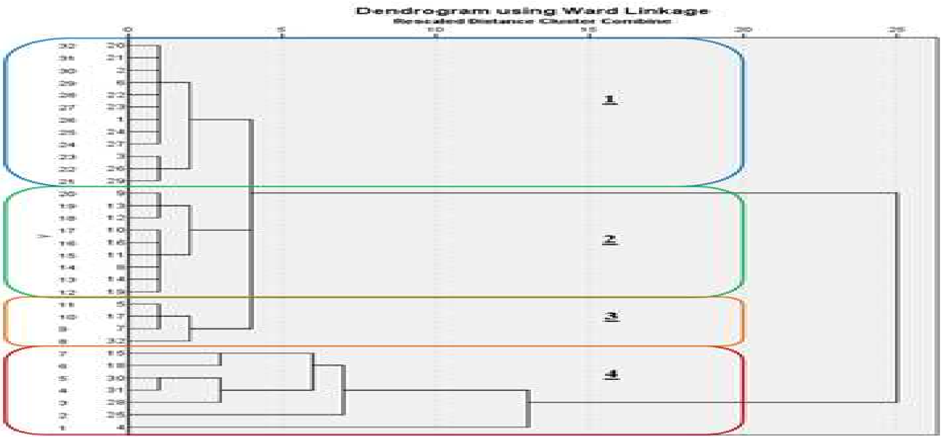

Figure 7- Zoning the points of Silakhor plains with dendogram

Table 3 shows the procedure of ion alteration in the existing zones of this plain. As it can be seen the procedure of alteration of these ions agrees with what said before.

As it is shown, the highest concentration of nitrate can be seen in the middle and downstream of this plain–because of high agricultural activities in this region.

Table 3- the procedure of ion alteration in the different zones of Silakhor plain

zone	EC	TDS	Ca	Mg	Na	K	HCO_3^-	Cl	SO_4^{2-}	NO_3^-
Zone 1	750	395	169	103	32	2.35	236	65	33	3.52
Zone 2	754	392	123	97	75	1.75	250	73	33	7.22
Zone 3	617	320	140	93	41	1.93	249	26	37	5.35
Zone 4	800	418	158	97	71	6.17	271	65	48	9.38

According to Figure 8, in wet season, in which irrigation is done widely and more water resources penetrate in to underground, Nitrate rises in water resources of Silakhor plain. Both in dry and wet season, the concentration of Nitrate in the middle and downstream of the plain is higher than concentration of Nitrate in the other parts of the plain.

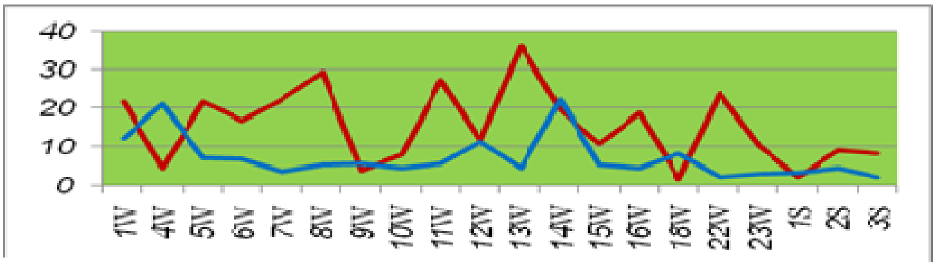

Figure 8- the comparison of the concentration of Nitrate in Silakhor plain's water both in wet and dry seasons.

Considering the alterations of concentration of some heavy elements in Silakhor plain's waters, the effects of industrial activities on the quality of this water was dealt with. In order to determine the effect of industrial activities, the alterations of more than 25 elements were measured, but because the region was not industrial, the concentration of these elements, like dry seasons, in these waters was nearly zero and lowers than the universal standard amount. The concentration of these elements is shown in table 4.

Table 4- The concentration of heavy elements in Silakhor plain's waters in dry season (by ppb)

Abbreviation	As	B	Cr	Cu	Fe	V	Mo	Si	Zn	Sr	F
W_1	<5	120	0	0	0	0	0	14.38	<50	0	1.12
W_2	0	100	0	<30	<50	<10	0	19.2	<50	830	0.89
W_3	0	100	0	<30	<50	<10	0	21.38	<50	430	1.2
W_4	<5	1260	0	<30	68	0	<10	0	<50	0	0.92
W_5	<5	180	<50	<30	<50	0	<10	0	<50	0	0.77
W_6	<5	100	0	<30	<50	0	<10	0	<50	0	0.88
W_7	<5	100	0	<30	<50	0	<10	0	<50	0	0.58
W_8	<5	190	0	<30	<50	0	<10	0	<50	0	0.75
W_9	<5	290	<50	0	68	0	0	0	<50	0	0.95
W_{10}	<5	130	0	<30	<50	0	<10	0	<50	0	1.02
W_{11}	<5	170	0	<30	<50	0	<10	0	<50	0	0.9
W_{12}	<5	210	0	0	<50	0	0	0	<50	0	0.84
W_{13}	<5	230	0	<30	<50	0	<10	0	<50	0	0.86
W_{14}	<5	160	0	<30	<50	0	<10	24.26	<50	0	0.78
W_{15}	<5	1050	<50	<30	<50	0	<10	0	<50	0	0.63
W_{16}	0	0	0	0	0	0	0	0	0	0	0.8
W_{17}	<5	250	<50	<30	0	0	0	19.15	<50	0	0.92
W_{18}	<5	730	<50	<30	<50	0	<10	0	<50	0	0.71
W_{22}	<5	150	<50	<30	<50	0	<10	0	<50	0	0.47
W_{23}	<5	110	<50	<30	<50	<10	<10	0	<50	360	1.02
SP_1	<5	120	0	0	0	0	0	13.29	<50	0	0.87
SP_2	0	150	0	<30	<50	<10	0	16.7	<50	530	0.95
SP_3	0	140	0	<30	<50	<10	0	17.83	<50	590	1.05
SP_4	<5	160	0	0	0	0	0	10.93	<50	0	1.2
SP_6	0	100	0	<30	<50	<10	0	20.83	<50	210	1.02
SP_7	0	190	0	<30	<50	<10	0	18.5	<50	670	1.3
SP_8	<5	190	0	<30	95	0	0	0	<50	0	1.11
SP_9	<5	170	<50	<30	<50	<10	<10	0	<50	550	1.38
S_1	0	0	0	0	0	0	0	6.2	0	0	1.23
S_2	0	0	0	0	0	0	0	17.08	0	0	1.02
S_3	0	0	0	0	0	0	0	13.43	0	0	1.62

Table 5- The concentration of heavy elements in Silakhor plain's water in wet season (by ppb)

Abbreviation	As	B	Cr	Cu	Fe	Mo	Si	Zn	F
W_1	<5	135	0	0	0	<10	14.96	<50	1
W_4	<5	1140	0	<30	162	<10	0	<50	0.85
W_5	<5	195	<50	<30	<50	<10	0	<50	0..84
W_6	<5	120	0	<30	<50	<10	0	<50	0.8
W_7	<5	105	0	<30	<50	<10	0	<50	0.66
W_8	<5	210	0	<30	<50	<10	0	<50	0.71
W_9	<5	270	0	<30	<50	<10	0	<50	1.03
W_{10}	<5	140	0	0	0	0	0	<50	0.9
W_{11}	<5	200	0	<30	<50	<10	0	<50	1.11
W_{12}	<5	200	<50	<30	<50	<10	0	<50	0.95
W_{13}	<5	220	0	<30	<50	<10	0	<50	0.88
W_{14}	<5	190	0	<30	<50	<10	24.93	<50	0.7
W_{15}	<5	1260	0	<30	66	<10	0	<50	0.79
W_{16}	<5	0	0	<30	<50	<10	0	<50	0.89
W_{18}	<5	770	0	<30	104	<10	0	<50	0.82
W_{22}	<5	185	0	<30	<50	<10	0	0	0.55
W_{23}	<5	160	<50	<30	<50	<10	0	<50	0.92
S_1	0	0	0	0	0	0	7.79	<50	1.02
S_2	<5	0	<50	<30	<50	0	<10	0	0
S_3	<5	0	<50	<30	<50	<10	<10	0	360

Based on the above tables, the concentration of the all measured elements was lower than their universal standard amounts. The concentration of Boron was just in 3 samples higher than universal standard, and it was due to the closeness of these regions to stone cuttings. It seems that these stone cuttings hare increased the concentration of Boron in these samples.

CONCLUSION

According to the studies done on Silakhor plain, the concentration of chemical parameters of the ground water resources increases from the upstream of basin toward its downstream. However, Bicarbonate has a very negative relation with Calcium and acidity and based on the alterations of its concentration it can be said that this concentration will increase from upstream toward downstream. Cations of Calcium and Magnesium just have a positive correlation with each other; this fact shows that they have a lot of similarities in behavioral and chemical actions from upstream downstream and it also shows that these two elements have the same origin. It has been also revealed that in wet season, when irrigation is done widely and more water resources penetrate in to the ground, the amount of nitrate in Silakhor plain's water resources will increase. Both in wet and dry seasons, the concentration of Nitrate in the middle and lower parts of the plain is much higher than the parts of the plain. The results calculated from the measuring of heavy elements prove that the concentration of all measured heavy elements is lower than the universal standards. The concentration of Boron is just in 3 samples is higher than universal standard; it is because of the adjacency of these regions to stone cuttings. It seems that it is these stone cuttings increase the concentration of Boron in these samples.

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