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Statistical Analysis of Dez River Water Quality, Southwest of Iran

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ABSTRACT: Dez River is considered as one of the highest water rivers after Karoon River, supplying water for tens of towns and villages as well as thousands of acres of agricultural lands, several fish farming plans and industrial factories. Hence, the water quality of Dez River is one of the major concerns of the area. This study was carried out using descriptive-statistical method based on a 39 year time span statistics. A number of 394 samples were analyzed and the concentration of physical and chemical parameters including pH, TDS, SAR, total cations and anions were measured. The obtained results were examined and compared based on the statistical analyses consistent with the World Health Organization (WHO) standards. Dez River water quality has been "Perfect" in most cases (99.8% of the statistical periods) on the basis of TDS and average sum of them amounting to 644 mg/l; indeed only in 2% of the statistical periods the water quality has been determined as Acceptable, while most of the water quality parameters have been within the permissible range of the WHO standards.
Keywords: Dez River, Physical and Chemical parameters, Statistic method, Pollution.

1. INTRODOCTION

Khouzestan Province with an area of 67130 Km^2 has been located in the southwest of Iran and shares its borders to the north and east with Ilam, Lorestan, Isfahan, Kohkiloyeh- Bouyerahmad, Charmahal- Bakhtiyari, and Boushehr provinces as well as Iraq country to the west and with Persian Gulf to the south. Khouzestan province, enjoying from major rivers including Karoon, Dez, Karkheh, Jarahi and Zohre Rivers fulfills its water needs through surface waters. Dez River is considered as one of the highest water rivers after Karoon River, supplying water for tens of towns and villages as well as thousands of acres of agricultural lands, several fish farming plans and industrial factories. Decrease of the yield due to increasing draw-off from the one hand and discharge of the urban, industrial and agricultural sewages into the river stream from the other has put the water quality status of Dez River at risk.Several studies have been undertaken in different parts of Dez and Karoon Rivers, some of them have been referred to below:

Kabi et al., (2002) tackled zoning of the River within the study range of Karoon River Reorganization Plan in terms of the quality of water contamination sources. The previous studies' results have also been evaluated. In this study it was determined that with respect to the contamination sources within the plan range from the physical, chemical and biological perspectives, the highest physical contaminant relates to the drainages, with the Pars Paper Industrial Group of Haftapeh, Ahvaz Slaughterhouse, and Ahvaz Imam Khomeini Hospital in the next ranks respectively. Kabi et al. (2002) determined the self-cleaning capacity of Karoon River for heavy metals in a selected 60 Km section of the river within Ahvaz City range. Findings of the study showed that the Zinc content of the River within Ahvaz City range was averagely higher than the standards in effect in the U.S. for protecting the aquatic life, and the river had a slight self-cleaning performance during the months of March, April, May, June and August, September. Also the Cadmium amount is not showing any decrease due to self-cleaning operations along the river route.Parham et al. (2008) have investigated the industrial wastewater quality output from major metal manufacturing industries in Ahvaz. The wastewater egress from Iran National Steel Industrial Group, Ahwaz Rolling and Pipe Mills co., Ahvaz Pipe Mills Co. and Kavian steel Co. is directly discharged into Karoon River, Maleh ditch and eventually Shadegan Wetland without any treatment. After statistical consideration and comparing the obtained results it was determined that the highest pollution load of fat, oil and suspended solids belonged to Iran National Steel Industrial Group and the oxygen needed for chemical reactions ending in formation of environmentally hazardous materials such as

chloride and nitrate were discharged into the environment by Ahwaz Rolling and Pipe Mills Co., so that the studied parameters appeared to be higher than the global standards for permissible ranges. Afkhami et al. (2002) have studied the impacts of industrial wastewaters on the Karoon River water quality discharged by Ramin thermal power plant into the River. Statistical analysis of the sampling results taken from sampling stations showed that the entry of power plant sewage in between the stations during sampling month did not indicate significant changes on 95% scale in terms of the study parameters and the conclusion was reached that the wastewater output of the power plant is not significantly affecting the Karoon River water quality considering the discharge volume and the sewage output. Haghighi et al. (2010) examined the microbial variability trend of Karoon River within Ahvaz City range. In this study, by suitably selecting the study stations during a 1 year water period, the microbial parameters including total Cliform (sure or guessed) and physico-chemical parameters have been measured from the entry point of the River into Ahvaz City range. The obtained results from the statistical analysis of the data shows that microbial contamination of the River from the upstream downwards has an increasing trend and by the decrease of discharge volume and precipitation in some months of the year the contamination rate also increased. It also allows the identification of possible factors/sources that influence water system and offer a valuable tool for the reliable management of water resources as well as rapid solutions to pollution problems (Vega et al., 1998 and Simeonov et al., 2003). Rasti et al. (2006) have investigated the effects of the fish farming wastewaters on the water quality of Gargar River which is the eastern branch of Karoon River using algae as biological indicators. These basins discharge their residue directly and indirectly into Gargar River. Shahidi et al. (2017) in their study on the effects of the qualitative factors of Karoon River water on the EC and TDS values modeled the EC and TDS using artificial neural networks, considering other qualitative parameters. Findings represented that the introduced model could predict the TDS and EC rates with high correlation and precision. Zarei et al. (2013) studied the effect of Gachsaran formation on the water quality of Karoon River and compared it with Dez River. This formation thanks to its special petrology can affect the chemical properties of run-offs resulting from precipitation. From the most important factors influential on the water sources quality are saline springs that are separated from this formation. Cao et al., (2014) have investigated the effects climatic factors and season changes in the upper catchments of the yellow River. As a result of global climate change and intense human activity, the spatio-temporal variations in vegetation are showing significant changes. Also multivariate statistical method including cluster analysis (CA) was used to assess temporal and spatial variations in the water quality of Euphrates River, Iraq, for a period 2008-2009 using 16 parameters at 11 sampling sites. And this study shows usefulness of cluster analysis method for analyzing and interpreting of surface water dataset to assess the temporal and spatial variations in the water quality parameters and the optimization of regional water quality sampling network.(Mohammad Salah et al., 2012). Moyel (2014) presents the results of statistical analysis of a set of physical and chemical water quality parameters, monthly collected from December 2012 to November 2013 at seven sampling stations spread over the Shatt Al-Arab River. This study suggests that principal component analysis and cluster analysis techniques are useful tools for identification of important surface water quality monitoring stations and parameters. The results of five-year (2008–2012) hydro chemical research of the Poprad River, the right bank tributary to the Dunajec, were analyzed in the paper. And result statistical differences between the values of individual indices assessed in various measurement-control points were estimated by means of Mann-Whitney nonparametric test Dangerous substances may find their way to surface waters also directly from the atmospheric air, to which dusts and gases are emitted by various industries (Policht-Latawiec et al., 2015). This study was conducted employing a descriptive approach using the information pertaining to a 39 years' time span and a number of 394 samples were taken from different parts of the river for physical and chemical parameters to be measured.

2. MATERIAL AND METHODS

***Hydrometery Network of Dez River basin*:** There are 37 hydrometery stations in Dez River basin from which lie 28 stations on the upstream and 9 stations are located in the downstream of Dez Dam. Distribution of hydrometery stations in Dez River network has been engineered in a way that before confluence of any important branch with the main stream, a hydrometery station has been constructed on the main fork of the river (Ebadati, 2014).12 stations out of the mentioned 37 stations have been installed in Khouzestan Province, and 21 and 4 stations have been located in Lorestan and Charmohal- Bakhtiyari provinces respectively.The statistics used in this study belong to a 39 year time span and the sampling included TDS, pH, total

cations and total anions. Accordingly, parameters like Sodium absorption rate, total hardness etc. were determined observing the current standards and using the facilities in Water, Soil and Sedimentation Laboratories Department of deputy basic studies and master Plans of Khouzestan Water Sources Management. Ske_Ngton et al. (2015) present 5 concerned with the accuracy and precision with which chemical status in rivers can be measured given certain sampling strategies, and how this can be improved. These results suggest that in some cases it will be difficult to assign accurate WFD chemical classes or to detect likely trends using current sampling regimes, even for these largely groundwater-fed rivers.(Ske_Ngton et al., 2015). Also application of Multivariate Statistical Techniques in the Assessment of Water Quality in Sakarya River studied. (Yerel et al., 2012). And Using Multivariate Statistical Techniques in Red Soil Hilly Region worked for Assessment of Surface Water Quality (Zhang et al. 2009). Analyze physical, chemical and microbiological quality were subjected to two multivariate methods, namely Cluster analysis (Ward's method) and Principal Component Analysis (PCA). Ali Khan et al., 2014) found that the water available in the Hingol River Bridge is not absolutely safe and contaminated with human and animal wastes. Multivariate statistical techniques namely factor analysis and cluster analysis were applied to evaluate spatial variations, and to interpret measured water quality data set (Alhassan et al., 2014). Assessment and benchmarking of Mediterranean Basin for water pipe networks performance worked (Kanakoudis et al., 2015).And methods were applied to Linggi River water quality data sets to evaluate spatial temporal variations and identify sources of pollutants. (Mohmad Khalil et al., 2015). The obtained results were used in statistical analyses as follows (Ebadati et al., 2014):

Statistical methods: Numerical mean μ: where *N* is the sampling volume and μ is the sample mean.The mean is the same as middle value. If the data are not present in the frequency table, we must adjust them in ascending or descending order. In case of add number of data, the middle data is considered as the mean and in case of having even number of data, the mean of the two middle data numbers shall be used as the mean. In frequency tables, the mean is the first value of the group the accumulated frequency of which is equal to half or higher than half of total sum of accumulated frequency. Defining a sampling time as part of the assessment procedure would be a straight forward process and reduce some of the uncertainty being discussed here, 25 as previously suggested for The Cut by (Halliday et al., 2015).

Variance: The second order central moment of data (random variables) is called the variance or dispersion of data (mean deviation). Variance is the square average difference of data from the mean. The root mean variance is called standard deviation which is of the same scale with data(Marsili-Libelli and Giusti 2007). And SPSS software was used for statistical analyses (Ebadati et al., 2014). For example the statistical test for investigating the correlation between data was performed using this software.

Factor analysis is used in Chemo metric methods to provide the most meaningful variables, with minimum loss of original information from PCA (Nayan et al., 2012; Vega, et al., 1998). The outcome is attempted to transform inter correlated variables into smaller set of new independent variables, also called as vary factors (Zhao et al., 2011).And Liu et al. (2014) used an objective method to optimize sampling frequencies on the Xiangjiang River in China, concluding that adequate characterization could be 20 obtained by sampling at intervals varying between every 2 months and every 6 months

3. RESULT AND DISCUSSION

The mean pH of Dez River water inside Dezful City range was 8.02. The water quality is at optimum range.As can be seen from graph, the years 2008 and 2012 have indicated the largest and smallest pH value during the study time span. Dez River pH seasonal changes are shown in the Fig. of 1. The numbers shown at the horizontal axis represents the summer and winter months.As can be seen no interference is observed between the two curves. Also the pH value in summer seasons is always larger than winter in the Dezful city.

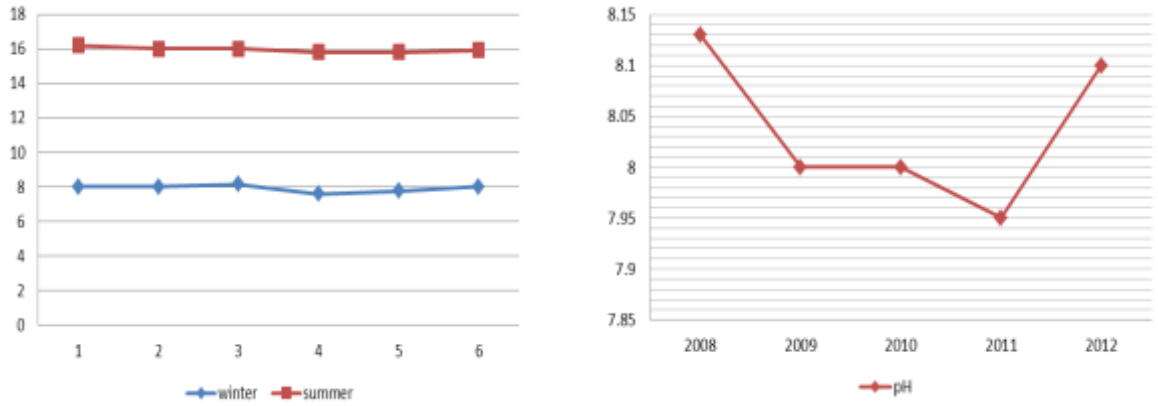

Fig.1- Dez River pH seasonal changes (left graph) and pH value during the study time span (right graph).

Dez River pH standard deviation was obtained as equal to 0.24; such a low value is indicative of the pH value being close to neutral and non-alkaline or non-acidic state.

Dez River pH data median value within Dezful City range was obtained as equal to 8 which is indicative of relatively neutral state of the water.

3.1. Statistical t-test between pH and other water parameters: Using SPSS software and statistical t-test the relationship between pH parameter and other qualitative parameters of the water were considered at 95 and 99% significance level the results of which are as follows:

-Relationship between pH and EC: at 95% and 99% significance level show in the table of 1. As can be seen from above no significant relationship can be observed at both 95 and 99 percent significance levels between pH and EC parameter. However in case the significance test value was lower than 0.05 we could be sure to see a significant relationship between the two.

Table 1 - Statistical t-test between pH and EC at 95% and 99% significance level

99% significance level		95% significance level		descriptive
EC	pH	EC	pH	
498.7157	8.015533	498.7157	8.015533	Mean
10084.66	0.057835	10060.05	0.057835	Variance
393	394	394	394	Observations
	5035.937		5030.055	Pooled Variance
	-		-	Hypothesized Mean
	0		0	Difference
	785		786	df
	96.9812		-97.1098	t stat
	0		0	P(T<=t) one-tail
	2.331108		1.646795	t Critical one-tail
	0		0	P(T<=t) two-tail
	2.582107		1.962987	t Critical two-tail

Total solid soluble materials (TDS): The results of statistical analysis of TDS data using statistical t-test have been represented in Table 2:

Table 2- statistical analysis of TDS data at 95% significance level

TDS	descriptive
314.7437	Mean
3.41316	Standard Error
311.5	Median
280	Mode
67.7493	Standard Deviation
4589.967	Sample Variance
12.98811	Kurtosis
2.12874	Skewness
701	Range
164	Minimum
865	Maximum
124009	Sum
394	Count
865	Largest(1)
164	Smallest(1)
-	Confidence
6.710336	Level (95.o %)

Considering the last result of the above table, it is manifested that the TDS has no relationship with seasonal changes and weather conditions.The mean total amount of soluble solid materials was about 314.74 mg/l which is 37% less than the maximum standard range of Iranian as well as permissible range of Indian standards. The minimum amount of TDS has been 164 mg/l which is 67.2% lower than the maximum standard range according to the Iranian standards and below of the minimum acceptable limit in accordance with the World Health Organization (WHO).

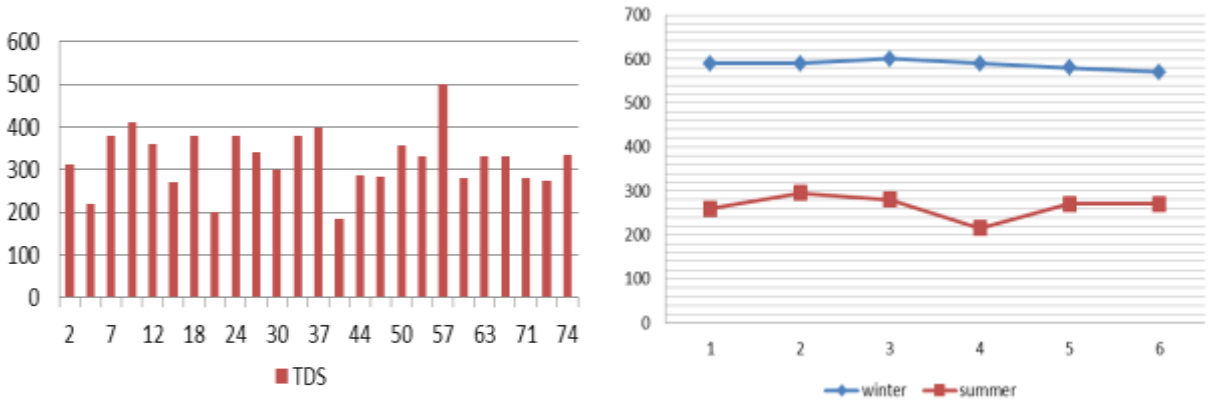

Fig. 2- Seasonal changes of TDS values (right graph) and illustrates the TDS monthly changes during the study time (left graph) in Dez River water at Dezful station.

Figure of 3 represents the correlation between TDS and total sum of anions and cations during the statistical period using mathematical relationship.
It can be observed that:

a- Separate considering and determining of the correlation would enhance the accuracy. b- The correlation between TDS and cations is higher than the correlation between TDS and anions.

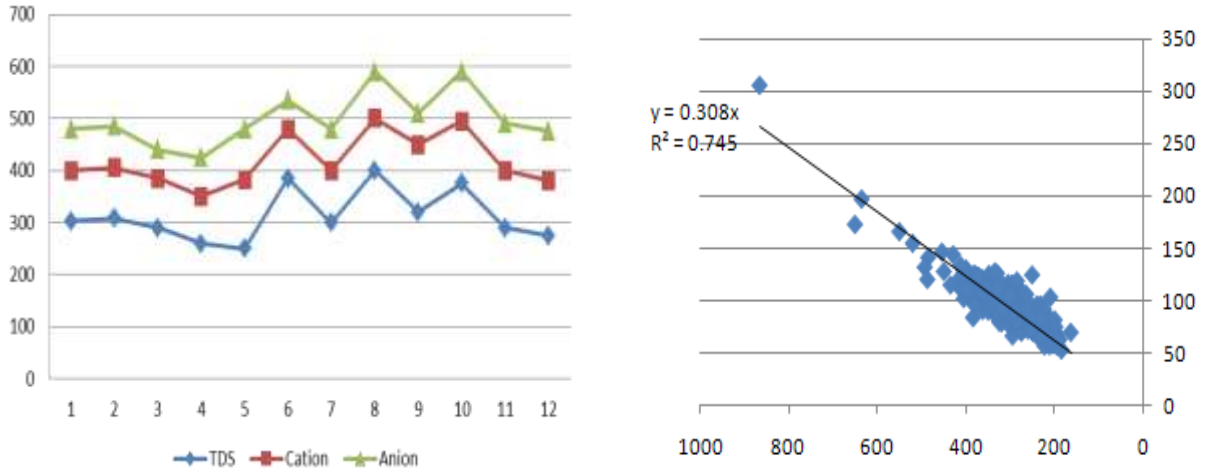

Fig. 3- Illustrates the monthly changes of TDS and total sum of cations and anions (left graph) and in the right graph shows coefficient of TDS with cations and anions, vertical axis (y) is indicative of TDS and horizontal axis shows the total sum of anions and cations.

The TDS standard deviation of Dez River water within Dezful City range was obtained as equal to 67.74 mg/l. Fig. 16 shows the standard deviation changes of Dez River water TDS.

3.2. Statistical t-test between TDS and other parameters: Using SPSS software and statistical t-test the relationship between TDS parameters and other water qualitative parameters were obtained at 95% and 99% significance levels, the results of which are as follows: Relationship between TDS and Discharge water (DIS): at 95% and 99% significance level shows in the table 3.

Based on the above tables there is a significant relationship between DIS and TDS at 95% and 99% significance levels.

-Relationship between TDS and Carbonate Co_3: This relationship was investigated at 95% significance level, the results of which have been given in Table 4.

Table 3 - Statistical t-test between DIS and TDS at 95% and 99% significance level

99% significance level		95% significance level		descriptive
DIS	TDS	DIS	TDS	
263.3905	314.7303	263.3905	314.7303	Mean
81742.41	4601.606	81742.41	4601.606	Variance
380	396	380	393	Observations
	42521.66		42521.66	Pooled Variance
	-		-	Hypothesized Mean
	0		0	Difference
	771		771	df
	3.46057		3.46057	t stat
	0.000284		0.000284	P(T<=t) one-tail
	2.331194		1.646832	t Critical one-tail
	0.000569		0.000569	P(T<=t) two-tail
	2.582221		1.963046	t Critical two-tail

Table 4- Statistical t-test between Co_3 and TDS at 99% significance level.

CO_3	TDS	descriptive
0.545216	314.7437	Mean
12.40637	4589.967	Variance
372	394	Observations
	2367.094	Pooled Variance
	-	Hypothesized Mean
	0	Difference
	764	df
	89.33085	t stat
	0	P(T<=t) one-tail
	1.646851	t Critical one-tail
	0	P(T<=t) two-tail
	1.963074	t Critical two-tail

Considering the statistical t-test value which is equal to 1.96 according to the Table 4, there is a significant relationship between TDS and Co_3.

- Relationship between the climatic conditions and TDS rate: For this purpose the TDS statistics in winter was considered using Excel software and statistical t-test, based on which the relationship rate was obtained as being equal to 20.29 and 27.95 at 95% and 99% significance levels respectively. This means that the climatic conditions and temperature changes have no effect on the TDS rate.

- The correlation coefficient of the determined parameters: The aim for obtaining the correlation coefficient is to determine the measured cations or anions having the highest correlation with total amount of the water soluble solid materials, (Table 5). From the Table 5 it can be inferred that the Sodium ion content has the highest correlation with total amount of TDS; in other words, Na from among the cations has the largest effect on the increase in total amount of TDS. Using Excel software different types of curves were fitted and through comparing the correlation coefficients it was determined that the linear type provides the highest correlation coefficient.

The fitted line equation is as follows:

$$Na^{+}=0.005TDS–0.516 \ , \ R^2=0.769 \quad (1)$$

The following equation describes the relationship between the Cl and TDS, having been plotted using the Excel software.

$$Cl^{-}=0.005TDS\ 0.508 \ , \ R^2 = 0.765 \quad (2)$$

From Table 5 it can be inferred that the Cl^- anion content has the highest correlation with TDS; in other words, Cl from among the anions has the largest effect on the increase in total amount of TDS.

Table 5- The correlation coefficient of the cations and anions between TDS

	TDS	Cl^-	HCO_3	SO_4^{-2}		TDS	K^+	Na^+	Mg^{+2}
TDS	1				TDS	1			
Cl^-	0.765	1			K^+	o.163	1		
HCo_3	0.235	0.105	1		Na^+	o.769	o.0411	1	
$So4^{-2}$	0.687	0.471	-0.106	1	Mg^{++}	o.454	o.128	o.332	1

Electrical conductivity (EC): The statistical analysis results of electrical conductivity (EC) obtained using Excel software have represented in Table 6. Considering the last result of the above table it is manifested that there is no significant relationship between the seasonal changes and the EC rate.The mean amount for EC was 498.71 µm/cm. It is about 66.67% lower than the maximum optimum level and 75% less than the maximum permissible level determined by the Iranian standard. In general, based on the EC it could be said that Dez River water quality is at very suitable level within Dezful City range. The minimum and maximum values of EC is respectively 290 and 1515 µm/cm; Figure of 4 (right) illustrates the monthly changes of EC values.The standard deviation of this parameter was obtained as equal to 299.01 mg/l.Based on the Covariance criterion there is a direct relationship between pH and EC.This is why the Covariance value was obtained as equal to 0.584.In the Figure of 4 (left) illustrates the TDS and EC time variability during the years 2012-2013 time span.On the basis

of this Figure, it can be possible to visually infer the appropriate relationship between the TDS and EC parameters.

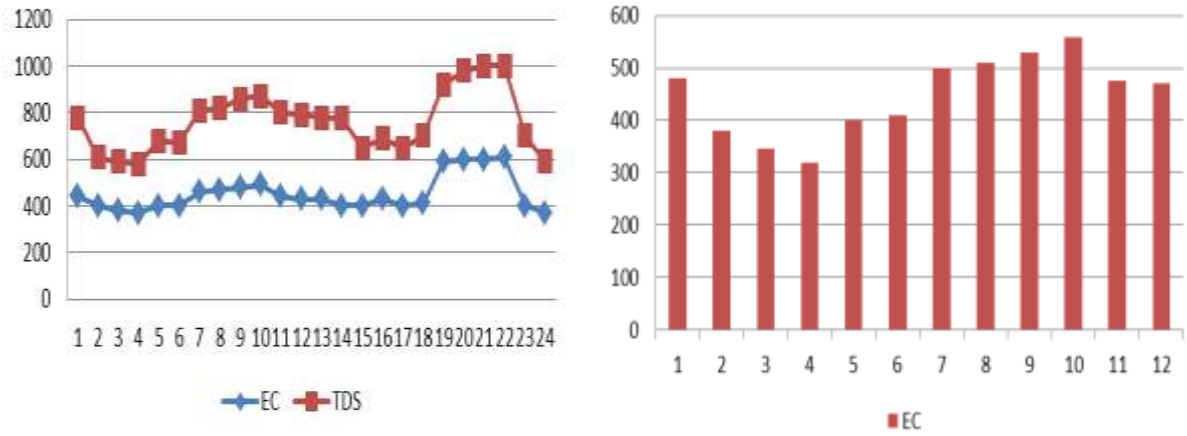

Fig 4 - Illustrates the monthly changes of EC values during 2013(right graph) and TDS and EC time variability during the years 2012-2013(left graph).

The mathematical relationship between TDS and EC parameters is as follows:

$$TDS = 0.63.\ EC \quad , \quad R^2 = 0.822 \qquad (3)$$

Using the SPSS software and statistical t-test the correlation between TDS and EC was investigated the results of which are the following: As can be seen from above, there is a significant relationship between TDS and EC at 95% and 99% significance levels. Graphic correlation between TDS and EC parameters are shown in Figure 5. Also the correlation between TDS and EC at 95% and 99% is shown in the following table.

Table 6- Statistical t-test results between TDS and EC at 95% and 99% significance levels.

95% significance level		99% significance level		descriptive
TDS	EC	TDS	EC	
314.8193	498.7157	314.8193	498.7157	Mean
4599.414	10060.05	4599.414	10060.05	Variance
393	394	393	394	Observations
	-		-	Hypothesized
	0		0	Difference
	690		690	df
	30.13623		30.13623	t stat
	28E-128		28E-128	P(T<=t) one-tail
	1.647065		1.647065	t Critical one-tail
	56E-128		57E-128	P(T<=t) two-tail
	1.963408		2.582973	t Critical two-tail

Also using Excel software, the relationship between EC and Discharge value (DIS) was studied. It can be observed that there is a significant relationship between water discharge value (DIS) and EC at 99% significance level.

Table 7- Significant relationship between DIS and EC at 99% significance level.

DIS	EC	descriptive
262.9518	498.7157	Mean
81600.59	10060.05	Variance
381	394	Observations
	45228.75	Pooled Variance
	-	Hypothesized Mean
	0	Difference
	773	df
	15.42871	t stat
	255E-47	P(T<=t) one-tail
	2.331182	t Critical one-tail
	5.1E-47	P(T<=t) two-tail
	2.582204	t Critical two-tail

Classification of agricultural water based on the EC parameter: Considering the water average EC value of 498.71µm/cm, Dez River water quality within Dezful City range can be classified in C_2 category. In other words, the water quality in terms of the risk for the soil can be classified in moderate category. Dez River water average EC value is 0.498 µm/cm and is by far less than 1.5 µm/cm; accordingly it can be said that Dez River water quality based on EC parameter is excellent for livestock and poultry. Total Hardness (TH): In Table 8 the statistical analysis of Dez River TH for Dezful Hydrometery station has been presented concerning the statistical period.

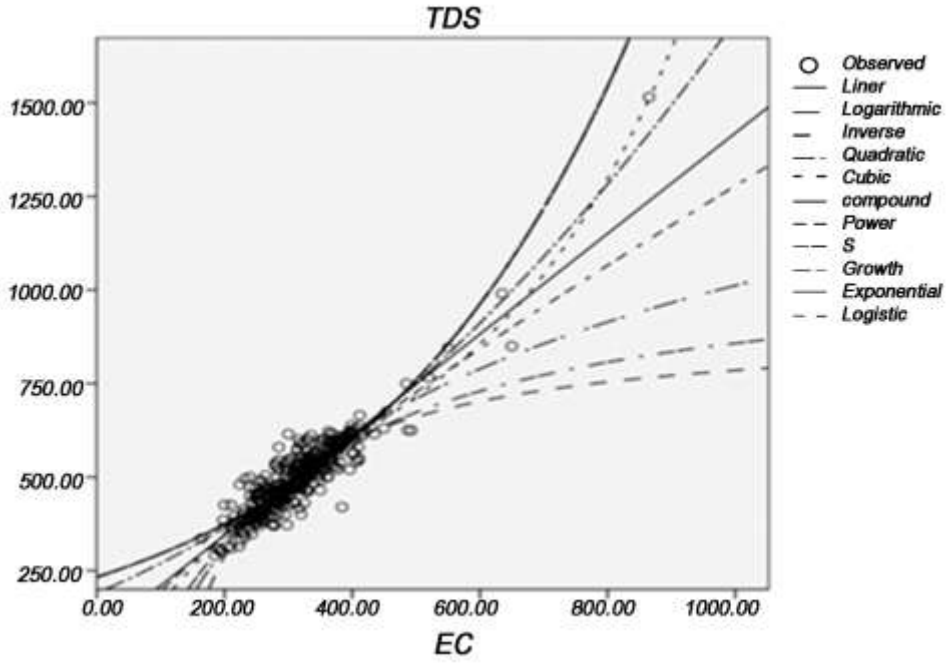

Fig 5 - Graphic correlation between TDS and EC parameters.

Table 8- Statistical t-test results at 95% significance level.

TH	descriptive
189.5	Mean
1.708481	Standard Error
187	Median
200	Mode
33.86931	Standard Deviation
1147.13	Sample Variance
13.62994	Kurtosis
2.348827	Skewness
350	Range
95	Minimum
445	Maximum
74473.5	Sum
393	Count
445	Largest(1)
95	Smallest(1)
-	Confidence
3.358931	Level (95.o %)

Considering the last result of the above table, it is manifested that there is no significant relationship between seasonal changes and the TH ratio. The mean value of this parameter is 189.5 mg/l.Comparing with the Iranian standard it could be understood that Dez River water quality in Dezful City has a suitable quality in terms of TH because it is 62.1% lower than the Iranian national standard. (Fig.6). However, compared with the WHO standard it is revealed that the Dez River water quality within Dez City range is 89.5% higher than the permissible level, making it qualitatively inadequate. The minimum and maximum values are 1.19 and 455 mg/l respectively. The maximum value of this parameter is higher than the maximum. Optimum value of Iranian standard is 11% lower than the maximum permissible value of the same standard. On the basis of the mean value of this parameter which is 144.32 mg/l, it could be said that Dez River water quality is suitable and has no problem. And based on WHO standard which has determined 100mg/l as the permissible value for TH, Dez River water quality in Dezful City is not suitable. Because the mean value is about 44%. Figure 6 (right) shows the monthly changes of Dez River Total Hardness in the Year 2013. Given that Total Hardness is obtained based on Calcium and Magnesium cation values, the cation content changes of these two together with mean TH changes have been shown for the year 2013.

Correlation between total TH and Ca, Mg and Na: Using the Excel software, the f statistical test was performed for TH in respect with anyone of the two Ca and Mg cations. F-test was also used to examine the joint-effects of several independent variables without taking into account the separate effects of each variable (Rhaman et al. 2014). The results are as follows in the Table 9.

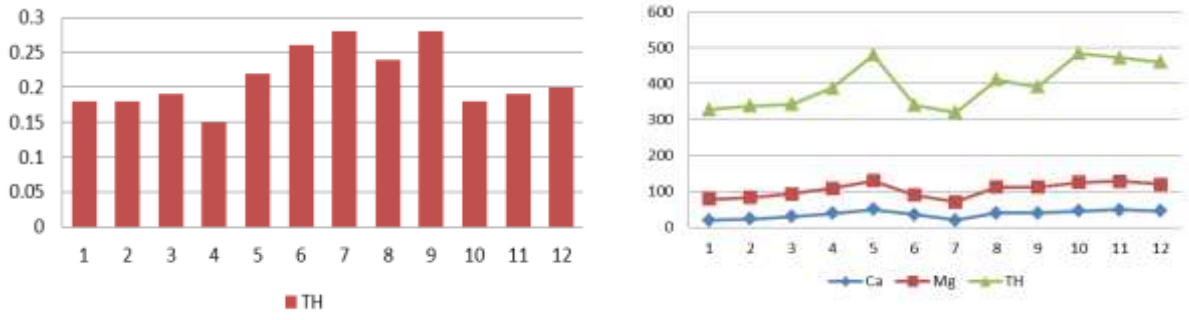

Fig 6 - The monthly changes of Dez River TH in the Year 2013 and change of Ca and MG cation values.

Table 9- The t statistical test between TH and Mg , Ca , Na.

Na and TH		Ca and TH		TH and Mg		descriptive
TH	Na	TH	Ca	Mg	TH	
1.300863	189.4632	2.595482	189.4632	1.193782	189.4632	Mean
0.258409	1144.745	o.281127	1144.745	o.134763	1144.745	Variance
394	394	394	394	394	394	Observations
	572.5016		572.513		572.4398	Pooled Variance
			-		-	Hypothesized Mean
	1		1		1	Difference
	786		786		786	df
	109.7901		109.0296		109.8589	t stat
	0		0		0	P(T<=t) one-tail
	1.646795		1.646795		1.646795	t Critical one-tail
	0		0		0	P(T<=t) two-tail
	1.962987		1.962987		1.962987	t Critical two-tail

As can be seen from the above figures, there is a significant correlation between TH and cations. Considering the above facts, there is more correlation between TH and Ca cation and hence TH is mostly influenced by the changes of this cation.

***Cations*:** Table 10 illustrates the statistical analysis of Ca , MG and Na content in Dez River water obtained in Dezful hydrometer station during total statistical period. Considering the last result of the Table 10 it is determined that there is no significant relationship between the seasonal changes and Ca rate.In the Table the Ca statistical analyses for the years 2010 to 2013 have been represented and taking into account such analyses results, no relationship can be found between the seasonal change and climatic conditions from the one hand and Ca from the other.The mean value of Ca was obtained as equal to 52.10 mg/l.Comparing with the Iran national standard (NO.1053) it can be realized that the Ca mean value of Dez River is by far below the Iranian standard permissible value. The water quality has been at optimum level for 73.95% of the cases but in appropriate for 26.05% of the measured cases.

The mean value of Mg was obtained as 14.51 mg/l which based on Iranian national as well as WHO standards is at optimum and suitable level. Based on the statistical analyses, Dez River Magnesium content in Dezful hydrometer station has never reached the permissible level boundary set by WHO and Iranian standards. The maximum value of this parameter is 85mg/l which is well below the WHO permissible standards (Nielsen 2006).This shows that Dez River water quality within Dezful City range is at optimum level.And the standard deviation factor of Mg in Dez River was obtained as equal to 0.36. However in Nayan et al. (2012) reported that the value of standard deviation factor was 2.8 and 2.4 for summer and winter respectively, showing better status for the water quality.So careful consideration should be given to choosing comparison parameters.

Relationship between total sum of Ca and Mg with total cations values**:** Using Excel software the correlation relationship between total sum of Ca and Mg values with total sum of cations was considered. The correlation equation between the parameters is as follows:

$Ca^{+2} + Mg^{+2} = 1.468$ (Sum Cation),

$R2 = 0.776$ (4)

In Table 10 the statistical analysis of Dez River Na content data relevant to Dezful City range has been given for the whole statistical period.

Table 10 - Statistical analysis of Ca, Mg and Na content of Dez River

Na	Mg	Ca	descriptive
29.91865	14.51583	51.75757	Mean
0.589002	0.224881	0.554092	Standard Error
28.74885	13.98346	52.10421	Median
22.99908	12.15953	50.1002	Mode
11.69135	4.463766	10.65818	Standard Deviation
136.6877	19.92521	113.5968	Sample Variance
20.9565	3.653902	13.96494	Kurtosis
2.7265564	1.338886	1.673603	Skewness
136.6145	33.07393	120.2405	Range
3.679853	2.796693	20.04008	Minimum
140.2944	35.87062	140.2806	Maximum
111787.95	5719.236	19150.3	Sum
394	394	370	Count
140.2944	35.87062	140.2806	Largest(1)
3.679853	2.796693	20.04008	Smallest(1)
-	-	-	Confidence
1.157988	0.442121	1.089575	Level (95.o %)

water at 95% significance level.

The mean value of Na in Dez River water during the statistical period has been 29.91mg/l which is well below the optimum level and maximum Iranian national standard.Hence based on the Iran national standard water quality within Dezful City range has no problem in respect with the Na amount.The highest content of Na during the statistical period has been 140mg/l which is 30% lower than the values specified in Iranian standard.Considering the identical values in accordance with the Iranian as well as corresponding of WHO standards the Na content of water, the same conclusion can be made based on the WHO standard criterion (Ebadati 2014).

Table 11 - Summary of the SO_4, Cl and HCo_3statistical analysis.

HCo_3	Cl	So_4	descriptive
157.8296	1.322163	1.183883	Mean
1.292216	0.026023	0.031289	Standard Error
160.4637	1.25	1.1	Median
152.532	1	1	Mode
25.64975	051588	0.621075	Standard Deviation
657.9099	0.266132	0.385734	Sample Variance
3.776114	17.72339	27.01858	Kurtosis
-1.11753	2.343846	3.839021	Skewness
217.2056	5.75	6.66	Range
35.99756	0.25	0.19	Minimum
253.2032	6	6.85	Maximum
62184.87	519.61	466.45	Sum
394	393	394	Count
253.2032	6	6.85	Largest(1)
35.99756	0.25	0.19	Smallest(1)
-	-	-	Confidence
3.344768	0,051162	0,061515	Level (95.o %)

***Anions*:** Table 11 represents the statistical analysis of the So_4, Cl and HCo_3 content of water in Dezful hydrometer station. Mean amount of So_4 in water within Dezful City range is equal to 59mg/l.Based on the comparison with the Iranian standards, the So_4 content is by far less than the permissible level. In other words, it is about 85% lower than the permissible value determined by the Iranian standard. Accordingly, Dez River water quality within Dezful City range has no problem in

respect with the Sulfate content.The permissible value determined by WHO for Sulfate anion is 200mg/l, so again the quality of Dez River within Dezful City range is at optimum state in terms of So_4 anion. The Mean value of this parameter has been above the WHO permissible level for only about 15 of the study time span (Nielsen 2006). The seasonal changes of So_4 content in water during summer and winter seasons of the years 2012 and 2013 show change trend of So_4 during summer and winter seasons has been almost identical, with the difference that the So_4 amount in summers has been higher than in winters (Ebadati 2014).

- Relative So_4 and TDS**:** Using the Excel software the Covariance between the two above parameters was obtained as equal to 1443.66 during the year 2013. Hence the relationship between the two parameters is a direct one. Changes trend of the two parameters is similar to each other.

The mean value of Cl has been equal to 46.72 mg/l. Based on the comparison with the Iranian national standard (No.1053), this value is about 88.32% lower than the permissible value set by the Iranian standard. Accordingly Dez River water has no problem in respect with the Cl content parameter.

The mean value of HCo_3 of water in Dezful City hydrometer station is 157.82 mg/l. No specific value has been determined by the Iranian National Standard (No.1053) for HCo_3. In sum it can be said that Dez river water quality within Dezful City range is undesirable in terms of HCo_3 content.

3.3. Investigating the water quality in terms of agricultural use.

Sodium absorption ratio (SAR): The mean Sodium absorption ratio has been 0.94, indicating the "Excellent" state for Dez River water quality within Dezful City range (Ebadati et al 2014).

Correlation between Sodium absorption ratio (SAR) and cations-anions: For this purpose the Excel software was used to obtain the Correlation matrix between Sodium absorption ratio (SAR) and cations, anions, TDS, EC and water pH, the results of which have been given in table 12.

Table 12- The correlation matrix between Dez River water quality parameters.

SAR	TH	Ca	Mg	Na	K	TDS	EC	PH	Co_3	HCo_3	Cl	So_4	
												1	So_4
											1	0.471	Cl
										1	0.105	-0.106	Hco_3
									1	-0.37	0.044	0.005	Co_3
								1	0.318	-0.226	0.126	0.076	PH
							1	0.024	-0.032	0.276	0.842	0.699	EC
						1	-0.907	0.071	-0.012	0.231	0.762	0.687	TDS
					1	0.163	0.093	0.083	0.077	-0.012	0.07	0.121	K
				1	0.040	0.769	0.848	0.136	0.043	0.116	0.948	0.532	Na
			1	0.328	0.115	0.447	0.435	0.54	0.054	0.106	0.347	0.562	Mg
		1	0.107	0.459	0.132	0.662	0.723	-0.032	-0.022	0.462	0.472	0.588	Ca
	1	0.842	0.627	0.538	0.166	0.761	0.803	0.003	0.011	0.42	0.559	0.766	TH
1	0.327	0.262	0.224	0.961	-0.002	0.65	0.717	0.154	0.048	0.015	0.899	0.38	SAR

Based on the above table it is manifested that Na cation, Cl anion, EC and TDS have the largest effect on the Sodium absorption ratio respectively.

Percentage of Sodium solution (SSP): The mean rate of the above parameter was obtained to be about25.05 eq/l. Which based on the quality criteria, water quality can be evaluated as Perfect. The statistical analysis of the SSP parameter has been given in table 13.

Table 13- SSP statistical analysis

SSP	descriptive
25.052	Mean
0.287274	Standard Error
24.70588	Median
26.66667	Mode
5.694985	Standard Deviation
32.43285	Sample Variance
0.352495	Kurtosis
o.222892	Skewness
43.22892	Range
3.940887	Minimum
47.16981	Maximum
9845.436	Sum
393	Count
47.16981	Largest(1)
3.940887	Smallest(1)
-	Confidence
0.56479	Level (95.o %)

4. CONCLOTION

- The minimum and maximum values of total sum of TDS in Dez River within Dezful City range are 164 and 865 mg/l respectively; this is while based on the statistical analyses only in 1.26% of the times during overall statistical period, the total amount of TDS has been more than 500 mg/l, i.e. In 98% of statistical time span the water quality of Dez River based on the TDS has been at optimum level in this hydrometer station.

- The reason for high concentration of Na could possibly be the gypsum and saline geological formations in the region. It is possible that the reason for the undesirable taste of potable water of the area could be attributed to the Na cation content the increase in concentration of which may put limitation for the use of water wells for potation purposes.

-The maximum value of SSP parameter has been 47.16 eq./l based on which it could be said that sometimes water quality has been at "acceptable" level.

-Dez river water quality based on sum total of TDS has been at " Perfect" level in most cases (99.8% of statistical time spans) and only in 2% of the time spans the water quality has been at "acceptable" state, during which the average total of TDS has been 644 mg/l. The same results are also obtained using Iran National Standard (No.1053).

-The average content of Na, So_4, TH, Cl, Ca, Mg and the Sodium absorption rate in Dez river water during the statistical period has been by far lower than the maximum optimum and maximum permissible standard values.

Accordingly based on the comparison to the Iranian national standard Dez River water quality within Dezful City range is at normal state.

In sum, based on the study results it can be said that Dez river water quality in Dezful hydrometer station is suitable for all agricultural, livestock watering and human drinking purposes.

-Most of the qualitative parameters of water quality had values within the permissible range of World Health Organization Standards.

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