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Identify the sources of drinking water for the city of Dezful (southwest of Iran)

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ABSTRACT

Iran is one of the semi-arid areas and shortage of water resources is considered. And identify and manage sources of the most important things.The water quality of Dez River is one of the major concerns of the area and for Dezful city. This study was carried out using evaluation based water sampling and statistics result. A number of 394 samples were analyzed and the concentration of physical and chemical parameters including pH, TDS,EC, total cations and anions were measured.The obtained results were examined and compared based on the analyses consistent with the World Health Organization (WHO) standards. Dez River water quality has been "Perfect" in most cases on the basis of TDS and considering the average sum total of them amounting to 644 mg/l during the mentioned period; 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. Drink water, Dezful city, water management.

INTRODUTION

Khouzestan Province with an area of 67130 Km^2 has been located 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 [1]. 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.They 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) has 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 [2]. 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 [3]. 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. (2002) examined the microbial variability trend of Karoon River within Ahvaz City range [4]. 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 increasing trend and by the decrease of discharge volume and precipitation in some months of the year the contamination rate is 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 [5 and 6]. 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. (2006) studied the effect of Gachsaran formation on the water quality of Karoon River and compared it with Dez River [7]. 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. 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 [8]. Moyel (2014) presents the results of statistical analysis of a set of physico-chemical water quality parameters, monthly collected from December 2012 to November 2013 at seven sampling stations spread over the Shatt Al-Arab River [9].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 U 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 [10]

This study was conducted employing descriptive 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 were measured.

MATERIALS 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 locate downstream of Dez dam. Distribution of hydrometer stations in Dez River network has been engineered in a way that before confluence of any important branch with the main stream a hydro meters station has been constructed on the main fork of the river [11].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 [13]. And 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. Also application of Multivariate Statistical Techniques in the Assessment of Water Quality in Sakarya River studied [14]. 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). Multivariate statistical techniques namely factor analysis and cluster analysis were applied to evaluate spatial variations, and to interpret measured water quality data set [15]. Assessment and benchmarking of Mediterranean Basin for Water Pipe Networks Performance worked [16].And methods were applied to Linggi River water quality data sets to evaluate spatial temporal variations and identify sources of pollutants [17].The obtained results were used in statistical analyses as follows [11 and 18].

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 odd 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 straightforward process and reduce some of the uncertainty being discussed here, 25 as previously suggested for The Cut by [19].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. And SPSS software was used for statistical analyses [18]. 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. The outcome is attempted to transform inter correlated variables into smaller set of new independent variables, also called as vary factors [2o and 21]. 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

RESULTS ND 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 20012 have indicated the largest and smallest pH value during the study time span. Dez River pH seasonal changes are shown in the Figure 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.

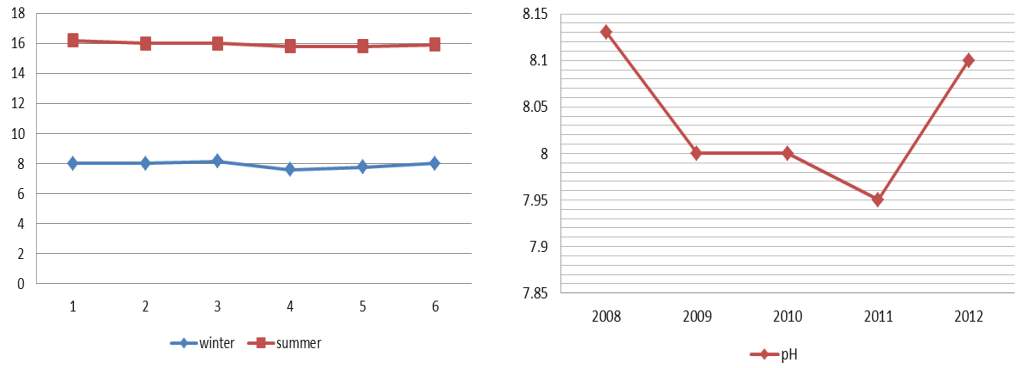

Figure 1- Dez River pH seasonal changes (left graph) and pH value during the study time span (right graph).

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.

Considering the result of the analysis, 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 optimum 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 optimum range according to the Iranian standards and below of the minimum acceptable limit in accordance with the World Health Organization (WHO) [22 and 23].

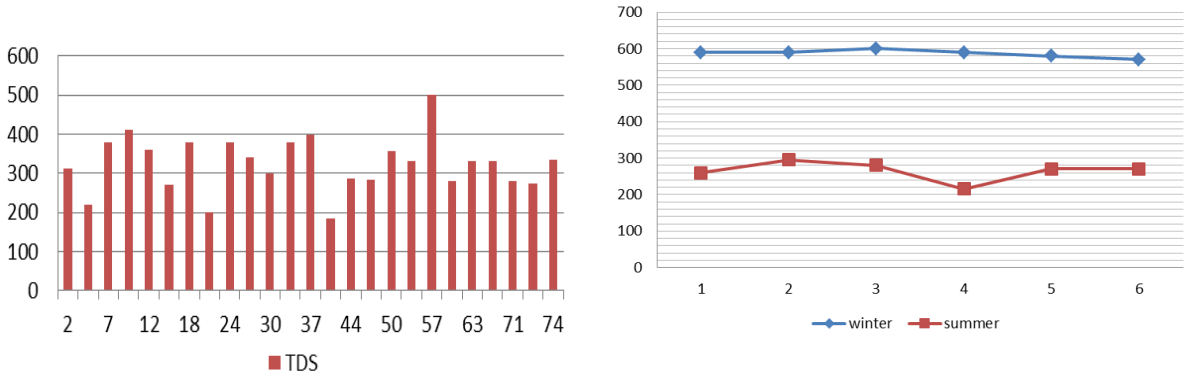

Figure 2- Seasonal changes of TDS values (right graph) and illustrates the TDS monthly changes during the study time (left graph) in Dez River water at Dezful station.

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.

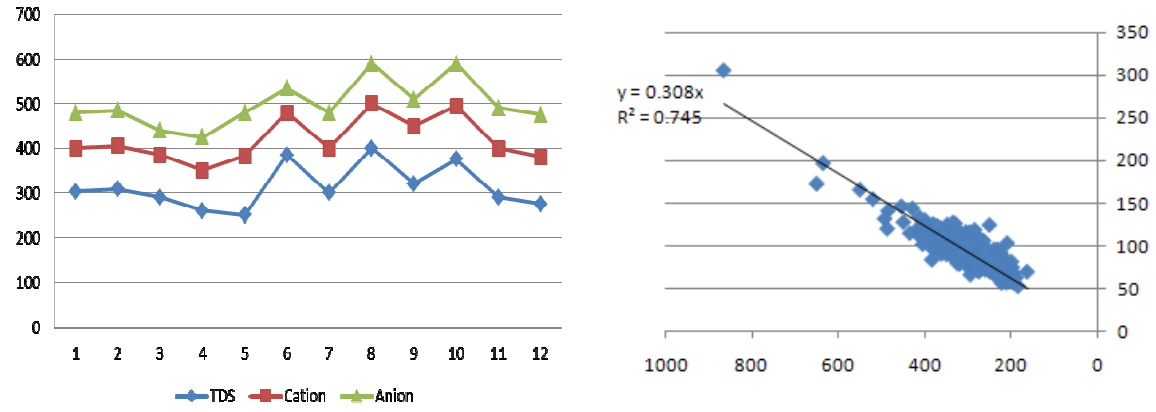

Figure 3- Illustrates the monthly changes of TDS and total sum of cations and anions(left graph) and In the right graph shows coefficient of TDS with cations and anions, vertical axis (y) is indicative of TDS and horizontal axis shows the total sum of anions and cations.

Electrical conductivity (EC): The statistical analysis results of electrical conductivity (EC) obtained using Excel software has been 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 are respectively 290 and 1515 µm/cm.

There is no significant relationship between seasonal changes and the TH ratio. The mean value of TH 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.4). However, comparing 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. Optimum value of Iranian standard but it 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. This is while based on WHO standard which has determined 100 mg/l as the permissible value for TH, Dez River water quality in Dezful City is not suitable. Because the mean this parameter is about 44% higher than the mentioned value. Figure of 4 (right) shows the monthly changes of Dez River Total Hardness in the Year 2013. Given that Total Hardness is obtained based on Ca and Mg 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 statistical test was performed for TH in respect with anyone of the two Ca and Mg cations. 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.

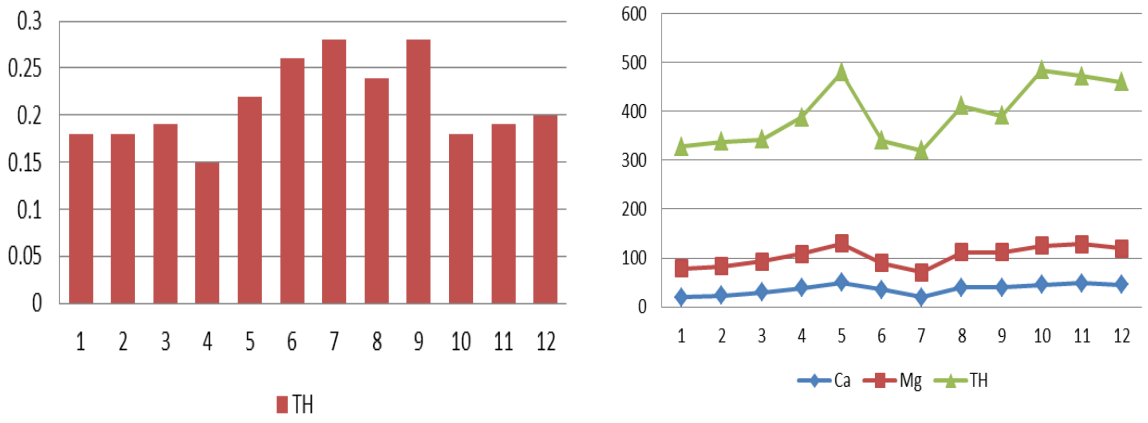

Figure 4 - The monthly changes of Dez River TH in the Year 2013 and change of Ca and Mg cation values.

Cations: Analysis of Ca, Mg and Na content in Dez River water obtained in Dezful hydrometer station during total statistical period. There is no significant relationship between the seasonal changes and Ca rate.In 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 [22 and 23]. Based on the statistical analyses, Dez River Mg 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 [23].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[24].

Anions: 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, as per the said standard, Dez River water quality within Dezful City range has no problem in respect with the So_4 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 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 [11].

Table 1 - 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

CONCLUSION

- 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 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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