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THE ORIGIN OF RIVER SEDIMENTS, THE ASSOCIATED DUST AND CLIMATE CHANGE

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***Abstract*:** In this research, the catchment area of the Karkheh River, Iran has been studied to determine the origin of sediments and its relationship with the dust and the effect of climate change. Accordingly, some sediment samples were taken from the River bed. Sediment aggregate size measurement is an important tool for studying its origin. Currently, for analyzing sediment aggregate size measurement, some statistical calculations from many samples are used, but these methods are time-consuming and difficult. Sediment size is an important factor in determining the origin, causing erosion and sediment transport. Therefore, the use of modern methods is essential. In the present study, for determining the texture and grading of the sediment, the data from the sediment sampling were introduced into the GRADISTAT. The results showed that the texture of the sediment is sand gravel. Then, sampling and testing on the dust particles showed that they are also of sandy origin, so it can be assumed that the extreme dust storm after deposit can make sediment in the river. In addition, in order to investigate the effect of climate change on the dust event, the relationship between three climatic parameters including rainfall, minimum temperature and relative humidity with the number of days with dust storm for two years of 2016 and 2017 were analyzed. The results showed that, with increasing temperature and decreasing precipitation and relative humidity, the number of days with the dust storm increases, and as a result, it can deposit and cause a part of sediment in the river.

***Keywords*:** Sediment, Particle Size, Karkheh, Dust, Climate Change, Wind Erosion

1. INTRODUCTION

Today, with the destruction of forests, the expansion of cities and the construction of highways, soil erosion, sedimentation and sedimentology have been highly regarded by experts (Liu *et al*., 2013). Particularly in a water catchment area that has water structures, or a plan for constructing these structures, as well as a basin with many problems in terms of water quality, it is necessary to consider sedimentology before any action is taken in terms of the construction of a new or optimal existing water structure (Tao *et al*., 2013). Therefore, more studies on the sedimentology and the origin of their creation, should be carried out with a greater confidence in the construction of a new structure or the decision to exploit river water (Roddaz *et al*., 2006).

Due to the fact that Karkheh River, Iran is a supplier of drinking water, agriculture and part of electric power and has the various hydrological structures, therefore sediment study, hydrology and sediment source in this basin are very important. For this reason, more detailed and intensive studies should be done on all relevant fields, especially sediment depositional problems. Also considering the issue of climate change, as well as the presence of terrible dust in the Karkheh area and the involvement of these cases on the formation of sediments in the River bed and the possible contamination of river water, so the study of sedimentology is necessary (Amiri and Eslamian, 2010).

The local and international studies that have been done only was based on the size of river sediments or solely on contaminated sediments. For example, some researcher (Shahriki & Ghareemi, 2015) studied on physical properties and grain size of the Sarbaz River in southern Iran. Also, Mahdavi and Pasdaran (2010) examined the chemical properties of sediments for the Jajroud River and the reuse of sediment for agricultural operations. (Keshavarzi *et al*., 2015) studied the concentration of heavy elements in the Karun river sediments. Thus, a comprehensive study has not been carried out in Iran to investigate the origin of sediments due to their physical characteristics and considering the contribution of dust and climate change (in areas facing this problem extremely) to river sediments deposit (Fakhri *et al*., 2012, 2013, 2014).

Therefore, due to the fact that the Karkheh River is one of the important river of Khuzestan province, Iran such that it receives a considerable amount of sediment annually, which has caused major problems in water using of this river. Due to the high volume of sedimentation in this river and the potential for pollution, it is necessary to investigate the origin of sediments according to their size. Also, because this area encounters the phenomenon of storm dust, the role of dust on the amount of sediment deposit has been studied in this paper, and also due to the impact of climate change on dust that has become abundant in recent years, the role of this effect has also been studied on the formation of dust and sediment deposit (Aghaei *et al.* 2017).

2. GEOGRAPHIC LOCATION AND CHARACTERISTICS OF THE STUDY AREA

2.1. Location

Karkheh catchment area is located between 33° 25′ to 34° 56′ northern latitudes and 46° 07′ to 49° 11′ eastern longitude. Figure (1) shows the location of the Karkheh catchment. This area is bounded from the north by the catchment areas of the White River and Markazi and from the west by the Border catchments and from the east by the Dez and Markazi catchment, and from the south by the Karkheh Safla. The area of Karkhe area covers 4262000 hectares and also cover parts of the provinces of Khuzestan, Ilam, Hamedan, Lorestan, Central, Kurdistan and Kermanshah. The most important sub-basins of the Karkheh River basin are: Gamasiab, Qara-Sou, Seymareh and Kashkan.

In Seymareh region with an area of 15735 square kilometers, the mean slope is 26.66 percent, under the domain of Gamsayeb with an area of 11690 square kilometers, the mean slope is 19.53 percent, in Kashkan region with a total area of 9560 square kilometers, the mean slope is 26.1 percent, under the Qara basin Sue with an area of 5635 square kilometers, the slope is 16.41 percent. The total length of the Karkheh River is 660 km with a gross slope of 32% and a net gradient of 25% with an average weight of 32% (Ashrafi *et al.*, 2014).

This area is located in the mountainous region and has intermediate-climatic in the Zagros basin, in the southern part of the region, the average rainfall is about 300 mm and in the northern part of the area, the average rainfall is about 1000 mm per year. The average outflow of Karkheh River is 200 m^3/s and the average of the inflow is about 12 billion cubic meters per year. The amount of soil erosion in the area is an average of 16 tons per hectare per year, so with the 430 hectares of the soil in the basin, the area of soil erosion is an average of 26 tons per hectare per year, which there is a need of efficient planning and management (Ashrafi *et al.*, 2014).

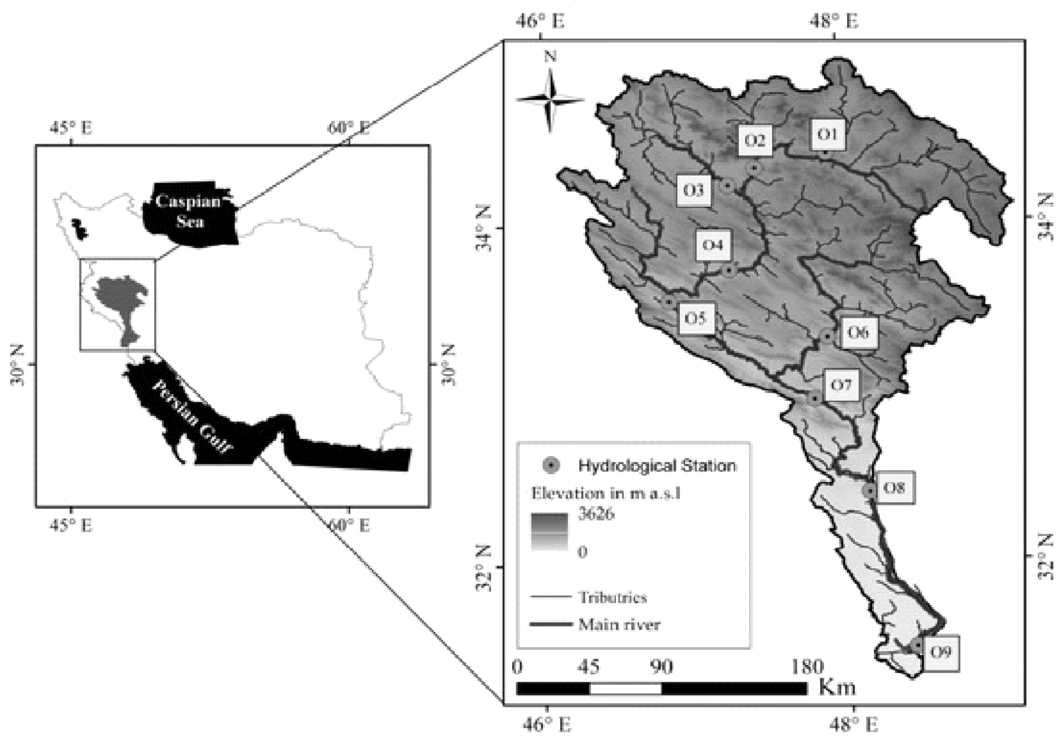

Figure 1: Location of Karkheh watershed (Khuzestan Regional Water Institution, 2016)

2.2. Weather and climate

In the Karkheh watershed, the main source of rainfall in the region is the humid Mediterranean air flow from the Sudanese (Persian Gulf and Red Sea) and North Atlantic. The average rainfall of the region is about 300 mm in the southern regions and more than 1000 mm in the northern and northeast parts (Ashrafi *et al.*, 2014).

2.3. Floods

The effective factors studied on the floods in this area are snowfall, accumulated snow depth, slope, basin shape, land cover, and vegetation. Poor vegetation cover causes a variable hydrological event. Therefore, in some dry seasons of the year, the Karkheh River reaches less than 18 cubic meters per second at the entrance to the dam and reaches more than 5100 cubic meters per second in the flood seasons (Abbaspour *et al.*, 2004).

2.4. Sediment Status

To study the sediment, samples were taken from different sections along the river's route. Hence, the grain size and particle size analysis are prepared and the results of these experiments are shown in the following sections. The purpose of the sampling is to understand the type of river sediments. Approximately 60% of the total suspended load was estimated during the months of November, December, April, May and June, and the main reason is that the sediments in the months of November and December is coincided with seasonal rainfall and the sediments in April and May months is coincided with the runoff from snow melting. Also, in the same months, autumn and spring cultivations are done. In total, about 99.5% of the suspended load of the sediment created in the months of November to June and only less than 0.5% (about 0.1 million tons) created in the months of July to end of October. The estimated values and the trends of suspended load show that in the month of January and February, the values decrease because of the snowfall and generated ice in the region.

3. MATERIALS AND METHODS

For obtaining granulation of sediments, the characteristics of the data acquisition stations were considered at appropriate distances of about 500 meters and the sampling was carried out on a monthly basis (the specified time) for each station.

Then to obtain size of the granulation of sediments, sieve method (or mechanical method) is used (section 3.1.1). In order to carry out granulation of sediment, the samples were transferred to the laboratory and dried by a drying machine with a temperature of 100 ° C. Then, a digital scale separate digested 100 g of each sediment sample and each sample was placed in automatic shaking machine for 5 minutes to separate the particles according to the size of their large diameters by the sieve in the machine.

Also to obtain distribution of sediments granulation, different statistical methods have been used (section 3.2) and compared in this study, however torque method gave the better results for distributing of sediments granulation with regards to the four parameters which used for describing the distribution of granularity (e.g. average size, distribution around the mean (sorting), the criterion of the existence or absence of distribution symmetry (skewness), A criterion of the curve sharpness at maximum point (stretching)).

Next to obtain texture of sediments in terms of their size, GRADISTAT software used (section 3.3). This software program uses a textual classification (such as clay, sand, and gravel (previously made by Felix 1924). It also includes a table obtained for the percentage of the fall of any size of the fraction. In terms of output, this program provides a graph of the distribution of grain size and the cumulative distribution of data in both micrometers and in Φ, and displays the sample size in a triangular diagram that is in the form of pebbles, clay and sand. Samples can be individually analyzed or provided to the user with up to 220 possible samples with all statistical analyzes.

Following sections, give us more details about the methodology for size of the granulation of sediments, distribution of sediments granulation and the texture of sediments in terms of their size.

3.1. Methods for obtaining granulation of sediments

3.1.1 Sieve method (or mechanical method) of grain size determination

The granulation of sediments was carried out by sieve method. In order to carry out granulation of sediment, the samples were transferred to the laboratory and dried by a drying machine with a temperature of 100 ° C. Then, a digital scale Separate digested 100 g of each sediment sample and each sample was placed in automatic shaking machine for 5 minutes to separate the particles according to the size of their large diameters by the sieve in the machine.

Sieves used in sieve screening with regard to, maximum and minimum of sand with pore diameter of 1, 0.25, 0.15, 0.05, 0.063, 0.9, 0.125 millimeters corresponding to the number of sieve 10, 35, 60, 100, 140, 230, 400, have been selected, that can separate the sediment grains from sand to coarse, medium grains, fine grains and silt and clay particles. The reason for the selection of these sieves is a type of sandy regimen with different granulations of sediments consisting of coarser grains larger than one millimeter to silt materials and particles smaller than 0.053 millimeters. After the completion of the sieve, the weight of the sediment grains was measured on each sieve and, finally, the total weight of the sample was measured by a scale of 0.01 g and the percentage and cumulative percentages according to the following equations for each sample was calculated:

(2) * Weight% = Sediment weight per sieve / total sample weight (× 100)

(3) * Cumulative percent = (weight percentage of each sieve + weight percentage of the sieve before)

Finally, the measured data including the weight of each sediment sample, weight percentage, cumulative percent and particle diameter were recorded in special tables. The results are presented in Table (3).

The tables were entered into the Excel software environment by plotting normal distribution curves and cumulative distribution of parameters such as 50 D average diameter of 50% by weight of one sample sediment and the mean (M) is determined using the curves, because the determined data in the analysis of the granulation distribution conditions of sediments is very effective in terms of sorting and uniformity coefficient. Also, sediment statistical parameters such as sorting, sharpening and tilting were determined by using normal and cumulative distribution curves as well as existing formulas. The amounts obtained in the Gridstat program were obtained and the granulation and sedimentation tissue were obtained. The results obtained for sediment texture for different depths are shown in Table 4 using the Gridstat program.

3.2. Basic analysis of distribution of the grain size

Determining the best distribution of the grain size of different sediments is often described using the standard deviation criterion. The computations performed with the assumption of normalization, or Gaussian distribution, with a counting scale for seeding, which are rarely used by the sediment scientists. Therefore, coarse-grained and fine-grained sediments are important in the distribution analysis.

In the geometric measurements, minor differences in fine particles and large disparities in large particles usually use. Most sediment scientists have adopted the Odententhoret logarithmic degree scale, in which the boundary between two successive classes is different from the two factors. Crombin (1974) suggested that the grading boundaries should be converted to a logarithmic scale with values of Ö to facilitate the presentation and statistical fit of the data on the frequency of aggregation (Krumbein, 1934).

$$\varphi = \log_2^d \qquad (1)$$

D is the diameter of the grain in millimeters.

The distribution used on this scale is log Normal-2, and is commonly used by sediment scientists. The parameters used to describe the distribution of granularity are divided into four main groups: (1) average size (mean), (2) distribution around the mean (sorting), (3) the criterion of the existence or absence of distribution symmetry (skewness) 4) A criterion of the curve sharpness at maximum point (stretching). These parameters can be easily obtained using mathematical or graphical methods. Among these, the torque mathematical method has a higher accuracy in the requirement of the number of sample.

Calculation of grain size parameters using a torque method is a difficult process. However, it is possible to obtain some parameters approximately, obtaining information from plotting the frequency of data either using the cumulative frequency curve, or by extracting or determining input values for the entire curve, using some formulas. The formula proposed by (Folk and Ward, 1957) is widely used for calculation of grain size parameters and the classification is shown in Table 1).

Table 1
General classification of sediment size with using a torque method (Folk and Ward, 1957)

Wentworth (mm)	*Unit φ*	*Type of sediment*
256<	-8>	Boulder
64-256	(-6) _ (-8)	(Cobble)
Apr-64	(-2) _ (-6)	(Pebble)
4-Feb	(-1) _ (-2)	Grain
2-Jan	0 _ (-1)	Very coarse
0.5-1	1-0	Coarse
0.25-0.5	2-1	Medium
0.125-0.25	3-2	Tiny
0.0625-0.125	4-3	Very Tiny
0.0312-0.0625	5-4	Coarse
0.0156-0.0312	6-5	Medium
0.0078-0.0156	7-6	Tiny
0.0039-0.0078	8-7	Very Tiny
0.00195-0.0039	9-8	Coarse
0.00098-0.00195	10-9	Medium

Such suitable methods are used for unrestricted the distribution analysis, then parts of the distribution, including the point which are too scattered, will ignore. With the development of computer analyzes in recent decades, calculating both torque and graphing parameters can be done automatically, however, generally some of the main advantages of other graphing methods cannot be applied (Kelts and Shahrabi, 1986).

3.3. GRADISTAT program for obtaining texture of sediments in terms of their size

With extensive researcher needs in the fields of geology and sedimentology, the Grade state program is made. This program uses approximately 20 samples per hour (the statistical calculation of the grains with using the method of Falck (1923) and the momentum is carried out rapidly (Krumbein, 1934), while the program can analyze the grain size data in (Saeedi *et al.,* 2011).

These calculations are often hard and difficult. This program is written in Visual Basic, which connects to an integrated Excel spreadsheet and provides the outputs in tabular and graphical form. The user is required to enter the input percentage in the program. This can be done using the residual weight in each sieve, or the percentage of deposition in any amount of the remaining class, which is used by granulometric laser, X-ray diffraction or cuvette counter.

The statistical samples to be computed are the mean, mode, standard deviation, skewness, stretch, and a range of values in terms of cumulative percentages. Granulation in a certain percentage of coarse grains), called D10, D50, D90, D90 / D10, D90-D10, D75 / D25, D75-D25.

In this program, a method of moments for statistical computations such as an arithmetic method, based on a normal distribution with values of the metric unit, geometric method, based on a normal distribution with values of the metric unit , and logarithmic based on a

Table 2
Different methods for distribution of aggregation

Accurate Moment Accounts			
Elongation	**Skidding**	**Standarddeviation**	**Average**
$K_a = \frac{\sum f(m_m - \bar{x}_a)^4}{100\sigma_a^4}$	$SK_a = \frac{\sum f(m_m - \bar{x}_a)^3}{100\sigma_a^3}$	$\sigma_a = \sqrt{\frac{\sum f(m_m - \bar{x}_a)^2}{100}}$	$\bar{X}_a = \frac{\sum fm_m}{100}$
Geometric Method of Torque			
Elongation	**Skidding**	**Standard deviation**	**Average**
$K_a = \frac{\sum f(\ln m_m - \ln \bar{x}_g)^4}{100 \ln \sigma_a^4}$	$SK_g = \frac{\sum f(\ln m_m - \ln \bar{x}_g)^3}{100 \ln \sigma_a^3}$	$\sigma_a = \exp\sqrt{\frac{\sum f(\ln m_m - \ln \bar{x}_a)^2}{100}}$	$\bar{X}_g = \exp\frac{\sum f \ln m_m}{100}$

Elongation(K_g)	**Skidding(SK_g)**	**Sorting(σ_g)**
widevery<1.70	Very good Skidding-1.3>	Well sorted 1.27>
wide1.70-2.55	good Skidding(-1.3) _ (-0.43)	Good sorting 1.27-1.41
Middle wide2.55-3.70	Symmetric (-0.43) _ (0.43)	Sorting fairly well 1.41-1.62
long3.70-7.40	Coarse skein0.43 - 1.30	Relative Sorting1.62-2.00
longvery>7.40	Very Coarse skein>1.3	Poor matching 2.00-4.00
		Very weak sorting 4.00-16.00
		Extremely weak sorting 16<

Logarithmic Method of Torque			
Elongation	**Skidding**	**Standard deviation**	**Average**
$K_\varphi = \frac{\sum f(m_\varphi - \bar{x}_\varphi)^4}{100\sigma_\varphi^4}$	$SK_\varphi = \frac{\sum f(m_\varphi - \bar{x}_\varphi)^3}{100\sigma_\varphi^3}$	$\sigma_\varphi = \sqrt{\frac{\sum f(m_\varphi - \bar{x}_\varphi)^2}{100}}$	$X_\varphi = \frac{\sum fm_\varphi}{100}$

Elongation(K_φ)	**Skidding(SK_φ)**	Sorting(σ_φ)
widevery<1.70	Very good Skidding1.3<	Well sorted0.35>
wide1.70-2.55	good Skidding(0.43) - (1.3)	Good sorting 0.35-0.5
Middle wide2.55-3.70	Symmetric (-0.43) _ (0.43)	Sorting fairly well 0.5-0.7
long3.70-7.40	Coarse skein(-0.43) _ (-1.30)	Relative Sorting0.7-1.00
very long>7.40	Very Coarse skein< -1.3	Poor matching 1.00-2.00
.	.	Very weak sorting 2.00-4.00
.	.	Extremely weak sortin 4<

Falck s' Logarithmic graphing measurements			
Elongation	**Skidding**	**Standard deviation**	**Average**
$K_G = \frac{\varphi_{95} - \varphi_5}{2.44(\varphi_{75} - \varphi_{25})}$	$SK_1 = \frac{\varphi_{16} + \varphi_{84} + 2\varphi_{50}}{2(\varphi_{84} - \varphi_{16})} + \frac{\varphi_5 + \varphi_{95} - 2\varphi_{50}}{2(\varphi_{95} - \varphi_5)}$	$\sigma_1 = \frac{\varphi_{84} - \varphi_{16}}{4} + \frac{\varphi_{95} + \varphi_5}{6.6}$	$M_2 = \frac{\varphi_{16} + \varphi_{50} + \varphi_{84}}{3}$

Elongation(K_G)	**Skidding(SK_1)**	**Sorting(σ_1)**
widevery<0.67	Very good Skidding0.3<	Well sorte0.35>
wide0.67-0.9	good Skidding0.1-0.3	Good sorting 0.35-0.5
wideMiddle0.9-1.11	Symmetric (-0.1) _ (0.1)	Sorting fairly well 0.5-0.7
long1.11-1.5	Coarse skein(-0.1) _ (-0.3)	Relative Sorting0.7-1.00
very long1.5-3	Very Coarse skein (-0.3) _ (-1)	Poor matching 1.00-2.00
Extremely long>3		Vey weak sorting 2.00-4.00
		Extremely weak sorting 4<

normal distribution with values in terms of φ, and formulations which proposed by Korambin and Pathedzhan (1938) are used.

The specified values from the cumulative percentage curve are obtained using linear interpolation between adjacent points defined in a curve. These points are used to compute the parameters of Folk and logarithmic parameters. The initial suggestion of Folk is based on the normal distribution with the values and also based on normal distribution with the metric values. The formulas used in the calculations are shown in Tables 2 and 3 (Krumbein, 1934).

Table 3: Values based on normal distribution with the metric values in Falck method

Falck s' Graphical measurements have been modified geometrically		
Standard deviation		**Average**
$\sigma_c = \exp(\frac{\ln p_{16} - \ln p_{84}}{4} + \frac{\ln p_5 + \ln p_{95}}{6.6})$		$M_c = \exp(\frac{\ln p_{16} + \ln p_{50} + \ln p_{84}}{3})$
Elongation		**Skidding**
$K_G = \frac{\ln p_s - \ln p_{95}}{2.44(\ln p_{25} - \ln p_{75})}$		$SK_G = \frac{\ln p_{16} + \ln p_{84} - 2(\ln p_{50})}{2(\ln p_{84} - \ln p_{16})} + \frac{\ln p_5 + \ln p_{95} - 2(\ln p_{50})}{2(\ln p_{25} - \ln p_5)}$
Elongation(K_G)	**Skidding**(SK_G)	**Sorting**(σ_c)
widevery<0.67	Very good Skidding0.3 - 1	Well sorted1.27>
wide0.67-0.9	good Skidding0.1-0.3	Good sorting 1.27-1.41
wideMiddle0.9-1.11	Symmetric (-0.1) _ (0.1)	Sorting fairly well 1.41-1.62
long1.11-1.5	Coarse skein(-0.1) _ (-0.3)	Relative Sorting1.62-2.00
very long1.5-3	Very Coarse skein (-0.3) _ (-1)	Poor matching 2.00-4.00
Extremely long>3		Very weak sorting 4.00-16.00
		Extremely weak sorting 16<

Statistical parameters are also proportional to descriptive components. For terminology consistent with the percentage of sand and gravel, divided into five categories; very small (2 mm) to very coarse (54 mm). In order to avoid confusion, so the suitable scale for skewness is based on metric or φ. Positive skewness (indicating that it is too fine particles), and the negative skewness (indicating a sequence of coarse particles).

This program uses a textual classification (such as clay, sand, gravel (previously made by Felix 1924). It also includes a table obtained for the percentage of the fall of any size of the fraction. In terms of output, this program provides a graph of the distribution of grain size and the cumulative distribution of data in both micrometers and in Φ, and displays the sample size in a triangular diagram that is in the form of pebbles, clay and sand. Samples can be individually analyzed or provided to the user with up to 220 possible samples with all of the statistical analyzes (Mohammadi, 2015).

3.4. Total comparison of parameters and different methods of grain classification

The characteristics of the data acquisition stations were considered at appropriate distances of about 500 meters and the sampling was carried out on a monthly basis (the specified time) for each station, and then the average of those that were considered in this research, it placed. The statistical formulas in Table 2, for calculating parameters of grain classification of the Patty Kvrmbyn John (1983) formula, and Folk (1957) formula are used. In these formulas, f is the percentage of frequency and m is the middle point of each class (or a metric unit or Φ unit); φ_x, P_x are the grain diameters (in metric units or in Φ unit), and the cumulative percentile of x (Krumbein, 1934).

4. RESULTS

4.1. Granulation and sedimentation

The data obtained from the aggregation including the weight of each sediment sample in different depth are presented in Table 4.

Table 4
Segregating sediments in different depths by sieve method for Karkheh river basin

20 (m)	*15 (m)*	*10 (m)*	*5 (m)*	*0 (m)*	*Depth Sieve number*
0	0	0	0	0	10
0.06	0.13	0.169	0.052	0.19	35
0.04	0.01	0.021	0.075	0.16	60
0.59	0.28	0.2	0.53	0.59	100
0.23	0.34	0.29	0.22	0.053	140
0.07	0.17	0.21	0.09	0.003	230
0.01	0.07	0.11	0.033	0.004	400

The results obtained for the sediment texture from different depths which using the Griadstat program is shown in Table (5).

Table 5
Results from the Grade Acetate Program for Karkheh river basin

		0(m)	*5(m)*	*10(m)*	*15(m)*	*20(m)*
Contexture type		Sand	Sand	Sand	Sand	Sand
Math Torque Method (µm)	Average	288.2	196.4	206.9	197.2	201.2
	Sorting	159.6	112.2	187.4	165.5	113
	Skidding	1.309	2.34	1.465	1.805	2.581
	Elongation	3.087	9.45	3.557	4.892	9.975
Geometric torque method (µm)	Average	248.4	168.7	146.4	149.8	175.6
	Sorting	1.612	1.643	2.162	1.958	1.536
	Skidding	0.724	0.015	0.58	0.63	0.481
	Elongation	3.082	4.286	0.464	3.084	5.126
Logarithmic Torque method (Φ)	Average	2.01	2.568	2.772	2.739	2.51
	Sorting	0.69	0.72	1.112	0.97	0.644
	Skidding	-0.724	-0.015	0.58	-0.63	-0.48
	Elongation	3.082	4.286	2.464	3.084	5.126

contd. table 5

Falck method (µm)	Average	266.1	167.3	165.8	136	170.4
	Sorting	1.694	1.648	2.451	1.93	1.592
	Skidding	0.452	-0.042	0.289	1.107	0.003
	Elongation	1.104	1.516	1.085	1.529	1.654
Falck method (Φ)	Average	1.91	2.58	2.592	2.878	2.553
	Sorting	0.761	0.721	1.293	0.949	0.671
	Skidding	-0.452	0.042	-0.289	-0.107	-0.003
	Elongation	1.104	0.516	1.085	1.529	1.654
	D10(µm)	154.3	82.16	60.02	67.09	108.2
	D50(µm)	219.2	173.7	130.5	137.2	176
	D90(µm)	590.3	283.6	577	542.1	250
	(D90/D10)(µm)	3.825	3.452	9.612	8.08	2.31
	(D90-D10)(µm)	436	201.5	516.9	475	141.8
	(D75/D25)(µm)	1.768	1.725	2.679	1.932	1.612
	(D75-D25)(µm)	135.2	93.2	134.1	97.92	83.18
	D10(Φ)	0.76	1.818	0.793	0.883	2
	D50(Φ)	2.19	2.525	2.938	2.865	2.506
	D90(Φ)	2.696	3.605	0.058	3.898	3.208
	(D90/D10)(Φ)	3.546	1.983	5.115	4.413	1.604
	(D90-D10)(Φ)	1.936	1.788	3.265	3.014	1.208
	(D75/D25)(Φ)	1.488	1.362	1.639	1.411	1.314
	(D75-D25)(µm)	0.822	0.787	1.421	0.943	0.489

4.2. The role of dust storms in the formation of river sediment

After obtaining the results of granulation of sedimentation of the river, the results of the sampling of the dust grains for testing, analysis and identification of the type of the particles for the two months of October and November 2016 were sent to the Reference Laboratory (laboratory for erosion of wind, mulch and micro-organisms in Yazd University (Laboratory for Wind erosion, 2016). The results showed that the origin of the dust grain is sand like the origin of the river sediment, so it can be assumed that the phenomenon of dust storm and wind erosion can transfer dust particles to the south of the catchment that can be effective in creating sand sediments in the river (Eslamian and Hasanzadeh, 2009). The relationships between dust grain and sediment grain were calculated by using correlation coefficient and SPSS software. These results are presented in Table 6.

Also, according to the obtained information and the abundance maps of the dust storms from the Iranian Space Agency (Space Organization of Iran, 2016), it can be concluded that the most frequency of the dust storm (Figures 3 and 2) happened in the two months of October and November (Matouq *et al.,* 2013). Also the greatest frequency of the sediment deposition happened in these two months (Table 7). In Figures 2 and 3, yellow and orange colors show the highest frequency of observed dust storm in the whole of Iran. As shown in the figure, the largest dust storm occurred in the Karkheh area in the months of October and November in 2016.

Table 6
Statistical analysis of the correlation coefficient between the dust grain and sediment grain, different samples from Karkheh River

The Correlation	*Sample Number*
0.7	1
0.68	2
0.8	3
0.67	4
0.85	5
0.89	6
0.74	7
0.72	8
0.76	9
0.76	10
0.83	11
0.84	12
0.77	13
0.82	14
0.86	15
0.71	16
0.79	17
0.88	18
0.85	19
0.85	20
0.69	21
0.71	22
0.66	23
0.73	24
0.8	25
0.81	26
0.69	27
0.74	28
0.77	29
0.8	30

Table 7
Monthly changes in the volume of suspended load and river concentration at the Karkheh dam

Month	*Average discharge (m^3/s)*	*Suspended load (Million tons)*	*Medium concentration of suspended matter (mg*lit)*
October	173	*8.79	9770
November	190	*28	3338
December	198	3.48	7720
January	240	2.3	5200
February	259	6.4	1106
March	266	7.9	1619
April	297	3.74	7932
May	289	6.74	8185

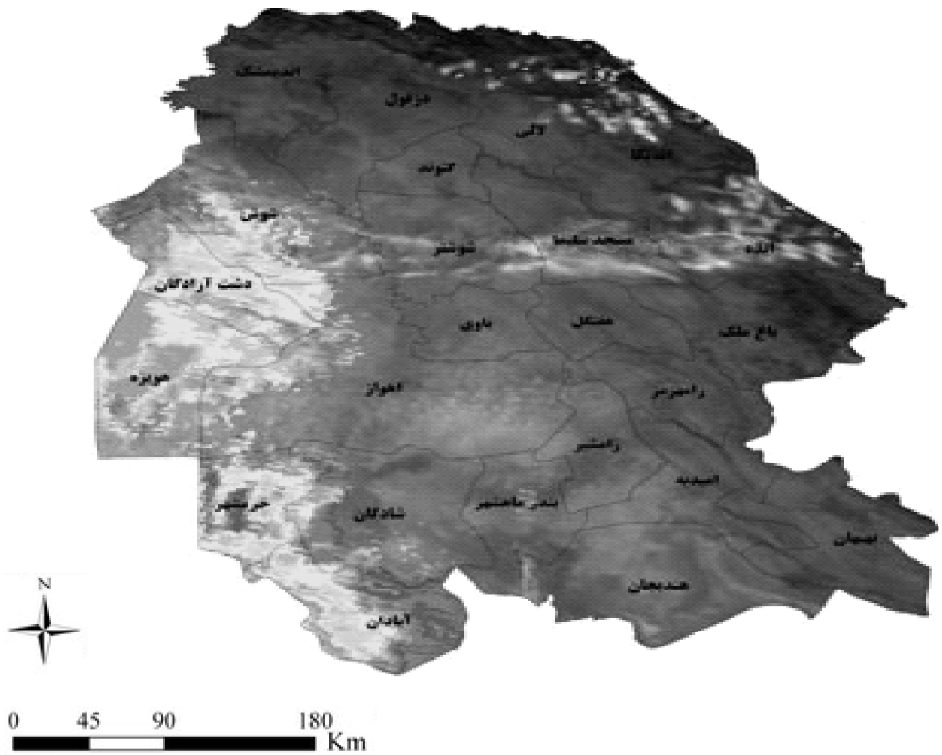

Figure 2: Map of the phenomenon of the Fountains in October 2016

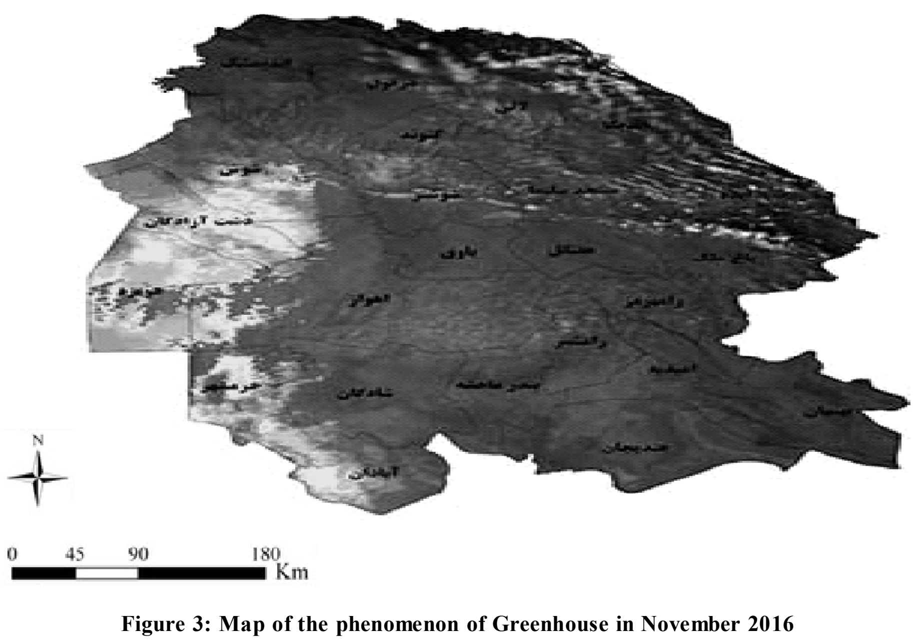

Figure 3: Map of the phenomenon of Greenhouse in November 2016

As shown in Table (7), the highest amount of suspended load in 2016 for the Karkheh River belongs to the months of October and November, which may be due to the fact that these months generally coincide with the season of precipitation in winter and the performance of the fall cultivation and the storm phenomenon of dust is high in these two months.

Figure 4 shows that the highest amount of sediment happened in October to April, because the higher rainfall also occurs in spring and autumn, 2013, Also, according to Figure 5, the highest amount of sediments is in November and August, which is the same as agriculture and dust phenomena (Figures 2 and 3).

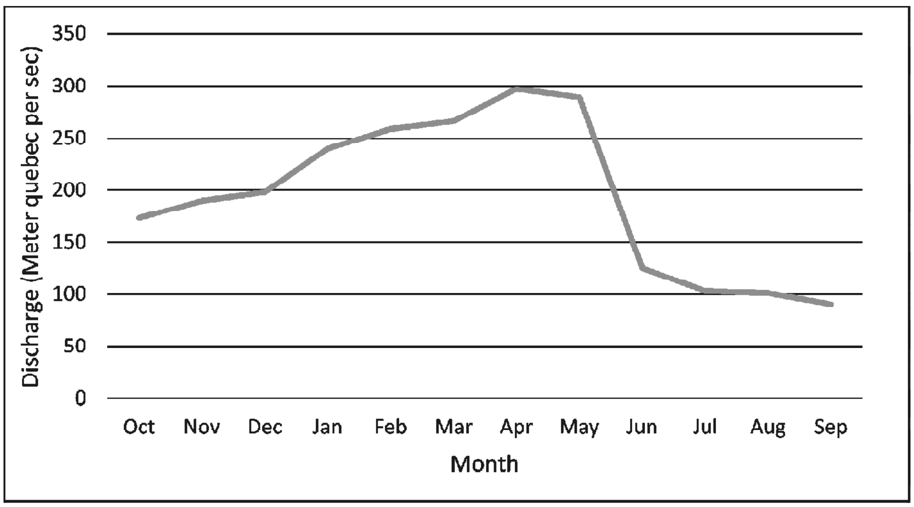

Figure 4: Monthly average flow of Karkheh River

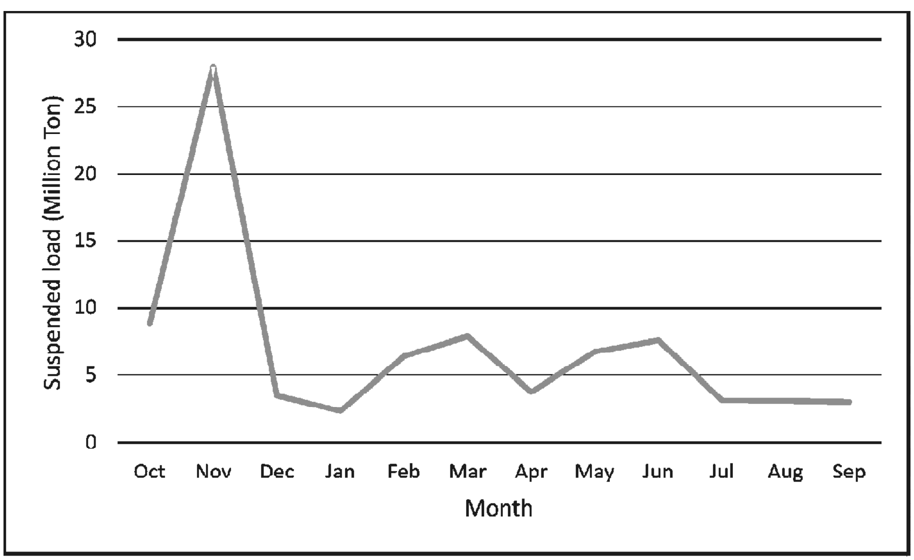

Figure 5: Monthly Sediment (suspended load) in Karkheh River

4.3. Role of climate change in the storm dust:

In order to investigate the role of climate change on the amount of dust, the relationship between three important climatic parameters including rainfall, relative humidity and minimum temperature with the number of days of dust was analyzed for two years of 2016 and 2017, and the results are shown in Figures 6, 7 and 8. The results in Figure 6 show

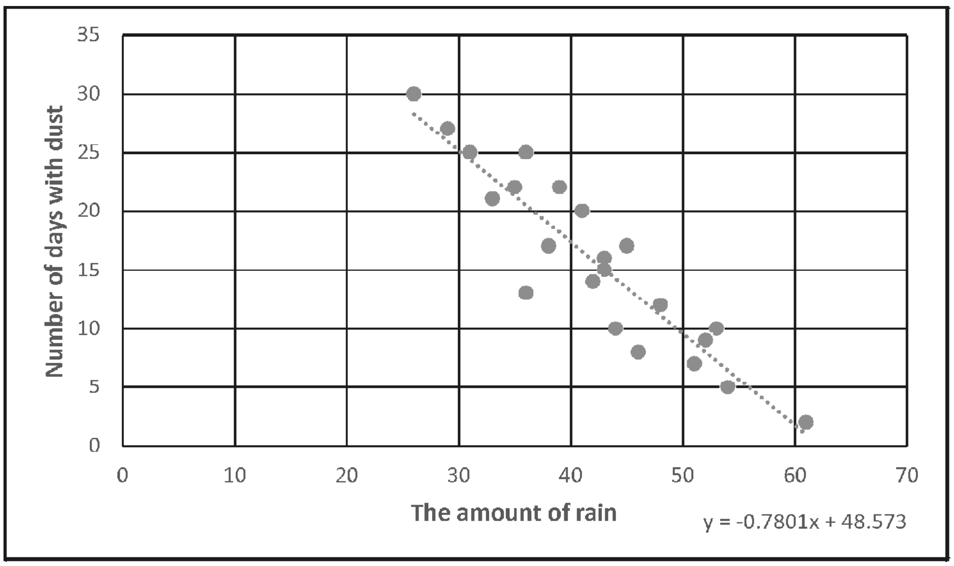

Figure 6: Monthly rainfall variation along with the number of days with a rider for the period 2016-2017

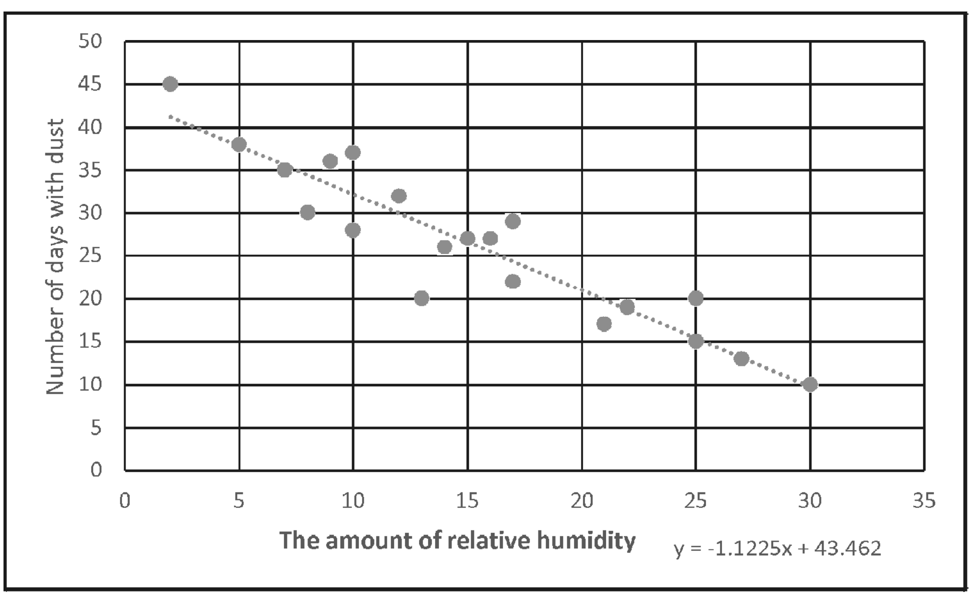

Figure 7: Monthly relative humidity variations along with the number of days with a rider for a period of 2016-2017

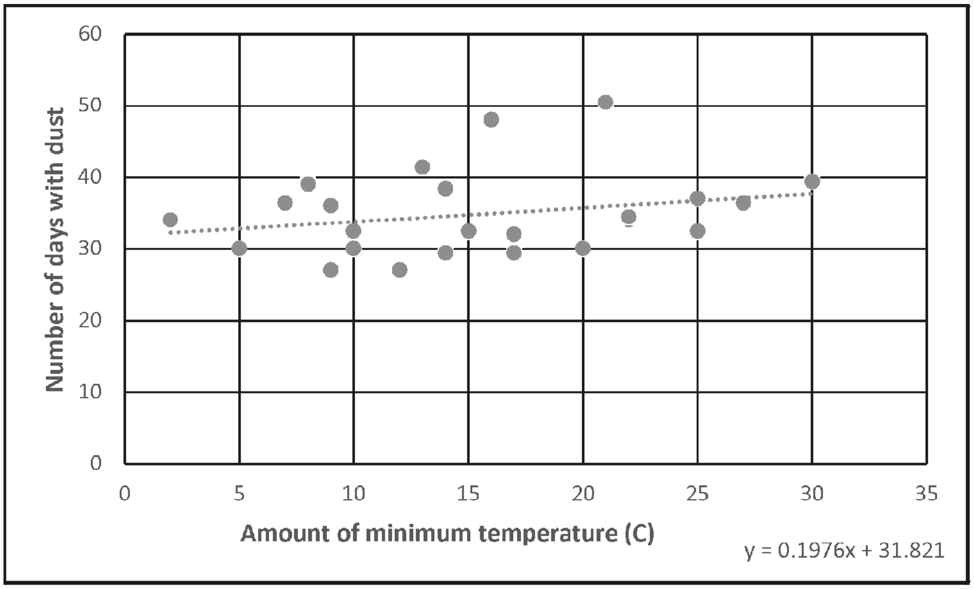

Figure 8: Changes in the minimum monthly temperature with the number of days with a small roundabout for 2016-2017

when the rainfall decreases, the number of days with dust increases. Figures 7 and 8, respectively, show that as the relative humidity decreases and the temperature increases and the number of days with dust increases.

4.4. Proposed measures to deal with dust and its effect on river sediment

In order to reduce the effect of climate change on sediment yield, it is possible to perform the functions that increase the air humidity and consequently the amount of soil erosion, which is one of the factors that cause retrieval, decreases of the soil stabilization, the power in the first solution of vegetation is suitable for even the plants that the water is used to enhance the humidity by photosynthesis. Another factor that prevents the formation of fine grains is the spraying of a petroleum mulch to reduce the flow of sand and, consequently, of microorganisms that can cause precipitation in the river. Another solution is the proper plowing of agricultural land in the region. For example, the protective method of plowing (border plowing and split plowing) causes more soil to penetrate and the soil is stabilized with less erosion, and so the soil moisture is raised and the micro-organisms are less developed and reduced from the effect of the recess on the sediment of the river. Also, the creation of a horizontal bank along the alignment lines and the creation of protective platforms on the river course causes more water to land and the moisture content of the whole area of the basin is high and therefore causes both soil erosion and erosion and as a result, less deposition occurs.

5. DISCUSSION

Discussion of the above-mentioned findings is a probability of a significant relation between the origin of sediment and the involvement of the dust storm phenomenon in sediment formation in the Karkheh River. Previous studies did not consider the relationship between the origin of sediment and the involvement of the dust storm (Mehta *et al.,* 2018), (Wang *et al.,* 2018), (Reed *et al.,* 2018) and (Bran *et al.,* 2018).

In this study, due to the type and size of the river sediment, its potential connection with dust was found. Also, there is a significant relationship between the increase of minimum temperature and the days with dust, indicating a close relationship between climate change and storm surges dust in the Middle East. Although for investigating the effect of climate alteration on any event, the data need to be at least for some decades, however, in this study, the climate data is extracted (precipitation, temperature and humidity) from the CMIP5 model for the year of 1972-2016, but the available observation data for the number of days with extreme dust storm were available only for two years. So, for the effect of climate change on dust storm, the results is only presented for two years and this is a limitation of this study. Nevertheless, the data for results of this study is in daily for two years (2016-2017). Also in the research of Ho *et al.* (2018) which worked on the effect of climate change on dust storm and air pollution, the results of their work for China were analyzed in three years (2006-2009) because of available data were for three years and also as An *et al.* (2018) mentioned the frequency of the dust storm still is unknown.

In addition, in the absence of dust storm control and management, the preparation must be made to deal with more dangerous dust storms in the west and south of the country from year to year. Although the variation in the windy region of the area also shows a significant level with dust (which can also be a consequence of the global warming), but there are the higher levels of matching between dust and relative humidity, and precipitation, humidity and precipitation along with temperature changes as the most important factor in creating dust in the region (which showed in Figure 6, 7 and 8). As Kutzbach et al. (2000) showed in their study results in north Africa during African summer monsoon, it may be initially thought that the increase in temperature would increase the evaporation and, consequently, increase the relative humidity in the atmosphere, but unlike the study of Kutzbach et al. (2000) what was found out in the result of this study is that in this area facing with a decrease in relative humidity, which is indicated the dryness of the area.

Clearly, dust has a direct relationship with soil moisture content, this can be seen in the effect of the months in which rainfall has a significant trend over the period studied on the amount of dust, clearly seen with the passage of time and the decline in the amount of precipitation in the spring, the amount of dust in this season is also more intense than the other seasons. However, regarding the relative humidity decrease in the warm months of the year, it can be noted that due to the fact that in the warm season, the main agricultural land of the sterile region and without cultivation, cause changes in moisture content in different seasons of the year. It is clear that this does not justify the severe changes of hot months in different years than the cold months, because if changes in relative humidity were due solely to crop cultivation, changes in different years should be roughly constant. So this should be the other reason. What has been seen in the recent years in the appearance of the Karkheh field is the rapid change in land use for urban development and the development of industrial centers in this region; the increasing trend of migrants seek to work in this city also in turn, this exacerbates it (Gohari *et al.,* 2013).

The effect of unsustainable development projects in the region as well as the excessive removal of the environment from surface water for the development of sugarcane cultivation plans and besides irregular irrigation of high agricultural lands, resulted in a sharp decline and river discharge will reduce (Zareian and Eslamian, 2018). On the other hand, in Iraq, which is adjacent to the Karkheh area, the Tigris rivers have been thinned out by irregular water withdrawal from the upstream countries, and their wetlands have dried up, and these wetlands in Iraq are considered as the most important centers of the crisis and dust have been identified in the region, which can also turn these fountains into the Karkheh area. On the other hand, pollution from industrial development in the Karkheh region, along with the reduction of water resources, can lead to further degradation of vegetation (Mujere and Eslamian, 2014). This is a positive feedback to increase of the rate of desertification and reduction of relative humidity and consequently increase dust and also increase river sediment. It can be noted that in the sediment phenomenon, not only dust, but also the use of fertilizers uncontrolled agriculture in the growing season, which is associated with rising river flow, helps to increase of the river sedimentation. This paper also confirms the study results of Khaleghi and Varvani (2018). As they mentioned there is a meaningful effect between the mean flow rate and the discharge of suspended sediment with a correlation of above 90% and there is a meaningful effect between the variable rainfall and the suspended discharge, which has a low correlation with the mean flow rate (which showed in Figure 4 and 5 and Table 5 as well). Therefore, as Restrepo *et al.* (2018) described; when river discharge decreases due to climate change effects and increases temperature, so the amount of sediment will increase (Kouhestani *et al.,* 2016).

Furthermore, as Khan *et al.,* (2018) mentioned a wide range of sediment concentration-related problems can occur (especially in upstream of the rivers and dams) which are listed below:

1. Reducing the reservoir: depositing sediment inside the reservoir reduces reservoir capacity and gradually eliminates the available capacity of the reservoir and makes the tank unusable for water supply or flood control. If the overflow capacity is based on the flood capacity inside the reservoir, sedimentation can make the uncertainty on the dam structure and uncertainty with the loss of the flood capacity.
2. Delta sediment: The coarse segment of the sediment flow is deposited at the beginning of the sedimentation reservoir, and by delta formation, it not only reduces reservoir capacity, but can also increase the river bed level above the reservoir. Increasing the level of the floor of the water can cause flooding of infrastructure and land in flood plains, increasing groundwater level, soil salinity, reducing the

navigational space through bridges and submerging the basins in the upstream. If delta areas have a dense vegetation, the flood levels in the upstream area will increase due to increased bed roughness and plant growth can exacerbate sediment trapping, which will increase floor level.

3. Shipping: Both commercial shipping and recreational shipping can be severely damaged by accumulation of sediments, especially in delta areas. In shipping projects created through a chain of low-altitude dams along a river, while the river is open, most of the sediments pass through the structures. However, accumulation of sediment can occur at the site of connections, connecting channels, and delta areas. Recreational access is also damaged by the accumulation of sediments in coastal resorts and sailing platforms.
4. Air pollution: In seasons where reservoirs are empty for irrigation purposes, fine-grained sediments may be eroded and transmitted by the wind, causing disturbances and risks to the health of the people around them.
5. Earthquake hazard: Sediment is weighed more than water, and some studies indicate that the presence of sediment in front of the dam can significantly increase the impact of earthquakes on the structure. The accumulated sediments near the dam may be flooded by the shakes created by the earthquake, so that they flow to the lower outlets and burrow them under sediments.
6. Eclipse: In power plants, the aggregates larger than 0.1 mm exacerbate the erosion of moving turbines, and in angular quartz sediments, and exploitation in the upper levels, injury can occur even in smaller particles sizes. . This issue can reduce the efficiency of electricity production and will require the removal of production units for repair. In high sloping rivers, the sediments larger than boulder can also pass through lower outlets.
7. Energy loss: The energy loss results in the loss of the potential for high-energy currents to generate energy. When a series of power plants are constructed along a river, the canal turns the transfer of water from a power plant to the delta range from the other tank downstream. Delta sedimentation can increase the level of the bed of the transmission channel of the power plant as well as the bed of the water supply, which will result in the reduction of power plant capacity and possible flood flow of the power station if no solution is found.
8. Ponds: Sediments may block the ponds and the outlets located at the bottom of the dams. During severe floods, several meters of sedimentation can occur within a few hours.

Obviously solving these problems will have no solution other than achieving proper management in a sustainable development beam. For example, (Bullard and Mockford, 2018) with using mulch and increasing vegetation cover control the temperature and humidity of the Kangerlussuaq region and so controling the amount of dust of the area and adapting with climate change. Another example which An et al. (2018) mentioned for practical solution to reduce the effect on climate change and to manage dust storm in China is use of the native plants and trees as buffer can reduce wind velocity and the sand drifts at the same can increase the soil moisture.

6. CONCLUSIONS

Sand and dust storms can cause the significant negative impacts on river flow, sediment, environment, society, economy at local, regional and global scale. The environmental and health hazards of such storms cannot be reduced permanently, however, their impact can be reduced by taking the appropriate measures. There are three key factors responsible for the generation of sand and dust storms: 1) strong wind, 2) lack of vegetation and 3) absence of rainfall.

Except of the main source of dust particles, dust also carries air borne pollutants such as toxins, heavy metals, salt, sulphur, and pesticides, etc. which cause the significant health impacts when people inhale the contaminated dust. Dust can corrode the buildings and other built infrastructure as it contains high level of salts. In addition, some dust particles can effect on the amount of river suspended load of sediment. To understand this effect, at first there is a need to know and analysis of the origin of dust particles, sediment particles and also to understand the relationship between the origin of dust particles and sediment particles. Therefore, to understand the origin of dust particles in terms of the particle s' size and particle s' type, the dust particles samples sent to the "Central Laboratory for Dust researches, Yazd University, Iran". The laboratory results showed that the type of the most samples, which collected are the sand type and the size of the particles in most of the samples are 0.125-0.25 mm.

Then, to understand the origin of the suspended load of sediment particles in terms of size, this study has used the sieve method which explained in section 3.1.1. Most of the size of the particles were as same as the dust particles.

Also to obtain the distribution of sediments granulation, different statistical methods have been used and compared in this study, however torque method (which explained in section 3.2) gave the better results for distributing of the sediments granulation with regards to the four parameters which used for describing the distribution of granularity (e.g. average size, distribution around the mean, the criterion of the existence or absence of distribution symmetry, a criterion of the curve sharpness at maximum point).

Next, to obtain texture of sediments with regards to their size, GRADISTAT software used (which explained in section 3.3). This software program uses a textual classification (such as clay, sand and gravel (previously made by Felix 1924). It also includes a table obtained for the percentage of the fall of any size of the fraction.

Generally, the results showed that the origin of the type and size of the dust and sediment particles are similar in most of the samples. So, it can be assumed that the dust particles can cause increase of the suspended load of sediment in Karkheh River.

For understanding the effect of climate change on dust storm, this study used the regression formula between the number of days with dust and the climatic parameters include humidity, temperature and rainfall. The results show that in this area facing with a decrease in relative humidity, which is an indication of the dryness of the area. Clearly, dust has a direct relationship with soil moisture content, this can be seen in the effect of the months in which rainfall has a significant trend over the period studied on the amount of dust, clearly seen with the passage of time and the decline in the amount of precipitation in the spring, the amount of dust in this season is also more intense than other seasons. Therefore with increase in dust, suspended load of sediment can increase. As mentioned in section 5, a wide range of sediment concentration-related problems can occur (especially in upstream of the rivers and dams) which are: reducing the reservoir capacity, more air pollution, energy losses of flow which needs for power houses, and also sediments concentration may block the ponds and outlets located at the bottom of the dams which has a negative impact on river ecology.

So, for adaptation with climate change and reducing the impacts of climate alteration on dust storm (Eslamian et al., 2011) and following on the effect on suspended load of sediment, there are some practical solutions, which are listed below:

1. To use vegetation appropriately even for the plants that use the water less to enhance the humidity by photosynthesis.
2. Another factor that prevents the formation of fine grains is the spraying of an oil mulch, which decreases for fixing sandy soils and as a result of microorganisms that can cause precipitation in the river.
3. Another important factor is how to plow the good agricultural land in the region. For example, the protective tillage method (border plowing and split plowing) causes more soil to penetrate and stabilize the soil and less erosion, and therefore the soil moisture is raised and the micro fluids are less created and the effect of fine grains on the sediment of the river is reduced.
4. Also, the creation of a horizontal bank along the alignment lines and the creation of protective platforms on the river course will cause more water to fall and soil moisture of the whole watershed area will increase and thus erosion and soil erosion will decrease. As a result, amount of sediment will decrease.

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