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Full Length Article

Evaluation of dunes sediments middle diameter spatial distribution in association to erosive winds direction using geo-statistic algorithms (Case study: Ashkzar and Khavidak erg in Yazd province)

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ABSTRACT
Erosive winds direction and velocity are of the most effective determinant factors in granulation shape and variation of dunes elements. The more homogenous soils in a specific area, the more dunes shape will be similar to barchans' and also elements gradually will be finer from the begining to the end of erg. In ingoing study, we are going to investigate and compare dunes sediments middle diameter spatial distribution in Ashkzar and Khavidak erg. For this, first monthly, seasonal and annual wind roses were developed using statistics from Yazd synoptic meteorology station. Then dunes morphology map was developed on basis of region satellite images and reconnaissance. At the next stage, sediment sampling was done based on 500×500 m regular grid. Results from sediment granulation were plotted based on ASTM classification using granulometer software of GRgraph and granulation indices including middle diameter was calculated. nisotropyAand geo-statistics tools were applied in order to evaluate effect of predominant wind direction on sediments granulation spatial distribution and to compare and select the most appropriate varyograms respectively. results showed that dunes elements middle diameter spatial distribution is approximately different in ashkzar and khavidak so that ashkzar erg displays the most scenario spatial distribution against spherical varyogram with isotropy angle of 240(northwest) and ordinary kriging (kO) is the most appropriate interpolation method with RMSE about 21.39 while the most scenery varyogram for khavidak erg is spherical varyogram with anisotropy angle 118 (southeast). The most suitable interpolation method for this erg is ordinary kriging with RMSE about 11.49. Obtained results indicated that local topographic factors and geographical position of Yazd affect predominant wind direction and spatial distribution of dunes sedimentation and just wind rose and storm rose analysis of synoptic station cannot provide correct estimation of sedimentation trend in a region or an erg.
Keywords: Erg, Geo-statistic, Wind Erosion, Erosive Wind Direction, Granulometry

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INTRODUCTION

Up to two thirds of Iran wide area is covered by arid and semiarid regions. Vegetation paucity and land bareness in these regions are factors increasing soil susceptibility and wind erosion. some methods such as to evaluate region wind roses and wind erosion types(Ekhtesasi,M.R,et al.1996), wind direction determination from dunes types[1, 2] investigation genetically relationship between dunes sediments to adjacent sediments [13] and finally to provide questioner and interviews from local people(Ekhtesasi. 1996) are specific for wind direction recognize and sediments movement path and sources in different regions among others. in yazdian khavidak and ashkzar in where kriging method was applied to estimate desert pavement percent and wind erosion velocity, results showed that using geo-statistic and ordinary kriging method are accurate and appropriate methods to construct map for effective parameters in wind erosion including vegetation distribution and threshold velocity isoline [4]. Geo-statistic methods have much more advantages than specific those for construct soil map for investigation soil properties spatial variations [12]. In soil characteristics analysis using geo-statistics methods specially kriging and co-kriging to measure phosphorous, calcium, magnesium, extractable iron, soil clay, silt and sand percent have high correlation to data real distribution [5]. in a study conducted out in three different times in

which classic statistics methods were used for expressing beds between differences and geo-statistic to express beds within ones and studied characteristics were include soil particle size distribution, soil carbonate calcium and organic matter. Results showed that soil characteristics variability has decreased from young beds to old ones indicating increasing trend of soil homogeneity over time [14], in ingoing study also geo-statistic method is applied to detection sediment average diameter dependency, its direction and anisotropy and possibility for estimate granulation in a dune complex. A variable dependency to itself in relation to temporal and spatial scale is studied in geo-statistic and it is based on regional variables those time and space dependant. Geo-statistics methods are used when there are regular huge volumes of information and stability hypothesis confirm spatial dependency in studied region. This investigation is based on presence of spatial dependency between sediments particle diameter and direction coincidence having the highest spatial dependency to erosive wind direction.

MATERIAL AND METHODS

Study area

Study areas were khadivak erg located at in thirty km southeast of Yazd with longitude 29 51-54 to 32 01 54 eastern and latitude 31 49 12 to 31 47 36 northern and Ashgzar erg located in 23 km from Yazd northwest with longitude 54 08 75 to 54 12 65 eastern and 32 04 14 to 31 59 14 northern. Positions of study area in country and province and also on satellite images have been shown.

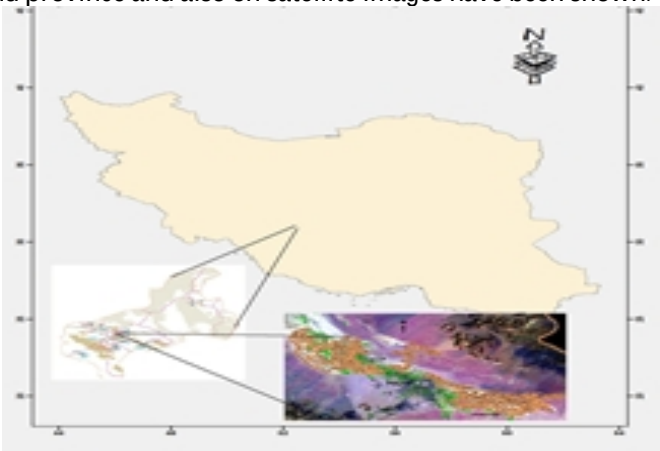


Figure1-study area geographical position in country and province

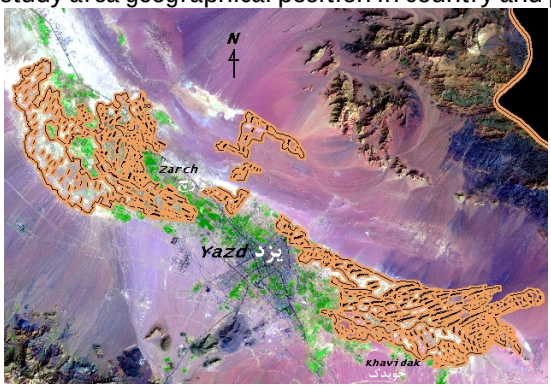


Figure2-Geographical position of studied ergs on aerial photographs

Data normalization:

To investigate spatial structure presence in data by variogram analysis it the first step in using geo-statistics methods. The major condition to use these data is data normalization. skewdness coefficient is one of the best way to assess normalized pattern of data. If this coefficient is less than 0.5, then there will no need to data transformation, but if it ranges between 0.5 and 1 or up to 1, square root and logarithm must be used to data normalization (Robinson and Metternicht, 2006). Kolmogrov –Smirnov test was used to confirm normalized state of data.

Materials:

In present study in order to investigate different types and characteristics of dunes, topographic maps with scale 1:500000 and regions satellites images were used and 2, 1; 0.5 mm, 250 and 63 micron mesh sieve were used in sieving analysis. Software WRPLOT was used for develop regions wind roses and GS, surfer and AcGis were applied in geo statistic studies.

Methods

In this study, 72 and 134 samples were taken from ashkzar and khavidak ergs dunes respectively, sieved in laboratory, then particle average diameter was calculated by plotting sediments particles diameter cumulative graphs and spatial dependency of particle average diameter and its direction evaluated using geo-statistics method. In order to find predominant and erosive winds, seasonal and annual wind rose and investigation of dunes types using satellite images and to provide questionnaire of local people.

Sampling method

in order to take samples from ashkzar and khadivak ergs and to prevent any sampling error and deviation and systematic errors in geo-statistics estimations, a regular grid along directions having the most and least hypothetically spatial connection (erosive winds and perpendicular on it) was landed these dunes satellite images and sampling was done within grid knots(figures 2&3).

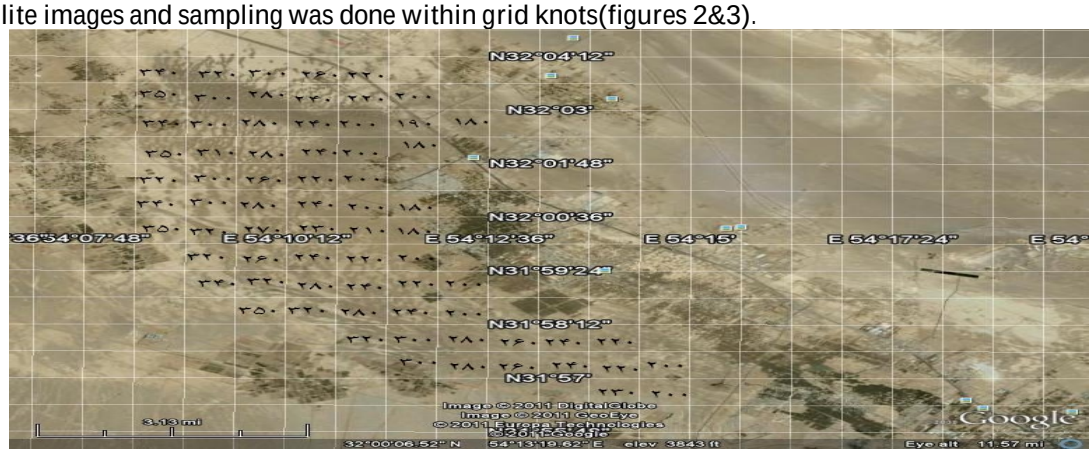


Figure2-sampling grid for Ashkzar erg dunes

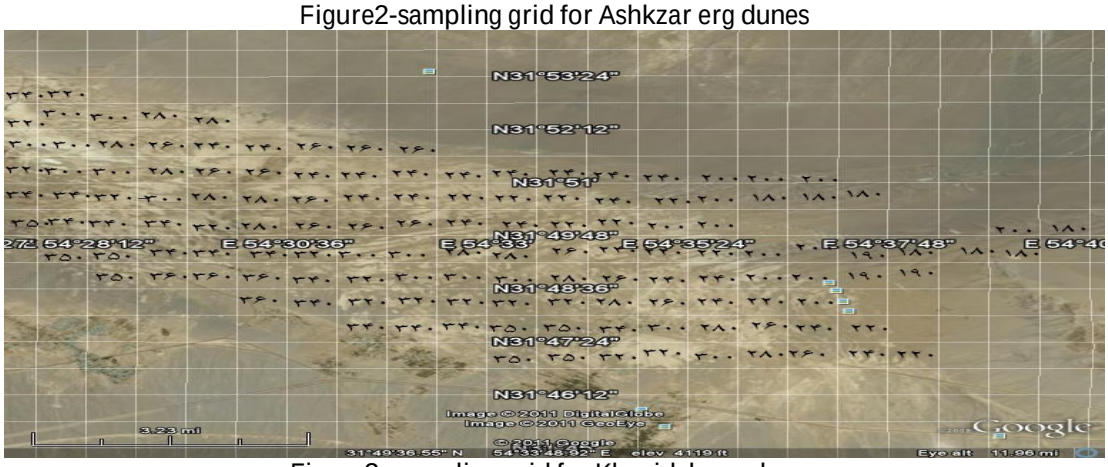


Figure3- sampling grid for Khavidak erg dunes

Sieving analysis was conducted for 500 g samples and sediments average diameter was calculated by sieve analysis data and following formula:

(1974Folck) $M = \frac{\emptyset 16 + \emptyset 50 + \emptyset 84}{3}$

Where, M is sediment average diameter, $\emptyset 16$‘ $\emptyset 50$‘ $\emptyset 84$ are diameters to which 16, 50 and 84 weighted percent of particles have diameters less than it.

Regions wind roses development

daily statistics in yazdian synoptic station were used for developing wind rose where this station is located in seventy five km further from dunes in present study statistics related to 1980 to 2010 was used to develop regions annual and seasonal wind roses.

Questionnaire circularize in local people

Since local people have complete acquaintance to predominant winds direction and this information can be used as an authentic source for sediment carrying winds direction, a questionnaire was filled during gathering information from countryside and adjacent villages on study area general wind direction and also sediment carrying winds intensity and direction and their occurrence time and required information were collected.

Dunes morphology detection

Study of dunes morphology using satellite image and reconnaissance can help to characterize dunes activity, erosive winds direction and sediment transportation as well as dunes activity type and level.

Since dunes morphology is a function of wind direction and its sedimentation or deposition manner, hence special type and shape of each dune and its position can be useful in finding sediment carrying and shaping winds direction. For his, dunes type and predominant wind direction in khavidak and hoshgozar ergs were evaluated.

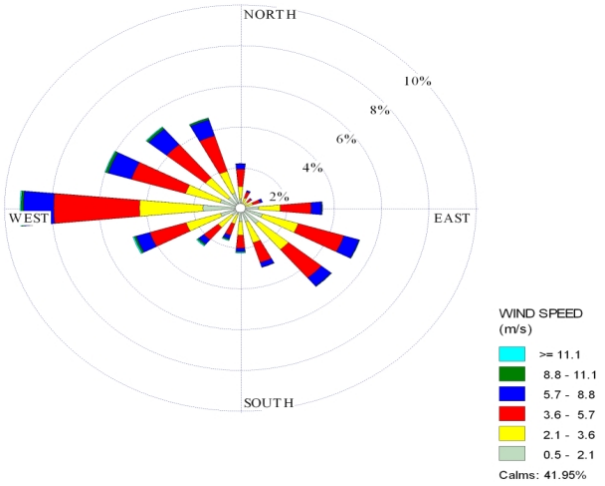


Figure4:annual wind rose in yazd station

Following results were obtained from filled questionnaires around dunes adjacent:
-Predominant winds blow direction in Ashkzar and Khavidak ergs are northwest and northeast respectively which served as main winds.
-Among khavidak ergs, eastern and southeast winds and among ashkzar ones northwest winds have more intensity respectively.
-Among main winds in ashkzar, northwest and east winds carry the highest sediment.

Investigation of dunes morphology

In order to study dunes morphology dunes general shape was dealt with using regions satellite images and their types were recognized and then some defects were obviated by reconnaissance and eventually regions morphology map was produced .various dunes type in erg is as following:

Seif dune

All active dunes are stemmed from a Seif in other words; seif is as dunes the most constituent factor [3].
Cross section dunes (forward and backward)
The main characteristic for these dunes is predominant wind direction which is perpendicular to dunes axes. In case two or more barchans' are formed together, cross section barchans is a result. Secondary winds having angle 180 degree (opposite each other) are the factors forming them. In this situation barchans s arms are chained together and created as bias strains perpendicular on main wind direction. Once main and secondary wind direction strength as equaled and be as mutual, rows created by cross section barchans' are joined and interweaved. In this situation, there will not any distance between rows but only there are closed cavitations between them called Akleh [3].
These dunes account for the highest erg area (97500 h).in these regions, northwest and southwest winds form these dunes type which forward and backward dunes have been compacted in many ergs. Presence of multidirectional winds in this region with different abilities in forming dunes has led to some interruption in cross section dunes.
Star like dunes
Presence of predominant winds in three directional has resulted in star dunes with highest height. These dunes are formed as a result of northwest and southeast and eastern winds and are concentrated in center of erg and have various crest.
Sediments granulometery:
Figures for sediments grain and particles distribution and accumulation were plotted using data resulted from sieving analysis in phi and micron scale. For instance, three cumulative graphs plotted in phi scale have shown in figure 6.

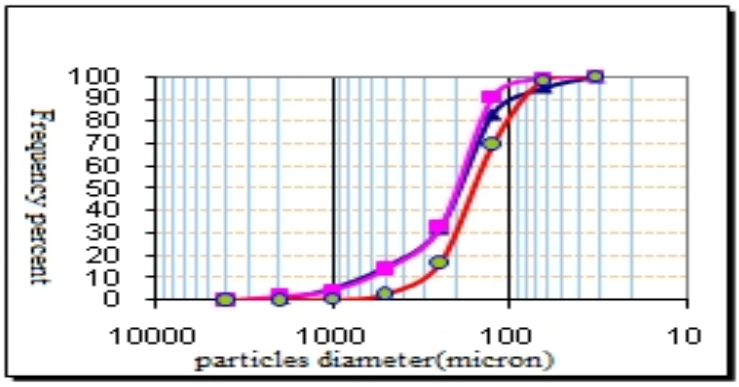


Figure5: cumulative granulometery graph for three erg sediment samples in Yazd

Geo-statistic method

In geo statistic studies, calculation and estimation stages after sampling and samples regularization is as following: varyography includes to calculate and fitting, varyogram validation, estimation and reporting in the next we will discuss about these studies on erg granolometery.

Bi-dimensional varyography of granolometry

In this investigation, varyogram is a tool for determine granolometry continuity, influence magnitude (garnolometry radius and spatial dependency), heterogeneity in bi-dimensional spatial dependency of granolometry in erg. in order to calculate granolometry empirical varyogrames in study area and to find varyogram represent erg granolometry distribution (which is scenery and fittable varyogram), on the other hand, to determine nahamsangardi of erg granolometry spatial relationship from the north (zero azimuth) a varyogram was drawed to each 5 degree which they are observed in figure 7 (A to P) some examples of ashkazr and khavidak varyograms are seen respectively.

Figure 6: a- ashkzar varyogram erg in zero point direction from northern zero point azimuth

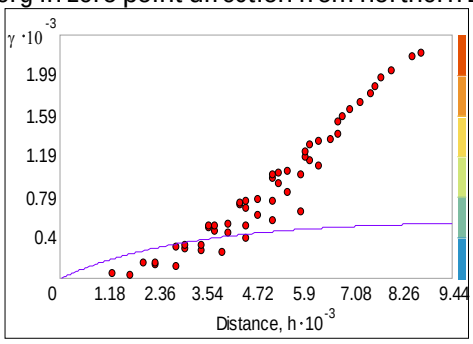


Figure 7-b- Ashkzar erg varyograms in 45 degree from zero azimuths point

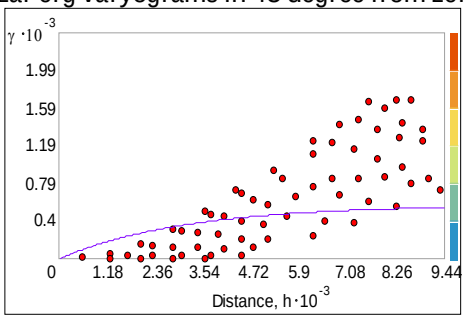


Figure8-b) varyogram for khavidak erg in 45 direction from zero azimuth(northern)

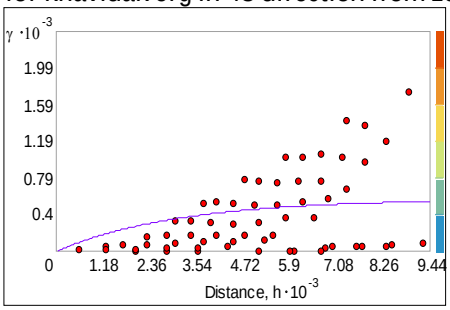


Figure7-p) varyogram for Ashkzar erg in 150 directions from zero Azimuth (northern)

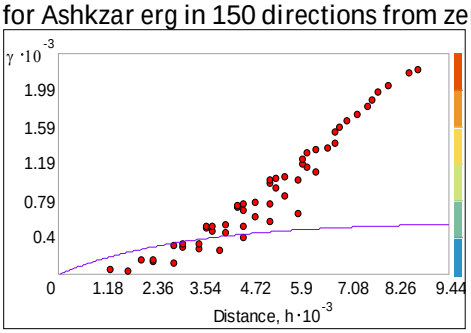


Figure8p) varyogram for khavidak erg in 150 directions from zero Azimuth (northern)

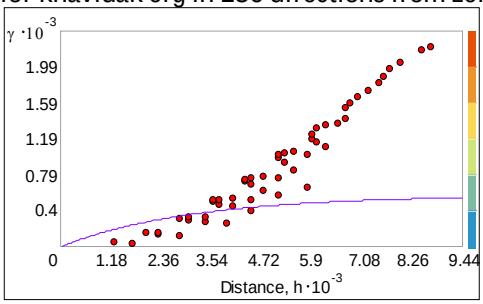


Figure7-g) varyogram for Ashkzar erg in 240 directions from zero Azimuth (northern)

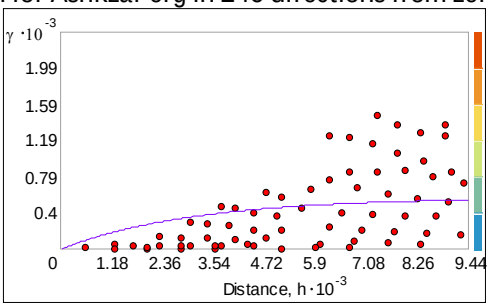


Figure8-g) varyogram for khavidak erg in 118 directions from zero azimuth (northern)

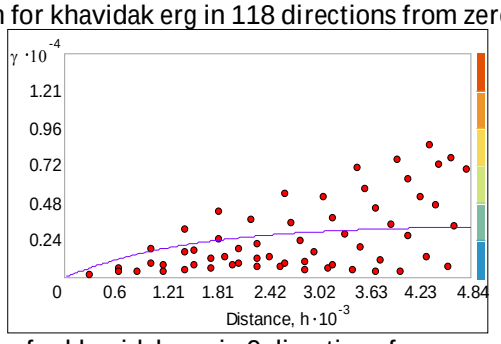
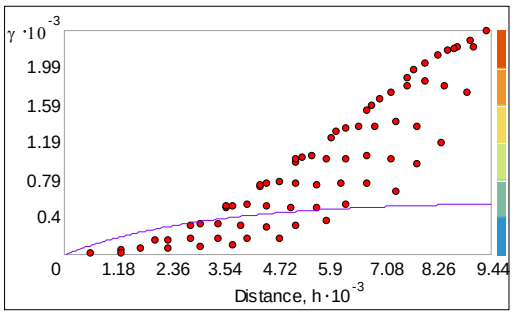


Figure8-A) varyogram for khavidak erg in 0 directions from zero Azimuth (northern)



Isoclinals map

Empirical varyogram in 240 and 118 degree (in ashkzar and khavidak ergs respectively) represent isoclinals n this direction. Among abovementioned plotted varyograms, just 240 and 180 degree varyograms show scenery spatial continuity in which theoretical varyogram is spherical. this varyogram parameters have shown in table2.

Table2-fitted model parameters on ashkzar and khavidak ergs

Meter)A	**(μ^2 Nugget**	**(μ^2)Sill**	**factor**
2920	0.0001	0.0433	ashkzar
34310	0.012	0.0466	khavidak
RSS	**R^2**	**$\frac{c}{c+c0}$**	**factor**
0.059	0.71	0.99	ashkzar
1.38	0.97	0.78	khavidak

RMSE	equation	method	
11.49	$0.94x + 14.76$	**ok**	kriging
11.5	$0.93X + 18.37$	**sk**	
18.27	$0.79x + 72.77$	**uk**	
17.3	$0.74X + 68.56$		IDW*
20.22	$0.85X + 42.76$		GB**

Fitted model validation on selective varyogram

While varyograms validation in geo-statistic, scenery varyograms model is controlled specially so that each known point (sample) is shown in terms of n-1 and in such condition a stable hypothesis is true and geo-statistic is used [7]. varyogram model base is estimated. Hence difference between known and estimated values gives total errors by which model validation is carried out. Table 3 and 4 shows sum of various estimator statistical errors.

Table3: statistical data for different error estimators in ashkzar region

RMSE	Equation	Method	
21.39	$0.89x + 27.02$	**ok**	Kriging
22.17	$0.86x + 35.6$	**sk**	
22.49	$0.78x + 52.7$	**uk**	
27.71	$0.57X + 110.8$		IDW*
29.99	$-0.166X + 42.04$		GB**

Anisotropy in sediment spatial granulation association

Another characteristic usually are in geostatistic and can be obtained by drawing varyograms in different directions is Anisotropy. This contribute appears as geometrical (in influence radius or magnitude) or regional (in threshold level) and is recognizable by drawing and matching different theoretical models and it is usually in two states of three dimensional and it is plot table and numerical by diameter proportion.

In study area it seems that Anisotropy is geometrical because threshold level does not change too much and influence radius or magnitude of 477 m (khavidak erg) and 2920 m. direction anisotropy ellipsoid displays the maximum and minimum spatial relationship which can be well confirmed with erosive and non erosive winds directions. In figures 11 and 12, anisotropy ellipsoid figure and effective wind direction is shown in study area.

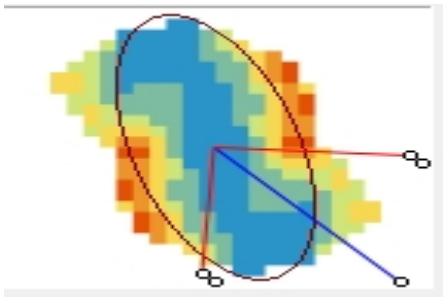


Figure 8- anisotropy ellipsoid and erosive wind direction in ashkzar erg

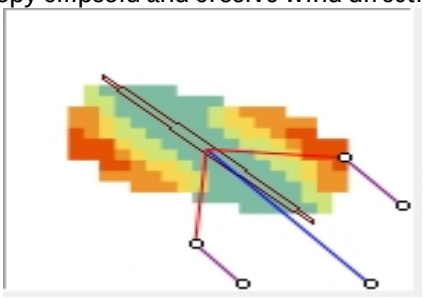


Figure9: Anisotropy ellipsoid and erosive wind direction in Ashkzar erg

Granulation estimation

One of the main application of geo-statistic in present study is to estimate blocky and three dimensional and bi-dimensional by various kriging methods. Study area in this study was divided into 50*50 m blocks and estimation was carried out by ordinary kriging at excellent accuracy which is illustrated in figures 11 to 13 of blocky and iso-diameter map of study area.

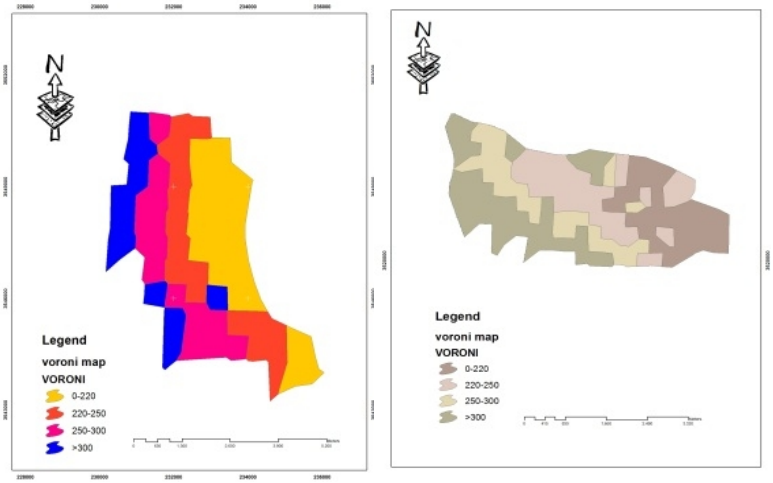


Figure 10 a: polygonal map of average diameter (micron) in Ashkzar erg area, b: polygonal map from average diameter (micron) in Khavidak erg area

Figure11-iso diameter map (micron) for ashkzar erg from ordinary kriging

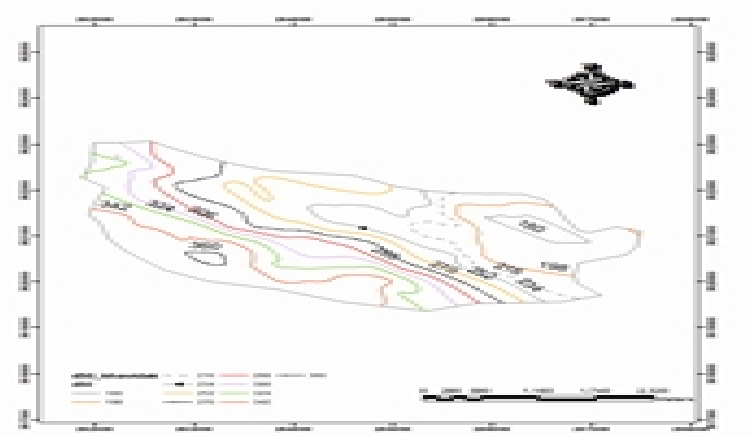


Figure12: iso-diameter map (micron) for khavidak erg from ordinary kriging

DISCUSSION AND CONCLUSION

Wind rosés studies

Northwest and western winds direction can easily recognized by plotted wind rose as year around in yazdian synoptic station. in respect to results from questionnaires and that sediment carrying winds are blowing much more from west it can be conclude that erosive winds directions are western and northwestern.

Studies related to dunes morphology:

Following results are inferred from total conducted investigations on dunes:

-Seif presence as the main dunes constituent which in western and central parts of both ergs represents more active deposition. General investigations on erg shape indicate that ashkzar erg is a left turn and khavidak is right turn one.

ranolometery studiesG

Isoclines contour maps show particles diameters distribution and general particles diameter variation direction is western-eastern one. This conclusion has inferred from studying polygon map produced by sediments diameter. In geo-statistics studies carried out on sediment mean diameter, substantial results were obtained as following:

Presence of bi-dimensional and experimental varyogram of ergs granulation and fitablity to spherical model prove presence of spatial dependency in sampled points and imply to hypothesis accuracy.

-among plotted varyograms in different directions (zero to 360) only varyogram 118 is scenery and has good coincidence with spherical model, hence spatial dependency is at highest rate in this direction. So good directional coincidence of this varyogarms to erosive winds direction allow identify erosive winds direction by geo-statistic approach.

-Polygon resulted from granulation estimation indicate sediments regular distribution from northwest to southeast so that courser and finer particles are located in northwest and southeast and this direction has complete coincidence with area predominant winds direction.

-as mentioned previously, sediment carrying direction in area is toward north and predominant winds direction is northwest-southeast and western-eastern.

in conducted studies it is assumed that sediments grains distribution is bi-dimensional, whereas in some ergs points, dunes height is too high and deep estimations could create too much errors. Therefore it is suggested that to conduct three dimensional studies by deep sampling and height effect on granulation distribution be studied.

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