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Research article

AEOLIAN DATA ANALYSIS TO EVALUATE WIND EROSION POTENTIAL (CASE STUDY; SABZEVAR)

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ABSTRACT: More than75 percent of Iran is located in arid and semi-arid and wind erosion is one of the most important processes in desert. Prevailing winds can shift sand dunes and affect their accumulation. Considering the location of Sabzevar in wind regime and because of the potential of region to form the sand dunes, investigation of wind processes is important. In this study after collected data during 1956-2010, studied the Indices of sand rose and wind rose as well as reviewed wind erosion potential of region. The results of sand rose show that the direction of sand is toward south west and UDI index is estimated about 0.55 in this region. These Indicated that the potential of sand carrying and aeolian processes are in intermediate class in this region. The rate of DP calculated 386 VU and also in this sense is in intermediate class as well as sand discharge is 17.31 (kg/m.s). The result of wind rose showed that the frequency of east and northeast winds in region is high and then dominant southeast winds and this matched with the sand transport as well as the most erosive wind class is 4-6 m/s in this study.

Keywords: Wind erosion, Wind regime, Sand rose, Wind rose, Sand dunes, Sabzevar

INTRODUCTION

From the second half of the nineteenth century erosion is as one of the most wide spread problems of environmental degradation, specifically in the areas that have contrasting seasonal climate as well as where human activities have been diagnosed as a factor of degradation [4]. This process occurs in all regions of the world, even in the wet and humid areas and it creates serious impacts. And can be said that wind erosion is a key process in arid and semi arid regions therefore land scape screated from it are consists of sand sea and various forms of sand dunes [24]. In global scale importance risk of wind erosion is lower than water erosion but greatness and aspects of it is higher than water erosion [18]. Wind deposits are very important in the evolution and the formation of desert lands capes as well as findings of geologic. Sand dunes form related to availability of sand dune sediment, evaporation and precipitation in an area and the intensity and variety of available wind [11]. Therefore anemometer data interpreting have direct connection with wind events as well as Sediments sequences in the past [14]. Studies have shown that wind regimes and their relevance with wind deposition are significantly differences in time and place. Lankaster [11] and zobeck (2002) mentioned that study of wind regime is aconvenient method for identify of erosion orientation and there is a relationship between wind regimeands and dunes form [13]. In studies of erosion, there are two types of factors that are erodibility and erosivity [1]. Wind as erosivity factor has vector direction as well as force. Speed and power of wind is a key element in the ability of wind erosion and studies have shown that wind erosion is positively correlated with wind speed [7]. Studies in dictated that prevailing wind can cause deformation in the sand dunes and affect the particles of deposition as well as the wind regime determines the sands movement [13]. Wind is equivalent to a quarter of the Earth's deserts are covered by and each year hundreds millions tons of soil are detach and move [15]. Problems caused by sand dunes movement that may be have damaging impact on infrastructure and populated areas require to region knowledge in relation to wind processes [8]. Because wind is a major factor of degradation and erosion then must have enough knowledge about it. Therefore, during astatistical period the study of area must be analyses.

And the most important factors that should be considered in this case are wind speed, dominant wind direction as well as wind frequency [1]. Several studies carried out in this field such as Fryberger et al [8], Werner et al [22], Barjian [5],Tsoar et al [21], Rajabi [17], Al-Awadhi et al [2], Kocurek et al [10], Ekhtesasi et al [6], Wilkins et al [23], Saqqa et al [20], Zareiyan Jahrome [26], HeziYizhaq et al [25], Pryor et al [16], Mashhadi et al [12], MesbahZade et al [13], Paul W. Jewell [14]. Due to the sediment carried by wind processes have damage and harmful effects on agricultural lands, residential areas, communication ways, network of drainage and irrigation, filling streams, reduce fertility and cause dangerous diseases in the region therefore the necessity and importance the study of wind process has been noticeable and these condition have increase with drought conditions in the region. Therefore in this study be addressed to anemometer data analysis in synoptic station of Sabzevar.

MATERIALS AND METHODS

Case study

Sabzevar is located in 57°40 eastern longitude 36°13 northern latitude and it is in the west of Khorasanrazavi Province of Iran. Joghatay Mountains separate Jovin plains from Sabzevar Plain as well as Mish Mountain is in the south, therefore Sabzevar is surrounded by the northern and southern high ands. Kalshvr seasonal river directs plain flood to the salt region of plain. Average annual rain fall of region is 188.6 mm and regional climate is arid. The average temperature 17.4°C as well as relative humidity is 41 Percent. Ranges of height area are Variation from 915 meter to 1375 meter and more wide spread of region is low land.

Methodology

In the first efforts that long-term data (1956-2010) be collected of Sabzevar synoptic station and then wind data extraction in the area and finally analysis. And the role of it in formation of sand dunes has been study. In this paper analysis of sand rose make with sand rose graph 3.0 and then with use of WR plot software were used for make of wind rose. Thus, in order to convert the weather data to Lake Format used from Saba Wind software. For each of winds greater than13 knots (wind erosion threshold velocity in region) the following equations are used to calculate sand rose indicators (8):

$$DP \propto V^2(V - V_t) \times T \qquad \text{Relation (1)}$$

V is the wind speed measured, V_t is the threshold velocity in the study area (13 knots) and T is relative duration of wind with V_t speed. DP is Ability to carry sand in all directions at a specified time.

$$RDP = \sqrt{(C^2 + D^2)} \qquad \text{Relation (2)}$$

$$D = \sum_{i=1}^{8 \text{ or } 16} (DP_i) \cos\theta_i$$

$$C = \sum_{i=1}^{8 \text{ or } 16} (DP_i) \sin\theta_i$$

$$RDD = Arc\tan\left(\frac{C}{D}\right) \qquad \text{Relation (3)}$$

$$UDI = \left(\frac{RDP}{DP_t}\right) \qquad \text{Relation (4)}$$

In this paper separately attempt to study of each parameter. And then has been paid to compare these variables during the statistical periods. According to Table1 the power of wind erosion into three groups of low, medium and high were classified. And then both index of DP_t and UDI according power of wind erosion during this period have been compared with each other.

Tab 1.Classification of sand drift potential (Fryberger and Dean, 1979)

Sand transport (m^3.year.m) rate	DP_t	UDI	Power of wind erosion
<17	DP_t<200	UDI<0.3	Low
17-33	200<DP_t<400	0.8<UDI<0.3	Medium
>33	DP_t>400	UDI>0.8	High

In this study, the equation to calculate the rate of sand Lettau & Lettau (1978) is used.

$$q = C\left(\frac{d}{D}\right)^{0.5}\left(\frac{\rho}{g}\right)U_*^{\,2}(U_* - U_{*t}) \quad \text{Relation (5)}$$

q is the flow rate of sand per (kg/m.s) and dis equivalent diameter of sand particles in millimeters that in the standard value it is considered 0.25. Air density is 1.225 Kg/m^{3}and g is the gravitational acceleration that it equal to8/9 m/s^{2}and finally U_* is shear velocity as well as U_{*t} is shear threshold velocity. C is considered 4.2 for this relation

$$TSF = q \times T \quad \text{Relation (6)}$$

TSF is the total amount of sand transported in different directions that usually would be expressed based on kg/m.year and T equals the time period (year, season, month) based on the monitoring of the number of hours during the day are calculated. Equations calculate of sand transport is similar to the above relationships with this difference in which the amount of sand transport rate calculated for each of the geographical direction eight and then from the sum of vector is used to calculate RQ sand DSF.

RESULTS

Statistical results of sand rose indicators and rate of sand in each year achieved and in Tab-2 is available. Also drift potential, percentage of wind calm and average velocity in each of the eight directions were listed in Tab-3.

Tab-2. Indicators related to sand rose and rate of sand during the statistical period (1956-2010)

Sand rate		sand rose indicators				year	Sand rate		sand rose indicators				year
TSF	**Q_s**	**UDI**	**RDD**	**RDP**	**DP_t**		**TSF**	**Q_s**	**UDI**	**RDD**	**RDP**	**DP_t**	
18899	6	0.482	207	81	169	**1984**	136277	46	0.972	184	816	839	**1956**
10926	3	0.246	238	31	129	**1985**	51953	17	0.949	189	284	299	**1957**
18981	6	0.586	215	118	202	**1986**	171259	58	0.945	190	889	940	**1958**
10519	3	0.328	252	35	108	**1987**	335116	114	0.966	185	1754	1816	**1959**
20415	6	0.468	246	79	170	**1988**	265694	90	0.952	188	1358	1426	**1960**
16657	5	0.504	217	67	133	**1989**	238593	81	0.588	248	765	1301	**1961**
21516	7	0.601	251	105	176	**1990**	184562	63	0.472	251	479	1016	**1962**
14539	4	0.554	238	67	121	**1991**	86299	29	0.539	241	257	478	**1963**
15021	5	0.369	233	43	118	**1992**	85589	29	0.419	256	239	571	**1964**
15972	5	0.405	229	50	124	**1993**	67265	23	0.044	282	28	655	**1965**
29124	9	0.573	264	128	224	**1994**	29870	10	0.22	272	75	340	**1966**
20617	7	0.408	228	64	158	**1995**	81606	27	0.43	252	314	732	**1967**
06704	5	0.267	252	32	122	**1996**	58483	20	0.561	242	261	465	**1968**
18902	5	0.32	238	43	134	**1997**	80759	27	0.509	246	272	535	**1969**
19957	6	0.357	185	56	157	**1998**	78584	26	0.596	257	419	703	**1970**
16496	5	0.434	213	58	134	**1999**	88420	30	0.538	255	445	826	**1971**
14795	5	0.395	198	42	106	**2000**	4518	1	0.704	253	33	47	**1972**
9617	3	0.482	276	36	75	**2001**	11585	3	0.563	260	76	135	**1973**
20739	7	0.352	206	55	157	**2002**	11649	3	381	269	54	141	**1974**
8993	3	0.404	225	25	63	**2003**	7484	2	0.465	249	39	85	**1975**
19509	6	0407	263	52	128	**2004**	5999	2	0.33	256	20	62	**1976**
25108	8	0.566	249	79	140	**2005**	5734	1	0.476	285	27	58	**1977**
64087	21	0.536	255	173	323	**2006**	3079	1	0.519	232	17	34	**1978**
52772	18	0.454	246	123	272	**2007**	4025	1	0.5	249	18	36	**1979**
79365	27	0.526	239	222	432	**2008**	2730	0.94	0.557	286	18	33	**1980**
45164	15	0.593	241	153	259	**2009**	6336	2	0.325	149	23	71	**1981**
31302	10	0.617	251	109	176	**2010**	3186	1	0.383	293	15	39	**1982**
							11462	3	0.379	240	40	106	**1983**

Tab-3. Drift potential indicator and percentage of wind calm

Wind direction	Average Velocity (knot)	DP	(%)V>V_t	Calm wind (%)
N	11.387	148.7	32.3	67.7
NE	9.005	54.7	15.51	84.49
E	9.313	117.8	17.16	82.84
SE	8.068	11.9	9.63	90.37
S	6.859	3.1	6.1	93.9
SW	8.566	18.1	14.64	85.36
W	8.166	16.3	11.23	88.77
NW	8.594	15.4	14.97	85.03

In Fig-1 is shown annual sand rose of Sabzevar station during the statistical period (1956-2010) and also in Fig-2 annual wind rose is shown. In order to be more precise analysis classes of wind rose is shown in Fig-3.

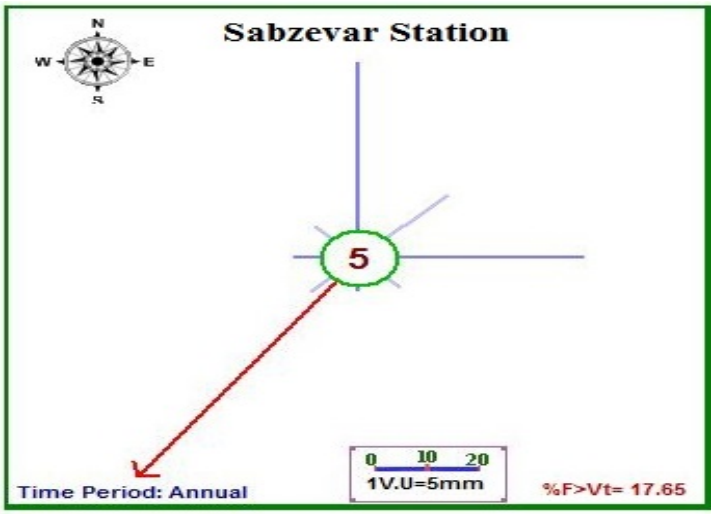

Fig-1. Sand rose of Sabzevar station during the period of study (1956-2010)

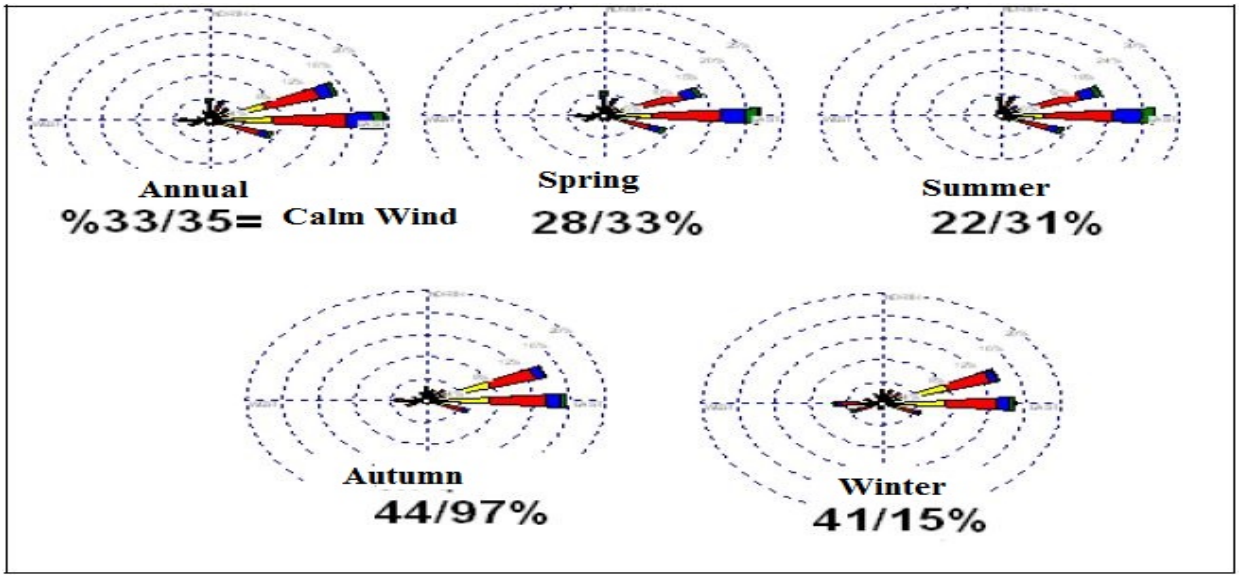

Fig-2. Wind rose of sabzevar station

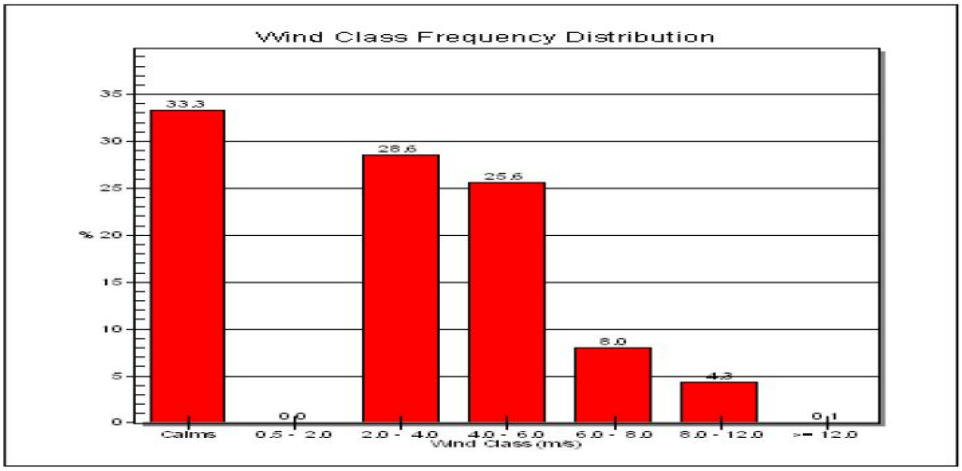

Fig-3. Wind classes of Sabzevar station

In Fig 4 to Fig 9 Results of change trend related to sand rose indicators as well as sand rate separation are shown.

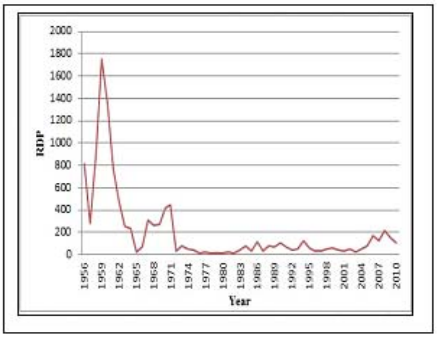

Fig 4. Change trend of RDP in period time

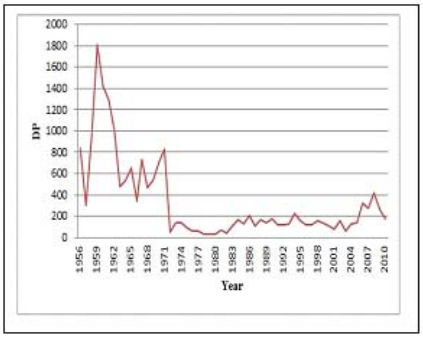

Fig 5. Changetrend of DP in period time

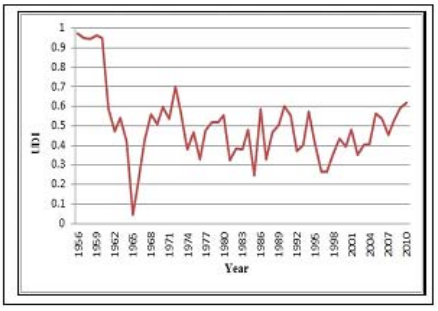

Fig 6. Change trend of UDI in period time

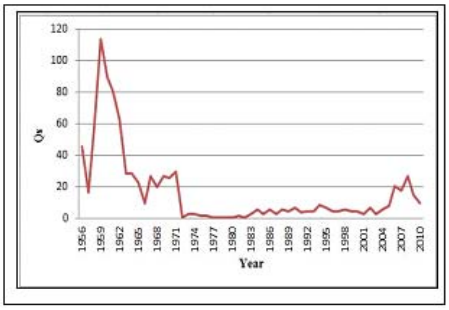

Fig 7. Change trend of Q, in period time

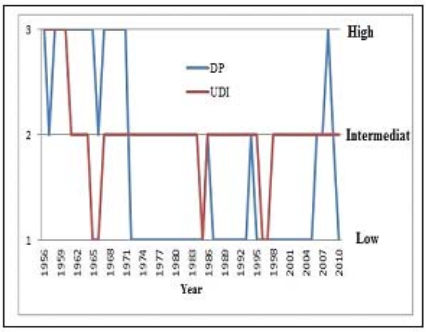

Fig 8. Compare of DP and UDI with wind erosion power

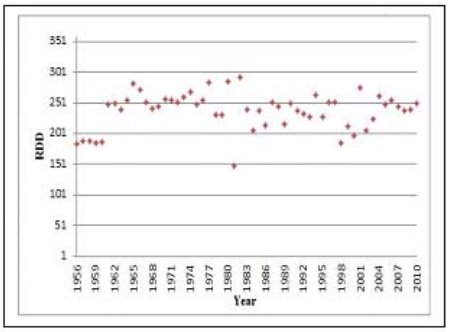

Fig 9. Change trend of RDD in period time

DISCUSSION AND CONCLUSIONS

The results of sand rose indicate that the direction of sand transport (RDP) in this study was being 216˚ and finally sand is moving toward the south west. UDI in this region has been estimated 0.55 that indicating region is in medium class in terms transportation of sand and wind processes. The results shown that under medium wind regime in the area rate of sand (Q_s) was been estimated 17.31 (Kg/m.s). The results of the analysis about the eight directions show that North and East had the greatest impact on the transport of sand and north east is in third range. Review of UDI trend change in region shown in the early period of study it was in maximum and represents a bimodal wind at this time. Over time it has under gone a downward trend as well as in 1965 reached to minimum although results indicate that in most years it was in the range 0.3-0.6 and was be a reason for medium wind regime in the area. The results showed that maximum range of DP occurred in the early period and means in 1959 equal to 1816 VU as well as at least value of it is calculated 33 VU. The rate of sand follows a downward trend in the region but with the difference that the maximum sand rate occurred in 2008 and this may be due to reduced wind erosion threshold velocity as well as increase dry in region. According to dispersion of the RDP in this period reached to this conclusion that in most years has been in the range of 200-300 degrees. It means that the mosts and dunes direction is in the South west and West as well as the result of this research shows that sand movement direction is similar with study of Ahmadi and Mesbahzade [1]. After the DP and the UDI Obtain in the different years by category Fryberger and Dean [8] was partitioned that in most years, these two parameters do not follow the same intensity in the region. Perhaps according to this classification may be different in each region and depends on various factors such as land and atmosphere. There are need to create a new classification based on these indicators and parameters according to specific conditions of the country and various geographical regions.

The results of the wind rose indicate that the east and north east winds in the region are more frequent and then south east winds are dominant inthe region as well as this well matched with the sand transport. The most frequent wind class is in 2-4 m/s (28.6 Percent) and in the next category there are 4-6 m/s class. The results showed that the most degenerative wind (Multiplication frequency of wind class in mean wind speed) is located in 4-6 m/s class. Finally recommended in order to accurately analyze of wind data in region and its impact on the formation of sand dunes in this area may be paid to compare satellite images in a long time and more accurate information is achieved of shape as well as speed of movement sand dunes.

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