HEALTH RISK OF WIND SEDIMENTS DISTRIBUTION IN HUMAN ENVIRONMENTAL IN SISTAN REGION, EAST OF IRAN

Behrooz Sahebzadeh[(1)], Kazem Shabani-Gorji[(1)*], Zieaodin Shoaei[(2)], Mahdi Afshari[(3)]

[(1)] Department of Geology, College of Science, Islamic Azad University, Zahedan Branch, Iran
[(2)] Soil Conservation and Watershed Management Research Institute Agricultural Research, Education and Extension Organization Coordinator, IAEG National Group, Tehran, Iran
[(3)] Department of community medicine, Zabol University of medical sciences, Zabol, Iran
[*] Corresponding author E.mail: K.Shabani@iauzah.ac.ir

Abstract

Sistan in east Iran is vast, lowland of which a great portion is consisted of alluvial-saline lands of dried out Hamoon lakes. Sistan has the highest population density in eastern Iran. This population is distributed in more than 1000 cities, villages and nomadic settlements. Sistan plain is extensively exposed to vigorous winds. 120-days wind is the most significant wind in the region which starts every year at the end of the spring and lasts all through the beginning of autumn, with a mean velocity of 100 km/h. This research utilizes a survey/descriptive method coupled with medical documents to rank the risk of destructive wind sediment dispersion in different regions of Sistan alongside the frequency of citizen's reference to medical centers due to respiratory problems or eye damages caused by these sediments during the summer of 2017. Wind sediment distribution in the environment, threatens the health of citizens. Human ecosystems in the Sistan region show a different ranking of the risks of dust on the health of the respiratory system and the eyes of citizens exposed to these materials. The citizens of these areas traditionally protect the health of their eyes and their breathing apparatus when dispersing wind deposits, using shawl cloths and his hand. As the last resort, they migrate from their homes and empty their habitats.

Keywords: *Iran; Sistan; Wind Sediments; Dispersion Risk; Health Repablic, Respiratory System Health; Eye Damage.*

Introduction

The wind flow and detachment, up rise and dispersion of loose sediment grains off the ground lead to undesirable environmental consequences (Middleton, 2017; Sprigg et al., 2014). Vigorous winds and long lasting storms have led to dispersion of a huge amount of small and large dust grains in the Middle East, especially in the last decades (Basart et al., 2016; Meibodi et al., 2015). In the last decade especially, frequency, duration and the severity of these winds and therefore the disper-

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sion of small and large dust grains has considerably exacerbated in this region(Cao et al., 2015).

Large portions of Iran's low precipitation dry lands are subjected to vigorous winds and dispersion of loose grains mainly because of their tectonic and geographical specifications (Karegar et al., 2017; Masoumi et al., 2013; Naserpour et al., 2015).

Wind dispersion of small and large dust grains happens repeatedly in far eastern residential areas of Iran, especially in Sistan's high density region (Ekhtesasi et al., 2012; Karegar et al., 2017). Around 61% of dust storm days in Sistan region are classified in the dangerous category and around 30% of these days are classified as very dangerous (Rashki et al., 2012).

Dispersion of sediment grains is harmful for all ages and sexes and can cause diseases (Chin et al., 2014; Parvaneh et al., 2013). The elderly, pregnant women and the children are more vulnerable to this phenomenon (Aali, 2013; Eslami et al., 2014; Zarrabi et al., 2013). Most of the traumas caused by the wind sediment dispersion in human ecosystems happen to respiratory system, the eyes (Kareei et al., 2015), Immune system and the heart (Meibodi et al., 2015; Naserpour et al., 2015). Wind dispersed small sediment grains with a PM10 size can penetrate the lungs through respiration (Goudie, 2014) and cause harm to people's health (Rashki et al., 2012). PM2.5 grains can penetrate the respiratory system even deeper and cause untimely death by entering the blood stream through the lungs (Meibodi et al., 2015). Larger sediments can damage the skin and eyes (Kumar et al., 2006). In 2016, Sistan's pollution ranking in the world based on density of PM2.5 and PM10 sediment pollutants in the environment (Zabol City, Sistan's main settlement is mentioned as the whole region's representative where the wind sediment dispersion observation post of Sistan region is located) has the highest level of PM2.5 wind sediment dispersion in the world and the third most polluted city in the world with PM10 wind sediments(WHO, 2017). Therefore this research studies the impact of wind sediment dispersion on the hygiene and health of Sistan's inhabitant's eyes and respiratory system and seeks to determine the hygiene risk ranking of different ecosystems in this region.

Materials and Methods

Study areas

Sistan region with an area of 15917 Km^2 is located in east Iran, north of Sistan & Baluchestan province, south east of Southern Khorasan province and south west of Afghanistan (Figure 1) between the 30˚18'N and 31˚20'N latitude and 61˚15'E and 61˚50'E longitude. The city of Zabol (31° 02′ 0″ N, 61° 29′ 0″ E) is the main central settlement of this region (Figure 2).

Sistan has a population of almost 390.000 people (Statistical Center of Iran, 2016) who are settled in more than 1000 cities, villages and nomadic areas. According to Iran's geopolitical classifications, this region is composed of Zabol, Zahak, Hirmand, Hamoon and Nimrooz districts(Sistan and Baluchestan Province Portal, 2018) (Table 1). Around 70% of Sistan's village and nomadic population work in agriculture and animal husbandry (Statistical Center of Iran, 2016).

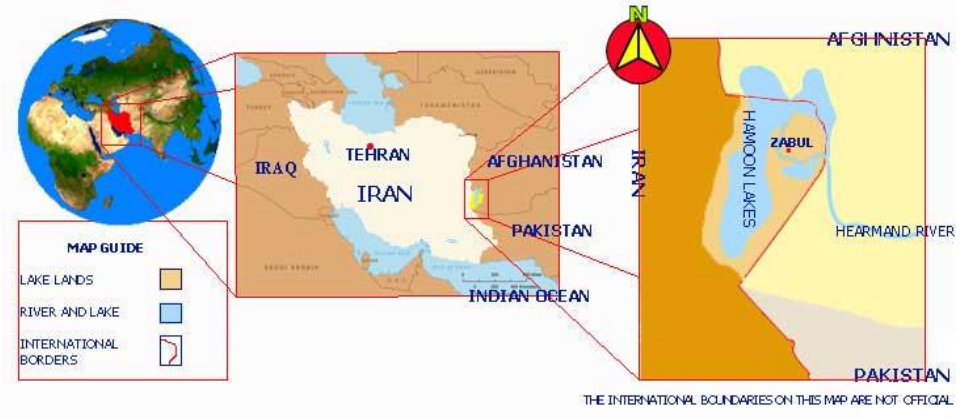

Figure 1. *Geographical position of region of interest, Sistan region, located in east Iran and north of Sistan and Baluchestan province (Sistan region)*

	Total Population	**Area of the district**	**Density (people/Km^2)**
Zabol	165666	344	481.6
Zahak	74896	945	79.2
Nimrooz	48471	8175	5.9
Hamoon	41017	4987	8.2
Hirmand	63979	1100	58.2
Overall	394029	15917	24.75

Table 1 *Population statistics in Sistan's district sin 2016. (Source: Statistical Center of Iran, 2016)*

Lowlands of Hamoon triple lakes consisting of Hamoon Poozak, Hamoon Saberi and Hamoon Hirmand (Figure 2) shape up some more than half of the Sistan region (Alaei Taleghani, 2017; Piri et al., 2013; Whitney, 2006).

The dried out bed lands of Hamoon triple lakes in Sistan are the main source of destructive sediments up rise in East Iran. Dispersion of these grains has expanded to a large portion of Afghanistan and Pakistan and even as far as Oman Sea and Indian Ocean (Rashki et al., 2012; Rezazadeh et al., 2013). Exacerbation of drought in Hamoon lakes, exposition of clay/salt bed lands and elimination of vegetation has caused the frequency, duration and severity of local winds to increase; especially the 120-days winds that in recent years, its duration has reached 165 days (Mofidi et al., 2013) and more. 120-days winds of Sistan start from late spring and continue till early autumn with a mean velocity of 100km/h and of 148km/h during the summer of 2017. These winds has caused an increase in the number of days and the volume of dust dispersion in Sistan region and mentioned areas.

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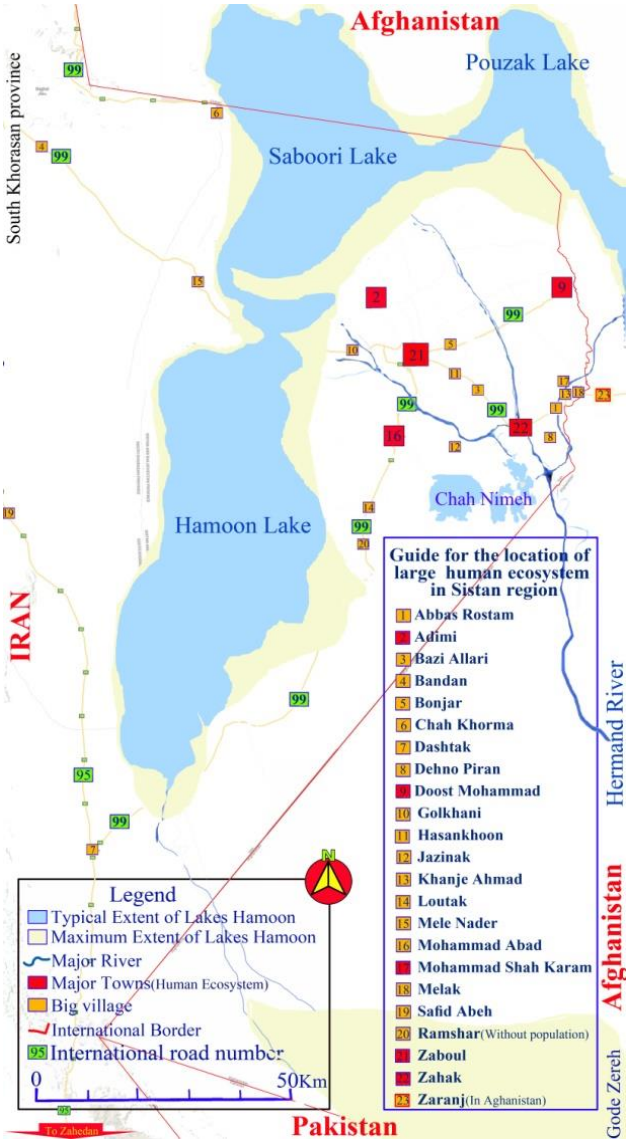

Figure 2
Geographical location and area of Hamoon lakes and large ecosystems in Sistan region

Research methodology

This research seeks to statistically study the impact of wind sediment dispersion on the health of inhabitant's eyes and respiratory system in Sistan's human ecosystems. The research utilizes a survey/descriptive method coupled with medical documents. In this method, medical information of Sistanian citizens who have referred to medical centers has been collected through the summer of 2017; both in days with and without wind sediment dispersion. To collect this information, a self-made, valid and reliable questionnaire was authored and used.

The collected information include: age, sex, place of residence, occupation, place of occupation, number of hours the person is exposed to wind sediment dispersion and the cause of reference to medical center.

Validity of the questionnaire was approved by using expert's opinions. Calculating the Cronbach's alpha for questionnaires with odd and even numbers, the reliability of the questionnaire was calculated as high as 0.89. Statistical population of this research is all the residing citizens in cities, villages and nomadic areas of Sistan. According to the latest national census, carried out in 2016, this population is 394029 people (Statistical Center of Iran, 2016). According to Morgan's table for sample size, the statistical sample size of mentioned statistical population is 384 (~400) people. Considering the scatter and diversity of human settlements of interest, this statistical sample was considered separately in each one of the five districts of Sistan; meaning that a 400 people sample population was studied in each one of these five districts, adding up to 2000 people in total.

Furthermore, considering the subject of the research which studies human health related issues, the size of the sample population was increased to 2500 people at the final stage of calculating the sample population size. Discarding the defective questionnaires, the information of 2455 questionnaires was extracted and put to statistical analysis.

To choose the mentioned sample population, this research carried out a simple random sampling of available population. Simple random sampling in this research means that medical information of all the referees during the days of interest (days with and without wind sediment dispersion in the ecosystem) was collected through questionnaires filled by medical staff.

This research studies the categorical variables of age and number of hours the person is exposed to wind sediment dispersion and nominal variables of sex, place of residence, occupation, place of occupation and the cause of reference to medical center. In this study, the human ecosystem rankings in Sistan, based on the number of citizens referring, are subject to the distribution of dust in the environment to medical centers due to respiratory problems and eye damage. This statistical variable is determined by calculation and comparison of frequency of different region's citizens' reference to medical centers during the wind sediment dispersion periods by using the questionnaire tool. The data analysis was carried out using inferential statistics methods including Chi-square test and necessary Post Hoc tests in the SPSS 25 software.

Results and Discussion

The following table illustrates the results of Chi-square test for two nominal variables of 1. Different human ecosystems (medical centers) including Adimi City, Bazzi-allari, Golkhani, Sefid-abe, Dehno-piran, Muhammad-Abad City, Doost-Muhammad City, Zahak city, Muhammad-shah-karam, Khaje-ahmad, Abbas-rostam, Jazinak, Hasankhoon, Zabol city and Lutak and 2.

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The number of days with wind sediment dispersion during the summer of 2017 (Table 2).

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	783.577[a]	28	.000
Likelihood Ratio	959.719	28	.000
Linear-by-Linear Association	7.745	1	.005
Number of Valid Cases	2453		

[a.] 0 cells (0.0%) have expected count less than 5. The minimum expected count is 10.33.

Symmetric Measures		Value	Approx. Sig.
Nominal by	**Phi**	.565	.000
	Cramer's V	.400	.000
Number of Valid Cases		2453	

Table 2
Calculation of Chi-square test for two nominal variables of different human ecosystems and the number of days with wind sediment dispersion in Sistan's human ecosystems during the summer of 2017.

This table (Table 2) shows that the calculated Chi-square from comparison of frequency of human ecosystems group and the number of days with wind sediment dispersion in Sistan ecosystems (785.577) and the result of Cramer Post Hoc test (0.400) are statistically significant with a $p \leq 0.001$; therefore, different human ecosystems in Sistan have a significant difference considering the number of days with wind sediment dispersion. Calculated Phi=0.656 shows that this significance is moderate.

The following chart and Figure 3 illustrates the risk ranking of different human ecosystems of Sistan based on the number of days with wind sediment dispersion during the summer of 2017 according to Chi-square test results.

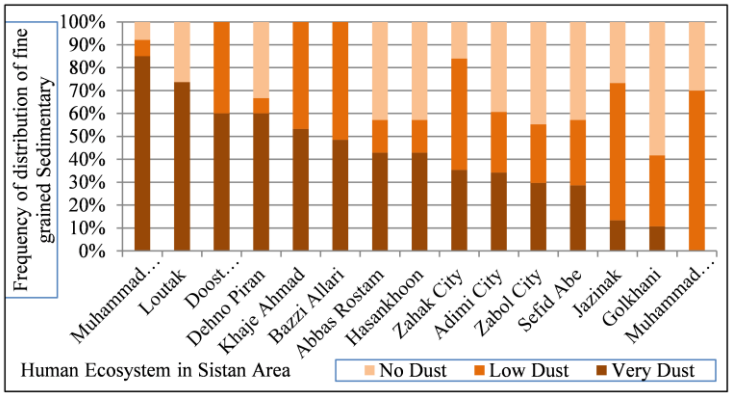

Figure 3
The risk ranking of human ecosystems of Sistan based on the number of days with wind sediment dispersion during the summer of 2017

Figure 3 shows that the highest number of days with wind sediment dispersion in Sistan region has been reported in Muhammad-Shah-Karam village in Hirmand district, Lutak village in Nimrooz district and Doost-Muhammad City in Hirmand district, Khaje-Ahmad village and Bazzi-Allari village in Zahak district. According to the results of Chi-square test for deciding the frequency distribution of number

of days with wind sediment dispersion in Sistan ecosystems (Figure 2), ranking of these ecosystems is as follows shown in Table 3.

Rank	Percentage	Settlement, Sistan's human ecosystems
1st	+61%	Muhammad-Shah-Karam, Lutak
2nd	60%-41%	Doost-Muhammad City, Dehno-Piran, Khaje – Ahmad, Bazzi-Allari, Abbas-Rostam, Hasan-khoon
3rd	21%-40%	Zahak City, Adimi City, Zabol City, Sefid-Abe
4th	-20%	Jazinak, Golkhani, Muhammad-Abad City

Table 3
Risk ranking of Sistan's human ecosystems according to the number of days with wind sediment dispersion.

Table 3 shows that the highest number of days with wind sediment dispersion during the summer of 2017 in Muhammad-Shah-Karam, Doost-Muhammad City, Dehno-Piran, Khaje – Ahmad and... in the near the border of Iran and Afghanistan (Figure 2) with about 41% to 60% of summer days with high distribution of dust in the environment have been reported. According to Chi-square test results for determining the frequency distribution of citizens' reference to medical centers due to respiratory problems during the wind sediment dispersion periods in Sistan's human ecosystems, risk ranking of these ecosystems is as follows shown in Table 4.

Rank	Percentage	Settlement
1st	+41%	Muhammad-Shah-Karam, Lutak, Bazzi-Allari, Dehno-Piran
2nd	20%-41%	Doost-Muhammad, Abbas-Rostam, Zabol, Khaje-Ahmad, Adimi, Muhammad-Abad, Zahak, Sefid-Abe
3rd	-20%	Hasankhoon, Jazinak, Golkhani

Table 4
Risk ranking of Sistan's human ecosystems according to the risk of respiratory problems during the wind sediment dispersion periods.

Figure 4 illustrates the ranking of Sistan's different human ecosystem based on citizens' reference to medical centers due to eye damages caused wind sediment dispersion during the summer of 2017.

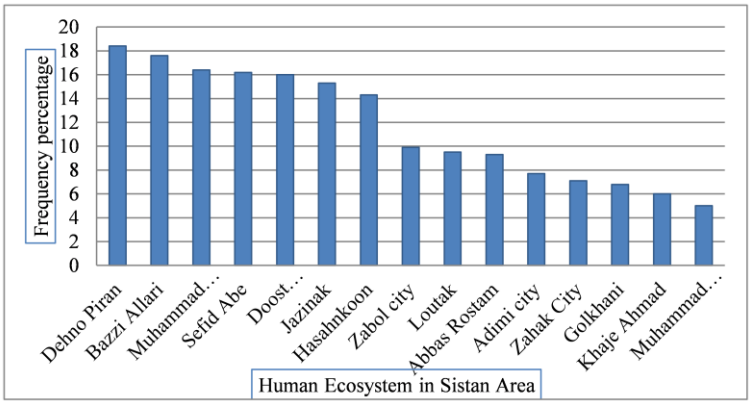

Figure 4
The ranking of Sistan's different human ecosystem based on citizens' reference to medical centers due to eye damages caused wind sediment dispersion during the summer of 2017

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According to Chi-square test results for determining the frequency distribution of citizens' reference to medical centers due to eye damages during the wind sediment dispersion periods in Sistan's human ecosystems, risk ranking of these ecosystems is as follows shown in Table 5.

Rank	Percentage	Settlement
1st	+15%	Dehno-Piran, Bazzi-Allari, Muhammad-Shah-Karam, Sefid-Abe, Doost-Muhammad City, Jazinak
2nd	10%-15%	Hasankhon
3rd	-10%	Zabol City, Lutak, Abbas-Rostam, Zahak City, Golkhani, Khaje-Ahmad, Muhammad-Abad City

Table 5
Risk ranking of Sistan's human ecosystems according to the risk of eye damages during the wind sediment dispersion periods

Table 6 illustrates the chi-square test results for two nominal variables of different human ecosystem (medical center) and the cause of reference to medical centers in Sistan's human ecosystem during the wind sediment dispersion periods in summer of 2017.

	Value	df	Asymp. Sig. (2-sided)
Pearson Chi-Square	391.369[a]	42	0.000
Likelihood Ratio	378.365	42	0.000
Linear-by-Linear Association	0.148	1	0.701
Number of Valid Cases	2453		

[a.] 7 cells (11.7%) have expected count less than 5. The minimum expected count is 1.84.

Symmetric Measures		Value	Approx. Sig.
Nominal by	**Phi**	0.399	0.000
	Cramer's V	0.231	0.000
Number of Valid Cases		2453	

Table 6.
Calculation of Chi-square for two nominal variables of Different human ecosystems (Medical Centers) and the cause of reference to medical centers in Sistan's human ecosystems during the summer of 2017

Table 6 shows that the calculated Chi-square from comparison of two categories of human ecosystems and the cause of reference to medical centers in Sistan's human ecosystems (391.369) and the result of Cramer's follow-up test (0.231) are statistically significant. Calculated Phi=0.399 shows that this significance is moderate. Chart 3 illustrates the frequency of citizen's reference to medical centers due to respiratory problems and eye damages (both, one or none) due to wind sediment dispersion in Sistan's human ecosystems during the summer of 2017.
According to the chart 3, ranking of Sistan's different human ecosystems based on the risk of respiratory problems and eye damages during the wind sediment dispersion periods is as follows shown in Table 7.
Table 7 shows the health risks of respiratory problems and eye injuries, or both, for citizens who are exposed to the distribution of wind sediments, in the human ecosystem of Dehno-Piran, Bazzi-Allari, Muhammad-Shah-Karam, Abbas-Rostam, more than 61%.

Rank	Percentage	Settlement
1st	+61%	Dehno-Piran, Bazzi-Allari, Muhammad-Shah-Karam, Abbas-Rostam
2nd	41%-60%	Doost-Muhammad City, Lutak, Zabol City, Hasankhoon, Sefid-Abe
3rd	21%-40%	Adimi City, Khaje-Ahmad, Zahak City, Muhammad-Abad City, Jazinak
4th	-20%	Golkhani

Table 7
Risk ranking of Sistan's different human ecosystems based on Respiratory problems or eye damages or both during the wind sediment dispersion days

Conclusion

Sistan region in east Iran with more than a 1000 city, village and nomadic settlements is subjected to vigorous and long lasting winds and dispersion of huge volumes of destructive sediment grains in its human ecosystems, especially during the summers. The aim of this study was to investigate the rate and cause of referral of residents of Sistan to medical centers on days with and without scattering of wind sediments in the environment. For analyzing medical statistics, descriptive indexes such as frequency distribution (for qualitative variables), standard deviation (for quantitative variables) and mean, with tables, graphs and inferential statistics indices such as Pearson correlation coefficient, Chi-square, Cramer tests and Phi Post Hoc were used to determine the relationship between the reference frequency of citizens to medical centers during the period of wind dispersion and other variables studied.The results show that:

- the following human ecosystems have the highest risk of wind sediment dispersion in the Sistan region: 1. Muhammad-Shahkaram region (Hirmand district) that located near the Iranian border with Afghanistan, Loutak area (Hamoon district) that Located on the dry shore of Lake Hamoon Hirmand.
- the following human ecosystems have the highest ranking of reference to medical centers due to respiratory problems caused by wind sediment dispersion: 1. Muhammad-Shah-Karam (Zahak district), 2. Lutak (Hamoon district) and 3. Bazzi-Allari (Zahak district).
- the following human ecosystems have the highest ranking of reference to medical centers due to eye damages caused by wind sediment dispersion: 1. Dehno-Piran (Nimrooz District), 2. Bazzi-Allari (Zahak district) and 3. Muhammad-Shah-Karam (Zahak district).

In recent years, due to the spread of drought and the interruption of the arrival of water into Hamoon lakes, the rise and distribution of fine grains in the environment have increased. For this reason, respiratory distress and eye damage have increased among residents of the Sistan area in eastern Iran and its adjacent areas in Afghanistan and Pakistan. This study could be also considered a warning for all the nations and geographical areas risking desertification in the near future due to global climate change.

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References

AALI A. (2013) Evaluating the effect of Sistan's 120-day winds on the geographic distribution of tuberculosis in the urban and peri-urban areas of Sistan. Master's thesis, trends Geography and Urban Planning,University of Zabol, Zabol, Iran.
ALAEI TALEGHANI M. (2017) Geomorphology of Iran. Ninth edition. Tehran, Iran: Ghoomes Publication. 360P.
BASART S., VENDRELL L., BALDASANO J. M. (2016) High-resolution dust modelling over complex terrains in West Asia. Aeolian Research, 23:37-50.
CAO H., LIU J., WANG G., YANG G., LUO L. (2015) Identification of sand and dust storm source areas in Iran. Journal of Arid Land, 7(5):567-578.
CHIN M., DIEHL T., BIAN H., YU H., QIAN Y., WILD M., STACKHOUSE P. (2014) Multi-decadal trends of solar radiation reaching the surface: What is the role of aerosols? Paper presented at the AGU Fall Meeting Abstracts.
EKTESASI M., GOHRAI Z. (2012) Determining Area Affected by Dust Storms in Different Wind Speeds, Using Satellite Images. Desert, 17(2):193-202.
ESLAMI A., ATAFAR Z., PIRSOHRAB M., ASADI F. (2014) Trends of particulate matter (PM10) concentration and related Air Quality Index (AQI) during 2005-2012 in Kermanshah, Iran. Journal of Health in the Field, 2(1):19-28.
GOUDIE A. S. (2014) Desert dust and human health disorders. Environment international, 63:101-113.
KAREEI M.T., LAK R., SHAHBAZI R., SHARAFI M., ZARGAR H. (2015) Sedimentology study of areas susceptible to the production of refrigeration in the marginal lands of northwest of Lake Urmia. Retrieved fromGeological Survey of Iran, Tehran, Iran.
KAREGAR E., BODAGH JAMALI J., GOSHTASB H., RANJBAR SADAT ABADI A., MOEINADINI M. (2017) Numerical Simulation of Extreme Sand and Dust Storm in East of Iran, by the WRF_Chem Model Case study; 1 May & 1 June 2011. Journal of Natural Environment, 69(4):1077-1089. doi:10.22059/jne.2017.124279.919
KUMAR R., JOSEPH A. E. (2006) Air pollution concentrations of PM2.5, PM10 and NO2 at ambient and kerbsite and their correlation in Metro City–Mumbai. Environmental Monitoring and Assessment, 119:191-199.
MASOUMI A., KHALESIFARD H., BAYAT, A., MORADHASELI R. (2013) Retrieval of aerosol optical and physical properties from ground-based measurements for Zanjan, a city in Northwest Iran. Atmospheric Research, 120:343-355.
MEIBODI A. E., ABDOLI G., TAKLIF A., MORSHEDI B. (2015) Economic modeling of the regional polices to combat dust phenomenon by using game theory. Procedia Economics and Finance, 24:409-418.
MIDDLETON N. (2017) Desert dust hazards: A global review. Aeolian Research, 24:53-63.
MOFIDI A, KAMALI S., ZARRIN A., (2013) The Evaluation of the Power of the RegCM4 Linked with the Dust Scheme in Detecting the Summer Dusty Storms Structure in

the Sistan Plain. First National Conference on Meteorology. Kerman University of Industrial and Technological Advanced Studies, Kerman, Iran.
NASERPOUR S., ALIJANI B., ZEAIEAN P. (2015) Sources of Dust Storms in South West Iran Using Satellite Images and Weather Maps. Physical Geography Research Quarterly, 47(1):21-36. doi:10.22059/jphgr.2015.53676
PARVANEH B., HEIDARI H. (2013) The effect of dust on asthma and pulmonary diseases. Paper presented at the The 3rd National Conference on Wind Erosion and Dust storms, Yazd, Iran.
PIRI H., ANSARI H. (2013) Study of drought in Sistan Plain and its impact on Hamoun international wetland. Wetland Ecobiology, 5(1):63-74.
RASHKI A., KASKAOUTIS D. G., RAUTENBACH C. J. d., ERIKSSON P. G., QIANG M., GUPTA P. (2012) Dust storms and their horizontal dust loading in the Sistan region, Iran. Aeolian Research, 5:51-62. Doi. 10.1016/j.aeolia.2011.12.001
REZAZADEH M., IRANNEJAD P., SHAO Y. (2013) Evaluation of three Wind Erosion Model within WRF_Chem Model in the Middle East. Paper presented at The 2nd International Conference on Plant, Water, Soil and Weather modelling, Kerman, Iran.
SISTAN and BALUCHESTAN Province Portal, S. i. (2018) Districts and Towns. www.sbportal.ir/ Sistan and Baluchestan Province Portal (2018) Districts and Towns. (Retrieved from onvert2mp3.net/en).
SPRIGG W. A., NICKOVIC S., GALGIANI J. N., PEJANOVIC G., PETKOVIC S., VUJADINOVIC M., PRASAD A. (2014) Regional dust storm modeling for health services: the case of valley fever. Aeolian Research, 14:53-73.
STATISTICAL CENTER OF IRAN. (2016) National Census of Population and Housing. The official report of the Iranian Center for Statistics on the Population and Housing general Census in Iran in 2016. www.amar.org.ir/.
WHITNEY J. (2006) Geology, Water, and Wind in the Lower Helmand Basin, Southern Afghanistan. https://pubs.usgs.gov/sir/2006/5182/pdf SIR06-5182_508.pdf (accessed on January 3rd, 2019).
WWW.WHO.INT (2017) WHO Global Urban Ambient Air Pollution Database.
ZARRABI M., REZVANI M., ABBASI S. (2013) Investigating the Environmental Effects of Fine grained sediments. Paper presented at the 2nd international conference on Environmental Hazards, Tehran, Iran.

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