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Review

Assessment of Dust Event By RS, GIS, MODIS and Statistical Methods Among Satellite Images

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Abstract: Dust is an event that occurs in most sections of the world that leads to financial loss and harmful environmental impacts. Several factors are included in dust event incidence, some of them are natural and others are due to human processes and their impact on the environment. Thus, very critical situations are coming and it is expected that the majority of urban and rural populations will migrate to the rest of the country, especially from western and southwestern regions leading the way to a lot of economic damage. Studies conducted in the country showed that the western regions of the country are more exposed to dust systems due to their geographical and climatic location and the proximity to the deserts of neighboring countries such as Iraq, Syria and Saudi Arabia, especially since most of the atmospheric system of the North West, West and Southwest are imported into the country. For this purpose, investigating, studying and recognizing physical and chemical composition of dust and soil resulting from it to determine and identify harmful elements and ultimately policy-making and planning for its elimination as regional alliances in the field of policy-making and foreign co-operation vital. According to the obtained results, it was found that the dust in spring of 2015 in Zahedan city has spatial and temporal changes. The spatial and temporal changes in dust can be caused due to the low green space, especially in the direction of wind blowing, developmental activities and 120-day winds of Sistan and the difference in urban density and urban marginal topographic complications. According to zoning map in the spring of 2015, the existence of an inconsistency in the dust spatial variations in the spring indicated that spring is the source of dust in the city. Since part of this amount is due to the drying of Hamoon Lake, wind erosion control measures in these areas can be effective in reducing the loss of dust in the city of Zahedan. In Iran, the use of geographical information systems and remote sensing to monitor natural hazards is increasing. Hence, the attention of managers of various fields of natural resources and environment to the capabilities of this software and attention to the researches have done in this regard sound necessary and useful. The results of many studies in the country showed that the frequency of dusty days is increasing.

Keywords: Dust, Heavy Metals, Remote Sensing, Geographical Information System, Statistical Methods

Introduction

Dust is recognized as one of the atmospheric phenomena and natural disasters, which has adverse effects on the environment. Dust may influence the temperature due to the absorption or diffusion of solar beams or may change the shape of the clouds (Goudie, 2009). Falling dust is a dust that falls from the atmosphere on the surface of the earth and we can indirectly examine the contamination of the entire suspended particles through studying the falling dust (Nimrozi and Moafpourian, 2012). The term "dust" refers to aerosols with a diameter of 12 microns or more, which can be deposited after the temporary suspension (Chung *et al*., 2003). The dust cycle is an important part of the planet Earth system. Annually 2000 tons of dust are released, of which 75% is deposited on the soil and 25% on the ocean, this process affects the energy, water and carbon cycle (Rodríguez *et al*., 2009). The highest amount of dust in the atmosphere occurs with the origin of fine-grained particles, which are more prevalent in arid and semi-arid regions. In recent years, seemingly, changes in the frequency of this risky climatic phenomenon occurrence have led to problems in some parts of our country (Hamzeh *et al*., 2009). In fact, the dust formation can be a reaction to the change in land cover, in which the role of human activities along with the natural environment of the geographic environment should be taken into consideration. Humans can also modulate the negative effects of dust storms through some large-scale engineering plans (Nadafi, 2009). The phenomenon of fine dust particles has been increasingly evident in the world system in recent years and the occurrence of dust storms caused environmental effects such as air temperature (Ridgwell, 2003), a significant increase in the melting of icebergs (Krinner *et al*., 2006), changes in the formation and evolution of soils (Yang *et al*., 2008) and damage in agricultural sector. The amount of dust particles' effect can be investigated according to their physical and chemical characteristics so that investigating the mineralogical properties and the size of the sedimentary particle, the erosion origin and distance that particle traveled can be realized (Frechen and Dodonov, 1998). More than two third of our country is located in desert and semi-desert climate due to its geographical location. One of the most significant events in these areas is wind erosion, which indicates the potential of nature to move soil particles (Toy *et al*., 2002). Most of the dust sources are in the Middle East and Southwest Asia, the Arabian Peninsula and the surrounding deserts, which are most active from April to July (Gossens and Rajort, 2008). Iran has encountered numerous dust storms in recent years (Prospero *et al*., 2002). Studies that have been carried out germane to the abundance of dusty days in the country showed that the central pits of Iran have the highest number of dusty days. Dust particles are considered as a great risk for human health because of the potentially toxic effects that various heavy metals have in these particles (dust containing mercury, arsenic and cadmium) (Holden, 2006). Pollutants are among the environmental disruptors (Wu *et al*., 2011). Heavy metals are among the environmental pollutants. The correct estimation of dust amount on the surface of the earth is essential in many fields, including water and soil contamination caused by toxic and polluted particles (Sow *et al*., 2006). Heavy metals are classified into the most hazardous group of human pollutants due to their toxicity and persistence in the environment (Sharma *et al*., 2008). Determining the number of metals in environmental samples such as dust, plants, soil and surface waters is greatly essential in monitoring environmental pollutants (Al-Khashman, 2007). The natural concentration of the elements in soils varies widely. The evaluation of dust pollution to heavy metals is one of the fundamental tasks for controlling and managing the dust phenomenon, although the natural concentration of heavy metals in soils are studied in many countries including Poland and many other European countries, the United States and China (Azimzadeh and Khademi, 2013; Su and Yang, 2008). This evaluation is based on the use of various indices such as geostationary index, normal enrichment factor, degree of contamination, pollution factor and pollution index (Loska *et al*., 2004). The present study is a structured review study aimed at monitoring and evaluating dust using remote sensing data, geographic information systems, satellite imagery, as well as sampling during spring of 2015 in Zahedan, in order to compare the results with the results of the previous and survey of spatial and temporal distribution of dust in the city of Zahedan. Shayestefar and Rezaei (2011) evaluated the amount of heavy metals' contamination in Sarcheshmeh copper deposits. In this study, the Contamination Factor (CF), Pollution Load Index (PLI), Enrichment Factors (EF) and geo-accumulation index (Igeo) were based on the following formula:

$$CF = C_{sample} / C_{background} \quad (1)$$

where, *CF* is the contaminant factor, C_{sample} is the concentration of metal in the sample and the $C_{background}$ is the concentration of metal in the sample field. If CF>1, it indicates the presence of contamination and, if CF<1, it means no metal contamination:

$$PLI = \sqrt[n]{CF_1 \times CF_2 \times CF_3 \times \ldots \times CFPI_n} \quad (2)$$

The index is closer to the number one heavy metal concentrations near background levels and if it is greater than 1, the soil is contaminated (Adomako *et al*., 2008; Qishlaqi *et al*., 2009):

$$EF = \left[Cx / Cref\right] sample / \left[Cx / Cref\right] background \quad (3)$$

where, *EF* is the enrichment factor, *Cx* is the concentration of the element studied, *Cref* is the concentration of the reference element in the shell:

$$Igeo = \log 2\left(\left(C_n\right) / \times 1/5B_n\right) \quad (4)$$

where, C_n is the concentration of the element studied in soil sample or sediment (mist), B_n is the concentration of the element studied in the field value (mean global shale) and the coefficient 1.5 to eliminate the lithology's effect (Muller, 1969). The results indicate that Cu, Mo, Zn, Mn, Pb and Fe metals have been enriched in sediment samples. According to the values of the geoaccumulation index, the sediment accumulation in the region has been heavily contaminated with Cu, Zn and Fe metals. The contamination coefficient for Cu, Mo, Zn, Mn, Pb and Fe metals is more than 1, which indicates the high concentration of these metals and the impact of human and natural factors on the concentration of these metals.

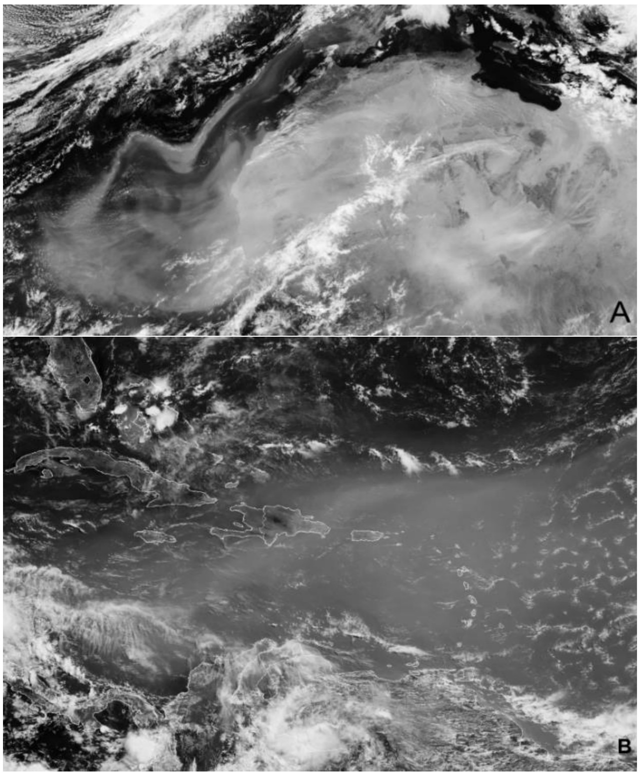

Fig. 1: True-color image of dust (A) and image enhancement (B) 2012 June 18

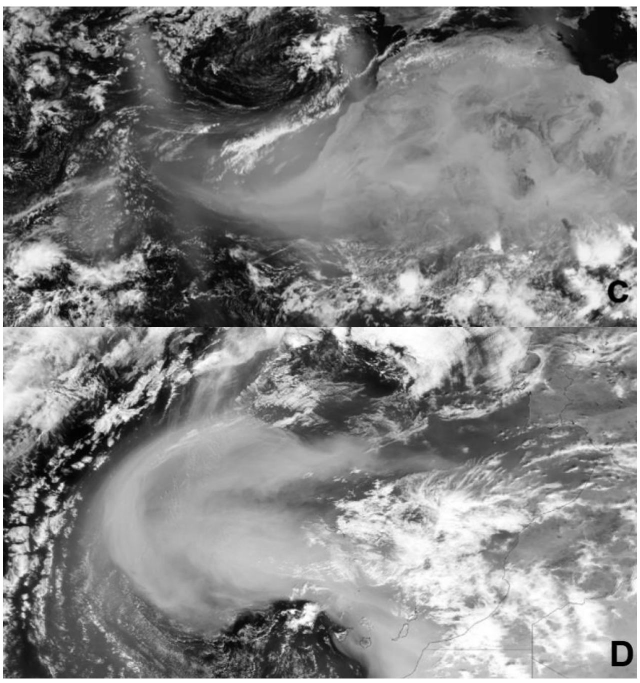

Fig. 2: True-color image of dust (C) and image enhancement (D) 2012 June 19

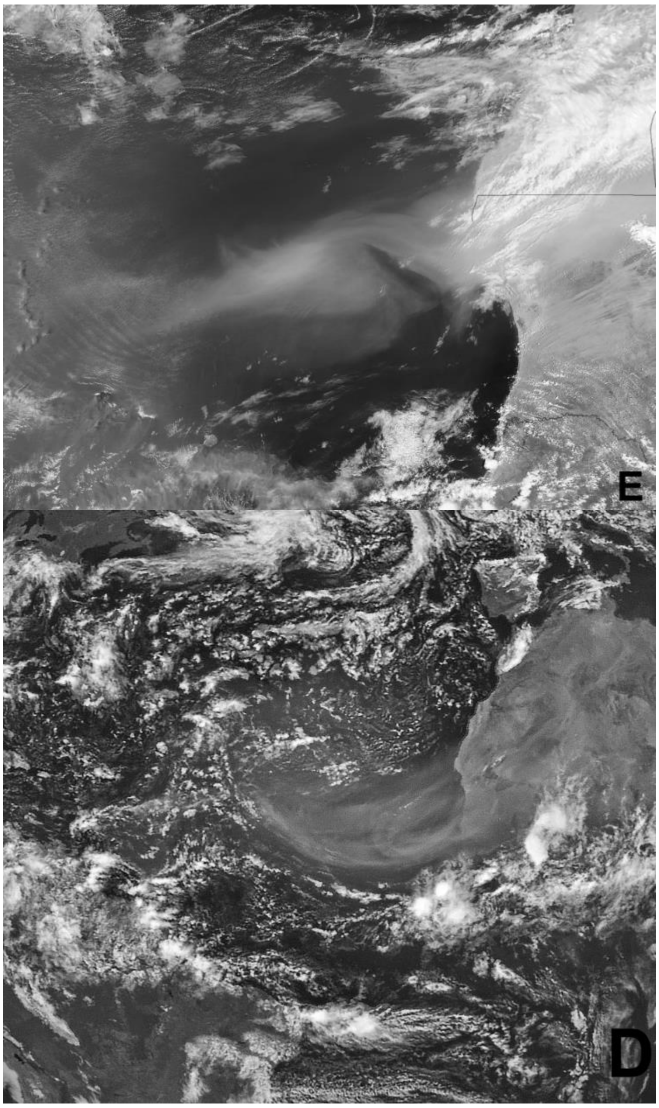

Fig. 3: True-color image of dust (E) and image enhancement (F) 2012 June 20

The spatial analysis of this phenomenon indicates that the main areas of dust activity are deserts, including sand deserts that have been destroyed by humans (Indoitu *et al*., 2012). The investigations showed that, according to the purpose, different materials and methods are used such as remote sensing data and related software in this field to highlight the dust phenomenon and the use of synoptic data in the analysis of the emergence of this phenomenon on the surface of the earth, as well as its transportation to the atmosphere and modeling their movement and displaying it in the GIS environment and other cases which will be referred to in other part of this study. In a study (Fallah-Zozooly *et al*., 2014) using the MODIS satellite imagery to monitor and evaluate the dust storm on June 18, 2012, in West and South-West Iran. The results showed that the main source of dust junction of the Tigris and Euphrates rivers, respectively. "Figure 1A" shows that this storm has started from the eastern border of Syria and the western border of Iraq, which is clear in the picture. "Figure 1B" is an acronym detection image, in which the black and pink areas show the amount of dust that darkens the dust and increases in the central part and near the eastern border of Syria and southern Iraq and northern Arabia. Furthermore, this dust is entering Iran and is observed in the provinces of Khuzestan, Ilam, Kermanshah and southeast of Iraq "Fig. 2C". In image enhancement by the 19 June 2012 "Fig. 2D" shows a dust density that is pink to black in color, indicating a high density in black. In" Fig. 3E" which relates to June 20, the dust entering Iran is due to lack of sufficient wind in the same provinces. In "Fig. 3F" a detected image of black density is observed in Khuzestan and Ilam provinces. Also, in pictures of June 21, dust completely entered Iran and is far from the southwest boundary and is entering the Persian Gulf "Fig. 4G and 4H".

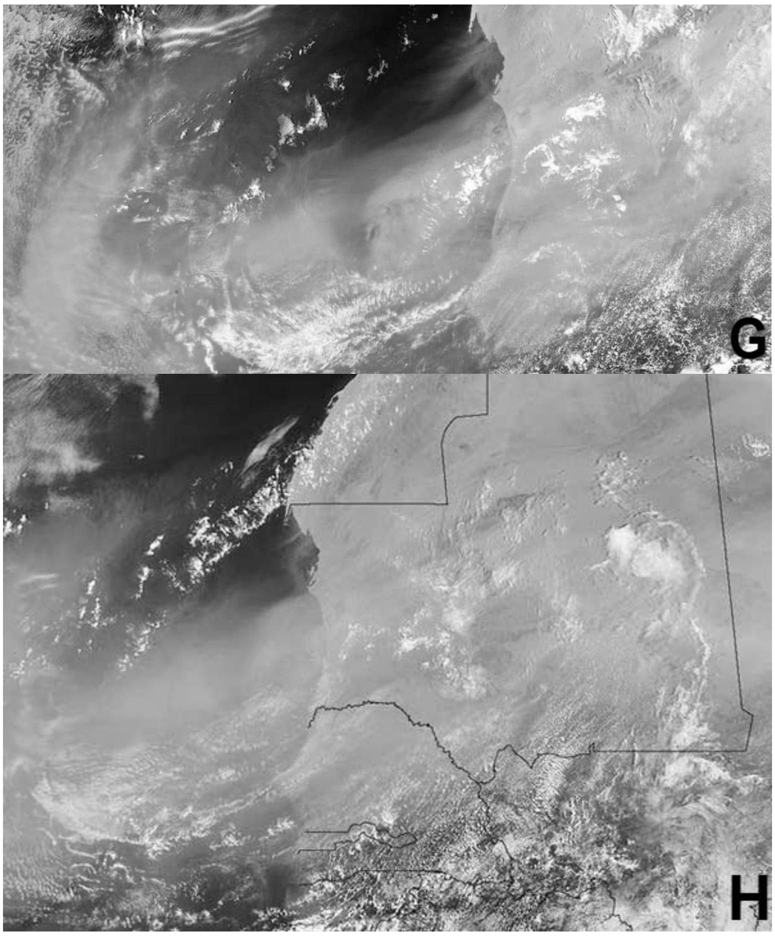

Fig. 4: True-color image of dust (G) and image enhancement (H) 2012 June 21

Fundamentals and Theoretical Framework

Firstly, definitions related to the dust topic will be given that are frequently mentioned in various articles.

Remote Sensing

Remote sensing Science is the technology and art of obtaining information about distant phenomena, in other words, collecting information from areas that are not directly accessible due to danger, high cost and distance (Darvish-Sefat *et al*., 2013).

Geographical Information System

This system allows you to save up-to-date information about Earth and to combine them with other information. This knowledge is applicable in various fields such as urban and regional planning, or environmental planning, geology and mining studies, agriculture and natural resources and etc.

Fine Dust Particles

A fine dust particles' storm is a complicated process that is affected by the interaction of the atmosphere-Earth system and often resulting from high wind speed, dry soil and dry climatic conditions (Mei *et al*., 2008).

Heavy Elements

Heavy elements are among those materials that have a higher atomic mass than iron and are highly absorbed into living tissues, accumulate in them and exhausting them from the tissue happens hardly such as zinc, cadmium, cobalt, copper, lead, nickel, arsenic, vanadium, chromium (Rossini *et al*., 2010).

Dust Falling

Dust falling defines as dust that falls from the atmosphere on the surface of the earth, studying which can lead the way to indirectly investigating all of the suspended particles' contamination (Hai *et al*., 2008).

Most studies done on dust phenomena have mostly addressed the statistical and storm origin investigations and less on the relationship between dust storms and the factors affecting their occurrence. Hence, investigating the researchers carried out in relation to dust storms, a comprehensive review of the occurrence of this destructive environmental phenomenon is indicated

(Tamsaki *et al*., 2016). According to the purpose of the study, various materials and methods such as the use of remote sensing data and software germane to this field in dust falling phenomena and the use of synoptic data in analyzing how this phenomenon happened on the surface of the earth, as well as carrying it in the atmosphere and modeling its movement and displaying it in the GIS environment (Fallah-Zozooly *et al*., 2014), which will be referred to in following parts of this study.

Methodology

This study is a collection of basic studies of dust phenomenon in the country. This paper has been dedicated to the evaluation of data and statistical analysis in the present time period after an initial examination and review of past generality and studies. Finally, efforts have been made to analyze the dust phenomenon according to the statistics obtained in different parts of the country. This research was conducted through structured review with the aim of monitoring and investigating the dust phenomenon in Iran. For this purpose, the SID, Google Scholar, Magiran and Iranmedex databases were searched for collecting local articles and the Science direct database was searched for English articles between 1992 and 2016. The English keywords include Dust fall, Heavy metal analysis, Soil contamination and remote sensing and Persian keywords including Dust, heavy metals, remote sensing and geographical information systems. The criteria for entering this study are research articles that use statistical methods, remote sensing and GIS in the source finding field and spatial distribution of dust. Then available full-text articles were taken into consideration. Required data including the introduction of the article, the location of the study, the purpose of the study, the sources of data collection and the area under study were extracted. Most of the articles collected their required data through dust sampling and some used MODIS images, TOMS and OMI images, AVHRR images, METEOSAT images and Sea-WIFS images to reveal and monitor dust storms. Mentioning differences of this study with previous studies, it can be noted that in this study, in addition to studying and analyzing previous studies, a dust sampling period and dust monitoring in Zahedan City in the spring of 2015 have been done. The random sampling method was used to determine the sampling points. Thus, 30 stations were selected in the city. Mildew Trap (MDCO) was used to investigate the loss of dust. The sampler was placed at a height of 1.5 meters from the roof. The sampling of mist was carried out during the spring of 2015. Overall, 90 dust samples were taken from 30 stations in the city. At the same time as each sample was taken, the geographic coordinates of each point were recorded using GPS in the UTM system. During this 6 month period, trapped mist in sediment traps was carefully collected on a monthly basis and weighed accurately using a scale of 0.001 g. One-way ANOVA was used to study the variation of dust in different sampling locations in the spring season. To investigate the spatial variability of dust, the geostatistical method was used. After the information file was prepared, the input file of Arc GIS 9.3 software was prepared. Finally, the distribution of dust in the city zoning map was obtained.

Findings

Structurally researching keywords in online databases, 102 articles were retrieved. After removing 12 duplicate articles, 90 eligible articles were selected for further analysis. The results indicated that the number of articles in the investigation and source finding of dust has increased over time. Various sources were used to collect data. The studied articles were classified into three categories including the concentration of heavy elements in dust and spatial distribution zoning of dust and dust detection. Statistical studies of dust phenomenon for the purpose of time analysis showed that the number of days of this phenomenon occurs is increasing and happening most frequently in June and July and among these studies, only one of them has shown a decreasing trend. (Mehrshahi and Nekounam, 2009; Omidvar and Nekounam, 2009; Zarasvandi *et al*., 2011). The spatial analysis of this phenomenon indicated that the main areas of dust field activities are deserts, including sand dunes which have been destroyed by humans (Indoitu *et al*., 2012). The results of One-way ANOVA obtained from sampling and analysis of dust data in Zahedan city, which was studied in this article along with previous studies, indicated that the variance between months and stations in spring is not significant, "Table 1 and 2". Geoaccumulation were used to zone the distribution of scattering dust in Zahedan. After analyzing and normalizing the data, the Kriging method was finally used for zoning. The study of the zoning map of falling dust in spring showed that the amount of the falling dust at the stations of Moallem, Hirmand and Mir-Hosseini is more than other stations and the falling dust measured at Mazar 2, Farrokhi-Sistani and Ashrafi-Esfahani stations are less than others "Fig. 5".

Table 1: The results of the variance analysis test of falling dust between the months and places in spring 2015

	Time				
Change sources	df	Sum of squares	Mean squares	F	Sig
Month	2	1.706	0.853	1.384	^{ns}0.25
Error	78	53.635	0.616		
Total	89	55.341			

^{ns}: No significant difference

Table 2: The results of the analysis of the variance of lavatory dust between different locations in spring 2015

	Place				
Sources change	df	Sum of squares	Mean squares	F	Sig
Month	29	16.661	0.575	0.891	ns0.62
Error	60	38.680	0.645		
Total	89	55.341			

ns: No significant difference

Table 3: The frequency of dusty days in the statistical period of 1988- 2008

Year	1989	1990	1991	1992	1993
Frequency	16	29	15	8	5
Year	1994	1995	1996	1997	1998
Frequency	14	13	9	19	10
Year	1999	2000	2001	2002	2003
Frequency	2	12	21	17	16
Year	2004	2005	2006	2007	2008
Frequency	27	19	23	19	49

Table 4: Subsidence rate of atmospheric dust in seasons (gr.m^2 *day)

Seasons	Autumn	Winter	Spring	Summer
Rate of Atmospheric dust	0.093	0.068	0.095	0.204

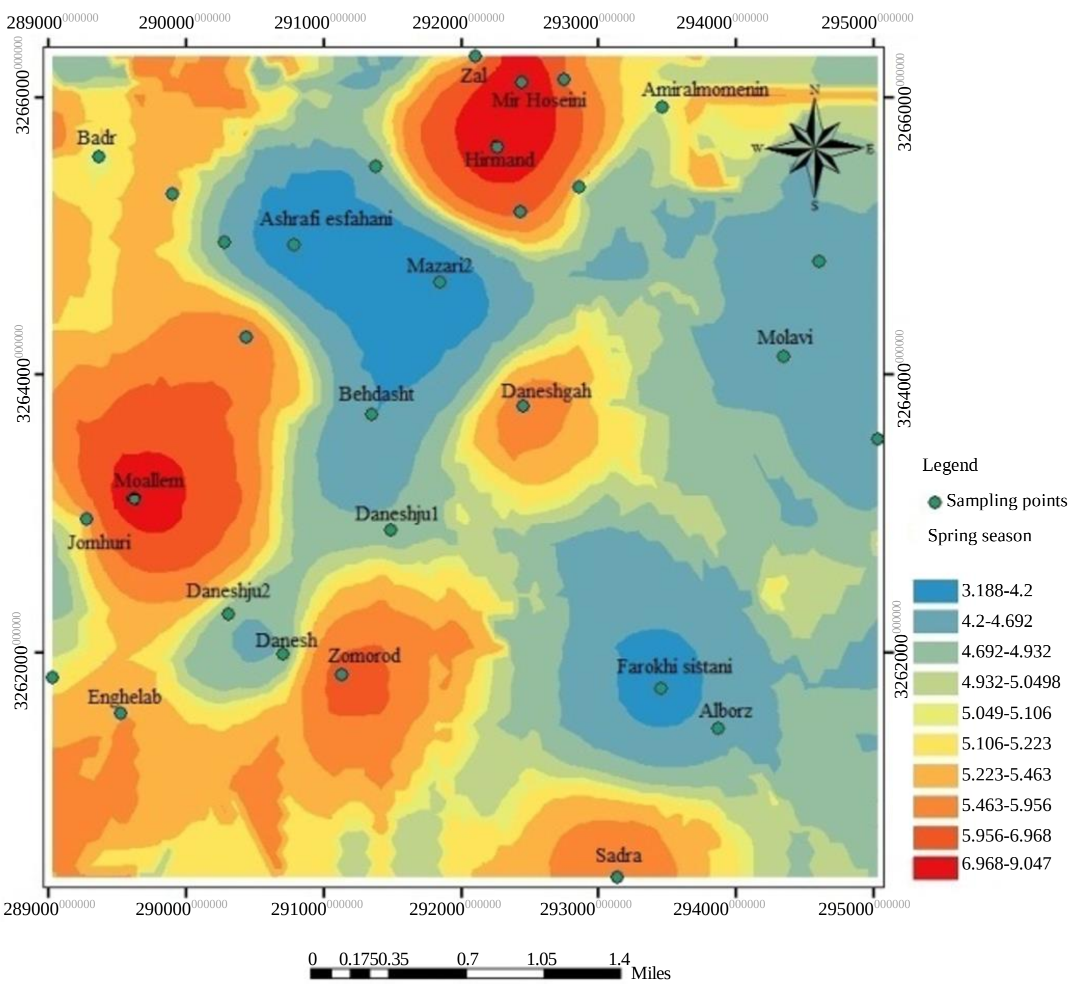

Fig. 5: Landing dust mapping schedule of spring 2015

In a study by Mehrshahi and Nekounam (2009), the spatial and temporal aspects of dust in a 20-year period from 1988 to 2008 in Sabzevar city were investigated. The statistical results of this study showed that during the study period, the number of days with dust had an increasing trend and the most likely occurrence was in May and June. "Table 3" showed the frequency of days with dust and graph 1showed the frequency percent and the annual trend of dusty days in the studied period. According to the statistics, 2008 with 49 days and 1999 with 2 have the highest and lowest frequency of dusty days, respectively. It reveals the fact that with all efforts done to control and promote this phenomenon by the Natural Resources Department, the number of dusty days has increased in this period.

Namazi *et al*. (2015) conducted another study to investigate the spatial and temporal variations of heavy metals in atmospheric dust in the Lenjanat region of Isfahan. Sampling was done in 60 regions with almost identical height in the areas using glass traps during the four seasons of the year and the total dust content and the number of heavy metals, cadmium, lead, zinc, copper and nickel were measured. To determine the weight of dust in the area and period of time, dust subsidence rate was calculated by the following formula:

$$\begin{aligned} &Atmospheric\ Deterioration\ Rate\ \left(gr.m^2 * day\right) \\ &= Dust\ Mass\left(gr\right) / Trap\ Area\left(m^2\right) * Sampling\ Period\left(day\right) \end{aligned} \quad (5)$$

The results demonstrated that the average amount of dust subsidence has a very significant difference in the level of %99 in all seasons except spring and autumn “Table 4". The average concentrations of the elements studied in the majority of seasons were significantly different. The average concentrations of lead and cadmium in all seasons and zinc element except spring were higher than the reported limit for soil. There was a significant correlation between the concentration of some elements that could indicate their common origin "Table 5".The interpretation of Kriging maps showed that the pollution of the area to zinc, lead and cadmium was more under the control of the lead and zinc mine in the region. The level of consistency indicated a significant difference in the maps of each element in various seasons which was related to various factors such as wind speed and its direction, the amount and type of mine and industry activities and the amount of soil and air moisture.

One of the articles on determining the concentration of heavy elements in dust was a study by (Feng *et al*., 2008) who studied the dust in Jinan city in northern China. The samples were analyzed to study the amount of copper, lead, zinc and cadmium. The results showed that all four elements had a significant accumulation in the dust particles of this city and their concentrations were more than the basic limits. Yahaya *et al*. (2010) used composite sampling method in wet and dry season from the surface soil of intersections and highways in the city of Uyar to determine the concentration of as, Cd, Cr, Cu, Fe, Ni, Pb and Zn in the obtained samples. The results showed that there is a high correlation between the studied metals except for nickel. Likewise, the concentration of metals in the dry season was higher than that in the wet season, “Table 6". Figure 6 Shows Regularity proportion and yearly tendency of rate of dirty times in Sabzevar city throughout the arithmetical time of 1988-2008. First, in 1990, Frequency Percentage has a miximum trend then the trend is decreased until suddendly It rises dramatically.

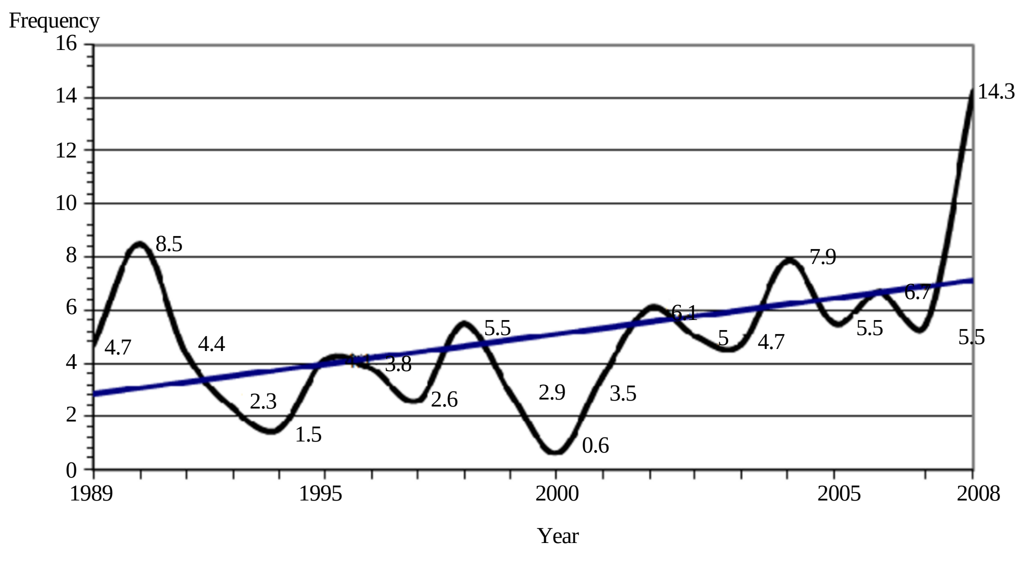

Fig. 6. Frequency percentage and annual trend of occurrence of dusty days in Sabzevar city during the statistical period of 1988 - 2008

Table 5: Average element concentrations (mg.kg) at four seasons

	Zn	Pb	Cd	Cu	Ni
Autumn	785.45b	256.83ac	3.28a	33.12a	37.49a
Winter	573.79a	160.85a	2.74a	33.61a	26.09b
Spring	279.31c	133.81b	1.35b	14.43b	24.16b
Summer	596.95a	524.31c	6.13c	22.32c	48.26c

Table 6: Correlation of metals between wet and dry seasons

Element	As	Cd	Cr	Cu	Fe	Ni	Pb	Zn
Correlation	0.71	0.46	0.86	0.75	0.56	0.23	0.87	0.66

p<0.05 leve

Other studies that investigated the heavy elements found in dust are the studies of (Acosta *et al*., 2011; Bini *et al*., 2011; Cai *et al*., 2012; Chabukdhara and Nema, 2012; Chen *et al*., 2009; Eze *et al*., 2010; Gu *et al*., 2012; Lin *et al*., 2010; Lu *et al*., 2010; Micó *et al*., 2006; Reilly, 2008; Chaoyang *et al*., 2009; Xia *et al*., 2011; Zhang *et al*., 2008) that in all of them, the adverse effects of heavy metals on humans and the environment were highlighted as a big disaster. Among researches that used statistical geology methods and geographical information systems for extraction and analysis of information about heavy elements, the study of (Cai *et al*., 2012; Chabukdhara and Nema, 2012; Davis *et al*., 2009; Eze *et al*., 2010; Guo *et al*., 2012; Li and Feng, 2012; Lu *et al*., 2012; Qishlaqi *et al*., 2009; Xia *et al*., 2011; Yang *et al*., 2011) can be pointed out in which the distribution zoning of heavy metals in dust was discussed. In dust detection studies, Miller (2003) developed a methodology that is used to visualize the amount of dust on the surface of water and land during the day. He used MODIS sensor data for this purpose. Roskovensky and Liou (2005) used a four-band spectrum in order to distinguish the dust from Cyrus cloud. They used bands 4, 16, 31 and 32 in this method and concluded that values greater than 1 represent dust in this method. In other research, researchers such as (Rasouli *et al*., 2010; Zolfaghari and Abedzadeh, 2005) have investigated the spatial and temporal analysis of storms. Most of them resulted in an inclination in storms in recent years, especially in western part of Iran. Dusting phenomenon identification and identification of their origin areas using satellite imagery and using wind tunnel by (Ekhtesasi *et al*., 2006; Iranmanesh *et al*., 2005; Khosravi, 2010; Schlesinger *et al*., 2006) were considered as noteworthy. These studies also suggested that the main sources of dust entering the western part of Iran are usually Syria Desert, Iraq and the Arabian Desert, while the role of the great African Desert is considered insignificant. Kimura *et al*. (2009), investigating the relationship between the occurrence of dust storms, vegetation and soil moisture, pinpointed that dust storms occur when the normalized vegetation index is less than 0.2, the wind speed is greater than or equal to 7 m. s. and surface soil moisture is less than 0.2 and for normalized vegetation, greater than 0.2, the wind speed must be greater than or equal to 9 m. s. and the soil surface moisture must be less than 0.2. Shamsipour and Safarrad (2012) investigated the spatial and temporal changes of dust phenomenon in southwest of Iran. In this study, two maximum dust periods with different characteristics were identified. Lashkari and Keykhosravi (2008) analyzed the statistical analysis of dust storms in Khorasan Razavi province between 1993 and 2005 and determined that dust storms in the south of Khorasan Razavi province are a prevalent phenomenon, increasing from the north to the south. According to studies conducted by (Mei *et al*., 2008), it was concluded that the dust reflection value in band 32 is higher than the MODIS band of 31 and the difference between the brightness values between bands 31 and 32 is negative. Likewise, the value of Normalized Dispersion of Dust Index (NDDI) is a positive value. Li *et al*. (2010) evaluated the largest Australian dust with MODIS satellite images and the light temperature difference index and considering its remarkable efficiency in detecting dust masses, the way this phenomenon occurs has been identified. Tabatabaie *et al*. (2013) investigated the suspended particles' average of ten stations in three dust periods in Bushehr city to analyze the spatial variations of heavy metals concentrations of arsenic, cadmium, cobalt, iron, nickel, lead and vanadium. Geomagnetic Engineering, Geographical Information System (GIS) and discrete Kirijing method were used to prepare the spatial distribution map of seven metal concentrations. Also, Principal Components Analysis (PCA) and Correlation Matrix (CM) were used for data processing. The results of the segmental effect (C_0) on the variogram threshold ($C_0 + C$) showed that the distribution of spatial variations of the seven elements is located in the middle average dependency class (0.25-0.75). This means that the entry of these metals into the studied area has an external origin. It should also be mentioned that, the

Krjing method was used to quantify the concentration of metals. The analysis of the main component of seven heavy metals can be categorized in three components. In the first component, vanadium, cobalt, nickel and lead, in the second component of cadmium and the third component of iron showed the highest correlation. The result of this analysis showed that the origin of the concentration of these elements is an external factor. These results will help the environmental management of the region. In a research, NDDI index and temperature threshold of 290°K in the band of 32 were used for revealing dust fine particles. NDDI one of the best known indices in remote sensing to study dust "Formula 6":

$$NDDI = b7 - b3 / b7 + b3 \quad (6)$$

where, $b3$ and $b7$ bands 3 and 7 sensors are MODIS. Then, the composition of the difference in the temperature of the brightness of the dust in the bands 32-31-29 (wavelengths of 8.5, 11, 12 micrometers) was measured by MODIS with negative values of the luminance difference of 31 and 32 bands, clear images of dust concentration were obtained. In this vein, during the warm seasons, especially in July, there has been a noticeable increase in dust and since 2007 it has an increasing trend. In this regard, December was the lowest due to the average rainfall and temperature decrease. During these years, the frequency of these storms in this province has not followed a certain pattern and order. The average concentration of particles in dusty days in Ahwaz compared to the standard concentration of particles in Iran is 11±16.5 times (Negin *et al*., 2013). In other studies, researchers such as (Rivera *et al*., 2006; Tsolmon *et al*., 2008; Zoljoodi *et al*., 2013; Ataie and Ahmadi, 2010), Shamsipour and Safarrad (2012) and other scholars using remote sensing methods and using AVHRR imagery, NOAA satellite data, MODIS sensor data, meteorological data, orbital component data, half-width, lines of pressure, lines of altitude and etc tried to reveal and monitor the fine particles in different parts of the world and in Iran.

In some of these studies, natural resources were recognized as the factor of causing dust. In the Middle East, regions such as the west of Baghdad and Mosul to Bahrellmullah and Horealam, the northern coasts of the Euphrates River in Syria and the desert areas of Iraq are known as dust production centers. Rezaie-Moghaddam and Mahdian-Broujeni (2015) used the AVHRR imagery of NOAA satellites to identify the fine particles in the southwestern part of Iran (Fig. 6). In this regard, getting advantages of meteorological data and using popular algorithms for detecting the fine particles, they initiate recognizing and revealing fine particles. The images were extracted from 62 sources in the southwest of the country and 3 areas of western Ilam and its border with Iraq, which has the highest number of values in terms of density, northern of Khuzestan and Iraq and areas around the Hourolazim wetland were introduced as regions with frequent production of fine particles "Fig. 7".

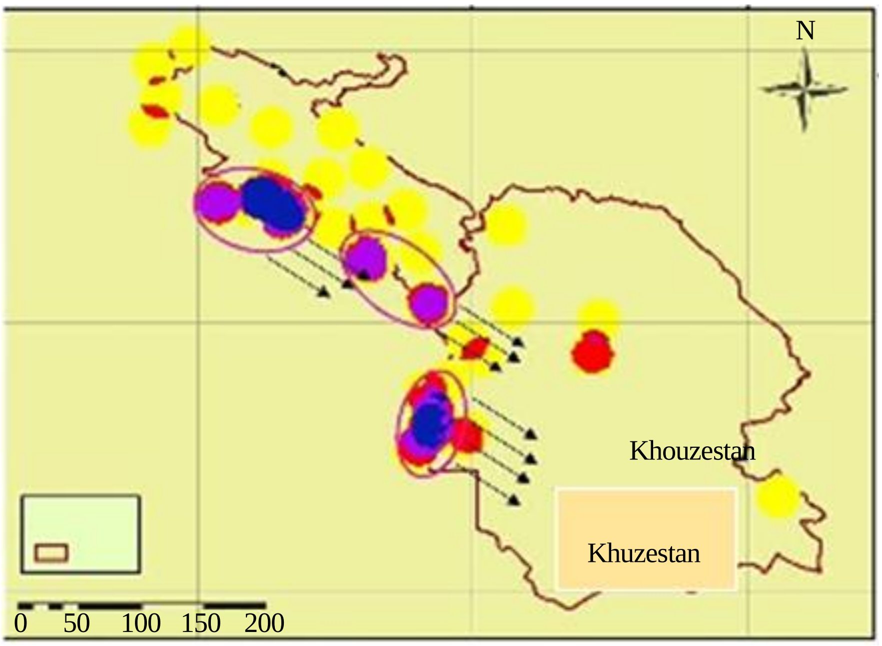

Fig. 7: Districts of the Fountains in the Southwest of the country

Discussion

A prospective review study was conducted to investigate studies on dust recognition and dust monitoring. A review of various studies showed that this field of study was both qualitative and quantitative. A high percentage of studies have used remote sensing capability and geographical information system to investigate and detect dust. Numerous articles have been satisfied with the information provided by meteorological stations. Another category of studies was to study and to provide the zoning map of spatial distribution of dust in the study area (Azimzadeh *et al*., 2010) and another group of studies tried to interpolate and distinguish the concentration of heavy elements found in dust particles (Ismail-Zadeh-Hosseini *et al*., 2013). The resulting map is a qualitative division for various regions. These types of models are prepared periodically and seasonally. One of the most important environmental challenges that recently have been arisen in the Middle East and Iran is the dust phenomenon. This phenomenon has become one of the major problems in arid and semi-arid regions (Shamsipour and Safarrad, 2012). One of the factors affecting the severity of dust is the density factor and vegetation structure, which plays an essential role in controlling the occurrence of dust storms (Ta *et al*., 2004). Another important and effective factor in the occurrence of dust phenomena is geographical location and climatic conditions of the regions of the origin and areas affected by this phenomenon. The presence of Iran in the arid and semi-arid belt of the world and, on the other hand, the proximity to countries such as Arabia, Iraq and Syria, which have poor vegetation cover, low rainfall and high temperatures in most parts of these countries which are mostly the desert and are affected by desert conditions, air instability and wind flow is severe in these areas causing dust to happen in these regions. The intermittent drought in these regions has caused a periodic dust phenomenon in the western and southeastern parts of Iran. On the other hand, undesirable use of natural resources and environment by humans inside Iran and in the neighboring countries has exacerbated the dust phenomenon. This has been intensified in drought conditions and some other human activities, including land use change happening frequently in recent years, which have caused many environmental, health, social and economic problems and for politicians caused political problems and residents; dissatisfaction in these areas. Studies have shown that the dust phenomenon is a natural disaster that yearly causes many damages in the western and southwestern provinces in Iran. Consequently, familiarity with the creation process of this phenomenon can be effective in reducing the resulting damage (Omidvar, 2006). Since, numerous researchers have been conducted on fine dust particles such as (Engelstadler, 2001; Jalali and Davoudi, 2008), the western and southwest regions of Iran are among the regions with high incidence of this phenomenon and other studies such as (Pourali and Taghizadeh, 2011), have emphasized on the intensity of the fine dust particle phenomenon in southwest regions of the country in recent years. Although the use of new satellite imagery and detection methods of fine dust particles appear less in domestic research, they have been used extensively in foreign research such as (Rivera *et al*., 2006; Tsolmon *et al*., 2008). Acceptable results have also been achieved. In the researches carried out to monitor and identify the southwestern fine dust particles of the country, which have been carried out using remote sensing techniques and climatic methods and grading, the main source of the fine dust particles of this region is recognized outside of Iran especially in Iraq, Syria and Saudi Arabia (Ataie and Ahmadi, 2010).

Conclusion

The most important natural source of air pollution is dust in the majority of cities located in arid and semi-arid regions of Iran. But this kind of air pollution cannot be considered quite natural. Dust phenomenon is affected by several factors; human factors and natural factors that are divided into two types of constant factors over time and variables over time. Controlling human factors and monitoring natural variables over time can play an important role in controlling this phenomenon. The existence of spatial and temporal differences in the falling dust in different cities and in different months in the reports of Akbari in Behbahan city in Yazd and in Isfahan has indicated that in all of these reports, the amount of falling dust in the spring and winter has a spatial and temporal difference matching the results of dust sampling in Zahedan in the spring of 2015. According to the obtained results, it was found that the dust in spring of 2015 in Zahedan city has spatial and temporal changes. The spatial and temporal changes in dust can be caused due to the low green space, especially in the direction of wind blowing, developmental activities and 120-day winds of Sistan and the difference in urban density and urban marginal topographic complications. According to zoning map in the spring of 2015, the existence of an inconsistency in the dust spatial variations in the spring indicated that spring is the source of dust in the city. Since part of this amount is due to the drying of Hamoon Lake, wind erosion control measures in these areas can be effective in reducing the loss of dust in the city of Zahedan. In Iran, the use of geographical information systems and remote sensing to monitor natural hazards is increasing. Hence, the attention of managers of various fields of natural resources and environment to the capabilities of this software and attention to the researches have done in this regard sound necessary and useful. The results of many studies in the country showed that the frequency of dusty days is increasing. Therefore, very critical situations are coming and it is expected that the majority of urban and rural populations will migrate to the rest of the country, especially from western and southwestern regions leading the way to a lot of economic damage. Studies conducted in the country showed that the western regions of the country are more exposed to dust systems due to their geographical and climatic location and the proximity to the deserts of neighboring countries such as Iraq, Syria and Saudi Arabia, especially since most of the atmospheric system of the North West, West and Southwest are imported into the country. For this purpose, investigating, studying and recognizing physical and chemical composition of dust and soil resulting from it to determine and identify harmful elements and ultimately policy-making and planning for its elimination as regional alliances in the field of policy-making and foreign co-operation vital.

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Author’s Contributions

All authors equally contributed in this work.

Ethics

In this article, all ethical principles related to scientific-research articles such as validity and authenticity, originality, data collection in a standard manner, integrity, the accuracy of research and etc were observed.

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