

Study of the vegetation effect on reduction dust using satellite images (Case study: Yazd city)

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Paper Refrence Number: 0110-769

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Abstract

Dust event is the most serious environmental problem in the arid and semi-arid areas. Every year, especially in warm seasons, many districts of Iran are affected by dust storms. It causes onsite and offsite damages in different aspects. Thus studying factors that control and reduce dust and its damages is essential. Green space, especially in tree form is considered as one of the effective factors in controlling air pollution, especially dust particulates. In order to prove this claim, the dust loss of the city of Yazd was measured in a three-month period (summer) using marble dust collector (MDCO) at 16 stations, scattered across the city. By using LANDSAT satellite images (TM sensor) of 2010, the vegetation index (NDVI) facing the dominant wind sector (North West) in each of the sampling stations was measured by Thiessen polygons. Finally, the correlation coefficient between the weight of dust collected and maximum vegetation index per sector was computed. Results indicated inverse relationship with high correlation ($p\text{-value} < 0.05$) between the amount of dust and vegetation cover. The results shows, specification of urban green space, especially in direction of the dominant wind, is one of the most efficient in dust control, especially in arid and semi-arid areas that face shortage of green space per capita.

Key words: Dust loess, MDCO, NDVI, Satellite images.

1. Introduction

Dust and dust storms include the most serious environmental problem especially in the arid and semi-arid areas. Every year, especially in warm seasons, parts of Iran are strongly affected by this problem. This problem causes damage in several different dimensions. Rolling out this dilemma in some provinces and large parts of the country, has increased concerns (Raeespoor et al., 2010). Results of research during the past 10 years show that dust particles of air are dangerous for public health, more than what we thought before.

Researches of New York University show that getting exposed to fine particles is cancerous in long term and causes heart disease (Hashemi et al., 2010). Among other destructive results, I can refer to (a) burying buildings and villages under the sand, (b) destruction of agricultural land and farms, (c) blocking Qanats(Kariz) and canals irrigation, (d) infecting surface waters, expanding deserts and dry areas, (e) creating difficulties in transportation because of decreasing the horizontal vision, (f) getting barrier in the path of rails and roads communication, (g) disabling of computer systems, (h) transmission of plant pests and weed seeds, (i) carrying pathogens which lead to infect plants, animals and humans (j) and finally carrying toxic and chemical materials attractive effects of dust (Raeespoor et al., 2010).

Hence studying factors that reduce dust is essential. Vegetation is one of the effective factors for controlling this problem. Green space, especially in tree shape can be effective in reducing air so that pollution the dust concentration of air on a tree planting area is one-fifth of a residential area. Purification ability of trees and green space in the Rough areas are residential flat regions (Majnonian, 1995). According to researches, amount of suspended particles in the street that has filled by trees, is 3000 and a street in the same area without tree is 10,000 to 12,000 (Rouhani, 1992). In order to study and monitor vegetation in the global and regional scale, access to field data is often difficult and limited. The conventional methods to estimate vegetation, including overall assessment of the vegetation, are time consuming and the information is not accurate. Thus, remote sensing technology with the ability of providing abroad and integrated vision of a region, reproducibility, accuracy and availability of information is very useful. Combining the results of the analysis of field observations and estimations with remote sensing data can be useful to assess the effective of vegetation on dust (Sanayi Nezhad et al., 2008). One of the indices of vegetation that is used in remote sensing and hence in our study is Normalized Difference Vegetation Index (NDVI)(Eq.1).

$$NDVI = \frac{NIR-RED}{NIR+RED} \quad (1)$$

The index value varies from -1 to +1. Indeed efficiency of NDVI based on the high reflection of fresh plant in the NIR band and it's low reflectivity in RED band of the electromagnetic spectrum. Thus fresh plants usually have high NDVI and about 0.5 to 1 .Viceversa bare areas usually have negative NDVI and arid and semi-arid areas with scarce vegetation due to the equal reflection in RED and NIR bands, value's NDVI is almost zero (Amiri, Esmaeeli, 2010). Some recent studies on the relationship between NDVI index and dust storm are reviewed below.

Iranmanesh et al. (2005) in a survey on dust deflation areas and their distribution characteristics in Sistan region storms by satellite images and NDVI index concluded that marginal strip of vegetation in the eastern Hamoon Sabury is an important factor in reducing the density of dust. Xu et al. (2006) studied the relationship between dust storms and vegetation index, snowfall and soil texture using NOAA satellite images. The author concluded that the reduction of vegetation increases the dust storm. Also the results showed positive correlation between the number of dust storm events and plant phonology. Reiji et al. (2009) studied on the relationship between the incidence of dust, vegetation and soil moisture in loess areas in China from 1999 to 2000. Their study concluded that threshold NDVI for preventing dust out breaks was about 0.2 when the wind speed ranged from 7 to 8 ms⁻¹. This threshold NDVI corresponds to a vegetation cover of 18%. In the present study the effect of vegetation on reduction dust by using

vegetation index (NDVI) and collected dust in marble dust collector(MDCO) for three month period of summer for Yazd city has been studied.

2. Data and Material

2.1.study area

Yazd city is located between 54°22'3"E longitude and 31°53'50" N latitude. It is located in Yazd-Ardakan plain with arid-cold climate. Dominant wind direction in the six months of the year (spring and summer) north-west and four months (November to February) and the southeast in March and October, is western. In a 24-year period, the numbers of dusty days are 59 days, with most of it in summer. It causes tangible and intangible damages for Yazd province with 526276 population.

2.2.Dust collecting

There are two methods for measuring dust: Theoretical and experimental. In experimental methods samplers and collectors are used to collect horizontal and vertical dust (Sow. et al, 2006). Goossens and Offer (1999) compared horizontal and vertical samplers and found marble dust collector (MDCO) has good efficiency for collecting horizontal dust. Thus this study used MDCO to collect dust. Designed trap for this study includes a circle plastic plate with 22.5 cm diameter that is covered by aluminum sheet for preventing static electricity between plastic plate and dust. From inside, the plate has been filled by three layers of marble with 1.6 cm average diameter (Fig1.)



Fig1: Marble dust collector

For suitable distribution of marble dust collectors in the city, the main and most populous neighborhoods, as sampling stations, have been selected. Also for calculating NDVI index, the image of Landsat satellite (TM2010 sensor) has been used.

3. Research Methodology

At the end of September, trapped dust in sediment retention was collected carefully (Fig.2) and weighted by balance with the accuracy of 0.01. Using Arc-GIS ver.9.3 Thessen polygons of sampling stations was drawn. NDVI index of per wind sector dominant of sampling stations was calculated by satellite image and ERDAS ver.9.2 software

(Figs.3~4). Finally, correlation between weight of collected dust and $NDVI_{max}$ of per dominant was analyzed by SPSS ver.16 .



Fig2: Trapped dust in sediment retention

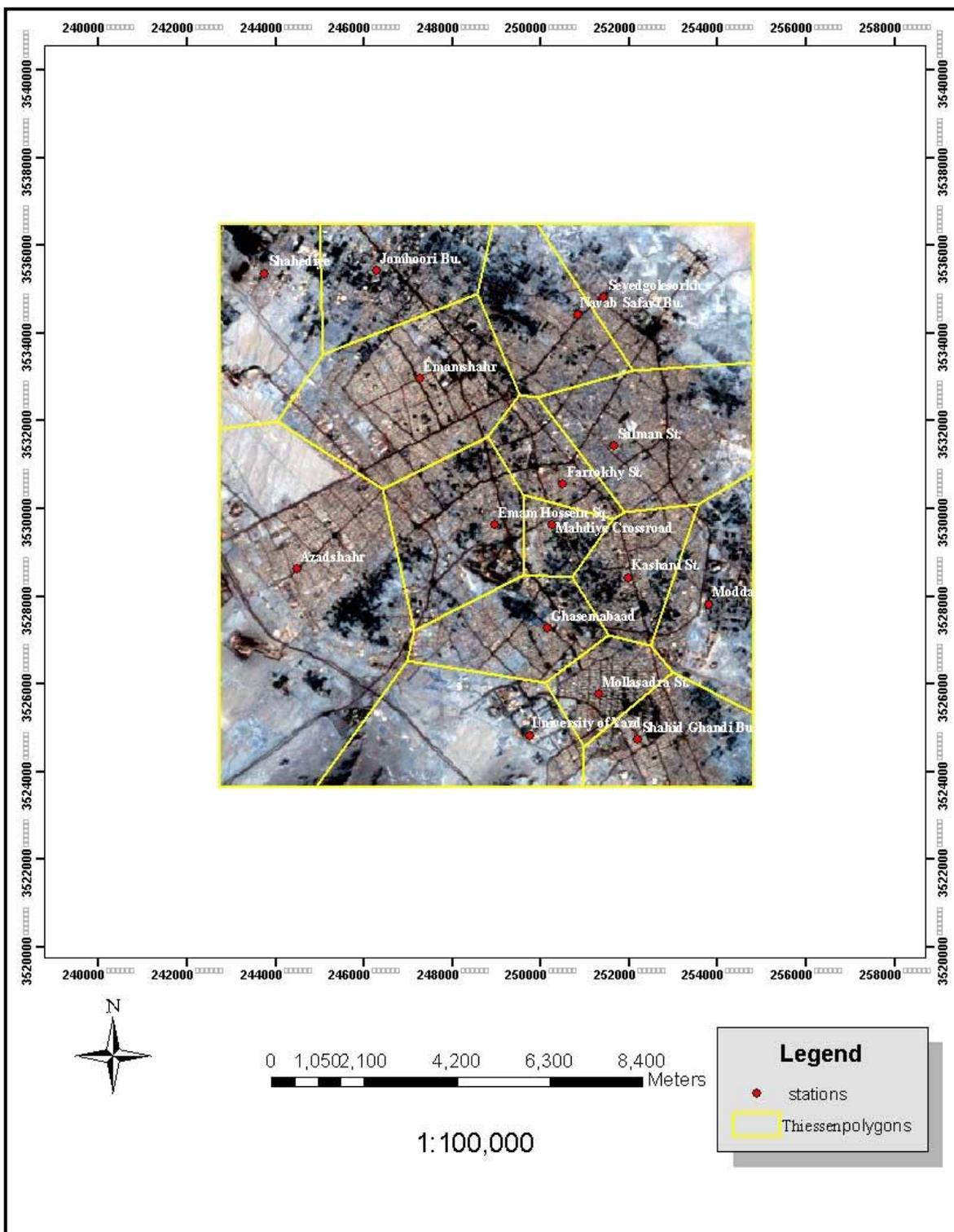


Fig3. Thiessen polygons of sampling stations

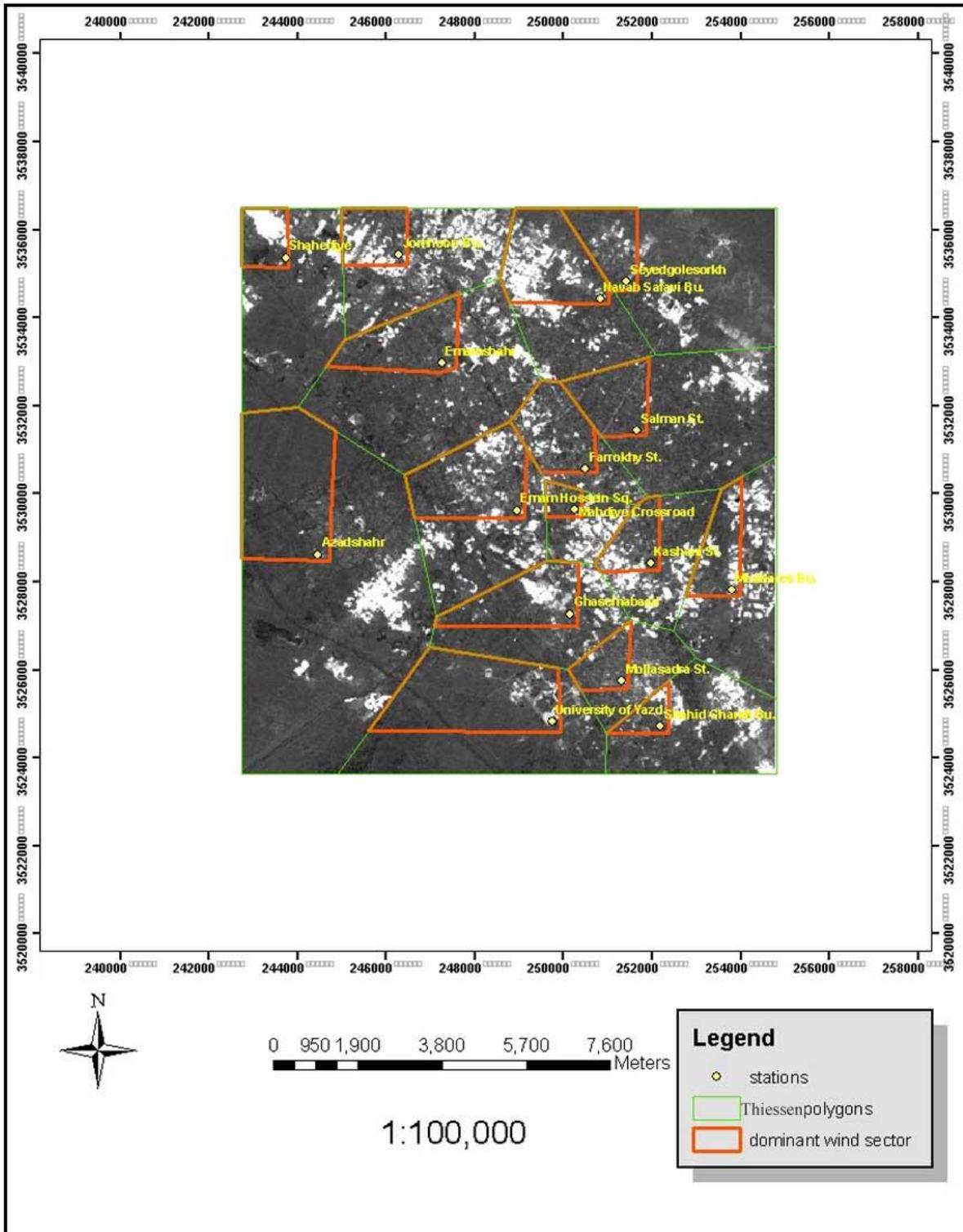
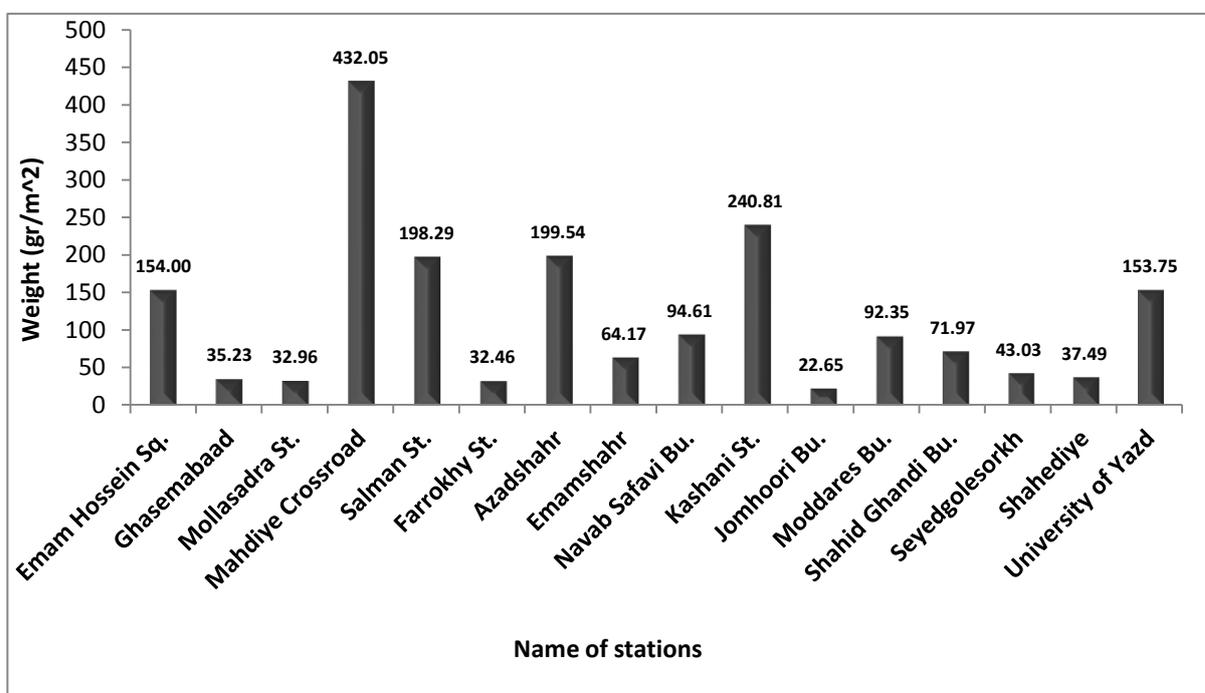


Fig4. NDVI index of per wind sector dominant of sampling stations**4. Results and Analysis**

As illustrated in Figure 5, result of data analysis showed differences between the weight of collected dust at each station.

**Fig5.** Dust weight for three month period of summer (2010)

Relationship between vegetation index (NDVI) and the amount of dust indicated the inverse relationship between these parameters with a high correlation (Tables1~2, Fig. 6).

NAME	weight (gr/m ²)	NDVI(max) dominate section
Emam Hossein Sq.	154.00	0.1
Ghasemabaad	35.23	0.3
Mollasadra St.	32.96	0.2
Mahdiye Crossroad	432.05	0.3
Salman St.	198.29	0.4
Farrokhy St.	32.46	0.2
Azadshahr	199.54	0.3
Emamshahr	64.17	0.44
Navab Safavi Bu.	94.61	0.2
Kashani St.	240.81	0.3
Jomhoori Bu.	22.65	0.4
Moddares Bu.	92.35	0.4
Shahid Ghandi Bu.	71.97	0.3
Seyedgolesorkh	43.03	0.5
Shahediye	37.49	0.3
University of Yazd	153.75	0.4

Table1. dust weight of stations and NDVI of dominate section

		DUST	NDVI
DUST	Pearson Correlation	1	-.524*
	Sig. (2-tailed)		.037
	N	16	16
NDVI	Pearson Correlation	-.524*	1
	Sig. (2-tailed)	.037	
	N	16	16

*. Correlation is significant at the 0.05 level (2tailed).

Table2. Results of data analysis in SPSS

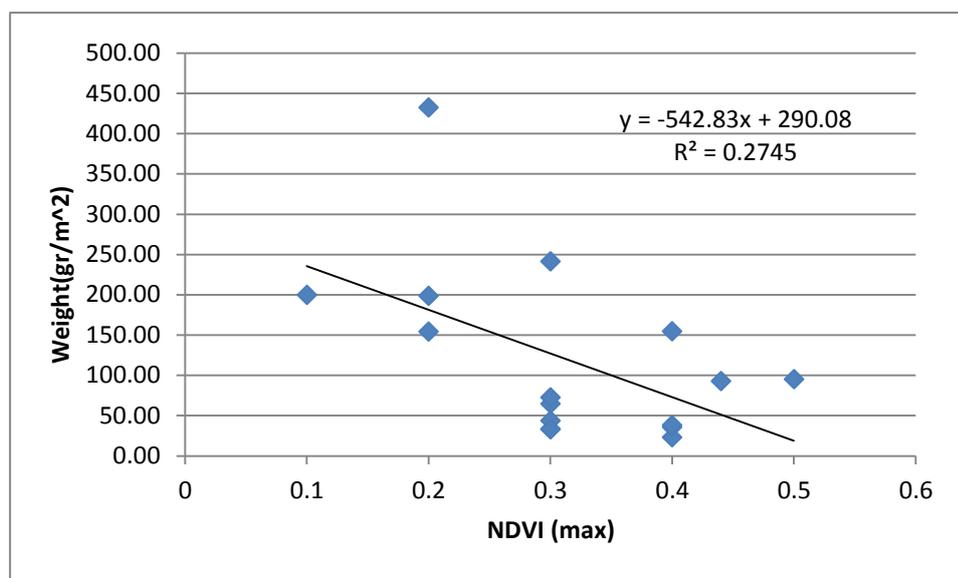


Fig6. The relationship between vegetation index (NDVI) and dust weight

5. Conclusions

Green space is one of the important factors to air pollution reduction, especially dust particles. The collision of the wind carrying the mass of dust with trees causes the reduction of wind speed and wind power and therefore leads to the residue of dust. In this study this claim is supported by the negative slope of the scatter plot and high correlation co-efficiency between vegetation index (NDVI) and the weight of dust. In areas such as Yazd city that the capita green space per person is about half the standard value (6.5m²), increasing the capita green space especially in the dominant direction of the wind, has an effective role in reducing air dust. However, differences in morphological features of plants such as vegetation height, canopy density, thickness and shape of the leaves have different effect on dust reduction. Today, air pollution has become a major and influential factor in human life. To reduce this problem, decisive and effective actions in large scale are necessary. Actions such as: (a) Discontinuing irrational exploitation of man made

forests, (b) restoration of green space, (c) restoration of desert vegetation, (d) preserving soil fertility and stability by green belts, (e) building and construction of parks and green spaces in uncovered and idle lands of cities with reasonable choice of species for, and (f) repairing the destroyed vegetation and preserving them are necessary to alleviate the problem.

It should be noted that although the importance of vegetation has an effective role in reducing dust, the impact of the other factors (listed below) on increasing the dust should not be ignored. These factors sometimes nullify the effects of vegetation on reducing the dust. These factors include:

- Construction activities around the city: For example, during the study period, in Mahdiah cross an underpass was constructed. The result of this study showed significant differences in weight of dust in this station compared to other stations.
- The abandoned lands are prone to create dust, due to existing bare soil.
- Transportation vehicles that increase distribution and transmission of dust.
- Accumulation of trashes that is prone to create dust.
- Man-made artifacts like tall buildings that increase the roughness factor and as a result cause the reduction of wind speed and the increase of dust.

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