

Determining the origin of the dust in the west and southwest of Iran using the MODIS Sensor satellite images and the Arc GIS

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ABSTRACT: Nowadays, the issue of dust storms has become a concern for the residents of certain areas of the earth. These dust storms are caused and influenced by high wind speed, regional soil type, dry climate, and regional vegetation, and greatly damage the environment and the health of human beings and animals. Numerous studies have been conducted on the effects of dust and the origin of this phenomenon in recent years. This study was conducted to determine the precise origin of the dust storms entering the west and southwest of Iran. For this purpose, the geological, topographic, and vegetation maps of the Middle East were used to investigate the origin of this phenomenon in the region. However, for a more detailed investigation of the origin of this phenomenon and its way of movement toward the western parts of Iran, the MODIS Sensor satellite images and the Arc GIS interpolation process were applied. The results showed that the origin of the dust storm phenomenon entering the west and southwest of Iran is a new dust-generating area located in the north and northwest of Iraq near the borders of Syria. The maps of geology, topography, and vegetation of the region confirmed these results.

Keywords: dust, MODIS Sensor, Arc GIS, geology.

INTRODUCTION

Being considered as a frequent event, the dust storms are reckoned as natural calamities, these storms are complex processes under the influence of the activities of the atmospheric systems which are mainly created because of conditions such as the high speed of wind, bare land, and dry climate. These storms can have effects on the climate alterations; they also cause great damages on people's life (Mie., 2008). Dust storms occur more around latitude 40° northern and southern of the earth.

The western winds, in these zones, carry the dust specks and transfer them to the other parts of the earth (Yang., 2008). When these dust specks enter the earth's atmosphere, they cause physical, chemical and biological alterations on it. Thus, this altered air is called polluted air. Pollutants are categorized based on the materials which cause. Considerable alterations on human beings, animals and plants. Therefore, each natural or artificial substance which enters the air and alters its nature is considered as an air pollutant (Diem and Comrie, 2002). Some studies have been done about the pollutant role of this phenomenon, however, there aren't studies which accurately determine the origin of this phenomenon. In this study, it has been attempted to scrutinize and determine the origin of this phenomenon, on the days of its creation, by using satellite images and also Arc GIS.

MATERIALS AND METHODS

At first step, in order to recognize the potential dust making part of the middle east, first, the south west of the middle east has been studied geologically and climatologically. Then, to determine the exact origin of the dust

phenomenon in the west and south west of Iran, the index vegetation map was drawn and then, in GIS zone on the fake color combination image, the origin places were navigated. After that, the navigated origin places were distributed on middle East's geology, topography and vegetation index maps.

To be more certain about the origion of this phenomenon, the way of its moving on the days a hich there were dust was drawn. Finally, it was discovered that most of the dust coming in to Iran was due to new dust generating areas located in the west and north west of Iraq and the borders of Syria.

RESULTS AND DISCUSSION

Because of Iran's geographic location, at first, Middle East's geology and climatology condition was studied. As we know, Middle East is the place which consists of west Asia and some parts of north Africa located on universal dust belt – it located on northern hermisphere and expanded from north Africa to china. Middle East generally has arid and hot weather and because of the little amount of rainfall, most parts of this area are deserts. It is common to have dust in this area specially in spring, summer and winter.

This area's dust potential climate, specially in large scale, can have a deep effect on the erosion of the soil, more over, dust storms, carried with seasonal winds coming from outside of tropical places, intensify this erosion (Anderson, 2004).

The rampancy of the phenomenon of the dust has been in existence since ancient time in some of the countries in Middle East such as Iraq, Jordan, Saudi Arabia peninsula and kwit. South west of Asia with its jagged topography can be a main origin for dust. Although this region is surrounded with black sea and Caspian sea in the north. Red sea and Mediterranean sea in the west and Persian Gulf and oman sea in the east and south, it is considered as a semiarid region (Evans, 2001). As it can be observed on south west of Middle East's geology map, most parts of this region consist of unsolid and infirm sediments which belong to the third period and they have potentiality and appropriaty to generate dust.

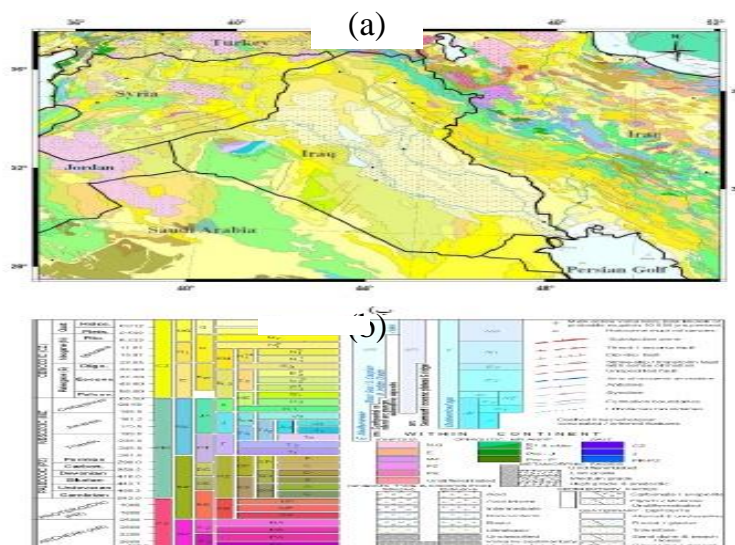


Figure 1-a. the Middle East's geology map (Abdoul Azim Haqi pour published by CGMW, 2009) b- the guidance of the map

According to Bartllet's researches (Bartllet, 2004), the primary region which are the origion of the dust in south west of Asia can be categorized in to some Zones (Figure 2). Zone1) fertile crescent plains between Dejjleh and Forat river's flood plains, Zone 2) AN Nafud Desert, zone 3) AN Dhana Desert, zone 4) Rub al-khali Desert. As it can be seen in Figure 2, fertile crescent plains are the region which consist of alluvial cones and flood plains composed of a mixture of clay particles (particles less than 2 micrometer) and silt (particles between 2 to 50 micrometer) and the other zone mostly composed of and (particles between 50- 1000 micrometer) and just some small zones composed of silt (Bartllet, 2004). These regions have the greatest contribution in generating dust in the Middle East.

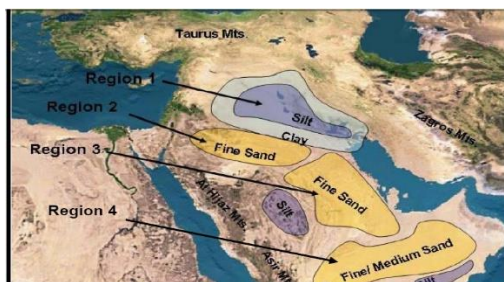


Figure 2. the zone which is the origin of dust in south west Asia (from Anderson, 2004)

3-1- Preparing vegetation index map

Because of the significant role of vegetation in preventing dust diffusion, vegetation index map with 250 meter location demodulation bands of MODIS Figure 3 is one of the things which can help to find the origin of the Dust in Iran. Vegetation index (NDVI) shows the probable vegetation with numerical alteration between +1 to -1. The vegetation index can be calculated according the following formula:

$$NDVI = (NIR - R)/(NIR + R)$$

In this formula, NIR represents the amount of reflexion in infra red band and R represents the amount of reflexion in red band. The highest number of this index (+1) represents the highest amount of vegetation congestion and the lowest (-1) represents terrain such as water and snow and for bare land this number was nearly zero. For calculating vegetation index, Band 1 MODIS (0/645 micrometer) was used for reflex ire amount of the red wavelength and Band 2 MODIS (0/856 micrometer) was used for reflexive amount infra red (Figure 3). In this Figure the parts which are red to brown show the regions with weak vegetation and those which are orange to green show the regions which have an average vegetation. This Figure also reveals that the main amount of dust entering Iran are coming from Iran and Saudi Arabia and specially their northern parts. But to detect the accurate origin of Iran's dust, the satellite images can be used.

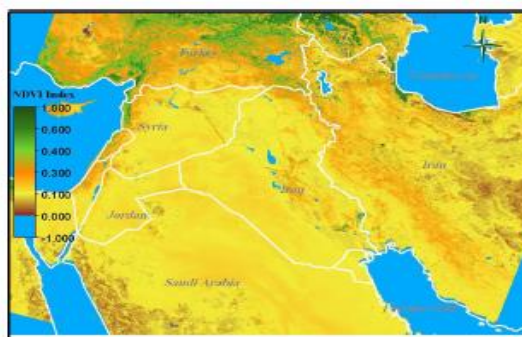


Figure 3. the calculated vegetation index map

To find the way of scattering the origin regions in GIS the image of color combination can be modulate with the whole extracted origins (Figure 4).

As it can be seen in this Figure the origin of the dust which enter to Iran, come from Saudi Arabia, north and north west part of Iraq (syria's borders). However, Both Figure 5 and 6 represent the origin of dust in Saudi Arabia and specially Iraq.

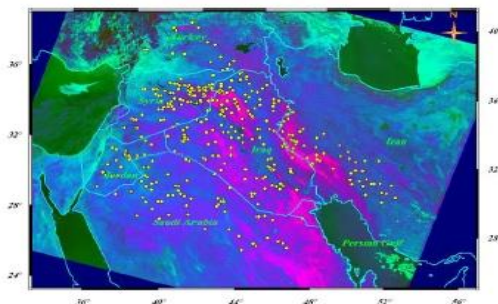


Figure 4. the way of scattering the navigated origin regions on fake color combination

Distribution of the navigated origin regions on the Middle East's geology map the navigated origin regions were implemented on the Middle East's geology map (Figure 5). As it can be seen in this Figure , the origin regions are mostly located in the west of Iraq and north east of Syria and these region are mainly located on the shoulders of for at and its offshoots.

Diffrent studies also reveal that Dejeleh and Forat Basins (Prospero, 2002) are one of the regions which, because of human's activities, has the potentiality of generating dust. These basin's geology stone bed are infirm neojen deposits. The other origin of dust are located in borders of igneous outcrops and also some of them are located on deposits which are in clay beds of Dejeleh and Forat. Deserts have covered lots of Iraq's space specially on its west, and sand hills are located in different parts of Iraq, specially on the west of Forat river. The texture of these hills alter from loom to sand with small to average sizes, and the potential of their erosion has been calculated about (25 tons in hectare per year (AL – Farajii, 2001). Thus, they can be carried with wind as the source of dust. On one hand these regions have a low-lying topography (Figure 6) and generally their heights are about or less than 400 meter which is a good potential for dust. On the other hand.



Figure 5. Distribution of the navigated origin regions on Middle East's map

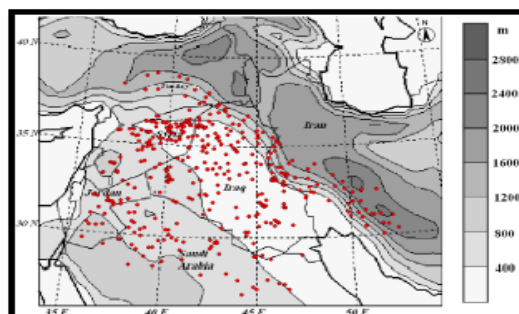


Figure 6. Topography map of south west of Asia and the origin regions on it (Evan & smith, 2001)

These regions have a weak vegetation (Figure 7) and the vegetation condition of these regions are potential to generate the dust . There fore these regions have a low-lying height in which the vegetation is weak.

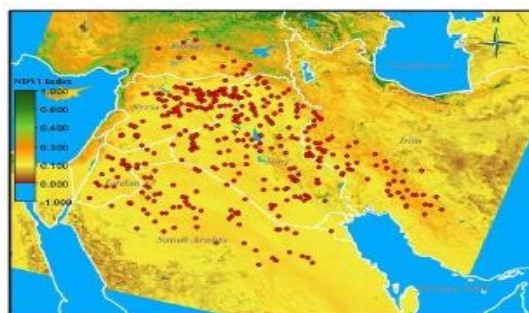


Figure 7. Vegetation map (NDVI) accounted from satellite images (Modis)

The map revealing the regions generating dust in the Middle Esat can also be drawn by using interpolation in GIS (Figure 8). The potential places generating dust can be clearly seen on this map which are on the west and north

west of Iraq, and the east of Syria and so this region can be called the most important cause of the Middle East's dust.

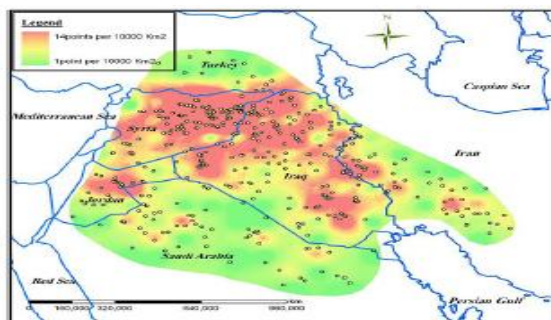


Figure 8- the map revealing the region generating dust in the Middle East taken out from interpolation in GIS

In order to find the exact places of the dust entering Iran, the available satellite image and faked color combination were used and then eye analyzing was used (Figure 9).

As it can be seen in this Figure , the dust speckles from some places east of Syria are raised with wind and then they are spreading, in winds direction, toward east and south east – which are in west and south west parts of Iran.

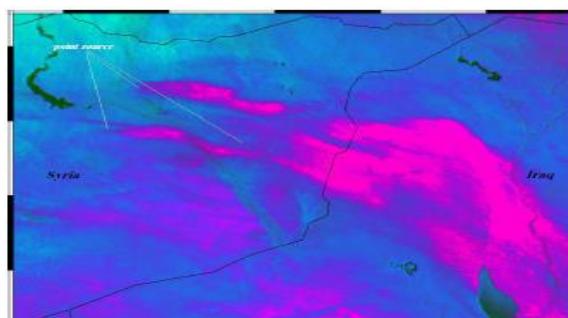


Figure 9- revealing the location of some of the source points navigated with faked color combination image

The way of spreading dust in Iran's regions

To determine the way of spreading dust in Iran's regions, the resultant vectors of wind's speed and direction on July, 2011, with selected meteorology stations on the target places, were drawn on the satellite images of that date. (Figure 10). According to this Figure it can be seen that the dust originated from the north and north west of Iraq and north east of Syria and it comes in to west and south west of Iran on the marked ways.

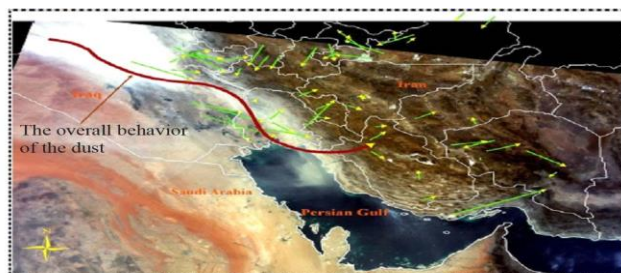


Figure 10- MODIS sensor satellite image and the resultant vectors of wind's speed and direction

The origin of the dust in the west and south west of Iran

Based on the mentioned discussions on Middle East's geological condition and dust generation phenomenon in this part, it is expected that the origin of the dust phenomenon in the west and south west parts of Iran is one of those region which has had a background of dust generation.

But according to the mentioned discussions, it seems that the origin of the dust coming in to Iran belong to a new dust generating area which has come to existence due to the recent year's famines. The new generating area encompasses the northern and western parts of Iraq which is a wide area in Iraq and Syria's borders. The thick dust, which covers western provinces of Iran and northern cities of Iraq, originates from the region which has had no background of dust generating. It is a sign of alteration and destruction of ecology of a region in the west of Iraq whose latitude is the same as the western provinces of Iran.

As the geology map of this region shows (Figure 1), in the west of Iran specially Iraq and Syria around Dejleh and Forat most of their stone are composed of unsolid Neogen deposits. From late Miocene the constituent material of most of deposits around the north of Arabian plate is sedimentary – destructive which originated mostly from shell and Jurassic sandstones, Cretaceous limestones and then Marni limes and Paleocene to Miocene shells. These young and infirm deposits are very vulnerable against erosive factors such as rain and wind. The destruction of these sedimentary – destructive units has caused that the production of this erosion be carried into low – height places by rivers, streamlet and running waters and they gathered in low-lying grounds. In the past, some of these low-lying grounds were watered with Dejleh and Forat, hence agriculture was prospered. Decreasing in water and vegetation and also human activities have caused the land be bare and its surface be eroded easily – specially for the reason that these region's sediments are generally fine particles. The weather fluctuations, famines and the increase of wind and storm intensify the process of erosion. However, lack of rain in this region and the inner regions in Saudi Arabia peninsula has caused an arid – surface region consists of sand, clay and silt which has the potentiality of generating dust storms which moves toward west and south west parts of Iran (Bartlett, 2004).

Conclusion

It has been attempted in this research to determine the origin of dust phenomenon and the way of its movements towards western parts of our country by using geology, topography and vegetation maps, MODIS sensor satellite images, and Arc GIS interpolation process. The studies and results have revealed that the origin of the dust entering the west and south west parts of Iran is due to a new dust – generating area which located in the north and north west of Iraq on the borders of Syria.

This area has Neogen infirm deposits which are especially around the rivers of Dejles and Forat. These infirm and young sediments are vulnerable against erosive factors such as rain fall and winds. Their erosion and destruction which has been done with rivers, streamlets, and running waters has caused the deposits of these regions being carried to low-height regions and gathers in low-lying regions.

These deposits are raised into the air because of the piles of weather cause the dust in these region and specially in west and south west parts of Iran.

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