The Aetiology of the Formation and Condensation of the Present Day Sand Hills

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Abstract

Sand hills are among the most amazing and the most beautiful sceneries of the arid and dry lands. They are caused by the process of removal of the soil from uneven surfaces and their movements to the margins. There are many factors involved in the process which encourage the question of whether this removal and replacement is accidental? and if not, what are the elements involved? Field studies show that there is always a direct relation between sand progression and the heights exposed to plains and playas. This means that higher the mountain, more the sand is drifted from the height, and vice versa. Therefore, it can be concluded that the difference between the heights of playa surfaces and that of the mountains causes temperature gradients and establishes a high pressure center over the heights. The temperature current which is produced from high pressure areas and moved to the lower levels prevents sand movement to the hillsides. On the other hand, the dominant currents which are flown from the surface of playa to the latitudes get diverted when they encounter latitudes at a level above the mountains, preventing the movement of sands. The exact place of the sands stalled is the meeting point of the counteracting currents, that is the dominant winds which pass the surface of playas and the local currents produced by the high pressure zones.

1. Introduction

Sand hills are among natural sceneries of the dry areas formed by winds which hinder the developments in the dry lands. There are more than 100 books, reports, basic descriptive and practical research articles which are available in the archives of Pastures and Forests Organization, Natural Resource Organization, Ministry of Road and Transportation, Armed Forces, and University Libraries, which give comprehensive information on their geographical spread, their formation, their shapes,… to the researchers.

This article, which is the result of 10 years observations and studies of the researcher in the central dessert area and the eastern dry lands of Iran, has attempted to explore the establishment of hills and specifically their localization. This research has attempted to provide answers to two following questions.

Q1: Is the formation and establishment of sand hills, accidental in any location or does it follow a disciplined rule?

Q2: Is it possible to provide a quantitative measure for the formation of sand hills?

It is clear that the positive answer to these questions might help policy makers who are involved in land processing.

2. Definitions

There is no single definition for sand hills, but three definitions presented in the sources are as follows:

The 1st definition: A pebble hill is a mass of sands that are accumulated (Refahi, 1999)

The 2nd definition: the most important shape of wind appears in the form of sand hills (Ahmadi, 1999)

The 3rd. definition: sand hills are among the diverse and mostly active geomorphologic shapes which are the results of sand and pebble drifts and replacement by wind (Asghari Moghadam, 2004)

3. Peculiarities of sand hills

The most important shapes of winds appear in the form of sand hills which pass various geomorphologic shapes (Ahmadi, 1999).

Sand hills form in the arid and dry lands (Ahmadi, 1999). Sand hills are deposits of wind which were made in the quaternary period

Sand hills make one of the particular and most beautiful phenomena in the kavirs and dry lands.

Concerning the above mentioned definitions, it can be in

dicated that sand hills are from condensed geomorphologic shapes formed by the wind and are of the peculiarities of the dry areas. (except in the beach sand hills in relation to the temperature).

Although many of the sand hills seem to be active today, most of them are considered as the land inherit ants, which have not still lost their potentiality, i.e. They have shown the same behavior in last climatic periods.

4. Difference between sands and pebbles

Since in many sources, books, and reports, sand hills and sand winds are considered as pebble hills and pebble winds, it is necessary here to clarify the definition of sand in these articles.

Pebbles: From the Geomorphologic point of view, pebbles are gradients with the diameters extending from 2 to 10 mm existing between sands and small stones. Ordinary powerful winds cannot move them, but very powerful winds and tempests roll and replace them on the earth.

Sands: They are particles with the diameters extending between 0.3-2 mm, which are classified as large sands with the diameters of 1-2 mm, medium sands with diameters of 0-0.5 mm, small sands with the diameters between 0.5-0.2 mm, and very small sands with the diameters between 0.2-0.02 mm, by reference to geomorphologic studies.

Depending on the size of sands any special type of wind can seize and drift a special type of sand.

5. Factors effective in forming sand hills

Although wind is the most effective factor in making sand hills, there are other factors that help the wind to make them. They are as follows-

a. Dry climatic condition
b. Wind blowing with necessary conditions.
c. The smooth and relatively smooth surfaces.
d. Loose materials with suitable diameters to be carried over.

Each of the mentioned factors can cause different effective conditions which are not dealt with in this article.

Field studies show that there is a direct relationship between even and low surfaces which are known as playas and sand hills.

Playa and even surfaces make the necessary conditions for the wind to make sand hills. In addition to mentioned surfaces, there are flood plains, flood ways, and inverted pillars which play the same roles.

By looking at the natural maps of Iran, it can be found that the mentioned surfaces are surrounded by mountains throughout the country. Field studies and surveys of photo-geometries have shown that the sand hills mostly extend along the distance between mountains and playas, as an example, sand hills in the south of the Chah Jam kavir extend in the distance between the south mountains (Hashtgah) and the mentioned kavir. Is there any relation between the Hashtgah mountains and the formation of sand hills extended in the distance between that mountain and the Chah Jam kavir? (figure 1). If yes, how? What has caused the formation of hills in the distance of <1 km away from the mountain, while as it has been shown in the horizontal slices of the hills, they have never crossed the road.

To find answers to the mentioned questions, the factors affecting the progression of sand hills with be surveyed based on the basis of observations-

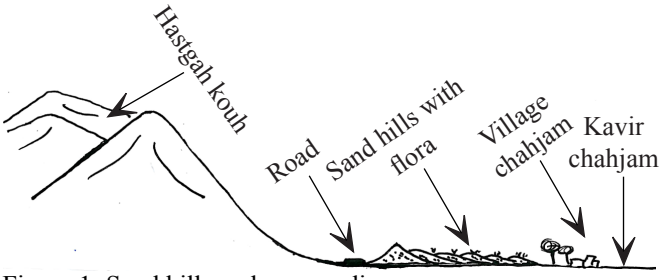

Figure 1: Sand hills and surroundings

a. Presence of an expanse and even surfaces like playas, plains, kavirs, Dagh, etc.) This expanse is important from two perspectives: one from the perspective of production of sands and drift able materials, and the other, formation of suitable bed for the materials drifted
b. Temperature of the playa surface should be so much to prevent materials from sticking together and to present their drifting and carrying.
c. Existence of wind, dominant wind, and necessary energy.
d. The amount of sunlight and the length of the illumination time.
e. The light wind from mountain toward land and from land to mountain,
f. The annual rate of rain, time dispersion of rain, and the kind of rain.
g. Heights exposed to playas and the smooth surfaces.
i. Temperature and its difference in the mountain peaks and playa surfaces.
j. Slope and the degree of height slopes exposed to smooth surfaces.
k. Type and the color of materials forming smooth surfaces and the surfaces of foothills.
l. Size, weight and density of material.
m. Topography of the surfaces between playas and the heights.
n. Existence or non existence of vegetation.

Considering the field study observations, the roles of the mentioned factors effective in the formation of hills, will be

discussed in detail

5.1. Plains, kavirs and flood ways

These are the sources of the material for the nearby sand hills, like the south hills of chah Jam, East hills of Tabagheh kavir, south hills of salt kavir in North Kashan.

5.2. Establishing zones of sand hills over the hillsides

These zones on the hillsides or in certain distances away from the heights indicate the relationship between the heights exposed to plains, playas and their places for establishment. Instances are hills on the East of Lut in relation to sistan mountainsides, Spakeh hills in the south of Jazmorian in relation to the Makran mountain and the hills mentioned in number 1 which are located in a certain distance from the mountain sides.

5.3. Slope of the hillsides, the areas enclosed and the even surfaces

The slower the slope the easier the progression of sands is. On the East of Tabagheh kavir where the wind blows horizontally over the process of Posht badam mountains, wherever the slope of the front mountains is low, the sand moves further as far as the mountain peaks and even it is drifted to the valleys behind them, continuing farther toward the following hills. Field studies have shown that the slow slope of between 5-10% caused the forward movement of the sands, while the next mountain with a slope of about 15-25% could well restrict the movement of sands toward the East (figure 2 and 3).
It seems that the establishment of the hills on the south of Chah Jam also followed the same condition.

5.4. The rate of moisture on the surface of plains and playas

Considering the point that fundamental sources of sands are the plains and playas. Moisture, wet days, amount of rain, and types of rain are the factors that determine how much sand is drifted from these surfaces annually. The more moisture of the soil because of rain, the later will be the suitable time for drifting power of the wind, which causes the low volume of the produced sand.(Field observations in chopanan area in September and October, This condition is specially more important in areas covered with more dust).

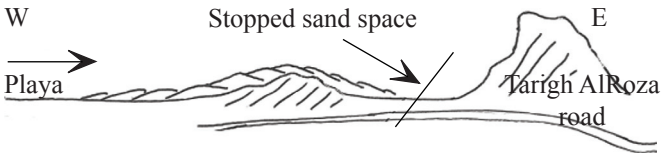

Figure 2: Sand hills on the East of Tabagheh kavir and the coverage of the hillsides by the sand, or on the East of Eshgh abad plain, the sand hills have stopped at a considerable distance from the Ozbak mountain. It seems that the high altitude of Ozbak koh has not only prevented progression of sands toward foothills, but also made their establishment and contraction at the mentioned distance.

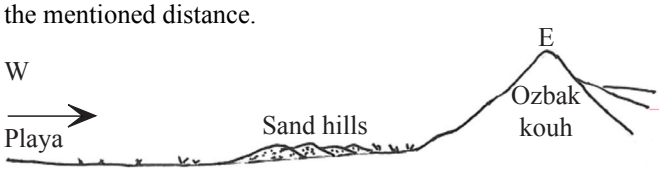

Figure 3: Establishment of sand hills on the Eshgh abad plain at the foot of Ozbak kuh.

5.5. Direction and speed of the dominant wind

The extension of the sand hills and the rail marks on the surface of these hills show the direction of the dominant wind which is in relation to the direction of the mountains, because if wind does not blow vertically over the mountains, there will be no sand hills along the mountains. As it was mentioned before, the speed of the dominant wind which provides energy for the wind is the main factor in drifting, carrying and forming hills. If these winds enjoy the speed of less than the minimum rate of 4 m s^{-1}, it cannot play its role effectively.

5.6. The size and the weight of the material

The size and the weight of the material are also responsible to form sand hill. This is in relation to energy and the limitation of the wind power, because wind chooses and carries the particles depending on its own energy. The particles that can be carried and replaced by wind are presented in the following table 1.
As the table shows, wind cannot move the particles with diameters more than 10 millimeters. Thus the smallest particles are drifted by wind, and sceneries are made which are called pebble plains.

Table 1: Replacement of particles depending on their diameters

Sl no	Diameter (mm)	Type of the wind	Remarks
1	0-2	Show and restricted	
2	2-0.5	Rolled	
3	0.5-0.1	Jumped	
4	0.1-0.09	Temporarily suspended	Particles are moved to the height of 10 m above the earth
5	0.09-0.01	Permanently suspended	Particles moved to 1000 m and replaced 100s of km away

5.7. *Topography of the sand hill beds*

Surveying the pictures taken from the sand areas and observation of these places from above shows the topography of

bed over which the sand hills are formed. Eg. the East of Lut, the south of Mesr, the south of Jazmorian etc. The replacement of sand does not make even surfaces along the horizon, and more unevenness in the sand bed, slower the movement and progression of the sand will be, and the topography is not only an effective element on the contraction of sands, but also affects its progression speed as well.

5.8. Vegetation

Although vegetation is one of the strategies for establishment of running sands, this itself challenges the production of sand, its drifting and carrying. With studies conducted on sand hills, and the points mentioned so far, following issues deserve considerations:

a. Establishment of sand hills is not haphazard and accidental, but it occurs because of many influencing factors.

b. There are relations between the sand establishment of sand masses and other factors that make it possible.

c. Studies have shown that the most effective factor is the relation between the lower areas and the height of mountains. This causes considerable temperature gradients, which means the more difference between the mentioned places, the more temperature gradient will be produced which in turn will affect the sand drifting.

Considering the role of temperature gradients over the heights exposed to playas, and even and lower lands and that it is the mountains that are the producers of temperature differences. It could be concluded that while wind is effective in making sand hills, but the mountain conditions are more effective in not only the establishment of sand hills, but in their movements. Generally, the effective conditions are as follows:

a. Regarding topographical slope of the mountain sides as it was mentioned before, less the slope, more the progression of sands will be (like the East of Tabaghah kavir).

b. Unevenness of the mountain sides, exposure of sands, and unevenness on the surfaces are among the factors that reduce the speed of sand progression. When the surface is even, with even a high attitude, sands accumulate to the time the slope does not destroy the balance of sands (like chopanan area in the south of Jandagh).

c. The height of the mountain, the more the difference between the altitude of mountains and that of the playa surfaces, the further the sand gets established. Actually their progressions stop as they meet the mountains but move along the curves of the mountains imitating the same curves.

6. What are the effective factors?

Why are the hills established in further distances, when the mountain is taller? What is the effect of the altitude on the progression of sands? To answer these questions two hypotheses are proposed.

a. The considerable altitude difference between playas and mountains produces temperature difference between the two zones, which makes a high pressure zone over the mountains. The stronger is this pressure, the less the speed of sand progression. This hypothesis is confirmed in the investigated places. Since there is always an air current from high pressure to the low pressure area. This causes the movement of sand hills from the surface of playas to the mountains, and when they meet this air current they stop and get fixated. Actually the meeting point of these two forces causes the establishment of sands (figure 4).

An example of this phenomenon is the sand hills in the south of Chah Jam. The difference between the height of playa and

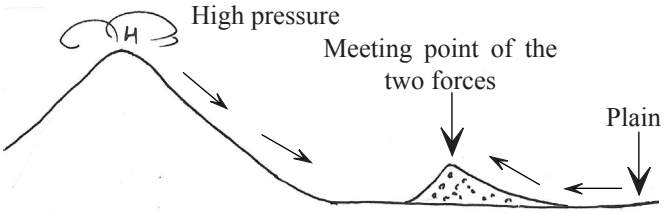

Figure 4: the meeting point of two high pressure forces of mountains and low pressure forces of plains

the highest point of Hashtgah mountain is a little more than 900 m. Since the mean temperature gradient is about 0.62, the temperature difference is something around 5.58 ^{0}C. This rate will increase at night and in cold seasons. Thus the cold air current which is heavy moves down toward the lower areas of the heights. This not only prevents the progression of sand toward heights, but also pushes the sand masses back to the plains. This is the reason why the sand hills distances from the heights of Hashtgah has remained stable (twelve years of field observations) in a way they have never crossed the road built along them and have always kept their distance from the road.

High pressure current moving down the mountains attempts to gather the small and the lose particles and pour them over the sand hills while crossing the high slope hillsides and inverted pillars at the foot of the mountains. This is the reason for the change in the color of the foothills exposed to mountains and those exposed to the playas. This change in color is caused because of the presence of the minerals like Biatit in the currents coming from hillside and inverted pillars to plains, while lighter colors can be observed in hillsides exposed to playas because of the presence of particles like Gips, plaster, salt and argil.

In the hills of east, south, and south-west of Mesr, the difference in color is not much evident but particles differ in nature.

b. Winds hitting the heights in very high altitudes with the dominant winds and their diversions to the even places and those in areas near the surface of the land prevent sands

from progressing toward mountains.

This process can be confirmed as well, because when dominant winds meet the heights they should either ascend or get diverted. Since, under such a condition, because of difference in the altitude, and temperature makes a high pressure center over the heights, it is very improbable for the air currents to ascend. On the other hand, the breeze from mountains which blows in this area, affects the wind current and converts and engraves it, then directs it to the plain, so that it could not only prevent sand hills from progression, but could also push them back and, sometimes even changes the morphology of wind back fronts and changes them to wind pro fronts (figure 5).

Considering the mentioned issues, and field observations, there

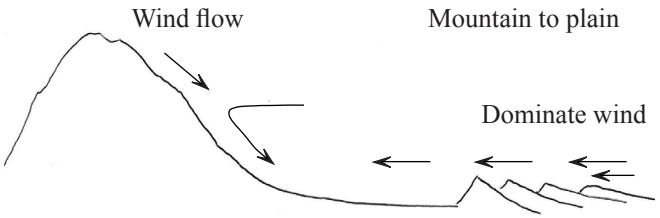

Figure 5: diversion and activation of the dominate wind according to the second hypothesis playa

is always an open space between sand hills and the heights (mountains) which should be paid attention to when data gathering, data processing, and policy making (picture six) and in any type of policy making it should be kept in mind that constructions in these fields causes decrease the speed of wind currents from mountains toward hills, as a result sands move faster toward mountains and endanger constructions (figure 6 and 7).

From the geo morphological perspective the hills toward mountains not only are higher than those toward playas which shows itself as air currents blowing from mountains toward plains, but also they are steeper when they are toward mountains than

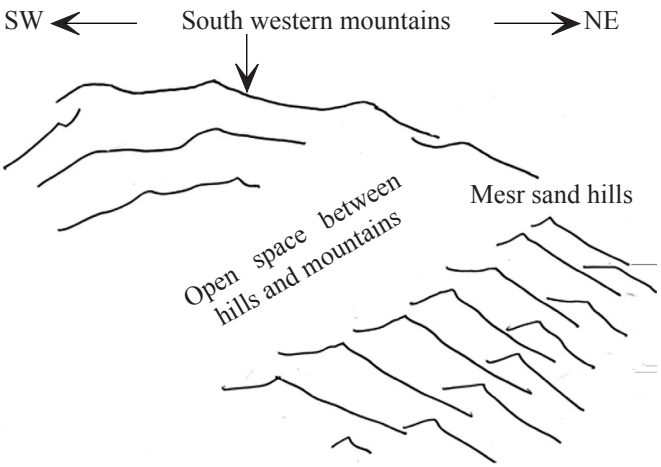

Figure 6: hills around Mesr and open spaces between hills

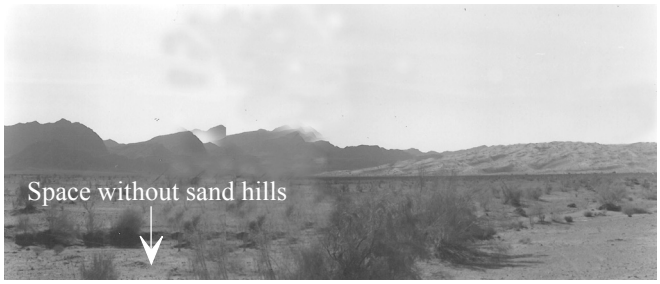

Figure 7: Sand hills in the South of an Mesrian village and the south altitudes and on the in between lands

when they are toward Playas, which shows the direction of dominant wind.

7. Conclusion

It can be stated that sand hills do not appear anywhere but only at the margins of Playas, plains, and even areas and their presence depends on

a. The difference in the altitude between the highest mountains exposed to nearby lower area more this difference, more the distance the hills have from the mountains.

b. Typographic slope % at the heights. More this degree, more the distance of hills is from the mountains

c. Temperature difference in centigrade between the heights and mountains or temperature gradients. More this difference, more the distance is.

d. Wind speed although is an effective factor in moving materials, it alone cannot have any role in the establishment of hills.

e. More this unevenness quotient, less the possibility of hills progression is. This depends on the topography of the bed.

f. Vegetation (quotient) that can facilitate sand progression or make it confront an obstacle.

g. Moisture is one of the very important elements that can be expressed as the moisture of air and moisture of sand.

8. Suggestions

While there is a need to recognize the behavior of running sand in different parts of the country, especially in the central Iran Plateau, it is suggested that this article may be helpful for policy makers because the behavior of sands cannot be scientifically determined unless there is a quantitative measure.

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