Shiraz University

Iran Agricultural Research (2023) 41(2)147-157

Research Article

Mineralogy assemblage of sand dunes in Khuzestan Province, Iran

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DOI: 10.22099/iar.2023.43750.1491

ARTICLE INFO

***Article history*:**

Received **11 May 2022**
Accepted **3 August 2023**
Available online **3 August 2023**

***Keywords*:**

Arid
Dust
Mineral
Sand dunes
X-ray diffraction

ABSTRACT- Sand dunes cover more than half a million hectares of Khuzestan Province in Iran. These areas are a serious threat to agricultural lands, buildings, and industrial facilities. Knowing the characteristics of these lands helps a lot to manage and control this threat. This research was done to determine the characteristics of sand dunes of Khuzestan Province and their management. The results showed that the dynamic characteristics of sand dunes, such as salinity, are different depending on the location and direction of the prevailing wind. However, the organic carbon, cation exchange capacity, and acidity (pH) were similar in all regions. Soluble K was inversely related to salinity. In the western regions, carbonates (lime and dolomite) along with quartz, kaolinite, chlorite, and illite were the dominant minerals, and smectite, palygorskite, and vermiculite were in the next order. The southeastern parts had a similar composition, but the proportion of minerals was different based on the location, especially for polygorskite. The proportion of smectite, polygorskite, and sepiolite minerals was high in the direction of prevailing winds, but their amount decreased in the inner parts. Sepiolite was observed only in the southeastern regions, which was related to the origin of gypsum soils in the neighborhood areas. A similar composition of these minerals and their proportion was also seen in the deeper parts. The similarity of the sand dunes minerals shows that they have the same origin and their similarity with the composition of soil minerals in the plains of Khuzestan indicating that these sands were formed from the wind erosion of the plain during different dry periods.

INTRODUCTION

The world's natural deserts, with an area of approximately 40 million square kilometers, are the largest ecosystems in the world (Hassanizade and Jafari. 2021). These deserts, which are constantly growing and expanding, have become one of the great problems of humans.

Iran is located in the global arid belt and 64.5% of its area is affected by dry and arid climatic conditions with rainfall of less than 250 mm (Abbasi et al. 2012). Of the country's total area, about 12 million hectares of its lands are deserts and sand dunes scattered in different provinces. Meanwhile, Khuzestan Province, with 1.27 million hectares of desert, is considered one of the most vulnerable provinces in the country, and over 218,000 hectares are covered with sand hills and sand dunes (Abbasi et al. 2012). These sand dunes are active and pose a serious threat to farms, buildings, facilities, etc. Sand dunes are located in the southeast and west of Khuzestan Province (Anonymous, 2018) and expansion of sand dunes continues. Parts of these sand dunes are either active hills due to deforestation or no stabilization, which move due to some wind storms (Abdoli and Jafari, 2018). The origin of these sand dunes has not been studied yet. It has been reported that these sand dunes are related to some geological formations such as Lahbari after the removal of the cementation agent (Jafari et al. 2013). However, it seems that the important source of these sand hills originated from the plain soil wind erosion that removed the fine particles and released coarse particles.

Understanding the characteristics of these sand dunes can help curb or reduce the environmental impact of this major threat. Part of this knowledge can be to know the mineral components and minerals in it. Due to the small amount of organic matter, it can be acknowledged that almost all the materials of sand dunes are minerals. In fact, more than 99.6% of the soil components of arid areas are composed of minerals that the identification of their minerals, especially in the silicate section, can help to determine the origin of soils (Azoogh et al. 2018; Wang et al. 2006; Zhang et al. 2003). In addition to the minerals inherited from the sand dunes, it has been reported that some minerals are added to the sand dunes after stabilization through dust storms, which mostly accumulate on the soil surface (Hassanizade and Jafari, 2021).

Studies have shown that the source of dust in Khuzestan Province is dust storms that are flowing in two main directions. One of the routes is northwest-southeast of Khuzestan Province, which is located in northwestern Iraq and eastern Syria. This route starts in the west of Iran and ends in the same region. The second route is the south-north route that starts from the southern shores of the Persian Gulf and reaches the west of Iran through a south-north route (Hassanizade and Jafari, 2021). Large amounts of dust enter Iran through these desert storms, some of which originate from the east bank of the Euphrates and the west of the Tigris and the deserts east and southeast of Saudi Arabia (Darvishi Blorani et al. 2012). These dust mineral particles are different mixtures of different minerals that have different properties from each other (Zhang et al. 2003). Due to the transfer of these particles to very long distances, it leads to a change in some of the characteristics of the soil at the place of deposition (Effati et al. 2012; Menendez et al. 2007). The composition of these substances is very different. For example, the elemental ratio between aluminum, iron, magnesium, and silicon has been considered to distinguish Asian dust from other areas (Zang et al. 2003). Also, the results of chemical analysis of atmospheric dust samples collected from different parts of the world showed that the main component of dust is 55-95% of silicates with CaO, K2O, MgO, Al2O3, and Fe2O3 (Zang et al. 2003). However, it has been reported that in arid and semi-arid regions, minerals such as palygorskite, smectite, chlorite, illite, kaolinite, vermiculite, quartz, calcite, and dolomite are the predominant clay minerals (Azoogh et al. 2018). Effati et al. (2012) in the study of dust particle minerals showed that the dominant minerals in Khuzestan Province, Hooral-Azim wetland area, are more than carbonates, silicates, and evaporative minerals and of course a small amount of other clay minerals. Carbonate minerals form a significant part of minerals in arid soils. These minerals affect many properties of soils, including the regulation of pH, and the effect on the uptake of organic pollutants, or their deposition (Jafari, 2019).

Different silicate minerals have been identified in the soils of Khuzestan which are different depending on the region and soil formation conditions. Also, the type of minerals is different in different parts of the soil. Jafari et al., (2020) in the study of loess soils showed that the silt component is predominant in these soils and is composed mostly of carbonates, gypsum, quartz, and palygorskite, which part of the gypsum has been washed in leaching. There were also other minerals such as illite, chlorite, and kaolinite in the silicate clay section (Jafari and Nadian, 2012).

Zaker-Moshfegh and Jafari (2016) showed that there is a relative diversity of clay minerals in the sediments of three important rivers in Khuzestan Province. What has made these differences significant is the source of the sediments that have been transported to the plains by rivers. The origin of sediments is also due to the weathering of the parent rock, which is different upstream of rivers. They reported the effects of soil-forming factors due to young soils and dry conditions. The identified minerals were chlorite, illite, kaolinite, polygorskite, quartz, smectite, and vermiculite. Lovineh et al. (2015) showed that the smectite was significant in Abadan's soils. They attributed the formation of this mineral to poor drainage conditions, high pH, and magnesium. Also, they attributed part of the origin of these minerals to their transfer due to diffusion in river water and transfer to the end sections due to the mechanical force of water flow. In general, among the five soil-forming factors in arid regions, the formation of soils was reported to be influenced mainly by topography and parent material (Jafari and Nadian 2012). Also, the results of studies on the minerals forming the sand dunes by Azoogh et al. (2018), showed that there are minerals of illite, chlorite, smectite, and vermiculite in Shush's sand dunes. Palygorskite was also observed in some areas, especially in the surface layer. Changes in the type and intensity of minerals have been reported in different regions that had stabilized at different times (Darvishi Boloorani et al. 2012; Azoogh et al. 2018).

Although a large area of the Khuzestan Province is covered by these sand dunes, few mineralogical studies have been done on them. Examination of their mineralogy can help determine the origin as well as the degree of homogeneity of these sand dunes. Therefore, the aim of this study was to investigate the diversity and ratio of silicate and non-silicate minerals in the sand dunes of Khuzestan Province and to determine its degree of homogeneity with plain soils.

MATERIALS AND METHODS

Study Area

Khuzestan Province is located in southwestern Iran, which has a dry climate (Azoogh et al., 2018). This province has been composed of mountainous plains in the northern part and flat plains in the southern part. Sand dunes have spread in two regions of the province, both parts of that parts have been stabilized by petroleum mulching and biological method during the years 1961-1968 (Azoogh et al., 2018). The average annual rainfall in the western regions is 155 mm and in the southeast is approximately 135 mm. Most of these hills continue in the western region between Ahvaz to the Iraqi border and along the border to the city of Shush (Hassanizade and Jafari. 2021).

In the western part of the province, five regions were sampled in the current study including North Gamboieh (NG), South Gamboieh (SG), Omodebes (OD), Albaji (AB), and Chazabeh (CH). These areas extend from 5 km west of Ahwaz to the Iraqi border. The difference in height between these hills varies from 1.5 to 6 meters.

In the southeastern region, from 15 km east of Omidieh city to east of Ramshir, samples were taken in four different areas. Samples included Omidiyeh (OM), Sar-e-Asyab (SA), Seyed-Yebor (SY) and Sovireh (SV).

The surface layer (0-10 cm depth) and the subsurface (10-60 cm) were sampled at all locations. The geographical coordinates of the study points are shown in Fig. 1.

For sampling, first, the distribution of sand dunes was examined using satellite images, Maps of the Geological Survey was prepared, and then by field visit, the location of points for sampling was determined and performed with a handheld GPS device in the field (Table 1). The predominant vegetation of these areas is the forests of prosopis, tamarisk, and calligonum planted for the biological stabilization of these sand dunes, which are mixed with other species such as melon and cerium that have been grown in wild. Part of the moisture requirement of these plants is provided through evaporation of water and surface condensation in the sands of the Karkheh and Jarahi rivers (Azoogh et al., 2018).

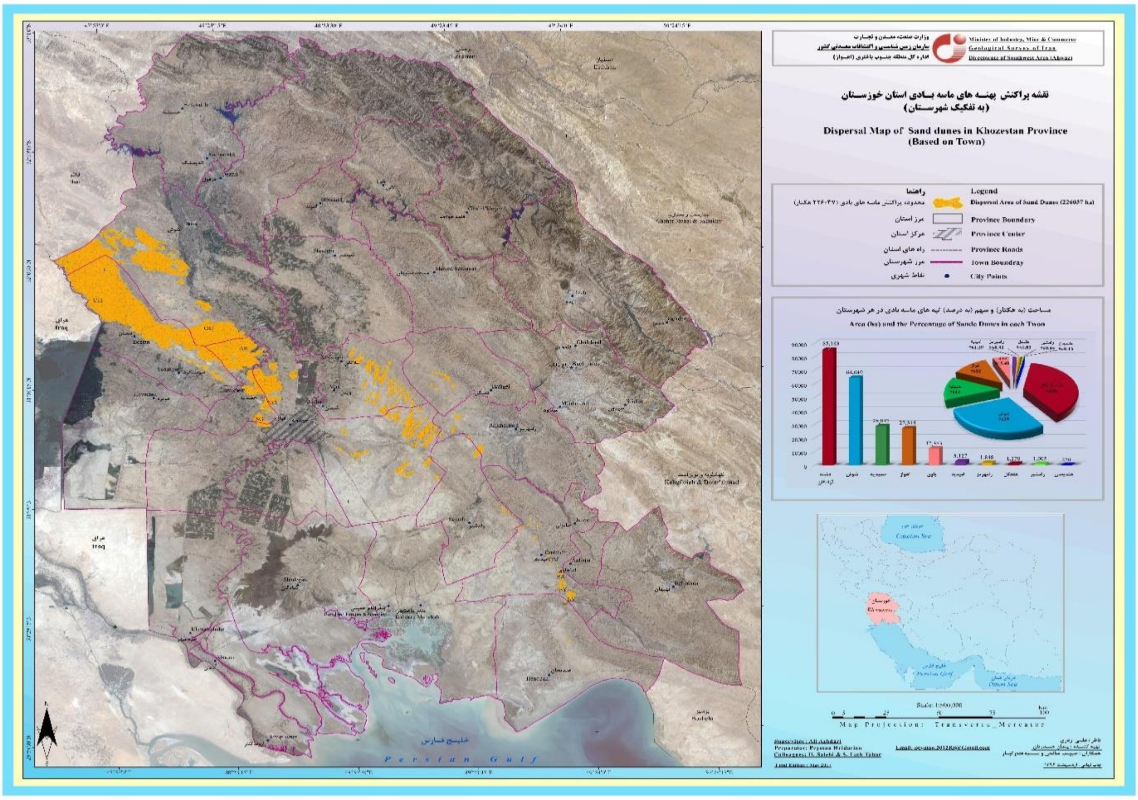

Fig 1. The location of the study area in Iran and sampling sites in the sand dunes of Khuzestan Province (yellow)

Physicochemical Properties and Mineralogy

Physicochemical properties of soils such as electrical conductivity were measured in saturated extract (US Salinity Laboratory Staff, 1954), organic carbon (OC) by heat-free oxidation (Walkley et al., 1934), and soil texture by hydrometer (Gee and Bouder, 1968). Cation exchange capacity (CEC) was measured using 1 M sodium acetate at pH 8.2 (Chapman, 1965). The calcium carbonate equivalent (CCE) was measured by digestion with hydrochloric acid (Nelson, 1982). Carbonates in untreated samples were also identified using X-ray diffraction.

Minerals in bulk samples were studied by the untreated (powder) method. Also, clay minerals in the samples were identified by X-ray after treatment of the removal of solutes and cementitious agents. In the treated samples, after removing the solute and cementitious agents such as gypsum and carbonates, the particles were separated from each other (Kittrick and Hope, 1963). The clay was then separated from the silt and sand components by the suspension. The separated clays were saturated with Mg and K. The K-saturated clay was heated at 550 °C for 2 h. X-ray diffraction (XRD) patterns were prepared using an X-ray diffraction device (Siemens model D-500) with CuKα source with a wavelength of 1.54 Å, at a voltage of 35 kV and a current of 40 mA for all samples. The resulting curves were compared with standard interpretation curves and available minerals were identified. Radiography was performed at 2θ angles between 4-32 degrees (Hassanizade and Jafari, 2021).

Clay minerals were identified based on the interpretation of the peaks in the diffract grams. To reduce the number of images and also to avoid repetition, some peaks were not shown. Then, the changes of different minerals identified in different study areas were compared with each other, and the results were analyzed and studied35 kV and a current of 40 mA for all samples.

In relation to the conditions of the region and various factors affecting the resulting changes, the results were finally compared with the results of the mineralogy of soils adjacent to the plain.

RESULTS and DISCUSSION

Western Region

The range of changes in some physicochemical properties of soil samples in stabilized sand dunes in different parts of the western region is shown in Table 1. As shown, salinity values vary from 0.06 to 4.5 dS m^{-1}. Although the leaching potential is very high in sandy soils, however, due to low rainfall on the one hand and the continuous increase of high salinity dust on the other hand, salinity in some parts of the region is high.

The pH is a buffer in the range of calcareous soils. The values of CEC, despite the repetition of the experiment, are higher than expected for sandy soils, which may be due to the dissolution of sodium silicates in the sandy part of the soil and making errors (Hassanizade and Jafari, 2021). The amount of soluble K was also too high, which could be related to the release of minerals and lack of plant uptake. All samples contain very large amounts of calcium carbonate and dolomite, which was in the range of 28-39%. Their organic carbon content was also very low. The texture of all soils was sandy; however, the surface layer was more stable in dry conditions due to the presence of more clay and adhesives.

Table 1. Some physicochemical properties of sand dunes in Khuzestan Province in western (A), and in the southeastern (B) sites

A

Site	EC dS m^{-1}	pH	CEC $_{C}mol_{+}$ Kg^{-1}	K* mg Kg^{-1}	CCE (%)	OC (%)	C (%)	Si (%)	S (%)	Text.
SG	0.7-2.4	8.0-8.6	3.7-5.9	2.8-10.3	34-39	0.03-0.09	7.3-16.1	5-27	36-80	S
NG	0.06-1.1	8.0-8.7	3.5-4.5	1.9-14.9	34-39	0.03-0.09	2.5-12.5	1-6	78-95	S
OD	0.4-2.2	7.7-8.5	3.5-4.7	2.6-9.7	28-39	0.07-0.01	2.5-8.8	2-9	79-95	S
AB	0.2-0.9	7.9-8.8	3.2-3.8	4.3-26.2	35-39	0.03-0.07	2.5-8.8	1-5	90-95	S
CH	0.4-4.5	8.1-8.6	3.5-4.2	2.5-24.2	32-37	0.003-0.04	4.0-11.0	1-17	70-94	S

B

Site	EC dS m^{-1}	pH	CEC $_{C}mol_{+}$ Kg^{-1}	K* mg Kg^{-1}	CCE (%)	OC (%)	C (%)	Si (%)	S (%)	Text.
SV	1.7-2.6	8.1-8.5	1.7-2.9	2.1-8.0	32-37	0.04-0.08	7-16	5-18	38-84	S
SY	1.1-1.3	8.1-8.4	2.5-3.2	1.9-12.9	35-39	0.04-0.09	3-11	2-6	87-95	S
UM	1.2-2.5	7.9-8.3	2.1-2.5	2.6-9.7	29-41	0.07-0.1	4-9	2-9	79-95	S
SA	1.0-2.9	7.6-8.8	1.2-2.8	4.3-21.2	37-39	0.04-0.1	5-10	0-5	89-91	S

*Potassium was measured in soil solution. EC= electrical conductivity, CEC = cation exchange capacity, CCE = calcium carbonate equivalent, OC = organic carbon,, C=clay. Si=silt, S=sand, Text. = texture. Sites: SG=south Gamboieh, NG=North Gamboieh, OD= Omodebes, AB= Albaje, CH= Chazabeh, SV=Sovireh, SY=Seyed-Yebor, UM= Umihieh, SA=Sar-e-Asyab.

Mineralogy

Mineralogical results of these areas showed that non-silicate minerals including calcite and dolomite minerals are predominant minerals that are similar to the composition of adjacent soils in the area. Quartz, kaolinite, chlorite, illite, smectite, palygorskite, and vermiculite minerals are also other dominant minerals in the western part of the province.

According to the XRD curves, the southern Gamboieh area in the silicate component contained quartz, palygorskite, chlorite, smectite, kaolinite, and illite minerals (Fig. 2b). Palygorskite was observed in the untreated sample (Fig. 2a) while it was not observed in the treated sample (Fig. 2b). This trend could be related to the removal of this mineral due to the removal of cementitious agents during the purification process and treatment steps (Singer and Galan, 2011). Due to the impossibility of forming this mineral in situ, its transfer and deposition in parts of this area due to the transfer of materials by wind is expected.

The elimination of cementitious agents and increase of Mg in the treatment of Mg+ET has led to the clarity of chlorite peak compared to untreated samples. The presence of this mineral in a significant amount in the treated samples indicates the presence of parent materials containing this mineral, which can be justified due to the predominance of clay in arid and semi-arid areas. In the treated and untreated samples, small amounts of smectite were observed. It is believed that this mineral has also been added to the soils of this region due to wind transfer.

The diversity and semi-quantitative estimation of minerals observed in this area was higher than the untreated northern samples, which could be due to the higher density of vegetation and the subsequent entrapment of more particles of this mineral by wind storms. Also, it is likely the dust has been transferred to these lands. In all samples of Gamboieh in both northern and southern parts, the presence of 7.1 Å peaks in different treatments in this area indicates the presence of kaolinite mineral. It is not possible to form kaolinite in the lands of Khuzestan due to the current climatic conditions, hoever, it has been reported that this mineral is formed from old parent materials due to the humid climates of the past and has entered these soils (Zaker-Moshfegh and Jafari, 2016).

An important silicate mineral is quartz, which is inherited from the parent material. Quartz was also highly identified in all parts of the region. This mineral could be identified by a peak of 3.34 Å and was not affected by any treatment (Fig. 2b). Therefore, a significant part of these sands is made of quartz. After carbonate minerals (calcite and dolomite), quartz is the second component of the mineral structure of these sand dunes.

In the southern part of the study area, Gamboieh, the increase in peak intensity clearly showed changes in the ratio of silicate minerals (their amount in the sample was based on the peak intensities of XRD patterns) compared to the northern part, but in the mineral diversity in this area, there were no significant changes in both untreated and treated samples compared to the northern part (Fig. 2a and b). In general, the minerals in these sands can be attributed to two different sources: First, some of these minerals have existed in these sands since the beginning of their formation and in other words have been inherited from the parent materials. These minerals are present along the surface to the depth of these sand dunes and their diversity is not significantly different. The second part is the minerals that have been added to the soil for many years during the process of increasing due to dust storms. These minerals are often more abundant in surface samples than in deep samples. Severe dust storms are common in these areas and add a large amount of dust to these soils. These materials are mainly deposited on the surface soil and due to their small size, they change most of the surface soil.

In the study area, the closer area get to the entry point of the prevailing winds, the more sediment is trapped by the wind colliding with rough surfaces. The prevailing winds of this region first enter the southern part of Gamboieh; therefore, it can be concluded that the amount of added materials due to dust in southern Gamboieh is higher than in other areas. The higher intensity of the new clay minerals added in the southern parts is due to the decrease in wind speed and more sediment due to wind impact on rough surfaces. However, in the northern and southern parts of Gamboieh, the type of minerals identified were almost similar.

Minerals added due to dust storms are the most common minerals in arid areas such as palygorskite and smectite, which due to their small size (smectite) or needle crystal (palygorskite) are more transmissible by wind. Therefore, due to the impact of the wind on the rough surface of the earth and as a result of its reduction in speed, dust particles are deposited on the surface of these areas. Due to the fact that the assemblage of the primary minerals of sand hills in all regions was almost the same in the beginning, only the peak intensity of these minerals or in other words the ratio of these minerals in the two northern and southern regions of Gamboieh was different. It can also be stated that soluble salts are also part of the additives due to dust storms that enter these soils.

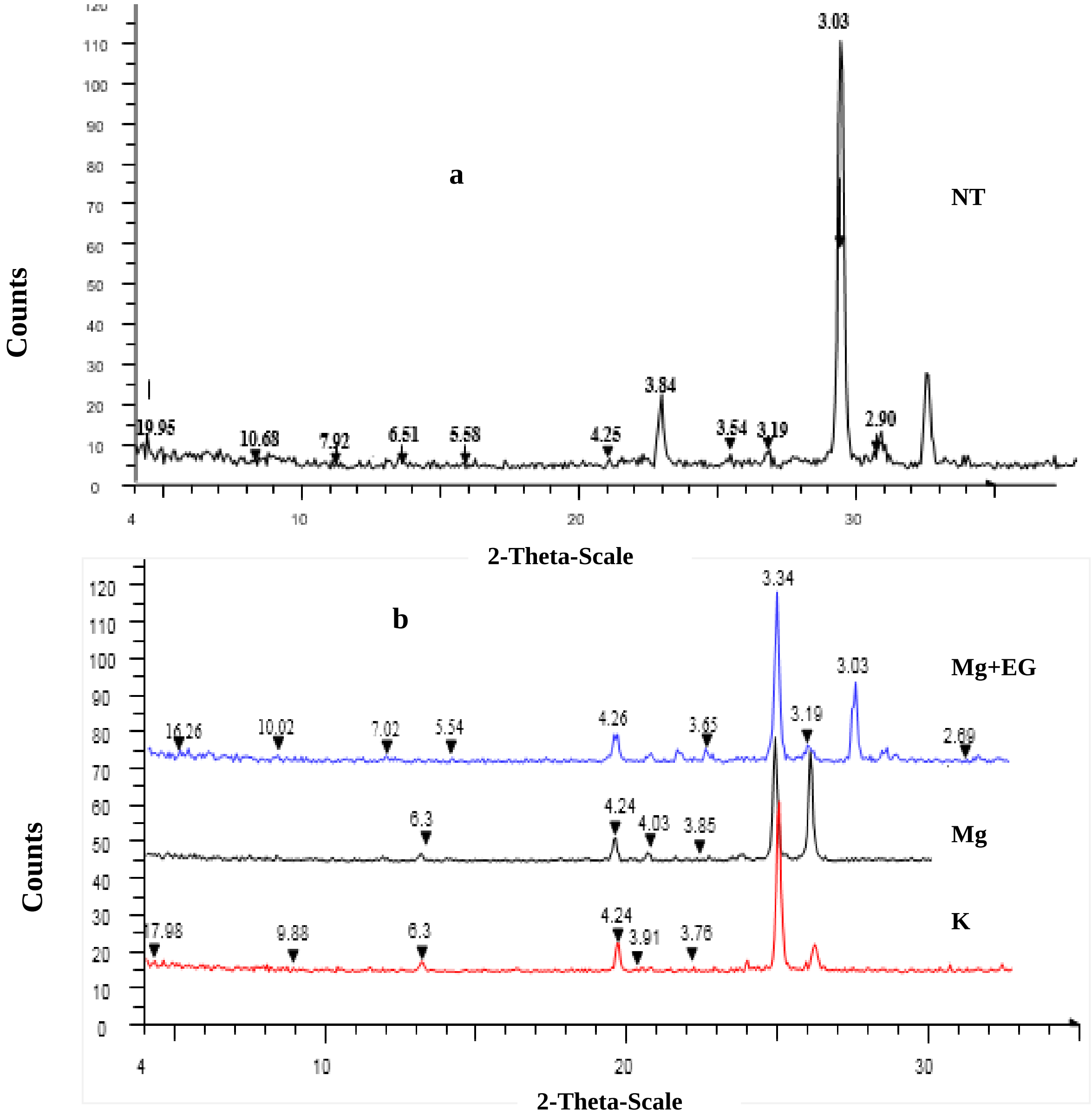

Fig. 2. a) XRD pattern of the no treatment sample of North (NT) Gamboieh site, b) XRD pattern of southern Gamboieh site. (potassium (K), magnesium (Mg) Mg+Etylen Glycol (Mg+EG) treatments

Chazabeh region (Fig. 3a) is also a part of that region where the prevailing westerly winds from Iraq first enter into this part. These winds generally bring a lot of suspended matter from the eastern regions of Iraq from the Euphrates to the Iranian border. With entrance winds to these rough surfaces, it leads to a decrease in wind speed, and most of the suspended matter, especially coarser particles, is deposited.

The most obvious mineral identified in this area was palygorskite clay, which accumulates on the surface due to very little leaching (due to low rainfall) and less transfer to deeper sections. It has been reported that this clay is common in dry areas and is transformed or destroyed by increasing humidity or rainfall (Singer and Galan, 2011). The surface layer of sand had the highest salinity in this area (Table 1). Small amounts of sepiolite minerals were also identified in this area. Peak 1.21 Å in untreated conditions in this area showed the presence of sepiolite which was removed from the XRD patterns in the treated samples. The absence of a peak of this mineral in the treated samples is probably due to the effects of acid treatment on the removal of this mineral from these samples.

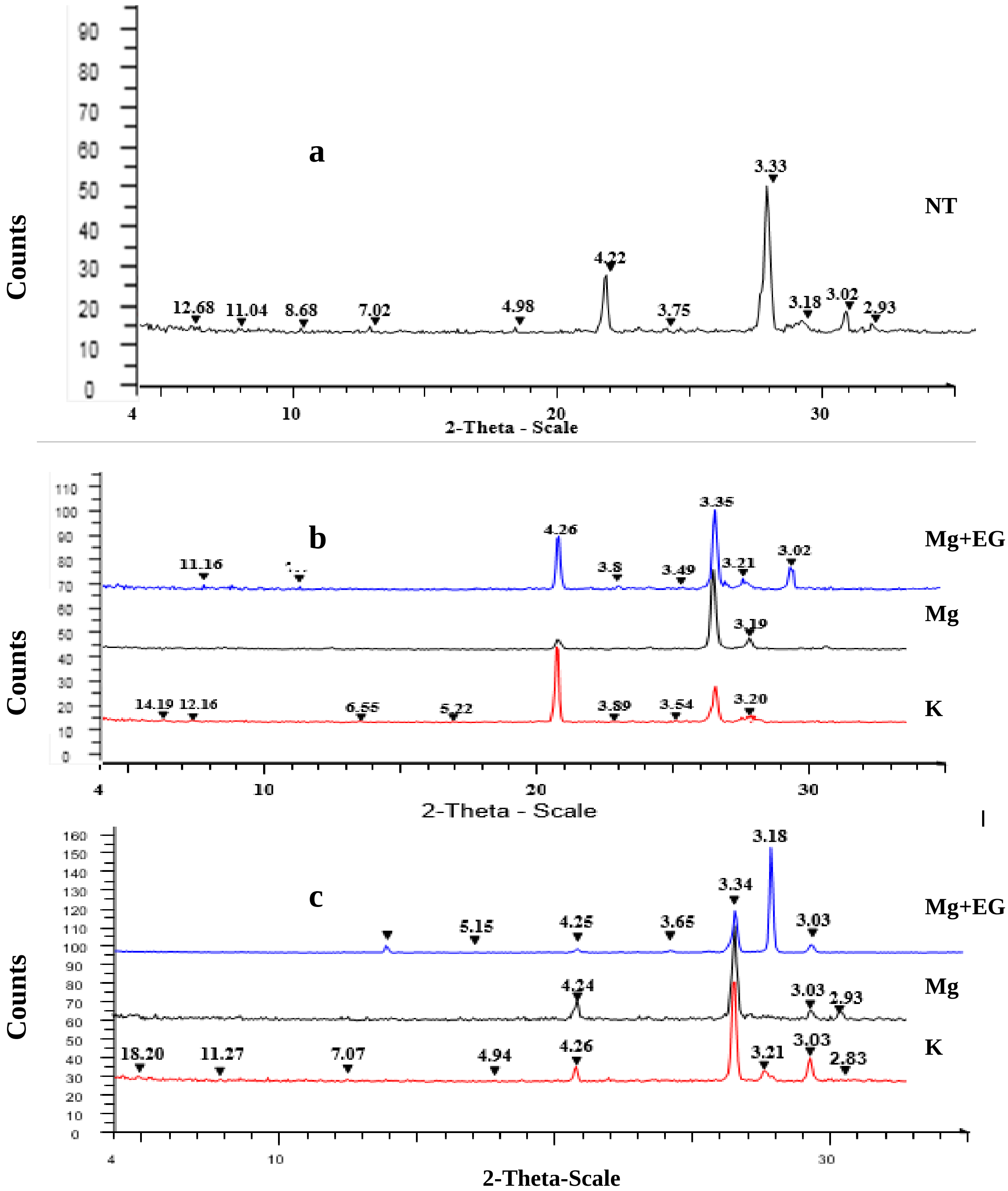

Fig. 3. a) XRD pattern of the no treatment sample of Chazabeh site, b) Omodebes site, c) and Al-Baji site. potassium (K), magnesium (Mg), Mg+Etylen Glycol (Mg+EG).

The Omodebes region is located almost in the center of the western region and at a great distance from the entrance of the prevailing winds from the west and south of the western region to the sand dunes (Fig. 1). The XRD patterns of the Omodebes region showed that the type of minerals present was more similar to the composition of minerals in the south Gamboieh region, but the amount of clay minerals in the fine section such as smectite was less than Gambou. The peaks created in all parts of the region were less intense. Polygorskite mineral has also been removed from the composition of these minerals (Fig. 3b). The low amount of this mineral in this area may be related to the low amount of wind sediments in the lands where this dust exists. This area is mainly composed of quartz, illite, kaolinite, and chlorite minerals.

Al-Baji region is located in the farthest distance from the entrance of the prevailing winds in the western region. In terms of mineral diversity, this region was similar to the three regions of Gamboieh (North and South), and Omodebes. The intensity of peaks in the area was less in the untreated sample, but with the application of treatments, the peak intensity of the samples increased so that the intensity of palygorskite and illite peaks increased (Fig. 3c).

It has been shown that in untreated samples, the presence of large amounts of carbonates in the sample prevents the clarity and consideration of other minerals in XRD (Azoogh et al. 2018; Zaker-Moshfegh and Jafari, 2016). The increase of illite ratio in K treatment occurred more intensely, which indicates that part of the minerals in this location was depleted and with the increase of K in this treatment, the mineral regenerated its structure initially, which led to improved crystal structure and its display in XRD peaks. Of course, this trend was observed with less intensity in other areas (ie, the area of South Gambuieh and Omodebes). The reason for this phenomenon in this area is related to the special conditions of the Omodebes' sandy soils. This area is located in the center of sand dunes and the amount of dust entering this part is less. A small amount of dust has reduced the amount of soluble salts. The low level of solutes entering the region has reduced salinity and thus increased the growth of spring grasses and shrubs in the region. Due to the decrease in salinity, the growth of seasonal plants has increased and K has been removed from the sand structure by plant uptake. Thus, the release of K from these soils may be more than the saline soils of other areas. ́s a resultو, with the addition of K to these samples, the crystal structure of illite's minerals is perfected and its peaks are created with greater intensity. A similar trend for the structural reduction of illite minerals has been suggested by Jafari (2019).

Southeastern Region

Some physicochemical properties of sand dunes in the southeastern region of Khuzestan Province are shown in Table 1-b. The results of this table show that the salinity of these soils is in a lower range (range 2.9 dS m^{-1}) than soils in the western part of the province. These soils are in the range of non-saline soils. The pH of these soils (in the range of 7.5-8.5) has been buffered due to the presence of large amounts of carbonates. More than 40% of all these soils are carbonates, which often contain calcite and dolomite. The texture of these soils is similar to the western sandy region.

Seyed-Yebor Area (SY)

In terms of age of consolidation, this region has a younger age than other areas studied in this part of the sand dunes of Khuzestan (about 30 years). Therefore, its minerals are mainly affected by parent materials and the amount of changes due to secondary processes such as increase due to dust as well as factors such as secondary changes due to leaching and transfer in the soil to a lesser extent. Therefore, in this region, it is expected that the ratio of minerals as well as their type in relation to other minerals will change due to the effects of the origin of the parent material. Fig. 4a shows the XRD patterns of the surface layer of this area. The intensity of the peaks of Palygorskite filaments in the surface layer of sands of this region is low. Due to the state of plows and agricultural lands around them in this area, the amount of material transferred from the surrounding area to this part is less and the intensity of peaks are minerals that can be transferred mainly due to wind and are found to be low in this area.

Sar-e-Asyab Area (SA)

As shown, the type and intensity of peaks in this area are similar to the Seyed-Yebor area, and due to the similarity of conditions in the two areas, the similarity of these two parts was expected. However, in this region, the intensity of illite peaks (10 A) has increased due to K treatment in carbonate-free samples (Fig. 4b). This may be related to the effects of K depletion in some minerals in this area. K depletion has probably taken place in the source soil or in the source rock containing these particles and the application of K treatment to these minerals has led to an increase in the intensity of the peaks of these minerals.

Sovireh Region (SV)

This section is located in the southern part of the southeastern region (Fig. 1). The mineralogical results of this section were similar to the samples of minerals identified in the sand dunes of this region. The results of the three samples showed that in the surface layer, the amount of illite minerals and minerals of polygorskite filaments is higher than other minerals (Fig. 4c). In other words, these two minerals have a higher relative rate among the other minerals observed. Kaolinite minerals and smaller amounts of smectites were also observed in this area. The presence of carbonate group minerals in untreated samples and also quartz minerals in treated samples were clearly observed. Thus, although the composition of the identified minerals is somewhat similar to the minerals of the western region of the province, nevertheless, the amount of filamentous minerals is higher. The reason for this can be attributed to the proximity of this area to the adjacent dust sources that create dust. Thus, in these areas (SV), due to the entry of suspended matter from the wards and adjacent lands to a greater extent and intensity than in the Seyed-Yebaor and Sar-e-Asyab areas, it was able to change the mineralogical composition of this area. As a result, the intensity of filamentary clay minerals in these areas is considerable.

Omidieh Region (OM)

Another part of the southeastern region of the province is the Omidieh region, which is located in the eastern part of Omidieh city. The studied samples showed a relatively similar composition of minerals compared to other regions. However, in this region, the peak intensity of palygorskite was higher than in the Sovireh region, which may be due to an increase in the ratio or greater stability of these minerals at the soil surface. The texture of the surface layer in these areas probably retains more of these filamentous minerals due to the longer time of sediment increase and also the greater amount of dust deposits in this area and the increase of these minerals in this area (Fig. 5). Such results have been stated by Jafari and Nadian (2012) for the northern regions of Khuzestan Province. Zaker-Moshfegh and Jafari (2016) observed a considerable amount of palygorskite minerals in this region. Mehrgan et al. (2017) also pointed out the existence of significant amounts of palygorskite and sepiolite in some parts of these lands (the northern part of this region in the adjacent soils). Gypsum was also attributed to these areas (Abdoli and Jafari 2018). Singer and Galan (2011) showed that gypsum formation can cause palygorskite by removing Ca and increasing the Mg:Ca ratio. The soils of these areas have originated from the parent rocks of the Gachsaran or Aghajari geological formation. It has been reported that these sediments with high gypsum and the possibility of polygorskite formation are important factors in the formation and development of this mineral in this part of the region in Khuzestan Province (Abdoli and Jafari 2018).

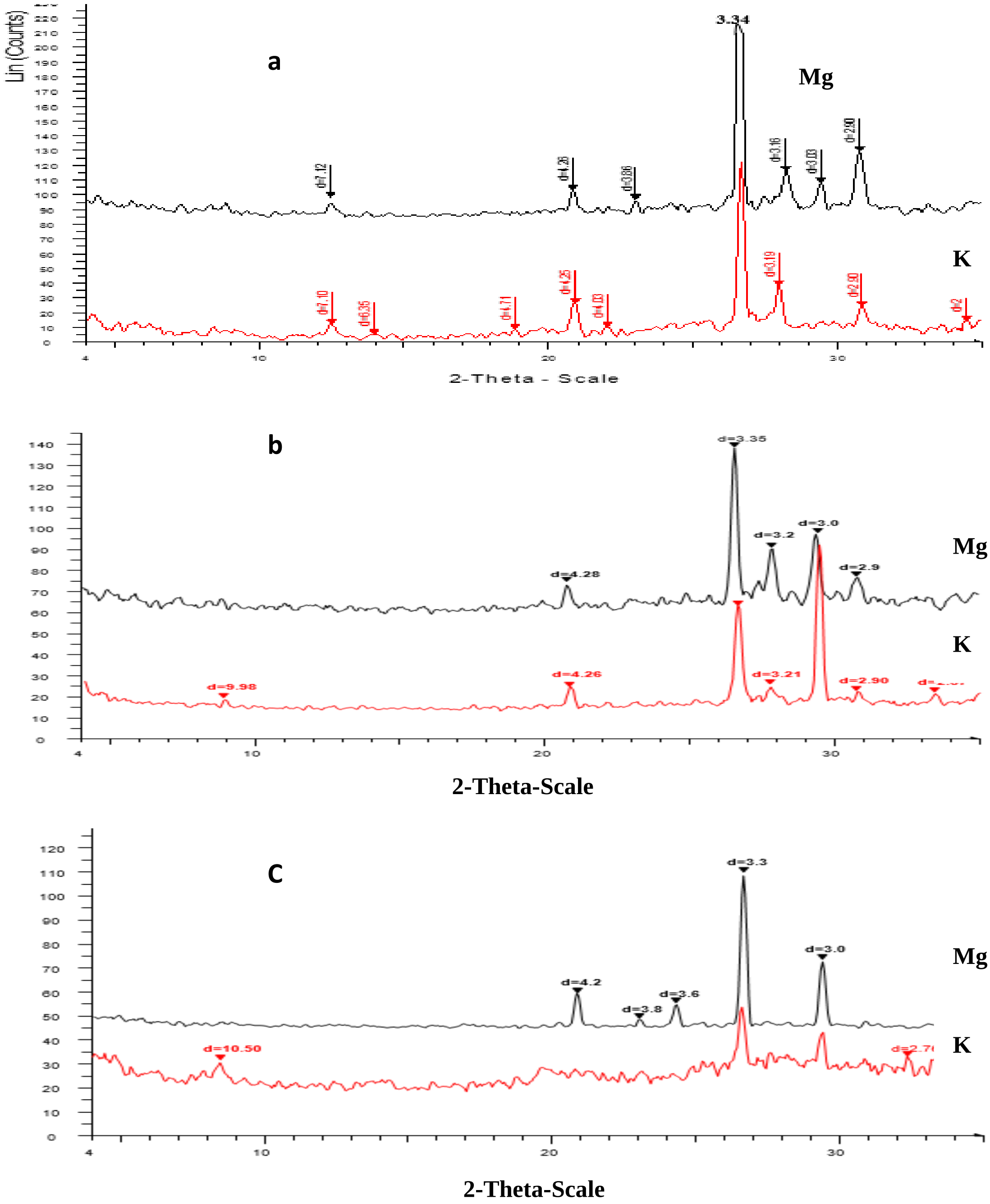

Fig. 4. a) XRD pattern of Syed-Yobor site, b) Sar-e-Asyab, c) and Sovireh site (Magnesium (Mg) and Potassium (K) treatment)

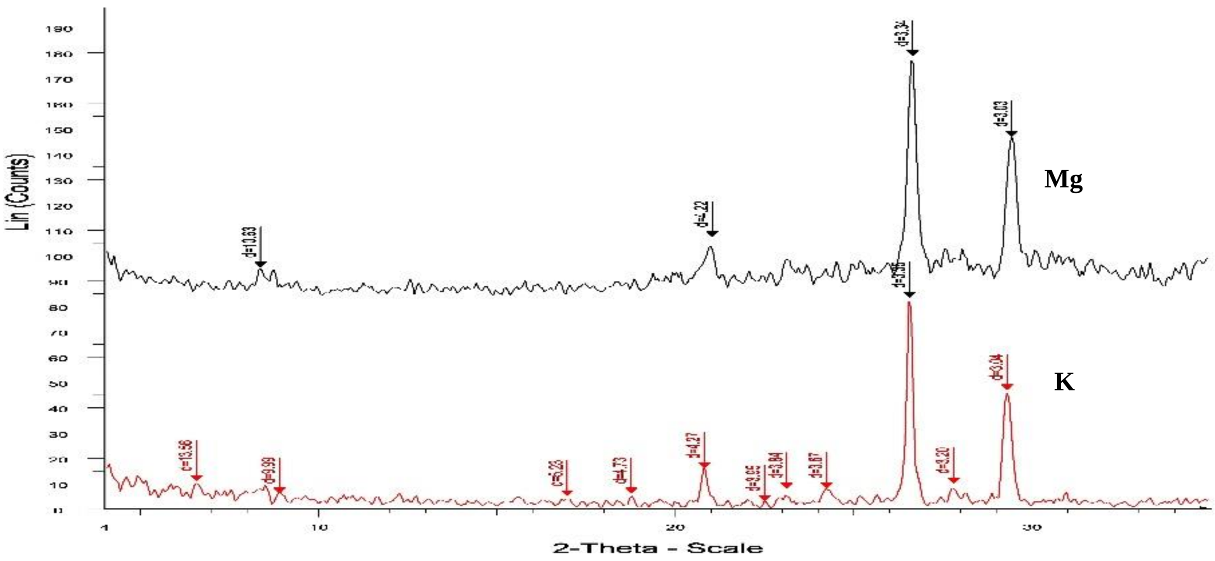

Fig 5. XRD pattern of Omidieh site, magnesium (Mg), and potassium (K) treatment

CONCLUSIONS

The results of this study showed that there was a small amount of soluble solutes in these sand dunes, which according to the relevant measurements could be of the type of chlorides and sulfates. Mineralogical results of the studied areas showed that carbonate minerals are among the most important minerals in these areas. Also, the quartz, kaolinite, and chlorite minerals were the most dominant minerals in all the studied areas, the changes of which were not subject to a special trend, it was considered that they were inherited from the parent materials.

Another mineral that was observed in all areas was illite, which due to some factors, its ratio was reduced in some samples. It seems that the mica mineral has been added to these sands both from the parent material and due to sediments caused by dust storms. In addition to these minerals, there were other minerals that were attributed to current dust storms in the region based on their size and location in the study areas. These minerals, which included smectite, polygorskite, and sepiolite, were abundant at the points of entry of the prevailing winds, and their distance was reduced by moving away from these points of entry. Also, some types of these minerals, for example, the sepiolite mineral, which was observed only in the southeastern regions of the province, had been previously identified in the soils adjacent to these sand dunes. Therefore, the mineralogical composition of these sand dunes was attributed to the parent material as well as sediments caused by dust. The low and high sand dunes on the one hand and the presence of vegetation cover for biological stabilization on the other hand have accelerated the deposition of airborne substances in these sand dunes.

ACKNOWLEDGMENT

Part of the cost of field studies and sampling of this project has been provided by Arvand Khak Azma Company. So many thanks and appreciation. The authors are grateful to Miss. Sara Jafari for preparing the correction of X-ray diffraction peaks.

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تحقیقات کشاورزی ایران (۱۴۰۱) ۴۱(۲)۱۵۷-۱۴۷

مقاله علمی- پژوهشی

ترکیب کانی شناسی تپه های ماسه ای استان خوزستان، ایران

سیروس جعفری* و سمیه حسانی‌زاده

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اطلاعات مقاله

تاریخچه مقاله:

تاریخ دریافت: ۱۴۰۲/۰۲/۲۱

تاریخ پذیرش: ۱۴۰۲/۰۵/۱۲

تاریخ دسترسی: ۱۴۰۲/۰۵/۱۲

واژه‌های کلیدی:

پراش پرتو ایکس

تپه‌های شنی

خشک

کانی

گرد و غبار

چکیده - تپه های ماسه بیش از نیم میلیون هکتار از استان خوزستان در ایران را پوشش می دهد. این مناطق تهدیدی جدی برای اراضی کشاورزی، ساختمانها و تأسیسات صنعتی هستند. شناخت ویژگیهای این مناطق کمک زیادی به مدیریت آنها میکند. این تحقیق به منظور تعیین ویژگی های تپه های ماسه ای استان خوزستان و مدیریت آنها انجام شد. نتایج نشان داد ویژگیهای دینامیک این تپه ها مثل شوری بسته به موقعیت و جهت بادهای غالب متفاوت است. با وجود این، ماده الی، ظرفیت تبادل کاتیونی و پ هاش تقریبا مشابه بودند. پتاسیم محلول با میزان شوری رابطه معکوسی داشت. در نواحی غربی کانی‌های کربناتی کلسیت و دولومیت و سیلیکاتی کوارتز، کائولینیت، کلریت، ایلیت غالب و کانی‌های اسمکتیت، پالی‌گورسکیت و ورمیکولیت در مرتبه بعدی قرار داشتند. بخش‌های جنوب شرقی نیز دارای ترکیب کانی‌های مشابهی بودند ولی میزان نسبی این کانی‌ها بخصوص پالی‌گورسکیت تفاوت داشت. کانی‌های اسمکتیت، پالی‌گورسکیت و سپیولیت در مبادی ورود بادهای غالب، زیاد و در بخش‌های درونی کمتر بودند. سپیولیت فقط در جنوب شرقی مشاهده شد که به منشاء خاک‌های گچی مناطق مجاور مربوط می‌شد.ترکیب مشابهی از این کانی ها و نسبت آنها در قسمت های عمیق تر نیز دیده شد. تشابه کانی‌های تپه‌های ماسه‌ای نشان می‌دهد که منشأ یکسانی دارند و شباهت آنها با ترکیب کانی‌های خاک در دشت‌های خوزستان نشان می‌دهد که این ماسه‌ها از فرسایش بادی دشت در دوره‌های مختلف خشکی به وجود آمده‌اند.