# The soil properties of dust source of south-eastern Ahvaz, Iran

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**Abstract.** The main goal of this study was to explore the physio-chemical soil characteristics in the dust hotspot of south-eastern Ahvaz in the Iranian province Khuzestan. The knowledge about physical and chemical characteristics of soils at the landscape scale is crucial for biological stabilization processes of soil surfaces to prevent or to reduce deflation processes. For this purpose, we collected soil samples in a 2 × 2 km grid and measured physical and chemical properties of the soils in the lab. Then, the erodible fraction (EF) and soil crust factor (SCF) were calculated based on an improved wind erosion model method. The results show that the erodible fraction of the soil classified into high susceptibility classes and SCF have significant variations throughout the study area. The majority of soils in dust source areas has heavy to very heavy texture and suffer from low organic matter, salinity, and alkalinity, which limit the growth of plants and make the prevention of wind erosion difficult.

## 1 Introduction

Sand and dust storms (SDS) play a huge role in Iran and in the surrounding countries of the Middle East [1-3]. Wind erosion is a serious problem in Khuzestan province in southeast of Iran [4]. In 2011, Ahvaz (Khuzestan) was ranked by the WHO as most polluted city in the world because of the occurrence and intensity of dust storms there [4]. Partly they originate from external dust sources in the Arabian Peninsula and Iraq, partly from internal sources in Khuzestan and Ilam provinces [5]. One of the critical SDS sources is the south-eastern Ahvaz area. Special active SDS events often took place here, for example on January 27 and 28, 2017. This event caused power outages and disrupted water supplies and phone lines across nine towns, resulting in the closure of all schools and government offices [6]. People living in South-West Iran are looking for solutions to control and to prevent SDS.

Soil surface properties of dust sources affect the amount, frequency and type of mineral aerosols emitted from them [7]. Physical and chemical soil properties influence both the dust production and the biological soil surface stabilization [8]. Factors such as particle size, organic matter, calcium carbonate content, salinity, and alkalinity of the soils influence the potential wind erosion [9].

The knowledge of physio-chemical soil properties and land resources in SDS source areas provide valuable insights into the processes related to wind erosion, aeolian materials, and dust source control. That is why the aim of the study is to determine physical and chemical soil properties of a dust source area.

## 2 Materials and methods

### 2.1 Study area

The study area of 180 km$^2$ is located along Ahvaz-Mahshahr highway (48°47′ to 49°17′E longitude and 30°45′ to 31°15′N latitude), 25 km southeast of Ahvaz city, the capital of Khuzestan province (Fig. 1). The mean precipitation, the maximum, and the minimum long-term average temperature in the study area are 218 mm, 27.7°C, and 24.4°C, respectively [3,5].

There are 17 villages in the dust source area. The number of livestock farmers in the region is reported by 237 with a grazing license of 6742 livestock heads [10]. According to the Natural Resources Department, the rangeland capacity in this area is one-fourth to one third of the livestock unit per hectare. Based on this, 6742 heads of livestock in the area are allowed for grazing, and the rest are over rangeland capacity [10].

The study area is located within the jurisdiction of three different rivers, namely Karun, Kopal, and Jarahi. Additionally, there are three wetlands situated in the region, namely Hor-e Sharifeh, Hor-e Saadiyeh, and Hor-e Shadegan. The area comprises of poor rangelands and abandoned rainfed fields, resulting in a high potential for runoff production due to lack of vegetation and soil quality [11]. Due to seasonal drought and dam's construction in the upper part of the watershed, less water reaches the lower part, and alluvium and wetlands become dry [12].

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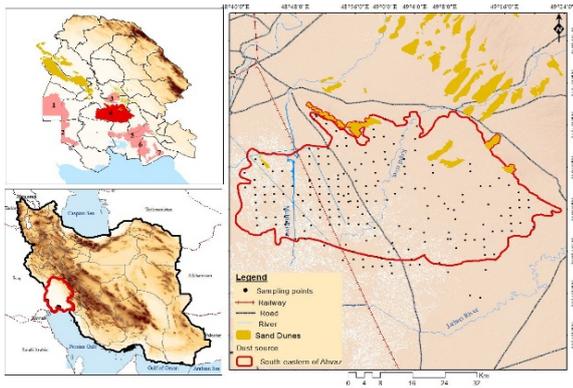\* Corresponding author: fsong52@gmail.com

**Fig. 1.** Location of soil samples within the study area in Khuzestan province, Iran.

## 2.2 Methodology

The map of land components was prepared by land resources method and considered as land units in landscape scale (1:25000) [13]. Soil samples were collected from 106 points at three depths of 0-30, 30-60 and 60-90 cm in a grid of $2 \times 2$ km by an auger soil sampler. The parameters of sand, silt, clay, pH, EC, SAR, ESP, calcium, magnesium, sodium, were measured for 300 soil samples in the lab, according to [14]. The erodible fraction (EF) and soil crust factor (SCF) were calculated for soil surface samples as equations 1 and 2 [15]:

$$EF = \frac{29.09 + 0.31\,Sa + 0.17\,Si + 0.33\frac{Sa}{Cl} - 2.59\,OM - 0.95\,CaCO_3}{100}, \quad (1)$$

$$SCF = \frac{1}{1 + 0.0066\,(Cl)^2 + 0.021\,(OM)^2}. \quad (2)$$

Here, Sa is the sand content (%), Si is the silt content (%), Sa/Cl is the sand to clay ratio (%), OM is the organic matter (%), $CaCO_3$ is the calcium carbonate (%), and Cl is the clay content (%).

Finally, each land compounds were evaluated for biological or physical stabilization methods by using physical and chemical characteristics interpretation [16].

## 3 Results and discussion

### 3.1 Land resource classification

In Iran, land resources mapping unit method are classified based on the type, unit (LU) and components of the land from top to bottom structure, each of which is represented by a number or word [13]. Within our study area, there are four types of land: Piedmont plains (4.3), River alluvial plains (tow land units 5.1 and 5.2), Lowlands (tow land units 6.1 and 6.2), non-gravelly fans (9.1), and sand dunes (X.1) (Table 1). On the study area the piedmont plain is actually a non-gravelly fan. This type of land is classified as piedmont plains according to the land resources method. Each land type was categorized into land units and compounds based on soil properties such as salinity, alkalinity, texture, and land

use (Tables 1 and 2). Calcaric Regosols and Haplic Solonchak, according to [16,17] were identified as the main soils occurred in the study area (Table 1).

**Table 1.** The taxonomy of soils in the study area in dependence on Land Units (LU).

| F.A.O, 1998 [16] | Soil Taxonomy (USDA) 2006 [17] | | | LU |
|---|---|---|---|---|
| | Order | Sub group | Family | |
| Calcaric Regosols Or Haplic Solonchak | Entisols Or Aridisols | Typic Torriorthents Or Typic Haplosalids | Fine loamy, Carbonatic , Hyperthermic | 5.1 |
| Calcaric Regosols Or Haplic Solonchak | Entisols Or Aridisols | Typic Torriorthents Or Typic Haplosalids | Fine loamy, carbonatic, Hyperthermic Or Fine loamy, carbonatic, Hyperthermic | 5.2 |
| Haplic Solonchak | Aridisols | Aquic Haplosalids | Loamy, Carbonatic, Hyperthermic | 6.1 |
| Haplic Solonchak | Aridisols | Aquic Haplosalids | Fine loamy, Carbonatic, Hyperthermic | 6.2 |
| Calcaric Regosols | Entisols | Typic Torriorthents | Loamy carbonatic, Hyperthermic | 4.2 |
| Calcaric Regosols | Entisols | Typic Psamments | Coarse sandy, Calcarous Hyperthermic | X.1 |

**Table 2.** Selected soil properties in the study area.

| Parameters | | Soil Surface (0-30 cm) | | | |
|---|---|---|---|---|---|
| | | Mean | Cv | Max | Min |
| Clay | % | 25 | 10.2 | 49 | 10 |
| Silt | % | 45 | 9 | 66 | 14 |
| Sand | % | 30 | 9.9 | 68 | 9 |
| pH | - | 8 | 0.3 | 8.9 | 7.5 |
| EC | ds/m | 49 | 24.9 | 111 | 4.2 |
| Na | mEq/L | 2115 | 1646 | 52 | 29 |
| Ca | mEq/L | 172 | 100 | 591 | 24 |
| Mn | mEq/L | 50 | 28.2 | 137 | 0.6 |
| SAR | - | 199 | 145 | 593 | 6.2 |
| ESP | - | 12.5 | 1.9 | 14 | 0.5 |
| EF* | - | 0.16 | 0.06 | 0.3 | 0 |
| SCF* | - | 0.26 | 0.2 | 1 | 0.1 |

### 3.2 Physicochemical soil characteristics

The alluvial plain of the river is flat and has deep to very deep soils, with limited salinity and sodium content. The wetlands Hor-e Sharifeh and a section of Hor-e Mansouri belong to the Lowland type. Two winds with

opposite directions, south-southeast and northwest, formed sand dunes which are divided into sand sheets, transverse, and topographic dunes based on geomorphology [18].

Table 2 displays the average physical and chemical properties of the soils determined in the lab.

Geospatial analysis was utilized to map the physio-chemical characteristics of the soils, as demonstrated in Fig. 2.
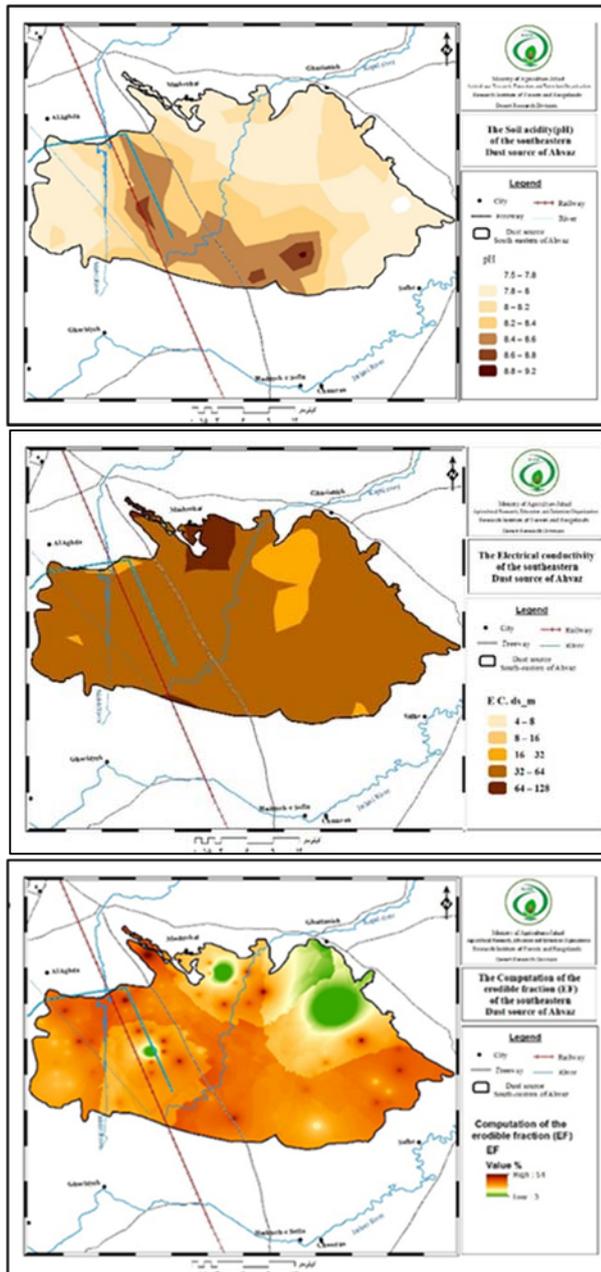


**Fig. 2.** Physio-chemical soil characteristics in the south-eastern Ahvaz study area.

## 4 Conclusion

High EC and Na values show that soil salinization was identified as one reason for the formation of dust in the study area. But the majority of soils in the land units have limited salinity and sodium values. However, the Khuzestan plain also experiences secondary salinization during the eight dry months of the year due to high levels of underground low salinity water. This is caused by capillary rise and evaporation from the soil surface. Under dry conditions solutes remain on the soil surface and increase the surface sensitivity to wind erosion and SDS origin. Although recent droughts have caused salt accumulation in the soil, most of this development is caused by the construction of dams and check-dams on permanent and seasonal rivers. These changes in soil salinity are one of the main causes for intensified dust production in the area. As more salinization occurs in the study area, as less vegetation occurs. Areas with a low coverage by vegetation are preferential dust source areas [19].

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