Shahrood University of Technology
Iranian Society of Mining Engineering (IRSME)
Journal of Mining and Environment (JME)
journal homepage: www.jme.shahroodut.ac.ir
THOMSON REUTERS

Influence of Physical and Chemical Material Properties on Mining Soil Erosion Processes Around Mineral Salts Company in Mighan playa, Arak, Iran

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Article Info

Received 23 March 2021
Received in Revised form 13 July 2021
Accepted 19 July 2021
Published online 19 July 2021

DOI:10.22044/jme.2021.10656.2023

Keywords

Soil erosion
Multiple statistic
Physico-chemical soil factor
Dust generation
Mighan playa

Abstract

In this work, we determine the factors affecting soil erosion and its effect on dust formation around the Mineral Salts Company in Mighan playa of Arak. Seventy samples are randomly sampled from a depth of 10 cm above the ground around Mighan playa. Some factors involved (e.g. sample aggregation, lime, organic matter, pH, Na, K, Ca, and electrical conductivity) are determined and compared with the statistical parameters such as the correlation matrix and cluster analysis in order to determine the erosion rate in each sample based on the soil properties. The results obtained show that soil salinity, as a major factor in erosion, causes soil depletion and degradation in the area. Also a high amount of sand in the environment causes the soil texture instability. The factors such as the amount of gravel, organic matter, and K are the main erosion inhibiting factors, which have little effect on the majority of the samples. The organic matter content in most samples is less than 4%, and does not have much effect on erosion. The amount of clay in the samples is less than 10%, and has no effect on the adhesion of soil texture. The main factor affecting the erosion rate is EC and Na in the soil. The inhibitors such as gravel, organic matter, K, and clay amount in the samples can be considered as a protective or reducing factor in erosioning. Rising in the mentioned factors in the soil causes a lack of density and instability in the soil, and increases the rate of soil erosion. The results of this work show that addition of soil erosion increases the amount of fine-grained soil, and dust is a result of increased production. Also the presence of mineral salt in the area increases the production rate of dense soil, and as a result, rises the amount of dust produced in the area. Therefore, we need to stabilize mining soil, and prevent dust generation around the Mineral Salts Company.

1. Introduction

Over the past few decades, many countries have adopted laws to manage the risk of contaminated soils, sediments, and contaminated water [1]. Soil is an essential natural resource that supports the terrestrial ecosystems and food production. The process of soil production takes thousands of years. In such a way that erosion losses are not compensated by the sedimentation rate, this will lead to increased soil pressure and detrimental effects on the terrestrial and agricultural ecosystems. In other words, soil erosion is one of the main problems for a sustainable agriculture [2]. Soil erosion is a complex gradual process that occurs when the impact of the separated water eliminates the soils and causes the decomposition of its raw materials [3]. This phenomenon is a major global environmental problem [4, 5]. Sheet erosion, for example, reduces agricultural production, and increases the cost of infrastructure [6]. Erosion is one of the most important forms of land, and also the main cause of land degradation. This degradation (soil degradation, loss of fertility,

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slope instability) has been strongly influenced by land use and management in arid and semi-arid regions [7]. Soil erosion is sensitive to climate changes [8]. Erosion strongly affects the sustainable land management in various environments around the world [9]. On the other hand, the production of microorganisms in arid and semi-arid regions will cause many diseases in the society. Studies have shown that the human activity is a major contributor to land degradation [10]. However, biophysical conditions of the soil such as soil characteristics, climate, topography, and vegetation are also the influential factors in erosion and land use change [11]. Changes in vegetation in all basins result in changes in hydrological response, soil erosion, and sediment dynamics. These changes are often one of the main causes of long-term climate change as the main cause of human and accelerated short-term erosion [12].

The first step for any soil conservation planning is to know the status of soil erosion [13]. Measurement of soil erosion reactions and sediment yield in land use changes can only be done by the numerical simulation of soil erosion [14]. Most soils in arid and semi-arid regions contain less than 1% of organic matter. Restoration of soil organic matter has beneficial effects on soil conservation, improving soil physical conditions and its characteristics in crop growth and crop production [15]. In contrast, the problems with soil salinity, alkalinity, and sodicity represent major challenges for the farmers [16]. The presence of each one of these factors in the soil causes changes in the soil properties, and the severity of erosion varies.

Wind erosion is a function of soil and wind [17]. The phenomenon of dust is mainly due to the diffusion of dust from the microcosm producing centers. The dust sources are a major challenge in quantifying the dust cycle and its environmental and climatic effects [18]. Wind is a major driver of heavy metal transport from the contaminated areas to the surrounding agricultural areas and its entry into the human food cycle [19]. Therefore, the entry of dust into the human areas causes an increase in the pathogenic elements in the human body and food, and as a result, increases the rate of disease. The degradation of urban air quality is also caused by the particulate matter that has a great effect on the human health due to its harmful effects [20]. The size and stability of soil aggregates are important factors that influence the degree of susceptibility to erosion. Thus with the help of these factors, the rate of dust generation can be investigated.

Micro-scattering often occurs when the dust particles in dry uncoated soil are prone to erosion when driven by wind [21]. In general, the soil composition consists of the minerals that are found in inorganic and organic soil [22]. The presence of organic matter in the soil causes the soil cohesion and avoids the dust. Therefore, it can be used as one of the factors to study soil erosion. The higher the amount of soil erosion and emptiness, the higher the rate of rainfall production in the area. The factors such as the size and stability of soil aggregates, clay content, and soil moisture near the surface affect the threshold velocity. Soil texture has a significant effect on soil erosion by wind [23]. In a way, sandy soils are inherently more eroded than fine-grained soils because they have less salt, clay, and silt to reinforce their structure. Therefore, changes in these factors affect soil erodibility, and are good cases in helping to study the soil. The soil organic carbon is an important soil element that acts as a nucleus in the formation of aggregates. As a result, increasing the soil organic carbon content results in soil strength and reduced erosion [24]. The effects of salinity and the presence of sodium in the soils of arid and semi-arid regions can decrease soil firmness and increase wind erosion. Among the factors affecting wind erosion, soil texture, moisture content, and soil organic matter content have the most important roles in soil erosion resistance [25]. With the help of the effects of the mentioned cases that each puts on the soil, the effect of each one, of the factors is determined and finally shows the degree of erosion of a soil sample. This work shows how much soil can suspend the soil particles and elements in the air when the wind blows.

In this work, the factors affecting soil erosion, and its effect on dust formation in the arid and semi-arid areas around the Mighan playa, NE of Arak (Iran) was investigated in 2018. In the present work, we tried to study the erosion intensity in each sample with the help of the physico-chemical variables in the soil, and determine which samples were most influenced by which one of the physico-chemical factors influencing wind erosion and micro-deletion.

2. Materials and methods

2.1. Studied area

The studied area is around the Mineral Salts Company in Mighan playa, and is located NE of Arak in Iran (Figure 1). This lake that is located 15 km NE of the city of Arak is a closed basin of Mighan, whose area is made up of 1970 km^2 of

Arak plain, 110 km^2 of Mighan plateau, and the others are basin elevations. The Mighan playa is a hydrologically closed intra-continental basin. Since the studied area is located in a semi-arid climate and the rainfall occurs in seasonal climate, it has no permanent river. The lake has no outlet but is fed by freshwater from all margins. The average annual rainfall in this area (350 mm) is much lower than the average annual evaporation (1450 mm) [26].

The Mighan sedimentary basin is located in the west of central Iran zone, in the central and southwestern part of the central province. The Mighan sedimentary basin comprises the entire sedimentary basin (erosion, deposition, and equilibrium) containing seasonal and saline Mighan Lake, alluvial margins of the lake, seasonal feeder rivers, and alluvial fans of elevations overlooking the lake. The sequences around the Mighan playa include the volcanic conglomerate, marl, and shale [26]. The soils of the northern Mighan playa vary from coarse-grained to fine-grained. The lake's water chemistry is dominated by Na, Mg, Cl, and SO_4^{2-} ions, and also contains lower amounts of Ca, K, and HCO_3^- [26].

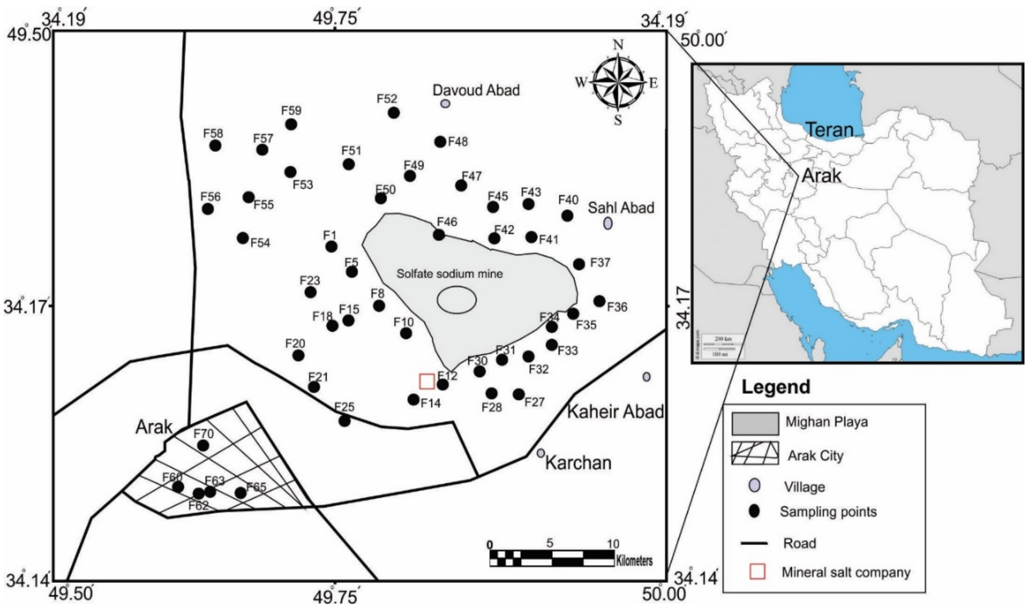

Figure 1. Geographical location of the studied area and some of the sample points.

In order to better understand the sedimentary conditions of the region, the geological maps of the region and land use map published in the article of Fouladi et al. in 2019 [27] are used. As it can be seen in the geological map of the area, the Mighan Lake is located in the center of the map in the range of Q_2 (Figure 2). The location of this lake and the presence of Pasture Mountains around it is evidence of the entry of sediments into the lake. It should also be noted that the land use map of the area shows the unused and unconsumption lands around Mighan (Figure 3).

2.2. Method and analysis

In order to investigate the factors affecting solfate sodium mine soil erosion in 2018, 70 samples were randomly sampled from a depth of 10 cm above the ground around the Mineral Salts Company (Figure 1). After drying the samples at 105 °C for 24 hours, the physical properties of the samples were first evaluated by wet sieve and hydrometric methods. Then its chemical properties (lime, organic matter, pH, electrical conductivity (EC)) were determined in the Laboratory of Minerals Research Center of Iran. The pH of ISO 10390 [28], EC of ISO11265[29], organic matter of ASTM D2974[30], and available lime content in the samples were obtained using the ASTM D3155 [31] method, and the Na, K, and Ca elements were determined by the ICP-OES method. 10 samples were selected from the soil samples for identification of clay minerals in soil and analyzed by XRD. For quality control, procedural blanks and duplicates were run for 7 samples. The standard deviations were below 10% for all variables. The detection limit for major metals was 0.1 mg/Kg for a soil sample. The statistical analysis was performed using the Statistica software, version 10. The zoning maps of the elements, which were plotted, and the factors affecting erosion were examined using the Arc GIS software, version 9.3.

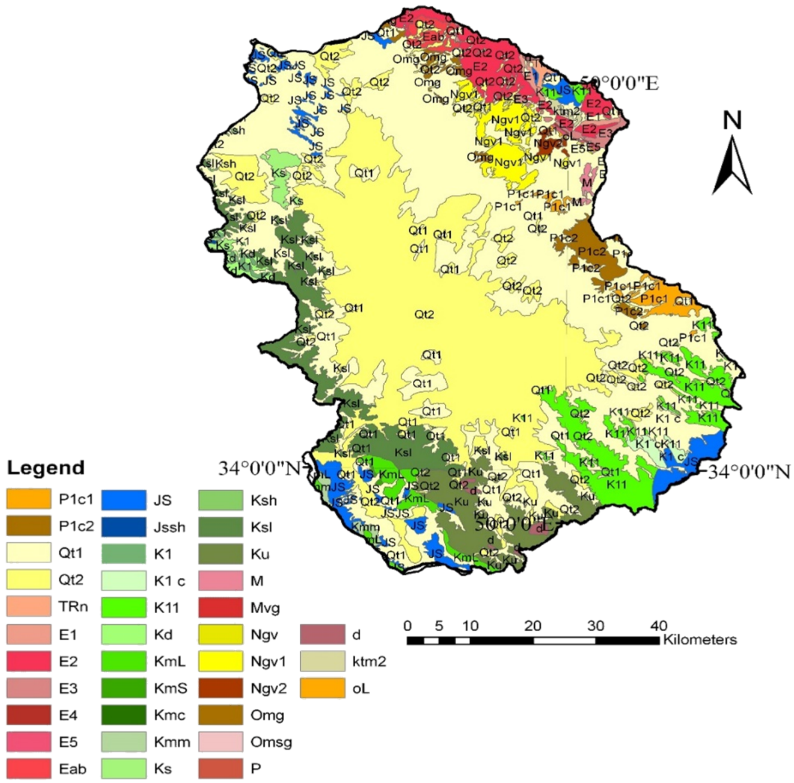

Figure 2. Geological map of mighan (Fouladi et al., 2019).

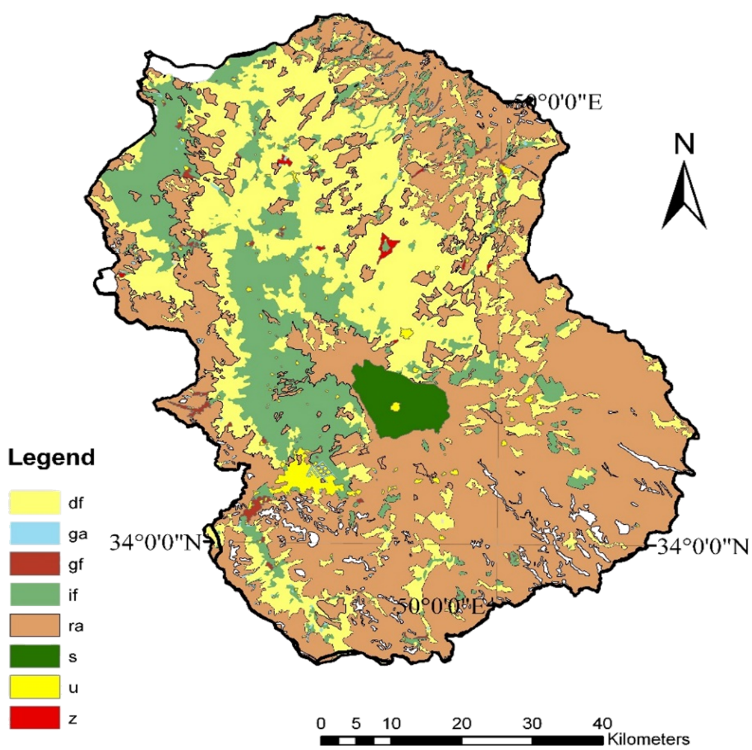

Figure 3. Land use map of mighan (Fouladi et al., 2019).

2.3. Statistical analysis

In order to analyze the data, all data was standardized at first, and then correlation matrix, cluster analysis, and factor analysis methods were used. In the correlation matrix analysis, the correlation between two variables means to measure the predictive values of one variable with respect to another one. This means that the higher the correlation coefficient, the greater the possibility of predicting the value of one variable over another. The Pearson's and Spearman's correlation coefficients are between 1 and -1. Thus if the correlation coefficient is close to or equal to 1, there is a strong and direct relationship between the two variables [32]. In this case, we can say that the direction of change of both variables are similar. In this case, it increases with the addition of another. There is also a correlation based on the decrease, which means that if one variable is reduced, the other will decrease. In this case, they say that there is a direct relationship between the two variables. Cluster analysis also includes the algorithms and methods for grouping similar items (including people, objects, events, etc.) into different classes. Cluster analysis categorizes the items based on their relevance. Therefore, the individuals in one cluster have the highest relationship with each other and the least amount of communication with other members of the cluster. Also in vector-based methods using eigenvalues and eigenvectors, the directions with maximum variability are identified [33]. Then by defining new variables, which are linear combinations of the initial variables, the number of dimensions (variables) is reduced and the role of each variable in variability is determined. These linear combinations, so-called factors, have the following properties. Much of the variability can be justified by a limited number of new variables, and the new variables that are the product of the linear combination of the initial variables do not correlate. This makes it easy to test the method. After analyzing the correlation coefficients of the samples, factor and cluster analysis on the samples, the map of each of the factors influencing the erosion was drawn and analyzed.

3. Results and Discussion

3.1. Physio-chemical indicators of soil quality

Table 1 shows the highest mean EC values is 2050 µmohs/cm. The maximum EC value over other values showed an increase in its impact on soil erosion [30]. As it can be seen in Table 1, the highest amount of variance in EC, gravel, and lime values in the sediment showed the greatest influence of these three components on the soil variability. Due to the large difference between the minimum and maximum values of gravel (0.45 to 27.67), it is necessary to examine the concentration and influence of this inhibitor on its erosion and zoning. The results obtained showed that the average gravel content in the samples was 3.88%; the amount of sand in the samples was 77.55%; and the clay content was 5.86%. Increasing the gravel aggregate diameter in the soil impedes sediment transport and reduces erosion rate. However, with increase in clay and sand in the soil, especially sand along with some chemical agents such as EC (mean 2050 µmohs/cm) in the soil, it increases soil osteoporosis and incoherence, and eventually increases soil erosion and displacement. The presence of the factors such as pH, EC, and Na increases soil erosion [22]. Also the factors such as organic matter, lime content in soil, and K can decrease the rate of erosion in sediments.

Table 1. Statistical relationships between the physic-chemical data of the studied samples.

	Mean	Minimum	Maximum	Skewness	Kurtosis
Gravel	3.88	0.45	27.67	1.24	1.58
Sand	77.55	64.10	87.90	-0.97	1.33
Silt	9.69	1.39	17.86	-0.15	2.99
Clay	5.86	2.86	13.55	1.54	2.52
pH	4.45	3.69	5.59	0.58	1.13
EC	2050	112	14530	1.61	1.13
$CaCO_3$	19.22	7.55	34.80	0.44	-0.76
OM	5.20	1.78	18.74	1.16	1.10
Na	0.23	0.0	1.00	1.11	1.51
K	0.14	0.0	1.00	1.83	1.36
Ca	0.51	0.03	1.00	0.44	-1.70

3.1.1. Soil aggregation

The presence of clay in the soil due to its adhesion properties reduces soil erodibility [35]. Increasing silt and sand in soil also increases soil erosion, and plays a major role in soil loss [36]. In the studied samples, sand and silt together account for the highest amount of sediment aggregation. The high percentage of sand in the samples causes soil incoherence and increased erosion and sediment yield. The average amount of sand in the studied samples was 77.50% and its variance was 37, indicating the effect of sand on soil looseness. As in samples 9, 12 to 14, the highest amount of sand was observed, and the soil in this region had the least coherence. Gravel presence in soil prevents soil erosion and displacement. As shown in Figure 2, the samples show the highest gravels in sample 17, which has the lowest erosion and microprocessor production, and in the other samples, the gravels were low and negligible. The amount of clay in the studied samples had an average value of 5.80% and variance of 8 compared to the other aggregates. According to the studies by Kemper and Koch [37], clay increases the stability of the soil when the amount of sodium in the soil is low, and in the presence of high sodium has a negative effect on the stability. As it can be seen in Figure 3 and Table 1, the presence of sodium in samples 9, 10, and 3 reduces the effect of clay on soil strength.

3.1.2. Organic matter

The soil organic matter has been identified as a key indicator of the soil quality that prevents aggregate degradation [38] as well as reducing the soil erodibility. Organic matter is one of the most influential qualitative factors in soil fertility, and contributes to the improvement of the soil chemical, physical, and biological properties. As land use increases, the amount of surface cover decreases and the quality of organic carbon decreases, resulting in an increased degradation. The mean organic matter in the samples examined was 5.20% (Table 1). This value, which ranges from 1.70% to 18.70%, indicates the difference in the amount of organic matter in the studied area, and therefore, its different impacts so that this material in urban areas and samples 15 and 16 that are abandoned agricultural areas due to the former presence of vegetation and fertilizers have a higher percentage of organic matter, and the other parts have a less organic content (Figure 4). Chibsa and Ta'a [39] have found that the soil surface layer is more suitable for organic matter than the lower soil layer. In a way, tillage operations cause the lower layers of soil to mix with a lower organic matter content, and thus reduce the soil organic carbon and increase erodibility [40]. The lack of soil consistency in most of the samples collected and the texture of the soil sandy as well as soil wash during the rain reduces the organic matter, and has a lesser impact on degradation.

3.1.3. Electrical conductivity (EC) and sodium

The accumulation of salt and increased salinity of the soil are usually due to the process of evaporation and water withdrawal by plants. The salt in irrigation water remains in the soil, while pure water is removed from the soil by the process of plant growth and evaporation. Soil salinity declines with decrease in the crop growth, decreasing the crop yield [41]. Due to the decrease in the osmotic potential due to soil salinity, water absorption by the plant is difficult. Salinity also disturbs the balance of plant nutrients. The surveys show that EC has the highest mean (2050 µmohs/cm) among the parameters studied (Table 1). This indicates the major impact of EC on soil degradation. As shown in Figure 3, this high numerical value reaches its numerical maximum in the Mighan playa area.

In addition, the composition of the existing salts affects the ion exchange between the soil particles. Salt composition, based on the degree of salinity and exchangeable ion composition, is effective on the water permeability and soil fertility. Sodium, unlike potassium, is a destructive agent of soil structure, and consequently, reduces soil permeability and soil moisture storage. High exchangeable sodium is one of the main reasons for clay removal from aggregates, increasing clay dispersion, and collapse of aggregates, and consequently, instability of the soil structure. For this reason, soils that become sodium, have undesirable physical, chemical, and biological properties, and have low crop yields. The presence of salt in the central part of the map and the Mighan playa (Figure 5) confirms the effect of salt on degradation and high EC content. Clay minerals, especially the smectites group, play an important role in erosion expansion due to swelling during water absorption. This group of clay minerals, especially in the presence of sodium ions, causes scattering of the aggregates and decreases permeability, and eventually, exacerbates the erosion [42].

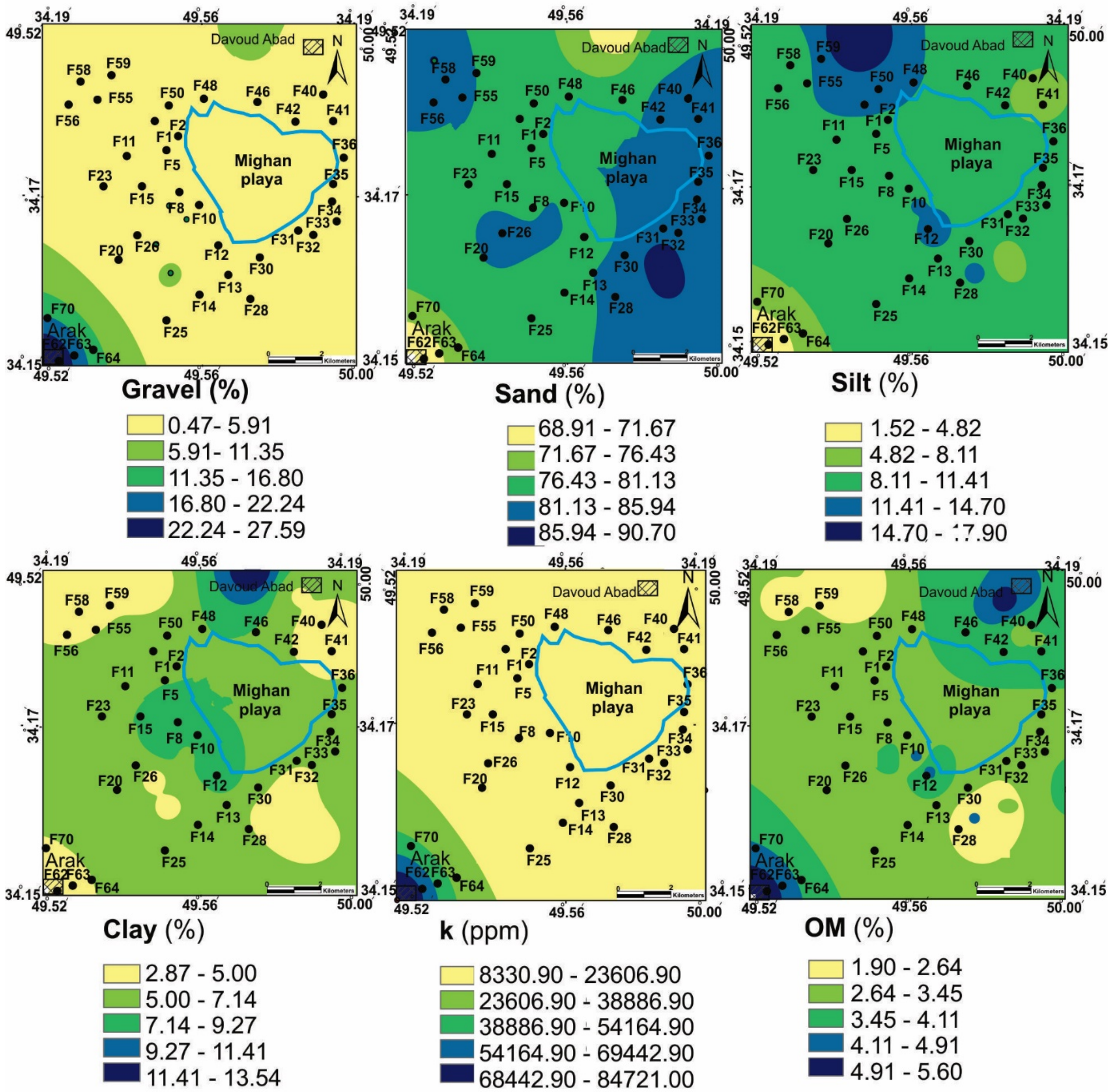

Figure 4. Zoning of the physical and chemical factors affecting soil erosion and some of the sample points.

3.1.4. Acidity (pH)

The acidity value scale of a solution is called pH, i.e. the negative logarithm of the concentration of hydrogen ions in solution. The pH dependence on temperature is important because, for example, at 120 °C, the pH of neutral pure water is 7 rather than 6 so the reactions that should not occur at pH = 7 can occur. Soil acidity is influenced by the factors such as the nutrient utilization of plants, mobility of trace elements, and activity of soil microorganisms. Although soil acidity may change due to different land management, Dormaar and Willms [43] have found in their studies that increasing the pH of rangeland under grazing compared to pasture soils results in increased surface erosion rate, and consequently, more carbonate proximity to the soil surface. As it can be seen in Figure 3, the pH values in the sedimentary samples are all within the range of play, indicating an increase in soil degradation. As one can see in Table 1, the control sample has a lower pH than most of the samples, which indicates, along with other factors, the lower rate of degradation in this sample (Figure 5).

3.1.5. Potassium

In arid and semi-arid regions, the soils are rich in potassium due to specific minerals such as mica and clay. The increase in potassium in the soil is due to the low vegetation cover and lack of uptake by the plant. The amount of potassium in the aggregate stability depends on the type of clay mineral in such a way that the amount of potassium in clays, which is higher than the ratio of silica to iron and aluminum oxides, becomes swollen due to moisture, and the aggregates become unstable and, unlike clays whose ratio is lower, their aggregates are water-resistant. They have more and less degradation. The susceptibility of clay minerals to swelling and swelling increases from kaolinite to chlorite, illite, vermiculite, and eventually montmorillonite, respectively. According to Table 1, the potassium content in the samples varied from zero to one, which is very low. It also has a zero variance, which indicates that it has no effect on preventing erosion in the region. In the XRD study of clay mineralogy performed on the samples studied, the illite minerals are one of the main minerals forming the clay samples. The presence of this mineral, which incorporates potassium in its structure, prevents soil erosion. However, due to the low clay content in the samples as well as low potassium content, its effect on preventing erosion is negligible (Figure 4).

3.1.6. Calcium carbonate ($CaCO_3$)

Calcium cation has an effective role in breaking down colloids and reducing erodibility. Duiker *et al*. [44] have showed that Ca plays an important role in the uptake of soil colloids and increased soil erosion resistance. The average calcium carbonate in the samples studied is 19.22 mg/Kg, and shows the variance of 62. These numbers indicate its effectiveness in preventing erosion. As one can see in Figure 5, the presence of $CaCO_3$, or the same tissue factor mentioned above, is visible and effective at all points.

3.2. Relationship between physico-chemical factors affecting erosion

3.2.1. Correlation matrix

As mentioned earlier, in order to understand the relationships between the physical and chemical factors affecting the erosion rate of each one of the samples studied, the effective physico-chemical parameters in the erosion were determined, and their numerical values were standardized. By extracting the mentioned values, the numerical relationships between the specified values of the statistical parameters and the correlation matrix of each of them were calculated. The factor analysis and cluster analysis were then performed in order to identify the sources of sediment physical/chemical data.

Based on the correlation matrix studies, it can be seen that gravel shows the highest correlation with organic matter (OM) and K with the 0.80 and 0.90 values, respectively (Table 2). On the other hand, Na has a moderate correlation with the numerical value of 0.50. Na and EC also have a strong correlation with a numerical value of 0.64. Sand and silt showed a moderate to strong negative correlation with organic matter, and K, indicating the interaction of these two factors against the gravel group. On the other hand, Na has a moderate correlation with the K value of 0.59.

Table 2. Correlation matrix relationship between the samples.

	Gravel	Sand	Silt	Clay	pH	EC	$CaCO_3$	OM	Na	K
Gravel	1.00									
Sand	-0.70	1.00								
Silt	-0.63	0.01	1.00							
Clay	-0.05	-0.53	0.25	1.00						
pH	-0.29	0.39	-0.01	-0.11	1.00					
EC	-0.23	0.03	0.21	0.24	0.23	1.00				
$CaCO_3$	-0.33	0.15	0.27	0.11	-0.47	0.18	1.00			
OM	0.80	-0.51	-0.64	-0.01	-0.26	-0.14	-0.10	1.00		
Na	0.52	-0.45	-0.28	0.08	0.05	0.64	-0.09	0.46	1.00	
K	0.93	-0.54	-0.69	-0.18	-0.17	-0.20	-0.28	0.75	0.59	1.00

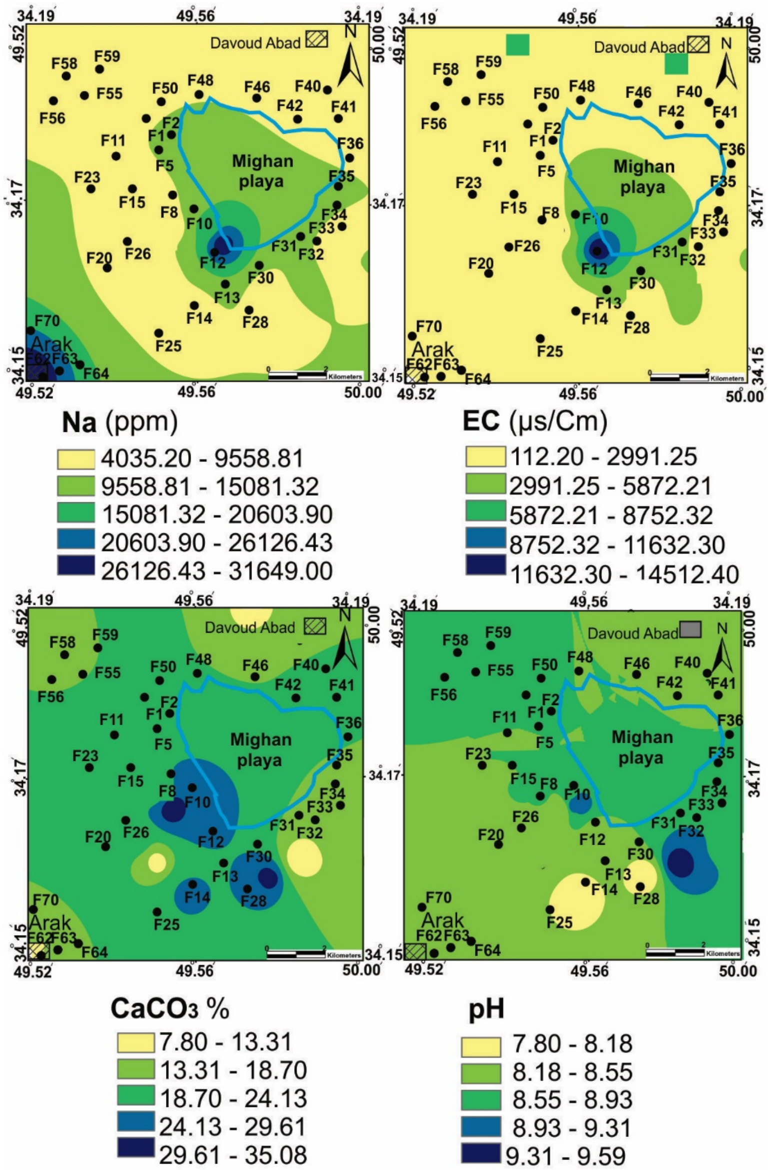

Figure 5. Zoning of the chemical factors affecting soil erosion and some of the sample points.

3.22. Factor analysis

After analyzing the main components of the studied samples, the factor analysis was performed based on the physico-chemical factors affecting erosion. The possibility of rotating the factors is one of the advantages of the factor analysis method over the principal component method [45]. The rotation technique is used in order to minimize cross-loading. In this study, the varimax normalized method was used. Four factors were identified in the surveys, based on which, the map of factors and factors affecting erosion was drawn (Figure 6). Based on the information obtained, the numerical maximum is assigned to factor 1, which is a deterrent to erosion (Table 3). Due to the presence of gravels, organic matter, and potassium, they are all considered to be erosion inhibitors, and are called the soil erosion resistance factors. Surface coverage of more than 5% gravel in arid and semi-arid regions with poor vegetation is effective in reducing wind erosion [46]. Gravel content was less than 5% in most of the samples studied, and this effect is only observed in sample 17, which has the lowest dust production potential [47]. The amount of silt in this factor is due to the influence of Na on its properties, which is in contrast to other factors, and has the role of degradation. The presence of albite minerals among the minerals obtained from XRD analysis confirms this. Also according to the studies conducted by Parysow et al. [36], the presence of silt in the environment increases the rate of degradation. In the second factor, sand and clay, which interact with soil degradation, are called the tissue factors. The soil property assessment investigated by Shahabinejad et al. [46] has shown that the higher the amount of clay and silt in the soil, the lower the erosion rate. The researchers determined an inverse relationship for sand erosion with wind erosion velocity with a total critical size of 0.3 mm. According to the Wakindiki and Ben-hur's [48] studies, if the clay content is less than 10%, there will be virtually no structure, and if the structure is formed, the soil particles will not be highly adherent, and will rapidly disperse as a result of erosion. Table 1 and Fig. 4 show that the amount of clay in most cases is less than 10%, indicating that this factor has no effect on the soil stability. The higher amount of sand than the other grain sizes increases the degradation rate in the investigated samples [36]. The third factor involves the influence of EC and Na on soil degradation, which is called the erodible factor among these four factors, and plays the most erosive role. In the fourth factor, we also see the interaction of $CaCO_3$, which reduces the degradation rate [44], in contrast to the amount of pH in the soil environment, which increases the amount of vegetation and increases surface erosion.

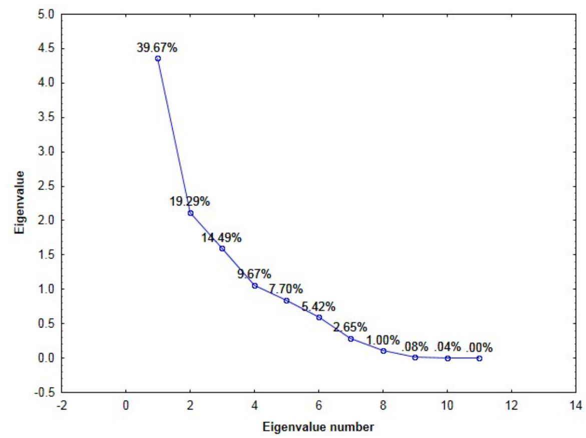

Figure 6. Scree plot of an appropriate number of invoices.

Table 3. Classification of degradation parameters in four factors

	Factor 1	Factor 2	Factor 3	Factor 4
Gravel	-0.96	0.21	-0.05	0.03
Sand	0.52	-0.82	-0.02	0.06
Silt	0.77	0.36	0.03	-0.14
Clay	0.18	0.85	0.14	-0.05
pH	0.25	-0.25	0.26	0.81
EC	0.21	0.08	0.95	-0.01
$CaCO_3$	0.27	-0.08	0.17	-0.88
OM	-0.87	0.09	0.03	-0.11
Na	-0.55	0.15	0.79	0.05
K	-0.96	0.01	0.03	0.05
Eigenvalue	4.11	1.96	1.67	1.15
% Total-variance	41.06	19.59	16.73	11.55
Cumulative-Eigenvalue	4.11	6.06	7.74	8.89
Cumulative-%	41.06	60.66	77.38	88.94

In Table 3, factor 1 has the highest variance with 41.06%. This value indicates the greatest impact of the erosion inhibiting agents on the environment. As explained in Table 1, the skewness and kurtosis are high in the three gravels, organic matter (OM), and K, and these values indicate abnormalities in the samples. This means that these factors, which affect non- degradation, have the greatest impact on sample 17 and have less impact on the other samples (Figure 4). The organic matter in soil can reduce the destructive effect of exchangeable sodium on the soil structure and increase the size of aggregates by increasing the specific stability level. The values of factor 2, factor 3, and factor 4 are 19.59%, 16.72%, and 11.55%, respectively. Overall, the percentage contribution of factors 2 to 4 that have the most impact on degradation is 47.87%, which is higher than the first factor. The data shows that factor 1 includes gravels, organic matter, and K, decreasing soil erosion resistance in the area. Based on Figure 4, it can be seen that in sample 17 as well as in samples 16 and 14 in factor 1 that are high (Figure 7), one can see the effect of these factors to some extent. The high amount of sand relative to clay in factor 2 can reduce or neutralize its inhibitory effect. Clay is the most important part of the soil body due to its high load and specific surface area than sand and silt [49]. The results of a field study conducted by Bhardwaj *et al*. [50] have shown that in aggregates, the degree of aggregate resistance decreases. This decrease in the aggregate resistance is inversely related to the salinity and sodium content. Also there is a strong positive correlation (r = 0.64) between EC and the sodium uptake ratio in the studied soil, which leads to a decrease in the strength and an increase in the aggregate dispersion. According to the studies by ShahabiNejad *et al*. [46], the rate of soil degradation is proportional to the EC content and is dependent on the type and concentration of the main soluble cations. As a destructive agent and Ca as a constituent cation has the greatest contribution to the increase in wind degradation.

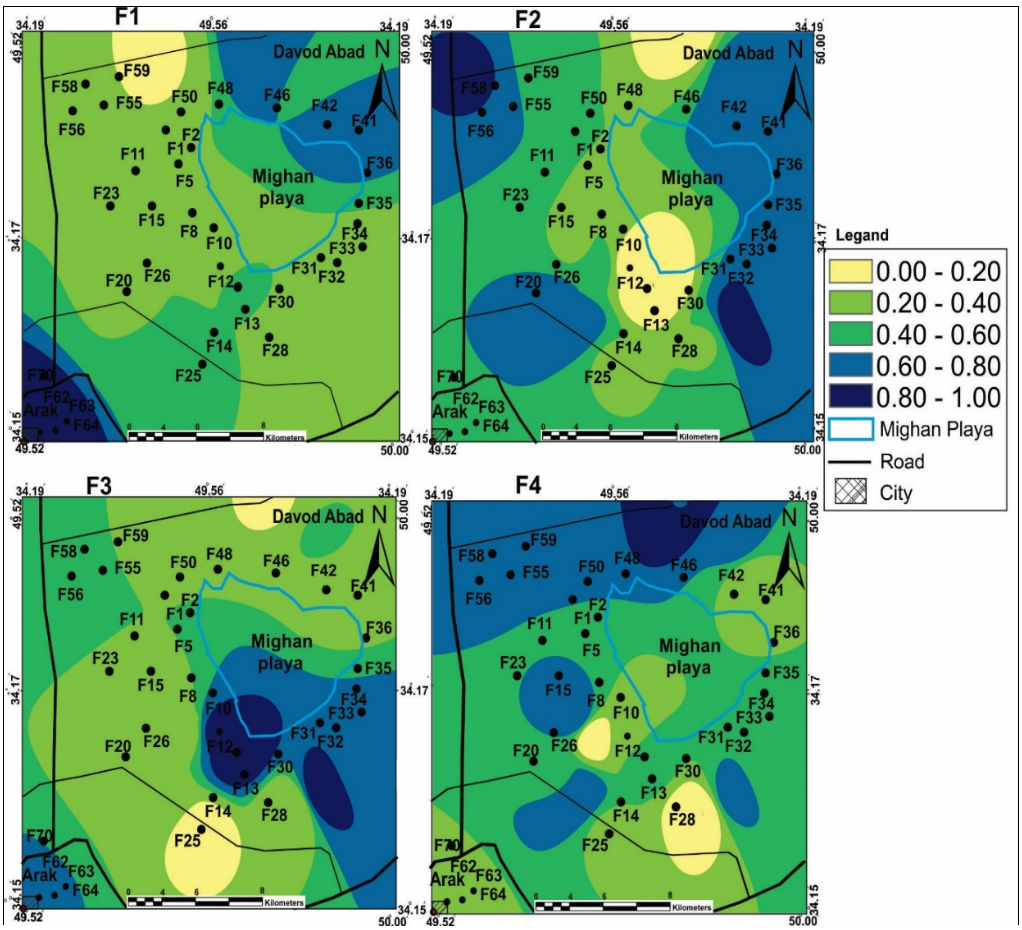

Figure 7. Factor maps 1 and 2 in the studied area. Factor 1 contains gravels, organic matter, silt, and K, and factor 2 contains sand and clay. Factor 3 contains EC and Na, and factor 4 is lime, pH, and Ca.

Gros et al. [51] have studied the results of numerous researchers, stating that increasing the amount of Na in soil solution and in the cation exchange capacity of the soil can damage the soil structure, thereby reducing the aggregate disintegration, and consequently, reducing the amount of pores, fracture or differential swelling of clays, and the reduction of pore size and clay separation and dispersion followed by clogging of the water conducting pores by the displaced clay particles. Also Na in the region, as mentioned earlier, is the degradation factor of the region. It can be seen that the highest concentration of the corrosive agents is in the Mighan playa and in the areas around it. A high Na exchange is one of the main reasons for clay separation, increasing clay dispersion, collapse of aggregates, and consequently, the instability of soil structure by absorbing sodium. Provided by aggregates, the collapse preparations of the aggregate provide Na by increasing the clay surface exchange, increasing the thickness of the electrically dispersed double layer, which results in the swelling and diffusion of the clay and the destruction of aggregates. As a result, the soils that are sodium-bearing will have poor physical, chemical, and biological properties, and have low crop yields. With the exception of samples 1 and 14, which have the lowest values in factor 3 and are affected by other erosive factors, the other samples are mostly affected by this factor in their erosion (Figure 5). Factor 4 in Figure 7, which includes the lime and pH, shows the effect of the pH rate and lime content in the sample. According to this maximum map, this value has an impact on the 14 sample, and shows that the 14 sample is more eroded due to this factor. It seems that samples such as 1 that do not show a maximum rate in any of the factors are due to the fact that all four factors have approximately the same effect on their erosion. It has been almost equally impressive.

In Figure 8, we also see the 2D graph of the factors relative to each other. In these graphs, the factors such as gravel, organic matter, and potassium are put together to act as a deterrent to erosion. As one can be seen in Figure 8, the amount of sand and clay is the most distant, indicating the interaction of these two factors. The proximity of EC and Na and their distance compared to the other factors is the evidence of their dominance over the other eroding factors (Figure 8). Calcium carbonate is as an independent agent, which, as mentioned earlier, has an effect on the soil texture in the samples. Increasing the organic matter and calcareous soils can reduce wind erosion in the arid and semi-arid regions [46].

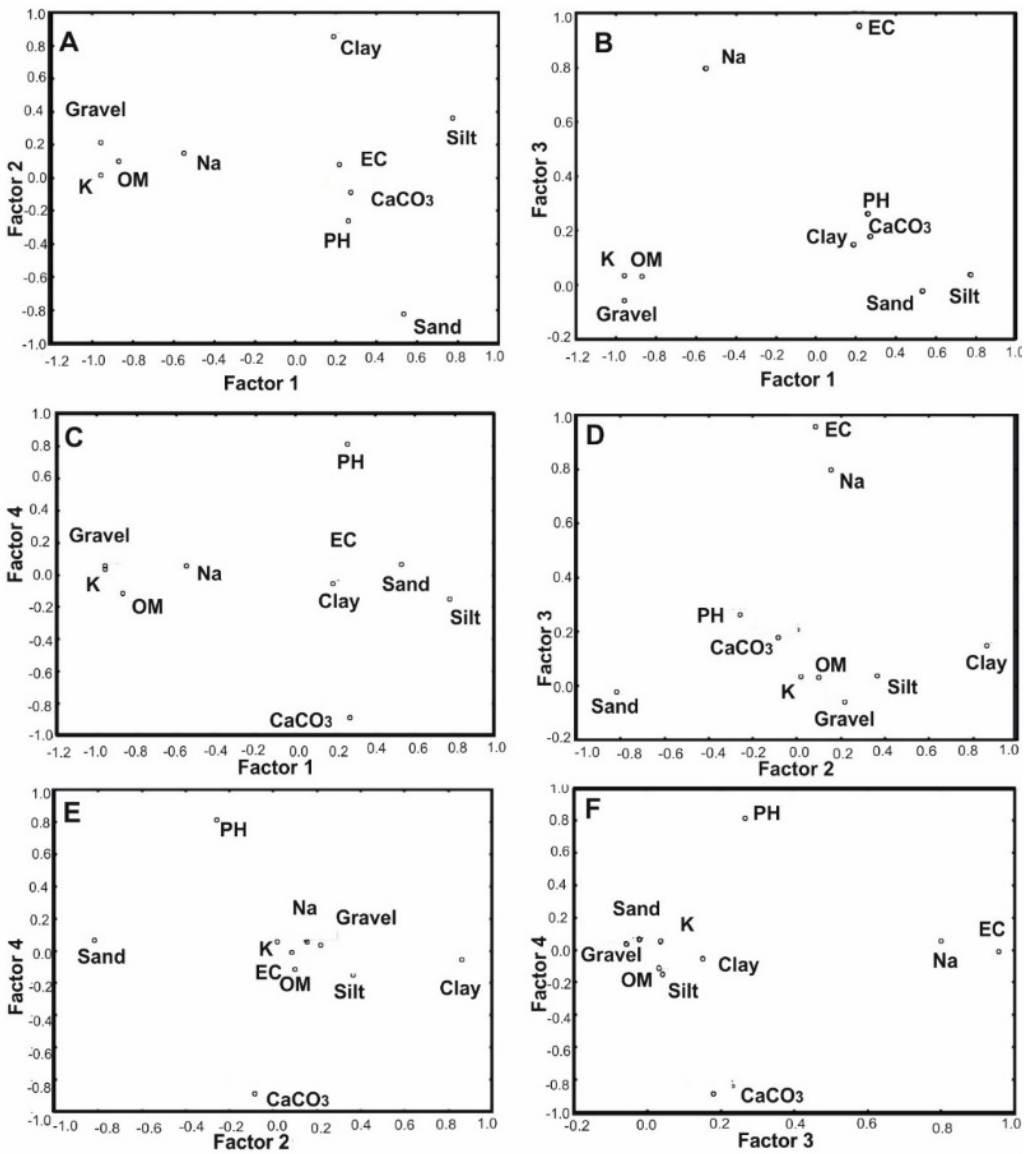

Figure 7. 2D representation of the relationship of the main factors to each other.

3.2.3. Cluster Analysis

The purpose of a cluster analysis is to find a criterion for classifying the variables more appropriately based on the greater intra-group similarity and inter-group differences. The cluster diagram for the corrosive factors was plotted (Figure 9). The Ward method was used to calculate the cluster analysis. In this method, the criterion of linking an object to clusters is to create the smallest increase in the sum of squares of deviation from the mean of the cluster. This method is used as a confirmation of the factor analysis. The graph shows that the factors such as gravels, organic matter, and K that reduce erosion (Factor 1) have the least correlation with the other factors in a way that the other factors, together with decreasing and increasing, influence the erosion rate (Figure 8). This graph shows that all erosion-reducing and increasing factors have their effects on the studied samples. Cluster 2 has the most relationship with each other, and is considered as a corrosive factor in dust production.

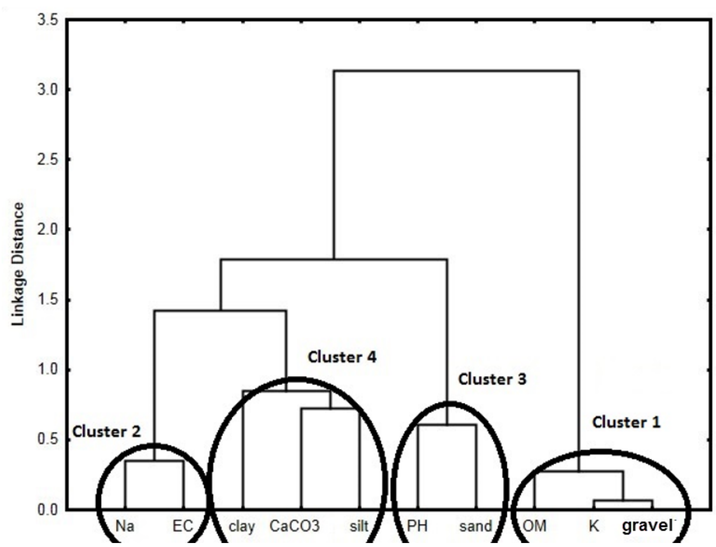

Figure 9. Cluster diagram of the physico-chemical factors affecting the erosion of the specimens.

The soil salinity was evaluated in the studies. The results obtained showed that 70% of the soil in the area was saline, 17.60% was brackish, 5.80% was low-saline soil, and 6.60% was very saline. The data obtained along with the climatic factors indicate that the soil is formed by the presence of sodium and the creation of salinity. The presence of the factors such as pH, sand, and silt are the other influencing factors that increase the degradation and increase sediment production, and consequently, dust production in the studied environment. The presence of the factors such as organic matter and potassium, which are inhibitors of erosion and dust production, will gradually fade with increasing weathering, and the dust production rate will increase gradually [31]. Therefore, it is necessary to reduce the factors affecting erosion, and to increase and inject the deterrent in dust creation and stabilization.

4. Conclusions

The results of this work show that the studied area has a high level of erosion in the mentioned dust originates from the areas around Mighan playa. As we get closer to the Mighan playa, the amount of soil porosity increases, and as a result, we will have more eroded soil, and as the distance from the playa increases and we move towards urban or mountainous areas, the amount of eroded soil decreases. Despite the extensive efforts to stabilize the soil, annual dust is generated from this area. The findings of similar studies show that increasing soil salinity, which will increase with increasing drought, along with other factors such as the presence of sand and silt in acidic soil, despite the minimum amount of gravel and clay as the inhibitors of erosion and crop production, can increase erosion and dust production in the area. Increasing these factors near the Mighan playa has raised the rate of soil erosion and dust in the area. The main factor affecting the erosion rate is the presence of EC and Na in the area, which also increases the amount of soil osteoporosis. However, the presence of the inhibitors such as gravel, organic matter, and K or clay in the samples can be considered as a protective or reducing factor for erosion and sediment production in the area.

The high amount of sand in the samples has caused the instability of the soil texture. According to the studies conducted in the mentioned area, the soil in the areas around the Mighan Playa has special conditions that have increased the amount of dust production and damage to the surrounding cities. The growing trend of droughts increases the erosion and dispersion of the sediment particles in the air. The studied area has a dry climate. This area dries up and dries up every year in summer and autumn when the amount of rainfall decreases. Harvesting and moving soil by the Minerals Company increases dust production. Another limiting factor in the region is rising temperatures and drought in the recent years. As a solution, we can say that adding either of these three factors in the form of vegetation or spraying potassium as clayey or gravel minerals in the environment, as well as elevating the soil organic matter level, reduce sediment production, and thereby, reduce the level of dust in the environment.

Acknowledgments

The authors wish to gratefully acknowledge the support provided by the Department of Geology, Islamic Azad University, Science and Research Branch, Tehran, for the PhD thesis. We also wish to thank the Arak University of Technology for some data preparation.

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تأثیر خصوصیات فیزیکی-شیمیایی مواد بر فرسایش خاک معدنی اطراف شرکت املاح ایران در پلایای میقان، اراک، ایران

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ارسال ۲۰۲۱/۰۳/۲۳ پذیرش ۲۰۲۱/۰۶/۱۹

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چکیده:

در این مقاله عوامل مؤثر بر فرسایش خاک و اثرات آن بر تشکیل گرد و غبار در اطراف شرکت معدنی املاح ایران در پلایای میقان بررسی شده است. هفتاد نمونه به صورت تصادفی از عمق ۱۰ سانتی متری از سطح زمین در پلایای میقان برداشت گردید. برخی از عوامل خاک (نظیر تجمع ذرات، آهک، مواد آلی، *pH*، سدیم، پتاسیم، کلسیم و هدایت الکتریکی) تعیین و به روش های آماری نظیر ماتریس همبستگی و تحلیل خوشه ای جهت ارزیابی فرسایش خاک مقایسه گردید. نتایج نشان داد که درجه شوری خاک مهمترین عامل فرسایش و تجزیه خاک است. مقدار بالای ماسه سبب پایداری خاک شده است. عواملی نظیر مقدار شن و پتاسیم نقش کمتری در پایداری خاک داشتند. مقدار مواد آلی در اکثر نمونه ها کمتر از ۴ درصد بوده و نقشی در فرسایش خاک منطقه ندارد. میزان رس نمونه ها کمتر از ۱ درصد بوده و نقشی در چسبندگی بافت خاک ندارند. بنابراین، عوامل فرسایش خاک منطقه هدایت الکتریکی و سدیم است. عواملی نظیر شن، مواد آلی، پتاسیم و رس نقش محافظ خاک و کاهش دهندهٔ فرسایش خاک را به عهده دارند. نتایج نشان داد که فرسایش خاک ذرات دانه ریز را افزایش و گرد و غبار تولید می کند. وجود کانی های نمکی در خاک نیز به تولید گردو غبار کمک می کنند. بنابراین باید خاک های معدنی منطقه تثبیت شده و از تولید گرد و غبار در اطراف شرکت معدنی املاح ایران جلوگیری شود.

کلمات کلیدی: فرسایش خاک، آمار چند متغیره، عوامل فیزیکو –شیمیایی خاک، تولید گرد و غبار، پلایای میقان.