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Chemical and morphological characteristics of the crusts in sedimentary soils using a scanning electron microscope

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ABSTRACT: This study aimed to characterize the formation of surface crusts of arid soil (Typical Torrifluvents) of an alluvial plain in eight locations of Basra Province, in the southern region of Iraq. The unique and intriguing morphological and chemical characteristics were studied with an exceptional level of precision using a scanning electron microscope, ensuring the reliability and accuracy of the results. The crusts were identified as structural crust, puffy crust and salt crust, with thicknesses of 1.0-3.0; 0.5-1.5; and 0.2-0.4 cm, respectively. The depositional environment, particularly the kinetic energy of rainfall, plays an active role in the formation of structural crusts. The swollen crusts occurred in different spatial locations in small hills with cores. These areas are in the form of hills with coverings resulting from the processes of capillary rise of salts and the effect of the processes of evaporation and condensation of water, which leads to an increase in the size of the salt crystal embedded in the construction of these crusts. The salt crusts appeared in interconnected layers as relatively medium-sized crystals resulting from the evaporation of salt solutions in small lakes after rainfall; in this case, they appeared as fine salt crystals in areas affected by capillary rise. The size of the crystals depends on the purity of the salt and the evaporation rate of the salt solution. Scanning Electron Microscopy (SEM) showed that the structural crusts appeared as layers between the closely packed layers of the microplate structure, and the pores were very fine or narrow. The salt crusts showed very small salt crystals, and the crystal size is affected by the purity of the salt in the brine.
Keywords: soil crusts; soil porosity; raindrop pressure; infiltration; water evaporation; southern Iraq.

Características químicas e morfológicas das crostas em solos sedimentares usando microscópio eletrônico de varredura

RESUMO: Estudo objetivou caracterizar a formação das crostas superficiais do solo árido (Torrifluventes Típicos), de uma planície aluvial em oito locais da Província de Basra, na região Sul do Iraque. As características morfológicas e químicas foram estudadas usando um microscópio eletrônico de varredura. As crostas foram identificadas como crosta estrutural, crosta fofa e crosta de sal, com espessuras de 1,0-3,0; 0,5-1,5; e 0,2-0,4 cm, respectivamente. O ambiente deposicional tem um papel ativo na formação de crostas estruturais, além do papel da energia cinética da chuva, cujo efeito é superficial nessas crostas. As crostas inchadas ocorreram em diferentes localizações espaciais, na forma de pequenas colinas com núcleos. Essas áreas estão na forma de colinas com coberturas resultantes dos processos de ascensão capilar de sais e do efeito dos processos de evaporação e condensação da água, o que leva a um aumento no tamanho do cristal de sal imbutido na construção dessas crostas. As crostas de sal apareceram em camadas interconectadas como cristais, de tamanho relativamente médio, resultantes da evaporação de soluções de sal em pequenos lagos após a chuva; nesse caso, elas apareceram como cristais finos de sal em áreas afetadas pela ascensão capilar. O tamanho dos cristais depende da pureza do sal e da velocidade de evaporação da solução de sal. A Microscopia Eletrônica de Varredura (MEV) mostrou que as crostas estruturais apareceram na forma de camadas entre as camadas compactadas da estrutura de microplacas, e os poros eram muito finos ou estreitos. As crostas de sal apresentaram cristais de sal muito pequenos, e o tamanho do cristal é afetado pela pureza do sal na salmoura.
Palavras-chave: crostas de solo; porosidade do solo; pressão das gotas de chuva; infiltração; evaporação da água; sul do Iraque.

1. INTRODUCTION

Soil crusting is common in arid and semi-arid regions (CHEN et al., 2013; ASSOULINE et al., 2015; CHAMIZO et al., 2017). About 35% of these lands constitute agricultural lands, and their soil often contains a low percentage of organic matter (Chen; Cai, 2013), which leads to surface runoff and sheet erosion. Soil crusts are a major structural feature of topsoil and sediments and represent a major problem worldwide, especially in arid and semi-arid regions, because they play a major role in the movement of water and NUTRIENTS, enhance surface runoff, and hinder seed germination (ASSOULINE et al., 2011; LI et al., 2018; HOU et al., 2020)

Laker; Nortj (2019) indicated that the susceptibility of soil to crusting depends on external factors (precipitation factors), irrigation methods, and internal factors (soil factors).

Soil crusts can be distinguished into three types: chemical, physical, and biological. Chemical crusts are formed by covering the soil with salts in dry or semi-arid areas. Physical crusts are formed due to the deterioration of the surface soil structure and can be classified as structural or depositional. Structural crust: It is formed due to the direct impact of raindrops on the soil's surface (WILLIAM et al., 2018).

Depositional crusts are formed by the transfer and deposition of fine particles from eroded surfaces to areas of deposition. Both rainfall characteristics and soil properties influence crust formation. Heavy, condensed rain has high kinetic energy. This is mainly due to the large droplet size and high precipitation rate. Likewise, irrigation systems also play a role in the formation of the building crust and the distribution of the size of the droplets that reach the soil surface. The most important characteristics of the common Structural crust are a thin, dense layer with high strength, low porosity, and poor water conductivity. It is formed on the soil surface by rainfall and surface runoff. While biological crusts (biocrusts) are formed as a result of the activities and growth of bacteria, algae, and lichens, they are a collection of soil particles, the products of these microorganisms, and the microorganisms present in the first few millimeters of the soil surface, and they grow on the soil, especially those produced on low-permeable soil (HU et al., 2012; WEBER et al., 2022).

The formation of soil crust can reduce the soil water infiltration rate and influence the soil erosion process (ASSOULINE, 2004; PI et al., 2020). As for salt, crusts are found and formed in soils affected by soil salinization factors due to the capillary rise of salty groundwater or irrigation with salty water with poor leaching operations. As a result, salt crusts are formed in thin layers separated from the soil surface and in the form of salt crystals spread on the soil's surface. The conditions help this. Atmospheric conditions result from a lack of rain and salt-leaching processes. Soil salinization processes and the formation of salt crystals of some salts Na_2SO_4, NaCl, and the rest of the salts contribute to the formation of Puffy salt crusts. It is a mixture of soil materials with a mixture of salt crystals that are affected by wetting and drying, which lead to the expansion of these crusts. They appear in small domed hills whose height does not exceed 10 cm.

Therefore, this study aimed to identify the types of surface crusts in the soil and to study their apparent morphological characteristics. Microscopic measurements using a scanning electron microscope and their relationship to the chemical properties of soil to infer the processes and conditions that help in its formation.

2. MATERIAL E METODS

2.1Study area

The study area is located within the southern alluvial plain of the specified area between the banks of the river of the Shatt al-Arab and the floodplain and part of the flats of the Najd marsh from the north to the south, forming areas of land surrounding the Karma Ali River up to the end of the Abu Al-khasseb traps, in which secondary salinization processes prevail as a result of Capillary rising of Salin water from saline water table to the surface of soil which enhancing by groundwater movement and activity. The hairline rises to the soil's surface, helped by the high evaporation potential with little precipitation, less than 150 mm per year. (9.833 mm)., according to the station.

The climate of Basra International Airport and the temperature rate (18-33.9) °C range from a maximum of 4.4 °C in August to a minimum of 6.3 °C in January. These factors interact with the lack of vegetation cover, representing the nature of the levels and their relationship to the movement of water Total.

2.2. Sample collection

The samples were collected by relying on the satellite visual of Landsat 8 of the OLI sensor for the year 2017 after removing distortions resulting from multiple causes. The SI salt index was also adopted to separate the types of soils affected by salinity. They were initially classified into 10 classes, and then the closely related bands were merged to become 8 photographic units. Then, the salt index index was calculated from the equation = (Salinity Index = B3 * B4)/B2, as in Figure 1.

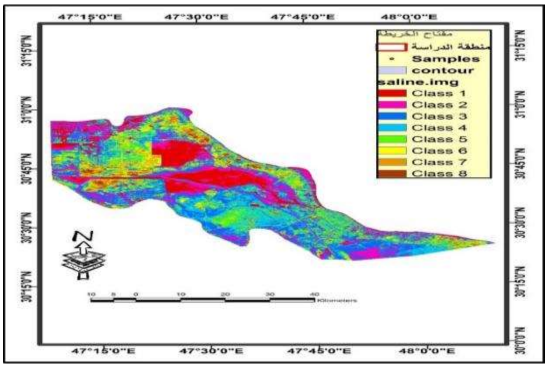

Figure 1. Spatial distribution of salinity index value categories: 8 categories.

Figura 1. Distribuição espacial das categorias de valores do índice de salinidade: 8 categorias.

The spatial distribution of the salt evidence sample is divided into 8 photographic units. Samples are taken from 0-5 cm depths, placed in suitable containers, and then transported to the laboratory for analyses and measurements.

2.3. Morphological description of the Crusting phenomenon

It includes measuring the horizontal dimensions and thickness of the crusts. The thickness of the soil crust was measured with a ruler. Samples were taken from natural crusts and included layers at a depth of 5 cm, according to their morphological description, structural, salty, or puffy. They were placed in nylon bags and numbered and classified according to location to conduct morphological and chemical tests and SEM microscopic examination. This microscope allows examination and analysis of the infrastructure's chemical, compositional, surface, and internal characteristics at micron and nanometer dimensions. The samples are dried well and covered with a thin gold-palladium layer. Before taking photos with the device

The scanning electron microscope (SEM) and the micromorphological characteristics were studied according to the method indicated by Xing et al. (2015) using a scanning electron microscope at the University of Basra, College of Pharmacy, with a JEOL JSM-IT300LV SEM device. Crust samples were taken, and a small piece of the top layer of the sample was carefully cut off and then mounted on the top of the heel of the microscope with a thin layer of gold cap. The prepared sample was placed in a scanning electron microscope (SEM). A series of vertical and horizontal photographs were taken. This is appropriate at a voltage of 5.00 KV, noting that there is more than one magnification power. This is done by placing 40 mg of crust in the scanner device, preparing the sample by pumping argon gas and nitrogen and transferring the sample to the device. Then, the sample will be transferred to the scanner, as shown in Figure 2.

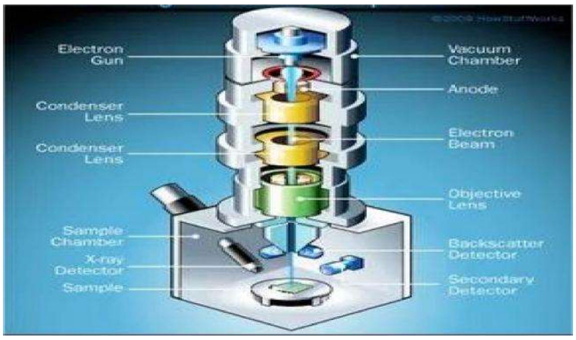

Figure 2. Parts of a scanning electron microscope Partes de um microscópio eletrônico de varredura. Fonte: Use of the scanning electron microscope at the University of Basra, College of Pharmacy, JEOL JSM-IT300LV SEM device.
Figura 2. Partes de um microscópio eletrônico de varredura. artes https://www.hazemsakeek.net

2.4. Chemical properties of salt crusts

Soil properties were determined using methods described before (BAO, 2000). Using the suspension (soil: water = 1:1), EC was in a 1:1 extract, while the ions of Mg^{+2} and Ca+2 were determined using the 1:1ration method, EDTA-Na+2. Na and K were estimated by measuring flame light. In the flame photometer, SO4-2 was determined by barium sulfate turbidity, Cl-1 was determined by silver nitrate titration and CO3-2 and HCO^{-3} were determined by equation titration with sulfuric acid.

3. RESULTS

Its horizontal lengths depend on several factors, the most important of which are the percentage of clay and solid carbonate and the dominance of binary ions Mg and Ca, which increase the strength of adhesion between soil particles (Table 1). At the same time, the presence of aggregates of sand and silt or some impurities such as organic matter or non-decomposed plant parts helps cause a weakness in the soil bonds, which increases soil cracks. These cracks are in fixed locations, as they close upon hydration and open upon drying due to the proportions of expanded clay minerals like smectite minerals.

The results in Table 2 and Figure 3 (1,2,8) show that the structural crusts appear as sheets of primary soil particles interspersed with cracks at different depths. These sheets appear in irregular geometric shapes and with different dimensions, and most of these crusts appeared in the sites of the northern part of the study area affected by secondary salinization factors. This made the soil relatively low-salinity and not hydrated, which led to drying out and cracking. Its horizontal dimensions range between (3-11) cm.

Table 1. Chemical properties of the soil crust.
Tabela 1. Propriedades químicas da crosta do solo.

Location	Layer Type	EC dsm^{-1}	Ca^{+2} Meq/L	Mg^{+2} Meq/L	Na^{+2} Meq/L	K Meq/L	CL^{-1} Meq/L	SO4 – Meq/L	HCO_3^{-1} Meq/L	$CO3^{-2}$ Meq / L
Al-Madina1	Structural crust	20.4	61.2	51	81.6	10.2	126	84	23.1	0
Al-Madina2	Structural crust	28.4	85.2	71	113.6	14.2	174	116	14	0
Al-adina3	Structural crust	25.3	75.9	63.25	101.2	12.65	156	104	13	0
Al-Sharish1	Puffy crust	27.2	81.6	68	108.8	13.6	168	112	15.2	0
Al-Sharish2	Puffy crust	29.6	88.8	74	118.4	14.8	180	120	17.0	0
Al-Sharish3	Puffy crust	35.5	106.5	88.75	142	17.75	216	144	16.4	0
Shafi1	Structural crust	28.5	85.5	71.25	114	14.25	174	116	26.1	0
Shafi2	Structural crust	18.7	56.1	46.75	74.8	9.35	114	76	17.1	0
Shafi3	Structural crust	23.6	70.8	59.0	94.4	11.8	150	100	14.5	0
Al-Dayr1	Structural crust	30.5	91.5	76.25	122	15.25	186	124	15.8	0
Al-Dayr2	Structural crust	25.5	76.5	63.75	102	12.75	156	104	12.8	0
Al-Dayr3	Structural crust	27.5	86.4	72	115.2	14.4	168	112	13.4	0
Basra Airport1	Salty	33.5	85	102	136	17	221	119	17.2	0
Basra Airport2	Salty	22.2	56.25	67.5	101.25	11.25	149.5	80.5	18.4	0
Basra Airport3	Salty	30.0	77.5	93	139.5	15.5	201.5	108.5	15.8	0
Shuaiba1	Salty	26.5	67.5	67.5	81	121.5	13.5	178.75	96.25	0
Shuaiba2	Salty	31.5	80	96	144	16	208	112	20.6	0
Shuaiba3	Salty	30.5	77.5	77.5	93	139.5	15.5	201.5	108.5	0
TalaaAl-Hamza1	Salty	33.0	85	102	153	17	221	119	17.2	0
Talaa Al- Hamza2	Salty	33.5	87.5	105	157	17.5	227.5	122.5	22.8	0
Talaa Al-Hamza3	Salty	34.5	85	100	162	18	224.25	120.75	22.6	0
Kut Al-Zein1	Puffy crust	24.75	65	78	117	13	159.25	85.75	19.6	0
Kut Al-Zein2	Puffy crust	26.6	70	84	126	14	175.5	94.5	21.6	0
Kut Al-Zein3	Puffy crust	25	67.5	81	121.5	13.5	169	91	20.8	0

Table 2. Morphological characteristics of the soil crust.
Tabela 2. Características morfológicas da crosta do solo.

Location	Layer width (cm)	Thickness of the layer (cm)		Crust type	Color in dry condition	Color in wet condition
Al-Madina1	2.5	2.5		Structural crust	6/1 Hue 10R	4/1 Hue 2.5YR
Al-Madina2		4	3	Structural crust	6/2Hue 5YR	3/1Hue 10R
Al-Madina3		4.5	3	Structural crust	6/1Hue7.5YR	4/1Hue 2.5YR
Al-Sharish1		3	0.5	Puffy crust	6/1Hue 2.5YR	5/1Hue 2.5YR
Al-Sharish2		3	1	Puffy crust	6/2Hue 7.5YR	6/1Hue 2.5YR
Al-Sharish3		8	3	Puffy crust	6/1Hue 7.5R	4/1Hue 10R
Shafi1		3	1	Structural crust	6/2Hue 10R	5/1Hue 7.5R
Shafi2		4	1	Structural crust	6/1Hue 7.5YR	5/1Hue 7.5R
Shafi3		3	1	Structural crust	6/2Hue2.5YR	5/2Hue 2.5YR
Al-Dayr1		4	2	Structural crust	6/2Hue 5YR	6/1Hue 2.5YR
Al-Dayr2		3	1.5	Structural crust	7/1Hue 5YR	5/2Hue 7.5R
Al-Dayr3		3	1.5	Structural crust	6/2Hue 5YR	5/1Hue 2.5YR
Basra Airport1		6	0.2	Salty	7/1Hue 7.5R	5/2Hue 10R
Basra Airport2		10	0.2	Salty	5/2Hue 7.5R	5/2Hue 10R
Basra Airport3		11	0.2	Salty	7/1Hue7.5R	6/3Hue2.5YR
Shuaiba1		3	0.2	Salty	6/2Hue 2.5YR	5/2Hue 2.5 YR
Shuaiba2		3	0.2	Salty	7/2Hue 7.5Y	6/2Hue 10YR
Shuaiba3		2.5	0.2	Salty	7/1Hue 7.5YR	7/3Hue 2.5 Y
TalaaAl-Hamza1		3.5	0.2	Salty	6/2Hue 7.5R	4/4Hue 10YR
TalaaAl-Hamza1		2.5	0.2	Salty	6/2Hue 7.5YR	4/3Hue 10YR
TalaaAl-Hamza1		8	0.2	Salty	6/2Hue 7.5R	4/3Hue 7.5YR
Kut Al-Zein1		3	0.5	Puffy crust	6/3Hue 10R	5/3Hue 2.5YR
Kut Al-Zein2		5	1	Puffy crust	6/3Hue 10R	4/4Hue 10YR
Kut Al-Zein3		5	1	Puffy crust	6/3Hue 10R	4/4Hue 7.5R

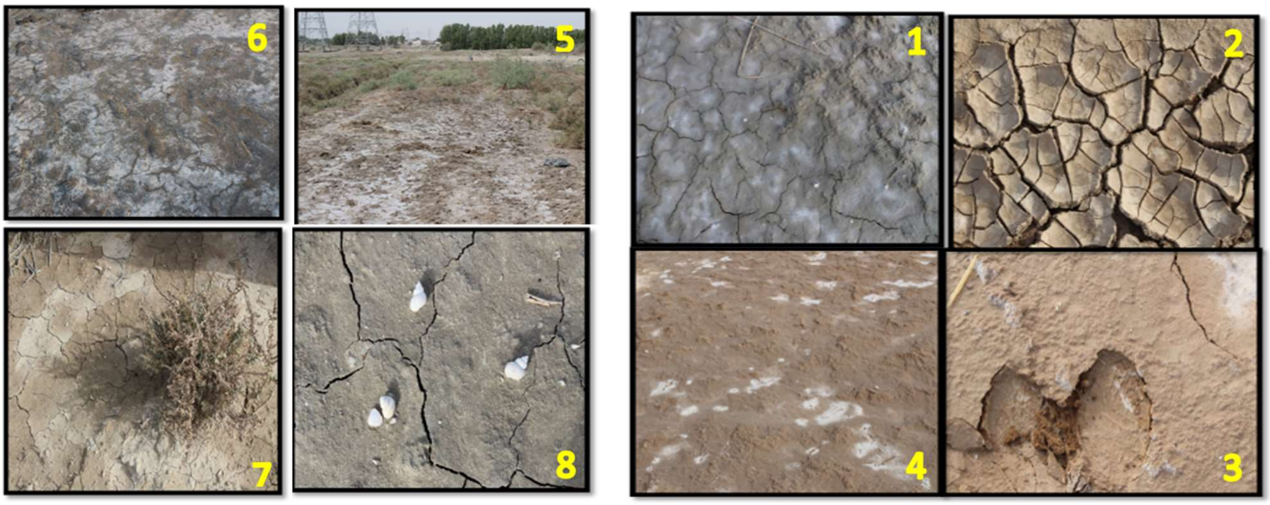

Figure 3. Some forms of salts in the study area (1,2, 8: structure cryst; 3: puffy crust; 4,5,6: salty crust).
Figura 3. Algumas formas de sais na área de estudo (1,2, 8: estrutura cristalina; 3: crosta fofa; 4,5,6: crosta salgada).

4. DISCUSSION

As for the thickness of the structural crusts, it is clear from Table 2 that their thickness ranges from (1-3) cm and that the highest thickness value is found in the northern areas of the study area in the city and Al-Dayr districts, the increase in the thickness of the structural crust is due to the intensity of the effect of the kinetic energy drop and the decrease in soil moisture content. And organic matter content and the stability of soil aggregates, where the movement of filtrate leads to the transfer of fine particles and their deposition between the soil pores and voids, forming a layer of low porosity and low permeability. This occurs as a result of the energy of falling raindrops or rapid flood irrigation (CHONG-FENG et al., 2013)

As for the puffy crusts, Table 2 and Figure 3 (3,7) in puffy soil, which consists of the process of the presence of Na_2SO_4 salts and successive cases of wetting at night and drying during the day, where the size of the Na_2SO_4 10 H_2O (Mirabilite) crystals increases at night, which causes pressure inside the crust, Formed between soil particles and salts, causing this crust to be drawn upward and bulge (LI and SUN, 2021). It consists of two layers: a disintegrated layer exposed to drought, especially on the surface, and moist saline soil (Moist), which has a compact, cohesive, moist surface often dark in color, watery, and sometimes hydrated. Very fluid due to the accumulated liquid liquefied salts absorbing air and humidity, making the soil appear wet.

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When drought occurs, a cracked salt layer and black soil appear on the surface, resembling wetlands in addition to the black color after irrigation, especially on the edges of irrigation lines and canals. These puffy crusts are found in parts of the study area, Al-Sharish, and Kut Al-Zein areas 1, 2, and 3. The horizontal dimensions of these crusts range between 3-8cm. These puffy crusts appear as covers of shallow hills whose height does not exceed 5 cm; they contain within them a mixture of mineral soil particles and salt components; the structure of the soil is of the pseudo-crumb type, and the thickness of these crusts ranges between (0.5-3) cm. The thickness of these crusts depends on the content of this crust of Na_2SO_4 salts, which turn aqueous at night to anhydrous during the day (ABBAS et al., 2020).

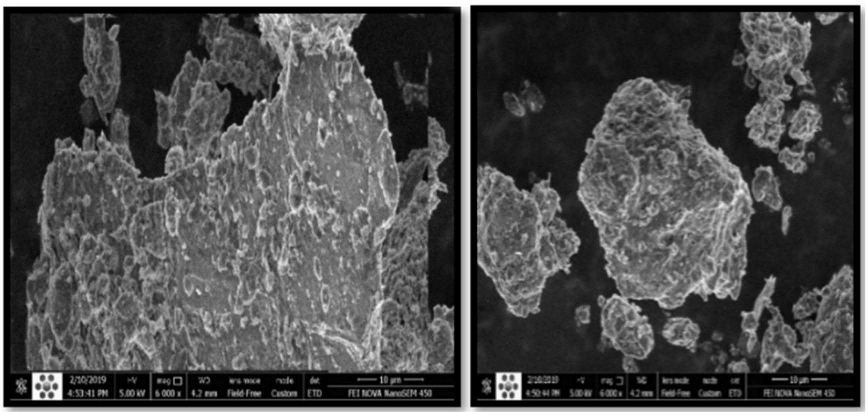

Figure 4. Some structural forms of salts are under the electron microscope.
Figura 4. Algumas formas estruturais de sais sob o microscópio eletrônico.

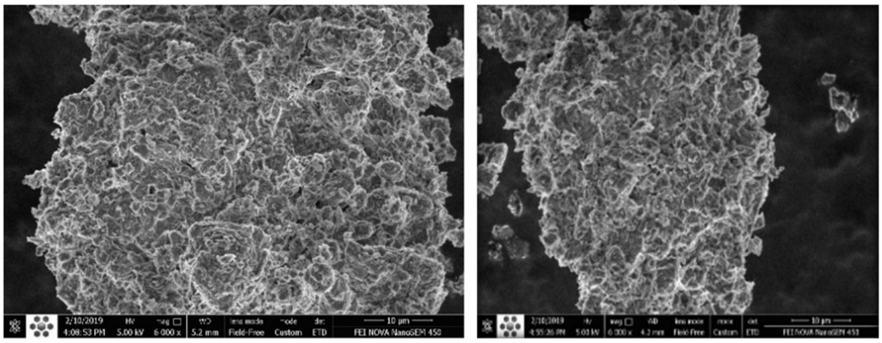

Figure 5. Some forms of dome salts are under the electron microscope.
Figura 5. Algumas formas de sais em cúpula sob o microscópio eletrônico.

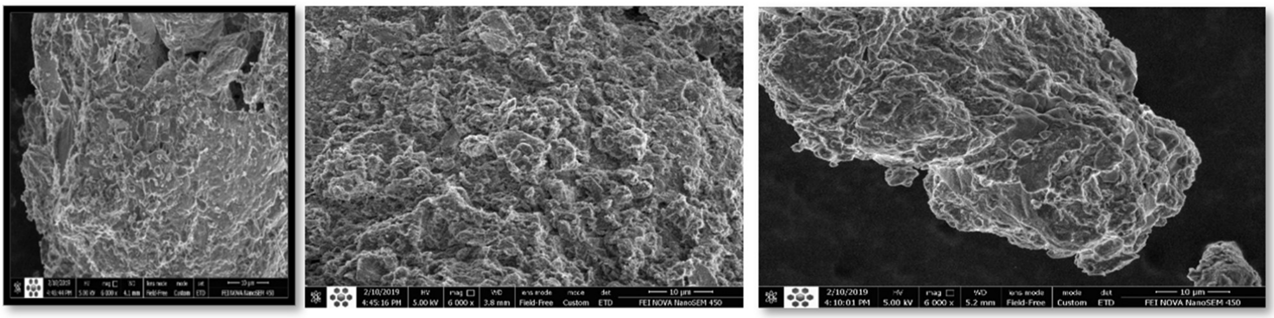

Figure 6. Some forms of surface salts are under the electron microscope.
Figura 6. Algumas formas de sais de superfície sob o microscópio eletrônico.

As for the salt crusts, Table 2 and Figure 4(6) Show the effect of low alleviation site and high water table levels on enhancing capillary rising at saltine water to the soil surface (Abbas et al., 2020). Their presence prevails in the southern part of the study area (Shuaiba, Basra Airport, Talaa Al-Hamza and Kut Al-Zein), where secondary salinization processes are most severe.

Therefore, salt crusts appear in several forms depending on their horizontal dimensions. Some are thin white crusts with a shiny surface, smooth to rough. Their roughness depends on the purity of the brine solution saturated with the prevailing salt. Their dimensions are identical to the shape of the water ponds resulting from the collection of rainwater before it dries; these crusts are thicker than the second type of crusts, which appear in the form of fine pieces or strips of salt, are made up of small, dispersed salt crystals resulting from the capillary rise of the salty water table during the dry period. The horizontal dimensions of the salt ponds range between (2.5- 10 cm) while the salty crust strip from a horizontal distance reaches several meters, with a thickness(of 2-5)mm, and this thickness does not represent all Salts accumulated on all the surface of soil rather, there are many quantities distributed in the voids and pores of the shallow depth of these soil as fine crystals or salt mycillium, the results showed the color of structural crust ranged between yellowish brown to between orange with hue 10R-2.5R. In contrast, the color becomes dull as salt concertation increases to (2.5R-5YR), especially in a greater presence of alkaline hydrolysis salt. This leads to dissolving humic acids and giving a dull color to the soil.

The puffy crust showed brown to dark brown (2.5YR-10R), and the darkening of color increases with the increase of alkaline salts that dissolve humic acids. As for salt crusts of 2.5 or 7.1 YR, and 7.5 R, they are pure salt crusts with crystals of salts that change to dark colors of 5,2.5 YR when impregnated with solutions of organic acids that dried after dissolving. As for the color of the domed crusts, it ranged between 10-2.5 and 10-7.5 YR. This color is brown to heavy brown due to the lack of organic acids in the soil.

4.1. Micromorphological characteristics / scanning electron microscope

Pictures and figures 1-4 show the results of Scanning Electron Microscope (SEM) sections of structural crusts with different magnifications. 1000X magnification, the image showed the horizontal dimensions of the secondary crust form consisting of lamellar layers; their horizontal dimension was higher in AL-Dayr soil than in AL-Medina soil; this is due to the variation in the weakness of binding material between these soil, in addition to the effect of the kinetic energy of falling raindrops with the dominant of clay that spread in pores forming these crust. Also, there is another effect the sedimentary environment has on the formation of structural crusts, as it is dried marsh soil; generally, the structural crusts are arranged vertically, similar to shist sheets. Still, they are the weakness of the binding materials in the AL-Dayr soils due to the increased Na concentration.

In addition to the effect of the Kinetic energy of falling raindrops, with the dominance of clay that spreads in the pores, forming these crusts, we notice that these sheets are arranged horizontally, similar to Shists sheets, but they are thicker; this is due to the effect of water nature when depositing these materials, the source of the conveyor, and its speed, as it is dried marsh soil. Convergence at the speed of the water carrier, in addition to the convergence in the texture of the transported materials, which deposited clay particles with the highest percentage compared to silt and sand in the crusts of the AL-Dayr and Shafi soil, and finally, the crusts of the Medina area, as is evident from the images under the scanning electron microscope. Image enlargement 12000X

A vertical section of the crust showed that the two fine layers differ in the collection and distribution of pores and appear brighter. This discrepancy between the interstitial pores and their size between the upper and lower parts of the slice is the presence of deposits of salts that filled the fine pores, which appeared in the form of thin salty hypnas under the surface. In the first part of the slide, the salts were lower hifat, possibly due to the effect of light surface washing, which caused the removal of salts from the surface layer or the scattering of light salt crystals from the surface. BELNAP et al. (2001) indicated that this structural crust is formed in soils with low organic materials and high amounts of silt.

The morphology of the puffy crust was analyzed using a scanning electron microscope (SEM), which showed that the typical pores of the salt crust are much smaller than those found in the underlying soil (NOROUZI et al., 2013). There is a capillary flow of water from the wet soil to the salt crust, which agrees with GUPTA et al. (2014) and VETTER et al. (2017). The salt of sodium chloride and sodium sulfate precipitates as heterogeneously packed cubic crystals through interconnected pores and channels that vary in size from micrometers to millimeters. As well as the precipitation of salts and the formation and development of the puffy crust, separate puffy results from three apparent pairs: advection and diffusion, water evaporation and condensation, and dissolution and precipitation.

The formation of the crust depends on the rates of diffusion or evaporation, especially when evaporation is rapid from the monohedral saline solution and forms from micrometers to millimeters of cubic crystals in the form (sodium chloride salt crystals and sodium sulfate). Evaporation helps the saline water through the salt crust and supports the growth of the crust; after its separation from the surface of the soil, the salt crust with soil moderate may continue to move due to the condensation of water and dissolution of the salt at the bottom of the crust, with the continued transfer of the salt solution moving through the crust driven by the moisture gradient. Larger salt crystals form during low evaporation rates. A salt crust saturated with sodium chloride may occur under the crust, from the soil surface, when water vapor condenses and the salt liquefies below the crust. The salt solution moves through the crust driven by the humidity gradient and the persistence of atmospheric humidity. This transport mechanism enhances the sodium chloride and sodium sulfate crust. The crust tends to form domes on the surface, so there is no direct contact between the evaporating soil and the salt crust. Li; Shi (2019) also confirmed that the puffy salt crust on the surface of the alluvial soil formed a semi-insulating layer above the soil surface that reduces the transport of salt water via capillary flow (LICSANDRU et al., 2019), as well as NACHSHON et al. (2018) demonstrated that salt domes may not prevent evaporation if porous salt columns are present because water is transported to the air through these columns by liquefaction. One of the Figures 3-5 is that increasing the concentration of salts in Kut Al-Zein causes particles to form parallel sheets glued to each other with small spaces between them, forming a denser texture. Therefore, when the sodium chloride concentration increases, the ions exchange between the soil and the pores increases the particle's degree of Flocculation and adhesion (KAYA et al., 2006).

The shapes in Figures 3(6) show the surface salt crust study area, there are layers of crystallized at southern locations of the study area, where there are layers of crystallized salts; the most dominant salt is sodium chloride, with layers of crystals generated due to the low evaporation rate and the dominance of NaCl compared to another Salt. The Formation of an accumulated layer of salt deposition in these southern cations of the study area, especially in the sites of small ponds while at the northern location of the study area (AL-Dayr, Medina, and AL-Shafi due to the high dryness which led to generated of salt crust consist of nano to fine crystals The shapes Figure 3 Surface salt crusts at southern locations study area (Basra Airport, Shuaiba, and Talaa al-Hamza) show special layers on the soil surface consisting mainly of crystallized soluble salt the most dominant salt is sodium chloride. The lower the evaporation rate from the soil surface, the larger crystals are generated. The salts formed are larger due to the greater degree of purity of NaCl because most of the water contains more. The emerging crystals are larger, and the evaporation conditions help this - transpiration in southern Basra is lower than the degree of evaporation in Al-Shafi and Al-Dayr because they are marshes exposed to drought.

The formation of accumulated layers also indicates a chronological sequence of salt deposition in the southern regions, especially in the sites of small ponds. Talaa Al-Hamza, Kut Al-Zein, Basra and Shuaiba Airports. The reason is that the soil is wet most days of the year. It has energy that reduces the energy of rain falling due to wet soil. It reduces rain falling when it collides and reduces the phenomenon of splashing. It occurs when the soil becomes dry, but when wet, it absorbs the rain energy, preventing the salt crystals from collapsing and mixing with the silt and clay particles, making them interconnected and sequential layers .As for the northern areas of Dayr, Medina, and Al-Shafi, due to the high dryness of the soil and the occurrence of rain energy. More soil particles are dispersed in the form of crystals, as shown in Figure 3. From high magnification 600 The result of the process of dissolution after raindrops fall on the surface salt crusts, as can be seen from these shapes, and the amorphous deposits of thin, amorphous films, which is a process that precedes the formation of nanocrystals. This results from rapid, short drying while mixing with air

4.2. Chemical properties of the peel

Table 1 results indicate that the EC for the surface layer 0-5 cm from the soil surface ranged from 36.5-18.7 dSm^{-1} and that all of them are located within highly saline soils according to the classification of salinity units prepared by the Division of Soil Survey, Land Classification, and Hydrological Investigations in the Environmental Studies Department in the Engineering Design Center of the Iraqi Ministry of Water Resources Solar, 1982.

As for the spatial distribution of salinity values and the concentrations of dissolved elements associated with them, they did not show a specific pattern of spatial distribution but rather showed clear variation, and this is subject to the influence of soil processes or characteristics and its role in the activity of the secondary salinization process, represented by the activity of capillary, the proximity of water table, and low rates of soil leaching, except for the southern part of the sites located in the far south of the study area, represented by the Basra Airport area, Shuaiba, and Talaa al-Hamza, which showed the highest salt concentrations due to this being linked to the high concentration of salts in the water table in these locations.

The soils showed differences in electrical conductivity values depending on the type of soil crust present. Structural crusts with a range of 25.711 m mohs Cm^{-1}, while salinity increased in soil containing fewer salinity crusts with a range of 25-35.5, with an average of 28.108, while soils containing salt crusts showed the highest salt concentrations, ranging from 36.5-22, with an average of 30.8, this indicates that structural crusts only occur in soils whose salinity is Rather low, with the presence of structure that allows the movement of leaching to infiltrate from soil surface to the subsurface depth water, of saline and dome soils, the structure deteriorates, and the soil surface approaches a state in which the hydraulic conductivity is low or very poor, which does not allow the formation of structural crusts, but rather activates the reverse movement. From bottom to top for salts

There is a predominance of sodium ions for all sites; their concentration ranges between (162-74.8) and an average of (121.093). The sodium concentration increases concerning cations in the northern part (the Medina, the Dayr, and Al-Shafi) of the study area, constituting 45% of the total positive ions in the southern part. At the same time, calcium ions ranked second after sodium from the northern part of the study area with a percentage of 30%, followed by magnesium ions with 25%. The lowest percentage is the potassium ion at 6%. In comparison, the magnesium ion ranks second at 30% in the southern part, followed by the calcium ion at 25%, and the lowest is the potassium ion at 5%.

The variation in the values of calcium and magnesium concentrations between the northern part and the southern part is due to the source of the salts in the northern part being continental. In contrast, salts in the southern part are marine sources, as calcium and magnesium ions increase in these areas. As for the negative ions, they followed the following order in terms of concentration: $Cl^{-}>SO_4^{-2}>HCO^{-3}$, in different percentages between the locations or northern parts than the southern parts, as their percentages reached 54, 36, and 9%. For chloride, sulfate, and bicarbonate, respectively. In the southern part of the study area, the percentages and concentrations of chloride ion, sulfate, and bicarbonate, respectively, increased. This indicates that the sources of salts in these areas are primarily sodium chloride salts, followed by sodium and magnesium sulfates.

5. CONCLUSIONS

Simple morphological criteria were used to describe a wide range of soils. Surface crusts are formed on clay soils in all locations, and the arrangement of coarse and fine particles (relevant distribution pattern, orientation and distribution). Several types of crusts may be related to our current knowledge of crustal processes determined by all soil and environmental conditions (structure crusts, puffy crusts, and salt crusts). The character of these crusts reflects the influence of the properties of the soil, its texture, and the nature of the depositional environment of the source material, being a depositional water environment.

The effect of salinization processes due to the capillary rise of the water table and the prevalence of dry conditions helped reduce organic matter, salt accumulation, and poor soil structure. Such a system appears to be relevant for predicting the susceptibility of soil crusts and the associated degradation stage, providing valuable information for predicting soil evolution.

After spraying and filtration due to the effect of raindrops, the kinetic energy of raindrops was the main factor in forming the structural crust in soil with a weak structure.

The scanning electron microscope allows good-resolution observation of the simple packing arrangement of particles or crystals in crustal samples.

When there is only one type of salt crystal, the microstructure of the salt crust is uniform and appreciation

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