Description and Classification of Soils in the Al-Mahawil District, Babylon Province, Iraq

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Abstract

A field experiment was conducted to describe and classify soils in the Mahawil district of Babylon province. This area is situated in the eastern and northeastern part of the province, between longitudes 44°41′28" to 44°45'20" and latitudes 32°46′54" to 32°36'21". Four soil pits were dug for morphological description as part of a semi-detailed survey utilizing a free-lance soil survey method. Soil samples were collected and analyzed to assess texture and various chemical properties.

The study revealed that the soils in this region were characterized by flat topography, with medium texture in the upper horizons that transitioned to finer texture in the deeper layers. Additionally, the soils exhibited moderate natural drainage. Chemical property analysis indicated a significant decrease in salinity, organic matter, and cation exchange capacity with increasing soil depth, while calcium carbonate and pH values increased with depth. Based on the findings, the soils were classified at the sub-group level as Typic Torrifluvents, indicative of alluvial soils formed from transported fluvial deposits.

Keywords: Classification, Morphological Description, Survey, Torriflevents, Al-Mahawil.

Introduction

Soils, as natural entities, exhibit characteristics that stem from pedogenic processes shaped by various environmental factors, including climate and biological conditions. These factors drive specific changes in the layers of the parent material from which soils develop. Even though many soils may have similar general characteristics, like climate, vegetation cover, and natural drainage, they might come from various materials and generate diverse types of soil. This reflects the influence of materials on soil formation to some extent within the transitional zone and the impact of neighboring areas (1,2).

Alluvial soils are newly formed soils resulting from the accumulation of sediments carried by rivers, exhibiting a range of textures. They exclusively occur in regions where rivers are present or where floods have taken place. The texture of these soils tends to become finer as you move further away from the riverbank. Although they can be quite deep, the depth of groundwater can vary significantly. These soils are typically found in flat landscapes and are known for their fertility and productivity. However, they face various challenges depending on their location. In riverbed areas, they are susceptible to flooding, while in other regions, they may experience saline conditions (3). Significant variations in the morphological features of the soils on the inheritance and development of particular alluvial soils in central Iraq, both vertically within individual sites and horizontally across

different locations (4). These differences were attributed to the proximity to and distance from the sediment source. The textures of the examined soils varied from fine to moderately coarse, with a predominant tendency toward a mixed type, characterized by a high calcium content.

Soil is regarded as a critical resource, particularly in agricultural contexts, and exists in various forms. Specialists in soil management classify soils to enhance our understanding of the types present in a specific geographical area. Land classification entails assessing its suitability for agricultural activities, with these classifications derived from an examination of both the economic factors influencing soil uses and the inherent properties of the soil. Due to the challenges associated with estimating economic productivity, emphasis is placed on soil characteristics and properties, as they are fundamental determinants of productivity potential.

Soil resource management operations, regardless of their objectives and procedures, are incomplete and ineffective without organized and accurate surveys that clarify the geographical distribution of soils across various landscapes. This involves first identifying the factors and processes that contribute to soil formation and second cataloging their properties in a way that supports their use. Thus, the study was conducted to highlight the soil types and their spatial distribution in the area, provide a detailed description of the soils at the study sites, and offer general recommendations for developing effective management programs.

Material and methods

The study area is located in the Al-Mahawil district of Babil Province in central Iraq. It occupies the eastern and northeastern parts of the province, taking on a rectangular shape that extends in a northwestern-southeastern direction. The center of the study area is approximately 20 km north of the city of Hilla and about 80 km from the capital, Baghdad. West, the Al-Hilla River borders the area, which is an important tributary of the Euphrates River in this region. To the north, the main outlet marks the boundary between the lands of the study area and the Al-Suwaira district, which is part of Wasit Province. (See Figures 1)

Field procedures

Identified four profiles for the study area, and a semi-detailed survey was conducted using the freelance soil survey method. A soil survey map prepared by (5) was utilized, and the locations of the sampling sites were determined using the GPS with UTM coordinates. The following activities were carried out:

Morphological Characteristics

The soils at the selected profiles were described, and soil samples were collected from the identified horizons. Based on their characteristics, the soils were classified to the sub-group level according to the guidelines of the Soil Survey Staff (6).

Laboratory Procedures

Samples of soil were pulverized, dried, and then run through a 2 mm filter to examine a number of physical and chemical characteristics. According to (7), the hydrometer method was used to ascertain the volumetric distribution of soil particles. A pH meter was used to measure the pH of the soil using the procedure outlined in (8). Jackson (8) measured electrical conductivity (ECe) in a saturated soil paste extract using a conductivity bridge electrical instrument. The cation exchange capacity (CEC) of ammonium acetate (NH4OAc N=1) at pH 7.0 was determined using the procedure described in (7). Hydrochloric acid (11N HCl) was used to determine the amount of calcium carbonate (CaCO3), and any remaining acid was neutralized with NaOH (N1). The wet digestion method, as described by Walkley and Black and cited in (8), was used to estimate the soil's organic matter (OM) content.

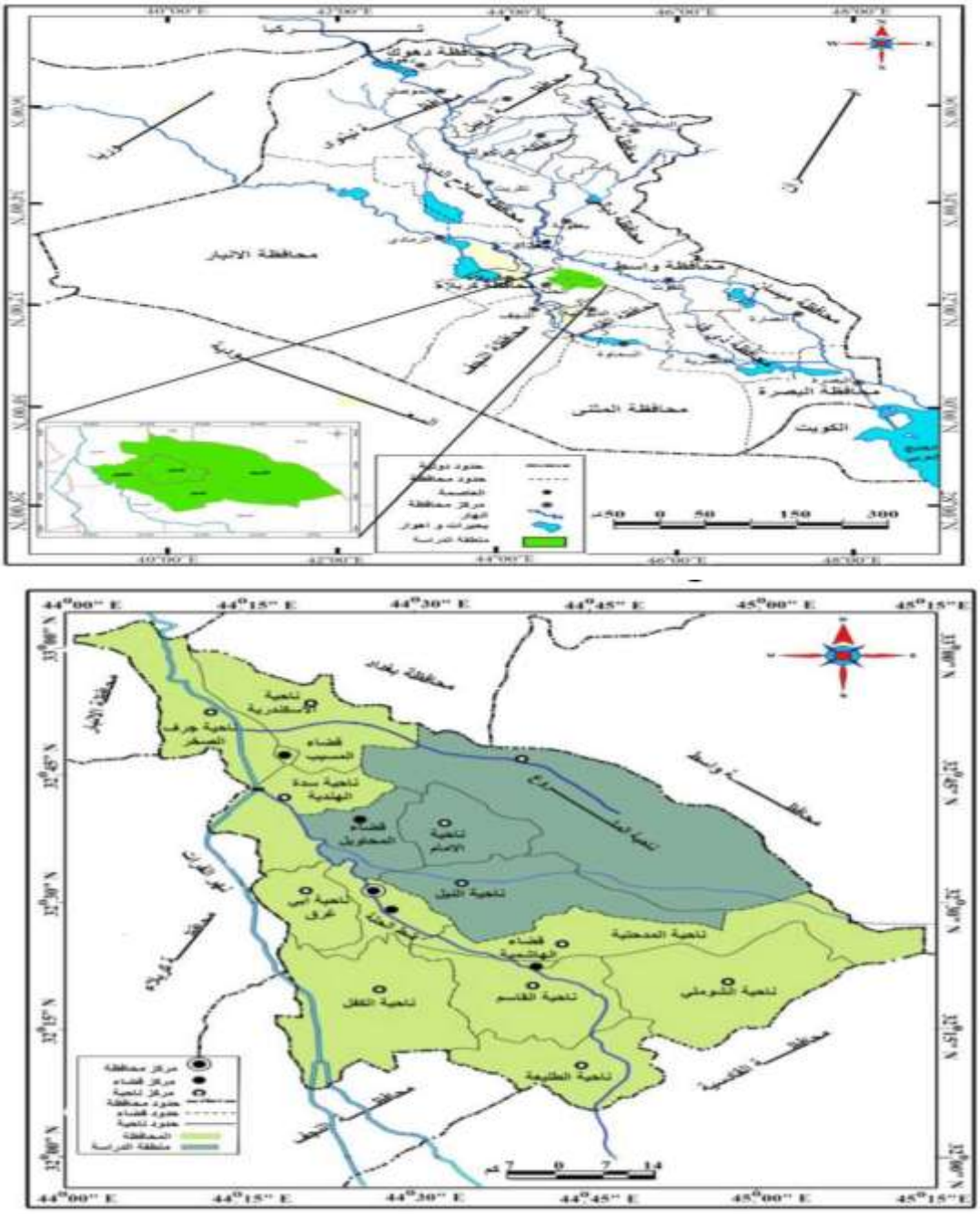

Figure (1): Location of Al-Mahawil District in Iraq

Results and Discussion

1- Physical and chemical and properties

The physical and chemical characteristics of the soil profiles were displayed in Table 1. In the first horizon of the second profile, the soil salinity values were 18.19 dS.m-1, while in the last horizon of the first profile, they were 5.09 dS.m-1. The low physiographic location, which creates transitional zones between irrigation basins and depressions, the high clay content, and the activity of capillary characteristics are all responsible for the high salinity, which resulted in salt accumulation on the surface. Conversely, the higher physiographic position, which creates terraces for rivers and irrigation channels, as well as the soil texture, which promotes increased salt leaching when water is available, are the main

causes of the low soil salinity values (9, 10). According to (11), the pH range for calcareous soils is normally between 7 and 8.4, and the values displayed for this attribute ranged from 7.82 to 7.14. This is a result of these soils' ability to serve as a buffer, maintaining pH levels within this range due to the presence of bases, especially calcium from the carbonate minerals they contain. Across all soil horizons under study, the cation exchange capacity values varied from 25.01 to 14.92 cmol charge.kg^{-1}. Since clay content and cation exchange capacity are directly correlated, larger levels of this property have been associated to clay content (12). The study area's soil horizons had varying carbonate mineral contents, ranging from 26.59% to 22.09%. This is typical of calcareous alluvial soils in the Iraqi alluvial plain, where secondary precipitation from soil solution and its accumulation in the soils, along with the soils' calcareous parent material origin, cause the carbonate mineral content to rise (13). While the values of calcium carbonate and pH increased with soil depth, it was observed that the values of chemical characteristics including salinity, organic matter, and cation exchange capacity clearly decreased (14,15). Sand content ranged from 127.5 g kg^{-1} in the second horizon of the second profile to 434.3 g kg^{-1} in the last horizon of the fourth profile, indicating a considerable variation in the percentage of soil components in the profile under study. The processes of sedimentation and geographic location have an impact on this variation in sand content. The third profile's second horizon had the highest clay concentration, 438.1 g kg^{-1}, while the fourth profile's fourth horizon had the lowest, 153.9 g kg^{-1}.

A range of textures, from coarse to medium to fine, were seen in the profile in the study region. This diversity results from the soils' placement within different pedological and physiographic units, the mechanism of sediment transport, and the varied sedimentation periods during which they were produced. Alluvial soils differ from other soil types in that they have this kind of textural variety (16, 17).

The purpose of this study is to investigate the distribution of soil texture throughout the study region as well as the differences between locations. The processes of soil formation, sedimentation features, and the elements affecting the development of these textures, as well as their impact on the sedimentation patterns in the profile under investigation, will all become clearer with an understanding of these elements (18).

Table (1): The physical and chemical properties of the soils.

Location	Horizon	Depth(cm)	pH	ECe dS.m^{-1}	O.M %	CaCO3 %	CEC cmolc.kg^{-1}	Soil particles gm.kg^{-1}			Soil texture
								sand	silt	Clay	
44°41′28 32°46′54	Ap	0-33	7.14	10.93	0.86	21.44	20.83	384.3	230.1	385.6	CL
	C1	70-33	7.35	8.87	0.75	23.03	17.05	394.5	386.4	219.1	L
	C2	120-70	7.62	5.65	0.59	25.09	15.02	309.8	478.7	211.5	C
	C3	120+	7.74	5.09	0.59	25.95	14.92	347.2	425.9	226.9	L
44°39′43 32°39′40	Ap	35-0	7.17	18.19	0.87	21.62	24.85	198.6	445.8	355.6	SiCL
	C1	65-35	7.28	12.28	0.76	22.81	22.65	127.5	497.9	374.6	SiCL
	C2	110-65	7.3	9.34	0.69	23.95	22.21	425.	348.	226.	CL

			6					2	2	6	
	C3	110+	7.45	6.17	0.55	25.01	18.55	373.5	458.2	168.3	C
44^{0}51'45''	Ap	30 – 0	7.32	17.95	1.01	22.43	25.01	168.7	478.9	352.4	C
32^{0}36'53''	C1	65 – 30	7.53	12.82	0.64	22.09	24.25	149.6	412.3	438.1	SiC
	C2	100 – 65	7.61	8.19	0.54	23.18	21.94	174.2	398.7	427.1	SiCL
	C3	100+	7.64	7.34	0.35	24.73	21.19	159.5	421.9	418.6	SiC
44^{0}45'20''	Ap	32 – 0	7.82	14.02	1.24	22.54	17.92	432.9	327.5	239.6	CL
32^{0}36'21''	C1	67 – 32	7.67	10.04	0.89	23.67	23.95	185.7	498.6	315.7	C
	C2	109 – 67	7.41	9.14	0.85	24.68	18.36	389.9	399.8	210.3	CL
	C3	109+	7.39	7.59	0.62	26.59	15.56	434.3	411.8	153.9	C

2- Morphological Description of Soil Units in the Study Area

The identification of soil types, their locations, and their distribution from a pedological standpoint forms the scientific basis for soil survey processes, according to (19). In this study, the characteristics of each soil unit were defined across four profiles, including the general morphological characteristics of the soil surface and the amount of natural vegetation compared to irrigated soils, which exhibit higher fertility and less degradation, and saline and non-irrigated soils.

Overall, the soils in the area are sedimentary, with texture variations influenced by different sedimentation processes and the nature of the transporting medium. This has resulted in stratification, a characteristic feature of these soils (20). Notable morphological chemical characteristics include pale-colored nodules, primarily composed of calcium carbonate, suggesting that calcification processes are significantly more dominant than other pedogenic processes, with the parent material being calcareous alluvial.

The study area is characterized by a dry climate, sparse natural vegetation, and a reliance on the cultivation of annual plants. Saline compounds are often transferred from abandoned soils to cultivated areas. Despite the prevalence of calcium carbonate, there is no distinct surface diagnostic horizon, instead, the dominant horizon is the ochric horizon, which is poorly developed and pale in color unless influenced by organic materials or continuous cultivation, which can lead to a darker brown hue. Furthermore, there is a complete absence of developed subsurface diagnostic horizons (21,22).

The soils were classified according to the modern USDA 1993 system at the subgroup level. The following is a description of the soil profile of the study area:

1- The first profile

Classified under the major group Typic Torriflevents, it is a alluvial soil formed from transported fluvial deposits, with a medium texture in the upper horizons while the deeper horizons have a fine texture. Its natural drainage is good, with a slope of 2-1%. The color of the upper horizon is light brown when dry and brown to dark brown when wet, with no signs of mottling within the classification profile. The consistency ranges from non-sticky to slightly sticky when wet and is very friable to friable when moist. The structure is blocky with rounded edges in the upper horizon and structureless in the deeper horizons. The natural vegetation consists of thorns, and it is cultivated with wheat and

barley in the winter season and vegetable crops in the summer season.

Morphological description of soil profile No. (1)

Profile No: 1
Classification: Typic Torriflevents.
Location: Hilla, 44°41′28 N 32°41′54E
Date: at 23/11/2022
Vegetation: Barley, Wheat.
Climate: semi-arid.
Erosion: Nill
Parent material: Alluvium.
Topography: Nearly level.
Moisture condition: Irrigated farms.
Physiography: Mesopotamia plain.
Slop: Gently Level.
G.W.D: 180 cm
Drainage: Moderately well drained.
Salinity: saline soil

Horizon	Depth (cm)	Description
AP	0-33	Dark yellowish brown (10YR3/6) d layer; brown to dark brown (10YR4/3) m layer; numerous medium and fine roots; clay loam; moderately fine granular structure; rather sticky; friable; calcareous; mildly alkaline; abrupt smooth border;
C1	33-70	Loam, calcareous, slightly sticky, friable, yellowish brown (10YR5/4) m layer, weak fine subangular block formations, weakly alkaline, and a distinct, smooth border.
C2	70-120	Structureless, clay, yellowish brown (10YR5/4) m layer, very friable, mildly alkaline, non-sticky, calcareous, with a distinct, smooth border
C3	120+	Loam; friable; mildly alkaline; non-sticky; calcareous; brown (10YR5/3) m layer; weak fine subangular blocky structures

2. The Second Profile

It belongs to the alluvial Typic Torriflevents type, which is made up of materials deposited by rivers. Its texture is fine in the deeper horizons and medium in the deeper horizons. The natural drainage is moderate, with mottling occurring at a depth of 90 cm within the profile. The slope is between 1-2%, and the upper horizon appears light brown when dry and yellowish brown when wet. The texture is crumbly and light in the upper layer, while it becomes cohesive and sticky in the deeper horizons. The structure is medium granular in the upper horizon, transitioning to blocky with rounded angles and edges in the deeper layers. The natural vegetation consists mainly of yellowish grasses, and this soil is used for cultivating wheat in the winter and various vegetable crops in the summer.

Morphological description of soil profile No. (2)

Profile No: 2
Classification: Typic Torriflevents.
Location: Hilla 44°39′43 و 32°39′40
Date: 23/11/2022
Vegetation: Wheat, clover
Climate: semi-arid.
Erosion: Nill
Parent material: alluvium.
Topography: nearly level.
Moisture condition: Irrigated farms.
Pysiography: Mesopotamia plain.
Slop: Gently Level.
G.W.D: 160 cm
Drainage: Medium

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Salinity: saline soil

Horizon	Depth (cm)	Description
AP	0-35	Pale brown (10YR 6/3) d layer; brown (10YR 5/3) m layer; silty clay loam; friable; slightly sticky; common fine roots; calcareous; abrupt smooth border; moderate to medium granular structure
C1	35-65	The layer is dark yellowish brown (10YR 4/6) m, has a moderate to medium angular blocky structure, silty clay loam, few fine roots, is sticky, calcareous, mildly alkaline, hard, and has a smooth, distinct boundary.
C2	65-110	Layer of brown (10YR 5/3) m; weak medium Subangular blocky structure; clay loam; non-stick; very friable; calcareous; somewhat alkaline; mottled at 90 cm with a few fine, definite (10YR 2/1) m layers; distinct, smooth border
C3	110+	Moderately medium subangular blocky structure; clay; slightly sticky; mildly alkaline; friable; calcareous; dark yellowish brown (10YR4/6) m layer.

3- The Third Profile

This profile is classified as Typic Torriflevents, which are recent alluvial soils formed from alluvial materials deposited by the Euphrates River. These soils are located in areas surrounding the northern and southern drainage systems (river basins). The soil profile consists of a single classification layer with predominantly fine textures throughout the horizons. Internal drainage is moderate, and the terrain is nearly flat, featuring a slope of 1-2%. The surface horizon appears light brown when dry and brown when wet. While the texture is mostly fine across most horizons, the surface layer has a medium texture. Mottling occurs at a depth of 72 cm. The texture ranges from slightly sticky to sticky when wet, becoming cohesive when moist. The upper horizons have a granular structure, transitioning from blocky with rounded edges to blocky with sharp angles in the deeper layers. Dominant vegetation includes thorny plants, wild artichoke, and bulrush. This soil is utilized for cultivating wheat and barley in winter and vegetables in summer.

Morphological description of soil profile No. (3)

Profile No: 3
Classification: Typic Torriflevents.
Location: Hilla $44^0$51'43" و $32^0$36'59"
Date: 23/11/2022
Vegetation : Wheat, barley.
Climate: semi-arid.
Elevation: 27m.
Erosion: Nill
Parent material: alluvium.
Topography: nearly level.
Moisture condition: Irrigated farms.
Pysiography: Mesopotamia plain.
Slop: Gently Level.
G.W.D: 270 cm
Drainage: Moderately well drained.
Salinity: saline soil

Horizon	Depth (cm)	Description
Ap	0-30	Light brown (7.5yr6/4) d, brown (10yr5/3) m ; clay ; Moderately; granular in structure; fine; friable; calcareous; slightly sticky; with many medium and fine roots and a smooth, abrupt border .
C1	65 – 30	A dark brown (7.5 yr3/4)M; blocky construction with a moderate to subangular shape, silty clay, friable, few fine roots, calcareous, slightly alkaline, sticky, and a smooth, distinct boundary.
C2	65-100	Mottling appears at 72 cm with a common medium distinct (5y3/1), dark brown (10yr3/3)m, silty clay loam, moderate medium angular blocky structure, sticky, friable, calcareous, mildly alkaline, and clearly smooth.
C3	100+	Sticky, friable, calcareous, silty clay, dark yellowish brown (10yr3/)m, moderately medium angular blocky structure, and weakly alkaline.

4- The fourth profile:

The soil is classified as Typic Torriflevents, a alluvial type formed from alluvial deposits. It has a medium texture in both the upper and deeper horizons and exhibits good natural drainage, sloping at a gradient of 1-2%. The texture of the upper soil layer transitions from clayey loam to clay, with mottling observed at a depth of 110 cm from the soil surface. Salinity levels are low to moderate, and the soil's consistency varies from light viscosity when wet to brittle and very brittle in horizons with medium and coarse textures. The upper horizons have a granular structure, while deeper horizons feature a blocky structure with rounded edges. Organic matter content is low, and the natural vegetation comprises primarily thorny plants and wild barley. This soil is utilized in an irrigation farming system to grow crops such as wheat, barley, cotton, and various vegetable crops.

Morphological description of soil profile No(4) .

Profile No: 4
Classification: Typic Torriflevents.
Location: Hilla $44^0$45'15" و $32^0$36'01"
Date: 23/11/2022
Vegetation: Wheat. Barley, cotton.
Climate: semi-arid.
Erosion: Nill
Parent material: alluvium.
Topography: nearly level.
Moisture condition: Irrigated farms.
Physiography: Mesopotamia plain.
Slop: Gently Level.
G.W.D: 185 cm
Drainage: Moderately well drained.
Salinity: saline soil

Horizon	Depth (cm)	Description
Ap	0-32	Brown (10yr3/3)d; dark brown (10yr5/3)m; It is a clay loam; it has a few medium and fine roots; a weak medium granular structure, a smooth, abrupt border, is friable, mildly alkaline, and calcareous.
C1	32-67	Dark brown (10 yr3/3)m, clay, slightly sticky, clear, smooth boundary, hard, slightly alkaline, calcareous, moderately medium subangular blocky structure.
C2	67-109	Clay loam, dark brown (10yr3/3) m, weak medium subangular blocky structure, slightly sticky, calcareous, with a smooth, distinct border, mildly alkaline, and extremely friable qualities
C3	109+	Mildly alkaline, slightly sticky, calcareous, yellowish brown (10yr5/6)m, moderate to medium subangular blocky structure, clay, friable, mottling at 110cm fine distinct (5y5/2)m

Conclusions

Based on the study's findings, we deduce that all profiles under investigation was categorized within the supergroup Typic Torriflevents. Salinity, organic matter, and cation exchange capacity all dramatically declined with increasing soil depth, according to the analysis of the chemical properties. On the other hand, there was a trend for the pH and calcium carbonate concentrations to increase with depth.

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