Kirkuk University Journal for Agricultural Sciences
ISSN:2958-6585
https://kujas.uokirkuk.edu.iq

RESEARCH ARTICLE https://doi.org. 10.58928/ku25.16423

Study of Some Morphological and Pedological Properties of the Soils in Dawodi Plain , Tooz Khurmato, Salah Al-Din

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Received:26/05/2025 **Revised: 20/07/2025** **Accepted: 17/09/2025** **Published: 08/12/2025**

ABSTRACT

The study area (Dawodi Plain) is located in the northeastern part of Iraq, Salah Al-Din Governorate. It covers a total area of 70,622 hectares, situated between longitudes (44° 55' 39" – 44° 33' 27") E and latitudes (34° 48' 48" – 35° 08' 30") N. The region experiences a climate characterized by rainy winters and hot summers, with an annual rainfall of less than 383 mm and an average annual temperature of 22°C. The soil moisture regime is classified as Aridic, while the soil temperature regime is Hyper thermic. The area has a plain morphology with a gentle slope of 2-5%. Five sites were selected for soil profile sampling, where one profile was excavated at each site and divided into its respective horizons. A total of 25 soil samples were collected from the profiles for physical, chemical, and morphological analyses. The study revealed that the pH values of the studied profiles ranged from slightly alkaline to neutral. The CK3 horizon of Profile 2 recorded the highest pH value (8.1), while the Ap horizon of Profile 1 had the lowest pH value (7.1). Additionally, pH values were generally higher in subsurface horizons compared to surface horizons. Most of the studied profiles exhibited low salt content, except for the Ap horizon of Profile 1. Calcium carbonate content was found to increase in subsurface layers. Gypsum content varied in Profiles 1, 2, and 5, while no gypsum was detected in Profiles 3 and 4. All studied profiles featured a surface diagnostic horizon of the Ochric type and a subsurface diagnostic horizon of the Calcic type. According to the USDA soil taxonomy, the soils were classified as Typic Haplocalcids, while under the WRB system, they were classified as Haplic Hypercalcic Calcisols.

***Keywords*:** Douadi plain, diagnostic horizons, Soil Taxonomy, Calcic horizon, WRB.

INTRODUCTION

Soil quality is an indicator of the land's ability to maintain its productivity and thus reflects its processes and properties [1]. Climatic variations play a decisive role in controlling soil characteristics, which in turn affect crop growth and yield [2]. chemical and physical properties of different soil horizons are This provides direct information about these distinctive features, as well as additional complementary properties of shared value [3]. Conducting a proper soil classification and integrating all data into a comprehensive framework can facilitate the inclusion of soil health, quality, and fertility in management decisions made by farmers, land managers, and crop consultants [4]. Systematic research on soil morphology and classification provides detailed information about the nature and types of soils, their boundaries, and their suitability for various uses [5]. A detailed description of different soil properties helps characterize the soil's potential and limitations for crop growth [6]. Studying soil properties is the cornerstone for understanding, classifying, and gaining a deeper insight into the environment [7]. Iraqi soils vary significantly due to differences in soil-forming factors. Generally, the degree of soil development decreases from northern to southern Iraq [8]. depending on prevailing local conditions, climatic and geological factors [9]. Most soils in Iraq are of Transported origin, meaning they consist of materials transported from their initial weathering site and deposited elsewhere [10]. Given that the Dawodi Plain is an agricultural area with insufficient soil studies, characterizing and classifying its soils will help uncover valuable information for sustainable soil management and land use. Therefore, this research aims to characterize and classify the soils of the Dawodi Plain area in Tooz Khormato District, Salah Al-Din Governorate/ Iraq.

Materials And Methods

Study Area

The study area (Dawodi Plain) is located in the northeastern part of Iraq/ Salah al-Din Governorate. It covers a total area of 70,622 hectares and located between longitudes (44° 55' 39" – 44° 33' 27") E and latitudes (34° 48' 48" – 35° 08' 30") N (Figure 1). The region experiences a climate characterized by rainy winters and hot summers, with an average annual temperature of 22 °C. The soil moisture regime is classified as Aridic, while the soil temperature regime is Hyperthermic.The area is characterized by a flat to gently sloping plain, with a slight gradient ranging between 2-5%. The land is primarily utilized for cultivating wheat, barley, sesame, and corn.

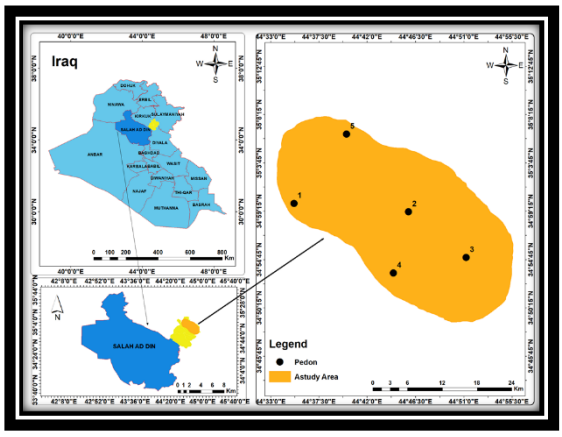

Figure 1. Map of Iraq show the study sites.

Soil Sampling and analyses

Five sites were selected (Table 1), and one Profile was excavated in each site. The Profiles were divided into their horizons, and soil samples were taken from each horizon. These samples were morphologically described according to the standards outlined in (Schoeneberger, 2012). A total of 25 samples were collected from the five pedons in the study area, for physical and chemical laboratory analyses (Table 2).

Table 1. Locations and coordinates of the study area Profiles.

Pedon	Location	N	E
1	Khader Wali	34° 59' 58"	44° 35' 11"
2	Nojol	34° 59' 11"	44° 45' 51"
3	Warani	34° 54' 55"	44° 51' 14"
4	Qalla	34° 53' 29"	44° 44' 27"
5	Kalahano	35° 06' 25"	44° 40' 05"

Table 2. Physical and Chemical Analysis Methods

Properties		Method
pH	1:25 H_2O	pH metar model , BP3001[11]
EC	1:25 H_2O	Hanaa model, HI98304[11]
Gybsum		Acetone [12]
$CaCO_3$		Piper,1950 in/Hesse,1972[13]
Orgaic matter		C.A Black,1965[14]
Partical Size distribution(P.S.D)		Gee,bauder,1986 - Hydrometar[15]

Soil Mapping

The input maps of the chemical and physical properties of the soil were created using Kriging method in ArcGIS 10.8.

Results And Discussions

Morphological Description of Soils

The results of the morphological description of the pedons in the study area indicated variability in the morphological characteristics of the soils depending on the topographic nature and their geographical locations, as shown in the Tables (3, 4, 5, 6, 7). The boundary separation between the horizons of the pedons in the study area ranged between and Clear Wavy. This variation is attributed to the nature of sedimentation during the

formation of these soils, as well as agricultural practices, tillage, and the type of farm machinery used, which significantly influence land and crop management. Additionally, the Hue values for all pedons in the study sites were10YR. Variations were observed in Value (3, 4, 5, 6, 7) and Chroma (3, 4, 6). These differences are due to variations in organic matter content, calcium carbonate levels, and the calcareous nature of the parent material [16]. there was a clear variation in the type, size, and degree of distinctness of structural units Size. The predominant structure types ranged between angular and sub angular. The sizes of the structural units varied between coarse, medium, fine, and very fine in both surface and subsurface horizons. As for the degree of soil structure, it was of the moderate type in all pedons.This variation in the nature of soil structure in some surface and subsurface horizons can be attributed to several factors, including the nature of parent material deposition, the presence of highly cohesive binding materials such as lime and organic matter, as well as differences in moisture content. The consistency of the soil varied between Very Hard, Hard, Slightly Hard, Medium, Extremely Hard, and Soft in the dry state. In the moist state, it ranged between Friable, Very Friable, Very Firm, Firm, and Extremely Firm. As for Stickiness, it varied between Slightly Sticky and Moderately Sticky, while Plasticity ranged between Slightly Plastic and Moderately Plastic. The reason for this variation in soil consistency is attributed to differences in the soil's content of lime, organic matter, and the presence of gypsum in some horizons, in addition to the mineral composition of soil particles, particularly the clay fractions. Root abundance ranged between Very Few, Few, Moderately Few, Common, and Many. As for root sizes, which decrease with depth, especially in subsurface horizons, they varied between Fine, Very Fine, Medium, Coarse, and Very Coarse. The distribution of roots was observed as "Throughout" in all pedons of the study area. Porosity abundance ranged between Many, Few, Very Few, Medium, and Common, while pore sizes varied between Fine, Very Fine, Medium, and Coarse. This variation in root distribution is attributed to the dominant vegetation cover, which consists of cereal crops (wheat, barley, corn, and sesame), characterized by their fibrous roots and their abundance in the surface horizons of the pedons. As for pore shapes, they were Irregular in all horizons.

Table 3. Morphological characteristics of Pedon 1

Pedon Description					Pedon 1						Field Book for Describing and Sampling Soils / V.32012						
Soil Moist Regime: Aridic			Classification: Typic Haplo Calcids				Photo: Landsat – 9			Map Unit:(47)			Series or Soil Name: Khader Wali				
Loc:Khader Wali TUZ KHURMATU			Latitude: 34° 59' 58" N Longitude: 44° 35' 11" E			Temp: Air:37° Soil: Dry Depth: 97(cm)				Weather: Sunny		Date: 21/9/2024			Describer: Goran Safar		
Land scape: Plains		Land form :Flood plain			Topography: Flat			Soil Survey Area: 706222 Ha			Path:169 Row: 36			UTM: WGS1984 Zone: WGS84UTM Zone38N			
Land Cover/Use: Cereal Crops			Runoff: Moderate				Aspect: N					Elevation: 240m			Slope(%): 2%		
Soil Moisture Status: Dry			Flooding: none		Ponding: none			Drainage: Well			Erosion: Water		Kind: Plate		Degree: 1		
Diagnostic Horizon: Ochric , Calcic									Parent Material: Limestone					Surface Frag % : Very Few			

Pedon	Observe Method	Horizon	Depth (cm)	Bnd	Hue	Soil color				Texture	Surface rocks	Structure			Consistence			
						Dry		Moist				Grade	Sz	type	Dry	Mst	Stk	Pls
P1	Field description	Ap	0 – 8	Clear Wavy	10YR	6/4	LYB	3/3	DB	L	%1	MO	VF	SA	SH	FR	SS	MP
		Bk	8 – 33	Abrupt Smooth	10YR	7/3	VPB	3/3	DB	L	%1	MO	VF	SA	MH	EF	SS	MP
		Ck1	33 – 60	Abrupt Smooth	10YR	7/4	VPB	4/3	DB	L	%0	MO	VF	SA	MH	VFR	SS	SP
		Ck2	60 – 87	Abrupt Smooth	10YR	7/4	VPB	4/6	DYB	SCL	%0	MO	F	SA	SH	VFI	SS	SP
		Ck3	+87	Abrupt Smooth	10YR	7/4	VPB	4/4	DYB	SCL	%3	MO	F	SA	H	VFR	MS	SP

		Hor.	Depth (cm)	Roots			Pores			Notes
				Qty	Sz	Loc	Qty	Sz	Shp	
		Ap	0 – 8	Common	Medium	Throughout	Common	Medium	Irregular	
		Bk	8 – 33	Few	Very Fine	Throughout	Few	Fine Very	Irregular	
		Ck1	33 - 60	Few	Very Fine	Throughout	Few	Very Fine	Irregular	
		Ck2	60 - 87	Few	Very Fine	Throughout	Few	Very Fine	Irregular	
		Ck3	+87	Few	Very Fine	Throughout	Few	Very Fine	Irregular	

LYB: Light Yellowish Brown, VPB: Very Pale Brown, DB:Dark Brown, DYB:Dark Yellowish Brown, SA: SubAngular, VF:Very Fine, F:Fine, MO:Moderate, SH,Slightly Hard, MH:Mod Hard, H:Hard, FR:Friable, VFR:Very Friable, VFI,Very Firm, EF:ExtrFirm, SS:Slightly Sticky, MS:Moderately Sticky, MP:Moderately Plastic, SP:Slightly Plast, L: Loam , SCL: Sndy Clay Loam.

Table 4. Morphological characteristics of Pedon 2

Pedon Description					Pedon 2										Field Book for Describing and Sampling Soils / V.32012			
Soil Moist Regime: Aridic			Classification: Typic Haplo Calcids				Photo: Landsat – 9			Map Unit:(51)			Series or Soil Name: Nogol					
Loc: Nojol TUZ KHURMATU		Latitude: 34° 59' 11" N Longitude: 44° 45' 51" E			Temp: Air:38° Soil: Dry Depth: 100(cm)				Weather: Sunny			Date: 25/9/2024		Describer: Goran Safar				
Land Scape: Plains			Land form :Flood plain			Topography: Flat			Soil Survey Area: 706222 Ha			Path:169 Row: 36		UTM: WGS1984 Zone: WGS84UTM Zone38N				
Land Cover/Use: Cereal Crops			Runoff: Moderate			Aspect: N						Elevation: 357m				Slope(%): 2%		
Soil Moisture Status: Dry			Flooding: none			Ponding: none			Drainage: Well			Erosion: Water		Kind: Plate		Degree: 1		
Diagnostic Horizon: Ochric , Calcic										Parent Material: Limestone				Surface Frag % : Very Few				

Pedon	Observe Method	Horizon	Depth (cm)	Bnd	Hue	Soil color				Texture	Surface rocks	Structure			Consistence			
						Dry		Moist				Grade	Sz	type	Dry	Mst	Stk	Pls
P2	Field description	Ap	0 – 18	Clear Wavy	10YR	6/4	LYB	3/6	DYB	SCL	1%	MO	ME	SA	SH	FR	SS	SP
		Bk	18 – 40	Very Abrupt Smooth	10YR	6/6	BY	4/6	DYB	C	0%	MO	F	A	EH	FR	MS	SP
		Ck1	40 – 64	Abrupt Wavy	10YR	7/4	VPB	4/6	DYB	SiC	0%	MO	ME	SA	SH	FI	SS	SP
		Ck2	64 – 84	Very Abrupt Smooth	10YR	7/4	VPB	4/4	DYB	C	0%	MO	ME	A	SH	VFR	SS	SP
		Ck3	+84	Very Abrupt Smooth	10YR	7/3	VPB	5/4	YB	SiC	2%	MO	F	SA	SH	VFR	SS	MP

Horizon	Depth (cm)	Roots			Pores			Notes
		Qty	Sz	Loc	Qty	Sz	Shp	
Ap	0 – 18	Common	Medium	Throughout	Common	Medium	Irregular	
Bk	18 – 40	Few	Very Fine	Throughout	Few	Fine Very	Irregular	
Ck1	40 – 64	Few	Very Fine	Throughout	Few	Very Fine	Irregular	
Ck2	64 – 84	Few	Very Fine	Throughout	Few	Very Fine	Irregular	
Ck3	+84	Few	Very Fine	Throughout	Few	Very Fine	Irregular	

LYB: Light Yellowish Brown, BY:Brownish Yellow, VPB:Very Pale Brown, Y:Yellow, DYB:Dark Yellowish Brown, YB:Yellowish Brown, SA:SubAngular, A,Angular, F:Fine, ME:Medium, MO:Moderate, SH:Slightly Hard, EH:Extremely Hard, FR:Friable, VFR:Very Friable, FR:Friable, FI:Firm, SS:Slightly Sticky, MS:Moderately Sticky, MP:Moderately Plastic, SP:Slightly Plastic , SCL:Sandy Clay Loam, C: Clay, SiC: Silty Clay.

Table 5. Morphological characteristics of Pedon 3

Pedon Description		Pedon 3		Field Book for Describing and Sampling Soils / V.32012	
Soil Moist Regime: Aridic	Classification: Typic Haplo Calcids	Photo: Landsat - 9		Map Unit:(69)	Series or Soil Name: warani sufly
Loc:Warani TUZ KHURMATU	Latitude: 34° 54' 55" N Longitude: 44° 51' 14" E	Temp: Air:39° Soil: Dry Depth: 105(cm)	Weather: Sunny	Date: 26/9/2024	Describer: Goran Safar
Land Scape: Plains	Land form: Flood plain	Topography: Flat	Soil Survy Area: 706222 Ha	Path:169 Row: 36	UTM: WGS1984 Zone: WGS84UTM Zone38N
Land Cover/Use: Cereal Crops	Runoff: Moderate		Aspect: NE	Elevation: 339m	Slope(%): 2%
Soil Moisture Status: Dry	Flooding: none Ponding: none	Drainage: Well	Erosion: Water Kind: Plate Degree: 1		
Diagnostic Horizon: Ochric , Calcic			Parent Material: Limestone		Surface Frag % : Very Few

Pedon	Observe Method	Horizon	Depth (cm)	Bnd	Hue	Soil color				Texture	Surface rocks	Structure			Consistence			
						Dry		Moist				Grade	Sz	type	Dry	Mst	Stk	Pls
P3	Field description	Ap	0 – 15	Gradual Wavy	10YR	6/4	LYB	4/4	DYB	L	%1	MO	VF	SA	H	VFI	Ms	MP
		Ck1	15 – 40	Abrupt Smooth	10YR	7/4	VPB	3/4	DYB	L	%1	MO	F	A	MH	VFI	MS	MP
		Ck2	40 – 70	Very Abrupt Smooth	10YR	6/4	LYB	4/4	DYB	L	%0	MO	F	SA	MH	VFI	MS	SP
		Ck3	70 – 91	Abrupt Smooth	10YR	7/4	VPB	4/3	DB	L	%0	MO	ME	A	EH	EF	SS	SP
		Ck4	+91	Abrupt Smooth	10YR	7/4	VPB	4/4	DYB	SCL	%85	MO	C	SA	VH	VFR	SS	SP

Horizon	Depth (cm)	Roots			Pores			Notes
		Qty	Sz	Loc	Qty	Sz	Shp	
Ap	0 – 15	Many	Medium	Throughout	Many	Medium	Irregular	
Ck1	15 – 40	Very Few	Very Fine	Throughout	Very Few	Very Fine	Irregular	
Ck2	40 – 70	Few	Very Fine	Throughout	Few	Very Fine	Irregular	
Ck3	70 – 91	Many	Very Fine	Throughout	Many	Very Fine	Irregular	
Ck3	+91	Few	Very Coarse	Throughout	Few	Very Coarse	Irregular	

YLB:Light Yellowish Brown, VPB:Very Pale Brown, DYB: Dark Yellowish Brown, DB:Dark Brown, SA:Sub Angular, A:Angular, VF:Very fine, F:Fine, ME:Medium, MO:Moderate, C:Coarse, H:Hard, MO:Moderate. VFI:Very Firm, EF:Extra Firm, VFR:Very Friable, MS:Moderatly Sticky, SS:Slightly Stick, MP:Moderatly Plastic, SP:Slightly Plastic, L:Loam, SCL:Sandy Clay Loam.

Table 6. Morphological characteristics of Pedon 4

Pedon Description						Pedon 4								Field Book for Describing and Sampling Soils / V.32012				
Soil Moist Regime: Aridic			Classification: Typic Haplo Calcids			Photo: Landsat - 9			Map Unit:(55)			Series or Soil Name: Qalla					
Loc:Qalla TUZ KHURMATU		Latitude: 34° 53' 29" N Longitude: 44° 44' 27" E			Temp: Air:38° Soil: Dry Depth: 102(cm)			Weather: Sunny			Date: 26/9/2024			Describer: Goran Safar				
Land Scape: Plains		Land form: Flood plain		Topography: Flat		Soil Survey Area: 706222 Ha			Path:169 Row: 36			UTM: WGS1984 Zone: WGS84UTM Zone38N					
Land Cover/Use: Cereal Crpos			Ranoff: Moderate						Aspect: N		Elevation: 358m			Slope(%): 2%			
Soil Moisture Status: Dry			Flooding: none		Ponding: none		Drainage: Well		Erosion: Water		Kind: Plate			Degree: 1			
Diagnostic Horizon: Ochric , Calcic								Parent Material: Limestone				Surface Frag % : Very Few					

Pedon	Observe Method	Horizon	Depth (cm)	Bnd	Hue	Soil color				Texture	Surfaces rocks	Structure			Consistence			
						Dry		Moist				Grade	Sz	type	Dry	Mst	Stk	Pls
P4	Field description	Ap	0 – 16	Abrupt Wavy	10YR	7/3	VPB	3/4	DYB	CL	%1	MO	ME	A	H	VFR	SS	SP
		Ck1	16 – 36	Very Abrupt Smooth	10YR	7/4	VPB	4/3	DB	L	%0	MO	F	SA	EH	VFI	MS	MP
		Ck2	36 – 59	Very Abrupt Smooth	10YR	6/3	PB	4/4	DYB	L	%0	MO	ME	A	H	VFI	MS	SP
		Ck3	59 – 79	Very Abrupt Smooth	10YR	7/3	VPB	4/4	DYB	L	%0	MO	C	A	H	FR	MS	SP
		Ck4	+79	Very Abrupt Smooth	10YR	6/3	PB	4/4	DYB	L	%1	MO	ME	A	H	FI	MS	SP

Horizon	Depth (cm)	Roots			Pores			Notes
		Qty	Sz	Loc	Qty	Sz	Shp	
Ap	0 – 16	Common	Coarse	Throughout	Common	Coarse	Irregular	
Ck1	16 – 36	Few	Very Fine	Throughout	Few	Very Fine	Irregular	
Ck2	36 – 59	Very Few	Very Fine	Throughout	Very Few	Very Fine	Irregular	
Ck3	59 – 79	Very Few	Very Fine	Throughout	Very Few	Very Fine	Irregular	
Ck4	+79	Very Few	Very Fine	Throughout	Very Few	Very Fine	Irregular	

VPB:Very Pale Brown, PB:Pale Brown, DYB:Dark Yellowish Brown, DB:Dark Brown, SA: Sub Angular, A: Angular, ME: Mediun, MO: Moderate, C:Coarse, H: Hard, EH: Extremely Hard, VFR: Very Friable, VFI: Very Firm, FR:Friable, FI:Firm, SS:Slightly Sticky, MS: Moderately Sticky, SP: Slightly Plastic, MP: Moderately Plastic,CL: Clay Loam, L: Loam.

Table 7. Morphological characteristics of Pedon 5

Pedon Description						Pedon 5								Field Book for Describing and Sampling Soils / V.32012				
Soil Moist Regime: Aridic			Classification:				Photo: Landsat - 9			Map Unit:(1)			Series or Soil Name: Kalahano					
Loc:Kalahano TUZ KHURMATU			Latitude: 35° 06' 25" N Longitude: 44° 40' 05" E			Temp: Air:39° Soil: Dry Depth: 111(cm)				Weather: Sunny			Date: 27/9/2024			Describer: Goran Safar		
Land scape: Plains			Land form: Flood plain			Topography: Flat			Soil Survey Area: 706222 Ha				Path:169 Row: 36			UTM: WGS1984 Zone: WGS84UTM Zone38N		
Land Cover/Use:			Runoff: Moderate			Aspect: N							Elevation: 423m			Slope(%): 2%		
Soil Moisture Status: Dry			Flooding: none			Ponding: none			Drainage: Well				Erosion: Water		Kind: Plate		Degree: 1	
Diagnostic Horizon: Ochric , Calcic													Parent Material: Limestone			Surface Frag % : Very Few		

NO	Observe Method	Horizon	Depth (cm)	Bnd	Hue	Soil color				Texture	Surface rocks	Structure			Consistence			
						Dry		Moist				Grade	Sz	type	Dry	Mst	Stk	Pls
P5	Field description	Ap	0 – 23	Gradual Wavy	10YR	6/4	LYB	4/4	DYB	C	%1	MO	F	SA	S	FR	SS	SP
		Bk	23 – 44	Very Abrupt Smooth	10YR	6/4	LYB	4/4	DYB	L	%1	MO	ME	A	S	VFR	Ms	MP
		Ck1	44 – 71	Very Abrupt Smooth	10YR	6/3	PB	3/6	DYB	SCL	%0	MO	ME	A	SH	VFR	MS	SP
		Ck2	71 – 95	Very Abrupt Smooth	10YR	6/3	PB	5/4	YB	SCL	%0	MO	F	SA	S	VFR	MS	SP
		Ck3	+95	Very Abrupt Smooth	10YR	6/3	PB	5/4	YB	SCL	%0	MO	ME	SA	SH	L	MS	SP

Horizon	Depth (cm)	Roots			Pores			Notes
		Qty	Sz	Loc	Qty	Sz	Shp	
Ap	0 – 23	Few	Coarse	Throughout	Common	Coarse	Irregular	
Bk	23 – 44	Very Few	Very Coarse	Throughout	Few	Very Coarse	Irregular	
Ck1	44 – 71	Moderately Few	Very Fine	Throughout	Very Few	Very Fine	Irregular	
Ck2	71 – 95	Very Few	Very Fine	Throughout	Very Few	Very Fine	Irregular	
Ck3	+95	Very Few	Very Fine	Throughout	Very Few	Very Fine	Irregular	

LYB: Light Yellowish Brown, PB: Pale Brown, DYB: Dark Yellowish Brown, YB: Yellowish Brown, SA:Sub Angular A: Angular, F: Fine, ME:Medium, MO: Moderate, S: Soft, SH: Slightly Hard, FR: Friable, VFR: Very Friable, L: Loose, SS: Slightly Sticky, MS: Moderately Sticky, SP: Slightly Plastic, MP: Moderately Plastic ,C:Clay, L:Loam, SCL: Sandy Clay Loam.

The Physical Properties of Soil

Particle Size Distribution of Soil Separates

The soil texture classes ranged between Loamy, Sandy Clay Loam, Clay Loam, Silty Clay, and Clayey, the Loamy texture being dominant in the pedons of the study area. The results indicate that the values of the soil particles were somewhat similar across the study pedons, reflecting the similarity in the prevailing soil-forming factors and processes (Table 8 and Figure 2).

Bulk Density of Soils

Bulk density was varied between Surface and subsurface horizons. The differences in bulk density values between surface and subsurface horizons are attributed to the relatively lower organic matter content in the subsurface horizons, as well as their higher calcium carbonate content.

The Chemical properties of soils.

pH

The soil pH ranged between 7.1 - 8.1, with an average of 7.5 (Table 8). The high pH values were found in the southern parts of the study area, while the low values were concentrated in the northeastern parts (Figure 3). The results also showed that the pH value increased in the subsurface horizons compared to the surface horizons. These differences are attributed to the higher organic matter content in the surface horizons than in the subsurface ones [17]. or due to the higher concentration of calcium carbonate, which, when dissolved in the soil solution, leads to increased alkalinity. It is noted that the pH values of the studied pedons ranged from slightly alkaline to moderately alkaline.

Electrical Conductivity (EC)

he values of electrical conductivity ranged between 0.44 - 4.88 dS m^{-1}, with an average of 1.9 dS m^{-1} (Table 8). The low values were observed in the northeastern parts, while the high values were concentrated in the southern and southeastern parts of the study area (Figure 3). The results indicated that all studied pedons (except for the Ap horizon of Pedon 1) were characterized by low salt content, which is attributed to the nature of the parent material and the depth of the groundwater.

Organic Matter (OM)

The Organic matter values ranged between 1.68 – 9.29 g kg^{-1} in the surface and subsurface horizons, with an average of 5.00 g kg^{-1} (Table 8). The lower values were observed in the southwestern and northeastern parts, while the higher values were concentrated in the northeastern areas (Figure 3). In general, a gradual decrease in organic matter content with depth was observed, consistent with the distribution pattern of organic matter under the prevailing climatic conditions in most of Iraq's arid and semi-arid regions. The variation in proportions may be attributed to the cultivation of summer and winter crops, which leads to continuous additions of organic matter through decomposed plant residues, as well as the use of organic fertilizers during the farming period. Additionally, the decrease in organic matter across the pedons in the study area can be attributed to the amount of rainfall and air temperature, which contribute to the rapid burning and oxidation of the limited organic residues [18].

Calcium carbonate ($CaCO_3$)

It was observed that calcium carbonate values ranged between 125.0 – 235.0 g kg^{-1}, with an average of 194 g kg^{-1} (Table 8). The lower values were found in the southeastern parts, while the higher values were concentrated in the southwestern parts of the study area (Figure 3). The soils of the pedons are characterized by containing calcium carbonate in all their horizons due to the climate, which includes a long dry season unfavorable for deep leaching of these soils. An increase in calcium carbonate values is generally observed in the subsurface layers of the pedons in the study area. This is attributed to the prevalent calcification process in the region, which promotes the accumulation of calcium carbonate in those horizons [19].

$CaSO_4$. $2H_2O$ (Gypsum)

It is noted that there is variation in the gypsum values of the pedons in the study area, as their values ranged between 1.2–11.4 g kg^{-1}, with an average of 2.24 g kg^{-1} (Table 8). The low values were observed in the northern and southern parts, while the higher values were concentrated in the northeastern parts of the study area (Figure 3). The lowest value was recorded in the Ck1 horizon of pedon 5, and the highest value was in the Ck2 horizon of pedon 2. Gypsum was concentrated in the surface Ap horizon, reaching 2.1 g kg^{-1}, and in the subsurface Ck3 horizon, reaching [value missing] g kg^{-1} in pedon 1. Higher concentrations were found in the subsurface horizons Ck1, Ck2, and Ck3, reaching

2.1, 11, and 9.9 g kg^{-1}, respectively, in pedon 2. In the subsurface horizons Bk, Ck1, Ck2, Ck3, and Ck4, the values were 1.7, 1.2, 11.4, and 10.4g kg^{-1}, respectively, in pedon 5. No gypsum was observed in pedons 3 and 4.

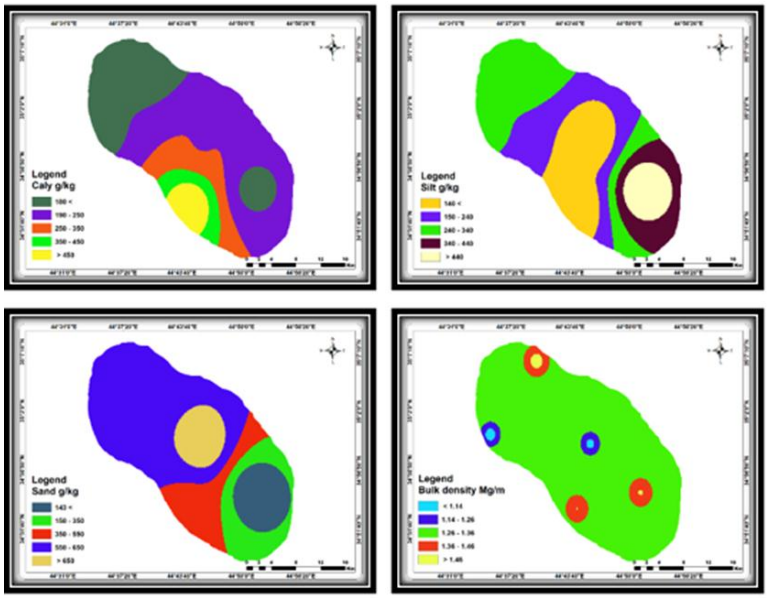

Figure 2. Spatial distribution Maps of soil physical properties values in the study area.

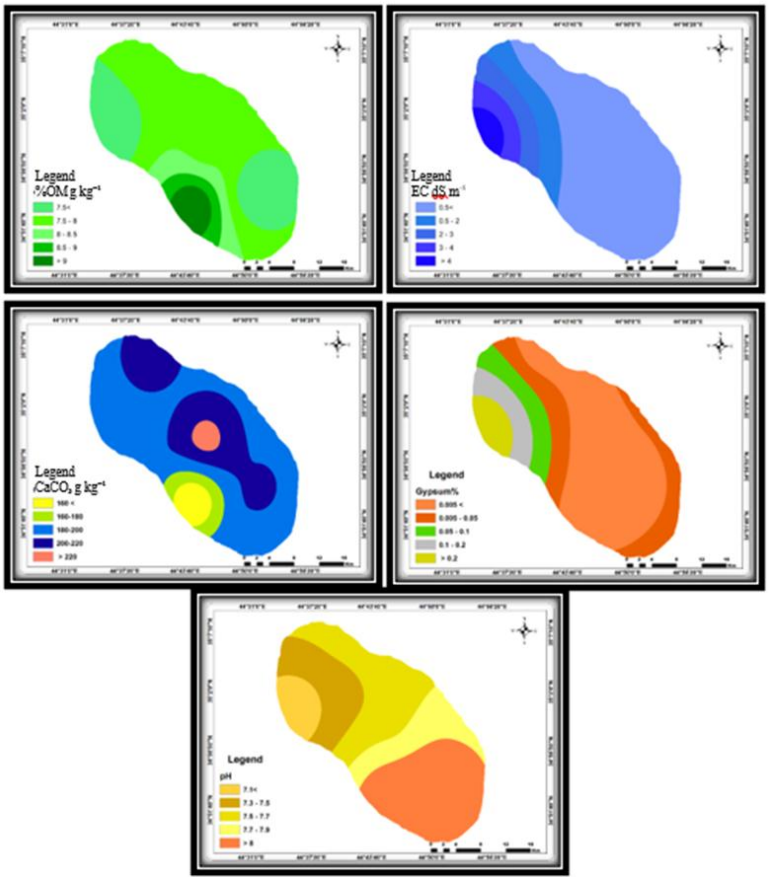

Figure 3. Spatial distribution Maps of soil chemical properties values in the study area.

Table 8. Values of the results of physical and chemical properties of the soils in the study area												
pedon	Horizon	Depth (cm)	pH	EC dS m^{-1}	Gypsum	$CaCO_3$	OM	P.S.D(g kg^{-1} Soil)			Bulk density Mg m^{-3}	Soil Texture class
					g kg^{-1} Soil			Silt	Clay	Sand		
P1	Ap	0 – 8	7.1	4.88	2.10	195.5	7.33	300	223	477	1.14	Loam
	Bk	8 – 33	7.2	0.80	0.00	235.0	6.49	280	222	498	1.42	Loam
	Ck1	33 – 60	7.5	0.98	0.00	190.0	5.66	340	243	417	1.45	Loam
	Ck2	60 – 87	7.4	1.20	0.00	220.0	3.77	240	243	517	1.57	Sandy clay loam
	Ck3	87+	7.7	2.87	6.10	180.0	3.00	200	203	597	1.62	Sandy clay loam
P2	Ap	0 – 18	7.2	0.54	0.00	235.0	7.96	200	262	538	1.16	Sandy clay loam
	Bk	18 – 40	7.3	0.66	0.00	225.0	5.03	140	476	384	1.41	Clay
	Ck1	40 – 64	7.3	1.95	2.10	210.0	4.89	400	457	143	1.43	Silty clay
	Ck2	64 – 84	7.4	2.45	11.00	225.5	4.33	174	340	243	1.46	Clay
	Ck3	84+	8.1	2.43	9.90	190.0	1.89	500	180	320	1.58	Silty loam
P3	Ap	0 – 15	7.3	0.53	0.00	205.0	7.40	440	221	339	1.41	Loam
	Ck1	15 – 40	7.8	0.48	0.00	155.0	5.24	480	219	301	1.66	Loam
	Ck2	40 – 70	7.6	0.44	0.00	230.0	5.03	400	240	360	1.71	Loam
	Ck3	70 – 91	7.8	1.22	0.00	175.0	4.03	360	258	382	1.73	Loam
	Ck4	91+	8.0	0.56	0.00	165.0	1.68	140	201	659	1.88	Sandy clay loam
P4	Ap	0 – 16	7.3	0.78	0.00	125.0	9.29	200	359	441	1.40	Clay loam
	Ck1	16 – 36	7.5	0.48	0.00	190.0	8.03	380	400	220	1.42	Clay
	Ck2	36 – 59	8.0	0.55	0.00	230.0	4.61	360	416	224	1.46	Clay
	Ck3	59 – 79	7.7	0.69	0.00	220.0	4.40	380	436	184	1.51	Clay
	Ck4	79+	7.7	0.61	0.00	180.0	3.77	380	457	163	1.54	Clay
P5	Ap	0 – 23	7.2	0.66	0.00	215.0	7.82	340	200	460	1.46	Loam
	Bk	23 – 44	7.2	0.79	1.70	235.0	4.19	300	219	481	1.54	Loam
	Ck1	44 – 71	7.5	1.05	1.20	205.0	3.56	240	236	524	1.55	Sandy clay loam
	Ck2	71 – 95	7.6	2.80	11.4	175.0	3.00	140	212	648	1.62	Sandy clay loam
	Ck3	95+	7.6	2.25	10.4	185.0	2.37	180	234	586	1.68	Sandy clay loam
Average			7.5	1.31	2.24	194.0	5.00	300	286	404	1.51	-

Soil Classification of the study area.

The obtained results revealed the presence of a Ochric diagnostic horizon in all pedons (a light-colored, thin horizon typically found in arid and semi-arid regions with low rainfall and high temperatures). Additionally, a subsurface diagnostic horizon of the **Calcic** type was identified (alluvial horizon characterized by the accumulation of secondary calcium carbonates or other carbonates, with a thickness of 15 cm or more, commonly found in arid and semi-arid regions). Ultimately, the soil was classified according to USDA Soil Taxonomy as Typic Haplocalcid, and according to the WRB system as Haplic Hypercalcic Calcisols.

Conclusion

Can be concluded from this investigation the study soils were calcareous and contain a high amount of carbonates, slightly alkaline, non- saline with occurs humification process that was closely related with (A) horizon. the clay content increase towards subsurface horizons of soil pedon as a result of mechanical migration through increasing precipitation. This study showed the most important pedogenic processes that happened in soil pedons includes is calcification, decalcification.

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دراسة بعض الخصائص المورفولوجية والبيدولوجية لترب سهل داوودي، طوز خورماتوو، من محافظة صلاح الدين.العراق

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الخلاصة

تقع منطقة الدراسة(سهل داوودي) في الجزء الشمالي الشرقي من العراق لمحافظة صلاح الدين، وتشغل مساحة إجمالية تبلغ 70622 هكتاراً، ، وتقع بين خطي طول (27" 33' 44° 55' 39" – 44° 55' 39") شرقاً ، ودائرتي العرض (48" 48' 34° – "30 08' 35°) شمالاً ، حيث يسوده مناخ يتميز بشتاء ممطر وصيف حار، مجموع هطول الامطار السنوي أقل من 383 ملم ، ومتوسط درجة الحرارة السنوية 22 درجة مئوية ، ونظام رطوبة التربة هو ***Aridic*** بينما نظام حرارة التربة ***Hyper thermic*** وتعتبر المنطقة ذات مورفولوجيا سهلية ، إنحدار بسيط 2–5% .أختيرت 5 مواقع لأخذ بيدونات وتم حفر بيدون واحد في كل موقع وقسم إلى آفاقها. وجمعت 25 عينة من ترب البيدونات للتحليلات الفيزيائية والكيميائية والمورفولوجية.بينت الدراسة أن قيم ***pH*** لبيدونات الدراسة تراوحت بين الواطئة القاعدية إلى المعتدلة، لوحظ أن الأفق ***Ck3*** لبيدون 2 أعطى أعلى قيمة بلغت 8.1 ، في حين أن الأفق ***Ap*** لبيدون 1 أعطى أقل قيمة بلغت 7.1 ، كما لوحظ أن قيمة ***pH*** كانت أعلى في الآفاق السطحية مقارنة بالآفاق تحت السطحية. لوحظ أن جميع البيدونات الدراسة تميزت بإحتوائها المنخفض من الأملاح ما عدا الأفق ***Ap*** من بيدون 1 . لوحظ زيادة قيمة كاربونات الكالسيوم الكلية في الطبقات تحت السطحية . لوحظ تباين في قيمة الجبس في بيدونات 1 و2 و5 ولم يلاحظ وجود الجبس في بيدونين 3 و 4 . وجود آفق تشخيصي سطحي من نوع ***Ochric*** وأفق تشخيصي تحت سطحي من نوع ***Calcic*** في جميع بيدونات الدراسة. وتصنيف التربة حسب نظام ***USDA*** هو ***Typic Haplocalcids*** ، وحسب نظام ***WRB*** كانت ***Hayplic, Hyperclacic Calcisols***.

الكلمات المفتاحية: سهل الدوادي، آفاق تشخيصية، تصنيف التربة، أفق اوكريك، أفق كالسيك.