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Characterization of Some Regosols in the Bursa Plain

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Abstract: In the Bursa plain, Regosols are extensively cultivated soils for horticultural crops and irrigated by water from aquifers. These soils are quite widespread on the west side of the plain and developed on different types of parent materials. This research was carried out to determinate genesis and classification of the Regosols developed on calcareous colluvium material. Five soil profiles were examined in this research and their characterization included field morphology and physico-chemical analysis. The soils were classified according to the systems of FAO/Unesco (1990), FitzPatrick (1988), and USDA Soil Taxonomy (1994). The soils show high sand and calcium carbonate contents increasing with depth.

Bursa Ovasındaki Bazı Regosolerin Karekterizasyonu

Özet: Regosoller Bursa ovasında yaygın olarak bahçe bitkileri tarımında kullanılıp, artezyenlerle sulanmaktadır. Ovanın batı kesiminde oldukça yaygın olarak bulunan bu topraklar çeşitli ana materyaller üzerinde oluşmuşlardır. Bu araştırma kalkerli kolüviyal materyal üzerinde oluşmuş olan Regosollerin genesis ve sınıflandırılmasının belirlenmesi için yapılmıştır. Bu araştırma kapsamında beş toprak profili incelenmiş ve bunların morfolojik, fiziksel ve kimyasal analizleri yapılmıştır. Topraklar FAO/Unesco (1990), FitzPatrick (1988), ve USDA Toprak Taksonomisi (1994) sistemlerine göre sınıflandırılmıştır. Topraklarda derinlikle artan yüksek kum ve kireç içeriği görülür.

Introduction

In the Bursa plain, Regosols are extensively cultivated soils on the west side of the basin. The soils have been cultivated by horticultural crops.

The investigated soils are colluvial according to the old system of soil classification (1). These correspond to the Regosols of FAO Legend as defined (2).

The term Regosol was used to replace the previous term colluvial soil that was firmly established in the literature (2). The term was being used by different authors. This soil group was described as follows (3):

"When the soil mass formed by weathering has been removed from the original site to such a degree as to cause it to intermingle with the materials of other rocks or layers, as is usually the case on hillsides, and in undulating uplands generally, as the result of rolling or sliding down, washing of rains, sweeping of wind, etc., the mixed soil, which will usually be found to contain angular fragments of various rocks, and is destitute of any definite structure, is designated as a *colluvial* one. Colluvial soil masses are frequently subject to disturbance from landslides, which are usually the result of water penetrating underneath, between the soil mass and the underlying rock, or sometimes simply of complete saturation of the former with water. Aside from such catastrophic saturation action, they commonly have a slow downward movement in mass (creep), which ordinarily becomes perceptible only in the course of years; most quickly where there are heavy frosts in winter, which act both by direct expansion, and by the state of extreme looseness in which the soil mass is left on thawing. Colluvial soils from a large portion of rolling and hilly up-lands, and are of very varying degrees of productiveness".

This soil is also described as follows (4):

"Colluvial soils are depositional, generally situated on piedmont areas, with uniform profiles without horizons, very porous, either made up of a mixture of fine and coarse materials (coarse-grained colluvium on lower parts of steep slopes in mountains) or, in contrast, of fine material (fine colluvium situated a certain distance from slopes which are themselves more gentle). Organic matter content is very variable, sometimes very low and at other times high, which is the case for humic colluvium mountains.

Stabilised colluvium, i.e. where new additions by deposition are infrequent, are generally more or less brunified in a temperate climate. As in the case of alluvial soils, there are two kinds of brunification, one resulting from development *in situ* (for example, sandy colluvial soils), the other when the transported material itself is brown.

Depending upon the type of bedrock, there are two kinds of colluvial soil: acid and calcareous. Because of their relationship with the rendzinas (certain of which are also colluvial), the calcareous colluvial soils, no matter whether they are humic (humo-calcareous soils and humo-calcic soils) or only slightly humic (colluvial brown calcareous soils), are generally found in most classifications in the calcimagnesian class of soils".

The new name Regosols was introduced to designate soil unit (2). This research was undertaken as preliminary investigation on the genesis of the Regosols in the Bursa plain in 5 profiles.

Material and Method

Material

Description of the study area

The study area is located on north-west of Turkey. The climate is semi-arid; mean annual precipitation and temperature are around 713.1 mm and 14.4°C in the Bursa plain, the highlands being used for forestry.

The geomorphology of the study area is described by Anonymous (5). The Bursa plain was formed by subsidence at the beginning of the Miocene period. Then, it was uplifted during the Pliocene or early Quaternary periods to form a high sea terrace with Manyas and Apolyont lakes. The basin is filled with Tertiary and Quaternary materials eroded from the surrounding higher ground including the Uludag mountain, where the colluvium from in which this soil is formed occurs.

Method

Representative bulk samples of the horizons in each profile were taken for laboratory analysis. Profiles were described according to Soil Survey Staff (6). Laboratory analyses were carried out for particle-size distribution (7), pH (8, 9), organic carbon (10), total nitrogen (11), calcium carbonate (12), CEC (13), exchangeable cations (14), and acid-oxalate extractable Al, Fe, and Si (15).

Results and Discussion

Investigated soil profiles are located on 40°10'15"N-28°52'10"E, 40°10'07"N-28°51'40"E, 40°10'10"N-28°51'25"E, 40°10'22"N-28°51'10"E, 40°10'08"N-28°50'55" E, respectively, on the west side of the plain and an altitude ranging from 150 m to 350 m above mean sea level. Five profiles were selected for the present study and developed on the calcareous colluvium parent material. All profiles are well drained. The natural vegetation is grass (*Agrostis capillaris*). Profile characteristics are described below. Horizon nomenclature is given according to FAO/Unesco (2), FitzPatrick (16), and USDA Soil Taxonomy (17).

Profile description

Profile 1

Profile description

Horizon FAO	EAF	USDA	Depth (cm)	Description
Ap	Tn_{30}	Ap	0-30	Olive brown (2.5Y 4/3 moist), yellowish-brown (2.5Y 5/3 dry); loam; weak fine granular structure; hard when dry, friable when moist; slightly sticky when wet; abundant fine roots; numerous earthworm passages; few small carbonate concretions; calcareous gradual smooth boundary change.
Ck1	$1Ck_{20}$	Ck1	30-50	Olive brown (2.5Y 4/4 moist), yellowish-brown (2.5Y 5/4 dry); loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky when wet; few fine roots; few small carbonate concretions; calcareous gradual smooth boundary change.
Ck2	$2Ck_{40}$	Ck2	50-90	Dull yellow (2.5Y 6/3 moist), grayish-yellow (2.5Y 6/2 dry); loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky and plastic when wet; few fine roots; frequent small and large carbonate concretions; calcareous wavy boundary change.
Ck3	$3Ck_{20}$	Ck3	90-110	Grayish-yellow (2.5Y 6/2 moist), yellowish–gray (2.5Y 6/1 dry); loam; weak fine

granular structure; friable when dry and when moist, not sticky and plastic when wet; rare spherical angular rock fragments; frequent small and large carbonate concretions; calcareous diffuse boundary change.

Profile 2

Profile description

Horizon			Depth (cm)	Description
FAO	EAF	USDA		
Ap	Tn_{35}	Ap	0-35	Olive brown (2.5Y 4/4 moist), yellowish-brown (2.5Y 5/4 dry); loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky when wet; abundant very fine roots; numerous earthworm passages; few small carbonate concretions; calcareous gradual smooth boundary change.
Ck1	$1Ck_{25}$	Ck1	35-60	Olive brown (2.5Y 4/3 moist), yellowish-brown (2.5Y 5/3 dry); loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky when wet; few fine roots; common medium carbonate concretions; calcareous wavy boundary change.
Ck2	$2Ck_{20}$	Ck2	60-80	Dull yellow (2.5Y 6/4 moist), grayish-yellow (2.5Y 6/2 dry); loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky and plastic when wet; common small and large carbonate concretions; calcareous wavy boundary change.
Ck3	$3Ck_{35}$	Ck3	80-115	Grayish-yellow (2.5Y 6/2 moist), yellowish-gray (2.5Y 6/1 dry); loam; weak fine granular structure; friable when dry and moist, not sticky and plastic when wet; few spherical angular rock fragments; frequent large carbonate concretions; calcareous gradual smooth boundary change.

Profile 3

Profile description

Horizon			Depth (cm)	Description
FAO	EAF	USDA		
Ap	Tn_{25}	Ap	0-25	Olive brown (2.5Y 4/6 moist), yellowish–brown (2.5Y 5/6 dry); clay loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky when wet; common very fine roots; numerous earthworm passages; few small carbonate concretions; calcareous diffuse boundary change.
Ck1	$1Ck_{15}$	Ck1	25-40	Olive brown (2.5Y 4/4 moist), yellowish–brown (2.5Y 5/4 dry); sandy clay loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky when wet; few very fine roots; common small carbonate concretions; calcareous diffuse boundary change.
Ck2	$2Ck_{70}$	Ck2	40-110	Dull yellow (2.5Y 6/4 moist), grayish-yellow (2.5Y 6/2 dry); sandy clay loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky and plastic when wet; few fine roots; common small and large carbonate concretions; calcareous diffuse boundary change.

Profile 4

Profile description

Horizon Depth (cm) Description

FAO EAF USDA

Ap Tn_{20} Ap 0-20 Yellowish-brown (2.5Y 5/3 moist), dull yellow (2.5Y 6/3 dry); sandy clay loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky when wet; many fine roots; numerous earthworm passages; few small carbonate concretions; calcareous abrupt boundary change.

Ck1 $1Ck_{30}$ Ck1 20-50 Yellowish-brown (2.5Y 5/4 moist), dull yellow (2.5Y 6/4 dry); sandy clay loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky when wet; few very fine roots; common small carbonate concretions; calcareous wavy boundary change.

Ck2 $2Ck_{70}$ Ck2 50-120 Dark-grayish (2.5Y 5/2 moist), grayish-yellow (2.5Y 6/2 dry); sandy clay loam; weak fine granular structure, hard when dry, friable when moist, slightly sticky and plastic when wet; few fine roots; common small and large carbonate concretions; calcareous wavy boundary change.

Profile 5

Profile description

Horizon Depth (cm) Description

FAO EAF USDA

Ap Tn_{30} Ap 0-30 Yellowish-brown (2.5Y 5/4 moist), dull yellow (2.5Y 6/4 dry); loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky when wet; abundant fine roots, numerous earthworms passages; few small carbonate concretions; calcareous gradual smooth boundary change.

Ck1 $1Ck_{30}$ Ck1 30-60 Yellowish-brown (2.5Y 5/4 moist), dull yellow (2.5Y 6/3 dry); loam; weak fine granular structure; hard when dry, friable when moist, slightly sticky and plastic when wet; abundant fine roots; numerous earthworms passages; common small carbonate concretions; calcareous diffuse boundary change.

Ck2 $2Ck_{60}$ Ck2 60-120 Grayish-yellow (2.5Y 6/2 moist, 7/2 dry); sandy loam, moderate fine granular structure; hard when dry, friable when moist, sticky and plastic when wet; frequent small and large carbonate concretions; calcareous irregular boundary change.

The soil profiles examined have similar morphological features. Regosols developed on calcareous colluvium material have thick surface horizons. The main morphologic developments are olive to yellowish-brown subsoil, weak fine granular structure, and small carbonate concretions.

Physico-chemical data

The physical and chemical properties of the studied soils are presented in Tables 1 and 2.

The particle size distributions of the profiles are fairly variable. The soils are composed predominantly of sand-sized particles throughout all profiles. Profiles 4 and 5 have higher amounts of sand fractions than profiles 1, 2, and 3.

Table 1. The particle size distribution of Regosols.

Horizon (FAO/Unesco))	Depth	Sand (cm)	Silt (%)	Clay (%)	Texture
Profile 1					
Ap	0-30	39.5	38.5	21.2	L
Ck1	30-50	40.7	34.3	23.0	L
Ck2	50-90	47.8	31.8	17.8	L
Ck3	90-110	52.1	29.7	15.3	L
Profile 2					
Ap	0-35	37.5	33.7	27.8	L
Ck1	35-60	43.5	32.5	22.4	L
Ck2	60-80	45.9	33.3	19.1	L
Ck3	80-115	51.3	35.3	11.5	L
Profile 3					
Ap	0-25	40.5	28.1	30.2	CL
Ck1	25-40	45.9	20.0	32.7	SCL
Ck2	40-110	50.6	23.0	25.4	SCL
Profile 4					
Ap	0-20	49.0	26.1	31.3	SCL
Ck1	20-50	46.9	18.3	33.3	SCL
Ck2	50-120	58.2	24.1	20.1	SCL
Profile 5					
Ap	0-30	47.8	29.3	14.0	L
Ck1	30-60	49.7	29.7	19.4	L
Ck2	60-120	55.4	28.2	14.6	SL

All the soils are alkaline, as expected from parent materials. pH values vary from 7.5 to 7.9. The cation exchange capacities (CEC) are generally moderate and values range from 17.9 cmol (+) kg^{-1} to 33.2 cmol (+) kg^{-1}. The base saturation (BS) values are 100% in all horizons. The soil profiles contain high amounts of calcium carbonate, and values increase with depth due to presence of the alkaline parent material. The value of calcium carbonate varies from 3.2% to 14.7%. The calcium carbonate distribution indicates that there is decalcification in these soils. The organic C, total N, and C/N values are generally very low, which is indicative of a high degree of decomposition. The acid-oxalate extractable Al values decreased from surface horizon to bottom horizon. A similar trend is observed for acid-oxalate extractable Fe and Si. These observations showed that the parent materials were rather uniform throughout the soil profiles.

Soil Classification

Generally, soils are classified according to the type and sequence of horizons present, therefore the first step in soil classification is horizon recognition. The nomenclature is that of FAO/Unesco (2) and the equivalent FitzPatrick (16) and USDA Soil Taxonomy (17) are given.

Table 2. The some chemical properties of Regosols.

Horizon (FAO/ Unesco)	Depth (cm)	pH CaCl$_2$ 0.01M (1:2.5)	pH H_2O (1:2..5)	Org. C (%)	Total N (%)	C/N	$CaCO_3$ (%)	CEC	Exchangeable cations Ca	Mg	K	Na	BS (%)	Acid-oxalate Extractable (%) Al	Fe	Si
									cmol (+) kg-1							
Profile 1																
Ap	0-30	7.5	8.2	0.5	0.06	8.3	3.8	27.5	22.0	2.8	1.1	2.2	100	0.80	0.29	0.07
Ck1	30-50	7.5	8.3	0.3	0.04	7.5	4.5	29.0	23.4	2.9	1.0	2.5	100	0.75	0.32	0.07
Ck2	50-90	7.6	8.3	0.0	0.0	0.0	4.9	25.2	20.7	1.7	0.9	2.6	100	0.76	0.34	0.06
Ck3	90-110	7.7	8.5	0.0	0.0	0.0	7.2	23.8	20.2	1.2	0.9	2.1	100	0.68	0.28	0.06
Profile 2																
Ap	0-35	7.5	8.2	0.4	0.05	8.0	4.3	29.2	24.1	2.5	0.9	2.4	100	0.78	0.27	0.07
Ck1	35-60	7.7	8.4	0.3	0.04	7.5	5.5	31.0	25.5	2.7	0.9	2.6	100	0.72	0.28	0.06
Ck2	60-80	7.7	8.4	0.0	0.0	0.0	5.8	25.8	21.2	1.9	0.7	2.6	100	0.73	0.32	0.06
Ck3	80-115	7.9	8.6	0.0	0.0	0.0	6.9	23.6	19.7	1.8	0.6	2.0	100	0.67	0.29	0.06
Profile 3																
Ap	0-25	7.7	8.3	0.5	0.07	7.1	4.7	31.5	26.3	2.6	1.2	2.6	100	0.79	0.32	0.07
Ck1	25-40	7.8	8.6	0.2	0.03	6.7	6.2	33.2	27.8	2.4	1.0	2.9	100	0.76	0.30	0.07
Ck2	40-110	7.8	8.6	0.0	0.0	0.0	8.5	25.0	22.5	1.3	0.8	1.7	100	0.62	0.26	0.05
Profile 4																
Ap	0-20	7.5	8.1	0.6	0.07	8.6	4.3	29.8	23.1	2.4	1.1	2.4	100	0.74	0.30	0.07
Ck1	20-50	7.9	8.7	0.2	0.03	6.7	5.6	30.5	24.6	2.0	0.9	2.7	100	0.77	0.28	0.06
Ck2	50-120	7.9	8.7	0.0	0.0	0.0	14.7	22.1	18.9	1.1	0.7	1.4	100	0.58	0.23	0.06
Profile 5																
Ap	0-30	7.7	8.3	0.7	0.07	10.0	3.2	23.4	21.2	2.0	0.9	2.7	100	0.78	0.33	0.06
Ck1	30-60	7.9	8.7	0.1	0.02	5.0	5.6	20.1	19.5	1.9	1.1	2.6	100	0.72	0.27	0.06
Ck2	60-120	7.8	8.7	0.0	0.0	0.0	11.4	17.9	16.8	1.2	0.6	1.8	100	0.61	0.20	0.05

The surface horizons in the soils studied have the same characteristics: olive to yellowish-brown colour, low organic matter content, low C:N ratio, high pH and moderate CEC, texture and structure characteristics of tannon according to FitzPatrick (16). These upper horizons were classified as tillage A horizon (Ap) by FAO/Unesco (2) and USDA Soil Taxonomy (17).

One kind of lower horizon was identified in these soils. The soils of lower horizons showed accumulation of carbonates throughout the profiles. According to FitzPatrick (16), these are identified as calcic (Ck) horizons. The lower horizons have been designated by the same symbol, which expresses their chemical and physical characteristics.

The common factor linking these soils is the tillage surface horizon, developed on calcareous colluvium material and reflecting the current pedological process, and hence is probably under the same climate with seasonal changes of precipitation and dryness, similar to that of the present.

Profiles	FAO/Unesco	FitzPatrick	USDA Soil Taxonomy	Parent Material
1	Calcaric Regosols	Fluvisols	Typic Xerorthents	Colluvium material
		$Tn_{30}1Ck_{20}2Ck_{40}3Ck_{20}$		
2	Calcaric Regosols	Fluvisols	Typic Xerorthents	Colluvium material
		$Tn_{35}1Ck_{25}2Ck_{20}3Ck_{35}$		
3	Calcaric Regosols	Fluvisols	Typic Xerorthents	Colluvium material
		$Tn_{25}1Ck_{15}2Ck_{70}$		
4	Calcaric Regosols	Fluvisols	Typic Xerorthents	Colluvium material
		$Tn_{20}1Ck_{30}2Ck_{70}$		
5	Calcaric Regosols	Fluvisols	Typic Xerorthents	Colluvium material
		$Tn_{30}1Ck_{30}2Ck_{60}$		

Table 3. The FAO/Unesco (2), FitzPatrick (16), and USDA Soil Taxonomy (17) classifications and parent material for profiles.

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