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Soil Characteristics and Classification at Maytm area in the city of Ibb, Yemen

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Abstract

The study was carried out to investigate the morphological and physio-chemical characteristics as well as classification of soil in Maytam area located at Ibb Governorate, Yemen. For this purpose, geomorphologic map was produced using remote sensing (RS) and GIS technology. Four soil profiles were selected. The land and profiles were morphologically described and then soil samples were collected according to the vertical variations for integrated physical and chemical analyses. The site observations indicated that, the whole topography of Maytam is graduated mountainous complex stepwise plain terraces with nearly level terraces surface. The studied soils have very high elevations varied widely as average of 1880 m. at Maytam (a. s. l.). These soils are deep and mostly well drained. The soils have manily slightly gravelly loam to gravelly loamy sand texture. Also, the soils have mostly moderate sub- angular blocky structure with hard to extremely hard (dry) and friable to firm (moist) consistence. The main hue notation of soil color is 10YR but some profile horizons in Maytam. All studied soils are non- saline having mildly alkaline reaction. OM is low and decreases with depth. $CaCO_3$ content is mostly low and varies between studied profiles of different with random distribution throughout their depth. Gypsum is low without clear distribution through soil profiles. CEC is mainly correlated with fine fractions and organic matter contents. ESP in the most of studied soils is lower then 15% are classified under Entisols according to soil Survey Staff (2010). The others that have Natric diagnostic horizon are affillated to Aridisols

key words: soil, remote sensing, GIS, geomorphologic unites.

Introduction

Yemen is located in southwest part of Asia at the southern tip of the Arabian Peninsula between Oman and Saudi Arabia. It lies on the entrance to the Bab-el-Mandeb strait, which links the Red Sea to Indian Ocean (via the Gulf of Aden). It borders Saudi Arabia to the north and Oman to the northeast. Yemen has an area of 527.970 square kilometers. Much of the earth's surface is covered by unconsolidated but distinctly layered mixtures of mineral and organic matter formed by the weathering of preexisting materials. Soils may be defined in two ways. Soil scientists define soil as solid earth material that has been altered by physical, chemical, and organic processes, such that it can support rooted plant life. Engineers define soil as any solid earth material that can be removed without blasting. Both of these definitions are important in the environmental studies (Joseph 2005). The Physical and Chemical conditions occurring in soils are closely interlinked with the processes responsible for soil formation and vary as much as there are soil types over the world. One of the most important factors controlling the Physical and Chemical processes in soil is the particles size distribution of soil material (soil texture). Together with the organic matter content, the soil texture determines the soil's capacity to hold water. Fine materials have greater water holding capacity rather than coarse materials. Soil texture also plays a significant role in the ability to exchange and retain substances that are transported in the soil solution. Both clays and organic matter have this important property (Marcel 2006).

Geographically, Ibb is located between Dhamar and Taiz governorates. It is about 193 km south of Sana'a, the capital of Yemen. It has an area of about 5383 km^2. It is located at latitude 13°58′48″ and longitude 44°10′48″ and is situated in a fault controlled valley close to the main watershed of the Zabid valley with an elevation of about 2000 m above sea level. The general drainage direction is towards the south. During and after heavy precipitation, run-off of exceptional force can occur which floods large parts of the alluvial plain of the Mitm valley. The climate of Ibb falls under the tropical highland types, characterized by two pronounced seasons. The greatest quantities of rainfall in the Republic of Yemen occur in Ibb. Sewage treatment plant of the

city is located in Mitm area. Its height is between 1870 – 1880-m above the sea level. The existing plant has a capacity of 5,000 m^3/day. The incoming flow is about 10,500 m^3/day (Dar Al Handasah 2010). There are several boreholes which are distributed around the Ibb Sewage Treatment Plant and the effluent of the plant is used for irrigation purposes. Therefore, the main objective of this study is to investigate the characteristics and classification of the soils representing the Maytam area located in the Ibb city.

Geology of the study area

The formations of Ibb are accompanied by widespread volcanism of Tertiary age which covered the major part of the area (Table 1). The rhythmic sequence of the plateau in the district extends over a considerable area. The landscape is typical of " trap volcanism" as a designation for the tremendous succession of volcanic effusions.

Table1. Geological formations of Ibb

Alluvial Deposits (Qa)	**Principally gravel, sand, boulders, and large detritus of volcanic origin as wadi filling.**
River – terrace Deposits (Qt)	**Loess with calcareous concretions, alluvial fans, gravel, silt, loamy sands as well as sandy loam.**
Alkali – trachyte (Tk1)	**Dikes and flows of alkali – trachytic lava.**
Volcanic breccia (Tk2)	**Fragments of basaltic lava flows and dikes, breccia of tuff and pyroclastica, bombs, and lapilli.**
Porphyric basalt (Tk3)	**Flows and dikes of lava rich in pyroxene.**
Tholeiitic basalt (Tk4)	**Dense black-greyish basaltic lava, rich in silica and plagioclase.**
Alkali – olivine basalt (Tk5)	**Lava flows, now and then pyroclastica.**
Plateau basalt (Tk6)	**Intermediate volcanics, mainly tholeiite and pikrite, velded tuffs, now and then ignimbrite.**

The Geological map (in Figure1) shows the whole geological study area from the south to the north of Ibb. In this connection, the above litho logical units are distinguished.

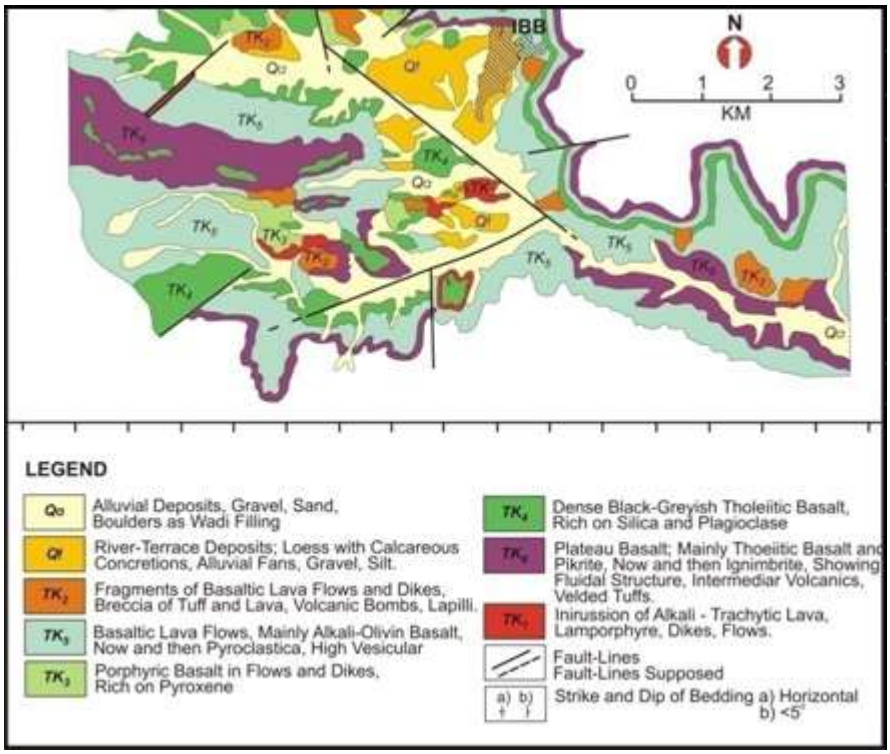

Figure 1: Geological map of Study area (Source: Dorsch 1983)

Materials and Methods

Mitm valley, located at the southern part of Ibb city, is intersected by the main road Ibb- Al Dalea. The highest elevation of this catchment basin is to the west on Al-Waseta Mountain at 3230 m above the sea level. The general drainage direction is towards the south. During and after heavy precipitation run-off of exceptional force can occur which floods large parts of the alluvial plain of the Mitm valley.

Geomorphology and soil mapping using GIS

Geomorphologic map was carried out using digital image processing of Land Sat 7.0 EMT+ image (Path/Row 166/50) executed using ENVI software 5.0 (ITT, 2012). Image was stretched using in linear 2%, smoothly filtered, and their histograms were matched according to Lillesand and Kiefer (2007). Image was atmospherically corrected using FAASH module (ITT, 2012). GIS works were performed to produce geomorphologic and soil map for the studied area using Arc GIS software 10.1(ESRI, 2012).

Field work

Four soil profiles were representing the geomorphologic units and morphologically described according to FAO (2006). Samples of the representative soil profiles were collected according to the vertical morphological variations and prepared for the different physical and chemical analysis.

Physio-chemical Analysis

Particle size distribution of soil samples was carried out after pretreatment and dispersion techniques according to Dana and Topp (2002). Electrical conductivity (EC), pH, organic matter (OM), calcium carbonate ($CaCO_3$), gypsum, catio exchange capacity (CEC) and exchangeable Na+ percentage (ESP) , were determined according to Page et al. (1982).

The studied soil profiles were classified down to family level according to soil survey staff (2010).

Results and Discussion

Geomorphology: Satellite images interpretation indicated that, the investigated area includes two geomorphologic units i.e. High Decantation Basin and Low over Decantation as given Figure 2.

Soil Classification

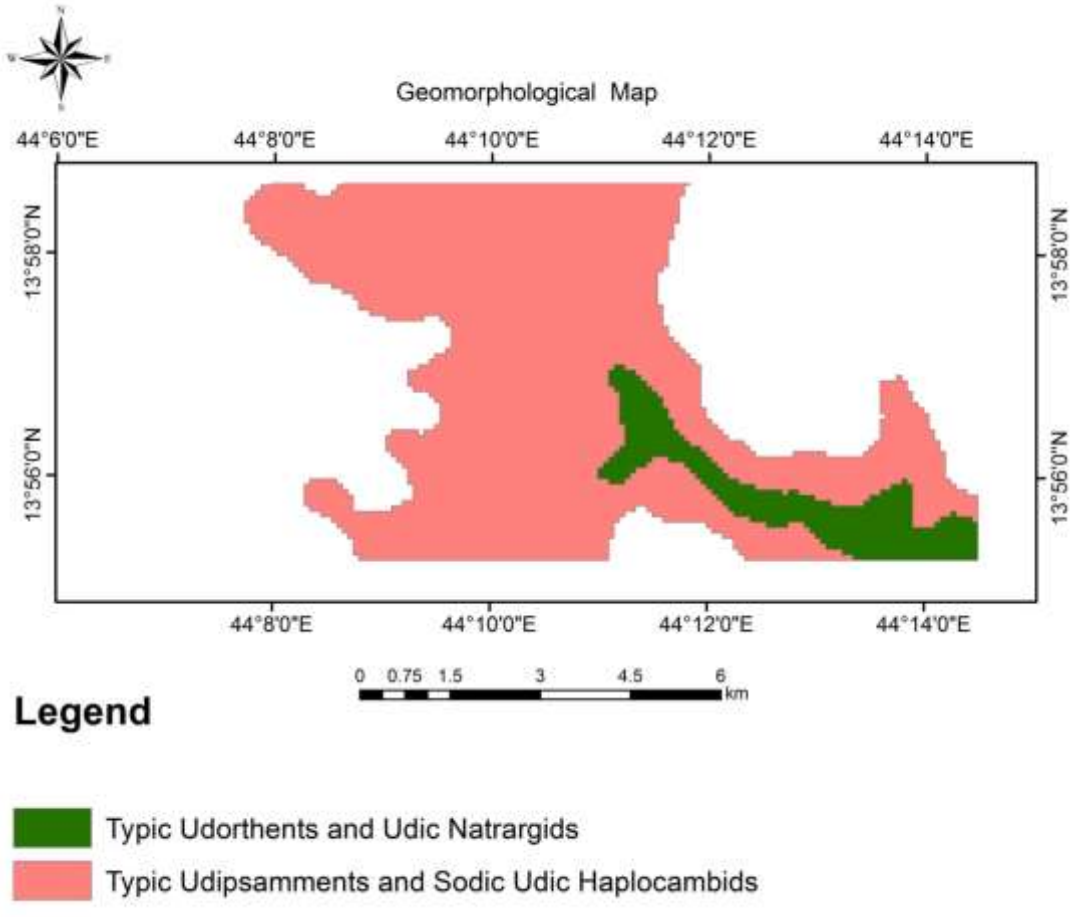

Figure 2:Geomorphological map of Study area (Source: Mayas 2013)

Soil characteristics

The site observations indicated that, the whole topography of Mayatm area is graduated mountains complex stepwise plain terraces. The surface land of the studied terraces is almost flat with nearly level topography. The morphological features (Table 2) indicated that, the studied soils have elevations varied between 1879 and 1887(m. a.s.l). These soils are deep and mostly well drained. The soils have mostly gravelly loam to sandy loam texture. The hue notation of most studied soils color is 10YR. Some horizons of profiles have 5YR and/or 7.5YR hue.

The physio-chemical properties are presented in (Table3). Data showed that, all studied soils are non-saline based on their EC values that vary from 0.82 to 4.03 dsm. Studied soils have midly alkaline reaction as indicated from their pH values that ranged between 7.40 and 8.5.

OM content is low (< 2.18%). On the other hand, $CaCO_3$ contents are mostly low and vary between studied profiles soil. Gypsum is generally low with random distribution through the profiles. CEC varies from 5.42 to 22.65.

Most of the studied soils have ESP values < 15 % indicating no sodicity effect on these soils.

Soil Classification and soil Map

The studied soils are classified according to Soil Survey Staff (2010). The dominant soil moisture regime of the studied areas is Udic with Isothermic soil temperature regime (Soil Survey Staff, 1999 and Bruggeman , 1997) Most of the studied soils have not any diagnostic Sub-surface horizons and could be classified as Entisols. The soils are classified down to family level as presented in Table (4) and Fig (3)

Table (*2) : Morphological description of the studied soil profiles*

Profile No.	Elevation m a.s.l	Depth Cm	Color		Texture	Structure	Consistence	
			Dry	Moist			Dry	Moist
1	1887	0-25	10YR 5/ 3	3/2	g . L	1 m sbk	v. hard	friable
		25-50	10YR 5/3	3/3	g . L	1 m bk	hard	friable
		50-75	10YR 5/3	3/ 1	g . L	1 f sbk	s . hard	v. friable
		75-95	10YR 5/3	3/ 1	v .g L	1 m gr	s . hard	v. friable
		95-110	10YR 5/3	3/3	g . L Sand	1 m sbk	soft	v. friable
		110-150	10YR 5/3	3/1	v.g Sandy L	1 m gr	soft	v. friable
2	1878	0-25	10YR 5/3	3/2	S .g Sandy L	2 m sbk	S . hard	s. Friable
		25-55	10YR 5/3	3/ 2	g . L Sand	2 m sbk	hard	friable
		55-90	10YR 5/3	3/ 3	v .g Sandy L	1 m sbk	hard	friable
		90-130	10YR 5/3		s . g L Sand	1 f sbk	hard	v. friable
3	1874	0-25	10YR 5/ 3	3/2	g.L Sand	2 m bk	Hard	Firm
		25-50	10YR 5/3	3/3	s.g L Sand	2 m sbk	hard	friable
		50-75	10YR 5/3	3/ 3	s.g L Sand	2 m sbk	hard	firm
		75-100	10YR 4/4	3/2	s.g Sand	1 m gr	hard	firm
		100-150	10YR 5/3	3/3	s.g L Sand	2 m sbk	ex. hard	firm
4	1879	0-30	10YR 5/ 3	3/ 2	S .g Sand L	2 m sbk	S . hard	.Friable
		30-60	10YR 5/3	3/3	g . L Sand	2 m sbk	hard	friable
		60-90	7.5 YR 5/3	3/2	v .g Sandy L	1 m sbk	hard	friable
		90-130	10YR 5/3	3/ 3	s . g L Sand	1 f sbk	hard	v. friable

Table (3): Some physical and chemical properties of studied soil profiles.

profile No	Depth Cm	Gravels %	Particle size Distribution			Texture Class	pH 1:2.5	EC dsm	CEC maq 100g soil	ESP	$CaCO_3$ %	Gypsum %	OM %
			Sand	Silt	Clay								
	0-25	12.28	19.50	44.6	18.70	L . S	7.95	2.87	21.65	12.20	11.21	2.49	2.18
1	25-50	25.63	23.40	36.20	17.10	Loamy	8.15	4.03	20.50	9.78	11.44	2.83	1.46
	50-75	36.86	25.70	37.70	17.80	L0amy	8.30	2.95	22.65	10.77	8.00	2.33	2.03
	75-95	32.58	33.30	47.20	18.90	Loamy	8.20	1.44	15.60	13.76	5.56	1.64	1.44
	95-110	37.20	73.57	20.13	04.27	L . S	8.21	1.48	11.75	12.40	6.88	2.01	1.32
	110-150	42.91	08.93	24.67	15.33	L . S	8.30	2.09	17.91	11.03	7.94	2.45	2.08
	0-25	20.05	8.39	3.33	15.33	Sandy L	7.40	1.80	14.00	09.70	9.68	1.48	1.48
	25-55	16.00	29.06	6.90	15.00	Sandy L	7.99	1.42	13.90	08.50	10.15	1.52	1.21
	55-90	9.30	3.93	12.50	8.67	Loamy S	8.08	1.54	09.45	09.20	10.24	1.61	1.15
2	90-130	6.70	5.10	1.30	10.65	Loamy S	7.90	1.37	8.50	12.22	10.34	2.14	0.76
	0-25	12.80	2.70	12.00	8.70	L . S	8.2	1.38	5.45	7.35	7.72	2.05	1.16
	25-50	4.40	5.10	22.00	2.00	L . S	8.5	1.06	5.51	10.25	8.22	2.00	0.95
	50-75	6.35	5.70	18.70	7.30	L . S	8.4	1.13	5.42	10.60	7.38	2.06	0.79
	75-100	7.65	4.10	8.69	3.32	Sand	8.3	1.55	6.25	8.80	6.13	2.21	0.64
3	100-150	7.29	28.30	2.70	10.70	L . S	8.00	1.62	7.61	8.11	6.43	2.39	0.68
	0-30	6.70	8.93	24.67	15.33	Sandy L	8.00	0.98	10.61	11.05	6.90	3.05	1.17
	30-60	27.25	16.73	11.33	8.67	Loamy S	7.98	0.82	11.78	12.13	6.05	2.94	0.96
	60-90	26.05	29.06	06.00	15.84	Sandy L	8.03	1.14	11.40	13.11	8.45	2.49	0.52
	90-130	10.93	5.12	1.33	10.67	Loamy S	7.94	1.36	8.51	13.21	10.25	2.47	0.66
4													

Table (4) : Classification of soils in the studied area .

Profile No.	Classification down to family level
Maytam area	
1	Typic Udorthents, loam, mixed, isothermic, alkaline
2 and 3	Typic Udipsamments, loamy sand, mixed, isothermic, alkaline
4	Typic Udipsamments, loamy sand, mixed, isothermic, alkaline

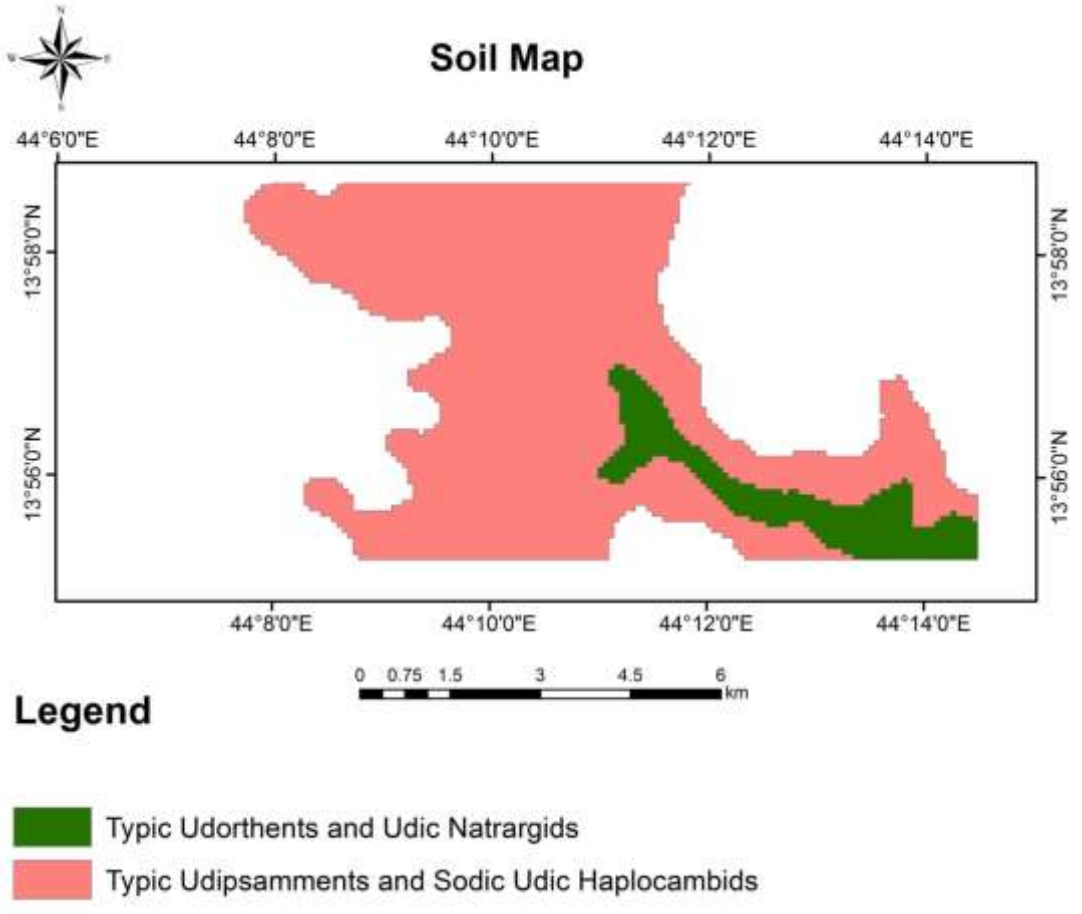

Fig. (3): The major soil mapping units in studied areas (Source: Mayas 2013)

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