Soils of Jordan

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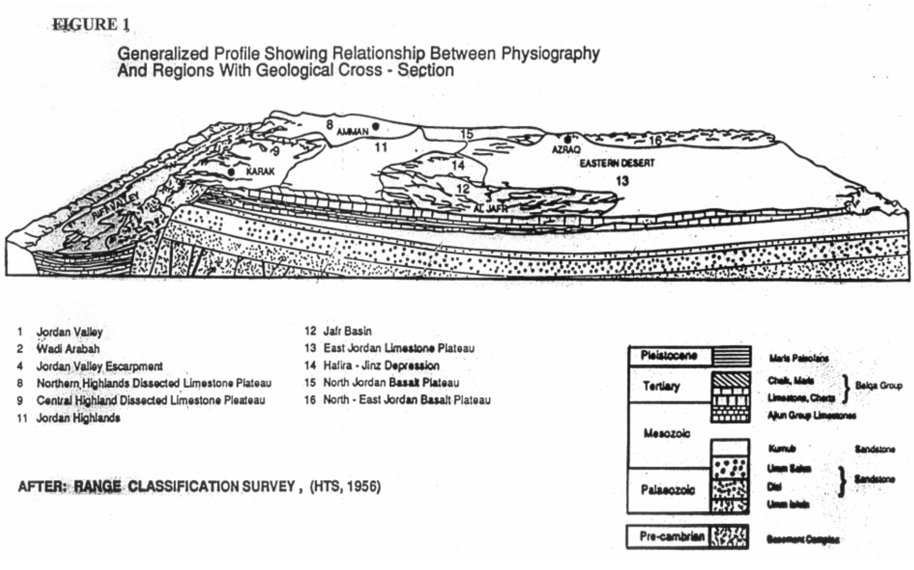
Baker Al-Qudah[1]

Introduction

Within its area of 89,275 km^2, Jordan encompasses a wide area of physical parameters. Altitude values range from minus 392m at the surface of the Dead Sea to the 1,754m of Jabal Rum. The climate varies from sub-humid Mediterranean in the north-western part of the country with annual rainfall of about 630mm to desert conditions to the east over a distance of only 100km. The geology (Bender 1964, 1974) includes Basaltic rocks, sandstone, limestone, chalks, marls and cherts and various Pleistocene and Holocene deposits, both of alluvial and eolian origin. Extensive lava flows have occurred in the north of the country. This wide range in physical features has produced an equally wide range of soils and landscapes. (See Figure 1)



Similar soil studies were conducted also in different parts of the country. An estimated area of 80,000 ha was mapped at a scale of 1:50,000 in Balqa.

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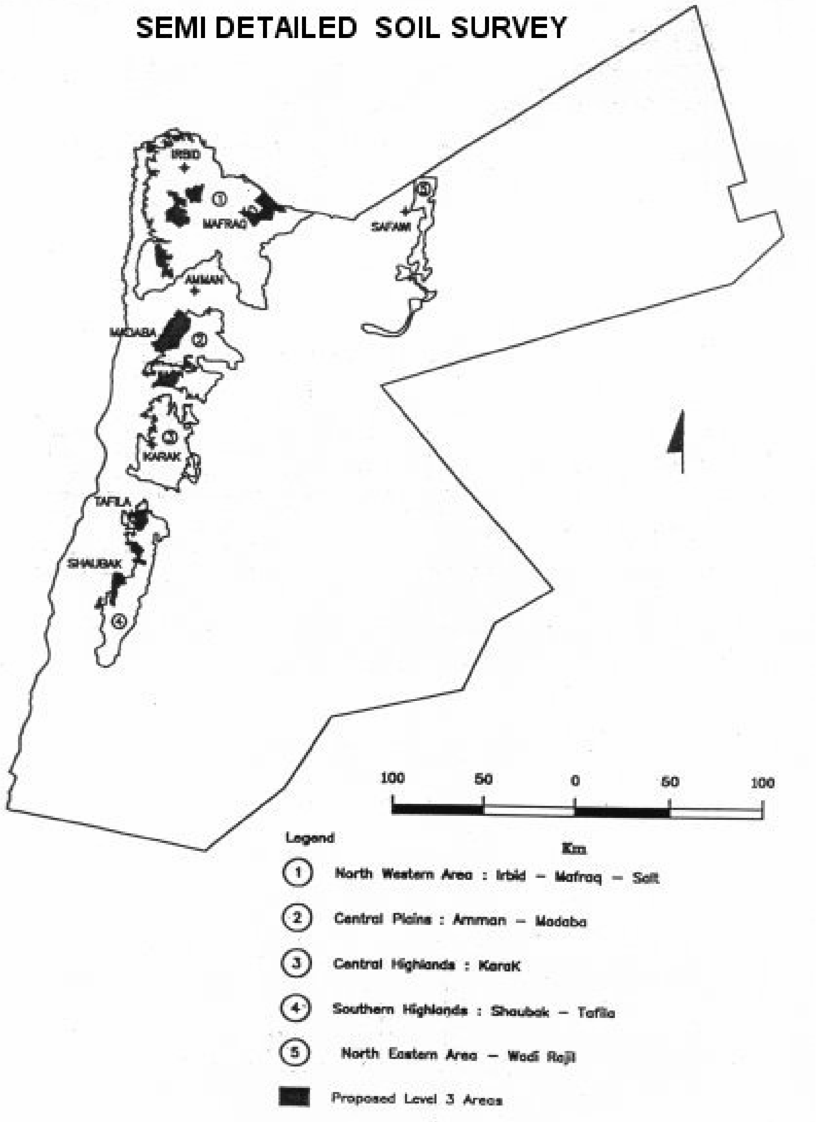
Status of soils survey in Jordan

Soil mapping and classification started in Jordan in the 1950s at a scale of 1:1,000,000, using the US soil classification system of 1938. Twelve great soil groups are recognized, the most common of which were grey desert soils, alluvial soils developed under desert climate, yellow soils developed under steppe conditions, and yellow and red Mediterranean soils developed where annual rainfall exceeds 250mm.

During the 1960s, West (1970) mapped the soils of Baqa'a Valley at a scale of (10,000) using the U S Soil Taxonomy (7th Approximation). The area covered by this study was about 6,700 ha. The dominant taxonomic units encountered were Xerochrepts and Chromoxerets. Usually these soils were located on gentle slopes and flat topography. Xerorthents were also identified in that area. However, their distribution was limited and they only occurred on the eroded slopes. This work was extended during

FIGURE 2



the 1970s to Irbid and Karak regions. A detailed survey was carried out for 2,500 ha, and a semi-detailed survey for 70,000 ha in Irbid region. (See Figure 2)

Similar soil studies were conducted also in different parts of the country. An estimated area of 80,000 ha was mapped at a scale of 1:50,000 in Balqa.

Major soils of Jordan and their constrains

Since soil surveys have been mainly limited to localised projects in separate parts of the country, comparatively little is known about the soils of Jordan at a national level. The only exception is the outdated Moorman (1959) study. So far, there has been no attempt to assemble or re-evaluate all previous activities in order to establish a general soil map in current terms. However, according to our present knowledge and based on all previously published soil studies and available data, the following soil taxonomic units, according to USDA Soil Taxonomy, have been identified in Jordan (Rihani, 1983; ACSAD, 1980). (see Figure 3)

Soils developed under Xeric Moisture Regime

Soil Taxonomy Order: Inceptisols

Great Group: Xerochrepts

These soils have an ochric epipedon and calcic subsurface horizon under a xeric soil moisture regime, which prevails in the rainfed and mountainous areas. They are developed on both upper and lower slopes. The Xerochrepts of Jordan are well represented by subgroups such as Vertic Xerochrepts, on the lower gentle slopes, and Lithic and Calcixerollic Xerochrepts on the upper, slightly convex slopes. These are generally productive soils. The main limiting factors for their utilisation in agricultural production are the effective soil depth to bedrock and the content of rock stones and gravel in the profile and on the surface.

Soil Taxonomy Order: Vertisols

Great Group: Chromoxererts

These are the Vertisols developed under a xeric soil moisture regime. They are deep, clayey soils, developed on hard limestone and basalt, and are distributed on level to nearly level areas in the Irbid basin in the North, and Madaba and Karak in the South. The Chromoxererts are well represented by subgroups such as Typic and Entic Chromoxererts. These soils are inherently fertile, have a high water-holding capacity and are well suited for all cereal crops. When fruit trees are planted in these soils, their root systems might be damaged because of the moderately wide cracks, which develop during the dry season.

Other soils such as Xeralfs, Xerolls and Xerorthents have a limited occurrence and distribution. These can be found in the mountains of Ajloun, Blaqa'a and Shoubak. Major constrains to these soils are shallowness, stoniness and steep slopes.

Soils Developed under a Torric (Aridic) Moisture Regime

Soil Taxonomy Order: Aridisols

These taxonomic units cover about 60% of the total area of Jordan. In addition to their aridic soil moisture regime, these soils are characterised by having an ochric epipedon and one or more pedogenic subsurface horizons. The dominant suborder is represented by Orthids. The most common subsurface horizons in the Aridisols of Jordan are the calcic and gypsic horizons. Aridisols with a cemented calcic horizon are also found in Jordan, especially in the northern plateau.

Great Group: Calciorthids

These are Aridisols with an ochric epipedon and subsurface calcic horizon. They contain high amounts of lime in the subsoil and in the parent material. Sometimes the calcic horizon becomes indurate, decreasing the rootability of the soil. These soils are distributed in the steppe region where rainfall is very low. Water harvesting therefore, can be very profitable on such soils. Land use is restricted to grazing during the spring season. Due to the high silt content in these soils, soil crusting is one of the major limitations because germination becomes very difficult.

Great Group: Gypsiorthids

These soils are distinguished by the presence of high gypsum amounts, deep in the profile. Some gypsiorthids have gypsum in all the horizons. They are common in eastern and south-eastern parts of Jordan (Sirhan basin and Mudawarah). Rainfall is very limited in these areas, not exceeding 50 mm annually, and the only possible land utilisation is grazing (Hunting Technical Services Ltd. 1956). However, the presence of gypsum or salts could severely decrease grass growth and production. The plant species are also specific to these conditions.

Great Group: Camborthids

Camborthids are Aridisols that have an ochric epipedon and a cambic subsurface horizon. Most Camborthids are deep and found on flat or gentle slopes. They are associated with Entisols and Calciorthids. The color of the cambic horizon is darker than the topsoil.

These soils have much less calcium carbonate content than the calciorthids. The extent of these soils in Jordan is very limited compared to other Aridisols. Crusting due to high silt content is one of their constrains.

Great Group: Salorthids

These are the very salty soils occurring in wet places in the desert, where capillary rise and evaporation of water concentrate the salts into a salic horizon. The Salorthids are usually deep and wet, but the dissolved salts make the soil physiologically dry because of the osmotic pressure. The Salorthids are good soils for crop production if the salts are leached beyond the root zone and irrigation water is available. Salorthids occur in Jordan around Azraq Oasis, the Qa-Disi mudflats and in some places in Wadi Araba. In these areas, Salorthids are associated with Torrifluvents and Torripsamments.

Soil Taxonomy Order: Entisols

These are very young soils. Some of them have an ochric epipedon at the surface, especially when they are protected from erosion. They are good soils for agriculture unless a lithic or paralithic content is present. In Jordan, they are mostly stony or sandy and are associated with the Aridisols. The main great groups observed are the following:

Great Group: Torrifluvents

These are the Fluvents of arid climates that are not flooded frequently or for long periods. They have a torric moisture regime and most of them are saline or alkaline. They are distributed in mud-flats such as Qa'Disi in the South, and Qa-Khana near Azraq in the North.

Great Group: Torripsamments

These are Entisols formed on sandy parent materials that could be poorly graded sands, shifting or stabilised sand dunes, and under torric soil moisture regimes. They have low or very low water-holding capacity and high infiltration rates and posses single-grain texture, mainly formed by quartz with or without coating. This coating is mainly iron oxides that give the red colour to the material inherited from the argillaceous sandstone near these soils. Some are slightly calcareous or saline due to the presence of shale fragments.

These soils are generally deep unless a lithic or paralithic contact is present. They are sometimes gravely and associated with gypsum. They occur mainly in Disi, Mudawarah and Wadi Araba regions. They are good soils for agricultural production if irrigation water and fertilisers are available. Descriptions of typical profiles are presented in Appendix I

Great Group: Torriorthents

These are the Orthents of arid climates that are dry or salty. They are gravely or of sandy loam texture and are associated with Torripsamments. They occur in the eastern desert and the southern sandstone plateau.

Major environmental soil problems

Soil salinity and sodicity

Due to the prevailing arid conditions, salinity is the major threat to irrigated soils, outside the highland to the west down in the Jordan Valley and to the east in the desert plateau. However, irrigated soils of Northern Jordan Valley are not threatened by salinity because winter rainfall is sufficient to leach down accumulated salts of the preceding spring and summer seasons. Salinisation increases along the north- south transact in the Jordan Valley.

Generally, the content of soluble salts in the soils increases with decreasing rainfall; notable exceptions being Wadi soils, which have additional leaching from run- off water. Study of the data shows soils with xeric moisture regime generally have surface and sub-soil ECe values around 0.9 ms/cm, soils with transitional xeric- aridic have ECe of 2.4 and 2.1 ms/cm in top and sub-soils, respectively. Whilst aridic soils have ECe values in excess of 60 and 20 ms/cm in top and sub-soils.

Structure deterioration

Man often changes soil structure, unfortunately, by several kinds of activities related to operations carried out at the wrong time or performed on soils that are not suitable for it. The result will be structure deterioration. It was observed that removal of permanent vegetation causes a strong suppression of the biological activities on and in the soil. As a result, the equilibrium that exists between biological and physical processes of structure formation is disturbed and physical processes become most important.

Another consequence of soil miss- management is tillage. Especially, in sandy soils in southern parts of Jordan, tillage increases the danger of wind and water erosion, both of which cause structure deterioration by stratification. In clayey soils, as in Irbid, the effect of tillage is the destruction of soil aggregates into their original constituents (sand, silt, and clay). These are then sorted by water and form a dense structure either in the form of a single grain or stratified crust.

Moreover, riding with heavy vehicles causes mechanical pressure, vibration and searing. Consequently, the total pore volume decreases and compaction and sub-surface plow-pans may be created. As a result, the effective rooting depth will be affected.

Soils maps available in Jordan

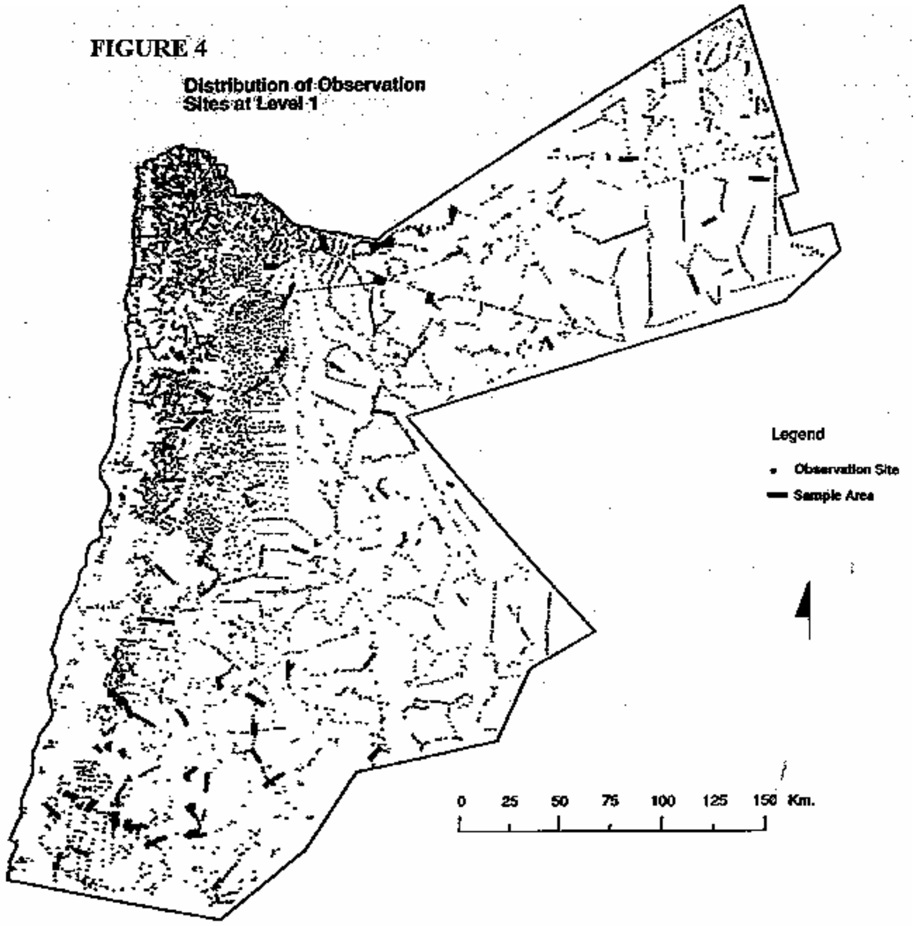
The systematic soils survey and land classification in Jordan started in 1989, where a combined team of expatriate consultants and Jordanian staff mapped the soils of Jordan at different levels of details, through a project that lasted for a period of about 72 months.

The initial survey (Level 1) was a reconnaissance study in which careful analysis of LANDSAT remotely sensed imagery and aerial photography was substantiated and expanded by field observation in sample areas and traverses of an overall density of one observation site every 7.6 km^2. Broad soil types thus were defined and grouped into appropriate mapping units and shown on a 1: 250,000 scale map. The report and an album containing different maps for Level 1 were completed in 1994.

Areas delineated as having some potential for agriculture on the above basis were then subjects of a semi-detailed soil survey. Panchromatic SPOT imagery combined with LANDSAT thematic mapper were used at a scale of 1: 50,000 to provide additional and more detailed information to form the basis of a preliminary soil map.

Field survey at an overall density of 3,5 observations/km^2 provided detailed information on the soils, landuse, topography etc. to permit a detailed classification into soil types and soil mapping units. The later map at scale 1:50,000, together with its accompanying report, form an accurate and reliable basis to identify priority areas for agricultural development.

Then, the priority areas were mapped at a scale of 1: 10,000 with an observation density of 15 observations/km^2. The various levels of soil survey and landuse studies generate a very considerable volume of data: soil characteristics being recorded at nearly 42,000 observation sites throughout the Kingdom at levels 1, 2 and 3. (See Figure 4)



To cope with the accumulate data a geo- coded database was then established. Without computerised methods, the data would fill several filing cabinets and could only be revised after a great deal of manual effort. The data are being stored in six microcomputers with a total of about 2,000 megabytes of storage. User-friendly access procedures have been developed which will enable the trained staff to use it. This will permit the user to pose complex questions and request information on a very wide and comprehensive range of soil and landscape details.

This database has made the collected data readily available and easy to manipulate. However, it has only the ability to manipulate data associated with points on the landscape. A frequent requirement of soil survey and land use studies is that they answer queries on where land of particular characteristics occurs. Traditional map preparation can provide only a single answer to such questions. To enable a range of thematic maps to be made quickly and readily, a Geographic Information system or (GIS) has been set up. This will permit new models to be devised from the basic datasets using new criteria set by scientists, planners and others, as needs dictate.

Map projections used in the country

The Royal Jordanian Geographic Center is the focal point for map production for the country. The projections used in producing maps are as follows:

1. Ed 50: European datum 1950.
2. UTM: Universal Transverse Mercator.
3. JTM: Jordan Transverse Mercator.
4. PB: Palestine Belt.

Specialised scientific institutions or research centers on soils

Several institutions are addressing the soil problems in Jordan. While primarily involved in water delivery and other development matters in the Jordan Valley, the Jordan Valley Authority (JVA), has done much work on soil classification, land drainage and salinity evaluations (Mitchell 1975) . It has also performed some applied research on crop response to irrigation. The Jordan Valley Authority does not maintain agricultural research staff, but has nevertheless useful information for growers regarding soil data.

The University of Jordan has no formal extension responsibility but has an active and relatively broad research program in the Jordan Valley and in the steppe area.

The Ministry of Agriculture, through its Department of Soils and Irrigation, is involved in both research and extension regarding soils. Soil information is available in hard copy, such as maps at different scales and in electronic media in the computers.

The present information needs to be translated into an easy language so as to be understandable by the extension staff and the farmers. Hence, there is an urgent need for substantial expansion of both research and extension programs if soils problems are to be solved or even contained, especially in the view of the rapid rate at which new technology and products are being introduced.

Conversion of national soil legend

The soils of Jordan show a wide variation in their characteristics, covering six of the US Soil Taxonomy soil orders. These soils where classified according to the above mentioned soil classification system and the appropriate units were correlated with definitions by the Soil Map of the Arab World, established by the Arab Center for the Studies of Arid Zones and Dry Lands. (ACSAD/SS/P16/80, Damascus 1980).

Laboratory methods used for soil analysis

The laboratory investigations included the analysis of soil and water samples in order to determine soil characteristics and possible relationships between soil and groundwater salinity. These tests were carried out according to the "Soil Survey Investigations Report No. 1, Soil survey Laboratory Methods and Procedures for Collecting Soil Samples", USDA, SCS, Revision August 1982 as recommended by. The Arab Center for the Studies of Arid Zones and Dry lands (ACSAD)

Soil analysis cover the following:

- Particle size.
- Bulk density and porosity.
- Soil moisture content at 1/10, 1/3 and 15 atmosphere tensions or representative samples.

- pH of water-saturated soil paste.
- Analysis of the saturation extracts for the determination of the electrical conductivity and soluble Calcium, Magnesium, Sodium, Potassium, Carbonate, Bicarbonate, Chloride, Sulfate and soluble nitrate.
- Cation exchange capacity (CEC).
- % Gypsum and Calcium Carbonate content.
- Gypsum requirements.
- Total Carbon, total Nitrogen, C/N ratio, and O. M.
- Total and assemble Phosphorus, in surface sample.
- Clay minerals identification.
- Water samples analysed to determine electrical conductivity, pH and soluble Cations, as described above.

Institutions doing soil studies in Jordan

A major component of the National Soil Map and Land Use Project, which was executed during the period 1990- 1995, was the setting up of a soil survey section or a soil department within the Ministry of Agriculture, which can use the database accumulated by the project. The main aim was to provide information to a wide range of planners and users, and which can respond quickly and effectively to requests for additional information on soils and land.

To achieve this, a training programme was set up, which has introduced eleven new graduates and five technical field assistants to the skills and procedures of soil survey and land evaluation. The programme has consisted of both formal and informal, on-the-job training. Suitable candidates were selected and attended courses in the UK. on remote sensing interpretation and data management systems; and computers section staff have completed courses at the University of Jordan on GIS methodology.

So, the Soil Department at the Ministry of Agriculture is doing at present soil studies in Jordan.

Suggestions for improving the actual Soil Information System in the country

- We suggest to establish a regional soil and water database network, based on unifying the electronic media used;
- Teaching small farmers how soils differ by on-site examination and by the visual aids. Attention should be given to the following:
- Soil depth, texture, permeability, erosion, slope, traffic pans, surface crust and natural fertility.
- A manual could be developed for the above permanent and temporary characteristics.

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Appendix I

Soil Profile Description

Information on the Site

Profile No.: PA264
Series 1 Phase: Had 1 / Gravelly
Soil Mapping Unit: level I:ISS (114)
Soil Classification: USDA (1990): Sandy-skeletal, gypsic, calcarcous, hyperthermic Family of Typic Gypsiorthids (FBDD)
ACSAD: RHY t 1/2 a: Typic Gypsiorthid
FAO/UNESCO: CLjy: Yermic-Gypsic Calcisol
Author: Austin Hutchcon
Date of examination: 25/11/91

Location: 1 km E of Jafr Aumary road
Sample -Area No.:
Map sheet: 1:25,000: 3353-11-WW - 1:100,000: 3353 - 1:250,000: Azraq
Coordinates: Geographical: 36.86727 E/ 31.65659 N
JTM: 487413 E/ 503133 N
Elevation: 542 m asl
Landform: Position: Lower slope gravel plain
Land System: 13/12 (Dissected ptateau and gravel terraces) -- 13.12.0 [GIS]
Land Facet: 1 (Gently undulating gravel plain with bedrock)
Microrelief: Class: Even (<25 cm)
Type: Undulating

Slope: Gently sloping (2 %), rectilinear to NNW

Land Use: 4.4 Unvegetated, bare
Plant/Crop:
Climate: Mean annual precipitation:
Mean annual temperature: Air: 19.4° C 1 Soil (50cm): 22.3° C
Soil moisture regime: Aridic
Precipitation zone: 0-50 mm p.a.
Nearest raingauge: Azraq (F 9)
Administrative unit village: (Zarke Governorate)

General Information on the Soil:

Geology: Limestone [q2 FLuv.gravels (Lisan) (Bender 1968)]
Parent Material: Alluvium (gravelly texture)
Drainage: Surface Runoff: Slow
Soil Drainage Class. Well drained
Surface Cover: Gravel (60 %)
Surface Feature: Patina
Soil Surface Conditions: Dry/Moderately hard
Erosion: Nil
Soil Depth: 265 cm +
Diagnostic Horizon or Property: Gypsic at 75 cm

Profile Description

0 -5 cm Reddish yellow (7.5YR 6/6) dry and strong brown (7.5YR 4.516) moist; clay loam; weak medium platy breaking to moderate medium subangular blocky dry slightly hard; moist loose; moderately sticky; moderately plastic; many fine (0.5-2 mm) irregular pores; 10 % angular chert coarse gravel (20-75 mm); strong reaction to HCl; gradual smooth boundary to:

5 -17 cm Yellowish red (5YR 5/6) dry and red (2.5YR 4/6) moist; very gravely fine sandy clay loam; very weak fine subangular blocky; dry loose; moist loose; non-sticky; slightly plastic; common fine (0.5-2 mm) tubular pores; 45 % platy chert coarse gravel (20-75 mm); 2 % medium (5-15 mm) soft gypsum crystals; violent reaction to HCL; clear wavy boundary to:

17 - 75 cm Light brown (7.5YR 6/4) dry and strong brown (<7.5YR 5/6) moist; extremely gravelly sand; massive; dry very hard; moist loose; non-sticky; non-plastic; many fine (0.5-2 mm) tabular pores; 70 % rounded chert coarse gravel (20-75 mm); 25 % small (<5 mm) moderately hard gypsum crystals; strong thick gypsum coating of gravel; strong reaction to HCL; abrupt smooth boundary to:

75 - 95 cm Light brown (7.5YR 6/4) dry and strong brown (7.5YR 5/6) moist; sandy loam; massive; dry very hard; moist very firm; non-sticky; non-plastic; many fine (0.5-2 mm) irregular pores; 5 % irregular chert gravel (5-20 mm); 60 % large (>15 mm) hard gypsum crystals; strong reaction to HCl; clear smooth boundary to:

95 - 165 cm Reddish yellow (7.5YR 7/5) dry and strong brown (7.5YR 5/6) moist; silty clay loam; weak coarse subangular blocky breaking to moderate fine subangular blocky; dry hard; moist very friable; slightly sticky; slightly plastic; common fine (0.5-2 mm) irregular pores; 5 % irregular chert gravel (5-20 mm); 10 % medium (5-15 mm) moderately hard gypsum crystals; violent reaction to HCL; abrupt smooth boundary to:

165 - 265+ cm Pink (7.5YR 7/4) dry arid strong brown (7.5YR 5/6) moist; very gravelly silty clay loam; weak coarse platy breaking to moderate medium subangular blocky; dry slightly hard; moist very friable; moderately sticky; moderately plastic; common fine (0.5-2,m) tubular pores; 50 % sub-rounded chert coarse gravel (20-75 mm); week thin $CaCO_3$ coating of gravel; violent reaction to HCL.

Note: Analytical analyses ere available for horizons: 1 / 2 / 4 / 5

PROFILE No: PA264 (1.analysis)

LAB No.	DEPTH	SAND	SILT	CLAY	SAND Coarse	SAND Med	SAND Fine	SAND Very fine	GRAVEL	TXT.	PSC	BD	POR	PERM
		<- 3A3 ->								3A3	3A3	4A3a		
	cm	<- % of < 2 mm ->							%			g/cm3		
188	0- 5	53.3	36.7	10.0	3.5	13.6	21.0	15.2		fSL	M			
189	5- 17	48.2	38.5	13.3	7.6	12.6	16.8	11.2		L	M			
190	75- 95	65.4	25.8	8.8	6.4	16.6	31.3	11.1		fSL	M			
191	95-165	30.5	58.9	10.6	2.1	3.6	11.6	13.2		SiL	M			

DEPTH	MOISTURE 10 kPa	MOISTURE 33 kPa	MOISTURE 1500 kPa	pH Paste	EXTRACTABLE BASES Ca	EXTRACTABLE BASES Mg	EXTRACTABLE BASES Na	EXTRACTABLE BASES K	CEC	CEC/clay	Na exch	ESP	ECe	SAT
				8C1	<---- 5B5a ----->				5A10a	8A1a	8D1	5B6b	5D1b	8A
cm					<---- meq / 100 g ---->					rat	meq/100g		mS/cm	%
0- 5				7.1			2.5		5.9	0.59			31.0	21.6
5- 17				6.9			5.9		5.7	0.43			76.8	30.4
75- 95				6.8			40.0		3.8	0.43			119.6	47.0
95-165				6.7			25.1		8.8	0.83			122.1	50.0

DEPTH	Ca CO3 tot	GYPSUM	GYPS REQU	SOLUBLE CATIONS Ca	SOLUBLE CATIONS Mg	SOLUBLE CATIONS Na	SOLUBLE CATIONS K	SOLUBLE ANIONS Cl	SOLUBLE ANIONS SO4	SOLUBLE ANIONS CO3	SOLUBLE ANIONS HCO3	NO3
	6E1a	6F1d	6F5	6N1b	6O1b	6P1a	6Q1a	6K1d	6L1d	6I1a	6J1a	6M1a
cm	%	%	t/ha	<---------------- meq / l ---------------->								ppm
0- 5	35.5	2.0		173.0	51.0		1.5	271.9	20.6		1.6	160
5- 17	40.0	3.9		515.3	104.7		0.6	738.7	14.2		1.4	581
75- 95	41.5	19.3		194.2	65.8		0.4	1150.4	16.4		1.3	311
95-165	41.5	3.2		610.6	159.4		0.4	1189.9	50.0		1.4	564

DEPTH	SALT tot	SAR	P total	P avail	N total	Org.C total	C/N	OM	MICRONUTRIENTS Cu	MICRONUTRIENTS Zn	MICRONUTRIENTS Fe	MICRONUTRIENTS Mn	MICRONUTRIENTS B
	8D5	5E	6S1a	6S2	6B1a	6A1d							
cm	%		ppm	ppm	%	%		%	<------ ppm ------->				
0- 5	0.43		1400	2.00	0.015	0.17	11.6	0.30					
5- 17	1.50												
75- 95	3.60												
95-165	3.91												

Outprint of JOSCIS - National Soil Map Project, SSLRC/NTS/MoA, Jordan (14/07/93)