X-RAY DIFFRACTION TO PROVIDE AN INDICATOR OF SOIL HEALTH

Tahoun, S.A.[1], A. A. Sheha[1], Atyiat E. M. Nasrallah[1], and A. A. Bayoumy[2]

1. Soil Sci. Dept., Fac. of Agric., Zagazig Univ., Egypt.
2. Soil, Water, and Environment Research Institute, Agric., Res. Center, Giza, Egypt.

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ABSTRACT: Soil samples were taken from the 0 – 30 and 30 –60 cm layers of five profiles at well-defined latitudes and longitudes in the Bahr El-Bakar domain north of El-Salam canal, Port Said Governorate. Fields in the area were previously subjected to reclamation processes comprising leveling and leaching numerous times. It is a pity that no record for these processes is available. The objective was to seek and define a simple and manageable indicator to describe what has been lately known as soil health. Soil samples were used in duplicates, after usual preliminary preparation treatment, to determine selected conventional physical, chemical, biological, and mineralogical properties. X-ray diffraction was utilized to determine certain mineralogical properties. The data indicate that almost all samples have high clay content, reaching 38.1% as a minimum and 52.5 % as a maximum. The $CaCO_3$ content is mostly less than 1%. The electrical conductivity of the saturated extract of most soils ranges around an approximate average of 10 dS/m. Some soils are heavily infested with exchangeable Na showing high SAR values of 40.2. Based on the x-ray diffraction data of this work, and supported by previous work on similar soils, it is confirmed that the clay mineral constituents of all investigated soils is the same, showing a suit of a smectite, chlorite, kaolinite, and illite. However, characteristic peaks in the pattern differed greatly in broadening indicating a considerable particle size effect. The results were interpreted in terms of the tactoidal structure of clay particles in soils. Soils infested with high sodicity have an impaired tactoidal structure due to thinning. In contrast, soils containing low levels of sodicity show fairly intact tactoidal structure with thick

particles. Therefore, it is concluded that x-ray diffraction may be used as an indicator to detect paleo-sodicity in soils, and as such to describe some basic aspects of the soil health.

Key words: X-ray diffraction, clay, degradation, indrcators.

INTRODUCTION

The so-called South of Port Said Plain is a typical mega agricultural development project in Egypt, being implemented at present to improve the utilization of land and water resources in the country. Its inception dates back to 1986 when a national Land Master Plan was elaborated to contemplate future soil reclamation campaigns in the country for the next 25 years (LMP, 1986). Geographically, the domain is bounded by the Suez Canal in the east, and the Nile Delta flood plain which constitutes the backbone of the fertile land of Egypt in the west and southwest. The northern boundary is delineated by Lake Manzala, where Port Said City occupies the most northeastern tip touching the Mediterranean Sea. The southern edge is occupied by deltaic deposits that change to young fluvio-marine deposits northward, and mounds known as turtlebacks southward. The climate of the region is arid Mediterranean with winter rainfall less than 100 mm, and therefore, irrigated agriculture is the main land use pattern (Mekki, 1996; Aly, 2005; Abdel Ghaffer, 2006; and El-Menshawy; 2006).

A prominent feature in the region is the Manzala Lake, which is a large brackish water body extending over the northeastern extremities of the Nile Delta, separated from Mediterranean shoreline by a narrow strip. The average depth of the lake is one meter but few localities may be deeper than 2.0 meters. The lake receives water discharge of numerous drains, notably Bahr El-Bakar, Bahr Saft, Bahr Hadous, El-Serw, and Faraskur drains, serving the entire Eastern Delta region. Water delivery of these drains dominates the hydrologic system of the lake, representing more than 98% of total annual recharge. The basic facts of life in the area in the past few decades necessitated drying up of large chunks of the lake to secure needed land for the agricultural, aquacultural, industrial, housing, and services sectors. It is estimated that the lake has shrunk from a total area of

300,000 to only 120,000 faddans in the span 30 years. Further evidence indicates that lake decreased in size at an average rate of 14.1 km^2 /year (Ahmed et al., 2000; and Ahmed et al., 2006.

FAO 1966, El-Fayoumy 1968. and Fathi *et al.* (1971, 1972) undertook probably the earliest detailed soil surveys of the South of Port Said Plain. It was revealed that the terrains are covered with Late Pleistocene to Holocene deposits, and that several fluvio-marine marches of clay deposits border the lake. Two soil series were identified: the Port Said series constitutes poorly drained soils characterized by fairly deep cracks, and El-Manzala series constitutes moderately well drained soils usually fluffy on the top. Most soils are saline-sodic dominated by sodium chloride but appreciable amounts of sodium, calcium, and magnesium sulfate are found. Subsequent work by Younes *et al.* 1977 and Hamdi *et al.* 1978 described more details. It was given that soils are collectively affected by the Nile, the Manzala Lake, and the Mediterranean Sea, and therefore referred to as fluvio-marine lacustrine flats. Some soils lie below sea level, and thus are badly drained and highly saline. Towards Manzala Lake there is vast clay swamps with conspicuous shore ridges of slightly higher elevation indicating former coast lines.

Further work was undertaken by Hamra 1982 El-Husseiny and Saadni 1992 El Nahry 1997, Ahmed 1998, Ebrahim. 2002., Abd El-Hady 2004 and El-Menshawy *el al.* 2006. It was reported that natural vegetation is scarce usually dominated by salicornia and phragmite. Soils are mostly clay to loam in texture, while some are sandy to sandy loam. Exchangeable Na and Mg dominate in the fluvio- marine soils, while Na and Ca dominate others. The soils were classified as Torrifluvents, whereas the sandy soils as Torripsamment. The clay flats were classified as Typic Haplosalids, Typic Aquisalids, Vertic Torrifluvients and Halic Haplotorrerts.

A newly developmental feature in the area is the El-Salam Canal. It was constructed in the closing years of the twentieth century, running south of the Manzala Lake toward northern Sinai. The objective is to supply irrigation water to about 200,000 faddans in the South of Port Said Plain, and 420,000 faddans in northern Sinai. Impressive as it may seem, soil reclamation and subsequent cultivation of such land is burdened by hazards imposed by point and non-point pollution sources. First come intrinsic and acquired salinity and sodicity in the land ecosystem. Second, the fact that the Manzala Lake has served as a sink receiving various effluents, impairs an already fragile environment.

In the salinity context, Eilers *et al.* 1995 presented soil salinity as the state in which soil contains enough dissolved salts in the plant root zone to hinder plant growth. Factors that control the occurrence, extent, and level of soil salinity fall into two main groups. Long-term factors include soil parent materials, topography, drainage, groundwater hydrology, and regional climate. Short-term factors include precipitation, evaporation, land use, and farming practices. Adverse effects of soil salinity include decreased absorption and uptake of nutrients by plants. Moreover, exchangeable Na may accumulate on the exchange complex to reach the critical sodicity level of 15% which defines the lower limit of sodic soils. The physical, chemical and biochemical properties of these soils deteriorate as the exchangeable sodium percentage (ESP) increases. This is particularly serious in heavy textured soils that contain much of the 2: 1 expanding clay minerals such as those of the smectite minerals group (James *et al.*, 1982; El-Desouki, 1988).

Furthermore, Tahoun and Hamdi. 1973. reported that soluble sodium salts may exert disruptive effect on clay minerals in soils, and that the effect is more drastic on the smectite group like montmorillonite. They observed distinctive broadening of x-ray diffraction peaks of intensively Na-treated clays. Similar observation was reported by Shata 1984 and El-Desouki 1988 during a study whose objective was to identify the clay mineralogical composition of several salt-affected soils. X-ray diffraction peaks of the very highly saline soils were rather weak and diffuse whereas those of the non-saline soils were distinct and fairly sharp.

Tahoun and Hamdi 1973 advanced two possibilities to account for this size degradation. First, clay particles disintegrated into smaller particles in a similar fashion to particle disintegration associated with the transformation of mica into expanding clays upon treatment with electrolytes. Second, the salt might have induced the formation of an amorphous material coating clay particles. The two possibilities are supported by the fundamental facts of x-ray crystallography as outlined by Cullity 1978 and Brindley 1980.

It is apparent, therefore, that soil clay mineralogy may serve as indicator to assess the status of soil degradation, in conjunction with long series of indicators outlined by Brinkman 1997, Dregne 1998, Van Lynden and Kuhlman 2002, and Penning de Vries 2002. The literature on indicators is flourishing at an accelerating rate as it was recognized that indicators are useful to identify "hot" and "bright" spots. However, the number of possible indicators is impractically large, and then it is rational to select SMART indicators that are sufficiently specific, measurable, achievable, relevant, and time-bound. Biophysical land degradation includes soil erosion, salinization and sodification, and biological degradation.

The current work was undertaken to formulate a mineralogical indicator of soil health that could contribute to the so-called minimum data set proposed by Doran and Parkin 1996. Potential hazard associated with salinity and subsequent sodicity would be assessed in terms of particle size effect utilizing x-ray diffraction as an instrumental tool.

MATERIALS AND METHODS

Samples were taken from five profiles representing different soil pedons in the Bahr El-Bakar domain north of El-Salam Canal. Fields in the area were subjected to reclamation processes comprising leveling and leaching numerous times. It is perfectly understood that the reclamation process is not complete yet, as indicated by field observation. More than often, the vegetative cover is thin in places leaving conspicuous fallow patches. Some fields reveal salinity symptoms in terms of surface salt crust and stunt dark green plants.

Fields in the area belong to small farms of about five faddans managed mostly by young university graduates. Dominant cultivated crops at the time of sampling were Egyptian clover, wheat, and barley. It is good to remember that these crops have adventitious roots with rather shallow effective root zone.

A Garmin GPSMAP 60 was utilized to define the exact geographical positions of the five profiles. The results read as follows:

Ghazalat: 31° 01' 58" north,

32° 12' 14" east

Gabbora: 31° 02' 33" north,

32° 12' 22" east

Quayta: 31° 03' 17" north,

32° 12' 03" east

El-Rayes: 31° 04' 05" north,

32° 11' 30" east

Hamalta: 31° 04' 07" north,

32° 10' 02" east

Soil samples were taken from two layers at depths of 0-30 and 30-60 cm. The samples were air dried at room temperature in the laboratory. Particular attention was made to remove virtually all shells and shell fragments from the soil materials. Thereafter, portions of homogenized samples were crushed by hand in a porcelain mortar, sieved through a 2 mm sieve, and then stored till needed for analysis. Subsamples were subsequently taken to determine selected conventional physical, chemical, biological, and mineralogical properties. The standard analytical procedures as given in Klute 1986 and Page *et al.* 1984 were used as follows:

Physical analysis: particle size distribution was determined by the pipette method after removing cementing agents and deflocculating clays; saturation percentage was determined by oven drying water saturated paste.

Chemical analysis: soil pH was determined in 1: 2.5 soil water suspension; EC_e and soluble ions were obtained from equilibrated soil saturated extract; Na and K were determined by a flam photometer; Ca and Mg by the versene method, Cl by titration with silver nitrate; CO_3 and HCO_3 by titration with an acid; SO_4 by difference; SAR by computation using the conventional equation.

Mineralogical analysis: clay films of sodium saturated specimen were prepared for each soil sample investigated in this work to perform x-ray diffraction analysis. The objective was to identify possible mineralogical particularities for different samples. The adopted procedure is somewhat similar to preparation for mechanical analysis by the pipette method. Cementing agents comprising organic matter, $CaCO_3$, and soluble salts were successively removed from samples, each weighing 50 grams. Particular attention was taken to remove electrolytes using the $AgNO_3$ test to detect chloride ions which were used as tracer in the system.

After time intervals indicated by Stokes Law, the Na saturated clay fraction was siphoned from the deflocculated soil suspension into elongated 600 ml bottles. Distilled water was added to reach a height 15 cm. The clay suspension was stirred vigorously for one minute, left to stand overnight to reach mechanical equilibrium. Thereafter, suspension aliquots were siphoned by pipette from depths of 5, 10, and 15 cm into small evaporating dishes. The suspension of each sample was left in open air for one day or two to concentrate. Thereafter, appropriate amounts of thickened suspensions were mounted onto glass slide serving as specimen holder. After another day or two, fairly homogenous clay films were produced.

Subsequently, the x-ray diffraction patterns were obtained using a Philips diffractometer. Standard instrumental conditions were used in all cases. Peak allocation to appropriate mineral phases was based on personal inspection of diffracted peaks and corresponding intensities utilizing the ASTM cards and relevant references. Relevant classical references include the treatise of Brindley and Brown 1980 and Dixon and Weed 1989. (Instrumentation of x-ray diffraction was performed by experts in the Desert Research Center, but data interpretation was undertaken by the author.)

Theoretical Considerations

Cullity 1978 and Brindley 1980 explained the principles of utilizing x-ray diffraction analysis in determining the particle size of examined mineral specimens. They stipulated that the theory of x-ray diffraction treats a crystal as a regular three-dimensional array of identical unit cells, each scattering x-rays with the same amplitude. Fundamentally, x-rays are diffracted by electrons of the structural atoms, and it is necessary to take account of the distribution of electrons within the atoms, the thermal vibration of atoms, and the distribution of atoms within the unit cell.

It is given that when a crystal is larger than a few hundred-unit cells in each direction, appreciable diffraction occurs only in the immediate vicinity of the direction given by the Bragg equation, $n\lambda = 2d \sin \theta$, where n is a multiplicity factor, λ is radiation wavelength, d is interplanar spacing, sin is the sine of the diffraction angle θ. When crystals are of the order of 10 unit cells in one direction, the scattering becomes appreciable over an extended range of the angle θ. The diffraction theory stipulates the intensity of the diffracted peak falls to zero when $u = 1/N$ where u is the displacement from the Bragg angle and N is the number of diffracting unit cells. The quantity u is easily converted to an angle $\Delta \theta$ as follows:

For the nth order reflection, $(2d/\lambda) \sin \theta_n = n$, and for an adjacent direction $(2d/\lambda) \sin (\theta + \Delta \theta) = n + u$.

Therefore:

$$1/N = u = (2d/\lambda) [\sin (\theta + \Delta \theta) - \sin \theta]$$

$$= (2d/\lambda) \cos \theta . \Delta \theta$$

The angular breadth, measured with respect to θ, between the directions where intensity falls to zero is $2\Delta\theta = \lambda / Nd \cos \theta$, where λ is wavelength of radiation, and θ is the Bragg angle. Since d is the spacing of lattice planes and N is number of planes, then crystal thickness $t = Nd$. The angular breadth, however, is always measured at half the maximum (or peak) intensity. When these considerations are taken into account, the net result is that the breadth B, measured in radians on the 2θ scale is given by:

$$B = \Delta (2 \theta) = \lambda / t \cos \theta$$

Obtained experimental results indicated that the data would be more fitting if the numerator of the equation is multiplied by 0.9 to yield the well-known Scherrer equation, which is usually written in the form:

$$t = 0.9 \lambda / B \cos \theta$$

Taken at its face value, the Scherrer equation explicitly states that the crystal size is inversely proportional to peak broadening in the x-ray diffraction pattern of minerals. Therefore, it is correct to state that whenever mineral crystals decrease in size to approach their extinction limit, broadening of peaks approaches the limit of diffraction humps, characteristic of amorphous materials. The work of Tahoun and co-workers (1973, 1976, 1990, and 1994) could be consulted for more details.

RESULTS AND DISCUSSION

Soil Samples Characteristics

Table 1 presents some of the physical properties of the studied samples. The data indicate that almost all samples have high clay content, reaching a minimum of 38.1 % as a minimum and 52.5 % as a maximum. These values are in the general values domain reported El-Nahry 1997, Aly 2005, and El-Menshawy *et al.* 2006 for soils in the area. Although the data of Table 1 are small to draw general trends, it may be noticed that the soil clay contents of all soils do not show marked changes from one location to the other and from one depth to the other. By the same token, there seems to an inverse relation between sand and silt, where an increase in one component implies reduction of the other.

The $CaCO_3$ contents of all soil samples in Table 1 is rather low, mostly less than 1 %. Such small values were reported also by El-Nahry 1997, Aly 2005, and El-Menshawy 2006, but as exceptions not the rule. They reported values ranging 0.5 to 9 %. This discrepancy could be resolved based on one or two differences. The first is that samples of this work were carefully cleaned form shell prior to sample preparation, and the second is that the difference represents actual genetic difference between soils.

Table 2 presents selected chemical properties of the investigated soils. In contrast to the findings of several previous workers, the soil salinity expressed in terms of the electrical conductivity of the saturated extract, is not too high with an approximate average of about 10 dS/m. FAO 1966, El-Fayoumy 1968, and Fathi *et al.* (1971, 1972) reported that the soils in the area are mostly saline-sodic with EC values often above 16 dS/m, the pH values are alkaline but never above 8.5, and the SAR are often high. El-Nahry 1997. Aly 2005, and El-Menshawy *et al.* 2006 reported EC values as high as 498 dS/m. But these values belong to barren soils, expected to be different from the soils of this

Table 1. Some physical properties of the investigated soils

depth, cm	constituent , %				CaCO3%	saturation %
	coarse sand	fine sand	silt	clay		
			Ghazalat			
00 – 30	0.0	23.0	35.0	42.0	0.73	100
30 – 60	2.3	27.1	27.7	42.9	1.10	99
			Gabbora			
00 – 30	1.1	20.3	22.9	55.7	0.40	95
30 – 60	3.4	21.2	26.1	49.3	0.48	105
			Quayta			
00 – 30	1.8	32.5	23	42.7	0.43	100
30 – 60	2.2	24.2	35.5	38.1	0.45	98
			El-Rayes			
00 – 30	3.3	11.9	32.3	52.5	0.53	105
30 – 60	2.3	22.4	23.6	51.7	0.45	97
			Hamalta			
00 – 30	2.8	31.1	26.4	39.7	0.31	110
30 – 60	2.5	27.1	25.3	45.1	0.39	100

Table 2. Some chemical properties of the investigated soils (in saturated extract)

depth cm	ECe dS/m	pH	ion concentration, meq/l								SAR
			Na	K	Ca	Mg	Cl	CO3	HCO3	SO4	
					Ghazalat						
0 – 30	11.6	8.3	95.0	0.8	7.8	12.5	87.0	--	11.0	18.1	29.9
30 – 60	9.5	8.5	82.0	0.6	5.4	7.5	67.0	--	8.0	20.5	32.3
					Gabbora						
0 – 30	14.6	8.2	120.7	0.9	11.1	12.9	116.0	--	9.0	20.6	34.9
30 – 60	13.4	8.1	115.0	0.8	11.3	5.1	112.0	--	10.5	9.6	40.1
					Quayta						
0 – 30	9.7	8.2	77.0	0.5	7.3	12.5	58.0	--	8.5	30.8	24.4
30 – 60	8.1	8.2	65.0	0.4	4.5	11.5	44.0	--	7.1	30.3	23.0

Table 2. Continu.

depth cm	ECe dS/m	pH	ion concentration, meq/l								SAR
			Na	K	Ca	Mg	Cl	CO3	HCO3	SO4	
El-Rayes											
0 – 30	12.8	8.2	101.0	0.8	13.2	11.8	94.0	--	8.0	24.8	28.6
30 – 60	10.6	8.1	90.0	0.7	10.1	4.7	54.0	--	10.5	41.0	33.1
Hamalta											
0 – 30	9.9	8.2	85.0	0.9	9.9	4.5	52.0	--	7.5	40.8	31.7
30 – 60	8.7	8.1	76.0	0.9	8.9	2.0	49.0	--	7.0	31.8	32.6

work, which were subjected to leaching and other reclamation processes. It is rather unfortunate that there is no record available to document these processes and to establish much needed monitoring system for the whole region.

It is well to remember that improving the management and use of saline soils requires an attitude shift on the part of policy makers and farmers. The basic concept is that reducing severity and extent of soil salinity is primarily a problem of water and land management. In this context, El-Shibini and El-Kadi (2005) expressed the suitability of irrigation water (SIW) in terms of an empirical function as follows: SIW = F (QSPCD), where Q is quality of irrigation water, S is soil type (soil characteristics such as clay %, etc.), P is plant salt tolerance, C is climate, and D is drainage condition . More than often, the issue of salinization is more complicated in soils of the arid and semi-arid regions due to constraints of water resources availability and feasibility of local and regional drainage.

Determination of exchangeable cations was not undertaken in this work, and the SAR values were taken to describe the sodicity status of soils. This is based with the well-established fact concerning the strong correlation between SAR and ESP values. Such high correlation was first reported by James et al. (1982), and subsequently supported by many workers (El-Naka, 1993; and Tahoun *et al.*, 1999). As given in Table 2, the maximum SAR value of the investigated soils is 40.1, whereas the minimum value is 23.0. Based on these figures, and the USDA criterion for the classification of salt-affected soils, it is evident that the soils of this work are saline-sodic in nature. As such, the pH values of Table 2, being invariably lower than 8.5, conform to the established facts of soil chemistry on the effect of electrolytes.

X-Ray Diffraction Interpretations

Figures 1 and 2 are the x-ray diffraction patterns of Na-saturated specimens taken from different depths of apparently deflocculated suspensions. The patterns are almost typical end-member representing a continuum connecting two distinct modes. The continuum covers 30 x-ray patterns that belong to three

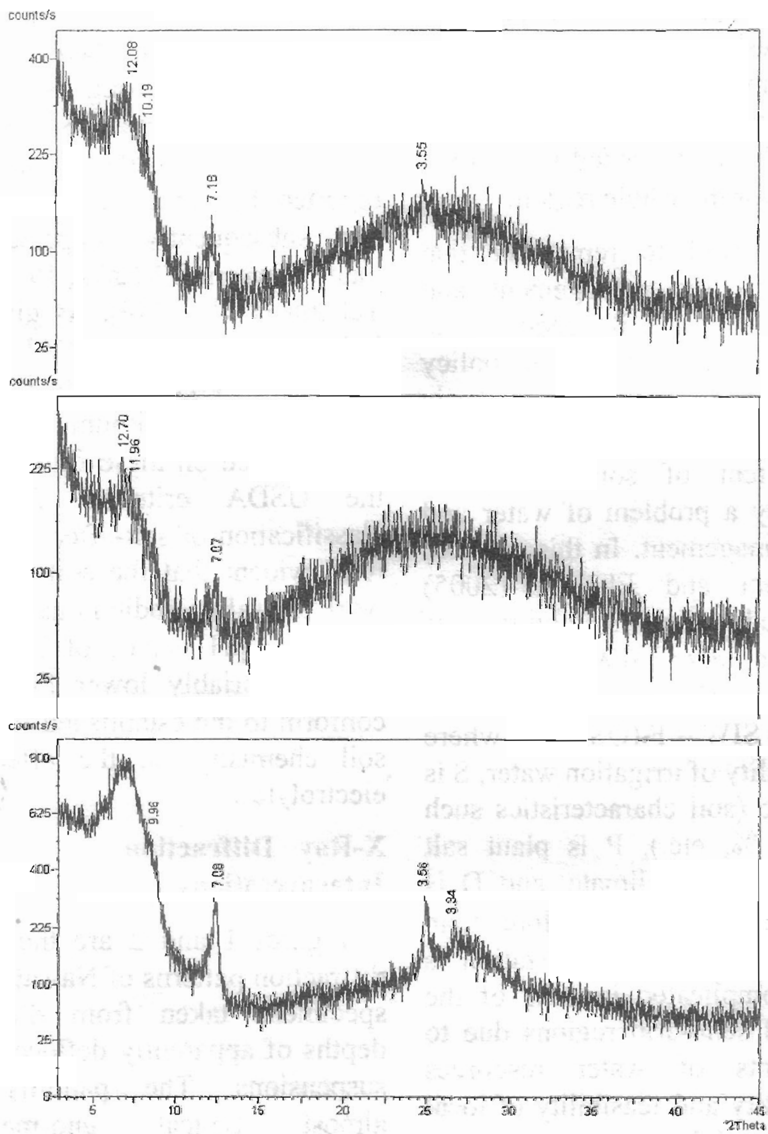

Figure 1. X-ray diffraction patterns of the clay fraction of the subsurface Gabbora soil after separation from suspension at depths of 5 cm (upper pattern), 10 cm (middle pattern), and 15 cm (lower pattern)

specimens taken at three suspension depths for each of the investigated 10 samples. It should be outlined on the onset that in normal circumstances of the conventional scientific wisdom, data of Figures 1 and 2 are inadequate to properly identify mineral phases in soils. However, given the voluminous available information on the subject as reported by Tahoun and co-workers (1973, 1976, 1990, and 1994), it is possible to correctly allocate peaks of the two figures and thus, interpret patterns of this work with high degree of certainty.

The first mode is abundantly clear with specimens of the subsurface sample of Gabbora as given in Fig. 1. The uppermost specimen of the suspension shows only kaolinite relics of extremely small particles as evidences by the faint peak at 7.2Å. The peak is overwhelmed by considerable amount of amorphous materials as evidenced by the large hump in the 2θ region of 20 to 30. Such hump was previously reported by Tahoun 1994, for dehydroxylated montmorillonite after loosing its crystal structure by heating at elevated temperature. The specimen from the 10 cm depth of the suspension shows no improvement in mineral crystallinity, as evidenced by the persistence of diffuse peaks 14 Å region for Na-saturated smectite and chlorite as well as that of 7 Å region for kaolinite, and the large hump in the 2θ region of 20 to 30.

The x-ray diffraction pattern of specimen taken from the bottom of the suspension reveals the full fledge of the mineralogical composition of typical mineralogical composition of the Nile alluvial soils of Egypt, showing several prominent peaks. Two of these peaks are fairly broad corresponding to interplanar spacings of 13.3 and 4.56 Å, whereas the third at 7.2 Å is sharp. The 13.3 Å peak is attributed to a mixture consisting of predominant smectite superimposing minor chlorite. The 7.2 Å peak is attributed to the 001 plane of kaolinite coupled with the 002 plane of chlorite. The higher diffraction orders of these two minerals couple again to give a fairly intense peak at 3.57 Å.

Imprints of illite occurs in the pattern as a component of a randomly interstratified smectite-illite system, and also as a discrete phase with a distinct shoulder at 10.2 Å for the 001 plane and 5.04 Å for the 002 plane. The rather faint peak at 4.47 Å is attributed to the 003 plane of smectite. The 3.33

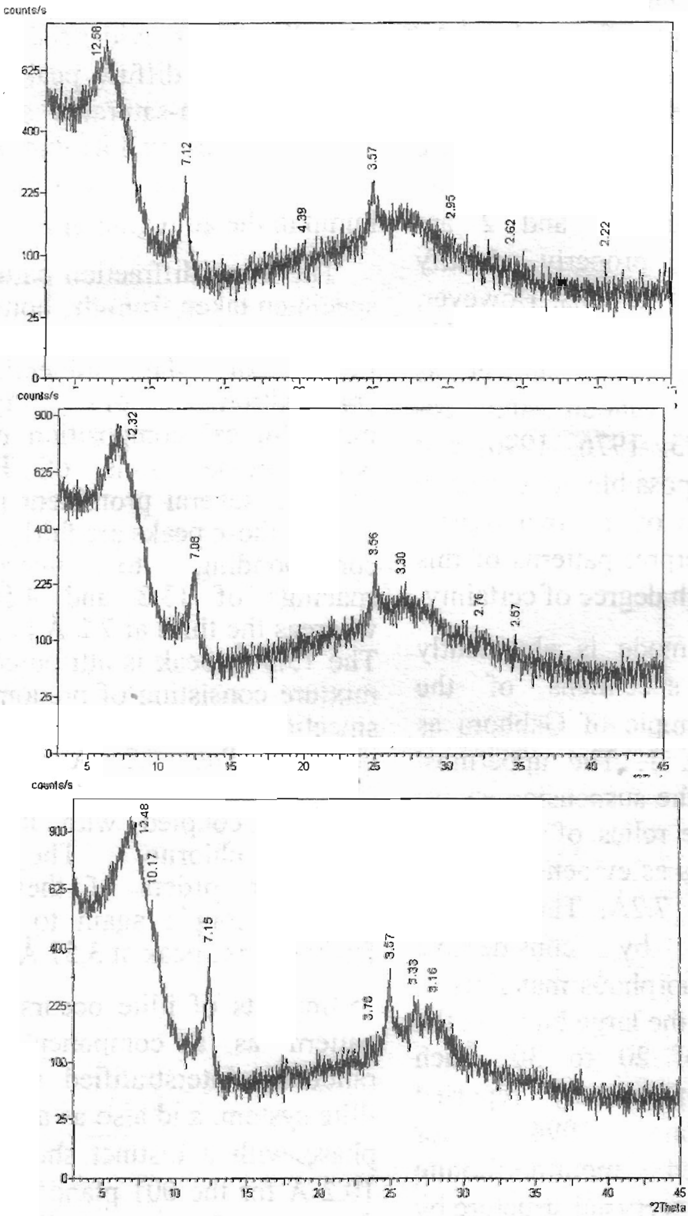

Figure 2. X-ray diffraction patterns of the clay fraction of the subsurface Quayta soil after separation from suspension at depths of 5 cm (upper pattern), 10 cm (middle pattern), and 15 cm (lower pattern)

Å in the pattern is allocated to 003 plane of discrete illite. Possibility of contribution by the 101 plane of quartz is remote based on two accounts. First is the noticeable absence of the characteristic quartz peak at 4.26 Å in the pattern as documented by Brindley and Brown 1980, and second is the mediocre presence of sand in all samples as documented by Table 1.

Figure 2 presents the x-ray diffraction patterns of specimens that belong to the surface layer of Quayta soil. Compared to patterns of Fig. 1, there is an overall qualitative similarity in the mineralogical composition. Thus it is safe to conclude that the clay mineral suite is comprised of smectite, kaolinite, chlorite, and illite. With this being rightly recorded, it should be added that there is a considerable difference in details of the mineralogical composition of the two samples, a common feature among the investigated soils of the area.

General Discussion and Conclusions

The data of this work clearly indicate that the clay mineral suite of Gabbora, representing several soils, showed a marked degree of size segregation and detectable amount of amorphous materials. In contrast, the clay mineral suite of Quayta, representing other soils, showed a sort of particle size coherence. Amorphous materials are there, but quantitatively less abundant than that of the first group.

The case of the Gabbora soil and the likes could be interpreted based on the work of Fernkel *et al.* 1978, subsequently as elaborated by El-Desouki 1988 and Keren 1989. They reported that each montmorillonite particles in suspension consist of packets of individual clay platelets which they called tactoids. As the exchangeable Na increases in the system, a diffuse electrical double layer develops around the tactoids. Consequently, individual platelets within tactoids begin to repel each other to commence dispersion. Therefore, extrapolating these findings to the current work would imply that excessive sodium salinity followed by raising the ESP content of soil clays must have had its toll, disintegrating existing micro colloidal clay aggregates. As such, thinned clay particles are unable to produce sharp well-defined peaks in the x-ray diffraction patterns.

The results of Table 2 for the conventional chemical analysis of soils may be invoked to provide supportive evidence for this argument. The soil of Gabbora is infested with exchangeable Na, as indicated by its high SAR which is analytically equivalent to ESP. Therefore, its tactoidal structure in all likelihood is greatly impaired. On the other side, the Quayta soil is less sodic, and as such it may be presumed that its tactoidal structure is fairly intact.

It is conceded that the soils of this work were subjected to several reclamation processes including leaching and gypsum application. It is unfortunate that no credible record was ever kept to allow more scientific elaboration. Nevertheless, specimens from different samples responded rather differently in their x-ray diffraction patterns. Actually this is an added value to evidence based on x-ray diffraction. Obtained results are not only indicative of the present circumstances, but also capable of detecting paleo-sodicity in soils, and as such to describe as an indicator some basic aspects of the soil health.

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دراسة بحيود الأشعة السينية لتقديم دليل يعبر عن درجة صحة الأرض

صلاح أحمد طاحون[1] - عادل عبد الرحمن شيحة[1]

عطيات السيد محمود[1] - علي عبد الجيد بيومي[2]

١- قسم علوم الأراضي- كلية الزراعة - جامعة الزقازيق

٢- معهد بحوث الأراضي والمياه والبيئة- مركز البحوث الزراعية- الجيزة

أخذت عينات سطحية وتحت سطحية من خمسة قطاعات أرضية محددة بخطوط طول وعرض قياسية ، في منطقة أراضي ناتج تجفيف بحيرة المنزلة ، في زمام مناطق بحر البقر شمال ترعة السلام التابعة لمحافظة بورسعيد . وكان هدف الدراسة هو البحث عن دليل بسيط ومباشر يعبر عن تأثير الصودية على بعض الصفات المنرالوجية للأراضي، وهي التي تؤثر بشدة فيما أصبح متعارفا عليه بصحة الأرض . وقد حللت العينات لتقدير خواصها الطبيعية، والكيماوية، والبيولوجية، كما حللت مفصولات الطين منرالوجيا بطريقة حيود الأشعة السينية. وتظهر النتائج أن عينات الأراضي تحتوى على نسب عالية من الطين تتراوح بين ٣٨,١ إلى ٥٢,٥%، ولا تزيد نسبة كربونات الكالسيوم في معظم الحالات عن ١%، وتتراوح درجة التوصيل الكهربى لعجينة التربة المشبعة ١٠ ديسيسامن للمتر. وتحتوى بعض الأراضي على درجات عالية من الصودية معبرا عنها بالنسبة الادمصاصية للصوديوم تصل في بعض الحالات إلي ٤٠. وطبقا لهذه القياسات تدخل جميع الأراضي تبعا لتقسيم معمل الملوحة الأمريكي ضمن مجموعة الأراضي الملحية الصودية. وتدل نتائج التحليل المعدني للجزء الطيني لجميع الأراضي أنه يتكون من مخلوط يسوده أحد معادن السمكتيت يكمله معادن الكلوريت والإلليت والكاؤلنيت. وتوضح النتائج أن منحنيات حيود الأشعة السينية في الأراضي شديدة الصودية كانت أكثر تفلطحا من الأراضي الأقل صودية. وقد فسرت هذه النتائج بمنطق أن تجمعات الوحدات الطينية في الأراضي والتي تعرف باسم "تاكتويد" تكون أقل سمكا من الأراضي الأقل صودية. وعلى ذلك فقد تستخدم درجة تفلطح منحنيات حيود الأشعة السينية كدليل علي تواجد صودية قديمة في الأراضي.