PEDOLOGICAL CHARACTERISTICS OF INDURATED LAYERS IN SOME SOILS OF EGYPT.

By

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B.Sc. Agric. Sc. (Soils), Ain Shams University. 2007

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ABSTRACT

Ali Hamdy Ali El-Naggar: Pedological Characteristics of Indurated Layers in some Soils of Egypt. Unpublished M.Sc. Thesis, Department of Soils , Faculty of Agriculture, Ain Shams University, 2012.

Occurrence of cementation, induration and compaction is a common feature in soil profiles of arid and semiarid regions. These layers have negative effect on soil quality and sustainable agriculture production. The pedological characteristics of the indurated or compacted soil layers have not received the attention they merit, particularly in the newly reclaimed soils, where soil induration or compaction should be avoided. The current study was conducted to study some pedological characteristics of indurated and/or compacted layers in some soil profiles in Wadi El- Natron (West Delta), El-Salhya (East Delta) and Toshka (South Egypt) regions .

The representative soil profiles were morphologically studied in the field and sampled. Collected soil samples were subjected to different analyses: chemical, physical and mineralogical analyses including the content and distribution of amorphous and poorly crystalline cemented materials.

Results indicated that compacted and indurated layers are present in the studied soil profiles at different depths. The compaction found in the soils of Wadi El-Natron is due to heavy machinery used during soil management, whereas, increasing calcium carbonate, gypsum contents and the presence of silica, iron and manganese in the mentioned soil layers increased induration in other soil profile. This could be related to the parent materials types, and/or the precipitation of $CaCO_3$, gypsum, with other cemented materials transported from the surface soil layers and accumulated causing the induration of the subsurface layers.

Key words: induration, compaction, genesis, cementing agents, amorphous materials.

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1- INTRODUCTION

Soils is a dynamic medium composed of mineral particles, organic materials, water, air and living organisms, Their physical, chemical and biological processes are changing all the time under the influence of nature and man. The rate at which soils change under the influence of man's activities are so fast and often negative. With the world population expected to reach 10 billion by mid of this century, and the ever-increasing demands on the world resources, pressures on agricultural resources are increasing. Hence, we need to find ways for better soil management and decreasing the damage that caused to the soil by nature or man's activities **(Lacombe and Burton 2010).**

The occurrence of cementation, induration and compaction is common feature in soil profiles of arid and semiarid regions. **(Lacombe and Burton 2010)**

Indurated layer are totally or partially cemented by different agents like silica, calcium carbonates, gypsum, amorphous materials, aluminum and/or iron oxides, and clays (**Sandoval and Roman 2000, and Ostrooumov et al, 2005)**

Soil susceptibility to compaction is the probability that soil becames compacted when exposed to compaction risk. Compaction can be low, medium, high and very high depending on soil properties and a set of external factors. Also compaction could occur when a force (external loading) compresses the soil and pushes air and water out of it, so that it becomes more dense, affects plant growth, root growth and crops yield **(lipiec et al 2003)**.

Despite the great economical and ecological importance of soil induration or compaction, few scientists paid attention to it in the past where research focused more on soil chemistry than soil physics, to improve plant growth and food production. After recognition of the damage done by soil compaction and induration, soil science community has to study it because of their increasing problem in soil management.

Egypt as a developed country, the problem of sustainable soil management and the pedological characteristics of the indurated or compacted soil have not received the attention they merit, particularly in the newly reclaimed soils, where soil induration or compaction should be avoided.

Studying of the pedological properties of indurated or compacted soil is considered one of the major steps for evaluating induration and compaction problems, and for suggesting the proper ways to manage those soils. Therefore, the current study was conducted to evaluate the pedological characteristics of indurated or compacted layers in some soils of Egypt. To fullfill the purpose of this investigation, three sites in three different regions were selected for soil sampling: El-Salhia (East Delta), Wadi el Natron (West Delta) and Toshka region (South Egypt); these regions have different environmental and soil forming factors which are expected to affect soil formation.

2- REVIEW OF LITERATURE

Soil is a complex medium, made up of a combination of solid mineral and organic particles and pore space. Pore space allows for air and water storage and movement in soils. Induration or compaction squeezes the soil and since solid does not compress, pore space is reduced.

Induration occurs as a result of some soil formation processes such as cementation of the layers by iron oxides, amorphous materials gypsum and/or calcium carbonate. While compaction occurs when a force (external loading) compresses the soil and pushes air and water out of it, so that it becomes more dense affecting root growth and propagation, plant growth **(lines kelly 2004 and Lacombe and Burton, 2010)**, and crops yield **(lipiec et al 2003 and Leprun et al, 2009)**.

Soils with indurated layers cover a widespread area in the world.

Compaction of agricultural soils is an important problem affecting not only root growth and crop productivity but also energy requirements for tillage operations. Soil ability for induration or compaction depends on both intrinsic and transient soil properties like texture, soil organic matter and soil moisture **(Diaz- Zorita et al, 2001 and Alonso-Zarza et al, 2008).** The following pages shows a brief review on the effect of compacted and indurated layers on the genesis and different characteristics of these soils

2.1. Genesis of indurated layers:

Campos (1991) studied the pedological induration in the soils of volcanic origin of Xalapa, Veracruz (Mexico). The results showed that these compact, indurated horizons have developed in clayey, halloysitic ferrollitic soils. Fe and Al contents are generally low but vary widely and were stongly correlated with rainfall. Silica content is always higher in the vicinity of the laminar horizons and plays an important part in the induration process.

Norton (1992) discussed the micromorphology of silica cementation in soils. Silica cementation is involved in the genesis of surface crusts, hardened horizons, fragipans and duripans. Only small amounts of silica are required to significantly increase soil strength. This increase is due to small bridging structures with isotic to undulic character. A better understanding of these siliceous naturally occurring cements will lead to the development of low cost, locally available cements for construction purposes as well as the development of amelioration techniques for soils where cementation is problematic. **(Freeland and Evans(1993)** studied the genesis of Typic Haplorthod (sandy skeletal, mixed, frigid, ortstein) from northern new Hampshire(USA). The results indicated two separate phases of translocation, in the first phase, inorganic sesquioxide and allophonic sols are deposited to form Bsm and BCm horizons and in the second phase, organic compounds were illuviated, creating Bhs and Bhsm horizons.

Pernandez and Werner (1994) reported that about 20% of the tepetates area of the central Mexican highlands were irreversibly damaged by erosion, with indurated hardpan (tepetate) at the soil surface. Evidence is presented that erosion in this area began later than had previously been reported, and that it was a much more accelerated process.

Chen (1998) studied the pedogenic gypcrete formation in arid central Australia. Apedogenic gypcrete contains > 80% gypsum with minor quartz sands, clays, carbonate and heavy minerals. The major processes of gypcrete formation include dissolution, leaching and recrystallization. Dehydration possibly occurs, helping to break down larger crystals. However, dehydrated forms of sulphates tend to be rehydrated to gypsum when any water is available from rainfall or atmospheric moisture.

Boulet et al (1998) stated that, iron bands, fragipans and duripans are common in yellow low-activity clay soils (Ultisols) developed from the Barreiras group in coastal plateaus of northeastern of Brazil. Such indurated horizons found in depressions of the plateaus

where sugarcane growth was greatly reduced. The formation of the indurated horizons studied was due to two sequential processes; development of aquic conditions and incipient podzolization such processes have affected the upper part of a thin (< 0.6 m in small depressions) or thick (>0.6m in large depressions) compact clay horizon, showing horizontal planes probably inherited from the sediment. Onsent of aquatic conditions formed the first fragipans overlying iron bands. Later, aquic conditions were combined with incipient podzolization to produce bleached loose horizons overlying duripans and iron bands. As the bonding agents in the duripans were organometallic complexes, these duripans appear to be very different from those described in arid environments.

Heck et al (1999) reported that, the distribution and the nature of Fe oxides in plinthitic soil (in Northeastern Brazil) indicated that plinthite formation and induration in all soils were accompanied by an enrichment of Fe oxides in all particle size fractions. This Fe segregation was accompanied by aggregation of particles leading to a greater degree of crystallinity, as indicated by analysis of Al / Fe ratios. Ratios of Al / Fe were larger in kandiustalfs than in the plinthuslalfs, and also larger than expected for Al-substituted Fe oxides. According to ratios of Al / Fe, Fe mobilization in all soils has likely occurred under reducing conditions, facilitated by organic matter on the soil surface. The indurated layers have different terms i.e different definitions according to the variation in the formation in different regions. The term "tepetate" in Mexico refers to indurated formations in usually sterile and erodel soils **(Ventura et al 1999 and Prat et al 2003)**.

Ventura et al (1999) revealed that, the presence of volcanic soil with indurated horizons is associated with semiarid condition, in the valley of Mexico. The hardened subsurface layers (tepetates) appear at the soil surface due to erosion of overlying topsoil.