HYDROSTRUCTURAL CHARACTERIZATION OF HIGHLY CLAYEY AND SALINE SOILS IN NIGER RIVER VALLEY

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Keywords: Clayey soil, Saline soil, Shrinkage, Swelling, Niger

In Niger, the introduction and development of irrigation systems have enabled the development of arable land in a climate of low rainfall and high evapotranspiration. However, these practices of large-scale irrigation changed the soil functioning sometimes leading to lower fertility, including salinization processes. The irrigated area of Sébéri nearby the Kollo village was selected as a study area. It is located 40 km south-east of Niamey (13°16'31"N, 2°21'25"E) on the lower terrace in the immediate vicinity of the Niger River. The climate is tropical and dry with a 24-year mean annual rainfall of 525 mm and a standard deviation of 113 mm. Soils are formed on alluvial deposits filling area depletions. Covering an area of 380 ha, the irrigated area was built in 1984 for rice intensification using a double cropping system each year (under rainfed and irrigated conditions) in bins of 0.25 ha. The rice fields are separated from each other by bunds that facilitate and promote infiltration flooding. The paddy soils of Kollo have specific characteristics not observed in other rice growing areas of Niger located on the lower terrace (Guéro, 2000). The soils are much more clayey, vertic, with marked acidity (pH from 3 to 5) and highly saline. In addition, a functional groundwater is present at shallow depths. Salinity severely restricts rice production in extensive areas. The salinity control in rice is a major challenge for Niger, a country that seeks to achieve food self-sufficiency through increased agricultural production. The present communication focuses to characterize hydrodynamic and structural properties of soils in order to infer the pedogenetic processes.

Four soil profiles were described and analysed to identify: i) the physical and chemical properties; ii) the mineralogy of clays, oxides and salt efflorescences, iii) the distribution of cracks in dry conditions. Hydrostructural analysis was performed to highlight the mechanical behavior of a clayey soil sample as a function of water content (Braudeau et al, 1999). Undisturbed soil samples were collected at four different depths (15-30 cm, 30-58 cm, 58-96 cm and 120-145 cm) in a given profile with a repetition for each depth (Adam, 2011). These measurements used to establish the shrinkage curve, that is to say, the change in volume of the sample according to its weighted water content. The entire device for measuring the shrinkage curve and data processing is described in detail in Braudeau et al. (1999) and Betsogo Atoua (2010). Raw data (weight, height and diameter of the cylindrical samples) are automatically recorded using a precision balance (mass), a laser spot (height) and a laser barrier (diameter), all being driven by a software properly configured (National Instruments, LabView 6.i). Characteristic points of the curve, denoted F, E, D, C, B and A, are determined (Braudeau, 1999). They correspond to different types of water and porosity and define the hydrostructural parameters of the soil sample.

Shrinkage curves show the volume evolution of a clayey soil sample depending on the water content in drying phase. Curves are established for a water content ranging from 0.35 $g\ g^{-1}$ to 0.1 $g\ g^{-1}$. During drying, the water loss does not result in air inlet of the macroporosity. The curves follow the saturation line and deviate at low water content (0.15 $g\ g^{-1}$), seen as the air inlet of the microporosity. The water behavior is the same at all depths. The pore volume, although it varies, remains in the same range for all samples (0.53-0.59 $dm^3\ kg^{-1}$). The water content of the samples after wetting phase is much lower than expected. Indeed, for clay, the water content at saturation is about 0.6 $g\ g^{-1}$. But here, we reach 0.37 $g\ g^{-1}$ for the highest value. Some of characteristic points, depending on the soil type, may not appear. Physical and chemical analyses of soils highlight the vertic and saline properties. Dominant clay minerals are kaolinite in near-surface and smectite in depth. Soil pH remains acidic and weakly variable. The minerals of magnesium sulfate (hexahydrite, epsomite), calcium sulfate (gypsum) and sodium sulfate (konyaite) are the major minerals inducing soil salinity and are more present in areas near the river dike.

Hydrostructural approach takes into account the soil deformation according to its mass water content over time. Applied to swelling clayey soils, it helps to assess the soil water reserves and improve the water transfer modeling for a better soil management.

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