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SANDBANK SPODOSOLS

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ABSTRACT

The goal of this paper is to perform a review of the existing literature on sandbank Spodosols. Spodosols are soils rich in acid and poor in exchangeable bases. From the physical standpoint, they are usually sandy in texture and have a very low water- and nutrient-retention capacity. They also have draining problems in the basin positions, where hardened horizons block the percolation of water. These horizons are formed by the podzolization process that consists of the translocation of organic material and Al, with or without Fe, from surface horizons to subsurface horizons, generating the spodic horizon. Understanding these soils is of major importance to the environmental studies in sandbanks, provided that they are more representative and little known. This study will subsidize environmental conservation and recovery measures in the sandbank ecosystems.

Keywords: spodosol, podzolization, sandy soils.

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1 INTRODUCTION

1.1 The Sandbank Environment

The term sandbank has different definitions: the geologic-geomorphologic, the botanical and the ecological one. In the geologic-geomorphologic one, it refers to bars or sandy barriers, especially when they close off coastal lagoons (COELHO et al., 2010). The coastal region is the most changed and exploited in Brazil (ROCHA et al., 2004).

As per Luz et al., (2011), today the occurrence of extensive contiguous areas of sandbank along the Brazilian coastline is rare, as they are now more fragmented. Santos et al. (2004) say that the Quaternary plain has a relatively flat surface, with max height of nearly 12 meters, slanting slightly to the Atlantic Ocean. Floodable zones are found between beach crests. The distribution of rain is strongly seasonal, with a monthly minimum precipitation of 41 mm in winter and max of 189 mm in summer; the yearly precipitation rate is 1,100 mm.

The different types of vegetation occurring in Brazilian sandbanks vary from herbaceous and shrubby formations to forests whose canopy is not higher than 20 m. (GOMES et al., 2007).

As per Mendonça et al., (2003), the sandbank substrate is made up of sandy sediments that are carried and deposited by the sea. These sediments are very much affected by the wind and marine waters, influencing the vegetation. These areas include differentiated environments like sand beads, bogs, dunes, foredunes, intermittent lagoons and permanent lagoons. The vegetation growing along those sand beads is found in the arboreal, shrubby or herbaceous form.

The vegetable communities associated with the beaches, dunes, sand beads, depressions in between beads, margins of lagoons, swampy and boggy environments and mangrove swamps are also named sandbank vegetation (COELHO et al., 2010).

Sugiyama (1998) presents a revision of the term sandbank in the botanical sense. He suggests that it be replaced by sandbank vegetation – the set of physionomically-different vegetable species, under marine and fluvio-marine influence, distributed in mosaic, occurring in areas of great biological diversity. This set can be verified in a study performed by Araújo et al. (1998) that classifies vegetable formations in the Restinga de Jurubatiba National Park which identified the following vegetable formations: reptant halophile-psammophile, dense post-beach shrubby vegetation, open shrubby vegetation of *Clusia*, open shrubby vegetation of Ericaceae, occasionally-flooded bush, permanently-flooded bush, sand-bead bush, open shrubby vegetation of Palmae, boggy and water herbaceous vegetation.

The soils under the sandbank vegetation are sandy and chemically poor. Their major nutrient source is the marine spray (Araújo & Lacerda, 1987; Gomes et al., 2007). As per Barcelos et al. (2012), coastline beads, called regressive, are also referred to as beach crests, sandbank strips or sandbank plains. They are made up of sandy soils occupying large coastal areas.

The soils under the sandbank vegetation include those that are generically classified as Spodosols and Quartz-sand Neosols (OLIVEIRA et al., 1992). Barcelos et al. (2012) highlight that soils can differ from each other by their level of saturation, water-table level, organic-matter content, age and exposition time or the nature of its material. In this paper, our focus will be on Spodosols.

1.2 Classification of Spodosols

The concept of Spodosol stems from Podzol, widely used in other classification systems to characterize soils developed from sandy sediments of temperate and boreal areas of the Northern Hemisphere. These areas stand out for the presence of a dark subsurface horizon resulting from the translocation and accumulation of organometalic complexes by the queluviation processes. The term Podzol was first used in 1979 by Dockuev in Russia, where it is part of the language. It is made up of prefix *pod* meaning under and *zola* meaning gray. It refers to the subsurface horizon whitened by aggressive organic acids, reminding one of the grayish color of burned wood (DRIESSEN & DUDAL, 1989). In Brazil, Spodosols are found in the coastal environments of the Barriers (Terciary) and Sandbanks (Quaternary), with different features, be in terms of their source material, their morphology or their genesis (MOREAU, 2001; OLIVEIRA et. al., 2010).

In the Brazilian Soil Classification System published by Embrapa (2006), the order Spodosol divides into Humiluvic Spodosols when the accumulation of organic C in the spodic horizon prevails (Bh); Ferrohumiluvic Spodosols, with the accumulation of organic C, Fe and Al (BHS) and Ferroluvic Spodosols, characterized by the accumulation of Fe (Bs). This designation of the suborders suggests the prevalence of organic-Fe complexes in the B-spodic horizon of Spodosols along the Brazilian coast, despite the fact that Al prevails over Fe in Brazil and in other countries (GOMES, 1995; MOREAU, 2001; GOMES, 2005; OLIVEIRA et. al., 2010).

In the current Brazilian Soil Classification System (SiBCS) published by EMBRAPA (2006), Spodosols are soils made up of mineral material having a spodic B horizon (Bh, Bhs or Bs) below any A or E horizon or a histic horizon less than 40 cm thick. Spodic horizons are formed by the accumulation of amorphous compounds of iluviated aluminum and iron associated with organic materials. Spodic horizons usually occur 200 cm from the soil surface or 400 cm if the thickness of the A + E or histic + E horizons exceeds 200 cm. By and large, the sequence of Spodols horizons is A, E, Bh/Bhs/Bs and C, and these horizons can be easily differentiated from each other. Spodic B horizons can be found cemented by organic matter and Aluminum with or without iron. In this case, they are named *ortsteins* (EMBRAPA, 2006).

1.3 Pedogenesis and Spodosols

Sandy soils like sandbanks undergo a process called podzolization, in which water percolation into the soil provides formation to the White bedding lying below everything that accumulates and is washed off from the upper soil, humus, cations and iron oxides, causing such soils to be poor and acid (BARCELOS et al., 2012). Podzolization is the process consisting of the translocation of organic material and Al, with or without Fe, from the surface horizons to the subsurface horizons, generating the spodic horizon (GOMES et al., 2007).

As per authors Sauer et al. (2007) and Coelho et al. (2010), the hypothesis of the formation of the podzolization is involving engagement and compound-translocation mechanisms. They can be summed up into three major theories: (1) the formation of complexes that are soluble in the water of organic acid like Fe, Al and Si; (2) the reduction of Fe by organic acids and the migration of organic-metallic complexes; and (3) the translocation of Al, Si and Fe as inorganic acids.

As cited by Dalri et al. (2010), the stability of the aggregates is determined by the so-called cementing agents that are represented primarily by the organic matter and iron and aluminum oxides. This way, as the amount of these elements in the soil increases, the greater the possibility that it has the most stable structure.

For tropical environments, the presence of material of essentially quartzose source and subsurface obstacles like a high water table and/or a cemented horizon) represents the common condition of the occurrence of a spodic horizon (SILVA *et al.,* 2013). The occurrence of Spodosols sometimes overtakes the forest as the climax vegetation, in an environment blending shortages of fertility, water and oxygen (BONIFACIO et al., 2006).

Silva et al. (2013) say that the shortage of water and oxygen in the same soil environment is related to the sandier texture of the subsurface horizons and to the hardended and waterproof bedding in the subsurface, influencing the rising of the water table in the humid season.

Spodosols usually have a Sandy textture with a very low capacity to retain water and nutrients and draining problems in the lower-basin positions, where hardened horizons block the water percolation, creaing the overhead water table in the rainy season. It also impacts the growth of roots when they are surface (CARVALHO et al., 2013).

As per Oliveira et al. (1992) Spodosols (formerly named Podzols) are mineral soils, with a sequence of horizons A-E-Bh and/or Bs and/or Bhs-C. They are mostly sandy, and references to other texture classes are rare. Tropical Spodosols are typically hydromorphic, often very deep. They get to grow into gigantic Spodosols (Coelho et al., 2012).

Spodosols can be identified by the color of the spodic horizon that can be gray, dark gray, black, red or yellow, and by the sharp differentiation of horizons. They can have cemented horizons like fragipan, duripan or *ortstein* underlying the spodic horizon as per SiBCS (EMBRAPA, 2006). One notices the process of losing aluminum compounds with or without iron in the presence of acid humus and the subsequent accumulation of said constituents deep down.

In Brazilian tropical environments, getting to know the conditioning processes and factors involved in the mobilization, migration and accumulation of organic matter (MO) and metals (Al and Fe) in the diagnosis horizons of Spodosols (Bh) is budding (COELHO et al., 2010).

Spodosols are characterized by the presence of the spodic horizon, where mixes of organometalic complexes accumulate, with or without oxyhydroxides of Fe and Al and aluminosilicates having different degrees of crystallinity (imogolite, allophane, halloysite, kaolinite and vermiculites with hydroxi in between beddings) (GOMES et al., 2007).

High concentrations of Al dissolved in the soil solution are often observed at the sites where Spodosols prevail. Therefore, they are of great environmental concern because of the potentially adverse effects of inorganic aquous AL in the ground and water organisms (COELHO et al., 2010).

The process of the spodic B horizon formation, relatively rich in Fe and Al oxides and/or organic eluvial carbon, sometimes poor in clay and hardened, is very much debates in the literature, mostly on Spodosols from the Northern Hemisphere. Reviews and articles discuss different hypotheses about the podzolization process (SAUER et al., 2007).

As per Silva et al. (2013), in tropical environments, the presence of material of essentially quartzose source and of subsurface obstacles (higher water table and/or a cemented horizon) represents a common condition for the occurrence of the spodic horizon.

2 FINAL REMARKS

Genesis studies of Spodosols in tropical and subtropical climates are still rare. High concentrations of Al dissolved in the soil solution are often observed at the sites where Spodols prevail and, therefore, are of great environmental concern. Understanding these soils is key for environmental studies in sandbanks, since they are well represented and little studied. Studying them will provide subsidies for conservation and recovery initiatives in sandbank ecosystems.

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