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Soils of Ecuador: Relationship between parental material and soil health

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Abstract

Soil properties control fundamental processes that contribute to soil health and quality; however, the parent material shapes the behavior of these properties. The term «tropical soil» is commonly used to identify soils from tropical regions, often as a synonym for highly weathered, red, acidic, and infertile soils. However, not all tropical soils possess these characteristics. The modification of normal weathering processes, the contribution of new parent material such as volcanic ash, and the altitudinal and temperature differences created by the *Andes* mountain range have allowed Ecuador, a country located on the equator, to host a variety of soils that support one of the highest expressions of biodiversity on the planet. The relationship between mineralogy and soil properties defines the characteristics of healthy soils. Soils dominated by 2:1 clays, such as montmorillonite and vermiculite, which are characterized by permanent charge, behave differently from variable charge soils, such as those dominated by short-range order clays like allophane and imogolite (volcanic soils) and those dominated by iron and aluminum sesquioxides. It is important to note that the nature and quantity of clay minerals control the persistence of the microbiome through the interactions between soil organic carbon and different types of clays. For that reason, organic carbon accumulation depends on the parent material and the clay minerals resulting from its weathering. Additionally, soil pH is a critical property that governs nutrient availability, influences microbiome activity, and controls the potential toxic effects of ions like aluminum [Al^{3+}]. However, these processes are dependent on the type of surface electrical charge developed by the clays present. Although the differences in soil behavior related to clay surface charge are clear, the distribution of permanent-charge and variable-charge soils is not homogeneous across the territory, complicating management practices. Furthermore, the strict parameters of taxonomic classification systems can lead to seemingly ambiguous situations. This is the case with soils classified as Inceptisols, which may be dominated by either permanent-charge or variable-charge clays depending on their location. It is, therefore, essential to seek technological tools that enable the analysis of the abundant metadata accumulated by various projects, such as the «Generation of Geoinformation for Territorial Management at the National Level». These tools should help identify relationships between parent

material, mineralogical and organic composition, and management options that can sustain or improve soil health and, ultimately, agricultural productivity.

Keywords: Tropic, Weathering, Clays, Acidity, Biome.