Soil Aggregation Effects on Water Movement and Nutrient Dynamics Across Three Costa Rican Land Uses

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Abstract

Soil structure plays a central role in regulating water movement and nutrient retention, particularly in tropical environments where high precipitation intensifies nutrient leaching. Agricultural management can disturb soil stability and soil aggregation, altering how water and nutrients move through the soil profile. While research has linked soil aggregation to infiltration and nutrient retention, little is known about how this relationship functions in tropical soils across different land uses. This study investigates how aggregation influences water flow and nutrient leaching across three land uses in the Peñas Blancas region of Costa Rica: a papaya farm (*Carica papaya*), a managed plantation of Pilón trees (*Hieronyma alchorneoides*), and a native forest. Soils were collected using 7x10 cm sampling cores, four sample locations were randomly selected per site and separated into intact and sieved <2 mm treatments. Sampling cores were refilled by dry mass and tested for infiltration and hydraulic conductivity using the falling head method. Leachate was analyzed for nitrate and ammonium under natural and amended conditions. Homogenized cores exhibited higher infiltration rates and hydraulic conductivity (Ksat) across all land uses, a trend strongest in papaya farm soils where homogenized cores had the highest Ksat values and intact cores had the lowest values. Intact cores overall retained more nutrients, particularly ammonium. Nitrate differences were minimal in native forest soils but more pronounced in agricultural soils, where intact cores leached less following nutrient addition. Disrupting aggregation accelerated water flow while reducing nutrient retention, posing concerns for long term soil health in managed tropical landscapes