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Quantification and Spatial Variability of Soil Organic and Inorganic Carbon in the Intermediate Zone Forests

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Abstract

Soil carbon plays a critical role in regulating ecosystem functions, nutrient cycling, and long-term carbon sequestration. Understanding the dynamics of Soil Organic Carbon (SOC) and Soil Inorganic Carbon (SIC) in tropical forest ecosystems is crucial for developing effective, sustainable forest management strategies. This study quantifies and analyses the spatial variation of SOC and SIC, along with the effects of environmental and human factors on their variability, in the intermediate zone forests of Sri Lanka. Field data were collected using a systematic random sampling approach, where 34 sampling points were selected across representative forest sites in Badagamuwa Conservation Forest and Dikkele Forest Reserve. A total of sixty-eight composite soil samples were extracted with an auger at two depth intervals (0-7.5 cm and 7.5-15 cm) for laboratory determination of SOC and SIC contents. Parallel to this, indices such as Leaf Area Index (LAI), Normalized Difference Vegetation Index (NDVI) Human Disturbance Index (HDI) were derived from hemispherical photographs and Sentinel-2 satellite imagery. In-situ measurements of soil pH, Oxidation-reduction Potential (ORP), temperature, and moisture were taken to capture micro-environmental variability. Laboratory analysis indicated that the average SOC content was 2.26%, while the average SIC content was 1.15%, with both forms of carbon showing depth-dependent variation. The 7.5-15 cm soil layer stored higher SOC (8.9 t/ha) and SIC (5.2 t/ha) compared to the surface layer, which contained 8.0 t/ha and 3.5 t/ha, respectively. Spatial interpolation using the Inverse Distance Weighting (IDW) method revealed a heterogeneous distribution of SOC and SIC across the landscape. Statistical analyses, including regression and Principal Component Regression (PCR), identified soil moisture ($p<0.001$), canopy light variability ($p=0.01$), and oxidation-reduction potential ($p=0.03$) as key predictors of SOC variation, while SIC was primarily influenced by soil moisture ($p<0.001$). Overall, this study shows the significant role of vegetation structure, soil moisture, and human disturbance in SOC and SIC dynamics in Sri Lanka's intermediate zone forests.

Keywords: *Soil carbon stocks, Intermediate zone, Anthropogenic disturbances, Predictors*