The Impacts of Tree Species on Soil Organic Carbon and Nutrient Pools in Reclaimed Post-Mining Soils

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Abstract

Revegetation of reclaimed post-mining sites with tree species plays a vital role in restoring soil organic carbon (SOC) and nutrient dynamics, critical for ecosystem recovery. This study evaluates SOC, nitrogen (N), and nutrient pools—along with their stoichiometric relationships—across five tree species (black alder [BA], black locust [BL], English oak [EO], European larch [EL], and Scots pine [SP]) in reclaimed hard coal mining soils. Results revealed that SOC in the litter layer (Oi+Oe) was significantly higher under BA and SP than BL, EL, and EO, while N content peaked under BA and BL. In the topsoil (0–10 cm), BA exhibited the highest SOC accumulation, with N similarly elevated under BA and BL. Subsoil (10–30 cm) C and N concentrations were highest under BA, BL, and EL. A reference natural forest (NF) retained significantly more SOC in the litter and topsoil compared to reclaimed sites. Nutrient analysis showed no significant differences in phosphorus (P), potassium (K), sodium (Na), hydrolytic acidity (Ha), sum of exchangeable cations (SEC), or share of basic cations (SBC) among species at both depths. However, in the topsoil, sulfur (S) and magnesium (Mg) were higher under BA, BL, EL, and SP than EO, while calcium (Ca) was elevated under BA, BL, EL, and EO compared to SP. Subsoil S was higher under EL and SP than EO, and Mg was greater under BA, EL, and SP. NF had higher topsoil P and elevated Na and Ha at both depths but lower Ca, SEC, and SBC than reclaimed soils. Stoichiometric analysis indicated higher topsoil C:N ratios under EL and SP, while BA had a greater N:P ratio than SP. No significant differences were observed in subsoil stoichiometry. NF exhibited lower C:N ratios than EL and SP in the topsoil and EL in the subsoil, alongside higher N:P ratios than SP in the topsoil. These findings highlight species-specific impacts on reclaimed mine soil biogeochemistry, offering insights for sustainable reforestation strategies.

Keywords

Soil nutrient dynamics, Ecosystem restoration, Carbon sequestration, Forest rehabilitation, Mine soil rehabilitation, C:N:P ratios.