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Soil quality and carbon sequestration in a reclaimed coal mine spoil of Jharia coalfield, India

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Revegetation of coal mine spoil helps in carbon storage and the success of remediation depend on the selection of appropriate tree species. A study was conducted at the coalmine overburden dumps of Jharia Coalfield, Dhanbad, India to evaluate the impact of revegetation on the overall soil quality and carbon sequestration. Morphological parameters (tree height, diameter at breast height, tree biomass, wood specific gravity) of the dominant tree species (Acacia auriculiformis, Cassia siamea, Dalbergia sissoo and Leucaena leucocephala) growing on the mine spoil was recorded. Mine spoil samples were collected under the canopy cover of different tree species and analyzed for soil physical, chemical, and biological parameters. In general reclaimed sites had better soil quality than the reference site. For instance, D. sissoo and C. siamea improved soil pH (+28.5%, +27.9%), EC (+15.65%, +19%), cation exchange capacity (+58.7%, +52.3%), organic carbon (+67.5%, +79.5%), N (+97.2%, +75.7%), P (+98.2%, +76.9%), K (+31.8%, +37.4%), microbial biomass carbon (+143%, +164%) and dehydrogenase activity (+228%, +262%) as compared to the unreclaimed reference coal mine site. The concentration of polycyclic aromatic hydrocarbons (PAHs) decreased significantly in the reclaimed site than the reference spoil, C. siamea was found to be more promising for PAH degradation. The overall impact of tree species on the quality of reclaimed mine spoil cannot be assessed by individual soil parameters, as most of the parameters are interlinked and difficult to interpret. However, combination of soil properties into an integrated soil quality index provides a more meaningful assessment of reclamation potential of tree species. Principal component analysis (PCA) was used to identify key mine soil quality indicators to develop a soil quality index (SQI). Coarse fraction, pH, EC, soil organic carbon, P, Ca, S, and dehydrogenase activity were the most critical properties controlling growth of tree species. The indicator values were converted into a unitless score (0–1.00) and integrated into mine soil quality index (SQI). Higher SQI values were obtained for sites reclaimed with Dalbergia sissoo (0.585) and Cassia siamea (0.565) compared to the reference mine spoil (0.303). The calculated index was significantly correlated (r = 0.84) with plant growth parameters. The carbon dioxide sequestration potential of the reclaimed site was 133.3 t/ha, while the total tree carbon density was highest in D. sissoo (13.93 t/ha) and C. siamea (11.35 t/ha). Based on SQI and C sequestration potential, Dalbergia sissoo and Cassia siamea was found to be more suitable for reclamation of mine spoil.