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Temperature & wood source control PyOM turnover in a Northern American forest

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Surprisingly little is known about how pyrolysis temperature and wood source affect the stability of forest-fire derived pyrogenic organic matter (PyOM). Here, we show that wood source and temperature affect in situ mineralization rates of PyOM in soils for two co-occurring gymnosperm (jack pine; JP [Pinus banksiana]) and angiosperm (red maple; RM [Acer rubrum])¬ species from North American boreal-temperate ecotones. We assess the effect of pyrolysis temperature on PyOM fates by following the decay of 13C/15N-enriched JP wood (JPwood) and PyOM produced at 300 °C (JP300) and 450 °C (JP450); and assess the effect of PyOM wood source by comparing fates of JP450 and RM450.

JPwood mineralized 18× faster than JP300 and 44× faster than JP450 after 2.8y. RM450 mineralized initially faster than JP450 during the first ∼2y, but became equivalent afterwards (1.1±0.2% of CO¬2 losses after 2.8y). Modeled turnover times suggest that this can be attributed to ∼1% of fast-cycling PyOM (<3y). Slower-cycling pools are 12× faster for JPwood (13±5y) than for JP300 (157±28y) and 55× faster than for JP450 (700±229y). Modeled turnover times of the slow-cycling pools were equivalent for JP450 and RM450. The priming effect was positive for JPwood (0.10±0.05), neutral for JP300 (-0.02±0.04), and negative for JP450 (-0.15±0.03) and RM50 (-0.59±0.03). DOC losses were minimal compared with CO_2 losses (DOC:CO_2 ratio ≤0.005), but followed the same patterns: JPwood 6× greater than that of JP300 and 39× greater compared with JP450. After 1y, C recoveries were lower for JPwood than for PyOM, with no influence of pyrolysis temperature or wood source (yet); N recoveries did not differ. PLFA-(13)C data reveal that (i) treatments have similar microbial communities after 1y, (ii) JPwood is preferentially utilized by fungi, and (iii) bacteria increasingly utilize PyOM as pyrolysis temperature increases. Estimated carbon use efficiency decreased with increasing pyrolysis temperature (JPwood∼JP300>JP450∼RM450). Although insignificant, potential phenol oxidase and peroxidase activities decrease with increasing pyrolysis temperature. Neither PyOM nor wood additions (∼11% of soil C stock 0–20 cm depth) affected pH or Ec after 1y.

We provide the first, field experimental evidence that pyrolysis temperature and wood source affect the turnover of PyOM in soil. We show faster, initial decay for PyOM produced at lesser temperature and RM (angiosperm) compared with JP (gymnosperm). This study offers realistic insights on (i) the controls underlying in situ PyOM turnover, and on (ii) how ongoing/projected changes in tree species composition and fire frequency/intensity/distribution may affect PyOM in soil of North America temperate-boreal ecotones.