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Black carbon characterization in Quebec black spruce forests

Laure Soucemarianadin (1), Sylvie Quideau (1), Roderick Wasylishen (2), and M. Derek MacKenzie (1)

(1) Department of Renewable Resources, University of Alberta, Edmonton, Canada (soucmari@ualberta.ca), (2) Department of Chemistry, University of Alberta, Edmonton, Canada

Black carbon (BC), an important component of the global soil carbon pool, is a major by-product of wildfires in Quebec black spruce forests. However, BC characteristics vary depending on the environmental conditions under which it is formed and this may further affect its resistance to degradation. The objective of this study was to characterize the chemical and physical properties of BC formed under variable fire severity to assess its potential for recalcitrance as a passive carbon pool. Samples (n = 267) of BC produced by early season wildfires in 2005–2007 were collected from the surface of black spruce forest floors to cover the range of severity encountered in these fire-affected forests. Representative samples (n = 33) were then analyzed using elemental analysis, solid-state ^{13}C nuclear magnetic resonance (NMR) spectroscopy, scanning electron microscopy and surface area analysis (BET method). Properties of BC sampled in the field were compared with those of samples produced under a range of controlled formation conditions in the laboratory. The NMR spectra of the BC collected on sites affected by low fire severity showed a distribution of total intensity between the different spectral regions very similar to those of unburned fuels, and were dominated by peaks indicative of cellulose, while spectra for BC from higher fire severity sites were dominated by a broad peak assigned to aromatic carbons. Atomic H/C and O/C ratios decreased along the fire severity gradient, confirming that increasing severity was associated with an increase in condensation. By comparing field- to laboratory-produced samples, we concluded that the temperature of formation in the field ranged between 75 and 250 ˚C. In all analyzed BC samples, the fraction of aromatic carbon:total carbon was low, suggesting that the freshly produced BC in this boreal forest environment may be susceptible to rapid physical alteration and chemical degradation. Nevertheless, it is important to highlight that the BC we investigated was characteristic of early season fires. These early season fires are typical in eastern Canada, and also present in regional and global scenarios of future fire regimes associated with climate change.