Black carbon as isolated by chemical oxidation: characterization and contribution in litter and soil

M. A. Alexis (1), C. Rumpel (1), H. Knicker (2), D.P. Rasse (1,3), N. Péchot (1), A. Mariotti (1)

(1) Laboratoire de Biogéochimie et Ecologie des Milieux Continentaux, Centre INRA Versailles-Grignon bât. EGER, 78850 Thiverval-Grignon, France, (2) Lehrstuhl für Bodenkunde. Technische Universität München, D-85350 Freising-Weihenstephan; (3) Bioforsk, Norwegian Institute for Agricultural and Environmental Research, Frederik Dahls Vei, 1432, Ås, Norway.

More than 400Mha of land surfaces are concerned by vegetation fire each year, in savannas, boreal forest and Mediterranean ecosystems (Lavorel et al., 2001). Biomass burning leads to a carbon loss to the atmosphere as gas and particles, and to the production of pyrogenic carbon that contains black carbon, considered as one of the most stable components of soil organic matter. Long term balance between these two processes is still unclear and Masiello (2004) highlighted the need to improve global carbon budget using new field measurements. The fire-induced conversion of above-ground biomass into black carbon and the use of soils with well-known fire history appear as essential data (Czimczik et al., 2003; Daï et al., 2005). The aim of this work was to link the quantity of black carbon produced during a fire event and the stocks remaining in soils after fire. We tested the capacity of chemical oxidation to isolate an aromatic, a priori stable fraction of the combustion continuum in litter as well as in soil organic carbon.

Litter samples were collected before and after the fire in a subtropical oak scrub. Post-fire material was visually divided into burned and unburned leaves. During the burning, temperature elevation was assessed with thermosensitive paints. Soils (0-30cm) were also sampled in four areas of the same ecosystem, protected from fire for 1 to 20 years. All samples were crushed and demineralised with a HF/HCl solution (10%/6M). The oxidation with H₂SO₄/K₂Cr₂O₇ solution was performed at a temperature of 80±5°C and during 24 hours. Black carbon quantification was obtained by
measurements of weight and carbon content. Isolated carbon (OREC) was characterized with solid-state $^{13}$C nuclear magnetic resonance spectroscopy.

In unburned litter samples, less than 1% of treated OC is resistant to the oxidation and repetition error represents about 0.4% treated OC. In litter charcoal, the oxidation allows concentrating aromatic carbon and the OREC content is correlated to the production of aromatic pyrogenic carbon by temperature elevation. When applied to soil organic matter, the oxidation concentrates aromatic carbon in soil surface samples, but some alkyl carbons are also preserved. The $^{13}$C NMR analysis is necessary to convert OREC measurement into black carbon value. Black carbon content of visually-identified charcoal varied from 4 to 16% OC. As a result, a typical oak scrub fire could produce from 10 to 30 g BC m$^{-2}$. The first 25 cm of soil contain between 40 and 90 g m$^{-2}$ of black carbon. But no black carbon (aromatic and resistant) is detected in deep soil horizon by oxidation. Results of this work indicate that black carbon can accumulate in soil surface for at least 100 years.

References:


