SOIL Discuss.,
doi:10.5194/soil-2016-57-RC2, 2016

SOIL Discussions

Interactive comment on "Thermal alteration of soil organic matter properties: a systematic study to infer response of Sierra Nevada climosequence soils to forest fires" *by* S. N. Araya et al.

Anonymous Referee #2

Received and published: 19 October 2016

General comments: The present work describes research performed to investigate the impact of fire temperature on the organic matter composition of soils from a climosequence derived from the Sierra Nevada (USA). It was intended to infer the implications of changing climate on topsoil SOM properties that might experience changing fire regime. This subject is of course of interesting for the readers of SOIL and deserves a proper treatment. In order to reach their objectives, the authors conduct a systematic study to examine the changes of topsoil organic matter from the selected soils occurring during their heating under laboratory conditions at increasing temperatures. Those experiments show that major changes occur at temperatures > 250°C and that those changes are expressed mainly in a loss of C and N and the formation of aro-

Printer-friendly version

Discussion paper

matic C. This approach has also been used in many other studies which came to the same results, although they used other materials. Taking this into account, the study is not really a novel idea or concept, but confirms already existing data. The authors try to put their results into the context of climatic change. Well, the climate change may change the C contents in soil, the quality of the litter and the fire frequency, but the chemistry occurring during combustion will not be altered. The climate change will also not have a considerable direct impact on fire intensity, since the latter is mostly determined by the available fuel and its moisture (OK, if there is more fuel due melting of permafrost soils, yes there is an indirect impact of climate on fire intensity. If the climate turns drier there are only more fires if the fuel density does not change etc.). I think, it is difficult to perform the relationship which was done by the others which turns some of the conclusions into opinions which can be obtained without conducting the present work. I think also, that it is difficult to conclude that climatic change lead to more fires with temperatures above 250°C. If the right fuel is present, the temperatures of a forest fire can easily increase to 1000°C and more - even without climatic change. Of course not much charcoal will accumulate under those conditions. The produced accumulated charcoal, on the other hand, is the material which enters the soil and will change the chemical composition of its SOM. This impact will be higher than the transformation of SOM in the mineral phase itself, since the low thermal conductivity of the latter prevents easy increase of soil temperatures and thus major heat-induced alterations of its SOM. Considering further that mineral soils were analyzed, I strongly suggest to include a part explaining the temperature profile of mineral soils during fire in the introduction. Summarizing my concerns together, it is not clear to me, how the used experimental design can add to a better understanding of the impact of climate change on the transformation of topsoil SOM due to fire. I think if the authors present their data as a relationship between soil properties and their alterations due to the impact of fire and the content of SOM (without trying to include climate change), the paper would still be of interest but less speculative. Specific comments: Introduction, line 12: sugars cannot be aromatic. I suggest, ...higher aromaticity due to transformation of carbohydrates and lipids (actually, the latter may rather transform into smaller units) Material and Methods: - Mention which Sierra Nevada was studied (USA). - The whole description of the study side is very extensive which is not necessary to be able to follow the approach. It should be considerably shortened. - I missed the information if the litter layer was included in the sampling o if only mineral soils was used. This question is of importance since the litter represents the fuel. - Why was oxygen supply limited? In natural above-ground fires, the fire commonly stops under oxygen depletion. In addition, it has to be considered that pyrolysis allows to go to higher temperatures before complete combustion occurs. Page 8, line 4: At the used temperatures no alteration of the mineral phase is expected. In addition, dry soils were used, thus higher moisture due to colder climate is not probed. Therefore, the only differences in soil properties which are relevant for the effect of fire temperature is the quality and the quantity of organic matter which can be related to climate regime but may also be altered by other environmental conditions (Whereas the quantity of C has been considered for the discussion of the data, the quality was largely neglected). Thus, in my opinion, it is difficult to relate unbiasedly climate regime to impact of fire on SOM. Results: Page 10: With respect to the concomitant loss of C and N, see also early work of (Knicker et al., 1996; Almendros et al., 2003) Page 11: A fact, which has to be considered with stable isotopic data interpretation is that different chemical compound classes don‘t exhibit the same resistance against heat. For example, carbohydrates transform into furans at temperatures at which lignin polymers are only cleaved and only some side chains are released as CO2 or water (Sharma et al., 2001; Sharma et al., 2004). Since different biomolecules have different stable isotopic ratios, this behavior can result in the shift of the ratios for the whole sample. Page 13: I suggest to include FTIR spectra of the unburnt soils which would allow to relate the initial quality of the SOM (most likely affected by the climate and vegetation cover) to changes induced by the fire. Page 14, line 6: The authors are certainly not discussing the physico-chemical properties of a soil, but the physical (pore size etc.) and chemical (pH, chemical composition etc.) properties. Line 8: In the reference "Knicker et al." it is stated that fire can lead to in-

Printer-friendly version

Discussion paper

crease or decrease of organic C in the soil, depending upon the intensity of the fire and the amount of produced char derived from the vegetation cover and litter layer. Page 15, line 4: Other studies showed that a considerable amount of N is transferred into the so called Black N (Knicker, 2010; de la Rosa and Knicker, 2011), which would much better explain the decrease of the C:N ratio with temperature (This does not mean that ammonium is not formed, but not all N turns into inorganic forms..) Page 17, line 5: The reference represents a review and does not show studies in which the degradation of lignin and hemicellulose starts at 130°C. However, studies of the same author showing complete removal of carbohydrate at 350°C are (Almendros et al., 1994; Knicker et al., 1996; Knicker et al., 2008)). As mentioned above, I have problems with the part Climate Change implications. For example, the statement of line 16 to 23 on page 18 is very general and has only very few relation to the results of the data. Actually, if the rain-snow transition zone is moving higher, considerable losses will occur due to increased SOM degradation. If less SOM is present, this may give less fuel to the fire (only a mind game. . .) Page 19: Fires in the range of 250 to 450°C (topsoil temperature) are in the range of low to medium severity fires. The respective mineral topsoil is expected to have temperatures which are still below 200°C. High severity fires are hotter than 510°C and are recognized by the fact that mostly ash remains on the soil.

Almendros, G., Fründ, R., Martin, F., González-Vila, F.J., 1994. Spectroscopic characteristics of derivatized humic acids from peat in relation to soil properties and plant growth. In: N. Senesi, T.M. Miano (Eds.), Humic Substances in the Global Environment and Implications in Human Health (Ed. by N. Senesi, T.M. Miano), Elsevier Science, pp. 213-218. Almendros, G., Knicker, H., González Vila, J.F., 2003. Rearrangement of carbon and nitrogen forms in peat after progressive thermal oxidation as determined by solid-state 13C- and 15N-NMR spectroscopy. Organic Geochemistry, 34, 1559-1568. de la Rosa, J.M., Knicker, H., 2011. Bioavailability of N released from N-rich pyrogenic organic matter: An incubation study. Soil Biology and Biochemistry, 43, 2368-2373. Knicker, H., Almendros, G., González-Vila, F.J., Martín, F., Lüdemann, H.-D., 1996. 13C- and 15N-NMR spectroscopic examination of the transformation of organic nitro-

Printer-friendly version

Discussion paper

gen in plant biomass during thermal treatment. Soil Biology and Biochemistry, 28, 1053-1060. Knicker, H., Hilscher, A., González-Vila, F.J., Almendros, G., 2008. A new conceptual model for the structural properties of char produced during vegetation fires. Organic Geochemistry, 39, 935-939. Knicker, H., 2010. "Black nitrogen" - an important fraction in determining the recalcitrance of charcoal. Organic Geochemistry, 41, 947-950. Sharma, R.K., Wooten, J.B., Baliga, V.L., Hajaligol, M.R., 2001. Characterization of chars from biomass-derived materials: pectin chars. Fuel, 80, 1825-1836. Sharma, R.K., Wooten, J.B., Baliga, V.L., Lin, X., Chan, W.G., Hajaligol, M.R., 2004. Characterization of chars from pyrolysis of lignin. Fuel, 83, 1469-1482.

Interactive comment on SOIL Discuss., doi:10.5194/soil-2016-57, 2016.