

Biomarker analysis in soils of the Amazon rainforest after vegetation fire

Janaina Berne da Costa¹, Deborah Pinheiro Dick¹, Maurifran Oliveira Lima¹, Larissa Zacher Lara¹, Maria do Carmo Peralba,¹ Falberni de Souza Costa²

¹Federal University of Rio Grande of Sul (UFRGS), Institute of Chemistry, 91501-970 Porto Alegre, RS-Brazil

²Embrapa, Centro de Pesquisa Agroflorestal do Acre, 69900-970 - Rio Branco, AC - Brazil
E-mail contact: bernejana@gmail.com

1. Introduction

Biomarkers, also known as molecular markers, refer to compounds that have a relationship with their precursors and indicate the occurrence of a particular process within an organism. Recently, the evaluation of biomarkers in plants or soil has become a more common procedure, since the abundance of these compounds are sensitive to changes in the soil organic matter (SOM) caused by the use and management of soil.¹

Soil organic matter is made up, among other moieties, by a lipid fraction, which is composed of insoluble organic substances in water. These compounds can be extracted with organic solvents such as dichloromethane and methanol, and may be separated and identified by gas chromatography coupled with mass spectrometry (GC-MS). The content of this fraction comprises much of the soil aliphatic structures and may give information about the source of the organic matter present in soil (microbial origin or higher plants) and is therefore called biomarkers. Studies on soil biomarkers can contribute to the understanding of the dynamics and stabilization of organic matter, which is of great importance from an environmental point of view.²

The objective of this study was to determine the origin of organic matter incorporated in Amazon forest soils subjected to vegetation fire by analyzing the aliphatic biomarkers (*n*-alkanes) present in lipid extracts of soil samples.

2. Materials and methods

The study area is located at Embrapa-Acre in Rio Branco, Acre/Brazil and consists of primary forest which was partially burned in 2011. Samplings were conducted in September 2012 (one year after burning) and September 2014 (three years after burning) in primary forest areas (PF) and burnt forest (BF) at two depths: 0-5 and 100-150 cm. The contents of C and N of the soil samples were determined by dry combustion.

Approximately 4 g of sample was used for lipids extraction. The samples were extracted via Soxhlet with dichloromethane/methanol (3:1 v/v) for 24 hours. Completed the extraction step, the lipid extract was concentrated in rotary evaporator. The extracts containing lipids were then subjected to fractionation using preparative liquid chromatography atmospheric pressure. It was used a column of silica and alumina and the *n*-hexane solvent for elution of *n*-alkanes biomarkers. The distribution of *n*-alkanes was determined by GC/MS using an Agilent 6890N gas chromatograph connected to a Waters Quattro Micro GC tandem Quadrupole mass spectrometer, equipped with Agilent HP-5 column (30 m length, 0.25 mm i.d, 0.1 µm film thickness) and automatic injector. The oven temperature programme was 70°C (2 min hold), followed by a rate of 30°C/min from 70 to 100°C and 40°C/min from 100 to 308°C (held 8 min). The GC-MS was operated using Selected Ion Monitoring (SIM) mode.

3. Results and discussion

3.1. *n*-alkanes (0 - 5 cm)

The mass chromatograms (*m/z* 71) for the *n*-alkanes for soils studied at the depth of 0-5 cm, one year after burning are shown in Figure 1A and Figure 1B. Gas chromatographic analyses of saturated hydrocarbons did not show a similar *n*-alkane distribution in soil of PF (Figure 1A) and BF (Figure 1B). Two types of *n*-alkane distribution can be distinguished. In the first type, which occurred with PF soil, a bimodal distribution profile was observed and it showed the presence of a series of *n*-alkanes ranging from C₁₇-C₃₁, and a predominance of even over odd with maximum C₁₈ and C₁₉. This distribution profile is characteristic of a SOM with contribution from both microbial and higher plants origin.

The second type of *n*-alkane distribution, presented by BF, showed an unimodal distribution profile with a presence of *n*-alkanes ranging from C₁₆-C₃₁ with maximum at C₁₆, C₁₇ and C₁₈. This is a typical profile of SOM from microbial origin. After fire, the samples showed a change in the distribution profile: the largest *n*-alkanes chain (C₂₉-C₃₁) related to higher plants has been reduced by the burning of biomass (Figure 1B)

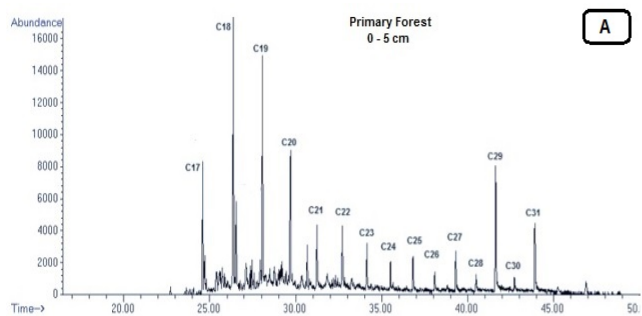


Figure 1A. Profile of *n*-alkanes for soil of PF (0-5 cm).

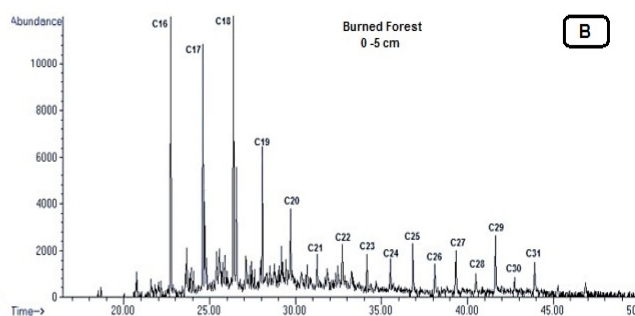


Figure 1B. Profile of *n*-alkanes for soil of BF (0-5 cm).

3.2. *n*-alkanes (100 - 150 cm)

The chromatograms of *n*-alkanes one year after burning of PF and BF at the depth 100-150 cm showed similar distribution profile as the corresponding surface layers (Figures 2A and 2B). Nevertheless, the lipids abundance was smaller than in the 0- 5 cm layer. This behavior corroborates with total C data (data not shown), that decreased steadily along the profile.

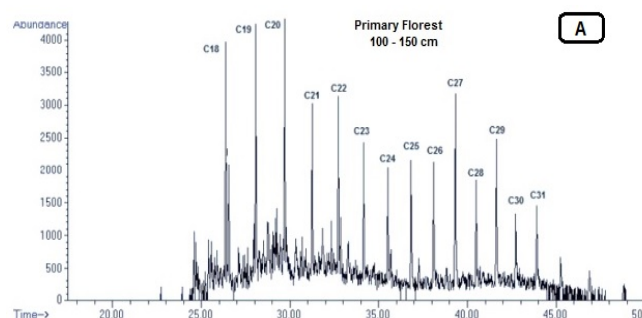


Figure 2A. Profile of *n*-alkanes for soil of PF (100-150 cm).

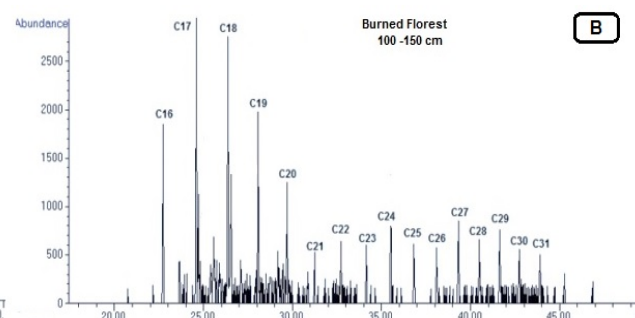


Figure 2B. Profile of *n*-alkanes for soil of BF (100-150 cm).

Conclusions

The SOM of the primary forest comprises contributions of microbial moieties and of higher plants along the whole profile. This similar distribution pattern of *n*-alkanes indicates that a percolation of SOM fragments produced at the surface to the deeper layers occurred. The higher annual precipitation of 2580 mm year⁻¹ and the lower content of clay (20%) favor this process. After vegetation burning, a lipids fraction original from higher plants are fragmented in smaller chains, enriching thus the proportion of C₁₆ to C₂₄ *n*-alkanes. This effect was also observed at the deeper layer, suggesting that the percolation of SOM along the profile is a constant and intense profile. It is therefore inferred that in this environment, in opposite to subtropical Brazilian soils, the alterations of SOM composition due to changes of forest management are very fast and have a great impact in deeper soil layers.

References

- [1] Killips SD, Killips VJ. 2005. Introduction to Organic Geochemistry, 2nd ed. Blackwell Publishing, Oxford, UK, 393 p.
- [2] Jandl G, Baum C, Blumschein A, Leinweber P. 2012. The impact of short rotation coppice on the concentrations of aliphatic soil lipids. Plant Soil 350:163–77.

Acknowledgement - The authors thank CNPq for financial support.