$\delta^{13}C$ Record in an Undisturbed Forest Soil

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$^{13}C/^{12}C$ variations of organic carbon have been investigated in an undisturbed forest soil with perched surface water. The measurements reveal a very distinct decrease of the ^{13}C-content with increasing depth of the soil horizons. Within 20 cm the $\delta^{13}C$-value is depleted by $1.5\,^0/_{00}$. At present it is however not possible to verify, whether this behaviour is characteristic for undisturbed soils in general.

Introduction

The ever increasing demand in energy has lead to the combustion of tremendous amounts of fossil fuels. As a result yearly increasing amounts of CO_2 liberated into the atmosphere have been recorded [1]. Up to 1974 the total input of fossil fuel CO_2 into the atmosphere reached already 13 percent of the preindustrial atmospheric CO_2 level [2]. An additional net transfer of CO_2 into the atmosphere results from biospheric changes such as deforestation; estimates about the amount still vary considerably but the contribution seems to be significant [3, 4, 5].

Predictions of the future development necessitate a thorough understanding of the natural carbon dioxide cycle with its sources and sinks. Present model calculations require additional CO_2 sinks; most of them consider the biosphere being a sink for excess CO_2 via stimulated photosynthesis. As a matter of fact the biosphere, comprising living and dead organic material, is the carbon reservoir about which the least information exists so far. Freyer [6] has shown that ^{13}C investigations in tree ring cellulose provide valuable information about the history of biospheric CO_2. Further knowledge about the biospheric CO_2 should be obtained from ^{13}C-analysis of various soils on a global scale. We started such an investigation analyzing a forest soil near Jülich.

Material and Methods

Soil samples were taken at the federal forest near Jülich (50° 54′ N, 6° 25′ E), which is located in North Rhine Westphalia near the Dutch and Belgian border of Germany. The investigated soil represents a "Pseudogley" (soil with perched surface water) of undisturbed natural conditions.

Within a range of 50 m five different locations were chosen for cutting soil samples. The various soil horizons have been restricted to a width of 2 cm each. This procedure minimizes uncertainties which may exist due to variations in a horizon itself. The cut samples were dried for 14 hours at 60 °C and afterwards thoroughly homogenized. pH values were determined by dissolving 10 g of soil in 25 ml of a 0.01 molar solution of $CaCl_2$. The total carbon content of each sample was analyzed by burning the material in an oxygen gas stream at 2000 °C and measuring the liberated CO_2 content. After pretreating the samples with hydrochloric acid the same procedure was applied for the determination of the organic carbon content.

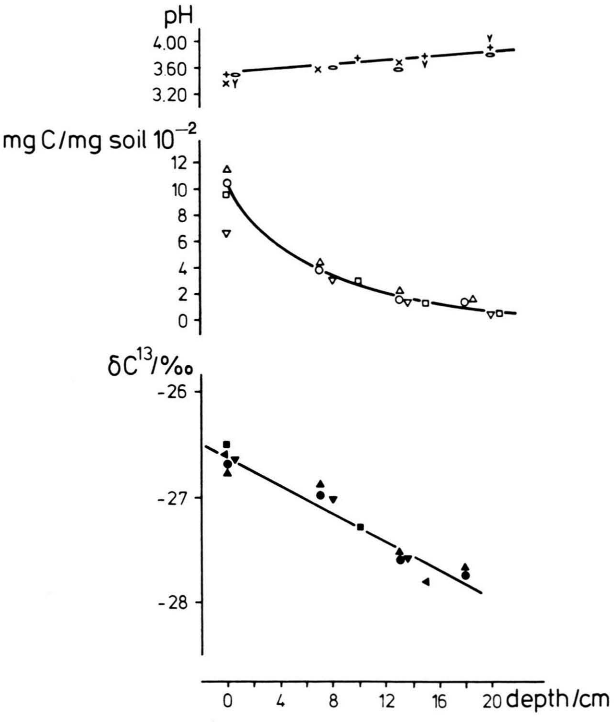

Fig. 1. $\delta^{13}C$ record in an undisturbed forest soil as a function of different soil horizons. Each symbol represents a different site at which samples have been withdrawn. Open and solid symbols of equal form correspond to each other.

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$^{13}C/^{12}C$-determinations were performed by first converting the organic carbon content of soil samples quantitatively into CO_2 (see e.g. Wiesberg [7]) and then performing a mass spectrometric analysis. The carbon isotope results are stated as $\delta^{13}C$-values relative to the PDB standard.

Results and Discussion

The results of this investigation are shown in Figure 1. The soil exhibits rather low pH-values ranging from 3.4 to about 3.9. Therefore almost all of the carbon content measured is of organic origin. This has been confirmed by values of 0.04% of total weight for the anorganic carbon content. The organic carbon content amounts to about 10% at zero horizon and decreases almost exponentially to a value of 0.8% at a depth of 20 cm. The rather low carbon content of one location at zero horizon may be due to insufficient homogenization. No samples beyond the 20 cm horizon have been taken for the present series of measurements, because the carbon content is already lower than 1% at a depth of 20 cm. This procedure seems justified because such low values are only marginally contributing to the total carbon cycle under investigation.

The variation of $^{13}C/^{12}C$ ratios across these horizons is rather marked as can be seen from Figure 1. A depletion in ^{13}C is observed with increasing depth, which amounts to almost 1.5‰ across 20 cm. This behaviour has been found in all samples taken, with rather low variations in corresponding horizons.

A possible explanation for this depletion may be the preferential removal of the lighter carbon isotope compounds from the upper horizons. Unfortunately dating of the soil layers in order to evaluate for carbon residence times was not yet possible.

We would like to acknowledge the accurate identification of the soil by Dr. Kerpen and the possibility of using a furnace facility of Dr. Freyer for preparing CO_2 samples for mass spectrometric analysis.

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