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Estimation of the efficiency of hydrocarbon mineralization in soil by measuring CO2-emission and variations in the isotope composition of carbon dioxide

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Estimation of the efficiency of hydrocarbon mineralization in soil by measuring CO2-emission and variations in the isotope composition of carbon dioxide

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Hydrocarbon mineralization in soil undergoing phytoremediation was investigated in a laboratory experiment by estimating the variation in the 13/12 ratio in the respired 2. Hexadecane (HD) was used as a model hydrocarbon pollutant. The polluted soil was planted with winter rye (Secale cereale) inoculated with Azospirillum brasilense strain SR80, which combines the abilities to promote plant growth and to degrade oil hydrocarbon. Each vegetated treatment was accompanied with a corresponding nonvegetated one, and uncontaminated treatments were used as controls. Emission of carbon dioxide, its isotopic composition, and the residual concentration of HD in the soil were examined after two and four weeks.
At the beginning of the experiment, the CO2-emission level was higher in the uncontaminated than in the contaminated soil. After two weeks, the quantity of emitted carbon dioxide decreased by about three times and did not change significantly in all uncontaminated treatments. The presence of HD in the soil initially increased CO2 emission, but later the respiration was reduced. During the first two weeks, nonvegetated soil had the highest CO2-emission level. Subsequently, the maximum increase in respiration was recorded in the vegetated contaminated treatments.
The isotope composition of plant material determines the isotope composition of soil. The soil used in our experiment had an isotopic signature typical of soils formed by C3 plants (13C,-22.4%■). Generally, there was no significant fractionation of the carbon isotopes of the substrates metabolized by the soil microbiota. The plants and microorganisms used had the isotopic signatures similar to that of the soil, whereas the 13C of HD was -47.9%■.
The HD mineralization level was assessed by determining the difference between the isotopic compositions of soil CO2 immediately after pollution and during remediation. In the unvegetated soil, about 13% of initially added HD was mineralized, the phytoremediation increased the total decomposition of the contaminant to 19%, and an additional plant inoculation with strain SR80 raised it to 33%.
The GC analysis of soil demonstrated that contaminant loss in the plant treatments and in the inoculated plant treatment was 71 and 72%, respectively, whereas in the nonvegetated treatments, it was 64 and 66%, respectively. Thus, the elimination of the contaminant resulted from its total mineralization (CO2 emission) and partial chemical transformation.