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Degradation rates of respiratory quinones (menaquinone-8 and ubiquinone-8) in soil at different temperature

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Objective Respiratory quinone profile method is one of the techniques to characterize microbial community in environment, using the profile of different quinones contained as a component of the respiratory chain in different microorganisms. Quinone profile has been considered to reflect active microorganisms in environment. However, the degradation rates of quinones in environment have not been studied. In this study, the degradation rates of quinones in soil were investigated at different temperature using menaquinone-8 (MK-8) and ubiquinone-8 (Q-8) extracted from a pure culture of *Escherichia coli* K-12.

Materials and methods Two soils were used. The two soils had the similar properties, in which total carbon was 0.8%, pH 4.9 and the total quinone 0.21-0.23 μmol/kg-soil, respectively. The culture of *E. coli* was treated with acetone, and applied to the soils. Initial concentration of MK-8 and Q-8 was both 0.25μmol/kg-soil. The soils were incubated at 37, 30, 22, 15, and 4°C under aerobic conditions and at 22 °C under anaerobic condition in the dark. The moisture content of the soil samples was maintained at 33.7% (pF1.8) by supplementing the weight loss with water every 10days during the incubation. After the incubation, respiratory quinones were extracted from the soil samples with a mixture of chloroform and methanol (2:1) and cleaned up with liquid-liquid extraction and Sep-Pak Plus® Silica cartridges, then analyzed by a high performance liquid chromatography equipped with a photodiode array detector. The degradation rates of MK-8 and Q-8 were evaluated by the fitting the remaining concentration of quinones (C) in soil at different incubation time (t) to the first-order kinetics $C=C_0e^{-kt}$, where, C_0 denote initial concentration of the quinone, and k the first-order degradation rate constant, respectively. The relationship between k value and absolute temperature (T) was expressed with an Arrhenius relationship, $Ink = -Eo/RT + InA$, where, Eo denote activation energy, R the universal gas constant (8.314 J/mol K), and A pre-exponential factor, respectively.

Results and Discussion Under aerobic conditions, the k values of MK-8 ranged from 0.012 to 0.025 day^{-1} under the different temperature conditions from 4 to 37 °C, corresponding to half lives of the degradation (DT_{50}) from 59 to 28 days. The k values of Q-8 ranged from 0.0072 to 0.024 day^{-1} at temperature from 4 to 37 °C, corresponding to DT_{50} from 96 to 29 days. At lower temperature, the degradation rate of MK-8 was higher than that of Q-8. With the increase of temperature, the k value increased. The relation fitted well to Arrhenius equation (the correlation coefficient > 0.957). The activation energy was estimated as 17.9KJ/mol for the MK-8 degradation and 28.6 KJ/mol for the Q-8 degradation, respectively. MK-8 needed less activation energy for the degradtion than for Q-8 probably due to their different ring structure. The effect of temperature on the degradation rate of MK-8 was smaller than on that of Q-8. In another soil, the k values under aerobic condition at 22 °C were 0.123 day^{-1} for MK-8 and 0.199 day^{-1} for Q-8, corresponding to 5.6 and 3.5 days of DT_{50}, respectively. The results suggested that degradation rates of the quinones differed between the soils. During the degradation of MK-8 and Q-8, other respiratory quinones increased, suggesting the growth of microbial groups responsible for the degradation. Under anaerobic condition, negligible degradation was observed in MK-8 and Q-8 within incubation period and accompanied by no change in the quinone profile. It was suggested that a large portion of respiratory quinones measured under anaerobic conditions would originate from dead microorganisms. Thus, respiratory quinoes were more effective as biomarkers in soils under aerobic conditions.

異なる温度における土壌中の呼吸鎖キノン(メナキノン－8、ユビキノン－8)の分解速度

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