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Biodehalogenation of low concentrations of 1,3-dichloropropanol by mono- and mixed cultures of bacteria

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Abstract The degradation of low concentrations of 1,3-dichloro-2-propanol (1,3-DCP) and related halohydrins by whole cells and cell-free extracts of soil bacteria has been investigated. Three bacteria (strains A1, A2, A4), isolated from the same soil sample, were distinguished on the basis of cell morphology, growth kinetics and haloalcohol dehalogenase profiles. Strain A1, probably an *Agrobacterium* sp., dehalogenated 1,3-DCP with the highest specific activity (0.33 U mg protein^{-1}) and also had the highest affinity for 1,3-DCP (K_m, 0.1 mM). Non-growing cells of this bacterium dehalogenated low concentrations of 1,3-DCP with a first-order rate constant (k_1) of 1.13 h^{-1}. The presence of a non-dehalogenating bacterium, strain G1 (tentatively identified as *Pseudomonas mesophilica*), did not enhance the dehalogenation rate of low 1,3-DCP concentrations. However, the mixed-species consortium of strains A1 and G1 had greater stability than the mono-species culture at DCP concentrations above 1.0 gl^{-1}.

Introduction

Chlorinated aliphatic compounds form one of the most important groups of xenobiotic chemicals that enter the environment. In Europe the total environmental load of these compounds was estimated as 50 000 tonnes per year (ECSC-EEC-EAEC 1992). Many of these organic pollutants are present in natural waters only at very low concentrations, yet such concentrations are still sufficient to be of public health and environmental concern. Microorganisms that metabolize and grow upon very low substrate concentrations have been designated as oligotrophs (Poindexter, 1981) and their characteristics have been reviewed (Kuznetzov et al. 1979; Poindexter 1981; Rittmann et al. 1986). Such microorganisms appear to be adapted to low substrate concentrations by virtue of their high substrate affinities (K_s), low specific decay rates (b), and low values of S_{min} (that substrate concentration below which no net growth occurs). Oligotrophic bacteria frequently are capable of accumulating poly-β-hydroxybutyrate.

Biodegradation of very low concentrations of xenobiotic compounds has been a relatively neglected field of research but several principles have been established. The rate of biodegradation at such concentrations usually decreases with lower initial substrate concentrations (Boethling and Alexander 1979). For example, 2.2 parts/billion of the herbicide (2,4-dichlorophenoxy) acetic acid (2,4-D) was mineralized more slowly than were higher concentrations (22 ppm) in stream water. Moreover, the carbon of very low concentrations of xenobiotics is often not converted to biomass carbon, thus other carbon sources may be required for cell growth under these conditions (Subba-Rao et al. 1982).

Epichlorohydrin and related compounds such as 1,3-dichloro-2-propanol (1,3-DCP), 2,3-dichloro-1-propanol (2,3-DCP), and 3-chloro-1,2-propanediol (CPD) are halohydrins that are used widely as reagents in chemical manufacture, solvents, rodent chemosterilants and precursors for the synthesis of optically active compounds (Kasai et al. 1990). 1,3-DCP and epichlorohydrin are suspected of being carcinogenic, mutagenic and genotoxic (Bwetra and Biswas 1990; ECSC-EEC-EAEC 1992). They have also been shown to induce hepatic necrosis (Haratake et al. 1993), whereas CPD has been reported to cause male infertility in rats and other spe-

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