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Indigenous Microbes from Two Oil Sands Tailings Ponds Methanogenic Biodegradation of iso-Alkanes

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EDITORIAL

Alkanes are among the least chemically reactive organic molecules and are commonly found in crude oils and petroleum products. Despite their inert nature, alkanes have been used by microorganisms as sole carbon and energy sources in aerobic environments for over a century. Microbial metabolism of alkanes in anaerobic conditions, on the other hand, has only been proved conclusively in the last three decades, and has primarily concentrated on n-alkanes. Because of their relative recalcitrance compared to n-alkanes, reports of anaerobic biodegradation of iso- and cycloalkanes are currently limited. Under anaerobic conditions, biodegradation of iso- and cycloalkanes takes substantially longer than under aerobic conditions, where degradation happens within a few days of incubation. Nonetheless, research into the biodegradability of iso- and cycloalkanes under anaerobic conditions is crucial because these isomers are important oil components that can have an environmental impact. Tailings ponds are a source of Greenhouse Gas (GHG) emissions, mainly Methane (CH_4), and are an important land feature of surface-mined oil sands operations in northern Alberta, Canada. Unrecovered extraction solvents, of which alkanes are a key component, make up a tiny portion of the oil sands processing effluents, which also include water, sand, silt, clay, and unextracted bitumen, and are deposited in massive oil sands tailings ponds, where methanogenesis thrives. Different operators use different extraction solvents, ranging from paraffinic (almost entirely aliphatic C5 and C6 hydrocarbons), as used by Canadian Natural Upgrading Limited (CNUL; formerly known as Shell Albian Sands Inc.), to various naphtha distillates (a mixture of mostly C5–C10 aliphatics plus monoaromatics), as used by Canadian Natural Resources Limited (CNRL). Previous research found that n-alkanes were an important substrate for the indigenous methanogenic microbial community in mature fine tailings (MFT) retrieved from the Syncrude Canada Limited tailings pond called Mildred Settling Lake Basin, whereas other major components like iso- and cycloalkanes were only degraded after prolonged laboratory incubation. Furthermore, we discovered that MFT microorganisms preferred to decompose n-alkanes found in their own tailings solvent over those found in other tailings ponds' solvents. The goal of this study was to see if this pattern of preference extended to resistant "secondary substrates" like iso-alkanes in these two tailings ponds, which differ in age, residual solvent, and other factors. Two mixtures were created of iso-alkanes based on solvent composition information to reflect the composition of solvents used in CNUL and CNRL activities. A mixture of three iso-alkanes (2-methylbutane, 2-methylpentane, and 3-methylpentane), the primary iso-alkanes in the CNUL solvent, represented the light paraffinic CNUL solvent. A mixture of five iso-alkanes (2-methylbutane, 2-methylpentane, 2-methylhexane, 2-methylheptane, and 2-methyloctane) was used to mimic the CNRL naphtha solvent. We measured CH_4 production, the extent and patterns of

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biodegradation of individual iso-alkanes within the mixtures, and changes in the microbial communities exposed to the iso-alkane mixtures as indicators of biodegradation potential in sealed microcosms with each MFT incubated with its cognate solvent and the other ‘exotic' solvent. Because iso-alkanes are present in all extraction solvents employed by surface-mined oil sands operators, assessing their biodegradation by MFT from various tailings ponds provides insight into anaerobic iso-alkane biodegradation processes..