Dioxin Degraders and Sydney Harbour

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Background/Objectives. Historical discharges from former industrial complexes have resulted in long-term contamination of Sydney Harbour sediments with dioxins. Despite successful efforts to remove and cap source areas of dioxin contamination in Homebush Bay, harbour sediments still contain high enough concentrations of polychlorinated dibenzo-*p*-dioxins (PCDDs) to justify a complete commercial fishing ban in Sydney Harbour, likely to be in place for decades. Currently, no practical solution to this intractable challenge has been proposed. Sediment data collected over the past 20 years (Birch et al., 2007) identifies octachlorodibenzo-*p*-dioxin (OCDD), as the most abundant dioxin congener in the sediments, however 2,3,7,8-tetrachloro-p-dioxin (TCDD), which 3000x more toxic than OCDD is also present. Over 30% of the total toxic equivalence in the sediments is due to the presence of TCDD, although it constitutes only ~0.1% of the PCDDs present in sediments.

The objective of the project was to understand the capacity of the existing sediment microbial population to degrade PCDDs, and to develop and test bacterial cultures for deployment in harbor sediments to accelerate the biological degradation of dioxins.

Approach/Activities. A collaborative project based at the University of New South Wales (UNSW) partnered with the NSW Office of Environment and Health, Can Tho University (Vietnam), and Coffey (a TetraTech company) have worked together over the past two years to assess the capacity of microorganisms to degrade PCDDs in Sydney Harbour sediments. Sediment samples were collected at multiple (ten) locations in Sydney Harbour at an increasing distance from where the highest concentrations of dioxins had been identified. Anaerobic cultures derived from the sediments were spiked with known concentrations of OCDD and TCDD, and monitored over a 12 month period. Parallel cultures were also tested with carbon donors and/or co-factors known to enhance the dehalogenation of other chlorinated hydrocarbon compounds. A number of the sediment cultures were also spiked with other chlorinated aliphatic and aromatic hydrocarbons to assess the overall dehalogenation potential, in the absence and presence of dioxins.

The research has identified that while the existing microbial consortia in the harbour sediment is capable of degrading chlorinated ethenes and benzenes, it is unable to degrade dioxins. The project has also involved the assessment of other dehalogenating cultures to potentially bioaugment the dioxin degradation capacity of the harbor sediments. A suitable pure dehalococcoides culture has been identified and confirmed in the UNSW laboratory to successfully degrade TCDD. The culture did not degrade OCDD, and therefore presents a low risk of producing undesirable biproducts that might otherwise be generated by breakdown of the less toxic, but more prevalent compound. The inability of the culture to degrade OCDD to TCDD, is considered key to using this culture for bioaugmentation to successfully decrease TCDD related toxicity in sediments.

Results/Lessons Learned. The project has confirmed that there is currently no intrinsic capacity in Sydney Harbour sediments to degrade TCDD, which has significant implications for the long-term ecological health of the harbor.

Microcosm studies are underway to assess the feasibility of bioaugmentation using the TCDD degrading culture under the conditions in Sydney Harbour.