Natural Attenuation and Anaerobic Benzene Detoxification Processes at a Chlorobenzene Contaminated Industrial Site Inferred from Field Investigations and Microcosm Studies

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Chlorinated benzenes (CBs) are widespread contaminants at many industrial sites, posing a threat to human health and the environment because of the persistence and potential carcinogenicity. Bioremediation has the advantage of using natural biological processes to possibly completely destroy target pollutants. A five-year site investigation was conducted at a former chemical plant in Nanjing, China. The main contaminants were 1,2,4-trichlorobenzene (TCB), dichlorobenzene (DCB) isomers, monochlorobenzene (MCB), and benzene. Over time, these contaminants naturally attenuated to below regulatory levels under anaerobic conditions. To confirm the transformation processes and to explore the mechanisms, a corresponding laboratory microcosm study was completed demonstrating that 1,2,4TCB was dechlorinated to 1,2DCB, 1,3DCB and 1,4DCB in approximately 2%/10%/88% molar proportions. The DCB isomers were dechlorinated via MCB to benzene, and finally, benzene was degraded under prevailing sulfate-reducing conditions. Dechlorination could not be attributed to known dechlorinators Dehalobacter or Dehalococcoides, while anaerobic benzene degradation was mediated by microbes affiliated to a Deltaproteobacterium ORM2, previously associated with this activity. Unidentified organic compounds, possibly aromatic compounds related to past on-site production processes, were fueling the dechlorination reactions in situ. The microcosm study confirmed transformation processes inferred from field data and provided needed assurance for natural attenuation. Activity-based microcosm studies are often omitted from site characterization in favor of rapid and less expensive molecular surveys. However, the value of microcosm studies for confirming transformation processes, establishing electron balances, assessing co-contaminant inhibition, and validating appropriate monitoring tools is clear. At complex sites impacted by multiple compounds with poorly characterized transformation mechanisms, activity assays provide valuable data to incorporate into the conceptual site model to most effectively inform remediation alternatives.

Keywords: Natural Attenuation, Field Investigation, Microcosm Studies, Contaminated Industrial Site, Chlorinated benzenes

