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# Demonstration of Monitored Natural Attenuation Using Molecular Biological Techniques: A Case Study

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**Background/Objectives.** Following closure of one of the largest petrochemical plants in Europe, the overall objective of the client (a company specializing in the regeneration of brownfield land) was to undertake the phased redevelopment of the site into a £500m employment hub. The programme included two former styrene manufacturing zones comprising approx. 10 ha of land. The styrene areas were viewed as the most significant contamination sources at the site, and the contaminants of concern (CoCs) comprised benzene, toluene, ethylbenzene and styrene (BTES). The primary objective for remediation in these areas was to reduce the residual contaminant load such that monitored natural attenuation (MNA) of benzene could occur and be demonstrated.

**Approach/Activities.** The first task was to quickly assimilate many years of data that had been gathered by others over preceding years. This task in itself was very complex and required a detailed GIS-based interrogation and management system, to develop a suitably robust conceptual model for the site. Following on from this, a carefully coordinated schedule of remediation works was developed that allowed structured progress, in considered phases. In the styrene source areas, the strategy was to assess geochemical and microbial evidence for MNA, define targets that would allow MNA to occur, and remove the contaminant source to achieve this target. The goal for this milestone for the styrene areas was to adequately demonstrate that MNA could occur after the removal of source materials. A particular challenge in this regard was that the there were less than 6 months to achieve this Milestone. This included the initial data assessment, the planning and implementation of the remediation work, and the assessment of the results – to a level that suitably demonstrated compliance to the key stakeholders. This would normally take several years to complete. To provide these additional lines of evidence the original ground investigation data was been supplemented with the use of molecular biological techniques to determine both the presence and activity of the microbial population. A number of biotraps were emplaced in selected monitoring wells and left in place for 30 days at a time to passively collect samples of the microbial population in groundwater, (qPCR to quantify specific microorganisms, groups of microorganisms and functional genes) and to determine the extent to which benzene mineralization could occur using Stable Isotope Probing (SIP) to track the environmental fate of “labeled” benzene to unambiguously demonstrate biodegradation. The results of this monitoring, proved that with the specific conditions that exist at Baglan, naturally occurring bacteria could break contaminants down into harmless daughter compounds, demonstrating that NA was occurring and providing a viable treatment option.

**Results/Lessons Learned.** The use of microbial population analysis, including genetic analysis to identify specific types of organisms, provided additional confidence in ‘lines of evidence’ and the subsequent derivation of site specific concentrations below which MNA would occur. An indirect result was considerable sustainability benefits, following demonstration of suitable MNA thresholds, a reduction in the volume of soils requiring treatment from a pre-works estimate of 40,000 $m^3$ to 25,000 $m^3$ was made. This reduced significantly the potential for odors and nuisance to a large number of neighboring residents. The reduction in excavation volumes also allowed for changes to plant specifications (i.e., smaller plant) which delivered less noise impact and reduced vehicle emissions (by nearly 50%).