Petroleum Metabolites: Friends or Foes?

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Background/Objectives. Petroleum hydrocarbon mixtures released to the environment often show at least partial attenuation from various weathering processes. However, at sites where large oil spills occurred significant contamination may persist. High “TPH” levels in groundwater near terrestrial release sites are frequently indicative of partial degradation products, also known as “polar compounds”, “oxyhydrocarbons” or “metabolites”. Observations from case studies suggest that metabolites can persist for a long time which raises concerns about their potential adverse effects on human health and the environment, especially when there is the possibility of discharge to surface waters, and questions for site management. These led to a closer look at the processes involved in the attenuation of petroleum spills.

Approach/Activities. The presence of metabolites at many older petroleum spill sites contradicts the common assumption that petroleum hydrocarbons are readily converted to carbon dioxide and water under ambient conditions. While physical processes such as evaporation or dilution can play a role in the attenuation of particular hydrocarbon types, the most versatile processes involve the action of microorganisms and are collectively known as biodegradation. Although microorganisms are present at virtually all spill sites biodegradation results are highly variable. In order to better understand the factors involved in biodegradation of hydrocarbons and the role of metabolites in these processes, a literature study was undertaken.

Results/Lessons Learned. It takes a collection of many different types (a “consortium”) of microorganisms to degrade a hydrocarbon mixture. Degradation of a given release depends on the consortium composition and numerous site-specific factors. Each microbial strain has strong preferences for certain hydrocarbon features and most will only work under a limited range of site conditions or not readily make CO_2. Hydrocarbon breakdown is a complex, multi-step process. Each step generates new metabolites. Microorganisms can use metabolites for other purposes besides energy production. Not all intermediate metabolites can be broken down further and some, especially dead-end metabolites, are toxic. One of the key factors that determines the nature and extent of biodegradation is the availability of oxygen. In the absence of sufficient oxygen hydrocarbon mixtures will be partially degraded by different anaerobic consortia or persist as a separate phase. Metabolites partition into ground water and possibly surface water due to their polar nature. Because metabolites constitute even more complex mixtures than fresh petroleum products they represent even greater challenges for analysis and the evaluation of toxic effects of the mixture at a given stage and location. Monitoring metabolite concentrations provides evidence that biodegradation has been occurring. However, the presence of metabolites does not prove that biodegradation will go to completion or that partially degraded petroleum mixtures are non-toxic. More studies on these aspects are needed.

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