16.6B: Petroleum Biodegradation

Petroleum oil can be degraded by microorganisms that use it as a source of energy.

Learning Objectives

• Show how microbes biodegrade petroleum waste

Key Points

• Biodegradation is the process of breaking down material in simpler components by living organisms, most often microorganisms.

• Oil spills occur due to accidents in the industry as a result of extraction or transportation. Since such spills spread over great areas and have deleterious effects on living organisms. It is important to use environmentally friendly mechanisms for their cleanup.

• There are many microorganisms that can break down petroleum, the most prominent being hydrocarbonoclastic bacteria. A representative of this group is Alcanivorax borkumensis, and its genome contains genes that code for the degradation of alkanes.

Key Terms

• hydrocarbons: Organic compounds made only of carbon and hydrogen. Examples include alkanes, alkenes, and aromatic hydrocarbons.

• emulsification: The process of forming a mixture of substances that are nonmixable under normal conditions.

• tarball: A blob of petroleum oil.
Biodegradation is the process in which living organisms, most often microorganisms, break down material into simpler components. Such material is usually organic matter that could be dissolved into chemical elements by organisms that possess the metabolic pathways to perform the reactions. Some microorganisms produce enzymes that can degrade a variety of chemical compounds, including hydrocarbons like oil.

Petroleum (crude oil) is a liquid fossil fuel. It is a product of decaying organic matter, such as algae and zooplankton. It is one of the major energy sources in the world, and is also used by the chemical industry to manufacture a large number of consumer products. However, oil drilling or transportation can cause accidents that lead to contamination of the environment. Oil spills in marine environments are especially damaging because they cannot be contained and can spread over huge areas. The aromatic compounds in oil are toxic to living organisms and such spills can render havoc in an ecosystem. Natural seepages from unexplored oil sources is another source of contamination.

In the environment, such spills are naturally cleaned by microorganisms that can break down the oil. The dominant group of such bacteria are the hydrocarbonoclastic bacteria (HCB). The concentration of these bacteria increases significantly in areas of oil spill. One of the best studied representative of this group is Alcanivorax borkumensis; it’s also the only one to have its genome sequenced. This species contains individual genes responsible for breaking down certain alkanes into harmless products. It also possesses genes to direct the production of a layer of biosurfactant around the cell to enhance the oil emulsification. The addition of nitrogen and phosphorus to the Alcanivorax environment increases its growth rate. However, the addition of these nutrients in natural environments to improve the cleanup of oil spills is not desirable, since it can have an overall negative impact on the ecosystem.

Aside from hydrocarbons, crude oil contains additional toxic compounds, such as pyridine. These are degraded by representatives of other genera such as Micrococcus and Rhodococcus. Oil tarballs are biodegraded slowly by species from the genera Chromobacterium, Micrococcus, Bacillus, Pseudomonas, Candida, Saccharomyces and others. In the clean up of the Deepwater Horizon oil spill, genetically modified microorganisms were used, but some scientists suspect they might have caused health issues for people in the affected areas.