Innovative Treatment of Vegetable Oil using Anaerobic Biodegradation

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Vegetable oil spills are among the most common spills of organic materials in the United States. Although vegetable oils usually are not toxic in the classic sense, at least not to the extent normally associated with crude oil and refined petroleum products, they can cause severe harmful effects in contaminated ecosystems. Since most of the adverse environmental effects of vegetable oils and animal fats appear to be a result of the presence of the oil on the water surface, on shoreline sediments, or (in emulsified form) in the water column, a prudent spill response is to remove floating and suspended oil from the contaminated water body as quickly as possible. Although skimming is an effective means of recovering floating oil, it is a slow, labor-intensive process. Since rapid response is the key to minimizing the environmental damage from vegetable oil spills, a less expensive, simpler, and faster method for removing floating and suspended oil is desirable.

An innovative response alternative that is based on adsorption and sedimentation of floating and suspended oil followed by anaerobic biodegradation in the sediments is currently under investigation. Rapid anaerobic biodegradation of the oil in the sediments will be facilitated by using an anaerobic electron acceptor (ferric iron) in the oil sedimentation process. Both aspects of this process, sedimentation of floating vegetable oil by adsorption to clay followed by coagulation of the clay-oil flocs and anaerobic biodegradation in freshwater sediment microcosms, will be discussed. Canola oil was used for all oil sedimentation and biodegradation experiments.

The oil adsorption capacity of wet and dry montmorillonite clay has been determined. For high specific-surface-area clay (220-270 m^2/g), the adsorption capacity of dry clay is about three times higher than for wet clay (1 g oil/g dry clay vs. 0.3 g oil/g wet clay). The adsorption capacity of wet low specific-surface-area clay (20-40 m^2/g), however, is about twice that of the wet high surface-area clay. The differences between the adsorption capacities of dry clays of differing surface area is not as large. The differences between wet and dry adsorption capacities suggest that the method of adsorbent addition will have a strong influence on the success of this approach, but for clay, larger particles may perform as well or better than smaller particles.

Preliminary investigations of the rate and extent of vegetable oil biodegradation under methanogenic and iron-reducing conditions have been conducted using sediment from several different types of freshwater environments (river, small lake, wetland). Anaerobic vegetable oil biodegradation occurs in all sediments that have been examined, usually preceded by a lag period of 2-3 weeks. It is not yet clear whether this apparent lag is due to growth of a small initial population of vegetable oil degraders, adaptation of the existing population to a new substrate, or if it is an artifact of inadvertent exposure of the microorganisms to oxygen during microcosm preparation. Biodegradation of vegetable oil (initial concentration = 2 g oil/kg sediment) was complete after about 40-45 days with recovery of about 75% of the added carbon and electrons as CO_2, CH_4, or ferrous iron.