DEGRADATION OF CRUDE OIL ENHANCED BY COMMERCIAL MICROBIAL CULTURES

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ABSTRACT: *Remediation and cleanup of oil spills has been attempted using different technologies. Biological methods such as bioremediation have been favored over others due to their cost efficiency and their low environmental impact. Bioremediation of Alaska North Slope crude oil was effectively attempted in a laboratory study using 13 commercial products. The products containing the microorganisms were provided by different vendors. The treatments were tested over a 28-day period, and the samples were extracted and analyzed using standard methods. After 28 days, four products showed an effective enhancement of the bioremediation process: the saturate fraction was degraded approximately 80%, and the aromatic fraction was degraded approximately 70%. Biological markers such as pristane, phytane, and C_{30} hopane were partially degraded.*

Background

Oil spills can cause great damage to sensitive environments. Along with the damage caused by the contaminant itself, the recovery tasks can also be detrimental to the ecosystem. Among the different technologies used during oil spill responses, a widely preferred and promising technology is bioremediation. Bioremediation is the use of highly adapted or indigenous microbial cultures to degrade toxic petroleum hydrocarbons into harmless products such as organic acids, aldehydes, and ultimately carbon dioxide and water (Atlas and Bartha, 1973). The main purpose of bioremediation is to remove the contaminant from the environment while disturbing the ecosystem as little as possible.

Laboratory and field studies have shown that bioremediation works when properly applied (Dott *et al.*, 1989; Venosa *et al.*, 1996). A question that arose a few years ago was the effectiveness of using indigenous, or autochthonous, populations. Some scientists have proven that bioaugmentation (i.e., the use of autochthonous populations) offers no advantages over biostimulation (i.e., the use of indigenous populations) (Atlas, 1995; Atlas and Cerniglia, 1995). Despite the different studies and results, the controversy is still ongoing. This study compared twelve bioaugmentation products and one biostimulation product to a control system. The control system was composed of a nutrient control and a non-nutrient control. Under the given experimental circumstances, biodegradation was achieved to a higher extent through the use of bioaugmentation; however, this result should be interpreted in light of the specific conditions under which this test was conducted. The samples were analyzed for specific analytes after 28 days using standard methods and procedures. These samples were analyzed for microbial densities and chemical composition.

Results and discussion

After 28 days, four of the thirteen products showed a statistical difference relative to the nutrient control. From the total range of petroleum hydrocarbons, the saturates were more rapidly degraded than the aromatics; even resistant compounds such as pristane, phytane, and C_{30} hopane were partially degraded. The four successful products showed that the saturates were severely degraded (Table 1), and products 1 and 2 showed partial degradation of hopane. However, our research regarding the partial degradation of hopane was limited, and we have not repeated these experiments. For the saturate petroleum hydrocarbons, the molecular weight was inversely related to the biodegradability. It is proposed that the hydrophobicity of the compounds had an affect on this result. The polynuclear aromatic hydrocarbons were also more degraded through the application of the commercial agents. In Tables 1 and 2, the tested products performed better than the nutrient and non-nutrient control. For aromatic petroleum hydrocarbons (see Table 2), it was detected that the number of rings in the molecular structure was related to the extent of degradation. As the number of rings increased, the compound became more resistant. Despite positive results shown by the nutrient control, the use of bioaugmentation proved to be statistically better. The efficacy of bioaugmentation can vary from system to system; in seawater this is relative to the water quality and the spill history of the site. The use and efficacy of a certain combination of microbes cannot be scaled to other systems from a study like this. The specific conditions of a specific site should be further assessed.

The results revealed that the addition of autochthonous populations effectively enhanced the biodegradation of petroleum hydrocarbons. Compared to the nutrient control, the treatments were 20% better in the worst case. Despite the success of some products, several products did not enhance this process but rather seemed to interfere with biodegradation. The exact reasons for this behavior were not determined, but other researchers have explained this as due to microbial competition (Venosa *et al.*, 1992).

Conclusion

It was shown that bioaugmentation was an effective method of enhancing the remediation process. Most of the petroleum hydrocarbons

Table 1. Percentage resolved saturates remaining after 28 days for the four successful treatments

Groups	Ctl	Nut	Prod 1	Prod 2	Prod 3	Prod 4
C10-C15	100	19	0	0	1	1
C16-C20[1]	93	17	0	0	1	1
C21-C25	98	17	0	0	4	1
C26-C30	100	26	1	0	15	2
C31-C35[1]	100	81	13	10	69	34
Hopane	100	100	73	50	100	100
Phytane	100	63	1	0	22	11
Pristane	100	63	0	0	27	11

1. Hopane, pristane and phytane are not included in the groups.

Table 2. Percentage resolved aromatics remaining after 28 days for the four successful treatments

Ring number	Ctl	Nut	Prod 1	Prod 2	Prod 3	Prod 4
2-ring	79	63	7	70	49	14
3-ring	94	68	23	87	56	42
4-ring	100	100	76	72	75	89

were degraded to a significant extent by the microbial cultures contained in the products. Some of the saturated hydrocarbons were degraded faster than others, and because the biodegradability decreased as the molecular weight increased, we think this variability is related to the hydrophobicity of the compound. The degree of alkylation also showed an effect on the biodegradability of the compounds. As the compound became more substituted, it was less degraded. Biodegradation should be further studied for its effectiveness in specific conditions. However, it is a promising technology for remediating sites contaminated with petroleum hydrocarbons.

Biography

Salvador Aldrett graduated in December 1992 from the Instituto Tecnológico de Monterrey in Mexico with a degree in chemical engineering. He worked for a year with Rohm and Haas Inc., in its Mexican headquarters, and was accepted in August 1994 at Texas A&M University to pursue a master's degree in environmental engineering. Currently, Mr. Aldrett is enrolled as a Ph.D. student in the chemical engineering program at the same institution.

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COSS: A TESTING FACILITY FOR OIL SPILL RESEARCH AND DEVELOPMENT

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ABSTRACT: *A facility known as the Coastal Oil Spill Simulation (COSS) system has been constructed to test the efficacy and environmental effects of physical, chemical, and biological oil spill response technologies under realistic coastal and nearshore environmental conditions. The COSS facility is located in Corpus Christi, Texas. Oil spill research and development experiments will begin at the COSS facility in the summer of 1997. The Texas General Land Office and the Marine Spill Response Corporation have sponsored the design and construction of the COSS facility.*

The Texas General Land Office (TGLO) in concert with the Marine Spill Response Corporation (MSRC) have sponsored the design and construction of a multiple-tank mesocosm facility known as the Coastal Oil Spill Simulation (COSS) system (Figure 1). The COSS system has been designed to test physical, chemical, and biological oil spill response technologies in a variety of nearshore habitats (e.g., marshes, tidal flats, and beaches). The facility is expected to be completed in the spring of 1997. The COSS facility is located in Corpus Christi, Texas.

The goal of the COSS facility is to provide a testing platform that readily models coastal and nearshore physical, chemical, and biological