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Project Summary

Surface Treatment Agents for Protection of Shorelines from Oil Spills

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Surface treatment agents for protecting shorelines from spills were evaluated by means of a literature review, laboratory tests, and field tests. Results of the literature review and laboratory tests were used as the basis for (1) analyzing the results of earlier tests on surface treatment agents for oil spills, (2) comparing effectiveness of surface treatment agents, and (3) recommending agents for preliminary field tests. The surface treatment agents evaluated during the preliminary laboratory tests included film-forming, dispersing, and surface-collecting agents. These (preliminary) tests recommended two film-forming agents (polyvinyl acetate and xanthan gum), a surface collecting agent, and a flowing film of water for full-scale field tests which were conducted at Sewaren Beach, New Jersey.

The full-scale field tests showed that polyvinyl acetate provided both beach and marsh plots with the most effective long-term protection. On the marsh plots, xanthan gum appeared to be the most effective short-term agent for protecting vegetation and substrate from oil contamination. The water film provided the best protection against beach surface contamination by oil, but it tended to erode channels in the sand, allowing some oil penetration. The water film was not effective for salt marsh protection. The surface collecting agent effectively confined oil under nonturbulent conditions.

This Project Summary was developed by EPA's Municipal Environmental Research Laboratory, Cincinnati, OH, to announce key findings of the research project that is fully documented in a separate report of the same title (see Project Report ordering information at back).

Introduction

This report discusses the results of a literature review, laboratory tests, preliminary field tests, and full-scale field tests to evaluate the effectiveness of various surface treatment agents in protecting shorelines from oil spills. The state-of-the-art for cleanup of oil-contaminated shorelines is well developed only for beaches; procedures for protecting other types of shorelines are less advanced. In 1974, the American Petroleum Institute (API) and the U.S. Environmental Protection Agency (EPA) funded four projects to discover useful materials for protecting beaches and salt marshes from oil spills and for reducing shoreline cleanup efforts after oil contamination. Several prospective agents were recommended for further testing.

The API then obtained additional funding from EPA to conduct further research and tests on the recommended agents. The API contracted with Woodward-Clyde Consultants and their subcontractors (Texas Research Institute, Inc., and URS Research Company). The present study was then conducted to evaluate the effectiveness, toxicity, and application techniques of the recommended agents. The surface treatment agents tested during this project are listed in Table 1.

Preliminary Evaluation and Tests

The first phase of this project used literature reviews and laboratory tests to develop baseline data on the eight recommended agents. The literature review provided a basis for analyzing previous tests of surface treatment agents and comparing their effectiveness A summary of the findings from the literature review appears in Table 2.

Three types of laboratory tests were conducted on the surface agents: (1) screening tests for solution and film properties (solubility, film formation, etc.), (2) small-scale tests of beach protection on mock beaches, and (3) percolation tests (on three agents) for effectiveness in preventing oil seepage. The tests also evaluated the toxicity of several of the agents on cordgrass (*Spartina foliosa*), a common salt marsh vegetation, and on the eastern blue crab (*Callinectus sapidus*).

Table 1. *Surface Treatment Agents Evaluated During Program*

Agent	*Laboratory*	*Preliminary Field Tests*	*Full-Scale Field Tests (Sewaren)*
Sodium silicate	x	x	
Sodium borate/sodium silicate mixture	x	x	
Citrus pectin	x	x	
Xanthan gum	x	x	x
Polyvinyl acetate	x	x	x
Flowing film of water	x		x
Surface collecting agent (Oil Herder)	x	x	x
Dispersant A (Corexit 7664)	x	x	
Dispersant B (BP 1100-X)		x	
Dispersant C (BP 1100 WD)		x	

Following the laboratory evaluation, several agents were selected for preliminary field tests at Seidler Beach, New Jersey. The agents selected for testing were Oil Herder (a surface collecting agent), Corexit 7664 (a dispersant), BP 1100-x (a dispersant), and polyvinyl alcohol/borate gel (a film-forming agent). The tests were conducted by spilling a quantity of light Iranian crude oil (approximately 50 to 75 liters for each test area) onto the water within containment booms just before high tide. The booms were then pulled onto the beach, drawing oil onto the test areas. Results were correlated in terms of substrate protection and ease of contaminant removal.

Full-Scale Field Tests

After the preliminary tests, full-scale field tests of three surface treatment agents were undertaken in two tasks — beach testing and salt marsh testing. These tests were conducted at Sewaren Beach, New Jersey, using three types of oil as contaminants: Arabian crude oil, fuel oil No. 2, and fuel oil No. 6. A selected

Table 2. *Summary of Results from the Literature Review of Surface Agents*

				Summary of Previous Investigations		
Agent Type	*Mechanism*	*Form/Application*	*Possible Limitations*	*Sand*	*Rocks*	*Marsh Grass*
Polyvinyl acetate	*Solid film*	*Synthetic polymer/conc. (55%) aqueous suspensions; sprayed on, high-pressure, airless sprayer; available dry*	*Removal, color, rainy/freezing weather, must have 1 hr to dry before it is effective*	*Effective*	*Effective*	*Not tested*
Surface collecting agent	*Has greater spreading force than oil, liquid monomolecular layer*	*Long-chain alcohols in organic solvent (water insoluble)*	*Short duration, loss of effectiveness, might need continuous supervision*	*Effective in lab and beach tests*	*Effective in lab and beach tests (less effective on dry rocks)*	*Not tested*
Dispersing agent	*Adjusts interfacial surface tension, develops micelles of oil in water*	*Nonionic detergent/aqueous solution (6%)*	*Must be applied directly to oil, large volume required*	*Not tested*	*Not tested*	*Not tested*
Xanthan gum	*Soft polar film*	*Sprayed on, dilute (0 5%) aqueous solution; available as dry powder or concentrated solution*	*Short duration, 1 hr drying time necessary*	*Not tested*	*Effective on dry rocks*	*Possibly effective*
Citrus pectin	*Soft polar film*	*Sprayed on, dilute (1%) aqueous solution, available as dry powder*	*Short duration, 1 hr drying time necessary*	*Not tested*	*Effective on dry rocks but less effective than xanthan gum*	*Possibly effective*
Borate-silicate mixture	*Solid film (if cured)*	*Inorganic coating, dilute (1-3%) aqueous solution, sprayed on*	*Toxicity?, pH, drying time necessary*	*Not effective*	*Effective*	*Not tested*
Sodium silicate	*Solid barrier (if cured)*	*Inorganic coating, dilute (1%) aqueous solution; sprayed on*	*Toxicity?, pH, drying time necessary*	*Not effective*	*Effective*	*Not tested*
Micrococcus cerificans	*Unknown*	*Freeze-dried, (3%) aqueous suspension; sprayed on, garden sprayer*	*Not commercially available, large preparation effort, half life, drying time necessary*	*Not tested*	*Effective on dry rocks, less effective than polysaccharides*	*Not tested*
Water film	*Liquid film*	*Sprinkler system*	*Continual application required (countercurrent), equipment costs*	*Not tested*	*Not tested*	*Not tested*

section of beach was divided into test and control plots each measuring 9.2 m^2. A section of salt marsh was similarly divided into plots measuring approximately 3.6 m^2. The plots were laid out along a portion of the upper intertidal zone. One plot in the beach and one in the salt marsh were designated as the controls, and the remainder were designated as test plots to be coated with different surface treatment agents. Booms were deployed in the water around the perimeter of the test zone. Just before tidal ebb, a specified volume of oil was manually released on the water. The ebbing tidal action and prevailing wind deposited the oil on the surface of the shoreline test and control plots. After the tide had receded, data were collected to assess the performance of each agent in protecting the shoreline from oil contamination. The ease with which the oil could be removed from the test plots was also evaluated. Photography was the major method of data collection and was used primarily to provide a permanent record of the observations. Depth of oil penetration into the test plots was determined by cutting sections across the plots, taking filter paper blots at 7.6 and 15.2 cm, and examining the filter papers under ultraviolet lights to determine the presence of oil by its characteristic fluorescence.

Three film-forming agents were tested: polyvinyl acetate, xanthan gum, and a flowing film of water. A surface-collecting agent was also tested by applying the collector to the beach and salt marsh substrate and also to the water ahead of the approaching oil slick.

Conclusions

The film-forming agents tested are ranked in Table 3. All three of the agents provided some degree of protection from oil contamination of beaches and salt marshes, but polyvinyl acetate provided the best long-term protection for both types of substrates. This agent proved to be the most durable and remained on the test plots for at least eight tidal cycles. On the marsh plots, xanthan gum appeared to be the most effective short-term agent for protecting vegetation and substrate from oil contamination. The water film provided the best protection against beach surface contamination by oil, but it tended to erode channels in the sand, allowing some oil penetration. The water film was not effective for salt marsh protection.

Test results for the surface-collecting agent were inconclusive. The agent effectively confined oil under nonturbulent conditions, but waves impinging on the test area caused the contained oil slick and chemical barrier to break up into numerous small oil slicks. Without the contaminant barrier, the surface-collecting agent may have held the oil offshore effectively.

Recommendations

The following recommendations are made based on the findings of this study:

1. Field evaluations should be made of other potential surface protection agents identified in the literature and preliminary tests.
2. A prototype application system should be designed and tested on an oil spill of opportunity using polyvinyl acetate as the surface treatment agent.
3. Additional testing should be conducted to verify tests for agent toxicity.

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Table 3. *Ranking* of Film-Forming Agents Evaluated at Sewaren Beach*

	Ranking									
	Sand Beach			Marsh						
	No. 6 Fuel Oil	No. 2 Fuel Oil	Arabian Crude Oil	No. 6 Fuel Oil		No. 2 Fuel Oil		Arabian Crude Oil		
Agent				Short Term	Long Term	Short Term	Long Term	Short Term	Long Term	
Polyvinyl acetate	1	1	1	2	1	1	1	2	1	
Xanthan gum	3	3	3	1	2	2	3	1	2	
Flowing water	1	2	2	3	3	3	2	3	3	

* *Agents are ranked in order of effectiveness in each test.*

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***Leo T. McCarthy, Jr.**, is the EPA Project Officer (see below).*
The complete report, entitled "Surface Treatment Agents for Protection of Shorelines from Oil Spills," (Order No. PB 84-177 898; Cost: $14.50, subject to change) will be available only from:
National Technical Information Service
5285 Port Royal Road
Springfield, VA 22161
Telephone: 703-487-4650
The EPA Project Officer can be contacted at:
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