Cleaning up of Simulated Oil Spill by Using Magnetic Wand.

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Abstract: This paper presents a simulation numerical model that can generate an oil-risk map for a given area. The map shows monthly and yearly probabilities of oil-slick presence for each grid area. The probability computation procedure includes the oil-slick movement at each time stage until it completes the given time interval. An example was presented to generate the Kuwait oil-spill risk map by using the simulation model. The results of the oil-spill risk map can be used to determine the relative sensitivities of coastal sections where oil-slick occurrence are most probable. The decision maker can use this information for strategic planning in environmental protection and for selecting sites for seawater intakes, fish farms, and coastal recreation areas. The model simulates a spill's location, size, and associated movement based on statistical data. Horizontal wind vector components are simulated using a Markovian time series model based on local wind statistics. The simulation of the slick's movement includes the mechanisms of spreading and drift by wind and currents.

INTRODUCTION: Groundwater, which is a major source of drinking water around the world, plays a significant role in the development of the water resources in many countries. Quality deterioration of this important source is a significant problem that may lead to a sharp decrease in its value. Groundwater can be contaminated by various sources including ruptured oil pipelines and leaks from chemical storage tanks. Underground storage tanks ~USTs! usually hold light non-aqueous-phase liquids ~LNAPLs! such as common fuels. Serious contamination of groundwater as well as soil can result from leakage through holes in the tanks themselves or the associated pipeline. This problem, which is faced at many older gas stations, is complex because early detection of such leaks is rare. Once such a problem is discovered, questions related to estimating the extent of contamination, which will be used to plan for site remediation and restoration, will arise. The most reliable way of estimating the volume of large spills could be using soil borings.

The oil content at various points in space is determined through analytical quantification in the laboratory. The total spill volume is obtained by integrating the spatial oil distribution. Monitoring wells are used to detect leaks; however, data collected from such wells will not be representative of the volume of the spilled NAPL present in the formation. Previous studies ~Farret al. 1990; Len hard and Parker 1990! indicate that hydraulic properties of the soil in the spill area as well as data from monitoring wells are important factors that may be used for estimating spill volumes. Marinelli and Durnford ~1996! showed that LNAPL thickness in monitoring wells is highly affected by the water table fluctuation.

RISK-MAP SIMULATION MODEL: An oil-spill risk map shows the probability of the presence of an oil slick within a given area based on repeated trials. For a typical trial, the model predicts the movement of a slick using six steps:

1. Simulating the oil spill's location based on the probability associated with the locations of oil-spill occurrences.
2. Simulating the spill size, based on the probability associated with the size of oil spills at a given location.
3. Selecting the initial time step at which the spill occurs, assuming the initial time step to be uniformly distributed over the dominant tidal cycle.
4. Determining the tidal current patterns that follow the initial time step.
5. Simulating the horizontal wind velocity components using a time-series model.
6. Simulating the processes of oil-slick drift and spread at each time step.

For each trial, the model first determines the location, size, and initial time of the spill and then predicts the movement at subsequent times, based on steps 4, 5, and 6. In this manner, the positions of the oil slick at each time step were determined for each trial until the final time step was reached. Consequently, the percentage risk of oil-slick occurrence for each given area can be calculated, and the oil-spill risk map follows accordingly.
LOCATING A SPILL SITE USING ON-SCREEN MAPS:

To use the model for a simulation, the x,y coordinates of the oil spill site must be found. Each river in this model has a shoreline data file that was generated by digitizing the maps of the study area as explained earlier. Upon request from a menu, the data file of the selected river/lake will be loaded into the memory. In the first instance, the entire map of the river can be displayed on the screen. Here the scale is too small to find the x,y coordinates of the spill site to any reasonable accuracy. The on-screen zooming feature, using cursor keys, can be used to enlarge any area of the map. When an arrow key is used for the first time, a colored cursor will appear on the screen. Subsequently, the four arrow keys can be used to move the cursor in any direction. The bottom of the screen displays the numerical x,y values of the cursor position. These values change when the cursor is moved. The zooming cursor movements can be repeated until the x,y values of the spill site are determined to the desired degree of accuracy.

MATERIALS:

Eight different grades of iron powder were obtained from a commercial manufacturer, Hoganas AB. The physical and chemical characteristics of these, as described by the manufacturer in the Hoganas AB Products booklet 2003, are given. The variation in chemical composition between these powders is very small and is not expected to have an influence on the oil sequestering studies. Physically, however, this choice of iron powders incorporates a wide range of particle size distributions broadly categorized as coarse, fine, or superfine and a wide variety of surface textures broadly categorized as spongy, atomized, annealed, or unannealed, see Table 1. Results for these grades were benchmarked to the results for the iron powder used in our original studies (Ajax Laboratory Chemicals) referred to above. Henceforth, this iron powder will be referred to as “original.” Three different crude oils and a crude oil/seawater emulsion were used. All samples were unweathered and were furnished by Exxon/Mobil Oil Pty. Ltd., Australia. Additional characteristics of these oils are described in Table 1. The Gippsland Crude was used to make a 50% v/v (oil/seawater) emulsion, prepared as described previously (Orbell et al. 1999). The feathers were breast contour feathers of the Mallard Duck (Anas platyrhynchos). The oil-laden iron powder was harvested using a “Laboratory Magnetic Tester” Alpha Magnetic, Victoria, Australia) (Orbell et al. 1997).

Table 1. Three Crude Oils Used in Experiments and Their Characteristics

<table>
<thead>
<tr>
<th>Geographic origin</th>
<th>Crude Oil</th>
<th>Used</th>
</tr>
</thead>
<tbody>
<tr>
<td>Date sample obtained</td>
<td>Saudi Arabia</td>
<td>May 15, 1999</td>
</tr>
<tr>
<td>Specific gravity (at 15°C)</td>
<td>0.85</td>
<td>0.88</td>
</tr>
<tr>
<td>Viscosity (cSt) (at 22°C)</td>
<td>4.13</td>
<td>50.10</td>
</tr>
</tbody>
</table>

METHODS:

An established gravimetric method (Orbell et al. 1999), developed for assessing the magnetic removal of oil from feather clusters, was used for these experiments. Each weighed feather cluster was completely immersed in a particular oil to achieve saturation. The cluster was then allowed to drain for 10 min prior to being reweighed. The oiled feathers were then covered with excess iron powder and adsorption of the contaminant was allowed to occur. At least 1 min was allowed for this process although previous experiments in our laboratory have indicated that it is almost instantaneous. The oil-laden iron powder was harvested from the feathers using the magnetic tester. The stripped feather cluster was then reweighed. This process was repeated until the percentage removal achieved a constant value. It is important to emphasize that our criterion for a superior grade of iron powder is based on a comparison of the maximum amount of oil that can be removed from the feathers. To achieve this an excess of iron powder is always used. Beyond a certain excess of iron powder, the percentage of removal of oil will not change. Also, since the application of magnetic particle technology to wildlife cleansing is not expected to require a large quantity of iron powder, the relative amount of iron powder used for a given mass of feather is not a major concern. A characteristic plot of percentage removal versus the number of applications. All experiments were carried out in fivefold replicate at 293 K. All electron micrographs were recorded using a Phillips XL30-FESEM instrument.

CONCLUSIONS:

This paper conducted an inquiry into the possible use of magnetic separation technology for oil spill remediation. The results in this study seem to suggest that this magnetic separation technology can facilitate the removal of dispersants because of short operating time, high sorption capacity, and high recovery efficiency of magnetic particles. The use of maghemite in
practical application is more reasonable than that of magnetite, because maghemite is less dependent upon various environmental conditions. The results from the experiments on regenerated particles indicated possible reuse, especially at the surfactant concentration above 500 ppm. For remediation of the crude oil, both of the magnetic particles have relatively high removal efficiency and maghemite looks more promising than magnetite, since less can be used for the same effect. This study shows the potential for the use of magnetic particle separation technology as a tool to remediate oil spill. However, additional field tests are needed for practical application. Future studies of practical application, such as determining the method to collect the contaminants and increasing the floating of magnetic particles, are in progress. This technique may also demonstrate the possible application of this technique for the remediation of industry wastewater and soil contaminated with oil as well as for the removal of dispersant and spilled oil in the sea.

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