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Review on Oil Spills and Their Effects

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1. INTRODUCTION

With increasing offshore oil exploration, drilling, and production activities, and with a huge amount of petroleum being transported by tankers and pipelines through the ocean and coastal environment and resoures has been realized among government decision makers, oil industry personnel, and the general public. Assessment must be made of the potential risk of damage resulting from the exploration, development and transportation activities, based on predictive impact evaluations of the fate of hypothetical or real oil spills. When an oil spill occurs, planning and execution of cleanup measures also require the capability to forecast the short-term and long-term behavior of the spilled oil.

A great amount of effort has been spent by government agencies, oil industries, and researchers over the past decade to develop more realistic models for oil spills. Numerous oil spill models have been developed and applied, most of which attempt to predict the oil spill fate and behavior. For an actual contingency planning, the oil fate and behavior model should be combined with an oil spill incident model, an environmental impact and risk model, and a contingency planning model.

The purpose of this review study is to give an overview of existing oil spill models that deal with the physical, chemical, biological, and socioeconomical aspects of the incident, fate, and environmental impact of oil spills. After the review on the existing models, future research needs are suggested.

In the study, available oil spill models are separated into oil spill incident, oil spill fate and behavior, environmental impact and risk, and contingency planning models. The processes of the oil spill fate and behavior are reviewed in detail and the characteristics of existing oil spill fate and behavior models are examined and classified so that an ideal model may be identified. Finally, future research needs are discussed.

2. OIL SPILL MODELS

2.1 Structure of Oil Spill Models

This section summarizes the major components of oil spill models by synthesizing various models proposed by a number of researchers. The comprehensive oil spill model is composed of

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several submodels and detail models as depicted schematically in Fig. 1. This figure shows the following four submodels: (I) oil incident model; (II) oil fate and behavior model; (III) oil impact and risk model; and (IV) contingency planning model. Each submodel includes some detail models indicated by (1), (2), (3),···; and (i), (ii), (iii),··· in Fig. 1. Submodels may be combined in different manners as indicated by (a), (b), (c), (d), (e) and (f) in Fig. 1. As a risult, Fig. 1 is useful for the synthesis and classification of existing models.

Most researchers dealt with one of the submodels or one of the detail models. Some researchers combined a few submodels and detail models. The most comprehensive oil spill model should consider all submodels and detail models but such a model is not available yet. However, some researchers tried to combine the submodels (II) and (IV) using very simple assumptions for the planning stage and/or combating purposes (e.g., Gallager and Heikamp, 1985 ; Gundlach and Moss, 1985 ; Danenberger et al., 1983 ; Wilkinson and McEwan, 1983). The present review is mainly based on 51 oil spill models. The existing models on the basis of the classification shown in Fig. 1 are summarized.

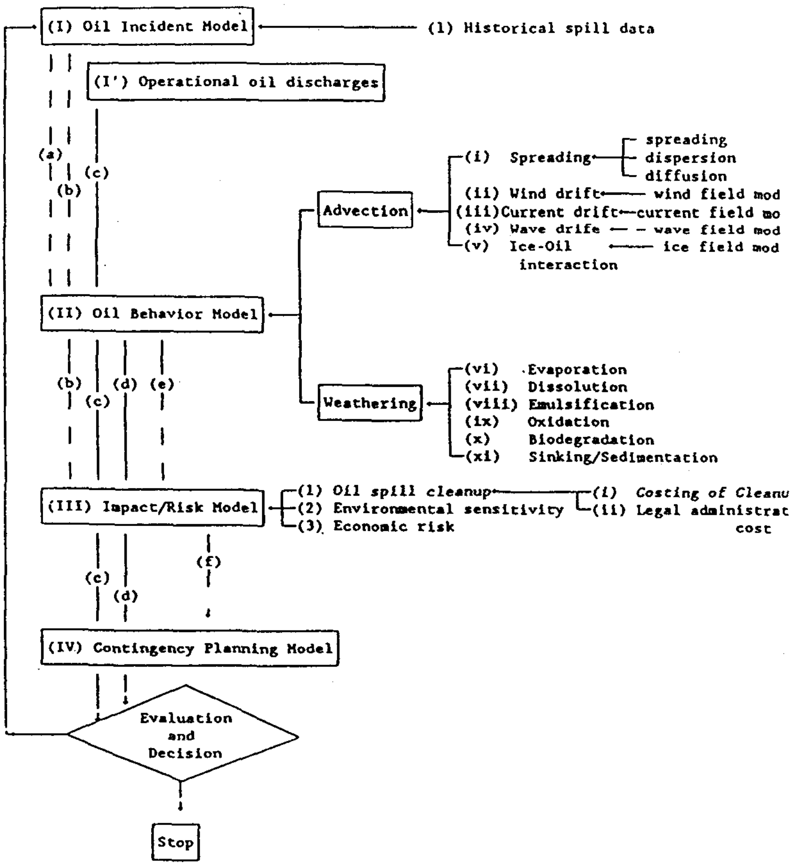

Fig. 1. Structure of oil spill models.

3. RECOMMENDATIONS AND CONCLUSIONS

3.1 Future Research Needs

For the oil spill incident modeling, prediction must be made of future oil spillage from marine tankers, ships, offshore petroleum development facilities and coastal cross-country pipe lines. Methods for accounting for increasing facilities, production, transportation and utilities as well as improvement in technology, operating procedures, safety measures, and environmental protection regulations should be developed for more accurate prediction of future oil spillage.

For the oil spill fate and behavior modeling, wind and wave fields should be simulated considering their temporal and special variations, espercially in the coastal region. Models are needed to account for land-sea breeze as well as three-dimensional hydrodynamics associated with wave and current. The accuracy of models needs to be evaluated by comparing simulated results with field data. Different models should be developed for different purposes and applications with varying degrees of accuracy and simplicity. Some oil weathering mechanisms can not be expressed quantitatively, since the associated processes are not understood at present. The modeling of those weathering processes will require reliable field and laboratory data. For example, the weathering of oil on beaches including penetration characteristics should be elucidated. Oil fate and behavior models considering the effects of artificial dispersants and cleanup operations are also needed for the realistic oil fate simulation and impact assessment.

For the impact and damage modeling, more systematic studies are needed to combine scientific, engineering, socioeconomic and legal aspects of oil spill.

For the contingency planning modeling, separate models are needed for actual oil cleanup and long-term impact assessment. For the reliable contingency planning against oil spills, the uncertainties of oil spill incident, fate, and impact need to be quantified.

3.2 Conclusions

The structure of oil spill models in terms of oil spill incidents, oil fate and behavior, environmental sensitivity and impact, and contingency planning have been reviewed and discussed in detail.

The quality of data input to the models plays an extremely important role in the success of the model prediction. However, most of the existing models use only temporally variable wind, current and wave data with the assumption of spatial uniformity over the study area and uses current data with a simple empirical data set or current charts. Even though some sophisticated models have been used previously, these models have not addressed uncertainties of model prediction.

Based on the review of the governing process of oil spill fate and behavior, emphasis has been placed on the development of a model for its intended use. The importance of an uncertainty analysis in a realistic model has been pointed out.

Various limitation of existing models has been pointed out. Future improvement of the models for oil spills were suggested for each submodel.

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