Numerical Simulation of the Spread of Oil Slick and Its Application on the Northwestern Coastal Water of Taiwan

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ABSTRACT
A numerical model employing the Lagrangian discrete parcel algorithm to simulate the oil slick spread on the coastal water was developed. The numerical model accounted for the conditions of the physical spreading process (including the mechanical spreading, wind and current drift), evaporation, and dissolution of oil slick. The simulation of shoreline conditions was also included in the model. The merit of employing the Lagrangian discrete parcel algorithm is to make the numerical calculations of oil slick spread and transport on water surface more efficient and faster. The model simulation on the final spreading area of oil slick is found the trend in good agreement as comparing with that of the experimental field data of Fannelop & Waldman. The developed model is applied to a case study on simulating the oil pipeline accidental spill of 220 m³ diesel fuel on October 23, 1995 near the coast region of Ho-Long river and Xi-Hu river, Miao-Li county, northwestern coast of Taiwan. The drift velocity due to current and wind exhibits no significant effect on the oil slick transport. Therefore it presents no predominant direction for oil slick spread. The time evolution of oil slick spreading and transport is presented. As considering on the conditions of oil evaporation and dissolution, oil slick residues as function of time after spilling is modeled and calculated.

KEY WORDS: Oil slick; oil spill; Lagrangian discrete parcel algorithm; mechanical spreading; advection.

INTRODUCTION
In Taiwan, oil supplies are all imported from outside countries. Most of important commercial harbors and fishery ports are located in the western coast of Taiwan. Oil tankers or pipeline leakage accidents happened occasionally on the coastal waters. Therefore, it is necessary to predict the oil slick transport on water surface after oil spilling. The prediction can help offer assessment of the impacts on marine environment and damage for marine life. To achieve this goal, an easy-use, efficient, and fast calculation of numerical model intends to be developed in the present study.

Fay (1969) had proposed a mathematical relation to describe the spread of oil slicks on a calm sea. Waldman et al. (1973) investigated the spreading and transport of oil slicks on the open ocean in considering wind, waves, and currents. Shen and Yapa (1988) modeled the transport of oil slick in rivers. Their model accounted for oil mechanical spreading, water currents in river, river bank conditions, oil evaporation, and oil dissolution. Recently, the developments of oil spill model for Korean (Song et al. (1995)) and Japan (Takeuch et al. (1995)) coastal waters have been made. These models are too complicated and they are uneasy to be used. The main purpose of the present study is to develop an efficient and easy-use numerical model to simulate the spread and transport of oil slick on the coastal water. And the model is applied to predict the oil slick spread of oil pipeline accidental spilling occurred on October 23, 1995, near the coast region of Ho-Long river and Xi-Hu river, Miao-Li county, northwestern coast of Taiwan (Refer to Fig.1).

MODELING OF THE FATE OF OIL SLICKS
To modeling the fate of oil spill on the coastal waters, we accounts for the oil mechanical spreading (including three stags: inertial-gravitational, gravitational-viscous, and viscous-surface tension), water advection, evaporation, dissolution, and shoreline condition.

Mechanical spreading