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Editorial: Waste management of petroleum hydrocarbons in marine environment

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Editorial on the Research Topic
Waste management of petroleum hydrocarbons in marine environment

Marine oil spill response is essential to mitigate the impacts of petroleum hydrocarbons accidentally released into on the environment. It is a complex and systematic approach involving the understanding of pollutant transport and fate, the assessment of various impacts, the implementation of various spill countermeasure techniques, and the management of oily waste. Although much effort has been made towards the safe and effective management of marine oil spills, many challenges remain to be addressed. This volume of the journal dedicated to Waste Management of Petroleum Hydrocarbons in Marine Environment provides an overview of some of the latest advancements for effective waste management of petroleum hydrocarbons in the marine environment.

Three articles review and evaluate the impacts of oil properties and associated processes on the performance of oil spill response alternatives. State-of-the-art knowledge is provided in the first article (Zhong et al.) on spills of diluted bitumen (Dilbit), an unconventional oil comprised of bitumen diluted with lighter components such as condensate to facilitate transportation by pipelines and ships at sea; that has become an Research Topic of concern due to an anticipated increase in the volumes being transported. The physicochemical properties and weathering processes (spreading, evaporation, emulsification, photooxidation, biodegradation, and sinking) were evaluated for different types of diluted bitumen, and the toxicity of diluted bitumen to aquatic organisms was discussed. Furthermore, numerical modeling on the fate and behavior of spilled diluted bitumen in marine environment was summarized and analyzed, followed by the methods used for oil recovery and oily waste disposal/treatment.

Spilled oil leads to adverse impacts on marine environments, and the situation can get even worse when oil reaches the shoreline where it can persist and induce long-term detrimental effects. The characteristics of five basic groups of spilled oil (i.e., nonpersistent light oils, persistent light oils, medium oils, heavy oils, and sinking oils) and their adhesion on shoreline matrix were discussed in the second article (Chen et al.). Differences in oil type (physical/chemical characteristics) and the influence of natural oil weathering processes on the performance of various shoreline cleanup methods such as physical and chemical treatment, as well as biodegradation, were discussed and evaluated in the context of providing recommendations for future research on shoreline oiling prevention and the development of improved response strategies. Among various marine oil spill response alternatives, decanting processes for oil/water separation and treated-water disposal at sea has received increasing attention as it would increase the effectiveness of booming and skimming operations by optimizing the effective use of onboard storage space on response vessels as well as reducing transit time to bring waste waters to shore for disposal. As decanting operations within some countries such as Canada is currently restricted by the concern of the negative ecological impacts associated with at-sea discharge of decanted water, the third article (Liu et al.) comprehensively summarized recent studies on the potential impacts of the organic composition in decanted water, including water accommodated fractions of oil, dispersed oil droplets, and other related chemicals, on various marine species. Toxicity effects and the ecological endpoints of total petroleum hydrocarbons (TPH) and polycyclic aromatic hydrocarbons (PAHs) on different species were included in the discussion to support recommendations for the monitoring of ecological impacts of decanting that would provide support for on-site disposal of decanted wastewater.

The effective management of various oily wastes generated from marine oil spill and its subsequent response operations is a significant challenge. To address this Research Topic, this volume has an article describing the development of a comprehensive pattern recognition modeling framework for grouping or clustering oily wastes (e.g., oiled sand, containment booms, sorbent booms, debris, oily vegetation, dead animals, and contaminated personal protective equipment), based on their unique characteristics (Hafezi et al.). A subtractive clustering algorithm (SCA) and a fuzzy C-means (FCM) algorithm to classify the oily wastes, with each oily waste cluster having relatively homogeneous pollution characteristics was integrated into optimization models to provide effective oily waste management strategies. Using system dynamics principle, another article (Hosseinipooya et al.) described the development of a model to estimate the quantity of various oily wastes generated from marine oil spill response operations, by considering different factors such as weather conditions, spilled oil volume and characteristics, spill response time, and response methods. This model provided a means to estimate the quantity of oily liquid (e.g., recovered oil, oily water) and oily solid waste (e.g., oily sorbents, oily personal protection equipment, and oily debris). The model was validated using data collected from the response operation of a real-world oil spill incident in British Columbia, Canada. Response surface methodology (RSM) experiments on the model illustrated significant interactions between sea temperature and response arrival time on the volume of total recovered oil, as well as between sorbent booms usage rate and the sorbent boom weight on the total oily solid waste quantity.

The formation of oil/water emulsions is known to influence the fate and behavior of oil spilled at sea, as well as the effectiveness of oil spill response options. Two research articles on oil/water emulsification are included within this journal volume. One describes a modeling approach to investigate the formation of water-in-oil emulsions as a function of bulk oil properties, oil composition, and turbulence level (French-McCay et al.). Results illustrated an increase in viscosity from emulsification prolonged floating oil exposure by preventing the oil from dispersing into the water column, and that persistent emulsified oils were more likely to come ashore than low viscosity oils that readily disperse. Since the emulsification greatly affects the trajectory and fate of spilled oil in the marine environment, the results from this paper highlighted the importance of considering emulsification process in the planning and implementing oil spill response actions and the evaluation of potential ecological impacts. Another paper (Shen et al.) investigated the preparation of oil/water emulsions in laboratory environment for oil spill response research as there is not a standard protocol for the generation of emulsified oil similar to that observed following actual oil spills. In this paper, a stable conventional heavy crude oil-in-water (O/W) emulsion was prepared by mechanical homogenization with the addition of a non-ionic surfactant. The optimal operating condition of emulsion formation was examined through a response surface methodology (RSM) experimental design on four factors (mixing intensity, mixing duration, water salinity, and the concentration of surfactant). The emulsion stability was evaluated using creaming stability test, turbidity measurement, and microscopic analysis.

Under the Research Topic of this dedicated journal volume, a research paper also investigated microbial degradation of petroleum hydrocarbons within marine sediments (Xu et al.). Oil spilled in marine environment may sink due to the formation of oil-particle aggregates leading to detrimental effects on the benthic organisms. In this paper, 16 S rRNA genes high-throughput sequencing and quantitative PCR were used to study the composition and distribution of bacterial communities in deep-sea sediments collected in the northeastern South China Sea. The isolation of petroleum hydrocarbon degrading bacteria under low-temperature deep-sea conditions showed that water depth and the concentration of exogenous organic matter affected the bacterial community composition and diversity in deep-sea sediments. Results such as the observation that bacteria of the genus *Stenotrophomonas* had a strong ability to degrade petroleum hydrocarbons under low temperature provided valuable information for the assessment and remediation of deep-sea pollution following marine oil spills.

In summary, the effective management of petroleum hydrocarbons in the marine environment has received increasing attention from governments, industries, communities, and researchers. This dedicated edition of the journal on "Waste Management of Petroleum Hydrocarbons in Marine Environment" provides the latest insights on various aspects of waste management associated with marine oil spill response operations.

Author contributions

JL: Writing original draft. KL: Reviewing and revising. BC: Reviewing and revising. GH: Reviewing and revising. SZ: Reviewing and revising.

Conflict of interest

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