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Emerging Energy-Related Hazardous and Noxious Substances: Rethinking Spill Risks, Preparedness, and Response in Energy Transition

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Abstract

The global energy transition is rapidly changing the types of fuels, energy carriers, and Hazardous and Noxious Substances (HNS) being produced, stored, and transported. Bio-derived fuels, low-carbon marine fuels, hydrogen, ammonia, and other emerging energy-related HNS offer important opportunities for decarbonization but also present new and evolving challenges for spill preparedness and response. Much of our existing scientific knowledge, predictive capability, and response practice has been developed around conventional petroleum products. As the energy landscape continues to evolve, a critical question emerges: Are our spill preparedness and response capabilities evolving at the same pace?

This keynote will examine how emerging energy-related HNS are reshaping spill science and what these changes mean for future preparedness and response. Drawing on research conducted at CanmetENERGY Devon, Natural Resources Canada, examples will illustrate how differences in physicochemical properties, environmental conditions, and release scenarios can lead to markedly different fate, behaviour, persistence, environmental impacts, and response challenges. Studies encompassing bio-derived oils, emerging low-sulphur marine fuels, and other transported HNS, including anhydrous ammonia, demonstrate the diversity of behaviours and impacts that can occur following release. Environmental factors such as temperature, ice, salinity, sediments, and shoreline interactions can further influence their fate, weathering, distribution, and associated risks. Meanwhile, hydrogen and other alternative energy carriers extend the challenge beyond conventional liquid spills and introduce new considerations for detection, hazard assessment, modelling, and emergency decision-making.

These evolving risks underscore the need for a stronger scientific foundation to support anticipatory and predictive spill preparedness, response, and decision-making. Integrating experimental research, environmental monitoring, advanced sensing technologies, predictive modelling, and decision-support tools can improve our ability to characterize hazards, anticipate environmental consequences, and support effective response decisions.

Ultimately, spill science and response capabilities must evolve alongside energy technologies to ensure that we are prepared not only for the substances transported today, but also for the emerging risks of tomorrow.

Keywords: *Hazardous and Noxious Substances (HNS); Energy Transition; Emerging Fuels; Spill Preparedness and Response; Environmental Fate and Behaviour; Predictive Spill Science*