Remediation of a Freshwater Wetland in the Presence and Absence of Wetland Plants through Enhanced Biostimulation. Part II: Habitat Recovery and Toxicity Reduction

Kenneth Lee, Fisheries and Oceans Canada
Christian Blaise and Kenneth G. Doe, Environment Canada
Lucy E.J. Lee, Wilfrid Laurier University
Makram T. Suidan, University of Cincinnati
Albert D. Venosa, U.S. Environmental Protection Agency

The St. Lawrence River/Seaway is one of the most difficult waterways to navigate due to the presence of strong currents and tides. Nevertheless, each year more ships pass through its waters than the Panama and Suez canals combined. This system plays an important role for the distribution of North America's energy reserves; in 1988, 10.8 million tonnes of refined petroleum products and 6.9 million tonnes of crude oil were transported on this waterway by tankers having a holding capacity as high as 160,000 tonnes. With such a heavy volume of marine traffic, the risk of a major shipping incident is high. Wetlands along the St. Lawrence are important ecologically and economically, as they provide the principal nursery ground for coastal fisheries, habitat for wildlife and endangered species, and protection against shoreline erosion. Indeed with the identification of more than 140 rare species, some wetland reserves in the region have been declared "world heritage sites".

Information on impact of oil spills in north-temperate freshwater wetland ecosystems is limited. In addition to the need to understand the potential environmental impact of oil spills on wetlands, there is a need to develop effective habitat restoration technologies. To address these issues, Fisheries and Oceans Canada and the US EPA have sponsored a joint project to refine and validate biostimulation strategies such as bioremediation and phytoremediation to accelerate habitat recovery (discussed in previous paper).

The public has responded favourably to biostimulation as an operational oil spill countermeasure, as its implicit goal is that of reducing toxic effects by converting organic molecules to benign cell biomass and "environmentally friendly" products such as carbon dioxide and water. However, a fraction of the oil spill response community, environmentalists, and the public remain concerned over the net benefit of such countermeasures. Concerns include the potential production of toxic metabolic by-products, possible toxic components in the formulation of bioremediation agents, and the incomplete degradation of highly toxic components within the residual oil. These environmental issues and a direct measure of remediation treatment success can be directly addressed by the application of ecotoxicological monitoring techniques.

An experimental oil spill experiment was conducted in the summer of 1999 at a wetland site situated along the St. Lawrence River, at St. Croix, Quebec, Canada. The study area consisted of 20 experimental plots (5 m x 4 m) dominated by *Scirpus pungens*. Experimental treatments included an unoiled control and 4 oiled treatments. The oiled treatments included a natural attenuation (no treatment) control, nutrient amendment with granular ammonium nitrate and super triple phosphate, a similar treatment with plants continuously cut back to suppress plant growth, and a treatment consisting of amendments with sodium nitrate rather than ammonium nitrate. Weathered Mesa light crude oil was applied during the week of June 7, 1999 at the rate of 12 L per plot. To ensure that nutrient limitation was not a factor suppressing treatment effects, nutrients reapplied when interstitial nitrogen concentrations fell below 5-10 mg/L.

Time-series sampling for chemical and toxicological analysis was initiated one week after oiling concurrent with the first nutrient application event. Samples were recovered over a

21-week period that effectively covered the natural growth season of the plants. The extent oil biodegradation was quantified by GC/MS analysis with analytes normalized to the conserved marker hopane.

Impacts and habitat recovery was assessed by monitoring the effect of oil on the growth and survival of *Scirpus pungens* and the reduction of sediment/interstitial water toxicity within a selected battery of toxicity tests. Regulatory biotests included the Microtox Solid Phase Test, the *Hyalella azteca* 14-day Growth and Survival test, the 48-hour *Daphnia magna* Survival Test, and the Algal Solid Phase Assay (ASPA). The indigenous prosobranch gastropod, *Viviparus georgianus* was also used as a biomonitor to assess the direct impact of oil on the survival, growth and reproduction of benthic invertebrates within the test plots. Initial results have demonstrated the tolerance of *Scirpus pungens* to the concentration of oil applied in during this experimental spill. While nutrient additions clearly enhanced the growth of the wetland vegetation in both oiled and unoiled test plots, results from the Microtox Test suggest that reduction of sediment toxicity did not occur at a rate higher than that found in the oiled control (natural attenuation). The results of this preliminary toxicity data set are supported by the GC/MS data presented in the previous paper, which suggest that there was little treatment effect. This conclusion based on the result of the Microtox Test results is preliminary, as an accurate environmental assessment cannot be made on the result of a single biotest. Conclusive remarks can only be made when all toxicological, chemical, and microbiological data have been interpreted.