Characterization and Spatial Distribution of Organic Contaminated Sediment Derived from Historical Industrial Effluents

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Background/Objectives. A bleached Kraft pulp and paper mill has been operating in Pictou County, Nova Scotia, since 1967. An effluent wastewater treatment facility for the mill was built and operated by the provincial government in nearby Boat Harbour, a tidal lagoon within the Pictou Landing First Nations (PLFN) community and has been used to discharge and treat pulp and paper mill wastewater effluents for 50 years under a provincial agreement. This has resulted in a large quantity of unconsolidated waste sediments (>170,000 m^3) being deposited in the former tidal estuary that will require remediation in the near future. Dozens of studies have been conducted at Boat Harbour since 1992 to characterize accumulated sediments. Previous studies related to Boat Harbour sediments indicated impacts from inorganic and organic contaminants (i.e., metals, polycyclic aromatic hydrocarbons [PAHs], polychlorinated dibenzo-p-dioxins, polychlorinated dibenzofurans [PCDD/Fs]). However, despite a plethora of studies, gaps still exist in our understanding of sediment characteristics (e.g., depth of impacted sediments, including spatial extent and magnitude of impacts).

Approach/Activities. To inform future remediation decisions, we reviewed over 200 reports focusing on relevant sediment data (12 reports). Because studies were often conducted by third parties, sampling methods (grabs, cores, discrete and composite sampling), and sampling depth (shallow versus deep sampling) varied widely. These challenges were addressed by grouping studies using similar techniques (e.g., shallow composite grabs were grouped with studies using shallow coring devices). This study: (i) compared PCDD/F sediment toxic equivalent (TEQ) concentrations and PAH sediment concentrations to sediment quality guidelines; (ii) sorted data according to vertical delineation and method of collection; and (iii) identified potential sources of contaminants and gaps in long-term monitoring data to help inform future remediation management decisions.

Results/Lessons Learned. Sediment PCDD/F concentrations exceeded severe effect thresholds over the entire period posing severe ecological health risks and have persisted in Boat Harbour despite implementation of *Pulp and Paper Mill Effluent Chlorinated Dioxins and Furans Regulations* in 1992. PAH concentrations varied greatly, likely due to inconsistent sampling techniques. Five individual PAH compounds frequently exceeded severe effect thresholds, in contrast to total PAHs, which were below severe effect thresholds. Forensic analysis using PAH diagnostic ratios suggests pyrogenic PAHs (derived from wood products and coal combustion) were the primary source. Analysis of 25 years of secondary data revealed large data gaps in our understanding of sediment characteristics in Boat Harbour. Gaps include spatial (vertical and horizontal), as well as temporal variation, which presents challenges for remediation decisions regarding accurate delineation of sediment contaminants. Deeper horizons were poorly characterized compared to shallow sediments (0-15 cm). Overall, spatial coverage across Boat Harbour was inadequate. More detailed sampling is required to better characterize these sediments prior to remediation. Because of the severe ecological health risks associated with high sediment PCDD/F concentrations, remediation of the entire sediment inventory along with an ecological risk assessment is recommended.