



## Effects of Thawing Permafrost on Legacy Industrial Sites in the Arctic – Insights from Drilling Mud Sumps in the Mackenzie Delta

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The thawing of permafrost-affected soils puts infrastructure and industrial sites at risk. In the Canadian Arctic, the long-term stability of permafrost was historically relied upon to contain drilling waste. During decades of oil and gas exploration activities from the 1960s to the early 2000s, drilling fluids and cuttings were often buried on site adjacent to the wellhead and covered with excavated material. More than 200 of these sites, called *drilling mud sumps*, have been documented in the Mackenzie Delta and Arctic Islands in the Northwest Territories [1]. With rapidly increasing air temperatures, the seasonally thawing active layers of permafrost soils are deepening [2]. Drilling fluid additives, such as salts, may act as freezing-point depressants and further contribute to permafrost degradation [3]. Consequently, many sumps now show signs of structural failure, including cracking and subsidence of the sump caps, often followed by water ponding [1,4]. The ability of permafrost to act as a hydrological barrier to contain the drilling waste may be diminished. As the volume of drilling mud buried at each site, as well as its chemical composition and properties, are poorly documented [1], there is considerable uncertainty regarding potential environmental consequences.

This study analyzes soil samples from seasonally unfrozen and perennially frozen soil horizons on the sump cover and in the surrounding area at four sumps close to the Inuvik-Tuktoyaktuk Highway. Extraction using acetone and *n*-hexane was enhanced via ultrasonication and dispersion techniques. Further fractionation of the extracts enabled the identification and quantification of distinct compounds using gas chromatography coupled with single-quadrupole mass spectrometry (GC-MS). A comprehensive non-target screening was performed using the Xcalibur<sup>TM</sup> Software linked to the NIST library.

The aim of the study is to identify potential contamination of soils related to the historical use and disposal of drilling fluids during oil and gas exploration activities. We further aim to assess the vertical and lateral dispersion of organic contaminants in the unique setting of permafrost-affected soils. Preliminary results indicate that soil contamination at the sites is dominated by polycyclic aromatic compounds (PACs) and heterocyclic aromatic compounds (NSO-PACs) of petrogenic origin. Concentration patterns suggest that petroleum hydrocarbons have migrated upwards into the active layer of the sump cover material. Concentrations in the active layer are generally highest directly above the permafrost table. Contaminant concentrations decline in soils downslope of the sites, suggesting limited lateral movement of the identified compounds through active layers.

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