Applied research project proposal :

# ''Development of *in situ* remediation technologies adapted to the context of cold and remote Arctic and Subarctic regions''

**Objet :** One pager presenting the overall context and main goals of the project

## Problematic

In the Canadian Arctic Northern Villages (NV), each building has its own heating oil (diesel) tank. Limited operational budget, logistical options and expertise together with challenging climatic conditions have led and still lead today to a vast number of small to medium diesel spill (*cf.* figure 1). In such context, the most widespread remediation method applied consists in moving the building, excavating the contaminated soil and sending it by boat to an appropriate landfill facility located in a temperate region (Taillard and Baïlon-Poujol, 2020; Taillard *et al.,* 2021). This remediation option implies prohibitive costs, large amount of greenhouse gas production and requires an excavation step that can equal or exceed the damage caused by the initial spill (Filler *et al.,* 2006). *In situ* and *ex situ* soil remediation technologies widespread in temperate regions can face major issues when implemented in the specific climatic and logistical context of cold climate regions, and require development and adaptation (Filler et al., 2006; Poland et al., 2003). **Canadian local actors and authorities are in a need for innovative and efficient solutions adapted to this specific context and considering the preservation of remaining permafrost** (Taillard and Baïlon-Poujol, 2020).

## Advantages of the technology once developed :

- ✓ Possibility to treat under stilted buildings when excavation is not an option;
- ✓ Alternative distribution method : no need for injection wells or specific and costly equipment;
- ✓ Remediation without temperature elevation (<3°C) : preservation of the remaining permafrost;
- ✓ Chemicals under solid forms, easy to transport and safe to operate by local workers;
- ✓ Efficient in unsaturated soil (raft soil, surficial material, etc.)

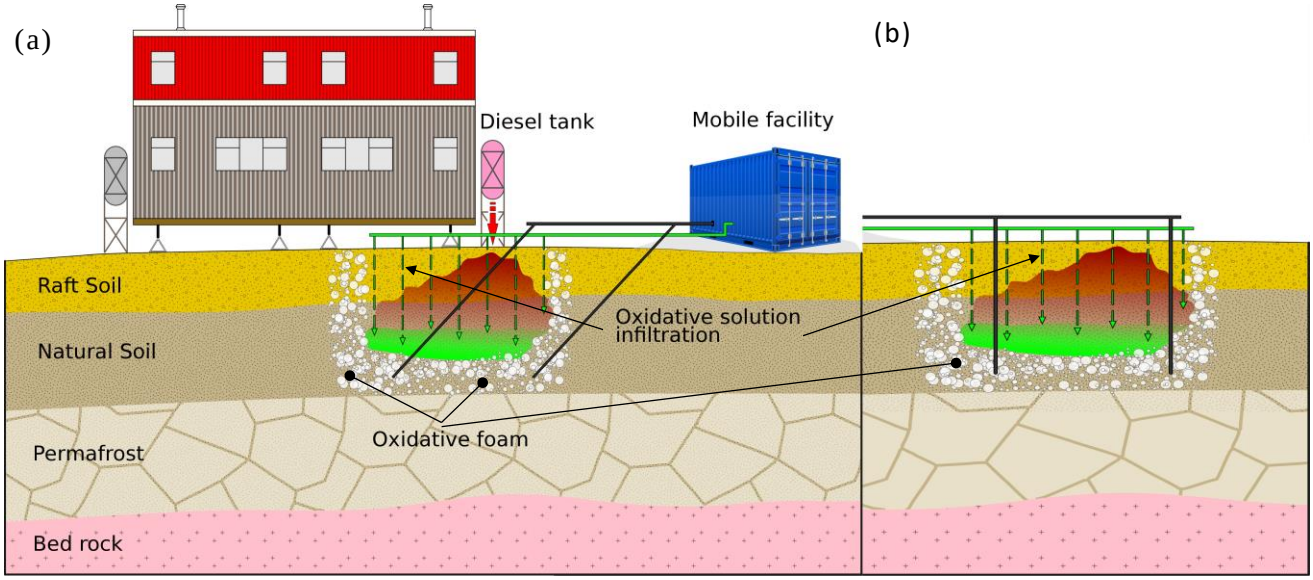


**Figure 1: Schematic representation of a diesel spill under a stilted building (a) and in an open space (b)**

INRS Institut national de la recherche scientifique

# Project proposal

## Environmental technologies developed and tested in laboratory and on the field

1. Percolation of an oxidative aqueous solution based on persulfate activated with calcium peroxide to degrade diesel in situ in the soil (continuation of the KRG-KMHB-INRS 2018-2021 project (Taillard *et al*, 2021, 2021a, 2021b));
2. Injection of an innovative oxidative foam above and around the observed spill. The foam will: (1) Create an in-depth retention zone in order to promote oxidant-contaminant contact, to reduce oxidant consumption and to reduce the treatment duration; (2) Dramatically reduce the formation of preferential fluid flow paths that may occur in the subsurface.
3. Enzymatic degradation of diesel under cold conditions. Laboratory validation of the medium-term applicability of the technology;

## Nature of work over two years

- ✓ Sampling of local representative contaminated soil : Identification of bacteria and enzymes capable of degrading diesel in cold conditions;
- ✓ Development of a foam compatible with the oxidant: selection from data available in the literature and laboratory tests on representative soil;
- ✓ Laboratory tests using a multiscale approach in a temperature-controlled environment: tests on 300 mL columns filled with contaminated soil, tests in 15 L container including targeted foam injection;
- ✓ On field pilot tests: percolation of an oxidative aqueous solution and injection of an oxidative foam on a recent diesel spill. *In situ* diesel concentrations and temperatures monitoring. Direct push injection (no need of injection wells). Pressures and temperature monitoring over a period of several months following injection thanks to an *in situ* network of thermistor and pressure sensors;

## Actors and collaborators

**KRG** (Kativik Regional Governement)**:** Project development / Administrative and logistical support;
**KMHB** (Kativik Municipal Bureau of Housing) : Logistical support / Transfer of expertise;
**SPN** (Société du Plan Nord): Administrative support / Financial support;
**NSERC, MITTACS** : Financial support;
**Environnement Canada** : Administrative support, authorization and transfer of expertise;
**INRS** (Institut National de la Recherche Scientifique); **York University; Yukon University** : Scientific and academic expertise;
**TechnoRem Inc.** : Professional expertise / Financial support / Commercial implementation;

## Local benefits

- ✓ South-North transfer of expertise leading to the implementation (3-4 years delay) of an effective remediation technology. Project initiated by the local communities in 2018, developed with the local communities and intended to be exploited by the local communities;
- ✓ Improvement of the life quality and health of community members by reducing their exposure to petroleum products. Improvement of the local environment quality by eliminating petroleum products residues in soils and water;
- ✓ Formation of highly trained workers used to operating in northern conditions and aware of the northern development context and potential issues.