EARTHMASTER
environmental strategies

Technical Case Study

Phytoremediation of Salt and Hydrocarbon Impacted Soil at a Remote Northern Location Using PEPSystems®

Abstract

Earthmaster successfully treated petroleum hydrocarbon (PHC) and salt (NaCl) impacted soil using a PGPR (plant growth promoting rhizobacteria) enhanced phytoremediation system (PEPSystems®) at a remote northern location. Approximately 7,800 m³ of impacted soil was successfully treated with PEPSystems utilizing perennial and annual grasses. Following treatment, all of the soil complied with surface soil and/or subsoil remediation guideline values and was suitable for re-use on the site.

PEPSystems® Technologies

PEPSystems is based on multiple complementary techniques that target different aspects of PHC and salt impacted soil remediation. PEPSystems not only degrades PHCs in the soil, but results in their metabolism to non-toxic molecules. PEPSystems also increases plant tolerance to elevated salt levels allowing for improved plant growth with commensurate salt uptake into aboveground plant tissue. PEPSystems lowers stress ethylene levels in plants which allows for improved plant root and shoot growth and results in efficient and timely re-vegetation of impacted sites. Soil can be treated both *in situ* and *ex situ* using PEPSystems.

Project Background

The site was located in the Sahtu Region of the Northwest Territories (NT), ~40 km SE of Norman Wells. The site had winter road access only. Portions of the salt and PHC impacted soil from drilling activities had previously undergone unsuccessful treatment using bioremediation. Several contaminated open and buried pits and sumps remained on-site. Laboratory analyses of the soil completed in 2008 showed elevated salt and PHC fraction F2 levels. Phytoremediation was identified as a potential means of remediating the salt and PHC impacts to avoid the costly and difficult option of off-site landfill disposal.

Remediation Objectives

The remediation objectives were to reduce PHC and salt levels in the soil to comply with Alberta Tier 1 Soil and Groundwater Remediation Guideline values for industrial land use for coarse grain surface soil or subsoil as agreed to by the NT regulator. The regulators approved the use of subsoil remediation guideline values for treated soil being placed deeper than 1.50 m below ground level. It was required that soil treatment be completed on-site.

Remediation Methods

Dr. Bruce Greenberg from the University of Waterloo isolated and characterized PGPR from soil collected at the site, and conducted greenhouse trials to identify effective bacteria and plant combinations to achieve remediation goals. PEPSystems utilizing Nota 4/7 *Pseudomonas* bacteria with perennial and annual grasses was deployed at the site in 2008 to treat surface soil for salt impacts (soil layer #1). Permanent assessment points were established

across the treatment area for use in conducting regular soil and vegetation sampling and analyses to monitor remediation progress. Following remediation of a soil layer, additional impacted soil was excavated from the pits and sumps and was spread across the treatment area. PEPSystems was re-deployed to treat the additional soil (layers #2 to #5). Aboveground plant biomass containing accumulated salts was harvested and landfilled.

Results

From PEPSystems deployment in June of 2008 through the 2017 growing season, a large volume of soil (~7,800 m³) was successfully treated in five different soil layers as necessitated by the small size of the on-site treatment area. At the end of the 2017 growing season, laboratory soil test results for EC (electrical conductivity) and PHC complied with remediation objectives. Remediated soil was placed back into the excavations and the site was re-contoured and re-vegetated to ensure successful closure based reclamation. Contaminant remediation at the remote site was completed within eight growing seasons. The cost to phytoremediate the contaminated soil on-site was 20% of the cost for off-site landfill disposal.

Layer #	Treatment Start Date	Treatment End Date	# Growing Seasons	Source	Soil Volume (m³)	Contaminant Concentrations	
						average at start	average at end
1	Jun 2008	Spring 2011	2	landfarm and lease surface soil	2,100	EC - 14.5 dS/m EC - 5.2 dS/m EC - 3.6 dS/m	EC - 5.3 dS/m (↓63%) EC - 2.2 dS/m (↓58%) EC - 2.2 dS/m (↓39%)
2	Jul 2011	Jun 2013	2	pits and sumps	2,100	EC - 5.5 dS/m F2 - 549 mg/kg	EC - 2.9 dS/m (↓47%) F2 - 84 mg/kg (↓84%)
3	Sep 2013	Sep 2015	2	pits and sumps	900	F2 - 1418 mg/kg	F2 - 307 mg/kg (↓79%)
4	Jun 2016	Jun 2017	1	pits and sumps	1,600	F2 - 644 mg/kg	F2 - 360 mg/kg (↓44%)
5	Jun 2017	Sep 2017	1	pits and sumps	1,100	F2 - 385 mg/kg	F2 - 152 mg/kg (↓60%)

Conclusion

Phytoremediation successfully removed salt and PHC contaminants from the soil allowing the soil to be conserved and reused on-site. While PEPSystems technologies are more time consuming than traditional disposal based

remediation methods, PEPSystems offers innovative and effective low cost green solutions to remediating and conserving contaminated soil. This technology is especially suited to remote and/or northern areas where traditional remediation techniques are not cost effective nor practical.

References

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