2016 CANADIAN CONSULTING ENGINEER AWARDS

CO-COMPOSTING OF SOILS IMPACTED WITH PAHS AND HEAVY PETROLEUM HYDROCARBONS - MONTREAL-EAST

Golder Associés

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SUMMARY

Photo 1: Remediation work zone

Golder was mandated by Dow and Petromont to treat soils impacted by high concentrations of high molecular weight polycyclic aromatic hydrocarbons (PAHs) and heavy fraction petroleum hydrocarbons C_{10}-C_{50} at the former Montreal-East plant. Following the plant's closure after 58 years of operation (from 1950 to 2008), Golder completed the characterization of this site, which has a surface area of 700,000 m^2. Golder identified a total of 140 zones of potential environmental concern, took 1,000 sample points and completed a detailed ecological characterization, resulting in Phase II 83,000 analytical results that led to the evaluation of 123,700 m^3 of impacted soils to treat.

The characterization studies demonstrated that the petrochemical plant site contained several contaminants with a wide spectrum of properties and characteristics. In light of this finding, Golder evaluated different site remediation scenarios with a view to developing the most sustainable approach, that is, an approach that generated the most environmental, technical, economic and social benefits. The selection criteria retained by Dow and Petromont, given their commitment to Responsible Care®, the Chemical Industry Association of Canada sustainable development program, required that the values of the mandated company incorporate principles of sustainable development. Golder's approach is designed to evaluate the different applicable remediation options for contaminated sites in a context of sustainable development.

INNOVATION

The technological treatment train was developed following laboratory testing and a pilot study. Different remediation options were also assessed using GoldSET, a decision support tool developed by Golder to perform semi-quantitative evaluations of projects using indicators for the three dimensions of sustainable development.

After completing treatability testing, Golder developed the following soil remediation approach:

- Treatment of soil using biopiles and co-composting with chicken manure amendment;
- Treatment of vapours extracted from biopiles using nutrient- and bacteria-rich leachate from co-composing piles to inoculate the filter media and maintain humidity levels; and
- Treatment of metal-impacted soils through phytoremediation.

Although there is widespread use of biopiles to treat excavated hydrocarbon-impacted soils, certain heavy hydrocarbons are recalcitrant to conventional biological biopile treatment.

Composting relies on microbial activity to mineralize the organic matter into water vapour and carbon dioxide through aerobic biochemical decomposition processes, which in turn raise soil temperatures. The composting process is initiated by aerating the mix of biodegradable carbon- and nitrogen-rich organic matter. Co-composting therefore consists in mixing compostable organic amendments into the contaminated soils. Co-composting advantages over conventional biopile are more rapid biodegradation (shorter treatment time), a greater diversity of bacterial populations and various other processes that enhance degradation.

The biopiles in Golder's innovative co-composting system are built on top of an impermeable base, covered with a liner to maintain the temperature, and equipped with an extraction system/soil aeration and leachate recirculation system.

Photo 2: Biopiles designed for the co-composting of contaminated soils.

Photo 3: Air extraction system

The project comprises 48 co-composting biopiles with 1,000 m[3] capacity, 8 air extraction units with individual capacity of 34 m[3]/minute, a leachate recirculation system and 8 biofilters.

Co-composting has allowed Golder to achieve the client's remediation objectives under time and at less cost than the other available soil treatment technologies, such as thermal desorption and conventional biopiles.

Figure 1 presents an example of the evolution of soil temperatures in time. It shows a rapid increase in temperature as well as high temperatures - which promote degradation kinetics - that are maintained for several weeks. Figure 2 illustrates the typical decrease in concentration levels within 71 days of treatment. In most cases, concentration levels were brought below the threshold of applicable criteria within a single season (4 months).

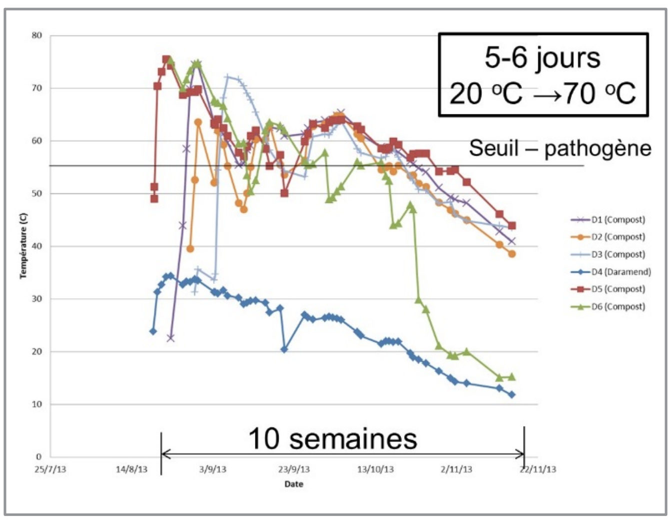

Figure 1: Evolution of temperature in time

	D2 (71 jours)	
Naphtalène	94%	
Phénanthrène	64%	
2-Méthylnaphtalène	85%	
Pyrène	34%	
Acénaphtène	54%	
Fluorène	67%	
Benzo(a)pyrène	27%	
Fluoranthène	39%	
Benzo(c)phénanthrène	33%	
C10-C50	59%	

Figure 2: Percentage of decrease of PAH and PH C10-C50 levels after 71 days of treatment

COMPLEXITY

The site presented significant complexity: mixed contamination (metals and hydrocarbons), soils located primarily in a non-saturated zone, and hydrocarbons from a mix of products that are resistant to biological treatments and chemical oxidation (heavy PAHs, hydrocarbons with more than 50 carbons, presence of BCEE, a chlorinated organic solvent).

Bioremediation through co-composting was the only technology that could be mobilized to meet all of the client's objectives for the site in terms of applicable standards and principles of sustainable development.

The treatment solution was developed first through small-scale benchmark studies, then on site using pilot biopiles. Other factors of complexity, which ultimately required that modifications be made to the treatment process, arose at a large scale due to the high temperatures generated and the production of a large quantity of water. The treatment of gases extracted from the biopiles was also complex given their temperature as well as contaminant composition and high concentration levels.

The clayey nature of the soils presented yet another challenge for bioremediation in terms of nutrient and oxygen transport, given the soil's very low air and water permeability and significant contaminant adsorption in the matrix. However, the heat generated and the production of biosurfactants by the bacteria, making it possible to destructure the clay and desorb contaminants, resulting in the volatilization and biodegradation of contaminants.

SOCIAL AND/OR ECONOMIC BENEFITS

Implanting a safe treatment process for workers and citizens that does not require the handling of chemical products and the transportation of contaminated soils off site yields a number of social benefits.

The project also requires that more than 20 seasonal workers be hired full time for a period of 7 years. There have been no work accidents resulting in lost time—a point of pride for Golder. Only one episode of psyllium had to be managed during the project. On a larger scale, the client met with local elected representatives to present the retained technology and the remediation timetable, thereby promoting their commitment to transparency, Responsible Care® and sustainable development.

All of the work is contained within the site. Golder Associate also made sure that the process would not generate any odours, particulate and VOC impact outside the site's periphery. The road was wetted and a fog VOC/particulate mitigation system was used near the soil manipulation points. Also, close monitoring of the air quality was performed using Hi-vol and PUF samplers.

From an economic perspective, the process developed by Golder does not have high energy requirements; given that the bacteria and bacterial activity generate the heat required for the process, there is minimal energy consumption. In addition, an innovative water extraction system that uses Venturi-style injectors was used.

Benefits of the selected option include competitive treatment costs, compared with disposal costs for the contaminants at hand. In addition, the treatment solution has already freed up part of the site for industrial development.

ENVIRONMENTAL BENEFITS

Co-compositing technology was selected following a comparative study of applicable technologies, namely thermal desorption, using the GoldSET tool.

GoldSET is a decision support tool that has been developed by Golder to integrate principles of sustainable development in projects in a way that is both robust and transparent. GoldSET is used to compare different treatment options according to environmental, social, economic and technical considerations. The study allowed Golder to identify the issues that would need to be managed throughout the project's life cycle. The results are represented in a visual diagram to clearly illustrate the strengths and weaknesses of each option. GoldSET can be adapted to the specific characteristics of each project to promote cooperation among multiple stakeholders, which is key to a successful sustainable development approach. The five-step process, illustrated in Figure 3, results in a robust, methodological analysis of the options.

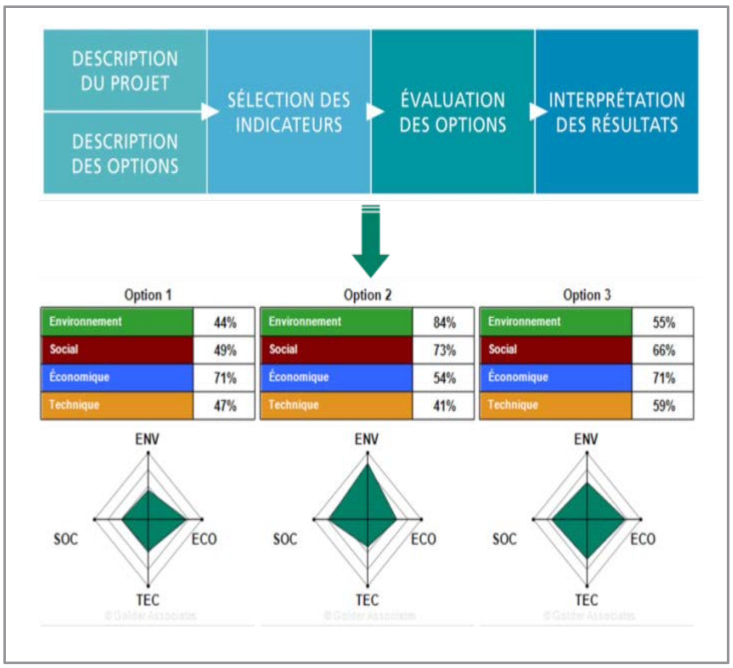

Figure 3: Option Evaluation

The axes on the visual diagram illustrate a given option's performance based on the retained dimensions for evaluation. Under normal circumstances, the optimal approach is illustrated by the largest and most balanced diagram. The performances illustrated in Figure 3 were obtained by evaluating a series of indicators representing the issues associated with the environmental, social, economic and technical dimensions.

Each indicator is chosen to reflect the decision-making criteria so that the evaluation captures a global understanding of the problem that leverages a detailed analysis of project-specific factors and issues. The indicators are then ranked on a scale of 100, based on a previously established scoring scheme, where a score of 100 indicates a superior performance. The indicators are also weighted to represent the relative importance of the issues considered in the evaluation. The tool facilitates the identification of the strengths and weaknesses of the different options, allowing the user to engage in a well-informed decision-making process.

The project's environmental impacts are minimal as the treatment train is 100% biological. Golder has also been able to reuse the site's backfill materials for the biopiles construction. The GoldSET analysis revealed that the chosen treatment option produced much less greenhouse gas emissions than other treatment processes, such as off-site disposal and thermal desorption. The energy needs are also very low, that is less than 0.005 hp/m^3 of soil. Contaminant desorption and clay destructuration is achieved through the energy generated by bacterial activity. This process produces very little wastewater since most of the leachate is recirculated and/or used to increase the bioavailability of soil and maintain humidity levels of the biofilters. The volatile organic compounds (VOCs) produced by the process are treated via biofiltration.

From an environmental standpoint, the use of a green technology that hinges on the biodegradation aided by the soil's native bacteria and an external amendment of natural organic nutrients has proven to be an excellent choice.

CLIENT SATISFACTION

Given their commitment to Responsible Care®, Dow and Pétromont's principal objective with this project was to adopt a sustainable treatment plan. Golder answered the call and put in place an approach to evaluate the different applicable remediation options for impacted soils, in a context of sustainable development.

Respecting budgets and schedules is a sizeable challenge when carrying out large-scale remediation projects over several years. Several unexpected factors can arise, from changes to the initial estimates of impacted soils to treat, to adjustments to deadlines in keeping with the technology's performance, or different requests from government bodies or other stakeholders.

By the end of the first three years (2012, 2013 and 2014) of the seven-year treatment plan, Golder had completed the scheduled work for under budget by 5%, 1% and 15%, respectively. In 2015, the budget was slightly exceeded by 2%, and an additional 8% of excavated soil was treated ahead of schedule; despite this, however, the overall schedule to 2019 has not been affected, and the total cost of the project should remain within +/- 10% of the initial projection.

Our client, Louis Rail, Pétromont's president, was openly enthusiastic about Golder winning the Grands prix du génie-conseil québécois at the 2015 annual gala: "We're thrilled and also very proud to have chosen Golder, and we're particularly proud of the results they achieved. Thanks to the creativity of the proposed technology—co-compositing and biopiles—we were able to determine an effective course of treatment, within a reasonable timeline and at a cost deemed acceptable by our company. Golder contributes to sustainable development in Montréal. We are very happy with the responsible management achieved with Golder."