St. Lawrence TECHNOLOGIES

CONTAMINATED SOIL

ROTAMIX PROCESS FOR THE BIOTREATMENT OF SOIL CONTAMINATED WITH PENTACHLORO-PHENOL AND PETROLEUM HYDROCARBONS

ABSTRACT

The off-site treatment of contaminated soil typically consists of remediaton in biopiles. The ROTAMIX process was developed and demonstrated with the aim of reducing the time required to treat contaminated soil, and broadening the range of matrices and non-volatile contaminants that can be treated biologically. This technology combines the use of a self-propelled rotary turner with bioactivating nutrients and structuring agents. In trials carried out on the ROTAMIX process, soils contaminated with pentachlorophenol (PCP) and heavy petroleum hydrocarbons, substances that do not easily break down, were decontaminated to a level corresponding to the C criterion of the ministère de l'Environnement du Québec.

HIGHLIGHTS

- **Technology**
  - Use of a self-propelled rotary turner
  - Controlled addition of structuring agents, organic nutrients and micro-organisms
  - Improved solid/liquid/gas exchanges
  - Increased water-retention capacity of treated soil.
- **Environment**
  - No leachate water or gaseous emissions generated
  - Homogeneous treated matrix respects MEF's C or B criterion
  - Broadens range of matrices and contaminants that can be treated
  - Possibility of treating contaminants known to be difficult to biodegrade.
- **Cost**
  - Significant reduction in treatment time compared to the static biopile approach.

Saint-Laurent Vision 2000

Environment Canada Protection Québec Region

Environnement Canada Protection Région du Québec

GSI Environnement

NRC·CNRC

Canada Economic Development

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PROJECT OBJECTIVES

In all, 50 tests were performed with the aim of:

- Determining optimal treatment conditions for different matrices and contaminants;
- Designing and building a self-propelled rotary turner prototype for demonstration trials.

Phase 1 - Forty-three laboratory tests were performed to examine:

1.1 The physical characteristics of the soil by measuring indices of its cohesion, macroporosity and microporosity;

1.2 The effect of adding a structuring agent, nutrients, a bioactivator or a specific microbial consortium;

1.3 The effects of turning over the matrix, biotreatment temperature and the addition of a microbial consortium.

Phase 2 - Four pilot-scale biotreatment tests were performed to:

2.1 Study the effect of soil conditioners and changes in scale;

2.2 Determine the design parameters of demonstration scale-up.

Phase 3 - Three scale demonstrations of the commercial prototype and comparison of two types of biotreatment:

3.1 Active treatment with the rotary turner;

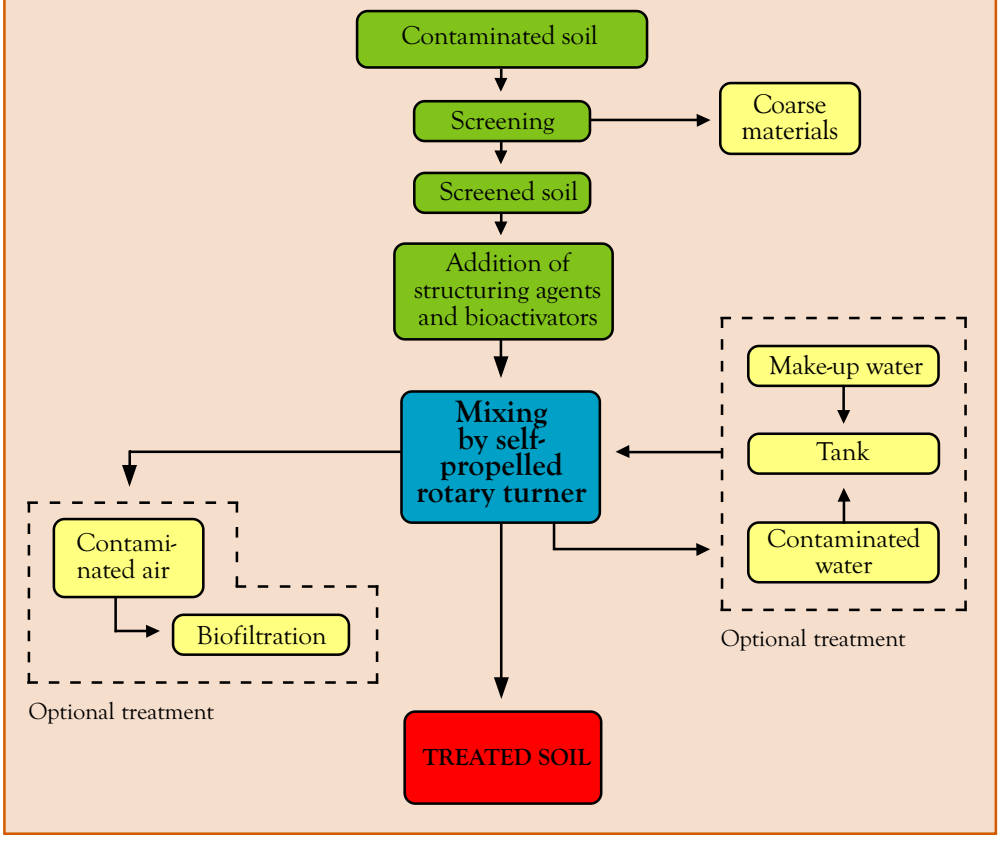
BACKGROUND

GSI Environment is an active player in the management of matrices contaminated by organic substances that are not easily biodegraded. The costs of disposing of such material in a controlled landfill site can be quite high. Moreover, such a management choice is not consistent with the company's commitment to promote the treatment and recovery of contaminated materials. In our climate, biopile treatment is ineffective for persistent contaminants, especially in clayey soils. Research into technologies better suited to the Canadian climate has led to the development of the ROTAMIX process.

TECHNOLOGY

The soil is first screened, watered and mixed with a structuring agent and a nutrient or bioactivator (see Figure 1) along with micro-organisms. An optimal mixture is obtained by use of a rotary turner designed especially for this matrix, thereby structuring the materials in such a way to promote an aerobic process, should it be necessary. The soil is then placed in windrows over ventilation pipes, and mixed at regular intervals by the self-propelled rotary turner. During these periods of turning, humidity, nutritional balance and/or microbial concentration may be corrected as required by use of the liquid distribution system mounted on the turner. Soil agglomeration is precluded by the addition of structuring agents and by the self-propelled rotary turner.

FIGURE 1.
SCHEMATIC OF THE ROTAMIX BIOTREATMENT PROCESS



RESULTS

The test results are presented in Table 1.

Phase 1: Laboratory trials

The addition of nutrients was found to have a positive effect on soil microporosity (soil humidity); structuring agents increased soil macroporosity (soil oxygenation).

In tests conducted on soil contaminated by heavy petroleum hydrocarbons (initial concentration of 3159 mg/kg dry weight (dw)), the final concentration obtained after treatment, 95 mg/kg dw, respected the MEF's B criterion.

Pentachlorophenol-contaminated soil also reached the C criterion, dropping from an initial concentration of 103 mg/kg dw to 5 mg/kg dw following treatment.

Phase 2: Pilot-scale treatment trials

Testing of the pilot unit confirmed the speed of degradation of heavy petroleum hydrocarbons witnessed in the laboratory (143 mg/kg dw.d), when the contaminated soil was turned at regular intervals (initial concentration of 24 500 mg TPH/kg dw). There was no contaminant degradation using the conventional static approach. In the case of PCP-contaminated soil, the B criterion was reached with a base concentration of 4 mg/kg dw.

The frequent measurement of operating parameters demonstrated the need to control the humidity and oxygen levels of the matrix. Rotary turning proved effective in this respect.

Phase 3: Scale demonstration of the commercial prototype

A comparison of the rate of contaminant biodegradation pointed out the advantage of regular rotary turning versus the static approach. The daily degradation rate of total petroleum hydrocarbons in soil treated by regular rotary turning is 92 mg/kg dw, versus 73 mg/kg dw during static treatment with only occasional turning. No decrease in TPH concentrations was observed when the soil was not turned.

Demonstration tests carried out on PCP-contaminated soil also revealed the utility of the ROTAMIX process. PCP concentrations fell from 4.4 to 1.7 mg/kg dw, whereas there was no bio-degradation using the static approach. After treatment with the ROTAMIX pro-cess, soil contaminated with PCP and TPH reached the MEF's C criterion.

TABLE 1.
ROTAMIX TREATMENT PERFORMANCE ON SOIL CONTAMINATED WITH HEAVY PETROLEUM HYDROCARBONS AND PENTACHLOROPHENOL (PCP)

Test scale	Description	Concentration (mg/kg dw)		Degradation rate (mg/kg dw.d)	Criterion *MEF**
		Initial	Final		
Laboratory (1.5 kg) – TPH	Regular rotary turning Regular rotary turning Initial turning (inoculated) Initial turning (not inoculated)	3150 16 500 3400 3100	95 10 500 260 2300	153 200 105 27	< B > C < B < C
Pilot unit – TPH	Regular rotary turning (2 m^3) Initial turning only (4 m^3)	24 500 10 500	7500 10 500	143 0	> C > C
Demonstration unit – TPH	Regular rotary turning (75 m^3) Initial rotary turning (75 m^3) Static pile (400 m^3) Static pile (11 m^3)	21 500 21 000 22 500 21 300	2350 6000 27 000 17 500	92 72 0 24	< C > C > C > C
Laboratory (1.5 kg) – PCP	Regular rotary turning Regular rotary turning Static pile with initial turning	103 2.4 1.60	5 0.95 1.00	1.78 0.02 0.01	= C < C < C
Pilot unit – PCP (2 m^3)	Regular rotary turning	4	0.5	0.5	= B
Demonstration unit (75 m^3) – PCP	Regular rotary turning Static pile with initial turning	4.4 7.5	1.7 7.5	0.03 0	< C > C

* According to the MEF's policy on protecting soil and rehabilitating contaminated lands, 1994 (1st ed.) and 1998 (2nd ed.).

POTENTIAL AND LIMITATIONS

The ROTAMIX process developed by GSI Environment combines bioactivation and soil conditioning (microbial seeding) with the use of a self-propelled rotary turner in a controlled off-site environment. Easy to operate, this technology is not constrained by the fine particle concentrations that may result from the addition of structuring agents. It can thus be used to treat sediment, sludge and clayey and/or silty soil.

The ROTAMIX technology may be useful on other contaminants that resist biodegradation. In fact, demonstration trials are now being conducted on soil contaminated with polychlorinated biphenyls (PCBs).

Compared to conventional static pile treatment, the ROTAMIX process reduces biological treatment costs for soil contaminated with heavy petroleum hydrocarbons by 35 to 40%. Using the same basis for comparison, treatment time can be reduced by 2 to 3 times, even in the presence of difficult-to-biodegrade compounds such as PCP.

In applying the ROTAMIX process, however, space requirements must be taken into account, along with the abrasive nature of some matrices, and the presence of volatile organic compounds in the soil or sludge to be treated.

INFORMATION

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For additional information, contact:

Environment Canada
Eco-Technology Innovation

Jean-René Michaud, P. Eng., M.Sc.A.
Tel: (514) 496-6851
E-mail:
jean-rene.michaud@ec.gc.ca

GSI Environment

Guy Viel, M. Env., Ph.D.
Director
Innovation/Biotechnologies
Tel: (819) 829-0101
E-mail:
sherbroo@serrener.ca

St. Lawrence TECHNOLOGIES

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Environment Canada
Eco-Technology Innovation Section
105 McGill Street, 4th Floor
Montreal, Quebec H2Y 2E7
Tel: (514) 496-6851
1-800-463-4311

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Production:
Suzie Thibodeau

Writers:
Jean-René Michaud
Frédéric Dutil
Guy Viel
Yannik Ouellette
François Gourdeau

Layout:
Christine LePage
Suzie Thibodeau

Editor:
Patricia Potvin

Reviser:
Christine LePage

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