Development of a New Sustainable Thermal Remediation and Recovery Technology Using Low Energy Rapid Exothermal Reaction Technique

REMTECH 2016

October 12, 2016
Jevins Waddell, P.Tech.(Eng.)
Proprietary products & services

- Chemical Oxidation (ChemOx®)
  - Soil and groundwater remediation
- Low Temperature Thermal (T-REX™)
  - Soil, sludge and hazardous waste remediation
- Metals Soil Stabilization (T-SS™)
  - Soil, sludge and sediment stabilization of heavy metals

Petroleum Hydrocarbons

Heavy Metals

Chlorinated & Recalcitrant
AGENDA

- Background – Thermal Remediation
- Development Principles of “Thermal Reaction Enhanced Extraction” (T-REX™)
- Protocol and Performance
- Future Development
Thermal Treatment Industry

High Temp Thermal Treatment
- Incineration
- Plasma
- Pyrolysis

Low Temp Thermal Desorption
- Thermal Desorption
- Geo Thermal (In-situ Heating)

Low Energy Alternative Heating
- Microwave
- Induction
Development Concept

- Reduce – Increase efficiency “inside and out”
- Recover - Functional reusable soil
- Recycle – Contaminant recovery
Fundamentals of T-Rex

- Low energy, rapid thermal heating and nano-scale chemical stimulation technique for enhanced organic contaminant extraction.

- Exothermic reactions for
  - Pressure
  - Cracking
  - Extraction
Concept Performance

- Accelerated Thermal Capacity
  - Two stage heating process

![Graph showing temperature vs. time for different fuels]

- Diesel
- Artificial Creosote
## Blending Optimization

<table>
<thead>
<tr>
<th>Condition</th>
<th>Treatments</th>
<th>Time (min)</th>
<th>Residual Conc. F2 (C10-16) + F3 (C16-32) (mg/kg)</th>
<th>Removal rate (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>0</td>
<td>T-Rex composite</td>
<td>0</td>
<td>74327</td>
<td>100</td>
</tr>
<tr>
<td>1</td>
<td>0</td>
<td>15</td>
<td>22098</td>
<td>70.3</td>
</tr>
<tr>
<td>2</td>
<td>0</td>
<td>20</td>
<td>16309</td>
<td>78.1</td>
</tr>
<tr>
<td>3</td>
<td>Composite I</td>
<td>15</td>
<td>7559</td>
<td>89.8</td>
</tr>
<tr>
<td>4</td>
<td>Composite II</td>
<td>15</td>
<td>7208</td>
<td>90.3</td>
</tr>
<tr>
<td>5</td>
<td>Composite III</td>
<td>15</td>
<td>5417</td>
<td>92.7</td>
</tr>
<tr>
<td>6</td>
<td>Composite IV</td>
<td>15</td>
<td>2914</td>
<td>96.1</td>
</tr>
<tr>
<td>7</td>
<td>Composite V</td>
<td>20</td>
<td>5558</td>
<td>92.5</td>
</tr>
<tr>
<td>8</td>
<td>Composite VI</td>
<td>20</td>
<td>1978</td>
<td>97.3</td>
</tr>
<tr>
<td>9</td>
<td>Composite VII</td>
<td>20</td>
<td>1665</td>
<td>97.8</td>
</tr>
<tr>
<td>10</td>
<td>Composite VIII</td>
<td>20</td>
<td>2399</td>
<td>96.8</td>
</tr>
</tbody>
</table>

![Graph showing F2 + F3 residual concentration](image)
**Concept Performance**

- **Diesel**

  - **Fraction 2**
    - (C10-C16)
  
  - **Fraction 3**
    - (C16-C32)

  ![Graphs showing concentration over time for Fraction 2 and Fraction 3.]

- **Total Organic Carbon**
  - Before = 6.3%
  - After = 5.7%

  ![Images of samples at different times (0min, 10min, 20min, 30min).]
Prototype Performance

- High concentration process comparison
- Refining process parameters
  - Retention time
  - Pressure
  - Temperature
  - Vapour capture

<table>
<thead>
<tr>
<th>Parameter</th>
<th>Control</th>
<th>T-REX (20min)</th>
<th>LTD (60m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Batch Processing Time (min)</td>
<td>0</td>
<td>20</td>
<td>60</td>
</tr>
<tr>
<td>TPH</td>
<td>80,597</td>
<td>815</td>
<td>3,896</td>
</tr>
</tbody>
</table>

Unit: mg/kg
## Vapour Recovery

- >50% by wt. recovery
- Opportunity for improvement

### Description

<table>
<thead>
<tr>
<th>Description</th>
<th>Component</th>
<th>Concentration (mg/kg)</th>
<th>Total Concentration (mg/kg)</th>
<th>Removal Percentage (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Before treatment</td>
<td>F2</td>
<td>67174</td>
<td>110334</td>
<td>0</td>
</tr>
<tr>
<td></td>
<td>F3</td>
<td>43160</td>
<td>6831</td>
<td>93.8</td>
</tr>
<tr>
<td>After treatment</td>
<td>F2</td>
<td>4634</td>
<td>6831</td>
<td>93.8</td>
</tr>
<tr>
<td></td>
<td>F3</td>
<td>2197</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>
Vapour Characterization

Table 1. Volatile Organic Compounds (Air)

<table>
<thead>
<tr>
<th>Compound</th>
<th>Concentration</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>Benzene</td>
<td>2650 ppm(V)</td>
<td></td>
</tr>
<tr>
<td>Ethylbenzene</td>
<td>451 ppm(V)</td>
<td></td>
</tr>
<tr>
<td>Toluene</td>
<td>2580 ppm(V)</td>
<td></td>
</tr>
<tr>
<td>Xylenes</td>
<td>1460 ppm(V)</td>
<td></td>
</tr>
<tr>
<td>F1-BTEX</td>
<td>72800 mg/m³</td>
<td></td>
</tr>
<tr>
<td>F2</td>
<td>7050 mg/m³</td>
<td></td>
</tr>
<tr>
<td>Sum</td>
<td>86991</td>
<td></td>
</tr>
</tbody>
</table>

Table 2. TVOCs amounts

<table>
<thead>
<tr>
<th>TVOCs</th>
<th>Concentration</th>
<th>Unit</th>
</tr>
</thead>
<tbody>
<tr>
<td>TVOCs</td>
<td>250000 mg/m³</td>
<td></td>
</tr>
<tr>
<td>TVOC (As Methane)</td>
<td>381000 ppm(V)</td>
<td></td>
</tr>
</tbody>
</table>
Field Prototype - S. Korea
Field Prototype Test Parameters

- 0.5 Ton/hour
- <20 min SRT
- 1% Diesel and 4% Lube Oil Tests
Field Prototype Observations

- >200°C activation increase, audible
- No visible difference with control in diesel test
- Significant removal difference in lube oil test
  - Visible in control, not in T-REX.
  - Sample results pending
Future Development Scope

- Patent filed September 2016
- Currently operating field system to establish engineering and economics aspects
  - Additional tests conducted for considerations for efficiency / metallurgical / heat transmission in a large scale operations
  - Lower temperature activation
  - Vapour collection
  - Commercialization in 2017
- Lab scale process testing & design of in-situ T-REX treatment
Acknowledgement

- National Research Council, Industrial Research Assistance Program (NRC-IRAP)
- MEDAL, Mechanical & Manufacturing Engineering, University of Calgary
- Korea Soil Remediation Company (KSR)
- Alberta Innovates Technology Futures
- Can Export
- CETAC-West
ChemOx®

Remediation is Our Service
Reality is Our Product

ChemOx® is a registered trademark of
TRIUM Environmental Inc.
Leading Applied Chemical Remediation Strategies

T) 403-932-5014    E) info@triuminc.com
www.chemox.org    www.triuminc.com

Locations
Cochrane (HQ) / Edmonton / Drayton Valley

International
USA / S. Korea / Middle East / China / Taiwan