Two Phases Bioremediation of Oil Contaminated Soil from Liaohe Oil Field

Li Peijun, Tai Peidong, Guo Shuhai, Liu Wan, Lin Xin, Zhang Chungui (Institute of Applied Ecology, Chinese Academy of Sciences, Shenyang 110016, China E-mail: lipiejunzh@sina.com)

Abstract: A treatment engineering of prepared bed was set up for the bioremediation of oil contaminated soil with oil in this study. Soils contaminated with different type of oils were treated using composting process in the prepared bed and the treatment period was divided into 2 phases with total time of 210 days. When the concentration of total petroleum hydrocarbons (TPH), which consist of thin oil, high condensation oil, special viscous oil, and viscous oil, were in the range of 25.8 - 77.2 g kg⁻¹ dry soil, petroleum removal rates can reach 38.37% - 56.74% by 53 days operation. In the second phase, total petroleum removal rates reached 66.59% - 80.96% by the 156 days operation in the next year. The results showed that most hydrocarbon pollutants that are easier to be degraded were removed in the first phase, the remedying efficiency obviously dropped in the second phase.

Keywords: bioremediation; soil contaminated by petroleum; Liaohe Oil Field; composting process
Table 1 Physical and chemical properties of 4 different crude oils

<table>
<thead>
<tr>
<th></th>
<th>H2O / %</th>
<th>N / %</th>
<th>TP / %</th>
<th>TK / %</th>
<th>pH</th>
<th>TPH / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>14.4</td>
<td>0.31</td>
<td>0.24</td>
<td>0.83</td>
<td>7.6</td>
<td>55.0</td>
</tr>
<tr>
<td>B</td>
<td>18.1</td>
<td>0.37</td>
<td>0.35</td>
<td>1.09</td>
<td>6.8</td>
<td>77.2</td>
</tr>
<tr>
<td>C</td>
<td>17.6</td>
<td>0.59</td>
<td>0.32</td>
<td>1.33</td>
<td>7.8</td>
<td>25.8</td>
</tr>
<tr>
<td>D</td>
<td>16.8</td>
<td>0.42</td>
<td>0.40</td>
<td>1.55</td>
<td>8.0</td>
<td>41.6</td>
</tr>
</tbody>
</table>


Table 2 Physical and chemical properties of 4 composting materials

<table>
<thead>
<tr>
<th></th>
<th>H2O / %</th>
<th>K-N / %</th>
<th>TP / %</th>
<th>TK / %</th>
<th>pH</th>
<th>TPH / °C</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>15.0</td>
<td>0.20</td>
<td>0.15</td>
<td>0.65</td>
<td>7.5</td>
<td>50.0</td>
</tr>
<tr>
<td>B</td>
<td>18.1</td>
<td>0.37</td>
<td>0.35</td>
<td>1.09</td>
<td>6.8</td>
<td>77.2</td>
</tr>
<tr>
<td>C</td>
<td>17.6</td>
<td>0.59</td>
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<td>D</td>
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<td>0.40</td>
<td>1.55</td>
<td>8.0</td>
<td>41.6</td>
</tr>
</tbody>
</table>

1) A: O2 %, B: CO2 %, C: O2 %, D: CO2 %.

Fig.1 The flow diagram of bio-remedying process.
Fig. 2 The changes of O₂ and CO₂ content in composting materials during operating period.

3.2

Table 3

<table>
<thead>
<tr>
<th>O₂ (%)</th>
<th>CO₂ (%)</th>
</tr>
</thead>
<tbody>
<tr>
<td>10</td>
<td>20</td>
</tr>
<tr>
<td>20</td>
<td>10</td>
</tr>
</tbody>
</table>

3.3

TPH

Fig. 3 Temperature changes of air and composting materials during operating period.
A \cdot B \cdot C \cdot D \cdot 4 \cdot 18 \cdot TPH \quad 75, 82, 72, 48, 66, 59, 71, 37, 17, 49, 3, 10, 12, 74, 4\ 18 \cdot TPH \quad 24, 22, 34, 11, 94, 21, 40, 2\ 4 \cdot 4 \cdot 4 \cdot 2 \quad 2 \quad 2 \quad 2 \quad 3 \quad 6 \quad 6 \quad 6 \quad 6

\begin{array}{|c|c|c|c|c|}
\hline
Y & 0 - 53 \cdot a (1 + b) & R^2 & n & 0 - 156 \cdot a (1 + b) & R^2 & n \\
\hline
A & Y_a = 48.894e^{-0.05521} & 0.8330 & 5 & Y_a = 23.806e^{-0.02917} & 0.9869 & 6 \\
B & Y_a = 70.913e^{-0.01461} & 0.7879 & 5 & Y_a = 33.458e^{-0.06532} & 0.9904 & 6 \\
C & Y_a = 25.556e^{-0.00974} & 0.9106 & 5 & Y_a = 15.418e^{-0.03472} & 0.9866 & 6 \\
D & Y_a = 40.328e^{-0.01131} & 0.9779 & 5 & Y_a = 21.926e^{-0.0321} & 0.9719 & 6 \\
\hline
\end{array}

Y = Y_0 e^{-kt}, Y_0 \text{ initial TPH concentration}

pH \quad \text{pH of composting materials}

\begin{array}{|c|c|}
\hline
a & b \\
\hline
2 & 3 & 4 & 5 & 6 & 7 & 8 \\
\hline
1 & 2 & 3 & 4 & 5 & 6 & 7 & 8 \\
\hline
\end{array}

\begin{array}{|c|c|}
\hline
I/d & A \cdot B \cdot C \cdot D \\
\hline
0 & 1.44 \times 10^4 & 1.04 \times 10^3 & 1.66 \times 10^4 & 1.46 \times 10^4 & 1.33 \times 10^3 & 1.04 \times 10^3 & 1.44 \times 10^3 & 1.30 \times 10^4 \\
3 & 1.44 \times 10^3 & 6.93 \times 10^3 & 8.31 \times 10^3 & 2.27 \times 10^3 & 3.0 \times 10^3 & 3.14 \times 10^3 & 8.50 \times 10^3 & 7.91 \times 10^3 \\
10 & 4.80 \times 10^3 & 2.12 \times 10^3 & 4.68 \times 10^3 & 3.26 \times 10^3 & 3.80 \times 10^3 & 5.55 \times 10^2 & 5.20 \times 10^3 & 1.37 \times 10^4 \\
53 & 3.80 \times 10^4 & 1.03 \times 10^4 & 1.64 \times 10^4 & 5.33 \times 10^3 & 1.14 \times 10^4 & 1.0 \times 10^5 & 3.86 \times 10^3 & 1.18 \times 10^4 \\
210 & 8.87 \times 10^3 & 4.18 \times 10^3 & 7.31 \times 10^3 & 3.45 \times 10^3 & 2.50 \times 10^3 & 2.72 \times 10^2 & 5.69 \times 10^3 & 2.95 \times 10^4 \\
\hline
\end{array}

Table 3: TPH residues and degradation rate of composting materials during operating period.

Table 4: Numbers changes of fungi and bacteria in composting materials during operating period (dry soil) \( g^{-1} \).
Table 1: TPH Concentrations and Bacterial Counts

<table>
<thead>
<tr>
<th>Sample</th>
<th>TPH Concentration</th>
<th>Bacterial Count</th>
</tr>
</thead>
<tbody>
<tr>
<td>A</td>
<td>8.78 x 10^5</td>
<td>183 d</td>
</tr>
<tr>
<td>B</td>
<td>5.09 x 10^5</td>
<td>16 g/kg</td>
</tr>
<tr>
<td>C</td>
<td>1.48 x 10^5</td>
<td>28°C</td>
</tr>
</tbody>
</table>

4.1.4

(1) 210d

TPH: 25.8 - 77.2 g/kg

O₂: 20°C - 40°C, pH: 6 - 8

(2) 6

O₂: 40°C, pH: 6 - 8

(3) 6

O₂: 40°C, pH: 6 - 8

(4) 6

O₂: 40°C, pH: 6 - 8

References: