Odour and odorant emission estimation of dredged sediment

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Overview

• Introduction
• Methodology
• Results and Discussions
• Conclusions
Review

- Dredging is a periodical action in many ports, channels, rivers, and lakes in the world.
- $248 \times 10^6 \text{ yd}^3$ from US Army Corp of Engineers built and managed channels
- 100,000 m$^3$ of fine sediment from UK’s estuaries in order to maintain navigation routes
- 400 billion m$^3$ was estimated to be dredged in Netherlands between 2002-2011. 75 billion m$^3$ is heavily polluted.
Well-known Dredging in Australia

- Newcastle Harbour – New South Wales
- Botany Bay – New South Wales
- Townsville Harbour – Queensland
- Brisbane River – Queensland
Possible Pollutants - Reported

- Hydrocarbons
- PAHs (polycyclic aromatic hydrocarbons)
- PCBs (Polychlorinated Biphenyls)
- HCB (Hexachlorobenzene)
- DD
- Odour
- $H_2S$
- VOCs
Two Sites Investigated in this Study

• Extension of shipping channels in Newcastle, NSW
• Manly Lagoon, NSW
Manly Lagoon Dredging Sites
Dredging
Emission Test on the Barge
Odour Pens
Emission Test – Manly Lagoon
Sampling and Analysis Methods

- Odour – Tedlar bag – Olfactometry analysis
- \( \text{H}_2\text{S} \) – Absorbing solution – HACH analysis
- PAHs – XAD2 tube – GC-MS analysis
- VOCs:
  - Charcoal tube – solvent extraction – GC-FID
  - Tenax TA – TD-GC-MS
Emission calculation

- The specific odour, H\textsubscript{2}S, VOCs, and PAHs emission rates were calculated based on the equation:

\[
ER_x = \frac{C_x \cdot Q}{A}
\]

- where, \( ER_x \) - specific odour, H\textsubscript{2}S, VOCs, and PAHs emission rate, OU/s.m\textsuperscript{2}; mg/min.m\textsuperscript{2}; µg/s.m\textsuperscript{2}; µg/min.m\textsuperscript{2};

\( C_x \) - odour, H\textsubscript{2}S, VOCs, and PAHs concentration, OU/m\textsuperscript{3}; mg/L; µg/L; µg/L;

\( Q \) - flow rate of purging gas, m\textsuperscript{3}/s;

\( A \) - inner surface area of the flux hood, m\textsuperscript{2}
Results

• Odour and H₂S

<table>
<thead>
<tr>
<th>Dredging Site</th>
<th>Situation</th>
<th>Odour Emission Rate (OU/s·m²)</th>
<th>H₂S Emission Rate (mg/min·m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Newcastle Harbour Dredging</td>
<td>Dredging/Loading/Unloading</td>
<td>3.357</td>
<td>0.00241</td>
</tr>
<tr>
<td></td>
<td>Cement Stabilisation</td>
<td>0.717</td>
<td>n/a</td>
</tr>
<tr>
<td></td>
<td>Geobag Dewatering</td>
<td>0.504</td>
<td>0.00229</td>
</tr>
<tr>
<td>Manly Lagoon Dredging</td>
<td>Site 1</td>
<td>8.421</td>
<td>0.21338</td>
</tr>
<tr>
<td></td>
<td>Site 3</td>
<td>22.406</td>
<td>1.76154</td>
</tr>
<tr>
<td></td>
<td>Site 5</td>
<td>29.069</td>
<td>3.72213</td>
</tr>
<tr>
<td></td>
<td>Site 8</td>
<td>5.414</td>
<td>0.06568</td>
</tr>
</tbody>
</table>
Odour and H₂S results

- Odour emission rates
  3.357~29.069 OU/s·m²

- H₂S emission rates
  0.00229~3.72213 mg/min·m²
## PAH results

<table>
<thead>
<tr>
<th>Compounds</th>
<th>Emission range (μg/min·m²)</th>
<th>Emission average (μg/min·m²)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Naphthalene</td>
<td>0.02536-3.44049</td>
<td>1.16819</td>
</tr>
<tr>
<td>Acenaphylene</td>
<td>0.00008-0.00581</td>
<td>0.00204</td>
</tr>
<tr>
<td>Acenaphthene</td>
<td>0.00080-0.36087</td>
<td>0.12101</td>
</tr>
<tr>
<td>Fluorene</td>
<td>0.00036-0.03408</td>
<td>0.01164</td>
</tr>
<tr>
<td>Phenanthrene</td>
<td>0.00012-0.00764</td>
<td>0.00269</td>
</tr>
<tr>
<td>Anthracene</td>
<td>0.00004-0.00044</td>
<td>0.00020</td>
</tr>
</tbody>
</table>
PAH results

- 6 of 16 target PAH compounds were detected
- Heavier members of PAHs are less volatile and are not usually found in the vapour phase.
VOC results

• No VOC detected in charcoal sorbent tube samples – indicating charcoal tube sampling and analytical methodology is not effective for detecting VOC emissions from flux hood emission test.

• 19~37 VOCs were detected from Manly Lagoon dredged materials with the emission rates varied from 0.01 to 31.00 μg/s·m²

• Tenax TA sampling + TD-GC-MS is an effective methodology for VOCs determination
Emission reduction of treatment

- Geobag dewatering
  - $H_2S$ reduced 2~7%
  - Odour reduced 85%
  - Naphthalene: 44~90%; Acenaphthylene: 39~85%; Acenaphthene: 54~85%; Fluorene: 57~93%; Phenanthrene: 70~98%

- Cement stability
  - Odour reduced 78%
Conclusions

• Odour and H$_2$S emission rates varied from 3.357 to 29.069 OU/s·m$^2$, and from 0.00229 to 3.72213 mg/ min·m$^2$, respectively from the dredged samples.
• Odour and H$_2$S emission rates of Manly Lagoon dredged materials were higher than those of Newcastle Harbour dredged materials.
• 6 of 16 targeted PAHs were detected and PAHs with high molecular weight were not detected as they are less volatile.
• Using Geobag dewatering could reduce odour, H2S, and PAHs emissions by 85%, 39~98%, and 2~7%, respectively.
• Odour emission rates decreased by 78% when cement stability treatment was employed for treatment.
• Tenax sorbent tube sampling followed by TD-GC-MS analysis was the preferred method for determination of VOCs from flux hood simulation tests.