An experimental use of hydrogen peroxide in water well rehabilitation

10th September 2008

Professor Rick Brassington
Newcastle University

Introduction

- The use of hydrogen peroxide
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- Outline of site procedures
- Example of treatment to restore yield
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- Outline of site procedures
- Example of treatment to restore yield
- Example of treatment to destroy PAH

Collaborators

Solvay Interox Ltd, Warrington
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Solvay Interox Ltd, Warrington

J.P. Whitter (Water Well Engineers) Ltd

Yield restoration

Example of yield restoration

Solvay Interox, Warrington
Site Location

Borehole details
History of treatment

- September 2000 – borehole relined & cleaned
- November 2003 – headworks modified
History of treatment

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- November 2003 – headworks modified
- May 2006 – pump failed
- December 2006 – cctv survey
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- May 2006 – pump failed
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- June 2007 – borehole treated
- July 2007 – cctv survey repeated
History of treatment

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- November 2003 – headworks modified
- May 2006 – pump failed
- December 2006 – cctv survey
- June 2007 – borehole treated
- July 2007 – cctv survey repeated
- July 2007 – borehole restored to service
- November 2007 – step test undertaken
Treatment details

- 5 m$^3$ of 35% hydrogen peroxide injected
- Injection at 10 levels from 70m depth upwards
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- Borehole rested for 24 hours before CCTV survey
- Submersible pump reinstalled
### Treatment details

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- Injection at 10 levels from 70m depth upwards
- Borehole rested for 24 hours before CCTV survey
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- Presence of peroxide using standard indicator paper
Treatment details

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- Injection at 10 levels from 70m depth upwards
- Borehole rested for 24 hours before CCTV survey
- Submersible pump reinstalled
- Borehole pumped to waste
- Presence of peroxide using standard indicator paper
- Borehole returned to service
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Well performance

[Graph showing specific capacity curve for Water Well No 1]

- Nov 2007
- Nov 2015
- April 2006
Well performance

Water Well No 1 - Specific Capacity Curve

- 2005 & 2006 results 20% more drawdown

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Well performance

Water Well No 1 - Specific Capacity Curve

- 2005 & 2006 results: 20% more drawdown
- 2007 values match 2004
- February 2004
- April 2006
- November 2005
- November 2007

Pumping rate (m³/day)

Drawdown (m)
CCTV

Removal of bacterial growths for well face

CCTV

Water clear after treatment
Site procedure

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Site procedure
Site procedure

Site practice
Peroxide decomposition

- Spontaneous decomposition
- Decomposition rate depends on temperature
### Peroxide decomposition

- Spontaneous decomposition
- Decomposition rate depends on temperature
- Decomposition rate depends concentration
- Decomposition rate depends presence of catalysts
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- \( 2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2 \)
- Large quantities of oxygen produced
Peroxide decomposition

- Spontaneous decomposition
- Decomposition rate depends on temperature
- Decomposition rate depends concentration
- Decomposition rate depends presence of catalysts
- $2\text{H}_2\text{O}_2 \rightarrow 2\text{H}_2\text{O} + \text{O}_2$
- Large quantities of oxygen produced
- Only other breakdown product is water

Exothermic reaction produces heat
Fenton’s Reagent

- Ferrous iron acts as catalyst
- Reaction is very vigorous
Fenton’s Reagent

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- Produces free hydroxyl radicals
- Increases oxidation and biocide properties
Fenton’s Reagent

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- Reaction is very vigorous
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- Increases oxidation and biocide properties
- $\text{Fe}^{2+} + \text{H}_2\text{O}_2 \rightarrow \text{Fe}^{3+} + \text{OH} + \text{OH}^-$

- $\text{Fe}^{3+} + \text{H}_2\text{O}_2 \rightarrow \text{Fe}^{2+} + \text{OOH} + \text{H}^+$
PAH contamination

Example of contaminant removal

- Location confidential
PAH contamination

- Location confidential
- Borehole 92.3m deep & 300mm diameter

PAH contamination

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- PAH contamination from carbon black
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- Borehole 92.3m deep & 300mm diameter
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- Treated with hydrogen peroxide on two occasions
- First treatment 1,500 litres used
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PAH contamination

- Location confidential
- Borehole 92.3m deep & 300mm diameter
- PAH contamination from carbon black
- Treated with hydrogen peroxide on two occasions
- First treatment 1,500 litres used
- Second treatment 720 litres used + ferrous sulphate

Original PAH contamination

<table>
<thead>
<tr>
<th>Depth</th>
<th>15m</th>
<th>22m</th>
<th>58m</th>
<th>63m</th>
<th>68m</th>
<th>75m</th>
<th>81m</th>
<th>82m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sample type</td>
<td>P</td>
<td>P</td>
<td>D</td>
<td>P</td>
<td>D</td>
<td>D</td>
<td>D</td>
<td>P</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>ng/l</td>
<td>&lt;0.3</td>
<td>1,020</td>
<td>3,370</td>
<td>2,650</td>
<td>4,730</td>
<td>5,090</td>
<td>2,220</td>
</tr>
<tr>
<td>Benzo 1,12, perylene</td>
<td>ng/l</td>
<td>1.6</td>
<td>106</td>
<td>356</td>
<td>294</td>
<td>520</td>
<td>526</td>
<td>253</td>
</tr>
<tr>
<td>Benzo 11,12, fluoranthene</td>
<td>ng/l</td>
<td>0.7</td>
<td>94.8</td>
<td>360</td>
<td>283</td>
<td>492</td>
<td>527</td>
<td>230</td>
</tr>
<tr>
<td>Inendo (1, 2, 3-cd) pyrene</td>
<td>ng/l</td>
<td>&lt;0.1</td>
<td>97.1</td>
<td>281</td>
<td>253</td>
<td>401</td>
<td>391</td>
<td>218</td>
</tr>
<tr>
<td>Benzo-3, 4-fluoranthene</td>
<td>ng/l</td>
<td>1.5</td>
<td>286</td>
<td>1,050</td>
<td>817</td>
<td>1,430</td>
<td>1,520</td>
<td>670</td>
</tr>
<tr>
<td>Benzo-3, 4-pylene</td>
<td>ng/l</td>
<td>1.0</td>
<td>207</td>
<td>773</td>
<td>618</td>
<td>1,060</td>
<td>1,130</td>
<td>502</td>
</tr>
</tbody>
</table>
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## After first treatment

<table>
<thead>
<tr>
<th>Sample depth</th>
<th>25m</th>
<th>60m</th>
<th>72m</th>
<th>76m</th>
</tr>
</thead>
<tbody>
<tr>
<td>Fluoranthene</td>
<td>ng/l</td>
<td>12.4</td>
<td>&lt;2.4</td>
<td>3.4</td>
</tr>
<tr>
<td>Benzo 1,12, perylene</td>
<td>ng/l</td>
<td>&lt;1.3</td>
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</tr>
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<td>Benzo 11, 12, fluoranthene</td>
<td>ng/l</td>
<td>&lt;0.6</td>
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</tr>
<tr>
<td>Inendo (1, 2, 3-cd) pyrene</td>
<td>ng/l</td>
<td>1.9</td>
<td>1.9</td>
<td>2.2</td>
</tr>
<tr>
<td>Benzo-3, 4-fluorathene</td>
<td>ng/l</td>
<td>1.3</td>
<td>1.1</td>
<td>0.9</td>
</tr>
<tr>
<td>Benzo-3, 4-pyrene</td>
<td>ng/l</td>
<td>0.5</td>
<td>&lt;0.4</td>
<td>0.5</td>
</tr>
</tbody>
</table>

### After second treatment

<table>
<thead>
<tr>
<th>Date</th>
<th>26/1/2008</th>
<th>27/1/2008</th>
<th>28/1/2008</th>
<th>25/3/2008</th>
</tr>
</thead>
<tbody>
<tr>
<td>Duration of pumping</td>
<td>90 mins</td>
<td>24 hours</td>
<td>36 hours</td>
<td>53 days</td>
</tr>
<tr>
<td>Fluoranthene</td>
<td>ng/l</td>
<td>34.7</td>
<td>&lt;2.4</td>
<td>5.9</td>
</tr>
<tr>
<td>Benzo 1,12, perylene</td>
<td>ng/l</td>
<td>10.7</td>
<td>&lt;1.3</td>
<td>&lt;1.3</td>
</tr>
<tr>
<td>Benzo 11, 12, fluoranthene</td>
<td>ng/l</td>
<td>4.6</td>
<td>&lt;0.6</td>
<td>&lt;0.6</td>
</tr>
<tr>
<td>Inendo (1, 2, 3-cd) pyrene</td>
<td>ng/l</td>
<td>7.9</td>
<td>&lt;0.7</td>
<td>&lt;0.7</td>
</tr>
<tr>
<td>Benzo-3, 4-fluorathene</td>
<td>ng/l</td>
<td>6.4</td>
<td>&lt;0.7</td>
<td>&lt;0.7</td>
</tr>
<tr>
<td>Benzo-3, 4-pyrene</td>
<td>ng/l</td>
<td>8.0</td>
<td>&lt;0.4</td>
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Summary

- Appears to restore borehole yield
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- Oxide deposits removed from borehole face
- Likely to be scrubbing affect of oxygen bubbles
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- Fenton’s Reagent produces free hydroxyl radicals

- Acts as strong biocide
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- Oxide deposits removed from borehole face
- Likely to be scrubbing affect of oxygen bubbles
- Fenton’s Reagent produces free hydroxyl radicals
- Acts as strong biocide
- Residual materials are oxygen and water

Further trials are currently underway.
The end