The Affect of Salt Impacted Water on the Expansive Capability of Sodium Bentonite Clay - Bench Test Study

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- Over 7 years of experience
- Environmental projects include:
  - Site assessment
  - Risk assessment and management
  - Remediation
- Commercial, industrial, and government properties supervision include:
  - Environmental site assessments
  - Environmental remediation's
  - Remedial design projects
- Environmental assessment projects in Alberta, British Columbia, and Saskatchewan

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Introduction

• Background
• Initial Study
• Follow up Study
  • Methodology
  • Results
  • Photos
  • Demonstration
• Discussion
• Questions
Background

- Use of sodium bentonite chips to seal of the borehole annulus in groundwater monitoring wells
- Salt impacted water may retard the seal
- Bentonite chips may not provide an adequate layer of impermeable material to isolate the well screen
- Exposed sodium bentonite chips to salt affected water and the expansion was observed
CAP

STICK-UP OPTION

GRADE

FLUSH MOUNT ROAD BOX OPTION

CASING SEAL

CASING DRAINAGE

SEAL

TYP. 51 mm SCHEDULE 40 SOLID PVC

SAND PACK (TYP. #9 SILICA SAND)

TYP. 51 mm SCHEDULE 40 SLOTTED PVC

BOTTOM OF MONITOR WELL INSTALLATION

SLOUGH

BOTTOM OF BOREHOLE
Initial Study

- 30 grams of sodium bentonite chips
- 100 mL of water in jar
- Varying concentrations of Salt
Initial Study – Tap Water

After 6 Hours
- Thick putty consistency
- 4 times original volume
- Shallow voids visible

After 24 Hours
- Expanded slightly more
- Voids were not visible
- No free water remained
Initial Study – 5,000 mg/L NaCl
0.5 g NaCl/100 mL water

After 6 Hours
• Thick soft paste
• Double the volume
• Appeared silty

After 24 Hours
• 2.5 times the volume
• Same consistency as 6 hours
Initial Study – 25,000 mg/L NaCl
2.5 g NaCl/100 mL water

After 10 Minutes
• Chips had crumbled
• Sediment layer at the bottom of the jar

After 24 Hours
• No additional expansion was observed
Initial Study – 50,000 mg/L NaCl
5.0 g NaCl/100 mL water

Within 10 Minutes
- Bentonite chips had crumbled
- Sediment layer formed at the bottom of the jar

After 24 Hours
- No additional expansion
- Gentle shaking the mixture became muddy and settled into segregated layering
Initial Study – 100,000 mg/L NaCl

10 g NaCl/100 mL water

After 24 Hours

• Chips remained as individual
• No evidence of bonding or expanding
• Some “crumbling” was observed

After 150 Days

• No change was observed in bentonite for all test samples
Follow Up Study - Methodology

- Constructed six model monitoring wells
  - 0.3 m of slotted pipe (1 inch diameter)
  - 0.9 m of solid pipe (1 inch diameter)
  - 0.4 m of 4 - 8 sand
  - 0.2 m of Sodium bentonite chips (not hydrated)
- Saturated bentonite using 4 L of water with varying concentrations of NaCl
Follow Up Study - Methodology

• Checked for bentonite layer expansion
• After seven days, the water:
  • Above the bentonite seal was dyed red
  • Level was increased to 15 cm above the top of the seal
• Peristaltic pump removed the water and the draw down was measured
## Follow Up Study - Methodology

<table>
<thead>
<tr>
<th>NaCl (ppm)</th>
<th>Na (ppm)</th>
<th>Cl (ppm)</th>
<th>Conductivity (mS/m)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap Water</td>
<td>n/a</td>
<td>n/a</td>
<td>0.416</td>
</tr>
<tr>
<td>5,000</td>
<td>1,967</td>
<td>3,033</td>
<td>10.02</td>
</tr>
<tr>
<td>10,000</td>
<td>3,934</td>
<td>6,066</td>
<td>18.64</td>
</tr>
<tr>
<td>25,000</td>
<td>9,834</td>
<td>15,166</td>
<td>43.15</td>
</tr>
<tr>
<td>50,000</td>
<td>19,669</td>
<td>30,331</td>
<td>77.33</td>
</tr>
<tr>
<td>100,000</td>
<td>39,337</td>
<td>60,663</td>
<td>140.0</td>
</tr>
</tbody>
</table>

Conductivity was determined using a YSI probe.
## Follow up Study - Results

<table>
<thead>
<tr>
<th>NaCl (ppm)</th>
<th>Time Elapsed (days)</th>
<th>Initial Thickness of Bentonite Chips (cm)</th>
<th>Final Thickness of Hydrated Seal (cm)</th>
<th>% Change in Thickness of Seal</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap Water</td>
<td>7</td>
<td>20</td>
<td>32</td>
<td>60%</td>
</tr>
<tr>
<td>5,000</td>
<td>7</td>
<td>20</td>
<td>25</td>
<td>25%</td>
</tr>
<tr>
<td>10,000</td>
<td>7</td>
<td>20</td>
<td>24</td>
<td>20%</td>
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<tr>
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<td>20</td>
<td>23</td>
<td>15%</td>
</tr>
<tr>
<td>50,000</td>
<td>7</td>
<td>20</td>
<td>22</td>
<td>10%</td>
</tr>
<tr>
<td>100,000</td>
<td>7</td>
<td>20</td>
<td>20</td>
<td>0%</td>
</tr>
</tbody>
</table>
## Follow up Study - Results

<table>
<thead>
<tr>
<th>NaCl (ppm)</th>
<th>Initial Water Level (cm)</th>
<th>Water Level After Purging (cm)</th>
<th>Water Level After 3 Days (cm)</th>
<th>Water Level After 7 Days (cm)</th>
<th>Water Level After 10 Days (cm)</th>
</tr>
</thead>
<tbody>
<tr>
<td>Tap Water</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
</tr>
<tr>
<td>5,000</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
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<tr>
<td>10,000</td>
<td>15.0</td>
<td>15.0</td>
<td>15.0</td>
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<td>25,000</td>
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<td>14.7</td>
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<tr>
<td>50,000</td>
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<td>15.0</td>
<td>11.5</td>
<td>7.5</td>
<td>5.0</td>
</tr>
<tr>
<td>100,000</td>
<td>15.0</td>
<td>0</td>
<td>0</td>
<td>0</td>
<td>0</td>
</tr>
</tbody>
</table>
Follow up Study - Photos

7 Days After Saturation
Follow up Study - Photos

**Tap Water**
After 7 Days
Bentonite thickness increased by 12 cm

**5,000 ppm**
After 7 Days
Bentonite thickness increased by 5 cm
Follow up Study - Photos

10,000 ppm After 7 Days
Bentonite thickness increased by 4 cm

25,000 ppm After 7 Days
Bentonite thickness increased by 3 cm
Follow up Study - Photos

50,000 ppm
After 7 Days
Bentonite thickness increased by 2 cm

100,000 ppm
After 7 Days
Bentonite thickness no increase
Follow up Study - Demonstration
100,000 ppm
Discussion

- Increased conductivity levels corresponded with:
  - A decrease in the expansion of the hydrated bentonite layer in the monitoring well
  - The amount surface water infiltration to the well as shown by the draw down in the sample wells
- Follow up study: monitoring well integrity is negatively impacted by salt impacted water
- Establish industry best-practice when installing monitoring wells at Sites where salt impacted groundwater is suspected
Special Thanks:

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- Oak Environmental
Questions