Stabilisation/solidification of synthetic drill cuttings representing Ras Shukier oil field in Egypt
Outline

I. Oil Drill Cuttings
II. Ras Shukier Case Study
III. Experimental Work
IV. Ongoing programme
V. Conclusion
Drill cuttings are heterogeneous wastes that are generated from petroleum drilling industry.
Drill Cuttings contaminated with chemicals from fluid & oil

Drill fluid Circulation System

Recycled fluid

Drill Cuttings + fluid
Treatment methods for drill cuttings

- Leave in place - disturbed
- Leave in place - undisturbed
- Entombment
- Capping
- Gravel Dumping
- Bioremediation in situ
- Bio-reactor
- Land Farming
- Mechanical Dredging
- Crawler retrieval
- Re-injection
- Re-spreading
- Mechanical separation
- Distillation
- Stabilisation
- Combustion
- Supercritical extraction
- Thermal Desorption
Ras Shukier is an offshore oil production site located in the Gulf of Suez, Red Sea, Egypt. This site generates approximately 2,740 tonnes of cuttings per year. Ras Shukier consists of nine complex platforms.
Transportation Service

Approved disposal by Environment

Waste Disposal Area

Drill Cuttings
### Physical and Chemical Characteristics

- Brownish black, sticky with a clayey texture soil.
- Distinctive crude odour.
- Density ranges between 1.2 and 2.0 g/cm³.

<table>
<thead>
<tr>
<th>(w/w)</th>
<th>Hydrocarbon%</th>
<th>Cr%</th>
<th>Zn%</th>
<th>Ba%</th>
<th>Pb%</th>
<th>Cl%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Average</td>
<td>11.0</td>
<td>0.1</td>
<td>0.2</td>
<td>0.2</td>
<td>0.1</td>
<td>2.1</td>
</tr>
<tr>
<td>Max</td>
<td>11.8</td>
<td>0.4</td>
<td>0.6</td>
<td>1.2</td>
<td>0.3</td>
<td>9.2</td>
</tr>
</tbody>
</table>
### III. Experimental Work

#### Synthetic drill cuttings and their properties

<table>
<thead>
<tr>
<th>Soil composition</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sand content</td>
<td>10</td>
</tr>
<tr>
<td>Silt (rock flour) content</td>
<td>50</td>
</tr>
<tr>
<td>Clay 1 (kaolin)</td>
<td>20</td>
</tr>
<tr>
<td>Clay 2 (bentonite)</td>
<td>20</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Cutting composition</th>
<th>%</th>
</tr>
</thead>
<tbody>
<tr>
<td>Sodium Chloride</td>
<td>3.5</td>
</tr>
<tr>
<td>Paraffin oil (of dry soil)</td>
<td>11</td>
</tr>
</tbody>
</table>

<table>
<thead>
<tr>
<th>Property</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Water content</td>
<td>20%</td>
</tr>
<tr>
<td>pH</td>
<td>9</td>
</tr>
<tr>
<td>Plastic Limit</td>
<td>25%</td>
</tr>
<tr>
<td>Liquid Limit</td>
<td>51%</td>
</tr>
</tbody>
</table>
Binder System

A. Conventional Binders
- Portland Cement (PC)
- Lime
- Pulverised Fuel Ash (PFA)
- Blastfurnace Slag (BFS)

B. Novel Binders
- MgO cement
- Zeolite
- Microsilica (silica fume)
- Cement Kiln Dust (CKD)
- Compost
Sample Preparation

Water : Dry binder: \(0.6 : 1\)

Dry binder content by weight: 10%, 20% and 30%

Binders: either PC only or 1:1 PC:other binder

Sample size: 50 x 100 mm
Tests at 28 days of curing

1. Unconfined compressive strength (UCS)
2. Leachability (Chloride and Oil)
3. Leachate pH
4. Microstructure analysis
1. **Unconfined Compressive Strength (UCS)**

The graph shows the unconfined compressive strength (UCS) for various materials and mixtures. The UCS values are given in kPa and are presented for different percentages of each material. The materials include:

- Microsilica-PC
- PC
- BFS-PC
- Zeolite-PC
- PFA-PC
- MgO-Cement 2
- CKD-PC
- Lime-PC
- Compost-PC
- MgO-Cement 1

The percentages indicate the proportion of each material in the mixture, with 30%, 20%, and 10% shown in the graph.
2. **Chloride Leachability**

![Graph showing chloride leachate concentration (mg/L) for various compounds at different percentages.](image)

- PC
- PFA-PC
- CKD-PC
- Compost-PC
- Lime-PC
- Zeolite-PC
- BFS-PC
- Microsilica-PC
- MgO cement 1
- MgO cement 2

- 10%
- 20%
- 30%
2. **Oil Leachability**

![Graph showing oil leachability for different materials with PC, PFA-PC, CKD-PC, Compost-PC, Lime-PC, Zeolite-PC, BFS-PC, Microsilica-PC, MgOcemnt 2, and MgOcemnt 1.]
3. **Leachate pH**

<table>
<thead>
<tr>
<th>Binder System</th>
<th>Binder content</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>10%</td>
</tr>
<tr>
<td>PC</td>
<td>12.0</td>
</tr>
<tr>
<td>BFS - PC</td>
<td>12.0</td>
</tr>
<tr>
<td>Microsilica - PC</td>
<td>10.5</td>
</tr>
<tr>
<td>Lime - PC</td>
<td>12.1</td>
</tr>
<tr>
<td>Compost - PC</td>
<td>11.6</td>
</tr>
<tr>
<td>PFA - PC</td>
<td>12.0</td>
</tr>
<tr>
<td>MgO cement1</td>
<td>9.9</td>
</tr>
<tr>
<td>MgO cement2</td>
<td>10.9</td>
</tr>
<tr>
<td>Zeolite - PC</td>
<td>11.6</td>
</tr>
<tr>
<td>CKD - PC</td>
<td>12.0</td>
</tr>
</tbody>
</table>
4. Microstructural Analysis

SEM at 28 days

PC

Microsilica - PC

Lime - PC

Zeolite - PC

Compost - PC

MgO cement 2
IV. **Ongoing Programme**

- North Sea Case Study
- Best S/S systems selected for more detailed study
- Next mixes to include heavy metals
- For chloride, possibility of a low pH cement
- Pelletisation of thermally treated drill cuttings
V. Conclusion

- Drill cutting is a big problem that the petroleum industry is keen to find solutions.

- The utilisation of S/S techniques to treat drill cuttings by using conventional as well as novel binders indicated the following:
  
  - UCS of the drill cuttings-binder mixes at 28 days covered a wide range of feasible applications.
V. Conclusion (contd.)

- Chloride leachate concentrations showed a change from hazardous to non-reactive hazardous waste.
- Oil leaching concentrations decreased as the dry binder content increased.
- The leachate pH values indicated the use of lower pH binders.
- The microstructural analysis suggested an advanced level of hydration.

Future work will give more detailed information on the relative performance of different binders.
Thank You

Marwa at Ras Shukier oil field May 2003