Lift up of lowlands

The reuse of sediments on peat meadows, looking at the physical, chemical and biochemical properties in relation to the local situation.

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Arjan Wijdeveld, Leon van Paassen, Roderick Tollenaar
Lift up of Lowlands

Part of the STW program “Bio-Geo-Civil”
- PhD. Wageningen University: Bruna Figueiredo Oliveira
- PhD. TU Delft: Roderick Tollenaar

Pilot site for CEAMaS (Civil Engineering Applications for Marine Sediments), an INTERREG IV-b program
Lift up of Lowlands

Goal of Lift up of Lowlands

Lift up of lowlands goes back to pre-historic sediment management, the reapplication of dredged sediments to **compensate subsidence** and to **improve the lands fertility**.

In this talk I will focus on compensation for subsidence in relation with the physical, chemical and biochemical properties of the sediment.

For more information on the improvement on the lands fertility, **please visit the talk by Bruna**:

- Friday 25-09, 10:00 – 10:20 Beneficial use of dredged material in agricultural land
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Location in The Netherlands, Wormer- and Jisperveld

Filling up of depot
Lift up of Lowlands

Wormer- and Jisperveld, a peat are. What is the historical implication of dewatering?

-1.2m AMS
-1.6m AMS
-3.8m AMS
-4.4m AMS

Highly organic clay
Fibrous ‘red’ peat
Slightly organic clay
Fine silty sand
With regard to subsidence, what are the main issues?
- What happens with the sub surface when sediments are used to increase the soil level?
- How quickly are sediments transformed to a stable soil? Dewatering
- What are the properties if this new soil, since the sediment itself is mostly peat.

Also, since the sediments are not 100% clean with regard to pollutants (due to historical industrial activity the classification is “class A/B”), what is the potential ecological impact of reuse on land?
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Topics for this presentation

• **Physical**
  • Thermogravimetric Analyzer (TGA) (water content & indicative composition)
  • Pressure measurements (dewatering & permeability)
  • “Zakbaak” (subsurface compaction, soil level)
  • Oedemeter test (soil consolidation)
  • Hyprop test (crack formation)
  • Zeta potential measurements (floculation)
  • Heat conductivity of the soil (local density)
  • SEM (peat fibre structure)

• **Chemical**
  • Total concentration & leaching test (metals)
  • ms-PAF (ecotoxicity)
  • Bio-available fraction (organic pollutants)

• **Biochemical**
  • Please visit the presentation of Bruna (Friday 25-09, 10:00 – 10:20 ...)

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[Image of TU Delft logo]
Lift up of Lowlands

**Physical: TGA**
60% mass loss for Lowlands sample during temperature ramping
Organic content: 70-98% of solid phase
Mostly Peat
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Physical: Pressure measurements (dewatering & permeability)

- Pressure sensors every 10 cm
- From +1.5 m to -1.6 m relative to bottom empty depot
- Range: 0 - 2000 kPa absolute pressure
- Accuracy: 0.36 kPa (3.6 cm water pressure)
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Physical: Pressure measurements (dewatering & permeability)

Pressure profiles with depth:

- At 2 days:
  - $P_{atm} = 1020$ mbar;
  - $dP/dz = 10$ kN/m$^3$ for $z<0.3$m

- At 6 days:
  - $P_{atm} = 1000$ mbar;
  - $dP/dz = 10$ kN/m$^3$ for $z<0.3$m

- At 9 days:
  - $P_{atm} = 1000$ mbar;
  - $dP/dz = 10$ kN/m$^3$ for $z<-0.7$m
  - $dP/dz = 10$ kN/m$^3$ for $-0.2<z<0.3$m
  - $dP/dz = 15$ kN/m$^3$ for $-0.7<z<-0.1$m

Hydrostatic gradient:
$dP = \gamma_w \cdot dz$ with $\gamma_w = 10$ kN/m$^3$

Hydraulic barrier between -0.7 and -0.2 m
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Physical: Zakbaak

Challenge the future
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**Physical: Oedemeter test**
1-Dimensional consolidation

Measurements

Results
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**Physical: Oedemeter test**
1-Dimensional consolidation

Results

Compression index

Swelling index
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**Physical: Hyprop test**
Soil water retention curve, determination of pF-curves and unsaturated conductivity.
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**Physical: Hyprop test**
We used the hyprop to determine the tension needed to start crack formation.

1\textsuperscript{st} drying phase  \hspace{1cm} 2\textsuperscript{nd} drying phase

Soil water retention curve of drying peat

Tension reaches vacuum

Air entry of capillary tip

Rewetting

Image of cracked ground
Physical: Zeta potential measurements
Particles have a so-called interfacial 'double layer' of charges, the zeta potential. The zeta potential is caused by the net electrical charge contained within the region bounded by the slipping plane, and also depends on the location of that plane.
At low repulsive forces, the Van der Waals force dominates and clays start to aggregate.
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Physical: Heat conductivity
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Physical: Heat conductivity

In potential a tool to follow the consolidation in the field during ripening.
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Physical: SEM
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Physical: SEM

Acc. V Spot Magn Det WD Exp
20.0 kV 5.0 1000x BSE 10.1 1

1.0 Torr Wormer dried

Acc. V Spot Magn Det WD Exp
20.0 kV 4.0 5000x BSE 10.1 1

1.0 Torr Wormer dried
Lift up of Lowlands

Physical: SEM, the real question, how does ripening impact the fiber structure?
## Lift up of Lowlands

### Chemical: Total concentration in (metals)

Classification according to different EU countries

<table>
<thead>
<tr>
<th>metals</th>
<th>Irish</th>
<th>Flamish</th>
<th>French</th>
<th>Dutch</th>
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<tr>
<td></td>
<td>Lift up Lowlander</td>
<td>Lift up Lowlander</td>
<td>Lift up Lowlander</td>
<td>Lift up Lowlander</td>
</tr>
<tr>
<td></td>
<td>Lower level</td>
<td>Upper level</td>
<td>Lower level</td>
<td>Upper level</td>
</tr>
<tr>
<td>Antimone (Sb)</td>
<td>0.8</td>
<td>141%</td>
<td>18%</td>
<td>36%</td>
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<tr>
<td>Arsenic (As)</td>
<td>16.5</td>
<td>160%</td>
<td>27%</td>
<td>93%</td>
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<tr>
<td>Barium (Ba)</td>
<td>23.9</td>
<td>155%</td>
<td>57%</td>
<td>86%</td>
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<tr>
<td>Cadmium (Cd)</td>
<td>2.2</td>
<td>180%</td>
<td>49%</td>
<td>90%</td>
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<tr>
<td>Chromium (Cr)</td>
<td>15.5</td>
<td>43%</td>
<td>25%</td>
<td>33%</td>
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<tr>
<td>Cobalt (Co)</td>
<td>22.7</td>
<td>14%</td>
<td>18%</td>
<td>36%</td>
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<tr>
<td>Copper (Cu)</td>
<td>84.5</td>
<td>138%</td>
<td>48%</td>
<td>52%</td>
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<tr>
<td>Lead (Pb)</td>
<td>135.1</td>
<td>14%</td>
<td>18%</td>
<td>36%</td>
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<tr>
<td>Molybdenum (Mo)</td>
<td>1.6</td>
<td>138%</td>
<td>48%</td>
<td>52%</td>
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<tr>
<td>Nickel (Ni)</td>
<td>9.1</td>
<td>14%</td>
<td>18%</td>
<td>36%</td>
</tr>
<tr>
<td>Selenium (Se)</td>
<td>1.7</td>
<td>14%</td>
<td>18%</td>
<td>36%</td>
</tr>
<tr>
<td>Tin (Sn)</td>
<td>0.9</td>
<td>14%</td>
<td>18%</td>
<td>36%</td>
</tr>
<tr>
<td>Vanadium (V)</td>
<td>10.9</td>
<td>14%</td>
<td>18%</td>
<td>36%</td>
</tr>
<tr>
<td>Zinc (Zn)</td>
<td>174.8</td>
<td>14%</td>
<td>18%</td>
<td>36%</td>
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</table>

### Classification

<table>
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<th>180%</th>
<th>57%</th>
<th>109%</th>
<th>17%</th>
<th>138%</th>
<th>69%</th>
<th>98%</th>
<th>44%</th>
</tr>
</thead>
</table>

Challenge the future
Lift up of Lowlands

Chemical: Leaching test & ms-PAF
Highest concentration of metals in eluate in comparison with the Dutch groundwater standard (intervention value). Concentrations used to calculate the ms-PAF.

<table>
<thead>
<tr>
<th>Timestep</th>
<th>L/S (sum)</th>
<th>Standard</th>
<th>ms-PAF</th>
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<tr>
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<td>Lift up Lowland</td>
<td>Lift up Lowland</td>
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<tr>
<td>k1</td>
<td>0.1</td>
<td>37%</td>
<td>6.3%</td>
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<tr>
<td>k2</td>
<td>0.2</td>
<td>44%</td>
<td>8.8%</td>
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<td>k3</td>
<td>0.5</td>
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<td>14.2%</td>
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<tr>
<td>k4</td>
<td>1.0</td>
<td>13%</td>
<td>5.1%</td>
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<tr>
<td>k5</td>
<td>2.0</td>
<td>17%</td>
<td>4.3%</td>
</tr>
<tr>
<td>k6</td>
<td>5.0</td>
<td>10%</td>
<td>4.2%</td>
</tr>
<tr>
<td>k7</td>
<td>10.0</td>
<td>13%</td>
<td>2.6%</td>
</tr>
</tbody>
</table>
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**Chemical: Bio-available fraction**
Measured with passive sampling.
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Chemical: Bio-available fraction
Results.
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Conclusions

The “Lift up of Lowlands” was successful with regard to compensating subsidence (+1.2 m) without causing an unacceptable impact on the emission of pollutants.

The (ongoing) measurements on the drying and compaction processes taking place during the transformation from wet sediment to dry soil help to define better models to predict the dewatering of peat rich sediments.

1 year later
Lift up of Lowlands

Alternative ways to use sediments at the Wormer-/Jisperveld location, the “baggerbuffer”

Lift up of Lowlands is one example to beneficially reuse sediments. Tauw has implemented a solution to protect against shore erosion by using locally dredged sediments.