Integrating composting into the life cycle assessment of palm oil production

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The challenge of sustainable palm oil production

Exponential increase of production in Indonesia.

Exponential land use change and environmental degradation.

Sustainability: long term balance between social/economical/ environmental

5 challenges in Indonesia:

1. Protecting primary forest, high conservation value areas and peatland

2. Reducing the environmental impact of existing plantations (water quality, soil quality, pesticides, GHG)

3. Closing the yield gap between smallholders and agro-industries

4. Building economically resilient territories (diversification, added value, self-reliance)

5. Building fair value chains (land ownership, working conditions)

*Source: Oil World*
Different stages of the oil palm crop cycle

- Pre-nursery
- Nursery 5 months
- Nursery 10 months
- 1 year after planting
- Juvenile - 2 years
- Harvest - 7 years
- Pruning - 15 years
- Harvest - 24 years
From the fruit to the oil

- Harvesting
- Transporting
- Loading
- Loading and cooking
- Pressing
- Oil decantation

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Palm oil co-products flow chart and waste management options

Main products
- Crude Palm Oil 25 tons
- Palm Kernel Oil 2 tons
- Palm Kernel Cake 2 tons

Fresh Fruit Bunch 100t

By products
- Shell 5-6 tons
- Mesocarp fiber 13 tons
- Empty fruit bunches 23t
- POME 65 to 25m3

Waste management options
- Fuel for burner
- Field application
- Compost
- Methaniser sludge
- Biogas production
- Anaerobic digestion in open ponds

Palm oil co-products flow chart and waste management options

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Research question:
To which extent can composting be beneficial from an environmental point of view?

Need for site specific data to better understand our system

Implementation of a composting trial in industrial conditions
System studied

Agro-industrial oil palm plantation with a mill for crude palm oil production:

• One year case study (2017)
• 13 816 ha planted between 2006 and 2014
• 272 929 tons of fresh fruit bunches (average yield of 19.8 t FFB/ha/year)
• One mill with capacity of 80 t/hour
• 68 805 tons of crude palm oil (25.21% OER)

+/- 5 tons of CPO/ha

Unit for LCA: fresh fruit bunch (FFB) or crude palm oil (CPO)
Industrial composting process

Composting is the **biological transformation of organic matter** carried out by a **succession of microbial** communities under **controlled environmental conditions**.
Compost production

<table>
<thead>
<tr>
<th>Energy and water consumption</th>
<th>Total Mill</th>
<th>Total Composting platform</th>
<th>Total per ton of CPO</th>
<th>Increase due to composting</th>
</tr>
</thead>
<tbody>
<tr>
<td>Diesel Fuel (L)</td>
<td>422 032</td>
<td>105 175</td>
<td>8</td>
<td>25%</td>
</tr>
<tr>
<td>Electricity (kWH)</td>
<td>5 137 296</td>
<td>526 454</td>
<td>82</td>
<td>10%</td>
</tr>
<tr>
<td>Water Consumption (m3)</td>
<td>266 743</td>
<td>6 809</td>
<td>4</td>
<td>3%</td>
</tr>
</tbody>
</table>

31 482 tons (51% FFB weight)

Final product: 75% water

Only 35% of POME treated aerobically
### Compost as a fertilizer

<table>
<thead>
<tr>
<th>Average dose (kg/ha/year)</th>
<th>Mineral and compost</th>
<th>Mineral</th>
<th>Land application of effluent</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urea</td>
<td>12</td>
<td>234</td>
<td>-</td>
</tr>
<tr>
<td>DAP</td>
<td>0</td>
<td>200</td>
<td>-</td>
</tr>
<tr>
<td>RP</td>
<td>11</td>
<td>31</td>
<td>-</td>
</tr>
<tr>
<td>TSP</td>
<td>189</td>
<td>100</td>
<td>-</td>
</tr>
<tr>
<td>KCl</td>
<td>122</td>
<td>471</td>
<td>-</td>
</tr>
<tr>
<td>Dolomite</td>
<td>0</td>
<td>29</td>
<td>-</td>
</tr>
<tr>
<td>Kieserite</td>
<td>11</td>
<td>145</td>
<td>-</td>
</tr>
<tr>
<td>Borax</td>
<td>7</td>
<td>7</td>
<td>-</td>
</tr>
<tr>
<td>Compost</td>
<td>17595</td>
<td>-</td>
<td>-</td>
</tr>
<tr>
<td>Effluent (m3)</td>
<td>-</td>
<td>0</td>
<td>375</td>
</tr>
</tbody>
</table>

Compost saves 78% of fertilizers on 13% of the land area = 10 % saved

Dose applied = 130kg/palm or 17,5t/ha (fresh compost weight)
Fertilisations practices are linked to a low quality of compost resulting from excessive leaching in an open composting system.
Roofing and recycling of the leachates will increase compost quality and nutrient recycling efficiency.

Nutrient content

Nutrient recovery

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Critical point for LCA

- Recycling leachates
- POME / EFB ratio
- Roofing
- Drying period
- Turning frequency
- Nutrient recovery efficiency
- % Effluent Digested Anaerobically
- Final moisture
- Substitution to mineral fertilizer
- Methane emissions
- Diesel consumption

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Thank You!