The Value of Fertilisers Derived from Human Excreta in Antananarivo, Madagascar

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Loowatt’s system
Digestion site in Antananarivo
Composting site
From digestate to vermicompost in 2 months

- Thermophilic phase of composting
- Once the compost has reached ambient temperature again it is fed to the worms

- Worms eat their own weight in compost in a day
- Worms digest fresh compost fed to them in 2 weeks
- 2 weeks for further processing, drying and grinding
Loowatt fertilisers

Human excreta + food waste

Digestate
- By-product of anaerobic digestion
- Contains all the nutrients present in the original waste material

Compost
- Biological aerobic process
- Nutrient fixation by organic matter
- Exothermic process that achieves pathogen inactivation

Vermicompost
- Organic matter digested by worms
- Higher micronutrient content
Crop trials using compost and vermicompost derived from human excreta

- 5 Treatments applied:
  - Compost (C)
  - Vermicompost (V)
  - Chemical fertiliser (NPK) (I)
  - Mix of compost and NPK (C+I)
  - Mix of vermicompost and NPK (V+I)

- 5 fertiliser application rates
- 3 repetitions
- Randomised pots layout
### Initial soil and soil amendments compositions

<table>
<thead>
<tr>
<th>sample</th>
<th>unit</th>
<th>Soil</th>
<th>Compost</th>
<th>Vermicompost</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td></td>
<td>7.93 ± 0.07</td>
<td>9.8 ± 0.15</td>
<td>9.23 ± 0.07</td>
</tr>
<tr>
<td>dry matter</td>
<td>%</td>
<td>99.83 ± 0.03</td>
<td>61.13 ± 0.33</td>
<td>89.77 ± 0.33</td>
</tr>
<tr>
<td>Total Nitrogen</td>
<td>g/kg</td>
<td>0.1 ± 0</td>
<td>27.8 ± 0.5</td>
<td>22.3 ± 0.1</td>
</tr>
<tr>
<td>Nitrate Nitrogen</td>
<td>g/kg</td>
<td>2.59.10^{-3} ± 0.09.10^{-3}</td>
<td>1.95 ± 0.40</td>
<td>0.303 ± 0.04</td>
</tr>
<tr>
<td>Ammonium Nitrogen</td>
<td>g/kg</td>
<td>0.81.10^{-3} ± 0</td>
<td>0.333 ± 0.11</td>
<td>0.023 ± 0.001</td>
</tr>
<tr>
<td>Total Carbon</td>
<td>% w/w</td>
<td>0.08 ± 0.01</td>
<td>22.67 ± 0.57</td>
<td>19.43 ± 0.23</td>
</tr>
<tr>
<td>Available Phosphorus</td>
<td>mg/L</td>
<td>7 ± 0.4</td>
<td>180.33 ± 3.84</td>
<td>215.33 ± 3.71</td>
</tr>
<tr>
<td>Available Potassium</td>
<td>g/L</td>
<td>&lt;20.10^{-3}</td>
<td>15.96 ± 0.90</td>
<td>15.73 ± 0.4</td>
</tr>
<tr>
<td>Available Magnesium</td>
<td>g/L</td>
<td>&lt;15.10^{-3}</td>
<td>0.122 ± 0.013</td>
<td>0.224 ± 0.002</td>
</tr>
</tbody>
</table>
Control: no fertiliser applied
V: vermicompost
C: compost
I: chemical fertiliser
C+I: mix of compost and chemical fertiliser
V+I: mix of vermicompost and chemical fertiliser

Pot trial plant growth
Corn cob harvest

Average maize yield

- Average cob mass
- Number of cobs

fertiliser treatment applied

mass (g)

control, V40, V60, V80, V100, C20, C60, C100, I40, I60, I80, I100, C+I 60, C+I 80, C+I 100, V+I 20, V+I 40, V+I 60, V+I 80, V+I 100, V+I 100
Soil nutrient content evolution

Evolution of exchangeable Potassium in soil

Available K soil concentration (mg/kg)

Fertiliser treatment and dose

Initial
Intermediate
Final
Soil nutrient content evolution

Evolution of exchangeable Magnesium in soil

- Start (June)
- Intermediate (July)
- Final (Sept)

Fertiliser treatment and dose

Exchangeable magnesium concentration in soil (mg/kg)

0 10 20 30 40 50 60

control V20 V40 V60 V80 V100 C20 C40 C60 C80 C100 I20 I40 I60 I80 I100 V+20 V+40 V+60 V+80 V+100 C+20 C+40 C+60 C+80 C+100 C+120 C+140 C+160 C+180 C+1100
Heavy metal concentrations in soil

![Graph showing heavy metal concentrations in soil with different fertiliser treatments applied. The x-axis represents the fertiliser treatment applied, and the y-axis represents concentration (mg/kg). The graph includes data for Zinc, Copper, and Cadmium.]
Conclusions

• Positive effect on soil and plants for both compost and vermicompost derived from human waste

• Different nutrient content between compost and vermicompost derived from human excreta

• Nutrients in vermicompost are present in more plant-available forms and worms add micronutrients to the final product

• Vermicompost is promising: faster production process and higher product value than compost.

• Heavy metals are not a concern for fertilisers produced from source separated human waste