JAN HRUBÝ, BARBORA BADALÍKOVÁ, JAN NEDĚLNÍK

UTILIZATION OF FAST COMPOSTS IN LANDSCAPE REHABILITATION

WYKORZYSTANIE KOMPOSTÓW Z KOMÓR FERMENTACYJNYCH PRZY REKULTYWACJI TERENÓW

Research Institute for Fodder Crops, Ltd., Troubsko, Czech Republic

Abstrakt: Praca dotyczy potencjalnej możliwości wykorzystania kompostów produkowanych z róż­
nych odpadów organicznych (ścieków i odpadów z przemysłu spożywczego, produkcji rolniczej
oraz osadów komunalnych) przy zastosowaniu tlenowej fermentacji w specjalnych komorach z
automatycznym procesem suszenia i z wykorzystaniem bioenergii generowanej przez odpady. W
pracy przedstawiono główne problemy związane z produkcją i wykorzystaniem tych kompostów,
takie jak: skład chemiczny kompostów przy różnym składzie odpadów, obecność nasion roślin
uprawnych, chwastów itp. oraz sposoby i efekty wykorzystania tych kompostów przy rekultywacji
terenów skażonych.

Key words: fast compost, manufacturing technology, germinating capacity of seeds, non-conventio-
nal crops, landscape revitalization, two-phase decontamination.

Słowa kluczowe: kompost z komór fermentacyjnych, energia kiełkowania nasion, rośliny niekon­
wencjonalne, rekultywacja, dwufazowe odkażanie terenu.

INTRODUCTION

Agriculture has a marked impact on the environment and its basic components
such as water, soil and air. Agriculture produces wastes (potentially residues), which
are partly recyclable, but also those which can be classed as hazardous waste materials
[Jelínek et al., 2001]. At present, costly constructions for environment conservation,
the so-called “end technologies” are being built. They are not an integral part of
manufacturing technology, but they are added to its end with the aim of absorbing or
managing pollution (incinerators, dumps, composting facilities, etc.).

In a great number of agricultural areas in the Czech Republic there is an objective
necessity to direct attention at the aspects of preserving soil fertility and revitalization
of landscape damaged by anthropogenic activity [Hrubý, Mezuliáník 1997]. The aim
of the study is to evaluate the newly developed “end technologies” of the production of
fast composts in fermentation beds with the maximum utilization of biowastes from agriculture and food processing and municipal solid wastes, establishing optimum conditions for humification of organic substances. The innovative approach of this technology is the development of and research into the new technical devices and technological processes enabling ecological and economic transport of organic substances present in biowastes to permanent humus with simultaneous utilization of mineral nutrients. Every technology of composting must establish optimum conditions for the activity of microorganisms converting organic matter. These are aerobic microorganisms with high oxygen demand that produce carbon dioxide [Váňa 1994]. According to the author the technology of composting must ensure maximum homogeneity and mixing of all components and establish optimum thermal regime for compost maturation.

The innovative approach of this technology also includes the multi-purpose utilization of fast composts not only as conventional organic manure, but also in biowaste conversion into powdery biofuel when the fermented mixture of biowastes is dried to a minimum of 70% of dry matter of pellets. A combination of fast composts and mineral sources of nitrogen can produce organo-mineral fertilizers with an increased content of nitrogen. Kolář and Kužel [2000] defined the conditions under which it is possible to meet all the agrochemical conditions for compost utilization as high-quality organo-mineral fertilizers. These include predominantly conditions for the optimum development of microflora by modification of pH of the environment and its nutrient regime, minimum losses of heat generated by fermenting mixtures during heat conduction, radiation and circulation, perfect homogenization of components, optimization of C : N components and easy microbial decomposition of organic components of composted mixture. An important condition is the absence of organic pollutants, sources of mineral pollutants, heavy metals and all pesticides, tensides, fats and oils in general. Váňa [1998] claimed that biowaste that is not contaminated with pollutants is suitable for recycling and should be applied to the soil as a source of organic matter and nutrients or should be used as an alternative source of energy but should not be disposed of in dumps.

The utilization of fast composts for the revitalization of landscape degraded by anthropogenic activity was tested in the decontamination of petroleum-polluted soil in the “two-phase decontamination“ in situ [Hrubý, Badalíková, Ševčík, 2000; Hrubý, Badalíková, Nedělník, 2003]. A statistically significant effect of fast compost on the decontamination of petroleum-polluted soil was proved. Similarly, Van Gestel et al. [2003] studied the conditions that would be optimal for bioremediation of soil contaminated with diesel oil using composts from biowastes when they focused, besides others, on the course of thermal conditions influencing the processes of decomposition.

MATERIAL AND METHODS

Within the international project Eureka the following problems concerning not only the production of fast composts and their quality, but also objective conditions for their utilization in landscape damaged by anthropogenic activity were studied:
Chemical composition of fast composts

The fast compost produced under the pilot conditions (reference workplace – composting plant Albrechtice, Agro-eko Ostrava) was analysed (at 3 replications) with respect to the following indices: pH of fast compost, content of: \( \text{P}_2\text{O}_5 \), \( \text{K}_2\text{O} \), MgO, CaO (in mg/100 g d.m.), combustibles (%), C (%), dry matter (%), \( \text{N} \) (%). The data were statistically assessed (Table 1). The soil reaction of pH was determined on the basis of KCl extract and measured using the pH-meter, the content of available phosphorus, potassium and magnesium was determined by using the spectrophotometer and following the method of Melich II and the content of total N by mineralization was determined by using the Kjeldahl distillation method (expressed in %).

Biological characteristics of fast composts

The studies directed predominantly at the determination of presence of seeds were made in 200 g of fast compost (at 3 replications). The evaluation was made using a desk magnifier magnifying to 1.5 times and a binocular microscope magnifying to 6.3–40 times. In a wet sample of 200 g of fast compost (at 3 replications) potential seed germination was studied for 30 days under the laboratory conditions.

Decontamination of petroleum-polluted soil

Different levels of soil contamination with diesel fuel (corresponding to standard ČSN EN 590) and subsequent soil decontamination by biological processes (the so-called two-phase decontamination) were studied in a model small-plot trial in the Research Institute for Fodder Crops Ltd. in Troubsko. The experiment was established in the year 1999 on Chernozem, not used for farming, with very good soil structure (to a depth of 0.20 m, the coefficient of soil structure being 2.22).

As controls were used the sowings of test crops into the soil:

a) without compost,

b) with compost applied at a rate of 4 kg \( \cdot \) m\(^{-2} \),

c) with compost and increasing rates of diesel fuel (0.6 l, 1.2 l and 1.5 l \( \cdot \) m\(^{-2} \)).

In the second stage of soil decontamination the following crops were tested in each treatment: ray (Secale cereale L. var.multicaule Metzg.ex Alee), white melilot (Melilotus albus), Canary grass (Phalaris canariensis L.), and safflower (Carthamus tinctorius L.).

In the years 2002–2003 a follow-up small-plot trial was established and conducted in which besides the control treatments with and without compost (a, b) the treatments with increased rates of diesel fuel at rates of 1.0 l, 1.5 l, 2.0 l and 2.5 l \( \cdot \) m\(^{-2} \) were involved. In the first phase of decontamination, fast compost at a rate of 4.0 kg \( \cdot \) m\(^{-2} \) was applied to the soil and subsequently two test crops: white melilot (Melilotus albus) and Indian hemp (Cannabis sativa L.) were sown.

The presence of NES (nonpolar extractable substances) in the soil was measured by the IR-spectrometer at the locally-determined wave numbers. The results were related to sample dry matter and are given in mg \( \cdot \) kg\(^{-1} \).
<table>
<thead>
<tr>
<th>Sample No.</th>
<th>pH</th>
<th>P₂O₅</th>
<th>K₂O</th>
<th>MgO</th>
<th>CaO</th>
<th>Combustibles</th>
<th>C org</th>
<th>N total</th>
<th>Dry matter</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>(mg · 100 g⁻¹ d.m.)</td>
<td>(%)</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>6.2</td>
<td>256</td>
<td>501</td>
<td>137</td>
<td>760</td>
<td>76.58</td>
<td>38.29</td>
<td>1.25</td>
<td>46.9</td>
</tr>
<tr>
<td>2</td>
<td>6.3</td>
<td>184</td>
<td>524</td>
<td>148</td>
<td>1940</td>
<td>78.69</td>
<td>39.34</td>
<td>1.35</td>
<td>65.7</td>
</tr>
<tr>
<td>3</td>
<td>6.6</td>
<td>214</td>
<td>477</td>
<td>194</td>
<td>990</td>
<td>70.47</td>
<td>35.24</td>
<td>1.45</td>
<td>44.0</td>
</tr>
<tr>
<td>4</td>
<td>6.5</td>
<td>304</td>
<td>972</td>
<td>128</td>
<td>830</td>
<td>77.78</td>
<td>38.89</td>
<td>1.115</td>
<td>73.7</td>
</tr>
<tr>
<td>5</td>
<td>6.4</td>
<td>352</td>
<td>1030</td>
<td>219</td>
<td>480</td>
<td>84.45</td>
<td>42.23</td>
<td>2.28</td>
<td>47.3</td>
</tr>
<tr>
<td>Mean</td>
<td>6.4</td>
<td>239</td>
<td>618</td>
<td>152</td>
<td>1130</td>
<td>75.88</td>
<td>37.94</td>
<td>1.291</td>
<td>57.6</td>
</tr>
<tr>
<td>s² - variation</td>
<td>0.025</td>
<td>5233.25</td>
<td>84366.5</td>
<td>1767.5</td>
<td>311025.0</td>
<td>28.68</td>
<td>7.17</td>
<td>0.2599</td>
<td>182.59</td>
</tr>
<tr>
<td>Standard deviation</td>
<td>0.16</td>
<td>72.34</td>
<td>290.46</td>
<td>42.04</td>
<td>557.7</td>
<td>5.36</td>
<td>2.68</td>
<td>0.51</td>
<td>13.51</td>
</tr>
<tr>
<td>Variation coefficient (%)</td>
<td>2.50</td>
<td>30.27</td>
<td>47.00</td>
<td>27.66</td>
<td>49.35</td>
<td>7.06</td>
<td>6.71</td>
<td>39.50</td>
<td>23.45</td>
</tr>
<tr>
<td>CI₁₀₀₅ (LL)</td>
<td>6.21</td>
<td>149.23</td>
<td>257.52</td>
<td>99.82</td>
<td>437.86</td>
<td>69.24</td>
<td>34.60</td>
<td>0.651</td>
<td>40.84</td>
</tr>
<tr>
<td>CI₁₀₀₅ (UL)</td>
<td>6.59</td>
<td>328.77</td>
<td>1214.48</td>
<td>204.18</td>
<td>1822.14</td>
<td>82.52</td>
<td>41.28</td>
<td>1.931</td>
<td>85.34</td>
</tr>
<tr>
<td>CI₁₀₀₁ (LL)</td>
<td>5.66</td>
<td>90.47</td>
<td>21.52</td>
<td>65.66</td>
<td>-15.26</td>
<td>64.89</td>
<td>32.42</td>
<td>0.231</td>
<td>29.86</td>
</tr>
<tr>
<td>CI₁₀₀₁ (UL)</td>
<td>7.14</td>
<td>387.53</td>
<td>1214.48</td>
<td>238.34</td>
<td>2275.26</td>
<td>86.87</td>
<td>43.46</td>
<td>2.351</td>
<td>29.86</td>
</tr>
</tbody>
</table>

CI - confidence interval; LL - lower limit; UL - upper limit
RESULTS AND DISCUSSION

The technical and technological proposal of fast compost production by innovative technology called „Ekobioprogres“ is characterized as follows:

- automatic turning of composted material during aerobic fermentation in fermentation beds with a bottom unloading device,
- preparation of liquid biowaste mixtures (e.g. pig slurry, cattle slurry, poultry litter, wastewater treatment sludge) with absorbent material of plant origin, e.g. chopped straw,
- loading machine for filling the fermentation beds, everyday turning of materials,
- unloading of composts – after 5 to 7 days of fermentation, fast compost is automatically delivered from the fermentation vessel to the storage facility, where it matures without turning for up to 4–8 weeks,
- conversion of fast compost to organo-mineral fertilizers with final drying.

Neither the processing line nor the fast compost produced is the source of odour and the innovative technology does not need to use any microbial or other preparation which would increase the operating costs.

Chemical composition of fast composts

A part of the project was also the evaluation of the quality of model fast composts which involved predominantly their chemical composition (Table 1) in relation to the different structure and proportions of input materials – biowastes (Table 2).

According to the general criteria for the evaluation of results of fast compost chemical composition, the average value of pH was slightly acid. The required pH in the Czech standard should be in the range of 6.0–8.5 [Kolár, Kužel 2000], so the pH determined was within the range prescribed by the standard. The content of nutrients was influenced by different proportions of input materials, but it complied with the valid national standards concerning requirements for compost quality (standard issued on 1 June 1991). For example, the higher content of potassium and total nitrogen in sample 5 was affected by a higher part by volume of sludge and straw. The statistical evaluation based on the analysis is summarized in Table 1.

Biological characteristics of fast composts

The study of the presence of weed seeds and seeds of cultivated plants in fast composts, predominantly their germinating capacity, was made with the aim of prevention of potential weed infestation of plots with germinating seeds in fast composts.

It may be concluded that if some samples of fast compost contained organic residues resembling seed coats, their morphological structure was unclear and could not be easily distinguished from other constituents of fast compost. If they somewhat resembled seeds of cereal crops, the grains had already been degraded and could not “infest” the fast compost and subsequently the soil environment after fast compost application. An overview of the proportions of different compost constituents is given in Table 2.
TABLE 2 Proportions of different components in fast composts – Albrechtice 2002

<table>
<thead>
<tr>
<th>Sample No.</th>
<th>Sampling date</th>
<th>Compost components</th>
<th>% proportions</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>22.5.</td>
<td>Wastewater treatment sludges Grass residues Sawdust</td>
<td>30.0 50.0 20.0</td>
</tr>
<tr>
<td>2</td>
<td>25.5.</td>
<td>Wastewater treatment sludges Grass residues Sawdust</td>
<td>30.0 50.0 20.0</td>
</tr>
<tr>
<td>3</td>
<td>27.6.</td>
<td>Straw Sawdust Grass residues Wastewater treatment sludges</td>
<td>16.1 21.9 22.2 39.7</td>
</tr>
<tr>
<td>4</td>
<td>13.8.</td>
<td>Straw Sawdust Grass residues Wastewater treatment sludges</td>
<td>24.0 9.7 3.8 32.5</td>
</tr>
<tr>
<td>5</td>
<td>24.9.</td>
<td>Straw Sawdust Wastewater treatment sludges</td>
<td>29.6 20.1 50.3</td>
</tr>
</tbody>
</table>

Decontamination of petroleum-polluted soil

The principle of two-phase technology of decontamination of petroleum-contaminated soils in situ might be characterized as follows:

The first phase includes the production of fast compost in the fermentation vessel with every day turning of compost material under the optimal conditions for the development of aerobic microorganisms. The fast compost with rich microbial activity and high content of nutrients is incorporated into the petroleum-contaminated soil where continual decontamination due to microbial activity of composts occurs. After mixing petroleum-contaminated soil with compost intensive development of aerobic microorganisms, depending predominantly on the presence of oxygen, takes place. Oxygen is supplied to the soil through technologically intensive soil tillage. Although the development of aerobic microorganisms in the soil gradually decreases with time, it can be fully recovered by re-incorporation of fast compost into the decontaminated soil.

For further reductions in the concentration of petroleum products the second phase of decontamination is economically more advantageous. It includes subsequent cultivation of plants with efficient utilization of the role of their rhizosphere. Under favourable conditions this process can (with controlling the soil environment by agronomy practices) gradually decrease the concentration of NES in the soil to the level of its natural background (i.e. the condition when the soil may be considered decontaminated).

Individual stage of „two-phase decontamination“ of petroleum-polluted soils

1. Study of the response of various non-conventional crops to different levels of soil contamination with petroleum
2. Application of fast composts to promote the biological activity of soil
3. Seeding non-conventional and energetic crops, determination of herbage and dry matter yields, including quality
4. Testing the rate of degradation of petroleum products in the soil
5. Analyses of the level of soil contamination with petroleum products (e. g. NES – nonpolar extractable substances)

6. Revegetation of rehabilitated areas.

7. Utilization of harvested plant material for re-composting or green manure application, utilization of harvested matter for energetic purposes – biomass combustion, evaluation of hygienic safety of harvested material.

The results of the evaluation of the course of two-stage decontamination of petroleum-polluted soil, including the statistical analysis for the period of 2000–2001 were already published by Hrubý at al. [2000]; Hrubý at al. [2002, 2003].

In the subsequent experimental period (2002–2003) the study of two-phase decontamination of petroleum contaminated soil continued on a site at Troubsko based on a small-plot trial (see Methodology). After fast compost application (4 kg · m⁻²) two test plants – white melilot and Indian hemp were seeded on 13 May 2002. NES contents in soil decreased already during vegetation in the year 2002 in both the crops and all treatments with different rates of application of petroleum products (Table 3), but the test plants responded to the soil environment in a different way.

The results of the analysis for NES contents in both small-plot trials showed that already after the first year of the so-called “two-phase soil decontamination” the concentration of petroleum products in soil markedly decreased at the end of the vegetation period, compared with the concentration at the start of vegetation. Soil contamination decreased in particular treatments with white melilot to 1.8–13.7% of the initial level and in Indian hemp to 1.4 to 13.5% of the initial level (Table 3).

### CONCLUSIONS

1. The innovative approach of the technology proposed lies in the multi-purpose utilization of fast composts, not only as traditional organic fertilizers, but also in converting biowastes to powdery biofuel or pellets. By combining fast composts and mineral sources of nitrogen, organo-mineral fertilizers with increased N content can be produced.

2. The production of fast composts does not have any impact on the environment and

<table>
<thead>
<tr>
<th>Treatments</th>
<th>White melilot</th>
<th>Indian hemp</th>
</tr>
</thead>
<tbody>
<tr>
<td>2.4.</td>
<td>24.10.</td>
<td>2.4.</td>
</tr>
<tr>
<td>1. Control</td>
<td>&lt; 20</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>2. Fast compost 4 kg · m⁻²</td>
<td>&lt; 20</td>
<td>&lt; 20</td>
</tr>
<tr>
<td>3. Fast compost + petroleum (1 l · m⁻²)</td>
<td>470</td>
<td>35</td>
</tr>
<tr>
<td>4. Fast compost + petroleum (1,5 l · m⁻²)</td>
<td>550</td>
<td>40</td>
</tr>
<tr>
<td>5. Fast compost + petroleum (2 l · m⁻²)</td>
<td>930</td>
<td>330</td>
</tr>
<tr>
<td>6. Fast compost + petroleum (2,5 l · m⁻²)</td>
<td>1670</td>
<td>910</td>
</tr>
</tbody>
</table>
it does not release odour into the atmosphere.

3. The chemical composition and nutrient contents of fast composts are affected by the composition of input materials. The fast compost did not contain any viable seeds of wild or cultivated plants.

4. The results of the study of the so-called „two-phase decontamination“ of soil polluted with petroleum products in situ revealed that the entire process is positively affected by incorporating fast composts with high microbial activity into the soil and the rhizosphere of the subsequently seeded crops.

5. Fast composts produced by the technology called „Ekobioprogres“ are widely used in the revitalization of soil damaged by anthropogenic activity, predominantly in the North Moravian region mainly on the localities where coal mines were closed and where fly ash was dumped.

REFERENCES


*Ing. Jan Hruby, csc.*,  
**Research Institute for Fodder Crops, Ltd.,**  
664 41 Troubsko, Zahradní 1, Czech Republic,  
e-mail: hruby@vupt.cz,