Sanitary aspect of using partially treated landfill leachate as a water source in green waste composting

Thrasyvoulos Maniosa,*, Edward I. Stentifordb

aSchool of Agricultural Technology, Technological Education Institute of Crete, Heraklion 71110, Crete, Greece
bSchool of Civil Engineering, Leeds University, Leeds LS2 9JT, UK

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Abstract

Shredded green wastes were composted in windrows, at the Harewood Whin landfill, near the city of York, in West Yorkshire, UK. Landfill leachate were added twice during the second and fourth week of the process in two piles. One pile was turned once every week for eight weeks and the other was turned twice, during the same period. Each time approximately, 2 m³ of leachate was added, into each pile. The two piles each contained about 45 m³ of shredded green waste. The effect of adding leachate on the sanitisation of the green waste during composting, was evaluated based on the changes in the levels of faecal coliforms and faecal streptococci. The results suggested that using leachate as the moisture source had no significant effect (tested with two factors ANOVA test) on the sanitisation process when compared with two similar piles, used as the control, for which tap water was used for moisture addition. In all four piles sanitisation was almost complete and below the acceptable levels. Additionally, the results indicated that there was no significant effect on the sanitisation process of the turning frequency.

1. Introduction

In a number of countries such as the USA, Greece, Italy and the United Kingdom green wastes have historically been disposed in landfills (Hartz and Giannini, 1996; Manios et al., 2001; Tittarelli et al., 2001; Stentiford, 2001). For many years environmentalists and legislators from both sides of the Atlantic have been trying to change this practice. One outcome of this in the European Union was the Landfill Directive which came into force in 1999 and one aspect of which was the phased reduction of these and other organic materials from landfills (EC, 1999).

In the UK, one of the mechanisms governing the implementation of the landfill directive was the “landfill tax” introduced in 1998, which had already been in force in a number of other Western European Countries (Stentiford, 2001). Under this legislation each tonne of organic waste entering a landfill is taxed with an amount increasing every year [in 2002 it was $13 (≈20 €) per tonne]. The tax is collected from the waste producers by the landfill operating companies. Up to 20% of the tax can be used for a range of projects including research and demonstration projects related to waste management and improving the environment. Under this scheme Yorwaste Plc (landfill operator), Yorventure Plc (waste collection company), the City of York and the University of Leeds ran a research and demonstration programme related to the collection, composting and reuse of green wastes produced inside the boundaries of the City of York.

The result of this co-operation was the construction of an open air composting site (reinforced concrete surface) at the Harewood Whin landfill site and the purchase of a composting turning machine with an appropriate tractor unit. A number of research activities took place at the site and one of these was the evaluation of the use of landfill leachate, for water addition during the composting process. Water addition is often necessary during composting to replace the water lost through evaporation as a result of the heat generated in the composting mass (Fang et al., 1998). Leachate are considered as a wastewater which contains both
chemical and microbiological contaminants (Bolton and Evans, 1991; Iza et al., 1992; Bernard et al., 1996; Boothe et al., 2001). The potential use of leachate in composting, should be assessed with respect to a range of impacts but the particular ones of interest are the pathogenic micro-organisms and heavy metals.

The twin objectives of this research were to evaluate:

- the effect of landfill leachate addition on the sanitisation process in green waste composting;
- the effect of the turning frequency on the sanitisation process and in any correlation with the leachate use.

2. Materials and methods

Green wastes were collected from the gardens and parks of the City of York, in West Yorkshire, by Yorventure Plc and then transferred to Harewood Whin landfill operated by Yorwaste Plc. The wastes were shredded into pieces approximately 20 mm diameter, using a tub grinder. The shredded materials were formed into windrows approximately 25 m long, 2.5 m wide at the base and 1.5 high, using the compost turning machine. Each pile contained approximately 45 m$^3$ of shredded green waste. All operations and experiments were carried out on the composting site. For these trials four such piles were used in pairs and sequentially.

In the first trial, pile A was turned twice a week (every Wednesday and Friday), and pile B was turned every Friday (once a week). Temperatures were recorded manually on a daily bases, at the core of each pile from where samples were collected every Friday before the turning. Piles A and B were watered only once (Friday, week 3) during the experimental period and with “clean” tap water. The watering was achieved by spraying onto the surface of each pile. As with rainfall, the water added could not penetrate the layers of green waste in the piles deeper than the surface 10–15 cm. This resulted in some leaching from the windrows. Approximately 2 m$^3$ were used for each pile. Efforts were made to increase this amount in previous experiments, however the leaching from the piles was increased suggesting some sort of satiation of the surface layers of green waste. Immediately after watering the piles were mixed using a mechanical windrow turner.

In the second run, piles C and D were prepared from similar material as shown by the physicochemical analyses (Table 1). The methodologies used for these analyses are described in the Methods Book for the Analysis of Compost (1996). The turning schedule for Piles C and D were the same for piles A and B. Piles C and D were watered twice, on the Fridays of weeks 2 and 4, with partially treated landfill leachate. The only treatment for the leachate was to allow it to settle for a few days before use. Table 2 presents some of the physicochemical and biological characteristics of the leachate used. For these analyses standard methods were used (APHA, 1995).

The compost samples were analysed for pathogens indicators (faecal coliforms and faecal streptococci), according to standard methods (APHA, 1995).

In order to evaluate statistically any significant differences among the results for each pile, a two factor ANOVA test was used. In all tests the significance level at which we evaluated critical value differences was 5%.

3. Results and discussion

Fig. 1, presents the temperature variations of Piles A, B, C and D, during the eight weeks of the thermophylic phase. In all four piles temperature remained high and above 55 $^\circ$C for more than 30 days. It is difficult to see from these temperature plots when the turnings took place since the temperature in the core increased rapidly to regain the level measured prior to turning in less than 24 h. Such behaviour is common with green waste windrows, especially when leaves and other easily decomposing materials account for a large part of its composition (Joshua et al., 1998; Rajabanshi et al., 1998). The energy produced by the accelerated decomposition of such materials is released in a short period of time which with the insulation properties of the material

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>Piles C and D</th>
<th>Piles A and B</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.71</td>
<td>7.26</td>
</tr>
<tr>
<td>Electrical conductivity (μS/cm)</td>
<td>793</td>
<td>618</td>
</tr>
<tr>
<td>Moisture (%)</td>
<td>52.14</td>
<td>51.14</td>
</tr>
<tr>
<td>Volatile solids (%)</td>
<td>46.65</td>
<td>46.08</td>
</tr>
<tr>
<td>Total nitrogen (g/kg d.w.)</td>
<td>4.08</td>
<td>3.87</td>
</tr>
</tbody>
</table>

Table 1

Physicochemical characteristics of the partially treated landfill leachate

<table>
<thead>
<tr>
<th>Characteristics</th>
<th>First application</th>
<th>Second application</th>
</tr>
</thead>
<tbody>
<tr>
<td>pH</td>
<td>6.70</td>
<td>6.10</td>
</tr>
<tr>
<td>Electrical conductivity (μS/cm)</td>
<td>520</td>
<td>425</td>
</tr>
<tr>
<td>Chemical oxygen demand (mg/l)</td>
<td>3680</td>
<td>3245</td>
</tr>
<tr>
<td>Biochemical oxygen demand (mg/l)</td>
<td>1876</td>
<td>1760</td>
</tr>
<tr>
<td>Faecal coliforms</td>
<td>$3 \times 10^{11}$</td>
<td>$4 \times 10^{12}$</td>
</tr>
<tr>
<td>Faecal streptococci</td>
<td>$2 \times 10^9$</td>
<td>$3 \times 10^9$</td>
</tr>
</tbody>
</table>

Table 2

Physicochemical and biological characteristics of the partly treated landfill leachate
results in a rapid temperature increase. Woody parts are far more difficult to biodegrade due to the presence of lignin. The low thermal conductivity of this type of composting material means that energy will be trapped in the core of the pile, sustaining higher temperatures for a long period (Robinson and Stentiford, 1993; Stentiford, 2001; Manios et al., in press).

Another conclusion to be drawn from Fig. 1 is that no substantial differences could be found between the temperature profiles for the cores of the four piles. A two factor ANOVA test was used for any correlation and the results suggested that no significant effect on the temperatures of the four piles resulted from either the watering process and/or the turning frequency. This strongly indicates that, for the composting of green waste, turning once or twice a week did not produce any discernible difference. This however cannot be generalised for all organic materials as indicated by Lasaridi et al. (2000) and Manios et al., (in press).

Fig. 2 shows the changes in faecal coliforms with composting time for the four piles, and Fig. 3 presents the data for faecal streptococci. With the exception of Pile B (and only for faecal coliforms), the piles showed a complete sanitisation at the end of the eighth week according to both indicators. These results are similar to those presented by Robinson and Stentiford (1993); Fang et al. (1998) and Manios et al. (in press). These authors suggested that temperature is the main parameter in the sanitisation if sustained for an appropriate period of time. In all four piles the period of time at high temperatures was thought to be more than adequate with at least 30 days above 55 °C. Again a two factor ANOVA test showed no significant differences in the degree of sanitisation in the four piles. The population of faecal coliforms in pile B at the end of the process was low and as such did not affect the results of the statistical analyses.

The overall performance of the piles with leachate addition suggests that its use did not significantly affect the sanitisation process of green waste composting. This could be attributed to several reasons:

(a) the amount of leachate added was small compared to the total amount of green waste in the piles;
(b) the addition took place at times when the green waste itself had relatively high levels of indicator micro-organisms and thus the effect of addition was not particularly high; and
(c) there was sufficient time between the addition of leachate and the next sampling occasion (1 week) for effective sanitisation to take place in the core over that 1-week period.

Fig. 1. Temperature (°C) profiles for Piles A and B (with water), and C and D (with leachate) during the composting period.

Fig. 2. Faecal coliform population reduction during the composting process in all four piles (A and B with water, C and D with leachate).
4. Conclusions

The results indicate that partially treated landfill leachate can be reused as a water source during composting of green waste, since it did not produce any negative effect in the sanitisation process. This use can be supported only when such wastewater is readily available and can be transported at small cost. In the case considered the site for leachate collection and treatment was only 800 m away from the composting site and on the same controlled site as the composting plant. No analyses for heavy metals and other chemical accumulation in the green waste were carried out. To support the use of leachate in this way these parameters need to be monitored.

Acknowledgements

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References


