Overview of green waste recycling research conducted by the Institute for Horticultural Development

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Introduction

The research program began in light of increasing community support and expectations for recycling programs. In 1995, EcoRecycle Victoria (formally known as the Waste Management Council) commissioned the Institute for Horticultural Development (IHD) to evaluate the risks of spreading pests, plant pathogens and weeds (PPW) through the recycling of green waste. A literature review conducted at the commencement of this research had failed to identify any major studies of a similar nature (Porter *et al.* 1995).

The need to evaluate these risks was essential, given that:

- State Government objectives set in 1990 aimed to reduce all waste going to landfill by 50% by the year 2000;
- 400 000 t of green waste is produced each year in metropolitan Melbourne, with 275 000 t going to landfill (Porter *et al.* 1995, Meinhardt 1996); and
- potentially 400 000 t of green waste and wood waste could be processed to produce composted products (Strickland 1999).

Cumulation of the past four years research has seen the development of the 'Guide to best practice – composting green organics' (EcoRecycle Victoria 1998) and a training program to compliment this publication. To date the guide has been well received by the industry and presently there is growing awareness for the need to adopt industry standards in order to minimize risks and develop sustainable markets for composted products made from green waste.

Potentially, composted green waste could supply much needed organic matter to some of our poorly degraded agricultural soils, which have long suffered from soil erosion, salinity, acidity and general poor soil conditions. However, identification and elimination of the potential risks associated with recycling green waste is essential to ensure that potential products are not intensifying the problem of land degradation.

This presentation aims to provide an overview of research undertaken by the Green Waste Project team at IHD (Agriculture Victoria, Knoxfield), that specifically relates to the composting of green waste.

Survey of Melbourne's green waste stream

Over a two year period the incoming green waste streams at six sites across the greater Melbourne region were monitored for botanical content and the incidence of weeds and plant pathogens. Each site was surveyed for a period of 1–2 hours, every 3–4 weeks where materials of incoming loads were identified and quantified. Incoming loads consisted of either council kerbside collections of green waste in compactor trucks or self-hauled green waste from home gardeners and landscape contractors.

The six sites monitored over this two year period included:

- Darebin Waste Transfer Station,
- Knox Waste Transfer Station,
- Wyndham City Council landfill site (Werribee),
- CSR landfill site at Springvale (Clarke Road),
- Mornington Waste Transfer Station 1 (tree prunings only, with no weeds and grass clippings being permitted),
- Mornington Waste Transfer Station 2 (less control on inputs i.e. weeds and grass clippings permitted).

After the first year of monitoring there were at least 285 different plant species recorded, with some plants being recorded frequently (Wilkinson *et al.* 1997). The majority, however, were recorded on fewer than 10 occasions. Overall the proportion of Australian natives to exotic plant species was similar and grass clippings made up 3% by volume (Figure 1). The three most common plants recorded at any one site in any season over the first year of monitoring were: eucalypts (*Eucalyptus* spp.), wattles (*Acacia* spp.) and paperbarks (*Melaleuca* spp.).

Environmental weeds

Weeds were classified as those plant species with 'serious' or 'very serious' invasive potential (Carr *et al.* 1992, Parsons *et al.* 1992). An average of 26% by volume of the incoming green waste stream was recorded as environmental weeds. These plants pose a risk to the recycling of green waste, either on a seasonal basis (i.e. fruit and seed set) or all year (as tubers, bulbs, roots seeds, or stem fragments) (Tymms *et al.* 1999).

Some 49 plants of the most serious environmental weeds in Victoria were recorded in the first year of monitoring, including seven noxious weeds (Table 1). Of these plants, only 12 were Australian natives but they made up the larger proportion (38%) of all such weeds recorded (Wilkinson *et al.* 1997). This high incidence was due to natives such as sweet pittosporum (*Pittosporum undulatum*), coastal tea-tree (*Leptospermum laevigatum*) and certain species of wattle (*Acacia* spp.) being recorded.

The high incidence of environmental weeds in the green waste stream makes them a significant risk factor in recycling green waste. This risk is somewhat reduced depending on the means by which the weeds spread. In many cases, there will only be a risk of spread if the plant has set seed (Wilkinson *et al.* 1997).

Variations at green waste recycling facilities

Some of the sites shredded the green waste without further treatment, others shredded it and turned it once or twice before stockpiling it, while others 'treated' the mulch by composting it for various periods.

Variation also existed with regards to public signage, staffing levels and allowable inputs. Overall, there was lack of controls and consistent guidelines for recycling green waste.

Composting trials

To address some of the discrepancies and risk factors associated with the processing of green waste, a series of trials were established to test the survival of a variety of organisms (weeds and plant pathogens) in mulching and composting operations. Prior to these trials, little was know as to

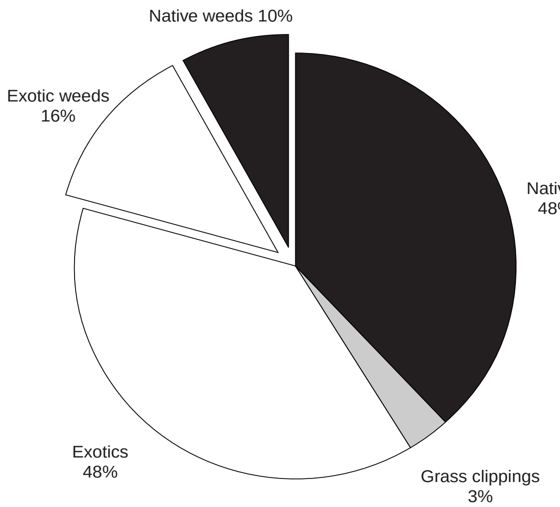

Figure 1. Composition of incoming green waste stream at six sites across metropolitan Melbourne after one year of monitoring.

Table 1. Plants recorded in green waste considered to be serious environmental and/or noxious weeds in Victoria, 1996.

Botanical name	Common name	Origin	Frequency	Weed rating[A]	Main risk period	Noxious in Victoria
***Acacia* spp.**	**Wattle**	Native	V. high	S–V	spring, summer	
Agapanthus (hybrid)	Agapanthus	Exotic	Medium	S	all year	
Allium triquetrum	Angled onion	Exotic	Low	V	spring, summer	Noxious
Avena fatua	Wild oat	Exotic	Low	V	spring, summer	
Buddleja davidii	Butterfly bush	Exotic	Low	S	winter, spring	
Cestrum elegans	Cestrum	Exotic	Low	S	summer, autumn	
Chlorophytum sp.	Spider plant	Exotic	Low	NL	all year	
Coprosma repens	**Mirror plant**	Exotic	V. high	V	autumn	
Cortaderia selloana	Pampas grass	Exotic	Low	V	winter, spring	
***Cotoneaster* spp.**	**Cotoneaster**	Exotic	V. high	V	autumn	
Crataegus monogyna	Hawthorn	Exotic	Low	V	summer, autumn	Noxious
Crocosmia sp.	Montbretia	Exotic	Low	V	summer	
Cynara cardunculus	Artichoke thistle	Exotic	Low	V	all year	Noxious
Cynodon dactylon	Couch grass	Exotic	Low	S	all year	
Cytisus sp.	Broom	Exotic	Low	V	summer	
Eucalyptus cladocalyx	Sugar gum	Native	Low	S	winter, spring	
Eucalyptus botryoides	Southern mahogany	Native	Low	S	winter	
Euryops spp.	Euryops	Exotic	Low	S	spring	
***Genista* spp.**	**Broom**	Exotic	Medium	V	summer	Noxious
Hakea salicifolia	**Willow-leaf hakea**	Native	Low	V	all year	
Hakea laurina	Pin-cushion hakea	Native	Low	S	all year	
Hakea suaveolens	Sweet hakea	Native	Low	V	all year	
Hedera helix	**English ivy**	Exotic	Medium	V	all year	
Hedera colchica	Persian ivy	Exotic	Medium	NL	spring	
Ilex aquifolium	Holly	Exotic	Low	V	autumn	
Leptospermum laevigatum	**Coastal tea-tree**	Native	High	V	summer, autumn	
Ligustrum vulgare	Privet	Exotic	Low	S	autumn, winter	
Lonicera japonica	Japanese honeysuckle	Exotic	Low	V	summer, autumn	
Melaleuca armillaris	**Giant honey-myrtle**	Native	Medium	V	autumn	
Melaleuca hypericifolia	Red honey-myrtle	Native	Low	S	autumn	
Melaleuca nesophila	Mauve honey-myrtle	Native	Low	S	autumn	
Olea sp.	Olive	Exotic	Low	S	autumn	
Opuntia vulgaris	Prickly pear	Exotic	Low	S	all year	Noxious
Oxalis pes-caprae	Soursob	Exotic	Low	V	all year	Noxious
Pinus spp.	Pine	Exotic	Medium	S	autumn	
Pittosporum undulatum	**Sweet pittosporum**	Native	V. high	V	autumn, winter	
Polygala myrtifolia	Myrtle-leaf milkwort	Exotic	Low	V	summer, autumn	
***Prunus cerasifera* 'Nigra'**	**Purple-leaf cherry-plum**	Exotic	Medium	V	summer	
Prunus laurocerasus	Cherry laurel	Exotic	Low	V	summer	
Rubus sp.	Blackberry	Exotic	Low	V	summer, autumn	Noxious
Salix babylonica	Weeping willow	Exotic	Medium	V	all year	
Schinus molle	Peppercorn tree	Exotic	Medium	S	summer	
Sollya heterophylla	Bluebell creeper	Native	Low	V	winter	
Sonchus oleraceus	Milk thistle	Exotic	Low	S	spring, summer	
Stellaria media	Chickweed	Exotic	Low	S	winter, spring	
Tradescantia albiflora	Wandering jew	Exotic	Medium	S	all year	
Trifolium sp.	Clover	Exotic	Low	P–V	spring, summer	
Ulex europaeus	Gorse	Exotic	Low	V	autumn, spring	Noxious
Zantedeschia aethiopica	White arum lily	Exotic	Low	V	spring, summer	

[A] based on risk ratings in Carr *et al.* 1992: V – very serious threat; S – serious threat; P – potential threat; NL – not listed.
Plants listed in bold were the most frequently recorded.

whether simply shredding and stockpiling green waste was enough to eliminate PPW, what conditions killed particular PPW or what the minimum requirements were for processing green waste to minimize the risk factors.

Stockpiles or windrows of shredded green waste were inoculated with the test organisms and their survival was monitored for up to 23 days. The test organisms were selected on the basis of their effectiveness for survival, means by which they could become weedy (e.g. hard-seeded native, grass seeds, stoloniferous grass, stem fragments) and the potential risk severity they would pose to horticultural industries and the general landscape (Table 2).

Example – Testing survival of Eucalyptus cladocalyx and Pennisetum clandestinum

In May 1997, sugar gum seeds (*Eucalyptus cladocalyx)* and segments of kikuyu grass (*Pennisetum clandestinum*) were inoculated at various depths into a heap of green waste feedstock at a recycling centre in metropolitan Melbourne. The survival of these weeds was tested over a 23 day process, where the pile was turned on day 8. Moisture content, temperature and particle size of feedstock was monitored throughout the process.

Moisture and temperature conditions throughout the heap were extremely variable at any one time, affecting the survival of these weeds. The major observations were (Com-post No. 5 1997):

- Weeds placed within the edges of the heap survived for the duration of the trial.
- After 24 hours, weeds in some regions of the central core were eliminated while in other regions survival rates were as high as 55%.
- Moisture content varied throughout the heap, e.g. on day 4, moisture content ranged from 38–63%. Microbial activity (and therefore heat generation) is usually lessened in drier regions of a heap.
- Particle size of the feedstock was generally too coarse and varied the length of the heap. Having appropriate proportions of the various particle size fractions is critical. The fine fraction is essential for moisture holding capacity and for microbial activity and the larger fraction for aeration.
- Temperatures above 55°C were uncommon in the edge region (i.e. edge to a depth of 85 cm) but were achieved at greater depths (1–2 m) in the heap for the length of the trial.
- Turning the heap revitalized the pasteurization process and increased temperatures greater than 55°C in the edge region of the heap.

General findings

Conditions within compost heaps are highly variable and subsequently so is the ability of the process to kill weeds and plant pathogens (Figure 2). Overall, temperature and time play key roles in maximizing the elimination of PPW. Other factors such as pH and direct microbial antagonism are also thought to assist, but temperature is one of the few factors that can be readily regulated (Com-Post No. 3 1996).

As temperature gradients exist from the cooler outside layers to the hotter central cores of a heap, simply stockpiling the shredded green waste is not enough to eliminate PPW (Figure 3). An efficient turning regime is required to ensure all of the green waste feedstock is exposed to temperatures of 55°C for at least three days. Practically, this requires several weeks to incorporate the required number of turnings.

Recommendations

The most obvious but also the most critical recommendation to be given to the green waste industry, was the need to properly manage green waste recycling processes and for appropriate monitoring. Recommendations have been given via a regular newsletter (i.e. Com-Post) and industry seminars.

Basic recommendations in order to minimize the risk of spreading PPW in recycled green waste have included (based on low-technology windrow systems):

- Appropriate preparation of green waste feedstock. Material should be ground/shredded enough to produce 35% fine fraction (<4 mm) and thoroughly mixed to ensure even distribution of particle size.
- At a minimum the green waste feedstock should be pasteurized for a period of three weeks incorporating three turns. That is, temperatures of 55–70°C are maintained for at least three days prior to turning.
- Regularly monitoring of temperature development.
- Maintain moisture content between 40 and 50%. Water may need to be added throughout the process to achieve this level.
- Eliminate noxious weeds, soil and diseased plants from the feedstock where possible.
- Educate and encourage the public to act responsibly, via signage, brochures and council documents.

Table 2. Organisms tested for survival in composting or mulching processes.

Weeds	Plant pathogens
Blackberry *Rubus* spp.	*Plasmodiophora brassica* (clubroot)
Wattle *Acacia* spp.	Tobacco mosaic virus
Couch grass *Cynodon dactylon*	*Armillaria luteobubalina*
Kikuyu grass *Pennisetum clandestinum*	*Sclerotium rolfsii*
Tall fescue *Festuca arundinacea*	*Sclerotinia sclerotiorum*
Perennial ryegrass *Lolium perenne*	
Tomato *Lycopersicum tomentosum*	
Watsonia *Watsonia* spp.	
Wandering Jew *Tradescantia albiflora*	
Honeysuckle *Lonicera japonica*	
Sugar gum *Eucalyptus cladocalyx*	

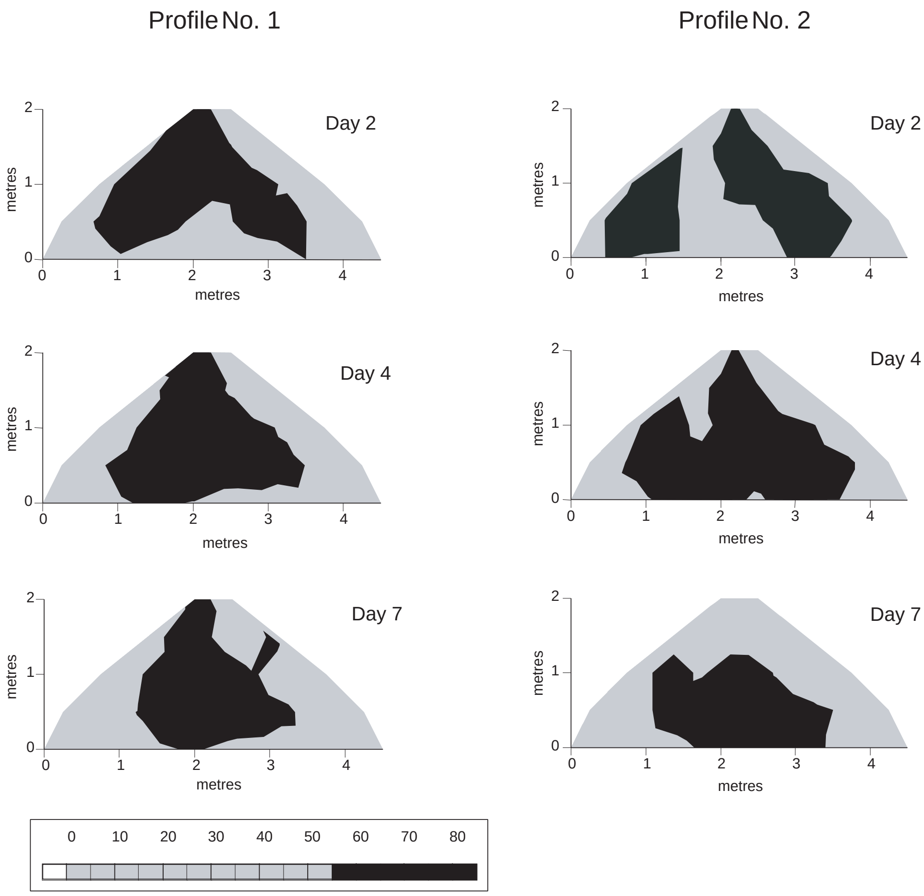

Figure 2. Temperature development within a compost heap at two positions along a 20 × 5 × 2.5 m windrow.

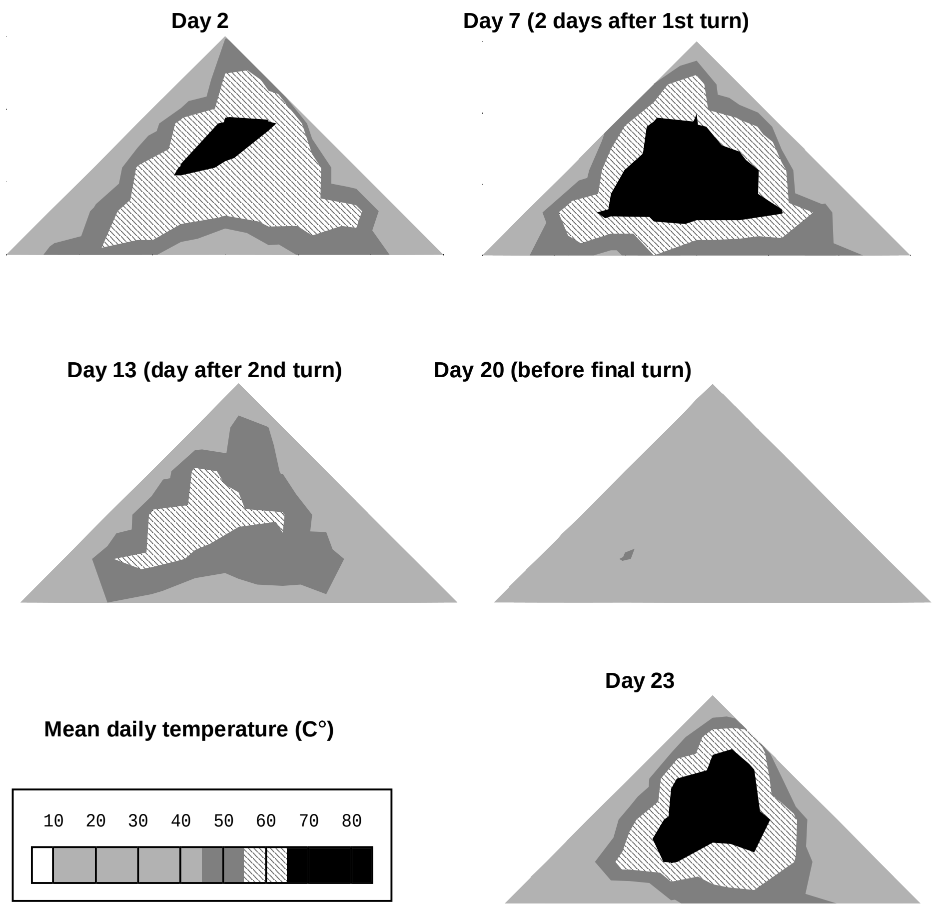

Figure 3. Cross-section of a compost heap illustrating temperature development of a compost heap during a 23 day period involving one turn of the heap.

Conclusion

Since the inception of the project, there has been gradual adoption of these basic recommendations at green waste recycling facilities. Further expansion of these recommendations and the cumulation of this research has been the publication of the 'Guide to best practice – composting green organics' (EcoRecycle Victoria 1998). The development of this guide has coincided with the industry's changing attitude towards recycling of green waste. Many within the industry identify the need to adopt best practice procedures and implement Quality Systems if they are to minimize the risks associated with processing green waste and subsequently develop sustainable markets for end products.

In recognition that research literature is not enough to encourage the industry to widely adopt best practice guidelines, a training program ('Quality in composting') has been established by IHD, sponsored by EcoRecycle Victoria to compliment the guide. To date there has been wide spread interest in the training program, which is soon to commence mid-July 1999.

References

Carr, G.W., Yugovic, J.V. and Robinson, K.E. (1992). Environmental weed invasions in Victoria. Conservation and management implications, 78 pp. Department of Conservation and Environment and Ecological Horticulture Pty Ltd. Melbourne.

Com-Post No. 1 (1996). Newsletter for the organic recycling industry and compost users. Agriculture Victoria and EcoRecycle Victoria, January 1996.

Com-Post No. 2 (1996). Newsletter for the organic recycling industry and compost users. Agriculture Victoria and EcoRecycle Victoria, April 1996.

Com-Post No. 3 (1996). Newsletter for the organic recycling industry and compost users. Agriculture Victoria and EcoRecycle Victoria, September 1996.

Com-Post No. 5 (1997). Newsletter for the organic recycling industry and compost users. Agriculture Victoria and EcoRecycle Victoria, August 1997.

Com-Post No. 6 (1998). Newsletter for the organic recycling industry and compost users. Agriculture Victoria and EcoRecycle Victoria, March 1998.

EcoRecycle Victoria (1998). Guide to best practice – composting green organics. EcoRecycle Victoria, December 1998.

Meinhardt Pty. Ltd. (1996). Organics recycling strategy for metropolitan Melbourne. Report prepared on behalf of EcoRecycle Victoria, May 1996.

Parsons, W.T. and Cuthbertson, E.G. (1992). 'Noxious weeds of Australia', 692 pp. (Inkata Press, Melbourne).

Porter, I., Miller, J., Todorovic-Clayton, S., Wilkinson, K. and Morgan, W. (1995). Green waste recycling. A literature review on the risk of spreading the major pests, diseases and weeds associated with green wastes. Agriculture Victoria, August 1995.

Strickland, M. (1998). Market outlook for green organics. Proceedings of the Business of Recycling Composting National Conference and Exhibition, 29–30 June 1999. EcoRecycle Victoria and Beverage Industry Environment Council.

Tymms, S., Wilkinson K., Tee, E. and Hood, V. (1999). Minimising the risk of spreading weeds in commercial mulches and composts derived from green waste. 12th Australian Weeds Conference, Tasmania, pp. 673-77.

Wilkinson, K., Tymms, S. and Porter, I. (1997). The risk of spreading plant pathogens, pests and weeds in recycled green waste. 1996 Annual Report prepared for Waste Management Council. Agriculture Victoria, February 1997.