SMALL-SCALE COMPOSTING

Are home and community compost systems effective?

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INTRODUCTION

The consciousness around global warming has exposed the role that food waste plays in greenhouse gas emissions

Background

When I recently moved from the outskirts of Frankfurt, Germany to the inner suburbs of Sydney, Australia, our composting practice faced some difficult questions. The previous environment featured plenty of space for the compost system, lawn area and beds with all the green (nitrogen-rich) and brown (carbon-rich) organic materials from the garden, as well as the organic waste collection provided by the council. Garden waste and leftovers from the kitchen were mostly composted onsite, and anything *difficult* went into the green bin to be processed by municipal recyclers. We could also collect free compost from the recycling centre, but the home compost system saved us the transport and time.

In our new home, the space outside is small, there are vast areas of concrete pavement left from a bygone era of garden management philosophy, the neighbours are close and rodents are hungry. While the local council does operate an organic waste collection service, this does not yet allow disposal of food waste. Here the households which do not compost themselves need to dispose of food waste via the normal (landfill) rubbish collection, or find a composter in the community. While the city of Sydney is currently working on an organic waste collection which incorporates food waste ('FOGO', which stands for *food organics and garden organics*), the timing is unclear and officials have acknowledged enormous challenges ahead, especially in the inner city[1].

The consciousness around global warming has exposed the role that food waste plays in greenhouse gas emissions and cities like Sydney are at a turning point in the waste management discussion. The public is increasingly aware that organic waste is the largest component of landfill in Australia (40-60%[2]) and the USA (40%[3]) and that this releases methane into the atmosphere, rather than putting nitrogen and carbon back into depleted soils. While food waste in landfill is an environmental timebomb, nitrogen prices have been doubling from 2021 to 2022[4] and the agriculture industry desperately needs to unlock more sustainable soil management models.

Organic 'waste' is simply too valuable to waste.

1 https://cityhubsydney.com.au/2022/03/fogo-to-face-enormous-challenges-in-the-inner-city/
2 https://www.dcceew.gov.au/environment/protection/waste/food-waste/recovering-organic-wast
3 https://www.epa.gov/facts-and-figures-about-materials-waste-and-recycling/national-overview-facts-and-figures-materials
4 https://blogs.worldbank.org/opendata/fertilizer-prices-expected-remain-higher-longer

Having established the municipal 'Biotonne' (organics bin) in 1983[5], Germany may seem like a good example to follow, but its agricultural nitrogen run-off[6] and soil degradation[7] has been devastating, suggesting that the benefits of compost were not always taken seriously by industry and policy. In any case, every country and city faces a unique set of factors such as climate, access, industry organisation and human behaviour.

With a huge amount of nitrogen- and carbon-rich organic waste originating in residential households, the question is whether this resource can be efficiently fed into the agriculture sector through large industrial composting operations, or better turned into compost at home as part of a 'decentralised recycling' set of measures. Is it worth starting a home composting system despite, and alongside a municipal collection service? Can households set up and operate a system that will actually break organics down in a small space, to reduce emissions and produce compost while avoiding rodents and odours? Can/should households without a garden compost? Are the systems that suppliers offer on the market fit for purpose or is something different needed? And will community composting start to play a bigger role, as it is starting to in the US[8]?

In the practice and discussion around small-scale composting, the question of which composting technologies or methods of composting are best-suited for smaller volumes of compost and small gardens is not easy. There are a growing number of composting technologies available to home gardeners which take the size of the garden, the volume of compostable material ('feedstock') and the preferences and conditions of smaller sites into consideration. All of these methods have benefits in terms of practicality, odour-reduction, pest-control and even aesthetics. But when compared to the efficiency of industrial composting operations, with their well-aerated, moisture-controlled, heat-producing 'windrows', the small-scale composting systems used in the home face challenges.

5 https://www.hna.de/lokales/witzenhausen/witzenhausen-ort44473/witzenhausen-neues-buch-erzaehlt-die-geschichte-von-40-jahre-biotonne-90893887.html
6 https://www.mdpi.com/2073-4441/11/12/2450
7 https://link.springer.com/chapter/10.1007/698_2022_948#:~:text=Nowadays%2C%20at%20least%2019%25%20of,and%20widespread%20soil%20degradation%20process.
8 https://ilsr.org/ccc-2023-makes-mark/

The 'windrows' typically used at industrial composting sites allow operators to efficiently control the volume, moisture, aeration and temperature. During the active composting phase, temperatures are maintained around a preferable range of 55°C (to kill pathogens and weed seeds) to 65°C (to avoid killing beneficial microorganisms). Photo: Alfred Hofer/Shutterstock

There is not much in the way of consensus on the pros and cons of different composting technologies, but we know enough to make things difficult when it comes to selecting the best approach. Experience, philosophies and half-truths include many notions on what will and will not work at a small scale, i.e.:

1. ***Processing organic waste at small scale is inefficient; better to compost industrially.***
2. ***Odour and pests make open piles and bays unsuitable in dense neighbourhoods.***
3. ***At least one cubic metre/yard of mass is needed for effective composting.***
4. ***Compost bins are slow to compost and difficult to turn.***
5. ***Vermicompost systems are small and fussy.***
6. ***Bokashi is complicated and costly.***

By examining the experience of small-scale composters and the methods they use, this study will hopefully improve peoples' experiences of composting and help process more urban organic waste sustainably. We can use it to think more carefully about how to promote composting from a municipal/community level, given its broad range of benefits. The potential synergies, overlaps, gaps and opportunities between small-scale, home, community, municipal and industrial composting will continue to adjust and will be extremely important for all actors to monitor and build upon. This makes it particularly interesting to look at how people are composting the enormous amount of organic waste coming from homes, and whether the systems we use should continue being promoted.

It will be challenging to capture the huge amounts of organic waste created in homes and divert them from landfill, but if different types of composting systems at the home and community level are working well, the greenhouse gas mediation, soil nourishment impacts and cost savings will be high.

Methodology

This study is designed to evaluate how people are managing their compost systems, which technologies they are using, and how well they are working. This will reveal which composting technologies and practices should work best for our own homes or communities. Community systems are included in the study, because like home composting, community composting is a) usually small-scale, b) based largely on common household feedstocks, c) not designed as a commercial or industrial operation, and (d) often uses the same types of technologies. It also seems that community composting occupies a similar space as household composting when it comes to generating solutions for denser urban communities, which are more challenging for waste collection, sorting and processing: both modes revolve around keeping the organic waste inputs and the finished compost outputs within a close proximity without requiring road transport.

The survey respondents, totalling 150 composters, have come largely from Australia/Oceania (30%), Europe (27%) and North America (40%). Responses were collected by disseminating the survey through gardening and composting forums and communities.

As we are also interested in *why* the respondents compost, two factors are particularly important to set the scene: context and motivations. To help establish context, respondents are asked to define themselves in terms of what kind of gardeners and composters they are, i.e. vegetable growers, flower growers or something else. Then to understand motivations, respondents list their priorities in terms of why they compost.

Naturally the hobby/pastime/passion of gardening lends itself brilliantly to composting and vice-versa, but there are also increasingly more options for people to compost even without having a garden. We want to find out whether the living environment has an influence on whether, how and why people compost.

The real substance of the study is around which types of composting systems people use and how the experience with different systems presents in terms of effectiveness and practicality. We hope to learn about which systems are best for the small-scale composter and to assess what kind of results can be expected from different systems.

The survey remains open at www.neeshgroup.com

Community composting occupies a similar space as household composting when it comes to generating solutions for denser urban communities

ANALYSIS

There is strong and symbiotic connection between growing your own food and producing your own compost

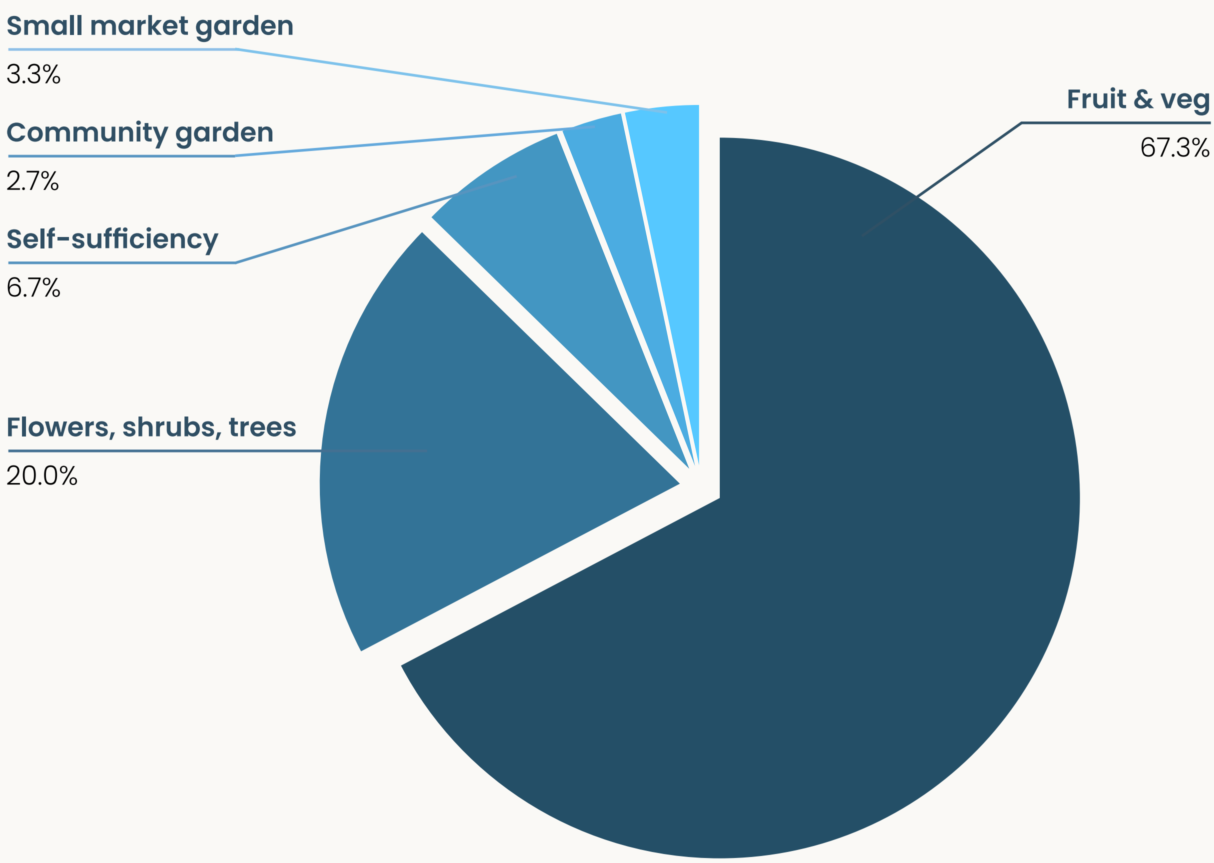
Even with the strong relationship between gardening and composting, the avoidance of sending organic waste to landfill is a very important reason for composting

Context

Composting and gardening goes hand-in-hand

The context in which people find themselves composting does, as expected, often include the practice of gardening. The respondents identify strongly as home gardeners of fruit and vegetables (67%). We have not recorded any respondents who operate a compost system *without* practising any form of gardening, although we do see some compost systems on the market (mostly vermicompost) that are designed with apartmenrts in mind. Apartment dwellers should probably be the highest priority for rolling out municpal organic waste collection and with FOGO pilots in Australia, this is actually the case.

Figure 1 - What types of gardeners are the respondents?



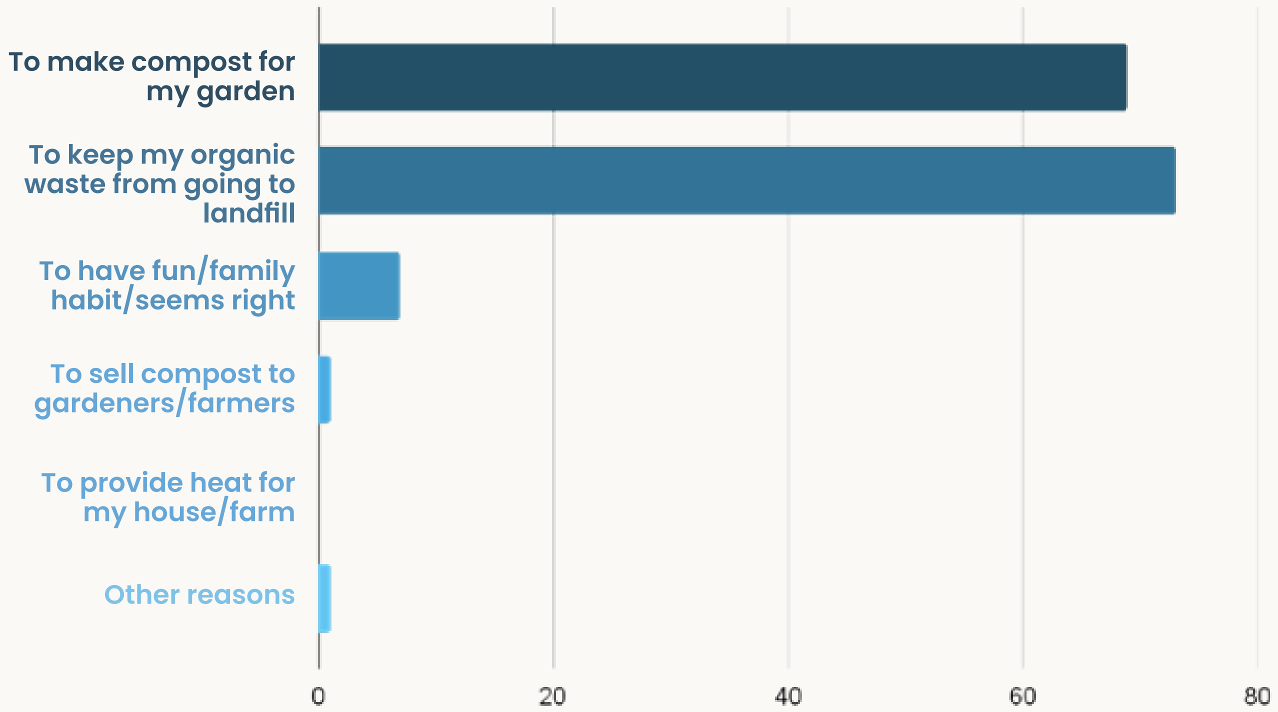
From the results collected, we are *not* extrapolating to suggest that two thirds of composters worldwide must be fruit and vegetable gardeners, but by asking this question we get a better idea of how respondents contextualise composting and measure success.

There is a strong and symbiotic connection between growing your own food and producing your own compost: when you grow vegetables you generate a lot of green residue (leaves, stalks, roots, peel, spoilt produce) that is best disposed of by composting, *and* thence you end up with the best growing medium and soil additive to use immediately on your beds, saving costs for commercial fertilisers, soil and compost. Of course other gardeners who focus on flowers, shrubs and trees (20% of respondents) also enjoy and benefit from composting, but perhaps fruit and vegetable gardeners are also particularly exposed not only to composting, but to the discussions, forums and studies such as this one.

Emissions reductions are just as important as soil improvement

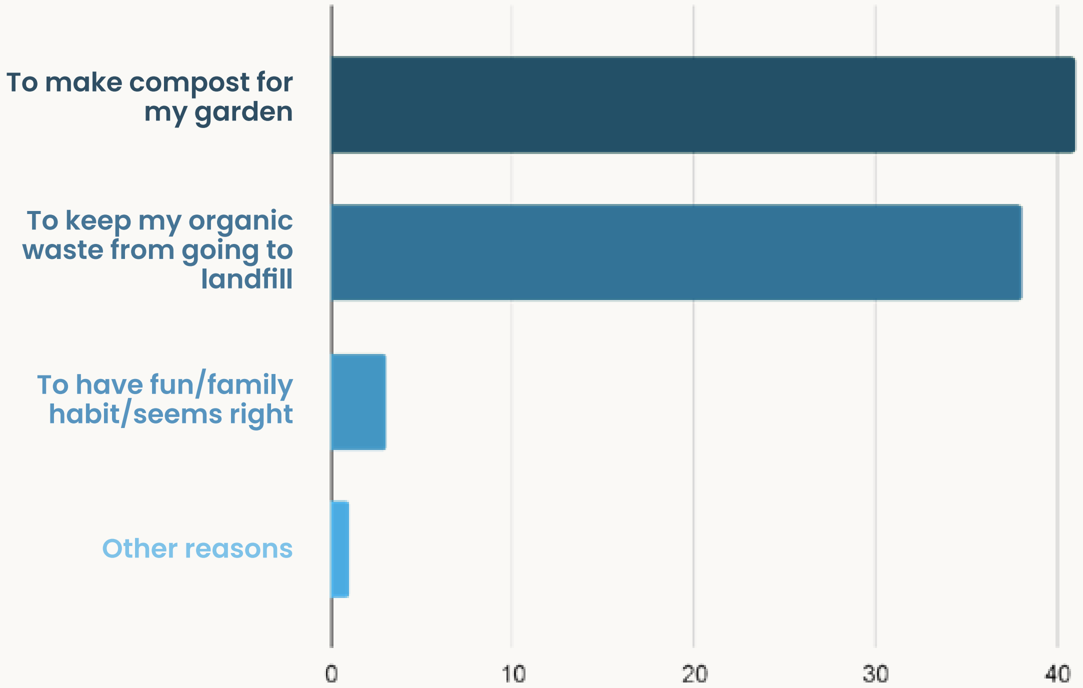
Even with the strong relationship between gardening and composting, the avoidance of sending organic waste to landfill is a very important reason for composting. A slight majority of respondents report that the diversion from landfill is the most important priority in their composting, just ahead of the actual production of compost.

Figure 2 -Why do respondents compost?



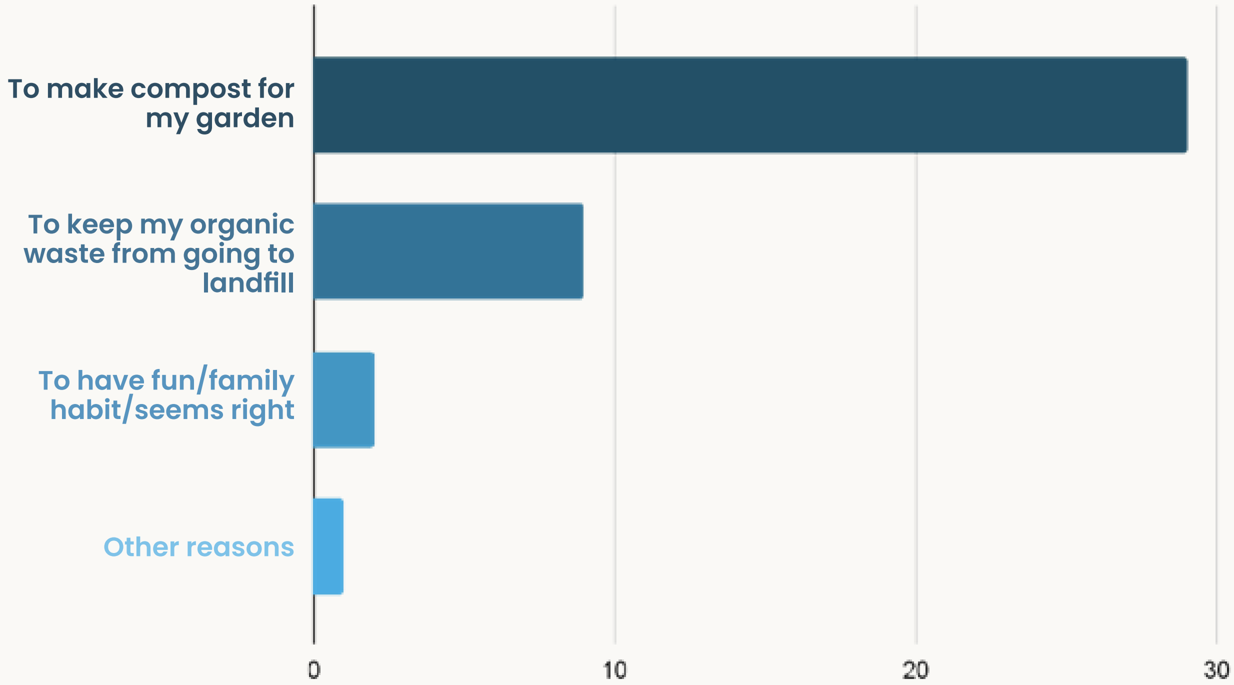
The respondents who list landfill diversion as their first priority list compost production as their second, and vice-versa. This tells us a lot about how successful the information around methane emissions in landfill has been, and that households could likely be convinced to conduct composting even if they are not big gardeners. Even when we filter the results to look only at the fruit and vegetable growers, who would presumably be most enthusiastic about producing their own compost, landfill diversion is still a close second.

Figure 3 - Why do the fruit and vegetable gardeners compost?



Interestingly among European composters, we see a much clearer priority for producing compost over that of landfill diversion. This makes sense as it underpins the strength of the greenhouse gas messaging and the role of comprehensive municipal composting. Many municipalities in Europe collect not only garden waste, but also household food waste in their organics collection. This slightly diminishes the rationale for households to manage their own food and garden waste, as they know/believe/hope that much of it will go to a sustainable recycling operation rather than landfill. In the US and Australia, households are all too aware of the likelihood of their nitrogen-rich waste going to landfill.

Figure 4 - Why do European respondents compost?



An encouraging insight related to context is that most respondents enjoy the practice of composting and do not see it as an unappealing chore. "To have fun" seems to be the overwhelming priority for respondents after reducing landfill and producing compost. In the open ended responses on motivation, composters express intrinsic motives like: *therapeutic, enjoy the process, interesting, mental health, learning and curiosity.*

Therapeutic, enjoy the process, interesting, mental health, learning and curiosity.

Technology

The range of technologies available to small-scale composters is large

Turning to technologies, methodologies, inputs and outputs, it seems that smaller systems have the potential to be effective, but can often under-perform. While there are dozens of different products available for small-scale composting, the respondents were able to place their approaches within seven distinct categories. By comparison, large-scale industrial composting mostly falls under just three formats: piles, windrows and contained/in-vessel composting. Apart from the pile/pit method, most of the methods used by households could certainly be referred to as contained/in-vessel composting, though there are some important biological and physical distinctions that really set them apart and make each approach more or less suitable for different situations. The seven most common technical categories of small-scale composting are set out below.

Figure 5 - Seven types of small-scale composting

Open pile or pit

Photo: Paul Maguire/Shutterstock

A pile or dug-out pit is probably the simplest composting system to set up and is thus a popular choice for 43% of respondents. They have the advantage of being completely flexible in size as feedstock sources increase - three quarters of pile users report volumes of between 1 and 5 cubic metres. Some of these composters also have bins and tumblers, and it seems that piles are common with composters who have some overflow feedstock. Piles are simple and effective as the necessary volume for higher temperatures can easily be reached.

Typical price: free

Bin or drum

Photo: Alison Hancock/Shuttestock

Bins and drums are one of the most popular small-scale technologies, employed by over 54% of respondents. They tend to come in smaller ~250 litre, and larger ~500 litre sizes (respondents use both, ~50/50). Bins are attractive around urban areas due to their perceived cleanliness. Complaints are often raised about low temperatures and slow composting. Some manufacturers supply bins with improved heat insulation and aeration, but the way bins are used is the key success factor. As with piles, tumblers and three-bay systems, decomposition is aerobic and relies on microorganisms breaking materials down.

Typical price: 50 - 100 (USD)

Tumbler

Photo: Grand Brothers/Shutterstock

A tumbler is similar in shape and structure to a bin, but is suspended on its side with a rotating functionality to make turning and aeration simple and keep the contents warmer. Around 23% of respondents use a tumbler and report decent results for small quantities of feedstock. Tumblers come at a slightly higher cost and are usually on the small side, from 100 - 250 litres.

Typical price: 150 - 200 (USD)

Three-bay system

Photo: Blue Java1/Shutterstock

Three-bay, or perhaps confusingly 'three-bin' composting is popular with more demanding gardeners, in our case, 22% of respondents. This method requires more space (around three cubic metres) but is capable of reaching higher temperatures, processing larger volumes of waste and producing more compost than other small-scale technologies. It is relatively easy to load, turn and unload the material, and it provides composters with separate feeding, composting and curing bays to avoid mixing compost with fresh feedstock.

Typical price varies, usually DIY

Vermicomposting

Photo: Holly Harry/Shutterstock

Vermicomposting, practised by 27% of respondents, contrasts with the above methods as it uses certain worms (often Eisenia fetida) to decompose organic waste into 'castings'. This does not really require specialised equipment, but suppliers offer various products suited to small residential spaces, even indoors. Temperatures remain low and the volume of waste need not be large, with many off-the-shelf worm farms holding around 50 litres (smaller and larger options available). The process is comparatively quick and the finished product is considered premium quality due to the high presence of various microorganisms.

Typical price: 150 - 200 (USD), vessel & worms

Leaf mould

Photo: Pataporn Kuanui/Shutterstock

In leaf mould composting, practised by 15% of respondents, fungi decompose the carbon-rich leaves into a light, mild soil organic matter with excellent moisture retention, highly regarded as a potting mix or mulch. The method is simple and very common in areas with many deciduous trees. Leaves can be stored in piles, bags, pits or bays, and are simply left moist and aerated for six to twelve months or until ready to spread. The very particular feedstock and processing method used here makes it less prudent to compare leaf mould to other technologies, but we know it works, slowly.

Typical price: free or neglible

Bokashi

Photo: My Bears/Shutterstock

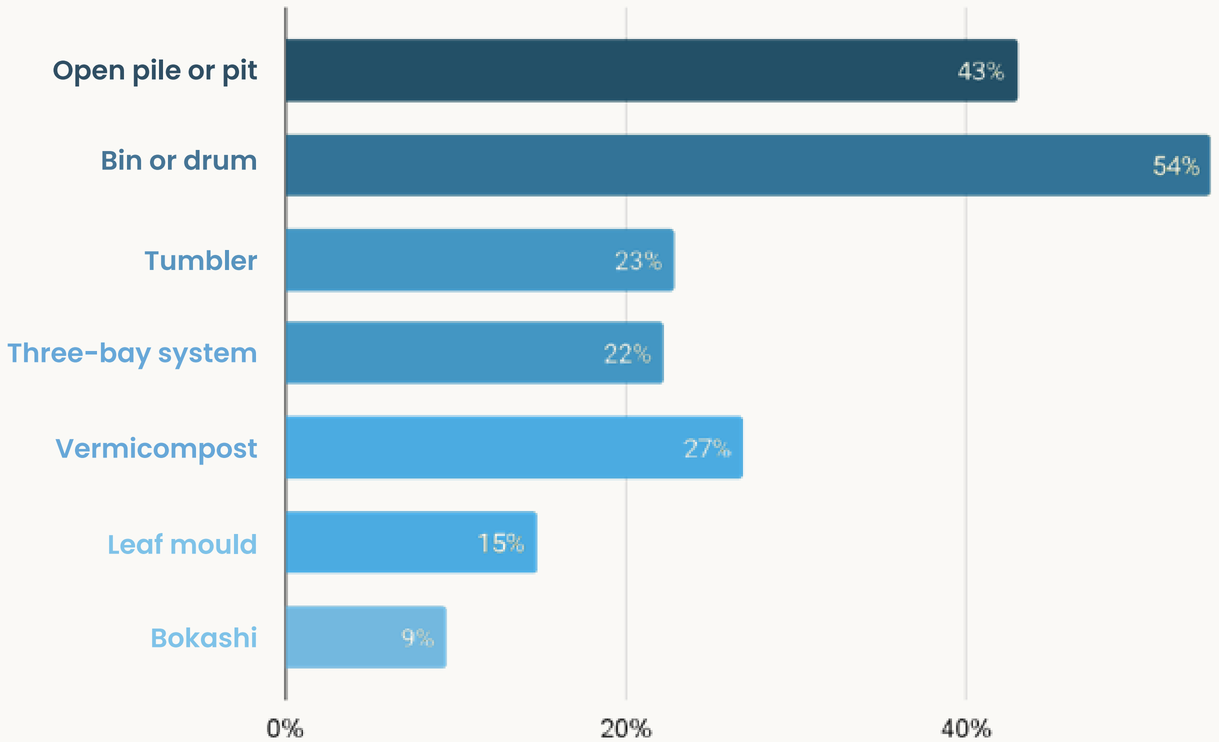
Only 9% of respondents practise Bokashi, where organic waste is converted into a soil amendment through fermentation by adding lactobacilli and carbohydrate-rich additives like molasses. Cooked leftovers, meat and dairy can also be composted this way, and the technology has been pitched at people with smaller spaces, as common vessels range from around 5 - 25 litres. After two weeks fermenting in these bins, the waste is piled or buried outside to compost for a further two weeks

Typical price: 100 - 200 (USD) plus additives

The right-sized, simpler methods are generally preferred

The results suggest that piles and bins are the most popular technologies with respondents, but many composters report using several methods side-by-side, or having tried various methods before finding the most effective solution. The pile and bin methods are usually the easiest to set up and seemingly straightforward to maintain, which is an important factor for home and community composters who are unlikely to spend a great deal of time; regardless of the method used, 80% of respondents report spending around one hour per week tending their systems, 13% spend around two hours. Vermicomposting, tumblers and three-bay systems are the favourites after bins and piles.

Figure 6 - Types of compost system(s) used by respondents



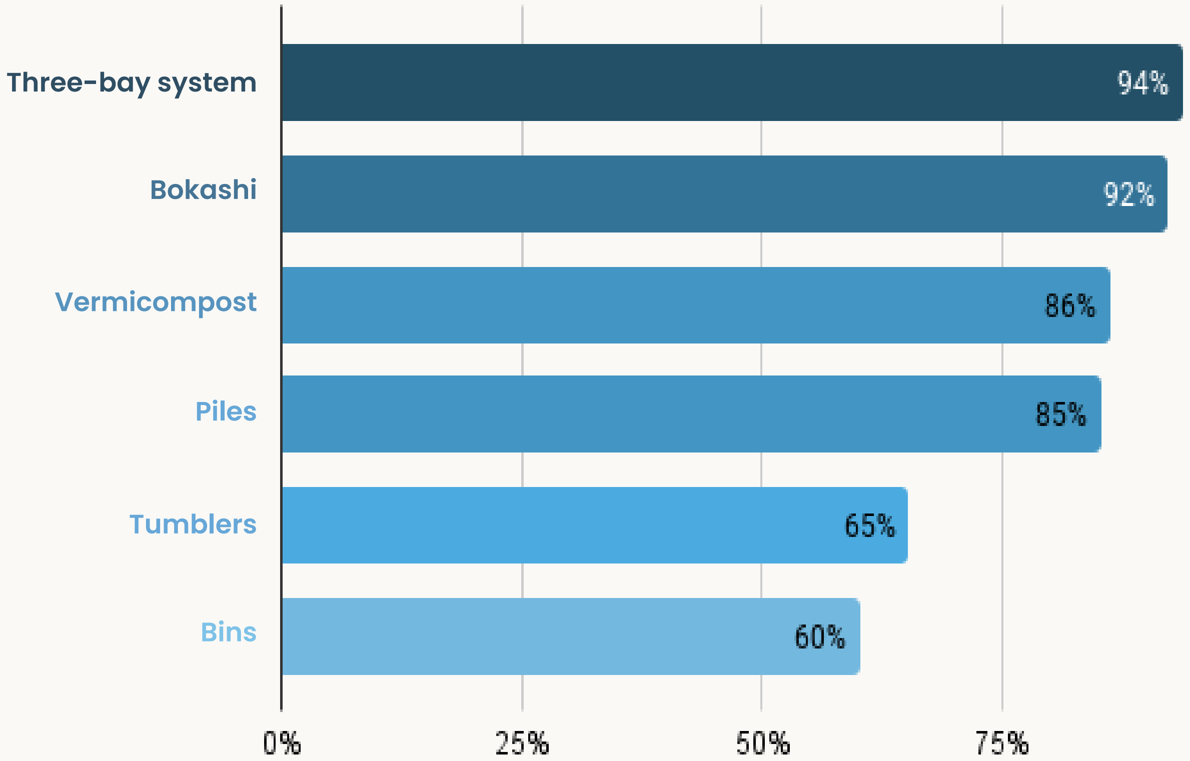
Not every method is equally effective

The criteria of effectiveness and practicality can unfortunately compete when it comes to selecting the most suitable system, and it may not always be the top priority for every composter to just process household waste as fast as possible. Typical limitations to best-practice composting could include the available space, the amount of regular feedstock, the problem of rodents and odours, aesthetics and costs. Bins tend to take much longer to produce compost than piles and three-bay systems, but their ability to contain the operation has made them very popular for a long time.

Short of going into an assessment of all the circumstances that make particular systems attractive, we are looking at whether the different technologies are effective in producing compost, and how long this takes. Overall, most respondents reported producing 'a fair amount of usable product'. This question was deliberately formulated in a way to allow some subjectivity from respondents, as laboratory-condition comparisons seem inappropriate in light of the various contexts composters face. Respondents can express some dissatisfaction with a system's productivity by clicking 'my system isn't performing as well as I think it should', or tell us 'I don't really get finished product from my system'.

Thankfully the majority of respondents consider their respective systems to be effective at producing usable compost, but for some methods there are a considerable number who are not producing compost, or feel that their systems are not performing as they should. Visualising this data by type of system used, we see that the three-bay systems closely followed by bokashi composters, are reporting the highest effectiveness, and bin users the lowest. Out of 81 bin composters, 60% reported producing a fair amount of compost, 30% felt their systems were not performing well enough, and 10% were not getting finished product. Although bins seem to work for some, it seems particular operating conditions are necessary for good results.

Figure 7 - Percentage of systems performing effectively



For richer data on their experiences, respondents also provide open-ended sentiments, from which we can draw more insights on problems faced with compost bins:

1. ***Bins are too small to achieve the temperatures which bays and piles can reach.***
2. ***Getting the carbon-nitrogen ratios right is difficult in a small enclosed space.***
3. ***Large, stringy organic feedstocks are abundant but they make turning in bins difficult.***
4. ***Moisture levels are critical yet tricky to perfect.***
5. ***The finished product gathers at the bottom, making unloading complicated.***

With tumblers (65% satisfied, 16% not quite, 19% no product), many users face similar issues, but the turning and aeration is significantly improved. Several users also find them helpful for 'pre-composting' before moving the material to vermicomposting systems.

The technology plays a strong role in the amount of time needed

Respondents were also asked about the length of time between a batch being full of feedstock and the compost being ready to use. There is an inherent challenge with this data, as the definition of 'completed compost' differs depending on whether and how much curing time is taken into account. At a healthy active composting temperature of around 55°C, a pile, bin, tumbler, bay or even a windrow will turn organic waste into compost in two to three months, but at this stage it is biologically still highly active and may cause damage to some plants; the curing phase, where decomposition continues at a low and slow rate, makes the compost stable and easier for plants to draw nutrients from. Hence, some composters only consider compost as 'finished' after some months of curing.

Figure 8 - Composting systems from fastest to slowest

Technology	< 3 months	~ 3 months	3-6 months	6-9 months	9-12 months	>12 months	Never
Bokashi	60%	20%	10%	0%	0%	10%	0%
Vermicompost	38%	18%	21%	12%	9%	3%	0%
Tumblers	23%	11%	29%	14%	9%	6%	9%
Three-bay	9%	18%	27%	18%	9%	18%	0%
Piles	9%	11%	33%	14%	11%	23%	0%
Bins	5%	14%	19%	12%	18%	25%	7%

The table above shows us the percentage of respondents reporting various periods according to the method used. While it is quite clear that a composter can expect very fast processing times from bokashi and vermicompost, we also see many users reporting a very reasonable three to six month processing time with tumblers, piles and three-bays. Compost bin users report a highly varied processing time: a majority of 62% report times of six months or more, with some never completing composting at all. However, 38% of bin users are also able to complete composting in under six months, which suggests that a bin can work well under particular conditions (which most respondents are not achieving).

With three-bay systems, piles and bins, several respondents reported >12 month periods. There are several possible explanations for this apart from slow composting, depending on the technology. For pile composting, it may indicate that the users, blessed with space, allow plenty of curing time given the ability to start a new pile and avoid mixing finished and unfinished compost. They may also be happy to conduct a slower more passive approach without turning, given their available volume upon completion. Likewise with the three-bay systems, where one bay can be reserved for curing. With bin composting, the qualitative data collected (presented below) suggests that batches really can take nine, twelve or more than twelve months to break down if no special measures are taken.

For the active phase in a small-scale system, anything under three months can be considered relatively fast with around three months representing a normal efficient rate; even large industrial operations by aerated static pile or windrow require around two months, with curing times of an additional two months[9], though many high quality compost producers take it slower.

9 Rynk, Robert. 2021. *The Composting Handbook*. Elsevier S & T, P. 88.

Can bins achieve the same results as other technologies?

The success indicators above reveal some issues with bin composting which deserve attention. The high proportion of composters who continue to use them (over half of all respondents) shows that they are still a favourite choice, and they do come with benefits which make them attractive under certain conditions:

1. ***The organic waste is well hidden and contained to reduce pests and odours.***
2. ***They are simpler to operate than faster systems like bokashi and vermicomposting.***
3. ***They are right-sized for many households where bays and piles are too large and worm farms and bokashi bins too small.***

While they may not score as highly in terms of speed and finished product, many composters like to use bins for these other reasons. Luckily we can draw some important techniques from the more successful bin users, which can help get bins operating closer to the level of bays and piles. Respondents shared several pro tips outlined below:

Photo: Ashley Wearne

Some issues with bin composting which deserve attention

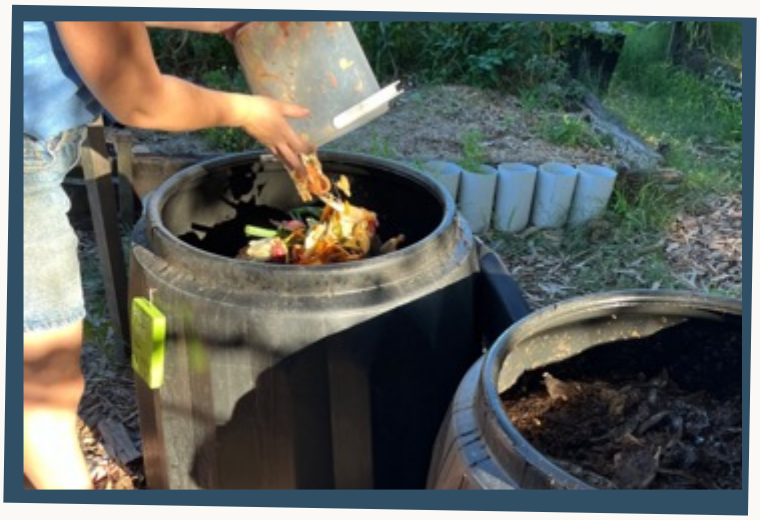


Photo: Ashley Wearne

Figure 9 - Effective bin composting tips from successful users

1. ***Larger bins achieve higher temperatures.***
2. ***Use nitrogen-rich feedstocks like coffee grounds, kitchen waste, animal bedding.***
3. ***Add plenty of light carbon-rich feedstock like wood shavings, dry leaves, and feed your system more carbon than nitrogen.***
4. ***Shred bulky or stringy feedstock finer.***
5. ***Aerate contents at least once per week.***
6. ***Keep contents quite moist but not sludgy.***
7. ***Use a thermometer, aim for at least 45°C.***
8. ***Use a sunny position to raise the temperature.***
9. ***Use two or more bins to keep new feedstock separate from a full, advanced batch.***
10. ***Worms and soldier flies are very welcome.***

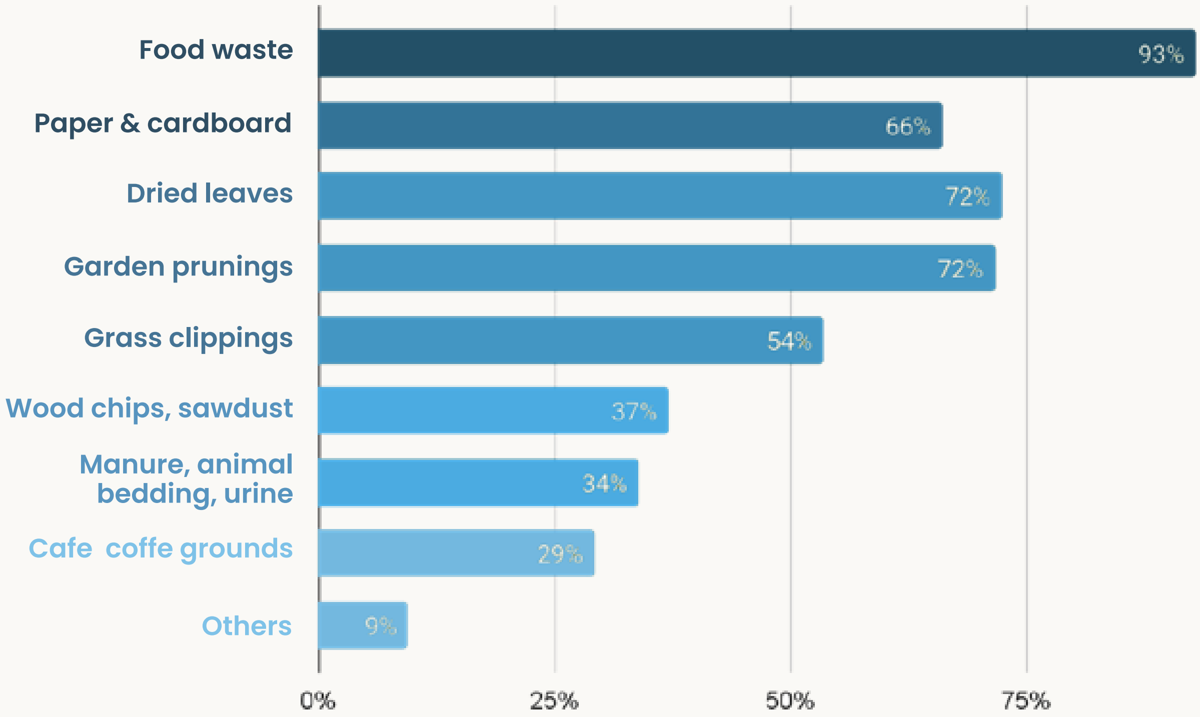
Process

We know *what goes in*, we don't really know *what goes on*

To dig a little deeper into why different systems may be performing better or worse, we need to ask more technical questions about practices and chemistry, starting with what materials are being fed. Unlike industrial compost operations which often receive exotic waste from other industries, the range of feedstocks that small-scale composters use tends to be fairly similar regardless of continent or technology. Bokashi and vermicomposters may be a little more picky, as the active biota in each case require specific conditions, but it is still fairly easy to predict the types of organic waste households have at hand. This questioning is also useful for the sake of promoting composting, giving us insights into which wastes are most common and how best to compost them.

Naturally almost all small-scale composters use food waste (which is an excellent nitrogen source). Another feedstock abundant in many homes is paper and cardboard, which two thirds of composters use; it is often noted that aeration is tricky with these materials and they are often avoided by those not in possession of a shredder. Dried leaves, prunings and grass clippings are all rich, workable feedstocks - logically those who have gardens or green neighbourhoods make use of them. The more industrial/commercial materials such as wood chips, manure and larger volumes of coffee grounds usually need to be sourced 'off-site' and hence only around a third of composters use them. Logically a composter whose motive is to mitigate landfill would tend not to gather off-site organics, while a production-oriented composter quite well would, particularly as some of these feedstocks (e.g. coffee grounds, chicken manure, wood shavings) can accelerate and enhance. A few pro tips were also shared under 'other' feedstocks, including straw, seaweed and spent grain and hops from breweries.

Figure 10 - Which feedstocks do respondents use?



Digging deeper into the science, we find most small-scale composters do not measure their system temperatures and moisture, at least not with precise instruments. These simple tests could hold the key for a lot of composters struggling to accelerate their cycles and generate finished compost. Thermometers cost around USD 20, far less than some other composting equipment, and are very helpful for piles, bins, bays and tumblers. For all these methods, thermometers tell us how active the composting process is. Higher system temperatures should be closely aligned with shorter composting periods (except with bokashi and vermicomposting).

Three-bay composters (a discerning bunch!) are the only group where the majority of respondents do monitor temperature. Bokashi and vermicomposters are able to monitor progress by sight so it is not surprising that these respondents rarely measure temperature, though vermicomposters may monitor to ensure the system is not too hot for the worms. It is encouraging to see the reporting spikes in the 55° - 60°C range from three-bay and pile composters, as this is considered the sweet-spot where microorganisms are most productive.

Figure 11 - What temperatures are observed in systems?

Technology	Over 70°C	61° - 70°C	55° - 60°C	45° - 54°C	35° - 44°C	Under 34°C	Don't measure
Bokashi	0%	0%	0%	0%	0%	0%	100%
Vermicompost	0%	0%	3%	3%	0%	21%	73%
Tumblers	0%	6%	3%	10%	0%	13%	68%
Three-bay	14%	11%	23%	3%	9%	6%	34%
Piles	3%	3%	16%	0%	9%	5%	64%
Bins	0%	3%	8%	7%	11%	8%	63%

When it comes to the water content in a composting system, only around 5% of respondents conduct monitoring. This is not in any way concerning, as moisture can be adequately monitored by sight and touch, but composters using piles, bins, bays and tumblers should be aware of the preferred moisture content range which is around 50 to 60%. As it is composting, the material should clump when pressed in the hand, without being sludgy or dripping wet.

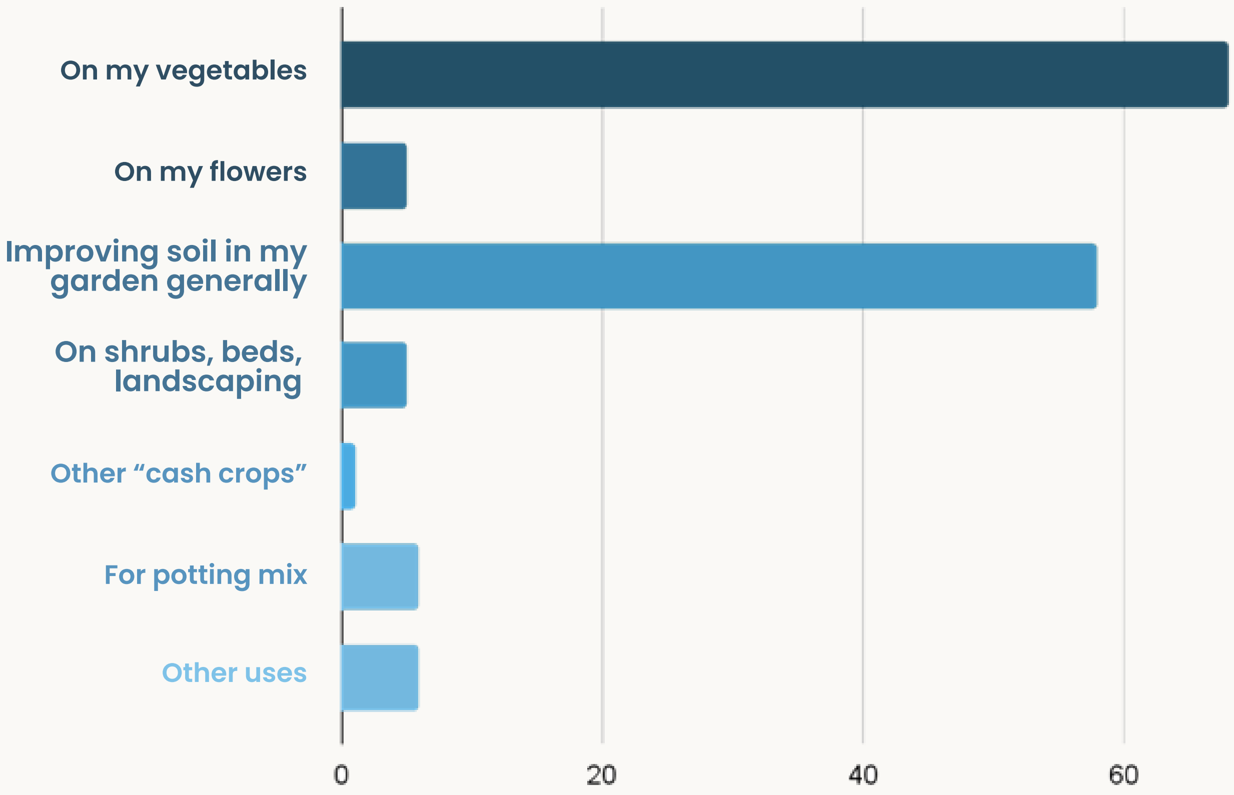
Having a little more information about carbon to nitrogen ratios, chemical profiles of feedstocks, and system temperature and moisture levels would likely improve the experience for small-scale composters, especially those using aerobic methods where microorganisms must be promoted.

Is the finished compost itself an opportunity or a challenge?

In the case of Australia, where food waste is starting to be collected kerbside, governments are not only facing the issue of waste collection and processing, but also the question around markets (off-takers) for the finished compost. The industrial composters are forecast to produce much more product given the additional food waste coming online, and the viability of this scale-up depends on unlocking more demand, whether from households, the private sector, or public projects where compost can be used. When it comes to small-scale composting, it is easy to imagine that households are less likely to compost if they cannot identify a suitable place to put or take their compost.

Respondents report using their compost mostly in their own vegetable gardening, followed by soil improvement more generally throughout their gardens. A very small number either give, sell or trade their compost with others, so there *is* an option of finding off-site demand for small amounts of compost, but few composters work this way and again we see the clear relationship between having a garden and operating a compost system. From an environmental perspective, this is important as it again suggests that people *without* gardens would be the key target group for food and garden waste collection. We should note a degree of survey bias here, as the informants who are responding are often those who participate in gardening dialogues. Still, it is not unreasonable to assume that even beyond these respondents, composters are likely to have access to gardens.

Figure 12 - How do respondents mostly use their compost?



The selection of a suitable, effective system for small-scale composting is really not easy.

Challenges, lessons and insights

After providing the quantitative information above, respondents also share their thoughts on an open-ended question around the most important challenges, lessons and insights gained in their composting practice. Listed below are some of the responses reported more than once and a frequency count (in brackets) of similar reports.

Challenges

- "I have used a number of composting systems… all have attracted rats" (8)
- "Obtaining a consistent source of carbon has been the biggest challenge" (8)
- "Volume is under considered when making compost" [small = cold] (7)

Lessons

- "Developing an understanding of the science" is key to success (21)
- "More aeration [turning] means faster production" (16)
- "Getting the right moisture content" [many report systems being too dry] (8)
- "I switched to using…" [another system after poor results with the first] (18)

The most common challenges seem to centre around pest control, feedstock collection and ratios, and undersized compost systems. All three of these challenges emphasise the effect of living in slightly denser urban communities, and again, this information should help governments and compost promoters think about the suitable support measures required.

The success achieved by digging a little deeper into the science behind composting features strongly in the lessons reported by respondents. Improving the understanding of carbon and nitrogen content alongside adequate oxygen and moisture levels generally improves results with the common aerobic compost systems.

It is interesting to note that quite a large number of respondents report having become dissatisfied with the systems they began with, and switching to something more effective. This confirms the hypothesis of this study, which is that **the selection of a suitable, effective system for small-scale composting is really not easy.**

Despite the challenges, most respondents really seem to like composting. Many respondents underline personal benefits to the individual and family, beyond just the environmental impacts, with responses such as: "It's a great way to stay aware of nature and to improve my mental, physical and spiritual health".

CONCLUSION

The practice of small-scale composting has an inherent challenge given the conditions required for aerobic composting

The conclusions possible from a study of this type relate primarily to issues around success factors under different methods of composting. Even with the current sample size of 150 respondents, the study presents some consistent experiences with particular technologies as well as a number of useful lessons that households as well as compost promoters such as government, scientists and suppliers can take into account.

The practice of small-scale composting has an inherent challenge given the conditions required for aerobic composting: many urban systems are smaller than one cubic metre, making it difficult to achieve adequate temperatures for all the beneficial microorganisms to really thrive.

When selecting a composting method, users need to know that they should look for larger options or be prepared to commit some extra efforts, perhaps even consider vermicompost or bokashi. As space and pests are such a common urban challenge, it seems bins are likely to continue to sell well, but we cannot ignore the problems people have with them.

There seems to be a significant number of systems sold that are underperforming or going unused due to poor results. **Better dissemination of the scientific information around composting[10] should provide better results than rapid dissemination of compost products**. It will help users select more suitable systems, and improve performance from the systems selected. Composting can be done well without buying anything.

While it may be useful to look at a larger sample size, the results from this study already suggest that **composting is more likely to happen in homes with gardens**. This is important to consider as we think about how to improve organic waste recycling for people without gardens. Greater uptake of kerbside food waste collection is one of several options, but there are also some lower hanging fruits that are more financially viable and environmentally friendly.

The community composting models being explored in some cities allow households to dispose of organic waste, and small processors to offload finished compost, without the need for road transport in the composting ecosystem. Community composting is also an excellent measure vis-a-vis the challenges of small-scale systems, as most community sites have adequate space for an efficient three-bay system, and usually come with a community of well-informed composters who can support other users in understanding the science for optimal performance.

10 Such as the Effective Bin Composting Tips above or a primer like Robert Rynk's *The Composting Handbook*

With urban areas presenting difficulties (translating into costs and CO2 emissions) for industrial composting, **it may be useful to consider city compost strategies under a three-tiered approach.** For instance, for households on larger blocks with adequate time and interest, home systems are probably the most efficient way to promote composting. For commercial and high-density residential zones with little need for finished compost, kerbside collection and industrial composting should be viable. Then for medium density greener urban areas, blocks are likely still on the smaller side but the community includes plenty of greenspace meaning good demand for compost in the immediate vicinity: here the community composting should be most viable, as both the feedstock and the finished compost will not require the transport and costs of industrial composting. A basis for further discussion could start from the model outlined in Fig. 13.

Figure 13 - Three-tiered compost promotion strategy

Home composting

Where: Outer urban suburbs with large blocks, and rural areas

Why:
- Ample space in gardens for systems to run effectively.
- Large distance to cover for kerbside collection.
- Households use their own compost and hence reduce transport to buy soil amendment.

Community composting

Where: Medium-dense inner urban suburbs with small blocks

Why:
- Better to process larger quantities of waste from several households than with many small home systems.
- Mix of smaller and larger houses: some compost, others do not, hence not ideal conditions for kerbside collection.
- Good demand for compost locally for parks, schools, reserves etc.

Industrial composting

Where: Dense inner urban, apartments and central business district

Why:
- Poor conditions for composting locally.
- Smaller area to cover for kerbside collection.
- Plenty of feedstock from commercial activity.
- Low demand for compost locally but high demand for this scale of compost from farmers who are further out where industrial compost operations work.

Promoting the right methods of organic waste management alongside the most suitable technologies for composting will be more effective than focusing on kerbside collection AND home composting everywhere all at once. Community composting is probably the least developed of the three modes defined here, at least in a lot of cities, and the definitions and methodology behind it should not be too prescriptive as yet. It deserves more piloting and promotion, and may soon become a more feasible way to recycle organics, perhaps also financially viable. Partnerships between the large-scale composting industry and small composting communities may also be an interesting avenue to explore.

As a growing number of cities enhance their strategies for organic recycling, emphasis should be placed on the captivating science of composting and the rewarding experience for the individual, family and community that it provides. Measures focusing too heavily on the dissemination of products without sufficient education and community interaction are likely to cost households and governments more and provide less impact than well-designed education, engagement and networking measures.

Partnerships between the large-scale composting industry and small composting communities may also be an interesting avenue to explore